1. Overview

The year 2006–07 augured well for Indian agriculture and the country recorded an all-time high production of foodgrains, sugarcane and cotton. The horticulture, livestock and fisheries sector also showed an impressive performance. The *kharif* production for 2007-08 is presently estimated to be 112.24 million tonnes.

The Planning Commission has approved a total plan outlay for the 11th Five-Year Plan of DARE/ ICAR at Rs 12,023 crore which is more than the double of the 10th Plan outlay of Rs 5,368 crore. The enhanced outlay would help boost institutional capacity, both in terms of human and infrastructural resources, to generate cutting-edge technologies.

The slowdown in the rate of growth in agriculture sector is a national concern and technological backstopping is an imperative to increase the velocity of agricultural growth. Recent initiatives have started paying dividends with agricultural growth of about 4 per cent. The Indian Council of Agricultural Research (ICAR) has documented *State-specific Technological Interventions* to address the location-specific technology dissemination which is being widely used.

The project on quality seed production in agricultural crops and fisheries has paid rich dividends, as the production of quality seed, saplings and fingerlings has more than doubled within a short span of an year of its launch. In the ongoing year, there is every indication that it would be further doubled in most of the cases. Virtually, this has triggered further growth.

Water for use in agriculture is rapidly becoming a critical limiting factor. Realizing the need to address this vital component of sustainable agriculture, a special corpus fund amounting to Rs 96 crore has been earmarked to impart training and conduct demonstrations for trainers and farmers in 32 institutions on water management. Climate change in the form of rising temperature, altered water cycles, melting of glaciers in the Himalayas, etc. now poses a threat to the sustainability of agriculture. A National Conference on climate change was organized to deliberate upon the probable scenario, and research strategies for adaptation and mitigation were drawn. Many of them are already put to implementation.

An annual financial support of Rs 388 crore was given to Agricultural Universities for modernization and strengthening of academic facilities and updating infrastructure and faculty improvement. This one-year support is more than the financial support provided in the entire IXth Five-Year Plan period. For strengthening the human resource development programme in the North-east region of the country, a new College of Post-graduate studies was established during the year at Barapani in Meghalaya and another on Post-harvest Management was made operational in Sikkim under the Central Agricultural University.

During the year, seven patents were granted, and 53 patent and 272 Plant Variety Protection applications were filed. An overview of the important activities, research achievements and new initiatives taken during the period under report is presented here.

Soil and water productivity

Soil resource maps were digitized and developed for Karnataka and Andhra Pradesh. A rapid biological field kit was developed to assess decomposability of farm-waste during composting. System of Rice Intensification was demonstrated for enhancing land, water and crop productivity and saving labour input. For reclamation of saline sodic soils, a horizontal flushing technique to reduce the gypsum requirement substantially has been proposed. Integrated farming systems combining agriculture, livestock, fisheries and

aquaculture, and a host of agri-enterprises with enhanced productivity, profitability and livelihoods were demonstrated. A highly remunerative cropping system involving plantation of drumstick with greengram-fennel was suggested in place of tobacco monocropping for the reclaimed Mahi ravines.

Genetic resources

Collection and conservation of plants, animal and fish genetic resources is one of the important activities for their improvement. A total of 22,003 cultivated and wild germplasm were collected from 21 states. About 25,000 accessions were characterized and evaluated, and over 16,800 plant genetic resources conserved in the National Gene Bank. Besides, salvaged 96.64% of the infected/ infested exotic accessions were processed for quarantine clearance. More than 365 exotic germplasm of *Gossypium hirsutum* could be acquired from the USA, China, Pakistan and Iran. Germplasm (49), possessing unique traits, were registered which included cereals, millets, pulses, oilseeds, fibre crops and forages, vegetables, tubers, ornamentals, medicinal and aromatic plants. In important fruit crops, 190 accessions enriched the genetic resources. More than 650 genotypes strains of different fruits grown in arid regions were collected. In vegetables 2,000 germplasm lines were also collected from different parts of country.

In case of freshwater and marine fish species, 1,200 tissue accessions and 550 DNA sequences were added to the NBFGR repository. DNA repository of sheep breeds Ganjam, Kendrapara, Deccani, Nellore, Nali, Magra, Chokla, Garole, Patanwari, Marwari, Kheri, Malpura, Muzaffarnagri, Jaisalmeri and Sonadi was established. The cDNA of uterine milk protein and genome sequence (>4 kb) of *ghrelin* gene of buffalo was cloned and characterized.

Nearly 3.2 lakh insects and mites were collected through field surveys in 27 states/union territories in 165 districts and over 2,500 cultures of isolated filamentous fungi, bacteria, actinomycetes and yeasts from soil, plants and insects were maintained in repository. Twenty different groups of *Bacillus* in Indo-Gangetic plains, based on 16S rDNA-RFLP analysis, could be identified.

Crop improvement

Ninety-six varieties/hybrids of major food crops including rice, wheat, barley, triticale, maize, pearl millet, and pulses and oilseeds have been released/ identified for different agro-climatic regions of the country.

The significant achievements in crop improvement research include: development of marker-assisted selection based Improved Pusa Basmati 1, having all the qualities of basmati rice and also resistance to bacterial blight; Indira Sona (hybrid of rice) with good grain and cooking quality for irrigated condition of Chhattisgarh; maize cultivar Vivek 27 for Bihar, West Bengal, Orissa, Jharkhand, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu, and Vivek 25 for Himachal Pradesh, Uttarakhand, Jammu and Kashmir and North-eastern region; Guinea-grass JHGG 04-1 for semi-arid condition; CMS-based pigeonpea hybrid GTH 1 for Gujarat; sunflower hybrid (DRSH 1) for *rabi*-summer; soybean variety Pratap Soya 2 for all the north-eastern states and Karnataka, Tamil Nadu and parts of Maharashtra and TAMS 98-21 for Vidharbha region of Maharashtra; high-yielding white-seeded sesame variety TKG 306 for Madhya Pradesh; linseed varieties, Kartika and RLU 6 for Chhattisgarh and Rajasthan respectively; six sugarcane varieties having higher yield and better-quality characters for commercial cultivation; and mesta variety Madhuri for roselle-growing tract. Some of these are value-added varieties.

Thar Sevika ber with early maturity and high yield with excellent fruits; CISH-G 1, a red colour guava selection promising for long shelf-life; Goma Ashwarya, a prolific bearer aonla maturing earlier than NA 7; and MP/98-71 and Kufri Himsona processing potato suitable for French fries are the improved horticultural varieties/hybrids showing higher productivity.

Kashi Unnati and Kashi Kanchan, photo-insensitive cowpea varieties, highly tolerant to golden mosaic virus and *Pseudocercospora cruenta* disease are suitable for growing in both spring-summer and rainy seasons. Onion variety Bhima Raj is suitable for *kharif* seasons in Maharashtra, Karnataka, Gujarat and for *rabi* season in Rajasthan, Gujarat, Haryana and Delhi. Black pepper hybrids IISR Garmunda and IISR Malabar and turmeric varieties LAP Supreme and IISR Kedaram were released for commercial cultivation.

A new genetic linkage map of sorghum and quality trait loci (QTLs) for shoot fly and terminal drought resistance was developed. Cytoplasmic male sterlity (CMS) system was developed in safflower. Indigenously synthesized genes *Cry 1F* and Cry *1Aa3* could be transferred in *desi* cotton and American cotton varieties.

Identification of pomelo with thin rind and pink pulp; cloning of anti-microbial peptide gene and formation of transformants in Ney Poovan and Rasthali banana; transformation of tomato plants with *DREB-1* gene for tolerance to moisture stress; development of breeding line for bacterial resistance in pomegranate; revelation of a transgenic watermelon with complete resistance to WBNV; evolvement of heat-tolerant lines in tomato, capsicum, peas and French bean; and

identification of donor sources of resistance to leaf curl virus in chilli (GKC 29, BS 35 and EC 49763) are new research innovations.

Livestock improvement

Six pure lines of White Leghorn were improved through intra-population selection. In S-23 generation, fertility and hatching ability could be improved and remained above 95% in both the lines. The phenotypic response to egg production up to 64 weeks of age was 3.2 and 6.8 eggs/ generation in IWN and IWP, and the corresponding genetic response was 8.3 and 4.7 eggs/generation, respectively, over last 5 generations. Naked Neck and Dwarf were used for improvement of gene lines for utilization in tropical poultry production. Biotechnological interventions were used for faster multiplication of superior germplasm of buffalo.

Transferrin partial complementary DNAs were cloned from the liver of 5 species in 4 genera of Indian carps and a phylogenetic tree of amino acid sequences of transferring cDNAs from carps was also drawn. In rohu *(Labeo rohita)* early maturity and breeding was achieved and it will help improve the pond fish productivity. Riverine catfish, *Pangasius pangasius* could breed in captivity, thereby indicating possibility of its artificial propagation and mass-scale seed production.

Crop management

Annada, Naveen and IR 64 rice varieties and Rajlaxmi and KRH 2 hybrids were found suitable for direct-seeded aerobic condition in coastal Orissa. The increase in soil organic carbon was about 0.1% after two years with full residue incorporation of rice or both rice and wheat. In sugarcane ratoon crop paired row planting system significantly reduced the gaps, produced the highest number of millable canes and cane yield over conventional planting in sub-tropical region of the country. Four plant health clinics were established for knowledge support and demonstration of IPM strategies. Pest Management Information System (PMIS) was evolved for cotton, brinjal and okra and decision making software (Pesticide Advisor) with information on available pesticides was developed. Bumble bees was found good pollinators of crops in temperate conditions and the research on their artificial rearing is in progress.

Global positioning system and geographical information system based information on bird-roosting sites vis-à-vis proximity to preferred food and feeding activity of birds to demonstrate correlation with cropping patterns and preparation of wooden nest boxes that are readily acceptable for breeding common myna and spotted owlet, are some of the important findings.

A meadow orchard system was developed for guava, accommodating 5,000 plants/ha for high yield. Rice-potato-okra or rice-potato-jute or French bean was found most remunerative cropping sequence for potato. Varieties of tomato, peas, okra, muskmelon and bean were standardized for polyhouse cultivation. Raised-bed planting of onion with drip irrigation was developed. Neem oil along with *Trichoderma harzianum* and *Pseudomonas fluorescens* proved effective in managing the anthracrose and greenaria leaf spot in grape. Walnut selections propagated vegetatively were found promising for earliness and nut quality. A package was developed for management of oily leaf spot disease/bacteria leaf spot disease of pomegranate.

Development of leaf-borer management technology in litchi; mass multiplication technique for biogents *Paecilomyces lilacinus, Pseudomonas fluorescens* and *T. harzianum*; revelation of osmo-air drying technology for bitter gourd, cauliflower and okra; standardization of dehydration process for rose, chrysanthemum, gomphrena and helichrysum; and effectiveness of cauliflower leaf waste in reducing snail population in elephant-foot yam are the developed technologies suitable for commercialization.

More than 61,000 tonnes quality seed was produced including 5,291 tonnes breeder seed of centrally released varieties and 2,520 tonnes of state released varieties of cereal, forage, oilseed, pulse and fibre crops. In addition, 52,000 tonnes seed was produced in horticultural crops including medicinal and aromatic plants. About 22.5 million saplings of horticultural crops and 2,800 packets of mushroom spawn were prepared.

Livestock management

District-wise database on feed and animal resources was developed for six agro-ecosystems of the country, to plan for filling the gap between demand and supply of feed and fodder. Cost-effective, locally available, feed resources were utilized in formulation of complete feed block for yak. A low-cost animal feed mixer for mixing heterogenous feed ingredients was designed and developed. Rapid and sensitive techniques were developed for assessing the Imidacloprid residue in water and soil samples to estimate the pollution in fodder farms that may harm the animals. In buffaloes, supplementation of bypass protein rich in limiting amino acids (lysine and methiomine) improved their milk production. Digestibility of nutrients and performance of birds improved after supplementation of deoiled rice bran-based diets with xylanase. Transcervical artificial insemination technique using frozen-thawed semen was

standardized in sheep for effective artificial insemination. As the semen collection is very difficult in mithuns, its effective method was standardized. Cumulative toxicity due to high concentration of cadmium caused infertility in buffaloes. An indigenous medicine, M-cure, was developed and evaluated for treatment of skin disease (sarcopticosis) in camel. A safe inactivated pentavalent vaccine was developed against bluetongue in sheep, and its has passed the safety test.

The total marine fish catch registered an increase of about 4.1 lakh tonnes compared to the previous year. Shrimp, produced using organic inputs, maintained a higher growth rate and health status than other shrimp. Culture practice was developed for the banana shrimp, *Fenneropenaeus merguiensis*, which has high potential as an alternative to tiger shrimp during winter in Gujarat.

Post-harvest management and value-addition

In a significant development, nanotechnology using nanoparticles of zinc oxide and silver oxide for coating has been successfully used to impart anti-microbial treatment to paper and fabric. This will help in retaining the quality of printed paper for a longer period and also in the manufacture of medical and healthcare textiles. New avenues for the development of smart textiles, have been opened. In another development, organically grown cotton has been processed to obtain "green" towels. Jute-synthetic fibre blends have been successfully prepared for diverse applications such as apparel and geo-textiles. Water- and termite-resistant jute-fibre glass reinforced shellac sheets have been developed for partition walls and window panels.

Community-level evaporatively cooled storage (ECS) structures could be an important link in the cool chain development for horticultural produce. The ECS structure enhanced the shelf-life of potato, knnnow and tomato significantly.

A low-cost technology for preparing extruded products from sorghum and legumes has been developed. Several value-added products from horticultural, livestock and fishery produce have been developed. These include jelly, leather, powder and toffee from aonla, Srikand from jackfruit, coated trout fillets, curried products from freshwater fish, canned trout, prawn soup powder, smoked fish, tuna *biryani*, and ready-to-serve mahaseer curry.

Technologies for long shelf-life of paneer, gulab-jamun mix and palada paysam mix were transferred to industry. A simple and rapid test was developed for detection of adulteration of ghee with vegetable oils and fats. Efforts have been made to develop rapid diagnostic kits to test for adulteration in ghee and milk; and probiotic yogurt has been developed as a functional food.

Agricultural engineering and energy management

The notable developments are zero-till drill with rotary slit opener, 7-row seed-cum-fertilizer attachment for rotavator, multipurpose implement for sugarcane, inclined plate planter with raised bed forming attachment for intercrop, turmeric harvester, banana shredder and banana clump remover as tractor-operated machineries. A self-propelled fodder harvester has been developed. Other implements and machineries developed are: barrow-type seed-cum-fertilizer spreader, single/two-row inclined plate planter for cotton, power-tiller-operated earthing-cum-fertilizer applicator for sugarcane, bullock-drawn sprayer for soybean, power-operated maize dehusker-cum-sheller, multiplier onion peeler, curry leaf stripper and tree climber. Sugarcane harvesting knife has been ergonomically designed for better performance. A feeding attachment for power-operated chaff cutter has been designed and tested to minimize accidents.

To facilitate the partial removal of water from the digested slurry from biogas plants, a rotating cylinder-type machine has been developed and demonstrated. Durable improved biomass cook stoves for agro-industrial and community applications were fabricated and demonstrated. A solar concentrator has been developed, which improved the performance of solar photovoltaic power-generation system.

Agricultural human resource development

Twenty-eight Niche Areas of Excellence were supported in different agricultural universities for building excellence in specific strategic areas in education and research. More than 180 Experiential Learning Units have been established in 43 Universities for providing skill-oriented hands-on training to the students.

A total of 1,332 students were admitted on UG Programmes in 45 Universities and 1,552 candidates in PG programmes in 51 Universities through Common Entrance Tests. Junior Research Fellowship was provided to 470 students in agricultural universities. National Talent Scholarship was given to over 1,000 students who got the admission in UG programmes. Scholarships and fellowships were also provided to meritorious and economically handicapped students.

The NAARM, Hyderabad, conducted 62 need-based programmes that benefited capacity building of 1,547 participants in different areas. Competence and research capability of 448 faculty members

was improved through Centres of Advanced Studies by organizing 68 trainings. Additional 400 scientists were trained in emerging subjects areas through 91 summer/winter schools.

Fourteen agricultural universities have been accredited for enhancing quality and relevance of education. A National Core Group, appointed by the ICAR, has initiated the revision of Post-graduate and Doctoral course curricula and syllabi. Under Indo-US Knowledge Initiative, 13 Borlaug Fellows were selected to get trained in the USA.

Information, communication technology and publicity services

Information, communication technology and publicity services have been reorganized under the Directorate of Information and Publications of Agriculture for better delivery system and marketing the technologies/products developed by the ICAR. New initiatives were started for transformation of information services by launching the scrolling on-line news, digitization of printed literature, single window of *ICAR News* by combining English, Hindi and ARIS News for various stakeholders.

Information services were brought under single umbrella and process is on to introduce/provide on-line library services in computerized mode. Initiatives have also been put in place to upscale internet connectivity by increasing bandwidth, dedicated lines and reduction in subscription charges. Video conferencing and IP Telephony has been started. The ICAR participated in 10 national and international exhibitions. Some of the regular publications are available in a public domain on ICAR Webpage (www.icar.org.in).

Technology assessment, refinement and transfer

A total of 1,058 technologies in various crops, livestock and fisheries were taken up for on-farm trials with its network of 558 Krishi Vigyan Kendras. The Krishi Vigyan Kendras conducted 18,306 demonstrations on oilseeds spread over 6,284 ha, and 13,042 demonstrations on pulses in 4,286 ha, showing 34.8 and 37.6% more yield than farmers' practice respectively. Besides, 6,206 demonstrations were conducted on cotton, covering an area of 4,281 ha, benefiting 2,495 and 2,450 farmers directly from demonstrations on production technology and farm implements, respectively, in 1,012 and 2,344 ha. The KVK also conducted 31,248 demonstrations, covering 10,149 ha on other crops, besides 2,838 on dairy, piggery, rabbit rearing, sheep, goat etc.

A total 39,912 training programmes were organized on various technologies, benefiting 10.94 lakh farmers and farmwomen. Skill-oriented trainings were imparted in different areas of agriculture, benefiting 1.52 lakh rural youth. More than 3,370 training programmes were organized for 80,416 extension personnel to upgrade their knowledge and skills in frontier areas of agriculture technology. Besides, 5,265 sponsored training programmes were conducted for 1.52 lakh participants from government and non-government organizations. Seed/planting material—111,164 q seed (value Rs 84,852,506) of cereals, oilseeds, pulses, and vegetables; 91.29 lakh saplings/seedlings of fruits, vegetables, spices, medicinal plants, ornamental plants, plantation crops and forest species; 8.94 lakh kg bio-products; 40.08 lakh fingerlings and other livestock/poultry strains were produced for availability to farmers. And 1.11 lakh samples of soil, water, plants, and manures were analysed during the year.

National Agricultural Innovation Project (NAIP)

The Council had launched NAIP in 2006 with an overall objective to facilitate the accelerated and sustainable transformation of Indian agriculture in support of poverty alleviation and income generation through collaborative development, and application of agricultural innovations by the public organizations in partnership with farmers' groups, the private sector and other stakeholders. The research funding is made on competitive basis. In the competitive grant scheme 992 Concept Notes were submitted for funding under NAIP components on production to consumption system research, sustainable livelihood security and basic and strategic research in agriculture. And 37 were recommended for full proposal development and 17 have been approved. Second call for competitive projects under NAIP has been made, and review of the Concept Notes by expert committees is in progress.

Twenty-one projects have been approved under National Fund for Basic Strategic Research (NFBSR) of the ICAR and 14 are in implementation. These projects are multi-institutional, multidisciplinary, diverse, novel and in advanced areas of molecular and genetic bases of crop plants, responses to biotic and abiotic stresses, physiology, rumen microbial manipulation to enhance feed efficiency in cattle, hybrid development in plant, etc. These projects are expected to generate new knowledge and solve outstanding scientific problems, and will also be directly applicable in the near future for technology development to tackle challenges in agriculture.

Organization and management

Perspective Plan-Vision 2025 documents of 94 ICAR Institutes have been published. Fifteen

Research Institutes/Centres of the ICAR have been notified in the Gazzette of the Government of India, raising total number of notified Institutions to 104 under rule 10 (4) of the Official Language Rule 1976. The Budget Estimate (BE) and Revised Estimate (RE) of the DARE and ICAR (Plan, Non-Plan) for 2006-07 were Rs 2,160 crore and Rs 2,276 crore, respectively, and BE for 2007-08 (Plan and Non-Plan) is Rs 2,460 crore. In recognition and to encourage professional excellence, the ICAR gave 54 awards under 12 different categories to honour institutions, scientists and their associates, farmers and journalist. Besides, *Rajbhasha* Award was also given.

Partnership and linkages

An MoU was signed between the ICAR, and College of Agriculture and Life Sciences, Cornell University, USA. Work Plans were also signed with University of Western Australia, Australia and the Ministry of Agriculture and Food Industry, Socialist Republic of Vietnam. Two projects, viz. Atmospheric Brown Cloud, and Multi-trophic Interactions in the Rhizosphere and Management of Nematode Pests and Diseases, were approved for implementation. India–US Joint Workshop on 'Curriculum Development' under the Agricultural Knowledge Initiative (AKI) was organized at New Delhi.

The XI Plan envisages an inclusive agricultural growth where key elements could be enhancement of resource-use efficiency, farm productivity and profitability. Keeping this in view, our priority areas would be eco-region specific technology generation and extension in continuation; systems perspective in research and education; enhancement of water productivity and nutrient-use efficiency; climate change and management of stresses; land-use systems for multi-functional agriculture; diagnostics, vaccines and delivery systems; value-added product development, food safety and quality assurance; biosensors, biofuels, biomolecules, biofortification, biosafety, biosecurity, bioremediation, and biofertlization; IT-based decision support systems for technology transfer; human resource development in niche areas; and enabling mechanisms for enhancing R&D productivity. This calls for significant new initiatives in research and development and enhanced investments for technology generation relevant to different regions/situations. In the national efforts to accelerate much-needed growth in farming sector, as in the past, the Council would continue to remain a committed partner.

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