1

Overview

With about 60% of the cultivated area as rainfed, our agricultural production is strongly influenced by the movement of South-west monsoon. The rainfall for the period, June-September 2009, was 77% of its long period average (LPA). The monsoon set in over Kerala on 23rd May, one week before its normal date of 1st June, it advanced rapidly and covered the entire country by 3rd July, compared to its normal date of 15th July. Out of 526 meteorological districts for which data are available, 215 districts (41%) of the meteorological districts received excess/normal rainfall and the remaining 311 districts (59%) received deficient/scanty rainfall during the season that reflected adversely on the overall production of *kharif* crops especially, rice and the coarse grains. Responding to the situation, the Council formulated and helped in implementation of the technology-driven contingency crop plan to mitigate the effects of drought like situation following erratic monsoon and to compensate the *kharif* crop losses during the *rabi* season. Crop-weather advisories were disseminated through the country-wide network of the ICAR research institutes, state agricultural universities and Krishi Vigyan Kendras (KVKs). An area of 36,675 ha with the participation of 56,719 farmers was brought under demonstrations on resource conservation technologies in districts facing drought. The drought like situation followed by floods in several parts of the country was a cause of concern and more so because we are witnessing this phenomena with increasing frequency.

The Indian Council of Agricultural Research continued to move forward in generating technologies towards sustainable scientific and knowledge-based advancements in agriculture and allied sectors, improving quality of higher agricultural education, institutional capacity building, and establishing linkages/partnerships with other national/international agricultural research and development organizations/systems. The research and development programmes undertaken during the year addressed areas of optimizing resources' use, improved cultivation techniques, development of improved varieties/breeds, excellence in agricultural education by implementing the reforms and frontline extension of technologies, providing improved planting materials, imparting training for skill development/enhancement especially to rural women and youth and various stakeholders. Human Resource Development (HRD) programmes and talent search in agricultural sciences to meet the future needs of agricultural research, education and extension received priority attention.

For cutting edge research across disciplines and commodities, a National Institute on Abiotic Stress Management, with deemed-to-university status, has been established in Maharashtra and is already operational. The National Institute on Biotic Stress Management and National Institute on Biotechnology have also been approved in principle. A DNA bank has been established, cutting across plant and animal kingdom, so that desirable traits could be incorporated while evolving new varieties, hybrids, breeds etc. For value-addition and efficient utilization of genetic resources and to check biopiracy, special thrust is being given on gene prospecting and allele mining; phenomics, functional genomics and bioinformatics. The ICAR has embarked upon an ambitious multidisciplinary programme 'Bioprospecting of Genes and Allele Mining for Abiotic Stress Tolerance' to meet the challenges due to climate change. Thirty-five institutes are involved in this project. This will also broaden the window of optimal growth conditions for cultivated crops under adverse climate, thereby increasing yield and reaping

enhanced stabilized production under changed climatic conditions.

To safeguard the livestock production, a high security animal disease lab with P-4 measures was established. It played a pivotal role in providing diagnostic services for avian influenza besides developing vaccine. "Garima" a cloned buffalo calf was born through a new and advanced 'Hand-guided cloning technique', at the NDRI, Karnal on 6 June 2009. The growth of the calf is normal and has good health status. For the first time a Mithun calf was born through Artificial insemination.

Some of the Council's initiatives and salient achievements during the year under report are presented here.

Soil and water: Among the *Pseudomonas* strains isolated from rainfed regions of India, *P. putida* 'GAP-P 45' was able to induce synthesis of novel proteins in the plants conferring tolerance to drought stress. Bagasse proved a successful bio-stimulator for the removal of ammonia and nitrate in shrimp aquaculture. This technology is available for adoption by farmers.

Farming system: Gmelina-turmeric based agroforestry was found suitable for Humid and Sub-Humid regions. Gmelina with turmeric, sapota, teak-based agroforestry system proved useful for adoption in transitional and hilly zone with medium/deep soils under irrigated condition in Karnataka.

A pond-based farming technology (deep water rice in *kharif* + watermelon, okra, spinach, chili in winter + on-dyke vegetables-fruits + fish inside pond) in a representative deep waterlogged areas (1.0-2.5 m water depth) of Puri district, Orissa enhanced the net water productivity to Rs 7.21/ m^3 and net returns (Rs 22,100) in rice. Rainwater harvesting system was designed and agricultural diversification model (on-dyke horticulture, fisheries, cultivation of diversified field crops, short-term fruits like papaya, banana, floriculture like marigold, tuberose etc.) with harvested rainwater was developed for small and marginal farmers with multiple use of water. The technology has been recommended for inclusion in the 'National Rural Employment Guarantee Act' (NREGA) for implementation in watersheds of eastern Indian states. Water requirement of animals fed on cactus + grass/straw feed was considerably reduced, making the cactus a feed admixture of choice in the regions facing water-scarcity. A network of 47 model watersheds has been developed that provides a basis for undertaking projects as part of the natural watershed development programme.

Climate change: The studies under controlled environment conditions (free air CO_2 enrichment, open top chambers) and modeling showed that a rise in atmospheric carbon dioxide up to 550 ppm enhanced the yields of wheat, chickpea, greengram, pigeonpea, soybean, tomato and potato between 14% and 27%. In coconut, arecanut and cocoa, increased CO_2 led to higher biomass production. A study on Sahiwal and Holstein Friesian crossbred (Karan-Fries) heifers revealed that HSP72 protein level increased due to thermal exposures, relatively higher in Karan-Fries (106%) than Sahiwal (22.4%). Resource conserving technology was the most cost-effective strategy to reduce N loss and GHG emission, whereas integrated N management costs high for mitigating greenhouse gases (GHG) emission.

Genetic resources: During the year, 38 explorations were undertaken and 2,892 accessions including 784 of wild species were collected. In the National Herbarium of Cultivated Plants, 294 specimens were added. A total of 32,260 accessions including 5,373 international trial material were introduced from 45 countries. As many as 720 germplasm lines have so far been registered. About 9,530 accessions of orthodox seed species were added to the National Gene Bank. Sixteen Phyto-sanitary Certificates were issued for export of 1,120 samples.

Among fruit crops, 78 accessions and 16 superior clones of mango, 122 accessions of guava, 4 of litchi, 24 of banana, 9 of citrus, 14 of grape, 25 of pomegranate and 8 of *ber* were collected. In the field gene bank, 5 distinct coconut, 23 oil palm and 14 cashew accessions were added. Late blight- and early blight-resistant source JX90 of potato was registered with the National Bureau of Plant Genetic Resources (NBPGR), whereas 30 indigenous and 29 exotic collections of sweet potato were collected from Meghalaya. In the national repository, 109 red onion, 57 white onion and 46 garlic collections got the place. Forty-one distinct strains of *Pleurotus* species were characterized. A total of 33 clove, 122 nutmeg, 42 cinnamon and 10 cassia germplasm lines were collected. Eight new accessions of rose, 89 endangered and rare species of orchid were collected from North-Eastern region. The new collections of medicinal and aromatic plants consisting of 42 of *ashoka*, 31 of *ashwagandha* and 43 of *giloe* were added in the repository.
The National Bureau of Agriculturally Important Microorganisms repository has now more than 2,000 collections of culture fungi, 500 bacteria, 30 actinomycetes and 20 yeasts. Bacterial inoculants, developed to alleviate the harmful effect of salinity for enhanced growth and yield of wheat in saline soils, were identified through sequencing of 16S rDNA. A *Catalogue of Microbial Cultures* was also brought out.

The role of A1 and A2 beta casein milk variants in human health is a matter of concern for scientific investigations. The ß-casein A1/A2 frequency data indicated predominance of A2 variant (0.987) in zebu cattle breeds, while buffaloes showed only A2 milk type. The results point towards the origin of A2 variant in *Bos indicus* cattle. This is the first report of A1/A2 milk variant in majority of Indian zebu cattle and riverine buffalo breeds. An association study showed higher adult body weight of the individuals carrying the allele in yak. This marker information could be incorporated in marker-assisted selection for higher adult body weight in yak, as the body weight determines draught and pack ability and quantity of meat production.

Chemo-litho-autotrophic bacteria, which can be used for bioremediation of shrimp-farm discharge, were identified. A molecular tool was developed for the detection of these bacteria and is being offered to private entrepreneurs for its commercialization. Barcoding of five species of tuna was carried out and deposited with the gene bank of the National Centre for Biotechnology Information (*http://www.ncbi.nlm.nih.gov/taxonomy*). Forensic investigations using DNA barcoding helped in identification of whale shark (*Rhyncodon typus)* meat designated as endangered species. And it can be used effectively in curtailing illegal trade.

Crop improvement: One hundred and thirty-one varieties/hybrids of major food crops including rice, wheat, barley, maize, pearl millet, and pulses and oilseeds have been released/identified for different agro-climate regions of the country.

Significant crop improvement research includes development of rice varieties, namely Improved Pusa Basmati and Improved Samba Mahsuri, identification of 17 high-yielding varieties of pulses, six varieties of groundnut, one variety of soybean and two hybrids of sunflower for release in different agro-ecologies and production of 7,339.7 tonnes of breeder seed of centrally released field crop varieties. Gene sources for resistance to Ug99 rust with new genes have been developed and race-specific and adult plant resistance to Ug99 and its cool temperature derivatives have been successfully introgressed in Indian wheat breeding materials.

In coconut, accession IND 125 S was recommended for cultivation in Karnataka, Tamil Nadu and Kerala, and hybrid IND 376 for Asom and Kerala. Two varieties, namely Kufri Nilima and Kufri Frysona, of potato were released for cultivation in Nilgiris hills of Tamil Nadu and Indo-Gangetic plains respectively. In spices, one variety each of ginger (Subhada) and cumin (RZ 345) was recommended for release.

Hybrid 1084 of dwarf stature mango with regular bearing was found promising. In banana, embryo rescue was standardized for wild species and hybrids involving wild species. Fingerprints of 44 grapes accessions were developed. Bhima Red variety of onion, developed through bulb to row selection method, possesses attractive red colour with yield around 30 tonnes/ha in *rabi* and yield potential of 50 tonnes/ha in late *kharif*.

The bud chip technology emerged as one of the most viable and economical alternatives in reducing the cost of sugarcane production, besides other advantages. Bacterial inoculants developed to alleviate harmful effect of salinity for enhanced growth and yield of wheat in saline soils were identified through sequencing of 16S rDNA. Leaf powders of *Vitex nigundi*- and *Polygonum*-treated food recorded least preference by *Rattus rattus* in laboratory, indicating their anti-rodent properties.

The double hedge row system of planting in guava, aonla and litchi proved best method for realizing high fruit yield.

Under salinity stress, Thompson Seedless grape when grafted on B2-56 rootstock exhibited high level of stress tolerance. Wedge grafting in walnut practiced under polytrench recorded high success rate. In arecanut, mined cropping with pepper, banana and citrus was suitable for North-eastern region. The intercropping systems involving ginger, tapioca, coleus, amorphophallus for black pepper; sweet potato + red gram; elephant foot yam with mango/sapota, potato + garlic have been identified for continuous and high yield. Release of bio-control agents, namely *Mallada boninesis* and *Tamarixia radiata*, in citrus orchards resulted in 31-33, 47-49 and 26-30% reduction of blackfly, psyla and leaf miner populations respectively. By releasing parasitoids, infestation on coconut leaf by leaf-eating caterpillar could be suppressed effectively. Soft rot of ginger could be managed by bio-fumigation using cabbage and mustard plant refuses. Marigold and yam bean were found to be effective barrier crops for sweet potato weevil. The problem of fruit cracking in pomegranate could be reduced with application of boron and zinc.

Livestock improvement: The average age at first calving of Frieswal cows was 979.56 days. The breeding value of Hariana sires for milk yield and draught ability confirmed that these 2 traits are of different nature. The introduction of *FecB* gene from Garole into Malpura and backcrossing of GM with Malpura increased body weights of their lambs, and GMM ewes produced 40.0% twins in the flock. Layer poultry variety Gramapriya was widely accepted by the farmers of Kashmir valley.

Puntius pulchellus locally called *Haragi Meenu*

in Karnataka, a threatened species of peninsular carp endemic to the Krishna river basin, was induced bred for the first time. A technology for round-the-year seed production of Asian seabass was developed. Electron beam irradiation method could be devised to reduce anti-nutritional factors in plant-based aquafeed ingredients.

To achieve targeted growth rate of 6% in livestock output, progress in livestock infrastructure, institutional efforts and availability of livestock feed is required to be accelerated by about 50%. Supplementation of zinc and copper from organic sources was more effective in inducing estrus and anoestrus crossbred cows. Methane emission from fresh dung on dry-matter basis was lower in zebu cattle than crossbred cattle. Green fodder feeding increased milk conjugated linoleic acid (CLA) in cows and buffaloes. The CLA has anticancer property, and it increases up to 310% in *ghee* prepared by indigenous method. Commercially available microbial feed additives enhanced growth by 12.0% and feed intake by 11.6% in fattening lambs for mutton production. As supplementation of concentrate mixture during post-weaning stages improved body weights of lambs, farmers fetched 25 - 33% more price in the market.

An antioxidant (vitamin E) in combination with liver stimulant was found detrimental for egg production in birds. Combination of melatonin and toxin binder alleviated adverse effects of aflatoxicosis in broilers.

The foot-and-mouth virus typing ELISA kits were manufactured, which ensured uniformity in application and test result across the country. Establishment of an international Foot-and-mouth Disease Reference Laboratory will facilitate Global participation and eradication of the disease from South Asia.

A 'FROGIN' software was developed for precise prediction and forecasting of haemonchosis in sheep. Complete *HN* and *F* genes of velogenic Newcastle disease virus were cloned for use as bi-cistronic DNA vaccine. PLG nanoparticles encapsulating outer membrane proteins of *Salmonella* Gallinarum induced good IgA antibody in chickens.

The marine fish landings in India during 2008-09 touched the 3.21 million tonnes mark with an increase of about 0.327 million tonnes (11.3%) against the estimates of the previous year. The percentage share of fishermen in consumer rupee (PSFCR) has also increased over the years. High-value fish like coastal tuna and oceanic tuna registered growth level of 23% and 39% respectively. The targeted fishery for the deep sea sharks on the west coast landed more than 14 species of sharks as well as chimaeras. Biosecured zero water exchange system technology is ready for on-farm demonstration and dissemination to farmers.

Post-harvest management and value-addition: A fermented drink/beverage from banana pulp and sorghum sprouts was produced from over-ripe bananas. The beverage can be preserved with flavour for 3 months under refrigerated conditions. For preparation of dried juice powder of citrus fruits, fresh fruits of four *Citrus* species, namely citron, acid lime, Nagpur mandarin and Mosambi, as well as juice blend of pummelo and citron fruits were utilized to manufacture the value-added products.

Carbonated beverages were prepared from mango, passion fruit and custard-apple. Two hair-care products, namely 'Aloe Shampoo' and 'Aloe Hair Cream' having shelf-life of more than 10 months were developed from *Aloe vera*.

Extrudates were prepared from cassava blended with corn flour, *maida*, wheat flour and finger millet. High protein and dietary fibre-enriched pasta were prepared from cassava-*maida* blends. The protein content could be enhanced to 11-12% with whey protein concentrate, defatted soy flour and prawn paste. Bonding applications was upscaled to 5.0 kg level and is ready for transfer. The solid adhesive was tested on various surfaces by a industry in Kerala.

A process patent (No. 1261/MUM/2008) has been filed by the Directorate of Medicinal and Aromatic Plants Research (DMAPR) at Indian Patent Office, Mumbai, for preparation of pure aloin from aloe through extraction and purification. The new method is easy, quicker, efficient (recovery up to 90%) and cost-effective (most of the solvent used can be recovered for reuse) and can be used for extraction of aloin of high quality from fresh, sun-dried, oven-dried or freeze-dried leaf exudates. As aloin purity of more than 90-95% can be achieved by this method, it is suitable for industrial purposes.

A technology was evolved for development of pulp and paper by mechanical pulping process (chemical free) from date palm leaf and carry bag, writing pad etc. The technology can be transferred to rural sectors at low capital investment. A lac-based formulation was developed for fruit-coating applications on apple and citrus fruits like kinnow and orange. The formulation yielded good results in respect of gloss and firmness to kinnow. Shellac-based dental plates were prepared. Natural-synthetic composite geotextile was used for protection of a part of the bank of Mayurakshi River (rainfed river) in West Bengal.

Pomegranate aril extractor is capable of processing whole pomegranate at a rate of approximately 30–35 fruits/minute, and this

technology was transferred for commercial exploitation. System for the storage of live fish with aeration was designed, developed and tested. The FRP silo for fish culture/holding system, which is first of its kind in the country, was designed and fabricated. Microbial assays were developed, which are useful in dairy industry as "ON FARM" milk screening test for β-lactam group. Health benefits of cow *ghee* were validated. Cow *ghee* decreases initiation and progression of mammary and gastro-intestinal tract cancer in rats.

A software Cotton Bale Manager was developed to perform design and generation of bale identification tag and to interface this bale tag with the bale database management software. Another software GINERP for managing a modern ginnery has already been commercialized.

Agricultural engineering and energy management: A number of implements such as manure spreader, hill drop planter, cumin planter, baler with reaping attachment were developed as tractor-operated machinery. A power tiller-operated two-row canopy sprayer was developed for cotton and pigeonpea that can remove more than 550 bud chips/hr/person. A suitable experimental model of continuous type animal feed block making machine was fabricated.

In a poultry litter-based biogas plant, the use of poultry litter increased the yield of biogas generation by 17% (from 66 to 83%) compared to normal cowdung-based biogas plant. The briquettes made from soybean and pigeonpea stalks can be used for domestic application, in gasifier and commercial boilers. A rapid process for ethanol production from kinnow waste (peel+ pulp) using galactose adapted yeast cells was developed. Significant achievements include development of novel micro-well chip based biosensor, revelation of methodology for isolation and purification of microbial polysaccharides, isolation of nitrate-reducing microbes having potential to be used as probiotics in mitigating methane emission for eco-friendly livestock production.

Agricultural human resource development: Efforts are being made for continuous upgradation and maintenance of standards and quality of higher agricultural education in the country through professional support and financial aid to the Agricultural Universities. The National Academy of Agricultural Research Management, Hyderabad, started the two-year post-graduate diploma programme on management (Agriculture) besides its other two programmes on Information Technology management and Intellectual Property management. Accreditation was granted to five State Agricultural Universities (SAUs) and to the MBA programme of the Rajasthan Agricultural University, Bikaner. Thus 31 institutions are accreditated for higher quality education.

Construction of one museum each in 38 SAUs, allocation of Rural Awareness Work Experience (RAWE) Programme to 44 Agricultural Universities (AUs) and institution of "Norman Borlaug chair in Agricultural Biotechnology for crop improvement" are expected to improve the quality of education. To face the emerging challenges, the Model Act for AUs in India was revised and communicated to all AUs for adoption. A national core group formed by the ICAR, has revised the course curricula and syllabi of all PG (masters and doctoral) programmes to make them utilitarian, updated and competitive. A new component of International fellowship was introduced for pursuing Ph.D. programme at the Indian Agricultural Universities and Overseas Universities for Indian and overseas candidates. More than 3,000 theses have been digitized and full text data uploaded (*http://www.hau.ernet.in*). The 'Agropedia' has further diversified and over 30,000 people from 165 countries visiting the site (*www.agropedia.net)*. aAQUA SMS and voice services are reaching more than 10,000 farmers regularly.

Information, communication and publicity services: The Council has redesigned and further developed website (*www.icar.org.in*). The *ICAR News* and *ICAR Reporter* were made available on-line, besides several other publications. Guidelines were developed for bringing uniformity in the websites of ICAR institutes.

The ICAR institutes/SAUs are being connected to National Knowledge Network through an electronic digital broadband to encourage sharing of resources for collaborative research and education. Under "e-Publishing and Knowledge System in Agricultural Research (E-PKSAR)", a fully automated, on-line electronic publishing system is being implemented for eleven journals/ periodicals. More than 1,000 research articles/ features were published in the noted periodicals of the ICAR during the year. A professional get-up was imparted to popular periodicals that included design, layout and contents.

Technology assessment, refinement and transfer: During the year, KVKs have assessed appropriate technologies by conducting 26,028 trials in 8,254 locations. Towards empowerment of rural women, KVKs have also assessed 99 technologies under the thematic area of drudgery reduction, health and nutrition involving 280 locations. A total of 86,285 frontline demonstrations involving an area of 51,101 ha were conducted by KVKs. Under the frontline demonstrations conducted, 76,206 were on oilseeds, pulses, cotton and other important crops covering an area of 30,664 ha.

A total of 4,600 demonstrations on-farm implements covering an area of 4,212.23 ha were conducted. Further, 5,479 demonstrations were conducted on 16,225 units of various enterprises including dairy, piggery, poultry, sheep and goat rearing, fisheries, bee-keeping, mushroom cultivation, nutrition gardening, sericulture, organic composting, home science and bio-products.

In the case of farmers' capacity building, 39,912 training programmes were organized, benefiting 11.27 lakh farmers and farm women. As many as 12,978 skill-oriented training programmes were organized for 3.10 lakh rural youths. A total of 3,929 training programmes were conducted covering 103,428 extension functionaries of state departments. The KVKs also organized 3.04 lakh extension programmes, benefitting 106.85 lakh farmers and extension personnel to create awareness about improved agricultural technologies. The KVKs have conducted 240 training programmes and 128 crop demonstrations by utilizing demonstration unit of rain water harvesting with micro-irrigation system.

The KVKs have produced seeds, planting materials, bio-products, livestock material, poultry and fisheries to a tune of Rs 1,304.47 lakh benefiting 4.22 lakh farmers. During the year, the KVKs produced 2.08 lakh quintal of seeds including cereals, oilseeds, pulses, commercial crops, vegetables, flowers, spices, and fodder and fibre crops. Besides, KVKs produced 146.09 lakh seedlings and saplings and provided to 159,000 farmers. Other achievements include motivation of more than 48,000 farmers in backward areas with large population of tribals; adoption of suitable drought mitigation measures with suitable advice to the farmers; introduction of lac cultivation in Jharkhand, Chhattisgarh and Madhya Pradesh as a major income-generating activity, particularly under rainfed/dryland situations.

A road map based on technological interventions has been adopted to enhance the production and productivity of *rabi* crops to cover the deficit in food production during the year.

Finance: The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan and Non-Plan) for 2008-2009 are Rs 2,680.00 crore and Rs 2,982.64 crore, respectively, and BE for 2009-10 (Plan and Non-Plan) is Rs 3,314.00 crore.

IP portfolio management: Patents were granted to the ICAR in 8 fields of invention. The ICAR institutes secured 4 Trademarks to distinguish the ICAR products. Six copyrights were registered by the ICAR institutes to protect their software from unauthorized copying. The premise of centralized planning and decentralized execution for Intellectual Property Management in the ICAR was strengthened. Some of the ICAR institutes have entered into MoUs with private and public sector companies for commercialization of plant varieties/hybrids.

Awards and incentives: Fifty-five awardees under twelve different categories were conferred awards. These comprised three Institutions, 47 scientists including nine women, three farmers and two journalists.

Partnership and linkages: The Memorandum of Understanding was signed between ICAR and Biodiversity International for Scientific and Technical Co-operation. Besides, four Collaborative Projects were approved for implementation by the various institutes of the ICAR. The ICAR is imparting training to foreign nationals belonging to Iran, Sri Lanka, Ethiopia, Rwanda, Myanmar, Bhutan, Botswana, Iraq, Nepal, Vietnam and Nigeria under agricultural knowledge empowerment. In Protocol activities, DARE facilitated foreign delegations, Indian scientists to foreign countries on deputation. The Council under the National Agricultural Innovation Project (NAIP) has also approved 61 sub-projects on the cutting-edge agricultural and allied technologies. These sub-projects have very diverse partnership such as ICAR institutes and State Agricultural Universities, general universities, IITs, IIMs, CSIR laboratories, other central and state government departments, private sectors and NGOs.

The Council is committed to meet the emerging challenges in the field of agriculture and allied sectors through technological interventions. Human resources to generate appropriate location-specific technologies and inter-institutional knowledge support is one of our priority areas. Alleviation of hunger, poverty and strengthening of livelihood security are our goals to achieve. In the wake of global climate change and looming global food crisis, our responsibilities have increased manifold, but I am sure, the pro-active steps taken by the Council will certainly help us in ensuring the food security for millions of countrymen.

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