



# 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<sup>2</sup>) area under the category of severe erosion. Geographical Information System (GIS) based soil organic carbon (SOC) map of six north eastern states (Assam, 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<sup>h</sup>-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<sub>1</sub> 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 dioica*) 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<sub>50</sub>G<sub>50</sub>: 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 *khari* 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 5SS, 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<sup>-2</sup>) 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 *Tenulosa 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](http://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. EATRIT 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 institutes 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 85<sup>th</sup> 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

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and  
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