Foreword

The Indian Council of Agricultural Research (ICAR) has completed over eight decades of service to the nation and as a vibrant organization, continues to generate technologies for sustained agricultural development in the country. Hon'ble President of India, Shri Pranab Mukherjee, who graced the 85th ICAR Foundation Day function on 16 July 2013, appreciated the achievements of the Council and called upon the scientific fraternity "*to reach out to the last farmland and equip them with the best cultivation methods*" and "*to work towards a technology-led path for development of agriculture and prosperity for the farming community*". These thoughtful words are being integrated in the research, education and extension programmes of the Council.

I am pleased to note that the DARE/ICAR became one of the first Departments in the Government of India to have the recognition of the ISO 9001:2008 certification by implementing the Quality Management System.

Towards enhancing productivity, production and quality of field and horticultural crops, one hundred and four new improved varieties/hybrids of different crops with potential for higher yields and enhanced tolerance/ resistance to various forms of stress were released for diverse agro-ecological regions of the country. Today, India is amongst the leading exporters of Basmati rice and landmark varieties such as Pusa Punjab Basmati 1509 with moderate resistance to leaf blast and brown spot diseases, and HD 3059, a wheat variety resistant to all three rusts, including stem rust race Ug99 and its variants are helping the farmers for enhanced production. This year, the Council produced over 11,835 tonnes of breeder seeds and 5,237 tonnes of quality planting materials of major food crops.

Changing consumption pattern has enhanced the demand for food items of animal origin. Crossbred pig ($H_{50}G_{50}$: Hampshire and Ghungroo) and a dual purpose rural poultry variety, Srinidhi, were developed to meet the growing demands. World's first mithun calf produced by embryo transfer; test tube yak calf 'Norgyal'; birth of calf from cloned buffalo mother; and a male cloned buffalo calf produced through advanced 'hand-guided cloning technique' are the breakthroughs towards conservation and multiplication of elite animals. Sea cage farming with seabass and cobia added a new dimension in fisheries towards enhanced utilization of coastal production potentials.

To popularize and promote agricultural education, a centralized portal, http://ecourses.iasri.res.in was launched for e-learning in Horticulture, Fisheries Science, Dairy Technology, Home Science, Veterinary and Animal Husbandry; UG level e-courses are available for free downloads. The first supercomputing hub for Indian Agriculture has been established at IASRI, New Delhi to provide seamless access to biological computing resources to the agricultural researchers in the country. The Open Access Policy of the Council is appreciable, be it the Institutional Metadata Repository to share all the agricultural knowledge generated or the ICAR journals and publications, the information dissemination has been reaching out to people both in India and abroad. To promote agricultural education in deprived areas, DARE/ ICAR has moved a bill for establishing a Central Agricultural University in Bundelkhand region.

Krishi Vigyan Kendra (KVK) in India has been a model that is globally appreciated and adopted. Within the country, the KVKs have been involved in technology demonstration that benefits farmers for enhanced production and productivity. Recent involvement of KVKs in demonstration of climate resilient agricultural technologies in 100 climatically most vulnerable districts has evoked good response from farming communities. On a need basis, four new KVKs, two in Jammu and Kashmir and one each in Karnataka and West Bengal, have been approved this year.

The ICAR has been involved in international partnerships for collaboration in advanced research that has global relevance as well as meeting local needs. India hosted the 3rd meeting of the ASEAN-India Working Group on Agriculture and Forestry (AIWGAF); Conference of Heads of Agricultural Universities and Research Institution of ASEAN Countries; Pact-50, commemorating the 50th Anniversary of the visit of Late Dr Norman E. Borlaug to India; and the 5th Borlaug Global Rust Initiative (BGRI) 2013 Technical Workshop, to further strengthen and foster international research cooperation in agriculture.

The Scientific Advisory Committee to the Prime Minister has observed "science-led growth in agriculture is a necessary condition for inclusive growth". Taking leads from this, the ICAR is contemplating a number of initiatives in the XII Plan such as Farmer FIRST, Student READY, Attracting Retaining Youth in Agriculture, Agriculture Technology Foresight Centre, Consortia Research Platforms and extra-mural funding to enrich agricultural research and education through innovation and integration. I hope the *DARE/ICAR Annual Report 2013-14* will provide useful information to the diverse stakeholders and prove to be helpful in planning future programmes in agricultural research for development.

(SHARAD PAWAR)
President
ICAR Society

Contents

1. Overview

Agriculture in India accounts for over 14% of the GDP and 12% of country's exports, providing employment to over 50% of the work force and striving towards food security as well as inclusive growth and development. This has been possible through pertinent agricultural research, education and extension enabling development and infusion of appropriate technologies by ICAR Institutes and Agricultural Universities, and taking them across to farmers through Krishi Vigyan Kendras (KVKs).

The monsoon-driven Indian agriculture witnessed 106% of long-term average rainfall during the cropping season 2013, that enabled 105 mha of total area sown during *kharif* 2013 as compared to about 100 mha during 2012. Eventually, the first advanced estimates target foodgrain production of 259 mt and a growth rate of over 5% for agriculture and allied sectors in 2013-14. Uttarakhand, Odisha and Andhra Pradesh were struck by natural calamities of differential, but severe intensities. The ICAR prepared doable and location-specific action plans of agriculture and allied sectors for rehabilitation and restoration of the affected areas through technological backstopping. The Council has also prepared the climatic vulnerability atlas of the country and district level contingency plans to enable farmers to choose appropriate means and methods for mitigating the climatic variability in different agro-climatic regions. Further, the Council is committed to need-based, location specific research for agricultural development in the country through innovations and integration.

DARE and ICAR became one of the first Departments in having the recognition of ISO 9001:2008 certification by implementing Quality Management System. This is also the success indicator of all the Government Departments, and testifies the commitment towards assuring quality services to its customers with continual improvement of its delivery system. The Council continued to successfully carry out its mandated programmes and an overview of the same is presented in the following paragraphs.

Soil and Water Productivity

The agro-ecological sub-region (AESR) map of black soil region (BSR) was revised by incorporating the latest soil database, newly calculated length of growing period data and quantitative drainage map. The revised map shows 54 AESRs as compared to the earlier 36 AESRs that will facilitate more specific regional level planning. Soil erosion map of Punjab at 1:250,000 scale was developed using soil resource inventory and soil loss data that showed 10% (5,751 km^2) area under the category of severe erosion. Geographical Information System (GIS) based soil organic carbon (SOC) map of six north eastern states (Asom, Manipur, Meghalaya, Nagaland, Sikkim and Tripura) was prepared. In order to prevent volatilization losses, urea was coated with pine oleoresin for slow release of nitrogen. Such fortified urea can supply 440 g zinc, 132 g copper, 212 g silica and 87.7 kg nitrogen/ha to the crops from an application dosage of 200 kg/ha.

Farming Systems

Location-specific integrated farming systems were designed for small and marginal farm households in different states with farmers' participation. The net returns ranged between ` 8,235 and ` 38,860 per year depending on the farm size. In the eastern plateau and hill region, livestock integrated farming system module for one acre area under rainfed ecosystem gave a net monetary return of ` 45,000/acre/year. Under the Rashtriya Krishi Vikas Yojna (RKVY) of Government of India, the ICAR Research Complex for Goa standardized low cost hydroponics protocols for green fodder production.

Climate Change

The atlas on climatic vulnerability at district level was prepared to develop appropriate adaptation measures in regions likely to be affected by climate changes, classified into very high, high, medium, low and very low categories. Terminal heat stress conditions across all the districts in six wheat growing states of Haryana, Punjab, Uttar Pradesh, Rajasthan, Bihar and Madhya Pradesh were monitored. The minimum temperature trends over the entire country were computed using 0.5 degree grid data from climate research units. The magnitude of change on annual basis over the entire country is 0.25°C over a 10-year period. Average amount of monsoon rainfall however, decreased as indicated by a study (1951-2007) in north eastern region. Simulations showed that increase in temperature by 2°C could reduce pigeonpea yield by about 16% in Gulbarga district (Karnataka). A bio-physical calibrated model, APSIM (Agricultural Production Systems Simulator) was validated to evaluate the impact of climate change on rice productivity under different levels of nitrogen in Meghalaya.

Genetic Resources

Genetic resources are of unique significance, as they provide valuable traits with potential for breeding

new varieties/hybrids/animal strains/breeds. In this endeavour, thirty-three explorations were undertaken in 16 states and 1,722 accessions, including 322 of wild species were collected. A total of 266 herbarium specimens have been added to the National Herbarium of Cultivated Plants. In the National Gene Bank for long-term storage, 5,414 accessions of orthodox seed species and 112 of non-orthodox species were cryo-stored, and eight were added to *in-vitro* Gene Bank. Over 44,000 accessions from 42 countries were imported including promising accessions of wheat, paddy, safflower and others. A total of 141,191 imported samples including transgenic and trial material were processed for quarantine clearance. Out of 3,838 samples infested/ infected with different pests, 3,437 were salvaged. Thirteen phytosanitary certificates were issued for export of 1,294 samples. New germplasm comprising cereals (12), millets (4), grain-legumes (8), oilseeds (19), fibres and forages (13), spices (1), tuber crops (2), medicinal and aromatic plants (9), commercial crops (7) and two parental lines of potato SS1735/02 (INGR-13048) and MP97-921 (INGR-13049), were registered with NBPGR, New Delhi, under elite germplasm category. A web-based portal was developed to facilitate access to information on plant genetic resources conserved at the National Gene Bank. One new genus, *Dvivarnus* Rajmohana and Veenakumari (Platygastridae) and 14 new species of insects and mites were described.

Germplasm accessions consisting of under-utilized fruits (417), coconut (410), mango (760), guava (142), cashew (528), tuber crops (6,151), pomegranate (281) and medicinal and aromatic plants (945) were maintained in the field gene banks. Thirty-nine unique germplasm accessions of *Mangifera* were collected from Andaman and Nicobar Islands, nine of which are polyembryonic and one cluster bearing. Among the accessions, March–April maturity mango variety (*Arka Neelanchal Kesari*) was identified for eastern region of India. The variety does not suffer fruit fly damage due to early maturity.

Under phenotypic characterization and conservation of farm animal genetic resources, identified breeds of cattle (Mizoram, Adilabad, Malnad Gidda), goats (Malkangiri, Raigari, Narayanpatna) and donkeys (Sindhi and geographically distinct donkeys) were studied. Study on genetic relationship of Indian native cattle represents the first approach to assess population structure of Indian breeds that evidenced the genetic distinctness of zebu from taurine cattle. Thirty bovine microsatellite markers from FAO list for measurement of domestic animal biodiversity (MoDAD) were tested in mithuns and gaurs individually. The present study will help in developing a suitable breeding policy for mithun.

The whole mitochondrial genomes of *Channa marulius*, great snakehead (NCBI accession no. KF420268), *Clarias batrachus*, walking catfish (accession no. KC572134) and *Pangasius pangasius*, yellowfin catfish (accession no. KC572135) were sequenced. Two ornamental barbs, viz. *Puntius denisonii* and *P. chalakkudiensis* endemic to the Western Ghats were found to have mtDNA size 16899 bp and 16989 bp, showing a difference of 90 bp mainly in control region. The genus *Glyptothorax*, sisorid catfishes, widely distributed in foothills of rivers and fast flowing mountain streams and benthic in habitat, has no previous record from plains of Uttar Pradesh. The present report is the first evidence of a broader distributional range of *Glyptothorax* genus, indicating that the species may be more widely distributed than previously acknowledged.

Crop Improvement

One hundred and four new improved varieties/ hybrids of major crops were released for different agro-climatic regions of the country. An early-maturing (110-123 days) basmati rice variety, Pusa Punjab Basmati 1509 with moderate resistance to leaf blast and brown spot diseases, a late sowing wheat variety HD 3059 and the large seeded (>30g/100 seeds) *kabuli* chickpea variety, CSJK 6, moderately resistant to root rot and tolerant to wilt, are the landmark releases of the year. During the year, 11,835 tonnes of breeder seeds, 14,984 tonnes of foundation seeds, 22,281 tonnes of certified seeds, 14,939 tonnes of truthfully labeled seeds and 5,237 tonnes of quality planting materials were produced.

The gene cassettes using tobacco as a model system for *Botrytis* grey mould disease resistance in castor was validated. It is noticed for the first time that Pi54 (Pi-k^h-Tetep) has a small zinc finger domain of NFX type. The candidate gene-specific markers in eighteen lines of rice exhibited high level of resistance against bacterial leaf blight in the background of Taraori Basmati and Basmati 386 introgressed with three BLB genes (*Xa21, xa13, xa5*). Sunflower necrosis disease (SND) resistant transgenics were developed through deployment of coat protein gene of tobacco streak virus using *Agrobacterium*-mediated transformation.

Microsatellite-based markers were used for genetic diversity analysis and cultivar identification in pearl millet (27), finger millet (35), maize (143) and flax (94). Molecular profiling was done in core collections of moth-bean (250), *Lathyrus* (225), sesame (450), and mini core (110) in finger millet, wheat (186) and aromatic and non-aromatic rice (104), using simple sequence repeat (SSR) markers. Imports of cotton, maize, rice and sorghum (1,186 accessions) were tested for transgenic elements and absence of terminator gene technology. For taxonomic identification, DNA barcodes were generated using *cox1* primers for eight insect pests of rice and submitted to BOLD (barcode of life data system) and gene bank accessions obtained.

Suitable markers were identified to develop DNA barcode for fungal and nematode pathogens.

A high yielding (50-60 tonnes/ha) determinate tomato variety Kashi Aman (VRT-0801) was identified and recommended for zone IV (Punjab, Uttar Pradesh, Bihar and Jharkhand). For the first time, advanced breeding lines of French bean (IC525260 × IC525283-07-1-6-5) resistant to Mung Yellow Bean Mosaic Virus were identified and successfully field demonstrated. Two F_1 hybrids namely DOGR Hy-1 (41.30 tonnes/ha) and DOGR Hy-2 (34.96 tonnes/ha) of onion suitable for *rabi* cultivation were developed. A seedless interspecific hybrid (*M. dioica*×*M. cochinchinensis*) was developed combining the desirable attributes of spine gourd and sweet gourd with fruits of bigger size (>20g) compared to normal spine gourd (<15g) with 2n=2x=28. A new fertile hybrid was developed by crossing of diploid spine gourd species (*Momordica dioca*) with increased ploidy level and natural tetraploid teasle gourd species (*Momordica subangulata* subsp. *renigera*). Sweet potato genotypes with high extractable starch (ST-10), high carotene (ST-14) and high anthocyanin (ST-13) were registered at NBPGR.

Ajmer Fenugreek 3 was identified for national release for its higher yield (1,288 kg/ha), 10% more than Hisar Sonali (national control). In medicinal plants, Arka Ashwagandha, was identified for high dry root yield (11.95 q/ha) and total withanolide content (0.580%). Eight superior varieties of white button mushroom (DMR-Button-03), brown button mushroom (DMR-Button-06), paddy straw mushroom (DMRO-247, DMRO-484), shiitake mushroom (DMR-Shiitake 38, DMR-Shiitake- 388), milky mushroom (DMR-Milky 334) and *Macrocybe gigantean* (DMR-Macrocybe-01) were recommended for release.

Livestock Improvement

The livestock sector plays an important role in providing livelihood to small farmers with over 87% of the livestock owned by small and marginal farmers. Improvement of indigenous cattle breeds through selection programme covers Ongole, Gir, Kankrej and Sahiwal breeds and is being executed in collaboration with State Agricultural Universities, NGOs, State Animal Husbandry Departments and ICAR Institutes. At CIRB, Hisar, 63,857 frozen semen doses of Murrah bulls were produced as farmers from all over India are evincing keen interest in Murrah breed improvement. Physical identification using injectable subcutaneous microchips was done in all female buffalo progeny to help in future milk recordings in the project. Under the Mega Sheep Seed Project, flocks of Chottanagpuri, Mandya, Mecheri and Sonadi were built up for production of superior seed. Crossbred pig ($H_{50}G_{50}$: Hampshire and Ghungroo) was found suitable for farmers because of its growth, adaptive and carcass characteristics with a marketable weight of over 75 kg in 8 months. A dual purpose poultry variety, Srinidhi was developed that attains a body weight of 668 g in 6 weeks.

The technology of seed production of silver pompano (*Trachinotus blochii*), a highly sought after fish due to its fast growth rate and high market demand was scaled up for bulk seed production and transportation. Off-season breeding of climbing perch, has paved the way for round-the-year production of its quality seed.

Crop Management

A low-cost and easy-to-use five-panel customized leaf colour chart was devised for nitrogen management in rice for different ecosystems. Indian mustard seed yield increased by 45% with incorporation of 2.5 tonnes/ha of mustard-straw and *Sesbania* green manure in soil. Sowing of chickpea on broad bed and furrow increased seed yield by 19-34% over flat method. Rice-straw mulch maintained 2-3% higher soil moisture during critical crop growth stages of chickpea and lentil in rice-fallow. Polymulch technology with cotton cv. Suraj was demonstrated in farmers' fields with substantially higher seed cotton yield. *In-situ* rainwater conservation through seeding in open-furrows or mulching with paddy-straw proved beneficial for jute cultivation. Application of bio-manures for yield and quality enhancement of sugarcane under multi-ratooning showed remunerative yields of sugarcane ratoons (56 tonnes/ha) up to the ninth ratoon with continuous application of 10 tonnes/ha sulphitation pressmud (a sugar industry by-product) + *Gluconacetobacter diazotrophicus*.

In rice, flucetosulfuron, a new post-emergence sulfonyl urea herbicide, when applied seven days after sowing at 25 g a.i./ha showed 90% efficiency in controlling predominant grassy weeds, sedges and annual broadleaf weeds. Application of metsulfuron+ carfentrazone (Ready mix) at 25 g a.i./ha in wheat-crop effectively controlled broadleaf weeds, and resulted in maximum grain yield.

New amphiphilic nano-polymers were synthesized and used to develop controlled release formulations of thiamethoxam against white-fly and stem-fly incidence in soybean. Two new anticoagulant rodenticides, difencoum (0.005%) and flocoumafen (0.005%) wax blocks showed good acceptability and palatability by *Bandicota bengalensis* and *Rattus rattus*. Both the rodent poisons registered 70-100% control under field conditions in rice and coconut crops in Andhra Pradesh, Karnataka, and Andaman and Nicobar Islands.

A new insect light trap was validated in farmers' participatory mode in rice fields during *kharif* and in chickpea fields during *rabi*. Significant reduction in wilt disease in pigeonpea was observed with *Trichoderma* strains IPT 31 and IPT 11 (9.5-10.8% against 23.7% incidence in control). Pusa 5SD, a seed-

dressing formulation of *Trichoderma harzianum*, was validated against wilt and root rot of chickpea. Aqueous extracts of *Acacia arabica* and *Datura stramonium* (seeds) and *Annona squamosa* (leaves and seeds) proved as effective as *Bacillus thuringiensis* in management of semiloopers and *Spodoptera litura* infesting soybean. New multi-residue methods for extraction, clean-up and analysis of pesticide residues in various food commodities and environmental samples were developed. Six stingless bee species, *Tetragonula canifrons, T. irridipennis, T. atripes, T. laeviceps, T. ventralis* and *T. ruficornis* were identified from north-east India.

Whole genome sequencing of Indian strain of *Phytophthora infestans* (A2 mating type) causing late blight and *Ralstonia solanacearum* causing brown rot of potato was completed. Area-wide IPM validation for fruit fly was implemented in over 11,650 acres, covering Andhra Pradesh, Karnataka and Tamil Nadu that resulted in savings of about 25-30% produce in mango. Intensive agro-techniques for higher saffron yield (7.51 kg/ha) were developed. Low-cost pasteurization tunnel technique for compost pasteurization of button mushroom was shown to be equally good for oyster and milky mushroom. Cotton ginning mill waste was successfully utilized in compost production for button mushroom cultivation. Validation and demonstration of bacterial wilt, TLC V and *Alternaria* resistant tomato 'Arka Rakshak' at farmers' fields showed record productivity of >90 tonnes/ha in south India.

Livestock Management

Livestock feed resources database and forecasting models gave accurate estimation of crop residue production and compared well with official data. Supplementation of feruloyl acetyl esterase enzyme improved digestibility and rumen fermentation in crossbred steers fed paddy straw based ration. Precision feeding of female buffalo calves achieved a growth rate of about 750 g/day. The first comprehensive microarray chip was developed to devise means to improve rumen function and reduction in emission of methane from buffalo rumen.

The supplementation of 'Combination-3' feed additive induced higher milk production (10.13 vs. 8.14 kg/day) in lactating cows. Feeding of nitrate @ 3% of dry matter intake to buffaloes reduced 34% methane production, enhanced the growth performance by 15% and feed conversion efficiency by 10%. The microscopic image characteristics were documented for qualitative analysis of feed within the shortest possible time. Organic selenium at 0.15 ppm in the diet of pullets resulted in better production performance of breeders and growth of progeny. Organic chromium in the form of chromium-enriched *Azolla* is ten times less costly than chromium enriched yeast, and its feeding reduced the cholesterol in yolk and enhanced chromium in the egg. Based on extensive data on methane production potential of different feed resources, a national catalogue was developed.

In the present scenario of growing demand of mutton, accelerated sheep mating system was developed; 76.7% ewes achieved fourth lambing within a period of 876 days. Use of frozen-thawed semen in goats resulted in 28 kids from 17 does. World's first mithun calf was produced by embryo transfer, a major breakthrough, as also the first test tube yak calf 'Norgyal' was born, a major development towards conservation and multiplication of yak. A reassortant rgH5N2 virus was generated for developing inactivated DIVA marker vaccine against H5N1 in poultry. Diagnostic techniques were developed for contagious ecthyma, PPR, Japanese encephalitis in pigs, bovine picobirnavirus, avian influenza, Marek's disease and Q fever. The two diagnostic kits for detection of FMD are proving useful for differentiation of infected animals in a FMD vaccinated population.

Microaerophilus stationary phase cultivation system is a major advance in theileriosis research as it helps the researchers in production of antigen for maintenance of parasite in laboratory system and testing the battery of drugs under *in vitro* culture system. The Council organised effective surveillance and awareness camps that helped in controlling the dreaded zoonotic disease. Genome sequence of *Mycobacterium avium* indicated the ability of strain S5 to survive in a wide range of environmental conditions. An effective module was developed for treatment of skin candidiasis in camel. The National Animal Disease Referral Expert System reported that incidence of majority of diseases declined indicating the effectiveness of control measures.

Spawning of cobia in recirculation aquaculture systems showed high survival rates of 86.7%, ensuring availability of quality seed for culture. Farm made feed for seabass enabled production of 2.7 tonnes/ha in 325 days of culture. The reported marine fish catch of 3.94 million mt during 2012-13 is an all-time record, with a growth rate of 3.37% over the previous year.

Low stocking density (20 no. m^{-2}) of *Litopenaeus vannamei* resulted in a single crop yielding about 3.5 tonnes in brackishwater without using any commercial probiotics and mineral supplement. The success of present trial outlines the possibilities of farming of *L. vannamei* at low stocking densities with good economic returns.The whole cell heat-killed Noda virus vaccine, evaluated with juveniles of Asian seabass (*Lates calcarifer*) indicated its use in protecting the fish against the infection. The monoclonal antibodies (MAbs) were raised against purified serum immunoglobulins of *Catla catla* that are crucial for developing sensitive and specific assays for detecting circulating antibodies to important fish pathogens and in evaluating efficacy

of vaccines.

PCR and RT-PCR-based diagnostics were developed for detection of koi herpes virus and spring viraemia of carp, respectively, diseases of trans-boundary importance. The nano-encapsulation of trypsin with chitosan enabled release of enzyme in a controlled manner and biomimicked zymogen-like activity, a first time in fish model.

Mechanization and Energy Management

Enhancement of land and labour productivity can be achieved by judicious use of farm machinery and energy management in different farming systems. Tractor operated five-row seed-cum-fertilizer-drill capable for placing seeds at 50 mm and fertilizer at 100-150 mm depth covers 0.2-0.35 ha/h. Compact and energy efficient arecanut sheath shredder shreds 100 kg of moist and dry sheath fodder in an hour. Crop canopy spraying system sprays 0.92 ha/h in pigeonpea and soybean crops. A multi-millet thresher operated by 1.5 kw motor with 95% efficiency reduces drudgery and minimizes post-harvest losses. A machine suitable for sugarcane and potato fields where row-row spacing is 50 cm or more, applies fertilizer in a band and simultaneously earths-up in 0.56 ha/h.

Dehusker for *kudo* and *kutki* millets with capacity of 100 kg/h and 95% efficiency and root crop harvester-cum-elevator suitable for carrot, potato, garlic and onion with less than 1% damage and field capacity of 0.2-0.28 ha/h are highly sought after engineering interventions. Bullock drawn wedge-plough, suitable for narrow terraces of Sikkim, has a field capacity of 0.025 ha/h and saves ` 300/ha compared to traditional wooden plough.

For efficient gassification of biomass (soybean and pigeonpea stalks), a torrefaction unit gives biomass recovery of 65 to 80% and increases calorific value from 17 to 20 MJ/kg. An electronic control module automatically supplements LPG for producing gas based electricity generation system.

The CIFT, Kochi, designed and developed a 10 kg capacity fish meal plant. The CMFRI, Kochi, procured a 19.75 m OAL fisheries research vessel F.V. Silver Pompano for carrying out fisheries related research in the territorial waters under NICRA. A prototype mobile fish vending unit was developed, suitable in urban /municipality areas with proper waste disposal.

Post-harvest Management and Value-addition

Mechanization of the processing of *makhana* and custard apple was attempted. Machines for roasting and popping of *makhana* and extraction of pulp from custard apple were developed. For improvement in quality of ground spices powder, a cryogenic grinder was developed. A hot air puffing machine was developed for utilization of by-products such as *dal* mill brokens and rice mill brokens. A novel kind of foldable plastic packaging box was designed in collaboration with industry for reducing post-harvest losses during transportation of fruits such as sapota and custard apple, this design can also be customized for other fruits. Molecular methods were developed for rapid detection of food pathogens and identification of meat species. A jaggery pilot plant for training and demonstration was established at Pantnagar.

Sweetened functional soft cheese from buffalo milk was developed that has high potential in the functional food market. Functional and shelf-stable restructured buffalo meat steaks were prepared with the incorporation of antioxidant and mineral rich *amla* powder (5%). Nuggets were prepared by incorporating pork with fermented bamboo shoot mince, which significantly checked quality deterioration of nuggets.

The fatty acid profiling of different sizes of *Tenualosa ilisha* revealed that medium-size hilsa has high PUFA and ω-3 PUFA content. A method was developed for isolation and purification of astaxanthin from deep sea shrimp and blood-spotted swimming crab that showed high antioxidant activity. Dietary chitosan supplementation in rats proved effective in treating age associated disorders. Succinyl chitosan may serve as an effective tool in micro/nano encapsulation of nutraceuticals for controlled and efficient drug delivery. Efforts of CIFRI, Barrackpore along with IITs, Kanpur and Varanasi, Peoples Science Institute, Dehradun and WWF, India, determined environmental flow requirement at Triveni Sangam, Allahabad, during Mahakumbh 2013, that enabled good water quality in River Ganga.

Agricultural Human Resource Development

The Education Division continued to contribute towards maintaining and upgrading quality and relevance of higher agricultural education. Financial and monitoring support was provided for Niche Area of Excellence (22), Experiential Learning units (375), besides refurbishing and maintenance of educational structures, student and faculty amenities, equipments, course curricula improvement, education and research and ICT and multimedia learning resources. HRD programmes and activities facilitated promotion, execution, monitoring and evaluation of several ICAR sponsored schemes that include centralized admissions in UG/PG to reduce inbreeding, infuse merit and promote national integration; award and distribution of fellowships to attract talent and promote merit, admission of foreign students for globalization of agricultural education; capacity building of faculty through summer-winter schools and Centres of Advanced Faculty training; National Professorial Chairs and National Fellow Scheme for promotion of excellence; and Emeritus Scientist Scheme as a structural method of utilizing skill bank of the outstanding superannuated professionals. Quality assurance of Agricultural Universities was ensured through accreditation.

Agricultural Economics, Marketing and Statistics

The growth trajectory of Indian agriculture is now heading to target the growth rate of 4%. The total food production in India increased at a much faster pace than the growth in human population during the last four decades. Rural labour market is undergoing profound changes with labour moving from agriculture towards non-farm sectors. Agricultural R&D has played vital role in terms of offering substitutes for labour in farm operations and in terms of offsetting cost push inflation resulting from structural shift in labour and rise in wages. An econometric study on water markets in canal command area of North-Western Rajasthan was undertaken to assess equity, efficiency and reliability in water use under different forms of water markets.

The first supercomputing hub for Indian Agriculture was established at the IASRI, New Delhi with an aim to provide seamless access to these biological computing resources to the researchers across the country. A software 'Web Generation of Experimental Designs Balanced for Indirect Effects of Treatments' was developed that generates three classes of Neighbour Balanced Block Designs and eight classes of Crossover Designs (www.iasri.res.in/webdbie). A web-based relational database was developed consisting of 865,210 microsatellite markers present in the whole genome sequence of goat (http://cabindb.iasri.res.in/goat).

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

Twenty-five new projects with a total budget of ` 50 crore were initiated. In order to create awareness about basic and strategic research projects, the working and philosophy of NFBSFARA and development of concept notes, six workshops were conducted in different parts of the country. Salient significant achievements during the year include: (*i*) identification of moisture deficit stress tolerant traits and genes in rice, (*ii*) endophytic bacteria providing tolerance to salinity and drought, (*iii*) use of virus derived micro-RNAs to control pod borer, (*iv*) development of rice plants tolerant of non-selective herbicides, (*v*) methods to study immune response genes in goat and fish, (*vi*) identification of fungi and processes to reduce gossypol and increase crude protein in cottonseed cake for its use as a poultry feed, (*vii*) development of encapsulated pediocin, a bactericide to be used in ready-to-eat food products, and (*viii*) identification of microorganisms efficient in producing bioethanol from agricultural wastes.

National Agricultural Innovation Project

The National Agricultural Innovation Project (NAIP), made satisfactory progress in enhancing the competence of NARS towards steering the agriculture R&D and introducing pragmatic pluralism; 91 public-private partnerships were established in 203 NAIP supported sub-projects, including three with GEF support. Promising results included 72 patent/intellectual property protection applications filed; 319 research papers published; 82 technologies/products commercialized; 51 new rural industries piloted, and over 3,800 ha area of farmers' agricultural land brought under sustainable land management practices.

The first Agri-Tech Investors' meet (18-19 July 2013) organised by NAIP resulted in a formal transfer of technologies to private entrepreneurs. E-courses for bachelor degree level programmes in agriculture, horticulture, veterinary science, home science, fishery science, dairy technology, and agricultural engineering were developed, deployed on-line, and also made available off-line on CDs. Online e-publishing system for ICAR research journals has increased their readership by 4-5 folds and reduced the article processing time. Consortium for e-Resources in Agriculture (CeRA) provided on-line access for about 3,000 scholarly journals to 142 CeRA member NARS institutions throughout India.

'Mahima', a female calf was born on 25 January 2013 to 'Garima-II' a cloned buffalo. This is the first calf in the world to be born to a cloned buffalo.

The NAIP value chain sub-projects have demonstrated innovation-led marketing success in flower export, eco-colours, Omega-3, millet products and Juliflora feed. Over 29,000 farmers benefitted by market linkage under different interventions and 51 new rural industries were piloted. EATRITE branded products were commercialized through retail stores.

Technology-led agriculture innovation systems for improving livelihood security in disadvantaged regions of the country were fairly demonstrated; three activities are making visible impacts in their respective areas/states: (*i*) Land shaping in West Bengal coastal zone which reclaims land parcels in saline affected areas, (*ii*) characterization of local breeds of goat, sheep, and their genetic up-gradation, nutrition and control of common diseases in Adilabad and Udaipur districts, and (*iii*) Potential Fishing Zone (PFZ) forecasting and promoting M-Krishi through mobile network in Maharashtra and Odisha. Successful restoration of red rice landraces from the long term storage vaults of the National Gene Bank to the farmers' fields in Chamba district of Himachal Pradesh is yet another milestone.

Technology Assessment, Refinement and Transfer

At present, 634 KVKs are operating across the country that act as the arm of ICAR to demonstrate the technologies to the farmers in the field. During the year, 2,174 technological interventions were made in 4,159 locations in different theme areas such as cropping systems, drudgery reduction, farm machineries and other interventions; 1.43 lakh extension programmes through electronic and print media also got good attention by the stakeholders. Realising the need and

the strength of KVKs two new KVKs were established in Jammu and Kashmir and West Bengal. Simultaneously, under the National Initiative on Climate Resilient Agriculture (NICRA), appropriate climate resilient technologies were demonstrated in 100 most-vulnerable districts. In order to refine agro-advisory, automatic weather stations were established in these districts. The Zonal Project Directorates have trained about 4,000 staff from KVKs, wherein the trainees were exposed to modified agricultural extension reforms, participatory impact monitoring and assessment. As part of regional cooperation, the ICAR also organized ASEAN-India Farmers' Exchange programme and also facilitated the study visit of Nigerian delegation that came to familiarize with Indian agricultural research and extension system in general and KVKs in particular.

Research for Tribal and Hill Region

The ICAR Research Institutes, Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora; the ICAR Research Complex for North-Eastern Hills Region, Umiam, Meghalaya; and the Central Agricultural Research Institute, Port Blair; evolved technologies to meet the needs of the tribal and hill farmers. Maize Hybrid 45, was notified for Uttarakhand, Himachal Pradesh and Jammu and Kashmir, while Vivek QPM 21 was released for Uttarakhand. Barley VLB 118, a high-yielding disease resistant barley strain was identified. VRB 3, a ricebean genotype, was identified for release.

Under the Tribal Sub Plan (TSP), ICAR closely worked with tribal farmers to enhance their livelihood security in different parts of the country. Jute seeds (6.83 q) of improved varieties (JRO 8432, JRO 524 and JRO 128) were provided to 96 tribal farmers in Purulia and Bankura districts for seed production of jute, rice and mustard. Modern tools (96 knapsack sprayers and 26 CRIJAF nail weeders) were distributed to farmers. The NRC on Yak organized training programme on Integrated Farming System; 65 tribal farmers from 13 villages of Namsai district of Arunachal Pradesh participated in the training programme. A Knowledge Sharing Meet was held at ICAR NEH, Barapani, focusing on the portal "KIRAN" for sharing the technologies available so that the information is disseminated to a larger audience. Families of *Sidi* African tribes, living on Gujarat coast near Veravel undertook sea cage farming as a highly profitable vocation.

IP Portfolio Management

Eighty-three patents taking the cumulative figure to 826 applications from 68 ICAR institutes were filed in five subjects areas. Indian Patent Office granted 161 patents from 25 institutes. Fourteen copyrights were filed/registered by the ICAR institutes, (CSWCRT&I, IASRI and IVRI). A total of 33 trademarks and 17 design applications were filed from 16 and 31 institutes, respectively. Protection of Plant Varieties and Farmers' Right Authority considered applications and granted registration certificates for 138 varieties taking the cumulative total to 469.

Awards

The ICAR recognized excellence in research, teaching and extension with 79 awards under 16 different categories during the year, including 10 women scientists. Sardar Patel Outstanding ICAR Institution Award, Jagjivan Ram Abhinav Kisan Puruskar (National) and NG Ranga Farmer Award for Diversified Agriculture were also conferred on State Agricultural Universities, ICAR institutions and progressive farmers.

AgrInnovate India Ltd

The registered company owned by DARE/ICAR, AgrInnovate India Ltd., a public sector undertaking company is working towards promotion and commercialization of ICAR technologies, and licensed the technology of tissue culture of oilpalm and related knowhow for commercialization.

To augment the availability of FMD vaccine Agrinnovate has initiated the establishment of a modern vaccine production plant (capacity 100- 150 million doses)in PPP mode at Bengaluru capus of IVRI, Izatnagar.

The company is also assisting DARE on projects related to establishment of facilities for soil, water and tissue testing, seed production and demonstration, and Farm Science Centres in different countries in Africa

Partnership and Linkages

The DARE/ICAR signed Work Plans with CIP, Bioversity international and INAI, Chile; and an MoU with School of Veterinary Medicine, Pennsylvania, USA. DARE/ICAR facilitated the visit of 18 Indian farmers from India to Malaysia under the ASEAN-India Cooperation. Over 30 collaborative research projects were approved for implementation by ICAR Institutes. A proposal was moved for the establishment of Central Agricultural University in Bundelkhand region. The Department also facilitated academic exchange by sending scientists on deputation and as consultants to different countries.

Finance

The Plan and Non-Plan allocation (R.E.) to DARE/ICAR for 2012-13 were ` 2,520.00 crore and ` 2,100.00 crore respectively. An internal resource of ` 185.47 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 during 2012-13. The Plan

and Non-Plan allocations (B.E.) for 2013-14 are ` 3,415.00 crore and ` 2,314.17 crore respectively.

The 85th Foundation Day of ICAR Society was celebrated on 16 July 2013. The Chief Guest, Hon'ble President of India, Shri Pranab Mukherjee addressed the august gathering and suggested integration of agricultural research for development by establishing partnerships and linkages and also emphasized upon the enhancement of agricultural production with a focus on small and marginal farmers in the country. These suggestions would guide us in aligning our research programmes in the coming years.

The demand for food is continuously increasing with rising population amidst the production constraints such as shrinking natural resources and increasing farm operation costs. The present food production has been achieved through productivity enhancement, striking a balance between environmental and agricultural sustainability, wherein research innovations are essential ingredients. Shri N.R. Narayana Murthy, Chairman Emeritus of Infosys Ltd., while addressing the ICAR Directors' Conference in 2013, emphasized the importance of leadership in agriculture given the contextual development scenarios to feed the billions. Appreciating the efforts of ICAR, he called for greater involvement of youth in agriculture. To this effect, a programme, ARYA (Attracting and Retaining Youth in Agriculture) is being launched in the XII Plan. Further to corroborate 'science-led growth,' as indicated by the Scientific Advisory Council to the Prime Minister, the ICAR is contemplating initiatives such as Farmer FIRST, Student READY, National Agricultural Innovation Foundation, Agricultural Technology Foresight Centre and Consortia Research Platforms.

I take this opportunity to express our gratitude to the Hon'ble Union Minister of Agriculture and Food Processing Industries and President of the ICAR Society, and the 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. The untiring efforts of the ICAR institutes in implementing the mandate of the Council deserve all appreciation. The cooperation and support received from various Ministries and Departments of the Government of India, Central/State Agricultural Departments and Universities, National and International Organizations and other stakeholders are thankfully acknowledged. I am confident that the continued and concerted efforts of the Council would enable inclusive growth of the farm sector in the country.

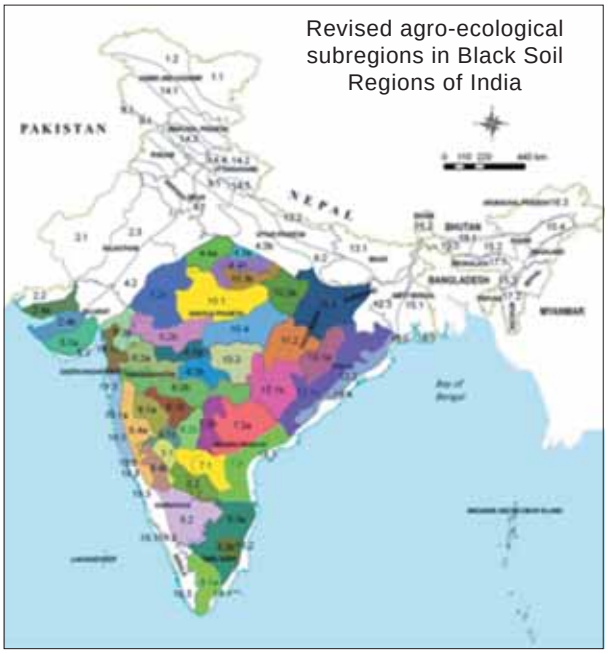
(S Ayyappan)
Secretary
Department of Agricultural Research and Education
and
Director General
Indian Council of Agricultural Research,
New Delhi

2. Soil and Water Productivity

Dependence of agriculture on natural resources such as soil and water is profound. The Natural Resources Management programme offers innovative management systems for efficient utilization and conservation of these resources. In particular, aspects relating to input use efficiency and economizing input use in agriculture, reducing nutrient losses, and conserving soils and water for achieving food, nutritional, livelihood and environmental security in the country are focused.

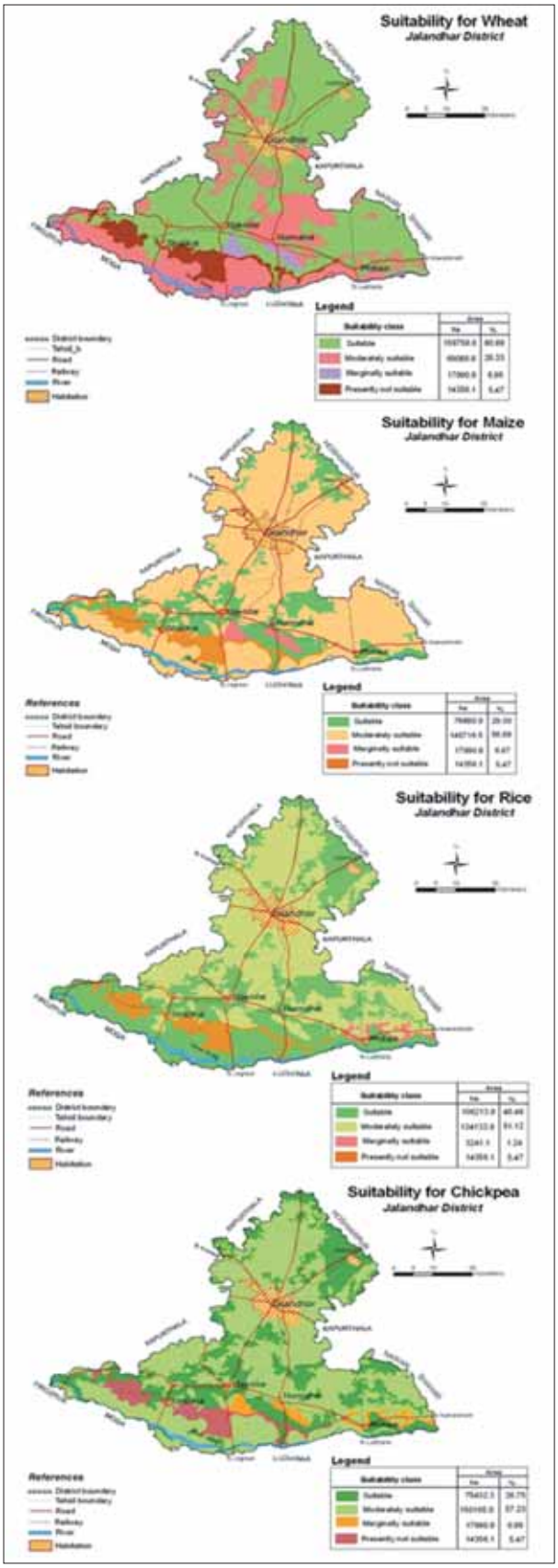
Soil resource inventory and management

Revision of Agro-ecological Sub-region (AESR) map of Black Soil Region (BSR): Black Soil Region (BSR) is an important food production region of the country. The NBSS&LUP published Agro-ecological Sub-region (AESR) map of BSR in 2002, which was revised by incorporating the latest soil database, newly calculated Length of Growing Period (LGP) data and quantitative drainage map. Previously there were 36 AESRs in the BSR, which after revision have become 54. The revised AESR map will facilitate more sound, specific and realistic regional level planning.



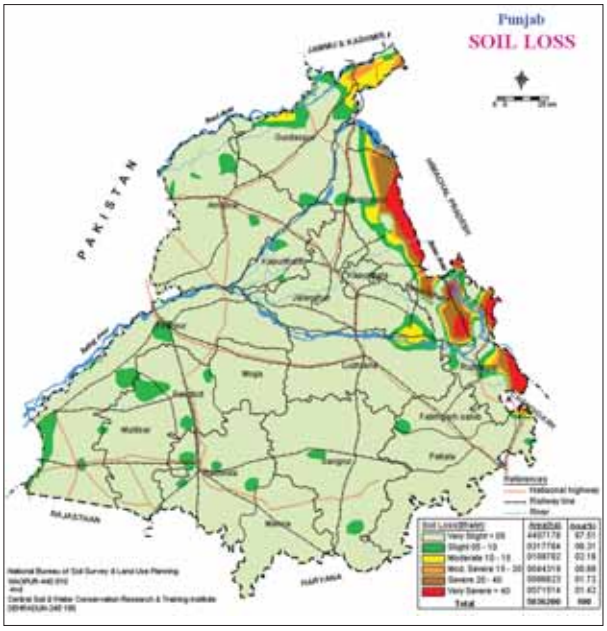
Revised agro-ecological subregions in Black Soil Regions of India

Soil-site suitability criteria for major crops of Jalandhar district, Punjab: Suitability of dominant crops of Jalandhar district, Punjab, namely rice, wheat and chickpea was assessed based on soil-site suitability criteria. Accordingly, 60% of the area in the district is highly suitable for wheat, 40% for rice, 29% for maize and 29% area is suitable for chickpea. Similar exercise is underway in other districts also.



Suitability maps for dominant crops, Jalandhar district, Punjab →

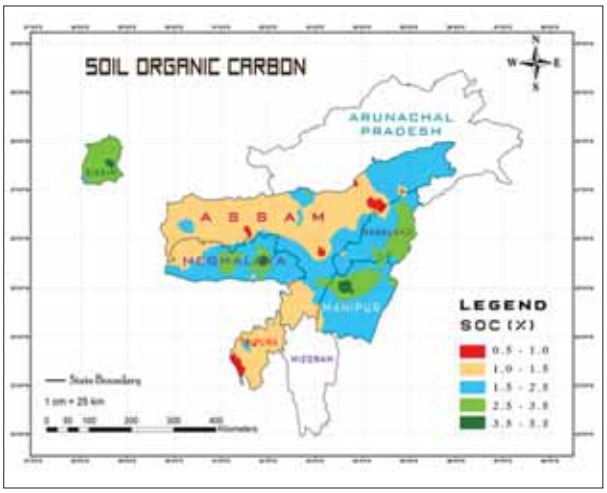
Assessment of soil erosion in Punjab: Soil erosion map of Punjab at 1:250,000 scale was developed using soil resource inventory and soil loss data. It revealed that more than 85% area (47,248 sq km) is under slight erosion, about 5% (2,396 sq km) experiencing moderate to severe erosion and 10% (5,751 sq km) area falls under the category of very severe erosion.



Management of medium-deep ravinous lands: Staggered trenching in the medium-deep ravines of Chambal region was advantageous for aonla + grass horti-pastoral system. *Cenchrus ciliaris* grass was planted in the interspaces of aonla (NA 7 or *Chakaya*) and bamboo (*Dendrocalamus strictus*). The system reduced runoff and sediment yields significantly while giving an aonla fruit equivalent yield of 7.46 tonnes/ha/year.

Staggered contour trenching for horti-pastoral land use in medium deep ravines – Kota

Distribution of organic carbon stocks in the soils of North-East India: Geographical Information System (GIS) based Soil Organic Carbon (SOC) map of six north-eastern states (Asom, Manipur, Meghalaya, Nagaland, Sikkim and Tripura), covering 15.61 million ha, has been prepared. Results show that 98.54% of



the area had >1% SOC content, of which 14.4% area had > 2.5% SOC content. Similarly, 76.5% area was having SOC density of 20 to 40 Mg/ha while 8% area was having very high SOC density of 40 to 60 Mg/ha. A total SOC stock of 339.8 Tg (1Tg= 10^{12}g) was estimated for an area of 10.10 million ha surface soils representing all major land use systems, with forest soils accounting for more than 50%. Complex interaction of geographic location, rainfall, soil texture and land use practices significantly influenced the spatial distribution of SOC content, density and stock. The SOC content was highest for Sikkim followed by Nagaland, Manipur, Meghalaya, Asom and Tripura.

CSR-BIO: a potential bio-growth enhancer for higher and sustainable crop productivity in normal and sodic soils: A cost-effective bio-growth enhancer CSR-BIO in liquid and solid formulations comprising two compatible bacterial strains CSR-B-2 (*Bacillus pumilus*), CSR-B-3 (*Bacillus thuringiensis)* and one fungal strain CSR-T-1 (*Trichoderma harzianum*) was tested on different crops like banana, gladiolus, wheat, and okra grown in sodic soils. It promoted root and shoot growth, increased crop productivity and quality, water and nutrient use efficiency and acted as a soil conditioner and bio-catalyst. The formulation gave 22, 25 and 27% more yields in banana, tomato and okra respectively. The solid formulation costs about `50/kg while the liquid preparation costs `70/L. A unit has been established at CSSRI, RRS, Lucknow for commercial production of CSR-BIO.

Integrated water management

***In-situ* moisture conservation through ridge planting:** In the Alfisols of Telangana region of Andhra Pradesh, which experience intermittent dry spells during the crop season, conservation furrow is recommended as an *in situ* conservation practice. Such furrows, usually made after first weeding, i.e. 30–45 days after sowing (DAS), although conserve moisture thereafter, do not conserve moisture from the preceding runoff. Therefore, a ridge planter was designed and fabricated for seeding and opening of conservation furrows simultaneously. The furrows conserve an additional 100–250 cubic meters of rainwater during the crop season depending

Ridge planter in operation and castor crop planted with ridge planter

upon rainfall, and width and depth of furrow. The ridger planter gave an yield increase of 15 to 20% in crops like castor, cotton, maize and sorghum with a one-time investment of ` 60, 000 towards the cost of machine.

Effect of growth regulators and crop water functions for wheat: Two trials were conducted to develop crop water functions and their interactions with bioregulators and fertilizer N for wheat (HD 2189). As expected, crop yield was a function of the amount of water applied and the decline in grain yield was 84, 72, 53, 32, 22 and 7% for treatments receiving 32.6, 28.4, 22.2, 15.2, 12.5 and 6.9 cm water, as compared with 37.9 cm as control. Bioregulators, in particular thiourea, alleviated the negative effects of water stress especially under medium and severe conditions. For example, with 12.5 cm applied water, yield was 48, 44, 31, 26 and 20 % with thiourea, GA_3, silixol, salicylic acid and control, respectively, compared with the treatment receiving 37.8 cm water.

Wheat under line source sprinkler system

Phytoremediation for removal of heavy metals in poor quality water: The efficacy of weed-based phytoremediation facility for removing heavy metals from industrial wastewater was tested. The fast growing giant reed (*Arundo* spp.) was planted hydroponically

Waste water carrying drain; *Inset:* Arundo grown in angular gravel media (without soil)

Reclamation of salt-affected sugarcane fields

An innovative system was designed to reclaim recently abandoned and low productive sugarcane fields through aquaculture and sub-surface drainage system in the four districts of Western Maharashtra, where more than 1.0 lakh ha sugarcane fields have become saline in the last 50 years. The productivity of such fields enhanced to 65.70 tonnes/acre by this innovative technology, and the sub-surface drain water collected in a pond used for carp culture achieved a production of 3.75 to 4.50 tonnes/ha.

Productive sugarcane fields through sub-surface drainage system

Sub-surface drain water collected in pond for carp production

in the tanks. Fe, Cd, Pb and NO_3 concentrations in treated water was reduced by 68.2, 51.4, 76.9 and 88.4% respectively compared with untreated drain water, implying the usefulness of *Arundo*-based wetland system for removal of heavy metals (Cd and Pb) from industrial drain water before it is used for irrigation purposes.

Microbial bioremediation of wastewater for heavy metals: Higher removal of Cu, Cr and Zn from liquid medium (40 to 60 ppm concentration) by fungi and bacteria was observed, than at lower concentration of 20 ppm**.** Pressmud, pressmud plus rice husk and rice straw inoculated with microbial consortium of six fungi and one bacterium removed substantial quantities of heavy metals like Cu, Ni and Zn from industrial effluents.

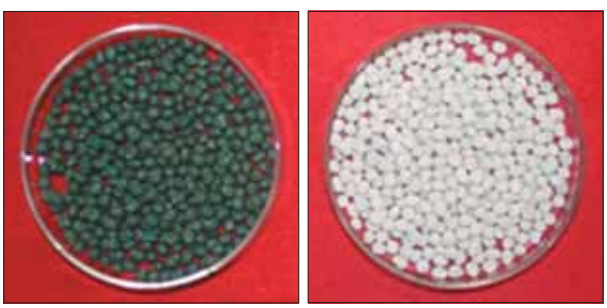
Integrated nutrient management

Pine oleoresin coated slow release urea: Urea was coated with pine oleoresin (3.8-4.4% pine oleoresin and 44.1-44.3% N), having levopimaric, palustric, l-abietic and neoabietic acids in different proportions. The resin not only acts as physical barrier around the urea granules reducing the release of N, but also inhibits urease activity through antibacterial properties, and being acidic in nature it also inhibits volatilization by reducing alkaline microsites. Time required for hydrolysis of 90% material increased from 88.6 to 328.9 hr in the presence of pine oleoresin. Volatilization loss of pine oleoresin coated urea from a Vertisol also decreased from 16.9% to 10.1% after 240 hr, implying that pine oleoresin coated urea can substitute neem coated urea.

Slow release urea fortified with nano-micronutrients: Urea granules was fortified with a consortium of nano-particles of Zn, Cu, Fe, Si using oleoresin to deliver nano-particles of micronutrients along with urea. The nano-particles coated urea contained 43.8% N, 2.2 mg Zn/g urea, 1.1 mg Fe/g urea, 0.7 mg Cu/g urea and 1.1 mg Si/g urea. Application of such urea (200 kg/ha) can supply 440 g Zn, 220 g Fe, 132 g Cu and 212 g Si along with 87.7 kg N/ha to the crops and is also less hygroscopic than the normal urea.

Nano-ZnO fortified customized seeds for Zn deficient areas: Seeds of maize, soybean, pigeonpea and okra were coated with micron-scale (<30 µm) and nano-scale (<100 nm) ZnO powder @ 25 mg Zn/g seed and @ 50 mg Zn/g seed. Crop growth of ZnO coated seeds was at par with that of soluble Zn treatment ($ZnSO_4.7H_2O$ @2.5 ppm Zn). Seed coating with nano-ZnO also did not exert any adverse osmotic effects on seed germination in pot culture studies, implying that total Zn requirement of the crop can be loaded on to the seed itself. ZnO coating also inhibited bacterial and fungal infection of the seed at the time of germination possibly because of pine oleoresin which was used as a binding agent. This protocol of seed coating with ZnO can be used by the seed companies to produce customized seeds for Zn deficient areas.

Maize



Okra

Phosphorus and potassium solubilizing actinomycetes from arid and semi-arid soils: Forty one isolates of actinomycetes were characterized; of which 35 produced indole acetic acid (IAA-1.2 to 5.7 µg/ml culture filtrate), all the isolates solubilized P on Pikovskayas medium (5.3 to 16 mm solubilisation zone) and 18 isolates solubilized K from insoluble mica. Seventeen isolates of actinomycetes were field tested on maize and chickpea; *Streptomyces* strains A1, A2, A6, A10, and A17 gave best response. All were positive for ammonia production and 40% were positive for urease production. Fifty per cent of the isolates also showed biocontrol potential against *Macrophomina phaseolina*, *Sclerotium rolfsii* and *Rhizoctonia solani*, while only 5% isolates were antagonistic to *Fusarium oxysporum*.

Efficacy of mixed biofertilizers

- In field experiments, DAPG (diacetylphloroglucinol)-producing fluorescent pseudomonads were applied to make groundnut soils suppressive to soil-borne fungal pathogens, *S. rolfsii* and *A. niger* causing stem- and collar rot, respectively. Seedling mortality of groundnut (cultivar GG 20) reduced from 70% in control to 35-42% in DAPG treatments.Inoculation with DPAG enhanced pod yield of groundnut (cultivar TG 37A) by 7 to 11% over uninoculated, control at DGR, Junagadh.
- Application of liquid biofertilizers of *Azospirillum* and phosphate solublizing bacteria (PSB) (300 ml/ac) along with 200 kg of FYM in field experiments gave best response on maize in Alfisols at Amaravathi, Andhra Pradesh. *Rhizobium* and PSB liquid biofertilizer along with organic manure also gave good response on pigeonpea. Wilt incidence reduced wherever biofertilizers were applied in pigeonpea.
- Inoculation of *Gluconacetobacter diazotrophicus* and *Azotobacter* in sweet sorghum in farmers' field trials increased green biomass yield (11%), grain yield (8%) and quality of the juice at MAU, Parbhani.
- Studies on mixed cultures in laboratory revealed that King's B agar, CRYEMA and N-free malic acid medium can be used to enumerate *Pseudomonas*, *Rhizobium* and *Azospirillum* respectively from consortia. Jensen's agar can be used when the consortium contains not more than one nitrogen fixer. None of the media proved to be useful for differentially counting all the members of a given consortium.

Biofertilizers for temperate horticulture

- Eighty five efficient PSB isolates of apple from

different districts of Himachal Pradesh exhibited plant growth promoting traits, viz. IAA production (24.2%), siderophore production (25.7%), HCN production (19.4%) and growth inhibition against root rot fungus *Dermatophora necatrix* (29.6%). *Bacillus methylotrophicus* was reported as unique plant growth promoting rhizobacteria (PGPR) in apple rhizosphere at YSPUHF, Solan. *Bacillus pumilus, Bacillus altitudinis* and *Bacillus firmus* from apple rhizosphere reported as PGPR.

- *Aneurinibacillus aneurinilyticus* strain CKMV1 from *Valeriana jatamansi* and *Bacillus subtilis* from *Picrorhiza* have been reported for the first time as PGPR for medicinal plants in YSPUHF, Himachal Pradesh.

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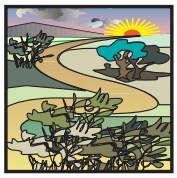
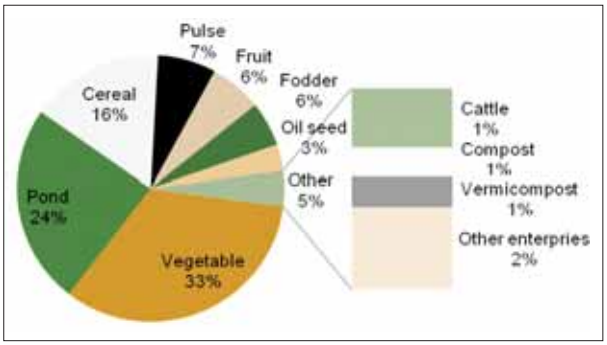


3. Farming System

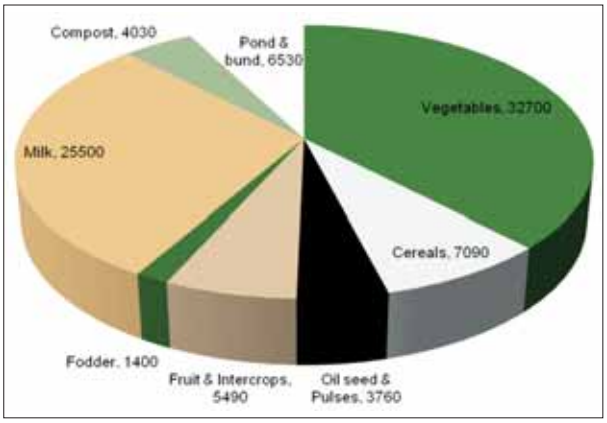
Crops and livestock systems constitute the predominant land use systems in the smallholder production systems of our country. Such Integrated Farming Systems (IFS) provide a potent tool to support income, employment, livelihood and nutritional security in a sustainable manner. Integrated farming systems embodies multiple crops (cereals, legumes, tree crops, vegetables etc.) and multiple enterprises (animal farming, bee keeping, fish farming etc.) on a single farm. Vertical expansion of IFS systems by integrating appropriate farming system components requiring less space and time is a novel feature that can ensure periodic returns to the farmers. Farming system research is a powerful tool for the management of natural resources and for enhancing site productivity.

Farmers' participatory improved integrated farming systems: Location-specific integrated farming systems were designed for 192 small and marginal farm households in different states with farmers' participation. Technological interventions including primary processing/value addition of farm produce, scientific grain storage, nutritional kitchen gardens, composite fish culture, and backyard poultry with improved breeds, mushroom production and vermi-composting led to about 6.8 fold increase in net returns over variable costs. The total cost of such interventions ranged from ` 616 to 8,220 per household and the total net returns over variable cost of intervention ranged between ` 8,235 to 38,860. Household consumption of produces from within the farm and per day profit were 51.4 and 69.2% more respectively. Such interventions also generated an additional employment of 53.6 man days/year for the households.

Buffalo component and onion in kitchen garden at Kangra (Himachal Pradesh)



Allocated areas (%) under 1 acre IFS model for EPHR



Layout of different components of 1 acre IFS

A view of integrated farming system

Integrated farming system modules for rainfed ecosystem for eastern plateau and hill region: To enhance productivity and improve livelihood and socioeconomic status of the people of eastern plateau and hill region, location-specific integrated farming system module for one acre area under rainfed ecosystem was developed. A total gross income of about ` 86,500 was obtained from one-acre IFS model during the first year with net monetary returns of about ` 45,060 per acre of land.

***Melia dubia* for farm and agroforestry:** *Malai vembu (Melia dubia)* is a promising agroforestry tree species in the tropical region cultivated for commercial

Melia dubia block plantation at Ayalur, Erode district (Tamil Nadu)

purposes (boundary or block plantation or agroforestry systems). The rotation length (time from planting to harvest) is 10–12 years and the tree yields 0.39 to 0.42 m^3 of timber per tree, which fetches a market value of ` 9,000/m^3. The 1100 seedlings/ha were planted on the farmer's field in Ayalur model watershed, Erode district (Tamil Nadu) under the Macro Management of Agriculture (MMA)-National Watershed Development Programme for Rainfed Areas (NWDPRA). The tree attained an average height of 8.5 m with 13.5 cm girth within two year after planting.

Gum/resin production from *Acacia jacquemontii:* *Acacia jacquemontii*, a lesser known gum-producing species, native of Thar desert, yields gum of better quality than gum arabic, especially considering its use for edible purposes and the produce is sold at around ` 1,000 per kg. Very low doses of ethephon at 1 ml/stem were injected in plants growing in Nagaur district in March and April and an average gum production of 30–40 g/plant was obtained.

A plant of *Acacia jacquemontii* and gum collected from the shrub *(inset)*

Conservation agriculture

Pulses in rice fallows: Rice-lentil cropping system was evaluated in both upland and lowland conditions under different tillage and residue management options at Umiam, Meghalaya. Rice grown under MT-ZT (minimum tillage for rice and zero tillage for lentil) system recorded significantly higher yield (3.41 tonnes/ha) in comparison to CT-CT (conventional tillage for both rice and lentil) system (2.46 tonnes/ha). In the lowland site, two rice varieties, viz. Mendri (long duration local) and Shahsarang 1 (medium duration and HYV) were evaluated during *kharif* and two lentil varieties (early duration with high biomass, DPL 81, and medium duration with high biomass, IPL 406) were grown in the rice fallow under zero tillage under different rice residue management practices. Early duration HYV Shahsarang 1 gave higher grain yield (5.02 tonnes/ha) compared to the local variety Mendri (3.63 tonnes/ha). The lentil crop grown after Shahsarang 1 recorded better growth parameters as compared to lentil grown after long duration rice, Mendri.

There was 65% and 30.2% enhancement in seed yield of lentil in upland due to mulching and 40 cm stubble heights compared to residue removal. Under lowland conditions, mulching and 20 cm stubble heights also recorded relatively higher lentil yield compared to residue removal but the extent of yield enhancement was lower than the upland.

Hydroponic fodder

Availability of green fodder is a major constraint in livestock production enterprises, especially during summer. Hydroponics technology (plant production without soil under controlled environment) is emerging as an alternative to grow fodder for farm animals. Dry matter digestibility of hydroponics maize fodder-based ration is higher than the conventional green fodder (hybrid napier)-based ration in dairy cows and heifers. However, to produce one kg of maize fodder, it would require about 1.50 l (if water is recycled) to 3.0 l (if water is not recycled and drained out) of water under Goa conditions, and the cost of production of the fresh hydroponics maize fodder is ` 4 to 4.50/kg. Recently, under the Rashtriya Krishi Vikas Yojana (RKVY) of Government of India, a hydroponics green fodder production unit was established at the ICAR Research Complex for Goa, for research, training, demonstration and technical guidance to the farmers.

Production of hydroponic fodder

Organic farming

Organic production package for passion fruit based cropping system: Bio-organic inputs for passion fruit based cropping system have been standardized. Suitable intercrops were identified and both main crop (passion fruit) and different intercrops were grown organically. In terms of yield, pineapple (39.15 tonnes/ha) and ginger (22.89 tonnes/ha) were most productive. However, maximum gross returns (` 14.54 lakhs/ha) were recorded for passion fruit + capsicum; followed by passion fruit + ginger (` 9.13 lakhs/ha). Application of vermicompost (6.5 tonnes/ha) + *Azospirillum* (20 kg/ha) + phosphate-solublizing bacteria (PSB) (20 kg/ha) + arbuscular mycorrhiza (AM) (65 kg/ha) resulted in maximum yield of passion fruit (23.63 tonnes/ha), ginger (28.45 tonnes/ha) and capsicum (9.27 tonnes/ha), as well as enhanced the quality of passion fruit (30% juice content, 16.30ºB TSS, 17.50 mg/100 g ascorbic acid, 4.75% reducing sugar and 8.43% total sugar). Application of pyrethrum and *Pseudomonas fluorescens* controlled major insect-pests and diseases of passion fruit.

Rice variety RC Maniphou 12: RC Maniphou 12 (RCM 13/IET No. 22828) variety of rice was released for cultivation in Manipur. It takes 75 days to reach 50% flowering and matures in about 90 to 105 days in summer (March-April sowing) in the valleys of Manipur. The variety is suitable as the first crop of the double cropping rice production system as well as for different cropping systems and is 100 cm tall with 50–200 spikelets/panicle and with a desirable soft cooking (low amylose content-11.70%) quality preferred by the people of north-eastern hill region. It has very low amylose content and the yield potential ranges between 4.5 to 5.0 tonnes/ha.

Tomato variety RC Manikhamenashinba 1: RC Manikhamenashinba 1, was bred with the objective of developing a HYV having tolerance to biotic and abiotic stresses. The variety is suitable for the rainfed/irrigated and rice fallows (life-saving irrigation). The variety has an yield potential of 4.25 tonnes/ha under good management practices and the fruits have smooth surface, soft firmness, juicy pulp, 6.7º Brix TSS and good shelf-life if properly stored. The variety is moderately resistant to bacterial wilt and tolerant to leaf curl disease. It is also tolerant to moisture stress and is relatively free from fruit cracking which is a major problem in tomato.

Tomato variety RC Manikhamenashinba 1

Oil palm-based cropping system: Cropping system with red ginger and *Heliconia* in grown-up oil palm gardens (under irrigated conditions) was standardized. Red ginger and *Heliconia* are shade tolerant cut flower crops which can come up well even under dense (70–80%) shade. Both the crops could be successfully cultivated as intercrops in grown-up oil palm plantations of 4–5 years. Each clump/plant produced annually 30–40 flowers (45,000 flowers/ha/year) in *Heliconia* and 15–20 flowers (22,500 flowers/ha/year) in red ginger under drip irrigation. In addition, 12–18 tonnes/ha rhizomes of red ginger were harvested after 4–5 years. The cost of cultivation varied from ` 15,000 to 20,000/ha/year. Red ginger and *Heliconia* provided income to farmers round-the-year with a net profit of about ` 40,000/ha/year.

Arecanut: Arecanut productivity improved significantly (12%) in arecanut + cacao integrated system (3,450 kg/ ha) along with 291.34 kg/ha cocoa yield as compared to arecanut solo crop (3,090 kg/ha). Diverse soil microorganisms like *Funneliformis mosseae*, *F. geosporum*, *Rhizophagus fasciculatus*, *Glomus macrocarpum*, *G. aggregatum*, *G. multicaule*, *G. glomerulatum* and *Acaulospora bireticulata* were isolated from arecanut-cocoa based cropping systems under organic management practices.

Seed spices—Sustainable and profitable intercropping model: Six seed spices were beneficially integrated as intercrops within aonla or ber orchards. Seed, stover and biological yield of intercrops were more under sole cropping but coriander equivalent yield (10,269.34 kg/ha) of ber and aonla fruit proved that there was higher yield of component crops due to intercropping with ber, followed by aonla as compared with sole cropping. Among seed spices, fenugreek intercropped with ber or aonla was more beneficial with higher coriander equivalent yield.

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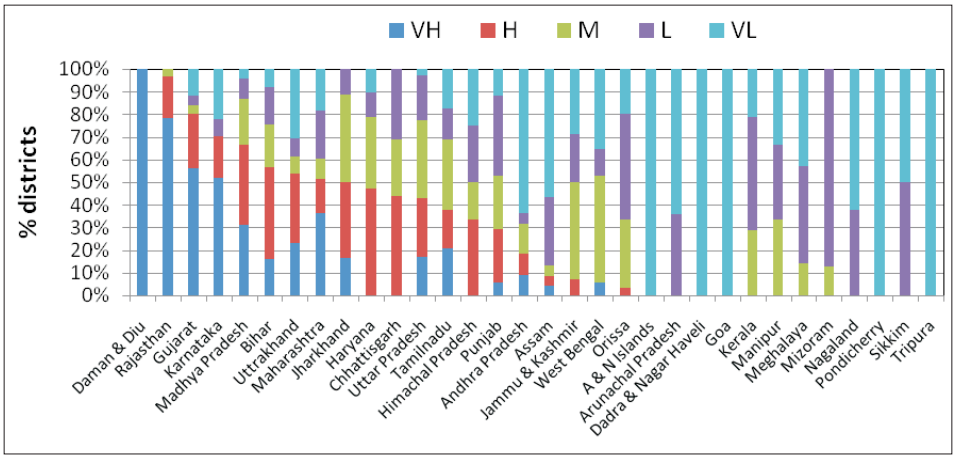
4. Climate Change

Seasonal variability in rainfall and long term warming trends are posing serious threats for sustainable crop and livestock production. The National Agricultural Research System (NARS) has been carrying out comprehensive research and technology demonstration activities on coping with climate change under the flagship programme of ICAR on National Initiative on Climate Resilient Agriculture (NICRA).

Identification of vulnerable districts

District level vulnerability atlas was prepared to develop and target appropriate adaptation measures to regions that are more affected by climate change. The Atlas classifies vulnerable districts into very high, high, medium, low and very low categories, based on the combined evaluation of exposure, sensitivity and adaptive capacity, as per the IPCC protocol. Most of the districts with very high and high vulnerability are situated in the states of Rajasthan, Gujarat, Uttar Pradesh, Madhya Pradesh, Karnataka and Maharashtra. Similarly, of the 115 districts that are highly vulnerable, 18 are in Uttar Pradesh, 16 in Madhya Pradesh, 15 in Bihar, 9 in Haryana, 7 in Chhattisgarh and 6 each in Jharkhand, Gujarat and Rajasthan.



State-wise distribution of districts with different levels of vulnerability
(VH: Very high, H: High, M: Medium, L: Low, VL: Very low)

Terminal heat stress during wheat growing season

A study was conducted to monitor terminal heat stress conditions in real-time at regional scale across all the districts in six wheat growing states of Haryana, Punjab, Uttar Pradesh, Rajasthan, Bihar and Madhya Pradesh. A database of weekly day-time and night-time Land-Surface-Temperature (LST) from MODIS satellite sensor was generated for January to March period over 2010–2013. The LST values for each week were aggregated district-wise. The district *rabi* season LST of 2013 was compared with the respective values in past three years temporally and spatially: 2010 was the hottest year while 2012 was the coldest. Majority of the districts showed negative value indicating absence of terminal heat conditions during 2013. Further, it was observed that all the districts of Madhya Pradesh and few neighbouring districts of Uttar Pradesh and Rajasthan remained very cold (as shown by large negative anomaly values) during February–March 2013 period as compared to the past three years, a condition beneficial for grain filling in wheat.

Community initiatives for fighting monsoon variability in Jharkhand

Gumla district in Jharkhand has a sub-tropical climate with temperatures of 20 to 40°C during summer and 3 to 21°C during winter and a mean annual average rainfall of 1233 mm. With no irrigation facility available, majority of the farmers cultivate the lands during *kharif* and leave them fallow thereafter.

Participatory Rural Appraisal conducted by KVK, Gumla, under the aegis of the National Initiative on Climate Resilient Agriculture, recognized that there is immense potential for harvesting rainwater from the small streams so that availability of water for agriculture during *rabi* season could be augmented. Gumla covers over 500 ha of cultivated area in a cluster of hamlets called Gunia, Burhu, Balagada and Kuhipat that are predominantly inhabited by small and marginal farmers. The KVK organized a *shramadaan* of the villagers for laying a sand bag check dam in December 2011 in the storm water drain called *Mahasaria*, a seasonal stream, to impound water and to prolong water availability beyond *kharif*, i.e. after the cessation of rains. The check dam (100 m long, 3 m wide and 2 m tall) impounded a large amount of water. Once the water level rose, farmers dug channels to divert water to their fields for cultivating vegetables and wheat. About 50 ha came under wheat during *rabi* 2011–12 while 10 ha was planted with vegetables like okra, tomatoes, cowpea and different types of gourds. Nearly 140 farmers were benefitted. The net return from wheat cultivation was ` 17,900/ ha while that from vegetable cultivation ranged between

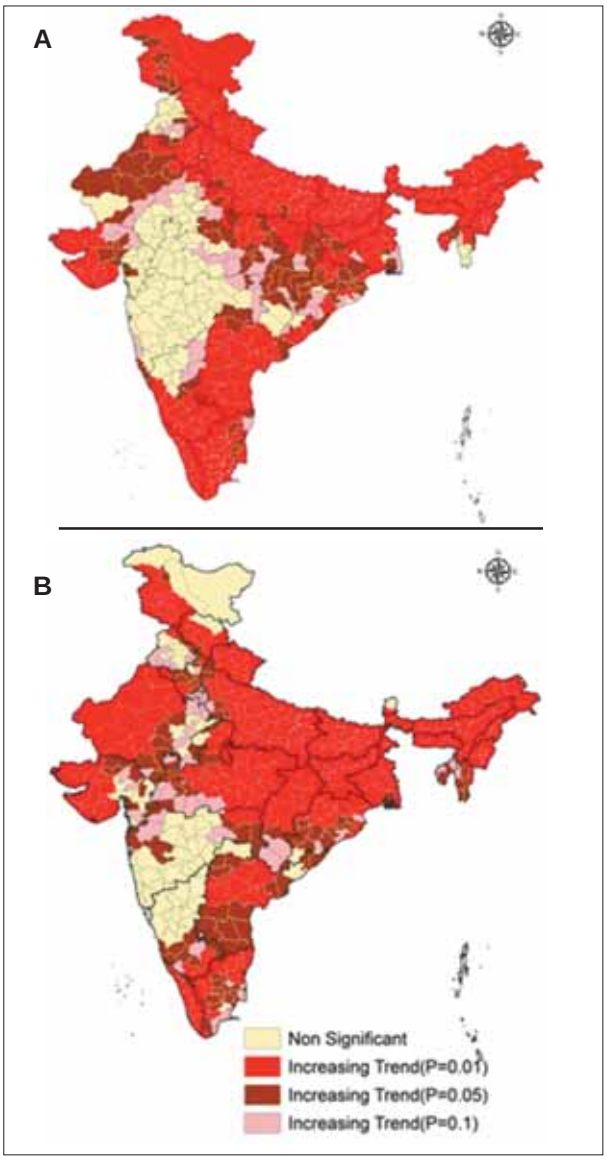
` 51,000 and ` 95,000.

As the news about the success of sand bag check dam in Gunia spread across the district of Gumla, the district officials attempted to replicate this intervention to other locations. For example, the minor irrigation division of the Gumla district administration identified nine locations for constructing a series of *pucca* check dams on Ghaghri nala, Bansari nala and Gomath nala in Ghaghra block and floated a tender worth ` 3,94,72,402. Two *pucca* check dams, one each at Gunia and Jargatoli, were completed by end of February 2013. The Member of Legislature Assembly of Bishunpur constituency visited the check dam at Jargatoli and was impressed with the work. Keeping in view the utility of the intervention, he funded the installation of water lifting device (currently operated by diesel on cost sharing basis) under the MLA-LAD. The device is shortly going to be provided with electric power. The past two years were eventful in the history of Gunia cluster during which saw several transformations: from laying of a sand bag check dam to cement check dam and other improvements for which the villagers give credit to the NICRA Project of ICAR. The farmers of Gunia are now confident of facing the challenge of droughts and monsoon aberrations.

Rising minimum temperature trends over India

The rising minimum temperature has become a concern for *rabi* crops. In order to have a clear assessment of the minimum temperature trends over the entire country, monthly surface minimum temperatures were computed using 0.5 degree grid data from CRU. The magnitude of change on annual basis over the entire country is 0.24°C for a 10 yr period. The extent of area with a strong increasing trend forms about 81.8% of the total geographical area.

Temperature rise during the *kharif* season is 0.19°C



Trends in minimum temperature over India (1971-2009) during (a) *kharif* and (b) *rabi* seasons

Magnitude of changes in minimum temperature over different seasons, regions and timeperiods

Season	Districts cluster based on temperature rise	No. of districts	1971-2009 (°C/10 yr)	1980-1989 (°C/10 yr)	1990-1999 (°C/10 yr)	2000-2009 (°C/10 yr)
Kharif	Entire country		0.19	-0.18	0.50	0.09
	Slightly warm	42	0.12	0.00	0.35	0.22
	Moderately warm	90	0.16	-0.17	0.47	0.10*
	Strongly warm	366	0.24	-0.16	0.59	0.03*
Rabi	Entire country		0.28	-0.06	0.36	0.25
	Slightly warm	56	0.17	-0.62	-0.01	0.51*
	Moderately warm	112	0.21	-0.49	0.12	0.37*
	Strongly warm	359	0.34	-0.15	0.39	0.41*
Annual	Entire country		0.24	-0.05	0.36	0.25
	Slightly warm	13	0.12	-0.66	0.20	0.36*
	Moderately warm	50	0.15	-0.31	0.00	0.21*
	Strongly warm	508	0.26	0.00	0.41	0.25*

(* t test significant at 5%)

over a 10 year period, with profound regional variations. Minimum temperatures during the *kharif* showed strong warming trend in southern states, Indo-Gangetic Plains (IGP), northeastern parts, most parts of Jammu & Kashmir, Gujarat and entire Himachal Pradesh. A strong warming trend was noticed over 52.7% of geographical area with a warming of 0.24°C/10 yr (Table 1). Though the magnitude of change was more during 1999, the trend line for the sub-period 2000–2009 for moderately and strongly warm regions was statistically significant.

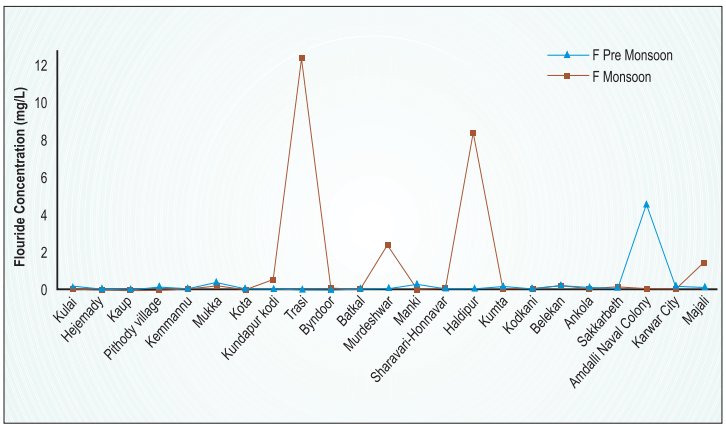
Minimum *rabi* temperatures during 1971–2009 showed strong warming over IGP, West Bengal, northeastern states, Chhattisgarh, Rajasthan, Gujarat and eastern parts of Madhya Pradesh. The rise during *rabi* over the country as a whole was greater in magnitude compared to *kharif*. The temperature rose @ 0.28°C/10 yr. The warming during 2000–2009 decade (0.25°C/10 yr) for *rabi* was about three fold more than *kharif*. A strong warming tendency was noticed over 54.9% of the geographical area, which was 2.2% more than the area during *kharif* season under the same category. The magnitude of change in area classified as slightly warm covering 7.7% of the geographical area was relatively high and proceeded @ 0.51°C/10 yr during 2000–2009 period, which was the highest across regions and sub-periods.

Monsoon rainfall pattern in North Eastern Region

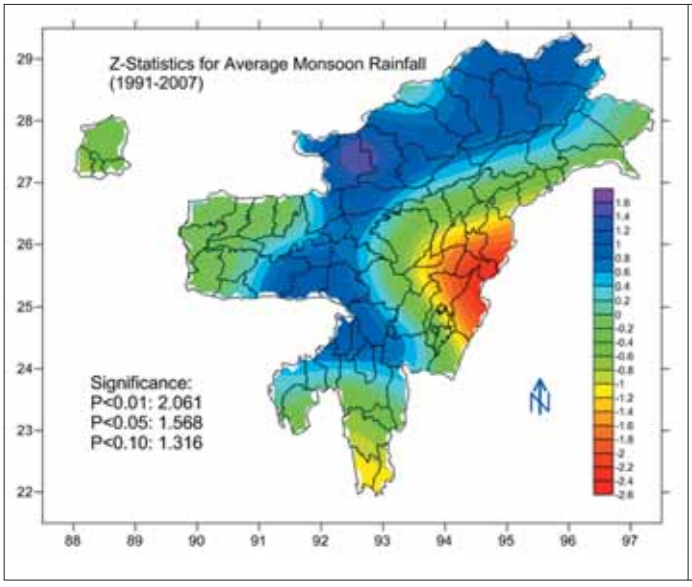
Long term rainfall trends in the NEH region was assessed to know its impact on agriculture and horticulture. Average amount of monsoon rainfall decreased from 900–3000 mm (1951–90) to 850–2350 mm (1991–2007), indicating an average reduction of 18% rainfall in the recent period. The study indicates significant (P<0.01) decrease in rainfall in Ukhrul and Senapati districts of Manipur and Phek, Zunheboto and Wokha districts of Nagaland. Similarly, the number of rainy days reduced from 65 to 91 days (1951–90) to 57 to 85 days (1991–2007) indicating an average reduction of 9% rainy days over the region. The reduction was significant (P<0.01) for all the districts of Nagaland; upper Asom districts of Tinsukia, Dibrugarh; and Tirap, Changlang, Lower Dibang valley districts of Arunachal Pradesh. The traditionally wet north eastern region has shown a tendency of moving towards a drier monsoon regime in recent times as evidenced through standardized precipitation index (SPI). More locations in the region moved to the negative side of SPI indicating water stress of varying degrees during the *kharif* crop season.

Sea water intrusion in the coast of Karnataka

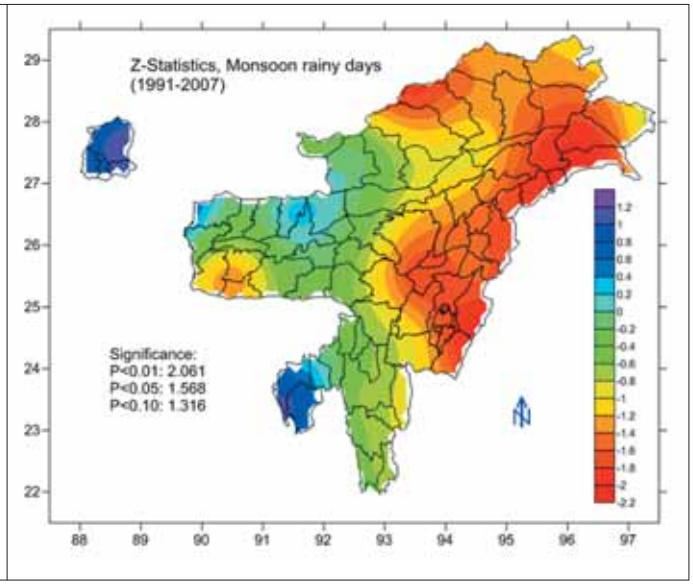
To evaluate the extent of salt water intrusion in the coastal Karnataka, soil and water samples were collected from 24 benchmark sites interspersed at every 10 km interval in the 320 km stretch along the coast in January 2012. At each location, five samples representing approximately 0 m, 0.5 km, 1 km, 3 km and 5 km were collected from shore towards inland to assess salt water incursion in land. To study the depth to which salt water has leached into the soil samples at 10, 50, 100 cm depth were collected. In total, 120 water samples and 360 soil samples were analyzed. Chloride, sulphate, bromide, fluoride, sodium,



Fluoride concentration measured from benchmark sites in coastal Karnataka



Average monsoon rainfall



Monsoon rainy days

potassium, calcium and magnesium concentrations in ground water were estimated during pre- and post-monsoon to assess the extent of coastal salinity. Fluoride concentration was below 1 mg/L except in a few locations, but it was more in winter. Bromide was present in 50% of the locations and very high concentrations of bromine (0.50–1.80 mg/L) was observed at Mukka and Kumta indicating that the region has experienced intrusion of sea water from the ocean.

Modeling pigeonpea yields under changing climate

Pigeonpea is the second most important pulse crop after chickpea in India. In Karnataka, Gulbarga area is the "Pulse Bowl of Karnataka". Pigeonpea area in Gulbarga has steadily increased from 0.14 M ha in 1970 to 0.43 M ha in 2007. Average pigeonpea productivity, however, is low at about 0.42 tonne/ha. Pigeonpea productivity in Gulbarga is affected by large variations in rainfall amount and distribution, increased temperatures and depleting soil fertility.Field experiments were conducted in 2011 and 2012 with three popular varieties of pigeonpea (ICP 8863-Maruti, ICP 87119-Asha and TS-3R) and one hybrid ICPH 2671 on farmers' fields at Farhatabad, Gulbarga district and at ICRISAT, Patancheru (Andhra Pradesh). Using the pigeonpea model in APSIM, genetic coefficients for the variety TS-3R were derived based on observed phenology, crop growth and yield data. Based on daily weather data of 41 years (1969–2009) of Gulbarga, productivity and water use of pigeonpea variety TS-3R under eleven climate scenarios were assessed. Simulations show that increase in temperature by 2°C would reduce pigeonpea yields by about 16%. Rainfall decrease of 10% from present coupled with 2°C increase in temperature would reduce yields further by 4%, making the total reduction as high as 20%. Crop duration decreased by about 10 days and water use declined by 25 mm with increase in temperature. Increased rainfall have considerably reduced the adverse effects of higher temperature. Breeding varieties tolerant to higher temperature and adoption of better water management practices (both *in-situ* and *ex-situ*) can help sustain pigeonpea yields in the region under changing climate regimes.

Inter-specific grafting in tomato for enhancing flood tolerance

Scions of tomato cv. hyb. ArkaRakshak (AR) were grafted on to self and four brinjal rootstocks: AR/BPLH-1, AR/MattuGulla, AR/ArkaNeelkanth, AR/ArkaKeshav, self-grafted (AR/AR) and ungrafted Arka Rakshak (ungrafted-AR). Within 24 hr of flooding there was a decrease in photosynthesis and 70.0 to 83.0% decrease by day 6 in the grafts with brinjal rootstocks, while in self-grafted and ungrafted plants the decrease in photosynthesis was 93.0 to 98.0%. In general, rootstock grafted plants had significantly higher gas exchange levels than AR/AR and ungrafted-AR under flooding. The effect of flooding on root growth was greater in AR/AR and ungrafted-AR as indicated by higher percentage reduction (36–49%) in these plants

Tomato plants grafted with brinjal root stock with better flooding tolerance

Effect of projected climate on phenology and productivity of pigeonpea cv. TS-3R

Climate scenario	Days to flower	Days to maturity	Total biomass (kg/ha)	Grain yield (kg/ha)	Change in yield (%)
Present (P)	103	157	8708	2057	0
P+1°C	101	151	8286	1875	-9
P+1°C-10%RF	99	150	7798	1771	-14
P+1°C-20%RF	99	150	7090	1615	-21
P+1°C+10%RF	101	151	8659	1961	-5
P+1°C+20%RF	101	152	8866	2005	-3
P+2°C	99	148	7943	1734	-16
P+2°C-10%RF	98	147	7465	1636	-20
P+2°C-20%RF	98	147	6763	1486	-28
P+2°C+10%RF	100	149	8302	1809	-12
P+2°C+20%RF	99	148	8525	1854	-10

after flooding. Further, brinjal rootstock grafted plants had more number of adventitious roots (5–7) than AR/AR and ungrafted-AR. In the flooded plants, 50% yield was maintained by rootstock grafted plants and in AR/ArkaNeelkanth the reduction in yield under flooding was only 11.7%. Tomato scions grafted over brinjal rootstocks showed better tolerance to flooding than the self-grafted and ungrafted plants based on physiological parameters like photosynthesis and chlorophyll fluorescence. The best recovery was found in AR/ArkaNeelkanth.

Short duration crop varieties to face with frequent droughts in Tumkur, Karnataka

Durgada Nagenahalli (DN) village situated in the central dry agro-climatic zone of Karnataka receives an average rainfall of 690 mm. The major climatic vulnerabilities of the village are drought particularly during the critical stages of the crop growth and farmers lose their crops. Finger millet, maize and groundnut are major crops grown in this village. The village experiences acute water shortage, soil erosion and there is a preponderance of wastelands and common lands. NICRA project implemented by KVK, Tumkur in this village covers nearly 270 households with a cultivable area of nearly 200 ha.

Ragi being the staple food crop in this region, every farmer cultivates it for meeting his consumption requirements. Due to frequent droughts in the recent past, however, many are unable to harvest enough. Ragi cv. ML 365 developed by UAS, Bangalore to cope with early season drought was introduced in this village over an area of 20 ha involving 70 farmers. Seedlings of ML 365 were raised in nursery and transplanted after 25 days with the onset of rainy season. The performance was significantly superior to local varieties. The farmers have retained the seed and also shared it with fellow farmers for sowing in the ensuing season. Salient characteristics of the variety ML 365 are:

- Short duration (about 105 days)
- Medium plant height
- High yielding (grain and fodder) due to more panicles and grain filling
- Tolerant to drought
- Resistant to leaf spot, neck blast and lodging
- Good cooking quality
- Suitable for dryland agriculture and late sowing (transplanting)
- Requires low seed rate (5 kg/ha)

Success of this intervention was evident during 2012 when a severe drought struck Karnataka. The DN villagers harvested reasonable quantities of grain while the neighbouring villages nearly lost the crop.

Climate-resilient aquaculture for Sundarban Islands

Flooding the freshwater ponds with saline water during cyclones is a major problem affecting the fish/prawn culture in Sundarbans. Studies over a 2 year period revealed that two hours of continuous aeration (0.2 kg/m^3 pressure with 4 L / m^3 / minute volume) at 4 hr interval is an effective adaptation strategy for salinity up to 5 ppt for freshwater fishes (*Cyprinus carpio* and *Puntius sarana)*. Inclusion of additives like immune-stimulant (Immutron)/ probiotic (Gut Act)/ prebiotic @ 10 ml/kg high energy floating feed (having 30% protein, 4% fat and 8% fiber) increased the growth rate under salinity stress. High energy feed fortified with immune stimulant showed best growth ($P< 0.05$) followed by probiotics and then prebiotics in *Cyprinus carpio, Labeo rohita* and *Oreochromis mosambicus*.

Water footprints for milk production

Consumptive water use (CWU) in milk production comprises direct (drinking, bathing and servicing) and indirect (feed and fodder) components. For stall-fed animals, the entire direct water requirement is met from groundwater and/or surface water sources (blue component of water footprint). For animals partly or fully under grazing system, however, rainwater may partly account for the water use (e.g. drinking and bathing). Direct water use by animals was estimated by assessing seasonal drinking water requirement of different breeds of dairy animals. Based on the diameter of water pipe, time of water flow and number of animals in the enclosure, the average water use of servicing and bathing worked out to be 50 L /day on the NDRI

Snowmelt harvesting saves orchards during dry spells in Kashmir

About 3.3% of total geographical area of Kashmir is under cultivation, of which 60% is rainfed. Horticulture-based farming systems are predominant. However, frequent dry spells during *kharif* affect cultivation of apples and pears, which are major crops of Pulwama region. In Drubgam village of the district where NICRA is being implemented, most of the cultivated area is rainfed and the apple and pear orchards generally suffer due to erratic rainfall. Further, the productivity of these crops is low due to lack of irrigation and low input use. In particular, irrigation is essential to ensure higher fruit retention if dry spells occur. To cope with this climate related problem, the KVK, Pulwama introduced rainwater/snowmelt water harvesting interventions and micro irrigations systems in the village.

Rainwater/snowmelt water harvesting structures have been demonstrated at select farmers' fields as effective means of collection and storing runoff and snow melt water. The stored water is used for providing irrigation at critical stages of growth of fruit crops and vegetables. This water is also useful for spraying orchards, vegetables in the absence of water source in nearby areas. During the past two years, it was observed that not only the growth of apple trees and other crops improved but also there was improvement in the yield and quality of the produce due to efficient utilization of harvested rainwater and snow. Impressed with the benefits, many farmers are coming forward to adopt this technology.

Total water footprints (m^3/tonne) of milk production in organized and unorganized farms

Breed	Average milk yield (L/day)	CWU (m^3/t)		
		Blue (Direct+ Indirect)	Green (Indirect)	Total
Organized farm				
Karan Fries	9.0	996	216	1212
Murrah	7.4	1031	238	1269
Sahiwal and Tharparkar	7.2	1279	304	1583
Unorganized farms				
Cross bred	8.3	1166	812	1977
Buffalo	5.2	1201	746	1947
Local Cow	4.5	981	563	1544

Shift in fish maturity and breeding period

A shift in fish maturity and breeding period of Indian Major carps (IMC) rainbow trout, golden mahseer and snow trout, was recorded recently due to climatic variations along Himalayan and sub Himalayan regions. The maturity of IMCs in North-eastern region of country has advanced by one month (from April to March) and the period extended one month (from July to August). The full matured rainbow trout was observed during December end to January, golden mahseer during April to June, and snow-trout in August in Uttrakhand. Increase in water temperature due to the global warming affects habitat, metabolism, growth and reproduction of fishes. Hatchery survey data comprising various aspects of breeding and spawning of fishes was compiled in the form of E-Atlas for West Bengal and Asom.

farm and marginally lower (40 L/day) on the farmer's field. Based on the monthly feed intake data of crossbred cattle, buffaloes and local cows at NDRI farm and the seasonal (three seasons) data from the farmer's field, total water footprints (m^3/tonne) of milk production were estimated. Results indicate that total consumptive water use (m^3/tonne) at organized farm was less than that of unorganized farms. Water use was more for buffalo and crossbred cattle than *desi* cattle breeds. Unorganized farm used 1950 to 1980 m^3/tonne water (cwu) for crossbreds and buffaloes as against 1540 m^3/tonne for local cows.

Mitigating climate change through plant growth promoting bacteria: Bio-priming of seeds with osmo-tolerant plant growth promoting bacteria was observed to improve and reduce the time taken for seed germination and enhanced seedling growth in tomato under osmotic stress conditions.

Mango phenology: In a roving survey of the coastal Konkan region of Maharashtra, it was observed that more than 95% of the mango orchards showed phenological stages between vegetative flush to panicle emergence leading to staggered flowering in all the varieties and even fruits at different stages of growth on the same tree. Pollen viability was the most important parameter determining fruit setting in Alphonso and Totapuri.

Fruit fly infestation: Climate change is expected to have adverse effect on the potential distribution of fruitfly (*Bactrocera dorsalis*) in India. The fly is expected to spread northwards into colder regions. A roving survey undertaken for the mango orchards in Karnataka revealed that the severity of black banded disease; leaf blight and mango malformation is increasing. Under conservation horticulture, inclusion of legume (*Mucuna* sp.) as cover crop has resulted in appreciable increase in the levels of soil organic carbon and nutrients.

Effect of elevated CO_2 and temperature on coconut: At the present level of available soil moisture, coconut would produce more biomass under changed climate scenario with higher CO_2 and increased temperature. However, inordinately delayed jorquetting is expected in cacao plants due to increased temperature as compared to plants grown at ambient temperatures.

Carbon sequestration through cassava cultivation: On the basis of soil fertility test, cultivation of NPK-efficient cassava genotype (Ac. No.130) along with optimum nutrient management practice and low-input integrated practices could sequester atmospheric CO_2 (13.867 ppm) to soil organic carbon (0.74–1.67%).

Potato: Climate change impact on potato productivity in Punjab was carried out using WOFOST crop growth model. It was estimated that productivity of potato cultivars in Punjab will not be affected in 2020 over the baseline scenario but will decline in 2055 (–2.62%–5.3%). However, if the present distribution of potato acreage in Punjab remains unaltered in future, there will be benefits from climate change as the potential productivity of potato will increase (+3.1 to +3.6%) in 2020 but it will again decline to baseline values in 2050.

Quantification of greenhouse gases: The green house gases (GHGs) N_2O, CH_4 and CO_2 emission were quantified from four *Litopenaeus vannamei* farms (at different stocking densities) and one *Penaeus monodon* farm in Andhra Pradesh and Tamil Nadu for four months. In addition, traditional farming system (Pokkali fields) of Kerala was also studied. Average emission of GHGs in g/ha/day was high in traditional farming compared to scientific shrimp farming with *L. vannamei* and *P.monodon*. Global warming potential (GWP) values in kg CO_2 eq/ha/season were 91 in tiger shrimp farm, 218 to 351 in *L.vannamei* farms, and 405 in pokkali shrimp farm.

Quantification of microbial biomass carbon: Microbial biomass carbon (MBC), an indicator for increased atmospheric carbon dioxide (CO_2), accelerates global warming. The changes in soil MBC were studied in scientific farms in Tamil Nadu and Andhra Pradesh

and traditional farms in Kerala. In scientific shrimp ponds, MBC in soil ranged from 50 to 938 µg C /g and 70 to 721 µg C / g in *L. vannamei* and *P. monodon* culture ponds, respectively, whereas in traditional shrimp farming ponds, the MBC in soil ranged from 584 to 2114 µg C /g. Organic matter content in pond soils ranged from 0.36 to 1.24% and 0.62 to 2.2% in the scientific and traditional shrimp ponds, respectively. The values of MBC and total organic carbon (TOC) were significantly correlated with days of culture (DOC) and were very high during summer crop compared to winter crop of *L.vannamei*.

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5. Genetic Resources

Crops

Agro-biodiversity component of the plant genetic resources covers whole gamut of genetic resources (from advanced cultivars to primitive landraces, domesticates, semi-domesticates, wild and weedy relatives) and the diversity of ecosystems and agro-ecosystems within the landscapes. The resources include all agricultural crops and some of their wild relatives that possess valuable traits. Occasionally genes, DNA fragments and RNA fragments are included under the purview of the genetic resources, and these genomic resources are conserved in gene banks. Plant genetic diversity provides valuable traits needed for meeting the challenges for evolving crop varieties suitable for changing environment. The ICAR institutions are involved in the augmentation and conservation of genetic resources for developing new crop varieties.

Germplasm augmentation, conservation and use: Thirty- three explorations were undertaken in 16 states, and 1,722 accessions, including 322 wild species were collected.

Sorghum-landrace diversity, collected from tribal pockets of Khammam district, Andhra Pradesh - *Dubba jonna, Tella jonna, Gaddi jonna, Konda jonna* and *Pachcha jonna*

A total of 266 specimens were added to the National Herbarium of Cultivated Plants. The National Gene Bank was enriched with 5,414 accessions of orthodox seed species and 120 of non-orthodox plant materials.

Forty-four thousand sixty-nine accessions imported from 42 countries included 10,295 accessions of international trial materials. Promising introductions are in wheat: alien disomic substitution genetic stock (EC758755) of durum, genetic stock with *ph1b* mutant allele in adapted Kansas winter wheat (EC 755279),

Promising wheat genotypes identified for quality components

Genotype	Traits
KLM 1005	Durum lines with bold grains (TGW*: 51g) and high protein (14% at 14% grain moisture)
WSM 24	Durum lines with bold grains (TGW: 53g) and high protein (13.5% at 14% grain moisture)
KLM 1008	Bread wheat lines with bold grains (TGW: 51g) and high protein (13.4% at 14% grain moisture)
BW 5872	Bread wheat line with good sedimentation volume (54 ml)

*TGW: Thousand Grain Weight

registered lines with genes from elite cultivars possessing alternate growth habit (EC762316-17) from the USA and Waagan (EC 759227) having drought tolerance from Australia; in paddy: resistant to sheath blight and blast diseases (EC758366-8) from the USA; in safflower with high oleic acid (EC755659-88) from Mexico; in snapmelon (EC 766817-33) with *Fusarium* wilt resistance and gummy stem blight resistance from the USA; in tomato: tolerant to heat and resistant to late blight, *Fusarium* wilt, tomato yellow leaf curl virus and tobacco mosaic virus (EC779308) from Taiwan, and wild tomato (EC 774472-3) from the USA; in chilli: CMS lines (EC 771549-54) and *Phytophthora*

Prunus mira (Behmi)– a cold hardy wild relative of peach and almond; used for edible purpose and as a source of oil locally, and as a rootstock

Germplasm Portal

A web-based portal has been developed to facilitate access to information on the PGR conserved at the National Gene Bank. The PGR Portal is a gateway to information on plant genetic resources conserved in the Indian National Gene bank, housed at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. The NBPGR is the nodal organization in India for acquisition and management of indigenous and exotic plant genetic resources for food and agriculture. The Indian National Gene bank conserved about 0.4 million accessions belonging to 1,812 species. The PGR Portal is an endeavour in this direction to facilitate easy availability of information about the conserved germplasm. The information provided through the PGR Portal is accessible to researchers, farmers, students and policy-makers. Users can either search for accession information (simple search) or for characterization and preliminary evaluation data (advanced search).

Jute and allied fibres germplasm from Tamil Nadu and Kerala

A total of 235 accessions of jute and allied fibres: 137 species of *Corchorus* , including *C. olitorius, C. pseudo-olitoirus, C. aestuans, C. tridens, C. fascicularis, C. trilocularis, C. urticifolius*; 35 species of *Hibiscus,* including *H. sabdariffa*, *H. cannabinus*, *H. hirtus, H. surattensis;* 36 species of *Crotalaria*; 17 species of *Agave* and 10 species of *Urena* were collected. *H. sabdariffa* WHIN 61 with about 3-m height was collected from monolithic rock in Kerala and *C. aestuans* WCIN 302 with high yield, soft and white fibre was collected from farmer's field in Tamil Nadu. Some unique mutants of *tossa* jute (cv JRO 204, JRO 8432) with soft stem and undulated phenotypes, producing lesser fibres with low lignin content, have been identified. In addition, hard stem mutant with coarser fibre-producing ability, super dwarf mutant plant of 30- cm height (control 320 cm) and a twisted bark mutant in *tossa* jute have also been identified.

resistant lines (EC 771558-60) including core sets in chilli; lima bean and hyacinth bean from Taiwan.A total of 25,438 accessions were characterized and evaluated. These included wheat evaluated for terminal heat tolerance, tolerance to spot- blotch disease and rusts. In all, 7,770 accessions were supplied for research and crop improvement within the country.

A total of 141,191 imported plant materials, including seeds, vegetatively propagated materials and transgenics were processed for quarantine clearance. Out of 3,838 samples infested/ infected with different pests, 3,437 have been salvaged. Thirteen phytosanitary certificates were issued for export of 1,294 plant materials.

In Maize, five lines V 334, V 336, V 400, V410 and V 414 exhibited moderate tolerance/ resistance against *Helminthosporium turcicum* leaf blight, banded leaf and sheath blight and *H. maydis* leaf blight. These can directly be used as parental lines for hybrid development or as donors in maize-breeding programme.

Moderately resistant (V414, V 410, V 400, V 336, V 334) and highly susceptible (CM 212, CM 145) maize inbreds

In Groundnut, Spanish bunch types NRCG 14500 for high protein content (33%), NRCG 14430 for high shelling out-turn (73%), and Valencia types NRCG 14379 for high shelling (72%), NRCG 14448 for high protein content (31%) and M 13, M 548 and ICGS 76 for low oil and high sucrose content and with a desirable fatty-acid composition have been identified. Safflower accessions GMU 184 and EC 523368-2 were validated for resistance to aphids, while castor accessions RG 631 and RG 2469 showed resistance to leafhopper.

A large number of wild accessions of different pulse crops were characterized and utilized in breeding programmes for widening genetic base. Chickpea genotypes Katila, Avrodhi, Vaibhav, GCP 105 and JG 11 exhibited combined tolerance to heat and drought. Mungbean genotypes MH 2-15 and IPM 02-3 showed multiple resistance against most of the prevalent *kharif* diseases– mungbean yellow mosaic virus (MYMV), *Cercospora* leaf spot, anthracnose, leaf crinkle, leaf curl, stem necrosis and *Macrophomina* blight. IPM 02-15-4 was found resistant to MYMV in *rabi*. Urdbean genotype UH 7-13 showed multiple resistance against MYMV, *Cercospora* leaf spot, root-rot and leaf crinkle while IPU 10-17 exhibited broad spectrum of resistance against MYMV, urdbean leaf curl virus (ULCV) and anthracnose. Urdbean accession PGRU 95016, besides, accessions of *Vigna glabrescens* (IC 251372) and *V. umbellata* (IC 251442) exhibited photo-thermo-insensitivity that can facilitate development of widely adaptable genotype. Urdbean genotype Mash 114, DPU 88–31, Khairagarh Agra and AKU 15 showed resistance to root-knot nematode, *Meloidogyne javanica*.

Number of fieldpea genotypes showed multiple and multi-locational resistance against many diseases. These include Pant P 172 which was resistant to powdery mildew and rust; HFP 919 was resistant to downy mildew; and Pant P 184 was resistant to powdery mildew and *Ascochyta* blight, and Pant P 74 showed resistance to powdery mildew, downy mildew and rust.

Germplasm registration: Germplasm registered at the NBPGR comprise cereals (12), millets (4), grain-legumes (8), oilseeds (19), fibres and forages (13), spices (1), tuber crops (2), medicinal and aromatic plants (9) and commercial crops (7). Three pearl millet hybrids, Pusa 415 (MP 739), Pusa 605 (MH 564), HHB 146 (MH 960), and one variety, Pusa Composite 334 (MP 334), were registered with PPV & FRA, New Delhi.

Vaidehi 95 (MSH 53), a dark-brown linted introgressed derivative of cotton, has been registered with the NBPGR, New Delhi (National Id: IC0584260

Important registered germplasm of crop-plants

Crop	National identity	Original identity	INGR No.	Unique features
Wheat	IC 0590875	UAS 320	13001	Resistant to flag smut disease
Wheat	IC 0595583	DBQW 1	13072	Good biscuit-making quality
Wheat	IC 0598203	HW 3601	13051	Carries gene for leaf rust resistance, *Lr 19,* and stem-rust resistance, *Sr 36*
Wheat	IC 0597682	UP 2672	13053	High protein content (14.1%)
Rice	IC 0594593	RPMRE 6	13073	Multiple resistance to gall midge, brown planthopper and white-backed planthopper
Rice	IC 0595533, IC 0595534	PANT CMS2A, CMS2B	13002	High panicle exertion (92.9%) and high out-crossing rate (41.30%)
Maize	IC 0594467	KDTML 82	13003	Drought tolerance
Maize	IC 0524594	MCM-11/01	13054	3-4 cobs / plant and early maturing
Maize	IC 0594369	DMR QPM 102	13074	Medium maturity, low ASI, high tryptophan, high protein
Sorghum	IC 0594687	BRJ 62	13005	Restorer on *Maldandi* source of male sterility
Sorghum	IC 0595529	PYPS 2	13006	Yellow grain, good *chapati*-making quality
Sorghum	IC 0597771	SSG 226	13055	Low hydrocyanic acid (66.6 ppm), high digestibility and high leaf-stem ratio
Pearl millet	IC 0283734	NSS 7809	13056	Popping trait
Greengram	IC 0546478	KSAS 06/105	13010	Photoinsensitive accession
Chickpea	IC 0595521, IC 0595522	GL 84100, GL 87045	13008 13009	Resistant to *Ascochyta* blight and wilt
Pigeonpea	IC 0594374	IPA 9 F	13024	Resistant to *Fusarium* wilt
Groundnut	IC 0595257	TGM 167	13011	Gibberellin- insensitive dominant dwarf mutant
Groundnut	IC 0595258	NRCG 12431	13012	Low level of infection (7%) and free from colonization of *Aspergillus flavus* in kernels
Indian mustard	IC 0595268	NDUH-YJ6	13015	Low glucosinolate content in seed (≤10 µ moles/gram), high oil content (≥ 45%), resistant to white rust, yellow-coloured seed- coat
Indian mustard	IC 0595525	BPR 549-9	13016	Salinity tolerant at juvenile stage, high water-use efficient
Indian mustard	IC 0593927	BPR 540-6	13027	Salinity, thermo- tolerant at juvenile stage
Soybean	IC 0595528	PK 515	13017	Resistant to yellow mosaic virus, moderately resistant to hairy caterpillar
Safflower	IC 0597598	Ole-9-P2-P1-P22	13066	High oleic acid (18.63%) and high oil (34%)
Cotton	IC 0594174	DDB 12	13029	Dark brown lint
Cotton	IC 0594175	DGC 78	13030	Green lint
Cotton	IC 0594176	DMB 225	13031	Medium brown lint
Cotton	IC 0584260	Vaidehi 95 (MSH 53)	13032	Dark brown lint
Cotton	IC 0584261	NISC 40	13033	Jassid tolerant
Cotton	IC 0584262	NISC 43	13034	Jassid tolerant
Cotton	IC 0584263	NISC 44	13035	Jassid tolerant
Cotton	IC 0597400	TCH 1728	13067	Leaf- hopper resistant, thick leaf, higher number of trichomes
Sugarcane	IC 0598218	SBI 1148-11-13-2-225	13071	Possessing high sucrose and red- rot resistance

Vaidehi 95 cotton

/Registration No: INGR13032). Three cultures, DTS 108, DTS 67 and DTS 44 have been identified as potential drought- tolerant cotton, based on their ability to withstand harsh summer.

Agriculturally important insects

Biosystematics and biodiversity: One new genus *Dvivarnus* Rajmohana & Veenakumari (Platygastridae) and 14 new species of insects and mites have been described from different parts of South India.

An undescribed species of *Montandioniola* (Anthocoridae) on *Butea monosperma* and a new genus and species of Anthocorini on *Ficus* sp. has been recorded.

A catalogue of Microgastrinae fauna of Reunion Island was published with a key for 34 species, belonging to 13 genera which include several species of Indian origin. *Blaptostethoides* sp. and *Xylocoris ater* are new records for India and *Carayonocoris affinis* has been recorded for the first time as a predator of *Hemiberlesia lataniae* on agave. Three potential pests *Pleotrichophorus chrysanthemi* (Theobald) and *Reticulaphis foveolatae* (Takahashi) (Aphididae) and Jackbeardsley mealybug (*Pseudococcus jackbeardsleyi* Gimpel and Miller) (Pseudococcidae) have been recorded for the first time from India. The new invasive mealybug *Pseudococcus jackbeardsleyi* Gimpel and Miller that was not reported earlier in India was documented in Sathiyamangalam**,** Tamil Nadu, for the first time along with *P. marginatus* on papaya.

Diversity of plant- associated mites: For the first time in the country, DNA sequences of 15 species of economically important mites have been verified and deposited in the NCBI GenBank database with GenBank accession numbers; particularly of European red mite *Panonychus ulmi* (from Mashobra, Himachal Pradesh) and tea spidermite *Oligonychus coffeae* (from Jorhat, Asom).

Image gallery of agriculturally important insects
(http://www.nbaii.res.in/insectpests/index.php)

An image gallery of the agriculturally important insects has been hosted on the NBAII's website, and currently it features 500 species with over 3,000 photographs. An interactive LucID Phoenix key to 28 known genera of Mymaridae of India has been prepared with fact sheets, diagnostics and illustrations. This will serve as an important herbarium for all stakeholders.

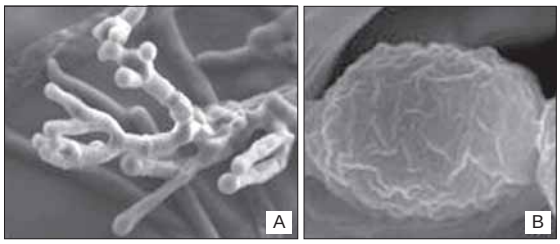
New Culture Storage and High Performance Computing Facilities

The National Agriculturally Important Microbial Culture Collection (NAIMCC) repository was enriched to house 4,500 microbial cultures. A set of lyophilized cultures and glycerol stocks are also being maintained for safety in the storage facility at the NBPGR, New Delhi.A high performance computing (HPC) infrastructure has been established at the NBAIM, Mau, to cater needs of high performance computing in the field of agricultural bioinformatics and computational biology under the National Agricultural Bioinformatics Grid (NABG). The facility along with number of computational biology and agricultural bioinformatics software databases at the IASRI, New Delhi, would provide seamless access to biological computing resources to researchers.

Agriculturally important microorganisms

A new halophilic extremophile fungus: Mangrove is a highly productive marine ecosystem, where halophilic microbes are active in bio-mineralization and biotransformation of minerals.

A new halophilic extremophile fungus *Penicilliopsis clavariiformis* has been reported for the first time in India from Chorao mangrove, Goa. The fungus tolerated extreme salinity up to 10 % (w/v) NaCl. Scanning electron micrographs revealed its unique morphology with biverticillate *Penicillium*, bearing masses of oval to ellipsoidal conidia.



Penicilliopsis clavariiformis AP SEM micrographs, showing biverticillate *Penicillium* (A) and conidia (B)

HORTICULTURE

Fruit crops

Trait specific germplasm were collected in mango (39), grape (38), pomegranate (92), rambutan (2), mangosteen (2), pulasan (1), jamun (32) and, bael and banana (2 each).

In mango, Safed Mulgoa had maximum fruit weight (1,813 g), Narayana Sheni and Ruswani had maximum TSS (24°Brix), while Appemidi (pickle mango) had unique sap flavour. These pickle mangoes have high terpenoids and a completely different combination of monoterpenes for their typical aroma. They contain more α-Phellandrene, β-Phellandrene, α-Pinene, β-Caryophyllene and Limonene. Of the 39 unique accessions of mango from Andaman and Nicobar Islands, nine were observed polyembryonic and one showed cluster-bearing.

Cluster bearing accession

In banana, Formosona (AAA) was high-yielding and resistant to *Fusarium* wilt (race - 4), while *Maia popuolu* had unique round, plump and starchy fruits. A banana introduction (*Pisang Awak* subgroup) was dwarf and promising for annual production with 15-18 kg bunch, 80-100 fruits and high TSS (30-32^{0}Brix).

In *citrus*, 212 accessions were characterized and deposited in cryobank at NBPGR, New Delhi, for long-term conservation.

Of the 232 accessions of grape screened, nine were free from berry scarring and cracking.

In jamun, CISH J-37 and CISH-J-42, were identified and registered for their high pulp and TSS content.

Plantation crops

A new collection in cashew was made and the total holding in National Cashew Field Gene Bank (NCFGB) was increased to 528. Four hundred ten germplasm accessions of coconut (132 exotic), 164 of arecanut (23 exotic) and 301 of cocoa were maintained. Ten oil palm *dura* germplasm were evaluated at Mohitnagar, West Bengal and accession CA-17 was identified for maximum number (8.2palm/year), yield (108.4 kg) and weight (13.2 kg) of bunches.

Vegetable crops

In vegetables, 428 germplasm accessions consisting of round gourd (1) from USDA and hyacinth bean (35), amaranth (33), Indian spinach (23), capsicum (81), tomato (103), brinjal (117), ridge gourd (8) and chilli (27) from AVRDC were introduced. In addition, 23 lines of teasel gourd (*Momordica subangulata* subsp. *renigera*) were collected from parts of the country.

Cucumber accession, VRCU-58, for powdery mildew resistance, ash gourd accession, VRAG-12-02, for wax-less fruits, pumpkin accession, VRPK-05-01, for ultra-small fruits and pointed gourd accession, VRPG-105, for cluster-bearing; EC-528380, VRT 101-A, VRT 102 and EC-620419 tomato lines for heat tolerance and Co-3, D-3-2, I-4-4, Kashmiriya, G-4-5,EC-528380, VRT 101-A and EC-620419 for drought tolerance; brinjal lines, CIAH-1, CIAH-2, CIAH-12, CIAH-16, CIAH-21, CIAH-22 and CIAH-67, for earliness and more yield at high temperature; ridge gourd genotypes, AHRG-29 and AHRG-41, which set fruits at high temperature during May-June; and cowpea accessions, EC 472283, EC 30590, EC 15296, and EC 390241, for drought tolerance were identified.

Okra, accession IIHR-296-22-10-11-598, IIHR-291-14-11-585, IIHR-294-1-10-1-595, IIHR-285-6-10-11-138, VROB-178 and 307-10-1, showed field resistance to yellow vein mosaic virus with a yield potential of 6.7 – 8.1 kg / 2.4 m^2 plot.

Cowpea, IIHR 310, recorded maximum pod yield while IIHR-317 was early (45 days) for pod maturity and accession IC 471955 showed resistance to aphid-borne mosaic virus.

In teasel gourd (*Momordica subangulata* subsp. *renigera*), considerable variability for vine pubescence (scarcely pubescent to pubescent), leaf margin (entire to dentate), leaf pubescence (sparse to dense), leaf colour (light to dark green), leaf lobing (unlobed to lobed), leaf tip (acute/acuminate/ovate/obovate), extent of marginal dentations (close to spaced), female flower bract size (minute to large), female flower bract position (near axis to just below gynoecium), fruit blossom end rostration (faint to appreciable length) and calyx persistence (semi-persistent to persistent) was observed. However, all the accessions were uniform in the shape of stem nodal region (quadrangular) and fruit surface echination (densely echinate). A wide range of variation was observed for fruit weight (20.43–71.33g), fruit length (4.27–9.93 cm), fruit diameter (2.55–4.27cm), fruit stalk length (6.43–17.00cm), inter-node length (4.22–11.70 cm), leaf length (7.44–13.22 cm), leaf width (6.66–12.04 cm) and petiole length (2.48–7.52 cm).

Variability in teasel gourd accessions

Inventory of 2,677 accessions of cultivated types and 408 wild relatives of different vegetables was prepared and IVGRIS (Indian Vegetable Genetic Resource Information System) database developed.

A highly pungent chilli accession, IC 553688, was registered with NBPGR and 140 germplasm in cherry tomato, *Luffa cylindrica*, *Capsicum annuum*, brinjal and tomato were shared through Material Transfer Agreement.

Muskmelon varieties/genotypes evaluated for fruit fly resistance indicated that AHMM/BR-1, RM-50 and AHMM/BR-8 were highly resistant.

Tuber crops

In tuber crops, 15 cassava, 4 sweet potato, 7 greater yam, 2 *Dioscorea*, 2 tannia, one *Curcuma* sp. and 7 taro germplasm were collected. A large accession of cassava (1,923), sweet potato (1,472), yams (1,151), taro (921), elephant-foot yam (277), tannia (28), yam bean (212), Chinese potato (130) and minor tuber crops (37) were maintained in field gene bank.

The short duration triploid cassava accession was most suitable for rainfed tracts of Andhra Pradesh. A new promising clone (CMR-100) suitable for chips making was identified along with cassava mosaic disease (CMD) resistance, middle branching, uniform tuber shape (cylindrical), light yellow flesh, non-bitter and high dry matter (43%).

Sweet potato genotypes with high extractable starch (ST-10), high carotene (ST-14) and high anthocyanin (ST-13) content were registered at NBPGR, New Delhi.

Anthocyanin rich ST-13, carotene rich CIPSWA-2, and high-yielding greater yam Da-25, were recommended for release. Promising greater yam accession (Da-331) with purple flesh and high yield; tall white yam hybrid (Dr-657) with high yield, good tuber shape and better cooking quality; dwarf white yam hybrids (Drd-1068, Drd-1157) with higher yield (25 t/ha) and good culinary property were identified for release.

Medicinal and aromatic plants

Six elite germplasm, one each of Madhunashini (DGS-22-INGR 13041), kalmegh (DMAPR AP3-INGR-13042), Aloe (DMAPR AB1(INGR-13043) Ashwagandha (DWS-6-INGR-13047), and two of guggal (NRC CW2-INGR-13044 and NRC CW1-INGR-13045) were identified and registered with NBPGR, New Delhi.

In Aswagandha, eight lines with more than 8q/ha dry root yield (control 5.2 q/ha) and more than 0.3 % of total withanolides content were identified. The lines, IIHR-WS-3 and IIHR-WS-48, had more than 0.3% total withanolides up to 300 days after planting. In addition, 29 lines with higher dry root yield (15g/plant) and withanolides in F_4 generation were advanced for further evaluation.

In Jatamansi (*Nardostachys grandiflorum*), a cross-pollinated, genomic hexaploid (2n=78) was observed.

Spices

In black pepper, three unique collections, a drought tolerant type, another farmer-bred line with profuse spikes (Ponmani) and; a third one with a spike length up to 27.3 cm were added to the germplasm.

In seed spices, 208 germplasm lines comprising coriander (133), cumin (68), fennel (54), fenugreek (208 indigenous and 54 exotic), ajowain (94), nigella (12), dill (14), anise (18) and celery (36) were evaluated.

Mushroom

In mushrooms, 178 specimens comprising mainly of *Morchella*, *Auricularia*, *Lentinula*, *Pleurotus*, *Leucocoprinus* and *Isaria* genera were collected from Rajasthan, Gujarat, Maharashtra, Haryana and Himachal Pradesh. Of these, 173 were identified up to genus level and 83 cultures deposited in DMR Gene Bank.

Livestock

Phenotypic characterization and conservation of farm animal genetic resources

Mizoram cattle: The native tracts of Mizoram cattle are Champhai and Kolasib districts of Mizoram. Phenotypic characters are: cylindrical body and strong legs; varying body colour, viz. brown (85%), black (11%) and grey (44%); small dewlap and hump; small to moderate ears in length and horizontal in orientation; small and black (72%) or grey (28%) horns with outward, upward and then curved towards face orientation; small (5–12 cm) and funnel (78%) shaped teats; brown (54%), black (39%) and grey (7%) tail switch. The cow and bullock weigh about 169 kg and 200 kg, respectively. The daily milk yield ranges from 1.0 to 3.5 kg with the average of 1.54 kg. A pair of bullock can plough about 0.5 acre of land in 5-6 h. The age at first calving, lactation length, dry period, service period and calving interval ranges from 28 to 42 months, 150 to 210 days, 4 to 6 months, 3 to 4 months and 12 to 24 months, respectively.

A herd of Mizoram cattle

Adilabad (Jhari cattle): Jhari cattle are mainly reared for draught and agricultural operations. Average body length, height at withers, chest girth, paunch girth, ear length, tail length and body weight of Jhari cows are 96.24±2.09, 102.52 ± 1.66, 133.83±3.5, 136.60 ± 3.89, 19.40 ± 0.34, 78.03 ± 2.46 cm and 181.12 ±

13.01 kg, respectively. Animals have either white coat colour (60%) or brown (40%), and are medium in size with well-developed dewlap. Horns are small to medium in size, cylindrical, sickle shaped and curved forward. The milk yield ranges from 1.5 to 2.0 kg/ day.

Malnad Gidda – Dwarf cattle (Karnataka): The Malnad Gidda, a unique dwarf cattle of Karnataka state, is registered with Accession Number INDIA_CATTLE-0800MALNADGIDDA-03037. The coat colour is mostly black with light shades of fawn on thigh and shoulder region. Cows have bowl shaped small size udder; funnel shaped teats with pointed tips. They thrive on grazing and play a unique role in farming systems of heavy rain fall in Malnad and

Elite Malnad Gidda cow with calf; Malnad Gidda Bull at NDRI Farm (inset)

coastal regions of Karnataka. Age at first calving is around 3 years and the cow gives milk for 8-9 months. Average lactation milk yield, daily milk yield, peak yield and inter-calving period are 522.33 litre, 2.17 litre, 3.42 litre and 14.91 months, respectively. Malnad Gidda cow milk and ghee are in huge demand due to preference for usage in ayurvedic medicine. The average fat and SNF in milk are 4.18 and 8.66% respectively. The animals have a short inter-calving period of 396 days even when thriving under low input regime. The cows yield 3–4 liters of quality milk per day and are well adapted to heavy rainfall conditions.

Malkangiri goat: Malkangiri goats are medium in size and are reared for meat only. The goats are mostly light brown or black brown, however, white and black are also seen. The face has strips of white or light

brown colour extending from base of ear to nose in brown goats. The top line is black. In males black ring is present around the neck. Muzzle and hooves are generally black. These goats are reared on semi- extensive management system. The average body length, height at withers, chest girth, paunch girth, face length, horn length, ear length and tail length in adult male and female are 62.67±0.99, 65.53±1.02, 67.53±0.86, 69.47±1.21, 15.80±0.22, 11.00±0.76, 15.13 ±0.52, 15.27±0.44 cm and 61.79±0.37, 63.20±0.39, 67.37±0.51, 70.69±0.61, 15.62±0.10, 9.64±0.33, 13.94±0.24, and 13.80±0.18 cm, respectively. Female animals sexually mature at about 12-18 months of age.

Raigari goat: Raigari goats, reared mainly for meat, are medium in size. Coat colour is light brown to dark brown; mixed colour animals are also seen in flocks. White or light brown colour strips extending from base of the ear to muzzle are present on either side of the nose line. Muzzle colour is black or brown and hooves are black or grey. The averages of body length, height at withers, chest girth, paunch girth, face length, horn length, ear length, and tail length are 60.87 ±0.53, 61.35±0.44, 65.85± 0.62, 70.06 ±0.85, 15.34±0.17, 9.38 ±0.39, 13.62 ±0.18, 12.66±0.18 cm respectively, in females and 61.71±1.43, 63.43±1.49, 65.14±2.10, 67.14±2.43,15.43±0.78, 10.57±1.29, 14.71±0.42, and 13.57±0.69 cm, respectively in males. The average age at sexual maturity and first kidding are 10–12 months and 15–18 months, respectively. Marginal and small farmers and landless tribes of Raigarh district, Odisha rear them.

Narayanpatna goat: Narayanpatna goats of Narayanpatna taluk, Koraput, Odisha, are medium in size and reared by tribals (Kondhs) for meat purpose. Animals are mostly brown-black, however, brown, off white and even mixed colour animals are also seen. The average body length, height at withers, chest girth, paunch girth, face length, horn length, ear length and tail length in adult male are 74.40 ± 2.77, 69.60 ± 3.71, 70.60 ± 4.39, 71.40 ± 4.07, 16.00 ±1.05, 9.60 ± 2.38, 15.20 ±0.86, 16.20 ± 0.37 cm, respectively, and in female 68.47 ±0.56, 65.63 ±0.57, 70.86 ± 0.60, 73.14 ± 0.73, 16.34 ± 0.12,11.49 ± 0.46, 13.96 ± 0.24, and 13.96 ± 0.22 cm, respectively. The average body weights of adult female and male animals were 27.33 ± 0.61 and 32.80 ± 6.82 kg, respectively. Female animals attain sexual maturity at about 12-15 months of age.

Sindhi donkey: Sindhi donkeys are reared in Barmer and Jaisalmer districts of Rajasthan. Sindhi donkeys are able to carry about 100 kg of load in sandy tracts. The animals are of small size with lean built. Predominant coat colour is light brown, however, small

percentage of animals have brown and grey. The belly, inner surfaces of legs, ventral side of neck and inner sides of ears are generally white and mane is comparatively dark. The body length varies from 82 to 105 cm. The height at withers of male and female animals is 98.8 ± 3.9 and 97.93 ± 4.9 cm, respectively. The chest girth is 104.3 ± 5.35 in males and 106.52±5.97 cm in females. The estimated weights of adult (above 3 years) male and female animals are 84.95 ± 10.12 and 89.54 ± 14.57 kg, respectively.

Geographically distinct donkeys: Systematic and scientific evaluation of donkeys was carried out for better utilization and improvement in health and reproduction efficiency. Fifteen biometric indices of donkeys from Leh area (Ladakh, Jammu and Kashmir) and Baramati area, Pune, Maharashtra were recorded. Coat colour of most of the donkeys at Baramati was grey, both light and dark with and without dark strip on back. Large white donkeys are mostly brought from Gujarat, but in Leh animals are bay black. Both Indian populations were found smaller than Poitu donkeys. Donkeys of Baramati area were significantly taller and bigger in size than donkeys of Leh area.

Donkeys from Baramati, Maharashtra (above); Leh (left) and Spiti (right)

Frieswal cattle: Coat colour is >75% black and <25% white in 43.75% of animals; 50-75% black and rest white in 28.52% of animals, and completely black with 1–2 small white spots in 15.63% of animals. Presence of white star (65%) on forehead and white patch on at least one fetlock (66.8%) are also among important features of Frieswal. Hoof colour is either black, creamy or black stripe over creamy base. The average heart girth, rear girth, height at withers, scrotal circumference, paired testicular volume and area of pelvic triangle are 168.82 cm, 164.28 cm, 124.69 cm, 30.12 cm, 444.97 cm^3 and 324.88 cm^2 respectively.

***In-situ* conservation:** A total of 451 Kilakarsal progenies of sheep were produced during 2012–13 at Tirunelvalli Station of TANUVAS. The tupping and lambing percentage at farm was 81.48 and 80.24, respectively. Inseminations (10,228) were performed for conservation of Krishna Valley cattle under the project operational in 25 cattle development centers of Department of Animal Husbandry, Karnataka. So far, 725 males and 627 females were born from 2,777 pregnancies.

***Ex-situ* conservation:** Frozen semen doses from 19 bulls of 10 cattle breeds (Red Sindhi, Tharparkar, Sahiwal, Amritmahal, Dangi, Hallikar, Red Kandhari, Gangatiri, Frieswal, Khilar) and three bulls of Banni buffalo breed were added (14,150) to the gene bank repository of National Bureau of Animal Genetic Resources during the year 2012–13.

Molecular genetic characterization

The real time qPCR analysis revealed the up-regulation of CatSper1 gene in poorly motile sperm as compared to those with good motility of crossbred bulls. A whole-genome (Black Bengal breed, male, 2.8 GB, 30X) was sequenced and assembled. Knockdown of myostatin gene using siRNA and shRNA in caprine fetal myoblast was demonstrated in goats.

Spiti donkey: Evaluation of Spiti donkeys distributed in Spiti and Yangthang regions of Himachal Pradesh was done for within breed genetic diversity and genetic bottlenecks. The allele number and heterozygosity values observed across the studied loci indicated presence of reasonably high levels of genetic variability in Spiti donkeys. The polymorphic information contents (PIC) ranged from 0.51 to 0.79 with mean value of 0.68±0.09. The mean genetic diversity estimate (F_{IS}) was 0.048 indicating moderate levels of inbreeding. The normal 'L' shaped distribution of allelic frequency strongly indicated absence of any recent genetic bottlenecks in the Spiti donkeys.

Genetic relationship of Indian native cattle: Individuals (23), adapted to different agro-climatic regions, representing seven native cattle breeds viz. Amritmahal, Gir, Ongole, Red Kandhari, Sahiwal, Tharparkar, Leh cattle, and two exotic breeds, viz. Holstein and Jersey cattle were genotyped. The native cattle from Leh region were genetically distinct from the rest of the Indian cattle. This is the first study to assess population structure of Indian native cattle breeds using the high density SNP chip, and supports the genetic distinctness of zebu from taurine cattle.

Differential heat shock response: The quantification of different members of heat shock protein family, viz. *HSP27*, *HSP60*, and *HSP70* was achieved to understand the magnitude of transcriptional response of heat stressed peripheral blood mononuclear cells (PBMC) in Holstein, Sahiwal cows and Murrah buffaloes. Comparatively at 2h time point, *HSP70* peak was highest in buffaloes (~73.0 fold) followed by

Holstein (~65.0 fold) and Sahiwal (~54.0 fold). Similarly, *HSP60* and *HSP27* transcripts were maximally induced in buffalo at this time point. The higher abundance of *HSP* mRNA after heat stress showed evidence of transcriptional differences in PBMCs of different cattle types and buffaloes suggesting their differential cellular tolerance to heat stress.

Polymorphism and evolution of toll like receptors: Sequence characterization and genotyping of eight Toll like receptor (TLR 1,2,4,5,6,8,9 and 10) genes was undertaken in Indian native cattle breeds (*Bos indicus*) to identify novel single nucleotide polymorphisms (SNPs). Kankrej, Hariana and Gir cattle were found to have the highest number of SNPs and the Kangayam was the least polymorphic among the analysed indigenous cattle breeds. Comparison of protein domain architecture for different TLR gene clusters of Indian native cattle with other mammalian species revealed conserved regions in the TLR. The study brought out diversity within Indian cattle as well as the divergence from the taurine counterpart.

Nucleotide diversity in candidate genes for mutton quality traits: Indian sheep breeds namely, Bandur, Chokla, Deccani, Ganjam, Garole, Madgyal, Magra, Malpura, Muzzafarnagri and Nali were analyzed for genetic polymorphism at the growth differentiation factor 8 (*GDF8*), β3 adrenergic receptor (*ADRB3)* and calpain (*CAPN)* gene. The analysis of the edited sequences of *GDF8* gene loci revealed an absence of SNPs in the exon 3 region. Three SNPs were identified in non-coding regions of *GDF8* gene in Indian sheep, out of which -16C>T was not reported earlier. Two SNPs identified in the Indian sheep are known to be associated with mutton quality and carcass traits in exotic sheep. The initial results showed genetic variability and presence of favourable alleles/SNPs in the *GDF8* gene. The sequence analysis of *ADRB3* gene revealed two synonymous SNPs in the exonic region (g.333C>T and g.497G>C). One SNP was detected in the 3'UTR (g.2621T>C), however, no SNP was detected in 5'UTR. The identified SNPs were present in the heterozygous state. A single C>T transversion in heterozygous state was detected in the intron 5 of ovine *CAPN* gene. The frequency of C and T alleles was 0.564 and 0.436 respectively.

BL41 microsatellite markers in Frieswal cattle: BL41, an autosomal microsatellite marker, located at the region of bovine chromosome 3 (BTA3), is well known for its lactogenic trait QTL property. Genotyping of the BL41 revealed that Frieswal cow genome has seven allelic pattern of BL41 microsatellite markers of which 245 bp allele is the most frequently distributed. A higher level of fat (4.45±0.05) and protein (3.09±0.09) percentages were observed among Frieswal cows, which had 238 and 234 allele of BL41 microsatellite marker respectively.

Novel SNPs in exon 2 and exon 3 of Leptin gene: Leptin affects tissue and endocrine system of the animal and influences production, reproduction and nutritional traits. Unique SNPs in the leptin and its receptor gene were identified and its association with milk yield and milk constituents were also worked out. The synergistic effect of SNPs in exon 2, intron 2 and exon 3 (w1/m2/m3+ mA/mB) combination showed significant association with milk protein percentage.

Expression of interferon-gamma gene: Interferon-gamma gene of dromedary was cloned at EcoRI and NotI sites of bacterial expression vector-pET 32 (a) and the recombinant plasmid obtained was named as pETCAMELGAM. It was expressed as a fusion protein of 38kDa size.

Camelpox virus: The complete nucleotide sequences of epidermal growth factor (EGF) encoding gene of camelpox virus (CMLV) from India has the size of 418 bp, and in this there is an addition of one cytosine residue at position 132. The resultant protein is a truncated polypeptide due to this mutation. The complete amino acid sequences of golgi anti apoptotic protein (GAAP) encoding gene and its relation to GAAP gene of other orthopox viruses indicated that it was 714 bp in length, encoding 237 amino acids.

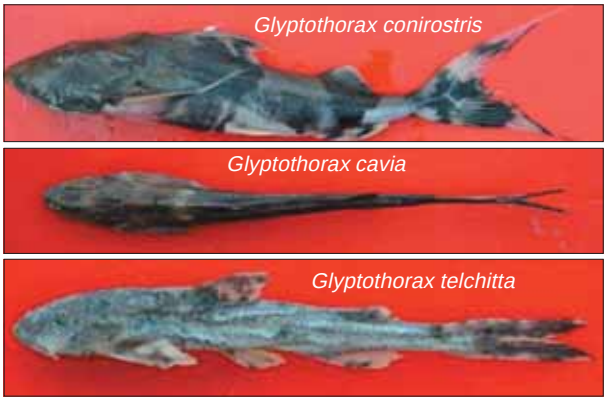
Heat shock protein 70 encoding gene: The gene sequences of heat shock protein 70 encoding gene (HSP A1B) of dromedary camel were amplified from the total cellular RNA isolated from blood. The open reading frame of *HSP 70* gene of Indian dromedary camel is 1926 bp and encodes a polypeptide of 641 amino acids.

Gut metagenomes of camel: Based on Ribosomal Database Project, in the adults and camel calves, abundant hits were for the firmicutes followed by bacteroidets, verrucomicrobia and proteobacteria. The genera mainly found in adult camels were *Bacteroides, Clostridium, Bacillus, Eubacterium, Ruminococcus* while camel calves had *Clostridium, Ruminococcus, Eubacterium, Treponema* and *Bacteroides*. The functional hierarchies in adult camels clustering based subsystems followed by carbohydrates, virulence, disease and defence showed more than 10% abundance whereas in camel calves DNA metabolism, RNA metabolism, metabolism of aromatic amino-acids, clustering based systems showed more than 10 % abundance.

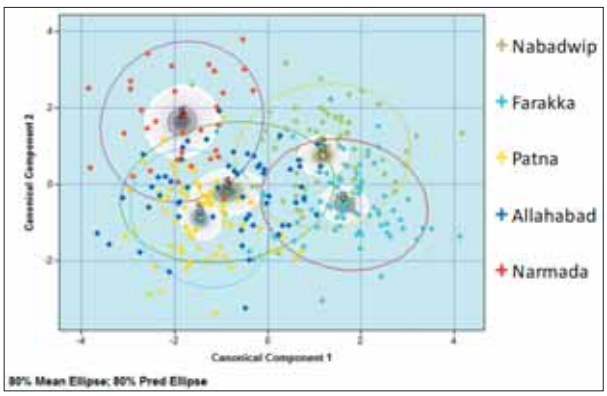
Microsatellite characterization of mithun - first report: Thirty bovine microsatellite markers from FAO list of measurement of domestic animal biodiversity (MoDAD) were tested in mithuns and gaurs individually. Nineteen markers (63%) successfully amplified mithun and wild gaur genomic DNA. However, 14 out of 19 markers (74%) were highly polymorphic with high polymorphic information content (PIC) value (> 0.50) in mithun and gaur with allele numbers ranging from 10 to 26 in mithun and 2 to 7 in gaur, respectively. Inbreeding coefficient was 30 and 6.53% in mithun and gaur population, respectively. The present study will help in developing a suitable breeding policy for mithun.

Fisheries

New biogeographically distribution of sisorid catfish: Genus *Glyptothorax*, sisorid catfishes, having 37 species, are widely distributed in India along fast flowing mountain streams and are benthic in habitat. The NBFGR collected, *Glyptothorax conirostris, G. telchitta* and *G. cavia* in the Ganga river basin which is a new distribution record. *G. conirostris* was collected from the Ganga canal at Roorki, and *G. cavia* and *G. telchitta* from upstream of river Gomti. Present report may be considered as the first evidence of a broader distributional range of *Glyptothorax* genus, indicating that the species may be more widely distributed than previously acknowledged.



Stock characterization of Indian major carps : Morphological differentiation in Indian major carps from different Indian rivers using truss morphometry showed that population of *Catla catla* in Ganga at lower stretch (Nabadwip and Farakka) was different from that of upper stretch (Patna-Allahabad) and Narmada, while *Labeo rohita* and *Cirrhinus mrigala* showed no such difference. Analysis of molecular variance (AMOVA) of PCR amplified partial cytochrome b (307bp) gene sequence from *L. rohita* (n=133) collected from Allahabad, Patna, Farakka, Nabadwip, Guwahati, Bharuch revealed that 92.16% of the total variation in the species was attributed to variation within population and 7.84% to differentiation among populations and population structuring. In *C. catla* (n=87) 69.93% variation was attributed to variation within populations and 30.07% to variation among populations and population structuring. AMOVA within four populations (Guwahati, Allahabad, Farakka and Bharuch) of *C. mrigala* (n=89) revealed that 96.45% of total variation was attributed to variation within populations and 3.55% to variation among populations and population structuring.



Bi-plot of scores corresponding to two canonical variates expressing morphological difference in *C. catla* in lower Ganga and Narmada

Genetic characterization

Whole mitochondrial genomes of Indian fish species: The whole mitochondrial genomes of *Channa marulius*, the great snakehead (NCBI accession no. KF420268), *Clarias batrachus*, walking catfish (accession no. KC572134) and *Pangasius pangasius*, yellow fin catfish (accession no. KC572135) were sequenced. Two ornamental barbs, viz. *Puntius denisonii* and *P. chalakkudiensis* endemic to the Western Ghats were found to have mtDNA size 16899 bp and 16989bp, showing a difference of 90bp mainly in control region. The fish mitogenome is small, circular and haploid DNA molecule, which is maternally inherited. The size of mitochondrial genome in animals ranges from 15–20 kilobases and approximately 15–17 kb in fish. Structural composition comprises 37 genes, 13 protein coding, 22 tRNA and 2 ribosomal RNAs (*12S rRNA* and *16S rRNA*). The concatenated protein coding genes have comparatively high potential to resolve phylogenetic pattern.

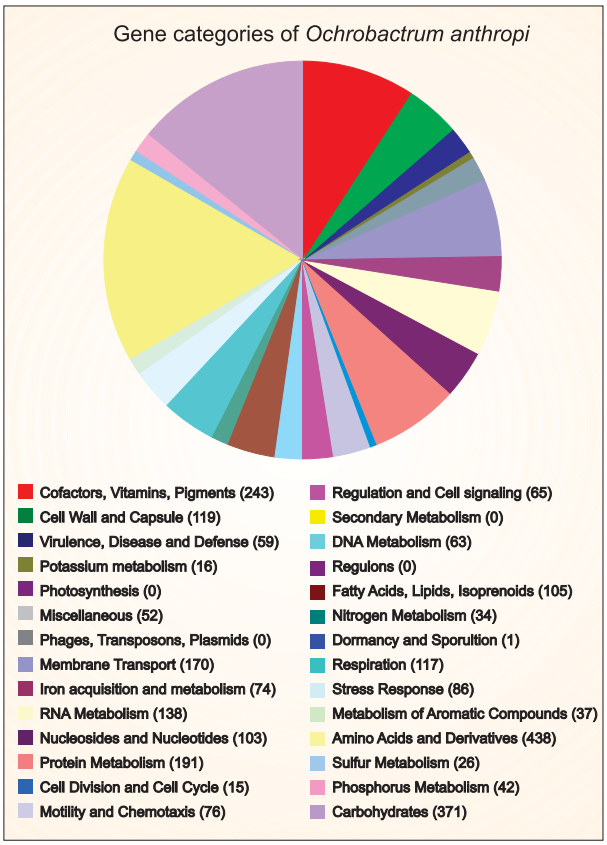
Mitochondrial genome organization of coldwater fish: The complete mitochondrial genomes of *Schizothorax richardsonii* and *Tor putitora* were sequenced for the first time. The mitochondrial genome of *S. richardsonii* and *Tor putitora* was found to be 16,592 bp (Accession number KC790369) and 16,576 bp (Accession number KC914620) respectively in length and both consist of 13 protein coding genes, 22 tRNAs, 2rRNA genes and one putative control region. Gene organization and its order are similar to other vertebrates. The present study will provide the rationale for the management and conservation of snow trout and mahseer species.

Microarray chip to identify genes against WSSV infection

To identify differentially expressed genes against WSSV infection, a challenge experiment (using 2.62 × 10^6/ µl viral copies) was carried out. Agilent microarray slide was custom designed for tiger shrimp gene expression studies, using the NCBI EST and nucleotide database. In addition, the microarray chip contained *P. monodon* gene sequences. A total of 42,013 sequences were used in the microarray chip to identify differentially expressed genes against WSSV infection.

Whole genome sequence of phenol degrading bacterium

The bacterium *Ochrobactrum anthropi* was isolated from polluted river and examined for its phenol and chlorophenol degradation. To examine all potential beneficial and harmful properties of the bacterium intended for bioremediation application in polluted environments, the whole genome of the bacterium was



sequenced. Genome analysis identified presence of genes involved in detoxification of formaldehyde, salicylate ester, toluene, quinate, benzoate, p-Hydroxybenzoate, chloroaromatic compounds and N-heterocyclic aromatic compounds, catechol branch of beta-ketoadipate pathway, salicylate and gentisate catabolism, protocatechuate branch of beta-ketoadipate pathway, aromatic amine catabolism, thioredoxin-disulfide reductase, alkanesulfonates utilization, and alkylphosphonate utilization, without presence of any important pathogenicity or virulence gene making it a potential candidate in pollutant degradation in field condition.

Testicular gene expression in Indian white shrimp: Genes influencing testicular development in *Fenneropenaeus indicus* were studied and specific primers for genes functionally related to testicular development, were examined by semi-quantitative RT-PCR using *EF1-α* as the internal control. *MIPP2*, *Dmc1*, *TST1* and *IAG* exhibited male specific expression while *HSP90* exhibited higher expression levels in females compared to males. Semi-quantitative RT-PCR analysis revealed weak expressions of male specific reproductive genes (*TST1*, *MIPP2* and *Dmc1*) in ablated group compared to control.

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6. Crop Improvement

Crop-improvement programme focuses on development of new crop varieties and hybrids with wider adaptability and higher yield along with tolerance/ resistance to various insect-pests and diseases and for overcoming adverse impact of abiotic stresses. To realize envisioned goal, greater emphasis is laid on the development of genomic resources for targeted traits and crops, besides pre-breeding for identification of desirable genes in related and wild species to broaden genetic-base by transferring desirable alleles from alien sources. Suitable biotechnological tools such as marker-assisted selections, transgenic crop variety development and many such novel tools and techniques have also been deployed for faster and accurate identification of promising crop genotypes.

Cereals

Rice: Two varieties and a hybrid of rice have been released by the Central Sub-Committee of Crop Standards, Notification and Release of Varieties, and

Rice varieties released

Central/State	Variety	Grain type	Ecosystem	Reaction to pests/diseases
		Central Releases		
	CO 4 (Hybrid)	MS	Irrigated	MR- BL, BS
	NDGR 201	SB	Semi- deep waters	MR- BS, SBr
	CR SugandhDhan 907	MS	Eastern India	MR-LBl, NBl, BS, ShR
		State Releases		
Andhra Pradesh	Sheetal	LS	Irrigated	MR- BPH
	Siddhi	MS	Rainfed, shallow lands	MR- GM
	Krishna	SS	Irrigated	R- BL
	Sujana	MS	Irrigated	T-BLB; R-GM
	Prathyumna	MS	Rainfed, upland	T-BL;MR-GM
	Pranahitha	LS	Irrigated	T-BL, BLB; MR-GM
	Nellore Sona	MS	Irrigated	T- BL
	Swetha	MS	Irrigated	T- Heat , BL
Asom	Kanaka Lata	MS	Boro areas	MR- BLB, ShBl, BS
Bihar	Sabour Surbhit	LS	Irrigated	MR- BL, BLB, BS, SBr BPH
Gujarat	GNR 2	MS	Coastal salinity	R-BLB
Maharashtra	Karjat 8	SS	Rainfed, shallow lands	MR- BL, GM
	Phule RDN 6	LS	Irrigated	R- BLB, GLH, BPH, WBPH; MR- BL, SBr
Odisha	Luna Sankhi	MS	Coastal salinity	MR- LBl, ShBl
	Luna Barial	SB	Coastal salinity	MR- ShBl, BS, LF
Uttar Pradesh	CSR 43	SB	Irrigated, salinity/ alkalinity	MR- BS
Uttarakhand	Pant Sugandh Dhan 21	LS	irrigated	MR- BL, SBr
Manipur	Mangalphou	LS	Irrigated	R-RTV
	Eenotphou	-	Shallow, deep waters	MR-GM
	RC Mani-phou 12	LB	Irrigated	R-GM

SB: Short Bold; MS: Medium Slender; LB: Long Bold; LS: Long Slender; SS: Short Slender; R: Resistant; MR: Moderately Resistant; T:Tolerant; BL: Blast; BLB: Bacterial Leaf Blight; BPH: Brown Planthopper; BS: Brown Spot; GLH: Green Leaf Hopper; GM: Gall midge; LBl: Leaf Blight; LF: Leaf Folder; NBl: Neck Blight; RTV: Rice Tungro Virus; ShR: Sheath Rot; ShBl: Sheath Blight; SBr: Stem Borer; WBPH: White-Backed Planthopper.

State Variety Release Committees have recommended 20 rice varieties for different ecosystems of the country.

The first early-maturing rice basmati variety Pusa Punjab Basmati 1509 released in Punjab gave average yield of 3.94 tonnes/ha; at a par with Pusa Basmati 1121. It was found resistant to leaf blast and brown spot.

Wheat: Nine varieties have been released for different production conditions in wheat-growing areas of the country.

Wheat HD 3059 released for late sowing after cotton or late-maturing rice in Punjab and Haryana is an early- maturing (121 days), semi-dwarf (93 cm) variety with an average yield of 4.25 tonnes /ha, and a genetic potential of 5.94 tonnes/ha under late sown, irrigated areas.

Wheat HD 3059 is resistant to all three rusts, including stem rust race Ug99 and its variants. It showed high protein content (13.6%), high sedimentation value (52 ml) and best Glu-1 Score (10/10), and meets all criteria for superior bread and *chapati*-making qualities.

Barley: Four barley varieties have been released for commercial cultivation for different production conditions in the wheat-growing areas of the country.

Wheat varieties released

Variety	Production conditions	Area of adoption
TL 2969 (triticale)	Rainfed, timely sown	North Hills Zone: Hilly area of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, West Bengal, Arunachal Pradesh and Sikkim Odisha, Asom and plains of north-eastern states
HD 3059	Irrigated, late sown	North Western Plains Zone : 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
HPW 349	Rainfed and irrigated, timely sown	North Hills Zone: Hilly area of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, West Bengal, Arunachal Pradesh and Sikkim
WH 1105	Irrigated, timely sown	North Western Plains Zone: 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
HI 8713 (Pusa Mangal) (d)	Irrigated, timely sown	Central Zone: Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh
HW 5216 (Pusa Thenmalai)	Restricted irrigation, timely sown	South Hills Zone:Nilgiri and Palani hills of Tamil Nadu and Kerala
DBW 71	Irrigated, late sown	North Western Plain Zone: 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
UAS 304	Irrigated, timely sown	Peninsular Zone: Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu
MP 3336	Irrigated, late sown	Central Zone: Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh

Barley varieties released

Variety	Salient characteristics	Production conditions	Area of adoption
DWRB 91	Two-row malt barley, resistant to yellow and brown rusts	Late sown, irrigated	North Western Plains Zone
VLB 118	Six-row feed barley	Timely sown, rainfed	North Hills Zone
RD 2786	Six-row feed barley, resistant to rusts	Timely sown, Irrigated	Central Zone
RD 2794	Six-row feed barley	Timely sown, Irrigated	Salinity conditions of North East/North Western Plains Zones

Malt-barley cultivation in late- sown conditions of northern plains

To widen the scope of malt-barley cultivation in the late-sown conditions of the northern plains in rotation with cotton, pearl millet, sorghum, maize and sugarcane, a new variety, DWRB 91 has been released for commercial cultivation. This variety gave good grain yield with acceptable malting quality under late sowing up to mid- December.

Maize: Five hybrids and one open-pollinated variety (OPV) have been released for different agro-ecological conditions.

Maize hybrids / open-pollinated varieties released

Hybrid/ OPV	Area of adoption
Late-maturing hybrids (> 95 days)	
CMH 08-282	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh
Early-maturing hybrids/OPVs (75 -85 days)	
Shalimar Maize Composite 3 (OPV)	Jammu and Kashmir
KDM 438	Jammu and Kashmir
Pant Shankar Makka 1	Uttarakhand
Extra-early maturing hybrid (< 75 days)	
Vivek Maize Hybrid 45 (FH 3483)	Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Punjab, Haryana, Delhi, Uttar Pradesh, Bihar, Jharkhand, Odisha, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu
Quality Protein Maize	
Pratap QPM Hybrid 1 (EHQ 16)	Rajasthan, Gujarat, Madhya Pradesh and Chhattisgarh

Small millets

In ragi, a partial genetic male sterile line (PS 1) identified in GPU 28 background having resistance to neck and finger blast, is extensively used in hybridization. In PS 1 line, partial seed set was observed to an extent of 11.8% under selfing, and progeny grown from these seeds was sterile, uniform and homogeneous. An increase in seed- set (20.54%) was observed under open pollination. Unlike conventional genetic male sterility, PS 1 could be easily maintained and propagated by selfing or multiplication in isolation.

Pearl millet

Three hybrids and one variety have been released for various agro-ecologies of the country.

Pearl millet hybrids / varieties released

Hybrid/ OPV	Area of adoption
Pratap Hybrid (MH 1642)	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu
PKV-Raj Hybrid (BBH 3)	Maharashtra
ABPC 4-3 (MP 484)	Maharashtra
Hybrid CO 9	Tamil Nadu

Forages

Sorghum variety SPV 2057(CSV 30 F) has been identified for cultivation in a single-cut forage- growing areas. This showed 7.2% higher green fodder yield (44.34 tonnes/ha) and 11.4% higher dry fodder yield (13.96 tonnes/ha) over the national variety CSV 21F. It also possessed superior fodder quality (50.2% *in-vitro* dry matter digestibility) and lower HCN content (56.5 ppm). Bundel Guinea 4 guinea- grass has been found resistant to lodging and responsive to fertilizer application, and remains green throughout the year in irrigated areas. Bundel Lobia 4 cowpea, a high- biomass yielding variety (average of green fodder yield 35 tonnes/ha), tolerant to flea beetle has been recommended for rainfed areas in the North- Eastern Hills.

Sorghum variety SPV 2057(CSV 30 F)

Oilseeds

Total 26 varieties/hybrids of oilseeds, including 10 of Indian mustard, four of soybean, three each of groundnut, sunflower and safflower and one each in castor, linseed and sesame have been released for different agro-ecological regions.

Oilseed varieties / hybrids released

Crop/ Variety/Hybrid	Recommended state/region	Salient features
Indian Mustard		
RGN 229	Delhi, Haryana, Punjab, Jammu and parts of Rajasthan	Tolerant to high temperature and salinity during seedling stage; seed yield (2,162-2,568 kg/ha)
RGN 236	Delhi, Haryana, Punjab, Jammu and parts of Rajasthan	Tolerant to high temperature and salinity during seedling stage
DRMRIJ 31	Delhi, Haryana, Jammu, Punjab and northern Rajasthan	Large seed , seed yield (2,246-2,757 kg/ha)
RH 0406	Delhi, Haryana, Jammu and Kashmir, Punjab and parts of Rajasthan	Lodging resistant; large seed, seed yield (2,200-2,300 kg/ha)
Raj Vijay Mustard 2	Delhi, Haryana, Jammu and Kashmir, Punjab and parts of Rajasthan	Moderately resistant to white rust; seed yield (1,276-1,874 kg/ha)
RH 0749	Delhi, Haryana, Jammu and Kashmir, Punjab and parts of Rajasthan	Timely sown irrigated condition; large seed, long siliqua; dominance of primary branches; seed yield (2,400-2,800 kg/ha)
Pusa Mustard 29	Delhi, Haryana, Jammu and Kashmir, Punjab and Rajasthan	Low erucic acid; timely sown irrigated condition
Pusa Mustard 30	Uttar Pradesh, Uttarakhand, Madhya Pradesh,Rajasthan	Low erucic acid; timely sown irrigated condition
RRN 573	Rajasthan	Irrigated, normal sown condition
Pant Rai 20	Plains of Uttarakhand	High temperature tolerant; large seed, seed yield (1,701-2,539 kg/ha)
Soybean		
Pusa 12 (DS 12-13)	North Plains Zone	Determinate growth habit; yellow seed and black hilum; matures in 124-131 days; resistant to YMV, *Rhizoctonia* aerial blight and bacterial pustules; oil content 19.6%; protein content 37.8%, seed yield 2,290 kg/ha
Pant Soybean 1368 (PS 1368)	Uttarakhand	Tall and sturdy plant; matures in 117-125 days; resistant to YMV, bacterial pustule and *Rhizoctonia* aerial blight; seed yield 2,120 kg/ha.
MACS 1188	Southern Zone	Determinate growth habit, yellow seed and black hilum; matures in 101 days; resistant to bacterial pustules, *Rhizoctonia* aerial blight and charcoal-rot diseases and defoliator, pod-borer, leaf-folder and leaf-miner pests; oil content 19.1%; protein content 41%; yield potential 2,500-3,950 kg/ha
Pratap Soya 45 (RKS 45)	Rajasthan	Determinate growth habit; creamy yellow seed and brown hilum; matures in 95-98 days; responsive to high fertility under irrigated condition and suitable for water-stress condition; moderately resistant to bacterial pustules, charcoal rot and YMV; oil content 21%; protein 40-41%; seed yield 3,000-3,500 kg/ha
Groundnut		
GJG 22 (JSSP 36)	Gujarat	Tolerant to collar-rot, seed yield (1,770 kg/ha)
GJG 17 (JSP 48)	Gujarat	Tolerant to stem-rot, seed yield (1,798 kg/ha)
Dharani	Andhra Pradesh	Drought tolerant; tolerant to dry root-rot and stem-rot; seed yield (1,100 kg/ha (rainfed) 2,600/kg/ha (irrigated)

Crop/ Variety/Hybrid	Recommended state/region	Salient features
Sunflower		
RSFV 901 (Kanthi)	Karnataka	Seed yield 1,200-1,400 kg/ha, oil content 39%; matures in 95-100 days; tolerant to necrosis disease
RSFH 130 (Bhadra)	Karnataka	Seed yield 1,200-1,500 kg/ha; oil content 40%; matures in 95-100 days; tolerant to necrosis disease
CO 2	Tamil Nadu	Seed yield 1,900-2,200 kg/ha, oil content 39%; matures in 85-90 days; moderately resistant to *Alternaria* leaf spot, rust and tolerant to thrips and leafhopper
Safflower		
SSF 708	Western Maharashtra	Seed yield 1,300-2,200 kg/ha, oil content 29%; matures in 115-120 days; tolerant to aphid
PKV Pink (AKS-311)	Maharashtra (Vidarbha region)	Seed yield 2,500 kg/ha, oil content 29%; matures in 115-120 days
NARI-H 23	Maharashtra, Karnataka, Madhya Pradesh, Chhattisgarh, Rajasthan, West Bengal	Seed yield 1,711 kg/ha, oil content 31%; matures in 114-156 days; tolerant to safflower aphid; suitable for irrigated conditions
Castor		
GC 3	Gujarat	Seed yield 2,340 kg/ha, oil content 49%; resistant to wilt, tolerant to *Macrophomina* root-rot; suitable for irrigated conditions
Sesame		
HT 9713 (HT-2)	Haryana, Punjab, Himachal Pradesh and Jammu and Kashmir	White seeded; tolerant to phyllody and leaf curl virus; seed yield 600-800 kg/ha, oil content 48-50%
Linseed		
Pratap Alsi 2	Rajasthan	Matures in 129-135 days; average yield 1,957 kg/ha, oil content 41.8%; suitable to irrigated condition; moderately resistant to *Alternaria* blight, powdery mildew and wilt

Pulses

Total 19 varieties of different pulses, including five each of chickpea and pigeonpea, three each of mungbean and urdbean, two of fieldpea and one of lentil have been released for different agro-ecological regions.

Varieties of pulses released

Crop/Variety	Maturity (days)	Recommended states	Salient features
Chickpea			
GNG 1958	146	North- western Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi	Large-seeded (25.4 g/100 seeds), seed yield 2,600 kg/ha; moderately resistant to wilt and tolerant to root- rot, stunt and collar-rot
GNG 1969	146	North- western Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi	Profuse branching, semi-erect and large seeded (26.2 g/100 seeds), tolerant to wilt and root- rot; seed yield 2,200 kg/ha
L 555	146	North- western Rajasthan, Punjab, Haryana, western Uttar Pradesh, Uttarakhand and Delhi	Large- seeded *kabuli* variety (27.8g/100 seed); semi erect, tall, light-green foliage; tolerant to wilt; seed yield 2,300 kg/ha
CSJK 6	188	Jammu and Kashmir, Uttarakhand and North-Eastern Hills region	Large- seeded *kabuli* variety (32.8g/100 seeds), seed yield 1,106 kg/ha; moderately resistant to root- rot and tolerant to wilt
NBeG 3	100	Andhra Pradesh	Large- seeded *desi* variety (24.0g/100 seeds), seed yield 2,300 kg/ha; tolerant to drought with good rooting quality, tolerant to wilt

Crop/Variety	Maturity (days)	Recommended states	Salient features
Pigeonpea			
Rajeshwari (Phule Toor 12)	135	Gujarat, Maharashtra, Madhya Pradesh., Rajasthan and Chhattisgarh	Semi-spreading, indeterminate; moderately resistant to *Fusarium* wilt, SMD and tolerant to pod-borer and pod-fly
RGT 1	150	Andhra Pradesh and Karnataka	Semi-spreading, indeterminate, resistant to wilt; white-seeded
Rudreshwar (WRG 65)	165	Andhra Pradesh	Semi-spreading, indeterminate; resistant to wilt, moderately tolerant to *Helicoverpa*
PKV Tara	165	Vidarbha region of Maharashtra	Semi-spreading, indeterminate; moderately resistant to sterility mosaic and wilt; medium seed sized
Prakash (IPA 203)	250	Eastern parts of Uttar Pradesh, Bihar, West Bengal, Asom, Jharkhand	Semi-spreading, indeterminate; resistant to sterility mosaic and wilt and tolerant to *Phytophthora* stem blight
Mungbean			
MH 421	60-65	Punjab, Haryana, New Delhi, western Uttar Pradesh	Suitable for summer cultivation; resistant to MYMV; seed yield 1,100-1,200 kg/ha
KM 2195	65-70	Uttar Pradesh	Suitable for *kharif* cultivation; resistant to MYMV, seed yield 1,000-1,200 kg/ha
BM 2003-2	65-70	Maharashtra	Green, shining bold grains, seed yield 800-1,100 kg/ha
Urdbean			
NUL 7	65-70	Madhya Pradesh, Maharashtra, Gujarat, Chhattisgarh, Bundelkhand region of Uttar Pradesh	Early type, suitable for *kharif* cultivation, seed yield 1,000-1,200 kg/ha
VBN 6	65-75	Tamil Nadu	Suitable for all seasons, resistant to MYMV, seed yield 800-900 kg/ha
UH 1	70-75	Haryana	Resistant to MYMV, medium-bold, attractive seeds, seed yield 1,100-1,300 kg/ha
Fieldpea			
IPFD 6-3	110-115	Uttar Pradesh	Dwarf type; resistant to powdery mildew; and tolerant to rust disease, seed yield 1,500-1,800 kg/ha
HFP 529	125-135	Punjab, Haryana, New Delhi, Western Uttar Pradesh	Dwarf type; resistant to powdery mildew; seed yield 2,200-2,500 kg/ha
Lentil			
IPL 316	120-125	Madhya pradesh, Bundelkhand region of Uttar Pradesh, Chhattisgarh and Rajasthan	Large-seeded; tolerant to wilt; seed yield 1,500 1,800 kg/ha

Commercial crops

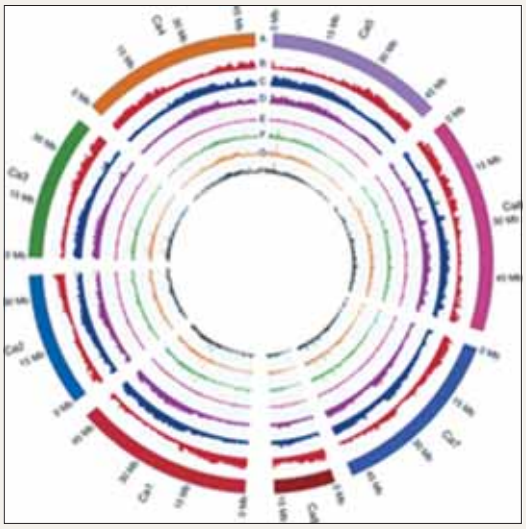
Jute: JROM 1 (Pradip) *tossa* jute variety has been recommended for release in all *tossa* jute-growing states. Its average fibre yield potential is 3.7 tonnes /ha, with yield advantage of 8.75% and 20.73% over the existing checks JRO 8432 and JRO 524, respectively. It is found resistant to major pests and diseases (stem-rot, root-rot and semilooper, Bihar hairy caterpillar and yellow mite), and produced fibre of grade TD_3 with lesser defects, and also yielded 6.2 tonnes of sticks /ha as a by-product.

White jute JRCM 2 (Partho) variety with yield potential of 2.8 tonnes/ha and resistance to major pests and diseases has been released for all white jute-growing states.

Mesta: Kenaf variety JBM 81 (Shakti) has been recommended for release in all mesta-growing states.

Draft whole genome sequence of chickpea

The draft whole genome sequence (~738 mb) of a *kabuli* chickpea variety CDC frontier was reported. A total of 28,269 protein coding genes in the chickpea genome were identified, in which 187 genes were found linked to disease resistance. The genome sequence shall be used to identify large number of markers which will be useful for marker-assisted breeding in chickpea. Knowledge of location of genes in the genome will help faster discovery of genes associated with agronomic traits such as yield, drought and heat tolerance, disease and insect resistance. The sequencing data of chickpea will provide not only access to agronomically important traits but would also speed up breeding work to develop high-yielding chickpea varieties that can tolerate better biotic and abiotic stresses and also to address climate change issues. This genome sequence of chickpea is the culmination of years of genome analysis by the International Chickpea Genome Sequencing Consortium, led by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India. The consortium includes 49 scientists from 23 organizations in 10 countries including Indian Council of Agricultural Research (ICAR), India.



The average fibre yield potential of the variety is 2.5 tonnes/ha, and is found tolerant of stem and- root rot disease. The fibre tenacity of the variety was 22.25 g/tex.

Sunnhemp: SUIN 037 (Ankur) variety is found suitable for Uttar Pradesh, Tamil Nadu and Maharashtra. Its yield potential is 1.0-1.2 tonnes/ha, and showed fibre tenacity of 21.0 g/tex.

Sugarcane: Co 06027 with a mean cane yield of 110 tonnes/ha has been released for Tamil Nadu, Karnataka, Andhra Pradesh, Kerala, Maharashtra, Gujarat and Madhya Pradesh. This variety gave 14.80 tonnes/ha sugar yield and 19.32 % of sucrose in 360 days. It was found resistant to red-rot and showed tolerance to drought and salinity.

Sugarcane varieties : (A) Co 06027; (B) Co 06030; and (C) Co 05009

Co 06030, a mid-late variety for Odisha, coastal Andhra Pradesh, Tamil Nadu and Puducherry, gave an average cane yield of 103 tonnes/ha, mean sucrose content of 16.60%, and was found resistant to red-rot.

Co 05009 (Karan 10), an early-maturing sugarcane variety, with a yield potential of 76 tonnes/ha and mean sugar yield of 9.2 tonnes/ha has been released for Punjab, Haryana, Rajasthan, western and central Uttar Pradesh and Uttarakhand. It showed resistance to red- rot disease along with non-lodging and non-flowering attributes.

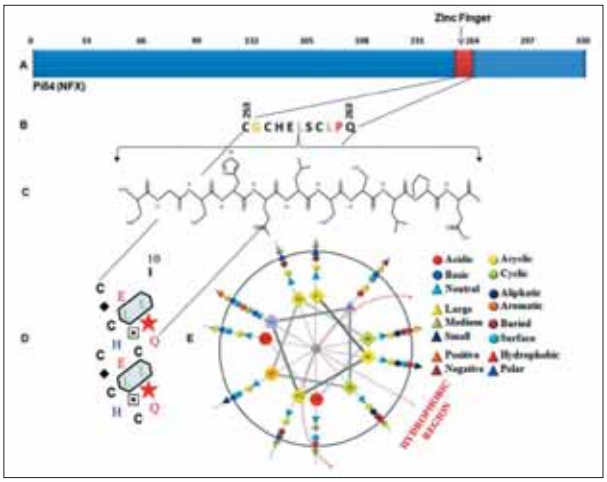
CoLk 9709, an early-maturing sugarcane variety, with yield potential of 72 tonnes/ha and moderate resistance to red- rot has been released for Uttar Pradesh.

Cotton: A genetic, male-sterility-based cotton hybrid CSHG 1862 has been released for cultivation in Punjab, Haryana and Rajasthan due to its superiority in lint yield, ginning out-turn and fibre quality with spinnability of 50s counts, and has been found moderately resistant to cotton leaf curl virus.

Tobacco: Two chewing tobacco varieties Abirami CR (HV.2000-6) and Kamatchi (VDH 3) have been released for Tamil Nadu. *Fusarium* wilt tolerant flue-cured tobacco (FCV) variety FCH 222 has been released for cultivation in Karnataka.

Biotechnology

Comparative analysis of Pi54 rice- blast resistant protein: For the first time, it has been reported that Pi54 (Pi-k^h-Tetep) has a small zinc finger domain of NFX type. Compositional analysis depicted by the helical wheel diagram revealed presence of a hydrophobic region within this domain, which may enable exposing LRR region for a possible *R-Avr* interaction. This domain is unique among all other cloned plant disease-resistant genes, and may play an important role in broad-spectrum nature of the rice-blast resistance gene, *Pi54*.



Structure of *Pi54* zinc finger domain. (A) Positional analysis of the domain showed that this domain is C-terminal in nature. The type of this zinc finger domain is NFX. (B) The amino acids, numbers and their positions in this domain. (C) Chemical structure of individual amino acids. (D) Secondary structure of zinc finger domain. (E) Helical wheel diagram of *Pi54* zinc finger domain. The helical wheel is a plot of the amino acid residues around a potentially helical segment. The graphical representation showed clustering of polar and/or non polar residues toward one face of helix.

Use of candidate gene-specific markers for rice lines: The validation of the selected material using candidate gene-specific markers in eighteen lines of rice in the background of Taraori Basmati and Basmati 386 introgressed with three bacterial blight(BLB) genes (*Xa21, xa13, xa5*) exhibited high level of resistance against BLB.

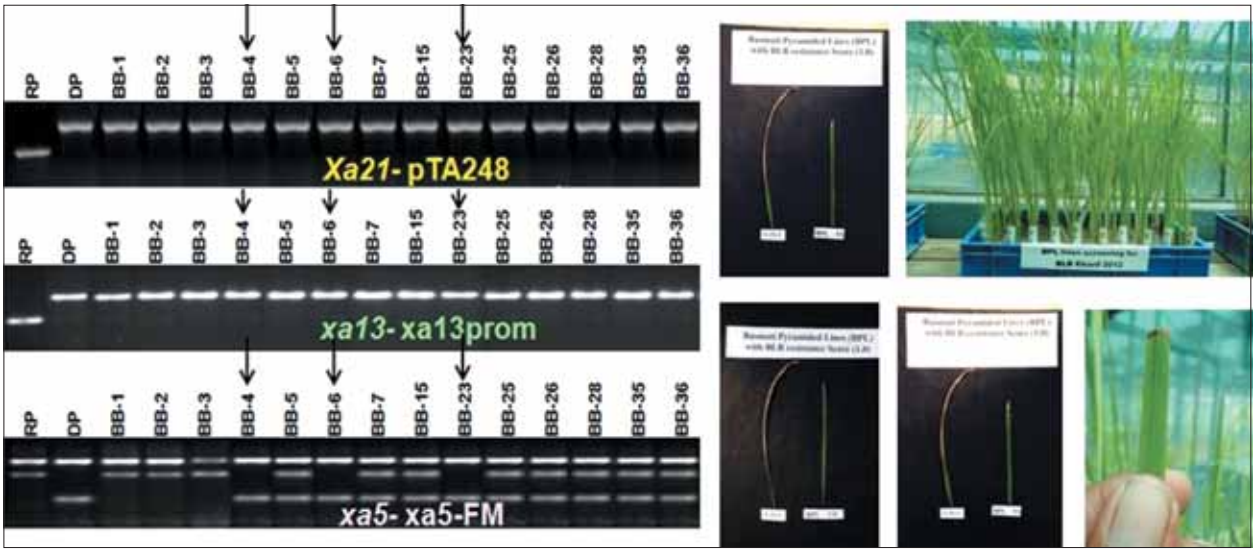
Functional marker for distinguishing *Glu-B3b* allele in common wheat: Full length sequence of *Glu-B3b* was cloned and sequenced from two wheat cultivars to develop functional marker for the allele. The marker was amplified in all genotypes carrying both *Glu-B3b* and *Glu-B3g* alleles. The marker in combination with the marker for *Glu-B3g* could distinguish *Glu-B3b* allele in diverse set of 182 Indian wheat cultivars. This removed discrepancy in identification of *Glu-B3b* allele using PCR-based markers.

Lipoxygenase- free soybeans for soy-food industry

Lipxygenase-2 is the major enzyme responsible for generating off-flavour in soy- products. NRC 109 and NRC 110, the first-ever two Indian lipoxygenase-2- free soybean genotypes developed, can contribute immensely in boosting soy-food industry. Crossing programme was carried out between Samrat and PI 086023 and advanced to F_7 generation. Validation of null lipoxygenase-2 plants in the advanced generations was performed using null allele-specific marker from the sequence analysis of *lox2* gene.

NRC 109 NRC 110

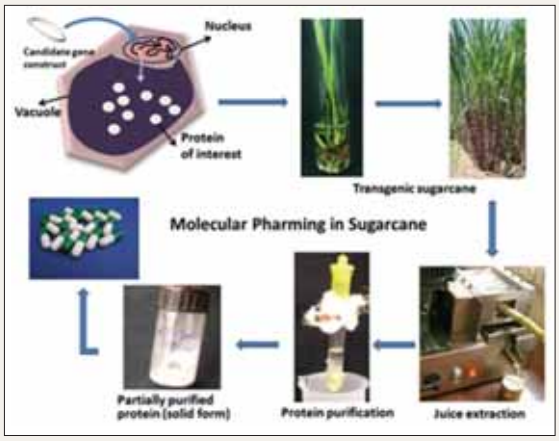
Amplicons generated using gene-specific marker for null allele of lipoxygenase-2 (*lox2*). Lanes 1, 2 NRC 109; 3, 4 Samrat; 5, 6 PI 086023 (donor of *lox2*) and 7, 8 NRC 110



Screening for *Xa21*, *xa13* and *xa5* using candidate gene-specific markers and validation by phenotyping

Molecular farming using sugarcane as a candidate crop

With the use of an in-house developed promoter for higher expression in sugarcane culm (stem) and a vacuole- localizing signal, transgenics were developed that express either Green fluorescent protein (GFP) or Beta-glucuronidase (GUS). GUS with his-tag could be isolated and partially purified from sugarcane- juice without any loss of enzymatic activity, and in some selected events, protein yield (70 % purity) was as high as 1 mg per ml of juice. Easy extraction and low protein content from sugarcane in juice made downstream processing easier. By using GUS and GFP as model proteins, possibility of sugarcane as a platform for molecular farming is being established. This technology will be useful for production of high- value protein molecules — pharmaceutical proteins like vaccines, therapeutic proteins, oral vaccines, or any other intermediate proteins of industrial value. With a definite advantage over other crops, sugarcane holds promise as a new candidate crop for molecular farming.



Marker assisted selection for kunitz-trypsin inhibitor-free soybean: Seventy-five BC_1F_2 homozygous recessive kunitz-trypsin inhibitor-free plants (*titi*) were identified from a population of JS97-52 × PI542044 and 9 from NRC7 ×PI542044 using SSR marker Satt228. One hundred and eighteen BC_2F_1 plants of JS97-52 ×I542044 were genotyped for hybridity using Satt 228 (tightly linked to *Ti* locus) and gene-specific marker. Twenty- four BC_2F_1 plants confirmed for trueness to hybridity.

Transgenic sunflower for conferring resistance to necrosis disease: Sunflower necrosis disease (SND) resistant transgenics have been developed through deployment of coat protein gene of tobacco streak virus in sense direction *via Agrobacterium*-mediated transformation. Stable integration of the introduced gene was confirmed through PCR, RT-PCR, Southern analysis; while expression analysis was done through Northern blotting and Real-time PCR analysis. Virus challenging homozygous plants in T_4 generation, followed by ELISA and RT-PCR confirmed resistance to sunflower necrosis disease. Five promising events have been multiplied for utilization in backcross breeding programmes.

Transgenic *Botrytis*-tolerant castor-plants: Two multi-gene cassettes, each carrying three genes previously reported to impart partial resistance, have been developed for imparting tolerance in castor against *Botrytis*. These vectors are being validated using tobacco as a model system and simultaneously efforts are on to use them for transforming castor with triple as well as double gene constructs using meristem- based as well as *in- planta* transformation methods. T_1 progeny plants were obtained from *in- planta* transformation procedure.

Detection of viruses infecting *Vigna* species

Species-specific primers were designed for accurate detection of viruses infecting *Vigna* species. Simplex-PCR protocols for detection of four viruses, Mungbean Yellow Mosaic India Virus (MYMIV), Mungbean Yellow Mosaic Virus (MYMV), Horsegram Yellow Mosaic Virus (HgYMV) and Groundnut Bud Necrosis Virus (GBNV), have been standardized.

Genetic transformation of chickpea and pigeonpea

Genetic transformation of chickpea (cv. DCP 92-3) with *AtDREB1A* gene was done, and 1,167 explants were co-cultivated. Three resistant shoots identified against kanamycin monosulphate were established. To discriminate transgenics from non-transgenics, 48 T_1 progenies (from 3 T_0 plants) were screened with new set of oligos for the presence of the gene.

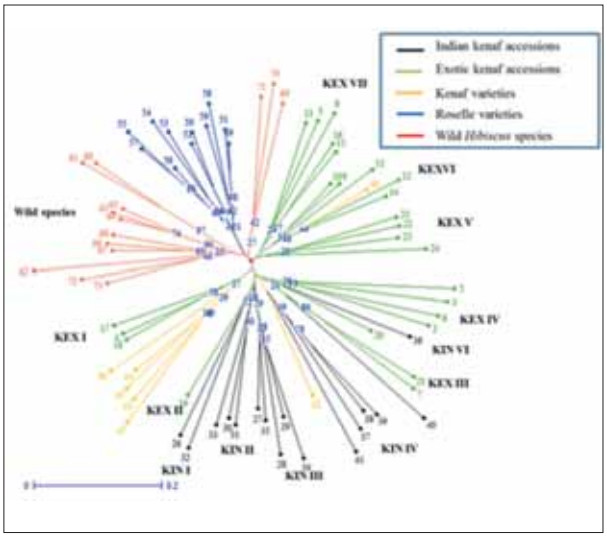
Genetic transformation (*Agrobacterium*-mediated and micro-projectile) in chickpea and in pigeonpea using *Bt* gene (*cry1Ac)* was done with 73,309 and 31,187 explants, respectively. This resulted in establishment of 32 and 211 independent primary transgenics of chickpea and pigeonpea, respectively. Further, pigeonpea variety Asha and chickpea variety DCP 92-3 were transformed using *Agrobacterium tumefaciens* harbouring a synthetic *Bt* gene (*cry1Aabc*).

Validation of gene cassettes using tobacco as model system for *Botrytis* grey mould disease of castor: Transgenic tobacco-plants carrying three single gene cassettes (ACS4-BIK1, ACS5-ERF1 and ACS7-AtEBP1) independently were crossed to stack gene cassettes. At least 24 progeny plants of each cross (ERF × BIK1, BIK1 × At EBP and AtEBP × ERF1) were confirmed using PCRs and RT-PCRs, and plants for the presence of the gene cassettes were identified. Plants that expressed two genes (e.g. *AtEBP, ERF1*) were crossed with tobacco-plants carrying corresponding third gene cassette (e.g. BIK1) to stack all three gene cassettes. Thus, three cross combinations were made to have plants carrying all the cassettes. The results indicated Mendelian segregation of three gene cassettes in one of the progenies analyzed.

Mapping *Fusarium* wilt resistance genes in chickpea and pigeonpea: Two mapping populations (JG 62 × WR 315 and K 850 × IPC 2004-52) of chickpea were advanced to F_4 generation. F_2 mapping population derived from cross JG 62 × WR 315,

representing 178 individuals was phenotyped for *Foc* race 1 in pots and genotyped with 84 polymorphic markers. In Marker Assisted Back Crossing (MABC), 12 F_1 plants confirmed true hybrid on the basis of molecular marker were backcrossed and 57 BC_1F_1 seeds were obtained. Similarly, 7 true BC_1F_1 plants derived from KWR 108 × ICC4 958 crosses were backcrossed and 35 BC_2F_1 seeds were harvested. In pigeonpea, mapping population comprising 191 F_5 lines (Asha × UPAS 120) for wilt resistance was advanced and 24 SSR markers were identified polymorphic between parents.

Genetic association of kenaf (*Hibiscus cannabinus*), roselle (*H. sabdariffa*) and wild *Hibiscus:* Evolutionary relationship between kenaf, roselle and their wild relatives have been elucidated using SSR (12 No.) and ISSR (13 No.) markers. Kenaf accession and varieties with similar genetic background and geographical origin formed closely related groups.



Genetic association of kenaf, roselle and wild *Hibiscus*

Hibiscus surattensis was found to have more genetic similarity with kenaf compared to other species. Other wild species were genetically more distinct from the cultivated species. At sub-genus level, members of sections like Trichospermum (*H. calyphyllus*), Ketmia (*H. caesius*) or Pterocarpus (*H. vitifolius*) formed separate groups and exhibited higher genetic distance from members of section Fucaria (*H. cannabinus, H. sabdariffa, H. surattensis, H. acetosella and H. radiatus*).

Identification of candidate genes for cotton fibre strength improvement: Expression profile of genes during secondary wall formation of cotton fibre such as *GhcesA1, GhcesA 2, and GhcesA 7, GhFLA3,* and *GhCobl4* were studied. The qRT-PCR analysis showed that all genes maintained relatively higher expression at the secondary wall synthesis phase in high fibre strength genotypes than those with low fibre strength. *GhcesA2* and *GhcesA7* showed relatively higher level of expression during secondary wall synthesis in *G. hirsutum* genotypes, especially at 27, 33 and 36 days post anthesis.

DNA fingerprinting

Microsatellite- based markers have been used for genetic diversity analysis and cultivar identification in pearl millet (27), fingermillet (35), maize (143), flax (94), pomegranate (45), *Luffa* (37) and others (46). Molecular profiling was done in core collections of cucumber (120), melon (155), mothbean (250), *Lathyrus* (225), sesame (450), and minicore in finger-millet (110), wheat (186) and aromatic and non-aromatic rices (104) using simple sequence repeat (SSR) markers. Trait-specific markers were generated for tomato leaf curl virus in sponge-gourd, for flowering characteristics in gynoecious bitter-gourd, high erucic acid in *Crambe*, for oxidative stress management and zinc transporter genes in cowpea and maize, and for biotic (UG99) and abiotic (drought, salt and heat) stresses in wheat. Curated transcripts were identified through transcriptome profiling for moisture- stress tolerance and allele mining from tolerant and susceptible genotypes, respectively, in *Cucumis* (12,859 and 13,448), mothbean (5,047 and 5,016) and *Lathyrus* (20,992 and 19,553). Qualitative and quantitative event-specific PCR/real-time PCR assays were developed for detection of *Bt* brinjal event EE1, and GM maize events TC1507, NK603, *Bt*176 and MON810; and multiplex PCR assays for GM maize events TC1507 and MON89034 × NK603 ×TC1507. Imports of cotton, maize, rice and sorghum (1186 accessions) were tested for the presence/integration of transgene. Loop-mediated isothermal amplification assays were developed for visual detection of screening elements (*P-35S, P-FMV, nptII* and *aadA*) in genetically modified crops.

Seed technology

Seed priming for micronutrient bio-fortification in forage crops: Generally requirements of Ca, P, Cu and Zn of lactating and mature cows are not met from the feed and forages given to them. Specially, availability of Cu and Zn were reported below the required level. Seed priming with 0.05% solution of $ZnSO_4$ + $CuSO_4$ + $MnSO_4$ for 12 hr + VAM + 50% RDM (Zn:Cu:Mn :: 10:2.5:5 kg/ha) resulted in significantly higher green forage yield of oat (517 q/ha) and sorghum (252 q/ha) in comparison to common practice (486 and 201 q/ha, respectively). The adoption of integrated nutrient management (INM) in sorghum and oat was effective in improving productivity and quality of forage.

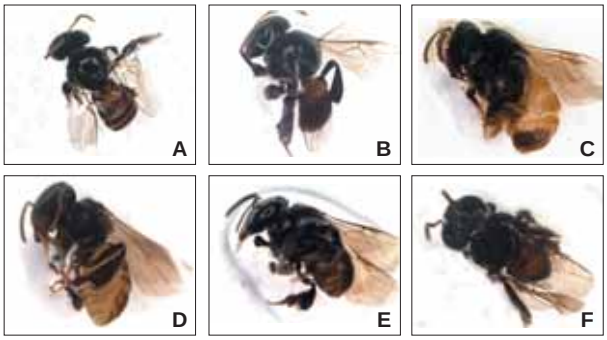
Quality seed production

Under the quality seed-production programme, 11,835 tonnes of breeder seeds, 14,984 tonnes of foundation seeds, 22,281 tonnes of certified seeds and 14,939 tonnes of truthfully labeled seeds were produced. Besides, 5,237 tonnes of planting material plus 3.7 lakh tissue-cultured plantlets of sugarcane and 182.44 lakh rooted cuttings of the forage grasses were also distributed.

Pollinators

Improved seed- setting in onion through honey bees. Pollination through honey- bee *Apis mellifera* resulted in enhancement of onion-seed yield by more than 10 times compared to open-pollination of inflorescence. Installation of two *Apis mellifera* colonies per hectare was required for optimum pollination in onion.

Stingless pollinators. Six stingless bee species, *Tetragonula canifrons, T. irridipennis, T. atripes, T. laeviceps, T. ventralis* and *T. ruficornis* were identified from the North -East India. For sustenance of these stingless pollinators, number of foraging plants have been identified and categorized according to the blooming period and floral rewards (nectar, pollen or both nectar and pollen sources). Stingless bee-colonies showed better growth and development in wooden boxes (25cm×15cm ×13cm) compared to earthen-pots or bamboo pieces.



Bee species: (A) *Tetragonula irridipennis,* (B) *T. canifrons,* (C) *T. atripes,* (D) *T. laeviceps,* (E) *T. ventralis* and (F) *T. ruficornis*

Horticulture

Fruit crops

An extra early-maturing (15 March to 15 April) mango variety, Arka Neelachal Kesari, with attractive fruit colour and shape was identified for cultivation in eastern coastal regions of India. It escapes fruit fly damage and yields 70-110 kg fruits /tree.

Progeny R_1P_2 of Amrapali × Arka Anmol hybrid had medium-sized fruits (224 g) with a TSS of 24° Brix, deep yellow pulp and 68.8% pulp recovery. Another hybrid progeny, H81 (Amrapali × Eldon), was selected for medium-sized fruits having attractive peel, pulp and high TSS (21°Brix).

Arka Neelachal Kesari mango

Of the 60 mutant lines generated in grapes, 6 (Mutant No. 320, 348, 375, 388, 391 and 528) were promising for fruit colour, weight and TSS.

Crossing of pomegranate Baghawa and Ganesh cultivars with wild, Himalayan land race of *Punica granatum* was successful. Four-year-old progenies of crosses between Bhagawa (commercial) and blight tolerant *Daru* and *Nana* were taller to female parent. Six hybrid progenies with more than 3% acidity (NRCP H-1, 3, 4, 11, 12 and 15) were identified for *anardana* preparation. Evaluation of 500 pomegranate seedlings of sub-Himalayan origin to challenged inoculation with *Xanthomonas axonopodis* pv. *punicae* (Xap) under glasshouse showed 45-100% disease index. Out of 321 M_0 population of Bhagawa, a potential mutant plant (M_0) with ≥ 400g fruit weight, red glossy and thin rind, dark red/dark pink juicy arils (> 60%), bold arils (> 550 mg), high TSS (> 18º Brix), less acidic (< 0.4 %) and very soft seeds was identified for further evaluation.

NRCP Hybrid-12 suitable for preparation of *anardana*

In papaya Coorg Honey Dew**,** F_6 generation with stable hermaphrodite and female plants were sib-mated and a few lines with no male plants, 50 % homozygosity for plant height, first flowering, fruiting height, fruit setting and fruit shape were identified for further evaluation. Five inter-generic progenies, viz. R_1P_{16}, R_1P_{17}, R_2P_{17}, R_1P_{20} and R_1P_{24} with 552.5g to 1.34kg fruit weight and 3.44 cm pulp thickness were selected, sib-mated and advanced to F_5 generation.

In guava, five hybrid progenies, two from Apple Colour × Purple Local and one each from Purple Local × Apple colour, Purple Local × Sardar and Thailand × Purple local crosses with 88.6 - 180.1 g fruit weight, TSS (11.0 - 13.5°Brix) and seed hardiness (8.0 - 13.5 kg/cm^2) were observed promising for further evaluation.

In litchi, a large number of crosses involving Shahi, China and Bedana were made in all possible combinations and 1,310 seedlings and 26 open pollinated progenies raised for identification of superior types.

In passion fruit, 43 promising hybrids from Kaveri × Yellow types were selected for further evaluation. One of them, hybrid IIHR-18/42 produced purple coloured,

Passion fruit hybrid suitable for direct consumption

high flavoured fruits with high juice recovery (35-38%), and is suitable for processing. Hybrid, IIHR 1/31, yielded fruits with low acidity (0.4 - 0.6%), more sweetness (TSS: 21-22 °Brix) and can be used for direct consumption.

Two rambutan cultivars, Arka Coorg Arun (red), weighing 40-45g, yielding 750 - 1000 fruits/tree and Arka Coorg Peetabh (yellow), with yellow fruits, weighing 25-30 g, white juicy and sweet aril were released.

Rambutan — Arka Coorg Peetabh

In almond, two new high-yielding genotypes, CITH-A-23 (4.69 tonnes/ha) and CITH-A-22 (4.53 tonnes/ha) and another accession, CITH-A-8, with maximum kernel recovery (56.14%) were identified for further evaluation.

In strawberry, a hybrid (Festival × Howard 17) with large fruits and good quality (TSS>10.0°Brix) was selected for further screening.

Plantation crops

In coconut, hybrid Kalpa Samrudhi (Malayan Yellow Dwarf × West Coast Tall) had excellent yield (100 nuts/palm), whereas another hybrid Malayan Yellow Dwarf × Niu Leka Dwarf (MYD × NLGD), had robust growth and recorded 400ml tender nut water.

In arecanut, three hybrids, Shriwardhan x Sumangala, Shriwardhan × Mangala and Mohitnagar x Sumangala, were identified for high nut yield. Two varieties, Madhura Mangala (VTL62) and Nalbari (VTL-75), were submitted for release and notification by Central Variety Release Committee.

In cocoa, two high-yielding varieties, VTLC-119 and VTLC-115, were developed.

In cashew, hybrid H-68 performed better (3.54 kg/plant at third harvesting). This hybrid is mid-season with bold nut (>10 g). Another hybrid H-73 recorded maximum cumulative yield (80.70 kg nuts/ tree) over a period of 15 years, whereas HC-6 showed dwarfism.

In olive, of the 25 varieties, Corotina was found high-yielding with optimum fruit maturity index and oil content when harvested between 10-30 October in Kashmir valley.

In noni, four varieties, CARI Samridhi, CARI Sanjivini, CARI Sampada and CARI Rakshak, were identified for cultivation in Andaman and Nicobar Islands.

Vegetable crops

In tomato (determinate), Kashi Aman, showed high level of resistance to both monopartite and bipartite viruses both under artificial and open field screenings. It yielded 50-60 tonnes/ha and was recommended for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand. Six F_1 hybrids pyramided with ToLCV resistant genes (Ty1+Ty2+Ty3) were evaluated for triple disease resistance to ToLCV+BW+EB. H-329 (56tonnes/ha), H-367 (53tonnes/ha) and H-363 (48tonnes /ha) were high-yielding with triple disease resistance.

In brinjal, for the first time, bacterial wilt resistant lines of were selected and advanced to F_3 and F_4 generations. Progenies of two cross combinations, IIHR-3 × IIHR-108-37-36-4-1 and IIHR-3 × IIHR-108-37-36-1-3, were promising for yield. Fertility of sterile F_1 interspecific hybrid in a reciprocal cross of *Solanum macrocarpon* × *Solanum melongena* was restored by backcrossing with *Solanum macrocarpon*.

In okra, four lines (IIHR-296-22-10-11-598, IIHR-291-14-11-585, IIHR-294-1-10-1-595 and IIHR-285-6-10-11-138) resistant to Yellow Vein Mosaic Virus were identified under naturally hot spot condition at Attur, Tamil Nadu. Among inter-specific crosses, 100 % fruit setting was observed in *A. tuberculatus* × *A. esculentus* followed by *A. tetraphyllus* × *A. esculentus* (97.3 %).

In carrot, of the ten male sterile lines evaluated, MS 32-3-3, MS 32-2-2, MS 50-7 and MS 40-2, were 100% sterile and stable with good root yield and quality characters. Two maintainer lines, MF 43-7-7 (root length 13.67 cm and root weight 86g) and MF 38-1 (root length 11.00 cm and root weight 70g), were stable for fertility. Carrot lines, SH-C-11, SH-C-52, SH-C-51 and SH-C-141-1, were identified with yield potential of 396.66, 385.55, 382.22 and 380.00 q/ha, respectively and were superior to Nantes and Shalimar Carrot-1 in yield and beta carotene content.

In garden pea, Arka Apoorva, a dual purpose (whole pod and as salad) variety with crisp and sweet pods, 12tonnes green pod /ha yield in 90 days, combined resistance to powdery mildew and rust was identified for release. Of six advanced breeding lines for high temperature tolerance, Arka Ajit × Arka Sampoorna-

IPS-3BK recorded maximum pod yield (5.8tonnes/ha), followed by 7-6 × KTP-4-IPS-12BK (5.6tonnes/ha). In dwarf types, IIHR 18 × Oregon 1-2 gave maximum pod yield (5.6 tonnes/ha) in 90 days, whereas Arka Ajit and IIHR 544 recorded 4.4 and 2.35tonnes/ha, respectively.

In *kharif*, Arka Ajit × Arka Sampoorna-IPS-3BK gave maximum pod yield (7.5 tonnes/ha) followed by IIHR 7-6 × KTP 4-IPS12BK (7.0 tonnes/ha). In dwarf types, IIHR 18 × Oregon 1-2 recorded maximum pod yield (8 tonnes/ha) in 90 days, whereas in Arka Ajit and IIHR 544 it was 6.43 and 2.65 tonnes/ha, respectively.

In French bean, for the first time, an advanced breeding line (IC525260 × IC525283-07-1-6-5) resistant to Mung Bean Yellow Mosaic Virus (MYMV) was identified and successfully field demonstrated. It has yield potential of 17.5tonnes/ha and 42 pods /plant. French bean, IIHR PB-1, IIHR PB-2, IIHRPB-7 (pole types) and rust resistant (IIHR 31 and Arka Anoop) were crossed and evaluation of F_1 progenies showed rust resistance to be a dominant trait.

In watermelon, line 42-174 recorded no incidence of

French bean IC 525260 × IC 525283-07-1-6-5 showing resistance to MYMV

water melon bud necrosis virus (WBNV) and produced round striped fruits with red pulp and 8%TSS. Arka Manik, Arka Muthu, Sugar Baby and IIHR-14 (yellow fleshed) varieties were treated with 0.2, 0.3 or 0.4% colchicine with or without PEG at cotyledon stage for six consecutive days which gave rise to 804 tetraploids. These were selfed and advanced to next generation.

In *Momordica* species, a seedless interspecific hybrid (*M. dioica* × *M. cochinchinensis*) was developed combining the desirable attributes of spine gourd and sweet gourd in addition to production of seedless fruits of bigger size (>20g) compared to normal spine gourd (<15g).

In Onion, two F_1 hybrids (DOGR Hy-1 and DOGR Hy-2) suitable for *rabi* cultivation were developed. The bulbs of DOGR Hy-1 are light red and flat-globular, with early maturity and yield of 41.30 tonnes/ha, while bulbs of DOGR Hy-2 are dark red and globular, early in maturity and yield of 34.96tonnes/ha compared to Bhima Kiran (28.91 tonnes/ha).

Indian spinach (Basella), CARI Poi Selection, is a new variety of Poi or Indian spinach (*Basella alba* L.), was developed through mass selection from local germplasm. It has broad and glossy leaves, short internodes and high yield (55-60 tonnes/ha) compared to local types (35-38 tonnes/ha).

Tuber crops

Potato, Kufri Gaurav and Kufri Garima were notified for commercial cultivation. Nine advanced hybrids for early and medium maturity were introduced.

Mushroom

Eight superior varieties of white button mushroom (DMR-Button-03), brown button mushroom (DMR-Button-06), paddy straw mushroom (DMRO-247, DMRO-484), shiitake mushroom (DMR-Shiitake 38, DMR-Shiitake-388), milky mushroom (DMR-Milky 334) and *Macrocybe gigantean* (DMR-Macrocybe-01) were recommended for release.

Flower crops

In gladiolus, Arka Amar, a hybrid (Watermelon Pink × Aarti) selection, blooms in 72 days, bears 101 cm long spikes with double rows of florets, resistant to *Fusarium* wilt, and Arka Kesar, a hybrid (Vink's Glory × Sagar) selection, blooms in 61 days, bears 111 cm long spikes and moderately resistant to *Fusarium* wilt were released. In addition, Punjab Beauty, Punjab Dawn, Punjab Pink, Elegance, Punjab Flame, Punjab Glance and Punjab Lemon Delight from PAU, Ludhiana; Phule Ganesh and Phule Neelrekha from MPKV, Rahuri; were identified for release.

In tuberose, Arka Sugandhi, a dwarf hybrid with field tolerance to root knot nematode and ideal for planting in beds was identified for release. The florets open at a time on the spike and the prominent stigma adds to the beauty. Phule Rajani, a new variety, was identified for cultivation in Maharashtra.

In Chrysanthemum, the cultivars, Anmol, Himanshu and Flash Point, for pot culture; Lucido, Red stone, Spacer, Autumn Eyes and Flash Point for early blooming; Coffee, Dark Eyes and Maghi for late blooming; Bindiya, Yellow Charm and Gum Drop for no-pinch and no-stake type; Gumdrop, Mother Teresa, Shyamal, Aprajita, Red Devil, Autumn Joy and Shobha, for late spring/early summer blooming were found suitable.

In marigold**,** Bidhan Mariold 1 (yellow) and Bidhan Marigold 2 (orange) were heat tolerant and suitable for round-the-year production in West Bengal.

In alstroemeria, Tiara and Aladdin with long rachis

and appealing colour were found suitable for cut flowers.

In orchids, the cross *Cymbidium* 'Red Beauty' × *Cym* 'Golden Elf' identified with novel colour combination and early flowering was suitable for pot cultivation. A clone derived from *C. lowianum* × *Cym*'Show Girl' with prolific and mid-season flowering was selected.

Spices

In turmeric, two nematode tolerant accessions Acc. 48 (31.94 tonnes/ha) and Acc. 79 (31.94 tonnes/ha) were developed and included for multi locational trials.

In fenugreek, Ajmer Fenugreek 3 (AFg 3) with 11.13% higher seed yield (1288 kg/ha) than Hisar Sonali (control) was identified for national release.

Medicinal and aromatic crops

In ashwagandha, a promising variety, Arka Ashwagandha, was identified for high dry root yield (11.95 q/ha) and total withanolide content (0.580%).

Biotechnology and tissue culture

Fruit crops

In mango, gene *WD*, encoding repeat proteins involved in WD40-bHLH-myb transcriptional complex was sequence characterized. The presence of *FLT*, member of multigene family, under the control of constans (*CON*), a photoperiod responsive gene, was identified in 18 mango cultivars. The *FLT* gene sequence analysis based on BLAST homology search compared 100 per cent identity with *Litchi chinensis FT1* and *FT2* genes with Dashehari mango for reverse primer for a short sequence. Real time assay evinced the upregulation of *FLT.*

In banana, EST SSR markers were designed from transcriptome analysis for both *Musa acuminata* (Calcutta 4) and *M. balbisiana* (Bee Hee Kela). In guava, linkage map was developed with a total of 160 SSR markers with two mapping population, viz. Kamsari (K), Local Purple (LP) and Allahabad Safeda (AS). In pomegranate, a total of 171 loci were used for designing SSR primers and these were characterized by evaluating the genetic diversity of 12 genotypes. In okra, 55 SSR markers were standardized using 10 gentoypes. In onion and carrot, markers were validaed to identify male sterility. In onion, Mk primers were employed to differentiate onion A and B line.

Multiple hybrid plantlet development through somatic embryogenesis and ECS was successfully accomplished in hybrid embryos of Marabale x PisangJajee (AAB × AA). DNA fingerprints of 14 unique land races of *Musa* representing AAA, AAB, ABB and AB genome was developed using SSR and ISSR markers. Putative transgenic cultures of Rasthali transformed with AMP gene for incorporating resistance to *F. oxysporum* f. sp. *cubense* (race 1) showed lower vascular discoloration compared to the control plants.

In grapes, hybridity of progenies in Seyve Villard (downy mildew resistant) and Thompson Seedless was confirmed using microsatellite markers. These plants were established in field for further evaluation. The EST and sequence databases of grape were analysed in silico and 165 genes were predicted to be uniquely expressed in response to salt. One hundred genes contained conserved domains like DNA binding and enzymatic functions. Five genes, which include transcription factors were also selected for their functional analysis.

In papaya, somatic embryogenesis from immature seeds of Surya variety resulted in rooting and establishment of plantlets *in vitro* which were transferred to the field. The RNAi approach was initiated for deriving PRSV resistance in papaya.

In guava, endochitinase gene was introgressed in guava for wilt resistance through *Agrobacterium* mediated transformation.

In pomegranate, maximum sprouting (80.0%) in explants was observed on medium (MS basal medium + NAA+ adenine sulphate + arginine+ activated charcoal), whereas MS basal medium + BAP + NAA, showed sprouting in 9.5 days. Maximum proliferation of established culture with 3.56 cm shoot length was observed when sprouts were inoculated on medium containing basal medium + nutrient supplementation 3 + Zeatin + NAA. For *in vitro* rooting of micro shoots, auxins along with activated charcoal and low salt basal medium played critical role.

Plantation crops

In oil palm, immature inflorescence collected below the 15th leaf axil was the best explant. It was possible to induce callus from immature male inflorescence in 3-6 months. The primary callus obtained was subcultured after every 4-6 months, gradually reducing the concentration of auxins.

An effective method for determining the pollen quality of oil palm in terms of viability and germinability was standardized. Among the dyes, 2, 5-Diphenyl Tetrazolium Bromide dye was best for testing pollen viability. A media consisting of 2.5% sucrose, 100ppm H_3BO_3 and PEG (10%) was most effective for oil palm, as it produced maximum pollen germination with a tube length of 317.88 µm. The oil palm pollen grains stored at –20° C in a deep freezer could retain maximum viability and germination.

In areca nut, maximum pollen germination (75%) was observed when incubated at room temperature (28-30°C) prior to cryopreservation. Rhizogenesis in tall varieties was enhanced by treating the meristemoid-derived plantlets in medium supplemented with NAA for four weeks, followed by sub-culturing in a hormone-free media. For overcoming the palm-to-palm variation in amenability for callus induction and somatic embryogenesis, individual responsive palms in GBGD, CGD, MGD, COD and PHOT cultivars were identified for multiplication.

Vegetable crops

In tomato, transgenic lines (Arka Vikas) containing coat protein gene (for resistance to PBNV), chitinase + PGIP double genes (for resistance to early and late blight), *Cry1Aa3* and *Cry2A*Bt genes and different RNAi constructs (*jhamt*, *chy*, *sp* for resistance to tomato fruit-borer), novel vacuolar pyrophosphatase gene (for drought and salinity tolerance) were produced. An anthocyanin-rich tomato line was also developed using engineered *rosea* and *delila* genes from *Antirrhinum majus*.

Homozygous T_2 plants of the 36 independent events of *rd29A*::*AtDREB1A*/*CBF3* transgenic tomato plants carrying single transgene copy to drought were imposed to stress for 7, 14 and 21 days. A total of 22 events showed enhanced drought tolerance and increased survival under drought stress.

In chilli, variety G4, a chitinase + PGIP construct was mobilized and preliminary analysis showed resistance to *Colletotrichum* and delayed disease development.

In brinjal, Arka Keshav (purple long back ground), *Cry2A*Bt transgenic advanced lines showed resistance to infective stages of freshly hatched first instar neonate larvae of brinjal shoot- and fruit-borer, *Leucinodes orbonalis* Guenee, upon resistance phenotyping. A novel method of screening for *Bt* resistance was also developed.

Tuber crops

Whole genome sequencing of Indian strain of *Phytophthora infestans* (A2 mating type) causing late blight and *Ralstonia solanacearum* causing brown rot of potato was completed.

Saffron

Stigma like structures were developed under *in-vitro* conditions from half ovary explants in saffron. ❑

7. Livestock Improvement

Cattle

Crossbred strain of cattle: The total population of Frieswal females in 37 different Military farms under the Frieswal Project of PDC Meerut was 18,537 (10,935 adult cows, 5,659 young stock and 1,943 calves). The number of elite cows producing 4,000-5,000 kg milk in a lactation was 920.

The overall mean of 300 days milk yield in Frieswal cattle based on 36,092 lactation records of the progeny of 135 bulls for the last 22 years (1991 to 2012) was 3,231.46 kg. Milk yield increased over the lactations and reached to 3,612 kg in fourth lactation. Peak yield averaged 14.68 kg. First lactation 300 days milk yield averaged 2,859.45 kg. The least squares means of age at first calving, service period, dry period and calving interval were 965, 155.54, 110.67 and 432.17 days, respectively. The breeding value of the top 10 Frieswal bulls ranged from 2,970 to 3,092 kg and their superiority over the herd average was from 146 to 268 kg.

Improvement of indigenous cattle breeds through selection: The programme covers Ongole, Gir, Kankrej and Sahiwal breeds and is being executed in collaboration with State Agricultural Universities, NGOs, State Animal Husbandry Departments and ICAR Institutes.

Ongole: The conception rate and age at first calving were 58.2% and 52.53 months, respectively; and 218 daughters were born at the SVVU, Tirupati. The average first lactation milk yield and peak yield were 711.24 and 4.02 kg. A total of 32 bulls in 4 sets have so far been evaluated and their breeding values ranged from 485.84 to 565.69 kg in first, 518.49 to 553.94 kg in second, 525.12 to 568.42 kg in third and 472.56 to 531.18 kg in fourth set. The superiority of top bulls ranged between 14.93 and 29.41 kg (2.15 to 6.19 %) over the herd average. Draught studies undertaken on the adult bulls using single harness plough with digital dynamometer revealed that the draught power varied from 0.60 to 0.72 HP.

Kankrej: The average first lactation milk yield and total milk yield of Kankrej cows at Sardar Krushinagar Agricultural University, Dantiwada, Gujarat were 2,431.99 and 2,517.97 kg respectively. The wet and herd averages were 8.82 and 5.49 kg. Age at first calving, dry period, service period and calving interval averaged 1,348.62, 119.75, 133.17 and 411.76 days. Semen of 8 bulls of the first set was used for 1,060 artificial inseminations with an overall conception rate of 50.94%.

Gir: The unit located at Junagadh (Gujarat) registered 3,575 breedable females at farmers' and 887 at associated herds. The Germplasm unit had 63 elite breedable females. Semen of 6 bulls of the first set was used for 2,580 artificial inseminations with an overall conception rate of 49.61%. The age at first calving averaged 1,412 days. The first lactation milk yield, first peak yield, total milk yield, and first lactation length were 1821.3, 7.4, 2,232.0 kg, and 315.0 days. The average dry period, service period and calving interval were 155, 213 and 504 days, respectively.

Sahiwal: The strength of breedable Sahiwal females in associated herds of the project was 985. Semen of eight bulls of the first set was used for 1,525 artificial inseminations with an overall conception rate of 35.86% and birth of 332 daughters.

Number of Sahiwal cattle is improving

Frieswal cattle

Kankrej cattle

Gir cattle

Genetic improvement of crossbred cattle under field conditions: The programme envisages to progeny test Frieswal and other Holstein – Friesian crossbred bulls under field conditions to improve crossbred field cattle.

GADVASU, Ludhiana: Daughters (2,100) from nine sets of bulls have completed first lactation. The average first lactation 305 days lactation milk yield of the daughters of first nine sets of bulls ranged from 2,698 to 3,364 kg. The milk yield showed increasing trend among the progenies of different sets. The average first lactation 305 days milk yield showed increasing trend over the years and it increased from 2,449 kg in 1993 to 3,256 kg in 2012. The average age at first calving also reduced from 1,192 days in first set to 732 days in ninth set.

KVASU, Thrissur: Daughters (1,326) from nine sets of bulls have completed their first lactation. The average first lactation 305 days lactation milk yield of the daughters of first nine sets of bulls ranged from 1,958 to 2,597 kg. The milk yield showed increasing trend among the progenies of different sets. The average first lactation 305 days milk yield showed increasing trend over the years and it increased from 1,480 kg in 1993 to 2,597 kg in the year 2012. The average age at first calving reduced from 1,136 days in first set to 1,007 days in ninth set.

BAIF Research Development Foundation, Uruli-Kanchan, Pune: Daughters (2,666) from nine sets of bulls have completed first lactation. The average first lactation 305 days lactation milk yield of the daughters of first eight sets of bulls ranged from 2,848 to 3,074 kg. The milk yield showed increasing trend among the progenies of different sets. The average first lactation 305 days milk yield increased by 11.69% from the year 1993 to 2012. The average age at first calving reduced from 995 days in first set to 669 days in eighth set.

GBPUAT, Pantnagar: So far 25 Frieswal bulls have been introduced in three sets. AI (4,416) resulted in 2,618 pregnancies with an overall conception rate of 63.74%; 733 daughters born from first two sets. Two daughters of first set of bulls calved and their first lactation milk yields are being recorded.

Reproduction: Semen doses (419,968) from Frieswal bulls were frozen of which 62,708 were distributed to Military farms, 13,860 used for field crossbred cattle improvement, and 165,245 were sold to various developmental agencies, para-vets and farmers for cattle improvement programmes. In addition, 2,450 semen doses were transferred to Gene bank of NBAGR, Karnal. In the semen bank 988,335 doses of Frieswal semen are presently available. Besides, semen doses from Ongole (16,930), Kankrej (32,775) and Gir bulls (9,403) were also frozen. The semen doses available in the semen bank of Ongole, Kankrej and Gir were 22,9185, 30,671 and 8,922 respectively.

In a controlled farm experiment it was observed that the average duration for exhibition of first postpartum oestrus in Frieswal heifers can significantly be reduced by individual feeding (67.45 vs. 80.7 days) in comparison to normal herd feeding.

Buffalopedia on CIRB Website

Buffalopedia (http://www.buffalopedia.cirb.res.in), an online database-cum-interactive information dissemination system, on buffalo production was made available at the official website of the Central Institute for Research on Buffaloes, Hisar (http://cirb.res.in). It presents buffalo husbandry data including facts, figures, demonstrations, examples, graphics, etc. The scientific concepts, practices and vocabulary used in buffalo husbandry configure the contents of database in user friendly formats.

Buffalo

Genetic resource improvement: During the year, milk yield data of first lactation was compiled from daughters born from the ninth set of bulls from all centres of Network Project, and sires were evaluated under the ongoing progeny testing plan. Murrah bull no. 1994 from GADVASU, Ludhiana top ranked with sire index value of 2,487 kg followed by bull no. 5258 from NDRI, Karnal having sire index of 2,466 kg with per cent superiority over contemporary daughters of 11.73% and 10.52 %, respectively.

Semen conservation and dissemination: At CIRB Hisar, 63,857 frozen semen doses of Murrah bulls were produced. Semen doses (13,188) were supplied to Network Project and sold (80,081 doses) to farmers for breed improvement. Champion bulls owned by progressive farmers in breeding tract of Murrah were identified, and 20,271 semen doses from such bulls were produced. Farmers from all over India are evincing keen interest in such elite germplasm for Murrah breed improvement in their respective locations. Semen doses (10,567) from these field bulls were also sold to farmers.

Performance parameters of CIRB herds (2012-13)

Traits	Mean ± SE (N)	
	Murrah	Nili-Ravi
305 DMY (kg)	2,335±45.71 (110)	2,017±46.7 (123)
Wet average (kg)	7.74 (109)	8.26 (90)
Herd average (kg)	4.76	5.34
Av. peak yield (kg)	11.23 (109)	11.14 (123)
Calving interval (days)	481±11.87 (73)	436±10.9 (75)
Service period (days)	174±8.19 (72)	126±10.8 (75)
Age at first calving (months)	44.48 (37)	39.6 (52)
Per cent (%) calf mortality (0–3 months)	5.92 (9/152)	3.75 (5/133)
Conception rate (%)	45.75 (151/330)	40.0 (166/415)

At CIRB Sub-campus Nabha, frozen semen doses produced during the year were 20,803, taking the frozen semen stock of Nili-Ravi bulls to 38,776 doses, after 13,245 frozen semen doses of Nili-Ravi bulls were sold to farmers during the year.

Field progeny testing programme: A conception rate of 50.05% was achieved with 4,204 inseminations carried out in 2012-13. During this period 70 progenies, 49 of 10th and 21 of 11th set calved at an average age of 41.43 months at first calving. The monthly test day milk recordings of 116 progenies were obtained, out of which 50 daughters completed their lactation with an average milk yield of 7.88 kg/day. Physical identification using injectable microchips was performaed in all female progeny and at present 744 daughters of bulls of 11th to 13th sets are standing at various field unit centers for future milk recordings.

Sheep

Production and reproduction performance of prolific sheep developed under organized farm were evaluated. Three-breed cross Garole-Malpura - Malpura × Patanwadi (GMM × P) sheep attained 3.46, 12.77, 19.42 and 28.16 kg body weights at birth, 3, 6 and 12 months of age respectively. Tupping rate of 95.08% was achieved in 3-breed cross sheep. Prolificacy of 32.69% with litter size of 1.33 in GMM × P ewes was achieved. The molecular studies indicated that prolific gene (*FecB)* has significant effect on litter size at birth and varied from 1.13 (*FecB*$^{++}$) to 1.67 (*FecB*$^{B+}$) in GMM × P ewes.

	GM (Garole × Malpura)	GMM (Garole-Malpura × Malpura)	GMM × P (Garole-Malpura-Malpura × Patanwadi)
Litter size	1.72	1.57	1.33
Single (%)	47.4	45.69	67.31
Twin (%)	36.8	51.61	32.69
Triplet (%)	11.8	2.69	-
Quadruplet (%)	3.95	2.69	-

Mega Sheep Seed Project

Flocks of sheep—Chottanagpuri (608), Mandya (342), Mecheri (390) and Sonadi (450)—were built up for production of superior seed. Rams of Chottanagpuri (80), Mandya (26), Mecheri (50) and Sonadi (67) breeds were distributed to farmers for improvement of their flock.

Goat

Genetic improvement of goats

Jamunapari: The population growth in Jamunapari goats at farm level was 100.8% and kidding rate varied from 1.38 to 1.55. The average 12-month body weight was 24.37 kg and the milk yield was 140.98 kg in 140 days.

Barbari: Population growth was high (182%) in this elite Barbari flock. Implementation of genetic, nutritional and health strategies at Farm Unit of CIRG resulted in significant improvement in survival rate, body weight gain at different ages and reproductive performance. Positive genetic trend (0.999±0.213 kg) was observed for body weight growth over the years with reduction in mortality.

Sirohi: Superior Sirohi bucks (147) were introduced to improve the genetic potential of farmers' flock along with intervention of technologies for health care, nutrition and management. The overall mortality reduced from 5.40% to 1.43%. The kidding rate was improved from 1.12 to 1.29. The overall population growth was 84.58%.

Black Bengal: The population growth of these goats in adopted villages of the natural habitat increased to 63.26% and the annual mortality rate reduced to 7.59%.

Sangamneri: In Sangamneri field unit at Rahuri, 642 breedable does in four clusters were registered

Performance of different breeds of sheep under Network Project on Sheep Improvement

	Body weight at different months (kg)					Tupping, lambing rate (%) on ewe's available basis	
	Birth	3	6	9	12	Tupping	lambing rate
Chokla	2.88	13.71	21.84	-	26.23	99.49	103.22
Marwari	3.41	15.74	22.01	24.37	28.43 kg	96.66	90.57
Muzaffarnagari	3.72	16.92	21.63	26.52	31.71	74.3	86.7
Deccani Farm based Unit	3.43	15.67	22.14	23.61	25.60	93.94	83.02
Deccani Field based Unit	3.29	14.35	21.00	23.61	27.95	-	-
Nellore	3.08	10.42	14.21	20.32	25.57	-	-
Magra*	2.95		19.93	27.10	38.75	-	-
Madras Red	2.83	11.36	15.89	19.42	23.09	-	85.39
Ganjam	2.80	11.72	17.08	21.68	24.74	-	81.94

*Average greasy fleece yield at 6-month age and adult annual were 1,058 and 2,213 g, respectively.


Jamunapari goat


Sirohi goat

and 33 elite bucks were rotated in the selected clusters. Population of Sangamneri goats increased by 25.15%. The improvement in body weight from base population at 6 months of age was 6.98% and improvement in milk yield was 21.42%.

Camel

Milk production potential: The average daily milk production from two teats was 3.3 L in Bikaneri, 3.8 L in Jaisalmeri, 3.2 L in Kachchhi and 2.8 L in Mewari, respectively. The peak yield was observed in fifth month of lactation. The mathematical equation $Y=106.727+ 238.597(Y_{5m})$ utilizing fifth month's average daily yield gave the best predictions (R^2, 0.90). The persistency of lactation was 76.20, 67.07, 55.67 and 35.87 % for the lactation length of 10, 12, 14 and 16 months, respectively.

Mithun

Performance of mithun carcass traits: Studies on growth and carcass traits of mithun showed better meat quality with less fat thickness, more marbling and juiciness. Its important traits are — slaughter weight, 349.33 kg; carcass weight, 198.33 kg; dressing percentage, 56.42%; carcass length, 49.66 inches; carcass oblique length, 52.16 inches; fat thickness, 0.74 inches; rib eye area, 84.29 cm^2; shrinkage, 5.00%; degree of marbling, moderately abundant; texture of marbling, fine; colour of lean, dark red; firmness of lean, slightly soft; texture of lean, fine; body condition score, 2.5/5.0.

Pig

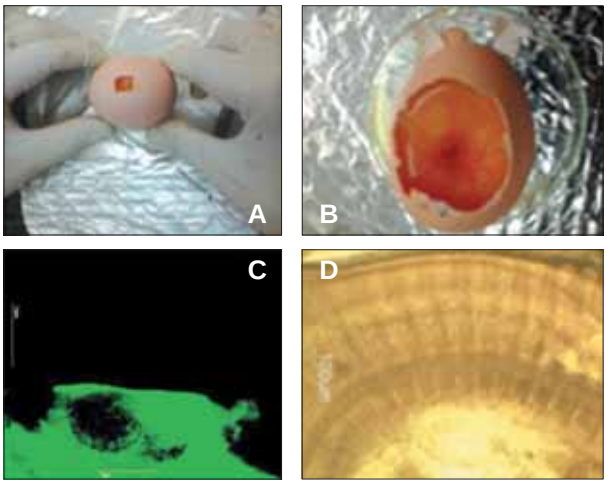
Pig varieties for breeding and fattening: Three pig varieties, viz. $H_{50}G_{50}$, $H_{50}M_{50}$ and $H_{25}G_{25}D_{50}$ were developed at National Research Center on Pig for breeding and fattening purpose. The variety 1 ($H_{50}G_{50}$) was developed by using pure parental lines of Hampshire (exotic) and Ghungroo (indigenous) breed of pigs. Its average litter size at birth and weaning were 9.86 and 8.81, respectively; average pre- and post- weaning growth rate, 142.59 and 331.17g/day, respectively; and the average slaughter weight at 8 month of age was 71.55 kg. Variety 2 ($H_{50}M_{50}$) was developed by crossing pure parental lines of Hampshire (exotic) and Niang Megha (indigenous) pigs. These two varieties of pigs were superior in terms of productive, reproductive and carcass traits as compared to the indigenous animals with higher adaptability in local climatic condition.

The variety 3 was developed by crossing selected population of Variety-1 pigs with pure Duroc (exotic) males. Duroc was used as terminal sire in this breeding programme due to its high potential of lean meat production with superior growth rate. As a fattener pig, this three breed cross was found suitable for farmers because of its growth, adaptive and carcass characteristics. As a fattening germplasm, this variety showed promisingly higher pre- and post-weaning growth rate of 173.19 and 379.23g/day. Marketable weight at 8 months of age was 76.26 kg.

Pig varieties were developed at NRC on Pig

Poultry

Silencing myostatin gene for growth in broilers: In *in-vivo* trial, the highest weekly body weight up to six weeks and the highest knock down of myostatin gene in heart and breast muscle were observed in chicks injected with GFP lentivector clones @ 6,000 pfu/chick (I/V). Only treated chicks showed GFP expression in cryosections of breast muscles.



Window (A) for injecting shRNA lentivector on germinal disc (B); embryos formation (6^{th} day of incubation) and GFP expression: (C) fluorescent light, (D) normal light

Under *in-ovo* trials 2,000 and 4,000 pfu/100 ml of DMEM of lentivectors containing myostatin RNA were injected on 16^{th} day of incubation through broad end of the egg. The results revealed that the body weights were highest in 2,000 pfu/100 µl dose group compared to un-injected control. Knocking down of myostatin gene in breast muscles of chicks of different groups at the age of 6 weeks ranged between 55.1 and 65.4%.

In-ovo lentivector injection (2,000 cells/100µl media) trial by making single window (approximately 2 mm × 2 mm) in fertile eggs just above the germinal disc, fertility of 37.5% and transfection efficiency of 33.33% were obtained. In repeat trial fertility improved to 55% (11/20) and transfection efficiency to 63.3%.

Germplasm for rural poultry

Four new crosses of rural poultry, viz. PD-1 × PB-2 (B), PD-1 × PD-3 (R), PD-1 × PD-4 (A) and PD-1 × IWI (W) were developed. The age at sexual maturity (ASM) and 72 weeks egg production of A, B, R and W crosses were 158, 160, 157 and 149 days and 161.9, 113.4, 219.1 and 212.5 eggs, respectively. The overall performance of R and W was better in terms of ASM and 72 weeks egg production.

All India Coordinated Research Project on Poultry Breeding

The BNR cross developed from BN cross (PB-2 × Native) × RIR at Udaipur centre was released as a dual purpose variety, Pratapdhan for rural poultry. The 72 weeks egg production is 161 eggs with adult body weight of 2,250 g at 40 weeks.

Poultry for egg: Six pure lines of White Leghorn chicken (IWD, IWF, IWN, IWP, IWH and IWI) are being improved through intra population selection under the AICRP on Poultry Breeding Programme. At KVASU, Mannuthy centre, the hen housed egg production up to 72 weeks of age in IWN and IWP were 308.2 and 297.5 eggs, respectively. At AAU, Anand centre, egg production up to 64 weeks of age increased by 5.3 eggs in IWN and by 13.9 eggs in IWP line over previous generation. The egg production of IWN × IWP and IWD × IWK crosses up to 72 weeks of age was 300.8 and 264.3 eggs, respectively.

Poultry for meat: Five synthetic colour broiler populations are being 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 5 weeks body weight of PB-2 was 1,022 g at KVAFSU, Bengaluru centre and 1,189g at GADVASU, Ludhiana centre. At Ludhiana centre, over the last 6 generations, the 5-week body weight in PB-2 improved by 25.7 and 25.8 g/generation on phenotypic and genetic scales, respectively. The 5-week body weight of PB-1 at KVAFSU, Bengaluru was 1,041g while that at Ludhiana centre 1,310g. At PD on Poultry, three colour broiler lines namely, PB-1, PB-2 and control broiler are being conserved and evaluated. Two gene lines, naked neck and dwarf were also maintained as resource populations.

Synthetic colour broiler

Srinidhi

A dual purpose rural variety, Srinidhi was developed at the Directorate of Poultry Research with body weights of 37.4, 131.8, 329.8 and 668.4 g at day- old, 2, 4 and 6 weeks of age in battery brooders. The shank length at 6 weeks of age was 75.63 cm. This bird was at par with body weight gain of Vanaraja and egg production of Gramapriya. Long shanks and multiple colour plumage make it well suited for rural area.

Srinidhi in rural backyard at Jharkhand

Poultry Seed Project (PSP)

Improved poultry germplasm for rural poultry were supplied through six centres located across the country. Patna centre supplied day-old 66,739 chicks of Vanaraja and Gramapriya during the period. Kolkata centre supplied 129,236 chicks of Vanaraja and Gramapriya to Sundarbans, Nadia, West Midnapur and South Dinajpur in West Bengal. At Jharnapani centre, under the tribal sub plan component of PSP, four training-cum-demonstration programmes were conducted for farmers for creating awareness and hands-on training in poultry rearing. At the Jharnapani centre, 45,150 birds were distributed to farmers of Nagaland, Asom, Meghalaya and Arunachal Pradesh. At Gangtok centre, 16,802 birds were distributed to Lower Chawang and Upper Chawang, Mangan, Pakyong, Ongchu Jongu, Tingvong areas of Sikkim state. At Imphal centre, 51,124 chicks were supplied to the farmers.

Fisheries

Spawning of cobia in recirculation aquaculture system: Spawning of cobia *(Rachycentron canadam)* was successfully achieved in recirculation aquaculture system (RAS) for the first time at Mandapam, CMFRI Centre. In this system, the brooders could be conditioned and maintained in healthy condition. One female and two male brooders were kept in the system. The ova size was assessed by cannulation and based on the same, the brooders were induced with HCG. The total number of eggs spawned was 2.40 million and the fertilization percentage was 86.1.The temperature range was 27.5 – 29°C. A total of 1.80 million larvae hatched out with a hatching percentage of 86.7%. The larvae

'*Purnima*' cloned from *Karan-Kirti*

A cloned calf named '*Purnima*', weighing 44 kg was born through hand-guided cloning technique by normal parturition on 6 September 2013. The calf is different from the earlier cloned calves as the donor cell was taken from the ear of an adult outstanding buffalo *Karan-Kirti,* which has highest recorded milk yield of 25.1 kg/day at NDRI, Karnal.

Spawning of cobia in aquaculture system

were stocked at different densities in the larviculture tanks.

Silver pompano fingerling production: The technology of seed production of silver pompano, *Trachinotus blochii*, a topmost fish due to fast growth rate and high market demand was scaled up for bulk seed production for distribution. The larval survival was directly proportional to larval stocking density and rotifer density. A larval density of 5 numbers/litre and a rotifer density of 25/ml ideal for getting best survival rates. The maximum survival rate obtained was 23.4%. By attaining better survival rate in seed production, more than 1.0 lakh seeds were produced at the Mandapam Centre. The first bulk transportation of seed was done in a truck by using 1.0 tonne capacity tanks fitted with oxygen cylinders. Each tank was stocked with 5,000 numbers of pompano seeds. The length of fingerlings ranged from 2.5 to 4.9 cm (mode 4.2 cm) and weight ranged from 0.25–1.14 g (mode 0.85 g). Ice bags were placed in each tank to reduce the temperature. No mortality occurred for 29 h. Thus scaling up technology of *Pompano* seed production and subsequent transportation have opened new vistas for this highly valued fish.

Improved fish production from marine resources

During 2012-13, an estimated catch of 3.94 million tonnes, an all time record landings for Indian marine fisheries was reported with a growth of 3.37% compared to 2011-12. Pelagic fishery (54%) contributed more to the landings followed by demersal (28%), crustacean (13%) and molluscan (5%) fishery. Major contribution was from Indian oil sardine with 7.2 lakh tonnes (18.2% of total catch) along South-west (Kerala) coast and major decline was observed in Hilsa fishery along North-east, West – Bengal coast. Region wise resources were as follows.

Year	NE	SE	SW	NW
2011-12	687,713	912,174	1,191,740	1,028,579
2012-13	403,056 10.2%	1,005,759 25.5%	1,386,360 35.1%	1,153,764 29.2%

Off-season breeding of climbing perch: Climbing perch, an air breathing fish, Koi (*Anabas testudineus)* having tremendous potential for farming in derelict and shallow waters can attain 98% and 90% fertilization and hatching, respectively, with the help of proper diet and water quality management. The off-season breeding of this species has paved the way for round-the-year production of its quality seeds. This fish contains high levels of available iron and easily digestible polyunsaturated fatty acids. It is considered a valuable item of diet during sickness and convalescence and fetches high price (` 300–500/kg) in West Bengal, Tripura, Asom, Manipur, Nagaland, Jharkhand, Bihar and Kerala.

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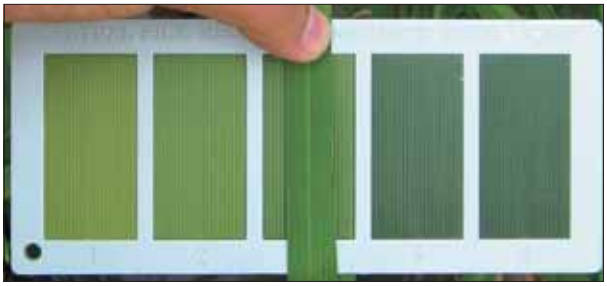
8. Crop Management

PRODUCTION

To maximize yielding ability of improved varieties and hybrids of different field crops, cost-effective and efficient production technologies have been developed for different agro-ecological conditions.

Cereals

A five- panel customized leaf colour chart (CLCC) for nitrogen management in rice for different ecosystems is being utilized. This is an easy- to- use, cost-effective tool. With this, farmers could adjust N application to actual crop demand, and thus obtained higher yields with reduced (10–20 kg/ha) N application.



Leaf colour chart for nitrogen management in rice

Use of mulch coupled with spray of KCl or $CaCl_2$ at 0.2% resulted in higher grain yield of wheat and also helped mitigate climate change effects on wheat productivity. And under restricted irrigation, hydrogel at 2.5 to 5.0 kg/ha enhanced wheat productivity.

Urea coated with 1,000 ppm karanj- oil/ palmarosa-oil/citronella-oil/neem- oil saved 30 kg N/ha in wheat (recommended dose is 150 kg N/ha); thereby reducing 20% on cost of fertilizers, besides enhancing nitrogen-use efficiency. Split nitrogen application as 1/3rd basal + 1/3rd just before first irrigation (21–25 days) after sowing and 1/3rd just before second irrigation (45–50 days after sowing) improved nitrogen-use efficiency compared to two or four splits.

Oilseeds

A native strain of the plant-growth promoting rhizobacterium was isolated and identified as *Bacillus aryabhattai* MDSR14 (JF 792521). Co-inoculation of this with arbuscular mycorrhizal (AM) fungi in soybean +maize intercropping significantly increased dry- matter accumulation, seed yield and phosphorus- use efficiency of both the crops.

Polythene mulch improved groundnut pod yield by 14.4%, and also resulted in saving of 25% NPK when applied through drip irrigation compared to the recommended dose of fertilizers applied to soil.

Polythene mulch in groundnut

Hydrogel at 1.5 kg/ ha significantly improved groundnut pod yield by 9.6 and of haulms by 16.4%. Incorporation of mustard-straw and *Sesbania* green-manure at 2.5 tonnes/ha in the soil enhanced Indian mustard seed yield by 45%.

Pulses

In Inceptisols, inclusion of pulses in cereal-cereal system and integrated nutrient management sequestered more soil organic-carbon and thus improved soil health. In maize- based cropping system, highest system productivity of 3,411 kg/ha in terms of pigeonpea equivalent was recorded in maize-wheat-mungbean system. Under rice-based system, highest system productivity of 5,140 kg/ha in terms of chickpea equivalent was recorded in rice-wheat-mungbean system.

Sowing of chickpea on broad- bed and furrow (BBF) enhanced seed yield by 18.9–33.8 % over flat method. Rice-straw mulch maintained 2–3% higher soil moisture during critical crop growth stages of chickpea and lentil in rice-fallow.

In rice-chickpea-mungbean system, yield of summer mungbean was higher with incorporation of residue (13%) and zero tillage (7%) in comparison to no-residue (1,528 kg/ha) and conventional tillage (1,481 kg/ha), respectively. Highest system productivity in terms of chickpea equivalent was obtained in rice-wheat-mungbean (6,546 kg/ha), followed by rice-wheat (4,424 kg/ha) and the lowest was in rice-chickpea (4,291 kg/ha).

Commercial crops

With polymulch technology, cotton cv. Suraj recorded 1.56 tonnes of additional seed-cotton yield /ha than the conventional method in farmers' fields.

In-situ rain-water conservation through seeding in open-furrows or mulching with paddy-straw for jute

Single Cane- Node Technology for higher yields

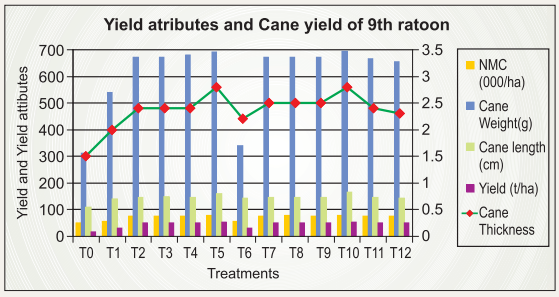
"Single- node technology of sugarcane planting" was initiated in the cropping season, and was observed in reducing quantity of seed-cane by 50% in sugarcane cultivation, besides rapid germination of cane- buds. Highest germination of 80.9% was recorded in a single-node cane segment as against 42.5 % under 3-bud setts.

Priming technique for improved germination in cane-node was also perfected using hot water (50ºC) + 3% urea solution for 2 hr or cattle-dung, cattle- urine and water in 1:2:5 ratio. Apart from germination, yield and yield attributes were notably higher in a single cane-node technology as compared to the conventional planting of 3-bud and 2-bud setts.

Sprouting enhanced (3-4 days) with priming. Uniform sprouting in single Cane Node technology *(inset)*

Bio-manuring for sugarcane multi-ratooning and for soil health

Effects of different bio-manures on yield and quality of sugarcane under multi-ratooning revealed remunerative yields of sugarcane ratoons up to 9th ratoon (56 tonnes/ha) with continuous application of 10 tonnes of sulphitation pressmud (a sugar industry by-product)/ha + *Gluconacetobacter diazotrophicus*. Bio-manuring improved cation- exchange capacity of roots and also improved composition of root biomass. Soil organic-carbon (SOC) showed increase from initial 0.32 to 0.69% and soil microbial biomass carbon (SMB-C) also recorded an increase.



T_0 - Control with *Trichoderma*; T_1-Trash compost @ 10 tonnes/ha; T_2- Vermicompost @ 10 tonnes/ha; T_3-FYM @ 10 tonnes/ha; T_4 - Biogas slurry @ 10 tonnes/ha; T_5-Sulphitation pressmud (SPMC) @ 10 tonnes/ha; T_6 -T_1+ *Gluconacetobacter diazotrophicus + Trichoderma;* T_7-T_2 + *Gluconacetobacter diazotrophicus;* T_8-T_3+ *Gluconacetobacter diazotrophicus;* T_9-T_4+ *Gluconacetobacter diazotrophicus;* T_{10}-T_5+ *Gluconacetobacter diazotrophicus;* T_{11}-*Sesbania* intercrop green manure + *Gluconacetobacter diazotrophicus*; T_{12}-NPK (150:60:60 kg/ha)

cultivation proved beneficial. Under deficit rainfall situation, use of higher seed rate (6-8 kg/ha), elemental sulphur use (30kg/ha), and intercropping of greengram or cowpea with an early-sown jute were found remunerative, and also ensured 30 kg jute fibre (equivalent) yield /ha.

For ramie cultivation, its waste-stalks were established as alternative planting material. With the consortium of alkalophilic pectinolytic bacteria, degumming of ramie fibre could be completed within 2–3 days at 34°C and in 4–5 days at < 31°C. The degumming liquor can be used twice with fresh decorticated ramie fibres without loss in degumming efficiency. Two additional neutral pectinolytic strains with better pectinolytic activity have been isolated.

HORTICULTURE

Fruit crops

In mango, two-year-old polyembryonic Bappakai, Goa, Kuroki, Mylepelian, Moovandan, Nekkare and Vellaikolamban rootstocks were evaluated at different salinity levels. The degree of senescence was less in Nekkare and Kurukkan compared to others. High salinity resulted in decrease in growth rate over the control, which was manifested by defoliation of leaves and stunted growth.

In Kinnow mandarin, analysis of microbial population in soil under semi-arid conditions revealed maximum total microbial population at 0-15 and 15-30 cm depth due to application of recommended dose of N, P, K + FYM and consortium of biofertilizer with maximum fruit yield (60kg/tree), fruit weight and quality (TSS, acidity and juice recovery). A microbial consortia consisting of *Azotobacter chroococcum* (asymbiotic N-form), *Bacillus mycoides* (K-solubilizer), *Pseudomonas fluorescens* (P-solubilizer), *Bacillus polymyxa (*P-solubilizer) and *Trichoderma harzianum* (P-solubilizer) isolated from citrus rhizosphere was prepared. It showed no antagonism among the component microbial species up to 90 days under laboratory incubation. Its application improved soil health besides growth and fruit yield.

In papaya, ultra drying technique of seeds was standardized to maintain original germination, vigour and viability under ambient temperature.

In grapes, increased vigour of Cabernet Sauvignon vines was recorded when grafted on 110R, Gravesac and SO4 rootstocks. Yield ranged from 8.97tonnes/ha (on Fercal) to 11.20tonnes/ha (on SO4 rootstock).

The drip irrigation schedule for grape Cabernet Sauvignon raised on 110R rootstock based upon stage of crop growth and pan evaporation was standardized. The maximum water-use efficiency (103.42kg grape/mm irrigation water applied) was recorded due to minimum application of irrigation water (182.81mm) along with rains received during annual growth cycle.

Covering the vines using shade net resulted in early and more number of sprouted buds (60 buds/vine) compared to un-covered ones (45 buds/vine).

Association of auxins with rachis swelling disorder was confirmed by application of NAA at parrot green stage of cluster. Application of NAA at this stage induced rachis swelling in Tas-A-Ganesh and Manjri Naveen (@ 20ppm), and Sharad Seedless (50ppm) cultivars.

In litchi, relatively early fruit maturity (5-6 days) was recorded with foliar spray of ethrel (100ppm) twice during October and February. Spray of 2.0 % KNO_3 led to early emergence of panicles in cv. China. Maximum flowering in China was recorded due to soil application of paclobutrazol @ 4 g a i/m canopy radius followed by spray of 2.0 % KNO_3.

In pomegranate**,** best month for budding *in situ* was January (90% success). For pomegranate cultivation in heavy textured soils, irrigation applied through 6 (2litres/hour) drippers fixed on two laterals and placed on both sides of the plant resulted in better vegetative growth. The soil moisture content in vertical direction in both heavy and light textured soils was sufficient even up to a depth of 90 cm in 2, 3 and 4 dripper system, while it was up to 75 cm depth in ring system and up to 60 cm in two lateral systems of dripper placement.

In aonla, studies on high-density planting systems revealed that different planting systems significantly affected vegetative growth, yield and quality of aonla under rainfed conditions of semi-arid environment. Application of paddy straw mulch recorded the highest bacterial population in basin soil.

In temperate fruits, maximum fruit setting and yield in peach were recorded in tatura trellis training at 2.5m × 2.5m spacing, while open centre training was best under 3m × 3m spacing. Light interception at different canopy height and overall maximum light interception was observed in tatura trellies training system followed by four scaffold system. Fruit colour was best in tatura trellies training followed by four scaffold system.

Y-tatura trellis in peach

Apple planting at 2.5m × 2.5m with tatura trellis training was best for fruit production.

In almond, 75% RDF through fertigation (applied N:K in the ratio of 2/3N : 1/3K from nut setting to development and 1/3N: 2/3K from kernel filling to maturation stage) increased the nut number (2,041 / tree) with maximum yield (5.15 tonnes/ha).

In propagation of temperate fruit crops, chip budding resulted in higher success with 93.6, 91.7 and 91.5% in pear and; 94.2, 93.1 and 90.6% in peach during February-March, June-July and September-October, respectively.

Chip budding in apricot gave 90.4, 86.9 and 85.9% graft/bud success in February-March, July-August and September-October, respectively, with a plant height of 73.4-142.8 cm.

In almond, chip budding during February-March, June-July and September-October gave 89.6, 84.3 and 82.2%. Whereas, chip budding in walnut gave higher success only during February-March with bud take of 83.1 and 77.9% at 8-10 cm and 13-15 cm budding height, respectively. Patch budding in walnut during July-August resulted in only 28.2% success.

Plantation crops

In coconut, two plant growth-promoting bacteria (KiSII and RNF 267) isolated from the rhizosphere of coconut were identified. Co-inoculation of *Bacillus megaterium* TSB16 with *Bacillus coagulans* RSB14 had significantly positive effect on dry weight of coconut seedlings. In addition, dual inoculation of *B. subtilis* VEB4 and *B. licheniformis* KGEB16 on cocoa seedlings had significant enhancement in total dry weight than individual inoculations.

BIOLOG and 16S rDNA sequencing of acid tolerant bacterial isolates from rhizosphere of coconut palms revealed presence of a diverse population of acid-tolerant *Bacillus* spp. For effective bio-waste utilization, *biochar* production from coir pith and tender nut husk was standardized using a simple charring kiln.

In arecanut, productivity (33.16-36.65 kg dry nuts/ha) was *at par* due to either fertigation with 75% NPK or 20% N through vermicompost extract or vermicompost extract (10 and 20% N) + 25% NPK.

In oil palm, duration of phenological phases (spear leaf to 17th leaf) and growing degree days (GDD) ranged from 209 to 244 days and 2760 to 3035 heat units, respectively. Among four oil palm hybrids, Deli × Nigeria recorded higher GDD and phenological duration, while it was lowest in Malaysian hybrid. However, Malaysian hybrids recorded highest phenological duration and GDD from anthesis to maturity. A sudden increase in oil formation was observed from 16-18 weeks and it reached maximum during 20-22 weeks. Malaysian hybrids recorded highest oil to dry mesocarp from anthesis to maturity with very less moisture content, compared to other hybrids.

In cashew, foliar sprays of major nutrients (3% urea + 0.5% H_3PO_4 + 1% K_2SO_4) resulted in 16.1% increase in nut yield and secondary and micronutrients ($ZnSO_4$ + 0.1% solubor + 0.5% $MgSO_4$) spray caused 30.5% improvement in yield over the Mg, Zn and B deficient soils (control).

Vegetable crops

In an attempt on organic production of vegetables, integrated use of poultry manure @ 2.5tonnes/ha + vermicompost @ 3.5tonnes/ha + bio-inoculation with *Rhizobium*/*Azotobacter* and PSB, recorded significantly higher yield of tomato (335q/ha), cabbage (354.6q/ha) and cowpea (106.2q/ha) as compared with inorganic nutrient management (tomato-268.5q/ha, cabbage-309.5q/ha and cowpea- 80q/ha) grown respectively in *kharif*, *rabi* and *zaid* in a crop rotation sequence.

Performance of four capsicum hybrids/varieties under naturally-ventilated net house (white, 40mesh) was better with respect to growth and yield (386.28- 506q/ha) as compared to open field (98-125q/ha) in *rabi*. The performance of Swarna (yellow) and Indra (red) varieties was better as compared to Cab-1201 and Popti.

Better yield in pumpkin (5.5kg/plant) and bitter gourd (1.25kg/plant) were realized due to application of neem compost, followed by green manuring with subabul (*Leucaena leucocephala*) and lowest in control.

In onion, N and K uptake was higher at 15-60 days after transplanting (DAT), attaining peak at 25-30 DAT (active vegetative growth) followed by sharp decrease at 60 DAT. Phosphorus and sulphur uptake was higher at 20-60 DAT with peak at 40-50 DAT (late vegetative growth and bulb initiation stages) and it continued up to 110 DAT.

Vernalization significantly enhanced the number of scapes and reduced the days to first scape emergence in onion Bhima Kiran and Bhima Super. On exposure to 10°C for 10 days, the seed yield in Bhima Kiran and Bhima Super was improved by 157 and 123% respectively, compared to untreated control.

Virus-free garlic plantlets were produced through meristem culture from virus indexed explants using 0.1 – 0.3 mm meristems. *In vitro* bulbils were induced from virus-free plantlets on medium containing 6% sucrose. Before planting, cold treatment of bulbils increased germination and reduced the period required for complete germination compared with untreated control.

Soil application of poultry manure at the rate of 10 tonnes/ha in onion and garlic produced relatively higher yields compared to other treatments. However, marketable bulb yield recorded in organic farming was 17-48 % lesser than inorganic farming. The status of available nutrients in soil after harvesting showed more available nutrients with application of inorganic fertilizers over organic sources.

In vitro raised mericlones | *In vitro* induction of micro-bulbils | Harvested micro-bulbils

Virus free garlic seed production through meristem culture

Tuber crops

In coleus, growing sunhemp for 45 days and incorporating into soil, application of FYM @ 80 kg/ha, raising nursery with *Trichoderma* (1kg/1000 kg of FYM) enriched FYM and planting 40 days old rooted cuttings at a spacing of 60cm × 40cm in a raised bed recorded a higher dry tuberous root yield (1851 kg/ha) with a benefit : cost ratio of 2.6.

Integrated application of organic manures (FYM @10 tonnes/ha), secondary elements ($MgSO_4$@25kg/ha) and micronutrients ($ZnSO_4$@10kg/ha) along with half of the recommended doses of NPK (40:30:40kg/ha) significantly enhanced the cormel yield (13.9 tonnes/ha) in taro as compared to control (without nutrient application – 6.39 tonnes/ha).

Drip irrigation equal to cumulative pan evaporation (CPE) up to stolon formation and thereafter, 1.50 times CPE till early tuber bulking and 1.25 times up to maturity produced significantly higher potato yield (36 tonnes/ha).

In fennel, application of irrigation through drip with low pressure or conventional method proved better for getting higher yield (2137 kg/ha), net return (Rs 70662 /ha), benefit : cost ratio (2.77) and water-use efficiency (6.24 kg /ha/mm) followed by all furrow irrigation. Further, all furrow irrigation proved better over conventional and alternate furrow irrigation. All furrow irrigation yielded 15 and 20 per cent higher grain and straw, respectively over conventional irrigation.

Scaling up water productivity in cumin (543kg/ha) and nigella (1,723.8 kg/ha) by applying irrigation through drip and conservation of moisture by mulching using 20 micron plastic sheet was achieved. Enhanced water productivity in nigella (5.44kg/ha/mm) and cumin (2.66kg/ha/mm) were recorded.

In coriander, 80% RDF in plastic walk-in-tunnel proved significantly better for yield (1582.16kg/ha) and its attributing characters. Plastic walk in tunnel recorded minimum aphid number (20.1) in January as compared to other structures.

Mushroom

Low temperature requiring species of paddy straw, *Volvariella bombycina* (DMRO-481) mushroom was identified and technology for its cultivation developed. Low-cost pasteurization tunnel developed for compost pasteurization of button mushroom also gave good results for oyster and milky mushrooms. Inoculation of *Alcaligenes faecalis* in casing enhanced yield of button mushroom.

Medicinal and aromatic plants

Organic production of kalmegh was standardized by growing sunhemp for 45 days, incorporating into soil, application of FYM @ 80 kg/ha, raising nursery with *Trichoderma* enriched FYM (1kg/1000 kg of FYM) and planting 40 days old seedlings at 30cm × 30 cm in a raised bed with drip irrigation. Harvesting 120 days after planting yielded 1,859 kg dry biomass with a benefit : cost ratio of 1.51.

Intensive agro-techniques for saffron production developed. Two to three irrigations through sprinkler or drip caused early sprouting, early flowering, increased foliage length and number of leaves and flowers as compared to rainfed (control). Pistil fresh and dry weight; length and yield per hectare improved due to sprinkler or drip irrigation as compared to control. Raised beds resulted in early flowering with improved plant growth and more number of leaves and flowers per unit area as compared to ridge and furrow, or flat bed planting. Planting at 10 lakh corms/ha resulted in significant yield improvement (7.51 kg/ha) as compared to 15 lakh corms/ha (7.08 kg/ha) or 5lakh corms/ha (4.64 kg/ha) in raised bed planting with drip irrigation. Maximum propagation coefficient (422%) was recorded due to sprinkler irrigation, followed by drip (410%) at 5 lakh corms/ha in raised bed planting. Propagation coefficient was lesser than 100% in flat bed.

The planting of saffron @ 10 lakh corms/ha on raised beds supplemented with 2–3 sprinklers or drip irrigations resulted in early germination and flowering with improved plant growth, fresh and dry weight of pistil and ultimately significant improvement in yield (7.5 kg/ha).

Maximum propagation coefficient (422%) was recorded in raised bed with sprinkler irrigation and 5 lakh corms/ha planting density, followed by flat bed (410%) with drip irrigation and 5lakh corms/ha planting density.

FLORICULTURE

In gladiolus, Purple Flora, Verona, Snow Princess, Priscilla, Amsterdam, Flavo Souvenir, Jester Gold, Hunting Song, Rosibee Red, Princess Margaret Rose, Yellow Stone, Novalux and Ocilla, varieites were suitable for November planting, while Snow Princess, Beau Jour and Bean Benton performed better for flower production under late planting under north Indian plains.

In orchid, *in vitro* protocol for induction of Protocorm Like Bodies (PLBs) was standardized for seven *Cymbidium* hybrids and *Paphiopedilum* species. The method for *in vitro* flowering in *Cymbidium dayanum* was standardized. The benefit:cost ratio of *Cymbidium* cultivation ranged from 1.43 to 1.6 in Asom and East Sikkim. Spraying of N75 P10 K10 @ 1.0 g/litre improved the survival (75%) and vigor of *ex vitro* grown *Zygopetalum intermedium* plants.

CROP HEALTH MANAGEMENT

To overcome negative impact of different insect-pests, diseases and weeds in major agro-ecosystems, crop- health management research has led to the development of improved practices and gadgets, in addition to innovative practices for management of pests.

Cereals

In rice, Flucetosulfuron, a new post-emergence sulfonyl urea herbicide, when applied 7 days after sowing at 25 g a.i./ha showed 90% efficiency in controlling predominant grassy weeds, sedges and annual broad-leaf weeds. Application of Metsulfuron+ Carfentrazone (Ready mix) at 25 g a.i./ha in wheat was found effective in controlling broad-leaf weeds, and resulted in maximum grain yield in the North Western Plains Zone, North Eastern Plains Zone and Central Zone. And application of ready mixture (Vesta and Total) provided effective broad spectrum weed control and higher wheat productivity in the North Hills Zone, North Western Plains Zone, North Eastern Plains Zone and Central Zone.

Oilseeds

Pre-emergence application of Pendimethalin at 1kg/ha + one intercultivation at 40 days after sowing (DAS) resulted in better weed- control efficiency to realize higher castor- seed yields and net returns. Isoproturon 75WP at 0.10 kg a.i/ha or 0.15 kg a.i./ha in 250 litres of water at 30 DAS; Oxyfluorfen 23.5EC pre-emergence (PE) or 0.75 kg/ha Trifluralin 48EC pre-plant incorporation (PPI); 0.06 kg a.i./ha Clodinafop 15WP (25-30 DAS) and 0.09 kg a.i./ha Oxadiargyl 80WP (PE) were effective against castor weeds and reduced yield losses significantly.

Soil application of $ZnSO_4$ at 15 kg /ha + S (location specific), followed by 2 foliar sprays of Carbendazim + Mancozeb at 0.2% at 45 and 60 DAS were most economical and effective in reducing major foliar diseases of mustard. Spray of Dimethoate at 1 ml/litre, followed by release of *Coccinella septempunctata* at 5,000 beetles/ha was recommended for eco-friendly integrated pest management of mustard aphid.

For management of safflower aphids, foliar sprays of Clothianidin at 50g/ha or Chlorpyriphos (50%) + Cypermethrin (5%) 55 EC at 1,000 ml/ha were effective with a field efficacy of 94.4% and 84.0%, respectively, and IBC ratio of 10.7 and 12.2.

Pulses

Pendimethalin 30 EC+ Imazethapyr 2 EC (Ready mixture Vellore 32) at 1.0 kg a.i./ha (3.125 litre/ha) for heavy clay soils and at 0.75 g a.i. (2.5 litres/ha) for light soils managed weeds effectively in mungbean, urdbean, lentil and fieldpea. In pigeonpea, pre-emergence herbicide, Pendimethalin at 0.75 kg a.i./ha

Trichoderma -based bioformulation (Pusa 5SD)

Pusa 5SD, a seed-dressing formulation of *Trichoderma harzianum,* was validated against wilt and root-rot of chickpea at different locations in Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, Jammu and Kashmir and Delhi. At 4g/kg of seeds, formulation reduced disease incidence by 8.3- 63.8% and enhanced grain yield by 14.7-39.6%. In combination with Vitavax (1g/kg), the formulation further reduced disease incidence by 51.1-100% and enhanced grain yield by 19.9-62.5%.

Accelerated Pulse Production Programme (A3P)

The programme was implemented on 114,000 ha in 11 states, covering 106 blocks, 576 villages and 23,594 farmers across the crops– pigeonpea, chickpea, lentil, mungbean and urdbean. A3P farmers' fields registered significant reduction in pest incidence and used less pesticides compared to non-A3P farmers. Besides there was an increase in yield of pulses by 15-18%, as the result of the implementation of the programme. "e-National pest reporting and alert system", aided A3P registered farmers to adopt appropriate measures for minimizing pest infestation on pulses through critical IPM inputs.

and post-emergence application of Imazethapyr at 100 g a.i./ha at 10–15 days after sowing (DAS) at 2-3- leaf stage of weed+one hand -weeding at 50 DAS effectively managed weeds. Two sprays of post-emergence herbicides, Imazethapyr + Imazamox in combination at 40 g/ha effectively managed weeds of guar and cowpea. Significant reduction of wilt disease in pigeonpea was observed with *Trichoderma* strains, IPT 31 and IPT 11 (9.5–10.8% against 23.7% in control). All treatments excepting *Trichoderma* strain from Bengaluru gave 198–255 kg/ha higher yield over the control.

Biological control

Production protocol for anthocorid predators: A protocol has been standardized to rear *Montandoniola indica,* predator of pepper gall- thrip, *Liothrips karnyi*, using UV irradiated *Corcyra cephalonica* eggs as prey and bean pods as an ovipositional substrate. Both nymphs and adults of *Blaptostethus pallescens* released over *Frankliniella schultzei* pupae in soil gave, respectively, 74.0 and 89.3% mortality compared to 41.3% mortality in the control.

Fruits and plantation crops pests: A multiple insecticide-resistant strain of *Trichogramma chilonis* was released to control fruit- and- shoot borer (*Leucinodes orbonalis)* on brinjal and bollworm (*Helicoverpa armigera)* on tomato in Tamil Nadu and Punjab. In Tamil Nadu, inundated release resulted in reduction of insecticides application by 80 and 50% on brinjal and tomato, respectively, with a concomitant increase in yield by 15–20%; resulting in an overall benefit of ` 15–20 thousand per acre to farmers. In Punjab, mean fruit damage and crop infestation in tomato were lesser by 85.8% and 89.0% with biocontrol measures as compared to farmer's practice. The intervention resulted in an increase in farm income by Rs 14,600 per acre.

Endosymbionts of insect-pests

Culturable endosymbionts of yeast and bacterial species were isolated from *Aphis gossypii, Aphis craccivora* and *Myzus persicae* from Karnataka. They possess potential to detoxify pesticides used to govern parasitism of the pests. Yeast *Wickerhamomyces anomalus* tolerated and grew in insecticide amended medium up to 96 hours of inoculation. Endosymbiotic yeasts, *Metschnikowia reukaufii, Pichia ohmeri, Wickerhamomyces anomalus* and *Candida apicola* increased fitness attributes like parasitism, sex-ratio and fecundity in *Trichogramma japonicum*. *Enterobacter* sp. isolated from *Chrysoperla zastrowi sillemi* larvae degraded Acephate and Indoxacarb. *Cotesia plutellae* fed with *Wolbachia* recorded higher parasitism (74.8–91.2%) and adult emergence (64.1–82.2%) than *Wolbachia*- cured populations (68.2–82.3 and 60.4–72.2%, respectively). These endosymbionts can serve as important candidates for biocontrol of pests.

Papaya mealy bug control: Parasitoid, *Acerophagus papayae,* provided a sustainable control of papaya mealy bug, *Paracoccus marginatus*, at all tested locations. It significantly protected papaya, tapioca and mulberry from this menacing pest, and saved on ` 700 crore during 2012-13.

Coconut leaf caterpillar, *Opisinia arenosella*: Systematic monitoring and release of larval parasitoids,*Goniozus nephantidis* and *Bracon brevicornis*, reduced damage by 42% due to *Opisinia arenosella;* the pest population was reduced by 93% in different regions of Kerala within a period of seven months.

Botanicals and bio-agents for control of soybean insects: Aqueous extract of seeds of *Acacia arabica* and *Datura stramonium* and of leaves and seeds of *Annona squamosa* proved as effective as *Bacillus thuringiensis* in management of semiloopers and *Spodoptera litura* on soybean-crop. Native isolates of *Beauveria bassiana* were effective against *Helicoverpa armigera*- infesting soybean.

Nematode control

Seed treatment with Carbosulfan at 1% was better than seed dressing with *neem*, *mahua* and jatropha kernel extract at 10% for controlling *Meloidogyne javanica*, while seed treatment with neem seed kernel extract at 10% was better than Carbosulfan at 0.5% and extracts of *mahua* and jatropha at 10% for controlling *Meloidogyne incognita.* Cropping sequence of non-host crops, wheat-*bajra*-wheat reduced root -knot nematode population by 45%, and of wheat-mungbean-wheat reduced nematode population by 35%.

Integrated pest management

In farmers' participatory mode, an IPM module was implemented in 120 ha with rice cultivar Pusa Basmati

Pest management in rice fields through light trap

Newly invented insect light trap was validated in farmer's participatory mode in rice fields (cv. Pusa Basmati 1121) at NCR Delhi during *kharif* and in chickpea fields during *rabi* at Aakasar, Distt Bikaner, Rajasthan. The "light trap for managing insects" has qualified the standards of the International Bureau of the World Intellectual Property Organization.

1121 at Bambawad village in Uttar Pradesh with only 20 g a.i. Carbendazim /ha during the entire season compared to 2,250 g a.i. /ha normally used in farmer's practice (FP).Incidence of *Bakanae* disease caused by *Fusarium moniliformae* was reduced to 3.3% in IPM plots as against 14.7% in farmer's practice (FP). Besides, IPM practice increased spider population (7.7 per hill in the IPM as against 5.9 in the FP) as well as paddy yield (4 tonnes in the IPM as against 3.3 tonnes/ha in the FP).

Pesticide residues

Residue analysis of fungicide, Tebuconazole 60 FS on wheat; neonicotinoid insecticide, Thiacloprid 240 SC, on brinjal, and synthetic pyrethroid, Deltamethrin 10 EC, on tea was done through multilocation field trials in different agroclimatic conditions of the country. On the basis of the persistence and dissipation study, Food Safety Standard Authority of India, Ministry of Health and Family Welfare has fixed the maximum residue limit (MRL) as 0.07 ppm for Tebuconazole 60 FS; 0.3 ppm for Thiacloprid 240 SC and 2.0 ppm for Deltamethrin 10 EC on respective crops. Based on the data, the Central Insecticide Board and Registration Committee, Ministry of Agriculture, has approved label claim for the above pesticides for their commercial use in the country.

DNA bar-coding of rice insect-pests

To facilitate identification of major insect- pests of rice, DNA barcodes were generated using cox 1 primers for eight pests. These include brown planthopper (*Nilaparvata lugens*), striped stem borer (*Chilo suppressalis*), green leaf hopper (*Nephotettix virescens*), yellow stem borer (*Scirpophaga incertulas*), white stem borer (*Scirpophaga innotata*), pink stem borer (*Sesamia inferens*), angoumois grain moth (*Sitotroga cerealella*) and red flour beetle (*Tribolium castaneum*). Barcodes of these have been submitted to BOLD (biodiversity of life database) system, and gene bank accessions have been obtained.

Improved diagnostics

PCR based diagnostics were developed for wheat stripe rust (*Puccinia striiformis* f.sp. *tritici*) and chickpea wilt (*Fusarium oxysporum* f. sp. *ciceris*) pathogens based on ITS and β tubulin , respectively. Polyclonal antibodies based on recombinant coat protein were developed for detection of *Grapevine roll associated virus* 3(GLRaV-3) in grapes, *Garlic common latent virus* (Gar CLV) in garlic, *Large cardamom chirke virus* (LCCV) in large cardamom and *Potato virus S* (PVS) in potato. Cocktail polyclonal antibodies were generated against multiple viruses for detecting mixed infections of *Potato virus Y* (PVY) and *Potato virus X* (PVX) in potato.

Simulation model for rice gall- midge

A simulation model for rice gall-midge, *Orseolia oryzae*, an important pest of rice in eastern India, was developed using thermal constants, development thresholds and abiotic and biotic mortality factors for different developmental stages of the pest. The model has projected that gall-midge incidence on rice may increase by 2020 but would decline by 2050 compared to 2000 under Cuttack and other similar environments.

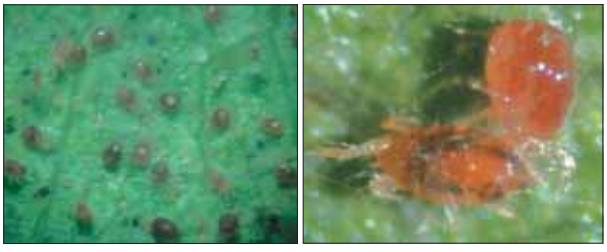
Identification of markers for development of DNA barcodes of plant pathogens

Suitable markers were identified to develop DNA barcodes for fungal and nematode pathogens. Multiloci sequence typing (MLST) revealed β tubulin as a suitable marker for interspecific differentiation of *Trichoderma* spp.; NADH dehydrogenase subunit 6 (ND6) as a suitable marker for *Fusarium* spp. and cox1 as a suitable marker for entomopathogenic nematodes.

Acarology

Biological control of mite pests: Spidermites have become an economic pest of vegetables and fruits and also of other crops. Two-spotted spidermite, *Tetranychus urticae*, infestation reduced yield by 21.1% of the marketable brinjal-fruits.

Pole-bean supported mass multiplication of obligatory predatory phytoseiid mite, *Neoseiulus longispinosus*. Pilot study with the predator against infestation of *T. urticae* on grapevine in Bengaluru in 1:50 (predator: prey) resulted in significant reduction in prey mite population (23 mites/leaf to <1/leaf) in 5 weeks. Acaro-pathogenic fungus, *Acremonium zeylanicum*, caused epizootics of *T. urticae* infesting brinjal- plants under polyhouse conditions in Thrissur.



Neoseiulus longispinosus, a potential phytoseiid predator of spidermites

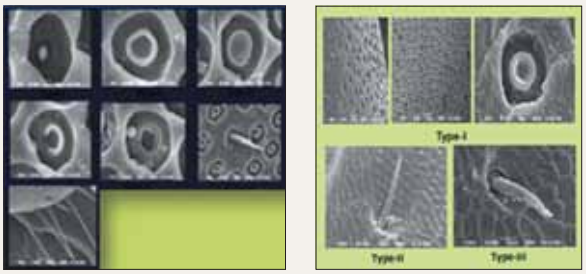
Wild boar management

Damage to crops due to wild boar (*Sus scrofa*) in four districts of Telangana region was estimated to the extent of 22–35% in paddy, 30–48% in maize, 28–42% in groundnut, 28–57% in sugarcane and 14–21% in vegetables. Since wild boar is protected

Characterization of white- grub (*Lepidiota mansueta)* pheromone to develop traps

White-grub (*Lepidiota mansueta*) has appeared as a severe key pest of many field crops in Majuli in Jorhat district of Asom; the largest mid-river deltaic island of the world. Potato, sugarcane, *Colocasia* and mungbean are most severely affected with annual damage ranging from 42 to48, 15 to 20, 35 to 40 and 30 to35 %, respectively.

Lepidiota mansueta is a biennial species and its adults exhibit sexual dimorphism; females have seven types of chemoreceptors and males have only three types.



Sensillae found in antennal lobes of female (*left*) and male (*right*)

Mating white grub (*L. mansueta*) adults

Third instar grub of *L. mansueta* was reared in the white- grub laboratory to obtain virgin adults, known to respond well to pheromones. Pheromone glands for sex pheromone extracted from male and female adults indicated that males have aggregation pheromone, signaling congregation of females at one place, while females have sex pheromone (s) to attract males. These results strongly reveal possible involvement of pheromones in mating behaviour of *L. mansueta*. Identification and synthesis of pheromonal compounds are in progress.

Border rows of castor around maize control losses due to wild boar

by Wildlife Protection Act 1972, their management needs to be logical, strategic and economical. Planting four wide border rows of castor around maize in the farmer's field showed higher yield (5,524 kg/ha) as compared to control (133 kg/ha). Castor plantation around maize prevented 95% wild-boar damage, besides additional income from castor (1,244 kg/ha). Similarly, groundnut surrounded with 4 border rows of safflower was protected from the animal and resulted in higher yields (1,560 kg/ha) compared to unprotected crop (457 kg/ha); and an additional income was generated from safflower (458 kg/ha).

Novel agrochemicals

Amphiphilic nano-polymer was synthesized and used to develop controlled release formulation of Thiamethoxam for controlling white-fly and stem-fly incidence in soybean. Significant reduction in whitefly incidence was achieved with polymer-coated Thiamethoxam formulation compared to commercial formulation. No residue of Thiamethoxam was detected in seed and soil at harvest.

New rodenticides

Two new anticoagulant rodenticides, Difencoum (0.005%) and Focoumafen (0.005%), wax blocks showed fairly good acceptability and palatability by *Bandicota bengalensis* and *Rattus rattus* causing complete mortality in no-choice and 80% mortality in free choice trials in laboratory. Both the rodent poisons registered 70-100% control success in controlling the pest under field conditions in rice and coconut crops in Andhra Pradesh, Karnataka and Andaman and Nicobar Islands.

Ornithology

The depredatory birds are dispersed from agricultural fields, especially sunflower and sorghum using bioacoustics. The technology chiefly uses alarm, distress and predator bird calls in sequences, interspersed with silences of various durations.

Call sequence-1 and 2 were tested in sorghum research plots and in farmer's fields in Andhra Pradesh. Interquartile Range analysis showed 43% and 59% dispersal using call sequence-1 and 2, respectively. The yield of sorghum and sunflower increased by 40-50% in bird -damage prone areascompared to traditional control methods employed. Acclimatization to call sequences was delayed by adjusting silence periods in the broadcasting equipment.

HORTICULTURE

Fruit crops

In mango, area-wide IPM validation for fruit fly management was implemented by deploying 70,000 fruit fly traps, covering 11,650 acres mango orchard in Andhra Pradesh, Karnataka and Tamil Nadu, which resulted in a saving of 25-30% fruit yield. The fruit fly infestation in Banganapalli cultivar was nil due to

0.5% 1.0% 2.0% Untreated

Management of shoulder browning and tear staining through tree oil formulation spray

adoption of pre-harvest IPM module for its management consisting of methyl eugenol traps; sanitation and bait sprays as against 23% in the control.

An artificial diet for rearing of the calliphorid pollinator of mango, *Chrysomya megacephala*, was standardized.

One new isolate of entomopathogenic nematode, *Steinernema abbasi*, was identified and validated using ITS region of ribosomal DNA tandem repeat unit. The DNA sequence (1-960bp) of *Steinernema abbasi* was deposited in the DNA Gene Bank (No. KF573496). Spraying of tree oil formulation @ 2.0% at the end of June (before onset of monsoon) was most effective for management of shoulder browning and tear staining diseases of mango.

In grapes, spraying of *Bacillus subtilis* (Milastin-K) followed by Chitosan (90% de-acylation grade) 10% solution @ 1.0 ml and 5 ml/ litre, respectively after fruit pruning showed good control of powdery mildew in Tas-A-Ganesh vineyard.

Pre-harvest spraying of Chitosan 10% solution (70 or 90% de-acylation grade) @ 2.0 ml/litre showed least rotting index and increased shelf-life in Sharad Seedless grape. Such a treatment could be useful for distant marketing of table grapes. Extensive survey and laboratory analysis of leaf samples revealed absence of Grapevine Fan Leaf Virus (GFLV) and *Botrytis cinerea* in vineyards in Maharashtra.

Isolates of *Colletotrichum* from hot arid regions were more virulent on grape leaves than the isolates from other regions. Leaf wetness, minimum temperature and RH contributed significantly for anthracnose severity.

Biochemical analysis of grape accessions with combined or variable resistance or susceptibility to anthracnose and downy mildew indicated the role of peroxidase in imparting resistance to anthracnose. SCAR markers were developed for the identification of Carbendazim resistant isolates of *Colletotrichum*. Isolates of *Bacillus* and *Pseudomonas* antagonistic to Carbendazim resistant *C. gloeosporioides* isolates were identified.

Sixteen *Trichoderma* isolates with potential for bio-control of grape diseases were further characterized for their sensitivity to fungicides and compatibility with other isolates. Most of the isolates were compatible to each other and may be used in singly or in consortia mode. Four *Bacillus* strains isolated from grapevines or grape rhizosphere enhanced the degradation of insecticide profenofos *in vitro*, in soil and on grape berries.

Of all the three species of thrips recorded infesting grapes in Nasik, Sangli, Pune and Solapur, *Scirtothrips dorsalis* was most common. Spinosad 45 SC and cyantraniliprole 10 OD were compatible with GA_3 and CPPU and most effective in reducing thrips damage when applied along with two application of GA_3 (40 ppm)+ CPPU (2ppm) through bunch dipping.

In addition to red spider mite, *Tetranychus* spp.; two new species of mites, viz. *Panonychus* spp. and *Oligonychus* spp. were observed infesting grapevines. Application of Hexythiazox 5.45 % EC @ 25 g a i/ ha was effective in managing mites.

Pesticide residue in grapes: Export purpose 350 grape samples, assessed for multi-residues of agro-chemicals, were in compliance to the MRL of European Union. In addition, 80 wine samples collected from different wineries of the country and 92 raisin samples had residues of agro-chemical, heavy metals and allergens (sulphur, albumin and casein) mostly either within the safety limits or below the MRLs.

In citrus, effects of Dimethoate, Endosulfan, Acephate, Thiamethoxam and Imidacloprid on Asian Citrus Psyllid (*Diaphorina citri*) populations from Nagpur and Amravati showed low to moderate resistance both in adult and nymphs, whereas adult thrips, *Scirtothrips dorsalis*, from Nagpur showed high resistance to Acephate (RR=25) and moderate resistance to Dimethoate (RR=9.3).

In pomegranate, all the isolates of *Xanthomonas axonopodis* pv. *punicae* produced typical yellow mucoid raised colonies on nutrient glucose agar after 8 days of incubation at 30°C. Colony growth was visible after 72 hours and Fuscan production was seen after 20 days. The isolates did not grow above 5.0 and 7.5 pH or more than two per cent NaCl. Comparative genomics of isolates from diverse geographical location (Karnataka, Andhra Pradesh and Maharashtra) indicated that the strain causing bacterial blight could have a single virulent lineage. The bacterial blight severity varied from 5.5% in September and increased (27.7%) in November.

Wilt affected 81.8% pomegranate samples had association of fungi *Ceratocystis fimbriata*, one per cent samples had shot hole borer (*Xyleborus fornicatus*) and *Fusarium* sp., whereas two per cent had root-knot nematode (*Meloidogyne incognita*).

Incidence of fruit-borer (*Deuodorix isocrates*) was

lesser than 10% but severity of thrips (*Scirothrips dorsalis*) was ~ 10.0% in Solapur.

In banana, wild and fungicide resistant mutants of *Trichoderma harzianum, Penicillium pinophilum, Pseudomonas putida* and *Bacillus* sp. applied five times at monthly intervals (50g/plant) either singly or in combination with talc based formulation from first month after planting in Mortaman recorded 50% reduction in vascular discolouration index of *Fusarium* wilt disease and increased the yield by 101%.

An entomopathogenic fungi collected from Asom was identified as *Beauveria bassiana* and its pathogenicity confirmed on banana weevils. *In-vitro* evaluation of six endophytic *M. anisopliae* isolates indicated 100% stem weevil mortality in 14 days.

Full genome of a new BSV species infecting Hill Banana was cloned using rolling circle amplification (RCA) technique. All the isolates except the two Indian ones (TN 14 and TN 16) of banana bract mosaic virus (BBrMV) clustered together in genetic diversity analysis. Five recombination events were detected in CP gene of BBrMV.

In guava, there was heavy infestation of root-knot nematodes in guava orchards of Badaun and Lakhimpur Kheri districts of Uttar Pradesh which were manifesting with *Fusarium* wilt symptoms. Infested plants showed reduced vigour, pale yellow leaves and unthrifty vegetative growth typically associated with nematode infestation. Both apparently healthy (<1-2mm) and sick (>2-5cm) roots had nematode galls.

In sapota, physiological disorder or internal breakdown (corky tissue) in sapota ranged from 20 to 70%, especially in summer. It was identified as one of the major constraints in the cultivation of Cricket Ball variety. The reduction or complete loss of seed viability during the early stage of fruit development was identified as primary cause for the development of this disorder.

In apple, survey of farmers' orchards at Lolab, Handwara, Khansahib, Charar-i-sharif, Uri, Tangmarg, Bandipora and Sopore in Kashmir valley revealed and ELISA detection of symptomatic leaves confirmed the presence of Apple Mosaic Virus (2.08-16.20%), Apple Chlorotic Leaf Spot Virus (2.83-19.64 %), Apple Stem Grooving Virus (up to 7.84 %) and Apple Stem Pitting Virus (0.69 -11.16 %).

Plantation crops

Coconut, arecanut and cocoa: Cultural, morphological, pathogenic and molecular characterization of *Phytophthora* isolates infecting coconut and cocoa revealed distinct inter and intra-specific variability, especially in *P. palmivora.* The rate of spread of infection (lesion size) by six *Phytophthora* isolates revealed Laccadive Orange Dwarf to be highly susceptible to *Phytophthora* infection, while a high level of resistance was observed in Malayan Green Dwarf.

A preliminary study conducted to assess the susceptibility of cocoa varieties to *Phytophthora* species showed variability among the seven varieties, and only NC × 45/53 to be susceptible to infection by all six isolates, with distinct differences in lesion size. Among the eight isolates of *P. meadii*, P8 was found highly virulent. Among fungicides, Melody Duo and Mixol (125ppm), curzate (500ppm) and Companion (1000ppm) showed 100% inhibition of mycelial growth of *Phytophthora*.

Among biocontrol agents, *Trichoderma virens* exhibited maximum inhibition of mycelial growth of *Phytophthora* (up to 62.5%) in simultaneous inoculation and was also found compatible with all tested fungicides except Companion. A simple low-cost technology for production of *Trichoderma* enriched coir pith formulation with a shelf-life of 12 months along with a simple activation process was developed for environment-friendly management of coconut stem bleeding and cocoa stem canker diseases.

Loop mediated isothermal amplification primers were synthesized and positive amplification obtained for quick detection of root wilt of coconut. Besides, chromosome preparation from actively growing root tips of coconut for fluorescent *in situ* hybridization with coconut specific probe was standardized.

Integrated pest management in plantation crops: Placing of banana food baits with pheromone lure had synergistic effect in trapping red palm weevils and when yeast was added to fermenting banana, there was increase in release of volatile compounds. In field trials, behavioural assay revealed that a blend of major and minor compounds released from the fermenting food baits caused increased orientation of weevils to pheromone which effectively trapped more weevils.

Integrated management of rhinoceros beetle (*Oryctes rhinoceros*) was demonstrated in a large area of 100 ha in Alappuzha district. After one year, there was 43-47% reduction in leaf damage and 60-80% reduction in site occupancy by the pest. A botanical cake with hexane and methanolic extracts of *Clerodendron infortunatum* and *Eupatorium* sp. was developed for prophylactic leaf axil filling against black beetle infestation in coconut. Laboratory evaluation of Cartap hydrochloride (Boregan 4% G) and Fipronil (Sargent 0.3% G @ 0.01g/grub) on red palm weevil grubs revealed 65 and 95% mortality, respectively in 24 hours.

Brontispa longissima was not located in any of the surveyed areas in the mainland, Lakshadweep and Andaman Islands. Coconut inflorescence moth (*Batrachedra arenosella*) was recorded from Minicoy Island, Bay Island and Kasaragod. Leaf mealy bug (*Pseudococcus cryptus*) and spadix mealy bug (*Dysmicoccus finitimus*) were observed infesting coconut in Kerala and Tamil Nadu.

Entomopathogenic nematode (*Steinernema carpocapsae*) caused 97.77% mortality of grubs when applied @ 20 lakh infective juveniles in 91.20 m^2 of area of vermicompost harbouring grubs of Royce's *rhinoceros*. Inundative release of EPN on organic substrate were not pathogenic to juveniles and adult

earthworms. The castings collected after two- and-a-half months showed presence of virulent (*Steinernema carpocapsae*) infective juveniles suggesting safe exclusion from the gut with no adverse effect on reproduction of earthworms.

In oil palm, a molecular diagnostic kit was developed for rapid detection of *Ganoderma*, causing basal stem rot disease in oil palm. Its specificity was confirmed through specific primers, *gan-1* and *gan-2*. Basal stem tissue recorded highest colony forming units of *Ganoderma lucidum* and the results were supported by *Ganoderma* specific primers.

In cashew, a total of 17 reduviid species were recorded and the biology of *Rihirbus trochantericus*, useful for biocontrol of tea mosquito bug (*Helopeltis antonii*) was worked out.

Reduviid *Rihirbus trochantericus* feeding on tea mosquito bug

The entomopathogenic nematodes (EPN), of the genus *Heterorhabditis* and *Steinernema* were found pathogenic on grubs of cashew stem-and root-borers, *Plocaederus* spp. An indigenous strain of EPN, *Steinernema feltiae* was isolated from soil samples of cashew ecosystem.

Vegetable crops

Molecular characterization of begomoviruses in French bean

Characterization of a new strain of tobacco curly shoot virus (TbCSV) infecting common bean revealed it to be a recombinant between tobacco curly shoot virus, mungbean yellow mosaic virus, tomato leaf curl Jodhpur virus, tobacco leaf curl Yunnan virus and *Ageratum* enation virus like ancestors, transmitted both by whitefly and inoculation of infected sap. An analysis of whole genome of this begomovirus revealed close association with TbCSV (89.1-94.5% sequence similarity) infecting Solanaceous and other weed crops. Absence of DNA-B and association virus isolate with betasatellite confirmed this as monopartite begomovirus. The identified betasatellite shared a highest sequence identity (53.9-93.9%) with tomato leaf curl betasatellite.

Summer squash showing severe yellow mosaic disease symptoms was confirmed as infected by begomovirus through ELISA, dot blot, IC-PCR and PCR amplification. The comparison of coat protein gene sequence revealed that virus isolate shared highest nucleotide identity of 99% with squash leaf curl china virus (SLCCNV) infecting pumpkin. The minimum acquisition access period (AAP) and inoculation access period (IAP) required by *Bemisia tabaci* transmitting SLCCNV were 15 and 10 minutes, respectively with females being more efficient than males in transmitting the virus.

In cucurbits, the incidence of Phytoplasma in bitter gourd, bottle gourd, cucumber, ridge gourd and watermelon ranged from 0.5 to 13.7%. SEM of infected samples revealed the presence of pleomorphic bodies in the cell which are Phytoplasma. For further diagnosis, PCR based diagnostics were developed using Phytoplasma-specific 16SrRNA primers. In addition, amplified 1.8kb and 0.7kb PCR fragment from infected plants was identified using phytoplasma specific 16SrRNA and ISR primers.

Promising bioagents identified

A promising parasitoid (*Apanteles paludicole*) with 45% parasitization during August-September was recorded from plume moth (*Sphenerches caffer*) infesting bottle gourd. Similarly, nymphal parasitoids *Aenasius bombawalei* and *Promuscidea unfasciati* were identified from mealybug (*Phenacoccus solenopsis*) infesting brinjal, tomato, okra, pointed gourd and chilli with maximum cumulative parasitization in tomato (36%). Another parasitoid (*Diaeretiella rapae*) showed differential response for parasitization to different aphid species, maximum being on *Myzus persicae* (59%).

The RT-PCR based detection protocol was standardized for detection of GCLV by using primers flanking its coat protein gene. Similarly, N gene of IYSV was characterized for recombinant antigen production for the preparation of indigenous ELISA kits in onion.

Tuber crops

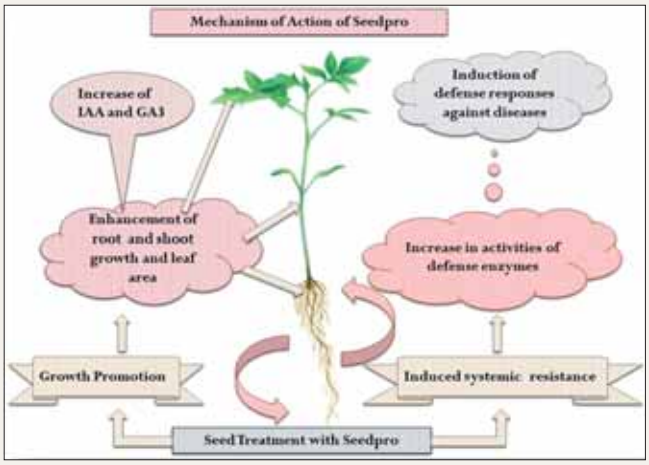
Serological and nucleic acid based diagnostic techniques were standardized for sweet potato leaf curl virus (SPLCV) and dasheen mosaic virus (DsMV) in *Amorphophallus* and yam mild mosaic virus (YMMV) infecting *Dioscorea* sp. Early and accurate detection technique for *Phytophthora colocasiae* was developed through PCR using species specific-primers.

Potato

Late blight forecasting model, JHULSACAST, was developed for *tarai* region of Uttarakhand. Protocols for detection of PLRV and PVY in aphids (RT-PCR), ToLCNDV-potato in whiteflies (PC-PCR), duplex RT-PCR for PVA and PVS, PVY and PVS, and real time PCR for PVX and phylotype detection in *Ralstonia solanacearum* were standardized.

Microbial growth promoter *Seedpro*

Seedpro, a microbial plant growth promoter and fungal disease suppressor has been developed as a seed coating formulation. It is an immobilized product of *Bacillus subtilis* OTPB1 and *Trichoderma harzianum* OTPB3. It induces systemic resistance against blights caused by *Alternaria solani* and *Phytophthora infestans* and is highly effective in promoting seedling growth, vigour and yield in major cereal/vegetable/fruit crops.



Spices

A quick detection assay based on loop mediated isothermal amplification (LAMP) was developed for detection of Piper Yellow Mottle Virus (PYMoV) and reverse transcriptase (RT) for detection of Cucumber Mosaic virus (CMV) infecting black pepper.

The transcriptome from infected and healthy tissues of susceptible ginger and resistant mango ginger (*Curcuma amada*) to *Ralstonia solanacearum* causing bacterial wilt were sequenced. Large-scale expression profiling showed that many of the disease resistance related genes were expressed more in *C. amada*. Comparative analysis also identified genes belonging to different pathways of plant defense against biotic stresses that were differentially expressed in either ginger or mango ginger. The identification of differentially expressed defense related genes provided an insight to the resistance mechanism in *Curcuma amada* and *Ralstonia solanacearum* pathosystem.

The bacterial endo-symbiont *Wolbachia* was identified from cardamom thrips (*Sciothirps cardamomi*) collected from major cardamom-growing areas in Kerala, Karnataka and Tamil Nadu. Entire thrips population was infected with sub-group 'Con' belonging to super-group B; both male and females being infected with the same sub-group.

❑

9. Livestock Management

Animal nutrition

Livestock feed resource database and forecasting models: Feed resource and livestock database for district, state, agro-eco regions and country was updated and is available in a compact disk with software support for graphical user interface to define query. The feed base version 2012 has special features like district-wise inter census growth rate for different categories of livestock, category-wise requirements of feeds in terms of fodder and concentrates and improved tools for graphical and spatial presentation of results.

Accurate estimation of crop residue production using remote sensing technique for *rabi jowar* showed that estimates arrived by remote sensing for acreage under *rabi jowar* crop compared well with official data available with agriculture department.

Prebiotics production from agricultural waste: Green coconut husks and palm press fibres were evaluated as source of xylan, a precursor for xylo-oligosaccharides (prebiotics). Green coconut husk contained 23.6 % more xylan content than palm press fibre.

Deconstruction of ligno-cellulosic biomass: Lignolytic enzymes harvested from *Coriolus versicolor* and *Ganoderma lucidium* fungi were evaluated in sheep. Enzyme treatment improved average daily gain, dry matter intake, ammonia N; protozoa count and xylanases, proteases and fibrolytic enzymes in rumen.

Newer feed resources: Feeding of detoxified neem seed cake replacing 25 % soybean meal in growing lambs showed no changes in terms of body weight gain, feed efficiency and nutrient digestibilities, N-balance and biochemical parameters and carcass characteristics. Silage was prepared with or without anti-fungal agents to enhance the keeping quality of pineapple fruit residue (PFR). Lactic acid content was highest and fungal count was least in PFR silage after 15 days of anaerobic fermentation. Feeding trial in growing sheep using PFR as total mixed ration along with concentrate mixture at 65:35 ratio for 75 days showed similar growth performance and nutrient utilization as compared to maize silage fed sheep.

Use of 50:50 maize stovers and pineapple waste and ground maize cob and pineapple waste yielded good quality silage after 21 days of anaerobic fermentation. A feeding trial in lambs with 100 and 50% replacement of *ragi* straw with ground maize cobs and pineapple waste showed no adverse effect on intake and digestibility of nutrients.

Moringa oleifera leaves have potential to be used as feed supplement because these leaves increased gas production in buffaloes, dry matter (DM) degradation and microbial biomass production with concomitant reduction in methanogenesis. Precision feeding of female buffalo calves achieved a growth rate of about 750 g/day.

Analysis of leaves of *jungli khajoor* (*Phoenix sylvestris*), *kainth* (*Pyrus pashia*), *akha* (*Rubus ellipticus*) and *meda* (*Litsea monopetala*), revealed that except *jungli khajoor*, addition of all these leaves in wheat straw based diet improved *in-vitro* dry matter and organic matter digestibility, and microbial protein synthesis. On the basis of *in vitro* studies, the nutritive value of these forages can be ranked as *L. monopetala* > *R. ellipticus* > *P. pashia* > *P. sylvestris.*

Prickly pear cactus (*Opuntia*), a fast growing xerophyte drought resistant plant and well-adopted to arid hot environment, contained 12% dry matter, 10.5% crude protein, 57.2% NDF, 25.9% ADF, 2.4% ADL and 3.9 Mcal/kg. With enough water content (88%), requirement of water can be easily met through fresh

Improved calf feeder device

A feeding device/appliance was developed to minimize the feed/fodder wastage. It is much more effective as compared to earlier trough. One device is sufficient for 6-8 calves (up to 6 months of age) at a time for all types of feeding materials. This will eliminate contaminations of feed/fodder through urine and faeces and reduce feed/fodder wastage (no wastage in pelleted feed, <10% wastage in dry and green fodder). Further, the calves can consume feed/fodder easily from the trough.

Opuntia feeding. Water requirement of around 1 litre is met through feeding of 1.20 kg of fresh *Opuntia* without any adverse effect on nutrient intake and utilization.

The supplementation of the combination 3 of herbal products as feed additive apparently induced higher milk production (10.13±0.88 vs. 8.14±0.77 kg/day) in lactating cows. The serum level of triiodothyroxine also improved in the supplemented animals. Detoxified jatropha meal or *karanj* cake effectively replaced 50% of soybean meal protein without any adverse effects on lactation performance and health of dairy cows. Supplementation of specific mineral mixture developed for high altitude of temperate Kumaon hills improved conception rate (28.6%) compared to control (14.3%) anestrous heifers. Feeding of oak leaves *(Quercus semecarpifolia)* along with supplemented mineral mixture further improved conception rate (57.2%). Feeding of oak leaves along with supplemental mineral mixture in concentrate mixture (40:60) improved mineral (Cu, Zn) digestibility showing some synergistic interaction of tannin with minerals improving reproductive performance. Feeding of nitrate, 3% of dry matter intake, to buffaloes reduced 34% methane production, improved growth performance by 15% and feed conversion efficiency by 10%. *Methanobrevibacter* sps. was the most abundant methanogen in buffaloes.

Rumen biotechnology: Gene construct encoding feruloyl acetyl esterase (FAE) was amplified in *Escherichia coli* BL21 stain for improving digestibility of fibrous feeds. Supplementation of FAE enzyme showed improved digestibility and rumen fermentation in crossbred steers fed paddy straw based ration.

A microarray chip was developed, which contains 895 oligonucleotide (17-50 mer) probes and covering 16S ribosomal RNA gene of archaea, mcrA gene of archaea, internal transcribed spacer and 28S ribosomal RNA gene of anaerobic fungi and 18S ribosomal RNA gene of rumen protozoa. Chip successfully tracked dynamics of archaea, fungi and protozoal communities in various *in vitro* and *in vivo* rumen manipulation studies. The chip indicated severe suppression in most of the species of archaea on dosing with garlic oil plus nitrate or saponin plus nitrate to rumen fluid of cow. Similarly, use of the chip for analysis of samples from cows differing in feed efficiency indicated significant difference in some of the archeal genus and species level operational taxonomic units. This is the first comprehensive microarray currently available for studying archeal, fungal and protozoal communities in rumen and is thus useful for providing direct linkages of microbial genes/populations to rumen ecosystem processes and functions, and will help develop effective means to improve rumen function and reduction in emission of methane from buffalo rumen.

Reconstituted milk formulation for lambs: Reconstituted milk formulation consisting of 22–24% crude protein, 30–32% crude fat, 22–25% lactose and 5–10% minerals fed to Malpura lambs @ 10 % of body weight with 3–4 feedings/day resulted in 19% more body weight at 90 days of age.

Poultry

Chicken diet: Solvent extracted *karanj* cake could be fed up to 6% on isocaloric and isonitrogenous basis to layer chickens (26-37 weeks of age) without any adverse effect. In broilers, *karanj* cake at levels beyond 3% significantly depressed performance. These toxic effects of *karanj* cake on broiler chicken could not be alleviated by dietary supplementation of protease (4,000 µ/kg), phytase (400 µ/kg) or liver tonic (0.1%).

Selenium in poultry diet: Organic Se at 0.15 ppm in the diet of broiler breeder pullets (PB-2) during 33-56 weeks of age, resulted in better production performance of breeders and growth of progeny. For hatchability 0.25 ppm Se was found optimum.

Micronutrients/toxic minerals: As inorganic chromium (chromium chloride) is less bio-available, organic chromium in the form of chromium enriched *Azolla* was standardized, which is 10 times less costly than chromium enriched yeast. Supplementation of organic chromium at 400 ppb could reduce cholesterol in yolk and increased chromium in the egg.

AICRP on Improvement of Feed Resources and Nutrient Utilization

Nanotechnology for enhancing bioavailability of minerals: Phosphorus, one of the most limiting minerals in livestock, is less bio-available from inorganic sources leading to environmental pollution. Experiment conducted to evaluate nano phosphorus in rats established that the gut absorption of nano P is higher as compared to conventional source of dicalcium phosphate (DCP).

Database on methane production and mitigation: Based on extensive data on the methane production potential (MPP) of different feed resources, a national catalogue was developed. Legume fodders produced less methane than cereal fodder, while straws produced more methane than green fodder, whereas tree leaves produced least methane. Total mixed ration (TMR) considerably reduced methane production than that of fodder and concentrate alone, and their methane reduction was directly proportional to the level of concentrate in the TMR.

Plant tannins as methane suppressants: Incorporation of tannin containing leaves such as jack fruit, neem and banyan @ 10–15% suppressed methanogenesis without any adverse effect on the fermentation. Jack fruit tree leaves @ 10% in the TMR significantly improved daily weight gain in lambs.

Methane emission: Methane emission from goats under different feeding systems was studied to develop suitable mitigation strategies. The *in-vitro* methane production of cereal crop straws, wheat *(Triticum aestivum)*, barley *(Hordeum vulgare)*, oat *(Avena sativa)*, and sorghum *(Sorghum bicolor)* ranged from 9.92 to 16.6 g/kg. DM CP content had a high correlation with methane production. Legume crop straws, *arhar (Cajnus cajan)*, gram *(Cicer arietinum)* and *guar (Cyamopsis teteragonoloba)* produced methane from 8.7 to 23.4 g/kg DM, which accounted methane energy loss of 482 to 1,299 kJ/kg DM. The major top feed resources produced methane ranging from 7.9 to 20.5 g for each kg digestible DM. Concentrate mixture replacing 50 % conventional protein source with mustard cake reduced methane production as glucosinolate content of mustard cake has antimicrobial properties for several microorganisms.

Physiology and Reproduction

Cattle and buffalo

Bull fertility differentiation kit: In the process of developing suitable fertility diagnostic kit to eliminate sub-fertile bulls, fertility markers like thyroid hormones, sperm functional parameters, tissue inhibitor of metallo proteinases-2 (TIMP- 2) were identified which differ between bulls of different fertility.

Embryo transfer under field condition: Embryo produced from a high yielding buffalo following insemination with the semen of a top ranking bull was flushed out and transferred fresh in a recipient buffalo of inferior type, under field condition resulting in the successful birth of a female calf.

'Mahima' born from cloned buffalo Garima at NDRI

Mahima born a female calf from a cloned buffalo 'Garima' was on 25 January 2013 at the NDRI. This is the first calf born from a cloned buffalo which was produced through hand guided cloning technique. Mahima weighed 32 kg at birth and its birth was normal. 'Garima', born on 22 August 2010, attained early sexual maturity at 19 months of age compared to her contemporaries (around 28 months) and was inseminated with frozen-thawed semen of a progeny tested Murrah bull of NDRI (No. 1875) on 27 March 2012.

'Swarn': A male cloned buffalo calf born NDRI, Karnal

A male cloned buffalo calf named 'Swarn' weighing 55 kg at birth was born on 18 March 2013. The birth of the calf was normal. The cloned buffalo calf is unique and is different from the earlier clones produced from NDRI as the donor somatic cell used was isolated from the seminal plasma of a bull currently being used for donating semen at Animal Breeding Research Centre (ABRC) of NDRI, Karnal. This achievement is of particular interest because, using this approach, it is expected to re-create highly valuable proven sire even after its death.

Sheep

Accelerated lambing system: In present scenario of growing demand of mutton, one lamb per ewe born in a year is not enough. Sheep rearing is shifting from extensive to intensive system, and accelerated mating system to target three lambs in two years was developed. Malpura ewes achieved fourth mating and fourth lambing within 683.33±12.77 and 821.30±8.57 days; 76.7% ewes achieved fourth lambing within a period of 876 days.

AI with 24 hour stored liquid semen: Protocol for use of short-term preservation of semen as an alternative to frozen semen for AI in sheep was developed. Semen of Malpura rams was collected, evaluated and extended 1:2 in egg yolk tris glucose (EYTG) and stored up to 24 h at 5°C. Lambing rate of 42.6% was achieved by fixed-time AI for one cycle with 24 h stored semen.

First test tube yak calf

The first test tube yak calf was born at Nyukmadung farm of National Research Centre on Yak, Dirang, Arunachal Pradesh on 15 July 2013. The male yak calf weighed 19 kg at birth, and was named 'Norgyal'. Transfer of a cryopreserved yak embryo produced through *in vitro* fertilization of oocytes (retrieved through ultrasound guided ovum pick up (OPU) technique from a donor yak resulted in birth of the male calf. The achievement is a breakthrough towards conservation and multiplication of elite yaks in the country.

Goat

Artificial insemination: Using frozen-thawed semen for AI in 32 Jamunapari goats, 17 does became pregnant (53.12%). One doe delivered triplets, nine does delivered twins and seven does produced single kids. Thus 17 does delivered 28 kids that resulted in 1.64 kids/goat. Results indicated that AI using frozen-thawed semen can be successfully used for propagation in goats.

Pig

AI technology in pigs at farmers' field: Artificial insemination technology was used extensively in organized farms and under village conditions. Villages (197) from Kamrup (rural) district, Asom were covered and 1,035 farmers registered as beneficiaries. Using single dose of insemination, a litter size varying from 7 to 18 piglets at birth and conception rate of >80% was obtained. Artificial insemination technique was extended to Kokrajhar district, Asom (265 km distance) on demand and to neighbouring tribal villages of Meghalaya. The artificial insemination technique increased the price of piglets from ` 1,200 to ` 2,000/ piglet due to better growth performance and physical appearance.

Poultry

Egg shell quality: Studies showed that age-associated deterioration in egg shell quality may be related to decrease in absorption of calcium from the duodenum and activity of carbonic anhydrase in egg shell gland.

Stress: Research on molecular mechanism involved in combating stress showed that expression of one of the molecular chaperons, heat shock protein-70, is up-regulated in brain and skeletal muscle of broiler birds exposed to heat stress compared to those reared under thermo neutral environment.

Combating heat stress in chickens: Inclusion of trimethylglycine in diet (300–1,200 mg/kg) of Vanaraja chicks during summer reduced lipid peroxidation and increased activity of super oxide dismutase (SOD) in a dose dependant manner indicating its favourable effects in combating heat stress. The lipid peroxidation reduced significantly in broilers fed with *tulsi* extract

Utilization of equine energy

Deployment of mules in agro-processing is being suggested as an alternative option for their optimum utilization. A study was conducted on use of mule power for chaffing green *bajra* straw with the help of a rotary gear complex, driven by a local mule of 350 kg body weight. The average output capacity of chopped *bajra* straw in rotary mode chaff cutter was 660 kg/h. This mule driven machine may not be as economic as electric chaff-cutter for chaffing operation but because of unavailability/shortage of electric power in rural remote areas, it would be helpful and eco-friendly to utilize mules/ equines in rotary mode operations during idle hours.

(50–200 mg/kg diet, 150mg being the best) as compared to those fed diet without the *tulsi* extract. The activity of glutathione peroxidase (GPx) increased with increase in dietary *amla* extract and maximum response was observed at 150 ppm in broiler chicken. The feed efficiency in Vanaraja chicks fed 0.10% KCl was significantly better than those fed the control diet during summer. A level of 260 meq/kg diet of electrolyte balance supported better performance in broilers. Lipid peroxidation decreased and activities of catalase and glutathione peroxidase increased in broiler chicken fed Zn (40 ppm), Cr (2 ppm) and Se (0.3 ppm). Feeding of organic Cr (400 µg/kg diet) considerably reduced mortality (from 2.22 to 1.61%) during 54 to 68 weeks of age in layers. The activities of SOD and GPx increased in Vanaraja female parents fed organic Se (0.15–0.3 ppm) and vitamin E (100–200 ppm).

Fisheries

Successful farming of Pacific white shrimp in freshwater: *Letopenaeus vannamei* can be cultured in freshwater. The specific pathogen free (SPF) post larvae of *L. vannamei* (PL 10) were stocked in 4 cement cisterns in pre-chlorinated water having a salinity of 2 ppt. Nursery rearing was continued up to 29 days

and the PLs were fed with a commercial pelleted feed during this period. During the nursery period the animals were slowly acclimatized to freshwater by partial water exchange. After nursery rearing, shrimps were shifted to grow out ponds, which were provided with soda mix, magnesium chloride and potash once in a week to avoid nutrient deficiency in addition to feeds. Growth rate of *L. vannamei* in freshwater was almost at par with brackishwater conditions.

Biofloc based shrimp farming technology: Biofloc, a conglomeration of heterotrophic bacteria, algae (dinoflagellates and diatoms), fungi, ciliates, flagellates, rotifers, nematodes, metazoans and detritus, acts synergistically to maintain water quality in aquaculture units reducing the need for water exchange and reutilize feed and reduce production cost. The technology is based on the concept of retention of waste and its conversion into biofloc as a natural food using some kind of biomats and supplementing with carbon addition to manipulate C : N ratio within the culture system. A very high survival of 98–99% was achieved in biofloc treatments compared to 91–92% in conventional system. One nursery tank of 100 tonne capacity can generate revenue of ` 50,000–100,000/ year. The shrimp grow-out culture under biofloc based rearing attained a final weight of 22–23g in 110 days, indicating scope for developing a tank based grow-out culture system, which has a potential to produce 20–25 tonne/ha.

Utilization of breweries waste in aquaculture: A feeding experiment was conducted for 90 days with catla fingerlings (average weight 5.0 g) in FRP tanks showed that utilization of breweries solid waste, an end product of beer industry is useful for fish food formation. Breweries waste has crude protein 43.50%, fat 1.05% and ash 8.30%. Study revealed that net weight gain was significantly higher in feed containing 15% breweries solid waste without any adverse effect.

Livestock protection

Genetic resistance to diseases in cattle

Tuberculosis: Out of 37 SNPs identified from candidate genes influencing disease resistance in bovines, seven significantly affected occurrence of

Success story

India's Largest Commercial Sea Cage Farm: Joint Efforts of ICAR and Tribals

The Veraval Centre of CMFRI established Sea Cage farm off Somnath temple in the Arabian Sea in partnership with 20 families of Sidi Tribes living along Gujarat coast. Cage culture technology including hands-on training and collection of seed from nature was transferred to them at Karwar and Mandapam Centres of CMFRI. Twenty cages of 5 m diameter were installed in the sea at a depth of about 7 m and stocked by lobster seed weighing about 50-80 g weight. These were fed well with trash fish and cultured for 110 days resulting in production of about 2,500 kg, which was sold at a price of Rs 1,200/kg valued about Rs 26 lakh being an export item. The farm can raise one more crop after September and get equal production and revenue within a year. Thus CMFRI/ICAR has provided the tribals a permanent livelihood from hunger to an income of about Rs 15,000/ month. In the process they have become – transformed then fully trained in the fabrication of cages, mooring, net handling, feeding and all other requirement for the cage farm management and emerged as very good cage farming entrepreneurs. This is the India's largest commercial sea cage farm.

bovine tuberculosis based on allelic and genotypic frequencies in case and control population.

Genotyping of case: Control population at 22 microsatellite loci revealed that polymorphism at 18 loci was significantly associated with the susceptibility to bovine tuberculosis.

Paratuberculosis: PCR-RFLP at 20 SNPs, located at the peak level of QTLs with significant association to susceptibility to bovine tuberculosis revealed significant association of one SNP i.e. rs41945014 with the susceptibility to bovine MAP infection.

Brucellosis: Five SNPs-2 from TLR1, two from TLR4 and one from Slc11A1, out of 21 SNPS from nine candidate genes showed significant effect on occurrence of brucellosis.

Vaccine development and tissue specific delivery

Avian influenza: A reassortant rgH5N2 virus was generated through plasmid based reverse genetics using mutated HA gene of one of the H5N1 field isolates and NA-N2 gene from H9N2 field isolate, as a non-pathogenic vaccine candidate for developing inactivated DIVA marker vaccine against H5N1 in poultry.

PNA as antisense molecules were transfected using both peptide and AuNPs, and provided better antiviral strategies as this can be easily conjugated with tissue specific ligand peptides. Presently use of brain homing peptides (identified by Phage Display Library) helped to deliver Au-PNA specifically to brain cells.

Diagnostic techniques

Diagnostic techniques were developed and improved for following diseases:

Orf: Loop mediated isothermal amplification (LAMP) assay was optimized for rapid detection of orf virus in clinical samples.

PPR: A lateral flow strip for detection of PPR virus was successfully tested and demonstrated in known samples.

Japanese encephalitis: Standardized indirect IgG ELISA using recombinant E domain III protein of Japanese encephalitis virus for sero-diagnosis of JE in pigs.

Bovine picobirnavirus: RdRp gene based RT-PCR assay was optimized for detection of bovine picobirnavirus.

Avian influenza: Indirect ELISA using recombinant nucleoprotein (rNP) for sero-diagnosis of Type A Influenza virus infection in chickens was optimized.

A liquid-phase immunoelectron microscopy (IEM) protocol was optimized for detection of avian influenza (H5N1) virus using AIV specific polyclonal serum.

Marek's disease: Loop-mediated isothermal amplification (LAMP) test was optimized using in-house synthesized LAMP primers for detection of MDV-1 specific oncogene *meq*.

Q fever: Standardized a novel multiplex PCR targeting *Trans* and c*om1* genes of *Coxiella burnetii* for detection of pathogen in clinical samples.

New castle disease virus: Different pathotypes specific PNAs were prepared and used to detect pathotypes specific RNA by PNA-RNA hybridization. This test was also performed using silver nanoparticles (SNPs). PNAs could differentiate pathotypes of NDV virus and nanoparticles plasmon changes leading to color variations in test solution, which could be visually seen and observed in visible spectrophotometer to have a quantification assay for assessing viral RNA concentration.

Quality control of veterinary biologicals

Vaccines for RD 'F' strain (58,600 doses); RD 'M' strain (600 doses); fowl pox vaccine (20,700 doses); lapinized swine fever (3,03,845 doses); sheep pox (7,96,400 doses); PPR (6,121,600 doses); *Brucella abortus* strain-19 (live) (64,987 doses); enterotoxaemia (2,950 doses); HS adjuvant (3,323 ml); tuberculin PPD (73,640 doses); Johnin PPD (49,800 doses); mallein PPD (22,730 doses); and antigens for *Brucella* agglutination test antigen (51,750 ml); *B. abortus* bang

Potential therapeutic application of stem cells

In vitro differentiation of embryonic mesenchymal stem cells (MSC) to tenocytes (fibroblast like differentiated cells that form matured tendon) was achieved and confirmed by expression of Decorin and Tenomodulin (tenocyte specific markers) by RT-PCR and immuno-cytochemistry. Buffalo and goat MSCs were isolated from Wharton's jelly and amniotic fluid, cultured and characterized using suitable markers. Canine MSCs were experimentally found effective in both allogenic and xenogenic treatment. The cells used were tracked during treatment using fluorescent dye PKH26. Caprine MSCs were transdifferentiated into neuron like cells and were characterized. Transgenic MSCs were transplanted in rats with induced spinal injury.

Molecular characterization of pathogens

- Complete genome sequence of classical swine fever viruses Indian strains (genotypes 1.1 and 2.2) was accomplished. Phylogenetic analysis of CSFV revealed that genotypes 1.1, 2.1 and 2.2 are prevalent in Indian pigs.
- Porcine circovirus 2 detected in pigs with clinical disease was sequenced. Phylogenetic analysis identified it as genotype PCV2a with close homology with viruses circulating in Slovakia, Romania and Serbia in Europe.
- Sequence analysis of bovine and human rotavirus isolates for NSP4 and NSP5 genes revealed possible reassortment event between bovine and human rotaviruses.
- The phylogenetic analysis of HA genes indicated that the 2011-2012 Indian and Bhutan avian influenza viruses belonged to clade 2.3.2.1 and grouped with Bangladesh virus of 2011.
- Determination and analysis of the entire genomic sequence of an Indian BVDV-2 cattle isolate was completed. Its phylogenetic analysis revealed that it is of BVDV-2a subtype and has close genetic similarity with a Chinese cattle BVDV-2 strain.

ring antigen (7,380 ml); rose Bengal plate test (23,320 ml); *Brucella abortus* positive serum (71 ml); *Salmonella*. Pullorum coloured (5,240 ml); *S.* Pullorum plain antigen (4,000 ml); *S.* Pullorum positive serum (38 ml) and *S.* Abortus equi 'H' antigen (1,000 ml); *S.* Pullorum Poly 'O' sera 25 ml, were produced, quality tested and supplied to various organizations. Goatpox vaccine (449,200 doses), 23 PPR c-ELISA and 22 PPR s-ELISA kits were produced and supplied to various institute/state veterinary biological/animal husbandry departments.

Herbal medicine: Poly-herbal formulation, Toxheal, ameliorates arsenic induced hepatotoxic, oxidative and immuno-disruptive injuries in poultry model, and also reduces arsenic deposition in liver and kidney.

Genetic and antigenic differentiation of equine influenza viruses: Analysis of genetic and antigenic differentiation of equine influenza viruses (EIV) showed homology of 98-99.5% to Chinese and Mongolian isolates. The specificity of MAbs-1D12, 1G4, 5A7 and 5F4 raised against EIV by indirect immunoperoxidase technique (IPT) was tested. EI virus-infected DCK cells gave positive immunoperoxidase reactions with all four MAbs and detected accumulation of immunizing antigen. Five EIVs isolates from various parts of the country during 2008-09 epizootic and the isolate of 1987 outbreak were characterized antigenically for HA activity using MAbs 1G4 and 5A7. MAb 1G4 recognized an epitope of 4 EI virus isolates/strains, while strains A/eq/Ludhiana/ 87(H3N8) and A/eq/Ahmedabad/1/09 were not recognised. However, 5A7 MAb recognised an epitope of all six EIV isolates. Ludhiana/87 isolate was found different from 2008-09 epizootic. A TaqMan probe based qRT-PCR for detection of EI targeting nucleoprotein (NP) gene showed specific amplification curve for positive control and for NP gene.

Mice model for pathogenesis of equine influenza was developed in BALB/c mice using EIV [A/eq/Jammu-Katra/08]. Tissues from lungs and nasal turbinates showed positive results by RT-PCR till 5 dpi and 3 dpi, respectively, while virus could be isolated on 1 dpi from lungs. Investigations in BALB/c mice model demonstrated the virus replication in respiratory tract.

Surveillance and monitoring of important equine diseases: During the reported period, 7,462 serum samples were examined for EIA, and one thoroughbred horse was detected positive for EIA. The animal was eliminated as per policy guidelines. No new cases/ outbreaks of EIA were reported during the year. Testing of serum samples (7,601) for glanders revealed seven positive samples from Uttar Pradesh.

Prevalence of bacterial and viral causes of calf scours: Presence of the causative agent – rotavirus - for diarrhoea in organized dairy farms was detected in 18.35% samples with G6 genotype predominating followed by G10. Other infectious agents include bovine carnavirus and *E-coli* (K99 Ag) in Indian calves.

Focal outbreaks of glanders: Suspected cases of glanders as focal outbreaks were detected from Auriaya, Hardoi and Ganjdundwara blocks in Kasganj District in Uttar Pradesh. Affected equines showed respiratory illness and cutaneous lesions. CFT, WB, iELISA and dot-ELISA revealed that seven horses were positive for glanders. Cutaneous and nasal forms of glanders were observed in the affected horses in Hardoi and Ganjdundwara whereas only its respiratory form was observed in Auraiya. The effective surveillance and awareness camps organized by the NCRE, Hisar helped in controlling this dreaded zoonotic disease.

Veterinary Type Culture Collection: During the period under report, 21 viral isolates, 187 pathogenic bacteria, 45 rumen bacteria, 100 dairy microbes, 76 recombinant clones and 138 genomic DNA of bacteria from different animal species were added to VTCC

MASP *in-vitro* cultivation technique for *Theileria equi*

Micro-aerophilus stationary phase system (MASP) was used for *in-vitro* cultivation of *Theileria equi* (Indian strain). MASP cultivation system is a major breakthrough in theileriosis research as it helps the researchers in production of antigen for various purposes, maintenance of parasite in laboratory system and testing the battery of drugs in *in-vitro* culture system.

Success story

Successful treatment and foaling in an Arabian mare

An Arabian mare aged about 12 years which was barren for last 7 years, despite repeated coverings with different stallions was successfully treated. Examination of the uterine swabs showed presence of *Streptococcus* spp., *Staphylococcus* spp., and *Bacillus* spp and the animal was diagnosed as suffering from open pyometra due to chronic bacterial infection. The treatment was successful as ultrasonography after second intrauterine treatment revealed that both uterine body and horns were normal with appreciable uterine folds characteristic of estrus. Pregnancy was confirmed on day 25 of last cover and she delivered a healthy foal.

Success story

Successful diagnosis of neurological trypanosomosis

Many cases of trypanosomosis in horses, manifesting neurological disorder followed by mortality, were reported in India. The episode of neurological disorder was investigated by various national and international labs without success. Thereafter, the first batch of serum samples was sent to NRCE, Hisar. It was subjected to ELISA using whole cell lysate (WCL) and exo-antigen of *T. evansi*, together with reference positive and negative controls. Of them, 8 horses were found sero positive with both antigens for *Trypanosoma evansi* antibodies. These serum samples were subsequently subjected to immunoblot, which further confirmed ELISA positive samples. Immunoblot with exo-antigen also revealed reactivity at 66 kDa region. PCR of the representative samples of blood, brain tissue, CSF revealed *T. evansi* specific amplification. Further, mass spectrometry based protein identification from the buffy coat of the infected horse blood sample revealed presence of variable surface glycoprotein (VSG) and other trypanosomal proteins. The results supported serological findings indicating *T. evansi* infection in horses. Satellitosis and neuronophagia around the necrosed neurons was present along with gliosis and gitter cells indicating neurological trypanosomosis as no concurrent infection of JEV, WNV and EHV-1 viruses was observed in *T. evansi* sero-positive horses.

repository. At present repository has accessioned culture collection (1,630), accessioned veterinary microbes (751, 627 bacterial and 124 viral isolate cultures), accessioned recombinant clones (267) and phage library (27). The VTCC is also maintaining 11 different cell lines along with one primary culture for isolation of different viruses in the repository.

A total of 140 rumen microbes were isolated, characterized, accessioned and deposited in the VTCC repository. During the period, 89 dairy cultures were isolated and characterized, and a total of 490 bacterial cultures are presently available in the dairy microbes repository.

Four new bacteria (*Nocardia otitidiscaviarum, Moraxella ovis, Bordetella bronchiseptica* and *Delftia* spp.) were confirmed by several biochemical tests and by cloning and sequencing of 16S rRNA.

Genome sequence of *Mycobacterium avium*: Whole-genome of Indian bison type biotype of *Mycobacterium avium* subspecies *paratuberculosis* (MAP) strain S5 was sequenced. The MAP was transferred to a commercial firm under PPP mode for preparation of Johne's disease vaccine. Sequencing the genome of 'Indian Bison Type' biotype of *Mycobacterium avium* subspecies *paratuberculosis* strain S5, revealed the genome size of 4.79 Mb. A total of 90 regulator genes were found, indicating the ability of strain S5 to survive in a wide range of environmental conditions.

Skin candidiasis: An effective module was developed for treatment of skin candidiasis in camel: (i) washing the lesions with sodium thiosulphate (10%) solution on first day; (ii) application of 6% sulphur (80% sulphur) and 3% salicylic acid in mustard oil (*Brassica* spp.) on every day for one week. The recovery of hairs on skin was achieved on day 10.

Prevalence of *Amblyomma testudinarium* in mithun: About 9% mithuns (3/33) showed prevalence of *A. testudinarium* infestation in eastern region of Mizoram bordering Myanmar.

A. testudinarium is one of the largest hard ticks, which are usually 1-9 mm long before engorgement and reaches up to 23 mm in length after feeding. This tick usually parasitizes the wild animals and may infest domesticated large animals near forest area. Highest record prevalence in the North Eastern border of India adjacent to Myanmar might be due to favourable ecological and climatological factors. The present report includes Mizoram also in the *A. testudinarium* distribution map of India.

Epidemiology and surveillance of diseases: Analysis of data on mortality revealed that yak calf mortality was more within 0-30 days of age (34.67%) followed by calves aged between 1 and 3 months (30.67%). The least mortality was observed in calves over 3 months of age. Calf mortality was maximum during the rainy season (48%), followed by autumn (44%), winter (6.67%) and spring (1.37%). Causes of mortality were calf scour, chronic debility and weakness, respiratory problems and parasitic infection.

Rapid detection of pig pathogens: PCR protocols for rapid detection of *Streptococcus suis* associated with pathological conditions like polyarthritis, polyserositis and bronchopneumonia etc. in pigs were standardized. Multiplex PCR for detection of prevalent capsular types (in India) of *Pasteurella multocida* from pigs was also standardized.

Success story

Infectious cDNA clone of serotype Asia 1 FMD virus

Full-length genomic cDNA clones provide a valuable platform to modify the virus through reverse genetic techniques for research on functional genomics, elucidating the molecular mechanisms of pathogenicity and developing genetically engineered next generation vaccines with desired attributes. More than 1,000 kb of nucleotide sequence data for Indian strains of FMD virus are available. This database could help navigate the FMD virus genome and select motifs for creating modified genomes to provide mechanistic insights into the intricacies of pathogenesis, virulence attenuation and advanced vaccine designs. A genomic cDNA clone corresponding to Asia1 IND 491/1997 virus was constructed and viable recombinant infectious virus particles could be rescued. The nucleotide sequence, *in vitro* growth characteristics, plaque morphology, tissue culture infectivity titres and antigenic profile of recombinant virus were indistinguishable from those of the wild-type virus suggesting the authenticity of the virus rescued, and its potential application in developing designer virus.

Mycoplasma incidence in chickens: Incidence of *Mycoplasma gallisepticum* was determined among Indian poultry farms using standard culture techniques and PCR. The prevalence of *M.gallisepticum* was 18.6% in central, 1.0% in eastern, 1.76% in northern, and 11.25% in southern regions of India. The prevalence was 12.45% in commercial layers, 9.2% in broiler parents and 7.85% in commercial broilers.

Foot-and-mouth disease: Almost 60% of the 331 FMD outbreaks were recorded in Eastern and North Eastern states, which are not covered under FMD control programme. Maximum outbreaks were recorded in West Bengal and Asom, but no FMD incidence in Punjab and Haryana. The FMD incidence reduced in the Southern and Western regions compared to previous year.

Serotype O caused maximum (79.8%) outbreaks followed by serotypes Asia1 (15.7%) and A (4.5%). Outbreaks due to serotype Asia1 decreased by 1.5 fold compared to the last year and occurrence of serotype A remained almost same. Serotype O was most prevalent in all the geographical regions. Serotype Asia1 has been occurring regularly in Eastern, North Eastern and Western regions of the country. Serotypes O, A and Asia1 occurred in North Eastern and Southern regions. Serotypes O and Asia1 occurred in the Central, Western and Eastern regions. Serotypes O and A occurred in the Northern region. In the Northern region, serotype Asia 1 could not be detected continuously for last three years (since 2010-11), and serotype A appeared after a gap of two years (2010-12). In the North Eastern region, serotype A dominated the scenario followed by serotype O. In Eastern region, incidence of serotypes O and Asia1 increased compared to previous year.

Phylogenetic analysis of serotype O virus revealed that 'Ind2001' strains, which re-emerged in late part of the year 2008, nearly out-competed PanAsia lineage in causing outbreaks in the county. A distinct genetic cluster of Ind2001 lineage (designated here as $Ind2001^{UP\text{-}11}$) responsible for the outbreaks in Uttar Pradesh, Uttarakhand, Himachal Pradesh and Odisha last year became the major cause. Serotype O outbreaks during 2012-13 and the lineage was detected in many states in different regions of the country. The Ind2011 lineage, which appeared during 2011-12 could not be detected in any of the outbreaks this year, probably due to infection immunity or natural extinction. In serotype A, all the isolates were clustered within the genotype 18 in the maximum likelihood tree, and grouped only in the clade 18c of the $VP3^{59}$-deletion lineage. Clade 18c which was first detected in Southern peninsular India during 2007 has disseminated to Central, Eastern, Western and Northern parts of India after 2009. In serotype Asia1, isolates clustered within the lineage C indicating its exclusive prevalence since 2005. Isolates of Western cluster, which were introduced to Southern region during 2011-12, now entered into Eastern region in West Bengal and Odisha. Disease owing to serotype Asia1 in Odisha is very significant as it was not detected during last five years.

Water quality at Triveni Sangam, Allahabad

Central Inland Fisheries Research Institute (CIFRI), Barrackpore collaborated with IITs, Kanpur and Varanasi, Peoples Science Institute, Dehradun and WWF, India to determine environmental flow requirement at Triveni Sangam Allahabad during Mahakumbh 2013.The flow was calculated by building block methodology (BBM). It was recommended to maintain 1.5 m water depth with corresponding estimated flow of 310 cumecs and water surface width of 325 m. Further, analysis of water samples from 7 sampling sites in the river Ganga-Yamuna before, during and after main bathing days showed no significant changes in water quality in River Ganga at Allahabad zone due to maintenance of recommended water flow during Mahakhumbh 2013.

CIFRI is also partnering with Consortium of IITs on biological monitoring and environmental flows in the Ganga river basin under the "Ganga River Basin Management Plan".

Vaccine matching exercise was carried out to evaluate antigenic relationship of field isolates with currently used vaccine strains to monitor antigenic variation, if any, occurring in the field, and also assessing appropriateness of in-use vaccine strains. In serotype O, the vaccine strain INDR2/1975 covered almost all the field isolates showing its appropriateness. A few divergent isolates always emerge and perish. In serotype A, about 60% of the isolates did not show perfect match with the vaccine strain, IND40/2000. As occurrence of serotype A FMD virus is limited in the country, such divergence did not have impact. However, search is on for an alternate candidate strains. In serotype Asia1, the currently used vaccine strain, IND63/1972 covered most of the field isolates.

Under National FMD Serosurveillance, 40,934 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/circulation regardless of vaccination status. The test revealed overall seropositivity in ~ 26.4% samples/animals. The pattern is similar to the previous year. Under FMD control programme, 155,611 pre- and post-vaccinated serum samples were tested and of which, 54,642 serum samples were from first phase FMDCP districts (54) representing XII, XIII and XIV phases of vaccinations, and remaining 100,969 serum samples were from FMD

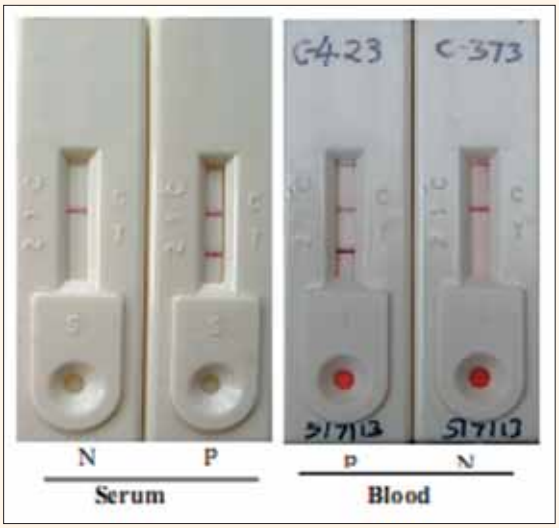
Success story

FMD pen-side diagnostic kit

Two diagnostic kits for detection of non-structural protein (NSP), 3ABC antibodies to foot-and-mouth disease (FMD) were developed at IVRI, Bengaluru. These are useful for differentiation of infected animals in a FMD vaccinated population.

1. **A rapid test:** An immunochromatographic test is intended for use by the farmers and veterinarians at the field level. The test is performed using a drop of blood/serum and gives result in 10 min.
2. **ELISA:** A laboratory based test which takes about 3 h to complete. It needs trained manpower and instrument to perform and interpret the results.

Both the tests detect FMD-NSP antibodies in all species of animals susceptible to FMD. Both the assays are highly cost effective compared to other kits. Rapid test and ELISA will be priced at a cost of Rs 40 and Rs 25, respectively. The kits have been commercialized and an MoU was signed between IVRI (ICAR) and a commercial firm.



LFD strips showing negative (N) and positive (P) results with serum and blood samples

CP districts (167) of 2010-11, representing phases I, II and III. After phase XIII vaccination, 53.6, 41.6 and 42.3% of animals tested were having protective antibody level (log_{10} 1.8 and above) against serotypes O, A and Asia 1, respectively, in post-vaccination serum samples. After phase II vaccination under expanded FMDCP, 67, 43.4 and 34.5% of animals tested were having protective antibody level against serotypes O, A and Asia 1, respectively, in post-vaccination serum samples. There was substantial reduction in occurrence of the disease in first phase FMDCP districts. The extended FMDCP areas are likely to yield positive result soon.

Epidemiology and surveillance

Web based interactive relational software NADRES (National Animal Disease Referral Expert System) developed by PD_ADMAS indicated that foot-and-mouth disease (FMD) and haemorrhagic septicemia (HS) are the top viral and bacterial diseases at national level, respectively. Classical swine fever (CSF) was next in order, of which more outbreaks were reported than *peste des petits ruminants* (PPR). Among the parasitic diseases amphistomiasis still continues to be the major disease affecting livestock. The data indicated that incidence of majority of diseases declined indicating that control measures taken up by the government are effective in controlling these diseases.

A microsoft access based software for storing the data generated at serum bank was developed. The said software was evaluated with incorporation of additional fields this year and currently, holds 14,813 serum samples. At PD_ADMAS screening of serum samples of diseases from 18 states indicated positivity for bovine, ovine, caprine, swine brucellosis; IBR, classical swine fever, bovine viral diarrhea and porcine respiratory reproductive syndrome (PRRS); and some samples were positive for IBR and BVD and IBR and bovine brucellosis; and classical swine fever and swine brucellosis.

Statistical analysis of the PPR outbreaks using data available in the NADRES database (1991 to 2011) revealed PPR as one of the top 10 diseases reported in small ruminants. Even though PPR is endemic in India, in some states especially North Eastern states, few cases were reported. Sheep- and goat-pox continues to be an important viral zoonotic disease of small ruminants. Serological survey for the prevalence of bluetongue indicated that about 80% of sheep population in Karnataka has antibodies against bluetongue virus (BTV) by one year of age. Classical swine fever (CSF) is among the most frequently reported viral diseases in the country. Serological screening of blood samples showed 48.19% prevalence of this disease— highest in North Eastern (NE) states followed by Kerala. Descriptive epidemiology performed during disease outbreaks in Karnataka and Arunachal Pradesh indicated uncontrolled movement of pigs from the neighbouring states. Phylogenetic analysis indicated that all belong to subgroup 2.2. Involvement of viruses of this subgroup in CSF outbreaks indicated a major shift from the past trend, wherein subgroup 1.1 viruses were major ones involved.

Among the bacterial diseases, haemorrhagic septicemia (HS) was the most prevalent, accounting for about 58.77% of the aggregate bovine mortalities in India. As occurrence of FMD precipitates HS, the data on FMD was also included for analysis. Comparison of disease patterns among the states indicated drastic reduction in occurrence of the disease in Andhra Pradesh from 2002-12 compared to Karnataka; the highest case fatality rate in Tamil Nadu for both HS and FMD; high prevalence rate of HS in Karnataka and of FMD in Kerala (2007-12). PD_ADMAS established microscopic agglutination test (MAT), gold standard serological test, for seroprevalence of leptospirosis in bovine and livestock species. The prevalence rate of 32 % was observed in Konkan region. The Hardjo serovar or Sejroe serogroup

was predominantly found.

Host-microbe interaction by genome-wide gene expression profiling in *Staphylococcus* aureus mastitis (Strain SA3, spa t267) was carried out. This is the first report that *S. aureus* subverts the host genome miRNA profile during IMI *in vivo*. The study demonstrated presence of intercellular adhesion genes (icaABCD), its associated genes and consequent biofilm production in *S. epidermidis* isolates of bovine milk.

Recombinant antigens targeting VSG and ISG genes of *T. evansi* were developed both in prokaryotic and eukaryotic host system. For sero surveillance of surra, 1,574 serum samples were collected from cattle and buffaloes from Karnataka, Odisha, Kerala, West Bengal, Maharashtra, Tamil Nadu and Uttarakhand; overall sero-prevalence of surra was 15.43%.

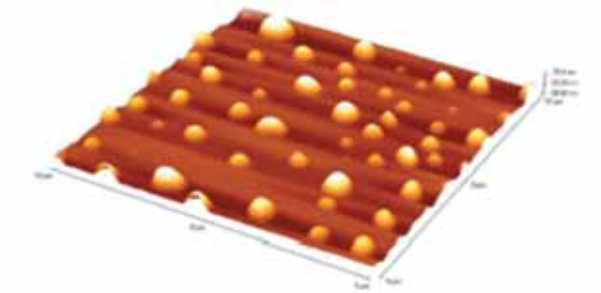
Fish health management

Viral vaccine against Noda virus: The whole cell heat-killed Noda virus vaccine developed under a collaborative project was evaluated with juveniles of Asian seabass *(Lates calcarifer)* under two different temperatures (25±1ºC and 28±1ºC) and observed for 30 days post vaccination for evaluating efficacy of the vaccine in terms of relative percentage of survival (RPS) of the vaccinated and the non-vaccinated. RPS was 80% at 25±1ºC and 60.66% at 28±1ºC. Important antioxidant enzymes like GPX, GST, SOD, GRX, CAT and LPO, and important hematological parameters like total erythrocyte count (TEC), hemoglobin, PCV, MCV, MCH and MCHC were assayed in the fish juveniles infected with Noda virus and also in fishes vaccinated and challenged with Noda virus. The results indicated that activities of enzymes elevated in vaccinated fishes compared to that of non-vaccinated suggesting the improvement of antioxidant defense system. In juveniles infected with Noda virus, haematological parameters count reduced but was at normal level in vaccinated ones. The immune genes expressed in thymus and head kidney of the vaccinated fish were higher in the vaccinated fish indicating that the vaccine is elevating immune related genes expression. These studies indicated that the whole cell heat-killed vaccine is useful for the Asian seabass to protect against the Noda virus infection.

Monoclonal antibody-based marker for monitoring humoral immune response: The monoclonal antibodies (MAbs) were raised against purified serum immunoglobulins of *Catla catla*. These MAbs are crucial for developing sensitive and specific assays for detecting circulating antibodies to important fish pathogens and are also useful tools in evaluating efficacy of vaccines. Quantification of surface Ig+ (sIg+) cells in lymphoid organs and blood revealed that a varying percentage of gated cells from kidney, spleen and blood had sIg. The percentage of sIg+ cells was highest in kidney, followed by blood and spleen. The lowest reactivity of G10/1 MAb was observed in catla thymus. This also implies that majority of thymocytes lack sIg and hence can be presumed to be T-lymphocytes. An increase in Ig+ cells was observed in kidney, spleen and blood following inoculation of killed *Edwardsiella tarda*. Therefore, G10/1 MAb can be a useful tool to study the kinetics of Ig+ cells following vaccination. The study showed that G10/1 MAb can improve understanding of architecture and functioning of immune system in a candidate species.

Diagnostics for transboundary freshwater fish viruses: PCR and RT-PCR-based diagnostics for detection of koi herpes virus (KHV) and spring viraemia of carp (SVC), respectively, were developed at CIFA. These diseases are of transboundary importance. These diagnostics having high sensitivity and specificity can be used in screening of presence or absence of these pathogens in freshwater culture environments, which has significance from export and surveillance point-of-view.

Chitosan nanoencapsulated trypsin biomimics zymogen like enzyme: Chitosan nanoencapsulated exogenous trypsin feed supplement prepared at CIFE, Mumbai first time on fish model releases enzyme in controlled manner and biomimics zymogen-like activity, thus improving the safety of use in addition to production efficiency in fish significantly. Effectiveness



Three dimension image of 0.01% trypsin nanoencapsulated in 0.04% chitosan

and safety of dietary nanoencapsulated trypsin at half the dose rate (0.01%) (D) of bare trypsin (0.02%) (C-1 and C-2) is evident from healthier villi with more height and absorptive surface.

❑

10. Mechanization and Energy Management

For achieving sustainable enhanced productivity and profitability in different farming systems, need-based and region-specific following engineering technologies related to agricultural mechanization and energy management have been developed. These include improved machinery for efficient farm operations, resource conservation; renewable energy technologies; gender-friendly tools for reducing drudgery of women farm-workers; efficient utilization of animal energy; and software for entrepreneurship development in custom-hiring of farm machinery.

Seed-cum-ferti drill for fertilizer application

For higher fertilizer-use efficiency, placement of fertilizers is recommended below the seed. Tractor-operated multi-row seed-cum-ferti drill places seeds at 50- mm depth and fertilizers at 50- to 150- mm depth. When fertilizer was applied at 150- mm depth to wheat with the drill, grain yield was maximum (5,565 kg/ha).

Five- row system weighing 180 kg requires 33-kW tractor for operation and covers 0.2-0.35 ha per hour.

Tractor-operated multi row seed-cum-ferti drill

Trench- planter for sugarcane

This tractor- operated planter is for planting cane in a trench of about 25–30 cm deep. Two rows of canes 30-cm apart are placed at the bottom of the trench. Fertilizers and insecticides are dispensed; cane setts are covered with soil, and sub-surface lateral for drip irrigation system is also laid; all these operations are carried out in a single pass. It can cover one hectare in 3–4 hours, depending upon the plot size. The cost of operation is one-third of the conventional planting.

Fertilizer-band placement cum earthing-up machine

This tractor (26- kW and above)- operated machine simultaneously places fertilizers, earths-up and cuts

weeds in maize, sugarcane and potato having more than 0.50-m row-to-row spacing. The field capacity and efficiency of the machine are 0.56 ha/h and 82.4%, respectively, and with this, there is considerable saving in fertilizers, time and labour over the traditional method.

Two-bed and eight-row carrot planter

This planter is for precise planting of carrot-seeds on the raised beds with a ridge height of 20 cm; and plants carrots in four rows on the each bed at row- to-row spacing of 7.5 cm. The average depth of seed placement is 2.25cm. The field capacity of the machine is 0.5 ha/h.

Manual onion-seeder

A two- row, manually -operated inclined plate- type onion-seeder covers 0.04 ha per hour effectively at an average speed of 1.24 km/h.

Manual drawn FYM applicator

The applicator fabricated consists of twenty-six rectangular openings, 3-cm apart at the bottom of the box to apply FYM in the field. An MS rod stand of 55 cm is also fitted at the centre of the arm to keep the unit in stationary position while filling-up FYM in the box. The storage capacity of the FYM applicator is 20-25 kg FYM with an application rate of 4.5-5.0 tonnes/ha.

Canopy-spraying system

Spray patterns of the selected nozzles of a modified intra-canopy spraying system were measured at 45 and 80 days after sowing (DAS) in soybean and at 90 and 120 DAS in pigeonpea. Six rows of pigeonpea were sprayed, covering a width of 3.6 to 7.2 m (row-to-row spacing varied from 0.6 to 1.2 m), and twelve rows of soybean were sprayed, covering a width of 4.2 to 5.4 m. The machine was also tested for spraying six rows of pigeonpea sown at 90 cm row-to-row spacing. The field capacity and efficiency of the machine were found 0.92 ha per hour and 77.4 %, respectively.

Air-assisted vertical boom sprayer

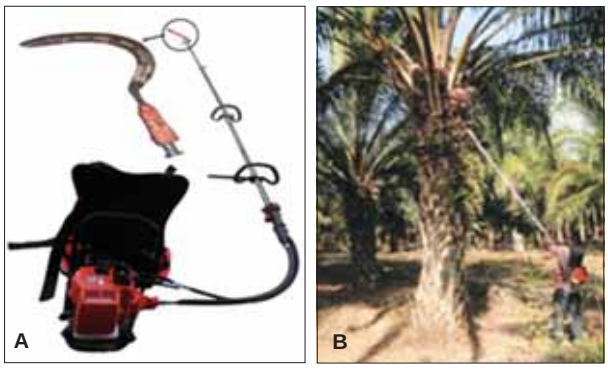
An air- assisted vertical boom sprayer for applying insecticides and other chemicals to fruit- crops operates at 540 rpm by tractor PTO; the nozzle discharge is 1.42 litres/min at 2,000 kPa pressure. Its field capacity and efficiency are 1.70 ha/h and 81%, respectively.

Solar powered knapsack sprayer

The knapsack sprayer developed for small and marginal farmers can be operated continuously for 6–8 hours. Its constant pressure system and quality spray result in effective control of pests.

Motorized tool for bunch-harvesting of medium-tall oilpalm

Motorized bunch-harvesting back-pack mounted tool for medium-tall oilpalms operates by a 50 cc, 2-stroke petrol engine of 1.3-kW. It weighs 12 kg; has a light-weight engine, flexible shaft, light- weight telescopic pole and a cutter- head mechanism. The equipment tested in Andhra Pradesh, Tamil Nadu and Kerala could conveniently be used up to a height of 5-6 m. The average number of oilpalm-trees harvested were 15 per hour, depending on the efficiency of the operator, number of mature bunches per plant, orientation of bunches and land profile.



(A) Back pack model oilpalm harvesting equipment;
(B Evaluation of motorized bunch harvesting tool

Tractor-operated groundnut-digger elevator

The tractor- operated digger elevator consists of a blade,an elevator-cum-pick-up reel, fenders, a gauge wheel, coulters and a power transmission system, and is operated with a tractor of 26- kW or more. The front end of the pick-up cum elevator reel is adjustable based on the depth of the working blade, and front end of the pick-up rod is adjusted so that spikes comb about 30- mm of the top soil to lift vines gently from loosened soil. The machine uproots and inverts 0.16-0.21 ha of groundnut per hour.

Particle drift of air-assisted spraying systems

Three different types of spraying equipment – air- sleeve boom, boom sprayer and aero- blast sprayer were evaluated for particle drift in fields for varying wind speeds (1.5, 1.7 and 1.8 m/s), temperature (22° C, 28° C and 34° C) and relative humidity (54, 58 and 69%).The increase in variables from 22 °C,54 %, 1.5 m/s to 34° C, 69 , 1.8 m/s augmented drift from 30.6 to 52.3, 37 to 57.6 and 57 to 83 µg at 5-m distance and 18.3 to 25, 19.6 to 31.3 and 35 to 48.6 µg at 10-m distance for air-sleeve boom sprayer, boom sprayer and aero- blast sprayer, respectively.

The highest drift was with aero- blast sprayer, followed by boom sprayer and air- sleeve boom sprayer. Maximum drift was observed at 0.4 and 0.9 metre high zone area at 5 and 10 m distances, respectively, from sprayers in the laboratory and in the field experiments.

Improved combine harvester

The two-row tractor-operated potato combine harvester has been improved for better separation (85%) and to reduce tuber bruising (<2%).

Large cardamom harvesting knife

An improved knife weighing 170 g, made of EN8 spring steel, reduces force required in operation and drudgery and thus minimizes chances of accident;400 improved knives were given to workers (270 males and 130 females).

Large cardamom harvesting knife used in the North-Eastern Hills

Tractor-mounted root crop harvester-cum-elevator

Digging onion and other root crops is a labour-intensive operation. A tractor- mounted machine for digging and elevating root crops has a field capacity of 0.28, 0.24, 0.21 and 0.21 ha/h for digging carrot, potato, garlic and onion, respectively, at a forward speed of 2.78, 2.41, 2.10 and 2.10 km/h. The damage was less than 1.0% for digging of carrot, potato, garlic and onion crops. Saving in labour for harvesting onion, carrot and garlic was 69.0, 59.2, 69.0 %, respectively, compared to manual harvesting.

Root crops harvesting system

Arecanut sheath shredder

Arecanut sheath is a good alternative as a fodder for cattle. Its sheath length and breadth ranges between 50-120 cm and 20-35 cm. A compact- and- energy-efficient arecanut shredder developed can be utilized for dry as well as moist arecanut sheaths. It consists of a drum that rotates at a speed of 800 rpm and has four blades, and a counter- shear to shear- cut in both directions. The shredder operates by a 2.2- kW electric motor, and has a capacity of 100 kg/h, and shreds sheaths into particles of 5-8 mm.

(A) Arecanut sheath shredder; (B) arecanut fodder

Multi-millet thresher

Threshing of millets is a labour- intensive practice. Multi-millet thresher of 1,300mm × 1,300mm × 1,100 mm, weighing approximately 150 kg and operated by a 1.5- kW-electric motor, considerably reduces drudgery. The thresher capacity is 50 kg of *kutki*-grains per hour with more than 95% de-hulling efficiency; and this can be customized easily for all small millets by changing sieves and operating parameters. The thresher may even thresh millet crops of higher moisture content compared to traditional practices, thereby minimizing post-harvest losses.

Multi millet thresher

Seed extractor

For onion, a power-operated seed-extraction machine to extract seeds from sun-dried umbels was developed to enhance the capacity and to complete operation in time as compared to manual seed extraction. The machine performs well with extraction capacity of 28.9 kg/hour), extraction efficiency (99.7%), specific energy consumption of 0.051kWh/kg and minimum seed damage of 3%. The mechanically extracted seeds have good germination (96%) and vigour index (7,736).

ARECANUT DEHUSKERS

Women- friendly rotary arecanut dehusker

Hand-operated arecanut dehusker suitable for women-workers consists of a hopper, a conveying screw, cutting tips and a handle. Graded nuts are fed into the conveying screw through the hopper. The capacity of the unit is 5 kg per hour and it costs ` 3,000.

Pedal-operated arecanut dehusker

Dehusking efficiency, kernel breakage and dehusking capacity of this arecanut dehusker is 97 %, 6.7 % and 15 kg per hour, respectively. The unit is mounted on wheels, weighs 110 kg, and costs ` 25,000. The mean heart rate of male- workers operating the unit was 127 beats per min.; indicates that it can be operated continuously and comfortably.

Hybrid *ber* grader

A hybrid *ber* grader of capacity 500 kg/hour was developed for grading mixed lot of *ber* into three sizes, i.e. >35 mm, 25-35 mm and <25 mm to enable farmers to get higher price on premium-size fruits.

Dehusker for kodo millet and *kutki*

An eco-friendly and an energy-efficient millet mill is being utilized for de-husking foxtail millet, little millet, kodo millet, proso millet and barnyard millet. It has a capacity of 100-110 kg of millet- grains per hour (at 10-12 % moisture content) with 95 % de-husking efficiency.

Software for custom-hiring of farm machinery

This software facilitates selection of an appropriate farm machinery for a given cropping system and a set of agroclimatic conditions. With the software, finalization of operating parameters of the selected machinery can be done for maximizing benefits, and it has been demonstrated to stakeholders from different states.

Gravity-based ropeway system

The ropeway system, consisting of two trolleys, rolling over two separate steel- wire ropes (track ropes), suspended from two towers, transports materials from road to fields in the hilly terrain. The trolleys are connected to a single looped wire rope of smaller diameter (hauling rope) in between two track ropes, at two extreme levels by means of cable ties. When the laden trolley rolls down by its own weight along the one-track rope from the upper station, another trolley with the lighter weight at the bottom station hauls up along the next rope. A flywheel brake is fitted at the lower station to regulate speed of moving trolleys. The ropeway has a slope of 30 degrees, and weight ratio of downward and upward moving load is at 3:1. Cost of 150-m ropeway unit is ` 2 lakh.

Gravity-based ropeway for hills

Fishing vessel for managing natural marine resources

The CMFRI procured a 19.75 m OAL fisheries research vessel F.V. Silver Pompano for carrying out fisheries related research in the territorial waters under NICRA. The vessel shall be used for trawl fishing both bottom and mid-water trawling using Issac-Kid Midwater Trawl system and collection of oceanographic parameters and marine biotic and abiotic samples from the sea. The vessel is equipped with underwater CTD sampler, Doppler current meter, instruments for chlorophyll measurement, zooplankton, TSS and sediment sampling. The vessel has a laboratory for preliminary analysis and to fix samples for further analysis. An automatic weather station is available to collect atmospheric parameters rainfall and humidity.

New Fishing Vessel for managing natural marine resources

Mobile fish vending unit

A prototype mobile fish vending unit was developed at CIFA. The major features of the system include a cycle rickshaw, 170 L chilled box (requires ice 42.5 kg); 66 L tray; cutting and processing area, 0.42 m^2; capacity of storage water, 10 L; waste disposal volume, 8.0 L; scales and fins disposal volume, 8.0 L; insentient disposal volume, 8.0 L; capacity of semi- process products, 50 kg; capacity of whole fish process products, 120 kg. The unit cost is estimated to be ` 52,780. It provides best possible market quality, a proper form of semi-processed or final product, health safety of

products, and applies the most rational raw processing method. Unit is suitable in urban/municipality areas with proper waste disposal.

Fish meal plant

CIFT, Kochi designed and developed a 10 kg capacity fish-meal plant out of SS 302. The equipment consists of a chopper to input fish/fish waste, which is followed by a fish cooker. Fish cooker is screw type with variable speed using VFD technology, which gives the flexibility of using different fishes having different cooking time. The cooker is fitted with pressure gauge, dial thermometer and safety valve for standardizing the system with different variety of fishes. The machine also contains a hydraulic type oil extractor to extract fish oil after cooking, which will be collected outside the machine. An electrical fish dryer is also incorporated to dry the slurry of the extractor, which is used as fish meal.

AGRICULTURAL ENERGY AND POWER

Biogas-storage system

A biogas-storage system consists of a moisture-absorption unit, a compressor and a storage cylinder. Moisture from the gas is removed by passing through moisture-absorption unit filled with 3A molecular sieves (alkali metal alumino silicate) prior to compression. Moisture- free gas is compressed into a cylinder at 9-bar pressure. Time required for compressing 1 kg gas is 20 min. The compressed gas is filled into CNG cylinder, and gas stored for 2 months under ambient conditions showed no change in its composition. Methane content was 80 % prior to storage and remained same even after two months storage.

Biomass-based decentralized power plant for agro-enterprises

A 100- kW biomass- based power generation system integrated with biomass-briquetting plant (500 kg/h) was installed and commissioned at Silari, Udaipura in Raisen district in a decentralized mode. It consists of an open-core gasifier, a gas cleaning-and-cooling unit, a Cummins engine gen-set and an electrical control panel. Briquettes of soybean-straw and pigeonpea- stalk (60 -mm diameter) were used as a fuel to operate the

100 -kW biomass-based power plant

gasifier. Electricity generated from the gen-set is supplied to operate a *dal* mill (65-kW) and a briquetting plant (30–35-kW). The biomass consumption of the plant varies from 95 to 100 kg/h.

Electronic Control Module for automatic supplementation of LPG to producer-gas

An electronic control module (ECM), consisting of a speed sensor (rev/min), a programmable logic controller (PLC) and a relay-and-power supply unit, supplements liquid petroleum-gas (LPG) automatically to a biomass-based power plant to avoid sudden fluctuations in load. The complete system (ECM + LPG) evaluated with producer- gas- based electricity generation system of 20- kW required recovery time of 5–7 seconds to govern speed change at different load variations while running gen-set with producer-gas alone, as compared to 7–9 seconds with manually controlled LPG supplemented system. The transient speed change was within acceptable limits; with no permanent speed change when load on the system varied, and ECM was used to supplement LPG- blended producer- gas at the time of changing of load.

Torrefaction unit for processing biomass

A torrefaction unit for thermal treatment of biomass (soybean and pigeonpea) reduces energy consumption and increases calorific value for efficient gasification. The system was evaluated for treating biomass at temperatures ranging between 200 and 250°C. The torrified biomass formed uniform-sized particles during grinding, and energy consumption was reduced by 20% as compared to the untreated biomass. The recovery of biomass after torrefaction varied from 65 to 80%, and calorific value of the biomass increased from 17 MJ/kg to 20 MJ/kg.

Kitchen-waste-based Prefab balloon digester

Prefab balloon digester was commissioned at Sainik School, Chittorgarh, to handle about 200 to 250 kg of kitchen-waste per day. About 12 m^3 gas/day was generated and was used for cooking meals; saving at least 15 LPG cylinders in a month. The capital cost of the plant was ` 2.50 lakh, and its operating cost was about ` 100 per day. The payback period is approximately 2.90 years.

Biomass combustor for bulk drying of farm produce

A prototype of biomass combustor to generate hot air up to 120°C for various thermal applications has highest thermal efficiency of 64.6% with mixed fuel- wood and 62.3% with biomass briquettes for air- flow rate of 800 m^3/h and fuel- feeding rate of 4 kg/h.

ANIMAL ENERGY UTILIZATION

Dung-collection machine

Two models of dung collectors have been developed to facilitate cleanliness and sanitation in animal/dairy to farms. One model operates by 750- W electric motor and the other by 1.0- kW petrol- engine. Capacity of dung collection was 225 kg at a speed of 1.99 m/s by the former model and was 105 kg at the speed of 0.84 m/s by the latter model.

(A) Petrol-engine-operated dung collector; and
(B) Electric-motor-operated dung collector

Animal-drawn drum seeder

An animal-drawn onion drum seeder with adjustable row-row spacing in seed chambers mounted on a rotating shaft driven by ground wheel for seed sowing on flat beds was developed. The operating width of machine is 1.7m with a field capacity of 3 ha/day and seed rate of 7.5 kg/ha.

Bullock- drawn wedge- and wing- plough for narrow hill terraces

A bullock- drawn wedge- plough, weighing 13 kg, for tillage and puddling on narrow terraces of hilly region of Sikkim, has a field capacity of 0.25 ha/h for tillage at 150- mm depth and of 0.02 ha/h for puddling at 190- mm depth.

A wing- plough for shallow tillage and puddling up to 100-120- mm depth, weighing 8 kg, has a field capacity 0.025 ha/h for puddling and of 0.03 ha/h for tillage at speed of 2.2 and 2.4 km/h; ` 300/ha were saved by these implements compared to the traditional wooden- plough.

❑

11. Post-harvest Management and Value-addition

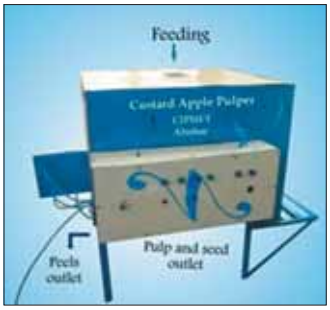
Post- harvest management and value-addition has the potential to reduce losses in food, enhance food nutrition, improve food quality, utilize by-products and improve income through employment opportunities. Development and commercialization of tools, equipment for primary and secondary processing of farm produce, process protocols for value-added products, methods for quality evaluation of foods have been attempted. The current research efforts are targeted for development of equipment, process protocols and value-added products for farmers, entrepreneurs and other stakeholders involved in the value-chain.

Equipment

***Makhana* popping and decorticating machine:** Manual processing of *makhana (*gorgon nut) involves cleaning, sun-drying, size-grading, roasting in the traditional earthen-pots or cast-iron pans over fire for 4-5 minutes; this is tedious, time-consuming, energy-intensive and involves lot of drudgery, and also requires skilled manpower.

A *makhana* popping and decorticating machine designed with a capacity of 35-40 kg of raw wet-nuts/h has a popping efficiency of more than 90%. The machine consists of a roasting and a decortication/popping unit. In the roasting unit, *makhana* is heated at 200 to 300ºC, and then conveyed to decortication /popping unit. The popping unit consists of a casing and an impeller assembly with a hard impact surface. When hot nuts strike the impact surface, shells get broken, and due to sudden drop in the pressure, kernels pop-up. The design of this machine has been licensed to M/s Jwala Engineering and Consultancy Ltd, Ambala, for mass manufacturing and marketing.

Automatic custard-apple pulper: The pulper performs three functions— fruit-cutting, fruit-scooping and pulping. Fruit- cutting part of the machine has two opposite rotating rollers with fruit- holding cups. Fruits are cut into two halves by a stainless-steel knife. The cut-halves are inverted and moved on to a stainless steel sieve and are pressed by a pressing plate. The seeds pass through the sieve, and peel remains on it.



Custard-apple pulp scooping machine

Custard-apple pulper

A pneumatically actuated scooping plate, running below the sieve, removes pulp collected in the tray. The peels are removed from the sieve with a sieve-cleaner. The capacity of the pulping machine is 120 kg/h with a recovery of 94 % pulp (coarse pulp 70-72% and fine

Foldable plastic boxes for safe fruit transportation

Foldable plastic- box has individual cell size fixed on the basis of the average size of the fruit to be packed and transported. For sapota transportation, size of the plastic box is 390 mm × 325mm × 245 mm (total volume 0.031 m^3), and cell size is 60 mm × 60 mm × 55 mm. Fruits are arranged in four layers in the box. Each layer is separated from the adjoining by a plastic sheet. Number of cells per layer is 30 and the total number of cells per box is 120. For air circulation, 5- mm holes are made on the sheet in each cell with the outer sheet having perforation of 0.90 %. The box is made with full-corner reinforcement to bear load of the upper boxes during transportation. The folded dimensions of the box are 725 mm × 585 mm × 30 mm (total volume 0.013 m^3).

A comparative study of the newly developed foldable plastic boxes with corrugated-fibre board boxes was done in transporting sapota-fruits from Junagadh to Jamnagar and from Jamnagar to Junagadh. The overall cost of packaging, handling and transportation of sapota over 300 km in the foldable boxes was ` 2 per kg of fruits. Hardness, firmness, bio-yield point, rupture force and marketable fruits were found better in newly developed boxes and losses in terms of bruising, cracking, impact damage, ripening and decay were also minimal in foldable plastic boxes.

Foldable plastic box with cells

pulp 28-30 %). The design of machine has been licensed to M/s NEXTGEN Drying Systems, Pune.

Cryogenic grinding system for spices: The conventional grinding of spices results in an inferior quality dark powder of coarse particles with lesser volatile oil. Moreover, it is difficult to operate conventional grinder continuously due to choking of powder over the grinding surface. To overcome, these problems, a cryogenic grinding system has been developed that consists of a precooling unit (a screw conveyor assembly and a liquid-nitrogen dewar), a grinding unit (pin or hammer mill), a cyclone separator to collect fine powder, a sieving unit for grading powder, and a control panel to regulate temperature, speed of screw assembly in the precooling unit and of grinder. All contact parts of the machine are made of stainless steel (SS-304).

Depending on the spices, capacity of the cryogenic system is 30-40 kg/h. The system was tested on black pepper, coriander and fenugreek seeds at 10°C and –50°C. At –50°C, about 25-30% higher volatile oil content could be obtained in ground powder in comparison to 10°C. Cryogenically ground powder also showed finer particle size, lighter colour, and higher retention of total phenols, and flavonoid and antioxidant contents. The design of the cryogenic grinding system has been licensed to M/s Spectra Cryogenic System Pvt. Ltd.

CIRCOT-phoenix *charkha:* The *charkha* has been found efficient for spinning coarse, long-staple fibres of banana pseudostem at the cottage level. It produces fairly fine yarn with sufficient uniformity from natural fibres, otherwise difficult to spin. A moderately skilled operator can produce about 4.0 kg of yarn in a day.

Yarn count from the *charkha* can vary from 150 to 600 tex. A trial was carried to produce various types of yarns; their tensile characteristics were found at a par with mill-made yarn. With this *charkha*, a yarn count as fine as 149 tex (4s Ne) could be produced for making home - furnishing fabrics.

Handloom for weaving jute-based ornamental fabric: An upgraded handloom has been developed with double jacquard system for weaving jute-based quality fabric, and especially ornamental fabric. This handloom has the following special features: Holding capacity of cloth- roller is more than 50 metres of decorative jute fabrics of 400 gram per square metre; has bigger shuttle box (58.5cm ×5.7cm) and slay-race (6.5 cm wide) to run large shuttle (up to 40cm × 5cm) that can accommodate larger (up to 18 cm length) pirn. The yarn content in the pirn increased to 24 g (almost 400% higher) as against 6.5 g used in the traditional

Mobile poultry processing unit-cum-retail meat stall

A mobile poultry processing unit-cum-retail meat stall designed is found suitable to produce safe and hygienic meat with the latest quality norms.

The stainless steel unit weighing 500 kg is of 2,410mm × 1,345mm × 2,058 mm, and costs approximately ` 5.50 lakh (2012-13). Its capacity is 35-40 birds per hour. It consists of two water tanks, bleeding cones and troughs, a scalding tank, a de-feathering machine, a carcass washing unit, a teflon board for cutting carcasses, an insulation box, crates for holding 50 line birds and work area for preparation of value-added products.

Success story

Gum -inducing technique for increasing income of farmers

A method of tapping gum from *A.senegal* using gum inducer (ethephon), which has been in use since 2008-09, has been developed. Farmers of 45 villages of Chauhatan and Baytu tehsils of Barmer district; Shergarh and Phalodi tehsils of Jodhpur district; and some villages of Nagaur and Pali districts have adopted this gum- inducing technology. Total number of 30,000 trees were treated with gum inducer during 2012-13, resulting in production of 12 tonnes of gum Arabic. This year, the average rate for gum Arabic was ` 700 per kg in the local market. Thus, farmers earned revenue of ` 8,400,000. Besides *A. senegal,* other gum- yielding trees —*A. tortilis, A. nilotica, A. leucopholea, Prosopis cineraria, P. juliflora, Annogesius rontundifolia,* — are also being treated by villagers.

Gum arabic production and economic returns in 45 target villages of Barmer, Jodhpur and Nagaur districts of arid western Rajasthan

Particulars	Year					Total
	2008-09	2009-10	2010-11	2011-12	2012-13	
Number of *A. senegal* trees treated (in thousand)	12.1	20.95	22.61	27.5	30	113.16
Production of gum Arabic by farmers (tonnes)	5.45	10.48	7.67	11	12	46.58
Total income earned by farmers (Rs in lakh)	27.23	52.38	38.33	77	84	278.93
Revenue generated by CAZRI (Rs in lakh)	1.21	2.1	2.25	2.75	3	11.3

cotton handloom; has automatic take-up and let-off arrangement; has double beam arrangement for different quality and fineness of warp yarn; and has special harnessing arrangement for coarser jute-yarn use in warp.

Continuous hot- air puffing system for oil-free puffed, ready-to-eat snack-food: The continuous operation of the system with recirculation of hot- air results in five-fold increase in capacity and 60 % reduction of heating- load over the existing conventional batch- type puffing system. The cost of the machine is ` 30,000, and the cost of the product works out at ` 125 to 140 / kg. The system operates with 1- hp blower and 8 -kW heaters, and has an input capacity of 6 kg/h and an output capacity of 5.0 to 5.5 kg/h. It prepares oil-free and shelf-stable puffed ready-to-eat snack-food from rice-mill and *dal* mill by-products. The optimum composition for production of puffed snacks is 80% rice brokens plus 20% dal brokens. Cold rectangular extrudates are puffed at 250°C, and the end- product has a shelf- life of 5 months.

Pilot plant for solid and liquid jaggery: The pilot plant consists of a three-roller crusher (capacity 800 kg/h), an electric motor (7-hp), a furnace with four pans, a stainless steel juice tank (500- litre capacity),a stainless steel trolley (200 kg), a juice pump, water pump and a weighing balance. Benefit: cost ratio, payback period and break-even point for preparation of solid jaggery were, respectively, 1.51, 1.15 years and 53.6 %, showing viability of the unit.

Process protocols

Tender coconut- husk extract for cotton-textile dyeing: Cotton-fabric mordanted with tannic acid and alum was dyed with extract from tender coconut- husk to reddish- pink shade at an alkaline *p*H. Treatment with copper sulphate or ferrous sulphate as secondary mordants improved shade. Dyed samples showed good grades for light shades, and very good grades for washing and rubbing. But, need improvement in fastness to perspiration, as colour changes to darker shades.

Samples dyed in rope-dyeing machine

Scale-up trials of the process were carried out with rope-dyeing machine and in rotary pressure vessel, and uniform colour dyeing was obtained on cotton- textiles with good colour strength (K/S) and UV protection (UPF).

Cotton- textile flame-retardant finishing with banana-pseudostem sap: Bleached and mercerized cotton-fabric mordanted with tannic acid (5% owf) and alum (10% owf) was treated with pseudostem sap in alkaline *p*H at the near boiling temperature with continuous shaking and then drying in an oven. The fabric showed good flame- retardant property, as its limiting oxygen index improved by 1.6 times of the untreated control to reach 31. Thermogravimetric analysis showed pyrolysis of the treated fabric being started at 240°C (as against 320°C in control), and it was much slower. Fixation of nitrogenous and phosphatic substances and minerals of the sap onto the fabric has imparted flame- retardant property. Finished fabric was light yellow and showed very good UV protection with a UPF of 50+.

Dry-retting of jute using pectinolytic fungi: Conventional retting of jute- plant for producing good quality fibres requires 20 times water of the biomass. A pectinolytic fungal culture has been developed for dry retting. These fungi function in aerobic condition, and produce alkaline reaction during retting by

producing a special enzyme pectin lyase and a common enzyme exo-polygalacturonase, and require no water for retting. Even methane or other obnoxious gases are not produced during fungal-retting.

Tensile strength at break, work of rupture, hairiness index, lustre percentage and thick and thin place ratio showed yarn of reasonably good quality for textile-use and for handicraft.

Fibre quality of 90-day-old plant by fungal dry-retting

Fungus	Root content (%)	Fibre strength (g/tex)	Fibre fineness (tex)	Fibre grade
Aspergillus tamarii	5	22.7	2.1	TD-5, 60% up
Aspergillus flavus	5	24.4	2.8	TD-4
Aspergillus niger	5	22.7	2.7	TD-5, 90% up
Sporotrichum thermophile	5	24.2	3.0	TD-5, 50% up

TD – *Tossa deshi*

Chemical-retting of raw-coconut fibres: The chemical process involves treatment of fibres with a combination of aqueous solution of sodium sulphide, sodium hydroxide and sodium carbonate at 90–100°C for 60–120 min. Coconut fibres softened up to 50% as compared to raw un-retted fibres.

Early detection of deadly lac insect parasitoid: *Aprostocetus purpureus* is the principal cause for pre-summer mortality of *rangeeni* lac, leading to crop failure. A PCR- based method facilitates early detection of parasitoids in lac-insect culture, using 18S rDNA primers specific for amplifying *A. purpureus* DNA. Early detection enables adaptation of timely management practices to save lac- crop.

Banana: Robusta banana harvested at 80% maturity could be stored for 72 days at Modified Atmosphere Packaging (3%O_2 + 10% CO_2). *Udhayam* banana harvested at 75% maturity had 60 days shelf-life at 13.5°C storage temperature when compared to 14 days at ambient room temperature. *Rasthali* (*Mortman*) banana could be stored up to 102 days at 13.5°C with improved post-harvest handling techniques. *Poovan* banana ripened with 100ppm ethylene treatment for five hours in the ripening chamber at room temperature was highly acceptable with a hedonic scale of 7.41.

Guava: With two per cent chitosan coating, unripe green Allahabad Safeda fruits could be stored for three weeks at 8°C temperature without affecting quality.

Bael: Technology for bael cider (4% alcohol, 16.9^{0}Brix TSS, 0.63 % acidity and 266 mg/100ml polyphenols) production having natural flavour and taste using *Saccharomyces cerevisiae* through alcoholic fermentation was standardized. It could be stored for one year at room temperature.

The powder prepared from bael pulp could successfully be stored up to five months at room temperature and RTS prepared from this powder was highly acceptable.

A rapid LC-ESI-MS/MS method was developed for simultaneous determination of five bioactive molecules, i.e. umbeliferone, psoralene, marmin, imperatorin and skimmianine in bael root and stem bark extracts, the content being higher in roots.

Jackfruit: Fresh flakes (without seeds) of ripe jackfruit were preserved by hurdle processing. The yield of fresh flakes was 28 %, loss in weight of flakes due to blanching 22.73% and the yield of finished product 51.79% of prepared flakes and 14.5% of whole fruits. It had 19-21.0% moisture and 6 months shelf-life.

Grapes: Early pruning with higher crop load (40 bunches/vine) caused reduction in acids (5.90 g/litre) in Cabernet Sauvignon berries. Degree days and sunshine hours were positively correlated with TSS and negatively with acidity. Raisins prepared from Thompson Seedless dipped for four minutes in 25 ml ethyl oleate + 40 g potassium carbonate/litre solution were of better quality. Better quality wines with respect to acidity (pH 3.63), total acids (4.48 g/litre) and malic acid (2.60 g/litre) were produced from berries harvested from late pruned vines. Early pruned vines produced wine having high colour intensity (3.71), tannins (1096.87 mg/litre), total polyphenol index (274.88) and malvidin-3-glucoside (348.04) as compared to later pruned ones.

Litchi: Post- harvest losses in litchi at various stages of delivery chain were quantified in the samples from retailers and venders. It accounted sunburn (1.5- 44.5 %), cracked (0.5-14.0 %) and physically or mechanically damaged (nil to 44.1%) fruits during growth to harvesting. Three fungal pathogens (*Alternaria* sp., *Colletotrichum gloeosporiodis* and *Aspergillus niger)* were identified causing post-harvest losses. In storage, sulphited fruits were spoiled due to *Alternaria* sp.Fruits treated with Carbendazim (0.05%) + citric acid (2%) + KMS (500ppm) and chitosan (1%) and packed in recycled poly bag (doubled) resulted in minimum fruit loss (6.57%) under ambient conditions on 4th day of harvesting, followed by LDPE packed fruits (7.77%). Post harvest losses of fruits transported to New Delhi market on third day of harvesting was reduced due to packing in polyethylene bags plus CFB boxes (15.6%) as compared to traditional packing (26.56%. Fermentation of litchi juice at 15°C retained freshness and fruity aroma like methyl propanol, ethyl ester (42.5mg/litre) and total acetate (2.40mg/litre) wine due to low sugar fermentation rate (0.61g/litre/hour). Maximum damage in nuts (76.04%) was observed due to pre treatment with boiling water followed by KMS (0.1%) and citric acid (2%).

Pomegranate: The maturity indices of pomegranate Bhagawa were 180 days after setting or 15.9°Brix TSS, acidity (0.48%) and TSS/acidity ratio (33.2), while for Ganesh, the fruit maturity indices were 150 days after setting or TSS (16.1°Brix), acidity (0.45%), and TSS:acid ratio (35.7) under Solapur conditions.

The technique of preparing ready-to-serve (RTS) beverage from pomegranate Bhagawa and Ganesh was standardized. The technique for wine (8-11% alcohol, 0.85g/100g acids and 11.5°Brix TSS) preparation through fermentation of juice was standardized.

Apricot: Type of material and sugar solutions significantly affected the time required for dehydration (15±2% moisture level). Half fruits without stone (HWOS) took minimum time for dehydration as compared to whole fruits without stone. Half fruits without stone dipped in 55° Brix sugar solution and pre-drying treatment with 1% KMS took least time (37 h) for drying up to 15±2% moisture. Maximum dehydration (moisture loss) during osmosis (dipped in sugar solution) was recorded in case of half fruits without stone treated with 1% KMS and dipped in 55° Brix sugar solution. Total soluble solids, acidity and ascorbic acid contents varied significantly due to type of planting material, sugar solution and treatment with KMS (1%). Maximum TSS (24.2°Brix), acidity (0.37%) and ascorbic acid (17.5 mg/100 g) were recorded in HWOS dipped in 55° Brix sugar solution and pre-drying treatment with 1% KMS.

Plantation crops: A simple technique to collect fresh and hygienic inflorescence sap (*neera*) from coconut and a process for making natural coconut sugar and jaggery from fresh sap was developed. Biochemical analysis indicated lower free fatty acid content, higher polyphenols and 9 times higher antioxidant activity of virgin coconut oil (as catechol @ 18mg/100g oil) when compared with traditional (2mg/100g oil) coconut oil.

Brinjal: After 12 days of ambient storage, minimum decrease in fruit firmness was recorded in PEG used as humectant and sodium alginate (SA) based carnauba wax emulsion as surfactant, followed by commercial 'Niprofresh' carnauba wax emulsion (8.56-4.95 N) and sodium dodecyl sulfate based carnauba wax emulsion. During storage for 12 days, maximum total phenol content and antioxidant activity was retained in PEG and SA based carnauba wax treatment and it can be adopted for enhancing storage life of highly perishable vegetables.

Chilli and capsicum: Green chilli packed in 3 kg CFB boxes and over-wrapped by shrink film wrapping could be stored for three weeks at 8°C with farm freshness and weight loss of 4.9 % as compared to 9 % loss in non-wrapped chilli. Capsicum could be stored in harvest fresh condition without shriveling and with maintenance of firmness for seven days in high humidity, low cost polyethylene storage tent with a weight loss of only 2.2% compared to 8% within three days in control (25 -30°C and 40-52% RH).

Carrot: Large variability in total phenols (7.98-291.48 mg/100g) and flavonoid (2.49-111.66 mg CE/100g) in 21 Indian carrot varieties was recorded. Maximum anthocyanin (243.05 mg/100g) was observed in black genotype Pusa Asita. Black Beauty, Pusa Asita, Pusa Meghali, Pusa Rudhira and Pusa Vristi varieties had higher antioxidant. Anthocyanin derived from black carrot exhibited higher stability as compared to black grape for lower rate constant, higher half-life and activation energy.

Onion: Application of CIPC @ 2% at 75 DAT reduced sprouting in *kharif* produced onion but was ineffective in *rabi*, whereas $CoCl_2$ was effective in arresting sprouting in *rabi* produced onion. Post-harvest application of ethanol (2%) was superior in reducing post-harvest physical losses in *rabi* onion up to four months.

Tuber crops: Gluten-free, low glycemic and functional pasta from cassava, low glycemic spaghetti from sweet potato; protein and fibre fortified pasta from *Amorphophallus* and yam were developed. Stable natural colour-cum-health protectant from *Dioscorea alata* and sweet potato was developed. Processes for the production of de-branched starch with high resistant starch content, neageli dextrins and lintnerized starches were developed. A technology was perfected for production of porous super-absorbent polymer from tuber crops.

Potato: In seed potato, treatment of 1,4-dimethylnaphthalene (20 ppm) was sufficient to delay sprouting under diffused light storage.

Floriculture: In gladiolus, longer vase-life (12-14 days) was observed in Invitatie, Flevo Souvenir and Argentina; medium (9-11 days) in Fidelio, Ocilla, Snow Princess and short (4-6 days) in Blues, Purple Flora and Chemistry varieties.

Pusa Narangi Gainda contained more carotene in comparison to Red Brocrade, Pusa Basanti Gainda and Pusa Arpita varieties.

The colour retention of dried *Helichrysum* flowers packed in polythene sleeves and kept at room temperature was better even after one year of storage, whereas slight discolouration was observed in *Limonium* and *Brumus*.

The cut rose stems of First Red variety treated with 50ppm chlorine during pre-cooling showed significant improvement in opening of bud, vase-life and water absorption.

Gladiolus Punjab Dawn was effectively stored for seven days under MA (3-4°C in PP-100 gauge packaging).

Spices: In fenugreek, diosgenin content in seeds of RMT 1, RMT 305 and AFg-3 genotypes was significantly more (2.1-2.5%) due to cryogrinding as compared to non-cryoground samples (1.3 to 1.5%). There was positive effect of cryogenic grinding on total phenolic, flavonoids, oil content and antioxidant activity of fenugreek and coriander powder during storage.

Rapid detection of food pathogens by polymerase chain reaction: PCR protocols for detection of five important food pathogens were standardized and developed. The genus specific primers were designed by targeting *Hyp* gene for *Campylobacter jejuni*, *prfA* for *Listeria monocytogenes*, *stx* for *Escherichia coli O157:H7*, *invA* for *Salmonella* spp., *nuc* for *Staphylococcus aureus*.

This technique can detect simultaneously *Escherichia coli O157:H7,* S*almonella* spp., *Staphylococcus aureus, Campylobacter jejuni* and *Listeria monocytogenes* within 24 h**,** while the conventional methods require more than 72 h. Organisms could be detected with meat sample of 25 g, and analysis cost was almost half in comparison to conventional methods.

Size of the amplified PCR products in 2% agarose gel electrophoresis was 500 bp for *Campylobacter jejuni,* 290 bp for *Listeria monocytogenes,* 632 bp for *Escherichia coli O157:H7,* 570 bp for *Salmonella* spp. and 384 bp for *Staphylococcus aureus.*

Bioactive properties of camel milk: The antioxidant property of camel milk was significantly higher in fermented milk compared to raw milk. The antimicrobial activity of fermented milk supernatants was 100% inhibitory at 5% concentration level against *Escherichia. coli*.

Detection of adulterants in milk: *L. monocytogenes* causes human listeriosis with high rate of mortality. Recently FSSAI implemented a "zero tolerance" policy for monitoring *L. monocytogenes* in dairy products. In view of food safety concern, NDRI developed the new technology which has immense industrial application. Assay can confirm the presence of *L. monocytogenes* within real time of 4.30 ± 0.10 h after initial pre-enrichment of milk samples in novel selective medium, i.e. LSEM for 18 or 24 h. Appearance of black colour indicates the presumptive presence of *Listeria* spp. and of green colour confirms the *L. monocytogenes.* Technology was validated with raw milk, pasteurized milk, ice cream, butter, cheeses etc. Memorandum of Agreement between a commercial company and NDRI, Karnal was signed for transfer of this technology entitled 'detection of *L. monocytogenes* in milk'.

Meat storage: Fresh meat can be stored in refrigerator for 3-5 days and up to 4 months at –20°C. Technology was developed for storing meat under super-chilling (1°C) condition and vacuum packaging for chicken

Vacuum packaged super chilled chicken drumsticks

drumsticks, which can extend the shelf-life up to 30 days without freezing. This technology reduces the cost of energy and ensures availability of fresh product.

Nutrient profiles of *Sperata seenghala* and *Tenualosa ilisha* : Proximate nutrient profile of giant river-catfish *Sperata seenghala* revealed moisture, crude protein, crude fat and ash contents of 79.40 ± 0.09%, 20.06 ± 1.13%, 1.40 ± 0.79% and 0.90 ± 0.08%, respectively. In addition, the fish flesh is rich in essential amino acids histidine, threonine and leucine and ratio of essential to non-essential amino acid is 0.89 indicating its superior protein quality. The mineral profiling indicated that the species is also a good source of zinc, iron and calcium.

The fatty acid profiling of different sizes of *Tenualosa ilisha*, a highly preferred food fish in South-Asian countries, showed that medium-size fish contained highest amount of unsaturated fatty acids as well as ω-3 PUFAs, EPA and DHA and the lowest amount of saturated fatty acids (SFAs). Small-size hilsa has highest PUFA content but lower ω-3 PUFA content, and higher SFAs content than medium-size fish. In large-size fish, although ω-3/ω-6 ratio was the highest, quantitatively they contained the lowest amount of PUFAs and highest amount of SFAs. Some important features of hilsa oil like oil content, PUFA and EPA + DHA content are shown in the Table.

Nutritional information on hilsa oil (fat)	Small fish	Medium fish	Large fish
Oil content (g/100 g wet weight)	15.33 ±0.12	16.35 ±0.07	19.15 ±0.29
PUFA (% of total fatty acids)	23.78 ±0.08	22.11 ±0.25	14.75 ±0.39
EPA+DHA (% of total fatty acids)	10.90 ±0.03	11.83 ±0.09	10.24 ±0.57

Enhancing shelf life of fish fillets: Natural extracts from sage, rosemary and origano were tried for the extension of shelf life of fish fillets under chilled storage. Treated sample exhibited antioxidant effect in fillets of *giant*- travelly. Oleoresin extracts of curry leaves and cloves on chilled storage of battered and breaded black clam enhanced shelf life upto 19 days and 21 days respectively; while control samples had a shelf life of 16 days.

Value-added products

Nail polish based on natural resin: A nail- polish formulation based on the natural lac resin, gives beautiful, very glossy, hard and smooth finish on nails, and is quick to dry and is non-hazardous to health. Properties of the nail- polish meet the requirement of IS: 9245:1994.

Lac- dye-based natural *alta:* Red- coloured natural lac dye is obtained during refining of stick-lac to seedlac. Natural *alta*, IINRG-LDA-91 (Orange coloured) and IINRG-LDA-94 (Deep- red coloured) from lac- dye and other skin -friendly ingredients, has been developed.

Success story

Lac cultivation on *Flemingia semialata* for livelihood security

Flemingia semialata is a bushy lac host for lac production. *Kusmi* lac in winter season is grown without irrigation and summer lac on the host requires irrigation. Mr Barnabas Nag, a farmer from village Lupungdih, P.O. Saparum, District Khunti, raised *F semialata* plantation of 2,500 plants and started lac cultivation in 2010. For assured broodlac production in summer, he took on lease *kusum* trees from neighbouring village at 50:50 share basis. He earmarked some portion of his *F. semialata* plantation for summer season lac cultivation under irrigated conditions. Inoculation of one- year- old plants with 5 kg *kusmi* broodlac was carried out in July 2010; from which he harvested 55 kg winter season *kusmi* lac in February 2011. Since then, he has taken up lac cultivation seriously. His profits reached an all- time high after harvest of *kusmi* summer crop in 2013 when he earned ` 2 lakh from the sale of broodlac only, besides inoculating 260 kg broodlac on *ber*, *kusum* and *semialata* plants.Mr Nag also motivated 30 farmers from an adjoining village to raise plantation for lac production.

Bio-enriched compost from cotton- plant residue: A process for preparation of good quality compost in 45 days from wet cotton- stalks by using microbial consortia has been developed. It took about 60 days when cotton- stalks were dry. Under normal conditions, composting of dry stalks takes 90 days and of wet stalks takes 60 days. The NPK content of the microbial compost from the cotton-stalks was found even better than the farmyard manure.

Compost prepared from cotton biomass and FYM

Parameters	Compost prepared from cotton biomass	FYM
Cost (`)	3,200	3,000 to 3,500
NPK content (%)	1.1, 0.9, 0.5 (wet cotton- stalks) 1.43, 0.78, 1.82 (dry cotton-stalks)	0.5, 0.2, 0.5
Duration of preparation	45 days (wet cotton- stalks) 60 days (dry cotton -stalks)	120 days

Sorghum-*til laddu:* Roasted *til* and roasted groundnut are powdered and mixed with sorghum flour and milk powder. This is then mixed either with jaggery powder or sugar powder and pressed into a desired shape.

Roasted flakes *pedha*: The broken sorghum flakes are thoroughly powdered and prepared in the form of a *pedha* with a little amount of jaggery syrup. This product is suitable for diabetic people as sorghum is a rich source of dietary fibre, iron and polysaccharides.

Bran *pedha*: Bran extracted from milling sorghum is finely powdered, dried and then mixed with skimmed milk powder, sugar and ghee. The mixture is then made into *pedha* and silver-foil is pasted to make it attractive.

Success story

Enhanced income through lac cultivation

Shri Yogendra Ahir, aged 57 yrs of Banta village of Silli block in Ranchi district (Jharkhand) was earning ` 3,000 a month from a small tea stall. He was motivated for lac cultivation by fellow farmers. He acquired three *Ziziphus mauritiana (ber)* trees from his fellow farmers and inoculated them with three kg of *kusmi* broodlac in July 2011 and harvested 30 kg broodlac worth ` 15,000 during January 2012. During 2012-13, he inoculated 8 *ber* trees with lac from winter crop and harvested 65 kg lac worth ` 32,500. By adopting scientific methods of lac cultivation he has at present raised a small *Flemingia semialata* plantation, a quick-growing bushy lac host plant, with tomato as an intercrop. The lac-crop on *F. semialata* is growing well.

Low-calorie, protein-rich crackers: Low fat sweet-salty *aonla* and beetroot crackers have good protein content (16.03%) and 60% less fat. The *aonla* crackers are rich in antioxidants (117.32 mmol/100 g) and flavonoids (389.1 mg/g), besides providing fibre from *aonla*.

Pearl pop–a ready -to-eat snack: A crunchy, soft and ready-to-eat pearl pop contains 11.2% protein, 7.36% fat, 2.96% crude fibre, 72.81% carbohydrate and is rich in micronutrients, especially iron (5.02 mg/100g) and zinc (3.01 mg/100g). The total antioxidant and phytic acid contents are found to be 15.47 µmol Trolox/100g and 373.82 mg/100g (product) respectively.

Sweetened functional chocolate cheese: Sweetened functional soft cheese from buffalo milk was developed by incorporating fructo-oligosaccharide (FOS), inulin and cocoa to enhance health attributes. Its shelf life is over 4 weeks under refrigeration without any preservatives. This product could have great potential in the fastest growing functional food market. It has following health benefits.

- Polyphenolic substances from cocoa powder reduces LDL cholesterol, elevates HDL cholesterol, suppresses oxidized LDL and even prevents cancer.
- Inulin, the soluble dietary fiber, acts as prebiotic.
- FOS, a very good probiotic, helps improve immunity and is a healthy sweetener for diabetic patients.

In-line production of basundi

Basundi, a popular heat desiccated Indian dairy product, is prepared by traditional method which is a labour intensive process. Therefore, for mechanization a scraped surface heat exchanger (SSHE) was integrated with conical process vat (CPV) for in-line production of basundi.

Flavoured sheep milk: Sheep milk contains 0.20% titratable acidity, 82.82% moisture, 5.21% total protein, 0.47% total casein and 17.18% total solid. It was diluted with water (3:1) and mixed with 10% carrot pulp, sugar and cardamom to prepare natural carrot flavoured milk. The sensory attributes of the flavoured milk ranged from good to very good.

Goat milk based products: Goat milk and cream based CIRG Beans and CIRG *Khasta* were developed using pure goat milk, cream, dietary fibres and natural antioxidants. These products contain higher amount of medium chain fatty acids, which are beneficial for human health. Product scored 8 out of 9 on Hedonic scale. These products have low moisture, high protein, desirable fatty acid profile with shelf-life of four months at room temperature.

Whey based media for *Lactobacillus* spp.: Much of whey, generated as by-product from paneer, cheese and casein industries, remains unutilized leading to pollution by increasing the biochemical oxygen demand (BOD) load in dairy effluent (BOD – 40,000 to 60,000 ppm). Thus, large quantities of valuable milk nutrients present in whey are also lost. Whey was used to formulate a media for culturing, biomass production, pharmaceutical applications and enumeration of *Lactobacillus* spp. This whey based media resulted in growth of lactobacilli similar to freshly formulated whey based media and MRS medium.

Baked egg product: Process of preparing baked egg product as breakfast meal was standardized. It offers a potential market at growing fast food outlets. Baked egg was prepared using 70% liquid whole egg, 12% grated cheese and 5% skim milk solids. The cost of formulating one processed baked egg product of 15.5 cm diameter and 2 cm thickness weighing about 240 g was ` 29.70. The product was acceptable for 12 days in vacuum and 10 days in aerobic packs at refrigerated storage with satisfactory physico-chemical and microbiological quality.

Functional meat products: Functional and more shelf stable restructured buffalo meat steaks were prepared with the incorporation of antioxidant and mineral rich *amla* powder (5%).

Shelf stable meat products: Formulation and processing condition for preparation of ready-to-eat shelf stable meat slices was standardized. Developed product has high protein (>30%) and low moisture (<15%) content.

Ready-to-eat traditional meat products: The ready-to-eat (RTE) traditional Indian meat varieties such as *Rista* curry, a component of the 13 course *Kashmiri* meal called *Wazwan*, was standardized and was filled and hermetically sealed into retort flexible pouches. Shelf life study revealed that the product was stable at ambient temperature for 12 months.

Pork nuggets: Nuggets were prepared by incorporating pork with fermented bamboo shoot mince, which significantly retarded quality deterioration of nuggets during refrigeration temperature storage, especially lipid oxidation and microbiological characteristics. Nuggets with 6% and 8% fermented bamboo shoot had significantly lower TBARS values. Further, addition of fermented bamboo shoot mince at 6% and 8% levels improved their microbiological characteristics, especially the total plate count, coliform count and *Staphylococcus aureus* counts and sensory attributes, particularly flavour. Incorporation of

Success story

Popularization of value-added pork products

People of North Eastern States are predominantly non-vegetarian and pork is the most relished meat. Currently, 10 different value added pork products (viz. frankfurter, cocktail, ham, nuggets, salami of different flavor and taste) are being marketed in five different states in NE region. The pork processing plant at National Research Centre on Pig, Rani, Guwahati, is undertaking active research and training in the area of clean pork production to ensure 'Farm to Pork' quality of pork and pork products to consumers, and development and codification of procedures for value addition/packaging/transportation and marketing of pork and pork products. The Institute signed a Memorandum of Understanding (MoU) with a private company in Public-Private-Partnership (PPP) mode.

In order to meet the quality requirements and to undertake the brand building activity of the final marketable products, the pork processing plant has adopted Hazard Analysis Critical Control Points (HACCP) procedures for processing of fresh pork as well as value added pork products. The unit has obtained ISO 9001:2008 certification and Food Safety Standards Authority of India License.

Success story

Meat Processing Business

Mr Ajay Raghav, a pig farmer of about thousand pigs near Meerut signed two MoUs with the IVRI for transfer of technologies, viz. Vegetable Incorporated Meat Products and Hurdle Tech Meat Pickles. Technological input from IVRI and his own innovation helped Raghav to turn into an entrepreneur from a pig farmer. During early period of business, due to unavailability of meat processing machinery, business incubator laboratories and meat processing pilot plant facilities of IVRI were extended to him. Mr Raghav started getting higher rates for his primal cuts and started supplying to hotels in Delhi. His profit margin increased substantially and now he is a dealer instead of live pig seller.He has also entered into processed meat market launching more than 10 varieties of meat products. The business expanded and now the firm has made franchisee at several places. Encouraged with the success, Mr Raghav has signed two more MoUs with IVRI for transfer of technologies namely Chicken chips and Milk chips.

Identification of meat species by polymerase chain reaction

Molecular technique by PCR for identification of meat species in fresh, frozen, cooked and processed forms within a short time of 8 hours has been standardized and developed by targeting *mitochondrial D loop region* for chicken and duck meat, *cytochrome b* gene for emu meat and *12S rRNA gene* for quail meat, beef and pork. Minimum meat sample required for identification was 50 mg.

Using species -specific primers, the size of the amplified PCR product in 2% agarose gel electrophoresis was 442 bp for chicken meat, 229 bp for duck meat, 292 bp for emu meat, 129 bp for quail meat, 230 bp for pork and 400 bp for beef. Beef and pork specific PCR was highly sensitive for identification of meat adulteration up to the extent of 5% level.

fermented bamboo shoot mince at 8% level also increased the storage life of pork nuggets by at least two weeks.

Poultry meat wafer: A process formulation was standardized for development of shelf-stable poultry meat wafers. Based on different physico-chemical and sensory quality characteristics, formulation containing turkey and spent hen meat (70:30) was observed to be the best. Cold extrusion method followed by microwave cooking was found to be the most suitable processing technique.

Poultry meat finger chips: The optimum formulation for preparation of meat finger chips contained turkey and spent hen meat (50:50). The finger chips were rated very good by the sensory panel members. The microwave cooking method was found to be the best.

Astaxanthin: A method was developed for the isolation and purification of astaxanthin from deep sea shrimp and blood-spotted swimming crab. Astaxanthin extracted from blood-spotted swimming crab (*Portunus sanguinolentus*) showed good antioxidant activity.

Valuation of carbon stock in Sunderban mangroves

Mangroves play a significant role in carbon sequestration due to high biomass density and productivity. The economic value of carbon stored in above-ground biomass of mangroves of Sunderbans was assessed based on secondary data. The average carbon stored (tonne/ha) in *Sonneratia* sp., *Avicennia* sp. and *Excocaria* sp. was 106.35±2.86, 36.98 ± 3.56 and 19.13 ± 2.45 respectively

Anti-aging chitosan: Dietary chitosan supplementation in young and aged rats restored the depleted myocardial antioxidant defense indicating its effectiveness as therapeutic agent in treatment of age associated disorders.

Micro/nano encapsulation: Succinyl chitosan was synthesized and characterized. This polymer may serve as an effective tool in micro/nano encapsulation of nutraceuticals for controlled and efficient drug delivery.

A web based database on fish proteomics

A web-based database, FISHPROT, exclusively on fish and shellfish proteogenomics has been developed to augment future research on fish genomics and proteome, metabolic pathways, fish biomarker dioscovery etc. Currently the database contains information on muscle proteome of IMC *Catla catla*, riverine catfishes *Sperata seenghala* and *Sperata aor*, muscle and lens proteome of riverine catfish *Rita rita*, liver proteome of the murrel *Channa striatus*, plasma proteome of IMC *Labeo rohita*. The database is linked to major national and international proteomics and bioinformatics databases like NCBI, SWISSPROT, SPS, BSPR etc. FISHPROT constitutes an actual structured data repository from the researchers and acts as a global repository for archiving proteomic information on different fish species. The database can be accessed at: http://www.cifri.ernet.in/fishprot.html.

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12. Agricultural Human Resource Development

To keep pace with the agricultural growth, high priority has been accorded to upgrade quality of higher agricultural education in Agricultural Universities (56 AUs), Deemed-to-be-Universities (5 DUs) and Central Universities (4 CUs) with Agricultural faculties under the National Agricultural Research System (NARS). During this year, three new universities, viz. Kamdhenu Agricultural University, Raipur, Shimoga University of Agricultural Sciences, Shimoga and Tamil Nadu Fisheries University, Nagapattinam, have been established by the respective State Governments. The Division through the implementation of Scheme-Strengthening and Development of Higher Agricultural Education in India, assists the AUs to plan, undertake, aid, promote and coordinate agricultural education in the country. The scheme has enabled these institutions in building excellence in specific strategic areas in education and research through Niche Area of Excellence (NAE), promoting holistic higher agricultural education by blending knowledge, skill and attitude through Experiential Learning Units, RAWE, and related aspects concerning infrastructural development, gender mainstreaming and capacity building of the students.

Infrastructural support

The infusion of development grant continued during the year for renovation and refurbishing of structures, maintenance of equipment, support for course curriculum delivery, student and faculty amenities, personality development and overall strengthening of infrastructure in AUs. In the XI Plan, a total of 89 girls, 42 boys and 35 international hostels, 37 educational museums and 45 examination halls were supported in 52 AUs. Creation and strengthening of educational museums helped in showcasing important research and agricultural innovations in a systematic manner leading to increased awareness and opportunity to access the displayed products/technologies. Smart classrooms, supported by the Council have enabled effective delivery of course curriculum, ensuring enriched learning experience. The support for the curriculum delivery enabled introduction of the practical manuals leading to improvement in conducting practical classes. Support provided for student and faculty amenities/tours/capacity building encouraged their participation in seminars, symposia, workshops etc. Education Technology Cells were strengthened by publication of booklets, pamphlets and exhibit model products. The total outlay during the year was ` 413.50 crore. In addition, the special grant of ` 120.00 crore was provided to eight AUs to strengthen the infrastructure for higher agricultural education and research in cutting edge areas.

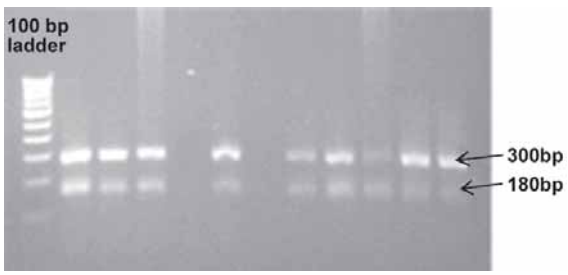
Niche Area of Excellence

Support for creating excellence in specific areas to 21 ongoing and one new centre of Niche Area of Excellence (NAE) on *Integrated Centre for Drought Research: Genetic Enhancement of Crops by Molecular Approaches and Phenotyping*, UAS, Bengaluru, has been extended during the year. The programme encourages and enhances competitiveness in agricultural research and education and focuses on capacity building in the cutting edge areas. Presently, seven programmes under animal, two in fishery sciences, one in post harvest technology, two in plant sciences, six in natural resource management, one in horticulture and two in plant protection are being supported. The VI Annual review meeting to fine tune the programmes was organized at New Delhi on 21 June 2012. NAE websites were created and maintained by the concerned centers.

Significant achievements under the programme are:

- Two different Newcastle disease virus (NDV) genotypes (NDV 2k3 and NDVD1) prevalent in India have been adapted to Vero cells for vaccine production and tetrARMS PCR for differentiating field and vaccine virus by targeting the pp38

Girl's Hostel, Dr YSRHU, Vgudem



tetrARMS PCR for differentiating field and vaccine viruses of Marek's disease

Talent attracted towards Agricultural Education

Publicizing the scope and relevance, e-initiatives like online submission of application, observance of "Education Day" in ICAR institutes and SAUs resulted in attraction of talented youth towards Agricultural Education. It is encouraging that out of 1847 candidates admitted in 55 Agricultural Universities through All India Entrance UG Examination (2013-14), 42% candidates secured 80% and above marks in their qualifying Intermediate Board Examinations, the highest being 99%. About 82% candidates had secured above 60% marks.

gene of Marek's disease virus (MDV) was developed.

- Flow cytometry revealed decreased percentage of CD4+ and CD8+ cells in T-2 toxin fed birds along with significant reduction in body weight, feed conversion ratio and lymphoid cells. High arginine in combination with vitamin E ameliorated the toxicity.
- Efforts were made towards establishing the tissue bank constituting the tissue blocks, H &E stained slides, special stained slides and non-stained paraffin sections from the animals suffering from different diseases in the programme on *Animal Disease Registry.*
- The surface plasmon resonance (SPR) biosensor chip was prepared by immobilizing recombinant -N proteins of PPRV. The positive and negative sera samples were tested on SPR biosensor platform. PPR monoclonal antibody 4G6 was affinity purified and immobilized on gold sensor surface.
- Molecular characterization of Indian myxosporeans parasites such as, carp gill infecting *Myxobolus catmrigalae* and carp fin infecting *Thelohanellus caudatus* was done at WBUAFS, Kolkata. High value species *C. punctatus* was reared successfully in pond -cage aquaculture.
- A protein rich novel pearl millet and sorghum based extruded snack with high nutritional, antioxidant and sensory properties was developed. A stable process for incorporating β-carotene from red capsicum in extruded products was also standardized.
- In the groundnut transgenics, co-expressing stress responsive Transcription Factors (AtABF3, AtHB7, AtDREB2A) diverse stress responsive genes were upregulated for tolerance to salt, drought and oxidative stresses.
- Success was achieved in developing rice lines suitable for semi-irrigated aerobic cultivation through trait introgression via molecular breeding and marker assisted selection through multi-parent intercross strategy.
- Two major QTLs, *QSB.bhu2B* and *QSB.bhu7D* associated with spot blotch resistance in wheat were successfully validated for use in marker assisted backcross breeding program for transfer of spot blotch resistance in susceptible, but promising wheat varieties.
- Infestation by *Sclerotium rolfsii* in groundnut JL24 seeds controlled by application of actinobacterial isolates *Streptomyces shandonggensis* AUDT 217 and AUDT 242.
- The late leaf spot resistance was successfully transferred in well adapted, but disease susceptible cultivars of groundnut (JL24 and TMV2) by transferring the QTL using the markers. F_1s were confirmed from JL 24 × GPBD 4 and TMV 2 × GPBD 4 for producing BC_1F_1.
- Vegetable based cropping system, mash–garlic and soybean-garlic, were observed as the most remunerative systems with benefit: cost ratio of 4.84 and 4.72, respectively under organic farming. Cucumber beetle and blister beetle of rice bean could be managed effectively by using 4 sprays of 5% extracts of neem seed kernel and *Lantana*, respectively. Effective management of plant hoppers and leaf-spot of beans, and downy mildew in cucumber was validated through traditional ways without using chemical pesticides.
- A manually operated Check Row Planter for dry seeding of rice seeds at a spacing of 25 cm × 25 cm was designed, developed and evaluated. The cost of sowing was 653/ha that was significantly less than manual transplanting (2,777/ha).
- The programme on identification of insects and mites facilitated the addition of 8681 new insects and mites to the existing collection. A complete manual was prepared with pictorial keys for 150 and 30 families of insects and mites, respectively.
- Optimized physicochemical and nutritional parameters for increased cellulase production in two important biocontrol species *Trichoderma harzianum* and *Trichoderma reesei*. Maximum production was recorded with 1% (w/v) of sucrose at 35°C, pH 6.
- Centres organized farmers' meet, awareness camps, workshops for rural agricultural extension workers, veterinary officers of State Animal Husbandry Departments, arranged demonstrations and provided consultancy for adopting the technologies generated. Five trainings were organized for the capacity building of the faculty in various areas. During the year 30 students initiated /pursued research for M.Sc./M.V.Sc./ MTech and 11 students for Ph D degrees with the support of NAE programmes.
- Farmers were motivated that led to conversion of 55 acres of salt affected waste land in districts Fazilka and Muktasar, to aqua farms. The success story was widely covered by media.

Entrepreneurship development

Experiential learning modules were provided that aimed at giving experience–based and skill oriented training to the undergraduate students to promote

entrepreneurship, knowledge as well as marketing skills by providing hands on experience, through end –to-end approach in product development and thus, it links education with professionalism. During last one decade 351 modules were established. Twenty-four new modules were established during this year in various areas, viz. protected cultivation and nursery management of horticultural crops, apparel manufacturing, production and designing of information material, processing of milk and milk products, aqua-farming and ornamental fish production and fish post- harvest technology.

The outcome of salient modules is as given below:

- The module on cultivation and utilization of medicinal plants enabled the students in production and successful marketing of herbal produce, besides empowering them with knowledge about cultivation and biodiversity assessment. The production of vegetable and fruits under protected cultivation gave high returns of up to ` 5.00 lakhs /annum at UAS, Raichur. High value crops like, capsicum, cucumber, tomato and flowers (gladiolus) were raised in polyhouses.
- Produced bio-inputs like bio-fertilizers, bio-agents and vermicompost giving impetus to organic farming.
- Students designed and created visiting cards, digital albums, posters, handouts, fliers, lab journals etc. in module on designing and development of information materials.
- The production, management, marketing and economics of bird rearing were important components of broiler production modules.
- Students were trained on various aspects of processing of cereals, vegetables, fruits, flowers, spices, milk, fish etc. alongwith their quality control, packaging and marketing strategies.
- Skills of apparel manufacturing and designing imparted by exposing students to technologically advanced industrial machines. Competency developed for software usage in pattern and textile designing. Permanent sale outlets for finished products were established in some universities.

Rural Agricultural Work Experience (RAWE)

RAWE provided real life experience at KVK's instructional farms, industrial attachment etc. as per the prescribed programme. It was implemented in adopted villages under the supervision of scientists. Activities focused on intensive observations /analysis of socio-economic and technological profile of the farm families in rural areas, participatory extension approach and acquaintance with farming situations, farm practices and interaction with farmers. About 8,000 students were benefited under RAWE through Council's support.

Library strengthening

The libraries were further strengthened and modernized with the financial support of ` 41.80 crore. The networking and online access to the literature ensured equity and availability of learning resources in the main campus as well as off campuses colleges and ensured procurement of additional need based journals not covered under CeRA. Some universities established book banks for the underprivileged students. All the universities have their own websites. RFID technology was installed in college libraries for easy and more secure stock management. A virtual centre for innovative learning and teaching was established at IARI, New Delhi.

National Information System on Agricultural Education (NISAGENET)

An online software system was developed for the management, monitoring, record keeping, and showcasing the activities of AUs. All the AUs were included in this system with improved and effective data entry by the participating universities and their constituent colleges. Sensitization-cum-training workshops for the nodal officers of the NISAGENET were also organized to sensitize and expedite data management. The reference guide for data management was prepared and uploaded on the website.

Support under Tribal Sub-plan

Financial support of ` 23.60 crore was provided in 10 states during the year under Tribal Sub-plan. The tribal population were trained in the areas of farm mechanization, integrated farming system, value addition, resource conservation, seed production, backyard poultry, quality milk production etc. ensuring livelihood security and employment generation by different universities. These programmes were executed in 340 villages that benefitted 7500 tribal farmers.

Manpower development

- **All-India Entrance Examination for Admission to UG:** The 18th Undergraduate Examination for degree programme for admission up to 15% seats in agriculture and allied subjects, other than veterinary sciences, including the award of National Talent Scholarships (NTS) was conducted on 20 April 2013. The examination attracted a record 96,096 applications out of which 86,661 candidates appeared and 1847 candidates were finally recommended for admission in 57 AUs through counselling. All the candidates, who joined a university outside their State of domicile, were awarded NTS of ` 1000/month.
- **All-India Entrance Examination for Admissions to PG:** The examination was conducted for admission to 25% seats in PG programme at 65 agricultural universities, including award of ICAR Junior Research Fellowships (JRF). A total of 21,294 candidates appeared in the examination out of 23,785 applicants, and 2,408 candidates were finally recommended for admissions. In all, 474 students were awarded JRF in 20 major subject groups.

- **All-India Competitive Examination for ICAR Senior Research Fellowship for Ph.D.:** The examination was held on 21 April 2013 at 16 centres across the country. Based on the merit, a total of 190 Senior Research Fellowships were awarded and 661 candidates were declared qualified for Ph.D admission without fellowship in 14 major subject groups and 56 sub-subjects.
- **Globalization of agricultural education:** Two Hundred Forty Seven Candidates from 37 countries like Afghanistan, Bangladesh, Bhutan, Burundi, Cambodia, Congo, Egypt, Eritrea, Ethiopia, Fiji, Guyana, Ghana, Indonesia, Iraq, Iran, Kenya, Mauritius, Maldives, Malaysia, Mozambique, Mongolia, Morocco, Myanmar, Namibia, Nepal, Niger, Nigeria, Rwanda, South Africa, Sudan, Sri Lanka, Syria, Tajikistan, Turkmenistan, Vietnam, Uganda and Zimbabwe, exercised their preference to join various agricultural universities under different fellowships or as self-financed candidates.

Capacity building

Summer/Winter Schools and Short Courses: Summer and Winter Schools (SWS) and Short Courses of 10 to 21 days duration (40 SWS of 21 days and 33 Short Courses for 10 days) were organized at ICAR Institutes and State Agricultural Universities in key areas of agriculture and allied sciences like Advances in Farm Equipment Designs, Advances in Micro-irrigation Technologies, ICT Oriented Strategic Extension, Decision Support Systems in Agriculture, Development of Web Application for Agriculture Information, Farmers Empowerment of Farming Community, Entrepreneurship Development, Functional Genomics and Proteomics, Resilient Agriculture, Geo-statistical Modelling, DNA Barcoding, Molecular Biology, Integrated Disease Management, Climate Change, Bio-fuels, Agri-business and Market Intelligence, Education Technology, etc.

Centres of Advanced Faculty Training: The 31 Centers of Advanced Faculty Training provided training to 830 scientists/ faculty members from the National Agricultural Research System through 43 training programs in cutting edge areas of agricultural and allied sciences. A Capacity Building Program portal was developed as a workflow based online management system of all training programs sponsored by Agricultural Education Division. It provides information on all training programmes, training proposal submission and evaluation, submission of application by a trainee, availability of e-books/lecture notes of a training and reports for all categories of users and several other features.

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 are as follows.

Designs for single factor and multi-factor experiments and their applications in agricultural systems research: General methods of construction of incomplete block designs for bioassays were obtained for multiple parallel line and slope ratio assays, besides, A-optimal block designs for asymmetric parallel line assays and a method for assessing the influence of masking in outlier detection for designed experiments with correlated errors. Optimization technique based algorithms were developed for obtaining efficient incomplete block design for given number of treatments, blocks and block sizes. A method of construction of row-column designs in two rows for estimation of main effects and two factor interactions in 2n factorial microarray experiments based on orthogonal parameterization was also developed. Sample Survey Resources Server provided with an online calculator for determination of sample size for estimating the population mean (population proportion) for simple random sampling design.

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: The 'Pant-ICAR Animal Drawn Six-in-One Tillage Outfit' for small and marginal farmers has been commercialized. Yet another innovative gadget 'Pant-ICAR Animal Drawn Multipurpose Tillage Device' was developed for performing field operations like soil tilling, puddling, weed raking, interculture/crop thinning, land levelling and clod crushing operations.

Assessment, prediction and enhancement of biotic carbon sequestration in agricultural soils: Impact of land use on quantity and quality of soil organic matter studied in the agro-ecological sub-region 4.1 of the country. Cultivation resulted in decline in total (21-36%) and labile pools of soil organic carbon (10-34%), dehydrogenase enzyme activity (2.8-3.4 mg/kg/h) and disruption of macro-aggregates. Agroforestry and sugarcane agro-ecosystems exhibited greater rate of soil C rehabilitation compared to rice-wheat and maize-wheat systems. Evaluation of results from sites across India showed that balanced fertilization results in C sequestration by a factor 1.19 and application of organic manure along with balanced NPK increases it by 1.48 times.

Broadening the genetic base of Indian mustard (Brassica juncea) through alien introgressions and germplasm enhancement: Gene controlling determinate plant growth habit in mustard cloned and sequenced for the first time and gene pools characterized. East European accessions of mustard were found to be distinct from Indian and Chinese mustard genotypes. Two gene pools co-existed in Indian mustard. Heterotic gene pools defined for the first time in this crop.

Allele Mining for Agronomically Important Genes in Wild Rice Germplasm and Stress Tolerant Landraces of Rice Growing in the Hot Spots: Accessions of wild rice were collected from the natural habitats in remote

villages of Uttar Pradesh, Bihar, Gujarat and Himachal Pradesh. A web portal was created for 300 wild rice accessions including additional 58 lines acquired from NBPGR, New Delhi with information on geographical location, passport data, morphological data and photographs of each of the wild rice accessions. The wild rice accessions were evaluated for drought, submergence and salinity tolerance under controlled conditions and resistant lines identified.

Design, construction and validation of DNA chips for virus identification and differentiation: It was observed that the ribosomal RNA depletion increases the efficiency of virus detection with the microarray chip. Not so random hexamer (hexamers from which ribosomal specific hexamer were removed) improved the efficiency of both dnase-sispa and microarray chip for virus detection. A DNA chip for identification of viruses infecting fish, animals and birds was tested sucessfully.

Changing consumption pattern in India: Opportunities for diversification towards high value commodities through production and marketing linkages: Pace and pattern of diversification of agriculture across states analyzed considering data for last 30 years of both production and consumption. Indian agriculture sector is witnessing a transition from food grains to High Value Commodities (HVCs).

Metagenomic analysis and manipulation of buffalo rumen ecosystem to improve fibre utilization and reduce methane production: Essential oils have synergistic effect on methane inhibition in buffaloes. Essential oils are well known anti-methanogens, but sometimes these oils have a detrimental effect on feed degradation. The *in vitro* screening of three essential oils (L, A and C) revealed methane inhibition varying between 10-25% at a concentration of 1.0 µl/ml reaction mixture along with 29-33% depression in feed degradability. But a mixture of the three at a similar concentration caused methane inhibition by 85.6% and 31% reduction in the feed degradability, indicating a synergistic effect of the mixture of essential oils on methane inhibition.

Development of chromosome segment substitution lines (CSSL) of rice from elite x wild crosses to map QTLs/genes for yield traits: CSSL are very useful genomic resource for mapping QTLs/gene for complex traits. One wild accession each of *O. nivara* and *O. rufipogon* was shortlisted as donor based on high photosynthetic efficiency and crossed with Swarna and MTU 1010 as recipients to develop CSSLs in these lines and true hybrids were obtained. Elite backcross inbred lines (14) derived from Swarna × *O. nivara* were grown along with 6 best varieties of different duration to select the best BIL for mapping QTLs for yield traits.

ICAR National Fellow Scheme: 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 given in following paragraphs.

Improvement of strain of Chaetomium globosum, a potential antagonist of fungal plant pathogens for enhanced bioefficacy and developing molecular markers for its identification: Phylogenetic relationship among different isolates of *Chaetomium* species based on β tubulin and gpd gene sequences revealed that gpd sequences separated *C. globosum* isolates from other *Chaetomium* species with transition/ transversion ratio of 1.773. A novel dienelactonehyderolase gene involved in secondary metabolite biosynthesis and biodegradation was cloned and sequenced from *C. globosum,* with 96% homology with hypothetical protein of *C. globosum* in NCBI database, 87% with *Myceliophthera thermophila* and *Thielavia terrestris*.

Decontamination of pesticide residues from edible commodities: Endosulfan could be detoxified using nano form of a transition metal as catalyst that resulted in formation of an environmentally safe compound, different from toxic α or β endosulfan or endosulfansulfate. It was also observed that neonicotinoid insecticides are harmful to non-target honey-bee based on the results of Photo Fenton's reaction used for degradation of neonicotinoids and synthetic pyrethroids.

Assessment of sustainability of treated / developed watersheds in rainfed agro-eco-sub-regions of peninsular India using GIS and remote sensing: A trans-disciplinary monitoring and evaluation procedure for assessment of impact of watershed projects has been developed with a copyright (L-45448/2013). It facilitated measurement of sustainability of watershed projects on agricultural productivity, livelihood security, economic viability, environmental protection and social acceptability at three spatial–levels viz., household (HH), field (FL) and watershed-level (WL). Study indicated that 15 - 35 % of area in treated watersheds were sustainable in Telengana region in AP owing to higher agricultural income and production due to cultivation of more number of crops (higher Crop Diversity Index).

Development of ELISA based immunodiagnostics for Classical Swine Fever: Double antibody sandwich ELISA was used to detect classical swine fever virus (CSFV) antigen in 432 samples of pigs from Asom and other North Eastern states and 56 (12.96%) of the samples were found positive for CSFV antigen. E2, 5/UTR and NS5B genes fragments of the selected CSFV were cloned and sequenced. The predominant genogroup of CSFV in Asom was 1.1 and genogroup 2.2 was found in Arunachal Pradesh.

Assessing soil quality key indicators for development of soil quality index using latest approaches under predominant management practices in rainfed agroecology: In alfisol soils of Hyderabad, the organic carbon content increased as the soil particle size (sieve size) decreased. It varied from 1.5 to 2.6, 2.3 to 3.6 and 3.4 to 5.0 g kg^{-1} with the mean values of 2.23, 2.82 and 4.03 g kg^{-1}, respectively in 0.5 to 1.0, 0.25 to 0.5 and 0.1 to 0.25 mm sieve sized particles, respectively. Sorghum grain yield significantly

correlated with advanced soil quality indicators such as labile carbon (LC), particulate organic carbon (POC), and aggregate associated organic carbon.

Evolution of textile articles through processing of wool with silk waste and cotton to create entrepreneurial skills in rural women: Fibers were processed and analysed for their physico-chemical properties. Ergonomic assessment of handlooms and weavers was carried out to make ergonomically suitable handloom for reduced fatigue and better productivity. Fabric weaves were designed using Computer-aided Design (CAD), without warp change (draft plan) through novelty yarns, different coloured waft yarns, variety yarn counts. Simulated impressions of woven designs, their draped effects were prepared.

Identification and quantification of phosphatase hydrolysable organic P sources for plant nutrition and refinement of a non-destructive technique for phosphatase estimation: Bacillus megaterium JCT13 was isolated and developed with ability to mycosynthesize P nanoparticles 5-80 nm size from phytin salts within 24 h at a concentration of 0.1 mM. The foliar application of nano-P @ 640 mg ha^{-1} resulted in 80 kg P equivalent yield of clusterbean and pearl millet under arid field condition.

Nanotechnology in aquaculture: an alternative approach for fish health management and water remediation: Laboratory synthesized CuO, ZnO, Ag and Ag-TiO_2 nanoparticles had broad spectrum antibacterial activity whereas, Zn and ZnO nanoparticles were effective against fungus and algae. CuO nanoparticles showed a good hatching and survivability of larvae and kept the microbial load at lower level without affecting other water quality parameters. Dietary administration of selenium nanoparticles improved the antioxidant enzymatic activities and muscle Se concentration of *Labeo rohita*.

Development of soy and multigrain based nutritionally balanced functional foods for children: Functionally and nutritionally rich porridge and biscuits were developed using cereals, millets, pulses, oilseeds, dairy ingredients and fruits with superior protein, fat, anti-oxidant, phenolic and flavonoid content incorporating multigrain concept in ready-to-eat, wholesome food. The multi-nutrient biscuits were commercialized and a MOU was signed for their production and distribution at a commercial scale. Both the products are ready to be distributed as mid-day meal snacks to under-nourished children in Madhya Pradesh.

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 Bhabar and Tarai Zone (BTZ), Mid-Western Plain Zone (MWPZ) and South-Western Plain Zone (SWPZ) was done under first, second and third pre-dominant cropping systems. Fertilizer use in different cropping systems was skewed in favour of N, whereas use of K, S and micronutrients were neglected. Homogeneous fertility management zones were prepared using Ordinary Exponential Kriging in Arc-GIS 10.1 environment in order to develop precision nutrient prescription. Among different fertility management options maximum area was under Low N-Medium P-Medium K category (63, 68 and 56% area in BTZ, MWPZ and SWPZ, respectively).

Development and evaluation of neuraminidase DIVA marker vaccines against highly pathogenic H5N1 avian influenza viruses in chickens: Areassortant rgH5N2 virus, generated through plasmid based reverse genetics, was successfully tested in specific pathogen free chickens for safety and non-pathogenic character as a vaccine candidate virus. It was characterized by nucleotide sequencing, growth in embryonated chicken eggs and virological tests for its suitability as vaccine seed virus. A mineral oil adjuvant vaccine was formulated using the inactivated rgH5N2 virus and is currently under testing.

Development of Commercially Viable Process Technologies for Weaning Food based on Underutilized Crops of Uttarakhand: Protocol for formulation of weaning food based on composite flour of underutilized crops of Uttarakhand Finger millet and *Amaranthus*, using submerged state fermentation technology comprising *Lactobacillus planatarum* as starter culture was developed. *Lactobacillus planatarum* reduced anti-nutritional characteristics upto 55-65% and the resultant flour was further used as a base ingredient for development of value added products like weaning mix, snacks, breads etc.

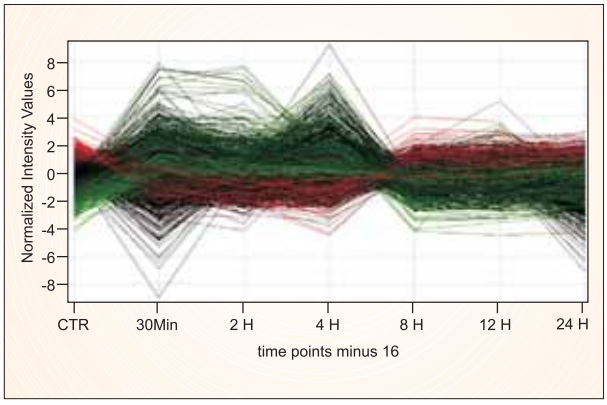
Functional Genomics, Epigenetics and Gene Silencing Technology for Improving Productivity in Poultry: Functional analysis of candidate genes, expressed in muscle of broiler chicken was studied. Three important candidate genes, i.e. Activin receptor2A (ACTVNR2A), Activin receptor 2B (ACTVNR2B) and Follistatin (FSTN) involved in controlling growth, were characterized in broiler chicken. The ACTVNR2A haplogroups showed significant effect on body weight at 6 weeks.

Studies on phyto-semiochemicals involved in Insect-Plant interactions of major horticulture pests: Oviposition site-selection by the oriental fruit fly, *Bactrocera dorsalis*, was mediated through an innate recognition template tuned to γ-octalactone. A mango cue that instigated oviposition behavior in the mango fruit fly, *B. dorsalis* was discovered. In an insect-host model that comprised *Bactrocera cucurbitae* and *Sechiumedule*, the insect oviposites eggs into the fruit and the fertilization process of the egg ended with a ROS blast. This process instigated the plant to produce more ROS resulting in increased levels of hydrogen peroxide and nitric oxide triggering defence against the invading eggs.

Development of transgenic goat using sperm-mediated gene transfer (SMGT) method and its use as a bioreactor for producing novel proteins of therapeutic importance: The urinary-bladder specific expression of UPKII gene using semi quantitative RT-

PCR was validated. Using electroporation mediated *in vitro*/*in vivo* gene transfer protocol, the reporter gene was successfully integrated in spermatozoa and spermatogonial germ cells of goat.

Whole genome wide SNPs based assessment of genetic relationship of Indian native cattle adapted to different agroclimatic condition: Buffalo mammary epithelial cells (MECs) were utilized as *in-vitro* model to evaluate the impact of heat stress both at cellular and transcriptional level. The primary buffalo MECs were exposed to 42°C and subsequently harvested at 8 different time points (30 min to 24 h). Cytotoxicity analysis indicated reduced viability, increased dead cells/ apoptotic cells and loss in plasma membrane integrity post heat stress. Microarray based transcriptome analysis revealed a total of 2256 transcripts to be differentially expressed at different time points post heat stress. Maximum transcriptional response was observed immediately after heat stress (30 min-4h). The responsiveness of MECs can be used as a model to understand the molecular changes in buffalo mammary gland in response to environmental heat load.



Transcription signature (line plot) of buffalo MECs in response to heat stress *in vitro*

Comprehensive Screening of Target, Non target and Unknown Emerging Organic Contaminants in Fruits and vegetables by GC-MS and LC-MS: A high resolution LC-MS based targeted and non-targeted residue screening method was developed for efficient separation, identification and confirmation of pesticides, plant growth regulators and emerging contaminants of different chemical classes in fresh fruits and vegetable matrices and processed products like wines and beverages. The pre-harvest intervals pertaining to maximum residue limits of the European Union were generated for trifloxystrobin, tebuconazole in tomato, fluopyram, tebuconazole in green chilli, fipronil, difenoconazole in okra and imidacloprid, carbendazim, kresoxim methyl, flubendiamide, λ-cyhalothrin, captan and hexaconazole in brinjal.

Development of sensitive and specific diagnostic assays for detection of Trypanosoma evansi infection in animals using modern molecular tools: A highly sensitive polymerase chain reaction (PCR) assay was developed for detection of *Trypanosoma evansi* infection in animals using gold standard TBR1/2 primers designed from repetitive sequence of mini-chromosome satellite DNA. The assay revealed amplification in multiple bands of 164 bp size with detection sensitivity of 0.1 pg of purified parasitic genomic DNA or 1-10 trypanosomes per ml in blood of experimentally infected mice.

Development of novel immune-potentiator molecules from fish host and pathogens for broad spectrum disease control in freshwater aquaculture: The full sequence information of some innate immune molecules and antimicrobial peptide genes (hepcidin, apolipoprotein A1, natural killer cell enhancing factor, lysozyme G, linker histone H1M, NAD(P)H quinoneoxidoreductase complex I and interleukin 15) of *Labeo rohita*was generated. The synthetic peptide of hepcidin was able to inhibit the bacteria *Aeromonashydrophila*, *Edwardsiellatarda* as well as *Pseudomonas putida* at a concentration of 50 µM at 3 h post incubation.

Environmentally sustainable termite control: integrative and inclusive approach of frontier and indigenous technologies: Accession numbers were obtained for two genes of *Heterotermes indicola* [KF170428 and KF170427]. Termiticidal seed treatments were found without deleterious effect on seedlings. (1) Wheat - chlorpyriphos @2; fipronil 4; and imidacloprid 3–5 ml/kg seeds. (2) Soybean-chlorpyriphos @4; imidacloprid 4–6; and fipronil @5-7 ml/kg seeds. (3) Maize - fipronil @ 5; and imidacloprid@1.5–5 ml/kg seeds. Benefit: cost ratio (BCR) worked out for termiticides as soil application (chlorpyriphos, imidacloprid, fipronil - granules and liquid, microbial pesticides - *Beauveriabassiana* and *Metarhiziumanisopliae*, EPN commercial formulation *Steinernemathermophilum*, botanicals - neem and neem + garlic derivatives). Fipronil (0.3% G) gave maximum yield (BCR: 4.90), but chlorpyriphos (20%EC) was most cost-effective treatment (BCR: 5.84).

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:

- Allelic variability was observed in the camel populations of Kachchi breed and Kharai strain of Kachchi breed that clearly established Kachchi camel as a distinct breed.
- A number of new monomers of tannins detected in Acacia pods.
- Developed pathogenicity gene (L-gene) and 3B3 deleted replicons using the available FMDV replicon for use of developing attenuated vaccine. GFP gene was inserted in the replicons carrying L and 3B3 deletions.
- Variations available in red rice varieties were studied for morphological and quality characters in hills of Himachal Pradesh. Some of the lines had high content of iron and zinc.

An e-learning portal launched

A centralized e-learning portal has been designed and developed by ICAR for refinement, updation, maintenance and sustenance of the e-learning in the field of agricultural education. The portal has been hosted on the web accessible at http://ecourses.iasri.res.in for teachers, researchers' and students. The online access of the interactive and multimedia UG level e-Course contents of five disciplines namely Horticulture, Fisheries Science, Dairy Technology, Home Science, Veterinary and AH has been made available as guest users.

The contents are available as free downloadable component from the same portal for remote area institutions/ faculty/ students, for offline usage. The downloaded file content folder could be independently executed offline on the local computers and courseware contents can be used exactly in the same manner as the existing CDs/DVDs contents created for offline e-learning. This will eliminate the process of physical supply of e-course contents on (CDs / DVDs) by post/ courier services. At present more than 1250 users for online access and about 2600 users for offline free downloads have been registered from NARS in the portal. More than 13000 e-course content files from different disciplines have been downloaded by the registered users. The portal link was provided on the ICAR as well as SAUs web sites. Sensitization cum awareness workshops for nodal officers of different disciplines were organized during the year.

- Trend analysis of the productivity changes in onion over the years in relation to changes in climatic factors was carried out in districts of Karnataka.
- The mapping of geo-temporal fish resources was achieved through a software developed in Mangalore catchment area to identify both commercial and non-commercial fish resources.
- MO-10 isolate of *Moringa oleifera* having high oil content was identified. Phenotypic screening of 34 genotypes was completed for seed and oil content of Moringa plant.
- Long time series secondary data on eleven climatic and oceanographic parameters were collected. The trend in chlorophyll anomaly was reasonably well related with the sea surface temperature trend (SST) along the Tamil Nadu coast.

Quality assurance and reforms

Accreditation: Quality assurance in higher agricultural education was pursued through accreditation of agricultural universities, their constituent colleges and programmes. Seven universities, including GADVASU, Ludhiana; CCSHAU, Hisar; CSKHPKV, Palampur; UAS, Raichur; KVAFSU, Bidar; UBKVV, Cooch Behar and IGKV, Raipur were accredited and Peer Review Teams of IVRI, Izatnagar; PAU, Ludhiana; NDUA&T, Faizabad; ANGRAU, Hyderabad and MAFSU, Nagpur were constituted.

India-Africa fellowships: To support the agricultural human resource development in Africa through formal education of African scientists/faculty and students, India has been offering fellowships to the nationals of African continent for pursuing Masters and Ph.D programme in agriculture since 2010. A total of 37 African candidates have completed their programmes so far. During current academic year, 187 applications were recommended for admission to 32 AUs, after considering the unutilized slots of previous years.

India-Afghanistan fellowships: To strengthen and expedite the process of human resource development in Afghanistan, India with its wide experience, infrastructure and facilities and competent scientific and teaching manpower in most of the aspects of Agricultural and allied sciences, offered 115 fellowships during the year for higher studies in Indian AUs for Afghan nationals. Since 2010, eight Afghan nationals have completed their programme. During the academic year 2013-14, a total of 134 candidates were selected and 54 have joined the programme.

ICAR International fellowships: With an objective to develop competent human resource and showcasing the strengths of Indian ICAR-AUs system, 58 ICAR International Fellowships, since 2009-10, have been awarded for pursuing Ph.D programme at the Indian and overseas universities. So far, 29 students have completed their studies in leading overseas Institutions, mainly in USA, UK, Taiwan, Germany and Canada.

ASEAN-India working group

ASEAN- India Working Group on Agriculture and Forestry was formed to facilitate promotion of joint efforts for development of Human Resource and Technology for increasing production and productivity of Crops, Livestock, Fish, Natural Resource Management, Post- harvest technology and value addition etc. In view of increasing population of India and ASEAN countries, productivity and profitability enhancement per unit area and per unit energy are critical for sustainable agricultural growth in the region. ASEAN-India Working Group on Agriculture & Forestry will help in attaining these objectives by means of development of joint ventures in Agriculture, Exchange of technologies, Exchange of scientists/ experts and germplasm.

A conference of Heads of Agricultural Universities and Research Institutions of ASEAN countries and Vice-Chancellors of Indian Agriculture Universities and Central Agriculture University was organized in New Delhi during 19-20 February 2013 to identify strategy and to work out on the modalities of co-operation among the Agriculture Universities and research institutions in ASEAN and India. The conference discussed the issues of exchange of scientists from agriculture research among the agriculture research, education and extension institutions in ASEAN member states and India; ASEAN-India fellowship for higher agricultural education in India and ASEAN countries.

The 3rd meeting of ASEAN India Working Group on Agriculture and Forestry was held during 6-7 May 2013 at NASC Complex, Pusa, New Delhi. Various joint collaborative projects proposals were discussed during the meeting. The 3rd meeting of Agriculture Ministers of ASEAN and India was held on 28 Sep, 2013 in Kuala Lumpur, Malaysia where Hon'ble Minister of Agriculture, and Food Processing Industries, Shri Sharad Pawar led the Indian delegation. It was agreed in the meeting to enhance ASEAN-India cooperation in Agriculture, especially to address the challenges of food security through capacity building, agricultural education and research and development. At this occasion, the 3rd issue of the Newsletter on India-ASEAN cooperation on Agriculture and Forestry was released. Directorate of Knowledge Management in Agriculture (DKMA) in the ICAR has been entrusted to bring out this Newsletter on half yearly basis in collaboration with all ASEAN Nations.

Liaising with other departments and academic institutions

Liaising 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.

Policy for higher agricultural education

A high level committee constituted by President ICAR Society submitted its report on *National Policy for Higher Agricultural Education.* The committee had several interactions with stakeholders and discussed policy issues with Vice Chancellors of SAUs, CAUs, DUs, Industry Representatives, Former and Existing DGs and DDGs of ICAR and students before evolving the Policy Document. The Policy document has been divided into 6 Sections viz. Status of Higher Agricultural Education, Issues and Concerns, Vision and Mission, Recommendations and Epilogue besides, guidelines for establishment of Central Agricultural Universities. The salient policy recommendations of the committee concern; Attracting students to agricultural education, Academic reforms, Curriculum improvement, Faculty improvement, Inclusive growth, Institutional Development, Governance and Structure, Globalization and partnership, Centre- State Partnership, Non-formal education and Financial Sustainability.

National Academy of Agricultural Research Management (NAARM)

NAARM, Hyderabad continued its innovative activities under the broad areas of capacity building, research, postgraduate education and policy support.

The NAARM finalized and signed a Memorandum of Understanding with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru with the intent to develop cooperation and collaboration in research for development, training and other agreed activities, keeping in view the increasing national and global need to create, disseminate, apply and exchange knowledge in agriculture for the sustainable development of farmers by increasing their income.

NAARM is the lead centre for an international project "Assessments of the Maize Situation, Outlook and Investment Opportunities to Ensure Food Security in Asia" funded by the International Maize and Wheat Improvement Centre (CIMMYT), Mexico and International Institute of Tropical Agriculture (IITA), Nigeria. The partner countries are Bangladesh, China, Indonesia, Nepal and Pakistan. Besides, consultancy was given to many agricultural research institutions in India and abroad for customized teaching, training and research support.

Capacity building programmes: The Academy organized 64 programmes for 1,798 participants that included 2 foundation courses for Agricultural Research Service (FOCARS) and 62 other senior-level training programme.

Capacity building programmes conducted by NAARM, Hyderabad during 2012-13

Name of capacity building programme	Number of CBP	Number of participants
Foundation Course: FOCARS	2	157
EDP Leadership Development	2	25
MDP Leadership Development (Pre-RMP)	2	77
MDP Agricultural Research Management (HOD)	2	44
MDP/Faculty Development Programmes	12	280
Refresher Courses/Summer Schools	3	89
Workshops/Seminars	21	555
Off-campus Programmes	18	514
Orientation Programmes	2	57
Total	64	1,798

Customized off-campus programmes were conducted for IIT, Kharagpur, GADVASU, Ludhiana, CAZRI, Jodhpur, IARI, New Delhi, PDKV, Akola, TANUVAS, Chennai, KVAFSU, Bidar, CSWRI, Avikanagar, IGKV, Raipur, IGFRI, Jhansi and Directorate of Mushroom Research, Solan.

Research: The NAARM addresses research needs in the major areas of Research Systems Management, Information and Communication Management, Human Resources Management, Agribusiness Management, Education Systems Management and Extension Systems Management.

Postgraduate education: Twenty-four students of Postgraduate Diploma in Management in Agriculture (2011-13 batch) successfully completed the diploma and were placed in reputed organizations. Twenty-three students of 2012-2014 batch are currently

undergoing their Summer Internship. Fifty-two students of Postgraduate Diploma in Technology Management in Agriculture (2011 batch) completed the course.

Policy support: A draft training policy for the ICAR was prepared and agreed in the Governing Body Meeting of the ICAR Society. Implementable recommendations that evolved from a workshop on "*Effectiveness and Training Transfer of Centre for Advanced Faculty Training (CAFT) Programmes*" at NARS were compiled and circulated to all stakeholders.

Round table discussion on Open Educational Resources (OER): Prospects and Strategies for OER and Creative Commons in SAARC Countries was the area of round table discussion held at NAARM to formulate open educational resources. Twenty eight participants including Directors, Head of Divisions and Principal Scientists, from Hyderabad research institutes participated in the discussion.

Participation in AP-TEC 2012: NAARM partnered with the Andhra Pradesh Technology Development Corporation (AP-TEC) as a knowledge partner for the AP-TEC 2012 at Guntur. The focal theme of the conference was Technologies for Modern Agriculture. The objective was to expose the farmers and the State Department Officials to modern agricultural technologies.

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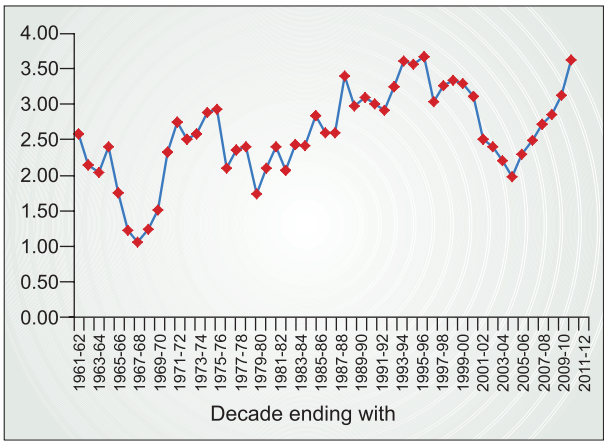
13. Agricultural Economics, Marketing and Statistics

All India and state level agricultural growth and its determinants: Indian agriculture during the decade of 1995 to 2004-05 faced slowdown but witnessed a turnaround in growth after 2004-05. The growth trajectory is now heading towards target growth rate of 4%. Various measures taken during 11th Plan and progress in technology were instrumental in reversing slowdown in agriculture growth.

State level growth: Performance of agriculture at state level during the last decade was examined based on growth rate in Net State Domestic Product (NSDP)-Agriculture during 2000-01 to 2010-11 at 2004/05 prices. Gujarat, Rajasthan, Chhattisgarh, Madhya Pradesh, Andhra Pradesh and Jharkhand out of 20 major states achieved growth rate higher than the national target. One-fifth states are close to the national target of 4% growth rate in agriculture. States of Kerala, Uttar Pradesh, Uttarakhand and Jammu and Kashmir achieved less than 2% growth in agriculture sector during 2001 to 2011. These results showed that action at state level is important determinant of agricultural growth.

Distribution of states according to agricultural growth

State	Growth rate
Kerala	1.11
Uttar Pradesh	1.72
Jammu and Kashmir	1.78
Uttarakhand	1.78
Punjab	1.85
West Bengal	2.18
Bihar	2.52
Tamil Nadu	2.74
Karnataka	2.90
Asom	2.93
Himachal Pradesh	3.41
Haryana	3.41
Odisha	3.61
Maharashtra	3.87
Madhya Pradesh	4.42
Rajasthan	4.76
Andhra Pradesh	4.76
Chhattisgarh	5.58
Jharkhand	6.16
Gujarat	6.85



Trend growth in GDP-Agriculture (at 2004-05 prices) based on 10 years period: Decade ending with 1961-62 to decade ending with 2011-12 (%)

Food security and undernourishment in India – Assessment of alternative norms and the income effect: Total food production in India increased at a much faster pace than the growth in human population during the last four decades. However, this did not articulate in terms of improvement in food and nutritional security in the country.

Estimates of undernutrition (calorie deficiency) and malnutrition (protein deficiency) were prepared for various income groups. The nutritional status in India was examined using two indicators—one based on ICMR-NIN (Indian Council of Medical Research-National Institute of Nutrition) norm and the second based on FAO norm of 1,800 Kcal. The average intake levels of poor households were at levels even lower than the FAO norm of 1,800 Kcal. Calorie deficiency was higher for rural areas than urban areas. More than half of the income poor population was calorie deficient in both rural and urban areas across all the choices of norms. Incidence of undernutrition and malnutrition was much higher based on ICMR-NIN norm.

Undernutrition was not confined to poor households. Such a population can be termed to be suffering from 'involuntary hunger' as they do not have the necessary income resources to take care of the quantity aspect of their intakes. However, more than 50% of middle

Prevalence of under-nutrition and malnutrition based on FAO norm and ICMR-NIN norm in various income groups

Locale and Expenditure class	Undernourishment (%)		Malnourishment (%)
	FAO norm	ICMR-NIN norm	ICMR - NIN norm
Rural			
Poor	56.9	82.6	50
Middle income	21.3	61.3	31.7
High income	7	39	14
All rural	32.3	67	36.7
Urban			
Poor	66.7	78.5	59.9
Middle income	33.7	55.2	40.8
High income	10.1	29.7	22.8
All urban	39.5	58.7	43.8
Rural+Urban	34.2	64.8	38.7

income and more than 30% of upper income households were also found consuming lower than required dietary energy. These individuals can be termed as suffering from 'voluntary hunger' as they have the necessary income resources but still they are not consuming – may be out of choice or due to other non-income factors. The percentage of population with inadequate protein intakes was higher in urban households as compared to their rural counterparts.

Empirical evidence showed that an inverse relationship between food prices and hunger cannot be generalised and recent spikes in food prices did not cause any adverse effect on prevalence of under-nutrition – they have rather improved under-nutrition through positive effect on food production. In terms of brief appraisal of the FAO methodology, it was concluded that such an approach is bound to lead to erroneous conclusions as it deals with food availability rather than food intakes. It was expected, and was found to be the case for India, that the level of hunger will be an underestimate till the use of food commodities for non-food purposes is underestimated. The paradox of hunger amidst plenty prevailing in India suggested that there are historical and cultural factors that make India a different case and need further research. The study clearly brought out that income growth and elimination of poverty is a 'necessary' but not a 'sufficient' condition for reducing undernourishment and malnourishment in India.

Changes in rural labour market and its implications for Indian agriculture: Rural workforce has increased during the last 16 years, mainly on account of the increase in male labour. The number of female workers did not increase despite 25% increase in their population between 1993-94 and 2009-10. This has resulted in decline in WPR of female as well as total workers in rural India. The decline in WPR for rural women is largely explained by withdrawal by female labour from agriculture presumably due to improvement in economic conditions of farm families. There has been a big increase in pursuit for education by rural female. Improved literacy and low preference for farm work require creation of employment opportunities at large scale in rural non-farm sector to attract women to workforce.

Rural labour market is undergoing profound changes with labour moving from agriculture towards non-farm sectors. Changes in rural labour market are influenced by a set of complex factors such as pattern of economic growth, inter-sectoral wage rate and worker productivity differentials, education, MGNREGS and socio-cultural factors. The output growth in non-farm sectors outpaced growth in agriculture sector during the last 16 years. This prompted workers to move towards non-farm sectors to fetch higher income. Similarly, higher wage rate and worker productivity in non-farm sectors were also found to be the driving forces for such changes. The movement of workers from agriculture to non-farm sectors can be accelerated further through improving employment opportunities in the later till wage and worker productivity differences equalize and excess labour in the former vanishes. MGNREGS has a significant influence in labour market by reducing the labour availability for farm operations, increasing wage rate and by influencing work culture and work environment of rural workers. MGNREGS constituted about 7% of the employment of rural labours on a full year basis. On actual employment basis the

Structure of employment and population by gender in rural India

Variable	Male			Female			Persons		
	1993-94	2009-10	CGR	1993-94	2009-10	CGR	1993-94	2009-10	CGR
Agriculture	139.13	145.61	0.29	90.31	83.07	-0.52	229.44	228.68	-0.02
Industry	13.14	16.23	1.33	7.33	7.85	0.42	20.48	24.08	1.02
Construction	6.01	26.20	9.64	0.94	5.44	11.58	6.95	31.64	9.94
Services	27.60	41.50	2.58	5.87	7.95	1.92	33.47	49.46	2.47
Total workforce	187.76	231.87	1.33	104.77	104.62	-0.01	292.52	336.49	0.88
Total population	339.53	423.89	1.40	319.41	400.85	1.43	658.94	824.74	1.41

CGR, Compound growth rate (%).

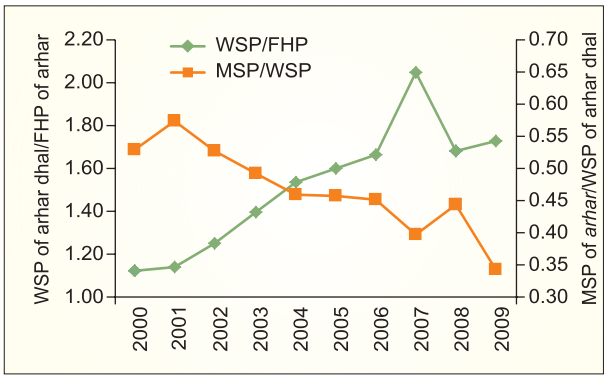
share of MNREGS in total labour supply will be much higher. Though in per cent term MNREGS share in rural labour supply looks small but it corresponds to total employment in industry sector and three-fourths of employment in construction sector in rural India. Therefore reduced labour supply for agriculture due to MGNREGS is obvious.

The consistent increase in real wages has potential for cost push inflation in the country. Changing work culture and emerging contractual arrangement between labours and labour hiring farm households are also affecting rural labour market. Changes in rural labour market are slow due to requirement of skill and education level in non-farm sectors, concentration of industrial unit away from rural habitation and limited capacity of non-farm sector to ensure productive employment to in-coming workers. The improvement in education and skills of the largely uneducated and unskilled rural labours will accelerate these changes.

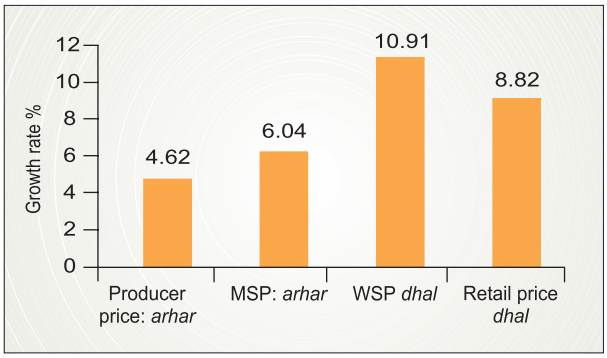
Though the movement of labour out of agriculture is a welcome development from the economic growth and development point of view, there is a strong need to develop effective strategy to face labour scarcity and wage rate increase, which subsequently increases cost of production and prices. This should include the strategy for farm sector in the form of appropriate mechanization, farm practices and custom hiring arrangements. Agricultural R&D has to play a vital role in terms of offering substitute for labour in farm operations and in terms of offsetting cost push inflation resulting from structural shift in labour and rise in wages.

Development policies and agricultural markets: Agricultural marketing suffers from inefficiency, disconnect between prices received by the producers and prices paid by consumers for agricultural products, fragmented and long marketing channels, poor infrastructure and policy distortions. With farm size getting smaller day by day, income from agriculture produce can be improved by enabling the farmers to get a share of value added in marketing by developing and strengthening marketing mechanisms which include producers as partners. Urgent reforms are needed in agricultural marketing to achieve such goals and to address conditions prevailing in agricultural markets.

A very serious consequence of present market system is declining competitiveness in marketing, because of which increase in prices at consumer level, resulting from various factors, is not passed on to farmers. A classic example of this was found in the case of *arhar* (pigeonpea) in Maharashtra where benefit of increase in prices of pulses was captured by middlemen without any benefit to farmers. Price spread between farm harvest price of *arhar* (whole grain) in Maharashtra and wholesale price of arhar *dhal* (split and polished grain) in Mumbai market increased from less than 25% to more than 70% in one decade during 2000 and 2009. Thus, in just 10 years, per cent rate of margin of middlemen recorded a three-times increase within the same state and for same type of product.



Ratio of wholesale price of *arhar dhal* in Mumbai to WSP and FHP of *arhar* in Maharashtra



Annual growth rate in price of *arhar* in Maharashtra and *arhar dhal* in Mumbai

This is a clear evidence of middlemen cornering benefit of increase in price of pulses experienced during the last decade.

During 1999-00 to 2009-10 the farm harvest price (FHP), i.e. price received by producers, for *arhar* in the state increased by less than 5% per year whereas wholesale prices (WSP) and retail prices of *arhar dhal* increased by more than 10% cent per year. Thus, crops like pulses, and farmers producing these crops, have suffered from market failure.

Farm incomes in India: Estimates of farm income are not available in India for country level and at state level. In the absence of such crucial information, all sorts of statements are made about income of the

Real farm income: Per cultivator, per farm and per unit of NSA at 2004-05 prices (Rs)

	Farmers' income per cultivator	Farmers' income per farm	Farmers' income per hectare of NCA
1972-73	14,582	20,972	11,317
1977-78	15,663	21,616	12,690
1983-84	18,331	24,230	15,863
1987-88	18,864	23,163	17,420
1993-94	22,200	27,305	21,470
1997-98	26,353	30,984	25,604
2004-05	31,200	32,143	28,988
2009-10	43,833	35,484	34,466

farmers and their plight. This study fills this gap by preparing a series of farm income. The total farm income in real terms has showed a rising trend during last four decades barring a few dips. More meaningful trend in farm income was obtained by looking at the level of farm income per cultivator, per holding and per unit of net sown area. During the last four decades, per cultivator farm income at 2004-05 prices increased from Rs 14,582 to Rs 43,833 while the farm income per holding increased from Rs 20,972 to Rs 35,484, which is less than two times. This has happened due to higher increase in the number of holdings as compared to the number of cultivators. Farmer income per hectare of net sown area followed almost same increase as farm income per cultivator.

STATISTICS

Advanced super-computing hub for OMICS knowledge in agriculture (ASHOKA): The first supercomputing hub for Indian Agriculture was established at the IASRI. This supercomputing environment is being developed for high performance computing in the field of agricultural bioinformatics and computational biology at Centre for Agricultural Bioinformatics (CABin). The facility is set up in a state-of-art data centre and two super-computers of this hub are listed at rank 11 and 24 in the list of top super-computers of India (http://topsupercomputers india.iisc.ernet.in/jsps/june2013/index.html).

This hub has approximately 1.5 Peta Byte storage divided into three different types of storage architecture i.e. Network Attached Storage (NAS), Parallel File System (PFS) and Archival. This hub also consists of super-computing systems at NBAGR Karnal, NBPGR New Delhi, NBFGR Lucknow, NBAIM Mau and NBAII, Bengaluru which form a National Agricultural Bioinformatics Grid in the country. The aim is to provide seamless access to these biological computing resources to the biological researchers across the country.

Experimental designs balanced for indirect effects of treatments: For easy accessibility and quick reference of Neighbour Balanced Designs and Crossover Designs by the experimenters, a software "Web Generation of Experimental Designs Balanced for Indirect Effects of Treatments" was developed and deployed at www.iasri.res.in/webdbie. The software generates five classes of Neighbour Balanced Block Designs and eight classes of Crossover Designs.

The webpage displays the layout plans along with the randomized layout for given number of treatments. The parameters of the designs so generated are also displayed. The details of the designs are also included. The online catalogue ($v \leq 20$) of Neighbour Balanced Designs and Crossover Designs was developed and is included in the software. Search facility of all designs and designs for some particular value of parameters is provided along with showing the layout of the design. This software provides freely available solution for the researchers and students working in this area.

Small area inference using survey weights: In this era of decentralization, the thrust of planning process has shifted from macro to micro level. Small area estimation (SAE) techniques are used to produce reliable estimates for small areas. Unit level linear mixed models are often used in SAE; and empirical best linear unbiased prediction (EBLUP) also proved to be efficient. However, this approach of SAE does not make use of the unit level survey weights. As a result, small area estimator based on this approach is not design consistent unless the sampling design is self-weighting within areas. The Pseudo empirical best linear unbiased prediction (Pseudo-EBLUP) approach overcomes this limitation by using sample weights and also leads to design consistent small area estimator. A bias-robust method for estimating the mean squared error (MSE) of Pseudo-EBLUP estimator that remain approximately unbiased under failure of assumptions about second order moments was developed. The proposed estimator provides area specific MSE estimates for the Pseudo-EBLUP. In addition, the conditional approach of MSE estimation leads to estimator of MSE that is simpler to implement, and potentially more robust.

Goat microsatellite database (GoSatDb) : A web based relational database was developed consisting of 865,210 microsatellite markers present in the whole genome sequence of goat. GoSatdb allows microsatellite search using multiple parameters like microsatellite type simple and compound, repeat types, viz. mono, di, tri, tetra, penta and hexa nucleotide, copy number, microsatellite length, pattern of the repeat motif itself and the location of the marker on the chromosome. Microsatellites can be retrieved by specifying the chromosome number (or numbers). The database also searches specified number of markers in a provided location range on a particular chromosome. The nucleotide sequences of the particular marker are also provided to facilitate primer designing for PCR amplification of any desired microsatellite. It is available at http://cabindb.iasri.res.in/goat/ for users.

Stochastic volatility (SV) models through particle filtering : The SV model was represented in the state space form. State space form of SV models where the errors are made independent by making some changes in the two equations was formulated. The implementation of particle filtering when disturbances term in transition as well as measurement equations are dependent was also carried out. The general formula for volatility process on the basis of its lag values was developed. Parameter estimation of SV was carried out using Matlab 2007 software package. The program for implementation of particle filtering for parameter estimation of SV was developed. The formulae for two-step ahead forecast as well as the conditional variance were derived. The kernel density estimate of the residuals of SV model revealed that the distribution does not have mode around zero. The modified estimated threshold type SV model with mean encapsulated the innovation was symmetric around

zero. Recursive measurement equation with asymmetric analysis was derived for maximizing the quasi-maximum likelihood which gave estimates of parameters of SVT model. SV in mean model was fitted to the All-India data of monthly export of spices through particle filtering technique; and comparison was carried out with GARCH to assess the benefits of using SVM over GARCH.

Econometric study on water markets: An econometric study was undertaken on water markets in canal command area of North-Western Rajasthan where water resources for agricultural purposes are becoming scarcer. Earlier this region (Sri Ganganagar and Hanumangarh districts) witnessed impressive development of canal irrigation and agriculture. The water markets are emerging due to shortage of canal water and saline groundwater in most of the deeper aquifers. This study examined irrigation development in the region, structure and determinants of water markets, to assess equity, efficiency and reliability in water use under different forms of water markets. It was observed that: (i) three-fifths of net sown area and two-thirds of gross sown area were irrigated; (ii) the region is dominated by canal irrigation, but growth in canal irrigated area was poor during 2000-01 to 2008-09; and (iii) the annual growth in groundwater irrigated area was impressive (14%) during the same period. In terms of volume, groundwater development was only 46 and 80% in Sri-Ganganagar and Hanumangarh districts, respectively, in 2009. There is a further scope for regulated and monitored groundwater development as salinity of groundwater in the lower aquifers is a serious problem in here. Out of 60 selected farmers, nearly a half were self-users only, two-fifths self-users plus buyers; and only 13% self-users plus sellers of canal and groundwater in this area. Nearly two-fifths of the total farmers were using both canal and groundwater and one-third of the total farmers were dependent on canal only as source of irrigation on their farms; of the total buyer farmers, nearly a half were purchasing canal water, 29% were purchasing groundwater and 23% were purchasing both canal as well as groundwater. The farm specific technical efficiency was good (80%) in wheat production in the region.

Application of optimization techniques for construction of incomplete block designs: Within blocks incomplete block designs are very useful to maintain homogeneity among the experimental units. An efficient incomplete block design may not be always available for given number of treatments, blocks and block sizes. For this purpose, the linear integer programming was used to obtain highly efficient incomplete block designs. A constraint satisfaction approach to construct incomplete block design with specified concurrence matrix was proposed. A multi-step linear integer programming approach to construct a proper binary incomplete block design with specified parameters and concurrence matrix was developed. Nearly balanced concurrence matrix was also generated through the algorithm. Using the two approaches, construction of different classes of binary incomplete block designs viz. balanced incomplete block designs, regular graph designs, semi-regular graph designs etc. were illustrated with examples. Modification of the algorithm for obtaining incomplete block designs for tests vs control(s) comparisons was also shown and illustrated with examples. All the proposed methods were implemented using R and SAS. An R package called 'ibd' was developed and is available on cran.r-project.org/web/packages/ibd/index.html. SAS macros were prepared. For the benefit of experimenters a catalogue of efficient incomplete block designs in a restricted parametric range was also prepared. The layouts of the designs are available on Design Resources Server at http://iasri.res.in/design/ibd/ibd and http://iasri.res.in/design/btib/btib.

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14. Information, Communication and Publicity Services

The Directorate of Knowledge Management in Agriculture (DKMA) is mandated to act as the nodal centre of ICAR for information, communication and knowledge management related activities of the Council. DKMA also contributes significantly as a knowledge resource centre of National Agricultural Research System (NARS) with linkages across ICAR Institutes, KVKs, Agricultural Universities, CGIAR institutions, other scientific and educational institutions and international organizations in related fields. Besides outreach, publicity and enhancing visibility of the ICAR are other thrust areas of the DKMA. The DKMA undertook a wide range of activities including development and creation of information and knowledge products in print and electronic format; maintenance and content management of ICAR and DARE websites, ICAR pages on social media; trainings and workshops in knowledge management and communication; organization of events for showcasing ICAR technologies; library services including collection, storage, retrieval and dissemination of information; and publicity and public relation services. DKMA is implementing two NAIP funded sub-projects as consortium leader, and two projects as consortium partner.

The DKMA coordinates network and connectivity infrastructure at ICAR headquarters (KAB-I, KAB-II and NASC Complex) and ICAR institutes through Agricultural Knowledge Management Unit (AKMU) and National Knowledge Network. More than 400 internet nodes are maintained in KAB-I and KAB-II.

New initiatives and highlights

- DKMA played a central role in the development of Open Access Policy for ICAR by piloting it first with its flagship research journals, providing relevant inputs and coordinating as the nodal agency.
- ICAR launched its Facebook Page in March 2013 to interact and share the vast knowledge resources of ICAR with faculty, staff, students and public in new ways on a social media platform. The response was instant as more than 16,000 likes were recorded and over 600 visitors are talking about the posts. A photo/drawing contest for the general public and Hindi slogan/punch line competition for ICAR employees were organized which drew an appreciable response. The site has earned an average four star rating for overall contents.

ICAR launched the facebook page

- A new website of DARE was designed and hosted at *www.dare.gov.in*. Content management and uploading is done regularly on this website.
- Live webcasting of important events on ICAR website was initiated with 85th Foundation Day of ICAR in which Honorable President of India delivered the Foundation Day Lecture. Complete proceedings of the 8th National KVK Conference 2013, held at Bengaluru, were also live webcast.
- The DKMA acted as a key facilitator in authentication and validation of processes for issue of ISO certification to the DARE and ICAR. The certificate was obtained by implementing the Quality Management System in the organization as per the ISO 9001:2008 standards.
- *Success Story in AR4D* a publication by GFAR & APAARI carried the success story of ICAR Journals, 'Opening Access to Agricultural Research Journals in India'.
- As a first comprehensive attempt towards documentation of nutrition standards of Indian livestock species (including fisheries and captive wild animals A series of 10 bulletins on-*Nutrient Requirements of Animals* was published**.** This series is an outcome of the recommendations of the National Committee on Nutrient Requirement of Animals, constituted by the ICAR.
- To further expand the horizon of ICAR's coveted handbooks a new title *Handbook of Agricultural Engineering* was published with contributions from leading experts of the country.

Window to the world

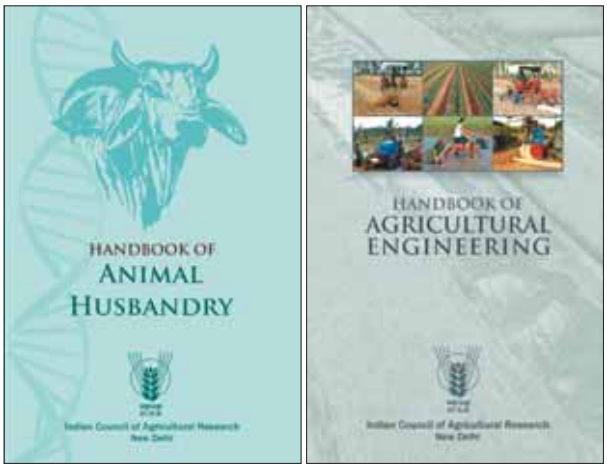
The ICAR website (*www.icar.org.in*) presents knowledge and information in bilingual mode (English and Hindi) for a wide range of stakeholders that include

researchers, students, policy planners, farmers and civil societies. The website is updated daily with news, success stories, announcements, circulars, tenders and other relevant content. Currently, on an average over two lakh hits per month from visitors across the globe are recorded with a significant percentage of new visitors. During the period under report 1,200 new pages were created and 1,500 pages were updated with latest inputs. Specific weather based agro-advisories and contingency plans for agricultural activities are updated on the website regularly to benefit farmers and extension functionaries. Crucial advisories developed by ICAR institutes and subject matter divisions were posted for various stakeholders to mitigate the aftermath of natural calamity. The YouTube Channel of ICAR includes video films, lectures/ interviews by dignitaries and eminent scientists, proceedings of national and international events etc. During the period more than two lakh hits were recorded for over 100 videos placed on the channel.

The ICAR website also hosts e-publishing platform *(http://epubs.icar.org.in/ejournal)* 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), India-ASEAN News on Agriculture and Forestry* and *Agbiotech Digest*. The on-line availability in Open Access mode has enhanced visibility and improved ISI impact factor of *The Indian Journal of Agricultural Sciences* from 0.088 to in 2009 to 0.17 in 2013, and of *The Indian Journal of Animal Sciences* from 0.137 in 2009 to 0.147 in 2013. The H indices for these research journals are 13 and 12 respectively. During the reporting period, more than 1.44 lakh visits and 9.63 lakh page-views were recorded from 202 countries with India, China, Iran, Turkey, USA, Pakistan, Egypt, Mexico, Brazil and Bangladesh being the top ten countries. Research journals have about 19,000 registered readers and total registered users on the e-publishing platform of research journals are more than 50,000. Besides, the platform also hosts 15 research journals of the related professional societies who have been trained by the DKMA for online processing and publishing of research articles. Two abstracting journals, i.e. *Indian Agricultural Sciences Abstracts* and *Indian Animal Science Abstracts* published half yearly by DKMA are also available on the ICAR website in open access mode.

Knowledge and information products

The DKMA continued to publish twelve regular publications that include research journals, semi-technical (popular) periodicals and in-house newsletters (eight in English and three in Hindi; one in Hindi, English and 11 regional languages). During the period under report, the content of these information products was given a new dimension to make it more informative and specific to meet the requirements of identified target audience such as researchers, students and farmers and other stakeholders. Review articles from leading



Revised and enlarged edition of *Handbook of Animal Husbandry* was released and *Handbook of Agricultural Engineering* was added in the series of Council's handbooks

experts appear as a regular feature in research journals and accent issues and special issues of semi-technical periodicals were brought out on topical themes. In addition, nearly 100 publications were brought out in English and Hindi as technical books, monographs, textbooks, handbooks, technical bulletins, brochures etc. The DKMA also provided expertise and assistance to various constituents of ICAR for printing and publishing of special publications, such as *A Journey in Search of Talent - Glimpses* for ASRB, and new and revised postgraduate curricula and syllabi for Education Division. DKMA coordinated and developed content for publications related to some of the major events of the Council such as Annual General Meeting, ICAR Foundation Day and Award Ceremony held during the year. The DKMA organized and participated in 14 exhibitions/showcasing of ICAR technologies 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 national and regional level. Revenue of nearly ` 75.54 lakh was generated through the sale of publications and e-products (January-December 2013). As the national input center for the AGRIS database of the FAO, the DKMA prepared and supplied 1,270 inputs to FAO in WebAgris software to enable on-line search by users. Training programmes

ICAR technologies were showcased through exhibitions during national and international events

Salient Points - ICAR Open Access Policy

- Each ICAR institute to set up an Open Access Institutional Repository.
- The authors of the scholarly articles produced from the research conducted at the ICAR institutes have to deposit immediately the final authors' version manuscripts of papers accepted for publication (pre-prints and post-prints) in the institute's Open Access repository.
- The authors of the scholarly literature produced from the research funded in whole or part by the ICAR or by other Public Funds at ICAR establishments are required to deposit the final version of the author's peer-reviewed manuscript in the ICAR institute's Open Access Institutional Repository.
- Scientists and other research personnel of the ICAR working in all ICAR institutes or elsewhere are encouraged to publish their research work with publishers which allow self- archiving in Open Access Institutional Repositories.
- Scientists are advised to mention the ICAR's Open Access policy while signing the copyright agreements with the publishers and the embargo, if any, should not be later than 12 months.
- M.Sc. and Ph.D. thesis/dissertations (full contents) and summary of completed research projects to be deposited in the institutes open access repository after completion of the work. The metadata (e.g. title, abstract, authors, publisher, etc.) be freely accessible from the time of deposition of the content and their free unrestricted use through Open Access can be made after an embargo period not more than 12 months.
- All the journals published by the ICAR have been made Open Access. Journals, conference proceedings and other scholarly literature published with the financial support from ICAR to the professional societies and others, to be made Open.
- The documents having material to be patented or commercialised, or where the promulgations would infringe a legal commitment by the institute and/or the author, may not be included in the institute's Open Access repository. However, the ICAR scientists and staff as authors of the commercial books may negotiate with the publishers to share the same via institutional repositories after a suitable embargo period.
- ICAR shall set up a central harvester to harvest the metadata and full-text of all the records from all the OA repositories of the ICAR institutes for one stop access to all the agricultural knowledge generated in ICAR.
- All the meta-data and other information of the institutional repositories are copyrighted with the ICAR. These are licensed for use, re-use and sharing for academic and research purposes. Commercial and other reuse require written permission.
- The institutes are free to place their unpublished reports in their open access repository. They are encouraged to share their works in public repositories like YouTube and social networking sites like Facebook ®, Google+, etc. along with appropriate disclaimers.

were also organized on data indexing for AGRIS database of FAO for the participants from ICAR institutions and Professional Societies. Under library services, about 2,000 publications were bar-coded. Nearly 600 titles have been digitized under e-Granth, sub-project of the NAIP that include research project reports and *ad-hoc* reports.

As Consortium Leader of the multi-centric (10 centres), NAIP sub-project on Mobilizing Mass Media Support for sharing Agro-information, DKMA mobilized appearance of nearly 500 news/features in national and regional media (Hindi, English, Punjabi, Malayalam, Tamil, Kannada and Gujarati) covering various agricultural technologies and innovations developed by ICAR and NAIP projects. The project also facilitated about 40 TV/Radio programs at the national and regional level and also aired audio capsules on radio channels in different regional languages. About 200 news items and 25 success stories were processed and uploaded to the ICAR website in English and Hindi. Around 14 Media Meets were organized at fields and laboratories of different ICAR institutes culminating into coverage in print and electronic media. Publicity and public relation services were provided to the following major events organized by the Council: XI Agricultural Science Congress, Bhubaneshwar (8 Feb 2013); 84th Annual General Meeting of ICAR Society, New Delhi (18 Feb 2013); Indian Agricultural Universities and ASEAN Countries Meet, New Delhi (19 Feb 2013); ICAR Director's Conference, New Delhi (20 March 2013); XXI Meeting of the ICAR Regional Committee III, Jorhat (17 April 2013); 3rd ASEAN-India Working Group Meeting, New Delhi (6 May 2013); CMFRI-SAARC International Workshop, Cochin (5 June 2013); 85th ICAR Foundation Day, New Delhi (16 July 2013); NAIP Agri-Tech Investors Meet, New Delhi (19 July 2013); Indian Dairy Summit 2013, New Delhi (24 July 2013); 'The 50 PACT' Commemoration of Dr. Borlaug's First visit to India, New Delhi (17 Aug 2013); Borlaug Global Rust Initiative Technical Workshop, New Delhi (22 Aug 2013); National Workshop on Out-scaling Farm Innovation, New Delhi (3-5 Sep 2013); VIII National conference of Krishi Vigyan Kendras, Bengaluru (23 Oct 2013); Foundation Day of AgrInnovate India Ltd. (19 Oct 2013); Foundation Day of ASRB, New Delhi (1 Nov 2013).

Currently, DKMA is revisiting its strategies in the light of open access policy, quality policy and e-governance modules. The gestation period of knowledge and information products is being reduced by adopting innovative management practices and latest IT tools. Linkages are being developed with international organizations to project the Indian agricultural research on global forum. DKMA, with all its efforts, is sensitizing and catalyzing ICAR system towards a new information and communication regime ensuring outreach of agricultural research to its stakeholders. ❑

15. Technology Assessment, Refinement and Transfer

The Krishi Vigyan Kendras (KVKs) as a grass root institution have taken up a number of activities for assessment, refinement and demonstration of technologies/products under different agro-ecosystems to facilitate faster adoption of technologies developed by the National Agricultural Research System of the country. At present, 634 KVKs are operating across the country with different host organizations like State Agricultural Universities (431 KVKs), ICAR Institutes (51 KVKs), NGOs (99 KVKs), State Governments (35 KVKs), Public Sector Undertakings (3 KVKs) and Central Universities/Deemed Universities and other educational institutions (15 KVKs). The activities of the KVKs include on-farm trials (OFTs) to identify location specificity of technologies in various farming systems; frontline demonstrations (FLDs) to exhibit the production potential of the technologies and training of farmers, farm women, rural youth and extension personnel to enhance their capabilities to take up various farm related activities. In addition, the KVKs contributed as knowledge and resource centres, produced technological inputs and made climate resilient interventions for mitigating challenges posed by climate change.

Technology assessment and refinement

Assessment: During the year, 2,174 technological interventions were assessed across 4,159 locations by laying out 23,568 trials on the farmers' fields on various crops under different thematic areas, namely cropping systems, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated farming systems, integrated nutrient management, integrated pest and disease management, organic farming technologies, processing and value addition, resource conservation technologies, seed/planting material production, storage techniques, varietal evaluation and weed management. The major crops covered were paddy, wheat, maize, blackgram, greengram, pigeon pea, chickpea, lentil, groundnut, mustard, sesame, soybean, sugarcane, cotton, onion, tomato, brinjal, okra, amaranths, chillies, cowpea, banana, mango, apple, turmeric, sweet potato and others.

In livestock, 452 technological interventions were assessed at 701 locations through 5,918 on-farm trials on animals under different thematic areas like disease management, evaluation of breed, feed and fodder management, fertility management, nutrition management, production and management practices, drudgery reduction, processing and value addition and storage techniques. The major livestock species included dairy cattle, buffaloes, sheep, goat, poultry birds, quails, pigs and fisheries.

A total of 143 farm-women specific appropriate technological interventions were assessed at 225 locations through 1,848 trials under the thematic areas, namely drudgery reduction, family resource management, health and nutrition, child care, processing and value addition and production and management. The major enterprises related to farm women specific interventions included - Vermicompost production, sericulture, lac, mushroom, nutrition garden, nursery raising, poultry, dairy, seasonal vegetable production, soyabean based products, processing and value addition, entrepreneurship, management of waste, handicraft and tailoring etc

Refinement: A total of 1,897 trials were conducted at 309 locations to refine 253 technologies under different thematic areas like cropping systems, drudgery reduction, farm machineries, integrated crop management, integrated disease management, integrated farming system, integrated nutrient management, integrated pest management, processing and value addition, resource conservation, seed and planting material production, storage techniques, and weed management. Major crops included paddy, wheat, pearl millet, mustard, groundnut, pigeon pea, chickpea, sugarcane, cotton, tomato, onion, brinjal, okra, apple and chillies.

Further, 39 technological interventions on livestock, poultry and fisheries enterprises under the thematic areas, viz. disease management, feed and fodder management, nutrition management, processing and value addition and production and management were refined through 402 trials at 41 locations.

In addition, 17 women specific income generation technologies were also refined by conducting 158 trials in 20 locations. The major enterprises included value added dairy products, aonla, mushroom products, etc.

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 enterprises on the farmers' fields. On-site training and field days for the benefit of farmers and extension workers were also organized at demonstrations. In all 1.71 lakh FLDs were organized by KVKs during the year, including 90,384 on crops (cereals, millets, oilseeds, pulses,

commercial crops, fibre, spices, medicinal, plantation, fodder, green-manure and horticultural crops) covering an area of 26,399 ha. For popularization of improved tools and farm implements, 5,388 demonstrations on 3,229 ha farm area; 11,180 demonstrations on livestock enterprises; and 4,113 demonstrations on other enterprises including gender-specific technologies for women empowerment were organized. Out of the total FLDs, as many as 51,956 demonstrations were conducted exclusively on climate-resilient technologies under NICRA project.

Cereals: For different cereal crops like rice, wheat, maize, and barley, as many as 30,505 demonstrations were conducted covering 9,865 ha area. The highest yield advantage was recorded in the case of wheat (43.4% over farmers' practice), followed by 26% in maize, 24.9% in barley and 22.3% in rice.

Millets: Demonstrations on important millet crops like barnyard millet, finger millet, pearl millet and proso millet were conducted on the field of 2,313 farmers with area coverage of 826.9 ha. The average increase in yield of different millets was 30.7% over local checks.

Oilseeds: During the year, 15,677 FLDs were conducted on oilseed crops like groundnut, sesame, soybean, sunflower, *toria*, linseed, mustard, castor, niger, rapeseed, and safflower with area coverage of 4,664 ha. The yield increase ranged from 21.7% in soybean to 49.3% in rapeseed over farmers' practices.

Pulses: As many as 20,956 FLDs on pulse crops like blackgram, cowpea, field pea, greengram, horse gram, lentil, pea, pigeonpea, and *rajmash* were conducted on farmers' fields in an area of 6,380 ha. The average increase in yield was recorded as 33.4% in blackgram, 26.8% in chickpea, 25.4% in cowpea, 47.1% in field pea, 34.9% in greengram, 63.5% in horse gram, 38.1% in lentil, 45.8% in pea, 34.2 % in pigeonpea, 50.4 % in *rajmash* and 29.2% in rice bean as compared to farmers' practices.

Commercial crops: Under commercial crops, 1,719 FLDs were laid out. These included sugarcane (335), cotton (1,217), betel leaf (32), coffee (20), tea (9) and cluster bean (106) in an area of 708.6 ha. The yield advantage in demonstration plots was 20.6% in cotton, 17.6% in sugarcane, 15.6% in coffee, 39.5% in betel leaf, 14.4% in tea, and 9.14% in cluster bean as compared to local checks.

Fibre crops: The demonstrations on fibre crops like jute and sunhemp involved 228 farmers covering an area of 50.6 ha. The average yield increase of 27.5% in demonstrations was recorded as compared to farmers' practices.

Fodder crops: FLDs on fodder crops like berseem, cowpea, maize, lucerne, napier, oat, pearl millet, sorghum and Sudan grass were conducted in 2,044 farmers' fields covering an area of 319.5 ha. The increase in fodder yield reported under these demonstrations varied from 23% for oat to 60% in napier grass as compared to the local checks.

Horticultural crops: Over 16,900 demonstrations were conducted on horticultural crops including vegetables (9,409), fruits (1,468), flowers (383), spices and condiments (4,646), tuber crops (492), plantation crops (318) and medicinal crops (216) covering total area of 3,581.7 ha. The yield advantages recorded was 28.3% in medicinal crops, 28.2% in fruits, 29.4% in flowers, 25.4% in spices and condiments and 26% in vegetables over the farmers' practices.

Hybrids: For exploiting the potential of hybrids at farmers' fields, total of 8,857 demonstrations over 3,093 ha were conducted for cereals, millets, oilseeds, pulses, fodder crops, cotton and horticultural crops. In cereals like rice, wheat, sorghum, pearl millet and maize, 3,470 FLDs were conducted by 272 KVKs covering 1,472 ha area achieving a yield increase up to 135% in the case of rice hybrids. A total of 548 demonstrations on hybrid cotton were conducted by 33 KVKs on 222 ha wherein the yield increase was found to the extent of 79% as compared to local checks. Similarly, 1205 FLDs on hybrids of castor, mustard and sunflower were conducted by 94 KVKs across the country covering an area of 426 ha and achieving yield increase as high as 136% in hybrid sunflower compared to local checks. Demonstrations (147) were conducted on napier hybrids achieving enhanced yield up to 150% as compared to local checks. Similarly, 1426 demonstrations were conducted on vegetable and fruit crop hybrids covering an area of 264.8 ha through 153 KVKs achieving yield increase as high as 85.7% in tomato hybrid as compared to local checks. The remaining 2061 demonstrations on hybrids were conducted on crops like soybean, *toria*, etc.

Farm mechanization: To showcase effective and efficient use of improved tools and implements, the demonstrations (5,388) were conducted on different farm operations like planting/sowing (1437), post-harvest and processing(1351), tillage (948), weeding (792), plant protection (411), harvesting (374) and threshing (75).

Livestock, fisheries and other enterprises: Demonstrations conducted were in total 15,293 covering 8,118 dairy animals, 3,866 sheep and goat, 30,570 poultry birds, 869 ducks, 537 pigs, 30 units of rabbits, 195 units of fisheries and 9 units of prawn cultivation. Besides, FLDs were also conducted on bee keeping (128 units), lac cultivation (56 units), mushroom production (2,495 units), vermicompost production (213 units), household food security (32 units), nutrition gardens (844 units), sericulture rearing (9 units), value-addition (242 units) and women empowerment (93 units) through economic activities which involved 4,113 farmers and farm women.

Capacity development

As many as 61,495 training programmes were organized wherein 16.06 lakh farmers/farm women, rural youths and extension personnel participated.

Farmers and farm women: For the benefit of 13.11 lakh farmers and farm women, total of 48,576 training courses were organized on various technologies to

update their knowledge and skills. Most of these courses were on productivity enhancement of field crops (21 %), horticultural crops (14%), empowerment of rural women (12%), plant protection (13%), livestock production and management (17%), soil health and fertility management (8%), farm machinery tools and implements (4%), and capacity building and group dynamics (5%), production of input at site (3%), fisheries (3%) and agro-forestry (2%). Out of these courses (48,576), 44% were conducted on campus and 56% were organized off-campus. The participants included 3.69 lakh farm-women. Among the crop production technologies, about 29% of the training courses were on integrated crop production technologies, followed by resource-conservation technologies (6.6%) and weed management technologies (9.12%). Out of 6,977 training courses on horticulture, 3,380 were on vegetable crops, 2,146 on fruit crops, 402 on spice, 317 on ornamental and 172 courses on medicinal and aromatic crops.

Rural youth: Skill-oriented training courses (7,489) were organized for 1.77 lakh rural youth, including 63,517 young women (36%) during the year. These courses were on integrated farming, mushroom production, value-addition, dairy farming, seed production, vermin-culture, nursery management of horticulture crops, bee-keeping, protected cultivation of vegetables, repair and maintenance of farm machinery implements, sheep and goat rearing, poultry production, production of organic inputs and small-scale processing.

Extension personnel: Capacity development programmes (5430 courses) were also conducted for 1.18 lakh extension personnel, out of which 28,289 were women extension personnel. These courses were organized for extension functionaries working in government and non-government organizations who were directly or indirectly related 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 of farm animals, rejuvenation of old orchards, women and child care, livestock feed and fodder production, protected cultivation technology and ICT applications.

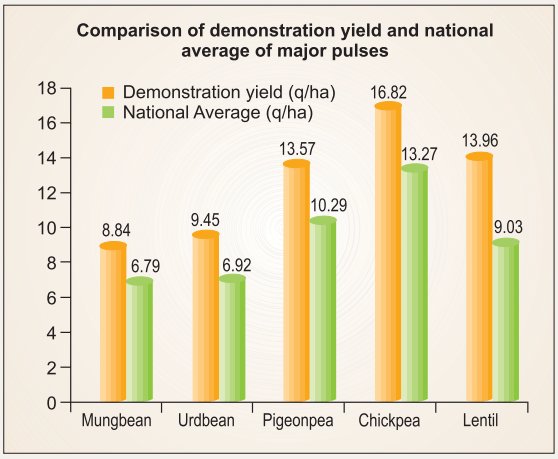
Sponsored training: Out of the total 61,495 training courses, 10,535 were sponsored programmes which benefitted 3.87 lakh farmers and farmwomen, rural youth and in-service extension personnel. Most of these courses were related to on-site input production, economic empowerment of women, processing and value-addition, methods of protective cultivation, farm machinery tools and implements, fisheries management, household nutritional security, animal nutrition management, animal disease management, fisheries and drudgery reduction technologies for farm women.

Extension programmes

For creating awareness among farmers about improved technologies and to provide timely advisory to farmers, KVKs organized different extension programmes. A total of 4.24 lakh extension programmes/ activities in the form of advisory services, diagnostic and clinic services, celebration of important days, exhibitions, exposure visits, ex-trainees *sammelan*, farm science club conveners meet, farmers' seminar, farmers' visits to KVK, field days, film shows, group meetings, *kisan ghosthi*, *kisan melas*, technology weeks, lectures delivered as resource persons, *mahila mandals* conveners meetings, method demonstrations, plant/ animal health camps, scientists' visit to farmer's field, self help group meetings, soil health camps, soil test campaigns, workshops and others were organized which attracted the participation of 102.41 lakh participants including farmers and extension personnel. The KVKs also organized 1.43 lakh extension programmes through electronic and print media to have wider coverage. These included electronic media in the form of TV programmes, radio talks, CDs/DVDs, extension literature, newspaper coverage, popular articles, leaflets, folders and books/booklets.

Technology demonstration for harnessing pulses productivity

A National level programme on 'Technology Demonstration for Harnessing Pulses Productivity' was operated through 137 KVKs in 11 states in partnership with and technological backstopping by IIPR, Kanpur and six Zonal Project Directorates. The programme focused on demonstration of district specific technology modules of five pulse crops and capacity building of KVK functionaries, representatives of line departments and participating farmers. A total of 5124 demonstrations on an area of 2049 ha were laid out on mungbean (388 ha), urdbean (241 ha), pigeonpea (445 ha), chickpea (768 ha) and lentil (207 ha) showing productivity gains of 30%, 37%, 32%, 27% and 55% respectively over national average yield.



Production of technological inputs and products

KVKs produced large quantity of technological products like seeds and planting materials of improved varieties and hybrids, bio-products and elite species of livestock, poultry and fish which benefitted 23.68 lakh farmers in the country.

Seeds: During the year, 1.57 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 2.61 lakh farmers.

Planting materials: In all, 167.19 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 2.35 lakh farmers.

Bio-products: Bio-products, namely, bio-agents, bio-pesticides, bio-fertilizers, vermi-compost, mineral mixture etc. were produced and supplied to the extent of 1.79 lakh q and 6.87 lakh numbers benefitting 13.74 lakh farmers.

Livestock, poultry and fish fingerlings: Animals of improved breeds of cattle, sheep, goat and buffalo including breeding bulls were produced and supplied to 800 farmers. Different strains of poultry birds (chickens, quails, ducks and turkey) were provided to 25,208 farmers. Improved breeds of pigs were provided to 455 farmers. KVKs also enabled 77 farmers to establish rabbit rearing units by providing 170 rabbits. A total of 102.53 lakh fish fingerlings of different types of fishes were produced and supplied to 23,887 farmers.

Soil, water and plant analysis

A total of 2.91 lakh samples (comprising 2.36 lakh samples of soil, 0.48 lakh of water, 0.04 lakh of plant, and 0.03 lakh of manure) were analyzed related to 2.29 lakh farmers of 0.37 lakh villages, with a revenue generation of ` 144 lakh.

Rainwater harvesting

A total of 347 training courses and 211 demonstrations were conducted utilizing this facility and produced 7.05 lakh planting materials. Further, 33,155 farmers and 1,662 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 KVKs benefitting 7.62 lakh farmers, farm-women, extension personnel, rural youth and members of self-help groups. The events included 4,916 extension activities such as seminars, skill demonstrations, film shows, field visits, demonstrations, exhibitions and scientist-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 being given to the farmers through Short Message Service (SMS). During the year, about 3.89 lakh short text messages were sent to 16.28 lakh farmers on various aspects of agriculture, horticulture and animal husbandry, weather forecast and pest and disease control. In addition, 148 KVKs also sent 1,749 voice messages on different aspects of agriculture and allied enterprises to 30,752 registered farmers, which cumulatively benefitted as many as 10.04 lakh farmers.

Demonstrations on climate resilient technologies

As part of NICRA project, 100 KVKs partnered in Technology Demonstrations and Dissemination for Climate Resilient Agriculture. More than one lakh farmers from 132 villages across the country were covered. Integrated packages of available and proven technologies were demonstrated in one village in each district for adaptation and mitigation under climate variability. During the year, 12,308 demonstrations on natural resource management in an area of 5,599 ha; 21,222 demonstrations on crop production technologies in an area of 6,380 ha and 18,426 demonstrations on livestock production including fodder cultivation and fisheries in an area of 14,505.08 ha

In-situ moisture conservation helping *rabi Jowar* cultivation

The efforts of KVK Baramati, Pune through village wise farmers' campaign for popularizing *in-situ* moisture conservation technology is showing the results. Total of 42 rainfed villages were selected for this activity and demonstrations were conducted for farmers by involving farmers' clubs and State Department of Agriculture. As a result, about 256 ha was brought under this technique. With just 60 to 70 mm rainfall before sowing of *rabi Jowar*, farmers could harvest good yields in Baramati, Purandhar and Indapur tehsils of the district. The technique has resulted in 60 to 70 % yield increase. Where this technology was not adopted, farmers could not harvest even dry fodder (*Kadbi)*. As a result of excellent sucess of this practice, more farmers are coming forward to adopt *in-situ* water conservation in forthcoming *rabi* seasons.

Moisture conservation in flat beds after first rain

were carried out. About 57,423 animals/ birds belonging to 24,211 farmers were attended through demonstrations related to livestock and fisheries. Capacity-building interventions and the extension activities like exposure visits benefitted 83,774 farmers.

Technological backstopping

For updating the technical knowhow of the KVK staff, the Directorates of Extension Education (DEEs) of SAUs/CAU organized 193 training programmes which helped 2791 staff of KVKs. These training programmes covered the important areas like identification of thrust areas, contingency planning, administrative and financial matters, extension methodology, OFT modulation, market intelligence, entrepreneurship development, participatory extension approaches, information and communication technology, natural resource management, impact assessment of extension programmes, integrated farming systems, high value horticultural crops, post harvest management of horticultural crops, pesticide residues and food safety, technologies for yield maximization in rainfed areas, protected cultivation, participatory seed production, livestock production management, scientific fish hatchery management, commercial poultry production, animal genetic resource conservation, clean milk production, etc.

Further, the DEEs also organized 196 workshops and meetings for effective implementation of programmes of KVKs. The officials of these directorates made 2,136 visits to the KVKs and also made 1,859 field visits to review and monitor activities at farmers' fields like on -farm trials, frontline demonstrations, etc. These directorates provided technological products like seeds to 413 KVKs, planting materials to 188 KVKs, bio-products to 137 KVKs, livestock breeds to 41 KVKs, livestock products to 26 KVKs, poultry breeds to 75 KVKs, poultry products to 32 KVKs, mineral mixture and urea molasses mineral blocks to 8 KVKs, fish seed to 18 KVKs, polyhouses to 8 KVKs and low cost vermin-compost technologies to 6 KVKs.

The Zonal Project Directorates through their HRD programmes upgraded the knowledge and skills of 3,988 staff of KVKs by arranging 93 training programmes at various SAUs and ICAR Institutes in the areas like Application of ICT in Modified Agricultural Extension Reforms, Participatory Impact Monitoring and Assessment, Administrative and Accounting Procedures for KVKs, Institutional Innovations in Agricultural Extension for Inclusive Growth, Knowledge Management in Agriculture, Different Communication Skills, Supply Chain Management in Agriculture, Soil Fertility Management, Orientation Programmes for Newly Recruited Staff, KVK Knowledge Exchange Meet, Micro-Irrigation System to Mitigate Climate Change, Soil Test based Nutrient Management, Mushroom Production, Sub-tropical Horticulture, Vegetable Production under Changing Climate Scenario, Sugarcane Production Technologies, Orchid Conservation and Sustainable Development for Community Livelihood, Piggery Production and Management, Goat Farming, Fish Production, etc.

Success story

Vanaraja poultry strain ruling backyards in Kashmir Valley

Backyard poultry farming plays vital role in augmenting the rural family income and food security especially for marginalized families. Farmers of district Pulwama in Kashmir valley have also come forward to adopt this practice. However, the existing backyard poultry farming system is mostly intensive or semi-intensive with use of local, less yielding poultry strain.

After identifying this problem, KVK Pulwama took the lead by demonstrating production potential of Vanaraja birds to the farmers. Initially, 900 Vanaraja birds were provided in the year 2011-12 to the farmers for encouraging rearing of ideal poultry strain by following good production practices in their backyard units. These backyard units acted as demonstration sites for other farmers of the district which helped in popularizing the Vanaraja as backyard poultry. The farmers who raised Vanaraja in their backyard, got the average weight of 2 kg/bird within six months as against 1 kg body weight of local bird. Thus, there was 100 % productivity enhancement. The initiative has succeeded in wide scale adoption of Vanaraja strain of poultry for backyard rearing in the district.

Vanaraja birds for backyard poultry

Agricultural Technology Information Centres (ATICs)

For single window delivery of technology information, farm advisory and diagnostic services and technology products to the farmers, 44 ATICs proved instrumental in attracting 6.12 lakh farmers who visited these centres for technological solutions to their problems. Technological information was provided to 1.63 lakh farmers both through print and electronic media. Similarly, 2.82 lakh farmers got quality technological products including 0.742 lakh q seed, 6.23 lakh seedlings/saplings, 5.55 lakh livestock species and fingerlings, 26,476 poultry birds and 0.14 lakh q bio-products. In addition, 4.25 lakh farmers were benefitted by farm advisory and diagnostic services like soil and water testing, plant/animal diagnostics, seed testing and different types of farm machinery and equipment etc.

Success story

Egg vendor to broiler farm owner

KVK, Bankura, West Bengal facilitated Shri Samir Chel with skill development training on 'Poultry farm management' using repetitive reinforcing approach. Initially, he started his first broiler farm with capacity of 500 birds. Gradually, over the period of two decades, Shri Chel up-scaled broiler production and now he has become the proud owner of six broiler farms in the district. The total capacity of his farm is more than 62,000 broilers. In order to increase his income he has also opened a professional shop of poultry meat and egg at Sonamukhi, West Bengal. Started with the initial annual income of ` 36,000. Shri Chel now earns more than ` 3.0 lakh per annum as the net profit. He has good knowledge of poultry market network within and beyond his district and his business has scaled up even to neighbouring state of Jharkhand. Broiler farming has elevated his livelihood status as he now owns two storied *pucca* house, two two-wheelers, one four-wheeler and other household amenities. Witnessing his success, more than 100 unemployed youths of the area have ventured into small scale poultry farming. These youths are now maintaining more than 50,000 broilers. The adoption of poultry farming as a livelihood option has now enabled these youths to earn a secured income every month.

8th National Conference on KVK

The 8th National Conference on KVK was organized at UAS, Bengaluru during 23-25 October, 2013 with focus on "Sustainable Intensification of Smallholder Farms". About 1,300 delegates took part in the deliberations including Programme Coordinators of 634 KVKs. There were eight technical sessions dealing with various sub-themes including i) Technological intensification for higher yields and improved nutrition; ii) Resilience to pests, diseases and climate for sustainable productivity of small farms; iii) Ecological intensification for sustainable cropping/farming systems, conservation agriculture; iv) Farmers rights and bio diversification of small farms; Farmer centric approaches, small agri-business models and development of social and human capital; vi) Innovative experiences of KVKs and farmers in sustainable intensification of small farms; vii) Integration of

Dignitaries releasing publications during 8th National Conference on KVK

livestock and fisheries for sustainability of small farms ;and viii) Experiences of KVKs under NICRA Project in sustainable intensification of small farms. In addition, a special session was also held on Facilitating KVKs on administrative, financial and management issues. Technology Exhibition and Innovation Market Place showcasing technologies of ICAR Institutes, Agricultural Universities, farm innovators and farm entrepreneurs were also organised. One National and eight Zonal Best KVK Awards for the year 2012 were conferred on the occasion. KVK Neempeeth bagged the National Best KVK award.

The action points agreed during deliberations in the Conference included working of KVKs as agri-intelligence centres; improving science communication to KVKs; organizing quarterly meeting/ interface with district administration; increasing scientific technical and administrative staff and adequate funds for contingency and infrastructure; development of training plan for all the SMSs; arranging visits of Directors of Research of AUs, ICAR Institutes, Heads of Divisions and Subject Experts to KVKs ; and regular feedback by KVKs to the Universities and ICAR Institutes on performance of various technologies; problems diagnosed and identified researchable issues. A number of recommendations also emerged in the eight technical sessions. For the first time, the proceedings of the KVK Conference were webcasted and accessed on websites of ICAR and KVK Hub by more than 51,000 people across the world.

Farmers' visit to Malaysia

As part of ASEAN-India Farmers Exchange Programme, an Indian farmers' delegation visited Malaysia during 14–23 April 2013. The visit was organized in cooperation with the Department of Agriculture, Ministry of Agriculture and Agro-based Industry, Malaysia, and the ASEAN Secretariat. The delegation comprising of 18 farmers from 17 states was accompanied by two ICAR officials. The purpose of the visit was to build capacity and confidence among Indian farmers while sharing experiences and technology among farmers of Malaysia and India.

Visit of Nigerian delegation

A study visit of a 17 member Nigerian delegation

of senior Agriculture Officers from Agricultural Research Council of Nigeria (ARCN), Federal Ministry of Agriculture and Rural Development, NGOs and Farmers Organizations was conducted from 25 September 25 to 3 October 2013 to familiarize them with the KVKs and Indian Agricultural Research and Extension Systems. The visit was sponsored by Nigerian Government under West African Agricultural Productivity Program (WAAPP). The delegation visited KVKs at Gurgaon, Karnal and Ludhiana; two premier ICAR institutes, the i.e Indian Agricultural Research Institute, New Delhi and National Dairy Research Institute, Karnal; besides Punjab Agricultural University and Guru Angad Dev Veterinary and Animal Sciences University at Ludhiana. In addition visit to three progressive and innovative farmers in Haryana and Punjab was also arranged. As part of above program,

Nigerian delegates visiting cattle farm at GADVASU, Ludhiana

the delegation members also interacted with senior officials of ICAR on 27 September 2013 wherein the delegation was briefed about activities of all Subject Matter Divisions. The delegation was led by Dr. Usman Ahmed, Deputy Director (Linkages and Partnerships), ARCN, who appreciated the ICAR for setting up KVKs in the country and desired to seek help in Nigeria for opening KVK like institutions to speed up agricultural technology transfer for the benefit of Nigerian farmers.

Pomegranate orchard management under deficit water condition

KVK Ahmednagar facilitated formation of pomegranate growers' group and addressed the problems related to water management, nutrient management, and pest and diseases management on community basis. Demonstrations on use of water absorbent polymer in pomegranate orchard showed the net saving of 14 lakh liters of water per hectare because of reduced water demand to an extent of 35 per cent over untreated control. Similarly, the fruit size and fruit retention was higher in absorbent polymer applied trees as compared to untreated trees. The fruit yield in treatment plots was observed to be about 20 kg as compared to 16 kg per tree in control plots. The yield in demonstration plots was 157q/ha as compared to135.6

q/ha in control plots. There was an average increase of 13.7 per cent in marketable yield under demonstration.

Due to efficient nutrient utilization the plants in treated plots showed no symptoms of leaf yellowing or other nutrient deficiency symptoms. In these villages the area under pomegranate has increased from 225 ha to over 630 ha (64%) and number of farmers has also increased six-fold, i.e. from 200 to 1200. Also, during last two years 150 farm ponds have been excavated to ensure timely availability of water for pomegranate production.

Hot arid region turns hot spot for medicinal plants

Arid regions of Barmer are known for wild growth of wide range of medicinal plants. KVK, Barmer had earlier conducted a survey on this issue and found 120 different kind of species, which mostly grow as wild herbs. People at times take out these plants and sell to local middlemen in low price. KVK identified wildly grown useful herbs in this desert tract and formed a group of farmers and linked it with a private company to get good rates for the product of these medicinal plants.

A private company initially gave a purchase order of 70 q dried leaves of Sankhpushpi (*Convolvulus pluricaulis)*. After checking the produce they got satisfied and gave another order of 300 q. The offered rate of Sankhpushpi was ` 19 per kg of leaves, and ` 1,600 per kg of seed as against ` 9 per kg given by local middlemen. These two successful supply of consignments made KVK trustworthy to farmers of

Shankhpushpi plants in field

the district. The KVK invited Senior Managment of the company to Barmer and asked to help farmers in producing two other medicinal plants, i.e. Mulethi (*Glycerrhiza grabra)* and Arnie (*Clerodendrum phlomidis*) along with Sankhpushpi on contract basis. Formal MoU of farmers with the company was signed in January 2012 for 3 years at a rate contract of ` 16 per kg for Shankhpushpi leaves and ` 55 / kg for Mulethi.

As part of technological interventions, the KVK organized meeting of 200 farmers from excluded communities and selected 50 for trials in first year. Each farmer cultivated 0.20 ha to 0.40 ha of land, making it a total of 20 ha. Since, Mulethi is susceptible to 'termite', therefore, fields were finally selected after initial soil and water testing. Farmers were given on an average 6 q of Mulethi tuber per acre of land for using as seed. The KVK gave detailed training for scientific cultivation of Mulethi. Tubers were given free of cost, with a condition that the same quantity of Mulethi will be taken out of their produces during harvest. Each farmer obtained 22 q/ha of Mulethi which earned an income of ` 1.21 lakh/ha with ` 25,875/ha as cost of cultivation. The KVK is regularly monitoring for appropriate treatment to the soil and herbs. For next crop season, 100 farmers have come forward for Mulethi and Shankhpushpi cultivation under this approach and hopefully better marketing avenues will be created in future.

Rice bowl in Kerala developing as a mushroom belt

The upper Kuttanad of Pathanamthitta district is known as rice bowl. In recent years, usage of combined harvester has increased due to which farmers are leaving paddy straw in the field itself. Except feed for cattle the paddy straw goes waste or remains unutilized. The other best alternative to make use of unutilized paddy straw is in cultivation of *Calocybe indica (*milky) and *Pleurotus (*oyster) species of mushroom. The KVK, Pathanamthitta has trained 3471 farmers through 161 training courses on mushroom cultivation, spawn production and value addition. KVK has also produced a total of 6010 Kg of spawn in its mushroom unit and provided to 250 mushroom farmers in the district.

The spawn production and supply has created an opportunity of extra income for the women folk involved. Under the aegis of KVK, the Confederation of mushroom growers in Pathanamthitta was formed under the name Edanadu Mushroom Growers Association, Pathanamthitta. The association includes five societies registered under the project, and individual or any farmers' club members who are willing to work for the objectives of the Confederation. Twenty-one members have signed the memorandum of association. As a result, mushroom production has enhanced in the district by 2,000 kg/month, spawn production in the district by 750 packets/month and employment man days by 750/month.

Sericulture productivity enhancement through cluster approach

Chickballapura and Kolar are the major silk producing districts of Karnataka. Kathariguppe a village in Chintamani taluk of the district with more than 60 sericulturists promoted community cluster approach for enhancing production, productivity and quality cocoon production and their conversion into quality silk fabric. Under RKVY, a *sangha* was formed and registered as *Kathariguppe Bivoltine Reshme Belegarara Sangha* in December 2011. The members of the *Sangha* were given technical and financial support required for Bivoltine silk production. An amount of ` 10 lakh was spent from the project to modify the mulberry gardens, silkworm rearing houses and equipment for scientific rearing. All the members of the *Sangha* started rearing Bivoltine hybrids after affecting modifications to the mulberry gardens and silkworm rearing houses. Appropriate production, grading, packing and marketing technologies were adopted and 34 crops were harvested in the cluster villages by 22 farmers (12 farmers completed two crops) with an average cocoon yield of 64.4 kg/100 Disease Free Laying (DFL) and the total cocoon production in 10 months time is about 25,000 kg. With an average price of ` 230/kg, an approximate return was ` 57.50 lakh. The Bivoltine cocoon productivity was 20 per cent more than the productivity of the taluk for the corresponding period.

A view of sericulture unit through a cluster approach

In addition, a second cluster village Lakshmidevakote was identified in which 15 farmers with 16.25 acres of mulberry plantation were provided technical support. The identified farmers have been trained on quality aspects of different activities such as, mulberry production, rearing house management, *chawki* handling, silkworm rearing, compost production, harvesting and grading of cocoons. This has created a big impact as evident by the fact that a total of 6,175 DFLs were brushed yielding 4,893.86 kg of cocoon with average yield of 79.25 kg per 100 DFLs.

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16. Empowering Women in Agriculture

With growing concern and realization on the need for empowering women in agriculture, focus has been on developing core competencies in the area of gender issues in agriculture, capacity building of stakeholders and inclusion of women perspective as an in-built component in agricultural research. In this context, a number of research and outreach programmes in institutional and collaborative mode were undertaken.

Technology application and gender mainstreaming in agriculture: In model village project, gender issues involved in transplanting of rice were studied in association with a local NGO. It was observed that the line planting took 20 per cent more time as compared to random planting. Men were involved mostly in carrying seedlings to the field (80.20%) and stretching rope for line planting (49%) while women were engaged in transplanting (98.80%) and making bundles of seedlings (65.60%). Ergonomical parameters such as musculo-skeletal discomfort (highest in midback and lowest in ankle), physiological stress (heart rate 88.7 to 103 beats/minute) and grip fatigue were within the acceptable range.

The composite analysis of extension needs indicated that out of nine dimensions, there were significant differences (more than 10%) between women and men in eight areas such as type of extension contacts, suitable time of contact, place of extension contact, effectiveness of extension agent, effectiveness of group method, boundary of tour, interval of contact and place of meeting.

Only in one case, i.e. approach for undertaking enterprise, there was no significant difference (less than 10%) between genders. The reasons being the socio-cultural environment, family responsibility, restricted mobility, less time availability, dual responsibility, lack of self confidence and lack of decision making power with farm women

Storage pest management: Under the project on Refinement of storage pest management techniques in selected cereals, pulses, condiments and spices, data were collected from 10 states. It was found that farm women prefer to store these items with the use of easily available additives without any standard dose at house hold level. On this aspect, an attempt was made to standardize the doses of easily available additives for the storage of cow pea seeds. Different doses of small and big cardamom, garlic cloves @ 10, 20, 30 number, salt, camphor (*Cinnamomum camphora*) @ 10,20,30 g, asafoetida (*Ferula asafoetida*) @ 2,4,6 g, clove (*Syzygium aromaticum*) @ 5,10,15 number, sand @ 1200 g and neem oil @ 5ml/kg were evaluated for the storage of cow pea seeds in the earthen pots. Use of sand was found very effective to minimize the egg laying and reduction in the multiplication of the insects in terms of number of eggs of cowpea seed weevil (*Callosobruchus*

Evaluation of different additives against cow pea seed weevil

First Global Conference on Women in Agriculture

The first Global Conference on Women in Agriculture held in New Delhi in March, 2012 deliberated upon a range of issues concerning women in agriculture. Some common areas of action included: Setting up of a platform for Gender in Agriculture Partnership (GAP) with hubs in different countries and its Secretariat in India to empower women for inclusive growth in agriculture; Research on human behaviour to support engendering agriculture; Forming advocacy groups to influence policies to empower women in agriculture; Policy analysis to provide alternatives and choices to farm women and Establishing gender assessment and monitoring units in R &D organizations. Further, the important recommendations of the Conference were: (i) assessment of women's empowerment in agriculture including technological needs, capacity building of researchers on gender issues, development of methodologies, tools and indices for assessment and generation of sufficient data/evidence on empowerment of women and engendering of R&D systems; (ii) development of a framework for generation, refinement and delivery of agricultural innovations for reducing drudgery; (iii) linking women farmers to markets keeping in view impact of policies, technologies and drivers and factors influencing linkages and identification of opportunities for collective group actions; (iv) role of women in household food and nutrition security including development of science and technology based innovations to address nutrition related issues at community level involving women groups; (v) development of indicators to measure access of farm women to assets, resources, knowledge, policies and services; (vi) impact of climate change related risks and uncertainties including assessment of agricultural vulnerability and strategies practiced by different communities to cope with the impact of climate change, enabling policy to support availability of clean energy, water, food, health and hygiene.

maculates), number of bored grain and germination percent. Use of big cardamom @ 10 number, asafoetida @ 6 g and small cardamom @ 20 number /kg seed were found effective as standard doses to minimize the egg laying of the insects. Due to juvenomimetic effects, the neem oil was also found effective to save the cowpea seeds from insect damage without any adverse effect on germination up to eight months of storage. These options of storage pest management for cowpea seeds were found gender friendly due to easy applications, availability at village level and their freeness from any type of chemical hazards.

Women in horticulture: To make quality planting materials available to rural women, *in vitro* propagation technique for pointed gourd was optimized using the nodal portion as explants. The best initial micro-shoot response was obtained when the explants were cultured on the MS medium containing Kinetin 8.0 mg/l. The sub-culturing medium with 4.0 mg/litre NAA produced maximum regenerated shoots with good shoot growth. *In-vitro* rooting was optimized with 0.4 NAA mg/ litre that gave highest root initiation and also number of roots. Considering the potential of vegetables,

Training on processing and value addition

technologies have also been standardized for protected cultivation of off- season tomato and cucumber; which gives returns of ` 250–400/ m² annually. Farm women were trained to upgrade their skills to earn more returns from the unit area of poly house/ net house. To reduce substantial post-harvest losses of the rainy season guava, lemon and ginger blended guava squash was prepared to enhance economic value of the crop. Guava-lemon-ginger squash was prepared with 22.5% guava juice, 5.0% lemon juice and 1.5% ginger juice. With the addition of 200 ppm potassium metabisulphite, the product can be kept for 80-90 days in refrigeration (4°C). The TSS, acidity, *p*H and total sugar of the product were 43.5 °Brix, 1.32%, 3.4 and 41.5%. Squash is rich in vitamin C content (212–235 mg/100g) and antioxidants.

Enhancing livelihood of rural women through livestock: Landless women in Giringaput village were motivated to initiate backyard poultry to increase the income and household nutritional security. Capacity building was done for scientific rearing of birds, making balanced diet and disease control. The male birds were sold at 2.5 to 3 months of age earning them ` 225 per bird. The female birds were retained for egg laying which were consumed in the household. Women were encouraged to make low cost houses for poultry birds using locally available materials like bamboo and polythene sheet to prevent predation by wild cats.
In the tribal hamlet of the Giringaput village, the villagers kept cattle mainly for draft purpose. The cattle rearing practices included grazing of the animals in groups during day time and supplementary feeding by offering paddy straw only in the evening. Demonstrations on green fodder production technology were conducted by introducing hybrid napier along the field boundaries of twenty farmers. The farmers reported that the milk yield in cattle was increased by 0.5 litre by supplementary feeding of green fodder. These farmers have also shown interest to take up fodder cultivation on larger plots.

AICRP on home science: The All India Coordinated Research Project (AICRP) on Home Science is in operation in ten State Agricultural Universities. The main thrust of the project is on empowerment of rural women for enhancing the quality of life of farm families. It focused on development of gender specific database and training modules for farm women, technology interventions for drudgery reduction in agriculture, nutritional security and health promotion of farm families, promoting vocational skills among adolescent girls, value addition of under-utilized natural fibre resources, utilization of degradable and non degradable farm waste and empowerment of rural women.

Three technologies were developed and one was modified to mitigate drudgery and occupational problems of women working in different production systems. At AAU, Jorhat a ladle made of iron with wooden handle was designed and fabricated for parboiling of rice. Mittens were developed by MKV, Parbhani for farmwomen involved in harvesting of okra and brinjal. A portable comb type ground nut stripper was developed by MPUA&T, Udaipur. A portable briquette stove with hand blower was fabricated in association with a private partner by ANGRAU, Hyderabad.

A work station with seating comfort was developed for *petha* making. It facilitates postural improvement of body movement while cutting, pricking and processing *petha.* The activities like cutting *petha* into

Okra and brinjal mittens

cubes and handling hot spots are easily done by using safety gloves and masks. Similarly, the mechanical method of cotton picking with a cotton picking machine reduced the physiological cost of work of women significantly by 9.52% compared to manual method and increased the cotton picking efficiency by 6 per cent.

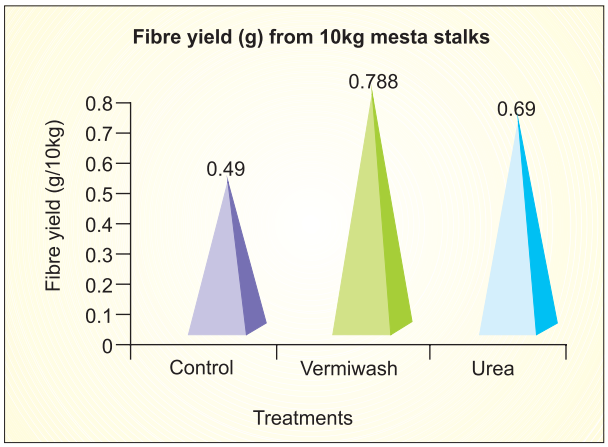
Data pertaining to 8,875 households from 46 agro-climatic zones was used and analyzed through selected indicators to study gender issues. For economic empowerment of women, nine training modules were developed for establishment of microenterprises. Results show that, in the Upper Central Brahmaputra Valley Zone of Asom, more than half of rural women participated independently in dehusking, cleaning, shelling, grading, drying, storage, parboiling and processing of rice. Though women played a major role in livestock management activities, men had the complete responsibility in care of livestock (71.38%), care of sick animal (71.27%), feeding of animal (70.37%) followed by fodder management. Overall picture of gender based participation in agriculture in the state of Himachal Pradesh show joint participation in farming, homestead gardening, horticulture, post harvest operations and animal husbandry by majority of the men and women. Percentage of independent participation by women was noticeably higher in case of homestead gardening (24.73%), post harvest (16.74%) and livestock management (18.27%). In Tarai and Bhabar zone of Uttarakhand, women from small land holding and landless category extensively participated in transplanting, weeding and harvesting. However, in this zone, independent role and complete responsibility was dominated by men 55.74% and 64.33% respectively, whereas in the hill zone rural women had independent role (52.61%) and complete responsibility of farming activities (62.33%).

In order to combat micro-nutrient deficiencies among rural families, 510 nutrition gardens were established in *rabi* and *kharif* season in 45 adopted villages of nine states including Andhra Pradesh, Asom, Haryana, Himachal Pradesh, Karnataka, Maharashtra, Punjab, Rajasthan and Uttarakhand. Commonly used recipes were selected and modified by different centres to obtain a minimum of 6-8 mg of iron/ serving. Forty-five recipes have been modified to obtain the desired iron value. The value of iron ranging from 4.7 mg in *poha* was reported by Ludhiana and 29.09 mg in *khatta meetha namkeen* of Palampur. The recipes were developed using different food groups. Fifteen recipes were based on cereals, six on pulses, four had nuts and oilseeds, six with green leafy vegetables and four with root vegetables. Remaining were developed by mixing different groups. Iron sources used in the recipes are lotus stem, rice flakes, Bengal gram flour, niger seed, mint powder, *rajkeera* seed powder, etc.

Major health hazards encountered while performing various farm activities during spraying of pesticides and threshing of different crops were eye irritation/ itching as reported by Hisar (76.66%), Pantnagar (80%), Ludhiana (47.5%) and Parbhani (33.33%) centres. Problems encountered during vegetables and flower cultivation varied from vegetable to vegetable and flower to flower and included backache due to bending during transplantation and plucking, cuts in hand, allergy in hand/arms. Clothing used during farm activities included *Kurta Pyjama*, *Kurta-Lungi*, Kurta, trousers. *Safa*/ Towel/ *Gamucha / Pagri* were used for protection of head. Most commonly used dress among women farm workers was *Kameez-Salwar* with *dupatta* as reported by Hisar, Ludhiana and Palampur centres whereas *Saree*–Blouse was being worn by women workers of Hyderabad, Dharwad, Pantnagar and Parbhani. Udaipur centre reported that Blouse-*Ghagra* and *Odhani* were worn by women workers and in Asom, Blouse-*mekhla* and *chaddar* were worn. To cover head, *dupatta* /towel or scarf was used. Hisar centre developed educational package on protective clothing for farm workers to disseminate the information to the target group for popularization of technology using pamphlets, video film and interactive CD. Three pamphlets were developed on i) Keetnashak *Sambandhit Karya Karne Vale Pursho Ke Liye Surkshatmak Vastar* (In Hindi), ii) *Threshing Karne Vale Pursho Ke Liye Surakshatmak Vastra* (In Hindi*) and iii) Threshing Karne Vali Mahilaon Ke Liye Surakshatmak Vastra* (In Hindi).

To study clothing disinfecting practices, data were collected from 660 respondents in the age group of 21-30 years or 31-40 years comprising rural and urban women. For disinfecting clothes, majority of the respondents used carbolic acid formulation while *neem* soap was used by a few respondents. Other respondents used ordinary soaps and detergent powders. Amongst disinfectants from natural sources, *neem* leaves were being used by majority of the respondents and *tulsi* leaves were also reported by a few respondents. Amongst synthetic disinfectants, a popular antiseptic solution was used in the final rinse by majority of the respondents. Clothes were also sun dried to disinfect them. Majority of the respondents had knowledge regarding medicinal value of *neem* and *tulsi* leaves, turmeric, ginger and garlic. A few respondents also had knowledge about medicinal nature of eucalyptus, orange peels or pomegranate rinds.

Dharwad center standardized a fibre extraction method from Mesta and Sunhemp and studied the effect of retting process on fibre yield and quality. Mesta species, *Hibiscus sabdariffa*, variety AS73, CD 560 and sunhemp species, *Crotalaria juncea*, grown in Institute of Organic Farming, UAS, Dharwad were selected for the study. The harvested stalks were dried completely and then subjected to retting. It retted after nearly 200 hours to decompose and it was used as control sample. To accelerate the retting process, biological cultures, i.e. 2% vermiwash, 2% urea, an organic compound were added. Fiber yield of Mesta and Sunhemp stalks treated with 2% vermiwash had maximum fiber yield. Fiber extracted from urea treated stalks was found to be longest whereas control sample



depicted better fineness, strength and elongation percentage. Sunhemp stalks treated with 2% urea exhibited an increase in fiber cell length, length of fiber strand, strength and elongation than control, while fiber fineness reduced after urea treatment. The fibers extracted with vermiwash exhibited better strength and elongation percentage. On the other hand, reduction in fiber cell length, length of fiber strand and fineness was observed after vermiwash treatment.

Parbhani centre conducted Phytochemical Analysis of leaves of five plant sources, viz Ashoka, Lantana camera, Lemon, Drumsticks and *Catharanthus roseus* to assess the anti-microbial properties of the plants.

The training module on Life Skill Education, developed for rural adolescent girls under AICRP during the previous plan was used for capacity development of youth. The module consists of 54 different lessons based on day to day situations. Participants were encouraged to actively involve in activities through which they could develop various life skills. These lessons are very easy, simple and can easily be adapted to age, gender, local situations and language. The approach is completely interactive, using role plays, games, puzzles, group discussions and other techniques to keep the participants involved during the sessions.

Results of the pre tests and post tests carried out on nine life skills showed an improvement in terms of mean scores showed comparatively better results in empathy and communication skills than the rest. Trainings at the field level were organized where rural girls actively took part in the activities related to the skills. Thirty-three (33) training programmes were conducted by all these centres on life skill education, parent adolescent relationship, management of adolescent behavior and income generating activities and about 865 beneficiaries, comprising rural youths, mothers, adolescent girl, *anganwadi* workers and *anganwadi* children.

Feedback from 30 fly shuttle weavers from different enterprises was taken on an ergonomically weaving chair designed by AAU, Jorhat. The results showed that all of the users were highly satisfied with the improved chair. Further, the weaving enterprises were ready to fabricate/adopt the chair in order to reduce musculoskeletal disorders prevalent among fly shuttle weavers. Moreover, initiative for dissemination of ergonomically designed weaving chair in different KVKs of AAU has been undertaken. Paddy harvesting with serrated sickle improved the pace of work by saving about 4 hours/ acre, reduced the human power needed for paddy harvesting by 2.37 labour days, increased the work output per hour and reduced the drudgery score (4.43) and disorders score (5.73) significantly by 13.09 and 9.10 respectively. The use of potato picker resulted in picking of 52kg potatoes as against 25 kg by the traditional method.

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17. Research for Tribal and Hill Regions

The ICAR research institutes such as Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, the ICAR Research Complex for North-Eastern Hills Region, Umiam, Meghalaya and the Central Agricultural Research Institute, Port Blair, located in the North-west Himalayas, North-east Himalayas and Andaman and Nicobar Islands have evolved technologies to meet the need of the tribal and hill farmers. The technologies developed are intended to improve the socio-economic status of the target groups. Capacity building programmes to improve the skills of local farmers on traditional and non-traditional crops, agroforestry, water conservation and harvesting, apiculture, horticulture, animal husbandry, poultry and fisheries are being implemented.

NORTH WEST HIMALAYAS

Vivekananda Parvatiya Krishi Anusandhan Sansthan

The VPKAS, Almora, caters to the agricultural research needs of the north-western Himalayan states of Uttarakhand, Himachal Pradesh and Jammu and Kashmir. Maize Hybrid 45, was notified for Uttarakhand, Himachal Pradesh and Jammu and Kashmir, while Vivek QPM 21 was released for Uttarakhand.

Maize Hybrid 45

Barley VLB 118, a high-yielding disease resistant barley strain was identified. With an average yield potential of 3,084 kg/ha, it is a 6-rowed hulled barley and has shown an overall significant yield superiority of 8.2 % over the latest 6-rowed hulled control UPB 1008 under rainfed timely sown conditions. This is also significantly superior by 33.2 % over 6-rowed hull-less control BHS 352 and 10.7 % over 2-rowed hulled control HBL 113. It has high degree of resistance

VLB 118 is a high-yieldig barley strain

against yellow rust under natural as well as artificial epiphytotic conditions.

VRB 3, a ricebean genotype, was identified for release. This is a medium-maturing (130-135 days) and high-yielding (17 q/ha) variety. With indeterminate growth habit and moderately resistance to seed shattering, it possesses field resistance to all major diseases. The seed colour is light greenish and 100-seed weight is 7.56 g. The protein content is 20.4 % compared to 19.7 % in the control. It is moderately tolerant to water stress conditions.

VW 0826 - A genetic stock of wheat for high tillers/m: A genetic stock VW 0826 (Raj 3777/ MV-EMESE) was identified for higher number of tillers/ m. Three years of testing of VW 0826 showed that it possessed 84 tillers/m as compared to 81.7 in HD 200, the best check.

Multiple disease resistant sources: Maize cultivation in the North-Western Himalayan region is affected by Turcicum leaf blight (TLB), banded leaf and sheath blight (BLSB), Maydis leaf blight (MLB) and Curvularia leaf spot and brown leaf spot. VPKAS Experimental Farm, Hawalbagh (Almora) is a hot spot for TLB. About 35 promising inbred lines developed from VPKAS were screened for disease by artificial inoculation in *kharif* 2011. The same set of inbreds was also screened for TLB by artificial inoculation and MLB under natural condition. Five lines, V 334, V 336, V 400, V410 and V 414, exhibited moderate resistance to BLSB. The first four lines were also found resistant to TLB and MLB. In order to validate the results, these five promising inbreds along with susceptible control (CM 145 and CM 212) were again screened during *kharif* 2012 under artificial epiphytotic condition for BLSB. They were also evaluated for TLB under artificial condition and MLB under natural condition. The lines identified as resistant/tolerant to multiple diseases can directly be used as parental lines

for hybrid development and as donors in maize breeding programme.

Gardenpea-french bean cropping system: The application of organic manure influences sustainability by improving physical, chemical and biological properties of soils. An experiment was conducted for six years in view to find out the application rate of locally available organic manure (FYM) as a substitute to chemical fertilizer and Integrated Nutrient Management (INM), and to optimize the application rate of FYM in garden pea-French bean cropping system. The estimation with the help of quadratic response curve showed that the application of 20.0 tonnes FYM/ha provided the economic optimum garden pea equivalent pod yield (31.2 tonnes /ha) of garden pea-French bean cropping system and was 54 and 29% higher than the pod yield of recommended NPK and INM (50% recommended NPK+FYM @ 5 tonnes/ha), respectively. Application of 5.87 and 8.87 tonnes FYM/ha could substitute recommended NPK through chemical fertilizer and INM, respectively. The pod yield was more sustainable than application of recommended NPK.

Plant growth-promoting bacteria: The quantitative estimation of Zn solubilization revealed that isolate Z1 (NVMRs-1) solubilized all the insoluble zinc sources ZnO, $ZnCO_3$ and $ZnPO_4$ up to 280.5, 272.64 and 266.22 µg/ml, respectively, followed by Z10 (NSarEn-3). Amongst the potential zinc-solubilizing isolates tested for plant growth promotion, Z4 (NVMEn-1) produced highest amount of IAA (19.23µg/ml). The isolates Z2 (CbNRp-5) and Z8 (NVMRs-3) showed strong HCN production and Z10 was strongly positive for siderophore production.

NORTH EAST HIMALAYAS

Characterization of colocasia germplasm in Nagaland: A total of 126 indigenous germplasm were evaluated, of which, 110 were characterized using IPGRI morphological descriptors. Among these, 9 lines were dwarf (< 50 cm height), 68 medium (50 - 100 cm) and 33 tall (>100 cm). Ten lines recorded no suckers, 99 lines had 1-5 suckers, while one showed more than six suckers. Twenty-six lines flowered, while the remaining ones were non-flowering types. Significant variations were observed for yield/plant (51- 1318 g) (line 60). Starch content was 10.9 - 45 g /100 g fresh weight and total sugar content 1.6 g - 8.6 g /100 g fresh weight. Most varieties evaluated against *Phytophthora* were susceptible while a few lines showed tolerance to this disease.

Indigenous colocasia germplasm

Seed production

About 236.55 q breeder seed of 67 released varieties/genotypes and 53.82 q truthfully labeled (TL) seed was produced. Under farmers' participatory seed production programme, 109.26 q seed of various crops was produced at farmers' fields at different places. Vivek QPM 9 developed through MAS was licensed to a commercial firm for commercial production and marketing. They are producing more than 1,000 q of hybrid seed in West Bengal.

Zero till furrow opener: A manual zero-till furrow opener was designed which opens furrows of 2-3 cm width and 3-4 cm depth on untilled soil. A long pulling handle and a guiding handle have been provided for ease of operation. Two labourers can operate this implement and it is suitable for making furrows for paddy, mustard, pea and lentil for sowing under zero till conditions. Its capacity is 0.06 - 0.2 ha/hour depending on the row width.

Genome characterization of banana bunchy top virus (BBTV): Preliminary characterization of Banana Bunchy Top Virus (BBTV) from Meghalaya (Umsning and Umiam isolates) on the basis of DNA R segment showed similarity to "Pacific-Indian Oceans" group. The six genomic DNA components of Meghalaya (Umiam) isolate of BBTV were amplified by polymerase chain reaction (PCR) with specific primers using total DNA extracted from infected banana leaves. The resulting ~1.0 Kb amplicons were cloned and sequenced. Analysis of sequence data revealed the presence of six full-length components of BBTV: DNA-R (NCBI Acc. No. KC119098), DNA-U3 (KC466373), DNA-S (KC466374), DNA-M (KC466375), DNA-C (KC466376), and DNA-N (KC466377).

Disease management of King chilli: A survey was carried out in the localities around Imphal to assess the incidence of different fungal and viral diseases on King chilli. The fungi isolated and identified were *Cercospora capsici*, *Colletotrichum capsici*, *Glomerella cingulata*, *Corynespora cassicola* and *Phoma destructiva*.

There was sporadic occurrence of virus diseases in the field. The symptoms consisted of inward rolling of leaves, shoestring, yellow mosaic and necrotic rings on leaves. The King chilli samples in wells B3-B10, C3-C10, D3-D10 had pepper veinal mottle virus (PVMoV) infection. The crude virus extract of PVMoV infected samples subjected to Transmission Electron Microscopy revealed the presence of flexuous virus particles, implying that the virus belonged to genus Potyvirus of family Potyviridae.

Bayleton was most effective in reducing *Colletotrichum* fruit rot and increasing crop yield by

167% and 54% decrease in disease incidence, followed by Derosal with 22.22% increase in yield and 44.79% decrease in disease incidence over the control.

The sawfly, *Arge xanthogaster*, has recently emerged as a major pest of roses in Meghalaya, causing around 80% damage to wild and cultivated roses. This appears to be the first report of *A. xanthogaster* as a pest of roses. Crucially, *A. xanthogaster* in Meghalaya is somewhat morphologically different from that of the previously reported specimens of Manipur and Sikkim, indicating that *A. xanthogaster* in Meghalaya could be a new subspecies or race. The species-specific DNA barcode based on standard barcoding cytochrome oxidase I (COI) gene of mitochondrial DNA was developed.

Low-cost pigpen: A low-cost improved pigpen with locally available materials was designed for high rainfall in mid and high altitude temperate regions. The saw dust-floor of the new pen provided warm and comfortable environment to pigs, while low temperatures in the conventional concrete pens caused stress and energy loss to animals during winter. Further, during the rainy and summer season, floor of conventional pens remained wet and it recorded significantly higher humidity and temperature-humidity index (THI), compared to the improved pens. Similarly, the stress hormone, cortisol level was within the normal range in the improved pigpen, as against significantly higher levels in the conventional pigpen. Daily body weight gain and feed conservation efficiency of pigs reared in the improved pen were also significantly higher compared to the conventional pens. The crossbred pigs reared in the new pens attained 148-157 kg body weight within one year. In conventional pens, leg lesion, incidence of diarrhoea and respiratory diseases were common problems. Since there was no washing of the newly developed pens, water requirement dropped substantially.

Screening for porcine viruses: For the first time, ICAR Research Complex for NEH Region, Barapani, identified the presence of PRRS (porcine respiratory and reproductive syndrome) virus in India. The virus was detected in September 2011 from Meghalaya as confirmed by the High Security Animal Diseases Laboratory (HSADL), Bhopal. A total of 3,590 serum samples were screened for the disease. Of 3,590 serum samples, 569 samples tested positive. Apart from this, 154 serum samples were also screened for porcine parvo virus and porcine circo viruses. Full length genome cloning of PCV-2 (12 isolates) and CSFV (4 isolates) were completed.

Phylogenetic relations of *Babesia* spp.: Cloning and sequencing of PCR product generated from *Babesia bigemina* was done. The BLAST analysis showed that sequence of PCR product generated with *B. bigemina* primers had 99% nucleotide identity with many sequences of 18 S ribosomal gene of *B. bigemina* (EF458191, EF458200, and DQ785311). The Indian isolate (Umiam) of *B. bigemina* showed close relation with Argentinian isolate and distinctly placed away from the isolates of the neighbouring country, China.

Improving living standards of tribal farmers through technological intervention

Tribal Sub Plan programme was implemented in Bali, a small Island within Sundarban inhabited by tribal and SC populations which was ravaged by the strong cyclonic storm "Aila" in 2009, causing heavy damage to the livestock and biodiversity, resulting in severe food crisis. In this area, carp breeding in FRP hatchery and subsequent rearing of Indian major carps by polycultural technique was successfully demonstrated and established in Adivasipara in 22 ponds, covering the water area of about 3.0 ha. A growth of fish from fingerling size to about 300-400 g within just 3-4 months was achieved. The local inhabitants are encouraged to adopt fish culture as means of livelihood.

Endocrine markers: Identifying prolificacy potential and determination of foetal number during pregnancy are essential for ensuring proper care and management of pregnant goats bearing multiple foetuses and achieving the benefits of multiple births. Multivariate step-wise discriminant analysis recognized that one blood sampling at 220 min after GnRH administration can be used to distinguish prolificacy potential in goats. Plasma progesterone levels were significantly higher in goats bearing triplet vs. twin vs. single foetus between day 84 and 21 prior to parturition.

Islands and coastal region

Management of degraded coastal land and water: A systematic, need based integrated approach was followed in which land improvement activities comprising six different methods, viz. broad bed and furrow, rice-fish, three-tier farming, farm pond, paired bed and furrow, and pond-nursery systems were made as a means of reclamation of these areas and bring them under cultivation. Nearly 200 acres of degraded land spread over several villages were brought under intensive cultivation of rice, vegetables, plantation crops and fish culture.

Farmers' participatory rice seed production at North Andaman: Every year about 40 quintal seed of high-yielding rice varieties like CARI Dhan 3, 4, 5, CSR36 and Ranjeet is being produced through farmers' participation in association with Out Reach Centre of CARI and distributed to stakeholders and farmers in the islands.

Bypass fat for dairy animals

A simple technology was developed at ICAR Research Complex for Goa for the preparation of bypass fat which is best choice 'energy rich feed supplement' for sustainable milk production. The technology is simple, cost-effective, user-friendly, and does not need sophisticated equipments; and hence is suitable for small and marginal farmers. The product remains in solid form, can be easily mixed with other feed ingredients, easily transportable and can be kept in air-tight containers in cool places. Supplementation of indigenously prepared bypass fat to dairy animals @ 15 - 20 g/kg increases milk yield by 7 - 20%, giving additional profit of Rs 12 - 40/ cow/ day and improvpng the reproductive capacity and health of animals.

Boosting fruits and vegetables availability in Minicoy Island, Lakshadweep: As a result of concerted effort by Regional Research Station of CPCRI, approximately 4,536 kg vegetables and 602 kg fruits were produced and distributed among the islanders. The successive production in the demonstration area resulted in revenue generation of over ` 130,000 over a period of 12 months in natural resource deficient and fragile ecosystems of Minicoy islands, which ensured sustainable livelihood and nutritional security to the island dwellers.

Impact assessment of technological intervention in Andaman: Economic feasibility analysis of five technological interventions at South, Middle and North Andaman indicated that adoption of composite fish culture with CRM in the ratio of 4:3:3 could give a net return of ` 22,950 against farmers' practices of stocking multiple species of fish (` 3,500) which fetched an additional return of ` 19,450/0.08 ha of pond.

Marine faunal diversity of Nicobar Group of Islands: A total of 200 marine specimens were collected, of which molluscs accounted for majority (84%). The other phyla were *Porifera*, *Polycladia*, *Cnidaria*, *Annelida*, *Crustacea*, *Mollusca*, *Echinodermata*, *Chordata*, *Vertebrata* and others. Fifty-six molluscan species were identified and catalogued. Assessment of benthic cover revealed 72% live coral cover at Nancowry Islands. Of which, *Acropora* spp. accounted for 66%, followed by *Porites solida* (3.7%) and *Favidae* (2.6%).

Cataloguing and conservation of marine sponges: Sponge species diversity and distribution at 43 new locations in Andaman was catalogued of which 25 records are new to India. Barcodes of 14 marine sponges were generated using cytochrome oxidase subunit 1 (COI 1) and ribosomal ITS region. Seven marine sponges were submitted to the Global Sponge Barcoding project database under reference category with full taxonomic description. A digital database of marine sponge diversity and a GIS-based resource map of the marine sponges diversity of Andaman was developed.

Sustainable Management of Degraded Coastal Land and Water

Land improvement activities comprising broad bed and furrow, rice-fish, three-tier farming, farm pond, paired bed and furrow and pond-nursery systems were made as a means of reclamation and nearly 200 acres of degraded land spread over several villages was brought under intensive cultivation of rice, vegetables, plantation crops or fish culture.

TRIBAL SUB PLAN

Under the Tribal Sub Plan (TSP), ICAR has been closely working with tribal farmers with main focus on enhancing livelihood security of the tribal farmers in diferent parts of the country. Emphasis is being laid on imparting the technical know-how to the tribal farming community by providing farm inputs, machineries, field demonstrations, quality planting material, seeds, and producing planting material and seed of their own. These activities mainly envisage the overall improvement in farm income and nutritional security and living standards of the tribal farmers.

Crop Sciences

All India Coordinated Research Project on Soil Test Crop Response (AICRP on STCR) is implementing TSP across the country in various tribal belts from 2012-13. Trials were conducted on tribal farmers' fields to demonstrate the value of soil test based nutrient recommendations.

Under tribal sub project, two districts of Jabalpur division, viz. Dindori and Mandla were selected which are dominated by the tribals. Under TSP, four varieties of gram (JG-11, JG-315, JG-16 and JG-130) were taken, seed treatment with rhizobioum, and *Trichoderma* was applied as soil treatment of three villages Palhera, Chaugan and Jhina. Some of the farmers have also used NPV treatment. The result was very much enthusiastic as the yield increased up to 54.5%, ranging from 8.69 to 54.5 %. This indicated that there is a great venue of using biofertilizers for bagging higher yields under low input. STCR technology was tested on tribal farmers' fields successfully with wheat, mustard, maize and chickpea crops. Hundred field demonstrations (one acre each) for tribal farmers in five tribal districts (Kanker, Jagdalpur, Dantewada, Korba and Ambikapur) of Chhattisgarh were selected for four major crops. The tribal beneficiaries were given seed, fertilizers, plant-protection measures and benefited with increased yields over their traditional practices. Training programmes on soil testing and balanced fertilizer application were also organized at each district level.

Under TSP programme, 564 field demonstrations on sorghum were organized during *kharif* 2012-13 at farmers' fields for socio-economic upliftment of tribals in 18 districts of Madhya Pradesh, Rajasthan, Andhra Pradesh, Gujarat and Maharashtra. The seeds

of high-yielding cultivars, fertilizers, agro-chemicals and small implements were supplied along with technical information through literature and demonstrations.

Jute: Frontline demonstrations on soil test and targeted yield based fertilizer application in mustard in jute-rice-mustard cropping sequence were conducted at farmers' fields in Bankura, Purulia and Nadia districts of West Bengal. Jute seed (6.83 q) of improved varieties (JRO 8432 , JRO 524 and JRO 128) was provided to 96 tribal farmers in Purulia and Bankura districts for seed production of jute, rice and mustard. Modern tools (96 knapsack sprayers and 26 CRIJAF, Nail weeders) were also distributed to farmers.

Ramie: Planting material of ramie was supplied to Assam Ramie Fibre Cultivation Cooperative Ltd, for plantating in 26.0 ha area of farmers' fields in Lakhimpur, Dhemaji and Sonitpur districts of Asom and West Siang district of Arunachal Pradesh. Use of alternate planting material (plantlets and stem cuttings) was encouraged. Use of ridge and furrow system protected the emerging small plants from rotting in high rainfall periods. These technologies have been well accepted by the tribal farmers.

Horticulture

Himachal Pradesh: Frontline Demonstrations (20) were conducted at farmers' fields at Udaipur in tribal district of Lahaul Spiti (Himachal Pradesh); 10 quintal of breeder seed of new potato variety, Kufri Himalini, was supplied. A training programme was organized at Udaipur and Lahaul Spiti on modern techniques of seed potato cultivation in which about 127 tribal farmers participated.

Jammu and Kashmir: The tribal families from Leh, Kargil, Bandipora, Ganderbal, Ramban, Anantnag, Rajouri and Poonch were selected under phase-I of this scheme. Keeping in view the climatic conditions, technologies like high-value fruit crops like apple, walnut, apricot, almond, cherry and strawberry, and nutritionally rich vegetables were included in the programme.

Odisha: Eight villages of Kashipur block of Rayagada were selected for mango plantation on 443 ha sloppy land with 1.77 lakh plants involving 550 households. The farmers were given training in soil and *in-situ* moisture conservation in sloppy lands, and demonstrations on fertilizer application technique were also organized. Fertilizers (1,053 bags of urea + DAP + MOP) were distributed among farmers.

In-situ soil management

Improved tuber crop production and processing technologies were demonstrated to 360 tribal farmers from Chhattisgarh (Narayanpur district), Jharkhand (Ranchi) and Odisha (Kandhamal and Koraput districts). Planting material of improved varieities of elephant-foot yam (Gajendra), colocasia (Muktakeshi), yam (Orissa Elite), cassava stems (Sree Vijaya, Sree Jaya and Vellayani Hruswa), yam bean seeds (RM-1) and sweet potato (Kishan and ST14) were supplied to farmers to cover 15 ha area, and 665 demonstrations on technologies of tuber crops were laid out.

Goa: Establishment of frontline demonstration on cashew and mango production technology and intercropping of turmeric were taken up involving members of 'Taleshir Group' (39 Tribal farmers) of Cancona Taluka. Cashew grafts of improved varieties (Goa-1, Tiswadi-3, Ganje-2 and KN 2/98), mango grafts (Mankurad, Amrapali and Kesar), and rhizomes of turmeric (Pratibha) were provided along with training in integrated nutrient management and productivity maximization practices.Quality planting material of acid lime (Sahi Sharabati, 750 nos) and Guava (Lalit and Shweta, 650 grafts) was provided to farmers from Gaondongruim village (Goa) for planting in homestead gardens.

Animal Science

North-east region: The NRC on Yak organised training programme on Integrated Farming System; 65 tribal farmers from 13 villages of Namsai district of Arunachal Pradesh participated in the training programme. Scientists and technical officers of NRC on Yak interacted with yak farmers (*Brokpa*) of Arunachal Pradesh in remote areas (*Nagaggi*). Farmers were informed of management and disease control of yak. Subsequently, five yak farmers were provided with micronutrient to enhance productivity of yaks under transhumance pastoralist system of yak rearing.

The NRC on Mithun took up activities under TSP in Nagaland, Arunachal Pradesh, Manipur and Mizoram. These included Technology Injection Programme in remote villages of Manipur for Marh tribes; in the Ezengo village of Idu Mishmi tribe of Arunachal Pradesh showcasing various technologies followed by health camps for mithuns and other livestock in Nagaland throughout the year. Apart from these, a mithun conservation and ONBS programme was started in Khonoma and Thevopisu villages of Nagaland for genetic improvement of mithuns.

Minicoy island: A poultry unit having 'White Leghorn' and 'Gramalakshmi' was established at the island for demonstration. Eggs and layers were distributed to Minicoy islanders.

National Resource Management

AICRP on Agroforestry: The TSP scheme under AICRP on Agroforestry was carried out at 13 coordinating centres of the project. The agroforestry interventions promoted for tribal farmers included plantation of MPTS; distribution of planting material and other inputs; nursery development and capacity building of tribal farmers. Under the TSP, tribal farmers were provided nursery material (polybags, irrigation pipe, storage tank, seeds) and small agricultural tools, sprinkler sets for enhancing the productivity and small polyhouses. Tribal farmers were provided trainings in agroforestry and trained to designed eco-friendly bamboo tree guards and other valuable items. The farmers appreciated the efforts and found new avenues for livelihood support.

Odisha: Tribal sisal planters in Sambalpur and Jharsuguda districts were provided with 81,272 healthy suckers of sisal. Thirty-one tribal farmers planted the material in 20.36 ha area using double-row planting geometry, accommodating 4,300 (±200) suckers/ha.

CARI, Port Blair: To maximize the benefit to tribal farmers through technological interventions and knowledge support, some of the livelihood options were identified.

Training programmes (28) in the field of fisheries, horticulture, field crops, animal husbandry, post-harvest, crop protection and value-addition technologies were conducted in Nicobar District and Little Andaman. About 1,515 tribal farmers attended the trainings.

Seeds and planting material of improved varieties, livestock and farm tools were provided, besides, support to properly utilize soil and water resources to improve the farm productivity. Tribal Captains from Nicobar also visited CPCRI, Kasargod and CTCRI, Thiruvananthapuram, to have a glimpse of technologies for improved coconut-based farming system, intercropping with spices, pineapple and tuber crops along with value-addition.

Fish

Pen culture in wetlands: A pen culture demonstration carried out in Takmu *pat* of Bishnupur district, Manipur indicated suitability of culturing *Osteobrama belangeri*, a high-demand indigenous minor carp, in pen enclosure in the *pats* of Manipur. Grass carp and catla were also found suitable for culturing in pen enclosures in Manipur.

A pen of approximately 0.1 ha was constructed using nylon net supported with bamboo poles and stocked with stunted yearlings of Indian major carps, a minor carp pengba (*O. belangeri*) and exotic carps @ 5 fingerlings/ m^2. After 180 days of rearing using commercially available feed, the highest average weight gain and highest specific growth rate were recorded for pengba, followed by grass carp and Indian major carps. The benefit:cost ratio obtained in the demonstration was 1.29. The demonstration showed that net pen enclosures can be used for culturing different fish species having local demand.

High density planting system for cotton in Vidarbha

The plant population with hybrid cotton in India ranges from 6,000 to 15,000/ha. The HDPS system requires dwarf varieties with compact stature bearing 6-8 bolls per plant.

Early-maturing compact plant types with short sympodia were identified for high density planting system during 2009-2011. Non- Bt varieties-AKH 081, NH 615 and Suraj, though not for high density planting, were found amenable to planting at 150,000–200,000 plants/ha at a spacing of 60cm ×10 cm or 45cm ×10 cm. By increasing plant population, yields of 1.8-2.0 tonnes/ha were achieved with these varieties on the marginal soils. Production costs were lowered and crop matured a fortnight earlier than the crop sown at normal density. The yields could further be improved by dry sowing (just after the onset of first monsoon rains), using 25% higher rate of fertilizers over the recommended rate and also by using established moisture conservation agro-techniques.

Encouraged with the three-year experimental farm results, CICR initiated a farmer participatory trial of HDPS in marginal soils in rainfed conditions of one-acre (0.4 ha) fields of 155 farmers in eight cotton-growing districts of Vidarbha during the *kharif* 2012. Suraj, NH 615 and AKH 081 were planted at 45cm × 10 cm or 60 cm× 10 cm spacing witht the early onset of the monsoon. The seed rate used was 12 kg/ha. Despite delayed onset and erratic monsoon during 2012, high yields of 2.5–3.0 tonnes of seed-cotton /ha were obtained by several farmers. Across the trial, yields averaged at 1.5–1.8 tonnes, which was double the average of Vidarbha. Highest yields were obtained in Chandrapur, Amaravati, Nagpur, Yavatmal and Akola districts. Severe drought in Buldhana, Washim and some parts of Wardha resulted in yields of 0.8–1.0 tonne/ha. The increase in yields was estimated at least 35-40% above the yields normally obtained by the farmers. The cost of cultivation was ` 20,000–25,000/ha. Net profit ranged from ` 12,000–90,000 / ha. A few farmers tested HDPS under organic conditions and obtained yields in the range of 2.5 to 2.8 tonnes/ha

Knowledge Sharing Meet (KSM) at ICAR Complex NEH, Barapani

Knowledge Sharing Meet was held at ICAR NEH, Barapani. The scientists were urged to make use of the portal "KIRAN" for sharing the technologies

available so that the information is disseminated to a larger audience. The diversity of North-Eastern States both in terms of agro and cultural biodiversity is enormous, perhaps the largest congregation of tribal India, hence, this meet was an opportunity to intervene through capacity building.

Publications

Shaya utpadant dastar bhumika (Assemese), *Shasya utpadanat boronar proyujaniyata aru iyar proyug* (Assemese); and *A Guide for Identification and Management of Nutrient Disorder in Crops*, were published for the benefit of local farmers.

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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 to coordinate and promote agricultural research and education in the country. DARE provides the necessary government linkages for the Indian Council of Agricultural Research (ICAR), the premier research organization for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. With 108 ICAR institutions and 65 agricultural universities spread across the country this is one of the largest national agricultural research systems in the world. Apart from ICAR the Department of Agricultural Research and Education has other autonomous bodies, viz the Central Agricultural University (CAU), Imphal and Agrinnovate India Limited, Delhi under its administrative control.

The CAU, Imphal was established in 1993 and is fully funded by the Government of India. It has its jurisdiction spread over the North-eastern States, e.g. Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Sikkim and Tripura. The DARE is the nodal agency for International Cooperation in the area of agricultural research and education in India. The Department liaises with foreign governments, United Nations, CGIAR and other multilateral agencies for cooperation in various areas of agricultural research. The DARE also coordinates admissions of foreign students in various Indian agriculture universities/ICAR institutions.

The Agrinnovate India Limited, incorporated on 19 October 2011, aims to work on the strengths of DARE and ICAR and promotes the development and spreads its research and development outcomes. The Agrinnovate India Ltd., a company is expected to stimulate, foster, enhance and catalyse innovation driven agricultural development through efficient use of innovations, human resource and capabilities of the NARS. The Company, as an extended independent commercial outfit, is expected to capitalize on the vast network of the ICAR institutes where the researchers are engaged in their mission to innovate and harness science to provide citizens access to food, nutrition, livelihood and income security.

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, it was established on 16 July 1929 as a Registered Society under the Societies Registration Act 1860, on the recommendations of the Royal Commission of Agriculture. The organization has been reorganized twice in 1965 and 1973. The ICAR's headquarters is located in Krishi Bhavan, New Delhi.

The Union Minister of Agriculture is the President of the ICAR. He also heads the General Body of the ICAR Society, which is the supreme authority of the ICAR. 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 Director General is the Principal Executive Officer of the ICAR, who also functions as Secretary to the Government of India in the Department of Agricultural Research and Education. He is assisted by the Secretary of the ICAR who also functions as the Additional Secretary of the Department of Research and Education, Ministry of Agriculture.

The Governing Body (Appendix 2) is the chief executive and decision-making authority of the ICAR which is headed by the Director General, ICAR. It consists of eminent agricultural scientists, educationists, legislators and representatives of the farmers. It is assisted by the Accreditation Board, Regional Committee(s) and Publications Advisory Committee. In the scientific matters, the Director General is assisted by the eight Deputy Directors General, one each for (*i*) Crop Science, (*ii*) Horticulture, (*iii*) Natural Resource Management, (*iv*)Agricultural Engineering, (*v*) Animal Sciences, (*vi*) Fisheries, (*vii*) Agricultural Education and (*viii*) Agricultural Extension. Besides, one National Director (NAIP), and one National Co-ordinator (National Fund Basic Strategic and Frontier Application Research in Agriculture) also assist Director General of the ICAR.

The Deputy Directors General are responsible for the functioning of the Institutes, National Research Centres, and the 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 NC (NFBSFARA) looks after the Secretariat of National Basic Strategic and Frontier Application Research in Agriculture.

The Research set up of the ICAR includes **51** Institutes (Appendix 4), **6** National Bureaux (Appendix 5), **34** Project Directorates and Zonal Project Directorates (Appendix 6), **17** National Research Centres (Appendix 7) and All-India Coordinated Research Projects and Network Projects (Appendix 8).

The 'Directorate of Knowledge Management in Agriculture' (DKMA) works as a 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 Media units. The 'E-Publishing Knowledge System in Agricultural Research', a project under NAIP has increased visibility of ICAR literature in 202 countries. There is also enhancement in the number of foreign authors for the research journals brought out by the DKMA.

The ICAR is funded thorugh the grants received from the Government of India and through internal resource generation. The Senior Officers posted at the ICAR (Headquarters) are listed in Appendix 3.

The ICAR recruits its scientists and other personnel through competitive examination/direct recruitment by selection etc. through its independent recruitment body, Agricultural Scientists' Recruitment Board (ASRB), which was established on 1 November, 1973. The ASRB is accountable to the President of the ICAR Society.

The ICAR promotes research, education and extension education in **55** State Agricultural Universities (Appendix 9), **6** Deemed Universities, and **4** Central Universities with Agricultural facility by giving financial assistance in different forms; DARE promotes 1 Central Agricultural University for the North-Eastern Hills Region and Agrinnovate India Ltd.

The total sanctioned as well as existing strength of the employees of the ICAR system, including those belonging to the scheduled castes, scheduled tribes and other backward classes is given in Appendix 10. Through its extensive network of research infrastructure, backed by an excellent team of scientists and other employees, the ICAR is making rapid strides in agricultural research, and provides support to the national efforts in achieving food security and self-sufficiency.

Intellectual Property and Technology Management

Intellectual Property and Technology Management (IP&TM) activities in the ICAR mainly cover: (i) IP protection applications as patents, copyrights, designs, trademarks and plant variety rights; (ii) technology showcasing and promotion organizing industry and stakeholders meets/workshops/ campaigns; and (iii) licensing agreements for multiplication and supply of technologies and services to user agencies and individuals.

IP protection and grant of titles

Patents: In five subject areas 26 research institutes filed, 83 patent applications taking the cumulative figure to 826 applications from 68 ICAR institutes.

Indian Patent Office published 87 ICAR applications

Table 18.1 Important patent applications filed

Subject Areas	Innovations/technologies
Agricultural Engineering	Process technology for utilization of digested biogas slurry for cellulose production; Cellulosic materials incorporating nano zinc oxide; Intracanopy spraying system for cotton and pigeon pea crops; LPG fired thermic fluid heated deep fat dryer; Optical scanner based fabric pilling measurement system.
Animal Sciences	Buffalo casein hydrolysates rich in *Caseino phosphopeptides;* Cell culture attenuated live Orf vaccine for protection of goat/sheep; Development of *Peste-des-Petits* Ruminants (PPR) negative marker vaccine; Kit for parentage verification in Indian Ruminant livestock; Novel enzyme substrate based rapid assay for detection of *Listeria monocytogenes* in milk; Novel method of chrome tannage of mithun hides with glyoxalic acid; Primer composition for molecular sex typing in pigs.
Crop Science	Amphiphilic polymers based slow release nano-formulations of α-carotene; Anti-oxidant and anti-bacterial di-aryl-indazol-3-ols; Cross flow flexible membrane filtration assembly for small processing volume; Development of nano-induced biological phosphorous fertilizer (NB-PHOS) using *Aspergillus flavus* CZR-2; Development of polymeric formulations of bioactive molecules; *Magnaporthe oryzae* polynucleotide associated with rice blast resistance; Method for producing gamete sterile plants; Process for preparation of bio-fumigants from leaves of *Lantana*; Rapid synthesis of platinum nano-particles from *Aspergillus flavus* TFR12.
Fisheries	*A* device and process to separate oyster meat from shell using pressurized steam; Development of galvanized iron cage for finfish culture in open sea, gene specific probe and primers, and nested RT-PCR for detection of Indian isolate of Mourilyan virus in *Peneaus monodon;* Process of unambiguous identification of inter-generic hybrid of *rohu* and *catla*, to isolate anti-inflammatory principles from green mussel *Perna viridis* L., and for imaging bacteria using immobilizing matrix from bagasse.
Horticulture	Modified CTAB method for isolation of high quality and quantity of genomic DNA form fresh mature leaves of orchids; DNA-based diagnostics for identification of citrus root stock cultivars; Micronutrient composition for ginger; Novel method of storing and slivering PGPR/Microbes through bio-capsules; Rotating drum roasting machine for raw cashew nuts.

Patent Numbers	Technologies/ Innovations	Date of grant/ priority date
IN255661	A mechanical system for chopping and crushing of water hyacinth plants	13 March 2013
IN256424	Product from lignocellulosic waste for the remediation of water contaminated with heavy metals	14 June 2013
IN256572	Immobilizing matrix from bagasse for bacterial biomass and a process for preparation thereof	03 July 2013
IN257068	Process for manufacture of spray dried cheddar flavour base/concentrate	30 August 2013

filed during 2003 (2), 2009 (4), 2010 (15), 2011 (44), 2012 (13), and 2013 (9). Two patent applications filed in foreign countries were: (*i*) A process for producing a bio-pesticide composition containing *Trichoderma harzianum* and *Pseudomonas fluorescens*, and (*ii*) A process for the production of organic formulation of bio-pesticide *Pseudomonas fluorescens*. Indian Patent Office granted four patents, taking ICAR's cumulative number of granted patents to 161 from 25 institutes.

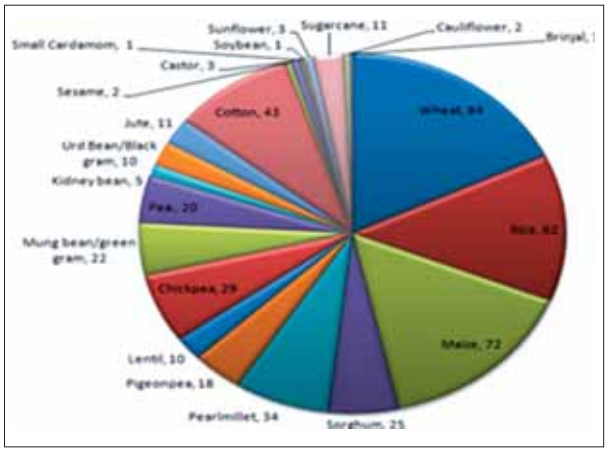
Copyrights: Fourteen copyrights were filed/ registered by CSWRT&I, Dehara Dun; IASRI, New Delhi; and IVRI, Izatnagar. These *inter-alia* included: web-based software for survey data analysis (SSDA 2.0); Indian NARS Statistical Computing Portal; Knowledge data Warehouse for Agricultural Research (KWAR); Soil Loss Tolerance Limit (SLTL) calculator (software); Decision support system for contour trenching; Design resource server; Monograph α-designs; and USAR-An EIA tool for managing salt affected agricultural lands and irrigation waters. A total of 48 filed copyrights have been thus recorded from 11 ICAR institutes.

Designs: Five applications were filed by IVRI, Izatnagar: *(i)* urinary catheter, *(ii)* interlocking nail system for tibia of cattle and buffaloes, *(iii)* designer locking compression plate for tibia of cattle and buffaloes, *(iv)* designer locking plate for repair of fracture in radius, and *(v)* portable restraining device for large animals (TRAVIPORT). The 17 filed design applications have been thus recorded from 31 ICAR institutes.

Trademarks: Registered trademarks included: *(i)* CARI, Izatnagar (*CARIBRO-DHANRAJA* - commercial multicoloured broiler chicken; *CARISWETA* - white feathered quail; *CARIPRIYA* - commercial layer chicken; *KADAMBARI*-guinea fowl); and *(ii)* CPCRI, Kasaragod (word and logo). A total of 33 trademarks have been filed from 16 ICAR institutes.

Plant varieties: As the Protection of Plant Varieties and Farmers' Rights Authority notified new genera, applications for 87 varieties (72 extant, 04 new and 11 farmers' varieties) were filed at the Registry. For earlier applications, 138 varieties (127 extant, 9 new and 2 essentially derived) were granted registration certificates; taking the cumulative figure of registered varieties to 469.

The cumulative total for plant variety protection applications rose to 982 (875 extant; 96 new and 11 farmers' varieties; which included: (*i*) cereals 518 (wheat, rice, maize, sorghum, pearl millet); (*ii*) oilseeds 89



Crop-wise distribution of registered plant varieties

(sesame, groundnut, castor, sunflower, soybean, linseed, Indian mustard, safflower, yellow *sarson*, *toria*, *gobhi sarson*, brown *sarson*); (*iii*) pulses 179 (pigeon pea, lentil, chickpea, *mung* bean/green gram, pea, kidney bean, *urd* bean/black gram); (*iv*) commercial crops 152 (jute, cotton, sugarcane); and (*v*) horticultural crops 44 (chrysanthemum, ginger, turmeric, black pepper, small cardamom, potato, cauliflower, cabbage, brinjal, tomato).

Outreach activities

A total of 79 awareness generation programmes/ interface/product specific meets/ workshops/ seminars were organized by 33 ICAR institutes. These *inter-alia* included: Agri-business camps/investors' Meet for different commodity groups (viz. fisheries, cotton technologies, seed and planting materials, and plant health management); Entrepreneurship Development Programmes (EDP) for technologies on biomass utilization and biotechnology in horticulture; Farm Innovators Day; ICAR-Industry Interface Workshop 2013; Interactive Meeting on 'Quality standards for raw cashew nuts'; NAIP Zonal Food Processing and PHT Industry Meet, 2013; National Workshop on Business Opportunities in Freshwater Fisheries; NDRI Industry Meet; Post-harvest Technology-cum-Agricultural Engineering Entrepreneurs Meet; and Training and Capacity Building for Plant Variety Protection and DUS Testing.

Technology Transfer / Commercialization

Business relationships were developed through Memoranda of Understandings, Licensing Agreements and Consultancies/Contract Research/Contract Service

with farmers, NGOs, government and private organizations (including seed/veterinary/processing/ pesticides companies). A total of 340 partnership agreements were finalized by 42 ICAR institutes with 193 organizations. These agreements were entered into for 157 technologies from different disciplines of agriculture viz, Agricultural Engineering (29), Animal Sciences (31), Crop Science (53), Fisheries (10), and Horticulture (34).

TECHNOLOGIES COMMERCIALIZED BY THE ICAR INSTITUTES

Farm Machinery: Adjustable row marker; Broad bed furrow machine; *Cassava* harvester and hand-operated and motorized chipping machine, Cono weeder, Palmyrah fibre separator, and Pusa aqua ferti-seed drill.

Veterinary Science: Diagnostic kits for parentage verification in buffaloes, camels (single and double humped), Indian ruminant livestock, and Zebu cattle (*Bos indicus*).

Dairy Science: A qualitative and quantitative test for anionic detergent in milk; Detection of *Enterococci* in milk technology; New colour-based method technology for detection of detergent in milk; Two stage enzyme-based assay for detection of *Listeria monocytogenes* in milk.

Animal-based value added products*:* Emulsion based chicken products; Hurdle technology-based meat pickle; method for preparation of salted chicken eggs.

Plant varieties: Rice, DRRH-2, DRRH-3, Pusa Punjab Basmati Rice-1509, Rice Hybrid HI 1544; cauliflower, Pusa Hybrid-2, Kartik Shankar; Carrot, Pusa Rudhira; Cucumber, Pusa Sanjog; Cowpea, Kashi Kanchan, Kashi Nidhi; tomato - Swarna Sampda, Swarna Vijaya; and gladiolus, Pusa Manmohak, Pusa Unnati, Red valentine.

Plant growth promotion and protection: Novel insecticidal WP formulations of *Heterorhabditis indica* strain NBAII *Hi1* for the biological control of white grub and other soil insects pests; Customised leaf colour chart; Seedpro—a microbial plant growth promoter and fungal disease suppressor; Nano-formulations of bioactive molecules i.e. Carbofuran, *Azadirachtin*, Imidacloprid; Nano-sulphur (Monoclinic, Orthorhombic and Nano-hexaconazole sulphur).

Post-harvest products and processes: Anthocyanin extraction from Black/ Purple Carrot, *Capsicum* salsa; Iron fortified biscuits; Lac-based Nail Polish; Pusa Nutri Cookies, Pearl Puff, Soya Nuts; Steviol glycoside extraction from *Stevia* leaves; Virgin coconut oil preparation by hot process; Wine from litchi fruits; and Nanocellulose production technology.

Fish production technologies

A device for breeding and culturing marine fish in open sea; Asian Sea base seed production technology; CIFABROOD - an exclusive carp brood stock diet; cadalminTM GAe (anti-inflammatory drug from seaweeds); FRP Portable Carp Hatchery; Immunoboost C- an immuno-stimulant for brood fish health.

ADMINISTRATION

Recruitment

During 2012-13, the following posts have been filled up under direct recruitment and promotion quota: Director (1); Deputy Secretaries (4); Administrative Officer (14); Deputy Director/Chief Finance and Accounts (5); Senior Finance and Accounts Officer (2); Finance and Accounts Officer (6); Section Officers (5); Assistants (40); Principal Private Secretary(1); Private Secretary (1); LDC(1).

Financial up-gradation granted under MACP scheme

During 2012-13, large number of eligible officers and staff of ICAR (Headquarters and Institutes) were granted assured career progression scheme in accordance with the Government of India (Department of Personnel and Training) instructions in this regard.

Staff Welfare Fund Scheme

During 2012-13, the following activities have been made under staff welfare:

- As per the recommendations of the Managing Committee of ICAR (Headquarters) Welfare Fund, financial assistance of ` 25000 was extended to the family of one deceased employee of the ICAR Headquarters.
- Forty-six Scholarships (` 2500/- each) were awarded to the meritorious wards of the Council's employees under the scheme.
- Ward of one employee of ICAR (Headquarters) who died in harness has been appointed on compassionate ground.

New Initiatives

ISO 9001:2008 Certification for ICAR: The DARE and ICAR have become one of the first departments in the country in obtaining the certification by implementing the Quality Management System in the organization as per the ISO 9001:2008 standards. Shri S.K. Khanna (Deputy Director General, Bureau of Indian Standards) presented the certificate to Dr S. Ayyappan (Secretary, DARE and DG, ICAR) on 16

July, 2013. Acquiring ISO 9001:2008 certification is one of the performance monitoring indicators required to be complied with by all the Government Departments in the country as per the Result Framework Document (RFD) prescribed by the Performance Management Division, Cabinet Secretariat.

The pesticide residue laboratory, IIHR was accredited in accordance with the standard ISO/IEC 17025:2005 in the field of chemical testing by National Accreditation Board for Testing and Calibration Laboratories, Department of Science and Technology, Government of India, on 16 October 2012.

Implementation of Office Automation system in ICAR (Headquarters): In a step towards e-governance for better transparency and efficiency, ICAR has undertaken office automation of the headquarters office. The e-office introduced involves computerization of the workflow covering the transmission of files, requests for leave, tour proposals, availability of required information for day-to-day work and many other useful features.

The Council is also on the RTI portal of the Government of India for online receipt, disposal and monitoring of the RTI applications. Other major initiatives at computerization include a systems for monitoring Court cases and Vigilance cases.

The Council is following the directions of the Ministry of Finance regarding publishing of all its tenders on the e-procurement portal of the Government of India and will also undertake the procurement process electronically to maximize participation and transparency.

Facebook page of ICAR: The ICAR has its facebook page (www.facebook.com/InAgrisearch) to connect with the people of the Country in general and youth in particular. The facebook page provides relevant information in a crisp and interesting manner. It has become popular with more than 15,000 likes in nine months.

FINANCE AND AUDIT

The Plan and Non-Plan allocation (R.E.) to DARE/ ICAR for 2012-13 were ` 2,520.00 crore and ` 2,100.00 crore respectively. An internal resources of ` 185.47 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 for 2012-13. The Plan and Non-Plan allocation (B.E.) for 2013-14 are ` 3,415.00 crore and ` 2,314.17crore respectively.

PROGRESSIVE USE OF *RAJBHASHA*

DARE

The 'Hindi Section' achieved all the targets pertaining to *Rajbhasha* as detailed below:

- The Official Language Division of the Department manned by an officer of the level of Assistant Director (OL) has made relentless efforts towards implementation of the instructions issued by the Department of Official Language policy in the Department and the Autonomous Bodies under its administrative purview, Hindi Section of the Department carries out translation work under Section 3 (3) of Official language Act. DARE has made the following efforts for progressive use of *Rajbhasha* in the Official Language Policy of the Government.
- Quarterly Joint Meetings of Official Language Implementation Committee with ICAR were held regularly under the Chairmanship of the Additional Secretary of the Department, who is the nodal officer for implementation of the official language policy in DARE. During the year, four meetings were organized and follow up actions were taken in compliance with the decisions taken in these meeting.
- Quarterly progress reports regarding use of *Rajbhasha* in the Department are sent to the Department of Official Language regularly.
- During the year, 3 offices were inspected and suggestions were given to solve the practical problems being faced by the employees of the offices while working in Hindi.
- Officers have been issued instructions to make use of the services of stenographers, PAs, PSs trained in Hindi Stenography for doing the work in Hindi. The Stenographers not knowing Hindi Stenography are being nominated for such training.
- During the year, some work relating to General Administration has been specified to be done in Hindi.
- Effective check points have been prepared for compliance of the implementation of the Official Language Policy.
- The *Hindi Chetna Maas* was observed from 14 September to 13 October, 2013 in the Department in collaboration with ICAR. On the occasion, the Messages of Union Minister, and Secretary, DARE and DG, ICAR regarding progressive use of Hindi were circulated. Various competitions with active participation of officers and employees were held.
- In an effort to fulfil the provisions of the Official Language Policy in the electronic mode, the Department has hosted its Official website in English and Hindi. Unicode has bee installed in all computers to enable officers/staff to correspond to use of *Rajbhasha* in the electronic mode.

ICAR

The ICAR has taken following steps for the promotion of Hindi:

- During reported period one meeting of the Joint Hindi Advisory Committee was held on 9 April, 2013 under the Chairmanship of the Union Minister of State for Agriculture in which all

the three departments of Ministry of Agriculture including DARE participated.

- The progress of Hindi implementation is reviewed in Senior Officer's Meeting (SOC) every month by the Director General, ICAR and instructions to follow the decisions taken in Joint Hindi Advisory Committee were brought to the notice of all concerned.
- Orders were issued by the Director General, ICAR to all the Officers having proficiency in Hindi to do their maximum work in Hindi.
- During the reported period 3 ICAR Institutes/ Centres were notified in the Gazette under Official Language Rule 10 (4) thus raising the total number of notified institutes/offices to 121.
- The Additional Secretary (DARE) and Secretary (ICAR) chaired 04 meetings of the Joint Other Language Implementation Committee's of DARE and ICAR as per the Annual Programme. During the reported period 04 workshops were organized for various categories of staff to make them aware of the Other Language Policy of Government of India and to impart training on Unicode. In most of the ICAR Institutes Other Language Implementation Committees have been functioning.
- During the reported period Cash Awards were distributed to 10 officials at ICAR Headquarters for doing their maximum official work in Hindi.
- *Rajarshri Tondon Rajbhasha Purskar* was awarded to the following ICAR Institutes:

ICAR Institution	Award
Big Institutes	
IARI, New Delhi	First
NDRI, Karnal, Haryana	Second
Institutes/Centre of 'A' and 'B' Region	
DSR, Indore, Madhya Pradesh	First
CARI, Port Blair	Second
Institutes/Centre of 'C' Region	
CRIDA, Hyderabad, Andhra Pradesh	First
CMFRI, Kochi, Kerala	Second

- *Ganesh Shankar Vidyarthi Utkrist Hindi Krishi Partika Purskar* was awarded to the following Institutes:

Hindi Magazine	Name of the Institute	Award
Neelanjali	CIFRI, Barrackpore, West Bengal	First
Pusa Surabhi	IARI, New Delhi	Second
Dugdha Ganga	NDRI, Karnal, Haryana	Third

- On-line reporting is started and quarterly progress reports are sent to the Regional Implementation Office. The review of the quarterly progress reports received from various Institutes were reviewed at the ICAR (Headquarters) and suggestions are being given to them to improve the implementation. Participation in TOLIC was done on behalf of the ICAR.
- This Directorate is imparting training on Unicode and Hindi typing.
- The Union Agriculture Minister delivered an inspiring message on the commencement of *Hindi Chetna Mass* (organized between 14 September and 13 October 2013) that was sent to all the ICAR Institutions. The Director General, ICAR also appealed to all staff of the Council to make progressive use of Hindi in their official work. 'Slogan Competition' was started on 'ICAR Face-book', wherein ICAR employees from all Institutes participated.
- In accordance with the recommendations made by the Department of Official Language more than 36 Institutes were inspected during 2012-13 and suggestions 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 including ICAR (Headquarters) and ASRB.
- *Krishika*, ICAR's Hindi research biannual journal, and *Rajbhasha Alok* depicting the Hindi activities of different Institutes were uploaded on the ICAR website. www.icar.org.in
- The Council and its institutes are organizing *Kisan Mela* and *Gosthies* in Hindi and other Indian Languages.
- Cabinet Notes, Audit Accounts, Annual Plan, SDG, Governing Body, Parliamentary Standing Committee on Agriculture, Annual General Meeting of the ICAR Society and many other meetings were prepared bilingually. The drafts speeches of Union Agriculture Minister and other higher officials of the ICAR were prepared in *Rajbhasha*.

- The Hindi magazine '*Ikshu*' of IISR, Lucknow was awarded Second prize by Hon'ble President of India on 14 September, 2013 at Vigyan Bhavan, New Delhi

ICAR TECHNICAL COORDINATION

The Council provided the financial support to 43 journals for publication, 36 societies/associations/ universities for holding National Seminars/Symposia/ Conferences and 23 societies/associations /universities for holding International Seminars/Symposia/ Conferences. Annual grant to NAAS, Indian Science Congress and IAUA were also released. Fifteen queries from VIPs, 10 queries under RTI Act, 26 Parliament Questions were replied. Of *DARE 2012-13* and *Audit and Account Report* were placed before the Parliament.

The meeting of ICAR Regional Committee No.III was organized on 17 and 18 April at Assam Agricultural University, Jorhat, and recommendations were issued after approval of the Competent Authority of the ICAR. Monthly reports of major activities achieved in research and other related matter at various ICAR institutes/ NRCs/Project Directorates were timely submitted to Cabinet Secretariat and circulated to various Ministries, and the Departments of Government of India. The ICAR collaborated with DSIR in recommending proposals for recognition of in-house research and development units of private entrepreneurs.

Work Plans (20) were prepared for collaboration in the field of agriculture and allied sectors with different countries. The deputation reports of scientists /staff of ICAR were evaluated and screened. The Memoranda of Understandings with State Agricultural Universities were approved by the Competent Authority of the ICAR.

The Proceeding of the Directors' Conference (held on 19 and 20 March 2013) was circulated on 12 April 2013. The Conference was inaugurated by Padam Vibhushan Shri N R Narayana Murthy (Chairman, Infosys Ltd.). Professor M S Swaminathan (MP, Rajya Sabha) also addressed the gathering. During the Conference, Best Annual Report award was conferred to Central Research Institute for Dryland Agriculture, Hyderabad for Big Institute Category, and National Research Centre for Grapes, Pune and National Research Centre for Banana, Tiruchirapalli in Small Institute Category.

ICAR FOUNDATION DAY AND AWARD CEREMONY

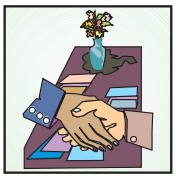
President of India, Shri Pranab Mukherjee bestowed the Best Institution Awards on University of Agricultural Sciences, Bengaluru, ICAR Research Complex for North-Eastern Hills Region, Umiam, and National Institute of Animal Nutrition and Physiology, Adugodi, Bengaluru on the occassion of 85th Foundation Day of the ICAR at NASC Complex, New Delhi on 16 July 2013.

Hon'ble President of India, Shri Pranab Mukherjee and Union Minister of Agriculture Shri Sharad Pawar releasing ICAR publications

The Union Minister of Agriculture and Food Processing Industries, Shri Sharad Pawar, distributed awards along with Shri Tariq Anwar and Dr Charan Das Mahant (Union Ministers of State for Agriculture and Food Processing Industries) on the occasion of ICAR Award Ceremony, 2012 (held at NASC Complex, New Delhi) on 16 July, 2013. Shri Sharad Pawar said that the recognition through Awards should lead to enhanced zeal and creative work by the Awardees.

Dr S. Ayyappan (Secretary, DARE and Director General, ICAR) announced that 79 awardees under sixteen different categories were conferred awards. These comprise 3 Institutions, 1 All India Co-ordinate Research Project, 9 Krishi Vigyan Kendras, 9 farmers, 2 journalists and 55 scientists including 10 women scientists.

❑



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 and Cooperation as the Nodal Department. Besides, Ministry of Science and Technology has developed Programme of cooperation with various countries and international organizations in which ICAR/DARE is the participating agency in the field of agricultural research. The Joint Commissions/Working Groups constituted by the Ministry of External Affairs, and the Ministry of Commerce have the component of agricultural research in which DARE participates directly or through the Department of Agriculture and Cooperation.

DARE organizes visits of foreign nationals on request. The Department also receives proposals for customized training courses for foreign nationals.

Work Plans

The following Work Plans have been signed during 2013-14 between ICAR and other institutions:

- Work Plan between ICAR-CIP
- Work Plan between ICAR-Bioversity International
- Work Plan between ICAR and INIA, Chile

MoU

- Memorandum of Understanding between School of Veterinary Medicine Pennsylvania, USA and ICAR signed on 21 August 2013 through exchange of letter.

Major Events

1. A group of 18 farmers from India and 2 officers of DARE/ICAR visited Malaysia from 14 to 23 April 2013 under ASEAN-India Cooperation.
2. The 3rd meeting of the ASEAN-India Working Group on 'Agriculture and Forestry' was held from 6 to 7 May 2013 in India.
3. The third issue of the *India-ASEAN Newsletter on Agriculture and Forestry* was released during the 3rd ASEAN-India Ministers' Meeting on 'Agriculture and Forestry' held in Kuala Lumpur, Malaysia on 28 September 2013.

Collaborative Projects with ICAR

Following projects were approved for implementation :

- 'Improving food and Livelihood Security in Punjab through Water-Energy-Agriculture Management under climate change and variability centre'. Its partners are Punjab Agricultural University, Ludhiana, and International Development Research Centre (IDRC), Canada with the trustee of Columbia University, USA.
- 'Ensuring food security: harnessing science to project our grain harvest from insect threats project' was received from IARI, New Delhi and funded by Department of Science and Technology. Its partners are Australia (University of Queensland) and India (TNAU, IARI etc) under AISRF fund.
- 'Collection and evaluation of data for NIAS gene bank sorghum genetic resources under tropical climate condition being operated by CPBG, TNAU, Coimbatore. It was funded by NIAS, Tsukuba, Japan.
- 'Exploitation of Inter-Specific Biodiversity of Wheat Improvement' was funded by BBSRC, BMGF, DFID, ICAR (DWR, Karnal) and Department of Biotechnology. Its partners are DWR, Karnal, ARI, Pune, UK and Australia.
- 'Using rainwater harvesting for resilient local groundwater management in the presence of saline aquifers' was received from MPUAT, Udaipur and WTC (IARI) in collaboration of University of Western Sydney, Australia and funded by the Department of Science and Technology under AISRF fund. Its partner are Water Technology Centre, IARI, New Delhi and University of Western Sydney, Australia and MPUAT, Udaipur.
- 'Evaluation of three phase micro-nano-emulsion based delivery sestems for selected nutraceutics for intend use in functional foods' was received from NDRI, Karnal under India-Ireland cooperative science programme.
- 'Safe water for the future through Indo-Oz Network' was received from NBFGR, Lucknow. Its partner are Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia, and NBFGR, and IITR, Lucknow.
- 'Value adding the gastropod fisheries and

Aquaculture industry in India and Australia'.

- 'Sustainable mariculture and Strategic research into Muricidae molluses for nutraceutical development' was received from CMFRI, Kochi.
- 'Sustainable marine food security and carbon challenges under a changing climate in Australia and India' was received from CMFRI, Kochi under DST-DIISR through AISRF fund.
- 'Application of dynamic simultation models to establish erosion-productivity relationships and soil organic carbon sequestration potential for a future changing climate' was received from CSWCRT&I and Dehra Dun.
- 'US-India consortium for development of Sustainable Advanced Lignocellulosic Biofuel system (SALBS)' was received from DSR, Hyderabad.
- The research project 'Enhancing resource uptake from roots under stress in cereal crops' was funded by Sirium Minerals, PLC, United Kingdom at University of Agricultural Sciences (UAS), Bengaluru.
- 'Tracking finger millet blast pathogen interaction and durable resistance source using genetic and genomic tools' as per the "Indo-Swiss" collaboration in Biotechnology (ISCB) call by DBT for association of Dr Dipnarayan Saha, PS, NBPGR, New Delhi as a collaborator under "Indo-Swiss" collaboration.
- 'Molecular epidemiology and rapid protection against Salmonellosis in India Pig Herds' to support FADH research was received from NRC on Pig, Guwahati, Asom.
- 'Control of Newcastle disease and Infectious bursal disease in Poultry using Nano- particles stabilized pDNA and mRNA vaccines' was received from IVRI, Izatnagar under DBT-BBSRC for collaborative proposals to support FADH.
- 'Development of Multiplexed diagnostic biosensor for infectious reproductive disease of cattle and buffaloes' was received from IVRI, Izatnagar under DBT-BBSRC call for collaborative proposals to support FADH.
- 'Genetic diversity of wheat root micro-biome and its manipulation for improved productivity under drought stress in Australian and Indian environments' was received from IARI, New Delhi.
- 'Global learning for local solution: Reducing Vulnerability of Marine-dependent coastel Communities' was received from CMFRI, Kochi in collaboration with the Rhodes University, South Africa and other partner countries under MoES, India.
- 'DNA barcoding, molecular phylogenetic and evolutionary genetics of fish inhabiting Russain far East and Indian Water' was received from NBFGR, Lucknow in response to the call from the DST-Russain Foundation for Basic Research.
- 'Development of Novel molecular diagnostic tests and Vaccination strategies for viral disease of cultured Salmonids' was received from DCFR, Bhim Tal, Naini Tal.
- 'Revealing key immune molecules and pathway that underlie resistance or Susceptibility to white spot disease in wild and cultured decapods crustacean' was received form CIBA, Chennai.
- 'Using ancestor plants to make rice more resilient to increasingly unpredictable water availability' was received from CRRI, Cuttack under Joint call proposal for SCPRID.
- 'Molecular characterization of the causal agent of Epizootic Ulcerative Syndrome (EUS), Aphanomyces invadans and immune responses in farmed fish' was received from NBFGR, Lucknow under BBSRC-DBT call for proposal to support FADH.
- 'Development and evaluation of novel nano-particle fish vaccine, delivery systems and associated diagnostic assays for economically important pathogens' was received from CIFA, Bhubaneshwar and called for support FADH.
- 'Genetic, Genomic and nutritional interaction of host resistance to internal parasites in Sheep' under the joint call given by DBT(India) and BBSRC (UK) jointly submitted by CSWRI, Avikanagar, Rajasthan and NARI, Phaltan, Maharashtra.
- 'Generation of novel anti-tick vaccine against *Hyalomma anatolicum anatolicum* and *Rhipicephalus annulatus* via a reverse vaccinology approach' was received from IVRI, Izatnagar under the joint call given by DBT and BBSRC on FADH.
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- 'Root-shoot signaling in dry soils; consequences for root and shoot architecture and yield in wheat' was received from IARI, New Delhi.
- 'Provision for Plant Protection and Quarantine Department Staff of the Ministry of Agriculture, Irrigation and Livestock of the Islamic Republic of Afghanistan in Plant Pest and Disease Diagnosis' was received from the TNAU, Coimbatore.
- 'Comparative studies on zoonotic poxvirus isolates from India and Brazil- a biological and genome approach" was received from the NRC on Equine, Hisar in collaboration with UFMG, Brazil under India-Brazil Inter-Governmental Programme of cooperation in Science and Technology.
- 'Expanding the *Brassica* germplasm base through collaboration with China and India' was received from Punjab Agricultural University, Ludhiana.

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- 'Expanding the *Brassica* germplasm base through collaboration with China and India' was received from Punjab Agricultural University, Ludhiana.

Fund release to CG Institutes

India is donor member to CGIAR, therefore DARE/ ICAR have made provisions both in Plan and Non-Plan budget for donating fund to CGIAR System in 2013-14.

CENTRAL AGRICULTURAL UNIVERSITY

Imphal: The Central Agricultural University Act empowers CAU, Imphal to establish need based Agricultural Education Institutions in the North-Eastern Hills Region of India covering the 6 states (7 campuses) offering 9 undergraduate, 34 postgraduate and 11 Ph.D.courses.

The intake capacity of all undergraduate programmes is 378, out of which 287 students were admitted and 218 students passed out during 2013-14.The postgraduate students' intake in College of Agriculture, Imphal (48), Veterinary and Animal Husbandry, Aizawl (72), Horticulture and Forestry, Pasighat (10), Fisheries, Tripura (30), postgraduate studies, Barapani (48) and Agricultural Engineering and Post-harvest Technology, Sikkim (06) offers 34 postgraduate programmes with total intake capacity of 214, 107 students admitted and 50 students passed out (from 1 April, 2013 to 31 October, 2013).

Major deliverable / recommendable achievements of research in CAU

- A modern rice variety CAU-R3, a 100 days duration and plant height of 90 cm with an average rice yield of 4 tonne/ha was released for cultivation in the name of *Mangalphou* by the State Variety Release Committee as a contingency crop which can be sown as early as 1 March and as late as 1 August.
- A new rice variety CAU-R4, a 145 days duration and plant height of 145 cm with an average rice yield of 4 tonnes/ha was released for cultivation in the name of *Eenotphou* by the State Variety Release in Committee for general cultivation in low lying semi-deep water ecosystem, locally known as *Patlou* and as a component variety for paddy-cum-fish farming.
- The technology was standardized to grow pulses and oilseeds in rice fallow during *rabi* through exploration of rain- water harvesting opportunities. The highest yield income was obtained from pea followed by Lathyrus, lentil and rapeseed under local conditions of Manipur valley.
- Production technique of virus free planting materials in Khasi mandarin was standardized. Seventy one orchards along the Basar region of Pasighat were thoroughly studied for detection of *Citrus Tristezaclostero Virus* (CTV) and *Citrus Exocortis viroid* (CEVd). The detection of CTV was done by bioassay of CTV with indicator plant, enzyme-linked immunosorbent assay and diagnostic strips and CEVd by bioassay of CEVd and RT-PCR. Seeds from virus free citrus plants were sown and budded with the buds collected from selected virus free mother plants. Thirty

thousand certified budded planting material has been produced for distribution to farmers.

- Pineapple production in North-East India is 40% of the total production of the country but due to inadequate market facilities, high bulk and less price (less than ` 5/piece), lack of storage infrastructure, improper transport facilities, most of the produce are spoiled/wasted. A process of value added product development of pineapple powder was standardized using pineapple produced in the region for better storability and wider markets.

Achievements of CAU quality seed production: Visualizing the need of quality seed production in NEH Region, the Central Agricultural University has started quality seed production.A large-scale demonstration of growing second crop of mustard following rice-harvest over an area of 1,100 ha in Manipur was conducted on farmers fields. This could add more than 7,700 q of mustard oilseed basket in Manipur.

Bundelkhand: The Department of Agricultural Research and Education has proposed establishment of Central Agricultural University for Bundelkhand Region, which covers 13 districts, i.e. 7 districts (Jhansi, Jalaun, Laltipur, Banda, Chitrakoot, Hamirpur and Mahoba) of Uttar Pradesh; and 6 districts (Sagar, Damoh, Tikamgarh, Panna, Chatarpur and Datia) of Madhya Pradesh

'The Rani Lakshmi Bai Central Agricultural University Bill, 2013' is pending in the Rajya Sabha for the purpose.

OTHER ACTIVITIES OF CAU

(A) Foreign deputation cases

Following type of cases of deputation/training/study abroad/ foreign assignment/ position and the exchange of seeds/germplasm were attended to foreign countries.

(i) Processing of applications for various training programmes abroad under various foreign governments announced by Department of Economic Affairs. DBTs Crest Award and DSTs BOYCAST Fellowship Programme against DBT/ DST open advertisements. UN/International organizations, International agencies in various fields of agricultural research and education.

(ii) Processing of applications for various fellowships/ scholarships announced by ICAR, HRD, DST, CGISR organization, foreign governments, etc. for higher studies/ research/ Ph.D./Post-Doctoral Research abroad.

(iii) Forwarding of applications of the Scientists for foreign assignments in foreign governments and International organizations.

(iv) Circulation of vacancies notified by the CGIAR organizations, other International organizations/ agencies such as ADB, World Bank, Commonwealth Secretariat, United Nations, etc.

Number of foreign visit cases finally approved by the Competent Authority (CCA) during November, 2012 to November, 2013 are given here.

(B) Germpasm exchange matters

1. Biodiversity encompasses the variety of all life on earth. India is one of the 12-mega diverse countries of the world. With only 2.5% of the land area, India already accounts for 7.8% of the global recorded species. India is also rich in traditional and indigenous knowledge both coded and informal.
2. Biodiversity is a multi-disciplinary subject involving diverse activities and actions. The stakeholders in biological diversity include the Central Government, State Governments, institutions of local self-governmental organizations, industry, etc. One of the major challenges before India lies in adopting an instrument, which helps realise the objectives of equitable sharing of benefits enshrined in the Convention and Biological Diversity.
3. The Department of Agricultural Research and Education (DARE) and the ICAR have a rich tradition of exchange of plant genetic resources with several countries. These resources are crucial for enhancing productivity and quality of our crops. No country is self-sufficient in these resources and the future of crop improvement programmes depends on active international cooperation in the area of exchange of genetic resources.
4. Essentially, the germplasm exchange programme of DARE/ICAR through bilateral MoUs with other countries has been on a *quid pro quo* basis.
5. The cases of export of germplasm are processed in IC Division as per the provisions/ guidelines of the Biological Diversity Act, 2002 and the Biological Diversity Rules,2004 also subject to guidelines/ notifications issued by Ministry of Environment and Forests, from time to time.

The six Bureaus/Institutes under ICAR system have been designated by the Ministry of Environment and Forests to act as repositories under the Bio Diversity Act, 2002 for different categories of biological resources:

(i) NBPGR : for exchange of plant germplasm
(ii) NBAGR : for exchange of animal germplasm
(iii) NBFGR : for exchange of fish germplasm
(iv) NBAII : for exchange of germplasm of agriculturally important insects
(v) NBAIM : for exchange of germplasm of agriculturally important micro-organisim
(vi) IARI : for exchange of germplasm of algae fungal.

6. Cases of germplasm exchange are processed in DARE for approval of the competent authority

in consultation with the Bureaus/Institutes/Subject Matter Division.

7. In the area of exchange of genetic resources, 26 cases received from friendly foreign governments/ government sponsored agencies /International Organization agencies were processed in accordance with the provisions of Biodiversity Act and further guidelines notified in this regard. Approval of the competent authority in respect of 15 cases were conveyed.

AGRINNOVATE INDIA LIMITED

Agrinnovate India Limited is incorporated on 19 October 2011 as a Section 3 "For Profit" Company under the Companies Act, 1956 (No. 1 of 1956). It is owned by the Government of India and is under the administrative control of the Department of Agricultural Research and Education, Ministry of Agriculture. The authorized capital of the company is ` 100 crores and the initial paid up capital is ` 50 crores.

It has a specific focus on providing technical support in the form of consultancies, contract research, contract service, and customized capacity building for turnkey project etc. with committed technical backstopping provided by network of the ICAR institutions.

The Company, Agrinnovate India Limited through a corporate framework, shall add to the availability of such quality products and services in the market and take initiatives for global brand building.

Commercialization of Tissue Culture Technology of oilpalm: Agrinnovate India Ltd. has taken the initiative of transferring the technology for tissue culture of oil-palm developed by the Directorate of Oil-Palm Research (DOPR), Pedavegi. The technology at the laboratory- scale has been licensed on a non-exclusive basis to M/s Beejo Shetal for undertaking further developmental work on the technology.

Turnkey projects: To augment the eradication of the Foot-and-Mouth Disease (FMD) and to increase the availability of FMD vaccine, Agrinnovate India Ltd. has taken up the establishment of a modern plant with a capacity to produce 100-150 million doses of FMD vaccine under Public-Private Partnership mode at Yelahanka campus of Indian Veterinary Research Institute, Bengaluru. Through this initiative, the Company endeavours to augment the availability of vaccine thus supporting the Foot-and-Mouth Disease Control Programme launched by the Department of Animal Husbandry Dairying and Fisheries.

To further strengthen the Indo-Africa relationship, Ministry of External Affairs has launched the Indo-Africa Forum Summit-II. Agrinnovate India Ltd. is also assisting DARE on projects related to establishment of eight centres each for Soil, Water and Tissue Testing Laboratory, Farm Science Centre and Agricultural Seed Production-cum-Demonstration Centre in different countries in Africa.

Capacity building: Agrinnovate India Ltd. is working in collaboration with well-equipped state-of-art laboratories and world-class faculty of the ICAR Institutes to harness the opportunities for meeting the existing global demand for skill development and capacity building. The initiatives taken by the Agrinnovate India Ltd. in this context include:

Training-cum-workshop on Conventional and Molecular techniques for diagnosis of trans-boundary animal diseases: Realising that highly pathogenic and economically devastating transboundary disease respect no boundaries, a training-cum-workshop has been designed in collaboration with High Security Animal Disease Laboratory, Indian Veterinary Research Institute, ICAR, Bhopal. The programme would benefit 20 participants, (in two batches of 10 participants) from ASEAN Member States by enhancing their knowledge and capability for diagnosis of trans-boundary animal diseases by strengthening their technical and practical skills based on conventional and molecular techniques; and enable them to make early diagnosis for effective control of the diseases in their countries.

Training on IT Application for Agricultural Extension (e-Extension): The success of India for the advancement in IT application for agricultural extension or e-Extension at different levels from national, regional, provincial, to community levels is well-recognized. Capitalizing on this strength, Agrinnovate India Ltd. has developed a training programme in collaboration with Agriculture Extension Division of ICAR and National Academy of Agricultural Research Management, ICAR, Hyderabad, India on IT Application for Agricultural Extension (e-Extension).

Training on effective National Seed Quality Control System: To enhance the food security and the national agricultural production, quality seed of all kinds and varieties is a dominant and critical input. India has a well established quality seed production system with adequate safeguards for quality assurance to maintain the seed purity as it flows from the breeder to the farmer. To share these experiences and provide an opportunity to 22 participants from ASEAN Member States for capacity building, a training programme on Organizing and implementing an effective National Seed Quality Control System is being organised at Directorate of Seed Research, Mau.

West Africa Agricultural Productivity Programme: Agrinnovate India Ltd. has taken the initiative to partner with West Africa Agricultural Productivity Programme that intends to sponsor researchers and technical staff from Nigeria. These include 30 days training on Chick Vent Sexing to be organized in collaboration with Central Avian Research Institute, ICAR, Bareilly and a three weeks training on 'Seed Quality Assurance' to be organized at the Division of Seed Science and Technology, Indian Agricultural Research Institute, New Delhi.

OTHER ACTIVITIES OF DARE

Consultancies

Following deputation/ consultancy proposals were submitted.

Dr (Mrs) R. Manimekalai (Senior Scientist, CPCRI, Kasaragod) was appointed as a FAO-TCDC Consultant in project 'Development of capacities for early diagnosis, surveillance, spread prevention and integrated management of Weligama Coconut Leaf Wilt Disease' in Sri Lanka – Second Mission (duration from 23 March to 7 April, 2013).

Dr V.S. Santhosh Mithra (Senior Scientist, CTCRI, Thruvanthapuram, Kerala) provided consultancy services to Michigan State University, USA as a Visiting J-1 Short-term Scholar from 30 March to 8 April 2013.

Dr U.C. Sud [Director (Acting) and Head, Division of Sample Survey, IASRI, New Delhi] provided 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– Third mission of consultancy duration from 20 to 30 April 2013; and Fourth mission of consultancy (duration from 17 to 26 September 2013).

Dr Hukum Chandra (Senior Scientist, IASRI, New Delhi) provided consultancy within the framework of the FAO project on 'Statistics from Space-support to Ethiopia to Improve Agricultural Statistics in Ethiopia as a consultant/Sampling Expert' from 27 July to 17 August, 2013.

Dr P. S. Naik (Director, IIVR, Varanasi) worked as a FAO/TCDC Consultant for international consultancy under Vanuatu's project TCP/VAV/3402 – Enhancing Capacity in Vegetable Production; (duration from 16 August to 4 October 2013).

Dr S.Anandan (Principal Scientist, Animal Nutrition Division, NIAN&P, Bengaluru) provided consultancy services to regional office, International Livestock Research Institute C/o ICRISAT, Patancheru, Andhra Pradesh for assisting in the activities of on going projects of ILRI for 60 days through multiple visits at ILRI, Hyderabad spread over two calendar years (2013 and 2014).

- Dr (Mrs) Prachi Mishra Sahoo (Senior Scientist, IASRI, New Delhi) provided short-term consultancy in Sampling as Expert in the field of 'Geographic Information System and Remote Sensing in Agriculture to Ministry of Agriculture, Sultanate of Oman from 15 September to 10 October,2013 under the programme of African-Asian Rural Development Organization, New Delhi.
- Dr Renu Pandey (Senior Scientist, IARI, New Delhi) provided consultancy on 'Metabolic Pathways of Nutrient in Plants Applied on Foliage' for Virtual Fertilizer Research Centre Programme Office, Washington DC, USA.
- Dr George V. Thomas (Director, CPCRI, Kasaragod) provided consultancy on 'Coconut Sector Development in Asia and the Pacific Region' from 30 October to 1 November, 2013 at Bangkok, Thailand.

International Conferences / Workshops

More than sixty International Workshops/ Conferences were held. Some of the International Conferences/Workshops are given here.

- Borlaug Global Rust Initiative (BGRI) technical workshop 2013 held at New Delhi from 19 to 22 August, 2013.

- International seminar on 'Greening Aquaculture and Fisheries' held at Society of Fisheries Technologists, Cochin from 18 to 20 April, 2013.
- International conference on 'Tropical Roots and Tubers for Sustainable Livelihoods under changing agro-climate' held at CTCRI, Thiruvananthapuram (Kerala) from 09 to 12 July, 2013.
- Organizing/ hosting of IX Session of the Technical Committee of Centre for Sustainable Agricultural Mechanization in 2013 in India by the Indian Council of Agricultural Research.
- International conference on 'Impact of Technological Tools on Food Security under Global warming Scenario' held at Shobit University , NH-58, Modipuram Meerut (Uttar Pradesh) from 11 to 12 May,2013.
- Two day workshop on 'Emerging Practices of Open Educational Resources in Higher Education and Training' held at NAARM, Hyderabad from 16 to 17 May, 2013.
- International workshop on 'Status of Aquaculture in the SAARC Countries' held at Central Marine Fisheries Research Institute, Kochi from 5 to 7 June,2013.
- International conference on 'Global Consultation on Millets Promotion for Health and Nutritional Security held at Directorate of Rice Research Auditorium, Rajendra Nagar, Hyderabad (Andhra Pradesh) from 18 to 20 December,2013.
- Inception workshop/meeting on 'Regional Adaptive Trial on Selected Pulses in SAARC

member countries' held at National Bureau of Plant Genetic Resources, New Delhi from 12 to 13 July,2013.

- Fourth International conference on 'Landscape and Urban Horticulture' held at Science City Auditorium, Kolkata (West Bengal) from 12 to 14 September, 2013.
- International conference on 'Role of Plant Biochemistry and Biotechnology in Food and Nutritional Security held at Sri Venkateswara University Campus, Tirupati (Andhra Pradesh) from 11 to 14 December, 2013.
- World Agricultural Forum Congress, 2013 and Agri-Tech Trade Fair held at Hyderabad International Convention Centre, Hyderabad (Andhra Pradesh) from 4 to 7 November, 2013.
- Bayor Crop Science Limited International event on 'Rice Future Forum 2013' organized at Gurgaon (Haryana) from 8 to 10 October,2013.
- Indo-German Bilateral workshop on 'Microbial Ecology and Application of inoculants in bio-control' held at IARI, New Delhi from 7 to 10 April, 2014.
- International conference on 'Agrarian' issues held at Kerala Institute of Local Administration, Thrissur, Kerala from 9 to 12 January, 2014.
- 'SOYCON-2014: International Soybean Research Conference' to be held at Indore in collaboration with Directorate of Soybean Research, Indore (Madhya Pradesh) from 22 to 24 February, 2014.

Foreign scientist(s) to India

- Dr Jens Vanselow (German PI from Gene Expression Laboratory, Germany) visited NDRI, Karnal from 3 to 24 April, 2013 under DST-DAAD Project based personnel exchange programme on 'Understanding the role of micro-RNA (miRNA) mediated gene regulation during folliculogenesis and liteinizaiton: a comparative study in buffalo and cow'.
- Dr Samarthia Thankappan (Lecturer, University of York, United Kingdom) visited CRRI, Cuttack under the project 'Using wild ancestor plants to make rice more resilient to increasingly unpredictable water availability' from 16 to 17 August, 2013.
- Dr V. Puvanendran (Senior Scientist, Project Leader-FK Norway-Nofima Feasibility Study, Nofima) and Dr Atle Gudmund Mortensen (Project Leader-FK Norway-Nofima Feasibility Study, Norway) visited Central Inland Fisheries Research Institute, Barrackpore from 15 to 19 September, 2013.
- Dr (Ms) Jenny Stauber (Deputy Chief); Dr (Ms) Anupama Kumar (Principal Research Scientist), Dr Peter Bain (Scientist), and Ms Merrin Adams (Ecotoxicologist) will attend the training workshop on 'Ecotoxicology' under the AusAID project, 'Safe Water for the future through Indo-Oz Network" from 02 to 07 December, 2013 funded by AusAID under Public Sector Linkage Programme (PSLP) 2010-2011.
- Dr Ian Graham (Professor and Director, Centre for Novel Agricultural Products CNAP, Department of Biology, University of York, United Kingdom) visited CRRI, Cuttack under the project entitled 'Using wild ancestor plants to make rice more resilient to increasingly unpredictable water availability' under SCPRID from 11 to 12 November, 2013.

No. of approved cases pertaining to fellowship/ scholarship/position/post in DARE

Fellowship/Scholarship/ Position/Post	No. of cases finally approved
Department of Biotechnology (DBT) DBT Crest Award	24
Erasmus Mundus Scholarship	3
INDO-US Research Fellowship Programme	1
Fulbright Fellowship, USIEF-USA	3
DSSAT,G.O.I	1
DST's INDO- Australia Fellowship	3
Ph.D. ICAR International Fellowship	3
Pest Management- MASHAV-CINADCO-ISRAEL	2
Netherland Fellow NFP	4
ICAR Lal Bahadur Shastri Award	3
Other Training Programme abroad	4
Collaborative Programme	1
TWAS-CAS Fellowship	1
Endeavour Fellowship in Australia	2
ICARDA Position/Post	2
IWMI Position/Post	1
CIMMYT Position/Post	1
ICRISAT Position/Post	1
Total	60

Technology development, evaluation, and promotion

- Dr V.V. Sumanth Kumar (Scientist, NAARM, Rajendranagar, Hyderabad) attended assignment of 'Scientist – ICT4D' at ICRISAT, Patancheru (Andhra Pradesh) from 22 January 2013 to 21 January 2016.Dr K. C. Bansal (Director, NBPGR, Pusa Campus, New Delhi) participated in the XIV Session of the Commission on 'Genetic Resources for Food and Agriculture, held at Rome from 13 to 19 April, 2013.
- Dr T. Srinivas (Senior Scientist, Agricultural Economics, CTCRI, Thiruvananthapuram, Kerala)

for the position/assignment of 'Project Socio-Economist' in International Centre for Agricultural Research in the Dry Areas, Aleppo, Syrian Arab Republic for three years.

- Dr K. V. Prabhu (Head, Division of Genetics, IARI, New Delhi) and Dr (Mrs) Kavita Gupta (Principal Scientist, Plant Quarantine Division, NBPGR, Pusa Campus, New Delhi) participated in the APAARI's organized Stakeholders Dialogue on 'Biosafety Regulations in the Asia Pacific Region' held at Royal Princess Hotel, LarnLaung, Bangkok, Thailand from 16 to 17 April, 2013.
- Dr T. Mahapatra (Director, CRRI, Cuttack) attended the special session of the International Rice Commission at FAO (Hqrs.) from 13 to 14 June, 2013 Rome, Italy.
- Dr Vishal Nath (Director, NRC for Litchi, Muzaffarpur, Bihar) attended meeting on Improving productivity and quality of Litchi in Chiangrai, Chiangmai and Bangkok, Thailand from 26 May, 2013 to 1 June, 2013 under FAO project on Litchi.
- Dr Atmaram Mishra (Principal Scientist, DWM, Bhubaneshwar, Odisha) assignment of 'Senior Research - Agricultural Water Management' at IWMI, Sri Lanka and posted at IWMI's Southern Africa Office in Pretoria, South Africa for three years w.e.f. 01 July, 2013.
- Dr K. K. Singh (ADG, PE, ICAR Hqrs.) attended the IV Meeting of FAO-UNEP Agri-Food Task Force on 'Sustainable Consumption and Production' at Food and Agriculture Organization (Headquarters) in Rome, Italy from 10 to 12 June, 2013.
- Dr C.N. Ravishankar (Principal Scientist, CIFT, Kochi) attended the World Bank Global Food Safety Partnership Training programme on Good Aquaculture Practices organized by NACA in Indonesia from 17 to 22 June, 2013.
- Dr (Mrs) Gurinderjit Randhawa (Principal Scientist, NBPGR, New Delhi) attended a meeting on GMO testing in the Regional Biosafety Workshop at Bangkok, Thailand from 17 to 20 June, 2013.
- Dr Hanuman Sahay Jat, (Senior Scientist, CSSRI, Karnal, Haryana) attended assignment of 'Senior Scientist (Research Platform Coordinator)' at CIMMYT (International Maize and Wheat Improvement Centre) India Office located at Karnal (Haryana) 3 years (fixedterm) [from the date of joining the CIMMYT India Office, Karnal, Haryana] as a nationally recruited staff (Grade VI).
- Dr C.S. Prasad, (Director, NIANP, Bengaluru) attended the FAOAPHCA Regional Workshop on 'Animal Feed Resources and their Management in the Asia-Pacific Region' at Bangkok from 13 to 15 August, 2013.
- Prof. Swapan Kumar Datta [DDG (CS), ICAR, New Delhi] and Dr Pratibha Brahmi (Principal Scientist, NB PGR, Delhi) attended the Third High Level Round Table on the ITPGRFA. It was organized under the patronship of the Government of Indonesia from 2 to 4 July, 2013 at Bandung, Indonesia.
- Dr RaghavendraBhatta (Principal Scientist, NIANP, Bengaluru) attended the Workshop on 'Life – Cycle Assessment on Animal Feeds' in Beijing, China from 8 to 10 July, 2013.
- Dr S. Anandan (Principal Scientist, NIAN&P, Bengaluru) participated in the FAO–APHCA Regional workshop on 'Animal Feed Resources and their Management in the Asia-Pacific Region' at Bangkok from 13 to 15 August, 2013.
- Dr Shalander Kumar (HD-VI and Principal Scientist, CAZRI, Jodhpur) attended assignment of 'Scientist – Dryland Systems in South Asia' in the Special Project Scientist (SPS) cadre at ICRISAT, Patancheru, (Andhra Pradesh) for 3 years.
- Dr (Mrs) Sandhya Gupta and Dr (Mrs.) Rekha Chaudhury (Principal Scientist, TC & CP Unit, NBPGR, Pusa Campus, New Delhi) participated in the 2 ISHS International Symposium on 'Plant Cryopreservation' at Fort Collins, Colorado, USA from 11 to 14 August, 2013
- Dr A.P. Dineshbabu (Principal Scientist, CMFRI, Cochin) participated in APFIC Regional Expert Workshop on 'Tropical Trawl Fishery Management' held at Phuket, Thailand from 30 September to 04 October, 2013.
- Dr B. R. Shome (Principal Scientist, Project Directorate on Animal Disease Monitoring and Surveillance, Bengaluru) participated in Second Regional Epidemiology Networking workshop between 13 and 14 August, 2013 at Paro, Bhutan organized by ECTAD, FAO, Nepal.
- Dr Aniket Sanyal (Principal Scientist, PD-FMD, IVRI Campus, Mukteshwar) continued as National Consultant-Senior Scientific Officer at FAO for one year i.e. upto 14 June, 2014.
- Shri Rajesh Ranjan (Director, DARE) participated in the 'Commonwealth Agricultural Bureaux International's XVIII Review Conference' held in Oxford, United Kingdom from the 26 to 28 June, 2013.
- Dr A.K. Misra (Project Coordinator, AICRP on Sub-troppical Fruits, CISH, Lucknow) attended the FAO/TFNet/MARD Events International Symposium on 'Superfruits:Myth or Truth'; International Tropical Fruits Network (TFNet) Board of Trustees Meeting; and Workshop on 'Policies to Facilitate Small-holder Integration into Tropical Fruits Value Chains and Markets' held at in Ho Chi Minh City, Vietnam from 1 to 6 July, 2013.
- Dr T.P. Rajendran (Officer on Special Duty, NIBSM, Raipur, Chattishgarh) participated in Biological weapons Conventions's: meeting of Experts in Geneva from 12 to 16 August,2013.
- Dr M. Anandraj (Director, IISR, Calicut) attended

the IPCR&D Committee meeting and International Seminar on 'Spice, Medicinal and Aromatic Plants' from 28 to 30 August,2013 at Jakarta, Indonesia'.

- Dr Sushil Pandey (Senior Scientist, Seed Technology, NBPGR, New Delhi) worked at ICRADA as a 'Seed Specialist' implemented Harmonized Support for Agriculture Development project in Iraq in collaboration, MoA, Baghdad and MoAWR, Kudistan. It was funded by USAID from 28 September 2013 to 31March 2014.

VIP delegations

1. His Excellency Mohannad Salman Al-Sady (Minister of Water Resources, Iraq) visited Indian Agricultural Research Institute, New Delhi on 20 May, 2013.
2. A 3-member delegation led by His Excellency Lakshman Senewiatne (Minister of Sugar Industry Development, Sri Lanka) visited Indian Institute of Sugarcane Research, Lucknow from 15 to 19 June, 2013.
3. His Excellency Inia Batikoto Seruiratu (Minister for Agriculture, Fisheries, and Forest and Rural Maritime Development, Fiji) accompanied delegation at Indian Agricultural Research Institute, New Delhi on 3 October, 2013.

Visit of foreign scientists to India during 2013

- Prof. Mukund V. Karwe (Professor and Chair, Rutgers University, USA) visited Central Institute of Fisheries Technology, Kochi between 18 and 31 October 2013.
- Under the NAIP sponsored training programme Dr Timothy Houlton (Senior Scientist, BecA-ILRI Hub, Nairobi, Kenya CISH, Lucknow) visited from 11 to 24 November 2013.

Visits of Secretary (DARE) and DG, ICAR and Additional Secretary (D) and Secretary, ICAR under CG

- Deputation of Shri. Arvind R. Kaushal (Additional Secretary (DARE) & Secretary, ICAR), Dr. A.K. Sikka (DDG (NRM), ICAR), Sh. Rajesh Ranjan (Director (IC), DARE), Dr. R.P. Dua (ADG (FFC), ICAR), Sh. Sarvesh Rai (Director (Trade), DoAC), and Dr. S.K. Mukherjee (Advisor (FE), DoAC), to participate in BRICS – 3rd Agricultural Experts Working Group (AEWG) meeting held at Pretoria, South Africa from 26 to 27 August, 2013.
- Deputation of Dr. S. Ayyappan (Secy(D) & DG, ICAR) to participate in the ICRISAT Governing Board Meeting held at Dakar Senegal from 7 to 10 April, 2013
- Deputation of Dr. S. Ayyappan (Secy (DARE) & DG, ICAR) to participate in the GLAST-2013 held in Beijing China during 5-6 June, 2013.
- Deputation of Dr. S. Ayyappan (Secy (D) & DG, ICAR) to participate in the IRRI Board of Trustees Meeting held from 3 to 5 April, 2013 at IRRI Hqrs Philippines
- Deputation of Shri Arvind R. Kaushal (Additional Secretary (DARE) & Secretary, ICAR) to visit IRRI (HQs,) Los Banos Philippines from 29 April to 02 May, 2013.
- Deputation of Dr. S. Ayyappan (Secretary (DARE) & DG, ICAR) to participate in ICARDA BOT Meeting held in Kuwait City, Kuwait during 28 April to 3 May, 2013.
- Deputation proposal of Shri. Arvind R. Kaushal, (AS (D) & Secy, ICAR) to visit research facilities in Kiboko Njoro and Naivasha in Nairobi on 25 and 26 September 2013.
- Deputation of Dr.S. Ayyappan (Secretary (D) and DG, ICAR) to attend the IRRI Board of Trustees Meeting at Bujumbura, Burundi from 28 to 30 October, 2013
- Deputation of Dr. S. Ayyappan (Secy (D) & DG, ICAR) to attend the FC-10 meeting at Kenya on 5 to 8 November 2013.

Fellowships

The Education Division, ICAR has nominated 65 foreign students for Ph.D., 107 foreign students for M.Sc./M.V.Sc. and 65 foreign students for B.Sc./B.V.Sc. for pursuing undergraduate, Postgraduate and Doctoral programmes in various Agricultural Universities/ICAR Deemed Universities under India-Africa Forum Summit,2008 and Indo-Afghanistan Fellowship programme, Nepal-Aid-Fund and self-finance scheme.

Approved depulation visit of Indian Scientist(s) to abroad

- Three scientists of National Research Centre on Equines, Hisar (Haryana) were deputed for taking part in a laboratory exchange programme under OIE Twinning Project 'Diagnosis on Glanders' at Institute of Bacterial Infections and Zoonoses, Jena, Germany as per details given below:
  - (i) Dr. R.K. Singh (Director) from 25 April to 01 May 2013.
  - (ii) Dr. Praveen Malik, Principal Scientist during 25 April to 31 May 2013.
  - (iii) Dr. Harisankar Singha, Scientist during 25 April to 31 May 2013.

ICAR – Foreign institutions collaborations

There were conferences/seminars/workshops (7), trainings (3), and bilateral visits (4).

Undert multilateral programme, a delegation led by Shri Sharad Pawar, Union Minister of Agriculture and Food Processing Industries visited Kuala Lumpur, Malaysia to attend 3rd ASEAN-India Agriculture Ministers Meeting on 28 September 2013. Dr S. Ayyappan[(Secretary (DARE) and DG (ICAR)} and Shri Sanjeev Chopra (Joint Secretary, DoAC) were also part of the delegation.

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20.

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

NFBSFARA is a platform for developing scientific capacity, partnership (beyond the traditional NARS) and culture, and is providing support for basic and strategic research as a source of continuous flow of knowledge required for solving agricultural problems of present and of future.

NFBSFARA undertook four major tasks— selection and awarding new projects; monitoring ongoing projects; creating awareness for the need and nature of the basic research for agriculture among institutions within and outside the traditional NARS; and assisting scientists in developing meaningful winning projects.

New Projects

During the year, 25 new projects were awarded with a total budget of ` 50.10 crore. These are in the following strategic priority areas: Conservation agriculture and climate change (7); Biotic stresses (10); Water quality and productivity (1); Alternate energy for agriculture (2); Use of nanotechnology for agriculture and studies on environmental safety of this technology (1); *RNAi* gene silencing technology (1); Minimization of agricultural waste and maintenance of product quality (3).

Monitoring and evaluation

Eleven Advisory Committee meetings (including seven joint meetings of more than one project) were held during the year for 25 projects. The Empowered Committee also reviewed once the large projects. All the projects were reviewed together by the Empowered Committee on 22 and 23 July 2013, and the Committee appreciated the overall progress of different projects. Seventeen completed projects were evaluated by peers. Eleven of them scored above 70%; the projects scoring very high had high quality publications/ patents too. A survey of Principal Investigators (PIs) indicated satisfaction level of scientists of about 90% with the steps and methods followed for the project development and implementation.

Awareness creation

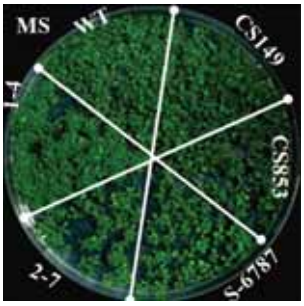
Six workshops were conducted to create awareness about (*i*) the nature of the basic and strategic research projects that ICAR wants, (*ii*) priority problem areas, (*iii*) about NFBSFARA, and its working and philosophy, and (*iv*) conception and development of Project Ideas and Concept Notes on projects through participatory discussions. These were held at the Assam Agricultural University, Jorhat (8-9 July 2013), Central Agricultural University, Barapani campus (11-12 July 2013), NAARM, Hyderabad (12-13 August 2013), NIRJAFT, Kolkata (23-24 August 2013), NDRI, Karnal (6-7 September 2013) and CIFE, Mumbai (27-28 September 2013). In all 229 scientists participated from 92 NARS and 48 non-NARS institutions.

SALIENT ACHIEVEMENTS

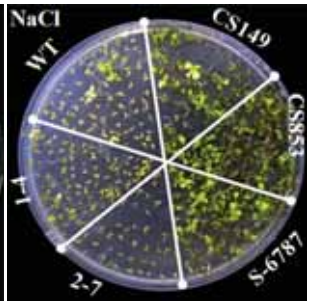
Subject-wise classification of 50 projects awarded before 2013 in different priority areas is as follows: Conservation agriculture and climate change (9); Biotic stresses(13); Water quality and productivity(5); Alternate energy for agriculture(4); Micronutrients and their use efficiency(1); Precision and controlled-environment agriculture(2); Use of nanotechnology for agriculture and studies on environmental safety of this technology (1); *RNAi* gene silencing technology (5); Minimization of agricultural waste and maintenance of product quality (4); Improvement of fibre quality in fibre crops (5); Development of pod-borer resistance in pulses (1). One patent entitled "An autoclavable microencapsulation system with multi stage break-up two fluid nozzle" has been filed.

Moisture-stress tolerance in rice

A high- throughput non-destructive method based on the near infra-red (NIR) and shortwave infra-red (IR) hyperspectral signatures has been developed for quantifying relative water content (a criterion of moisture-stress tolerance) of rice-plant in laboratory and pot-culture. Twenty candidate genes related to moisture-stress tolerance from rice have been cloned, and 33 different plant transformation vectors have been constructed. Two rice genes, *OsFBX257* (F-box protein) and *OsHOX22* (homeodomain protein), when expressed



Arabidopsis seedlings grown on MS media



Arabidopsis seedlings grown on MS media supplemented with 100 mM NaCl for induction of moisture stress

in *Arabidopsis*, a model plant, behaved as a negative regulator for moisture- stress tolerance.

Moisture-stress tolerance in groundnut

Bacillus subtilis, *B. firmus*, *B. tenquilensis*, *Pseudomonas aeruginosa*, *Acinetobacter* sp., *Enterobacter* spp., *Brevibacterium* sp., *Alcaligenes* spp. and *Pantoea* sp. identified as seed endophytic bacteria of groundnut appear to help groundnut-plant in tolerating salinity and moisture-deficit stress.

Resistance to pod-borer in pulses

- Thirty- two independent primary transgenics of chickpea and 211 of pigeonpea have been established. In preliminary insect-feeding assay with T_2 lines of pigeonpea, mortality of gram pod-borer was up to 90%, 60% and 75% in leaf, flower and pod, respectively.

Feeding pattern of neonate pod -borer larvae in leaf bioassay involving *Cry2Aa*-transgenic lines (T_2) and non-transgenic plants

- MicroRNAs have been identified which could shut down chitin production and larva development of pod-borer upon their force feeding. Tobacco plants carrying microRNA have been produced for validation. Viral DNA in nucleopolyhedrovirus (NPV) of *Helicoverpa armigera* has been characterized using inhibitor of apoptosis (*iap)* gene with specific primers and the ssDNA binding protein encoding gene of NPV with specific primers. This method would help identifying NPV proteins leading to control of pod-borer.

Enhancement of bioavailability of iron in soybean and rice-grains

Putative transgenic rice-plants have been developed using RNA*i* technology.These plants showed 5-7 fold increase in inorganic phosphorus and up to 40% decrease in phytic acid content in selected rice transgenic (T_2) lines. Phytic acid decreases bioavailability of iron in grains. Similarly, up to 60% reduction in phytic acid content was observed in selected transgenic lines (T_2) in soybean.

Fibre strength in cotton

A simple staining of developing fibre using calcoflour white is useful in identifying high- fibre strength genotypes of cotton.

Tolerance to weedicides

Rice-plants with enhanced (through molecular techniques) activities of EPSP synthase and sulfonylurea insensitive acetolactate synthase encoding genes showed tolerance of non-selective herbicides, glyphosate and sulfonylurea, respectively.

Disease resistance in animals and fish

A method has been developed for isolation and maintenance of peripheral blood mono-nuclear cell (PBMC). *In-vitro* model of PBMC-derived macrophages has been developed for functional analysis of immune-response gene against *Mycobacterium avium* ssp. *paratuberculosis* (MAP) and *M. fortuitum* (MF) for goat/ buffalo and MF for fish. An *in-vivo* model for studying infection parameters due to MF infection in fish has been developed.

Whole genome has been sequenced for goat. Transcriptome and small RNA profiles of macrophages of goat and buffalo when infected with MAP and MF have been worked out to understand immune-response genes in goat.

Food and feed quality enhancement

- The fungal isolates, LF1-2F1, LF1-5F1 and SV-2F2, reduced gossypol (up to 57%) and improved crude protein (up to 4%) and lysine content (up to 0.32%) in cotton-seed cake and this enhaneed its value as a poultry-feed. A solid-state fermentation process has been optimized using a combination of *Pleurotus sajorcaju* and *Saccharomyces cereviseae* and *S. cereviseae* + *Candida tropicalis* for maximum detoxification to the extent of 0.04% of free gossypol and total gossypol (0.87%) in cotton-seed cake and improved lysine content within 36 to 48 hours.
- Mode of action of *si*RNA in inhibiting fatty acid regulatory enzyme ELOVL6 in pig mesenchymal stem cell lines has been studied. This will help further using *si*RNA to reduce fat content in pig. Laboratory methods have been optimized for estrus synchronization, harvest and grading of different stages of developing transgenic pig embryos expressing *si*RNA against *ELOVL6* and *SCD1* genes and their transfer.
- Pediocin is a wide-spectrum bactericide usable in food material. Encapsulated pediocin in microcapsules made of sodium alginate (2.0% w/v), guar gum (0.22% w/v) and phosphtidylcholine (0.15% w/v) supplemented with nonencapsulated free pediocin gave best antimicrobial activity against *Listeria innocua* up to 48 hours in Brain heart infusion (BHI) broth media.

Bioenergy

- Delignification and saccharification of agricultural biomass are important steps for production of bioethanol. A broad database of cellulose- and lignin-degrading microbes available in diverse growing conditions has been prepared. Three microbes, *Myrothecium roridum*, *Trametes hirsuta*

and *Steptomyces griseorubens*, have been found efficient in delignification of paddy- straw, carrot grass etc. *M. roridum* released 408.33 mg/g reducing sugar from bio-pretreated paddy- straw and 376.75 mg/g from sterilized carrot- grass after 32 hr of enzyme action. Fermentation of hydrolysate derived from alkali-treated paddy-straw and carrot- grass with *S. griseorubens* produced ethanol (16.5g/litre) with addition of β- glucosidase. Plant pathogens like *Xanthomonas axonopodis* pv. *punicae* and *Phoma exigua* ITCC 2049 showed saccharification of lignocellulosic biomass.

- Calcium, nitrogen and phosphorus starvation and magnesium and common-salt supplementation increased cellular lipid content in three selected microalgae, *Scenedesmus obliquus, Chlorella vulgaris* and *Chlorella minutissima*, to the extent of 42, 43 and 61%, respectively. Up to 91% biodiesel could be obtained from transesterification of microalgal oil at the laboratory level. A low- cost medium with fertilizers used for agriculture has been standardized. Extraction and quantification protocol for β-carotene, a precursor of vitamin A, from microalgae has been developed.

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21. National Agricultural Innovation Project

The National Agricultural Innovation Project (NAIP), effective since September 2006, is the initiative of the Indian Council of Agricultural Research (ICAR), funded jointly by the Government of India and the World Bank to broadly identify and promote technology-led innovations in agriculture sector. The project continues to enhance multi-dimensional competence of the National Agricultural Research System (NARS) for steering-up agriculture R&D. The 13th Institutional Support Mission of the World Bank (ISM 13; 12-20 August 2013) has re-confirmed that the competitive consortia based funding through the NAIP has introduced a pragmatic pluralism in the NARS. A total of 91 public-private partnerships have been established in 203 sub-projects, approved with the NAIP financing, including 3 sub-projects with the additional financing from the Global Environment Facility (GEF).

Promising results emerging from the NAIP research and development activities as determined by select key performance indicators include, 72 patent/ intellectual property protection applications filed; 319 research papers published in the high impact peer reviewed journals; 82 technologies/products commercialized based on the NAIP research; 51 new rural industries piloted, and over 3,800 hectares of farmers' agricultural land brought under sustainable land-management practices.

The first Agri Tech Investors meet (18-19July 2013) conducted by the NAIP on the recommendations of the ISM 12 came out successfully in catalyzing and managing change in the Indian NARS with a formal transfer of 58 technologies, including 30 technologies developed under the NAIP, to private entrepreneurs generating licence fees of ` 3.2 crore, besides deals worth another ` 1.50 crore in the pipeline.

The other components of the NAIP have focused on the three high-priority research themes— market-oriented collaborative research alliances; rural livelihood research alliances; and basic and strategic research alliances.

ICAR as a catalyzing agent

In terms of harnessing the knowledge flow through information, communication and dissemination system, potential of information and communication technology (ICT) for enhancing quality of education has been augmented by developing e-courses for 7 bachelor degree-level programmes in agriculture, horticulture, veterinary science, home science, fishery science, dairy technology and agricultural engineering; deploying them on-line, and also making them available as off-line copies. Further, operation of an online e-publishing system for the ICAR research journals has increased their readership by 4-5 folds, and reduced article processing time from 2 years with conventional publishing to 2-4 months. And the Consortium for e-Resources in Agriculture (CeRA) has provided an on-line access of around 3,000 journals to 142 CeRA member-NARS institutions throughout India. The sustainability of such an access is being secured by the concerned institutes through XII-plan funding.

A knowledge management platform – Agropedia – for aggregation and dissemination of information; a rice knowledge management portal – RKMP – for a complete information package on rice; a group catalog "AgriCat" (http://www.agricat.worldcat.org) of 12 major libraries for online access by researchers and students; a new platform vKVK (http://www.vkvk.in) as a knowledge network for the Krishi Vigyan Kendras (Farm Science Centres); and a strengthened statistical computing platform in the NARS (http://www.iasri.res.in/sscnars) are some other achievements, which have been strengthened during the period. And e-Granth provides digital access to library resources of 39 partner institutes; 27 new partners have been included.

Over 85 lakh pages have been scanned and are being uploaded to the repository, Krishikosh, at four digitization centres. Over 4,900 post-graduate theses from 36 agricultural universities have been processed and uploaded. Improved library services have been provided in 12 KOHA-LMS partner institutions. A

Success story

Management of change

The Agri-Tech Investors Meet organized in July 2013 in New Delhi was the first of its kind that brought inventors into direct contact with industry and investors. The investors meet was able to successfully commercialize 58 technologies, generate a license fee of ` 3.2 crore (` 2.28 crore from NAIP technologies and ` 0.9 crore from non-NAIP (ICAR technologies). The ten Business Planning and Development (BPD) units established under the project have generated total revenue of ` 14.6 crore through license fees from technology commercialization, training, consultancy assignments, membership fees, etc. Apart from technology commercialization, these units have played vital role in identifying and mobilizing agro-entrepreneurs and facilitating investments in agribusiness sector. Encouraged by the success, 12 more Business Planning and Development (BPD) units in different ICAR institutions have been established which will continue to be funded by the ICAR from Plan funds/other resources after the closure of NAIP.

total of 473,756 records have been added to the Agricat (Union Catalogue).

Establishment of a National Agricultural Bio-informatics Grid would provide scientists' access to high performance computing facilities for biotechnology-related research and of an online examination system would be for recruitment of agricultural scientists' across the country.

Advance price forecasts of 20 agriculture commodities provided by the network of 10 market-intelligence cells before the sowing of crops have been used by farmers in pre-sowing decision-making. More than 700 scientists have received international training in cutting-edge areas of agricultural sciences, and 82 national trainings, many involving international experts, have also been completed.

Research on production-to-consumption systems

Research aimed at harnessing innovations involving production, processing, value-addition, marketing, resource use, pilot-scale testing of developed technologies, income generation and employment is addressed by the NAIP under 51 value-chains on food and agricultural commodities, including processed foods and agro-industrial commodities. Broadly, six models of value-chains have been supported**: Model-1:** Producer technology ⇨ Farming ⇨ Post-harvest ⇨ Marketing, Export; **Model-2:** Pre-harvest technology ⇨ Post-harvest ⇨ Open market; **Model-3:** Farming ⇨ Post-harvest ⇨ Entrepreneurs/Self-Help Groups; **Model-4:** Post-harvest ⇨ Products/Processes ⇨ Enterprises; **Model-5:** Products/Processes ⇨ Organized Industry; **Model-6:** On-shelf technology ⇨ Post-harvest processes ⇨ Community marketing (Social mobilization/Community participation/ Sharing resources)

More than 29,100 farmers have been benefitted by market linkage under different interventions like export

of flowers and fruits, afforestation, meat production, fish production, development of value-added products. Fifty-one new rural industries were piloted by the consortia funded under the NAIP, including 43 consortia in public-private partnership mode. Salient achievements include establishment of a pilot plant for extraction of bioactive components of *Melia* and *Eupatorium* using green-extraction technology; the estimated cost (` 1.3 lakh/litre) and returns (` 1.7 lakh/litre) of the formulation produced indicate this to be an economically viable enterprise.

Biopesticides-based good agricultural practices modules were successfully demonstrated and tested for production of clean cabbage, cauliflower and peas in 18 on-farm trials/ demonstrations in Kangra, Kullu and Mandi districts of Himachal Pradesh. These practices have increased overall average returns of growers by Rs 5,903/ha. Field-level demonstrations in Vadapadur area of Gujarat on intercropping of cotton with ragi and radish resulted in its adoption by 148 farmers; including 48 farmers not supported under the sub-project. Adoption of clean-cotton picking practices reduced trash content, and with 2-3 protective irrigations, farmers received benefit of ` 24,700/ha.

A value-chain on industrial agroforestry in Tamil Nadu addressed constraints in paper and matchwood industrial raw material generation by designing model bi-partite, tri-partite and quad-partite contract farming systems involving farmers, research institutes, wood-based industries and financial institution as stakeholders. New industrial wood species for pulp, plywood and bioenergy were demonstrated; 7,500 hectares were brought under these species involving 2,378 farmers covering 30 districts of Tamil Nadu incorporating high-yielding pulpable clones of *Casuarina*, *Eucalyptus* and *Melia*.

In agro-processing value-chains, two rural feed-processing units were established at Mahabubnagar, Nellore, which produced complete feed, 50 tonnes/day, by utilizing locally available crop residues like sorghum-straw, maize-straw, groundnut-haulms and blackgram-straw. Scientifically managed pig farm and feed mill unit with a milling capacity of 8 q/hour has been developed. Regular disposal of slaughterhouse waste in aerobic-waste disposal pond maintained environmental safeguards in farm premises.

More than 200 millet-foods processing clusters were promoted across the country with technologies developed and adopted over the past two years; EATRITE branded products were commercialized through retail stores in Hyderabad, and their horizontal expansion has been initiated in Mumbai, Delhi and Pune. Sorghum-based products, including sorghum-fibre biscuits, 4 types of trans-free biscuits, sorghum crispies, and other value-added by-products like roasted flakes *pedha*, bran *pedha*, and bran soup have been developed and standardized. Sorghum-processing technologies were showcased through International Trade Fair, New Delhi, National Conference of KVK, Ludhiana, Industrial Exhibition, Hyderabad, and 48

Sustainable-use-based revival of endangered *Kadaknath* poultry

A notable achievement is the restoration/revival of endangered *Kadaknath* poultry. The poultry birds are now commercially viable in Dhar and Jhabua districts of Madhya Pradesh.

Initiating with just 10 *Kadaknath* poultry sheds under the project, a total of 133 poultry sheds are at present functioning in the area. *Kadaknath* growers are getting a profit of Rs 0.95 to 1.00 lakh/year/shed. Thus, an annual income of around Rs 107.10 lakh is being generated by *Kadaknath* farming in Jhabua. The additional income generated is promoting tribal-farmers for better education of children, renovation of old houses, creation of transportation facilities, and for better management of their social functions.

road shows in Hyderabad. Over 12,000 farmers, rural-women, entrepreneurs, and self-help groups were made aware of sorghum value-added foods and nutrition by aggressive campaigning through *choupal haats*.

A novel fruit-grader for grading cylindrical fruits like *ber*, and a custard-apple extraction machine have been designed and developed. The latter was commercially manufactured in Pune, and is presently commercially used by two more industries in Udaipur and Bengaluru.

For production of barley-milk based probiotic drink containing indigenously isolated and characterized probiotic strain *Lactobacillus plantarum* NCDC-344, technological process has been optimized. The beverage possesses anti-microbial activity, excellent anti-oxidative activity, and is a good source of dietary fibres. An entrepreneurship development programme with women self-help group resulted in the establishment of two processing units in Karnal (Haryana).

Research on sustainable rural livelihood security

About 143,000 farming families have been covered in poorer villages of 91 backward districts, sharpening poverty focus in the demonstrations. Adoption of a few high pay-off interventions is continuing in 28 on-going sub-projects.

Based on the adaptive on-farm technology assessment and refinement research carried out, 78 production models for crop, horticulture and livestock have been recommended for mainstreaming through state-extension system. All the consortia have set up sustainability funds, and a corpus of ` 6.2 crore has been collected; guidelines for operation and maintenance of sustainability fund have also been issued.

Promotion of high-value watermelon and crop diversification from paddy to turmeric and ginger in Kalahandi and Kandhamal districts has been successful. River-bank watermelon cultivation, an intervention with high impact, is covered on 28.8 hectares by 100% of 72 households contacted. Subsequently, impressed by the economic benefits, 78 households not related to the project have also adopted this technology.

Ten technical support centres have been created in

Dungarpur district, Rajasthan, to provide advisory services to farmers. The consortium demonstrated potential of hybrid maize in 6,187.4 hectares, covering 21,006 beneficiaries. Average yield obtained showed 97.6% increase in hybrids (3.42 tonnes/ha) as against an average yield of 1.73 tonnes/ha from traditional varieties; there was an additional economic benefit of ` 8.8 crore. Observing the success of the hybrid maize demonstration in Udaipur, Banswara, Dungarpur and Sirohi districts, the Rajasthan Government has launched a Golden Rays Programme, and provided hybrid-maize seeds to 8 lakh farmers.

Creation of agribusiness producer companies in Rajasthan, West Bengal and Madhya Pradesh has been encouraging; more such initiatives on market linkages were reported, which altogether benefitted over 8,100 farmers.

Significant adoption and diffusion has been reported of interventions involving low-cost bio-enhancer for higher productivity; innovative drip irrigation technique for vegetable cultivation; modified system of trench farming in cucurbits; maize variety “Pragati” - a boon to farmers in Sonbhadra; mustard horizontal spread in Sahibganj and Pakur; ornamental fish farming in Keonjhar; and organic farming in Waynad.

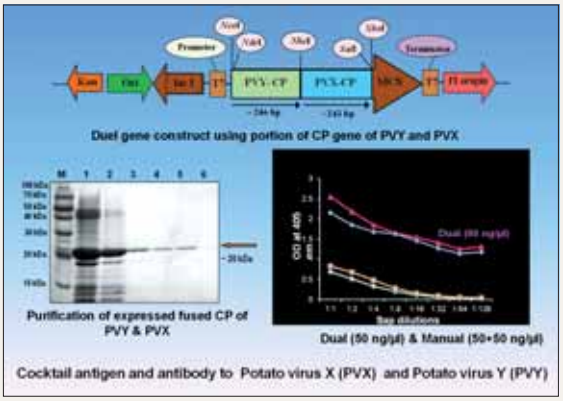
Sustainable land and environment management (SLEM)

The GEF-financed SLEM project is another component of PIU-NAIP, consisting of three sub-projects. It was scheduled to close on 31August 2013 but has been extended up to 30 June 2014 making it *co-terminus* with the NAIP. Among the successful practices supported, three activities are making visible impacts in their respective areas/states— (*i*) Land

Cocktail polyclonal antibodies against Potato virus Y and Potato virus X

Cocktail polyclonal antibodies (PAb) against two most important potato viruses - Potato virus Y and Potato virus X - have been generated, which were found to efficiently detect mixed infection of PVY and PVX in infected potato samples.

The Cocktail PAb showed better reaction compared to manual-mix of individual PVY and PVX PAbs when validated on potato plant samples.



shaping activities in West Bengal coastal zone, which reclaims land parcels in saline-affected areas, (*ii*) Activities in the livestock sector, including characterization of local breeds of goat, sheep, and their genetic upgradation, nutrition and control of common diseases in Adilabad and Udaipur districts, and (*iii*) Activities undertaken on Potential Fishing Zone (PFZ) forecasting and promoting M-Krishi® through mobile network in Maharashtra and Odisha. Successful restoration of red rice landraces from the long term (–20°C) storage vaults of the National Gene Bank to farmers' fields in Chamba district of Himachal Pradesh has been another milestone achieved under this component.

Basic and strategic research in the frontier areas of agricultural science

A total of 52 patent applications have been filed in India, including 15 published applications; also filed an international PCT application, and an Australian short patent has been granted; 246 research papers have been published, 149 in high impact journals with a NAAS rating of >6/10. More than 5.5 lakh molecular resources have been reported and documented at the GenBanks.

Twenty-four bench-scale technologies developed by the researchers have been commercialized in the recent Agri Tech Investors' Meet 2013. Scientific outputs and important developments include the following.

Conspicuous discoveries in molecular domain for abiotic stress tolerance in maize involve 'binding' and 'oxidation-reduction' related linkage (mapping) of genes induced under stress conditions in a waterlogging-tolerant genotype, and 'chloroplast', 'plastid' and 'transferase' gene-sets in a susceptible genotype. In rice, stunted expression in homozygous transgenic lines expressing abiotic stress responsive *OsFBK1* gene was reported to be tagged with *myc* gene; this expression could be reversed by silencing *OsFBK1* gene using RNAi approach. Ten differentially expressed proteins that may impart tolerance to salinity stress have been identified from *Bacillus pumilus* SB49 cultured on 20% saline medium. Inheritance factor for Endosulfan tolerance in *Trichogramma chilonis* strains was reported to be 'recessive' to 'semi-dominant' whereas tolerance for λ-cyhalothrin was found 'dominant' one.

Allelic variants of dominant blast resistance rice gene *Pi54* have been searched from 92 Indian landraces and cultivars using diagnostic blast fungal isolate Monwi-37'1. Allele- specific markers have been developed for marker-assisted blast resistance breeding Programme; 120 homozygous advanced backcross derived lines carrying genes *Pi54*, *Pi1*, *Pita*, *Pi9*, *Pi5*, *Pib*, *Piz5* and simultaneously having basmati- grain phenotype have been field evaluated in replicated trials.

A controller-based five-row seed-cum-fertilizer drill has been developed. With this, required quantity of seeds and fertilizers can be dropped by matching with the speed of the tractor, which is sensed by a proximity sensor, mounted on the front wheel of the tractor. Field validation of the drill along with software developed has been successfully done on soybean farms.

Micronutrient efficient and inefficient cultivars of rice, wheat, maize, pigeonpea and chickpea have been identified. The efficient cultivars can be grown in deficient soils without affecting yields. Micronutrient localization studies have showed deposition of Fe and Zn in epidermis of chickpea, and apical cortical regions of pigeonpea stems. In wheat, Zn concentration was more in aleurone layer and seed embryo. Mn application influences vessel size of vascular bundle, and thus enhances translocation to grains.

An integrated ICT model, involving toll-free Interactive Voice Response System (IVRS), Smart Phone Application and Web-based agri-advisory system, has been developed to address farmers' information needs on important aspects in a location-specific manner. The model is under field validation in Andhra Pradesh through Krishi Vigyan Kendras ANGRAU.

In-silico modeling of the leucine-rich repeat domain (LRR) of the TLR of farm animals and their docking with different ligands indicate potential of structural variations contributing to differences in the downstream cytokine levels across species and different breeds. A simple PCR- based DNA test has been developed for differentiating cattle and buffalo meat and milk.

Two herbal acaricides products developed for control of tick infestations in animals have been found 50-75% effective against resistant-tick lines; and 60-80% against lice, dog tick (*R. sanguineous*) and *Hyalomma anatolicum*. They were safe with no adverse reaction on animals (OECD guideline-410 followed), and were stable in storage for more than a year at room temperature.

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22. Science Resource Management

Agricultural Scientists' Recruitment Board, established in 1973 as an independent recruitment body for the ICAR, plays a key role in induction of best quality scientists and other senior management personnel in the Council. The Board aids and advises Council in evolving and implementing policies related to human resource development as well as Career Advancement Schemes for ARS Scientists.

The ASRB is consistently endeavouring to reform and refine talent-search strategies to meet existing as well as emerging needs of the national agricultural research system. Its main mandate is to make available the best human resource to man various positions in the ICAR and its institutes across the country.

NET and ARS examinations

For the first time, the NET Examination–2012 and ARS (Preliminary) Examination–2012 were conducted as separate and independent examinations on 24 February 2013 at 33 centers across the country as per the revised scheme and syllabi. For the NET examination–2012, a total of 29,011 candidates had applied while 16,790 had applied for ARS–2012 (Preliminary) Examination 22,537 and 11,472 candidates actually appeared in the NET and ARS (Preliminary) examinations respectively. Only a total of 1,845 candidates (8.19%) qualified in the NET, and in eight disciplines i.e. Agricultural Microbiology, Economic Botany and Plant Genetics Resources, Animal Biochemistry, Poultry Science, Agricultural Chemicals, Agricultural Business Management, Home Science and Agricultural Structures and Environmental Management – none could qualify.

The ARS (Preliminary) examination–2012 was for recruitment to fill 431 vacancies at the initial grade scientists in 36 disciplines. ARS Main examination – 2012 was conducted on 30 June, 2013 at 12 centres across the country. Out of 16,790 candidates, who applied for the ARS examination, only 2,476 passed in the examination, and 745 candidates obtained marks above the cut-off level to be called for the interview.

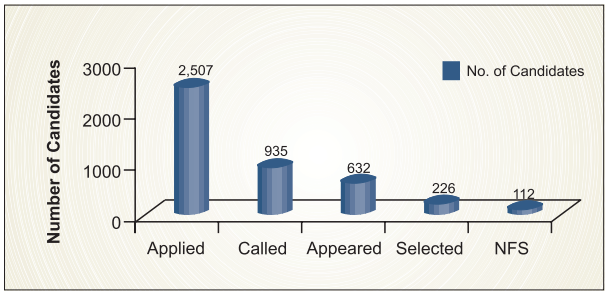
NET Examination of 2013 was conducted on 27 October 2013 in 55 revised disciplines at 33 centers across the country. Applications along with E-Payments for this were received through completely online system. A total of 24,770 candidates applied for the NET examination.

Discipline- wise break-up of NET candidates

Disciplines	Applied	Appeared	Qualified
Crop Science	12,154	9,215	1,209
Agricultural Engineering	1,991	1,623	41
Horticulture	2,421	1,955	106
Natural Resource Management	4,819	3,789	143
Animal Sciences	3,522	2,892	185
Fisheries	893	705	85
Social Sciences	3,211	2,358	76
Total	29,011	22,537	1,845

Direct recruitment

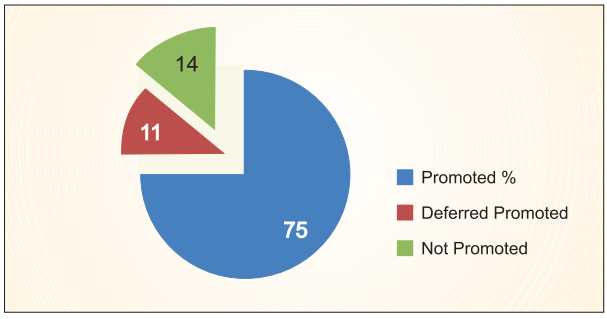
During the year, the Board completed the recruitment process for 338 posts. Of these, 11 were Research Management Positions, 32 were in the middle-level cadre (Project Coordinators, Joint Directors of other than national Institutes and Heads) and the remaining were for Principal Scientists and Senior Scientists. The Board made positive recommendations in 227 posts.



Details of direct selection posts

Assessment of scientists

Assessment/ Promotion of Senior Scientists under Revised Career Advancement Scheme: Consequent upon the adoption of Sixth Pay Commission UGC package for the ARS, the revised Career Advancement Scheme was promulgated by the Council from 1 January 2009. In terms of its time-bound



Assessment of Senior Scientists for promotion to principal scientists under the Career Advancement Scheme

implementation during the year, the Board considered more than 749 proposals in 57 disciplines for promotion from Senior Scientist (RGP ` 9,000) to Principal Scientist (RGP ` 10,000).

The performance for assessment promotion was quite satisfactory, as 86% (11% Deferred Promoted) of the candidates were recommended for promotion to the next higher grade. Of the successful candidates, 50% secured more than 80% marks and amongst the unsuccessful ones, only 7% secured less than 65% marks. This reflects on the positive strength of the ICAR research system.

New initiatives

Online system for NET/ARS Preliminary examination in ASRB, ICAR: Computers, servers, UPS and software were procured and delivered by the outsourced agency at the Data Centre (DC), Data Recovery (DR) Centre and at 23 online examination centres across India. These equipments have been installed at DR, DC and 15 centres. Software modules for question bank, test display, online registration and generating admit cards have been finalized. For the first time in the ASRB, online applications were successfully invited from the candidates for NET-2013. ❑

APPENDIX I

(A) SUBJECT ALLOCATED TO DEPARTMENT OF AGRICULTUREAL RESEARCH AND EDUCATION

Part I

The following are subjects which fall within list I of the Seventh Schedule of the Constitution of India.

1. International co-operation in the field of agricultural research and education including relations with foreign and international agricultural research and education institutions and organizations
2. Fundamental, applied and operational research and higher education including co-ordination of such research and higher education in agriculture, agroforestry, animal husbandry, dairying, fisheries, agricultural engineering and horticulture, including agricultural statistics, economics and marketing
3. Co-ordination and determination of standards in institutions for higher education or for research and scientific and technical institutions in so far as they relate to food and agriculture including animal husbandry, dairying and fisheries, Development of Human Resources in agricultural research /extension and education
4. Cesses for financing to the Indian Council of Agricultural Research and the commodity research programmes other than those relating to tea, coffee and rubber
5. Sugarcane research

Part II

For Union Territories the subjects mentioned in Part I above so far as they exist in regard to these territories and in addition the following subject which falls within list II of the Seventh Schedule to the Constitution of India.

6. Agricultural Education and Research

Part III

General and consequential:

7. Plant, animal and fish introduction and exploration
8. All- India Soil and Land-Use Survey relating to research, training, co-relation, classification, soil mapping and interpretation
9. Financial assistance to state governments and agricultural universities in respect of agricultural research and educational schemes and programmes
10. National Demonstrations
11. Indian Council of Agricultural Research and its constituent institutes, National Research Centres, Project Directorates, Bureaux and All-India Coordinated Projects
12. Research and Development on production and improvement of bio-fuels plants

APPENDIX II

TOTAL NUMBER OF POSTS AND NAMES OF IMPORTANT FUNCTIONARIES

Group	Designation	Sanctioned strength
A	Secretary, DARE and DG, ICAR	1
A	Additional Secretary, DARE and Secretary, ICAR	1
A	Additional Secretary and Financial Adviser	1
A	Director	1
A	Deputy Secretary	1
A	Senior Principal Private Secretary / Principal Staff Officer	1
A	Joint Director	1
A	Under Secretary	7
A	Principal Private Secretary	3
B	Assistant Director (OL)	1
B	Private Secretary	3
B	Section Officer	4
B	Assistant	4
B	Personal Assistant / Steno Grade “C”	3
C	Junior Hindi Translator	1
C	UDC-cum-Cashier	1
C	UDC	2
C	Stenographer Grade “D”	3
C	UDC-Hindi Typist	1
C	Staff Car Driver	1
C	LDC	2
D	Daftry	1
D	Peon	5
	Total	49

NAMES OF THE IMPORTANT FUNCTIONARIES

Sl.No.	Name	Designations
1.	Dr S. Ayyappan	Secretary, DARE & Director General, ICAR
2.	Shri Arvind R. Kaushal	Additional Secretary, DARE & Secretary (ICAR)
3.	Shri P.K. Pujari	Additional Secretary & Financial Adviser (DARE/ICAR)
4.	Shri Rajesh Ranjan	Director, DARE
5.	Smt. Nirnanjan Kaur	Deputy Secretary
6.	Shri Mohinder Kumar	Sr. PPS
7.	Shri R.C. Yadav	Under Secretary
8.	Smt. Alka Ahuja	Under Secretary
9.	Shri Harihar Mishra	Under Secretary
10.	Shri Irsad Alam	Under Secretary
11.	Shri V.K. Singh	Under Secretary
12.	Shri Vijay Singh	Under Secretary
13.	Ssmt. Rekha Anand	Under Secretary
14.	Shri A.K. Bhardwaj	Principal Private Secretary
15.	Shri V. Kurien John	Principal Private Secretary
16.	Dr Puran Singh	Assistant Director (OL)

APPENDIX III

ACTIVITY PROGRAMME CLASSIFICATION

The Budget Estimates (BE) of DARE (Plan, Non-Plan) for 2012–2013 is Rs 15500.00 crores and Rs 1965.00 respectively and Revised Estimates (RE) of DARE (Plan, Non-Plan) for 2012-13 is Rs 4724.00 and Rs. 40,412.00 respectively. The BE for 2013–14 (Pan, and Non-Plan) is Rs. 5214.30 crore and Rs. 40453.00. The detailed break-up these financial figures are given below in Tables 1.

Department of Agricultural Research and Education (DARE): The details in respect of BE and RE for 2012–2013 and BE for 2012–2013 are given in Table 1. This excludes the payment to the ICAR.

Table 1. Budget estimates and revised estimates of DARE

(Rupees in lakh)

Item		Budget Estimates 2012–2013		Revised Estimates 2012–2013		Budget Estimates 2013–2014	
		Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
Major Head '3451'							
090	Secretary	–	382.00	–	377.00	–	490.00
Major Head '2415'							
80	-General International Co-operation						
(010032)	-India's membership contribution to Commonwealth Agricultural Bureau International (CABI)	–	35.25	–	35.25	–	35.25
(020032)	-India's membership contribution to Consultative Group on International Agricultural Research	–	1500.00	–	400.00	–	400.00
03	-Other programmes						
(030012)	-Foreign Travel expenses	80.00	–	35.00	–	–	–
(030020)	-Other Administrative expenses	20.00	–	15.00	–	–	–
(040032)	-India's contribution to Asia Pacific Association of Agricultural Institutions		5.25	–	5.25	–	5.25
(050032)	-India's contribution to NACA		31.00	–	31.00	–	31.00
(060032)	-India's contribution to CGPRT		8.00	–	8.00	–	8.00
(070032)	-India's contribution to Seed Testing Associations		3.25	–	3.25	–	3.25
(080032)	-ISHS Belgium		0.25	–	0.25	–	0.25
Major head "2415"							
02	Grant-in-Aid Central Agricultural University Bundelkhand						
120	Assistance to other institutions						
(020031)	-Grants-in-Aids-General	200.00	–	5.00	–	200.00	–
(020035)	-Grants for creation of Capital assets	1600.00	–	90.00	–	4600.00	–
(020036)	-Grants-in Aid Salaries	200.00	–	4.00	–	200.00	–
(03)	-Grants-in-Aids to Central Agricultural University, Bihar						
(030031)	-Grants-in-Aids-General	100.00	–	0.33	–	900.00	–
(030035)	-Grant for creation of Capital Assets	100.00	–	0.33	–	900.00	–
(030036)	-Grants-in-Salaries	800.00		0.34	–	1200.00	–
Major Head '2552' North Eastern Areas							
259	-General (Agri.Res.& Edn. Schemes)						
(01)	-Grants-in-Aids to Central Agricultural University, Imphal						
010031	-Grants-in-Aids-General CAU, Imphal	2075.00	–	1356.00	–	1089.90	–
010035	-Grants-in-Aids-Capital CAU, Imphal	2965.00	–	2490.00	–	3760.80	–
010036	Grants in Aid Salaries	5460.00	–	4653.00	–	5049.30	–
02	Grant-in-Aid Central Agricultural University, Barapani						
020031	Grants in Aid General	200.00	–	0.33	–	20.00	–
020035	Grant for creation of Capital Assets	1000.00	–	0.33	–	60.00	–
020036	Grants in Aid Salaries	800.00	–	0.34	–	20.00	–
	Total	**15600.00**	**1965.00**	**8650.00**	**860.00**	**18000.00**	**973.00**

Table 2. Details of financial outlay
Demand No. 2 Department of Agricultural Research and Education

The gross provision for Demand No. 2 - DARE, excluding recoveries, is as under: *(Rupees In crore)*

Particulars	Actuals 2011-12			Budget 2012-2013			Revised 2012-2013			Budget 2013-2014		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
Revenue	2581.51	2156.34	4737.85	3220.00	2172.00	5392.00	2520.00	2100.00	4620.00	3415.00	2314.17	5729.17
Capital	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Total	**2581.51**	**2156.34**	**4737.85**	**3220.00**	**2172.00**	**5392.00**	**2520.00**	**2100.00**	**4620.00**	**3415.00**	**2314.17**	**5729.17**

Recoveries *(In crores of Rupees)*

Particulars	Actuals 2011-12			Budget 2012-2013			Revised 2012-2013			Budget 2013-2014		
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
Less Amount met from Social and Infrastructure Development Fund	-8.54	0.00	-8.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**-8.54**	**0.00**	**-8.54**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

The Budget allocations, net of recoveries, are as under: *(In crores of Rupees)*

Sl. No.	Group/Sub Group/Sub Sub Group/ Scheme/Sub Scheme/Programme/ Sub Programme	Major Head	Actuals 2011-2012			Budget 2012-2013			Revised 2012-2013			Budget 2013-2014		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
	Revenue		2572.97	2156.34	4729.31	3220.00	2172.00	5392.00	2520.00	2100.00	4620.00	3415.00	2314.17	5729.17
	Capital		*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
	Total		**2572.97**	**2156.34**	**4729.31**	**3220.00**	**2172.00**	**5392.00**	**2520.00**	**2100.00**	**4620.00**	**3415.00**	**2314.17**	**5729.17**
1.	Secretariat - Economic Service	3451	0.00	3.42	3.42	0.00	3.82	3.82	0.00	3.77	3.77	0.00	4.90	4.90
	Agricultural Research and Education													
	Payments to Indian Council of Agricultural Research (ICAR)													
2.	*Crop Husbandry*													
2.01	Payments of net proceeds of cess under Agricultural Produce Cess Act, 1940	2415	0.00	0.47	0.47	0.00	1.50	1.50	0.00	0.50	0.50	0.00	0.25	0.25
2.02	Other Programmes of Crop Husbandry													
2.02.01	Crop Science	2415	392.77	589.16	981.93	448.00	629.68	1077.68	401.00	621.87	1022.87	453.00	694.79	1147.79
2.02.02	Horticulture	2415	191.20	240.23	431.43	226.00	257.23	483.23	135.00	242.33	377.33	186.00	269.91	455.91
2.02.03	Agricultural Extension	2415	510.57	2.98	513.55	449.00	3.67	452.67	409.60	3.90	413.50	462.00	4.05	466.05
2.02.04	Agricultural Education													
2.02.04.01	Agricultural Education	2415	566.54	192.09	758.63	563.00	57.56	620.56	531.00	46.54	577.54	455.00	55.39	510.39
2.02.04.02	*Less Amount met from Social and Infrastructure Development Fund*	2415	*-8.54*	*0.00*	*-8.54*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
2.02.05	Economic Statistics and Management	2415	3.00	31.46	34.46	5.00	36.97	41.97	3.50	32.87	36.37	10.00	38.02	48.02

(Table 2 continued) *(Rupees In crore)*

Sl. No.	Group/Sub Group/Sub Sub Group/ Scheme/Sub Scheme/Programme/ Sub Programme	Major Head	Actuals 2011-2012			Budget 2012-2013			Revised 2012-2013			Budget 2013-2014		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
2.02.06	Agricultural Engineering	2415	69.56	72.14	141.70	75.00	82.97	157.97	49.00	79.50	128.50	72.00	92.24	164.24
2.02.07	ICAR Hqr. Admn. including Agricultural Scientists Recruitment Board, Directorate of Information & Publication in Agriculture and Intellectual Property Rights Management	2415	121.33	135.03	256.36	200.00	140.21	340.21	96.00	141.94	237.94	395.00	121.31	516.31
2.02.08	National Fund for Basic, Strategic and Frontier Application Research in Agriculture	2415	38.00	0.00	38.00	80.00	0.00	80.00	55.00	0.00	55.00	75.00	0.00	75.00
2.02.09	National Agricultural Innovation Project/Externally Aided Project	2415	176.00	0.00	176.00	121.00	0.00	121.00	133.00	0.00	133.00	385.00	0.00	385.00
	Total-Other Programmes of Crop Husbandry		**2060.43**	**1263.09**	**3323.52**	**2167.00**	**1208.29**	**3375.29**	**1813.10**	**1168.95**	**2982.05**	**2493.00**	**1275.71**	**3768.71**
	Total-Crop Husbandry		***2060.43***	***1263.56***	***3323.99***	***2167.00***	***1209.79***	***3376.79***	***1813.10***	***1169.45***	***2982.55***	***2493.00***	***1275.96***	***3768.96***
3.	*Soil and Water Conservation*													
3.01	Soil and Water Conservation Research Institute	2415	6.00	31.25	37.25	7.00	34.32	41.32	3.00	32.54	35.54	0.00	0.00	0.00
3.02	Other Natural Resource Management Institutes including Agro-Forestry Research	2415	228.09	257.39	485.48	225.00	275.26	500.26	161.00	256.77	417.77	175.00	324.54	499.54
3.03	Climate Resilient Agriculture Initiative	2415	132.00	0.00	132.00	100.00	0.00	100.00	68.00	0.00	68.00	80.00	0.00	80.00
	Total-Soil and Water Conservation		***366.09***	***288.64***	***654.73***	***332.00***	***309.58***	***641.58***	***232.00***	***289.31***	***521.31***	***255.00***	***324.54***	***579.54***
4.	*Animal Husbandry*	2415	201.53	390.07	591.60	230.00	416.36	646.36	179.00	414.65	593.65	205.00	465.60	670.60
5.	*Fisheries*	2415	94.00	206.42	300.42	98.00	216.62	314.62	65.00	217.99	282.99	80.00	238.34	318.34
6.	*National Institute for Biotic Stress Management*	2415	0.01	0.00	0.01	20.00	0.00	20.00	1.00	0.00	1.00	0.00	0.00	0.00
7.	*Indian Institute of Agricultural Biotechnology*	2415	0.01	0.00	0.014	20.00	0.00	20.00	2.00	0.00	2.00	0.00	0.00	0.00
	Total-Payments to Indian Council of Agricultural Research (ICAR)		***2722.07***	***2148.69***	***4870.76***	***2867.00***	***2152.35***	***5019.365***	***2292.10***	***2091.40***	***4383.50***	***3033.00***	***2304.44***	***5337.44***
8.	Contributions to Commonwealth Agricultural Bureau, Consultative Group on International Agricultural Research and Association of Asia Pacific Agricultural Research Institutions	2415	100.98	4.23	105.21	1.00	15.83	16.83	0.50	4.83	5.33	0.00	4.83	4.83

(Table 2 concluded)

(Rupees In crore)

Sl. No.	Group/Sub Group/Sub Sub Group/ Scheme/Sub Scheme/Programme/ Sub Programme	Major Head	Actuals 2011-2012			Budget 2012-2013			Revised 2012-2013			Budget 2013-2014		
			Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
9.	Central Agricultural University, Bundelkhand	2415	0.00	0.00	0.00	20.00	0.00	20.00	0.99	0.00	0.99	50.00	0.00	50.00
10.	Central Agricultural University, Bihar	2415	0.00	0.00	0.00	10.00	0.00	10.00	0.01	0.00	0.01	30.00	0.00	30.00
11.	Lumpsum provision for projects/ schemes for the benefit of North Eastern Region and Sikkim	2552	0.00	0.00	0.00	322.00	0.00	322.00	226.40	0.00	226.40	302.00	0.00	302.00
	Total-Agricultural Research and Education		**2823.05**	**2152.92**	**4975.97**	**3220.00**	**2168.18**	**5388.18**	**2520.00**	**2096.23**	**4616.23**	**3415.00**	**2309.27**	**5724.27**
12.	Actual Recoveries	2415	-250.08	0.00	-250.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Grand Total		**2572.97**	**2156.34**	**4729.31**	**3220.00**	**2172.00**	**5392.00**	**2520.00**	**2100.00**	**4620.00**	**3415.00**	**2314.17**	**5729.17**

Major Head-wise Totals		Actuals 2011-2012			Budget 2012-2013			Revised 2012-2013			Budget 2013-2014		
		Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total
	2415.00	2572.97	2152.92	4725.89	2898.00	2168.18	5066.18	2293.60	2096.23	4389.83	3113.00	2309.27	5422.27
	2552.00	0.00	0.00	0.00	322.00	0.00	322.00	226.40	0.00	226.40	302.00	0.00	302.00
	3451.00	0.00	3.42	3.42	0.00	3.82	3.82	0.00	3.77	3.77	0.00	4.90	4.90
Total		**2572.97**	**2156.34**	**4729.31**	**3220.00**	**2172.00**	**5392.00**	**2520.00**	**2100.00**	**4620.00**	**3415.00**	**2314.17**	**5729.17**

(B) INDIAN COUNCIL OF AGRICULTURAL RESEARCH

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

The Society shall have the following *Ex-Officio* Members:

i) *Minister-in-charge of the portfolio of Agriculture in the Union Cabinet- President of the Society*

1. Shri Sharad Pawar,
   Union Minister of Agriculture and Food Processing Industries,
   Government of India
   Krishi Bhavan,
   New Delhi-110 001

ii) *Minister of State in the Union Ministry of Agriculture dealing with the ICAR-Vice-President*

2. Shri Tariq Anwar
   Union Minister of State for Agriculture & Food Processing Industries,
   Krishi Bhavan,
   New Delhi-110 001

iii) *Union Ministers holding charge of Finance, Planning, Science & Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry/Department concerned)*

3. Shri P. Chidambaram
   Union Minister of Finance
   Government of India
   North Block,
   New Delhi 110 001
4. Shri Rajeev Shukla
   Union Minister of State for Planning
   Government of India,
   Yojna Bhawan,
   New Delhi-110 001
5. Shri Jaipal Sudini Reddy
   Union Minister for Science & Technology
   Government of India,
   CSIR Building, 2 Rafi Marg,
   New Delhi-110 001
6. Dr. M. Mangapati Pallam Raju
   Union Minister of Human Resource Development,
   Government of India
   Shastri Bhavan,
   New Delhi-110 001
7. Shri Anand Sharma,
   Union Minister of Commerce & Industry,
   Government of India,
   Udyog Bhavan,
   New Delhi-110 001

iv) *Other Ministers in the Union Ministry of Agriculture*

8. Dr Charan Das Mahant
   Union Minister of State for Agriculture & Food Processing Industries
   Krishi Bhawan
   New Delhi-110 001

v) *Ministers in the States in-charge of Agriculture/Horticulture/ Animal Husbandry / Fisheries*

ANDHRA PRADESH

9. Shri K.L. Narayana
   Minister for Agriculture,
   Government of Andhra Pradesh,
   A.P. Secretariat
   Hyderabad (Andhra Pradesh) 500 022
10. Shri Ramreddy Venkata Reddy
    Minister for Horticulture,
    Government of Andhra Pradesh,
    A.P. Secretariat
    Hyderabad (Andhra Pradesh) 500 022
11. Shri Viswarupu P
    Minister for Animal Husbandry and Fisheries,
    A.P. Secretariat
    Government of Andhra Pradesh,
    Hyderabad (Andhra Pradesh) 500 022

ARUNACHAL PRADESH

12. Shri Setong Sena
    Minister for Agriculture, Horticulture and Animal Husbandry
    Government of Arunachal Pradesh
    CM Secretariat,
    Itanagar (Arunachal Pradesh) 791 111
13. Shri Rajesh Tacho
    Minister for Fisheries
    Government of Arunachal Pradesh
    State Secretariat Complex,
    Itanagar (Arunachal Pradesh) 791 111

ASOM

14. Shri Nilomani Sen Deka
    Minister for Agriculture & Horticulture
    Government of Asom,
    Janta Bhavan,
    Dispur, Guwahati (Asom) 781 006
15. Shri Khorsingh Engti
    Minister for Animal Husbandry
    Government of Asom,
    Janta Bhavan, Dispur,
    Guwahati (Asom) 781 006
16. Shri Basanta Das
    Minister for Fisheries,
    Government of Asom,
    Janta Bhavan, Dispur,
    Guwahati (Asom) 781 006

BIHAR

17. Shri Narendra Singh
    Minister for Agriculture
    Government of Bihar,
    Vikas Bhavan, New Secretariat,
    Bailey Road,
    Patna (Bihar) 800 015
18. Shri Giriraj Singh
    Minister for Animal Husbandry & Fisheries Resources,
    Government of Bihar,
    Vikas Bhavan, New Secretariat,
    Bailey Road,
    Patna (Bihar) 800 015

CHHATISGARH

19. Shri Chandrashekhar Sahu
    Minister for Agriculture, Fisheries & Animal Husbandry
    Government of Chhattisgarh,
    Sachivalaya,
    Raipur (Chhattisgarh)

DELHI

20. Shri Raj Kumar Chauhan
Minister for Power, Development and Food & Civil Supplies
National Capital Territory of Delhi,
Delhi Secretariat, I.P. Estate,
New Delhi 110 002

GOA

21. Shri Manohar Parrikar
Chief Minister (holding the Charge of Agriculture, Horticulture & AH)
Government of Goa, Secretariat,
Panaji (Goa) 403 001
22. Shri Avertano Furtado
Minister for Fisheries
Government of Goa, Secretariat,
Panaji (Goa) 403 001

GUJARAT

23. Shri Babubhai Bokhiria
Minister for Agriculture, Fisheries & Animal Husbandry
Government of Gujarat, Sachivalaya,
Gandhinagar (Gujarat)-382 010

HARYANA

24. Shri Paramvir Singh
Minister for Agriculture, Fisheries and AH
Government of Haryana,
Haryana Civil Secretariat,
Chandigarh (Haryana)

HIMACHAL PRADESH

25. Shri Virbhadra Singh
Chief Minister (holding the Charge of Animal Husbandry)
Government of Himachal Pradesh,
Himachal Pradesh Secretariat,
Shimla (Himachal Pradesh) 171 002
26. Shri Sujan Singh Pathania
Minister for Agriculture,
Government of Himachal Pradesh,
Himachal Pradesh Secretariat,
Shimla (Himachal Pradesh) 171 002
27. Smt. Vidya Stokes
Minister for Horticulture,
Government of Himachal Pradesh,
Himachal Pradesh Secretariat,
Shimla (Himachal Pradesh) 171 002
28. Shri Thakur Singh Bharmouri
Minister for Fisheries
Government of Himachal Pradesh,
Himachal Pradesh Secretariat,
Shimla (Himachal Pradesh) 171 002

JAMMU and KASHMIR

29. Shri Ghulam Hassan Mir
Minister for Agriculture Production
Government of Jammu & Kashmir,
Civil Secretariat,
Jammu (Jammu & Kashmir) 180 001
30. Shri Raman Bhalla
Minister for Horticulture,
Government of Jammu & Kashmir,
Civil Secretariat,
Jammu (Jammu & Kashmir) 180 001
31. Shri Nazir Ahmad Khan
Minister of State for Animal Husbandry,
Government of Jammu & Kashmir,
Civil Secretariat,
Jammu (Jammu & Kashmir) 180 001
32. Shri M.L. Sharma
Minister of State for Fisheries
Government of Jammu & Kashmir,
Civil Secretariat,
Jammu (Jammu & Kashmir) 180 001

JHARKHAND

33. Shri. Yogendra Sav
Minister for Agriculture
Government of Jharkhand,
Project Building HEC, Dhurva,
Ranchi (Jharkhand) 834 002
34. Shri. Mannan Mallick
Minister for Animal Husbandry & Fisheries
Government of Jharkhand,
Project Building HEC, Dhurva,
Ranchi (Jharkhand) 834 002

KARNATAKA

35. Shri Krishna Byre Gowda
Minister of State for Agriculture
Government of Karnataka,
Vidhan Soudha,
Bengaluru (Karnataka) 560 001
36. Shri S. Shivashankarappa
Minister for Horticulture
Government of Karnataka,
Vidhan Soudha,
Bengaluru (Karnataka) 560 001
37. Shri T.B. Jayachandra
Minister for Animal Husbandry & Fisheries Department
Government of Karnataka,
Vidhan Soudha,
Bengaluru (Karnataka) 560 001
38. Shri K. Abhay Chandra Jain
Minister of State for Fisheries
Government of Karnataka
Vidhan Soudha
Bengaluru (Karnataka) 560 001

KERALA

39. Shri K.P. Mohanan
Minister for Agriculture & Animal Husbandry
Government of Kerala
Secretariat Annexe
Thiruvananthapuram (Kerala) 695 001
40. Shri K. Babu
Minister for Fisheries,
Government of Kerala
North Block, Secretariat
Thiruvananthapuram (Kerala) 695 001

MADHYA PRADESH

41. Dr Ramkrishna Kusmariya
Minister for Agriculture Development,
Government of Madhya Pradesh,
Vallabh Bhavan, Bhopal (M.P.) 423 006
42. Shri Kailash Vijayvargiya
Minister for Horticulture,
Government of Madhya Pradesh,
Vallabh Bhavan, Bhopal (M.P.) 423 006
43. Shri Ajay Vishnoi
Minister for Animal Husbandry & Fisheries
Government of Madhya Pradesh,
Vallabh Bhavan, Bhopal (M.P.) 423 006

MAHARASHTRA

44. Shri Radhakrishna Eknathrao Vikhe Patil
Minister for Agriculture,
Government of Maharashtra,
Mantralaya,
Mumbai (Maharashtra) 400 032

45. Shri Madhukarrao Devrao Chavan
Minister for Animal Husbandry & Fisheries,
Government of Maharashtra,
Mantralaya,
Mumbai (Maharashtra) 400 032
46. Dr Vijaykumar Krishnarao Gavit
Minister for Horticulture
Government of Maharashtra,
Mantralaya,
Mumbai (Maharashtra) 400 032

MANIPUR

47. Shri Gaikhangam
Dy Chief Minister (holding charge of Horticulture),
Government of Manipur
Secretariat, Imphal (Manipur) 795 001
48. Shri Mohammed Abdul Nasir
Minister for Agriculture & Fisheries
Government of Manipur,
Secretariat, Imphal (Manipur) 795 001
49. Shri Govindas Konthoujam
Minister for Animal Husbandry
Government of Manipur,
Secretariat, Imphal (Manipur) 795 001

MEGHALAYA

50. Dr Mukul Sangma
Chief Minister (holding the Charge of Agriculture,
Horticulture and Fisheries)
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong (Meghalaya) 793 001
51. Smt. Deborah C Marak
Minister for Animal Husbandry
Government of Meghalaya,
Meghalaya Secretariat (C),
Shillong (Meghalaya) 793 001

MIZORAM

52. Shri H. Liansailova
Minister for Agriculture and Horticulture
Government of Mizoram,
Aizwal (Mizoram) 796 001
53. Shri N.K. Chakma
Minister of State for Animal Husbandry
Government of Mizoram,
Aizwal (Mizoram) 796 001
54. Shri R. Lalzirliana
Minister for Fisheries
Government of Mizoram,
Aizwal (Mizoram) 796 001

NAGALAND

55. Dr Benjongliba
Minister of State for Agriculture
Government of Nagaland,
Civil Secretariat Complex
Kohima (Nagaland) 797 004
56. Shri Neiba Kronu
Minister of State for Horticulture
Government of Nagaland,
Civil Secretariat Complex
Kohima (Nagaland) 797 004
57. Shri Yitachu
Minister of State for Animal Husbandry,
Government of Nagaland,
Civil Secretariat Complex
Kohima (Nagaland) 797 004
58. Shri Shetoyi
Minister of State for Fisheries
Government of Nagaland
Civil Secretarial Complex
Kohima (Nagaland) 797 004

ODISHA

59. Shri Debi Prasad Mishra
Minister for Agriculture, Fisheries & Animal Resource
Development,
Government of Odisha,
Orissa Secretariat,
Bhubaneswar (Odisha)-751 001

PUNJAB

60. Shri Prakash Singh Badal
Chief Minister holding the charge of Agriculture &
Horticulture
Government of Punjab,
Punjab Civil Secretariat,
Chandigarh (Punjab)
61. Shri Sarwan Singh Phillaur
Minister for AH & Fisheries
Government of Punjab,
Punjab Civil Secretariat,
Chandigarh (Punjab)

PUDUCHERRY

62. Shri M. Chandrakasu
Minister for Agriculture, Horticulture &
Animal Husbandry
Government of Puducherry,
Puducherry-605 001
63. Shri N.G. Pannirselvam
Minister for Fisheries
Government of Puducherry
Puducherry-605 001

RAJASTHAN

64. Shri Harji Ram Burdak
Minister for Agriculture, Horticulture
Animal Husbandry & Fisheries
Government of Rajasthan,
Rajasthan Secretariat,
Jaipur (Rajasthan)-302 005

SIKKIM

65. Shri Dawa Norbu Takarpa,
Minister for Agriculture Development & Horticulture,
Government of Sikkim,
Secretariat,
Gangtok (Sikkim)-737 101
66. Shri Dawcho Lepcha,
Minister for AH & Fisheries
Government of Sikkim,
Secretariat,
Gangtok (Sikkim)-737 101

TAMIL NADU

67. Shri S Damodaran
Minister for Agriculture & Horticulture
Government of Tamil Nadu,
Chennai (Tamil Nadu)-600 009
68. Shri K.A Jayapal,
Minister for Fisheries,
Government of Tamil Nadu,
Chennai (Tamil Nadu)-600 009
69. Shri T.K.M Chinnayya
Minister for Animal Husbandry,
Government of Tamil Nadu,
Chennai (Tamil Nadu)-600 009

TRIPURA

70. Shri Aghore Debbarma
Minister for Agriculture,
Horticulture & Animal Resource Development,
Government of Tripura,
Civil Secretariat, Agartala (Tripura)-799 001

71. Shri Khagendra Jamatia,
Minister for Fisheries,
Government of Tripura,
Civil Secretariat,
Agartala (Tripura)-799 001

UTTARAKHAND

72. Shri Harak Singh Rawat
Minister for Agriculture
Government of Uttarakhand,
Dehra Dun (Uttarakhand)
73. Smt Amrita Rawat
Minister for Horticulture
Government of Uttarakhand,
Dehra Dun (Uttarakhand)
74. Shri Pritam Singh Panwar
Minister for AH & Fisheries
Government of Uttarakhand,
Dehra Dun (Uttarakhand)

UTTAR PRADESH

75. Shri Anand Singh
Minister for Agriculture,
Government of Uttar Pradesh,
UP Civil Secretariat,
Lucknow (Uttar Pradesh)
76. Shri Paras Nath Yadav
Minister of State for Animal Husbandry,
Government of Uttar Pradesh,
Sachivalaya Annexe,
Vidhan Sabha Marg,
Lucknow (Uttar Pradesh)
77. Shri Akhilesh Yadav
Chief Minister (holding the Charge of Fisheries)
Government of Uttar Pradesh,
Sachivalaya Annexe, Vidhan Sabha Marg,
Lucknow (Uttar Pradesh)
78. Shri Rajkishore Singh
Minister for Horticulture,
Government of Uttar Pradesh,
Sachivalaya Annexe,
Vidhan Sabha Marg,
Lucknow (Uttar Pradesh)

WEST BENGAL

79. Shri Moloy Ghatak
Minister for Agriculture,
Government of West Bengal,
Writers' Building,
Kolkata (West Bengal) 700 001
80. Shri Nure Alam Chowdhury,
Minister for Animal Resources
Development Department,
Government of West Bengal,
Writers' Building,
Kolkata (West Bengal) 700 001
81. Shri Chandra Nath Sinha
Minister for Fisheries Development Department
Government of West Bengal
Kolkata (West Bengal) 700 001
82. Shri Subrata Saha
Minister for Horticulture & Fisheries,
Government of West Bengal,
Writers Building,
Kolkata (West Bengal) 700 001

vi) *Member, Planning Commission, In-charge of Agriculture*

83. Prof. Abhijit Sen
Member (Agriculture)
Planning Commission,
Yojana Bhawan, New Delhi-110 001

vii) *Six members of Parliament—four elected by Lok Sabha and two elected by Rajya Sabha*

84. Smt. Renuka Chowdhury 02.04.2018
Member of Parliament (Rajya Sabha),
H.No.8-1-116, Khanapuram(V)
Khammam Urban(M), Khammam District,
(Andhra Pradesh)-507 002
Smt. Renuka Chowdhury
Member of Parliament (Rajya Sabha),
76, Lodhi Estate,
New Delhi-110 003
85. VACANT
86. Shri Thangso Baite Till the expiry
Member of Parliament (Lok Sabha), of term in
88, Super Market, Lok Sabha
Lamphel, Imphal (Manipur)-795 004
Shri Thangso Baite
Member of Parliament (Lok Sabha),
14 North Avenue
New Delhi-110 001
87. Shri K. Jaya Surya Prakash Reddy -do-
Member of Parliament (Lok Sabha),
Vill. Laddagiri, Taluka Kodumur,
District- Kurnool
Hyderabad, Andhra Pradesh-500 034
Shri K. Jaya Surya Prakash Reddy
Member of Parliament (Lok Sabha),
16, Talkatora Road, New Delhi-110 001
88. Shri Jayant Chaudhary -do-
Member of Parliament (Lok Sabha)
20- Vishawa Laxmi Nagar
Near Goverdhan Chauraha
Mathura, Uttar Pradesh
Shri Jayant Chaudhary
Member of Parliament (Lok Sabha)
12, Tughlak Road, New Delhi-110 011
89. Shri Ramashankar Rajbhar, -do-
Member of Parliament (Lok Sabha)
185, North Avenue, New Delhi-110 001
Shri Ramashankar Rajbhar,
Member of Parliament (Lok Sabha)
Vill.-Shivpur, PO-Laxmipur via Rudrapur
District-Deoria (Uttar Pradesh)-274 001

viii) *Director-General, Indian Council of Agricultural Research.*

90. Dr. S. Ayyappan Ex-officio
Director-General,
ICAR, Krishi Bhavan, New Delhi-110 001

ix) *All Secretaries in the Ministry of Agriculture*

91. Shri Ashish Bahuguna Ex-officio
Secretary (Agriculture and Cooperation)
Department of Agriculture and Cooperation
Krishi Bhavan, New Delhi-110 001
92. Shri A.K. Thakur Ex-officio
Secretary (ADF)
Department of Animal Husbandry,
Dairying & Fisheries,
Krishi Bhavan, New Delhi-110 001

x) *Secretary, Planning Commission*

93. Ms. Sindhushree Khullar Ex-officio
Secretary, Planning Commission
Yojana Bhavan, Sansad Marg,
New Delhi-110 001

xi) *Secretary, Department of Bio-Technology*

94. Prof. K. Vijay Raghavan Ex-officio
Secretary,
Department of Biotechnology,
Block 2, 7th Floor, CGO Complex,
Lodhi Road, New Delhi-110 003

xii) *Director-General, Council of Scientific and Industrial Research*

95. Prof. S.K. Brahmachari — Ex-officio
Director General,
Council of Scientific and Industrial Research,
Anusandhan Bhavan,
2-Rafi Ahmed Kidwai Marg, New Delhi-110 001

xiii) *Chairman, University Grants Commission*

96. Prof. Ved Prakash — Ex-officio
Chairman,
University Grants Commission
Bahadur Shah Zafar Marg, New Delhi-110 002

xiv) *Chairman, Atomic Energy Commission (or Director, Bhabha Atomic Research Centre, if nominated by the Chairman, Atomic Energy Commission)*

97. Dr. R.K. Sinha — Ex-officio
Chairman, Atomic Energy Commission
Department of Atomic Energy,
Anushakti Bhavan,
Chhatrapati Shivaji Maharaj Marg,
Mumbai-400 001

xv) *Member, Finance (Secretary/ Additional Secretary) in the Ministry of Finance, Government of India*
Alternate Member – Financial Adviser (DARE/ICAR)

98. Smt. Anjuly Chib Duggal, — Ex-officio
Additional Secretary (Expenditure)
Department of Expenditure,
Ministry of Finance, North Block
New Delhi-110 001

xvi) *Four Vice-Chancellors of Agricultural Universities, nominated by the President*

99. Dr. B.S. Dhillon, — 10.07.2015
Vice Chancellor,
Punjab Agricultural University,
Ludhiana (Punjab)-141 004

100. Dr. B.V. Patil — 02.05.2014
Vice Chancellor,
University of Agricultural Sciences,
Raichur (Karnataka)-584 102

101. Dr. K.E. Lawande — 25.12.2015
Vice Chancellor,
Dr Balasaheb Sawant Konkan Krishi
Vidyapeeth, Dapoli,
District-Ratnagiri (Maharashtra)-415 712

102. Dr. Vijay Kumar Taneja — 22.04.2016
Vice Chancellor,
Guru Angad Dev Veterinary and Animal
Sciences University,
Firozepur Road, Ludhiana (Punjab)-141 004

xvii) *Five technical representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner, Fisheries Development Commissioner, from the Union Ministry of Agriculture and Inspector-General of Forests, Government of India*

103. Dr. J.S. Sandhu — Ex-officio
Agriculture Commissioner,
Department of Agriculture & Cooperation,
Ministry of Agriculture.
Krishi Bhavan, New Delhi-110 001

104. Dr. S.K. Malhotra — Ex-officio
Horticulture Commissioner,
Department of Agriculture & Cooperation,
Ministry of Agriculture
Krishi Bhavan, New Delhi-110 001

105. Dr. Amarjit Singh Nanda — Ex-officio
Animal Husbandry Commissioner,
Department of Animal Husbandry, Dairying and Fisheries
Ministry of Agriculture,
Krishi Bhavan, New Delhi-110 001

106. Shri B. Vishnu Bhatt — Ex-officio
Fisheries Development Commissioner
Department of Animal Husbandry, Dairying and Fisheries
Ministry of Agriculture,
Krishi Bhavan, New Delhi-110 001

107. Shri Anoop Badhwa — Ex-officio
Inspector General of Forests (NAEB)
Ministry of Environment & Forests,
Paryavaran Bhawan, B-Block
CGO Complex, Lodi Road, New Delhi-110 003

xviii) *Fifteen scientists from within and outside the Council including one from the Indian Council of Medical Research, nominated by the President*

108. Dr. P.L. Gautam — 31.01.2014
C-I/29, Tilak Lane,
Adjoining Patiala House,
New Delhi-110 001

109. Dr. K.L. Chadha — 31.01.2014
President, The Horticultural Society of India,
F-1, National Societies Block,
NASC Complex, DPS Marg, Pusa
New Delhi-110 012

110. Dr. R.S. Paroda — 31.01.2014
Chairman, Trust for Advancement of Agricultural Sciences & Haryana Farmers' Commission
Avenue II, IARI Campus,
New Delhi-110 012

111. Prof. (Dr.) M. P. Yadav — 31.01.2014
H.No. 365, Sector-45,
Gurgaon (Haryana)-122 003

112. Dr. Lalji Singh — 31.01.2014
Vice-Chancellor,
Banaras Hindu University,
Varanasi (Uttar Pradesh)-221 005

113. Dr. S.D. Tripathi — 31.01.2014
701, Ankita,
Sardar Vallabhbhai Patel Nagar,
Four Bungalows, Versova, Andheri (West),
Mumbai (Maharashtra)-400 053

114. Dr. R.K. Gupta — 31.01.2014
South Asia Co-ordinator (DACST),
CIMMYT, CG Block, NASC Complex,
DPS Marg, New Delhi-110012

115. Dr. Anwar Alam — 31.01.2014
Secretary, NAAS
NASC Complex,
Dev Prakash Shastri Marg, Pusa,
New Delhi-110 012
Dr. Anwar Alam
S-319, Vivekanand Apartment,
Sector-5, Plot -2, Dwarka,
New Delhi-110 075

116. Dr. Anupam Varma — 31.01.2014
INSA Honorary Scientist,
Advanced Centre for Plant Virology,
Division of Plant Pathology
IARI, Pusa, New Delhi-110 012
Dr. Anupam Varma
253, Jaimaa Apartments, Sector 5,
Dwarka, New Delhi-110 075

117. Dr. B.S. Pathak — 31.01.2014
KC-5, Kavi Nagar
Ghaziabad (Uttar Pradesh)-201 002

118. Dr. Mruthyunjaya — 31.01.2014
(Ex National Director, NAIP, ICAR)
A-701, Vasundhara Apartments,
Plot No.16, Sector-6, Dwarka,
New Delhi-110 075

119. Prof. S.S. Acharya — 31.01.2014
Honorary Professor
33 Shahi Complex, Sector-11,
Udaipur (Rajasthan)-313 002

120. Dr. R.P. Kachru 31.01.2014
Ex-ADG, ICAR,
303, D.K. Rainbow,
Chuna Bhatti, Kolar Road,
Bhopal (Madhya Pradesh)-462 016
121. Prof. B.N. Johri 20.03.2014
PC Ray Fellow (MPCST)
Department of Biotechnology & Bioinformatics Centre,
Barkatullah University,
Bhopal (Madhya Pradesh)-462 026
Prof. B.N. Johri
LV-32, Indus Gardens,
E-8, Gulmohar Extension, Bawadia Kalan,
Bhopal (Madhya Pradesh)-462 039

Representative of ICMR

122. Dr G.S. Toteja 18.11.2015
Director,
Desert Medicine Research Centre, ICMR
New Pali Road, Jodhpur (Rajasthan)-342 005

xix) *Three representatives of commerce and industry, nominated by the President*

123. Shri Rakesh Bharti Mittal 01.10.2016
VC/MD, Bharti Enterprises Limited
Bharti Crescent, 1 Nelson Mandela Road
Vasant Kunj, Phase-II,
New Delhi-110 070
124. Shri Narendra Murkumbi 01.10.2016
Managing Director
Shree Renuka Sugars Limited
7th Floor, Devchand House,
Shiv Sagar Estate,
Dr. Annie Besant Road,
Worli, Mumbai – 400 018
125. Shri Jayprakash Dandegaonkar 01.10.2016
Vice Chairman,
Maharashtra State Co-Operative Sugar Factories Federation Limited,
Sakhar Bhavan, 11th Floor, Plot No. 230,
Nariman Point
Mumbai (Maharashtra)-400 021

xx) *One farmer from each region of the country as mentioned in Rule 60(a) and four representatives of rural interests, nominated by the President*

126. Shri M.V.S. Nagi Reddy 08.06.2014
Vice President,
A.P. Rytanga Samakhya,
R.C.M. Church Complex,
Gudivada,
Krishna District (Andhra Pradesh)-521 301
127. Shri Dhirendra Deb Adhikari, 08.06.2014
Rajobala,8, Sankarpur,
Gopinath Nagar,
Guwahati-781016 (Assam)
128. Shri N. Kumara, 08.06.2014
Canna Cottage, 16th Cross,
SIT Extention, Nandeesh Layout,
Tumkur (Karnataka)-572 103
129. Shri Kuldeep Dhaliwal, 08.06.2014
Mayapuri Colony,
Karnal Road, Kaithal,
(Haryana)-136 027
130. Shri Amardeep Singh Cheema 08.06.2014
Gobind Nagar,
Kahnuwan Road,
Batala,
District Gurdaspur (Punjab)-143 505
Shri Amardeep Singh Cheema
Core-4, 2nd floor, Scope Minar,
Laxmi Nagar District Centre,
Vikas Marg, Delhi-110 092
131. Chaudhary Gyan Singh 05.03.2016
Village-Sakauti, Post- Gurukul Narson
District-Haridwar (Uttarkhand)-247 670
132. Shri Fazle Masood 05.03.2016
14/627, Murad Ali Lane, Nai Basti,
Lucknow (Uttar Pradesh)-226 001
133. VACANT

Four Representatives of Rural Interests

134. Prof. D.P. Tripathi 08.06.2014
Member of Parliament (RS)
13-D, Firozshah Road,
New Delhi-110 001
135. Shri Sudhir Kumar Bhargava 08.06.2014
Director, Agroman Systems Pvt. Ltd.
25/2, Tardeo AC Market, Tardeo
Mumbai (Maharashtra)-400 034
136. Dr Chanda Nimbkar 08.06.2014
Director,
Animal Husbandry Division,
Nimbkar Agricultural Research Institute
P.O. Box 23,
Phaltan (Maharashtra)-415 523
137. VACANT

xxi) *Four Directors of the Indian Council of Agricultural Research Institutes, nominated by the President*

138. Dr. A.K. Srivastava 21.05.2016
Director,
National Dairy Research Institute,
Karnal (Haryana)-132 001
139. Dr. Ramesh Chand 21.05.2016
Director,
National Central for Agricultural Economics & Policy Research,
Post Box No.11305, Library Avenue,
DPS Marg,
Pusa Campus,
New Delhi-110 012
140. Dr. P.S. Minhas 21.05.2016
Director,
National Institute of Abiotic Stress Management,
Malegaon, Baramati,
Pune (Maharashtra)-413 115
141. Dr. S.M.K. Naqvi 21.05.2016
Director,
Central Sheep & Wool Research Institute,
Avikanagar,
P.O. Malpura,
Tonk-District (Rajasthan)-304 501

xxii) *Secretary, Indian Council of Agricultural Research-Member Secretary*

142. Shri Arvind Kaushal
Additional Secretary (DARE) and Secretary, ICAR
Krishi Bhavan, New Delhi-110 001

APPENDIX 2

LIST OF THE MEMBERS OF THE GOVERNING BODY OF THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

Chairman

1. Dr. S. Ayyappan
   Director-General,
   Indian Council of Agricultural Research,
   Krishi Bhavan,
   New Delhi-110 001

Ex-Officio Members

Member, Finance

2. Smt. Anjuly Chib Duggal,
   Additional Secretary (Expenditure),
   Department of Expenditure,
   Ministry of Finance,
   North Block
   New Delhi-110 001

Secretary, Planning Commission

3. Ms. Sindhushree Khullar,
   Secretary,
   Planning Commission,
   Yojana Bhavan,
   Sansad Marg,
   New Delhi-110 001

Secretary, Agriculture

4. Shri Ashish Bahuguna,
   Secretary (Agriculture & Cooperation)
   Department of Agriculture & Cooperation
   Ministry of Agriculture
   Krishi Bhavan,
   New Delhi-110 001

Chairman, University Grants Commission

5. Prof. Ved Prakash,
   Chairman, University Grants Commission,
   Bahadur Shah Zafar Marg,
   New Delhi-110 002

Secretary, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture

6. Shri A.K. Thakur
   Secretary (ADF),
   Dept. of Animal Husbandry, Dairying & Fisheries,
   Ministry of Agriculture, Krishi Bhavan,
   New Delhi-110 001

Secretary, Department of Biotechnology

7. Prof. K. Vijay Raghavan
   Secretary,
   Department of Biotechnology,
   Ministry of Science & Technology,
   Block-2, 7th floor,
   CGO Complex,
   Lodhi Road
   New Delhi-110 003

Director-General, Council of Scientific & Industrial Research

8. Prof. S.K. Brahmachari
   Director General,
   Council of Scientific & Industrial Research,
   Anusandhan Bhavan,
   2, Rafi Ahmed Kidwai Marg,
   New Delhi-110 001

Members

Four Scientists (including one Management Expert who are not employees of ICAR—nominated by the President
Management Expert

9. Dr. R. S. Paroda — 31.01.2014
   Chairman, Haryana Farmers'
   Commission and Trust for Advancement of Agricultural Sciences,
   Avenue II, IARI Campus,
   New Delhi-110 012

Scientists

10. Dr. Lalji Singh — 31.01.2014
    Vice-Chancellor,
    Banaras Hindu University,
    Varanasi (Uttar Pradesh)-221 005

11. Prof. Anwar Alam — 31.01.2014
    Secretary, NAAS,
    NASC Complex, DPSM, Pusa
    New Delhi-110 012
    Prof. Anwar Alam
    S-319, Vivekanand CGHS Limited,
    Sector-5, Plot -2, Dwarka,
    New Delhi-110 075

12. Dr. Mruthyunjaya — 31.01.2014
    (Ex National Director, NAIP, ICAR)
    A-701, Vasundhara Apartments,
    Plot No.16, Sector-6,
    Dwarka,
    New Delhi-110 075

Three Vice-Chancellors of Agricultural Universities - nominated by the President

13. Dr. B.V. Patil — 02.05.2014
    Vice Chancellor,
    University of Agricultural Sciences,
    Post Box-329, Lingasugur Road,
    Raichur (Karnataka)-584 102

14. Dr. K.E. Lawande — 25.12.2015
    Vice Chancellor,
    Dr Balasaheb Sawant Konkan
    Krishi Vidyapeeth, Dapoli,
    District-Ratnagiri (Maharashtra)-415 712

15. Dr. B.S. Dhillon, — 24.07.2015
    Vice Chancellor,
    Punjab Agricultural University
    Ludhiana (Punjab)-141 004

Three Members of Parliament (Two from Lok Sabha and one from Rajya Sabha, nominated by the President)

16. Shri Jayant Chaudhary — 23.08.2015
    Member of Parliament (Lok Sabha),
    12, Tughlak Road,
    New Delhi-110 011
    Shri Jayant Chaudhary
    Member of Parliament (Lok Sabha),
    20-Vishwa Laxmi Nagar,
    Near Goverdhan Chauraha,
    Mathura (Uttar Pradesh)

17. Shri Ramashankar Rajbhar 23.08.2015
Member of Parliament (Lok Sabha),
185, North Avenue,
New Delhi-110 001
Shri Ramashankar Rajbhar
Member of Parliament (Lok Sabha),
Village-Shivpur, Post- Laxmipur,
Via Rudrapur, District- Deoria (Uttar Pradesh)-274 001

18. Smt. Renuka Chowdhury 31.05.2015
Member of Parliament (Rajya Sabha),
76, Lodhi Estate,
New Delhi-110 003
Smt. Renuka Chowdhury
Member of Parliament (Rajya Sabha),
H.No.8-1-116, Khanapuram(V)
Khammam Urban(M),
Khammam District (Andhra Pradesh)-507 002

Three Farmers/ Representatives of rural areas (nominated by the President)

19. Prof. D.P. Tripathi 08.06.2014
Member of Parliament (RS),
13-D, Firozshah Road,
New Delhi-110 001

20. Dr. Chanda Nimbkar 08.06.2014
Director, Animal Husbandry Division,
Nimbkar Agricultural Research Institute
P.O. Box 23, Phaltan (Maharashtra)-415 523

21. Shri Sudhir Kumar Bhargava, 08.06.2014
Director,
Agroman Systems Pvt. Ltd.
25/2, Tardeo AC Market,
Tardeo, Mumbai (Maharashtra)-400 034

Three Directors of Research Institutes of the Council (nominated by the President)

22. Dr. A.K. Srivastava 21.05.2016
Director,
National Dairy Research Institute,
Karnal,
Haryana-132 001

23. Dr. Ramesh Chand 21.05.2016
Director
National Central for Agricultural
Economics & Policy Research,
Post Box No.11305, Library Avenue,
DPS Marg, Pusa Campus,
New Delhi-110 012

24. Dr. P.S. Minhas 21.05.2016
Director,
National Institute of Abiotic Stress
Management, Malegaon, Baramati,
Pune (Maharashtra)-413 115

Secretary, ICAR (Member-Secretary)

25. Shri Arvind Kaushal
Additional Secretary (DARE) & Secretary (ICAR),
Krishi Bhavan,
New Delhi-110 001

APPENDIX 3

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. Dr S. Ayyappan
Director General, ICAR and
Secretary to the Government of India,
Department of Agricultural Research and Education

2. Shri Arvind R. Kaushal
Secretary, ICAR and Additional Secretary to Government of India,
Department of Agricultural Research and Education

3. Shri P.K. Pujari
Financial Advisor, DARE/ICAR and Additional Secretary to Government of India
Department of Agricultural Research and Education

Deputy Directors General
1 Dr K.D. Kokate (Agriculture Extension)
2 Dr S.K. Datta (Crop Sciences)
3 Dr Arvind Kumar (Education)
4 Dr K.M.L. Pathak (Animal Sciences)
5 Dr (Mrs.) B. Meenakumari (Fisheries)
6 Dr N.K. Krishna Kumar (Horticulture)
7 Dr A.K. Sikka (NRM)
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3 Dr P. Chakrabarty (Plant Protection)
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1 Dr B. Mohan Kumar (Agro. & Agro Forestry)

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2 Dr G.N. Mishra (CC)
3 Dr Dinesh Kumar (F&FC)

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1 Dr R.K. Tomar

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3 Dr S.K. Bandyopadhyay, Member
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10 Sh. V.K. Sharma
11 Ms. Roja Sethumadhavan
12 Sh. G.G. Harakangi
13 Sh. K.K. Kulshreshtha

APPENDIX 4

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2 Dr Gaya Prasad (Acting)
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3 Dr A.K. Srivastava
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15 Dr Nazeer Ahmed
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APPENDIX 5

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APPENDIX 6

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APPENDIX 8

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AICRP on Groundnut
Directorate of Groundnut Research
Junagarh (Gujarat) 362 001

45 Dr S. K. Srivastava
AICRP on Soybean
Directorate of Soybean Research
Indore (Madhya Pradesh) 452 001

46 Dr J. S. Chauhan
AICRP on Rapeseed and Mustard
Directorate of Rapeseed Mustard and Research
Bharatpur (Rajasthan) 321 003

47 Dr K. S. Varaprasad
AICRP on Sunflower, Safflower, Castor
Directorate of Oilseed Research
Hyderabad (Andhra Pradesh) 500 030

48 Dr B. S. Bhumannavar
AICRP on Biological Control
Bengaluru (Karnataka) 560 024

49 Dr S. Rajendra Prasad
AICRP on NSP (Crops)
Directorate of Seed Research
Maunath Bhanjan (Uttar Pradesh) 275 101

50 Dr A. S. Sidhu
AICRP on Tropical Fruits
IIHR
Bengaluru (Karnataka) 560 089

51 Dr A. K. Misra
AICRP on Sub-tropical Fruits
CISH
Lucknow (Uttar Pradesh) 227 107

52 Dr S. K. Sharma
AICRP on Arid Zone Fruits
CIAH, Bikaner (Rajasthan) 334 006

53 Dr Manjit Singh
AICRP on Mushroom Improvement Project
Directorate of Mushroom Research
Solan (Himachal Pradesh) 173 213

54 Dr Satyabrata Maity
Directorate of Medicinal and Aromatic Plants
AICRP on Medicinal and Aromatic Plants and Betelvine
Anand (Gujarat) 387 310

55 Dr Ramesh Kumar
AICRP on Floriculture
Directorate of Floricultural Research,
IARI, Delhi 110 012

56 Dr L. P. Gite
AICRP on Human Engineering and Safety in Agriculture,
CIAE
Bhopal (Madhya Pradesh) 462 038

57 Dr K. C. Pandey
AICRP on Renewal Sources of Energy for Agriculture
and Agro-based Industries,
CIAE, Bhopal (Madhya Pradesh) 462 038

58 Dr S. K. Agarwal
AICRP on Goat Improvement Project
CIRG
Farah (Uttar Pradesh) 281 122

59 Dr C. S. Prasad
AICRP on Improvement of Feed Sources and Nutrient
Utilization for Raising Animal Production
NIANP
Bengaluru (Karnataka) 560 030

60 Dr Arjava Sharma
AICRP on Cattle Research
PD on Cattle
Meerut (Uttar Pradesh) 500 030

61 Dr R. N. Chatterjee
AICRP on Poultry
PD on Poultry
Hyderabad (Andhra Pradesh) 500 030

62 Dr Dilip Kumar Sharma
AICRP on Pig
IVRI
Izatnagar (Uttar Pradesh)

63 Dr B. Pattanaik
AICRP on Foot-and -Mouth Disease
Mukteshwar (Uttar Pradesh)

64 Dr H. Rahman
AICRP on ADMAS
Bengaluru (Karnataka)

65 Dr M.P.S. Arya
AICRP on Home Science
Directorate on Women Research
Bhubanaeshwar (Odisha)

APPENDIX 9

AGRICULTURAL UNIVERSITIES AND THEIR VICE CHANCELLORS

State Agricultural Universities

1. Dr A Padma Raju
   Acharya NG Ranga Agricultural University
   Rajendranagar,
   Hyderabad (Andhra Pradesh) 500 030
2. Dr A M Shekh
   Anand Agricultural University
   Anand (Gujarat) 388 110
3. Dr K M Bujarbaruah
   Assam Agricultural University
   Jorhat (Asom) 785 013
4. Prof. Chittaranjan Kole
   Bidhan Chandra Krishi Viswavidyalaya
   Mohanpur, Nadia (West Bengal) 741 252
5. Dr M L Choudhary
   Bihar Agricultural University
   Sabour (Bihar) 813 210
6. Dr M P Pandey
   Birsa Agricultural University
   Kanke, Ranchi (Jharkhand) 834 006
7. Prof. Munna Singh
   Chandra Shekar Azad University of Agriculture & Technology,
   Kanpur (Uttar Pradesh) 208 002
8. Dr KS Khokhar
   Chaudhary Charan Singh Haryana Agricultural University,
   Hisar (Haryana)125 004
9. Dr Krishan Kumar Katoch
   Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidhalaya,
   Palampur (Himachal Pradesh) 176 062
10. Dr Kisan E Lawande
    Dr Balasaheb Sawant Konkan Krishi Vidyapeeth
    Dapoli, Ratnagiri (Maharashtra) 415 712
11. Dr Ravi G Dani
    Dr Panjabrao Deshmukh Krishi Vidyapeeth
    Krishi Nagar, Akola (Maharashtra) 444 104
12. Dr Vijay Singh Thakur
    Dr Yashwant Singh Parmar University of Horticulture and Forestry
    Solan, Nauni (Himachal Pradesh) 173 230
13. Dr A Padma Raju
    Dr YSR Horticultural University
    Post Box no. 7
    Venkataramannagudem (Andhra Pradesh) 534 101
14. Sh Subhash Kumar
    Govind Ballabh Pant University of Agriculture & Technology, Pantnagar
    Udhamsingh Nagar (Uttara Khand) 263 145
15. Dr V K Taneja
    Guru Angad Dev University of Veterinary and Animal Sciences
    Ludhiana (Punjab) 141 004
16. Dr S K Patil
    Indira Gandhi Krishi Vishwavidyalaya,
    Krishak Nagar, Raipur (Chhattisgarh) 492 006
17. Dr Vijay Singh Tomar
    Jawaharlal Nehru Krishi Vishwavidyalaya
    Krishi Nagar,
    Jabalpur (Madhya Pradesh) 482 004
18. Dr N C Patel
    Junagadh Agricultural University
    MotiBagh, Agril. Campus
    Junagadh (Gujarat) 362 001
19. Dr U K Mishra
    Kamadhenu Veterinary University
    Raipur (Chhattisgarh)
20. Dr C Renuka Prasad
    Karnataka Veterinary Animal and Fisheries Science University,
    P.B. No. 6, Nandinagar
    Bidar (Karnataka) 585 401
21. Sh. P Rajendran
    Kerala Agricultural University,
    P.O Vellanikkara,
    Thrissur (Kerala) 680 656
22. Prof. B Madhusoodana Kurup
    Kerala University of Fisheries & Ocean Studies
    Papangad,
    Kochi (Kerala) 682 506
23. Dr B Ashok
    Kerala University of Animal Science University
    Directorate of Dairy, Development Pattom
    Thiruvanthapuram (Kerala) 695 004
24. Dr R R Jowel
    Lala Lajpat Rai University of Veterinary & Animal Sciences,
    Hisar, (Haryana) 125 001
25. Dr Govind Prasad Mishra
    Nanaji Deshmukh Pashu Chikitsa Vigyan Vishwavidyalaya,
    Civil Lines
    Jabalpur (Madhya Pradesh) 482 001
26. Dr O P Gill
    Maharana Pratap University of Agriculture & Technology,
    Udaipur (Rajasthan) 313 001
27. Shri. A K Mishra
    Maharashtra Animal Science & Fishery University,
    Nagpur (Maharashtra) 440 006
28. Dr T A More
    Mahatma Phule Krishi Vidyapeeth
    Rahuri (Maharashtra) 413 722
29. Dr Milka Singh Aulakh
    Manyavar Shri Kanshiram Ji University of Agricultural and Technology,
    Banda (Uttar Pradesh)
30. Dr K P Gore
    Marathwada Agricultural University
    Parbhani (Maharashtra) 43 1402
31. Dr R S Kureel
    Narendra Deva University of Agriculture & Technology,
    Kumarganj, Faizabad (Uttar Pradesh) 224 229
32. Dr A R Pathak
    Navsari Agricultural University,
    Vijalpore
    Navsari (Gujarat) 396 450
33. Dr M Kar
    Orissa University of Agriculture & Technology
    Siripur,
    Bhubaneshwar (Odisha) 751 003
34. Dr B S Dhillon
    Punjab Agricultural University
    Ludhiana (Punjab) 141 004
35. Prof. Ajay Kumar Gahlot
    Rajasthan University of Veterinary & Animal Sciences,
    Bijay Bhawan Palace Complex
    Near Pt. Deendayal Circle
    Bikaner (Rajasthan) 334 006
36. Dr R K Mittal
    Rajendra Agricultural University,
    Pusa, Samastipur (Bihar) 848 125
37. Dr A K Singh
    Rajmata VRS Agricultural University
    Gwalior (Madhya Pradesh) 474 002

38. Dr H S Gaur
Sardar Vallabh Bhai Patel University of Agriculture & Technology, Modipuram
Meerut (Uttar Pradesh) 250 110
39. Dr K Sreedharan
Sardarkrushinagar-Dantiwada Agricultural University
Sardarkrushinagar, Dantiwada
Banaskantha (Gujarat) 385 506
40. Dr D K Arora
Sher-e-Kashmir University of Agricultural Sciences & Technology,
Railway Road,
Jammu (J&K) 180 009
41. Dr Tej Pratap
Sher-e-Kashmir University of Agricultural Sciences & Technology
Shalimar,
Srinagar (J&K) 191 121
42. Dr V Prabhakar Rao
Sri Venkateswara Veterinary University
Tirupati,
Chittoor (Andhra Pradesh) 517 502
43. Dr A K Dahama
Swami Keshwanand Rajasthan Agricultural University
Bikaner (Rajasthan) 33 4006
44. Dr K. Ramaswamy
Tamil Nadu Agricultural University
Coimbatore (Tamil Nadu) 641 003
45. Dr Baskaran Manimaran
Tamil Nadu Fisheries University
Nagappatinam (Kerala) 600 007
46. Dr R Prabhakaran
Tamil Nadu Veterinary & Animal Sciences University
Madhavaram Milk Colony
Chennai (Tamil Nadu) 600 051
47. Dr H S Vijayakumar
University of Agricultural Sciences
Dharwad (Karnataka) 580 005
48. Dr K Narayana Gowda
University of Agricultural Sciences
Bangaluru (Karnataka) 560 065
49. Dr S.B. Dandin
University of Horticultural Sciences
Navanagar,
Bagalkot (Karnataka) 587 101
50. Dr B.V. Patil
University of Agricultural Sciences
Raichur (Karnataka) 584 102
51. Dr P.S. Salimath
University of Agricultural & Horticultural Sciences
Shimoga (Karnataka) 577 204
52. Dr A C Varshney
UP Pandit Deen Dayal Upadhaya Pashu Chikitsa Vigyan Vishwa Vidhyalaya Evam Go Anusandhan Sansthan,
Mathura (Uttar Pradesh) 281 001
53. Dr Matthew Prasad
Uttarakhand University of Horticulture & Forestry
Bharsar Pauri Garhwal (Uttara Khand) 246 123
54. Dr Biswanath Bandyopadhyay,
Uttar Banga Krishi Vishwavidyalaya
Cooch Behar (West Bengal) 736 165
55. Dr C S Chakrabarti
West Bengal University of Animal & Fishery Sciences
68 KB Sarani
Kolkata (West Bengal) 700 037

Central Agricultural University

1. Dr S N Puri
Central Agricultural University
Imphal (Manipur) 795 004

Deemed-to-be Universities

1. Dr H S Gupta
Indian Agricultural Research Institute
Pusa, New Delhi 110 012
2. Dr Gaya Prasad
Indian Veterinary Research Institute,
Izatnagar, Bareilly (Uttar Pradesh) 243 122
3. Dr A K Srivastava
National Dairy Research Institute
Karnal (Haryana) 132 001
4. Dr W S Lakra
Central Institute of Fisheries Education
Mumbai (Maharashtra) 400 061
5. Dr R B Lal
Sam Higginbottom Institute of Agriculture Technology & Science,
Allahabad (Uttar Pradesh) 211 007

Central Universities with Agriculture Faculty

1. Dr Zameer Uddin Shah
Aligarh Muslim University
Aligarh (Uttar Pradesh) 202 002
2. Prof. Lalji Singh
Banaras Hindu University,
Varanasi (Uttar Pradesh) 221 005
3. Prof. Bolin Kumar Konwar
Nagaland University,
College of Agriculture,
Medizipherma (Nagaland) 797 106
4. Prof. Sushanta Data Gupta
Vishwa Bharti, Palli Bhavana
Shantiniketan (West Bengal) 731 235

APPENDIX 10

Total number of employees in the ICAR and its research institutes and number of Scheduled Castes, Scheduled Tribes and Other Backward Classes

Categories of employees	Total posts sanctioned	Total employees in position	Scheduled Caste employees		Scheduled Tribe employees		OBC employees	
			No.	% to total employees	No.	% to Total employees	No.	% to total employees
1. Scientific Posts								
Scientist	3897	2613	479	18.33	330	12.63	480	18.37
Senior Scientist	1659	1039	96	9.24	34	3.27	143	13.76
Prinicipal Scientist	757	695	59	8.49	04	0.58	48	6.91
RMP Scientist	160	137	05	3.65	01	0.73	04	2.92
Total	**6473**	**4484**	**639**	**14.25**	**369**	**8.23**	**675**	**15.05**
2. Technical Posts								
Category I	4188	3313	565	17.05	299	9.03	320	9.66
Category II	2650	2201	418	18.99	157	7.13	332	15.08
Category III	675	626	98	15.65	63	10.06	99	15.81
Total	**7513**	**6140**	**1081**	**17.61**	**519**	**8.45**	**751**	**12.23**
3. Administration Posts								
(a) Category "A" posts: Senior Registrar/Director/ Dy. Secretary/Under Secretary/ CAOs/SAOs/AOs/CF&AO/SF&AO/ F&AO/Legal Adviser/Director (OL)/ DD(OL)/AD(OL)PPS	332	257	49	19.06	17	6.61	22	8.56
(b) Category "B" posts: AF&AO/AAO/PS/SO/AD (OL)/ ALA/Assistant/PA/ Sr. Sales Assistant/ JAO/ALA	2989	2391	364	15.22	176	7.36	422	17.65
(c) Category "C" posts: UDC/Steno/LDC	1552	1240	223	17.98	99	7.98	219	17.66
Total	**4873**	**3888**	**636**	**16.36**	**292**	**7.51**	**663**	**17.05**
4. Skilled supporting Staff	**8351**	**6167**	**1625**	**26.35**	**546**	**8.85**	**726**	**11.77**

ANNEXURE 11

AWARDS

AWARDS	AWARDEES
Sardar Patel Outstanding ICAR Institution Award 2012	1. ICAR Research Complex for NEH Region, Umiam, 2. Meghalaya National Institute of Animal Nutrition and Physiology, Adugodi, Bengaluru (Karnataka) 560 030 3. University of Agricultural Sciences, GKVK Campus, Bengaluru (Karnataka) 560 065
Chaudhary Devi Lal Outstanding All India Coordinated Research Project Award 2012	1. All India Coordinated Research Project on Application of Plastics in Agriculture CIPHET, Ludhiana (Punjab) 141 004
Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences 2012	1. **Dr K.V. Prabhu** Division of Genetics Indian Agricultural Research Institute, New Delhi 110 012 2. **Dr Jai Singh Parihar** Dy. Director, EPSA Space Applications Centre, ISRO Jodhpur Tekra, Ambawadi Vistar P.O., Ahmedabad (Gujarat) 380 015 3. **Dr Joykrushna Jena** Director National Bureau of Fish Genetic Resources Canal Ring Road, PO Dilkusha, Lucknow (Uttar Pradesh) 226 002
Lal Bahadur Shastri Outstanding Young Scientist Award 2012	1. **Dr Maganti Sheshu Madhav** Senior Scientist Biotechnology Laboratory Crop Improvement Section Directorate of Rice Research Rajendranagar, Hyderabad (Andhra Pradesh) 500 030 2. **Dr Pratap Bhattacharyya** Crop Production Division, Central Rice Research Institute, Bidyadharpur, Cuttack (Odisha) 753 006 3. **Dr Veerasamy Sejian** Senior Scientist (Animal Physiology) Animal Physiology Division National Institute of Animal Nutrition and Physiology Adugodi, Hosur Road, Bengaluru (Karnataka) 560 030 4. **Dr Hukum Chandra** Senior Scientist Division of Sample Surveys Indian Agricultural Statistics Research Institute (IASRI) Library Avenue, Pusa Campus New Delhi 110 012
Panjabrao Deshmukh Outstanding Woman Scientist Award 2012	1. **Prof. Rintu Banerjee** Agricultural & Food Engineering Department, Indian Institute of Technology, Kharagpur (West Bengal) 721 302 2. **Dr Radha Prasanna** CCUBGA & Division of Microbiology Indian Agricultural Research Institute (IARI), New Delhi 110 012
Bharat Ratna DrC.Subramaniam Award for Outstanding Teachers 2012	1. **Dr M.K. Naik** Professor and Head, Dean (PGS), Department of Plant Pathology, Agriculture College, University of Agricultural Sciences, Raichur (Karnataka) 504 102 2. **Dr Indra Mani** Principal Scientist Division of Agricultural Engineering, IARI, Pusa Campus, New Delhi -110 012

AWARDS	AWARDEES
	3. **Dr Ashok Kumar Tiwari** Head, Division of Animal Biological Standardization, Indian Veterinary Research Institute, Izatnagar (Uttar Pradesh) 243 122
Hari Om Ashram Trust Award for the Biennium 2010-12	1. **Dr B.C. Viraktamath** Project Director, Directorate of Rice Research, Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
	2. **Dr M.S. Ramesha** (Associate) Directorate of Rice Research, Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
	3. **Dr R.M. Sundaram** (Associate) Directorate of Rice Research, Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
	4. **Dr A.S. Hari Prasad** (Associate) Directorate of Rice Research, Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
	5. **Dr Dinesh Kumar Sharma** Central Soil Salinity Research Institute, Karnal (Haryana) 132 001
	6. **Dr Vinay Kumar Mishra** (Associate) Central Soil Salinity Research Institute, Karnal (Haryana) 132 001
	7. **Dr Amaresh Kumar Nayak** (Associate) Central Soil Salinity Research Institute, Karnal (Haryana) 132 001
	8. **Dr Yas Pal Singh** (Associate) Central Soil Salinity Research Institute, Karnal (Haryana) 132 001
	9. **Dr Tarun Kumar Bhattacharya** ICAR National Fellow Agricultural Research Institute, Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
	10. **Dr Rudra Nath Chatterjee** (Associate)
Fakhruddin Ali Ahmed Award for Outstanding Research in Tribal Farming Systems 2012	1. **Dr A.S. Panwar** Principal Scientist, Division of Natural Resource Management ICAR Research Complex for NEH Region, Umroi Road, Umiam (Meghalaya) 793 103
	2. **Dr S.V. Ngachan** (Associate) ICAR Research Complex for NEH Region, Umroi Road, Umiam (Meghalaya) 793 103
	3. **Dr Anup Das** (Associate) ICAR Research Complex for NEH Region, Umroi Road, Umiam (Meghalaya) 793 103
	4. **Dr Bandi Venkateswarlu** Central Research Institute for Dryland Agriculture Santsohnagar, Saidabad, P.O. Hyderabad (Andhra Pradesh) 500 059

AWARDS	AWARDEES
	5. **Dr Sreenath Dixit** (Associate) Central Research Institute for Dryland Agriculture Santsohnagar, Saidabad, P.O. Hyderabad (Andhra Pradesh) 500 059
	6. **Dr M. Osman** (Associate) Central Research Institute for Dryland Agriculture Santsohnagar, Saidabad, P.O. Hyderabad (Andhra Pradesh) 500 059
	7. **Dr K.V. Rao** (Associate) Central Research Institute for Dryland Agriculture Santsohnagar, Saidabad, P.O. Hyderabad (Andhra Pradesh) 500 059
Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2012	1. **Dr Prashant Vikram** C/o Dr Arvind Kumar, Senior Scientist, Plant Breeder, International Rice Research Institute, DAPO BOX 7777, Metro Manila, Philippines
	2. **Dr Ganapati Mukri** #16, Directorate of Maize Research, Pusa Campus, New Delhi-110 012
	3. **Dr Charu Lata** Room No. 221 NRC on Plant Biotechnology, L.B.S. Building, Pusa Campus (IARI), New Delhi-110 012
	4. **Dr Abhinav Grover** DST INSPIRE Faculty, School of life Sciences, Jawaharlal Nehru University, New Delhi-110 067
	5. **Dr Tushar Kanti Dutta** Room No.327, Division of Nematology, Indian Agricultural Research Institute, New Delhi-110 012
	6. **Dr Nandani Shukla** C/o Dr Sumit Chaturvedi, Assistant Professor, Department of Agronomy, College of Agriculture, GBPUA&T, Pantnagar, U.S. Nagar (Utarakhand) 263 145
	7. **Dr Gulab Pandove** 6982, Sunil Park, Jassian Road, Haibowal Kalan, Ludhiana (Punjab) 141 001
	8. **Dr Arabinda Sharma** Civil Engineering Department BRCM College of Engineering & Technology Dist: Bhiwani, Bahal (Haryana) 127 028
	9. **Dr Partha Saha** Scientist, Division of Vegetable Science IARI, Pusa, New Delhi-110 012
	10. **Dr Prabhanjan Kumar Pranav** Assistant Professor, Department of Agricultural Engineering, North Eastern regional Institute of Science and Technology (NERIST), Nirjuli, Itanagar (Arunachal Pradesh) 791109
	11. **Dr R.C. Pradhan** Department of Farm Engineering Institute of Agricultural Sciences Banaras Hindu University Varanasi (Uttar Pradesh) 221 005

AWARDS	AWARDEES
	12. **Dr Gaurav Kumar Sharma** Project Directorate on Foot-and-Mouth Disease, Mukteshwar, Nainital (Uttrakhand) 263 138
	13. **Dr Gurpreet Kaur** Post Doctoral Fellow Department of Oncologic Sciences, USA Mitchell Cancer institute, 1660 Springhill Avenue, Mobile, AL. 36604
	14. **Dr Raghunath Ravi** 'Roshni' Chavara Centre Road, Cochin (Kerala) 682 011
	15. **Dr P. Mahalakshmi** Central Institute of Brackishwater Aquaculture No.75, Santhome High Road Raja Annamalai Puram Chennai (Tamil Nadu) 600 028
	16. **Dr Sanchita Garai** Scientist Division of Dairy Extension National Dairy Research Institute, Karnal (Haryana) 132 001
Jagjivan Ram Abhinav Kisan Puruskar/Jagjivan Ram Innovative Farmer Award (National/Zonal) 2012 (National)	1. **Shri Uddhav Asaram Khedekar** At. Shivni, Post:Ner Tq.& District Jalna(Maharashtra) 431 203
Jagjivan Ram Abhinav Kisan Puruskar /Jagjivan Ram Innovative Farmer Award (National/Zonal) 2012 (Zonal)	1. **Zone 1** **Sh. Gurpreet Singh Shergill** Village Majhal Khurd, P.O. Panjola, Distt. Patiala (Punjab) 147 101
	2. **Zone 2** Vill-Mahddiganj, Po-Sasaram, P.S – Sasaram Distt-Rohtas (Bihar) 821 115
	3. **Zone 3** -Nil-
	4. **Zone 4** **Mr Sandeep Goel** H.K. Agriculture Farm, Vill. Jaitpur, P.O. Kundeshwari, Kashipur (Uttarakhand) 244 713
	5. **Zone 5** **Mr Mohanrao Janrao Jayale** At Post:Akole (J), Tq. Akot. Dist. Akola (Maharashtra) 444 101
	6. **Zone 6** **Mr Sohan Singh Chouhan** Shri Ashapura Bagwani Farm Village & Post-Joyla, Tehsil-Sheoganj District-Sirohi (Rajasthan)
	7. **Zone 7** **Mr Dolamani Sahu** At-Malipali, Po-Gaisama Via-Tora, Dist-Bargarh (Odisha) 768 040
	8. **Zone 8** **Shri H. Sadananda** Tapasihalli Village, Antharahalli Post, Doddaballapur taluk, Bangalore rural district (Karnataka)
N.G. Ranga Farmer Award for Diversified Agriculture 2012	1. **Major Manmohan Singh Verka** D-107, Ranjit Avenue, Amritsar (Punjab) 143 001
Dr Rajendra Prasad Puruskar for technical books in Hindi in Agricultural and Allied Sciences 2012	1. **Dr Rajendra Kumar Yadav** Department of Genetics and Plant Breeding, C.S. Azad University of Agriculture & Technology, Kanpur (Uttar Pradesh) 208 002

AWARDS	AWARDEES
	2. **Dr Ram Krishan** (Associate) C.S. Azad University of Agriculture & Technology, Kanpur (Uttar Pradesh) 208 002
	3. **Dr Chandra Bhanu** Scientist, Plant Pathology, Project Directorate for Farming Systems Research, Modipuram, Meerut (Uttar Pradesh) 250 110
	4. **Dr V.S. G.R. Naidu** (Associate) Project Directorate for Farming Systems Research, Modipuram, Meerut (Uttar Pradesh) 250 110
Vasantrao Naik Award for Research Application in Agriculture 2012	1. **Dr O.P. S. Khola** Principal Scientist & Head Central Soil and Water Conservation Research and Training Institute Research Centre, Rees' Corner, Fernhill Post, Udhagamandalam, The Nilgiris (Tamil Nadu) 643 004
	2. **Dr (Ms) V. Selvi** (Associate) Central Soil and Water Conservation Research and Training Institute Research Centre, Rees' Corner, Fernhill Post, Udhagamandalam, The Nilgiris (Tamil Nadu) 643 004
	3. **Dr D.V. Singh** (Associate) Central Soil and Water Conservation Research and Training Institute Research Centre, Rees' Corner, Fernhill Post, Udhagamandalam, The Nilgiris (Tamil Nadu) 643 004
	4. **Dr K. Kannan** (Associate) Central Soil and Water Conservation Research and Training Institute Research Centre, Rees' Corner, Fernhill Post, Udhagamandalam, The Nilgiris (Tamil Nadu) 643 004
Swami Sahajanand Saraswati Outstanding Extension Scientist Award 2012	1. **Dr Dayaram** Senior Scientist, Plant Pathology, Department of Microbiology Faculty of Basic Sciences and Humanities Rajendra Agricultural University, Bihar Pusa Samastipur, (Bihar) 848 125
	2. **Dr Sarla Lakhawat** SMS (Home Science) 5/4 CAD Colony, Anta, Baran (Rajasthan) 325 202
Chaudhary Charan Singh Award for excellence in Journalism in Agricultural Research and Development 2012	1. **Electronic Media** **Shri Virsain Malik** (Programme Executive Farm & Home) Sansad Marg, All India Radio, New Delhi 110 001
	2. **Print Media** **Shri Naseeb Saini** S/o Sh. Daya Ram, Vill. Roherian PO Chandana, Tehsil and Kaithal (Haryana)
Zonal Best Krishi Vigyan Kendra Award 2012 (National)	**Ramkrishna Ashram Krishi Vigyan Kendra**, P.O. Nimpith Ashram, Distt., South 24-Parganas Sundarbans, (West Bengal) 743 338

AWARDS	AWARDEES
Zonal Best Krishi Vigyan Kendra Award 2012 (Zonal)	1. **Zone 1** Krishi Vigyan Kendra, Mandi at Sundernagar District Mandi (Himachal Pradesh) 175 019 2. **Zone 2** Krishi Vigyan Kendra, Birauli Samastipur (Bihar) 848 113 3. **Zone 3** KVK-Senapati Hengbung Village BPO Hengbung, P.O. Kangpokpi, Senapati District (Manipur) 795 129 4. **Zone 4** Krishi Vigyan Kendra, Dhakrani (Zone-IV)G.B. Pant University of Agriculture and Technology, Krishi Vigyan Kendra Dhakrani, Dehra Dun (Uttarakhand) 248 142 5. **Zone 5** Agriculture Development Trust's Krishi Vigyan Kendra, At Sharadanagar, Malegaon Colony, Tal-Baramati, District Pune (Maharashtra) 413 115 6. **Zone 6** Krishi Vigyan Kendra, Sirohi (Rajasthan) 307 001 Programme Coordinator Krishi Vigyan KendraNear Ambeshwarji Temple Pali Road, Post Box-15 Sirohi (Rajasthan) 307 001 7. **Zone 7** Krishi Vigyan Kendra, Kanker District-Kanker (Chattisgarh) 494 334 8. **Zone 8** Krishi Vigyan Kendra Hadonahalli Thubagere Hobli Doddaballapura Taluk, Bengaluru Rural District (Karnataka) 561 205

APPENDIX 12

RESULTS-FRAMEWORK DOCUMENT FOR DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION (2012-2013)

RFD
Results-Framework Document
For
Department of Agricultural Research and Education
(2012-2013)

Section I
Vision, Mission, Objectives and Functions

Vision

Harnessing science to ensure comprehensive and sustained physical, economic and ecological access to food and livelihood security to all Indians, through generation, assessment, refinement and adoption of appropriate technologies.

Mission

Sustainability and growth of Indian agriculture by interfacing agricultural research, higher education and front-line extension initiatives complemented with institutional, infrastructural and policy support that will create efficient and effective science-harnessing tool.

Objective

1 Improving natural resource management and input use efficiency
2 Strengthening of higher agricultural education
3 Utilizing frontier research in identified areas / programs for better genetic exploitation
4 Strengthening of frontline agricultural extension system and addressing gender issues
5 IP management and commercialization of technologies
6 Assessment and monitoring of fishery resources
7 Development of vaccines and diagnostics
8 Post harvest management, farm mechanization and value addition

Functions

1 To develop Public-Private-Partnerships in developing seeds, planting materials, vaccines, feed formulations, value added products, agricultural machinery etc.
2 To serve as a repository in agriculture sector and develop linkages with national and international organizations as per the needs and current trends.
3 To plan, coordinate and monitor research for enhancing production and productivity of agriculture sector.
4 To enhance quality of higher education in agriculture sector.
5 Technology generation, commercialization and transfer to end users.
6 Human resource development and capacity building.
7 To assess implementation of various programmes in relation to target sets and provide mid-course correction, if required.

Section 2

Inter-se Priorities among Key Objectives, Success indicators and Targets

	Objective	Weight		Action		Success	Unit	Weight 100%	Target/Criteria Value				
									Excellent 90%	Very Good 80%	Good 70%	Fair 60%	Poor
[1]	Improving natural resource management and input use efficiency	17.00	[1]	Integrated nutrient management (INM)	[1.1.1]	Developing GIS based district / block level soil fertility maps	Number	2.55	112	100	88	78	67
					[1.1.2]	Developing INM packages for different agro-eco regions of the country	Number	2.55	7	6	5	4	3
					[1.1.3]	Organizing training & demonstrations	Number	1.70	27	25	22	19	16
			[1.2]	Integrated water management (IWM)	[1.2.1]	Technologies for enhancing water use efficiencies	Number	1.70	6	5	4	3	2
					[1.2.2]	Technologies for water harvesting storage and groundwater recharge	Number	1.70	6	5	4	3	2
					[1.2.3]	Models / DSS for multiple uses of water	Number	0.85	4	3	2	1	0
					[1.2.4]	Organizing training & demonstrations	Number	1.70	17	15	14	12	10
			[1.3]	Climate resilient agriculture	[1.3.1]	Awareness building amongst stake holders through trainings / demonstrations	Number	1.02	170	150	136	119	102
					[1.3.2]	Human resource development and capacity building	Number	1.02	170	150	136	119	102
					[1.3.3]	Testing crop varieties for climate resilience at different locations	Number	2.21	12	10	9	8	7
[2]	Strengthening of higher agricultural education	17.00	[2.1]	Accreditation / Extension of accreditation of agricultural universities	[2.1.1]	Number of universities granted accreditation / extension of accreditation	Number	2.55	9	8	6	5	4

	Objective	Weight		Action		Success	Unit	Weight 100%	Target/Criteria Value				
									Excellent 90%	Very Good 80%	Good 70%	Fair 60%	Poor
			[2.2]	Grant of ICAR International fellowships to Indian and foreign students	[2.2.1]	Number of fellowships awarded (subject to availability of competent candidates)	Number	2.55	13	12	10	8	6
			[2.3]	Grant of JRF and SRF to students	[2.3.1]	Total No. of fellowships granted every year (subject to availability of competent candidates)	Number	4.25	630	625	575	500	475
			[2.4]	Establishment of experiential learning units	[2.4.1]	Experiential learning units established	Number	1.70	25	22	20	18	15
			[2.5]	Financial support and monitoring of progress	[2.5.1]	Amount released	Rupees in crores	2.55	380	360	340	320	300
			[2.6]	Capacity building and faculty up-gradation	[2.6.1]	Number of teachers trained per year	Number	1.70	1000	900	800	700	600
					[2.6.2]	Number of Summer / Winter Schools organized	Number	1.70	25	22	20	18	16
[3]	Utilizing frontier research in identified areas/programs for better genetic exploitation	13.00	[3.1]	Collection, characterization and conservation of genetic resources	[3.1.1]	Number of germplasm collected/ characterized and conserved (other crops)	Number	1.17	5000	4000	3000	2500	2000
					[3.1.2]	Number of germplasm collected (horticultural crops)	Number	1.17	350	315	280	245	210
			[3.2]	Evaluation of genetic resources / improved varieties for suitable crop husbandry practices	[3.2.1]	Number of germplasm evaluated	Number	1.17	3000	2500	2000	1500	1000
			[3.3]	Production of breeder seed, other seeds and planting materials	[3.3.1]	Quantity of breeder seed produced (other crops)	Tonnes	1.30	8500	8200	8000	7500	7000
					[3.3.2]	Quantity of breeder seed produced (horticultural crops)	Tonnes	1.17	4000	3600	3200	2800	2400

	Objective	Weight		Action		Success	Unit	Weight 100%	Target/Criteria Value				
									Excellent 90%	Very Good 80%	Good 70%	Fair 60%	Poor
					[3.3.3]	Quantity of planting materials produced annually	Number (in lakhs)	1.17	45	40.5	36	31.5	27
			[3.4]	Development of improved varieties suited to diverse agro ecologies	[3.4.1]	Number of varieties developed (other crops)	Number	1.17	15	12	10	8	5
					[3.4.2]	Number of varieties developed (pulses / oilseeds)	Number	1.17	17	13	11	9	7
					[3.4.3]	Number of varieties developed (horticultural crops)	Number	1.17	20	18	16	14	12
			[3.5]	Production of piglets (8-12 weeks of age)	[3.5.1]	Provisioning of piglets to farmers and development agencies	Number	1.17	1000	900	800	600	550
			[3.6]	Production of day old as well as 6 weeks old chicks	[3.6.1]	Provisioning of day old / 6 weeks old chicks to farmers and development agencles	Number (in lakhs)	1.17	2.5	2	1.5	1	0.5
[4]	Strengthening of frontline agricultural extension system and addressing gender issues	13.00	[4.1]	Technology assessment through on-farm trials	[4.1.1]	Number of technologies assessed	Number	5.20	240	220	200	150	140
			[4.2]	Capacity building through training programmes	[4.2.1]	Number of training programmes organized	Number	5.20	20000	18000	16000	15000	14000
			[4.3]	Promotion of technologies covering gender concerns	[4.3.1]	Gender-related technology promotion programs conducted	Number	2.60	30	25	20	16	15
[5]	IP management and commercialization of technologies	9.00	[5.1]	Partnership development, including licensing of ICAR technologies	[5.1.1]	Partners (private sector) identified	Number	4.50	30	25	20	15	10

	Objective	Weight		Action		Success	Unit	Weight 100%	Target/Criteria Value				
									Excellent 90%	Very Good 80%	Good 70%	Fair 60%	Poor
			[5.2]	Patents and other IPR titles	[5.2.1]	Applications filed	Number	4.50	95	90	80	70	60
[6]	Assessment and monitoring of fishery resources	6.00	[6.1]	Fish resources assessment and eco-system monitoring	[6.1.1]	Number of explorations / surveys carried out	Number	3.60	70	65	60	55	50
					[6.1.2]	Development of GIS based aquatic resource database	Number	2.40	8	6	5	4	3
[7]	Development of vaccines and diagnostics	5.00	[7.1]	Production of diagnostic kits and field validation	[7.1.1]	Diagnostic kits developed	Number	3.00	5	3	2	1	0
			[7.2]	Production of vaccines against important animal diseases and their validation	[7.2.1]	Production of vaccines	Number	2.00	3	2	1	0	0
[8]	Post harvest management, farm mechanization and value addition	5.00	[8.1]	Develop / refine equipment for crop production & processing	[8.1.1]	Equipment developed / refined	Number	1.25	20	18	16	14	12
			[8.2]	Testing of commercial prototypes/technologies	[8.2.1]	Commercial test reports/ samples tested	Number	1.25	12	11	10	8	6
			[8.3]	Process protocols for product development, storage, safety and improved quality	[8.3.1]	Process protocols	Number	1.25	11	10	8	6	5
			[8.4]	Development / refinement of products from crops, fibres, natural gums / resins, livestock / fishes	[8.4.1]	Value-added products	Number	1.25	14	12	10	8	6
*	Efficient Functioning of the RFD System	3.00		Timely submission of Draft for Approval		* On-time submission	Date	2.0	05/03/ 2012	06/03/ 2012	07/03/ 2012	08/03/ 2012	09/03/ 2012
				Timely submission of Results		On- time submission	Date	1.0	01/05/ 2012	03/05/ 2012	04/05/ 2012	05/05/ 2012	06/05/ 2012

	Objective	Weight	Action	Success	Unit	Weight 100%	Target/Criteria Value				
							Excellent 90%	Very Good 80%	Good 70%	Fair 60%	Poor
*	Administrative Reforms	6.00	Implement mitigating strategies for reducing potential risk of corruption	% of implementation	%	2.0	100	95	90	85	80
			Implement ISO 9001 as per the approved action plan	Area of operations covered	%	2.0	100	95	90	85	80
			Identify, design and implement major innovations	Implementation of identified innovations	Date	2.0	05/03/ 2013	06/03/ 2013	07/03/ 2013	08/03/ 2013	09/03/ 2013
*	Improving Internal Efficiency/responsiveness/ service delivery of Ministry/Department	4.00	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2.0	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2.0	100	95	90	85	80
*	Ensuring compliance to the Financial Accountability Framework	2.00	Timely submission of ATNs on Audit paras of C&AG	Percentage of ATNs submitted within due date (4 months) from date of presentation of Report to Parliament by CAG during the year.	%	0.5	100	90	80	70	60
			Timely submission of ATRs to the PAC Sectt. on PAC Reports.	Percentage of ATRS submitted within due date (6 months) from date of presentation of Report to Parliament by PAC during the year.	%	0.5	100	90	80	70	60
			Early disposal of pending ATNs on Audit Paras of C&AG Reports presented to Parliament before 31.3.2012.	Percentage of outstanding ATNs disposed off during the year.	%	0.5	100	90	80	70	60
			Early disposal of pending ATRs on PAC Reports presented to Parliament before 31.3.2012	Percentage of outstanding ATRS disposed off during the year.	%	0.5	100	90	80	70	60

* Mandatory Objective(s)

Section 3

Trend Values of the Success Indicators

	Objective	Action		Success indicator		Unit	Actual value FY 10/11	Actual value FY 11/12	Target value FY 12/13	Projected value for FY 13/14	Projected value for FY 14/15
[1]	Improving natural resource management and input use efficiency	[1.1]	Integrated nutrient management (INM)	[1.1.1]	Developing GIS based Number district/block level soil fertility maps,	Number	10	13	100	71	15
				[1.1.2]	Developing INM Number packages for different agro-eco regions of the country	Number	4	4	6	6	8
				[1.1.3]	Organizing training & demonstrations	Number	15	25	18	25	25
		[1.2]	Integrated water management (IWM)	[1.2.1]	Technologies for Number enhancing water use efficiencies	Number	4	4	5	2	2
				[1.2.2]	Technologies for water harvesting storage and groundwater recharge	Number	5	5	5	3	3
				[1.2.3]	Models/DSS for multiple	Number	2	2	3	1	1
				[1.2.4]	Organizing training & demonstrations	Number	10	13	15	15	16
		[1.3]	Climate resilient agriculture	[1.3.1]	Awareness building amongst stake holders through trainings / demonstrations	Number	0	100	150	100	100
				[1.3.2]	Human resource development and capacity building	Number	0	100	150	50	100
				[1.3.3]	Testing crop varieties for climate resilience at different locations	Number	0	7	10	10	10
[2]	Strengthening of higher agricultural education	[2.1]	Accreditation / Extension of accreditation of agricultural universities	[2.1.1]	Number of universities granted accreditation / extension of	Number accreditation	8	8	8	10	10

Objective	Action		Success indicator		Unit	Actual value FY 10/11	Actual value FY 11/12	Target value FY 12/13	Projected value for FY 13/14	Projected value for FY 14/15
	[2.2]	Grant of ICAR International fellowships to Indian and foreign students	[2.2.1]	Number of fellowships awarded (subject to availability of competent candidates)	Number	12	12	12	14	15
	[2.3]	Grant of JRF and SRF to students	[2.3.1]	Total No. of fellowships granted every year (subject to availability of competent candidates)	Number					
	[2.4]	Establishment of experiential learning units	[2.4.1]	Experiential learning units established	Number	20	25	22	35	37
	[2.5]	Financial support and monitoring of progress	[2.5.1]	Amount released crores	Rupees in	289	325	360	375	385
	[2.6]	Capacity building and faculty up-gradation	[2.6.1]	Number of teachers trained per year	Number	1000	100	900	1000	1000
			[2.6.2]	Number of Summer/ Winter Schools organized	Number	40	35	22	35	35
[3] Utilizing frontier research in identified areas / programs for better genetic exploitation	[3.1]	Collection, characterization and conservation of genetic resources	[3.1.1]	Number of germplasm collected/characterized and conserved (other crops)	Number	2000	2000	4000	2200	2300
			[3.1.2]	Number of germplasm collected (horticultural crops)	Number	45	300	315	400	400
	[3.2]	Evaluation of genetic resources / improved varieties for suitable crop husbandry practices	[3.2.1]	Number of germplasm evaluated	Number	1800	2000	2500	2200	2400
	[3.3]	Production of breeder seed, other seeds and planting materials	[3.3.1]	Quantity of breeder seed produced (other crops)	Tonnes	8000	8000	8200	8200	8500
			[3.3.2]	Quantity of breeder seed produced (horticultural crops)	Tonnes	2250	3500	3600	4500	4800

Objective	Action		Success indicator		Unit	Actual value FY 10/11	Actual value FY 11/12	Target value FY 12/13	Projected value for FY 13/14	Projected value for FY 14/15
			[3.3.3]	Quantity of planting materials produced annually	Number (in lakhs)	13	40	40.5	50	52
	[3.4]	Development of improved varieties suited to diverse agro ecologies	[3.4.1]	Number of varieties developed (other crops)	Number	10	10	12	12	12
			[3.4.2]	Number of varieties developed (pulses / oilseeds)	Number	–	–	13	13	13
			[3.4.3]	Number of varieties developed (horticultural crops)	Number	4	15	18	20	20
	[3.5]	Production of piglets (8-12 weeks of age)	[3.5.1]	Provisioning of piglets to farmers and development agencies	Number	900	900	900	900	1000
	[3.6]	Production of day old as well as 6 weeks old chicks	[3.6.1]	Provisioning of day old / 6 weeks old chicks to farmers and development	Number (in lakhs) agencies	0.6	2	2	2	2.5
[4] Strengthening of frontline agricultural extension system and addressing gender issues	[4.1]	Technology assessment through on-farm trials	[4.1.1]	Number of technologies assessed	Number	–	200	220	260	280
	[4.2]	Capacity building through training programmes	[4.2.1]	Number of training programmes organized	Number	–	–	18000	20000	22000
	[4.3]	Promotion of technologies covering gender concerns	[4.3.1]	Gender-related technology promotion	Number programs conducted	–	20	25	30	35
[5] IP management and commercialization of technologies	[5.1]	Partnership development, including licensing of ICAR technologies	[5.1.1]	Partners (private sector) identified	Number	20	25	25	35	40
	[5.2]	Patents and other IPR titles	[5.2.1]	Applications filed	Number	70	90	90	130	150
[6] Assessment and monitoring of fishery resources	[6.1]	Fish resources assessment and ecosystem monitoring	[6.1.1]	Number of explorations / surveys carried out	Number	40	60	65	70	75

Objective		Action		Success indicator		Unit	Actual value FY 10/11	Actual value FY 11/12	Target value FY 12/13	Projected value for FY 13/14	Projected value for FY 14/15
				[6.1.2]	Development of GIS based aquatic resource database	Number	4	6	6	7	8
[7]	Development of vaccines and diagnostics	[7.1]	Production of diagnostic kits and field validation	[7.1.1]	Diagnostic kits developed	Number	2	4	3	3	4
		[7.2]	Production of vaccines against important animal diseases and their	[7.2.1]	Production of vaccines validation	Number	2	2	2	3	3
[8]	Post harvest management, farm mechanization and value addition	[8.1]	Develop / refine equipment for crop production & processing	[8.1.1]	Equipment developed / refined	Number	20	20	18	25	25
		[8.2]	testing of commercial prototypes/technologies	[8.2.1]	Commercial test report/ samples tested	Number	12	12	11	15	15
		[8.3]	Process protocols for product development, storage, safety and improved quality	[8.3.1]	Process protocols	Number	10	11	10	13	13
		[8.4]	Development / refinement of products from crops, fibres, natural gums / resins, livestock / fishes		Value-added products	Number	12	14	12	18	18
*	Efficient Functioning of the RFD System		Timely submission of Draft for Approval		On-time submission	Date	05/03/ 2010	06/03/ 2011	06/03/ 2012	–	–
			Timely submission of Results		On- time submission	Date	27/04/2011	–	03/05/2012	–	–
*	Administrative Reforms		Implement mitigating strategies for reducing potential risk of corruption		% of implementation	%	–	–	95	–	–
			Implement ISO 9001 as per the approved action plan		Area of operations covered	%	–	–	95	–	–
			Identify, design and implement major innovations		Implementation of identified innovations	Date	–	–	06/03/2012	–	–
*	Improving Internal Efficiency / responsiveness / service delivery of Ministry / Department		Implementation of Sevottam system		Independent Audit of Implementation of Citizen's Charter	%	–	–	95	–	–

Objective	Action	Success indicator	Unit	Actual value FY 10/11	Actual value FY 11/12	Target value FY 12/13	Projected value for FY 13/14	Projected value for FY 14/15
		Independent Audit of implementation of public grievance redressal	%	–	–	95	–	–
* Ensuring compliance to the Financial Accountability Framework	Timely submission of ATNs on Audit paras of C&AG	Percentage of ATNs submitted within due date (4 months) from date of presentation of Report to Parliament by CAG during the year.	%	–	–	90	–	–
	Timely submission of ATRs to the PAC Sectt. on PAC Reports.	Percentage of ATRS submitted within due date (6 months) from date of presentation of Report to Parliament by PAC during the year.	%	–	–	90	–	–
	Early disposal of pending ATNs on Audit Paras of C&AG Reports presented to Parliament before 31.3.2012.	Percentage of outstanding ATNs disposed off during the year.	%	–	–	90	–	–
	Early disposal of pending ATRs on PAC Reports presented to Parliament before 31.3.2012	Percentage of outstanding ATRS disposed off during the year.	%	–	–	90	–	–

* Mandatory Objective(s)

Section 4

Description and Definition of Success Indicators and Proposed Measurement Methodology

Objective 1. Improving natural resource management and input use efficiency

Improving natural resource management and input use efficiency with respect to improving soil health and water productivity, integrated nutrient and water management are essential. The action points/ success indicators for INM cover developing GIS based soil fertility maps, macro / micro-level land use plans, developing and disseminating integrated nutrient management packages, technologies for improving the productivity of problem soils, IFS models etc. For facilitating IWM, enhancing water storage and ground water recharge, multiple uses of water, precision/microirrigation systems, recycling of wastewater and other on-farm management issues like resource conservation technologies, deficit irrigation, tools and models to support decision making are planned. For mitigating adverse impact of climate change on crops, livestock, horticulture and fisheries, emphasis will specifically be on climate resilient agriculture through identifying the vulnerable zones and mitigating measures through basic and strategic research. In order to improve the capacity of research and developmental organizations and their staff, provision has been made for strengthening them with state of the art technologies through training programmes / field demonstrations etc.

Objective 2. Strengthening of higher agricultural education

The success will be measured from the indicator the number of universities having developed appropriate e-learning tools and resources. Similarly, Accreditation / Extension of accreditation of agricultural universities will require number of universities granted accreditation / extension of accreditation; Grant of ICAR International fellowships to Indian and foreign students, and JRF and SRF, as applicable, will cover number of such fellowships awarded. However, such numbers of grants will also depend upon the availability of competent candidates for the fellowships. Capacity building and faculty upgradation of teachers will be measured from the number of teachers trained per year.

Objective 3. Utilizing frontier research in identified areas / programs for better genetic exploitation

The emphasis on natural resource management is laid to ensure efficient use of natural resources under the changing situations. This can be supported by developing high yielding varieties, requiring less input like fertilizers, water and pesticides. With respect to conservation of genetic resources for sustainable use, it is envisaged to conserve plant genetic resources to have repository, evaluation and further utilization of resources for improving yield in a sustainable manner. The genetic diversity of various horticultural crops will be collected from different eco-regions, characterized and utilized to develop varieties for higher yields, quality and biotic and abiotic stresses. The action points /success indicators include production of quality seed and planting materials.

Objective 4. Strengthening of frontline agricultural extension system and addressing gender issues

The success indicators with respect to assessment of technology through OFTs is measured by the actual number of technologies assessed by conducting on farm trials. Capacity building and trainings organized are measured with the actual numbers of such programme / activities undertaken by the KVKs. Regarding support for promoting gender issues is measured through the success indicators of actual number of gender related technology promotion programmes conducted by the DRWA.

Objective 5. IP management and commercialization of technologies

With respect to commercialization of technologies and promoting public-private partnership, it is envisaged to bring commercial ethos in agricultural research. Indicators for commercialization of technologies, promoting public-private partnership, and protection of intellectual property rights will be determined by the commercialization through partnership development, including licensing of ICAR technologies. The increasing numbers over the years may indicate a higher emphasis on technology transfer through enterprises; thereby contributing to larger adoption and improved socioeconomic impact of ICAR technologies.

Objective 6. Assessment and monitoring of fishery resources

To enhance fish production and productivity on a sustainable basis from the available resources, and to address the issues and strategies to overcome the critical research gaps in realizing the full production potential from fisheries and aquaculture sector, the research activities have been consolidated and prioritized. The action

points and the success indicators under this objective have been identified depending on the priority and availability of the resources and the needs and requirements of the stakeholders. It is expected that by undertaking these programmes, there would be an increase in fish production, conservation of resources, more opportunities for livelihood and employment generation.

Objective 7. Development of vaccines and diagnostics

The production of diagnostic kits and vaccines would involve delineation of process (processes) and thereby denoting a specific number for field testing / validation.

Objective 8. Post harvest management, farm mechanization and value addition

The action points / success indicators for development / refinement of equipment would include intended performance of the equipment and its commercial viability. Test results and on-farm trials will be used to judge the expected output. The success indicators will cover technologies developed to create innovative products that are commercially acceptable in competitive markets.

Section 5

Specific Performance Requirements from other Departments

1. A strong network support for channelizing awareness through training programmes, inputs like monetary support / loans, availability of germplasm, medicines, etc. and market access through state development agencies, KVKs and NGOs would play a major role. (State AH departments, DADF, KVKs, NGOs).
2. Development of animal disease diagnostics and vaccines requires sound commitment for monitoring support for production of diagnostic vaccines whereas for validation under field conditions, a strong commitment and participation of state agencies will be required. (State AH departments, Pvt. Industry for up-scaling).
3. The quantity of breeder seed produced is based on the quantity indented by Department of Agriculture and Cooperation, which in turn collects indents from various seed agencies including State Departments of Agriculture.
4. Technology adoption would depend upon the proactive role of development departments namely DAC, DST, DBT, DADF, SAUs etc.
5. Regarding the achievements related to technology assessment through OFTs and capacity building through training programme, the support of ICAR institutions and SAUs are required in order to ensure timely technology and methodology backstopping. In addition, farmers participation, sponsorship of trainees from the line departments, availability of required demonstration plots for conducting OFTS trials are some of the much needed support from the stakeholders.
6. The success with respect to promotion of technologies covering gender issues requires the collaboration of AICRP centres, Agricultural Engineering Division and the line departments are important in generating suitable gender data base, assessment of the technologies keeping in view the gender perspectives and their dissemination.
7. Popularization and commercialization of tools and equipment will require continued support of Department of Agriculture and Cooperation, Ministry of Agriculture for frontline demonstrations on large scale and capacity building of stakeholders and proactive role taken by various line departments in promoting improved technologies.
8. The Fisheries Division is working in close coordination and linkages with the Ministry of Agriculture; Ministry of Commerce; Ministry of Science & Technology; Ministry of Environment & Forest; Ministry of Earth Sciences; Ministry of Food Processing Industries, funding institutions, private entrepreneurs, NGOs, stakeholders etc. through interface and participation in various committees and meetings addressing the researchable issues in fisheries and aquaculture for formulating the strategies and guidelines for policy interventions to facilitate increasing fish production and productivity. Support from all these agencies and organizations are essential for achieving the mission of providing required food, nutritional, socio-economic and livelihood security.
9. The support of the Ministry of Finance and the Planning Commission would be crucial for realizing of set objectives, target and goals. Further, successful executing of the programmes would depend on the proactive role of other line departments of states and stakeholders for technology adoption and timely implementation of suggested strategies & guidelines.
10. Support from the concerned central / state line departments / SAUs, soil testing laboratories, KVKs, watershed associations, Pani Panchayat for promoting adoption of developed technologies.
11. Support from associated Institutes/DUs/SAUs/line departments for promoting adoption of developed technologies.
12. Financial support as per EFC / SFC allocation of institute under Horticulture Division including AICRP / network projects.
13. Support from SAUs, KVKs and line departments for promotion and adoption of technologies developed by the institutes.
14. Financial and technological support from other government departments like, DAC, NMPB, NHB, APEDA, MoRD, MoHFA, MoWR etc., State line departments and others including foreign collaborations.
15. The development and strengthening of the SAUs / AUs will depend upon the support / timely availability of sufficient fund from the central government.

Section 6

Outcome/Impact of Department/Ministry

	Outcome/Impact of Department/Ministry	Jointly responsible for influencing this outcome / impact with the following department (s) / ministry(ies)	Success Indicator	Unit	FY 10/11	FY 11/12	FY 12/13	FY 13/14	FY 14/15
1	Enhanced agriculture productivity	DADF, DAC, Planning Commission, Ministry of Environment & Forests, Ministry of Panchayati Raj, Ministry of Rural Development and State Governments	Increase in agriculture productivity	%	0	2	2	2	2
2	Enhanced milk, egg meat & fish productivity		Increase in egg productivity	%	0	3.8	4	4	4
			Increase in meat productivity	%	0	2	2	2	2
			Increase in fish productivity	%	0	2.5	2.5	2.5	2.5
			Increase in Graduates / PG	%	0	4	4	4	4
3	Enhanced availability of quality human resources for agricultural research & development activities	SAUs, SVUs, Ministry of Panchayati Raj, Ministry of Rural Development and State Governments	students passed out and capacity building	%	0	5	5	5	5
4	Enhanced rural livelihood security	DAC, DADF, SAUs, SVUs, Ministry of Panchayati Raj, Ministry of Rural Development, Ministry of Fertilizers and State Governments	Decrease in rural poverty	%	0	1	1	1	1
			Increase in farm income	%	0	3	2	2	2
5	Improved nutritional security	DST, DBT, ICMR, Ministry of Food Processing, Ministry of Panchayati Raj, Ministry of Rural Development and State Governments	Increase in per capita availability of agricultural products	%	0	1.6	0.8	0.8	0.8
6	Enhancing frontier research / programmes		Technical papers published in recognized journals	Number	0	4000	4500	5000	5000
			New varieties developed Number	Number	0	60	70	80	80
7	Commercialization of technologies	SAU/DU	Research converted into commercialized technology	Number	0	10	10	10	10

Acronyms

ADF	: Acid Digestible Fibre
AFLP	: Amplified Fragment Length Polymorphism
AI	: Artificial Insemination
AICRP	: All-India Coordinated Research Project
AINP	: All-India Network Project
AKC	: Agribusiness Knowledge Centre
AKI	: Agricultural Knowledge Initiative
AKMU	: Agricultural Knowledge Management Unit
AM	: Arbuscular mycorrhiza
APAARI	: Asian Pacific Association of Agriculture Research Institutions
APSIM	: Agricultural Production Systems Simulator
AR4D	: Agricultural Research for Development
ARS	: Agricultural Research Service
ASEAN	: Association of South-east Asian Nations
ASRB	: Agricultural Scientists' Recruitment Board
ATIC	: Agricultural Technology Information Centre
ATK	: Anytime KVK
AU	: Agricultural University
AUTM	: Association of Universities for Technology Management
BBF	: Broad Bed and Furrow
BCM	: Billion Cubic Metres
BHU	: Banaras Hindu University
BLS	: Brucella Lumazine Synthase
BOD	: Biochemical Oxygen Demand
BPD	: Business Planning Development
BTV	: Bluetongue Virus
BVDV	: Bovine Viral Diarrhoea Virus
CAFT	: Centres of Advanced Faculty Training
CARI	: Central Agricultural Research Institute
CAU	: Central Agricultural University
CAV	: Canine Adino Virus
CeRA	: Consortium for e-Resources in Agriculture
CFT	: Complement Fixation Text
CGIAR	: Consultative Group on International Agricultural Research
CGM	: Corn Gluten Meal
CIFE	: Central Institute of Fisheries Education
CIMMYT	: Centro International de Mejormento de Maize Trigo
CLCuV	: Cotton Leaf Curl Virus
CMS	: Cytoplasmic Male Sterile
CMV	: Cucumber Mosaic Virus
CN	: Chitosan
CP	: Crude Protein
CPE	: Cumulative Pan Evaporation
CPRI	: Central Plantation Crops Research Institute
CSF	: Classical Swine Fever
CTCRI	: Central Tuber Crops Research Institute
CTMC	: Central Technology Management Committee
CPC	: Corn Protein Concentrate
CWM	: Chicken Waste Meal
DARE	: Department of Agricultural Research and Education
DAS	: Days After Sowing
DAT	: Days After Transplanting
DBT	: Department of Biotechnology
DDG	: Deputy Director General
DG	: Director General
DKMA	: Directorate of Knowledge Management in Agriculture
DM	: Dry Matter
DRWA	: Directorate of Research on Women in Agriculture
DU	: Deemed-to-be University
ECM	: Electronic Control Module
EGC	: East Ganga Canal
EHV	: Equine Herpes Virus
EIA	: Enzyme Immuno Assay
EICA	: Egyptian International Centre for Agriculture
ELISA	: Enzyme-linked Immunosorbent Assay
ENVI	: Environment, Public Health and Food Supply
EPN	: Entomopathogenic Nematode
ETL	: Economic Threshold Level
EXPSS	: Expert System on Seed Spices
FAO	: Food and Agriculture Organization
FBS	: Fetal Bovine Serum
FMD	: Foot-and-Mouth Disease
FSH	: Follicle-stimulating Hormone
FYM	: Farmyard Manure
GADVASU	: Guru Angad Dev Veterinary and Animal Sciences University
GBNV	: Groundnut Bud Necrosis Virus
GBPUAT	: Govind Ballabh Pant University of Agriculture and Technology
GFAR	: Global Forum on Agricultural Research
GDD	: Growing Degree Days
GDP	: Gross Domestic Production
GIS	: Geographical Information System
GPA	: Global Plan of Action
GPS	: Global Positioning System
GRD	: General Recommended Dose
HAPA	: Hybridization-supplemented Apomixis Components Partitioning Approach
HDPE	: High Density Polyethylene
HPTLC	: High Performance Thin Layer Chromatography
HRD	: Human Resource Development
IAA	: Indole Acetic Acid
IARI	: Indian Agricultural Research Institute
IASRI	: Indian Agricultural Statistics Research Institute
IBR	: Infectious Bovine Rhinotracheitis
ICAR	: Indian Council of Agricultural Research
ICARDA	: International Centre for Agricultural Research in Dry Areas
ICMV	: Indian Cassava Mosaic Virus
ICRISAT	: International Crops Research Institute for Semi-Arid Tropics
ICT	: Information and Communication Technologies
IFS	: Integrated Farming System
ILWIS	: Integrated Land and Water Information System
INM	: Integrated Nutrient Management
IPGRI	: International Plant Genetic Resources Institute

IPM : Integrated Pest Management
IPR : Intellectual Property Rights
IRRI : International Rice Research Institute
IVDMD : *In vitro* Dry Matter Digestibility
IVRI : Indian Veterinary Research Institute
JEV : Japanese Encephalitis Virus
KM : Knowledge Management
KVASU : Kerala Veterinary and Animal Sciences University
KVK : Krishi Vigyan Kendra
LCV : Leaf Curl Virus
LDPE : Low Density Polyethylene
LMU : Land Management Unit
LPG : Liquid petroleum gas
MAb : Monoclonal Antibody
MAP : *Mycobacterium avium* subsp. *paratuberculosis*
MAS : Molecular Marker-assisted Selection
MGNREGS : Mahatma Gandhi National Rural Employment Guarantee Scheme
MNRE : Ministry of New and Renewable Energy
MDV : Marek's disease virus
MoU : Memorandum of Understanding
MPP : Methane Production Potential
MPAUT : Maharana Pratap University of Agriculture and Technology
MR : Moderately Resistant
MSCs : Mesenchymal Stem Cells
MW : Molecular Weight
NA : Nutrient Agar
NAARM : National Academy of Agricultural Research and Management
NABG : National Agricultural Bioinformatics Grid
NAE : Niche Area of Excellence
NAIP : National Agricultural Innovation Project
NARC : Nepal Agricultural Research Council
NARD : National Agricultural Research Database
NARS : National Agricultural Research System
NBSS&LUP : National Bureau of Soil Survey and Land Use Planning
NDF : Non-digestible Fibre
NDRI : National Dairy Research Institute
NEH : North-eastern Hills
NET : National Eligibility Test
NFBSFARA : National Fund for Basic, Strategic and Frontier Application Research in Agriculture
NGOs : Non-Government Organizations
NHCP : National Herbarium of Cultivated Plants
NIABI : Network of Indian Agri-business Incubators
NICRA : National Initiative on Climate Resilent Agriculture
NISAGENET : National Information System on Agricultural Education Network
NISM : National Information Sharing Mechanism
NPV : Nuclear Polyhedrosis Virus
NRC : National Research Centre
NSKE : Neem Seed Kernel Extract
NTS : National Talent Scholarship
OBCs : Other Backward Classes
OER : Open Educational Resources
OL : Other Languages
OMP : Outer Membrane Protein
OUAT : Orissa University of Agriculture and Technology
PAGE : Polyacrylamide Gel Electrophoresis
PAU : Punjab Agricultural University
PCR : Polymerase Chain Reaction
PCV : Packed Cell Volume
PG : Post-graduate
PGPR : Plant Growth Promoting Rhizobia
PLC : Programmable Logic Controller
PPGSE : Plausible Potato Growing Seaons Estimator
PPR : Peste des Petits Ruminants
PSE : Pale Soft Exudative
PSS : Porcine Stress Syndrome
PTO : Power Take Off
RAU : Rajendra Agricultural University/Rajasthan Agricultural University
RAWE : Rural Agricultural Work Experience
RDF : Recommended Dose of Fertilizers
RE : Revised Estimate
RFD : Results-Framework Document
RFLP : Restricted Fragment Length Polymorphism
RH : Relative Humidity
RMP : Research Management Positions
RNFE : Rural non-farm Employment
SAARC : South Asian Association for Regional Co-operation
SAB : Spore Associated Bacteria
SAUs : State Agricultural Universities
SCAR : Sequence Characterized Amplified Region
SCSMV : Sugarcane Streak Mosaic Virus
SiRNA : Small interferring RNA
ShRNA : Small hairpin RNA
SLCMV : Sri Lankan Cassava Mosaic Virus
SMA : Single Marker Analysis
SNP : Single Nucleotide Polymorphism
SOC : Soil Organic Carbon
SOD : Superoxide Dismutase
SRF : Senior Research Fellowship
SSD : Surface and Subsurface Drainage
SRI : System of Rice Intensification
SSH : Suppression Subtractive Hybridization
SVVU : Sri Venkateswara Veterinary University
SWYMOD : Surface Water Yield Model
TANUVAS : Tamil Nadu University of Veterinary and Animal Sciences
TDN : Total Digestible Nutrient
TFP : Total Factor Productivity
THI : Temperature Humidity Index
TLCV : Tomato Leaf Curl Virus
TLR-1 : Toll Like Receptor-1
TNAU : Tamil Nadu Agricultural University
TOT : Transfer of Technology
TSBV : Thaisac Brood Virus
TSP : Tribal sub-Plan
TSS : Total Soluble Solids/Sugars
UAS : University of Agricultural Sciences
UG : Under-graduate
UGC : University Grants Commission
UV : Ultra Violet
VACV : Vaccinia Virus
VCRMC : Village Climate Risk Management Committee
VPKAS : Vivekananda Parvatiya Krishi Anusandhan Sansthan
VTCC : Veterinary Type Culture Centre
WB : Western blot test
WNV : West Nile virus
WUE : Water-use Efficiency
WPR : Workforce participation rate

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