Report of the
Quinquennial Review Team
(2000-2008)
of
Indian Agricultural Research Institute
New Delhi

Indian Council of Agricultural Research
New Delhi-110114

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Preface

Indian Agricultural Research Institute is the premier Institute of the Nation, which has been in the forefront for propelling agricultural growth through generation of new technologies and their dissemination to the farming community. Therefore, the Committee was happy to review its progress of research, teaching and extension education during 2000-08.

Overall in the considered opinion of the Committee, the Institute made excellent progress in all spheres of its activities. It was a pleasure to see the excellent infrastructure for research in new and emerging areas specially biotechnology, protected cultivation, controlled atmospheric research, modernization of library and access to information, computerization, etc. In addition, Institute continued generating skilled human resource through its post graduate programme despite declining faculty strength. However, the Institute still suffers from several constraints articulated in this Report which need to be addressed. The Committee has made fewer but important recommendations which if implemented, we believe, would lead to positioning IARI as world class research and teaching institution.

The Chairman and members of the QRT would like to express their gratitude to Dr. Mangala Rai, Secretary, DARE and Director General, ICAR, for giving the Committee an opportunity for reviewing the work of IARI. The Committee would like to thank, Dr. S.A. Patil, former Director, IARI and Dr. H.S. Gupta, present Director, IARI, most sincerely for their utmost cooperation, support and making the QRT work an enjoyable experience. Dr. K.R. Koundal, Joint Director (R) also deserves appreciation for shouldering major responsibility for planning visits of the Committee, collating information and preparation of the report. The QRT is also thankful to Dr. H.S. Gaur, Dean & Joint Director (Education), Dr. Baldeo Singh, Joint Director (Extension), Dr. A.K. Ganguly, PS (PPI), the Heads and Scientists of various Divisions and PPI Unit, Regional Stations of IARI and the staff of the office of the Directorate for their willing cooperation and providing the requisite information.

(Dr. N.N. Goswami)
Member

(Dr. S.L. Mehta)
Member

(Dr. S.N. Puri)
Member

(Dr. K.R. Koundal)
Member Secretary

(Dr. Asis Datta)
Chairman

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Executive Summary

The Indian Council of Agricultural Research (ICAR) constituted a Quinquennial Review Team (QRT) consisting of Dr. Asis Datta, former Vice Chancellor, JNU as Chairman and Dr. N.N. Goswami, ex-VC, CSAUA&T, Kanpur, Dr. S.L. Mehta, VC, MPUA&T, Udaipur, and Dr. S.N. Puri, VC, Central Agricultural University, Manipur as members to review the progress of research achievements made by the Indian Agricultural Research Institute (IARI) during 2000-2008.

In all ten meetings of the Quinquennial Review Team (QRT) were held to review the work of IARI. The QRT visited all the divisions/units and facilities of the Institute. They also visited IARI Regional Stations at Karnal and Indore. The activities of Post Graduate School and those of Finance & Administration of the Institute were also reviewed and discussions held with the representatives of P.G. School Students Union, Master of Halls and Associate Wardens of students hostels among others.

One of the important milestones during the review period has been the centenary celebrations of the Institute in 2005. The centenary celebrations of IARI were launched on January 1, 2005 at a ceremony held in front of the Library. The "IARI Centenary Declaration", made on the occasion highlights the future plan on strengthening post graduate programme; developing environmentally sound, economically viable and socially accepted crop production technologies; exploiting heterosis for conventional and non-conventional crops and developing new plant types; strengthening molecular biology and biotechnology programme to focus marker assisted plant breeding, functional genomics and development of transgenics; strengthening research on horticultural crops and developing post harvest technologies; directing greater research efforts to contain crop losses caused by pests, diseases and weeds; addressing issues related to Sanitary and Phytosanitary (SPS) Agreement, Codex, biodiversity and bio-safety needs and strengthening the Business Development Centre to forge an alliance with private sector for commercialization of technologies and their rapid dissemination to the farmers.

The Institute developed 127 varieties/hybrids of cereals, pulses, oilseeds, fruits, flowers and vegetables during the period. A series of early maturing, extra long grain high yielding aromatic rice varieties such as Pusa Sugandh 2, Pusa Sugandh 3 and Pusa

Sugandh 5 were released. These varieties have yield potential up to 7 t/ha and typical *basmati* quality. Rice variety Pusa 1121 developed by the Institute is gaining popularity among the farming community. Since its release in 2003, the area under Pusa 1121 has been growing very fast. Encouraged by the response in the international market, the traders/millers in India were able to pay higher price for Pusa 1121 to farmers. The average yield of Pusa 1121 recorded in farmers' fields was 5 t/ha with an average paddy price gross return of Rs. 1,50,000/ha to farmers as against Rs 45,000/ha from cultivation of Taraori Basmati and Rs. 60,000/ha from Pusa Basmati 1.

The wheat varieties bred by IARI have been consistently contributing to food security in the country. A conservative estimate based on indented seed without including self-saved seed of farmer's shows that about 30% of total wheat area of the country is covered by IARI wheat varieties and accounts for an additional wheat production to the tune of around 23 million tonnes.

In the area of basic and strategic research, the highlights of research achievements include designing of a new plant type of wheat, new alleles for HMWGS, alien transfer of disease resistance, identification of novel genes, development of high protein lines, diversity analysis using molecular markers and pyramiding genes for leaf rust resistance. The Institute has been successful in developing DNA markers linked to genes *Lr9, Lr19, Lr24, Lr28, Lr32* and *Lr48.* This strategy of marker assisted breeding was adopted at the Institute to pyramid genes *Lr24 + Lr28, Lr24 + Lr9, Lr9 + Lr28, Lr9 + Lr24 + Lr28 and Lr24 + Lr28 + Lr19* together against rust.

The Institute developed a number of mustard varieties. Prominent among them are Pusa Swarnim and Pusa Agrani. The varieties of pulse crops developed at the Institute are chickpea (Pusa 1088, Pusa 1103, Pusa 1105, Pusa 1108 and BGD 128), pigeonpea (Pusa 992 and Pusa 2001), mungbean (Pusa Vishal, Pusa Ratna and Pusa 9531). Several hybrids and varieties of fruit crops, vegetables and flowers developed by the Institute with high yield potential have been commercialized in Public-Private Partnership (PPP) model and also used extensively in demonstration programmes across the country.

A novel vegetative insecticidal protein (VIP) gene of Bt was discovered sequenced and characterized (vip3A14). The gene is specific to tobacco caterpillar, diamondback moth and brinjal shoot & fruit borer. In addition, several agronomically important genes have been isolated, characterized and indexed in the Genebank. The transgenic crop plants, including tomato, brinjal, mustard, cabbage and rice, by deploying these genes are at different stages of development and commercialization. In addition, promoters have also been isolated and used for tissue specific and stage specific expression of cloned gene. A transgenic cotton variety Bikaneri Nerma was developed in collaboration

with UAS-Dharwad and field-tested. Biosafety tests of the transgenic event are underway and soon will be released for commercialization.

A novel strain of *Aspergillus niger* (AN27) that has been isolated controls six devastating soil borne pathogens, viz., *Fusarium oxysporum*, *F. solani, Macrophomina phaseolina, Pythium aphanidermaturm, Rhizoctonia solani* and *Sclerotinia sclerotiorum* belonging to different classes of fungi in diverse groups of crop plants. It inhibits the formation of pathogen resting structures and kills the existing ones. AN27 induces resistance in the plant by augmenting its defence enzymes peroxidase, polyphenol oxidase and phenylalanine ammonia lyase. Two growth promoting compounds isolated from AN27 are responsible for increasing the root and shoot lengths and biomass of crop plants. Increased crop production and excellent disease control by single application of *kalisena SL* in soil or *kalisena SD* on seed make them desirable bioformulations with long (two years) shelf life. A new species of entomopathogenic nematode, *Steinernema thermophilum*, described from India, has been reported to have very high biocontrol potential against different insect pests (*Agrotis ipsilon, Helicoverpa armigera* and *Spodoptera litura*) of agricultural crops.

Rice-potato-greengram cropping system has been found to be more productive than rice-wheat system. Results of a long-term fertilizer experiment have shown that both maize and wheat crops continually fertilized with super-optimal NPK dose (150% of recommended) out-yielded optimal (100%) NPK, indicating a need for upward revision of 'optimal' fertilization rates that have become inadequate to sustain a high productivity under intensive cropping. Use of 15 t ha^{-1} FYM during monsoon season along with 100% NPK, gave yields similar to 150% of normal dose of NPK. Application of N alone was clearly detrimental to soil quality and productivity.

Crop growth simulation models were used to assess the direct impact of global climatic changes on cereal growth and production in different parts of India. The results indicate that even a small increase in temperature associated with climate change can cause considerable losses in cereal production. The impact of elevated temperature on productivity of rice and wheat showed that late sowings in wheat and high temperature stress in rice during reproductive growth phase caused maximum reduction in biomass and grain yield. Impact assessment of climate change by the Institute has been utilized for policy development by the Government of India.

During the review period, the Institute developed a number of technologies for protected cultivation. Different designs of low cost, naturally ventilated greenhouses were developed and evaluated for making them economically viable and cost-effective for small growers. The designs developed are simple to construct by growers themselves

at minimum cost. A high intensity plug-tray technology for growing seedlings of different vegetable and ornamental crops in all seasons was developed. A plastic low tunnel technology for off-season cultivation of muskmelon and summer squash crops was developed, which was found highly profitable for vegetable growers in peri-urban areas of northern plains of India during winter.

IARI was identified as the main global centre for CO_2 enrichment research on crops in South Asian region. Open Top Chamber CO_2 enrichment technology was designed and made available to Bangladesh, Nepal, Pakistan and Sri Lanka. A mid FACE facility, the first of its kind in South Asian region was established in IARI. Scientists, students and research scholars from South Asian countries and Indian scientific institutions were trained for CO_2 enrichment resource & technologies.

Elevated CO_2 leads to increase in photosynthesis rate due to the increased activation of the rubisco enzyme in wheat. Interactive study of elevated CO_2 and nitrogen supply on wheat showed that nitrogen application improved growth and photosynthesis rate and also helped in maintaining a higher nitrogen and protein content in the tissues. In mungbean, elevated CO_2 enhanced the nodulation and nitrogenase activity due to higher photosynthesis and partitioning of assimilates to the roots.

The Institute has developed a large number of engineering technologies/ processes for various targeted user groups, some of which are: a tractor drawn okra planter; an anthropometer; a harness for manual loading; a two-row seed-cum-fertilizer drill; an aqua-ferti seed drill; a fruit and vegetable grader; an okra seed extractor; an onion detopper; jigs and fixtures for wheel hoe; a two-row maize planter; a vegetable extracter; a pulse polisher for pigeonpea; an improved atta chakki; an integrated rice mill and grader; and a rotating screen grader for rough shaped fruits and vegetables.The concept of aqua-ferti sowing was developed and a device fabricated. The aqua-ferti sowing of wheat under rainfed conditions gave significantly higher grain yield (2.44 t/ha) compared to that given by conventional method (CS) of sowing (1.68 t/ha). This technique has the potential of increasing production in rainfed areas of the country.

A sustainable extension model developed and established in the villages of Alipur Block of Delhi helped the farmers in solving the problems related to availability of farm inputs and enhancement of their income. A web-based expert system of extension was developed to disseminate demand-driven farm information to the farmers. In order to improve the managerial skills of agricultural extension professionals, fourteen training modules on different management skills were developed and validated. Studies also showed that self-help groups were effective in empowering rural women, and in adopting drudgery reducing farm implements.

The regional stations of the Institute have contributed significantly in their mandated activities including seed production, development of new varieties of cereals, pulses, temperate fruits and vegetables, screening of plant material against various biotic and abiotic stresses. The IARI Regional Station, Karnal played an important role in producing and supplying high quality seeds of 80 different crop varieties of cereals, pulses, oilseeds, forages and vegetables. Seed production increased from 142 tonnes in 2005 to 431 tonnes in 2008 owing to the implementation of ICAR Mega Seed Project. Similarly IARI Regional Station, Indore produced 1077 tonnes of breeder seed of wheat varieties, and Pusa (Bihar) produced 109 tonnes of quality seeds of wheat, paddy, pulses, oilseeds and papaya. A total of 24651 kg seed comprising of 1225 kg nucleus, seed 5790 kg breeder seed, and 17636 kg IARI (TFL) seed of 58 varieties of 26 vegetable crops was produced by the IARI Regional Station, Katrain.

The Institute offers Master's (M.Sc.) and Ph.D. programmes in 23 and 22 disciplines, respectively. During the review period, 633 M.Sc. students and 853 Ph.D. students including 103 foreign students were admitted to Post Graduate School. The Institute awarded M.Sc. degrees and Ph.D. degrees to 600 and 698 students, respectively, which include 32 foreign students for M.Sc. degree and 46 for Ph.D. degree. IARI has a Placement Cell, and frequent Institute-Industry meets have been arranged for career counseling and placing outgoing students in the jobs of their choice. Most of IARI students because of their skills got selected in ARS or went overseas for higher studies.

Faculty members of the Institute have been honoured with various awards like Om Prakash Bhasin Award, VASVIK Award, Rafi Ahmed Kidwai Award, Hari Om Ashram Award, and Best Teacher Awards of IARI and ICAR during the period under review.

The Institute developed close linkages with the institutes and universities in the NARS. It is heartening to note that the Institute attracted external funds to the tune of Rs. 66.46 crores during the review period from several national and international agencies. The Institute has taken new initiative towards public-private partnership in commercialization of technologies and resource generation and established an Institute Technology Management Unit (ITMU).

The major constraint which hindered the robust growth in the research and education areas of the Institute was the depleted staff strength of scientists and faculty. This situation still continues and need to be rectified without delay.

The recommendations made in the report are based on visits and discussions with scientific and other staff and the Committee's own assessment of the Institute's achievements. The important recommendations include introduction and strengthening

of research programmes in bio-informatics, food science and technology, agribusiness management, heterosis breeding, molecular breeding, climate change in relation to adoption and mitigation, processing and value addition in food and horticultural crops, development of machinery and decision support system for precision farming, remote sensing and simulation modeling, conservation agriculture and development of holistic INM and IPM modules. For strengthening post graduate education, the Committee recommends direct recruitment of Professor, fast track recruitment of the vacant positions, introduction of new PG courses in Food Science and Technology, Bio-informatics and establishment of a Centre for Distance Education. The Institute should have a career development plan for faculty competence. The QRT recommends that a Committee be constituted to critically assess the various steps needed and to give recommendations for making IARI's academic programme world class. In extension education, the Committee has recommended the implementation of National Extension Programme to develop location-specific integrated models and new technology transfer approaches for market-led agriculture. In administrative and financial aspects, the QRT recommends training of the staff and online financial management system.

1. Introduction

The Indian Agricultural Research Institute (IARI) is the country's premier national Institute for agricultural research, education and extension and has been the flagship of India's agricultural research and technology development. It has served the cause of science and society with distinction through first-rate research, generation of appropriate technologies and development of skilled human resource. In fact, the Green Revolution that has sustained the agricultural economy of the country for nearly five decades was born in the fields of IARI. Alumni of the Post Graduate School of IARI constitute the core of the quality human resource in India's agricultural research and education.

Ever since its establishment in 1905, the Institute has provided an inspiring leadership in the development of agricultural research and technologies that led to India's emergence as a food-sufficient country. Consequence upon the grant of "Deemed to be University" status to IARI, the post-graduate school was established in 1958 and it continues to be the centre of excellence in post-graduate education. The Institute, over the past 100 years, had responded to the needs, challenges and opportunities of Indian agriculture and adjusted its mandate, plans and programmes accordingly and has played a key role in transforming agricultural research, education and extension in the country.

The Institute is moving upstream with an increased thrust on strategic and basic researches to generate new scientific knowledge, technology and product development leading to enhancement of the nation's competitiveness. While crop Improvement and breeding will continue to be its major mandate, the thrust has been shifted to new strategic areas such as exploitation of heterosis and development of hybrids, including apomixes, new plant types combining high biomass production with high harvest index, marker assisted selection, identification of genes for resistance/tolerance to biotic and abiotic stresses, and creation of pre-breeding stocks combining multiple resistances and other desirable attributes.

Basic and strategic researches have been strengthened also in the areas of resource management, GIS, remote sensing, and crop modeling, etc., to generate new concepts, tools and methodologies based on systems approach. Agronomic research addresses the needs and opportunities of small farmers through the development of new cropping systems and crop diversification modules consistent with sustainable use of land, water and other natural and purchased production resources. Basic research in nutrient

management, soil-plant-water relations, soil physics, soil-water dynamics and kinetics leading to the development of integrated plant-soil-water-nutrient management systems has been given high priority. The Institute provides leadership in emerging areas such as climate change, impact of CO_2 enrichment on crop productivity, methane emission from rice fields and approaches for minimizing emission of greenhouse gases and ways to obviate and mitigate the adverse effects of such gases. Socio-economic research includes policy research on evaluation of agro-biodiversity, farmer's rights, plant breeder's rights, intellectual property rights and bio-safety. Mission and centers of excellence modes are being adopted to ensure inter-disciplinarity, excellence and efficiency in research.

1.1 Quinquennial Review Team (QRT)

In consonance with the policy of the Indian Council of Agricultural Research of quinquennial review (achievement audit) of its institutes, the QRT was constituted under the Chairmanship Dr. Dr. Y.L. Nene, ex-DDG, ICRISAT, vide the Council's Office Order No. F.No.16-8/06-IA.IV dated July 17, 2006 and even number dated December 9, 2009. The terms of reference, final composition, and working of QRT were as follows:

Composition of QRT

Since Dr. Y.L. Nene expressed his inability to act as Chairman, QRT, Dr. Asis Datta was given the responsibility of Chairman of QRT by the Council. Dr. D.N. Jha expired before the commencement of QRT and Dr. C.V. Ramaswami, VC, TNAU was put in his place. Initially he agreed but later on expressed his inability to attend the meeting because of his pre-occupation. Similarly, Dr. R.L. Paliwal did not accept the responsibility because of his pre-occupation (Details are given in Annexure-I).The final composition of the QRT is given below:

1.	Dr. Asis Datta, Former Vice Chancellor, JNU	-	Chairman
2.	Dr. S.L. Mehta, VC, MPUA&T, Udaipur	-	Member
3.	Dr. N.N. Goswami, ex-VC, CSAUA&T, Kanpur	-	Member
4.	Dr. S.N. Puri, VC, Central Agricultural University, Manipur	-	Member

Terms of reference

The terms of reference as laid down by the Indian Council of Agricultural Research are given under the following broad heads. Details are given in Annexure-II.

i. Research achievements and their impact
ii. Research relevance and budget allocation

iii. Policies, priorities and strategies

iv. Relationships/collaborations with SAU's and other stakeholders

v. Linkages with clients/end users

vi. Proposed changes in organization, programmes and budget

vii. Organization and management

viii. Constraints

ix. Looking forward

Visits of QRT

In all ten meetings of the Quinquennial Review Team (QRT) were held during 2007-2009 to review the work of IARI. The first meeting was held on 8.1.2007 in the Conference Hall of IARI Library. During the discussions, the QRT members obtained first hand information from the various project directors/heads of divisions of IARI and apprised them as to how the QRT will proceed with the review of the work of various divisions, etc. In the subsequent meetings, the QRT visited at different periods of time, Nuclear Research Laboratory; NRC on Plant Biotechnology; Water Technology Centre; Divisions of Biochemistry; Plant Physiology; Agricultural Economics; Agricultural Extension; Plant Pathology/Virology; Entomology; Agricultural Chemicals; Nematology; Fruits & Horticultural Technology; Vegetable Science; Post Harvest Technology; Floriculture & Landscaping; Genetics; Seed Science & Technology; Agricultural Engineering; Soil Science & Agricultural Chemistry; Environmental Sciences; Agricultural Physics; Microbiology; Agronomy; Units of National Phytotron Facility; Centre for Agricultural Technology Assessment and Transfer (CATAT); Agricultural Technology Information Centre (ATIC); Seed Production Unit; Centre for Protected Cultivation Technology; Centre for Conservation and Utilisation of Blue Green Algae; Unit of Simulation and Information; Farm Operation & Service Unit; Experimental Farm of IARI; and IARI Library. They also visited IARI Regional Stations, at Karnal and Indore to review the research activities, experimentation and seed production programme. The activities of Post Graduate School and those of Finance & Administration were also reviewed and discussions held with the representatives of P.G. School Students Union, Master of Halls and Associate Wardens of students' hostels among others. In the eighth meeting held on 29th December 2008, the information received from various divisions/units/stations was handed over to the QRT members. Details of schedule of QRT meetings and visits are given in Annexure-III

1.2 Mandates and Objectives

Mandates

The mandates of the Institute are as follows:

- To conduct basic and strategic research with a view to understanding the processes, in all their complexity, and to undertake need-based research, that lead to crop improvement and sustained agricultural productivity in harmony with the environment.
- To serve as a centre for academic excellence in the area of post-graduate education and human resources development in agricultural sciences.
- To provide national leadership in agricultural research, extension, and technology assessment and transfer by developing new concepts and approaches and serving as a national referral point for quality and standards.
- To develop information systems, add value to information and serve as a national agricultural library and database.

Objectives

Under the above mentioned four mandates, the major thrust given is as follows:

Research

- Utilization of global plant genetic resources, to produce efficient, productive and stable genotypes of crops, especially hybrids with improved bioenergetics.
- Generate knowledge related to production and productivity of agricultural crops leading to the development of research, concepts, methodologies, materials and technologies.
- Develop and use systems approach, crop modeling, bio-indicators, nuclear tools, remote sensing and GIS and other modern scientific tools to achieve greater understanding of the production systems, the resources, the environment and its sustainability and modify them to reduce the environmental and human health risks to make them more sustainable in the context of holistic ecological and socio-economic systems.
- Pay greater attention to the problems of agriculture under unfavourable conditions.
- Foster excellence in agriculture related to basic and social sciences, strengthen synergism between traditional knowledge and modern science, and harness management sciences and communication systems for improving overall efficiency.
- Develop capabilities in post-harvest technology, agro-processing, product development, value addition of agricultural commodities, by-products, agricultural wastes and renewable energy resources.

- Concentrate on new and emerging cutting edge technologies such as molecular biology and biotechnology.

Education

- Promote excellence, foster high standards and orient the educational programme towards future needs and opportunities.
- Develop skilled human resource in agriculture, especially in frontier areas such as biotechnology, computer application and information technology, environmental science, post-harvest technology, and agricultural biodiversity and genetic resources.
- Provide opportunities for post-doctoral research, continuing education, faculty upgradation, and development of human resources in new and cutting edge technology areas, especially through international collaboration.
- Strengthen non-formal training to promote entrepreneurial skills and commercialization of agriculture.

Extension

- Generate innovative extension models, dovetail them to developmental models, and disseminate them through regional stations, universities and state extension systems.
- Promote client oriented on-farm research and technology assessment, refinement and transfer through participatory approaches and by promoting the Institute-Village Linkage Programme.

Information

- Modernization and digitization of IARI Library, which in the NARS, acts as the national agricultural library and development of Central eResources in Agriculture for providing online access to journals & database to scientists & faculty in ICAR institutions & SAUs. Build databases on agricultural research and share them with all bonafide users throughout the world.
- Add value to information and use it for analyzing the impact of research and technology development on national agriculture.

1.3 Organization

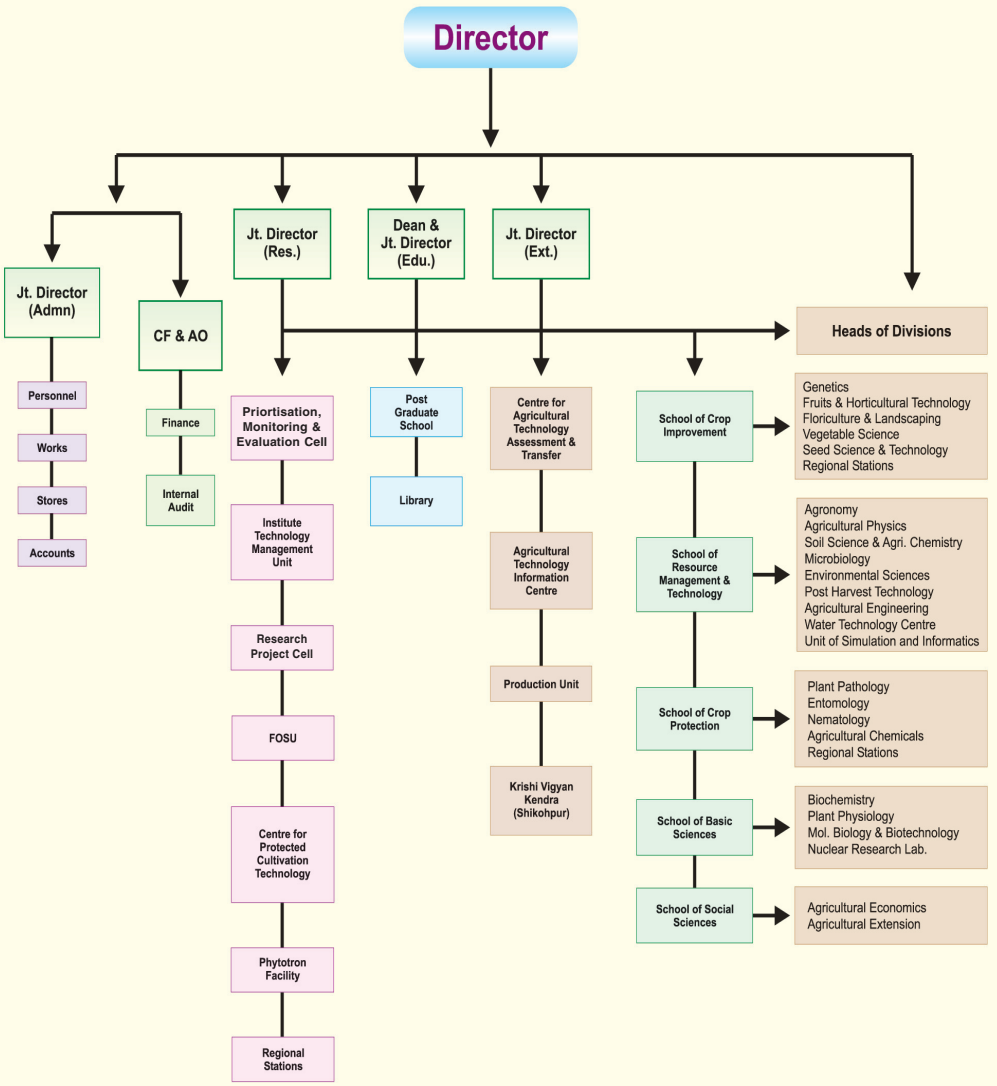
The highest policy making body of the Institute is its Board of Management. The Staff Research Council is responsible for the formulation of research projects and monitoring of their progress. The Academic Council takes decision in all matters related to post-graduate education.

The Director is the executive and academic head of the Institute, which is also a Deemed-to-be-University and is the ex-officio Chairman of the Board of Management,

Executive Council, Academic Council and Extension Council. The Board of Management and the Academic Council are the apex bodies of the Institute, which take decisions on administrative, financial and academic matters. Academic Council, Executive Council, Staff Research Council, Extension Council and various Standing Committees provide the necessary recommendations/suggestions to facilitate the Board of Management to take appropriate decisions.

The research activities are monitored by the Joint Director (Research). The Dean and the Joint Director (Education) co-ordinates the academic activities of the Institute. Matters pertaining to extension education of the Institute are executed through the Joint Director (Extension). The Joint Director (Administration) of the Institute provides the necessary support to the Director in taking decisions regarding service matters of both faculty and staff. Matters pertaining to financial and budgetary aspects are channeled through the Chief Finance and Accounts Officer. A chart showing the Organizational Structure of the Institute is given at Page 7.

Indian Agricultural Research Institute



Organizational Structure

2. Management

The Director is the administrative head of the Institute. The Institute Management Committee plays a vital role in the smooth functioning of the Institute activities. The Director is supported by three Joint Directors, viz., Joint Director (Research), Dean and Joint Director (Education), and Joint Director (Extension) dealing with research, teaching and extension, while in administration and finance, he is assisted by the Joint Director (Administration), and the Chief Finance and Account Officer, respectively. Various organs provided under the constitution of the Institute as well as those constituted by the ICAR facilitate taking decisions for the smooth functioning of the Institute. These are: Board of Management, Research Advisory Committee, Executive Council, Academic Council, Extension Council and Staff Research Council. The Institute Joint Staff Council and Institute Grievance Cell are the two other important statutory bodies for the smooth functioning of the Institute.

2.1 Board of Management

During the period, nine meetings of the Board of Management were held under the Chairmanship of Director, IARI. Some of major the decisions taken were: Establishment of Dr. B.P. Pal Horticulture Service and Information Centre; appointment of authorized medical attendants at IARI Regional Stations, changing the name of Division of Vegetable Crops to Division of Vegetable Science, write off damage/loss due to flood at IARI Regional Station, Pusa (Bihar), IARI centenary year celebration, amalgamation of IARI Regional Stations at Amartara Cottage (Horticulture), and Tutikandi, Shimla, and changing the name of the Indo-Israel Project to Centre for Protected Cultivation Technology.

2.2 Research Advisory Committee (RAC)

The function of RAC is to give directions and suggestions on the research programmes of the Institute and review the research achievements of the Institute and to see that these are consistent with the mandate of the Institute. The RAC for 2000 was held under the chairmanship of Dr. M.S. Swaminathan, for 2002-04 under the chairmanship of Dr. V.L. Chopra, Member Planning Commission, for 2005-07 under the chairmanship of Dr. H.K. Jain, former Director, IARI and 2008 under the chairmanship of Dr. R.S. Paroda, Former DG, ICAR & Secretary DARE. From 2000

to 2008, eight meetings of RAC were held and the RAC members also visited several Regional Stations of the Institute.

2.3 Staff Research Council (SRC)

The Staff Research Council has a major role in monitoring research activities of the Institute. The SRC is also responsible to assess and evaluate the performance of current research programmes including externally funded projects. During the period, eight SRC and four pre-SRC meetings were organized under the chairmanship of Director, IARI. In the main SRC, the project directors, heads of divisions and regional stations, and Unit In-charges made their presentation on action taken report of the last SRC, significant achievements of the projects, awards received, list of publications during the period and comprehensive planning monitoring and impact assessment. In the pre-SRC, individual scientists of each division/Project Directorate/Unit made a brief presentation of his or her contribution in various in-house projects.

While formulating a research project, the targets in the form of activity milestones are delineated. The progress of the project in terms of activity milestones is monitored during the Institute SRC meetings involving outside experts/subject-matter specialists. For evaluation of externally-funded projects like NATP, a separate project monitoring and evaluation committee was in place in addition to the Institute's own mechanism.

As per the recent directives and guidelines received from the Council, the quantifiable and monitorable targets of individual scientists have been monitored at six monthly intervals. The report on the targets achievement with the comments and grading by the Director of the Institute was submitted to the Council twice a year for monitoring at the Council level.

2.4 Executive Council

The meetings of Executive Council of IARI were held under the chairmanship of the Director, IARI. The salient actions/decisions taken are: the approval of the Director to distribute profit earned in the revolving fund; the need to integrate the projects of development schemes of the Institute under a common objective; and the need to have economic analysis on the contribution of IARI to the Indian economy.

2.5 Extension Council

The Extension Council of IARI reviews extension programmes, monitors progress and suggests changes in the programmes to promote participatory extension with outside agencies and institutions. During the period, seven meetings were held (on June 26,

2002; November 3, 2003; October 1, 2004; July 16, 2005, June 24, 2006; June 13, 2007; and June 7, 2008). The major/significant decisions taken during the meetings are as follows:

1. Development of short duration videos, CDs and DVDs on IARI technologies; utilization of extension strategies/methodologies developed to accelerate TOT programmes of the Institute; publication of achievement of TOT programmes.
2. Emphasis on integrated farming system approach in TOT programmes; organization of programmes of 'Open Education' in crops, namely, rice, pulses and oilseeds on the lines of Wheat School on AIR; implementing RRAP (Rural Research Appraisal Project) under IARI Centenary Year Celebration in Jhunjhunu district of Rajasthan in order to cater to the specific regional needs of farming community.
3. Development of location specific extension models in the areas of commercial agriculture and marketing extension.
4. Emphasis on disseminating complete package of practices; compilation of report on outcomes and impact of IARI efforts in Tsunami affected areas.

2.6 Academic Council

The Academic Council is supreme in the matter of academic activities of the Institute at the Post Graduate School. All the matters relating to post graduate education and training are decided by the Academic Council which is supported by the Board of Studies in each discipline and four Standing Committees, namely, i) Faculty and Discipline, ii) Scholarships, iii) Financial Assistance and Academic Progress, and iv) Students' Problems, Welfare, Board and Residence. The Dean & Joint Director (Education) takes decisions regarding the constitution of the Board of Studies. At the Divisional level, the Board of Studies takes decisions and/or makes recommendations to the Academic Council. The Academic Council is also empowered to take decisions on all academic matters and translate them into action. Some of the important decisions taken by the Academic Council during 2000-2008 are: adoption of 10 point OGPA scale by P G school, keeping in view the difficulty faced by the students of IARI due to 4.00 OGPA system and the need to bring uniformity in the GPA system with the agricultural universities across the country; institution of the best student of the year award in both M.Sc. and Ph.D. programmes; introduction of a new teaching discipline of Post Harvest Technology; introduction of Ph.D. programme in Plant Genetic Resources; approval of the guidelines for appointment of Professor in teaching disciplines and revision of the entire course curriculum relating to all teaching disciplines for strengthening the P G education at IARI.

2.7 Institute Joint Staff Council (IJSC)

Twenty-one meetings of the Institute Joint Staff Council were held from 2000 to 2008. Some of the major issues taken up were: competitive departmental tests; assessment of technical staff and removal of category bar; settlement of pending medical bills; nomination of welfare officer; settlement of pay anomaly cases of SSG staff; issue of electronic identity cards, bonus for DPLs.; promotion of Key Punch Operator and fencing of NPRC ground.

2.8 Institute Grievance Cell (IGC)

IGC met four times during the period under report, considered various issues and took decisions to the satisfaction of the staff. No major issues are pending. Some of the major issues taken up were: grievance case of Smt. Anuradha Kapoor, T-III for placement in the grade of T-II-3; change in the date of birth of Shri. Bhutan Rai, SSG-III in official records; and grievance case of Shri Yog Raj Singh, PA, WTC for not counting his previous service rendered in the Grade of Jr. Stenographer. A general circular has been issued to the staff of IARI for the awareness of Institute Grievance Cell of IARI.

3. Miscellaneous Information of the Institute

3.1 IARI Centenary Celebrations

The Indian Agricultural Research Institute (IARI) celebrated 100 years of its existence in 2005. The centenary celebration of IARI was launched on January 1, 2005 at a ceremony held in front of the Institute's Library. A large number of people associated with the Institute in the past and present participated in the launching ceremony. Prominent among them were Dr. M.S. Swaminathan, Chairman, National Commission on Farmers, Dr. Mangala Rai, Secretary DARE, and Director-General, ICAR, Dr. Panjab Singh, former Director-General, ICAR, and former Directors of IARI, Dr. H.K. Jain and Dr. R.B. Singh and Dr. S. Nagarajan, Director, IARI.

The Institute also organized a scientific convention from March 16 to 19, 2005 to mark its centenary. A large number of scientists, mostly the alumni of IARI from India and abroad, participated in the convention. The convention was inaugurated by Shri Sharad Pawar, Hon'ble Union Minister of Agriculture, Consumer Affairs, and Food and Public Distribution, while Shri Kanti Lal Bhuria, Hon'ble Minister of State for Agriculture, Government of India was the chief guest. Nobel Laureate Dr. Norman E. Borlaug, President, Sasakawa Africa Association; Dr. M.S. Swaminathan, Chairman, National Commission on Farmers; Dr. V.L. Chopra, Member, Planning Commission; and Dr. Mangala Rai, Secretary, DARE and Director-General, Indian Council of Agricultural Research graced the function as the guests of honour. A souvenir to mark the centenary was released by the Hon'ble Union minister of Agriculture at the inaugural function. A special issue each of Indian Farming and "Kheti" was also released on this occasion by the chief guest. A series of lectures such as the Coromandel Lecture on the topic "From Green Revolution to the Gene Revolution: A 21st Centenary Challenge" by Dr. Norman E. Borlaug; Centenary Lecture on "India's Greatest Living Industry: Hundred Years Later" by Dr. M.S. Swaminathan; a lecture on "Biotechnology Research: Our Experiences with Oilseed Brassica" by Dr. V.L. Chopra; a panel discussion on "Global Vision" under the chairmanship of Dr. Mangala Rai; a lecture on "Wheat Breeding: Achievements and Challenges" by Dr. S. Rajaram; a lecture on "IARI's Contribution in the Area of Nutrition and Plant Biochemistry" by Dr. S.L.Mehta; a lecture on "Role of Basic Sciences" by Dr. H.K. Jain; a lecture on "Plant Pathology: Challenges Ahead" by Dr. Anupam Varma; and a panel discussion on "A Century of

Wheat Research in India– The Way Ahead" under the chairmanship of Dr. M.S. Swaminathan were organised. The "IARI Declaration" presented by Dr. S. Nagarajan highlighted the future plan on: strengthening post graduate programme; developing environmentally sound, economically viable and socially accepted crop production technologies; exploiting heterosis for conventional and non-conventional crops and developing new plant types; strengthening molecular biology and biotechnology programme to focus marker assisted plant breeding, functional genomics and development of transgenics; strengthening research on horticultural crops and developing post harvest technologies; directing greater research efforts to contain crop losses caused by pests, diseases and weeds; addressing issues related to Sanitary and Phytosanitary (SPS) Agreement, Codex, biodiversity and bio-safety needs; and strengthening the Business Development Centre to forge an alliance with private sector for taking technology to the farmers.

A documentary video film entitled 'IARI–A Catalyst of Change' on the Institute's historical developments and research achievements was prepared. A folder entitled "IARI – A Century of Service to Indian Agriculture" was also released as part of the centenary programme.

An agro-industrial exhibition was organized at the Institute from November 8 to 9, 2005. A three-day centenary year *Pusa Krishi Vigyan Mela* of the Institute on the theme "Prosperity through Seeds" was inaugurated by Shri Sharad Pawar, Hon'ble Union Minister of Agriculture, Consumer Affairs, and Food and Public Distribution on February 14, 2005.

A Foundation Stone of IARI Centenary Building was laid on 16th October 2006 at IARI Regional Station, Pusa, Bihar by Shri Sharad Pawar, Hon'ble Union Minister of Agriculture, Consumer Affairs, and Food and Public Distribution, Government of India.

To mark the occasion of completion of 100 years of service of IARI to the nation, a commemorative postage stamp on the Institute was released on March 30, 2006 by Dr. Shakeel Ahmad, Hon'ble Minister of State for Communications and Information Technology, Government of India. Shri Sharad Pawar, Hon'ble Union Minister of Agriculture, Consumer Affairs, and Food and Public Distribution was the chief guest of the function.

In the centenary year, the Institute paid its homage to Rao Bahadur Dr. Vishwanath, the first Indian Director of the then Imperial (now Indian) Agricultural Research Institute by instituting an award in his name to be given for encouraging excellence in agricultural research in the country.

In addition various regional stations of the Institute and societies celebrated the centenary of the Institute during the period.

3.2 Awards, Trainings and Publications

During the period of review, the scientists of the Institute have been honoured with various awards and fellowships owing to their outstanding contribution in the field of research and teaching. Some of them are : Rafi Ahmed Kidwai Award, Fellowship of the National Academy of Agricultural Sciences, Hari Om Ashram Trust Award, Dr. B.P. Pal Memorial Award, Lal Bhadur Shastri Young Scientist Award, Jawaharlal Nehru Award, NAAS-TATA Young Scientists Research Fellowship, BOYSCAST Fellowship, Dr. P.B. Sarkar Memorial Endowment Lecture Award, Punjabrao Deshmukh Woman Agricultural Scientist Award, R.D. Asana Gold Medal, Dhiru Morarji Award of the Fertilizer Association of India, P.P. Singhal Memorial Award, IARI and ICAR Best Teacher Award, etc. The year wise awards received by the faculty are listed in Table 1.

Table 1: List of awards, trainings and scientific research publications

Year	Awards received by the scientists	Trainings arranged	Publications		Total
			National	International	
2001-02	26	74	722	241	**963**
2002-03	25	63	433	126	**559**
2003-04	28	37	475	175	**650**
2004-05	22	45	567	191	**758**
2005-06	10	39	894	299	**1193**
2006-07	24	26	1089	364	**1453**
2007-08	24	27	1029	343	**1372**

The Institute also organized several national and international short term training courses (regular, *ad hoc* and individual) and refresher courses in specialized areas for the scientists of National Agricultural Research System (NARS) under the programmes like "Centres of Excellence" and "Centres of Advanced Studies". Some special training courses were also organized for the benefit of farmers and extension workers (Table 1).

Total number of publications including research papers published in national and international journals of different disciplines contributed by the scientists of the Institute are mentioned in Table 1.

During the review period, a total of 1566 research papers have been published in journals, which have a rating of 5 and above as per in NAAS criteria. The discipline-

wise publications are given in Table-2. Overall, good publications have emerged in most of the divisions.

TABLE 2: List of publications during the period 2000-2008 which have more than five impact factor

S. No.	Division	Number of Publications									Total
		2000	2001	2002	2003	2004	2005	2006	2007	2008	
1	Genetics	0	1	2	10	20	17	17	21	18	**106**
2	CPCT	-	-	-	-	2	-	2	4	1	**09**
3	Veg. Science	1	1	-	1	1	1	4	4	5	**18**
4	FHT	4	6	4	2	5	6	10	7	7	**51**
5	PHT	2	3	1	3	10	4	12	9	10	**54**
6	FLS	-	-	-	-	-	-	1	1	2	**04**
7	SST	2	-	-	7	5	5	4	3	3	**29**
8	Agric. Chemicals	10	10	22	17	15	19	16	16	15	**140**
9	Entomology	6	9	4	4	6	7	8	8	6	**58**
10	Nematology	1	2	12	9	4	4	9	8	9	**58**
11	Plant Pathology	3	3	4	8	16	15	14	11	12	**86**
12	Agronomy	17	16	15	15	17	16	15	19	18	**148**
13	WTC	2	2	3	8	3	8	10	14	15	**65**
14	SS&AC	-	-	-	-	-	-	3	11	21	**35**
15	Agric. Engg.	-	4	10	-	5	6	9	17	10	**61**
16	Agric. Physics	3	6	5	4	2	3	3	4	6	**36**
17	Env. Science	10	5	4	9	8	4	12	16	13	**81**
18	Microbiology	6	3	4	9	6	8	16	16	28	**96**
19	NRCPB	10	14	16	15	19	18	20	25	30	**167**
20	Biochemistry	8	7	5	2	11	9	3	1	4	**50**
21	Plant Physiology	9	15	12	4	8	4	12	12	13	**89**
22	NRL	7	1	1	-	4	6	2	7	6	**34**
23	Agric. Extension	5	10	5	6	9	2	2	1	-	**40**
24	Agric. Eco.	5	1	4	8	7	3	6	5	7	**46**
25	R.S. Karnal	-	-	-	-	-	1	2	1	1	**05**
	Total	**111**	**119**	**133**	**141**	**183**	**166**	**212**	**241**	**260**	**1566**

CPCT- Centre for Protected Cultivation Technology, FHT- Fruits and Horticultural Technology, PHT- Post Harvest Technology, FLS- Floriculture and Land-scaping, SST- Seed Science and Technology, SS&AC- Soil Science & Agric. Chemistry, WTC-Water Technology Centre, NRCPB- National Research Centre on Plant Biotechnology, NRL- Nuclear Research Laboratory, R.S.- Regional Station

3.3 Externally Funded Projects

Given the national leadership in almost all major agricultural research areas, the Institute has close linkages with almost all research institutes, centres, project directorates, coordinated projects as well as a few selected institutes of the ICAR. At the international level, the Institute has close linkage with CGIAR's international agricultural research centres (IARCs), more particularly with ICRISAT, CIMMYT, IRRI, IFPRI, ISNAR, IWMI, ICARDA, and IPGRI and CABI. Other international organizations such as FAO, IAEA, UNDP, WMO, UNIDO and UNEP have been the closest allies. The number of externally funded projects undertaken by the Institute is given in Table 3.

Table 3: Number of externally funded projects operated at the Institute

Sponsoring agency	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
ICAR	52	49	64	58	52	49+	29+
DBT/DST, etc.	41	41	48	63	58	83	81
NATP	97	95	69	04	00	-	-
NFBRSA*	-	-	-	-	-	4	4
NAIP	-	-	-	-	-	6	15
Foreign aided	10	06	08	09	08	9	6
Total	**200**	**191**	**189**	**134**	**118**	**151**	**135**

***** National Fund for Basic and Strategic Research in Agriculture
+ Include 10 ICAR Plan Projects

3.4 Faculty Strength

Educational and research institutions world over are known for the competence of their teachers and scientists, and IARI is no exception. The eminent position of IARI in agricultural research and education is largely due to its highly competent and adequate faculty. This was also complemented by the students' community, which forms the cream of the country. The Institute continued to meet the new research and technology development needs of Indian agriculture. Total number of scientific, technical, administrative and supporting staff of the Institute during the period under review is given in Table 4.

Table 4: Staff position of the Institute as on 31.12.08

Year	Scientific		Technical		Administrative		Supporting	
	Sanctioned	Filled	Sanctio-ned	Filled	Sanctioned	Filled	Sanctioned	Filled
2000	654	545	1059	938	664	634	2241	1966
2002	654	513	998	895	650	598	2134	1817
2003	652	490	993	856	627	576	2042	1752
2004	652	473	993	836	594	533	2042	1730
2005	650	473	941	808	557	509	1880	1651
2006	608	428	856	749	548	499	1587	1504
2007	608	392	758	713	541	480	1430	1361
2008	608	375	730	683	540	450	1363	1301
Present strength	608	372	730	639	530	437	1359	1277

However, the QRT notes with concern the decline in the sanctioned strength of scientists over the years. Even during the review period the faculty sanctioned strength declined from 654 in 2001-02 to 608 in 2008. Even of the lowered sanctioned strength, the faculty in position was 375 as on 31.12.2008 and only 372 now which represents 61% of the sanctioned strength, 39% of the posts are vacant. The division-wise, centre-wise, project-wise and regional station-wise statements of scientific manpower as on 7.7.2009 are given in Table 5.

Table 5: Scientific manpower at IARI as on 7.7.2009

Division-wise statement

Name of the Total Divisions	Sanctioned strength				Scientists in position				Vacant position			
	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total
Agronomy	16	9	3	**28**	11	3	2	**16**	-5	-6	-1	**-12**
Genetics	35	27	8	**70**	24	11	1	**37**	-11	-15	-7	**-33**
Plant Physiology	15	6	2	**23**	11	1	0	**12**	-4	-5	-2	**-11**
Seed Sci. & Tech.*	11	6	3	**20**	9	1	2	**12**	-2	-5	-1	**-8**
Nematology	13	5	2	**20**	11	0	1	**12**	-2	-5	-1	**-8**
Biochemistry	10	5	2	**17**	6	0	1	**7**	-1	-5	-1	**-10**
Entomology	20	8	3	**31**	9	2	3	**14**	-11	-6	0	**-17**
Fruits & Hort. Tech.	10	4	2	**16**	6	1	1	**9**	-4	-2	-1	**-7**
Vegetable Sciences	9	4	2	**15**	8	0	1	**10**	-1	-3	-1	**-5**
Flori. & Land Scap.	9	4	2	**15**	7	1	1	**9**	-2	-3	-1	**-6**

Name of the Total Divisions	Sanctioned strength				Scientists in position				Vacant position			
	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total
P.H & T	7	4	1	**12**	7	1	0	**8**	0	-3	-1	**-4**
***(A)** Microbiology*	10	6	2	**18**	7	0	2	**9**	-3	-6	0	**-9**
***(B)** B.g.algal*	3	3	1	**7**	3	2	0	**5**	0	-1	-1	**-2**
Agric. Extension	10	7	3	**20**	8	2	1	**11**	-2	-5	-2	**-9**
Agric. Economics	12	5	3	**20**	7	1	1	**12**	-5	-1	-2	**-8**
Plant Pathology	23	10	4	**37**	11	6	2	**19**	-12	-4	-2	**-18**
Agri. Engineering	16	8	2	**26**	12	0	3	**16**	-4	-7	1	**-10**
Soil sci. & Ag. chem.	22	8	3	**33**	15	0	1	**18**	-7	-6	-2	**-15**
Agric. Chemicals	12	5	2	**19**	15	0	0	**15**	3	-5	-2	**-4**
Environmental Sci.	13	5	1	**19**	19	0	0	**19**	6	-5	-1	**0**
Agric. Physics	10	5	1	**16**	11	1	1	**13**	1	-4	0	**-3**
CPCT	4	1	0	**5**	2	0	0	**3**	-2	0	0	**-2**
Out Reach Ext. Prog												
***(A)** CATAT*	3	0	0	**3**	3	0	0	**3**	0	0	0	**0**
***(B)** ATIC*	2	0	0	**2**	1	0	0	**1**	-1	0	0	**-1**
Nat. Phytoron Faci.	1	0	1	**2**	0	0	0	**0**	-1	0	-1	**-2**
Total	**296**	**145**	**53**	**494**	**223**	**43**	**24**	**290**	**-73**	**-102**	**-29**	**-204**

(+) Excess (-) Vacant *(Note : S-3, SRSCI.-2, PS-1) 6 Post of Cstl Included

Centre-wise statement

Name of the Total Divisions	Sanctioned strength				Scientists in position				Vacant position			
	SCI	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total
Water Tech. Center	10	3	2	**15**	11	2	1	**14**	1	-1	-1	**-1**
Nuclear Res. Lab.	6	3	3	**12**	9	0	2	**11**	3	-3	-1	**-1**
Unit of Simu. Inform.												
(A) BIC	2	0	1	**3**	2	1	0	**3**	0	1	-1	**0**
(B) UASSA	0	0	0	**0**	2	0	0	**2**	2	0	0	**2**
KVK, Shikohpur	0	1	0	**1**	0	1	0	**1**	0	0	0	**0**
Total	**18**	**7**	**6**	**31**	**24**	**4**	**3**	**31**	**6**	**-3**	**-3**	**0**

(+) Excess (-) Vacant

Project-wise statement

Name of the Total Divisions	Sanctioned strength				Scientists in position				Vacant position			
	SCI	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total
Nematology	1	1	1	**3**	1	1	1	**3**	0	0	0	**0**
Flori.improvement	1	1	1	**3**	2	0	0	**2**	1	-1	-1	**-1**
Network Project on Pesticide Residue	2	1	1	**4**	1	0	0	**1**	-1	-1	-1	**-3**
Total	**4**	**3**	**3**	**10**	**4**	**1**	**1**	**6**	**0**	**-2**	**-2**	**-4**

(+) Excess (-) Vacant

Regional station-wise statement

Name of the Total Divisions	Sanctioned strength				Scientists in position				Vacant position			
	SCI	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total
R.S. Indore	5	3	1	**9**	4	2	0	**6**	-1	-1	-1	**-3**
R.S. Katrain	6	3	1	**10**	7	0	0	**7**	1	-3	-1	**-3**
R.S. Karnal	8	6	1	**15**	10	1	2	**13**	2	-5	1	**-2**
R.S. Pune	2	3	1	**6**	3	0	1	**4**	1	-3	0	**-2**
R.S. Pusa Bihar	4	6	1	**11**	1	2	1	**4**	-3	-4	0	**-7**
R.S. Kalimpong	3	1	0	**4**	0	1	0	**1**	-3	0	0	**-3**
R.S. Aduthurai	1	1	0	**2**	1	1	0	**2**	0	0	0	**0**
R.S. Dharwad	1	1	0	**2**	1	0	0	**1**	0	-1	0	**-1**
R.S. Wellington	3	2	1	**6**	1	1	1	**3**	-2	-1	0	**-3**
R.S. Amartara & Tutikandi, Shimla	4	3	1	**8**	2	3	1	**6**	-2	0	0	**-2**
Total	**37**	**29**	**7**	**73**	**30**	**11**	**6**	**47**	**-7**	**-18**	**-1**	**-26**

(+) Excess (-) Vacant

Consolidated statement of IARI divisions/centers/ projects/regional stations as on 7.7.09

Name of the Total Divisions	Sanctioned strength				Scientists in position				Vacant position			
	SCI	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total	Sci	Sr Sc	Pr Sc	Total
IARI Divisions	296	145	53	**494**	223	43	24	**290**	-73	-102	-29	**-204**
IARI Centres	18	7	6	**31**	24	4	3	**31**	6	-3	-3	**0**
IARI Projects	4	3	3	**10**	4	1	1	**6**	0	-2	-2	**-4**
IARI R.S.	37	29	7	**73**	30	11	6	**47**	-7	-18	-1	**-26**
Total	**355**	**184**	**69**	**608**	**281**	**59**	**34**	**374**	**-74**	**-125**	**-35**	**-234**

It is seen that divisions like Biochemistry, Fruits & Horticultural Technology, Floriculture, Microbiology, Plant Pathology and Plant Physiology have faculty strength nearly 50% or less of the sanctioned strength and the situation in other divisions is no better. In most of the divisions, the faculty strength is only 60%. This has seriously impacted quality and quantity of research. The QRT, therefore, recommends that all unfilled positions at IARI be filled on priority over the next three years. If necessary, a special recruitment drive may be undertaken for IARI.

3.5 Transfer Policy

Because of its preeminent position IARI attracted the most competent faculty. However, after the creation of ARS and the consequent transfer policy, scientists have been transferred to the Institute without considering their research competence and teaching ability befitting IARI's requirement. It is, therefore, suggested that the transfer to IARI should be bare minimum and need-based in consultation with the Director, IARI.

3.6 Patents Filed

The Institute filed 57 patents during the period under review. Yearwise number of the patents filed is given in Table 6 and the details are given in Table 7.

Table 6: Patents filed during the period of review

Period	Number of patents filed
2000	02
2001	12
2002	04
2003	04
2004	09
2005	05
2006	10
2007	05
2008	06
Total	**57**

Table 7: Details of patents filed

Sl. No.	Patents filed
1.	Pusa fruit coring device (hand operated)
2.	A process for the preparation of neem oil emulsion concentrate EW (emulsion oil in water)
3.	Improved process for the preparation of Mancozeb
4.	Improvement in or relating to the preparation of powdered Azadirachtin-A-rich concentrate from neem seed kernel
5.	Bioinoculator
6.	Improvement in process and device for production of quality rhizobial inoculants at door step of farmers
7.	Diagnostic kit for testing of air contamination in fermentation industry
8.	Bioseed vessel
9.	Biofermentor
10.	A hyper-spectral data analyzing method for characterization and discrimination of natural/ man made resources from air borne platforms
11.	A process for the preparation of mosquito larvicidal formulations based on *Rabdosia melissoide* ingredients
12.	Environmentally sound process for improvement in or relating to soil fertility and rice productivity
13.	Improvement in or relating to cultivation of azotobacter by fermentation for sustainable agriculture
14.	Pusa seed-cum-fertilizer disc drill
15.	Additives for improved photostability of Azadirachtin-A
16.	Animal feed block formation machine
17.	A process for the production of blue green algal biofertilizer
18.	A simple thin layer chromatographic process for obtaining Azadirachtins A,B and H from crude azadirachtin concentrates
19.	A process of preparing a herbicidal composition against *Phalaris minor* from neem and the herbicidal composition prepared thereof
20.	Pesticidal oxime esters
21.	Process for the preparation of mono/di/polyol pesticides ester
22.	Improvement in/or relating to preparation of reduced azadirachtin (S) biopesticides
23.	Improvement in/or relating to the preparation of thiophanate methyl
24.	Improvement in/or relating to synthesis of 4-methyl 6 alkyl-2H pyran-2 ones as potential fungicides
25.	Power animal feed mixer
26.	Improvement in/or relating to synthesis of O-alkyl derivatives of Oxime ethers of piperonal as potential fungicides

Sl. No.	Patents filed
27.	Urea molasses mineral block machine
28.	Pusa process for dried onion flakes
29.	Animal feed crusher
30.	Improvement in/or relating to the preparation of liquid pesticidal concentrates of neem meliacin(s)
31.	Light, heat and water resistant neem meliacin concentrates and product with controlled release
32.	A process for isolation of parthenin from parthenium hysterophorus as potential herbicide
33.	A process for the detoxification of chlorpyrifos residues in drinking water
34.	A process of expressing & isolating recombinant protein from prokaryotic cells
35.	Composition for early, profuse sporulation under solid state of the improvised isolate of *Trichoderma harzianum* and a process thereof
36.	Novel super absorbent hydrogel/s and the method of obtaining the same
37.	Process for the preparation of 5 substituted 1-3,4 oxadiazole-2 thiols as new urease and nitrification inhibitors
38.	A novel composition of biocontrol agent(s)
39.	Pusa process for experimental controlled atmosphere (CA) generation system
40.	Polymeric seed coats based on bioactive botanicals
41.	Pusa process for production and storage of frozen ginger slices
42.	Pusa process for ready to use dehydrated carrot shreds
43.	Synthetic gene encoding a chimeric d-endotoxin of *Bacillus thuringiensis*
44.	Synthetic gene encoding Cry1Fa1d-endotoxin of *Bacillus thuringiensis*
45.	A novel bio-pesticidal formulation with improved shelf-life and the method for its preparation
46.	A process for the decontamination of vitavax residues from wheat seed
47.	Decision support system for on farm Water Management – Farm Wat
48.	Improvement in Pesticidal neem preparations with Oxime Esters
49.	Precision seeder for plug tray nursery
50.	Development of entomopathogenic nematode-based termite bait and a technique to disseminate the bait for attracting and killing subterranean termites
51.	Solid-State Digesters for Anaerobic Fermentation of organic wastes for Biogas and Manure
52.	*Bacillus licheniformis* MTCC 7445 for control of soil borne pathogenic fungi
53.	Synthetic gene encoding Cry 2 Aal d-endotoxin of *Bacillus thuringiensis*
54.	Pusa Chickpea Thresher
55.	Pusa 5 SD- a bio-formulation of *Trichoderma harzianum* (IARI P-4) for seed treatment
56.	Pusa Bio-Pellet- a bio-formulation of *Trichoderma harzianum* (IARI P-4) for soil application
57.	Methodology and composition of artificial diet for mass rearing of lepidopteran pests (in particular *Halicoverpa armigera, Spodoptera litura* and *Earias vittella*)

3.7 Budget of the Institute

The consolidated year-wise statement of budget grants during the years 2002-03 to 2007-08 is given in Table 8.

TABLE 8: Year-wise budget details

Consolidated statement of budget grants during 2002-03 to 2007-08

(Rs. In lakhs)

Budget	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Non-Plan	7641.96	7816.30	8347.55	8485.00	9141.43	9246.00
Plan	589.83	367.22	950.71	1070.75	1702.82	1750.00
AP Cess Fund	144.58	150.02	192.30	113.80	105.92	49.40
NP+P Schemes	2951.26	4018.11	2430.75	2844.10	1696.43	2132.35
Deposit	1321.16	762.88	1276.67	1645.19	1844.09	1801.23
Total	**12648.79**	**13114.53**	**13197.98**	**14158.84**	**14490.69**	**14978.98**

4. Policies, Priorities, Strategies and Programmes

4.1 Prioritisation in Relation to Mandate, Objectives, Programmes, Strategies and Perspectives

The following were the Institute's well developed priority areas and programmes during the X Plan:

Productivity Improvement through Genetic Potential Enhancement

- Development of novel plant types, hybrids in open- and self-pollinated crops, new varieties of wheat, scented rice, oilseeds, pulses, fruits, vegetables and flowers having varying maturity, improved quality, nutritional enrichment, and suitability for export backed by an appropriate production and post harvest technology for value addition and processing
- Registration of genetic stocks and protection of plant resources of IARI under PPV&FR, IPR and other regimes
- Seed production, processing and maintenance breeding and seed technology development particularly for vegetables and flower seeds
- Acceleration in plant breeding efforts through Marker Aided Selection (MAS) for specific character trait
- Augmentation of the scion bank, root stock research, innovative orchard management for higher production, fruit quality, high density planting, micro propagation of fruits, technology for fresh pulp, syrups, juices and other value added products
- Strengthening of hybrid seed production, protected horticulture and saplings production

Resource Management and Environment Protection

- Integrated pest management (IPM), integrated nutrient management (INM), precision agriculture, geographic information system based resources mapping, water conservation, organic farming, and crop residue management in different cropping systems
- Watershed management, water harvesting, optimal use of water, micro irrigation system based farming including fertigation and conjunctive use of water, encouraging ground water recharge and on-farm water management on a holistic basis

- Soil, water and nutrient management, maintenance of soil fertility to sustain agricultural productivity, resource conservation technology (RCT) for maximizing crop production, crop modeling using GIS, GPS and remote sensing technology
- Strengthening of research in the area of global warming, management of impact of climate changes, and alleviation of environmental degradation
- Issues related to sanitary and phytosanitary (SPS) agreement, Codex, biodiversity and bio-safety needs

Basic Sciences

- Enhancing the capability and capacity in cutting-edge science and technologies such as molecular biology and biotechnology, informatics, crop and resource modeling
- Gene isolation and gene sequencing, development of transgenics for biotic & abiotic stress resistance and quality improvement, marker development, molecular probes for the detection and identification of plant pathogens
- Physiological and biochemical approaches for crop improvement through identification of constraints limiting productivity under different environments

Dissemination and Transfer of Technology

- Extension management, improving managerial skills of extension personnel, rural entrepreneurship development, gender empowerment, expert system, capacity building for programme monitoring and evaluation, indigenous technical knowledge system and marketing extension
- Advisory service for proper nutrient usage, pest identification and diagnosis, and soil and water quality, weather-based agro-advisory to farmers on resource management and environment protection
- Developing extension methodology for quality seeds production and location-specific extension models for public-private partnership to facilitate commercialization of agriculture
- Developing and promoting village-based models for market-led agriculture for accelerating the adoption and diffusion of technologies in different states
- Popularization of IARI varieties and technologies in different states
- Catalyzing the public-private partnership to facilitate commercialization of agriculture

Socio-Economic and Policy research

- Making agriculture cost-effective and sustainable with focus on strengthening of market information system, agri-business management, product launching, and development of expert system/potential

- Research on impact assessment and priority setting, environmental accounting, agro-diversity, contract farming, subsidies, economic zones, farmer's concern and linking production with marketing
- Strengthening of policy research on agro-biodiversity, plant varietal protection, plant breeders' rights, farmers' rights, intellectual property rights, biotechnology and GMOs, biosafety, etc., and national and international trade related issues
- Strengthening of the Institute Technology Management Cell (ITMC) to reach our products to farmers and others at affordable terms, and taking steps to protect innovation through intellectual property rights, trade mark, copy right, patent, etc.

Human Resource Development

- Development of the post graduate school to function as an important international centre for Human Resource Development in the field of agriculture
- Development of need-based basic and advanced courses and hand-on practical experience aimed to produce skilled human resources in the areas of biotechnology, precision agriculture, GIS, etc. Strengthening of trainings on molecular breeding, judicious use of natural resources, plant protection and hybrid seed production technologies
- Development of Centres of Advanced Studies to play leadership role in scientific research and technology generation

4.2 Programmes

Crop Improvement

Heterosis breeding and development of hybrids; pre-breeding activities and development of basic strategies for genetic reconstruction; maintenance breeding of parental lines of hybrids, inbreds and varieties of crops, vegetables, fruits and flowers; conventional breeding for improvement of mandate cereals, pulses, oilseeds, cotton, vegetables, flowers and fruits; molecular breeding for improvement of specific traits with precision in mandate crops; breeding for biofortification and nutrition use efficiency of both macro and micro nutrients, quality improvement; biotic stress resistance and abiotic stress tolerance; seed quality enhancement and production of quality seed/seed or planting material; DUS testing of plant varieties; genetic/molecular and structural basis for regulation/facilitation of germination, dormancy and vigour in seed; value addition for post-harvest processing and development of varieties of vegetables, fruits and flowers suited to protected cultivation technologies; post harvest management of arable crops; enhancement in quality and productivity of horticultural crops under protected conditions.

Basic Sciences

Biotic and abiotic stress tolerance (insect pests, viruses, drought, salinity and temperature); post-harvest physiology and preservation; nutritional quality improvement; biological nitrogen fixation and biocontrol and nutrient dynamics; impact of climate change and related variables; development of a central facility with modern instrumentation.

Crop Protection

Molecular strategy to develop and sustain improved plant resistance to biotic stress; biochemical and physiological interactions between crop plant and biotic stress; integrated pest management; forecasting and forewarning of pests and diseases; pest and pesticide risk analysis; pesticide resistance management; insect vector and disease relationship; development of novel agrochemicals and residue management; quality assurance, and safety of food products.

Natural Recourse Management

Microbial bio-control agents; integrated plant nutrient management systems; soil resource management; geo-informatics applications in agriculture; agro-advisory services; water and land resources management; recycling of waste waters in agriculture; water and nutrient synergy for enhancing crop productivity; enhancing productivity of rainfed areas; crop diversification; resource conserving technologies; organic farming; farm mechanization and development of equipment; precision farming and surface covered cultivation; post harvest engineering; climate change and agriculture; environmental impact assessment of agriculture; biofuels; agri-informatics.

Social Sciences

Policy research for sustainable agriculture; diversification of agriculture for enhanced livelihood security; institutions, policies and impact assessment; agricultural markets, trade and globalization; management of agricultural knowledge and information system; participatory technology generation, transfer, constraints analysis and intersectorial planning; rural entrepreneurship development and women empowerment; organizational strategy for commercialization and peri-urban agriculture.

4.3 Perspectives

The Institute has developed an excellent Vision 2025 document, which articulates perspectives in crop improvement, resource management, crop protection, basic sciences, social sciences and human resource development. However, the QRT feels that the Institute should develop a 5-yearly strategic plan with benchmark and clearly identifiable deliverable for every 5 year period.

5. Achievements of Various Project Directorates/ Divisions/Units

The most significant achievements of project directorates/divisions/units are given below:

5.1 School of Crop Improvement

Division of Genetics

Wheat

In the recent past the Institute has been able to release many varieties of wheat, viz. HW 2044, HD 2733, HW 2045, HD 2781, HD-2824, HW 2034, HD 2864, HD 2851, WR 544, HD 2833, HD 2888, HD 2932, HD 2894 and HD 4713 (*durum*). IARI wheat varieties like HD 2687 have shown their distinction in comparison to other wheat varieties. Although the variety PBW 343 has set a new yield standard globally, the impact of HD 2687 has been significant and is adding diversity. For example, during the year 2005-06 DAC indents for breeder seed of PBW 343 and HD 2687 were 141.7 tonnes and 36.2 tonnes, respectively. In some areas of Haryana, another variety HD 2733 is gaining ground having adapted well, and in Punjab, over the last three years, a quality wheat variety HD 2851 has been not only yielding better than PBW 343, but also fetching better price than PBW 343. The variety HD 2733 is covering a large area in NW and NE Plains Zones, and one variety HD 2851 is currently in demand in Punjab.

The varieties of wheat by IARI have been consistently providing a major food security input to the country. A conservative estimate reflecting only indented seed without including self-saved seed of farmer's show that about 30% of total wheat area of the country is covered by IARI wheat verities which mean IARI varieties account for additional wheat production to the tune of around 23 million tonnes. In basic and strategic research, the division was involved in designing of new plant type of wheat, new alleles for HMWGS, alien-transfer of disease resistance, identification of novel genes, development of high protein lines, diversity analysis using molecular markers and pyramiding genes for leaf rust resistance.

Wheat varieties at IARI field

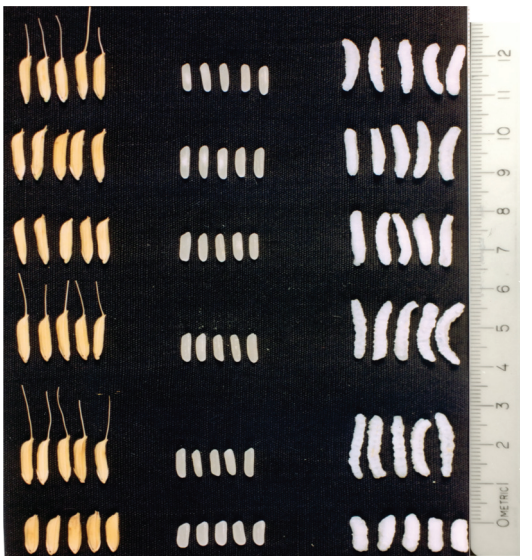
Rice

The Institute has developed and released 9 rice varieties, namely, Pusa Sugandh 2; Pusa Sugandh 3; Pusa RH 10; PNR 546; JD13; Pusa Sugandh 4; Pusa Sugandh 5; Improved Pusa Basmati 1(Pusa Basmati 1460) and Pusa Basmati 6 during the period under report. Out of these, early maturing, extra long grain high yielding aromatic rice varieties such as Pusa Sugandh 2 and Pusa Sugandh 3 were released by the CVRC in 2001 and Pusa Sugandh 5 which mature in 120-125 days was released in 2005. These varieties have potential yield up to 7 tonnes/ha and typical *basmati* quality. Since these varieties combine high yield with earliness, their per day productivity is very high. At the same time, these varieties require less input in terms of water and nutrients. In rice, the Institute has made unprecedented progress in improving yield and quality of *basmati* rice.

Pusa basmati 1121 combines unique *basmati* quality characters with high yield. It possesses extra long slender (7.71 mm) highly aromatic grains with 52.9% head rice recovery. It has the highest kernel length (up to 20 mm) after cooking with an exceptionally high cooked kernel elongation ratio of 2.5 and volume expansion of nearly four times. It has intermediate desirable amylose content, appealing taste, good mouth feel, and easy digestibility. In the panel test conducted by the Directorate of Rice Research, Pusa Basmati 1121 featuring highly elongated slender grains on cooking, achieved high scores for taste, aroma and attractive appearance during all three years of testing (2002-04). Since its release in 2003, the area under Pusa 1121 has been growing very fast. Encouraged by the response in the international market, the traders/millers in India were able to pay good price for Pusa 1121 to farmers. During *Kharif* 2008, the average yield of Pusa 1121 in farmers' fields was recorded as 5 t/ha and the average

paddy price of this variety in the *mandi* was Rs. 30,000/t, bringing a gross return of Rs 1,50,000/ha to farmers as against Rs 45,000/ha from cultivation of Taraori Basmati and Rs. 60,000/ha from Pusa Basmati 1.

Typical resistance reaction of Pusa Basmati 1 to the bacterial blight (BB)disease inoculums in the field



Rough, milled and cooked rice of Pusa 1121, Pusa Basmati 1 and Taraori Basmati (top to bottom)

Between the years 2003-04 and 2007-08, the export of *basmati* rice has increased from 7.71 lakh MT to 14.00 lakh MT, an increase of 81.5%. On the other hand, the acreage of notified and non-notified Basmati varieties has grown by 2.8% between the years 2003 and 2007. Although there was a negligible growth of *basmati* growing area, the additional export demand (81.5%) was met by India without increasing acreage. Earlier, India was utilizing 1.5 acre of land to export 1 matric tonne of *basmati*. After the acceptance of Pusa 1121 by the farmer, India utilizes 1 acre of land to export 1 matric tonne of *basmati*. The earning of foreign exchange is much higher from 1 acre of land compared to that in the previous years after the usage of Pusa 1121.

Pusa RH 10, the superfine grain aromatic rice hybrid was developed by using the *basmati* quality parental lines and was released by CVRC in July 2001 for commercial cultivation in the irrigated eco-systems of Haryana, Delhi and Uttaranchal. Pusa RH 10 is an early maturing hybrid of 115 days against 135 days taken by the best check variety Pusa Basmati 1, with 40% higher yield and 76% higher per day productivity.

Pusa RH 10 - First fine grain aromatic rice hybrid

The Pusa rice varieties cover more than 60% of rice grown in Punjab, Haryana, Uttaranchal and western Uttar Pradesh. Of the *basmati* varieties covering the area, more than 80% varieties were from the Institute making up a volume of more than 90% exported from India. Hybrid rice 'PRH 10', the first *basmati* quality hybrid in the world, significantly outfields 'Pusa Basmati 1' and has been taken up by a large number of seed companies.

In farmers' fields, Pusa RH 10 has yielded up to 10 t/ha. On account of its earliness, Pusa RH 10 fits well in the rice-wheat cropping system and saves up to 3 irrigations. During *Kharif* 2007, Pusa RH 10 was planted on approximately 50,000 ha area. Its average yield on farmers' fields was recorded between 7.5 and 8.0 t/ha with Rs. 18000/t paddy price giving a gross return of Rs. 1, 35,000/ha. This hybrid is in great demand and will help in enhancing the production of quality rices.

A stepwise strategy involving conventional selection for the target grain and cooking quality traits, the marker assisted foreground selection for genes, namely, *xa 13* and *Xa 21,* and background selection using STMS markers for resistance to bacterial leaf blight was incorporated in Pusa Basmati 1.

A strategy based on the *Rf*-gene linked marker RM258 developed for testing the genetic purity of the hybrid seed lot of aromatic rice hybrid Pusa RH 10 was found to be quite efficient.

In basic and strategic research, the division was involved in pyramiding of genes for resistance to bacterial blight and blast diseases in Pusa 6A, PRR 78 and Pusa Basmati 1460 and marker assisted backcross breeding to combine four bacterial blight resistance genes (*Xa4, xa5, xa13* and *Xa21*) with comparable yield, grain and cooking quality attributes.

A new variety of rice was developed in collaboration with the NRCPB by adopting molecular marker assisted backcross-breeding to make the variety Pusa Basmati 1 resistant to bacterial leaf blight with incorporation of genes *xa13* and *Xa21*. This variety is the first rice variety being released and notified under MAS programme in the country.

Pusa Basmati 6, an improvement over Pusa Basmati 1121 was released having higher yield, better grain quality and better aroma. This new variety responds well to higher nitrogen application and does not lodge.

A noble genetic stock of wheat WR95 (INGR08070) carrying newly identified gene for apical lethality apd1 was registered with NBPGR in 2008 as a tester stock for gene apd1.

Maize

The Institute has developed and released 5 maize varieties/hybrids, namely, PEHM 3; PEHM 5; PC 3; PC 4 and AH 58 during the period under report.

The division has contributed in fingerprinting of selected Indian maize inbreds and landraces using multiplexed, fluorescent-labeled SSR loci, identification of QTL conferring resistance to sorghum downy mildew and Rajasthan downy mildew and their marker-assisted introgression, genetic and molecular analyses of banded leaf and sheath blight (BLSB) resistance, mapping QTLs for drought stress tolerance and genetic, biochemical and molecular analyses of quality protein maize (QPM) lines.

A noble genetic stock of maize INGR08117(SC-24-92-3-2-1-1) for maydis leaf blight resistance was registered with NBPGR in 2008.

Pearlmillet

Two pearlmillet varieties Pusa Comp.383 and Pusa Comp.443 developed by the Institute have been released during this period. The pearl millet microsatellite or simple sequence repeat (SSR) markers were utilized for molecular characterization of 21 elite inbred parental lines of 13 pearl millet cultivated hybrids. In total, seven SSR markers differentiated eight of the 21 inbred lines. Among the three datasets, the combined SSR+RAPD dataset proved to be more useful in identifying the genetic relationships among the lines under study in comparison with the individual datasets. Experimental hybrids were produced by using five newly developed male sterile lines, viz., MS 411A, MS 431A, MS 419A, MS 589A and MS 549A along with three checks MS 841 A, MS 189 A and MS 576 A to assess the combining ability and disease reaction of the parental lines and hybrids.

Sorghum

During the period the Institute has developed two varieties/hybrids of sorghum, namely, Pusa Chari Hybrid 109 and Pusa Chari 615.

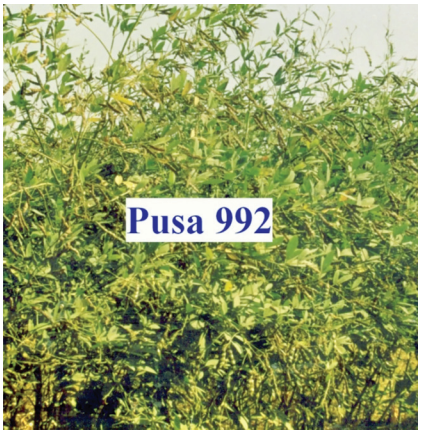
Chickpea

Eight chickpea varieties, namely, Pusa 1053, Pusa 1088, Pusa 1103, Pusa 1105, Pusa 1108, BG 547, BGD 128 and Pusa 2024 were developed and released by the Institue during this period. The chickpea varieties such as Pusa 1053, Pusa 1088, Pusa 1103, Pusa 1108, etc., developed by the Institute were released for commercial cultivation and are able to yield more than 2500 kg/ha. These varieties have significantly out yielded all the national checks by 20-40% in yields under all India coordinated yield trials. The farmers planting IARI varieties in U.P., Haryana, Punjab and Rajasthan are harvesting between 2000 and 3000 kg/ha. The farmers in M.P. and Bihar are also favouring IARI varieties for cultivation due to their yield superiority.

The varieties, viz., Pusa 362, Pusa 372, Pusa 391, BGD 72, Pusa 1053, Pusa 1088, Pusa 1103 and Pusa 1108 possess multiple resistances against *Fusarium* wilt and root rot. Owing to their multiple resistances, these varieties are in great demand by farmers of various states. The varieties Pusa 362, Pusa 372, Pusa 1103 and Pusa 1108 are giving about 25% higher yield in comparison to national checks under late plantings (November 25 to December 5) in northern states with high degree of adaptation.

Pigeonpea

The Institute has developed and released four pigeonpea varieties, namely, Pusa 991, Pusa 992, Pusa 2001 and Pusa 2002 during this period. In order to develop CMS based early duration pigeonpea hybrids research activities are being carried out. CMS lines derived from *Cajanus scarabaeoides* source came into existence during the year 2000. During the the period under review attempts were made to transfer the cytoplasm of A line into good combiners, well adapted to



agronomic bases. Four A lines (BC_6), viz., Pusa 33A, Pusa 2008 A, GPL 100A and GPL 290 A were established by incorporating sterile cytoplasm from GT 288A and two A lines (BC_3) stage, viz., Pusa 9 and Pusa 855. In order to search for fertility restorers, crosses between fertile derivatives and A lines are being attempted and evaluated. A new dwarf plant type of pigeonpea was developed from population improvement programme. Ten SDT and 25 IDT single plants characterized by a large number of secondary branches having extra-early maturity were developed.

Mungbean

The mungbean breeding programme of the Institute has led to the development of three varieties, namely, Pusa 9531, Pusa Vishal and Pusa Ratna. Fifteen advanced breeding lines from diverse cross, IPM 99-125× Pusa Bold 2 along with check variety PDM 139 were characterized with 14 primers. Eight RAPD primers, five URP primers and one SSR primer, exhibiting polymorphism were used for diversity analysis. RAPD primers amplified 51 loci, URP primers amplified 26 loci and one SSR primer used amplified 5 alleles.

In addition, three varieties in pea (Pusa Prabhat, Pusa Panna and Pusa Mukta), one variety each in cowpea (Pusa 578) and lentil (Pusa Masoor 5) were also released by pulse improvement group of the Institute.

Mustard

The Institue's mustard breeding programme has developed 10 mustard varieties namely Pusa Swarnim, Pusa Agrani, LES 39, JD 6, NPC 9 and Pusa Mustard 21, Pusa Vijay, Pusa Mustard 22, Pusa Mustard 24 and Pusa Tarak during the period under report. In a diallel analysis involving 12 parents, it was found that oleic acid, linolenic acid and erucic acid were governed by additive gene effects while there was predominance of dominant component of ecosenoic acid. Ten fixed lines tolerant to high temperature at seedling stage and short duration breeding material with less than 100 days maturity were identified for early sown (September) mustard. A line NPJ-102 (SEJ-8 X PA) was characterized by 93 days' maturity and 2000 kg/ha seed yield. Other cultures in early maturing (<105 days) material were NPJ 103, NPJ 90, NPJ 95 and NPJ 96.

Soybean

Two soybean varieties, namely, Pusa 9712 and Pusa 9814 were developed and released by the Institute during this period.

Cotton

The *Gossypium hirsutum* variety Pusa Arvindam (PSS2), a compact plant type, early maturing (130-135 days), resistant to *Cotton leaf curl virus* disease, tolerant to jassids and having an average seed cotton yield of 1.18 t/ha was released for West Bengal.

Division of Vegetable Science

During the period, the Division of Vegetable Science developed and released 15 varieties and 3 F_1 hybrids of major vegetable crops like tomato, brinjal, cauliflower, bottle gourd, bitter gourd, ash gourd, sponge gourd, cucumber, muskmelon, snap melon and carrot for higher and early yield, resistance to biotic and abiotic stresses, superiority in quality and nutritional values and also for industry and export. These are: Pusa Rohini, Pusa Hybrid 8, F_1 hybrid of tomato; Pusa Shyamla of brinjal; Pusa Meghna, Pusa Sharad, and Pusa Kartik Sankar', F_1 hybrid of Cauliflower; Pusa Samridhi of bottle gourd; Pusa Hybrid-2 of bitter gourd; Pusa Ujwal of ash gourd; Pusa Sneha of sponge gourd; Pusa Uday of cucumber; Pusa Shandar of snap melon; DMDR-2 of muskmelon, Pusa Mridula of table radish, Pusa Sukomal of cowpea, and Pusa Rudhira (IPC 122) and Pusa Asita (IPC 126) of carrot.

Pusa Rohini

Pusa Meghna

Several promising selections and F_1 hybrids, viz., DAG 4 and DAG 6 in ash gourd; DBTG 1 in bitter gourd; DBSR 53, DBL 02 and DBHSR 66 in brinjal; DT 2 in tomato, Sel 402 and Sel 383 in onion; DCL 352 and DCL 524 in chilli; DC 76 and DC 5 in cauliflower; GP 4 and GP 17 in garden pea; DMV 1 in muskmelon and DOV 1 and DOV 2 in okra were promoted to AVT-II trial of AICRP (VC). Stable CMS and maintainer lines in short day onion were developed and utilized in the development of promising F_1 hybrids H 42, H 52 and H 44. Promising Sel 126, Sel 397, Sel 106 and N

53 were identified for off-season cultivation. Two varieties of white onion, viz., Pusa White Round and Pusa White Flat were found superior for dehydration and producing onion flakes. In cauliflower promising F_1 hybrids CH 598, CH 5113 and CH 406, CH 413 were developed by utilizing CMS lines and SI lines, respectively. In brinjal, resistance sources against *Phomopsis* blight and fruit and shoot borer were identified and utilized for the development of high yielding disease resistant varieties and F_1 hybrids.

In tomato, resistance sources against *Tomato leaf curl virus*, early blight and root knot nematode were identified and utilized in breeding programme. Hot and cold set and thermo-insensitive lines Booster, New Wonder and Sel 3 (hot set) and Pusa Sadabahar, Pusa Sheetal, Balkan, S 693, New Wonder and Booster (cold set) were identified for growing under high/low temperature regime. In cucumber, promising F_1 hybrids DCHG 2 and DCHG 4 were developed by utilizing stable tropical gynoecious lines. In sponge gourd, resistance source against *Luffa yellow mosaic virus* was identified and utilized in the development of virus resistant variety.

In bitter gourd, two predominant gynoecious lines, DBTG 201 and DBTG 202, were developed and used to assess their potential in the development of hybrids. In okra, C 289, C 302, C 316, C 317, C 320 and A 9 showed promise for export and had 10-12 fruits/plant, and short (8-10 cm), dark green fruits.

In carrot, promising selections, IPC 122 (red) and IPC 133 (orange) with self-colourd core rich in anthocyanin and carotene contents were developed. In garden pea, resistance sources against *Fusarium* wilt and powdery mildew were identified.

The Division has taken up the production of breeder seeds of high yielding varieties and parents of hybrids and sold them to public/private institutions for further multiplication and distribution. Over two tones (2.255 t) seed of the vegetable varieties was produced from 2000-01 to 2007-08. The National Seeds Corporation has 70% share of our vegetable varieties in their vegetable seed production programme. More than 30 institutions, both public and private, are annually purchasing seed and multiplying them further for sale.

Molecular diversity and its relationship with morphological traits and heterosis have been studied in bitter gourd, snap melon, cucumber and brinjal. In cauliflower, five cytoplasmic male sterile lines (MS 01, MS 4, MS 5, MS 11 and MS 23) in early group and 2 (MS 09 and MS 10) in mid-maturity group were developed and utilised in hybrid programme. In tropical carrot, cytoplasmic male sterility was introgressed and established in the background of elite genetic material and is being exploited for F_1 hybrid development. In cucumber and bitter gourd, gynoecious lines were developed and were utilized in hybrid breeding programme.

Low cost poly-house for growing off-season vegetables

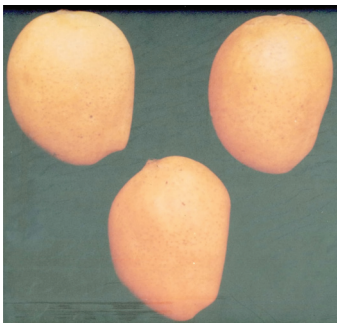
The Division has developed six production technologies, viz., raising off-season nursery of cucurbitaceous vegetables, easy and efficient method of hybrid seed production of cucurbits, cultivation of high value vegetables in low-cost poly-house, technology for successful storage of Broccoli, ratooning of brinjal, and cultivation of cauliflower in different seasons.

Hybrid seed production in cucurbits (bitter gourd and pumpkin) through 'pinching (male flower) technique' has become popular among several progressive farmers to make profits and help in seed availability.

Division of Fruits and Horticultural Technology

Two new mango varieties Pusa Arunima (Amrapali × Sensation) and Pusa Surya (selection from Eldon) were released. Pusa Arunima bears attractive red peel coloured fruits, which have medium TSS (19.5%), fibreless pulp and long shelf-life (12 days after ripening). Pusa Surya bears attractive apricot-yellow fruits of medium TSS (18.5%), good size (270 g) and long shelf-life (12-14 days). Both these varieties are suitable for international markets.

Pusa Arunima



Pusa Surya

In addition, two new promising mango hybrids, namely, H 1-1 and H 1-6 were identified for release by the Institute Variety Release Committee in July 2006. Both these hybrids are regular and bear red peeled fruits with good quality. Other hybrids H 2-6, H 4-12 and H 8-11, which are performing consistently well, are in advanced stage of their release.

In guava, a dwarfing guava rootstock, Pusa Srijan (Aneuploid No. 82) was released by the State Variety Release Committee of National Capital Territory of Delhi in 2004. It was found to induce dwarfing effect in Allahabad Safeda and recommended as a suitable rootstock for establishing high-density orchards (3 m × 3m) in guava. It also improved the fruit quality in terms of TSS and reduced seed content.

Grape improvement work was attempted for earliness and better berry quality. During the period, two new hybrids, namely, Banqui Abyad × Perlette-75-32 and Hur × Cardinal-76-1, performing well on Head and Bower systems of training have been identified for their future release. In order to enrich the existing germplasm conserved at the Institute, 75 genotypes in citrus, 8 in grape and 15 in guava were added to the existing germplasm.

Trials were conducted for identification of suitable rootstock for sweet orange. Cleopatra mandarin was identified as a potential rootstock for Mosambi sweet orange for producing better quality fruits.

Division of Post Harvest Technology

Several technologies have been developed in the area of post harvest management of horticultural crops for fresh marketing. Controlled atmosphere storage conditions for many horticultural crops, especially, mango and guava have been developed for export. Strategies for fruit fly disinfestations in rainy season guava have been developed by the use of high CO_2 as insecticidal controlled atmosphere. Various packaging technologies have been developed for IARI bitter gourd varieties and marigold flowers by using both passive and active atmospheric modifications. CA storage technology using Pusa Controlled atmosphere generation system has been transferred to M/S FHEL.

Processes for production and storage of frozen ginger slices, lime-aonla and mango-pineapple beverage, lime-ginger spiced beverage, jamun juice concentrate, whole tomato crush, sauerkraut, fortified fruit cheeses, osmotically dehydrated mango slices, high moisture bittergourd rings, ready-to-eat dehydrated carrot shreds, dehydrated *aonla* shreds, and minimally processed capsicum have been standardized. Varieties have been identified for their antioxidant content and action has been taken for exploring ideal

genotypes high in antioxidant. The technology developed for making RTE snack from maize is useful to develop nutritious products at commercial scale. A laboratory model of the microwave assisted convective dehydration system has been developed by modifying a domestic microwave oven. The developed system was found to be 50 to 500% more energy efficient than the conventional convective dehydration system. The quality of the products was significantly better than the convective dried products. An experimental controlled atmosphere generation system has been made. A small scale batch type roasting equipment of 30-40 kg/h capacity consisting of a cylindrical hopper, a roasting bin, an agitator, a delivery section, a heating unit and a temperature control unit was developed for studies on roasting of maize and *jowar* to develop snack food. A hand operated roller flaker machine was fabricated for making flakes having drastically reduced cooking time.

Division of Floriculture and Landscaping

The Division of Floriculture and Landscaping has developed 19 rose varieties during the period. The Division has the distinction to evolve the first ever thorn less large flowered rose variety, Pusa Mohit, in India. Eight varieties, namely, Pusa Gaurav, Pusa Bahadur, Pusa Priya, Pusa Garima, Dr. Bharat Ram, Pusa Baramasi, Pusa Virangana, Pusa Pitamber, were released in 2000, six varieties, namely, Pusa Abhishek, Pusa Manhar, Pusa Muskan, Pusa Urmil, Pusa Ranjana, and Pusa Mohit in 2002, one variety Pusa Mansij in 2004 and four varieties, namely, Pusa Ajay, Pusa Arun, Pusa Shatabdi and Pusa Komal in 2005.

Fourteen varieties of gladiolus were released during the period. Nine gladiolus varieties, namely, Gunjan, Kamini, Lohit, Mohini, Rangmahal, Surya Kiran, Swapnil, Swarnima and Urmil were released during 2000 while five varieties, namely, Urmi, Jyotsna, Gulaal, Shabnam and Urvashi, were released in 2002.

Three male sterile lines of African marigold *(Tagetes erecta),* viz., MS 5, MS 7 and MS 8, were crossed with different promising lines of French marigold *(Tagetes patula)*, viz, French maroon, French orange and French bicolor to obtain triploid interspecific hybrids. Among the hybrids developed, MS-5 C French maroon, proved to be very promising. It had intermediate growth habit and flower size. It was found most ideal for loose flower production.

Under pre-treatment studies, fresh marigold petals before drying lead to higher retention of carotenoids in Pusa Narangi Gainda. Treatment with cysteine (0.1%) gave best results. Cabinet drying was found to be the best method requiring less time for drying and retaining maximum total carotenoids (355.04 mg/100) in dried petals.

In the case of Chrysanthemum, potential mutants were noticed in one of the promising standard cultivars Thai Chen Queen, and two of the spray cultivars, Ajay and PC 10. Significant chimeras of variable colours were noticed at 1.0 and 2.0 Kr dose. Very useful variants having different flower shape, floret shape, leaf shape and sizes were noticed.

Rose variety- Pusa Garima

Red Yellow Mutant from Thai Chen Queen (28C) variety of Chrysanthemum

Promising mutants have been identified from cultivars, Poornima, Tata Century and Sadbhavana. About 15 promising mutants have been isolated during the period under report.

Varietal evaluation studies in four cultivars of single petalled tuberose, viz., Mexican Single, Shrinagar, Prajwal and Sikkim Selection revealed that variety Prajwal gave the maximum plant height, fresh and dry weight of leaves, diameter and fresh weight of individual bulb and floret and width of leaf. On the other hand, the maximum number of leaves and tillers per clump and weight of individual bulblets were produced by variety Mexican Single. The maximum number of florets per spike and total number of spikes per plot were obtained from variety Shringar. Among the three double cultivars of tuberose, viz., Pearl Double, Suvasini and Vaibhav, Suvasini performed much better than the remaining two varieties. February to April plantings are better for tuberose. Studies indicated that daughter bulbs can be harvested seven months after planting.

In protected cultivation of flower crops, out of six exotic varieties, four of them, namely, First Red, Grand Gala, Konfetti, and Noblesse, were grown under low cost

poly-houses for fertigation trial. A plant population of 8 plants/m^2 was found to be optimum for all the cultivars. Based on the performance, the variety First Red among the exotic cultivars and Raktima among the Indian bred varieties were better with regard to various qualitative characteristics.

Centre for Protected Cultivation Technology (Erstwhile Indo Israel Project)

During the period, the Centre for Protected Cultivation Technology developed a number of technologies for protected cultivation. Different designs of low cost, naturally ventilated greenhouses were developed and evaluated with a view to making them economically viable and cost-effective for small growers in local conditions. The designs were so simple that these could be constructed by the growers themselves to minimize the initial cost. High intensity, plug-tray technology for growing seedlings of different vegetable and ornamental crops in all seasons was developed. Plastic low tunnel technology for off-season cultivation of muskmelon and summer squash crops was developed. The technology was found to be highly profitable for vegetable growers in peri-urban areas of northern plains of India during winter season when the temperature goes below 5 ^oC for a period of 40-60 days with this technology; advantage can be taken of bringing produce early in market.

Fertigation control system at Centre for Protected Cultivation Technology

Further, production technology of high quality tomato and parthenocarpic cucumber grown under naturally ventilated greenhouse conditions was standardized. Tomato crop grown for a period of 9 months yielded 120 to 150 tonnes of tomato fruits per hectare with a cost: benefit ratio of 1:2. Three crops of cucumber were grown in a year and

fruit yield levels of 100 to 120 t/ha were obtained with a cost: benefit ratio of 1:2.2 to 1:2.5.

A low pressure drip irrigation system was found particularly suitable for protected horticulture where the crop grown area is relatively small, and precise fertigation is required to get quality products. This system requires a hydraulic head of about 2 meter for irrigating an area of about 500 m^2. It requires comparatively less pressure compared to normal pressurized irrigation system and is suitable for small land holdings, greenhouses and nursery. It has high irrigation efficiency (greater than 90%) and is easy to install, operate and maintain. The low pressure drip irrigation system overcame the two major limitations of the pressurized irrigation system, viz., continuous requirement of energy and high initial cost.

Division of Seed Science & Technology

Seed production of rice hybrid Pusa RH-10 has been standardized for north Indian conditions to achieve an average yield of 2.5 to 3.0 t/ha with the application GA_3 @ 90-135 g/ha + 1% boric acid in 3 split doses with 2:8 row ratio. A technology for hybrid tomato seed production under low cost polyhouse conditions has been developed. The presence of optimum temperature (26 $\pm$ 2 ^{0}C) and relative humidity (75 $\pm$ 2%) along with frost free conditions in polyhouse prolonged the period of flowering and hybrid seed set resulting in economic yield. Hybrid seed production technology developed for brinjal in insect proof net house was cost effective and eco-friendly with better seed quality parameters. As a result, several farmers have undertaken training and initiated hybrid seed production at village level from 2006 to 2008.

In view of the recently enacted PPV&FR Act, 2001, it has become mandatory that all plant varieties bred by the public or private institutions or individuals are protected from unauthorized use. The Division had taken a lead in this area and generated technical information as well as manpower to implement the Act. Recognizing the need for scientific competence and facilitating the implementation of PPV&FR Act, 2001, a team of excellence was established under NATP in the Division to create a national facility for this purpose.

DUS test guidelines were developed based on morphological, biochemical and molecular characterization for rice and pearlmillet for the purpose of plant variety protection.

Seed coating with synthetic polymers resulted in improved field emergence, and packing in 'Super Bags' retained high germination up to 12 months.

Germination testing procedures, including TZ test for viability and dormancy release methods, were standardized for medicinal species. Seed quality assurance at national level was facilitated by the Division through referee testing and service sample testing of a large number of samples in cereals, pulses, oilseed and vegetables, as the Division performed the functions of the Central Seed Testing Laboratory and imparted training for personnel in seed testing. Simple and reliable methods of testing hybrid seed purity, based on SDS-PAGE of seed globulins/methanol extracted fractions and RAPD markers, were developed for 3 cotton hybrids.

5.2 School of Crop Protection

Division of Agricultural Chemicals

For developing natural and synthetic agrochemicals and their adjuvants, the Division of Agricultural Chemicals has identified compounds such as O,O-di (pentachlorophenyl) O-2-chloroethylphosphorothionate (*Helminthosporium oryzae* ED_{50} 190 ppm), O, O-di-(2, 4-dimethylphenyl) O-ethyl phosphorothionatet (*Rhizoctonia solani* ED_{50} 66 ppm and *Sclerotium rolfsii* ED_{50} 42 ppm), methyl 3, 5-dinitro-salicylate (*R. solani* ED_{50}=28 ppm), methyl 2-methoxy-benzoate and methyl 2,4-dichloro-benzoate (*S. rolfsii* ED_{50}=47 ppm), methyl 4-nitro- benzoate (*P. aphanidermatum* ED_{50}=70 ppm) and methyl 2-methoxy-benzoate (*F. oxysporum* ED_{50}=56 ppm), which exhibited highest fungicidal activity. Carvone oxime N-O-acetyl ester (EC_{50}, 145.3 ppm) and carvone oxime N-O-pentanoyl ester (EC_{50} 155.1 ppm) were found to be most effective against *R. solani*, whereas carvone oxime N-O-acetyl ester (EC_{50} 83.2 ppm) and carvone oxime N-O-cinnamoyl ester (EC_{50} 61.5 ppm) were found effective against *S. rolfsii*. 4-Methyl-6-pentyl-2H-pyran-2-one and 4-methyl-6-hexyl-2H-pyran-2-one showed antifungal activity similar to carboxin, a systemic commercial fungicide (EC_{50} 1-2ppm). NAS I and NAS II were found to be active against J_2 of *M. incognita* (LD_{50} 1.9 and 4.0 ppm, respectively), whereas NAS I was also found active against *R. reniformis* (LD_{50} = 3.9 ppm).

Parthenin, isolated from *Parthenium hysterophorus,* and three of its derivatives which have been found effective in inhibiting seed germination of *Cassia tora* (500 mg l^{-1}) also showed herbicidal activity against *Amaranthus viridis, Avena fatua, Bidens pilosa* and *Chenopodium murale*. Two compounds, namely, 8-allyl-2-phenyl-chroman-4 one and 8-allyl-2- (4-hydroxyphenyl) chroman-4-one from hexane extract of *Phyllanthus niruri* and alkaloids, namely, palmatin and tetra hydropalmatin from chloroform extract of *T. cordifolia* with maximum nematicidal activity against *M. incognita,* have been identified.

A mixed fungal culture isolated from metolachlor acclimatized field soil was able to degrade metolachlor with a half life of 3-5 days. *Proteus vulgaris* and H_5 strain were

found to degrade fenvalerate up to 73% in 3-4 weeks. Two nematophagous fungi, namely, *Aspergillus terreus* and *Cladasporium oxysporum* dissipated endosulfan by 89-91% in 15 days. Cell free extract of *A. flavus* has been found to degrade metolachlor in phosphate buffer. Culinary process like washing with water, peeling and steaming could reduce residues of l-cyhalothin from fruits.

The Division filed a number of patents during the period of review and seven technologies developed were transferred to six industries.

Division of Entomology

During the period, the Division of Entomology has developed INFOCROP, a generic crop growth simulation model coupled with different pest damage mechanisms for assessing crop losses due to multiple pests, and devised decision support tools in rice. Under insect pest management, the screening of some sorghum varieties and hybrids led to the identification of eleven lines, viz., SPV 1517, SPV 1518, SPH 1270, SPH 1183, SPH 1148, SPH 1280, SPV 1562, SPV 1572, SPV 1575, SPV 1576, and SPH 1363 resistant to shoot fly; thirteen lines, viz., SPV 1518, SPV 1489, SPV 462, SPH 1148, SPH 1270, SPH 1280, CSH 17, SPV 1572, SPV 1563, SPV 1565, CSH 16, SPH 1335 and CSV 15 against stem borer, and five lines, viz., SPV 1489, CSH 18, SPH 1270, SPV 1567 and SPH 1365 against *Pyrilla.* Two entries, viz., SPV 1518 and SPV 1572, were identified as multiple resistance sources showing resistance to both shoot fly and stem borer. In brinjal, borders of either radish or guar or maize followed by two foliar sprays of Spinosad @ 75 g a.i./ha gave good protection against *L. orbonalis*. Okra intercropped with baby corn recorded most encouraging performance against leafhopper *A. bigutulla*, fruit borer *Earias vitella* and whitefly *Bemisia tabaci*. One spray of acetamiprid at 60 DAG gave the highest yield. Harvest of baby corn additionally increased economic return. Abamectin, emamectin benzoate, spinosad and α-Cyfluthrin protected the crop against bollworms very effectively leading to increased cotton production to the extent of 164% over that of control.

Carboxylesterases were found to be responsible for imparting resistance to insecticides in the bollworm *Helicoverpa armigera*. The baseline susceptibility studies on *H armigera* showed the populations from Delhi, Akola, Navsari III and Mansa to be the least susceptible while populations from Bhatinda, Muktsar, Navsari I and Amravati (M.S.) to be highly susceptible to *B. thuringiensis* var. *kurstaki* HD-73. Of the six midgut proteases of *H. armigera* characterized, 29.5 kDa protease was mainly responsible for the activation of protoxin to toxin of Cry1Ac.

Under the Insect Identification Service, 721 specimens belonging to the orders Coleoptera and Hymenoptera were identified for 53 correspondents. Inventories of the

biodiversity of Hemiptera, Thysanoptera and Acarina were prepared. A CD-ROM was developed for the pest diagnostics of lepidopterous insects associated with rice in India.

A number of technologies were developed during the period such as vermicompost; apiculture; pusa bin for storage of food grains; microbial pesticides like NPV of *Spodoptera litura* and *Helicoverpa armigera;* formulation technology for Bt, fungi and NPV; IPM technology for cotton and vegetable crops; production technologies of bioagents like *Chrysoperla carnea, Mallada boninensis;* and parasitoids, *Trichogramma* spp*, Chelonus blackburni,* and *Bracon* spp.

Division of Nematology

The research work was concentrated mainly on nematode biodiversity, biosystematics, biocontrol, host-parasite interaction, use of entomopathogenic and microbivorous nematodes, botanical pesticides, use of molecular techniques in identification of nematodes, and development of integrated nematode management packages and their demonstration in farmers' fields. Biosystematics studies revealed the description of new species of plant parasitic nematodes, viz., *Tylenchorhynchus* and *Helicotylenchus* from Haryana, *Heterodera* from Assam, *Paratylenchus* from Uttranchal, *Xiphinema* and *Xenocriconemella* from Himachal Pradesh and Bhutan. Another two new species of predatory nematodes of genera *Mylonchulus* and *Ironus* were identified from brinjal and squash gourd at IARI, New Delhi. Biodiversity of cyst nematodes showed moderate to heavy infestations of maize cyst nematode *Heterodera zeae*.

The Division developed a distribution map, a diagnostic key and a compendium of root-knot nematodes *Meloidogyne* spp., and a compendium as well as a diagnostic key to the species of Group 3 of *Xiphinema.*

The National Nematode Collection of India (NNCI), the largest repository of nematodes in Asia, has been augmented with new type and wet suspensions totalling 2006 type accessions. The database of 2180 type accessions has been converted into DSS (Decision Support System) in HTML file format.

Molecular characterization of different populations of cyst nematode *Heterodera* spp. by the use of *Rsa*1 and *Hinf*1 revealed more intra-species variation in populations of *H. zeae* from Bilaspur, Hoshiarpur, Delhi, Kulu, Samastipur and Panipat. Restriction digestion of rDNA with restriction enzyme Hinf1 revealed that *Heterodera avenae* population of Hosiarpur, Sirsa and Ludhiana belonged to the species *H. filipjevi* and others to *H. avenae*. PCR-RFLP of ITS of rDNA of Indian isolates also revealed that they were different from the European, French and Australian populations. Molecular characterization of five populations of root-knot nematode *Meloidogyne incognita* from

Delhi, Bangalore, Devanahalli, Udaipur and Vijayapura done using PCR-RFLP of internal transcriber spacers (ITS) with six restriction enzymes revealed that the populations from Bangalore and Udaipur were highly variable.

A proteolytic fragment of fibronectin with Mr-30 kD (the gelatin binding domain) was found effective in inhibiting the spore attachment of *Pasteuria penetrans* to *M. javanica* and *M. arenaria*. Fatty acids from the petals of *Tagetes erecta,* revealed that Dodecanoic and myristic acid showed the antinemic property.

Steinernema thermophilum, the first new species of EPN, described from India, has shown very high biocontrol potential against different insect pests (*Agrotis ipsilon*, *Helicoverpa armigera* and *Spodoptera litura*) of agricultural crops. *Photorhabdus luminescens* isolated from *Heterorhabditis indica* was found toxic to insects and root-knot nematodes. Fresh cells from *Photorhabdus* culture were formulated into alginate beads.

Cell suspension and cell free filtrates of *Pseudomonas fluorescens* and *Bacillus subtilis* significantly suppressed hatching and caused mortality of the reniform nematode *Rotylenchulus reniformis.* Indigenous isolates of *Aspergillus niger* and *Paecilomyces lilacinus* were established as biocontrol agents against root-knot nematode infecting vegetable crops. The biocontrol potential of nematode specific indigenous isolates of *Pasteuria penetrans* on *Meloidogyne incognita* and *Heterodera cajani* was also identified. A talc-based formulation of *Aspergillus terreus* and other fungi have been prepared for their use against root-knot (*Meloidogyne incognita*) and reniform (*Rotylenchulus reniformis*) nematodes in vegetables.

Carbofuran @ 1.0 kg a.i./ha gave greater effectiveness in reducing the root-knot nematode population in the soil as compared to other treatments. Further, soil solarization in May-June before sowing okra reduced the root-knot nematode population by more than 80% compared to 50% with single layered mulch, under Delhi climate.

Division of Plant Pathology

Herbarium Cryptogamae Indiae Orientalis (HCIO) and Indian Type Culture Collection (ITCC) are "show-windows" of the Division. At present, the specimens available with HCIO are 46,619, and about 3400 fungal cultures belonging to diverse groups are maintained at ITCC. Critical examination of the specimens and cultures led to the creation of 52 new species and 11 new genera. Besides, a revenue worth Rs. 7,40,600 was generated by rendering identification services and supply of cultures.

Full genomes of *Citrus yellow mosaic virus* (CYMV), *Clerodendron yellow mosaic virus*, *Cucumber green mottle mosaic* (CGMMV), *Groundnut bud necrosis* (GBNV), *Mungbean yellow mosaic virus* (MYMV), *Mungbean yellow mosaic India virus* (MYMIV), *Tomato leaf curl*

New Delhi virus (ToLCNDV) and *Tomato leaf curl Bangalore virus* (ToLCBV) were sequenced. Sequences of genome of DNA viruses have helped in isolating promoters and developing infectious constructs. The etiology of several emerging diseases like sunflower necrosis, citrus corky vein and potato apical leaf curl, etc., was worked out. Besides, pathogenic and genomic profiles of selected fungal pathogens such as Karnal bunt of wheat, wilt of chickpea, pigeonpea and cucurbits, and Alternaria blight in vegetable crops have been studied to facilitate precision breeding targeting individual species/races/pathotypes.

The role of toxin in the pathogenicity of the fungus *Bipolaris sorokiniana* causing spot blotch of wheat was investigated which led to the development of *in vitro* assay to screen wheat genotypes for resistance. The role of ORF-AV2 of MYMIV in pathogenicity and silencing suppressor role of viral proteins AC4, AC2 and βC1 of Tomato leaf curl viruses were elucidated. Maize lines, POP 145, XP-102, and L 173 showed resistance to banded leaf and sheath blight, and have been registered as resistance sources at the National Bureau of Plant Genetic Resources.

An outstanding strain of *Aspergillus niger* (AN27) hunted out from the nature's treasure, controls six devastating soil borne pathogens, viz., *Fusarium oxysporum, F. solani, Macrophomina phaseolina, Pythium aphanidermaturm, Rhizoctrnia solani* and *Sclerotinia sclerotiorum* belonging to different classes of fungi by a single application under different agro-climates in diverse groups of crop plants (cereal, millet, pulse, oilseed, fruit, tuber, vegetable, ornamental, fodder and fibre crops). It inhibits formation of pathogen resting structures and kills the existing ones. AN27 induces resistance in the plant by augmenting its defense enzymes, peroxidase, polyphenol oxidase and phenylalanine ammonia lyase. Two growth promoting compounds isolated from AN27 are responsible for increasing root and shoot lengths and biomass of crop plants. Increased crop production and excellent disease control by single applications of Kalisena SL in soil or Kalisena SD on seed make them desirable bioformulations. These have extraordinarily long (two years) shelf life. *Aspergillus niger* has been explored for the first time in the world to make bioformulations.

Two *Trichoderma* based bio-formulations "Pusa 5SD" and "Pusa Bio-pellet 10G" effective against wilt of chickpea (*Fusarium oxysporum* f. sp. *ciceris*) and dry root rot (*Rhizoctonia bataticola*) and wet root rot/web blight (*Rhizoctonia solani*) of chickpea and mungbean have been developed. Patent applications for these two formulations have been submitted with patent application numbers 2032/DEL/2008 and 2033/DEL/2008 dated 28-08-2008.

Immuno- and nucleo- diagnostic reagents (polyclonal antisera and cDNA probes) and protocols have been developed for the detection of chronic and emerging viruses

affecting several crops. The DBT has identified the Advanced Centre for Plant Virology (ACPV) as the "Referral Centre for Virus Testing of Tissue Culture Raised Plants".

Transgenic resistance to *Tomato leaf curl New Delhi virus* (ToLCV) was achieved by incorporating antisense Rep gene. Six transgenic tomato lines released showed 50-77% resistance compared to control. Gene constructs for developing transgenic resistance against viral diseases have been developed. *Tobacco streak virus* coat protein gene construct for sunflower necrosis disease and *Tomato leaf curl New Delhi virus* Rep gene construct for tomato leaf curl disease are already commercialized to Ms. J.K. seeds, Hyderabad and Bejo Sheetal Ltd. Jalna respectively. Besides, viral gene constructs have been shared with various organizations under National Agricultural Research System.

T2-T3 stage of transgenic tomato resistant to ToLCV and CMV tested at NPF

Field testing of ToLCV resistant transgenic tomato

5.3 School of Resource Management

Division of Agronomy

Neem oil coated urea (500 ppm) gave higher rice yield and agronomic efficiency (20.4 kg grain/kg N) as compared to prilled urea (11 kg grain/kg N) at the same level of N. Studies have shown that indigenous sources of phosphorus such as rockphosphate and press mud could be effectively used along with phosphate solubilizing bacteria (*Pseudomonas striata*) and crop residues in pigeonpea-wheat cropping system. PSB and crop residues both improved P utilization efficiency.

Introduction of summer greengram, cowpea, and *Leucaena* green manuring in rice-wheat and maize-wheat systems gave higher productivity, profitability and effected an economy of 20-40 kg N/ha. Alternative sustainable cropping systems identified to rice-

wheat include rice-wheat-greengram, rice-mustard-greengram, rice-potato-greengram and pigeonpea-wheat, which give higher productivity, and maintain soil fertility.

Cotton-sunflower system proved more remunerative than cotton-wheat under delayed sowing of wheat. Intercropping of groundnut with Bt cotton in 3:1 row ratio gave 19% higher productivity, and application of 75% N through FYM and 25% N as urea recorded 11% higher productivity over 100% N as inorganic. Spring cotton sown during the first fortnight of February (5-15 Feb.) followed by its ratoon in *Kharif* was found promising, yielding about 3.5 t/ha.

Herbicides, sulfonylurea chlorsulfuron and triasulfuron @15-20 g/ha) were effective against broad-leaved weeds in several field crops. Herbicides like clodinofop @ 60 g/ha, fenoxaprop-p-ethyl @ 100 g/ha and sulfosulfuron @ 25 g/ha were effective against isoproturon resistant *Phalaris minor* in wheat. Zero tillage was found successful in *Rabi* crops (wheat, mustard, linseed and chickpea) grown after maize.

In organic farming of *basmati* rice-wheat cropping system, the maximum yield of rice and wheat were obtained when wheat residue and *Sesbania* green manure were incorporated together. In another study, *Sesbania* green manuring + 10 t FYM/ha + BGA in rice and green leaf manuring + 10 t FYM/ha + *Azotobacter* in wheat recorded the highest productivity of 9.67 t/ha (5.14 t/ha rice and 4.53 t/ha of wheat), and maintained the highest organic carbon, ammonical and nitrate N in soil throughout the crop growth period of crops. In broccoli based cropping systems, broccoli-tomato-*Sesbania* was the most remunerative, and recorded the highest productivity and net returns with 5 t FYM/ha + 2 t vermicompost/ha + *Azospirillum*. In organic brinjal, application of 4 t vermicompost/ha + biofertilizers (PSB + VAM) recorded the highest productivity.

Water Technology Centre

Water Technology Centre carried out geophysical investigations at (i) Krishi Kunj (near IARI Farm), New Delhi, (ii) Krishi Vigyan Kendra, Shikhopur, Gurgaon (Haryana), (iii) National Research Centre for Citrus, Nagpur (Maharashtra), and (iv) Central Institute for Sub-Tropical Horticulture, Lucknow (U.P.), and (v) farmers' fields in Nalawas village, Mahendragargh, (Haryana) for locating potential ground water zones after accounting for both quantity and quality, and specific recommendations were made in each case. Conjunctive water use plan for the command of Dadupur distributary under Upper Ganga Canal system in the Bulandshahar district of Uttar Pradesh was developed by using optimization and simulation approaches. However, in *Rabi*, the net benefit could be increased to 96 million rupees from the existing level of 87 million rupees. A micro-watershed in the Shimla district of Himachal Pradesh was monitored

for hydrologic parameters to study the effect of land use and conservation measures on water and sediment yield. The study helped in developing water utilization plan for the watershed. Various forms of Artificial Neural Network (ANN) were used to predict the peak runoff rate and sediment loss from an agricultural watershed.

The concept of aqua-ferti sowing was developed at the Centre and the device was fabricated in collaboration with the Division of Agricultural Engineering. The aqua-ferti sowing of wheat under rainfed conditions gave significantly higher grain yield (2.44 t ha^{-1}) compared to that of conventional method (CS) of sowing (1.68 t ha^{-1}). This technique is of great help in rainfed areas of the country.

The System of Rice Intensification (SRI) method resulted in higher grain yield (more than 0.7 t ha^{-1}) compared to that of conventional practices. Irrigation water could be saved to the tune of 40-45%. Rice varieties, IR74371-46-1-1 and Proagro 6111, produced the highest yield of about 5.5 t ha^{-1} under aerobic conditions of rice cultivation. Under aerobic conditions, irrigation at 40 kPa soil moisture tension saved over 50% of irrigation water requirement when compared to zero kPa irrigation. A multi-year, multi-crop, daily time step cropping system simulation model, CropSyst, has been successfully calibrated and validated for quantifying irrigation-nitrogen interactions for maize-wheat and rice-wheat cropping systems. CERES-RICE and WHEAT models satisfactorily predicted grain and biomass yield in rice and wheat in non-stressed conditions.

Simulation of water and nutrient transport under drip irrigation revealed that irrigation scheduling with emitter discharge of 2.5 l/h on an alternate day basis was appropriate for onion crop grown in sandy clay loam soil. It was also found that in all types of soils, emitter discharge rates of 1 l/h and 2.5 l/h were appropriate from the points of view of nitrogen saving, distribution and leaching. Based on three years of

Onion crop under drip irrigation

field experimentation, it was found that drip tape placement at surface and buried at 5 cm depth, resulted in upward movement of water with 21.5% soil moisture at the surface. Maximum yield of potato (33.6 t ha^{-1}) was obtained by applying 23.6 cm of irrigation water and by placing the drip tape at 10 cm soil depth.

The studies on SALTMOD Model suggested that the model could be used to evaluate various drain spacings of a subsurface drainage system and facilitate reasonable prediction of the reclamation period. The centre developed softwares, namely, COBASIM, Venturi, IRRIMETHOD, FERGON, MICROS, and DRIPCRITERIA.

Division of Soil Science and Agricultural Chemistry

Results at the end of thirty-four cycles of on-going long-term fertilizer experiment with pearl millet/maize-wheat cropping sequence showed that both maize and wheat crops continually fertilized with super-optimal NPK dose (150% of recommended) out-yielded optimal NPK, indicating a need for upward revision of 'optimal' fertilization rates that have become inadequate to sustain a high productivity under intensive cropping. Use of 15 t ha^{-1} FYM during monsoon season along with 100% NPK, nonetheless, gave yields similar to super-optimal NPK. A significant build-up in organic C status was recorded under NPK+FYM, whereas it was almost maintained at the initial level of 0.44% under super-optimal NPK, NPK+Zn or NPK+S treatments. The highest activity of dehydrogenase, acid and alkaline phosphatase and arylsulphatase obtained under NPK+FYM indicated the possibility of integrated use of inorganic fertilizers and organics as a soil-quality-sustaining practice. Under rice-wheat and maize-wheat systems, the highest increase in organic carbon content in soil was recorded under 100% organics, followed by 100% N + green manure and 100% N (25% substituted by FYM) signifying that integrated nutrient management relying on the mix of organic and inorganic sources is the carbon-sequestering practice. A study of interactive effects of soil factors, sources of applied S and soil moisture content on retention and movement of S in acid soils indicated that free Fe_2O_3 and Al_2O_3 were primarily responsible retaining added S. A universal model of nutrient uptake, named, PNUS 1.0 (Pusa Nutrient Uptake Simulator) was developed by incorporating the threshold concept of P and K release in soil.

Soil test based fertilizer adjustment equations were developed for making fertilizer recommendations to achieve pre-determined levels of productivity for wheat (five varieties), maize (two varieties), pearl millet (two varieties) and soybean (one variety). Follow-up trials confirmed the possibility of achieving the yield targets within a standard deviation of 10%. A sequential fractionation scheme for boron in soils compatible with colorimetry was developed. This procedure allows undertaking research on boron

dynamics in the laboratories of the developing world, which cannot afford costly optical emission spectrometer.

A new product of enriched organo-mineral fertilizer was developed by using rice-straw mixed with low-grade rock phosphate @ 4% P, waste mica @ 4% K and phosphate solubilizing microorganism (*Aspergillus awamori*). This proved to be effective in enhancing the soil quality and productivity of crops like mungbean, potato and soybean. In pigeon pea-wheat cropping system, foliar spray of 10% urea solution at physiological maturity of pigeon pea, resulted in almost complete defoliation of the crop. This urea-induced-additional leaf litter (about 1.3 t/ha) fall on senescence recycled about 40 kg N/ha and substantial quantities of other plant nutrients to the soil, besides incorporation of organic matter.

Assessment of impact of long-term sewage irrigation on soil, plant and groundwater in peri-urban areas of Delhi indicated significant build up of Zn, Cu and Ni in soils but the metal contents in sewage effluents were within permissible limit for its use as irrigation water, and leafy vegetables grown thereon can be consumed safely without fear of metal poisoning. Lime emerged as a viable and effective chemical amendment as it significantly reduced the bioavailability of toxic metals in near neutral and moderately alkaline sewage and industrial effluent-irrigated soils in peri-urban areas of Delhi. *Brassica carinata* (Ethiopian mustard) was identified as a hyper-accumulator for remediating zinc, nickel and lead contaminated soils; one crop of *Brassica carinata* could reduce the total metal load of zinc, nickel and lead by 14.3, 10.7 and 12.5%, respectively.

Division of Agricultural Engineering

The Division of Agricultural Engineering had developed 26 hardwares/technologies. A tractor drawn okra planter; an anthropometer; a harness for manual loading; a two-row seed-cum-fertilizer drill; an aqua-ferti seed drill; a fruit and vegetable grader; an okra seed extractor; an onion detopper; jigs and fixtures for wheel hoe; a two-row maize planter; a vegetable extracter; a pulse polisher for pigeon pea; an improved *atta chakki*; an integrated rice mill and grader; and a rotating screen grader for rough shaped fruits and vegetables; a precision pneumatic seeder for nursery plug trays and a motorized vegetable seed extractor were developed.

A prototype manufacturing workshop (27.5 m × 17 m) was constructed and equipped with state-of-the-art production machines for undertaking fabrication of large variety of agricultural machines. Manufacturing drawings of nine machines (mini *dal* mill, no till drill, raised bed planter, pedal operated paddy thresher, etc.) were developed along with appropriate jigs, fixtures and dies. The workshop manufactured 1297 prototypes

of 11 machines/ equipment, and items worth Rs.2.0 lakhs were sold. More than 1200 farmers/village artisans were exposed to the manufacturing technologies established.

Three-year tillage studies on rice and wheat crop resulted in identification of engineering parameters and development of a simulation model on tillage effects and soil compaction at varying soil depths. A model was developed to calculate soil stresses and bulk density under loading of tractor for different soil conditions created during seedbed preparation. The studies also found little evidence to suggest that there is long-term influence of tillage practices on soil tilth index of tilled layer.

An animal feed compaction machine, without the use of a binder, has been developed that can compact animal feeds as well as make bales of straws and grasses. The machine operated by a 10 HP electric motor can make 30 feed blocks/h (20 cm × 20 cm and of desired length and density of 400-550 kg/m^3) using different compositions depending upon the feed requirements of animals. Commercial exploitation of the machine has been successful. A trolley mounted, 6.5 hp engine operated, mobile unit of the animal feed block formation machine developed for fodder can prepare feed blocks (15 × 15 cm in cross section with variable thickness) weighing 500 g to 2.5 kg. The minimum bulk density of the feed block is 400 kg/m^3. The capacity of the machine ranges between 0.1 and 0.125 t/h. The machine has found very good acceptance among the farmers.

A solar dehydrator for fruits and vegetables was developed. The tunnel type dryer is 1m wide and 2 m long. It has a movable truck with 20 trays on which material is loaded for drying. Studies on dehydration of cauliflower (Pusa Snowball) and three varieties of onion (EG, Pusa white round and Pusa white flat) revealed that the product pre-treated with KMS and dehydrated in the newly developed dehydrator could be safely stored for six months in the laminated foil.

Mobile unit of animal feed block formation machine

Aaqua-ferti seed drill

A multi-span green house for high value vegetable crops like tomato, cherry tomato, capsicum, etc., for their year round cultivation was developed. A naturally ventilated green house was developed for vegetables like tomato, cherry tomato, summer squash, capsicum, etc., for their year round cultivation except from May to July.

Division of Agricultural Physics

Physical rating index was computed by including easily determinable soil physical parameters and linked with the crop capability. Continuous practicing of rice-wheat system resulted in the formation of platy structure in the sub-surface layer, accumulation of Fe and Mn mottles, depletion of available potassium and build up of available P in soils.

Both the broadband and hyper-spectral vegetation indices gave good results in the detection of crop stress. In comparison to that of conventional system, lower bulk density, lower penetration resistance of upper 0-20 cm soil and high infiltration rate on bed created better soil physical environment, resulting in high root length density in 0-25 cm soil layer. Similarly, irrigation water applied reduced by 30%, 20% and 5% in the first, second and third irrigations under bed planted system as compared to that in conventional system. Crop water stress index measured at different crop growth stages also showed that crop experienced the same level of stress in bed and conventional systems. For the first, a forewarning hypothesis (thumb rule) was developed by using the degree days concept to forewarn the peak mustard aphid *Lipaphis erysimi* (Kaltenbach) infestation one month in advance. An attempt has been made to understand the problems arising from the unique biophysical and socio-economic characteristics of the *diara* land of Ganga river areas of Bhagalpur district of Bihar, and an effort was made to solve the complex problems faced by the poor inhabitants of the diaras and identify the possible areas for adoption of resource conserving technologies through satellite remote sensing.

Spatial variability maps of soil fertility, inherent soil, crop biophysical and other parameters were prepared by using geo-statistical techniques in GIS environment, and cause effect relationships were found out. Based on this information, site-specific management was done to reduce the variability of yield as well as optimizing it. Based on various plant parameters, it could be inferred that rice husk performed better than polyethylene (black and transparent) mulches in maintaining optimum plant water status and growth in *Rabi* wheat under limited irrigation without much effect on yield.

A new thumb rule for incidence of white rust disease emerging from this study based on four consecutive years' data, is: "If the sum of hours in consecutive ten days

with temperature ranging from 10 to 20 °C is more than 150, relative humidity more than 80 per cent is more than180 and actual bright sunshine hours is less than 10, then, it is quite likely that the white rust disease would appear in the mustard crop" or "If there are rainy days during December and January along with the total sunshine hours of past ten day less than 40, then the white rust disease would appear".

The Division established Satellite Interactive Terminal facility to impart off-campus EDUSAT based training to students and faculty of the Institute on '*Basics of Remote Sensing, GIS* and *GPS*' in association with Indian Institute of Remote Sensing (Department of Space), Dehradun. The first training was conducted during August-November, 2008.

Division of Environmental Sciences

The Division of Environmental Sciences has conclusively shown that the annual contribution to global methane budget from Indian rice paddies is less than 3 Tg and not 37 Tg as was propagated by the western agencies. Revised inventories of GHG emission by the use of models and databases indicate lower estimates compared to earlier calculations. These estimates made by the Division have helped Indian policy makers greatly in their negotiations on global climate change. Inventory of GHGs from agriculture prepared by the Division is being utilized for international negotiations by Ministry of Environment & Forest, Government of India. Further, the estimates of methane emission from landfill sites have been utilised by CPCB for policy development regarding management of landfills.

Crop growth simulation models were used to assess the direct impact of global climatic changes on cereal growth and production in different parts of India. The results indicate that even small increase in temperature associated with climate change causes considerable losses in cereal production. The impact of elevated temperature on productivity of rice and wheat showed that late sowings in wheat and high temperature stress in rice during reproductive growth phase caused maximum reduction in biomass and grain yield. Impact assessment of climate change done by the Division has been utilised for policy development by the Government of India.

The research has shown that post methanation distillery effluent (PME) and paper mill effluent can be used in agriculture as sources of plant nutrients. Application of PME as pre-sown irrigation increased the yields of rice, wheat, mustard, sugarcane and medicinal plants like *Mentha arvensis* significantly as compared to the yield obtained with the recommended levels of N, P and K application. The Division has developed a protocol for the use of PME, which has been accepted by the Ministry of Environment

and Forests, Government of India and is being implemented in all the distilleries in India. The Division has developed a dry fermentation technology (solid state fermentation) for the production of energy and manure from agricultural residues and kitchen wastes.

The vegetable samples collected from different locations in Delhi showed higher level of heavy metal (Zn, Cu, Pb and Cd) contamination. Washing of vegetable samples twice and thrice reduced the level of heavy metal contamination drastically. The Division has quantified the impact of increased tropospheric ozone levels on the growth and productivity of rice and wheat grown in open top chambers under elevated ozone concentrations.

Geographic Information System (GIS), remote sensing and hydrologic/ economic model based novel and practically applicable tools (viz., Img2Info©, Ref2Info©, Resources©, IMPASSE©, USAR©, etc.) for extracting precise land use/land cover information and quantifying short/long term impacts of a range of (geo) climatic/ hydrologic conditions and resource management strategies on regional soil-water degradation have been developed and copyrighted by the Division. A dynamic crop simulation model (named InfoCrop) for estimating the impacts of climatic variability/ change on the actual/potential crop yields and assessing yield losses due to pests has also been developed. The Division also provided consultancy services on monitoring, impact assessment and mitigation of environmental problems to various agencies.

Advanced controlled environment facilities such as free air carbon dioxide enrichment (FACE), temperature gradient tunnels (TGT) and open top chambers fitted with temperature, humidity sensors and automatic data logging/display and recording systems have been developed at the Division to screen crop/varieties to high temperature, CO_2 and ozone at different time periods at IARI. These facilities are being used to mimic closely the future climate and its impact on experimental crops.

Unit of Simulation and Informatics (USI)

Using simulation studies and application in agriculture, the end user can retrieve information about six varied modules, namely, Crop Details, Crop Practices, Crop Protection Measures, Resistant Varieties, Irrigation System, and Weed Control. In India, traditionally a blanket fertilizer recommendation is given based on soils that are classified into low, medium, and high fertility on the basis of soil test. This results in lower fertilizer use efficiency, imbalanced use of fertilizers, environmental pollution and lower yield. The Unit had developed very handy spreadsheet based software called INFOSOIL to overcome these problems.

Infocrop: The Infocrop model was calibrated with historic datasets, and subsequently validated with field experiments conducted at IARI farm, New Delhi. Simulated results matched well with the observed values in terms of growth and yield of rice and seasonal nitrogen uptake. The components of soil nitrogen balance differed among varying nitrogen level treatments, which were also captured by the use of Infocrop.

Infosoil: The software on soil information system in relation to physical, chemical and biological characteristics of Indian soils has been developed for determining soil quality index for suitability with respect to various crops.

Simulation of crop-pest interactions: USI scientists used modeling approaches in crop pest relationship. It was observed that the economic injury levels with empirical and mechanistic approach were comparable, thereby suggesting the utility of simulation models for establishing site-specific economic injury levels of pest in crops.

Agri-informatics and Bio-informatics: The Unit had developed databases on varietals pedigrees of wheat, chickpea and rapeseed-mustard, which depict their parentage and association with physical and biotic factors. User-friendly information system software had been developed in rice, maize, rice IPM and pesticides. Databases that will be applied in different crops in various agro-ecological zones were compiled from published papers, annual reports, and bulletins. Active Server Pages (ASP) is Microsoft's server-side technology for dynamically generated web pages that are marketed as add-on to Internet Information Services (IIS).

Software development: Web-based computer software on research monitoring had been developed to monitor and update research initiatives of IARI projects by using database in MS Access and front-end through ASP.NET.

Division of Microbiology and CCUBGA

The Division of Microbiology is known for its pioneering work on *rhizobi*a, *Azotobacter*, cyanobacteria and phosphate solubilzing bacteria. It maintains the National Facilities for *Rhizobium* and cyanobacteria germplasm.

A consortium of fungal cultures (*Aspergillus nidulans*, *Trichoderma viride*, *Phanerochaete chrysosporium* and *Aspergillus awamori*) having ability to decompose lignocellulosic waste was developed. A compost of paddy straw was prepared by using the developed consortium in perforated pits. The inoculant is regularly supplied for commercial purpose. Phosphate enriched compost was prepared in 65 days by initially supplementing paddy straw with urea and rock phosphate and inoculating it with *Aspergillus awamori*.

A new isolate *Schizomycete* sp. showed more than 50% mortality in infective juvenile stage larvae of *Meloidogyne incognita*. This also exhibited growth inhibition of phytopathogens *Macrophomina phaseolina* and *Sclerotium rolfsii*. A soybean endophyte identified as *Paenibacillus polymyxa* (HKA-15) was found to be the best for the control of charcoal rot disease caused by *Rhizoctonia bataticola* for soybean.

Cyanobacterial strains with enhanced potential for hydrogen production under various cultural manipulations were identified and genes responsible for hydrogen production were cloned and sequenced.

Liquid formulation for *Azotobacter chroococcum* was developed with a shelf life of eighteen months and the population maintained was as high as 10^8 cfu ml^{-1}.

Protocol for organic *basmati* rice cultivation under rice-wheat-green gram cropping system has been optimized.

5.4 School of Basic Science

National Research Centre on Plant Biotechnology

In order to enhance the productivity through exploitation of heterosis new cytoplasmic male sterile (CMS) system and fertility restorer (FR) system were developed in Indian mustard. Both the CMS and fertility restorer systems were found to be stable for the respective traits. Two female and five male parents were identified as most heterotic, and CMS and these parents were backcrossed with respective CMS and restorers. Five experimental hybrids (BC_5 generation hybrids) were produced and their yield potentiality was tested in experimental field trial. The hybrids were entered for testing in coordinated trials under AICRP. Molecular characterization of CMS and FR systems was caried out and the mitochondrial genome in all CMS lines was found to differ from euplasmic *B. juncea.* Specific changes were also recorded in the expression of *atpA* gene in the above CMS lines. The *atpA* gene and transcripts were cloned and sequenced. A constitutive promoter giving very high level of expression was cloned and characterized from *Arabidopsis thaliana.*

Several genes encoding protease inhibitor and lectin genes from tropical grain legumes were isolated and characterized; a chick pea lectin has been cloned and transgenic mustard has been developed for aphid resistance; a cDNA encoding (E) - ß –farnesene synthase was isolated from Mentha plants and expressed in mustard to repel aphid attack. By using T-DNA tagging, several tissue-specific genes and promoters were isolated from *Arabidopsis* and evaluated for GUS expression. Anther and root specific promoters have been identified and characterized. Antifungal genes, viz., glucanase

and chitinase were isolated and a transgenic mustard was developed for *Alternaria* resistance. Isolation and genetic engineering of novel insecticidal Bt genes from *Bacillus thuringiensis* and cloning of four novel Bt genes from new 9 Bt isolates were accomplished.

A novel vegetative insecticidal protein (VIP) gene of Bt was discovered, sequenced and characterized (*vip3A14*). The gene is specific to tobacco caterpillar, diamondback moth and brinjal shoot & fruit borer. Three different chimeras were constructed by swapping the domains of Cry1Ac and Cry1F. One chimera was specific to both Cotton bollworm and Tobacco caterpillar. Four codon modified synthetic Bt genes, viz., *cry2Aa1, cry1Aabc, cry1Ac-F* and *cry1Fa1* were constructed and validated in transgenic tobacco. Bt pigeonpea expressing Cry1Ac was developed. The transgenic lines exhibited varied levels of insect protection at different locations. Transgenic cotton variety Bikaneri Nerma was developed in collaboration with UAS-Dharwad and field tested. Biosafety tests of the transgenic event are underway.

Four codon modified synthetic Bt genes, viz., *cry2Aal, cry1Aabc, cry1Ac-F* and *cry1Fa1* were constructed and validated in transgenic tobacco. Bt brinjal expressing *Cry1Fa1* was developed for resistance to Shoot and fruit borer. Limited field trails were conducted to ascertain the level of insect protection under field conditions. The transgenic brinjal event (Event 142) was licensed to four private seed companies under public-private partnership.

Genes implicated in abiotic stress tolerance, viz., osmotin (tobacco), annexin (*Arabidopsis*), *cod*A (*Arthobacter globiformis*) were cloned in suitable plant transformation vector and validated their role in transgenic plants vide physiological, biochemical and molecular analyses. Annexin gene was cloned and characterized from rice and wheat. Several abiotic stress related genes such as *CBF2, CBF3, tAPX* and *Lea*1 were cloned and characterized. Transgenic tomato and mustard over-expressing osmotin with enhanced tolerance to drought and salt stress were developed. The transgenics have been tested under field conditions. Transgenic tomato with delayed ripening, extended shelf life and improved texture was developed.

The task of complete sequencing of rice genome (Long arm of chromosome 11) was accomplished. QTLs were identified for quality related traits like grain length, aroma and salinity stress in rice. Single nucleotide polymorphism analysis was carried out for resistance gene analogue sequences in mustard, and for the aroma and fertility restorer genes in rice.

A major locus for fertility restoration was mapped on rice chromosome 10 long arm. AFLP and CAPS markers flanking the gene for white rust resistance in mustard were developed. Marker assisted selection was used to combine two bacterial blight

resistance genes *Xa13* and *Xa21* with *basmati* quality traits of Pusa Basmati 1. Rice blast resistance gene *Pi-k*^{h} was mapped with SSR makers. Blast resistance gene *Pi-k*^{h} was cloned by using map based cloning approach.

Division of Biochemistry

Some of the major genes involved in lipid biosynthesis have been isolated, cloned and characterized from *Brassica juncea*, namely, (i) Acyl-ACP-thioesterase *(Fat A)* – the chain length determining enzyme (Accession No: A3294419); ii) omega –3 desaturase *(fad-3)* which converts linoleic to linolenic acid, (iii) acetyl-COA carboxylase (*Accase*), which is involved in the first committed step of fatty acid biosynthesis (Acc No.AJ582176), (iv) glycerol–3 phosphate acyl transferase (*GPAT*) Accession No.AJ42504, (v) lysophosphatidic acid acyl transferase (*LPAAT*), and (vi) diacyl glycerol acyl transferase (*DGAT*) (Accession No. DQD16105). Microsomal w-6 desaturase encoded by *fad 2-1* gene plays a major role in controlling the conversion of oleic to linoleic acid during seed development. A 180 bp fragment of *fad 2-1* was amplified by using primers specific to the region at the 3 non coding end of the gene, the expression of which was induced during early stages of embryo development and peaked during mid maturation stages.

Two dimensional gel analysis of proteins performed on contrasting rice genotypes, i.e., N22 (drought tolerant) and Panidhan (drought susceptible) revealed both qualitative and quantitative differences. The differential cDNAs associated with water deficit stress were isolated by using differential display. Four of these stress responsive clones showed homology to chloroplast QB protein (PSBA) gene, calcium dependent protein kinase, invertase and drought induced cDNA clone.

The antiviral proteins (AVPs) isolated and purified from *Celosia cristata, Amaranthus tricolor* and *Bougainvillea xbuttiana* were found to be multifunctional proteins exhibiting broad-spectrum systemic resistance against different viruses such as TMV & SRV. The genes encoding these proteins were expressed in *E. coli,* which showed that AVPs were similar to native proteins with variable toxicities in prokaryotic system. Some of the isolated AVPs were also found to be effective against the fungi. The AVPs were isolated, purified and characterized from non-host plants, and genes encoding these proteins were isolated and expressed in *E. coli*.

Dwarf wheat cultivars contained significantly higher levels of pyruvate and labile phosphorus contents as compared to tall cultivars, which could be the possible reasons for higher level of AOX in dwarf wheat cultivars (which may be) imparting suitability of these cultivars to withstand adverse physiological conditions.

Division of Plant Physiology

Differential photosynthetic acclimation to elevated CO_2 was observed in wheat, sunflower and mungbean. A down regulation of photosynthesis under long term CO_2 enrichment was observed in wheat but not in sunflower and mungbean. Leaf starch accumulator sunflower and mungbean showed no such effects. A parallelism in the effect of high temperature on grain growth, grain starch accumulation and soluble starch synthase (SSS) activity in the grains of wheat was observed. Granule bound starch synthase (GBSS) in the grains of wheat was found to be less sensitive to high temperature than soluble starch synthase (SSS). At low range of external nitrate concentration (0.05 -0.5 mM), the rate of nitrate uptake was higher in LNR genotype, and at high external nitrate concentration the uptake of nitrate was more in HNR genotype.

Membrane injury index was found closely linked with duration of flowering and pod formation. Early to medium flowering was correlated with low membrane injury index and high biomass production. High temperature induced decline in photosynthesis was associated with comparatively greater damage to small sub unit of rubisco (*rbcS*) as compared to large sub unit (*rbcL*), which was more in PBW 343 than in tolerant C 306. Abiotic stresses (water deficit, salinity and high temperature) resulted in generation of oxidative stress in the form of reactive oxygen species (ROS), such as superoxide ($O_2^{\cdot-}$), hydrogen peroxide (H_2O_2) and lipid peroxidation, which are scavenged by antioxidant enzymes such as superoxide dismutase (SOD), ascorbate peroxidase (APX), glutathione reductase (GR) and catalase (CAT). Induction of antioxidant enzymes during abiotic stress in wheat was regulated by ABA and calcium via NADPH oxidase mediated redox signaling. Waterlogging tolerance in pigeon pea was associated with root sugar content, activity of ADH and SS, lower ROS generation and induction of antioxidant enzymes to scavenge ROS formed during and post hypoxia period. Ethylene induced aerenchyma formation in tolerant genotypes provides some oxygen to waterlogged hypoxic roots and thus helps in waterlogging tolerance. Membrane stability index was found to be a good parameter for selection of genotypes for various abiotic stresses.

Shelf life of tomato fruits can be extended by ethanol, and vase life of rose flower by sucrose with ethanol. *Gamma* radiation (0.12 and 0.15 kGy) treatment maintained the external greenness of mango fruits for a longer duration. 1-MCP could enhance shelf life of tomato through reduced PG activity and higher activity of superoxide dismutase (SOD). 5-sulphosalicylic acid, α-lipoic acid, polyamines and polyols delayed the senescence of gladiolus flowers due to enhanced antioxidative activity and reduced oxidative stress. Two gladiolus full-length cDNA homologues of *Arabidopsis* ethylene receptor genes were isolated and designated as *GgERS1a* and *GgERS1b*. A partial cDNA for putative cysteine protease (GgCyP) was also cloned from gladiolus.

IARI was identified as the main global centre for CO_2 enrichment research on crops in South Asian region. Open Top Chamber CO_2 enrichment technology was designed and made available to Bangladesh, Nepal, Pakistan and Sri Lanka. A mid FACE facility was established in IARI, the first of its kind in South Asian region. Scientists, students, and research scholars from South Asian countries and Indian scientific institutions were trained for CO_2 enrichment resource & technologies from crops.

Free Air CO_2 Enrichment (FACE) technology

Elevated CO_2 led to increase in photosynthesis rate due to the increased activation of rubisco enzyme protein in wheat. Interactive study of elevated CO_2 and nitrogen supply on wheat showed that nitrogen application improved growth and photosynthesis rate and also helped in maintaining higher nitrogen and protein contents in the tissues. In mungbean, elevated CO_2 enhanced the nodulation and nitrogenase activity due to higher photosynthesis and partitioning of assimilates to the roots. In chickpea, elevated CO_2 grown plants exhibited better growth performance in terms of shoot growth, leaf area and biomass production.

Five cDNA sequences of genes related to carbohydrate metabolism/waterlogging tolerance have been registered with NCBI in 2008.

Nuclear Research Laboratory

Gamma radiation ameliorated the age-induced deterioration in aged seeds. Also, *gamma* irradiated seeds withstood ageing process better than un-irradiated controls. In mung (Asha, and PS-16), 1.0 kGy irradiation most effectively contained insect (weevil) infestation even after 3 months, and up to 2 months in pea, chickpea and lentil. Soybean seeds (*cv*. PK-1189) irradiated and sown in the field gave enhanced yield at dose 0.1

kGy. Tomato (cv. Pusa Ruby) exhibited 25-30% higher germination at 0.05 kGy compared to that of un-irradiated control. 1 kGy dose increased its storability up to 2 weeks with minimum change in its toughness and without any rotting or weight loss. Mangoes (var. Amrapali) irradiated with 0.5, 0.75 and 1.0 kGy just after the harvest indicated delay in softening of the fruits up to 6 days as compared to that of control.

Seeds of maize and chickpea exposed to varying magnetic fields (50-2500 mT) showed improved germination per cent and seedling vigour. Onion (Pusa Madhavi) seeds showed enhanced germination rate, speed of germination, and seedling vigor at an exposure of 2000 gauss for 1h compared to those of control. Microwave energy reduced hard seed coat dormancy of *Stylosanthes sebrana,* and germination per cent increased from 7% in control to 46% in microwave treated seeds (840-1360 W/g/min) owing to increased imbibition of water by micro-channels created in treated seeds.

Nodulation capacity, i.e., nodule mass and number, under salt stress was found to be a reliable selection marker for identifying salt tolerant lines in chickpea. Foliar spray of salicylic acid at 3 ppm level improved water stress tolerance of wheat plants by inhibiting protein degradation thus allowing normal enzymatic and metabolic activities even under stressful conditions. Static magnetic field exposure significantly increased leaf area, root length, root surface area and root shoot ratio in moisture stressed maize plants that can be exploited in rainfed agriculture. NMR based stem T2 measurements were related to high temperature tolerance in wheat. The developed screening parameters could give impetus to the ongoing programs to breed/improve abiotic stress tolerance of crops.

^{18}O isotope signatures in groundwater in Delhi region showed that average recharge from rainfall declined from 10% in 1995-99 to <1-5% in 2000-06 owing to urbanization induced shrinking of the exposed land surface. Canal water seepage loss was estimated to be 20-30% of discharge. Fresh groundwater reserve became more vulnerable to depletion, high salinity, nitrate (50-716 mg/l), and fluoride (1-14.5 mg/l) from over exploitation, indiscriminate disposal of wastes, and groundwater intermixing along specific flow-pathways. The research findings have been used by the Delhi government for framing policy guidelines on protection of groundwater from depletion and pollution.

Application of higher level of potassium (@120 kg K_2O ha^{-1}) with 120 kg N ha^{-1}, and 5 Mg FYM ha^{-1} to wheat-soybean cropping system resulted in increased straw N content, wheat grain N content and also the highest fertilizer ^{15}N recovery (54%), which proved beneficial in improving the protein content of grain and thus its quality. Under rainfed conditions the fertilizer N use efficiency in mustard was higher (43.2-76.4%) compared to that in wheat (22.1-41.6 %). Mustard crop extracted more water from soil

compared to wheat crop which was also evidenced through delta C-13 signatures, i.e., $\delta\ ^{13}C$ values in mustard stover at harvest showed a positive linear relationship with consumptive water use efficiency, seed yield and total N uptake. The use of ^{15}N stem injection technique for evaluation of below-ground nitrogen (BGN) in soybean and wheat showed that contribution of leguminous crops to the N economies of cropping systems has been largely underestimated and the effort to increase fertilizer use efficiency in cereals should also take into account the below-ground nitrogen requirement. In rice, the fertilizer N use efficiency by using ^{15}N showed an increase of nearly 8.3% under raised bed conditions from 37.4% obtained under flat bed condition. The transfer factor of ^{137}Cs in rice grain and straw reduced by half from that was a year before and the application of potassium fertilizer at 150 kg ha^{-1} reduced it further. The transfer factor of ^{137}Cs in mustard was found to be nearly three times higher compared to wheat and maize after nine years of radionuclide contamination indicating mustard to be a hyper accumulator of ^{137}Cs. Measurements of soil organic matter dynamics in intensive cropping systems showed higher carbon management index in the plots under conventional puddling of rice in rice-wheat and bed planting in maize-wheat system.

5.5 School of Social Sciences

Division of Agricultural Extension

Action research on promoting entrepreneurship development among rural youth revealed that motivational interventions enhanced the internal motivation and helped the youth to understand personal resources and realize their potential through entrepreneurial achievement. The motivational trainings were the major input, without providing other support in terms of inputs like seeds, fertilizers, plant materials, etc. Significant impact was observed on enhancing the individual's entrepreneurial orientation and locus of control (internal). A sustainable extension model was developed by establishing Rural Social Centres in Palla and Mazara-Kulakpur villages of Alipur Block of Delhi. The centers helped to reduce the gap between consumers and producers and also provided employment opportunities to unemployed youths in the villages. Interventions for group mobilization, gender equity, entrepreneurship development and vocational training, micro-credit management and drudgery reduction were reported as imperatives for empowerment of women in agriculture. Viability of small farms and gender empowerment may be enhanced by bringing gender equity, reducing drudgery through appropriate tools, fruitful utilization of leisure time for productive works, capacity building through self-awareness, self-development, organization of SHGs, developing SHG market linkages, training of extension agents, and leadership training to women. An analysis of training needs of extension personnel in management skills

revealed that the extension managers needed training in the critical areas of managerial skills. The training modules were developed and validated which resulted in significant improvements in the knowledge and skill levels of the respondents in different areas of management. Expert system of extension (Web-based) was developed to disseminate demand driven information to the farmers. Information relating to the selected crops/ technology was collected and entered into the database, and was uplinked on the IARI server. Sixty per cent of the farmers experienced an increase in crop yields but steady decline in net profit. Increased soil salinity conditions were reported. The modernization had positive effect in terms of better education, increased material possessions, better communication, health and housing facilities.

Division of Agricultural Economics

Research focus was on major issues of national importance, particularly, agricultural sustainability, food supply and demand projections, diversification, input use efficiency, export potential and trade liberalization. Diversification in Indian agriculture is prominent in rainfed resource starved regions for risk mitigation; in resource endowed regions, it is minimal and directed towards high value crops for increased earnings. The pulling factors for diversification are the availability of suitable cultivars and quality seeds, post harvest handling and processing facilities, efficient marketing services, and stable and remunerative product prices. The support required for promoting sustainable development in secondary crops was identified in the areas of crop improvement, crop management, and resource management (technological); technology dissemination, value addition and processing, and market services (socio-economic); contract farming, cooperatives, and group action (linkages and group action); price and non-price incentives (marketing and trade); and focused infrastructure development in fragile areas (infrastructure). Total factor productivity (TFP) indices by districts/regions of the Indo-Gangetic plains indicated that productivity alone contributed one-third to the total output growth in the IGP. However, the productivity growth attained in 1980s was not sustained in 1990s which poses a challenge for researchers. Investment in research, extension, education and infrastructure were identified as the major sources of TFP growth in the IGP. Ecological problems that have emerged in a large number of districts in the IGP may aggravate in future if proper soil management practices are not undertaken.

Economic losses due to degradation of land in Punjab were estimated at Rs. 4841 million per annum. For the 17 major states of the country taken together, the losses were estimated at Rs 285 billion annually (Rs 1521 per hectare). Such a high magnitude of losses due to degradation of soils has adverse implications for sustainability of agriculture in the country.

Households were observed to diversify their food consumption pattern by shifting towards high-value and high-quality food items as incomes rose. Shifts in dietary pattern were significant even among the bottom income group. Cereals continue to be major sources of calories and non-cereals like pulses, edible oils, horticultural products, and animal and fishery products were major providers of proteins, fats, vitamins, and minerals. However, a temporal decline in calorie intake from cereals was observed which may be attributed to a decrease in cereal consumption that was compensated by a marked increase in the intake of calories from high value products (milk, vegetables, fruits, meat, and sugar).

An analysis of technological change and production performance in maize-based agro-eco system showed that despite considerable extension efforts, nearly 50 per cent area continues to be under traditional maize technologies. Around 54 per cent of farmers were low adopters of technology on account of high costs of inputs and marketing constraints. Excluding Punjab and Uttar Pradesh, farmers in different states have not adopted the recommended package of practices. Lack of institutional support and inadequate infrastructure has hindered the adoption of new technologies in maize which calls for greater extension efforts to generate awareness and to disseminate information on recommended technologies.

Research on pesticide use and sustainability of agriculture showed that the high intensity of pesticide use was coupled with widespread use of high-risk pesticides. Adoption of IPM practices had reduced the quantity of pesticides use without adversely affecting the yields in paddy, vegetables and cotton leading to a reduction in their unit cost of production. The major constraints for low adoption of biological control were found to be their slow action against target pests, short shelf life and survival of bio-agents in field, high prices and irregular supply. IPM technologies demonstrated a potential of avoiding pesticide risk hazards by 20-30 per cent in paddy, 39 to 46 per cent in vegetables and 32 to 40 per cent in cotton. Farmers were willing to pay a price premium of up to 22 per cent for environmentally safer formulations of pesticides.

Quantification of the impact of inadequate market information among horticultural producers and traders revealed that value loss on account of this ranged from 16-22 per cent to growers and 10-12 per cent to traders. The adverse impact of lack of market information is severe in North East region and Orissa and moderate in Maharashtra and Karnataka. Producers and traders desire critical decision making information such as price and arrival forecasts, alternative markets, quality and grades, processing facilities, and export prices.

Farm Operation Service Unit (FOSU)

As per the mandate, the FOSU was involved, during the period, in the following activities:

The unit has 37 tractors, 3 plot combines, a precision space planter, 2 self-propelled plot seed drill and their matching implements. With the help of these machines, time-bound farm operations were done by FOSU on IARI farm and met the requirements of scientists. Irrigation water distribution system comprising two storage reservoirs of 5 acres feet capacity each and more than 15 kilometers of underground RCC pipe water distribution lines both connected to 18 deep tube wells, has to be kept strengthened.

For the upkeep, repair and maintenance of the above machinery and farm equipment, FOSU has a full-fledged workshop comprising a machine shop, a repairs shop, a welding and electrical section, a car washer and an air compressor. Around 6-8 engines and equal number of gearboxes are overhauled every year, and daily servicing, greasing and periodic maintenance has been done regularly.

The QRT's assessment is that IARI water distribution system is not efficient. It is recommended that the entire farm of IARI should be under a most efficient irrigation system to maximize water use efficiency. Flood irrigation is outdated and needs to be replaced with drip, sprinkler and sensor controlled irrigation system.

5.6 Regional Stations

The Institute has eight regional stations at Shimla, Katrain, Karnal, Indore, Pusa (Bihar), Pune, Wellington, and Kalimpong and two off-season nurseries at Dharwad and Aduthurai located in different agro-climatic zones of the country as per their mandated activities.

The QRT members visited two regional stations at Karnal and Indore to review the research activities and experimentation and seed production programme. Although the team did not visit other centers but their work was reviewed and highlights presented.

IARI Regional Station, Karnal

The IARI Regional Station, Karnal has played an important role in producing and supplying high quality seeds of 80 different crop varieties of cereals, pulses, oilseeds, forages and vegetables. During the period from 2000 to 2008, a total of 2031.422 tonnes seeds of 29 different crops and 86 cultivars belonging to cereals (wheat, rice, forage sorghum, pearl millet), pulses (mung bean, pigeon pea, cowpea, field pea, lentil) oilseeds (mustard) and vegetables (25 different vegetable cultivars) was produced. This included nucleus (29.443 t), breeder (825.072 t) and labeled (1176.907 t) seeds. From the table

it is clear that the seed production has increased more than two times from 2006 onwards.

Seed Production from 2000-08

Year	Crops (No.)	Varieties (No.)	Seed Production (t)			Total (t)
			Nucleus	Breeder	Labelled (IARI)	
2000	32	77	3.416	97.416	102.074	202.906
2001	31	86	2.897	85.897	109.632	198.363
2002	28	80	4.045	72.792	107.255	184.092
2003	29	76	2.182	76.782	71.883	150.847
2004	27	79	3.997	72.098	87.891	163.986
2005	27	80	3.391	86.660	52.612	142.663
2006	27	87	2.982	98.578	82.162	183.722
2007	31	111	4.017	112.136	257.463	373.616
2008	28	96	2.516	122.776	305.935	431.227
Total	**29#**	**86#**	**29.443**	**825.072**	**1176.907**	**2031.422**

Average

The Regional Station, Karnal has been generating >30% of the total revenue of the Institute through the sale of quality seeds. In addition, the Regional Station, Karnal, developed several technologies for seed production, quality control and post harvest management. Some of the most adopted techniques are as follows:

Nucleus seed production of wheat at Regional Station, Karnal

A new technique of blanket application of 1% Glyphosate was developed to control obnoxious weeds in Cucurbitaceous and Solanaceous seed crops such as melons, gourds, chillies, brinjal, etc., by covering the plants with PVC pots.

The bioagents *Gliocladium virens, Pseudomonas fluorescens, Trichoderma viride,* and *Trichoderma harzianum* in combination with 0.125 per cent vitavax (half dose) and vitavax alone (full dose) gave better control of loose smut disease of wheat (cv. PBW 343) to that given by the bio-agents alone in the field.

The growth of *Aspergillus flavus* was restricted by turmeric treatment @ 0.1% that gave 43% control.

Significant effect of smoke on the mortality of *C. maculates* was observed with 82% kill in 120 h of exposure. *R. dominica* appeared tolerant with only 27% mortality during the same period of exposure. Complete mortality of *C. maculates* and *R. dominica* was observed at 50% and 60% concentration of CO_2, respectively. Complete mortality of *C. maculates* and *R. dominica* adults were achieved with the smoke generated from burning of cow dung + 40 ml neem oil. However, smoke from burning of 500 g cow dung mixed with 40 ml castor oil resulted in 90.42 per cent mortality of *R. dominica*. Smoke enhanced the susceptibility of *R. dominica* and *C. maculates* to phosphine.

IARI Regional Station, Indore

The major thrust has been on the improvement in productivity of *durum* and bread wheats in central India through development of high yielding, early maturing and rust resistant varieties. Five bread wheat and two *durum* varieties were released during 2000-2008, namely, HI 1418 (Naveen Chandausi), HI 1454 (Abha), HI 1479 (Swarna), HI 1500 (Amrita), HI 1531 (Harshita), HD 4672 (Malav Ratna), and HI 8627 (Malav Kirti), which are highly resistant to stem and leaf rusts. This helped in protecting the wheat crop of Madhya Pradesh as well as of the northern wheat belt from both the rusts, by cutting down the inoculum supply along the *Puccinia* path, since central India serves as the secondary locus of infection for the northern plains.

The Regional Station, Indore is presently one of the biggest producers of the breeder seed of the Central Zone wheat varieties. Nearly 1077 tonnes of breeder seed was produced during 2000-2008. This assured availability of "quality seeds" of 8 *aestivum* and 4 *durum* improved wheat varieties created an effective genetic diversity in Madhya Pradesh. *Durum* wheat was brought back under cultivation, and Madhya Pradesh was declared as "Agri-Export Zone" (AEZ) for *durum* wheat.

The Station has developed protocols for evaluating rust resistance in *durum* and bread wheats. Seedling tests of 120 representative genotypes each of *durum* and bread

wheats with 40 pathotypes of leaf rust and 24 of stem rust revealed that leaf rust pathotypes 162-2, 1205, 12-2, 104-2, 162-3, 11, and 106, and stem rust pathotypes 117-6, 117A, 117-1, 117A-I and 117-3 be used for evaluation of rust resistance in *durum* wheat; while leaf rust pathotypes 77-6, 77-5, 77-7, 77-2, and 77-1, and stem rust pathotypes 40A, 40-1, 295, 11 and 117-4 be included for evaluating resistance in bread wheat. Out of 21 'susceptible' genotypes tested, *durums* – Local Red, Local Yellow, Karnataka Local, SV 683 B, A 28, GW 1, Chadur Biswa 7, A 206, Bansi Local and Malvi Local; and bread wheats – Pissi Local and Dhar Local, were identified as appropriate components of 'infector' rows, based on their susceptibility to virulent pathotypes and high AUDPC values.

IARI Regional Station, Katrain

In cabbage, SI based hybrid KGMR 1 was identified for release under AICRP (VC) for zones I and IV. Another hybrid KCH 5 has been entered in AICRP (VC) trials. Cabbage hybrid KIRCH-5, resistant against DBM, was identified for eastern zone of the country. In the case of cauliflower (late group), a black rot and *Sclerotinia* resistant selection Kt-25 had been released. Two promising CMS based hybrids, KTH-1 (36.2 t ha^{-1}) and KTH-2 (34.8 t ha^{-1}), have been entered in AICRP (VC) trials. Sources of resistance against black rot, *Sclerotinia* rot and downy mildew were identified. Capsicum hybrid KTCPH-3 was identified for release in AICRP (VC) Group Meeting (2005) for zones I, VI and VII. Another capsicum hybrid KTCPH-5 is in the pipeline. The CMS system developed in temperate carrot was used for the first time in India to develop hybrids. Thus, hybrids, KTCTH-7 (37 t ha^{-1}) and KTCTH-8 (35 t ha^{-1}) with desirable root traits were identified for AICRP (VC) trials. Kullu district, being a temperate fruit belt, adoption rate of 9.33% was recorded for vegetable production.

Seasonal incidence of major insect pests and diseases were studied in the summer vegetables and in their seed crops in the winter seasons in order to develop pest management modules. Temperate snail (*Macrochlamys glauca*) was the major pest in summer, and a module for its management was developed. A total of 24.651 t seed comprising of 1.225 t nucleus seed, 5.790 t breeder seed, and 17.636 t IARI (TFL) seed of 58 varieties of 26 vegetable crops was produced with a total seed sale proceeds of Rs. 60.31 lakhs during the period under review.

IARI Regional Station, Amartara Cottage, Shimla

The Regional Station, Amartara Cottage (including Cereals Centre) Shimla have developed new wheat varieties, Himgiri (HS 375), Shivalik (HS 420) and Pusa Baker (HS 290), and one barley variety, Himadri (BHS 352). The Station developed two

varieties, Pusa Gold and Pusa Amartara Pride of apple from its apple-breeding programme and identified a promising clone of walnut the "Pusa Khor". Four new wheat resistant sources and one new barley germplasm were resistered with NBPGR.

The Station has excellent germplasm collection of apple, apricot, strawberry, cherry and Chinese gooseberry. *M. zumi* and cvs. Prima and Priscilla are being used as donors to improve the commercial apple cvs. Starking Delicious, Tydeman's Early Worcester and Golden Delicious. Further, an easy and low cost technique for large-scale multiplication of kiwifruit plants was developed. The strawberry cultivars collection was augmented from sixteen to ninety six.

IARI Regional Station, Pusa (Bihar)

The Regional Station, Pusa laid major emphasis on wheat improvement. Promising wheat cultures with diverse genetic background have been developed. Foliar blight resistant/tolerant lines HP 1882 and HP 1890 have been identified. Pusa (B) 0039 and Pusa (B) 0038 have been found superior in yield and resistance to *Alternaria* sp and

Shri Sharad Pawar, Hon'ble Union Minister of Agriculture, Consumer Affairs, and Food and Public Distribution inaugurating the Centenary Gate at IARI Regional Station, Pusa (Bihar)

ranked first and second in multi location trials. These have been promoted to AVT-I. Eighteen germplasm were collected and are under evaluation for quality traits. The wheat varieties HUW 234, HP 1744, NW 1014, and HD 2733 were found suitable under zero tillage condition. The use of bio-fertilizers in wheat crop was found to improve the available phosphorus in rice-wheat cropping system. During the period, the Station produced more than 109.23 tonnes of quality seed of wheat, paddy, maize, pigeon pea, papaya, lentil, *moong, urd* and oil seeds.

IARI Regional Station, Wellington

The Regional Station, Wellington has successfully introgressed several alien rust resistance genes, viz., *Lr9*, *Lr19+Sr25*, *Lr24+Sr24*, *Lr28*, *Lr32*, *Lr37+Sr38+Yr17* through backcrossing into several well adapted Indian bread wheat cultivars. Backcross programme has yielded several new high yielding rust resistant genotypes, viz., HW 2004, MACS 6145, HW 2044, HW 2045, HW 1085, HD 2833, etc., which have been released as cultivars and many more got registered with NBPGR as genetic stocks. The leaf rust gene sources up to *Lr57,* stem rust gene up to *Sr44*, yellow rust gene up to *Yr30,* and a number of *Pm* and head scab resistance stocks were maintained at this Station and made available to Indian wheat breeders. The Station successfully maintained more than 2000 accessions of primary, secondary and tertiary gene pools. Characterization, phenotyping and utilization of these alien sources/wild relatives of wheat particularly for the development of synthetic hexaploid using colchiploidy was also undertaken. Successful interspecific crosses between *T.timopheevii, T.durum* × *Ae.longissima* and *Ae.biuncialis* × *Ae.geniculata* have been establised and useful traits like high tillering and resistance to biotic and abiotic stresses have been exploited for creating variability in Indian wheat germplasm. The Station has released six wheat varieties, viz., HW 2004, MACS 6145, HW 2044, HW 2045, HW 1085, and HD 2833. Twenty genetic stocks were registered with NBPGR. Through extension programmes, the Station succeeded in spreading cultivation of wheat varieties in non-traditional wheat areas of Tamil Nadu and Karnataka.

IARI Regional Station, Pune

The Regional Station, Pune worked on virus and virus like diseases of fruits (banana, papaya and citrus) and vegetables (tomato, capsicum and cucurbits). Incidence and distribution of *Citrus tristeza virus* (CTV) and *Papaya ringspot virus* (PRSV) at different areas in Pune region were recorded. A mild strain of PRSV was identified and its effectiveness was successfully tested under field condition. Seedlings of popular, high yielding papaya cultivars inoculated with mild strain of PRSV were distributed to the farmers for large scale cultivation which resulted in reduced incidence of PRSV in

farmers' fields in Pune region. It was found that by shifting the time of planting of papaya seedling to February, infection by PRSV can be greatly avoided and good yield harvested.

First report of *Zucchini yellow mosaic virus* (ZYMV) in Zucchini, muskmelon, bottlegourd and cucumber, and a tospovirus in cucurbitaceous crops was made. Natural occurrence of PRSV-W and ZYMV in sponge gourd was reported for the first time from India. Immunological and molecular testing of 14 CTV isolates was done. It was found that mixed infection by severe and mild strain of CTV might occur in nature. Satisfactory performance of kagzi lime plants cross protected with Tm-Strain (mild) of CTV was proved. It was found that banana plants, when used as a border crop, effectively checked the entry of aphid vectors in papaya field. Incidence of banana mosaic, banana streak and banana bract mosaic viruses in tissue culture raised banana plants in Pune region was reported.

The Station provided diagnostic services to the farmers for plant virus identification and technical know-how for the management of virus diseases of crops.

IARI Regional Station, Kalimpong

The Regional Station, Kalimpong has identified large cardamom viruses, namely, *Chirke* and *Foorkey,* and large cardamom mosaic including their respective insect vectors. Virus causing *Chirke* disease was purified and polyclonal antibodies against the virus were produced. Molecular cloning of one of the genome segments of the virus causing *Foorkey* disease was achieved. Virus causing *Chirke* disease was found to be a probable member of the family *Potyviridae,* whereas the virus causing *Foorkey* disease was a probable member of the genus *nanovirus*. Altogether, fifteen CTV isolates were collected and maintained. Genome segments of four CTV isolates were cloned and sequenced. Further, yellow mosaic disease of chayote/chow-chow could be transmitted using *Bemisia tabaci* and the virus causing the disease was a probable member of the genus *begomovirus*. Mosaic disease of chilli in the Darjeeling hills was associated with the infections by a *potyvirus* and a *cucumovirus*. Disease-free planting materials of large cardamom and Darjeeling orange were produced and distributed to the farmers of Sikkim and Darjeeling hills.

IARI Centre for Pulses Improvement, Dharwad

The Centre for Pulses Improvement, Dharwad is an off-season nursery of IARI for advancing breeding generations, disease screening and strengthen shuttle breeding programme of the Institute for pulses like chickpea, fieldpea, lentil, *moong, urd,* cowpea, pigeonpea, soybean and *Brassica* for generation advancement, generating more variability

by virtue of the possibility of effective crossing programme and screening of breeding material and germplasm against major diseases.

Rice Breeding & Genetics Research Centre, Aduthurai

The Rice Breeding & Genetics Research Centre, Aduthurai has helped in developing twelve high yielding *basmati* as well as non-*basmati* rice varieties since its inception in 1982. They include high yielding dwarf *basmati* rice variety Pusa Basmati 1, early maturing varieties like Pusa 834 and Pusa 677 for multiple cropping with exemplary high yield potential Pusa 150, Pusa 169, Pusa 205, and Pusa 44, early maturing *basmati* varieties, Pusa Sugandh 2, Pusa Sugandh 3, Pusa Sugandh 4, and Pusa Sugandh 5 combining male fertility restoration, and the world's first *basmati* and hybrid quality rice Pusa RH 10 for wheat-rice cropping system.

Krishi Vigyan Kendra, Shikohpur (Gurgaon)

The Krishi Vigyan Kendra of IARI at Shikhohpur, Gurgaon plays a vital role in combating unemployment of rural youth through technological empowerment and improving farmers awareness and farm productivity through various TOT programmes.

During the review period, 744 front line demonstrations (covering 376.72 ha) were laid out in 42 villages of Gurgaon district. Out of 744 demonstrations, 317 (221.78 ha) on oilseed crop (Mustard), 304 (102.04 ha) on pulse crops (*arhar, moong*, gram and lentil) and 123 (52.90 ha) on cereal crops (wheat and paddy) were conducted in farmers' fields under the direct supervision of KVK scientists/ subject matter specialists.

Four hundred fifty one (451) training programmes were organised for different target groups. Out of 451 trainings, 80 vocational courses for unemployed rural youth and girls, 186 day long on-campus trainings for progressive/FLD farmers, 10 in-service trainings for agriculture development officers of the state agricultural departments, 180 one day long off-campus trainings for practicing farm men and farm women and 3 sponsored training courses for self-help groups (members of BPL) were organised. Through these trainings, 11310 persons (8524 male and 2786 female) were benefited.

5.7 Socio-economic Impact

Rice variety, Pusa 1121, which is under cultivation for the last four years, has spread to 0.8 million hectares in Indo-Gangetic plains. This most long and fine-grained *basmati* rice in the world is being sold in export market at a premium price. Other *basmati* varieties take 170 to 190 days for maturity whereas this variety takes 140 to 150 days to maturity, thus providing better scope for double cropping. Combined with quality and

short duration, this variety was fetching prices up to Rs 2000 per quintal of paddy, to the farmers. It has been recommended under *basmati* category by the Ministry of Agriculture, and Commerce and Industry in October 2008. With this variety branded as *basmati*, the next day itself the price of paddy had gone up to Rs 3500 per quintal. Considering its area spread mainly in Haryana, a newspaper (The Indian Express) reported that the state farmers would get additional Rs 2000 crore this year itself with that price. If we consider its spread in Punjab, western UP, Uttaranchal, and Delhi also, the additional income would be more than Rs 5000 crores this year alone. It is expected that the traders will earn more benefit than the farmers. Compared to traditional *basmati* varieties, which yield around 2.5 to 3 tonnes per hectare with 170 to 190 days' duration, this variety yields 4 to 5 tonnes easily per hectare.

The percentage share of IARI varieties in total breeder seed production in the country varies from 20.4% to 32.9% in wheat. High yielding wheat varieties developed by IARI occupy 30% of the area under wheat in India. Many varieties such as HD 2189, HD 2285 and HD 2329 played a major role in increasing wheat production, not only in India but also in other countries of Asia and Africa.

The mustard varieties developed by the Institute are giving additional yield of one tonne per hectare, and have covered more than two million hectare in northern India. Even at the rate of Rs. 2000 per quintal, additional benefit will be Rs. 20,000 per hectare and for two million hectares it will be Rs. 4000 crores. Similar is the case of varieties in pigeonpea, and chickpea in pulses.

The Institute is working on a number of vegetable crops, a dozen fruit crops and a dozen flower crops, which have changed the income level of farmers in the entire country. The varieties, which have been released in vegetables, viz., Pusa Kranti (brinjal), Pusa Sawani (*bhindi*), Pusa Jwala (chilli) Pusa Ruby (tomato) and Pusa Red (onion) are not only popular even today but also formed the base for the establishment of private companies like Mahyco. Similarly, the fruit varieties developed by the Institute like Amrapali and Mallika (mango) are very popular in the country and are being exported. The improved varieties developed in flower crop like *gainda*, viz., Pusa Narangi Gainda and Pusa Basanti Gainda have improved the socio-economic status of farmers by earning an income of about one lakh rupees per hectare.

The Regional Stations of the Institute located in different agro-ecological zones of the country have also played an important role in the development of area specific (mandated) crop varieties and their production technologies. The Regional Stations at Karnal, Indore, and Pusa are engaged in seed multiplication programmes of the crop varieties for meeting the demand of Pusa seed in their respective areas.

The technologies developed by the Institute are gaining popularity among the private companies for their commercialization. As a result, a number of seed companies like J.K. Agri Genetics Ltd, MAHYCO Seed Ltd., MAHYCO Research Foundation, Bejo Sheetal Seeds Pvt. Ltd., West Bengal Hybrid Seeds & Bio Tech Pvt. Ltd. signed Memoranda of Understanding with the Institute to produce foundation and certified seeds of vegetable hybrids (cauliflower, cabbage, brinjal, and transgenic brinjal) and Pusa rice hybrid in 2007. In addition, the Basmati Export Development Foundation (BEDF) and IFFCO Foundation agreed to take consultancy services from the Institute for grain quality analysis, and cooking quality analysis and establishing DNA profiling and rice quality analysis lab, and modern high tech horticulture nursery in Aligarh district. In 2008, the Institute has signed MOUs for the development of transgenics; commercialization of Pusa RH-10 rice hybrid; nematode isolates and farm implements with several companies like M/s. Bejo Sheetal Seeds Pvt. Limited, Jalna; Mechanical Engineering Research & Development Organization (MERADO), Ludhiana; Advanta India Limited, Secunderabad; Zuari Seeds Limited, Bangaluru; Devgan Seeds and Crops Technology Pvt. Ltd., Hyderabad; J.K. Agri Genetics Ltd., Secunderabad; and Nath Biogene (I) Ltd., Aurangabad; Nuziveedu Seeds Ltd., New Delhi; Bhawani Seeds & Bio Tech, Mathura; Namdhari Seeds Pvt. Ltd., Bangaluru; Amareswara Agri-Tech Ltd., Hyderabad; Yashoda Hybrid Seeds Ltd., Wardha; Atash Seeds Pvt. Ltd., Bangaluru and Krishidhan Seeds Ltd., Jalna. The Institute also signed MOUs with Multiplex Biotech Pvt. Ltd. Bangaluru on entmopathogenic nematode (*Steinernema thermophilum*) and Sipani Krishi Anusandhan Farm, Mandsaur (M.P.) for crop improvement in pigeonpea, soybean, maize and wheat varieties.

5.8 Library and Learning Resources

The IARI Library is one of the 10 best agro-biological libraries of the world, and possibly the best in South Asia. It is also one of the oldest libraries.

The Library today houses over 6 lakh highly specialized research publications on agriculture and related sciences consisting of books, monographs, reference materials, journals, annual reviews, abstracting and indexing journals, translated periodicals, statistical and data publications, bulletins, reports, post-graduate theses of IARI, and ICAR research fellowship theses. The collection gets enriched annually by 8,000 to 9,000 documents. The Library has 10,500 serial files, and 4000 current serials are being procured from 80 countries through subscription, gifts and exchanges. The Library also provides reference service, bibliographical services, documentation services, CD-Rom database searches, reprography services, etc.

The Library has been engaged in the following automation services: (i) digitization of IARI/ICAR RFT theses, (ii) digitization of 27 rare books; (iii) scanning of abstract/summary pages of each thesis, making the PDF file and making the database searchable, (iv) digitization of Bibliography of Indian Agriculture (BIA) and (v) creation of membership database and preparation of bar coded library agriculture membership cards.

The Library provides the following information services to the scientists/research scholars of IARI and other users from all over India: (i) current awareness service, (ii) selective dissemination of information, (iii) document delivery, (iv) bibliographies on demand, and (v) inter-library loan.

At present, the Library is subscribing to 353 foreign and 343 Indian Journals. The Library had 135 on-line journals in 2005, which are free against print subscribed journals and accessible through Intranet.

The IARI Library has been assigned the job of AGRIS database input for National Agricultural Research Database (NARD).

The IARI Library has a well-equipped Facility Management Unit with ten personal computers attached with internet facilities for M.Sc. and Ph.D. students. The Library also has a well-equipped 'Computer Lab.' with 24 terminals with internet connectivity. The two reading halls of the library have been equipped with WIFI system and computers with intra-net connectivity. Periodic training is given to scientists and students of the Institute for CD ROM search, Web of Science, Current Contents Connect, Digital Resources, E-Journals, On-line information retrieval, etc.

The NAIP supported project Consortium for e-Resouces in Agriculrure (CeRA) has been initiated, which provides online access to over 2000 scientific journals to 123 libraries of the National Agricultural Research System (NARS).

One compulsory credit course of Agricultural Information System (AIS) for M.Sc. and Ph.D. students was started in 1982. The aim of the course is to acquaint students with Library literature, searching of literature, services rendered by the Library, and information retrieval technology and techniques.

5.9 Post Graduate School

Before IARI became a 'Deemed to be University' in 1958, students numbering 903 were awarded Associateship of IARI which was recognized as equivalent to the M.Sc. degree of Indian universities. The Institute presently offers Master's (M.Sc.) programme in 23 disciplines, namely, Agricultural Chemicals, Agricultural Economics, Agricultural

Engineering, Agricultural Extension, Agricultural Physics, Agricultural Statistics, Agronomy, Biochemistry, Computer Application, Entomology, Environmental Sciences, Genetics, Horticulture, Microbiology, Molecular Biology & Biotechnology, Nematology, Plant Genetic Resources, Plant Pathology, Plant Physiology, Post-Harvest Technology, Seed Science & Technology, Soil Science & Agricultural Chemistry, and Water Science & Technology. The Institute also offers doctoral (Ph.D.) programme in all the above - mentioned disciplines, except Computer Applications.

The Institute has a sanctioned strength of 608 scientists, of which, 372 are in position and 236 positions are vacant as on 31st December 2008. This includes the sanctioned strength of 7 research management positions, of which, 5 are filled and 2 are vacant.

The Institute, at present, admits students to the Post Graduate School under five separate streams, namely, (i) open competition, (ii) foreign students, (iii) in-service candidates of SAUs for faculty up-gradation, (iv) departmental students (scientific and technical), and (v) ICAR in-service nominees. Since the year 2000, M.Sc. entrance test is conducted by ICAR. Entrance test for Ph.D., however, is conducted by IARI. Approximately, 30 foreign students are admitted to the M.Sc. and Ph.D. degree courses.

During the period of 2000-08, 633 M.Sc., and 853 Ph.D. students (including 103 foreign students) were admitted to the P.G. School. The Institute has awarded Ph.D. degrees to 698 students and M.Sc. degrees to 600 students including 32 MSc. and 46 Ph.D. foreign students.

Training

In addition to the regular M.Sc. and Ph.D. programmes, the Institute also organizes short-term training courses and refresher courses in specialized areas for the teachers and scientists of SAUs, NARS and other countries. During the period of review, the Institute organized 353 training programmes in which 6482 scientific staff from SAUs/ Institutes updated their skills in the various fields of agricultural research.

Miscellaneous

During 2000-2008, forty-five faculty members were awarded the Best Teacher Awards for their untiring efforts in improving the teaching in different subjects. Several awards like Hooker Award, Dr. B.P. Pal Memorial Award, Hari Kishan Shastri Memorial Award, Sukumar Basu Memorial Award are given by the Institute to promote excellence in agricultural research in the country. During the period under report, the IARI instituted Rao Bahadur Dr. B. Vishwanath Award for giving recognition to agricultural scientists for outstanding research. Two eminent scientists were awarded during this period. These awards are open to all the scientists of the country.

Faculty members of the Institute have been honoured with various awards like Om Prakash Bhasin Award, VASVIK Award, Rafi Ahmed Kidwai Award and Hari Om Ashram Award.

Student Development

Spacious playgrounds are provided, and necessary facilities exist for outdoor games like cricket, hockey, foot ball, volley ball, basket ball, badminton and tennis, besides various athletic events. Well-equipped Gymnasia are available for physical development of the students and staff. The students of the Institute also regularly participate in various literary, cultural and sports competitions organized by the Institute, ICAR, and by other Universities/Institutions in India. A Student Counseling Centre operates to provide regular guidance and support to the needed. IARI Alumni Association serves as an effective bridge between the past and the present students and faculty members. Air – conditioned reading rooms and internet facilities have been provided in the hostels.

The unemployed graduates are less than about 2% in M.Sc. and 4% in Ph.D. The placement pattern of outgoing M.Sc. students in recent years is as follows: agricultural universities and research organizations (2%), Agricultural Research Service (20%), Union Public Service Commission (5%), contractual JRF/SRF (3%), and enrollment for Ph.D. progrrame (70%).

5.10 Administrative Achievements of IARI (2000-2008)

1. Human Resource Development (HRD)

A number of promotion and assessment cases in various categories of staff were processed. Nine hundred thirty six (936) cases of promotion of supporting staff in various grades have been cleared and 334 cases related to Assured Career Progression Scheme were finalised. Nearly 1650 assessment/promotion cases in different categories (Categories-I, II and III) of technical and functional groups were cleared and orders issued. Similarly, 75 cases of promotion under various categories have been done in respect of administrative staff. In respect of scientific staff, nearly 185 cases of assessment/promotion in various disciplines were completed.

Approximately, 220 officials from administrative services have been deputed for training to different training institutions such as ISTM, NAARM, NIFM, IASRI, etc., on different subject matters for upgrading and enhancing their skills.

2. Upgradation of Technology & Modernization

(i) Computerisation: Computer facilities along with relevant softwares have been provided to all the sections/branches of the Director's Office (Administration & Audit Wings). In the Administrative Wing, most of the office work is being

done with the latest version of softwares. In the same manner, the Pay Bill Section, Compilation Section and Audit Branches are working with the latest version of softwares.

(ii) Internet & Intranet facility: Internet & e-mail facilities have been provided on all the computers provided to the senior officers, and sections/branches of the Director's Office.

(iii) Communication Facility -EPABX – Intercom System : A modern EPABX system at a cost of Rs. 55 lakh was installed connecting each and every section/ division in IARI.

3. E-governance/R- governance

A committee constituted under the chairmanship of Dean & Joint Director (Education) of IARI with 07 other members to introduce e-governance in the Institute as a part of modernization, especially, in view of the globalization phenomenon and to cope with the decreasing administrative staff strength. The committee has given various suggestions for effective implementation of e-governance.

4. Sports, Recreational Activities

The following facilities are available for recreational activities of staff and students:

For students - Outdoor stadium, Tennis court, Badminton court, Indoor T.T., Billiards, Gyms, etc.

Faculty Club - Outdoor stadium, Courts for volley ball, Kabaddi, Tennis, etc.

However, in the opinion of the QRT, sports and faculty amenities are not commensurate with the status of IARI as a Deemed University. The QRT recommends financial support for the construction of faculty club, state of the art sports and games facility including indoor stadium, and swimming pool.

Depletion in the Strength of Technical and Administrative Staff

Even though higher efficiency has been achieved administratively, there has been a considerable depletion of staff strength in various categories, thus affecting the functioning of the Institute. The reduction in staff strength was due to redeployment of staff to other institutes by ICAR, ADRP cuts, surrendering/lapsing of vacant posts, non-recruitment by ICAR, etc. The QRT recommends that the vacant positions of technical & administrative staff be filled on priority.

5.11 Future Proposals in EFC

i) Complete Computerisation: A proposal has been submitted under EFC Plan for complete computerisation at headquarters & Regional Stations. Computers will be provided to all the dealing hands for making paper free, fully computerized

data/records. This is also the requirement because of the implementation of RTI Act. Computerisation will enable access to records by higher authorities at any time and facilitate decision making.

ii) **Construction and repairs/maintenance:** Under EFC (XIth plan), an allocation of Rs. 5500 lakhs has been made for new building to house the Divisions of School of Crop Improvement, along with provisions for a Farmers' Hostel; a Farmers Hostel for Women; a building for Post Graduate School; a Gymnasium and Indoor Facility including Swimming Pool for students; an additional building (4-story) adjacent to Library; a 100 beds Trainees Hostel; an Office cum Lab Building at IARI Regional Station, Shimla; a new girl Hostel (75 rooms); a Boys' Hostel (150 rooms); a Married Students' Hostel (75 sets), etc.

iii) **Modernization:** Under the EFC Plan an allocation of Rs. 4000 Lakhs has been made for the puchase of equipment during XIth Plan. Some of the major equipment recommended are: Confocal Microscopy with accessories, DNA Micro Array System, Plant Growth Chambers, Robotics for high throughput system (PCR Workstation), LS-MS-MS, Transmission Electron Microscope, Scanning Electron Microscope, Inductively Coupled Plasma Spectrometer-MS with DCR Technology, DNA Sequencing, Plot Harvester, Plot Combine, Microscope with Image Analyzing System, NIR Automatic Protein Analyzer, etc.

Plan Main Scheme: Strengthening/Continuation of IARI, New Delhi
Broad Head-wise break-up of IX, X & XI Plan outlay
as approved by the SFC/EFC meeting

(Rs. In lakhs)

Head	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Total
A. Recurring								
Pay & Allowances		-	-	-	-	-		-
T.A.	20.00	21.35	22.88	29.95	25.00	0.82	25.00	145.00
HRD		-	-	-	50.00	59.00	5.00	114.00
Contingencies	656.62	316.8	272.64	630.02	650.00	649.54	945.00	4120.62
Total (A)	**676.62**	**338.15**	**295.52**	**659.97**	**725.00**	**709.36**	**975.00**	**4379.62**
B.Non-Recurring								
Equipment		13.13	7.36	-	1000.00	479.51	425.00	1925.00
Works	560.00	189.24	-	30.92	416.00	600.54	250.00	2046.76
Library		49.31	64.34	259.82	90.00	86.53	100.00	650.00
Land		-	-	-	-	10.00		10.00
Total (B)	**560.00**	**251.68**	**71.70**	**290.74**	**1506.00**	**1176.58**	**775.00**	**4631.70**
Grand Total(A+B)	**1236.62**	**589.83**	**367.22**	**950.71**	**2231.00**	**1885.94**	**1750.00**	**9011.32**

Expenditure

(Rs. In lakhs)

Head	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Total
A. Recurring								
Pay & Allowances		-	-	-	-	-		-
T.A.	20.00	21.35	22.88	29.95	24.92	0.86	21.92	141.88
Contingencies	637.04	316.8	272.64	630.02	915.41	619.07	944.32	4335.30
Total (A)	**657.04**	**338.15**	**295.52**	**659.97**	**940.33**	**619.93**	**966.24**	**4477.18**
B.Non-Recurring								
Equipment		13.13	7.36	-		531.77	409.73	961.99
Works	560.00	189.24	-	30.92	40.00	465.02	238.19	1523.37
Library		49.31	64.34	259.82	90.41	86.10	99.99	649.97
Total (B)	**560.00**	**251.68**	**71.70**	**290.74**	**130.41**	**1082.89**	**747.91**	**3135.33**
Grand Total (A+B)	**1217.04**	**589.83**	**367.22**	**950.71**	**1070.74**	**1702.82**	**1714.15**	**7612.51**

Statement showing Allotment/Expenditure under Non Plan from 2001-02 to 2007-08

Allotment

(Rs. In lakhs)

Sub Head	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Estt.charges	4900.00	5100.00	5250.00	5525.00	6014.00	6772.50	6375.00
OTA	4.50	4.50	4.50	4.50	4.50	3.50	3.50
TA	19.00	17.00	19.00	31.00	21.00	20.00	28.00
Other charges including equipment	1450.50	1405.00	1553.80	1540.00	1900.00	1800.00	1734.50
Works	1010.00	977.85	1009.70	999.50	727.36	745.00	905.00
Other items	160.00	145.00	107.00	262.00	150.00	170.00	200.00
Total	**7544.00**	**7649.35**	**7944.00**	**8362.00**	**8816.86**	**9511.00**	**9246.00**

Expenditure

(Rs. In lakhs)

Sub Head	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08
Estt.charges	4903.80	5105.52	5152.93	5524.54	5981.89	6404.86	6374.30
OTA	4.50	4.50	4.10	4.49	4.13	3.33	3.47
TA	19.00	16.85	18.20	26.39	19.37	19.98	27.36
Other charges including equipment	1462.59	1404.91	1534.70	1535.04	1891.80	1799.47	1714.91
Works	1010.05	976.85	1007.97	998.16	726.90	743.82	903.07
Other items	145.90	133.33	98.40	258.93	141.89	169.97	199.74
Total	**7545.80**	**7641.96**	**7816.30**	**8347.55**	**8765.98**	**9141.43**	**9222.85**

6. Technology Transfer

The extension role of IARI is to provide national leadership in socio-economic and policy research, extension and technology assessment and transfer by developing new concepts and approaches and serving as a national referral point for quality and standards. Matching with the strong research and education traditions, the Institute has played a significant role in extension and developed many concepts and extension approaches/strategies to help disseminate new technologies to the users.

The Institute has addressed the issues related to technology assessment and refinement through participatory extension research for effective transfer of technology facilitating application of improved technologies in different agro-ecoregions through village cluster approach for sustainable productivity in semi-arid areas and promotion of agri-horti system in tribal areas for socio-economic upliftment. Front line demonstrations and on-farm demonstrations were found to be effective tools for this endeavour. Partnerships with private agencies were formulated and strengthened to develop and validate effective public-private partnership model in the field of agricultural research, education and extension. The Agricultural Technology Information Centre (ATIC), which is based on a Single Window concept, provided farm information advisory services, sale of seed and other critical inputs at one location. Trainings were organised for capacity building and empowerment of farm men, farm women and rural youth for initiating farm based enterprises on commercial agriculture quality seed production, etc. Need-based training modules were developed for different clientele group and those training modules were put to use for promoting entrepreneurship in agriculture. Pusa Krishi Vigyan Melas, forming a potential platform for creating awareness and generating interest among a large number of farmers, researchers, extension personnel of different states and other stakeholders were organised every year at IARI, New Delhi and its regional stations and KVK. Farm School on AIR (All India Radio), field days, field visits, and farmer-scientist interaction are other extension methods undertaken to reach the farmers.

The transfer of technology programmes of the Institute encouraged the farming community to work towards their economic gain. The following are some of the highlights:

- Intensification of Rice-Wheat Cropping System with the inclusion of *moong* variety- Pusa Vishal in combination with different rice and wheat varieties

demonstrated that rice (Pusa Sugandh 4) - wheat (WH 711) - *moong* (Pusa Vishal) gave 45% higher returns as compared to those given by local check crop rotation of rice (PB 1) - wheat. Diversification of rice- wheat cropping system with pea as vegetable and gram as pulse gave encouraging results, i.e., rice-pea gave 74% higher returns and rice-gram gave 16% higher returns compared to those of the existing rice-wheat cropping system, with less use of nitrogenous fertilizers, improved soil health and reduced cost of cultivation. Improved farm implements (i) Pusa Wheel Hand Hoe and (ii) Improved Pusa Sickle, were helpful in reducing the drudgery of farm women. More than 250 farmwomen adopted these improved implements. The efficiency was increased by 2-3 times with an economic gain of Rs. 1250/- per hectare. Organized 25 on campus skill trainings for 545 women beneficiaries on value addition and reducing wastage of surplus seasonal vegetables.

- Demonstrations on Orobanchae management with different resistance/tolerant varieties, use of castor, *guar* and onion as a trap crops, use of aqua seed plough for sowing mustard and use of chemicals and bio-control agents. Organised demonstrations on *bajra* (146), *moong* (140), cowpea (78), *guar* (110), *bhindi* (92), onion (78), bottle gourd (25), *palak* (5), chillis (5) to prove production potentials and facilitate adoption of improved varieties. One hundred twenty four on-farm demonstrations on soybean, maize, *arhar*, bitter gourd and muskmelon were carried out to introduce these crops in the existing crop rotation. Produced 145.7t seed of paddy varieties PB 1 Pusa, Pusa Sugandh 4, Pusa Sugandh 5 and Pusa 44, 2.2t of sorghum PC 9 and 113.176t seeds of wheat varieties HD 2851, WR 544, HD 2864, HD 2643 and HD 2733 and sold them to the progressive farmer members of Young Farmer's Association of Punjab for varietal diversification in different parts of Punjab. Integrated agriculture development was implemented in different TOT areas and the strategy of organic farming, vegetable based farming system and integrated farming system was conceptualized for further verification.
- Animal husbandry based interventions like deworming, complete balanced ration feed block, and UMMB supplementary feeding technologies were implemented. Post-calving deworming in 39 buffaloes and ectoparasite control in 192 milch buffaloes, deworming in 74 buffaloes and control of ectoparasites in 58 buffalo calves were done. Interventions on control of endoparasites in 199 calves and ectoparasites in 138 calves to reduce mortality and improve growth rate in buffalo calves; and control of endoparasites in 89 buffaloes and ectoparasties in 50 buffaloes for improved productive and reproductive performance were done. Seventeen animal health care camps were organised in which 2802 animals were examined for treatment/advice.
- A total number of 70222 farmers/entrepreneurs from 26 States and 3 Union Territories of India visited ATIC for farm advisory, diagnostic services, purchase of technological inputs / products and trainings. Maximum numbers of farmers

visited ATIC to purchase/enquire about seeds/varieties (30641). This was followed by visitors to seek information related to horticultural crops (15878), plant protection and agronomic practices (11192), and to collect / purchase extension literatures (7997), and agro-based enterprises (894). About one-fourth of farmer-visitors from Delhi, UP, and Haryana were interested in floriculture and horticulture, which indicate that the farmers in the periphery of the Delhi are shifting towards commercialization/diversification of agriculture. A few visitors from foreign countries like USA, Germany, Pakistan, Srilanka, Nepal, South Africa, Australia, Austria, Ireland, France, Bangladesh, Trinidad also visited ATIC's Single Window Delivery System. Seeds, publications, processed products, implements, etc. worth about Rs. 39 lakh were sold during the period.

- ATIC helpline, and Kisan Call Centre (IInd level) started w.e.f May 2001 and January, 2004, respectively, were used by a total of 5936 farmers/entrepreneurs from 18 States and 2 Union Territories to get information about seed availability of various crops, cultural practices, plant protection measures, medicinal plants, agro-based enterprises, training, farm literature, soil and water analysis, etc. Maximum calls were made by the farmers/entrepreneurs from UP (1460) followed by those from Delhi (1020) and Haryana (970). Maximum callers sought information about seed availability (3050). This was followed by those seeking information on cultural practices and seedling availability of agronomic, horticultural and medicinal crops (1940) and plant protection measures (1785). Besides, more than 600 farmers got farm advisory services through letters during the period. A total of 23 on-campus training programmes including 1 international training programme, of varying durations from 3 to 28 days were organised for farmers, entrepreneurs and extension functionaries of state development departments and SAUs.
- About 198 one-day field training programmes benefiting 4132 farmers/ farmwomen were organised in different villages of the operational areas under

A subject matter specialist (plant protection) demonstrating the use of light trap in checking the insect population in gram crop at Teekli village, Gurgaon district, Haryana

OEP/TOT/IVLP programmes. Six co-operative societies, 3 kisan clubs and 4 women SHGs were mobilized for integrated bio-farming systems, high-tech agriculture, and entrepreneurship development in agriculture related enterprises, respectively. More than 15 potential agro- based enterprises were identified and promoted.

- In addition to the publication of the different extension literature and Prasar Doot magazine, publications on important technologies and compilation on various governmental programmes/schemes were brought out and distributed among the farmers. In all 39 research publications in different journals were published.
- IARI technologies were displayed in 11 farmers fairs, 11 international and 50 national exhibitions besides annual Pusa Krishi Vigyan Melas at the main campus and regional stations.
- The crop varieties and technologies introduced in different parts of the country contributed in terms of higher yields and economic returns, thereby motivating farming communities to adopt improved technologies.

7. Interaction and Linkages

As the leading and premier Institute in agriculture in the country, the Institute has close linkages with the institutes and universities in the NARS. Collaboration also exists with selected conventional universities, several institutes of the CSIR and the departments of Ministry of Science and Technology such as the Departments of Biotechnology, Space Research, Meteorology, etc.

During the period, the Institute had linkages with ACIAR (on overcoming production constraints in rainfed sorghum), IAEA (on nuclear techniques and nuclear management), AP-Netherlands (biotechnology programme), IRRDB, England through Rubber Research Institute (on etiology of brown-based rubber), CIIMMYT (on RCT using GIS, and characterization of genetic diversity in maize), IDRC, Canada (on rural resource management), CGIAR (programme on development of aerobic rice), IRRI (on ecoregional land use planning), USAID (on risk assessment and management options for stacked-genes transgenic crucifers).

In addition to these foreign aided projects, the Institute had linkages with ICAR institutes and SAU's under NATP Project and ICAR network projects.

The Institute had signed two MOU's with TNAU Coimbatore and UAS, Dharwad for sharing the facilities and expertise to work with off-season nursery.

A programme is currently being operated at the Institute under the INDO-UK programme where a Ph.D student admitted to the Institute can do thesis research work at an advanced laboratory in UK. Such kind of programme at the Institute should be encouraged.

The Institute has also signed Memoranda of Understanding for collaboration with various state agricultural universities on village-based model for market-led agriculture.

8. Resources and Organization

Resources Required, Mobilized, Plan for Mobilization and Infrastructure Organization

A sum of Rs. 1500 lakh was approved under 'Equipment' and a sum of Rs.1236.70 lakh was approved under 'Works' for the period from 2002 to 2007 under Plan. Equipment worth Rs.552.26 lakh was procured and an amount of Rs.725.18 lakh was spent on 'Works' out of the Plan funds. Some of the equipment procured include Gas Liquid Chromatograph, HPLC, Rhizoctron, NMR, Handheld Spectro-radiometer, Scanning Electron Microscope, DNA Microarray facilities, Real-time PCR, Atomic Absorption Spectrophotometer, NIR, Automatic Nitrogen Analyzer, Leaf Chamber Fluorometer, Laboratory Fermentor, etc. Under 'Works', some of the major items sanctioned were (i) augmenting the water resources at IARI, (ii) Construction of centenary building at IARI Regional Station, Pusa, Bihar, and (iii) Research Laboratory-cum-Study Centre at Shimla.

The EFC for the XIth Plan has an amount of Rs. 4000 lakh for purchase of equipment and Rs.5500 lakh for items of 'Works'. Some of the major equipment recommended are Confocal Microscopy with accessories, DNA Micro Array System, Plant Growth Chambers, Robotics for high through-put system, LS-MS-MS, Transmission Electron Microscope, Scanning Electron Microscope, Inductively Coupled Plasma Spectrometer – MS with DCR Technology, DNA Sequencing, Plot Harvester, Plot Combine, Microscope with Image Analyzing System, NIR Automatic Protein Analyzer, etc. Under items of 'Works', several new buildings have been recommended, viz., a New Building to house the Divisions of School of Crop Improvement; a Farmers' Hostel; a Farmers Hostel for Women; a building for Post Graduate School, a Gymnasium and Indoor Facility including Swimming Pool for students; an additional building (4-storey) adjacent to library; a 100-beds trainees' hostel; an office-cum-lab building at IARI Regional Station, Shimla, etc. In addition, provision has been made for national containment facilities for virus and vectors; modernization of the research farm of the Institute with better irrigation and infrastructure facilities, etc.

Resource generation by the Institute has increased over the years, which is a welcome development. There is further scope for augmenting resources by commercialization of technologies, and efforts may be made in that direction. The revenue receipts of various years are as follows:

Year	Rupees (in lakhs)
2000-01	354.91
2001-02	287.34
2002-03	257.26
2003-04	330.55
2004-05	511.30
2005-06	399.00
2006-07	427.97
2007-08	539.35
Dec. 2008	347.50
Total	**3455.18**

9. Summary and Recommendations

9.1 Summary

The Indian Agricultural Research Institute (IARI) is the country's premier national institute for agricultural research, education and extension and has been the flagship of India's agricultural research, technology development, human resource development and dissemination of technologies. As per the ICAR's policy of conducting achievements audit of progress made by its Institutes during every five years' period, the QRT reviewed the progress made by IARI during the last eight years period from April 2000 to March 2008. The QRT reviewed the achievements and progress made by the Institute including its Regional Stations through interaction with the scientific staff/officials and carried out the task assigned in the context of terms of reference set out by the Council. The QRT perused various documents, reports and proceedings of RAC, SRC, IMC and XIth Plan proposal document and the revised Perspective Plan Vision 2025 of the Institute. The findings and observations of the QRT with reference to the progress made by the Institute in terms of research achievements, future project requirements of infrastructure in terms of land, building, farm development, manpower, human resource development, equipment, linkages with other institutes/organizations and its recommendations are presented in this report.

The QRT observed that the Institute has made significant progress during the period of review not only in excellent research achievements and human resource development and technology development but also in farm development and equipping laboratories with state of the art facilities. The Institute has also established strong linkages with many national and international institutions and organizations. The Institute has contributed significantly in technology transfer. The technologies developed during the period have gone to the farmers' fields and many technologies are commercialized through public and private partnership approach. The Institute has filed a large number of patent applications and many patents are granted and MoU's signed with a large number of seed companies. The Institute has also been involved in training programmes for farmers, stakeholders, extension officers and scientists of various ICAR institutes and state agricultural universities and contributed specifically in human resource development. With respect to future prospective, the Institute has already prepared a Perspective Plan for the period 2007-2025 as Vision 2025. The QRT has reviewed the

Institutes'programmes in this document and made recommendations in the broad areas of Crop Improvement, Crop Protection, Natural Resource Management, Basic Sciences, Social Sciences and Human Resource Development.

Keeping in view the constraints in terms of infrastructure and manpower, and expectation of the society, the Committee made the following recommendations.

9.2 Recommendations

Scientific

- Heterosis breeding in rice, pigeonpea, mustard and wheat should be strengthened and research on pulses should focus more on crops like pigeonpea and chickpea.
- Molecular breeding should be an integral part of the crop improvement programmes.
- Research and teaching in the area of biotechnology should be strengthened. In this context, work on isolation and characterization of novel genes and promoters should continue for the development of transgenic crops resistant to biotic and abiotic stresses; nutritional quality improvement and post harvest technology.
- IARI should continue to develop high yielding varieties of crop plants along with appropriate production and protection technologies for different agro-ecologies of the country.
- Studies on the effect of climate change in relation to adaptation and mitigation should be undertaken in an interdisciplinary manner.
- A well-equipped screening system for abiotic stress tolerance at different stages of crop growth be developed at the Institute.
- Research programmes on Farm Machinery and Power need to be focused on development of precision farm implements and machinery and utilization of renewable energy resources.
- The Institute should focus research on remote sensing and simulation modeling approach for better crop planning.
- Research on resource conservation technologies be strengthened.
- Research linkage and coordination between the regional stations and the relevant main division of IARI should be strengthened.
- Analysis of cost: benefit ratio should be an integral part of technology development, especially, for INM, IPM and conservation agriculture.
- Basic research on soil processes involving nutrient fluxes and flows, organic recycling in relation to organic matter formation and its stability, nutrient availability and soil quality for enhanced productivity and environment safety should be emphasized.

- Research on modified fertilizers and technologies for improving fertilizer (nutrient) use efficiency and its economics should be strengthened.
- Considering the possibility of new insect pests and disease causing organisms entering into the country in new WTO regime, emphasis on phytosanitary issues in research programmes is recommended.
- The Institute should continue studies on plant diseases with greater emphasis on plant-microbe interactions.
- Presently, the work on pest management is not carried out in a holistic manner. Therefore, QRT recommends interdisciplinary approach for developing IPM technology.
- Considering the importance of new molecules in plant protection, the Institute should concentrate more on synthesis and development of new molecules of pesticides.
- In view of the development and introduction of transgenic crops, the Institute should take leadership role in evaluating benefits, biosafety assessment and developing resistance management strategies.
- In view of the importance of processing and value addition in food and horticultural crops, the QRT recommends the establishment of a new Center for Food Science and Post Harvest Technology at IARI with full component of human resource and infrastructure.
- Research programmes of the Nuclear Research Laboratory (NRL) are no longer viable and, therefore, the QRT re-endorses the recommendations of RAC 2005 for the reorganization of the Nuclear Research Laboratory.
- The QRT is of the considered opinion that the names of the Division of Genetics and the Division of Fruits and Horticultural Technology be changed as 'Division of Genetics and Plant Breeding' and 'Division of Fruit Science', respectively.
- The Seed Production Unit be made an integral part of the Division of Seed Science and Technology.

Human Resource Development

- Shortage of faculty in most disciplines is seriously affecting the research and teaching activities of the Institute. In view of this, the QRT recommends that the vacant positions of scientific staff in each discipline be filled on priority over the next three years.
- The position of Professor in each discipline may be filled by direct recruitment with the designation of Principal Scientist (Professor).
- As IARI is a University (Deemed), the posts of Head, Library Services and Registrar, PG School should be filled in the grade of Professor/Principal Scientist.

- New PG courses may be introduced in the disciplines of Food Science and Post Harvest Technology and Bio-informatics. However, such courses may be started only when critical competent faculty and infrastructure are provided.
- IARI may involve scientists working in other ICAR institutes and other reputed institutions in research guidance of the students at the Institute only after due accreditation and commitment to participate in teaching.
- The Institute should develop a Center for Distance Education and have a major responsibility for the development of e-content at PG level.
- The Institute should have a career development plan for faculty competence improvement. Advanced trainings in the new and emerging cutting edge areas need to be imparted to young scientists at the best institutions overseas.
- The post of Head of the Division be made RMP.
- IARI should institute Adjunct Professor Scheme as per guidelines being adopted by ICAR.
- The students' hostels at IARI are very old and require major renovation. In addition, the capacity in hostels is much less than its requirement. The QRT recommends the construction of a new hostel and major renovation of old hostels. ICAR should help the Institute to get necessary approvals from Urban Arts Commission and other bodies.

Extension

- IARI Extension Education Programme be implemented on pilot basis in different regions with the involvement of SAUs/ICAR institutes/extension agencies/industry.
- Senior level extension specialists from five disciplines (Agronomy, Soil Science, Genetics, Entomology and Pathology) need to be identified as members of 'Production Unit' to assist the Joint Director (Extension). This is required to keep liaison, ensure easy flow of latest technology and provide linkages for feedback of field problems and issues.
- The Institute should develop appropriate concepts and methodologies for better agricultural extension and technology transfer at national level.
- The Institute should make more efforts in expanding and strengthening the existing public-private partnership and linkages in research, extension and marketing of technologies. Linkage and collaboration should continue to exist with several national and international institutions.

Administrative

- Historically, Heads of Divisions of IARI occupied a pre-eminent position. However, after the creation of ARS, the Heads of Divisions at IARI were not included in research management position (RMP). As a result, there is a flight

of competent scientists to research management positions with equal grade, elsewhere. In order to retain competent scientists and provide leadership at IARI, which has a Deemed University status, the QRT recommends that the Heads of Divisions at IARI be given the status of RMP.

- The QRT recommends that the Institute should develop a time bound programme for training of technical and administrative staff.
- The Institute should also work on paperless system of governance as far as possible.

Financial

IARI should develop a Financial Management package online linking the Divisions to the Directorate.

ANNEXURE-1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI BHAVAN: NEW DELHI-110001

F. No. 16-8/06-IA.IV **Dated the 10th July, 2006**

OFFICE ORDER

The Director General, Indian Council of Agricultural Research has been pleased to constitute the following Quinquennial Review Team (QRT) to review the research work done under the IARI. New Delhi for the period (2000-05)

COMPOSITION

1.	Dr. Y.L. Nene, Ex-DDG, ICRISAT	Chairman
2.	Dr. Ashish Dutta, Former Vice-Chancellor, JNU, New Delhi (Basic Sciences)	Member
3.	Dr. S.N. Puri, VC, Central Agricultural University, Manipur (Plant Protection)	Member
4.	Dr. D.N. Jha, Ex-Director, NCAP, New Delhi (Social Sciences)	Member
5.	Dr. S.L. Mehta, VC, MPUA&T, Udaipur (Basic Sciences)	Member
6.	Dr. N.N. Goswami, Ex-VC, CSAUA&T, Kanpur (Resource Management)	Member
7.	Dr. R.L. Paliwal, Ex-Director, CIMMYT (Crop Improvement)	Member

I. The guidelines for the QRT and its terms of reference are given in the annexure circulated vide Council's office order No. 4(2)/97-Plang. Dated 10-2-2000. The team shall conduct the review of the work of the IARI, New Delhi keeping in view the guideline and submit its report to the Council within six months at the latest for submission to the Governing Body of the Council.

II. The Director, IARI, New Delhi will seek confirmation from from the above members and circulate the background document within fifteen days of issue of this order. The Institute will provide necessary stenographic, technical and administrative assistance to the QRT for its efficient functioning and preparation of report etc.

III. The payment of honorarium and T.A/D.A. to the non-official members of the QRT for attending its meetings will be made by the IARI, New Delhi in accordance with the relevant rules of the Council.

(RAJIV MANGOTRA)
UNDER SECRETARY (CS)

Distribution:

1. All the Members of the QRT.
2. Chairman of QRT.
3. The Director, IARI, New Delhi. T.A. of Non-Official Members of the QRT will be met by the Insitute from Budget provisioin under the head "other charges" and not under T.A. Additional information/ documents, if rquurred by the Members, may be provided to them.
4. DDG(CS), ICAR. Director (Finance), ICAR.
5. ADG(FFC), ICAR.
6. The Sr. Admn. Officer/Sr. Finance & Accounts Officer, IARI, New Delhi.
7. Sr. PPS to D.G., ICAR.
8. PPS to Secretary, ICAR.
9. Budget Section/Computer Cell, ICAR.
10. Spare copies (5).

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI BHAWAN, NEW DELHI- 110001

F.No. 16(8)/2006-IA-IV **Dated 5th December, 2006**

OFFICE ORDER

In partial modificaiton of Council's Office Order of even No. dated 17-7-2006, the Competent Authority has been pleased to nominate that Dr. C. Ramaswamy, Vice Chancellor. Tamil Nadu Agricultural University. Coimbatore to act as a member of Quinquennial Review Team (QRT) in place of Dr. (late) D.N. Jha, ex Director, NCAP, New Delhi. The other members of QRT of IARI as conveyed vide Council of even No. dated 17-7-2006 and 22-8-2006 will remain the same.

The Competent Authority has decided that QRT may review the work of IARI upto 31st December, 2006 and the report may be submitted to the Council by 31st January, 2007 positively.

The terms & conditions as mentioned in the office order dated 17-7-2006 will also remain the same.

(RAJIV MANGOTRA)
UNDER SECRETARY (CS)

Distribution:

1. Dr. C. Ramaswamy, Vice Chancellor, Tamil Nadu Agricultural University, Coimbatore.
2. Dr. Ashish Dutta, Chairman of QRT.
3. All members of the QRT.
4. Director,IARI, New Delhi
5. DDG(CS), ICAR
6. ADG(FFC), ICAR
7. Director (Finance), ICAR
8. Sr. A.O./Sr. F&AO, IARI, New Delhi
9. Sr. PPS to DG/PPS to Secretary, ICAR
10. Budget Section/Computer Cell, ICAR
11. Spare copies (5)

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI BHAWAN, NEW DELHI- 110001

F.No. 16(8)/2006-IA-IV **Dated 22th August, 2006**

OFFICE ORDER

In partial modification of Council's Office Order of even number dated 17.7.2006 the Competent Authority has been pleased to decide that Dr. Ashish Dutta, Former Vice-Chancellor, JNU, New Delhi (Basic Sciences) will now act as the Chairman of Quinquennial Review Team (QRT) instead of Member, QRT to review the research work done under the IARI, New Delhi for the period 2005-06 in place of Dr. Y.L. Nene, Ex-DDG, ICRISAT. The other Member of QRT of IARI as conveyed vide Council's Office Order of even number dated 17.7.2006 will remain the same. The terms and conditions as mentioned in the Office Order dated 17.7.06 will also remain the same.

(RAJIV MANGOTRA)
UNDER SECRETARY (CS)

Distribution:

1. Dr. Ashish Dutta, Chairman of QRT
2. All the Members of the QRT
3. The Director, IARI, New Delhi T.A. of Non-Official Members of the QRT will be met by the Institute from Budget provision under the Head 'Other Charges' and not under T.A. Additional information/documents, if required by the members, may be provided to them.
4. DDG(CS), ICAR, Director (Finance), ICAR
5. ADG(FFC), ICAR
6. The Sr. Admn. Officer/Sr. Finance & Accounts Officer, IARI, New Delhi
7. Sr. PPS to D.G., ICAR
9. Budget Section/Computer Cell, ICAR
10. Spare Copies (5)

ANNEXURE-II

Terms of Reference of the QRT

I. Research Achievements and their Impact

To examine and identify the research achievements of the Institute, Projects/KVKs, its Regional Station and Sub-stations, AICRPs operated by them *vis-à-vis* sectoral programs since the previous QRT and critically evaluate them. Commensurate with the objectives, mandates and resources of the organization, the social-economic impact of research on farmers, beneficiaries and transferability of results to farmers through extension should be critically reviewed.

II. Research Relevance and Budget Allocation

To examine the objectives, scope and relevance of the research programmes and budget of the Institute for the next 5 years in relation to overall/state/regional/national plans, polices and long and short-term priorities. The Committee may also draw its attention to the EFC/SFC memo in relation to recommendations of the previous QRT and also the Perspective Plan and Vision – 2025 document of the Institution.

III. Policies, Priorities and Strategies

To examine the policies, priorities, strategies and procedures adopted by the Institute and the system in relation to Perspective Plan in arriving at these decisions particularly the effectiveness of working of the Institute Research Committee, Research Advisory Committee and the Institute Management Committee as well as the Consultative Machineries like Grievance Cell and Institute Joint Staff Council**.**

IV. Relationship/Collaboration with SAUs and Other Stakeholders

Whether the research programmes of the past and proposal for future are in harmony with the Vision of ICAR (HQ) and the programme of related Centres of research and Agricultural Universities, State Government, Private Sector and IARCs.

V. Linkages with Clients/End users

To examine the kinds of linkage established with the clients and end users of research results, i.e., farmers/fishermen and extent of interest displayed in conducting "on farm research", on farmers' fields and in organizing demonstrations/training courses for the transfer of technology to extension agencies.

VI. Proposed Changes in Organization, Programmes and Budget

To examine whether any changes in the organizational set-up are called for, to achieve an improved and effective working. The Committee may also examine and draw attention to any imbalances in the staffing pattern consistent with the scientific, technical and administrative needs as well as the allocation of research funds towards capital works, establishment and research contingencies. Further the Committee may also examine the resource generation efforts and assess the problems and prospects of the same. The progress and problems of implementing Project Based Budgeting may also be highlighted. While proposing major changes in organization and function their feasibility in relation to ICAR's rules, autonomy, resources, etc. need to be kept in view.

VII. Organization and Management

Whether the organization structure of the Institute is conducive to efficient functional/working autonomy, decentralization and delegation of authority in day-to-day routine working and whether the Director and senior staff are interested in promoting a collegiate and co-operate method of administration is to be assessed. The Committee may also critically examine the status of implementation of O & M reforms as introduced by the Council from time to time and suggest ways and means to implement them at the Institute level. They may also suggest further reforms to be considered by the Council. The suggested staff ratio by the Council may have to be kept in view while reviewing the staff position in the Institute.

VIII. Constraints

To examine constraints hindering the Institute in achievement of its objectives and implementation of its programme and goals and to recommends ways means of minimizing or eliminating them.

IX. Looking Forward

To look into any other points considered relevant by the committee or referred to it by the ICAR, the Institute Director or the Management Committee, in respect of future project development, research prioritization and management changes.

The above terms of reference may be modified at the suggestion of Director of Institute/Project/Management Committee of Institute/Project/ICAR Headquarters/ GB keeping in mind any specific problems of the Institute.

Schedule of QRT Meetings and Visits

S. No.	Dates	Place of Meeting/Visit	Members, who attended the Meeting/Visit
1.	8th January, 2007	IARI, New Delhi. Meeting with the Director, IARI and finalization of the programme for visits.	Full QRT
2.	12th, 13th and 14th March, 2007	Visit and discussion with scientists of the Divisions of Biochemistry, Plant Physiology, Agricultural Economics, Agricultural Extension, National Phytotron Facility, NRC on Plant Biotechnology, Nuclear Research Laboratory, Centre for Agricultural Technology Assessment and Transfer (CATAT) and Agricultural Technology Information Centre (ATIC).	Full QRT
3.	6th and 7th June, 2007	Visit and discussion with scientists of the Divisions of Plant Pathology/Virology, Entomology, Agricultural Chemicals, Nematology, Fruits & Horticultural Technology, Vegetable Science, Post Harvest Technology and Floriculture & Landscaping.	Full QRT
4.	4th and 5th August, 2007	Visit and discussion with scientists of the Divisions of Genetics, Seed Science & Technology, Seed Production Unit, Centre for Protected Cultivation Technology and IARI Regional Station, Karnal.	Dr. Asis Datta Dr. S.N. Puri Dr. N.N. Goswami
5.	19th and 20th September, 2007	Visit and discussion with scientists of the Divisions of Agronomy, Agricultural Engineering, Soil Science & Agricultural Chemistry, Environmental Sciences, Agricultural Physics, Microbiology, Centre for Conservation and Utilization of Blue Green Algae and Unit of Simulation and Informatics.	Dr. Asis Datta Dr. S.N. Puri Dr. N.N. Goswami
6.	15th and 16th January, 2008	Visit to Farm Operation Service Unit, Water Technology Centre and Experimental Farms of IARI. Discussion and review of Post-Graduate School programme and Finance & Administrative activities.	Full QRT
7.	3rd and 4th March, 2008	Visit to IARI Library, Discussions with the representatives of P.G. School Student Union, Master of Halls and Associate Wardens of student's hostels, visit and discussion with scientists of the IARI Regional Station, Indore.	Dr. S.N. Puri Dr. N.N. Goswami

S. No.	Dates	Place of Meeting/Visit	Members, who attended the Meeting/Visit
8.	29th December, 2008	IARI, New Delhi. Review of achievements of the Institute programmes.	Dr. Asis Datta Dr. S.N. Puri Dr. S.L. Mehta
9.	15th and 16th June, 2009	IARI, New Delhi. Preparation of the draft final report.	Full QRT
10.	12th and 13th August, 2009	IARI, New Delhi. Finalization of the QRT report.	Full QRT

ANNEXURE-IV

Recommendations of QRT in respect of IARI (1990-2000) (as approved by the Governing Body of ICAR) - Present Position Regarding Action Taken

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
1.	The Team observed that in spite of very few cases of sharp and purpose oriented research by individuals, the flagship role of IARI is not evident: cutting edge research, synergistic functioning, multi-disciplinary and team research and the integrated research-education-extension model do not seem to emerge. IARI needs to move away from isolated research projects to goal oriented/problem solving time-specific research programmes.	The research projects of the Institute have been prepared as per the research programmes identified in the IARI Perspective Plan (Vision 2020 and 2025). Interdisciplinary mode involving number of scientists for various Divisions. All round efforts are being made through effective monitoring of these programmes to yield the tangible results.
2.	Agriculture now needs to transcend the limits of primary production objectives and include the broad range of agri-business, information technology, post harvest handling, agro-processing, market systems and non-farm use of agricultural products. The entire supply chain management needs to be addressed. We recommend that ICAR and IARI recognize such a need for 'inclusive agriculture' and the consequent programme changes and extend the necessary support-financial and otherwise.	The Institute formulated the research project for the period 2004-09 embedded the suggested components like agribusiness, information technology, post harvest handling, agro processing, market systems and nonfarm use of agricultural products. The supply chain management is also being addressed in various NAIP projects proposals. The Institute is also competing for funding by submitting suitable proposals.
3.	The Team recommends that IARI re-look at its research planning processes, prioritize issues of national importance, and translate them into holistic multi-disciplinary programmes/ component subprojects to provide holistic solutions. Disciplinary strengths are essential to support multi-disciplinary programmes. A shift from the present discipline-based generic and open-ended researches to problem solving multifaceted approaches is required.	Research Programme of the Institute has been prepared keeping in view the national problems and multidisciplinary mode. The Programmes and sub-programme have been re-shaped. Multi disciplinary approach has been established by intra and inter-disciplinary linkages keeping in mind the present national and international agricultural scenario.

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
4.	The Green Revolution model, which focused on semi dwarf varieties and hybrids, has served its purpose. In the context of yield plateaus, and resource and environmental concerns, there is a need to define alternative model/models and its/their focal elements to direct research efforts towards a second Green Revolution now being talked of.	The Institute has been focusing on hybrid crops as the main thrust of crop breeding wherever the hybrid seed production system accompanied with heterosis is exploitable. Where the system is not in place, basic work on developing such systems is on. The release and popularization of the first *basmati* quality rice hybrid, Pusa Rice Hybrid 10 (PRH10). Eight new fertility restorers, namely, PWR3, PWR4, PWR5, PWR6, PWR7, PWR8, PWR9 and PWR10 have been developed. Five Cytoplasmic Male Sterile (CMS) lines Pusa 2022A (WH147), Pusa 2019A/11 (WH542), Pusa 2099A (HW2099), Pusa 2338A/20 (UP2338) & Pusa 2046A/8 (HD2329) and two fertility restorers PWR 4099 & PWR 4101 were registered in NBPGR and very promising hybrids of *bajra* like Pusa 605 and Pusa 415, which are very popular among the farmers, have been developed. As far as crop diversification is concerned, the Institute has developed so many short duration varieties in all the crops. In case of wheat and mustard, the varieties Pusa Gold (WR 544), Pusa Agrani, JD 6 and EJ 13 are the examples. In case of mungbean, the Institute has developed varieties like Pusa Vishal, Pusa Ratna and Pusa 9531 for spring, summer and *kharif* sowings which can very well used for crop diversification. The Institute is actively engaged in conducting research on Protected Horticulture initially with the support of Israel for infrastructure development. During the Xth Plan it was named as Centre for Protected Cultivation Technology (CPCT). The Centre is not involved in development of protected cultivation technology for sustainable production of horticultural crops in semiarid tropics.
5.	Wheat, mustard, rice and maize are the most profitable crops. Short season pulses, oilseeds, and soybean need attention as component crops of cropping systems to further augment yield (11.1.2)	In addition to short duration varieties and hybrids in rice, wheat, mustard and maize, efforts have been made to associate high yield in minimal input conditions as with successful development of pearl millet

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
		hybrids Pusa 605 and Pusa 415. In order to augment yield in rainfed and/or limited irrigation situations through an additional crop, in Indian mustard, varieties like Pusa Agrani (110 days), JD 6 (120 days), EJ13 (100 days) have already been released for general cultivation which can fit in any cropping system. In pulses, chickpea varieties with 130 days duration have already been developed, as also the pigeonpea varieties, viz., Pusa 991, Pusa 992 and Pusa 2001 with 140 days maturity. In case of mungbean, the high yielding varieties like Pusa Ratna, Pusa Vishal and Pusa 9531 have been developed which mature in 60-70 days. Two soybean varieties, viz., Pusa 9814, Pusa 9712 released recently are short duration (112-115 days). In case of pea and lentil, the short duration varieties have already been released. In all these crops there are separate full fledged projects for developing high yielding short duration varieties
6.	In view of the yield plateaus, there is a need for more basic research on yield per se both in major and component crops. The component legumes in cropping systems need stress on yield per se, adaptability and pest and disease resistance.	The Institute has taken the pre-breeding research in crops like chickpea, lentil, maize, wheat and rice. Increased grain number per panicle without compromising on number of tillers has been achieved in wheat and rice, identification of quantitative trait loci for resistance to banded sheath blight as well as downy mildew in maize and mobilization of adult plant resistance for leaf rust in wheat has been achieved. In chickpea, through *C. reticulatum*, drought tolerance and resistance to wilt has been achieved (two of the recent varieties carry the resistance like Pusa 1107). In addition, characterization of increased seed size trait has been done and sixty lines identified with higher kernel weight.
7.	Yield related research for better endowed and less endowed regions	The Institute has taken up constraints and factors related to adoption of improved farm technologies as one of the thrust areas of research. A project on "Farming System Research and Extension for

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
		Sustainable Agricultural Development" has been undertaken with a specific aim to improving yield of crops and income of farmers is operated at Division of Agricultural Extension.
8.	Comprehensive goal oriented multidisciplinary programmes with sub projects need to be developed to capitalize on cereal/legume systems for promoting cost effectiveness, competitiveness, sustainability and profitability (11.1.4).	The Institute has formulated project with sub projects and nutrient management for sustainable productivity and soil health in cereal based cropping system taking into consideration of nitrogen economy and rhizosphere augmentation in the Division of Microbiology.
9.	It is recognized that conventional and biotechnological approaches are complementary and yet, regretfully, field oriented research is being treated as pedestrian. As of now, phenotype based technologies have advantages for incorporation, selection and adaptation of complex traits. Even if the genetic tool changes, selection, adaptation and population processes are indispensable. Some problems that need attention are Nutritional quality in wheat, rice, sorghum, maize, *bajra, ragi,* and fatty acid composition in oilseeds, etc., and research for meeting the prescribed standards for both domestic and export trade, and product oriented research.	The projects on nutritional quality in wheat, rice, maize and *Brasscia* are already in progress. Various components of quality being taken care of in different crops are as under: **Maize:** The programme on development of QPM in maize is in progress and efforts are being made to transfer the quality gene from the tropical germplasm lines to the elite inbreds lines of different hybrids of maize. **High Protein in Wheat:** In the project on "Mobilization of superior genes for flour quality in bread wheat" seven genotypes have been identified with superior bread making quality in a high yielding and disease resistant background. Another project on "Biofortification of wheat for micronutrients through conventional and molecular breeding approaches" has started from January 2006. Characterization and use of grain hardness trait in bread wheat using molecular approach is also operating in the Division. **Biofortification in Rice:** Project entitled "Marker assisted backcross breeding for development of provitamin-A rich *indica* rice" is functioning in the Division. Under "Network Project on Golden Rice", the provitamin A trait through marker assisted backcross breeding to popular *indica* rice varieties, viz., Swarna, which is widely grown in the areas where VAD is prevalent is under progress. Rice being the staple food, the transfer the provitamin A trait from the golden rice lines to the

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
		widely grown *indica* rice varieties could be a potential strategy for alleviating VAD in India. ***Brassica:*** In *Brassica,* IARI is the first Public Sector Institute to develop the single zero (Low erucic acid) varieties of Indian mustard. Pusa Karishma is the first single zero variety released from the ICAR-SAU system. Now two more promising varieties, viz., LES-1-27 and LET-17 have already been identified. Efforts are on to develop the double zero i.e., zero erucic and glucosinolate varieties.
10.	More efforts on lessening the usage of chemicals and shift towards plant products and organics.	The Institute is working to reduce the pesticide use and Plant product and organics through the use of biopesticides, resistant varieties, organic cultivation through biofertilization, PSB etc. and biocontrol agents under Plant Protection School.
11.	Introduction of new crops for energy and special products and alternative uses.	The Institute undertook the research projects on Development of bio fuel for energy security and environmental protection since 2004 especially on production and utilization of biodiseal oil and meal of *Jatropa* in the Division of Environmental Sciences.
12.	Biotechnology Centre should concentrate on genomics and develop a bio-informatics unit. Biotechnology/Biochemistry should develop proteomics as a specialized area of research.	NRC on Plant Biotechnology, IARI has taken several steps towards strengthening genomics and bioinformatics research. NRCPB, IARI had committed to sequence the long arm of Chromosome 11 in collaboration with University of Delhi, South Campus. The task was successfully accomplished. Currently, Choromosome 5 of tomato genome is being sequenced in collaboration with the University of Delhi, south Campus and NCPGR. Infrastructure for bioinformatics research was put in place and databases for rice genome. Proteomics in collaboration with NRCPB will be taken up in due course of time.
13.	Cell physiology should concentrate on metabolic efficiencies.	Complete genomic sequences of omega-3 desaturase *(fed7*) and acyl ACP thioesterase (Fat A) alongwith their promoters have been isolated and characterized from *B. juncea.* Two full

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
		cDNA sequences encoding DGAT (diacylglycerol acyl transferase) specific to triacyl glycerol synthesis have been isolated and characterized from *B.juncea*. The gene ecoding *fad-2-1* from soybean has been isolated and characterized and is being expressed in *Aralidopsis* in sense and antisense orientation. All these gene sequences have been deposited in Gen Bank.
14.	Genetics and Plant Breeding should work on marker assisted selection (MAS) and develop QTLs in addition to conventional approaches.	The Institute has in fact been taking national leadership in development identification of molecular markers as well as initiating marker assisted selection programmes in wheat, rice and maize with excellent internationally recognized results within last five years. An in-house project on molecular breeding for crop improvement is working in which eight crop (wheat, rice, maize, pearl millet, chickpea, pea, mungbean and mustard) have been included.
15.	The setting up of an institutional mechanism to evaluate the transgenics for their efficiency, food, feed and environmental safety, related IPR issues and transfer of transgenic for commercial/ farmer's use.	The National Phytotron Facility and nearby areas of the Institute is worked for evaluation and testing of transgenic material development by the Institute. The Institute Biosafety Committee under the Chairmanship of Director regularly meets and reviews the programme in such areas and will take care of the food, feed and environmental safety before their release. The Institute Technology Management Unit has been established to deal with IPR issues and other commercialization aspect of transgenic with the private sector.
16.	**Sustainability:** Sustainable development has to focus on production systems, social systems, ecological and ethical concerns in the context of long-term food security and sustainability of agriculture. IARI needs to integrate the sustainability elements with production and profitability concerns at the farm level and with resource, social and ecosystem, health and environmental pollution dimensions at the regional level. The multi-disciplinary research, technology transfer and information management also need to be integrated to develop farm scale/ regional scale models.	The programmes of various Divisions in the School of Resource Management are addressed in multidivisional approach as indicated in Research proposals 2004-09. The Mega projects operated in the Resource Management are also address issues raised regarding sustainability.

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
17.	**Water:** The dichotomy between irrigated and rainfed agriculture is being erased in favour of optimal utilization of water from the hydrological cycle to optimize crop production. IARI need to take cognizance of the discussions at World Water Forum, Hague (2000), the dialogue on water and environment, Stockholm (2000) and the comprehensive assessment and challenge programme of CGIAR. Instead of isolated experiments, the water team should focus on integrated researches on a basin/watershed basis with the purpose of (a) improving crop water productivity (b) multiple uses of upland watersheds, and (c) integrated water resource management system. The studies should reflect technical, economical, management and institutional dimensions (11.4.1).	Research activities are focusing on all these issues covering irrigated and rainfed agriculture. Assessment and utilization of water resources and their conservation for agriculture production, generation digital elevation models of water shed, application of remote sensing, GIS and water quality assessment, water and nutrient use efficiency, evaluation of Aerobic rice production system, System of Rice Intensification (SRI), Water quality analysis, Technologies for efficient utilization of irrigation water, namely, drip and micro sprinkler, sub-surface drip irrigation and validation of CROPSYST simulation model at field and irrigation command are some of the areas where the Institute is concentrating their research efforts.
18.	**Soil health:** While we understand the factors associated with land degradation, quantitative data on environmental damage, costs involved, and value of output consequent to rehabilitation are not available. IARI needs to develop planning systems for sustained land use and soil health through appropriate amendments (11.4.2).	The on-going projects entitled "Sustaining Soil Health for Increasing Productivity and Quality of Crops through Integrated Nutrient Supply and Management" and "Soil Quality, Pollution and Biodiversity in relation to Changing Land Use and Management" are adequately addressing the issues of 'Soil Health' at the Division of Soil Science and Agricultural Chemistry. The outcome from these projects will ultimately lead to development of planning systems for sustained land use and soil health though appropriate interventions.
19.	**Climate change:** Inspite of the increasing focus on climate change, our efforts are not addressed at the impending/anticipated changes. Climatologists should have characterized the areas and anticipated the changes in the country. Agricultural scientists have to look at this problem in two ways (a) mitigation of adverse effects through measures like carbon sequestration and others, and (b) adaptation through crop modification and agronomy. IARI has a phytotron for controlled studies. Focussed research is needed to meet climate challenges.	IARI is addressing the issues related to impacts, adaptations and mitigation of climate change for many years. This work has been strengthened further by financial support from Institute as well as ICAR. Data has been generated on the impacts of various crops and appropriate models have been developed under action research to meet the climate changes in future.
20.	While we frequently talk of comparative and competitive advantage, there are no research	The Institute at its strength of comparative and competitive advantage of well trained

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
	programmes specifically oriented towards deriving these advantages. IARI needs to undertake research for deriving comparative and competitive advantages for specific crops/ commodities (11.7).	scientists and Post Graduate Students have the projects on computer based decision support system, Cost effective production system, issue related to marketability, quality improvement for domestic and export market, like, addressing fertigation, green house, Market information system, organic farming, biofortification, Nutrient use efficiency and quality for meeting the quality standards for export and domestic market.
21.	There are no systematic research programmes. Precision agriculture is designed to understand the complex interactions between multiple factors affecting crop growth by incorporating information about soils, moisture, nutrient, pest populations, etc., which enable decision making in the environmental complex and pot application/correction to remove deficiencies. We recommend that IARI take the lead and develop a comprehensive precision farming research centre (11.6).	The equipment essential to conduct meaningful experiments on precision farming being addressed in XI plan so that the Institute take a lead and develop a comprehensive precision farming research centre in the coming years.
22.	Modeling is becoming increasingly precise and used in several fields – estimating crop areas, yields, and demand projections, crop and resource modeling, pest and disease forecasting, etc. IARI has a phytotron, which could profitably be used to determine the process rate data under controlled environments and changes due to environmental factors such as temperature, day length, etc. IARI has a modeling unit, which has to assess priorities and initiate relevant studies in collaboration with the respective divisions/centers.	The work pertaining to modeling and its application in agriculture especially area, production and yield estimation, and demand projections are now being persisted with newly established Unit of Simulation and Informatics. 1. Physiology based crop growth models such as WTGROWS, ORYZA and INFOCROP have been modified and evaluated for crops, in order to work out the impact and suggest the suitable agronomic management options to sustain the productivity. 2. Rice, Chickpea, Wheat, Maize informatics have been prepared. These are targeted to identify suitable cultivars for various agro-ecological regions, optimal agronomic management practices for water, fertilizers and pesticides, coupled with pest management options for higher economic returns that may help farmers to readily accept these crop(s) for sustainable agricultural production on long term basis.

S. No.	Recommendations of QRT	Present position regarding action taken on these recommendations
		3. InfoCrop, locally developed generic crop model had been updated to estimate, monitor and predict the effects of crop(s), management practices and cropping systems in Indian agriculture. 4. A generic pest dynamics simulation model based on concept of thermal time requirement of different life cycle stages of the pest, has been formulated for rice stinkbug, *Leptocorisa acuta.* Calibration and validation of the model is being carried out. 5. The models are validated in different agro-climatic zones and are currently being used for crop production estimates, crop and resource use modeling and to understand impacts of climate change. This work is being further strengthened in 11th Plan.
23.	The poverty reduction objectives and the neo-liberal market oriented models have been reconciled in a refreshing approach which recognizes that the low income population and lower end markets constitute over 50% of the economic pyramid IARI needs to recognize some of these aspects in developing the agri-business unit and its research programmes.	Research projects formulated and being undertaken by the Division of Agricultural Economics take care of the income and livelihood potential in rural areas, predominantly aiming at poverty reduction. Several such projects are in progress in the Division. The Division has also added Agri-business Management as a field of specialization in its P.G. Programme and various courses have been developed to support this specialization. At the Institute level, a Institute Technology Monitoring Unit (ITMU) has been set up and is now functional under charge of a Principal Scientist.

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
Krishi Bhavan : New Delhi-110 001

F.No. 3(5)/2010-FFC Dated the 8th June, 2010

To,

Sh. K.K. Bajpai
Director (Personnel)
ICAR, Krishi Bhavan
New Delhi

Sub: Action Points emerged from the minutes of previous and 216th meeting of the Governing Body.

Please find enclosed herewith ATR on the above subject for further needful action.

Sd.-
(R.P. Dua)
Assistant Director General(FFC)

Encl: a.a.

Copy to:
1. The Director, IARI, New Delhi-12 with a request to take necessary action.
2. Project Director, Dte. of Rice Research, Hyderabad, Hyderabad-500030 for necessary action.

Sd.-
(R.P. Dua)
Assistant Director General(FFC)

भारतीय कृषि अनुसंधान, नई दिल्ली-110012
प्राथमिकीकरण, अनुवीक्षण एवं मूल्यांकन प्रकोष्ठ

Indian Agricultural Research Institute, New Delhi-110012
Prioritization, Monitoring & Evaluation Cell

डॉ. बी. आर. अत्री
प्रधान वैज्ञानिक एवं प्रभारी - प्रा.अ. एवं मू.प्र.
Dr. B.R. Atteri, Ph.D (Agril. Economics)
Principal Scientist & In-Charge-PME

Tel. : (O) 91-11-25733416
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incharge.pme@gmail.com

No. PS(PPI)/2008/ATR Dated: 02.07.2010

Dr. R.P. Dua
Asstt. Director General (FFC)
ICAR, Krishi Bhawan,
New Delhi-110141.

Sub: Action Taken on the action Point emerged from the minutes of previous and 216th Meeting of the Governing Body of ICAR.

Sir,

Kindly refer to lyour letter F.No.3(5)/2010-FFC dated 8.6.2010, on the subject mentioned above. The Action Taken Report on the item No.7/216, duly approved by the Director, IARI, is enclosed herewith for further necessary action.

Yours faithfully

sd/-

(B.R. Atteri)
Principal Scientist (PPI)

Encl: As above.

ITEM No. 2

SUB: ACTION POINTS EMERGED FROM THE MINUTES OF PREVIOUS AND 216th MEETING OF THE GOVERNING BODY.

Item No.	Action Point (ICAR)	Action Taken
7/216	Recommendations made by QRT in respect of Indian Agricultural Research Institute, New Delhi for the period 2000-2008.**The recommendations made by QRT in respect of Indian Agricultural Research Institute, New Delhi for the period 2000-2008 with the comments of the council were accepted, with the following observations:**	
	(i) The recommendations were not consistent with the revised QRT guidelines. They did not touch upon various aspects that were required to be covered.	The revised guidelines for the QRT were issued by the ICAR on 16-2 2009 only. The QRT reviewed the work of IARI for the period 2000-08. By that time the QRT had almost finalized its report. The revised guidelines will be considered for the next QRT.
	(ii) With regard to recommendation No. 16, that synthesis and development of new molecules involve heavy expenditure, and if ICAR is to do it at all, which is doubtful, then at least it should be done only if there is a partner who would invest and commercialise the new molecule (s).	Development of new agrochemicals from concept to commercialization involves a huge investment. It is estimated that on an average, development of a new agrochemical entity costs approximately one billion dollars, Which also includes cost of generation of toxicology data. Throughout the world, synthesis and development of new agrochemical molecule(s) is usually taken up by the chemical industry. Industry partner would venture to invest in the new chemical entities only when the product in reference is highly effective and safe to man, non target organisms and the environment. In view of the importance of new agrochemical molecules in plant protection**,** the Institute has initiated a project on the development of agrochemicals from natural and synthetic sources. It aims at synthesis, bench-scale know-how development

Item No.	Action Point (ICAR)	Action Taken
		and generation of bioefficacy data under laboratory conditions for new products and/or their formulations. Recently some companies have shown interest in products developed by the Institute and are interested to take up data generation on field efficacy, toxicology and environmental safety aspects. However, if funds are made available to IARI, data on bioefficacy (laboratory & field) toxicology (animals) and safety (environmental), etc. can be generated to facilitate development and commercialization of the new bioactive pesticidal molecules/ formulations.
	(iii) That in the ICAR system, Pr. Scientists also act as Professor, and there is no need for separate post of Professor to be created.	The observation of GB has been noted.
	(iv) That ATR on the recommendation of QRT of IARI should be put up to GB after one year.	The observation of GB has been noted.

ITEM No.2

SUB: ACTION POINTS EMERGED FROM THE MINUTES OF PREVIOUS AND 216th MEETING OF THE GOVERNING BODY.

Item No	Action Point (ICAR)	Action Taken
7/216	Recommendations made by QRT in respect of Indian Agricultural Institute, New Delhi for the period 2000-2008. **The recommendations made by QRT in respect of Indian Agricultural Research Institute, New Delhi for the period 2000-2008 with the comments of the council were accepted, with the following observations:** **(i) The recommendations were not consistent with the revised QRT guidelines. They did not touch upon various aspects that were required to be covered.** **(ii) With regard to recommendation No. 16, that synthesis and development of new molecules involve heavy expenditure, and if ICAR is to do it at all, which is doubtful, then at least it should be done only if there is a partner who would invest and commercialise the new molecule (s).** **(iii) That in the ICAR system, Pr. Scientists also act as Professor, and there is no need for separate post of Professor to be created.** **(iv) That ATR on the recommendation of QRT of IARI should be put up to GB after one year.**	IARI has been asked to take up necessary action on these points and reply accordingly to the Council.