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Annual Report

2001-2002



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Indian Council of Agricultural Research

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Foreword

The National Agricultural Research System (NARS) with the Indian Council of Agricultural Research (ICAR) as an apex body is striving for the holistic development of agriculture at the national level through planning, promoting, conducting and coordinating research, education and extension and training on all aspects of agriculture for ensuring optimal utilization of land, water and plant and animal genetic resources.

India has achieved worldwide acclaim in the field of agricultural research, education and extension by achieving more than four-fold increase in foodgrains production besides significant increases in the milk, oilseeds, fruits, vegetables and fish production since independence. Growth in Indian agriculture which benefited from increased area under plough in the earlier years, has now to rely mostly on productivity gains, both through increasing cropping intensity and yield. Accordingly, the thrust of Council's research efforts during the year focused on genomics and biotechnology, Information Technology (IT), Management of Information System (MIS) and Geographic Information System (GIS), natural resource management, post harvest technology and value addition, and agri-business management.

In the identified priority areas, the ICAR Institutes and State Agricultural Universities have exhibited remarkable achievements during the year under report. More than 84 high-yielding and disease-resistant varieties/hybrids of various field crops, and 78 varieties/hybrids of horticultural crops including fruits, vegetables and floriculture, were released for various agro-ecoregions and production systems of the country. This was supported by the generation of the appropriate agro-techniques. Promising major crop-based cropping systems, having economic viability in different agro-ecoregions, have been evolved, keeping in view the resource availability and its efficient utilization. Soil map of the country on 1:1 million scale, state map on 1:250,000 scale and several district soil maps on 1:50,000 scale have been prepared. Soil degradation map of the country on 1:4.4 million scale has also been prepared. Twenty agro-ecological regions and sixty agro-ecological sub-regions of the country were delineated based on the physiography, soils, climate, length of growing period etc. Water-use efficient irrigation schedules and methods (including micro irrigation) for major crops were evolved that resulted into considerable saving of irrigation water and increase in crop yields. More emphasis was given on the development of farm machinery and post-harvest technology, and on-farm and off-farm value-addition, processing and storage.

In the livestock and poultry improvement and management efficient techniques for micro-satellite DNA markers, monoclonal antibody kits, diet supplements and semen preservation were developed. In the fish improvement and management, identification and cataloguing of potential ornamental fish species, health assessment index for rapid evaluation of fish condition in field, sprawling Asian catfish



spontaneously, and domestication of the tiger shrimp were achieved. Strengthening of eight Zonal Coordinating Units and 29 Directorates of Extension Education at the State Agricultural Universities by providing modern IT facilities, and approval for the start of four new Agricultural Technology Information Centres (ATICs) are significant achievements under Innovations in Technology Dissemination programme of the NATP.

In the context of changing global agricultural scenario due to globalization and liberalization, the Council has identified 30 thrust areas for the X Five Year Plan which include agricultural biotechnology, genomics research and transgenics, bio-informatics, conservation of natural resources and agro-biodiversity, crop improvement and management, post-harvest technology and management, animal and fisheries improvement and health management, agri-business management, agricultural human resource development and strengthening of research extension mechanism. A cropping/farming system approach has been envisaged, and effective partnerships with advanced institutions in India and abroad are being fostered for the technological capacity enhancement.

It gives me immense pleasure to present DARE/ICAR Annual Report 2001-2002, in which multiple activities of agricultural research, education and extension are highlighted. It is hoped that the report would be useful for policy-makers, planners and development agencies.

(AJIT SINGH)

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The Mandate of the Indian Council of Agricultural Research

- (i) To plan, undertake, aid, promote and co-ordinate education, research and its application in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- (ii) To act as a clearing house of research and general information relating to agriculture, animal husbandry, home science and allied sciences and fisheries through its publications and information system, and instituting and promoting transfer of technology programmes.
- (iii) To provide, undertake and promote consultancy services in the fields of education, research, training and dissemination of information in agriculture, agroforestry, animal husbandry, fisheries, home science and allied sciences.
- (iv) To look into the problems relating to broader areas of rural development concerning agriculture, including post-harvest technology by developing co-operative programmes with other organizations such as the Indian Council of Social Science Research, Council of Scientific and Industrial Research, Bhabha Atomic Research Centre and the universities.
- (v) To do other things considered necessary to attain the objectives of the Society.



1 Overview

The first-ever announced National Policy on Agriculture seeks to actualize the vast untapped growth potential of Indian agriculture, strengthen agricultural development, promote value addition, accelerate the growth of agri-business, create employment in rural areas, secure a fair standard of living for the farmers and agricultural workers and their families, discourage migration to urban areas and face the challenges arising out of economic liberalization and globalization. It is reliably estimated that in the year 2020, under the scenario of 5% growth in GDP, the total domestic demand of foodgrains will be 294 million tonnes to feed around 1.3 billion our people. To meet the projected demand, the yield level over the base period yield (1994-95) has to be enhanced by 136-157%. Considering these uptrends, the Policy rightly envisaged growth rate in excess of 4% per annum in agriculture sector, which is higher than even the highest decadal (1979-80/1989-90) growth rate (3.54%) achieved so far. We have to achieve these growth targets against the constraints of diminishing land resources, increasing biotic and abiotic stresses, threatened loss of biodiversity, shrinking natural resources, intensifying competition in international trade, etc. Therefore, producing enough food to banish hunger and to create employment and income for buying food remains our biggest challenge in the coming years. It is strongly felt that increasing agricultural growth is the only way. The present report is an attempt in this direction.

Evaluation of plant and animal genetic resources and their conservation had been the main thrust of our efforts to maintain our biodiversity and broadening the genetic base by having improved varieties to increase productivity. Under Plant genetic resources, 16,597 accessions comprising cereals, millets, minor millets, psuedocereals, pulses, oilseeds, fibres, vegetables, fruits, medicinal and aromatic plants, spices and condiments and others were collected. A total of 15,876 samples of diverse crops from 40 countries and 50,230 samples of international trials from the IRRI, CIMMYT and ICARDA were introduced. Through quarantine clearance, 41,229 samples were imported and

2,693 exported. During the year, 7,946 accessions were added to the long-term conservation, and 9,403 were grown for characterization, evaluation and maintenance. Promising accessions were identified for (i) high oil (%) and low erucic acid in *Brassica* spp.; (ii) seed oil oleoresin, colour value and capsinin in chillies; and (iii) protein content in pea and mungbean. The other accomplishments include production of molecular profiles of 79 non-aromatic rice cultivars; identification of the NRC on Plant Biotechnology to participate in a global endeavour to sequence rice genome; and isolation of a novel vegetative insecticidal protein *vip 3A* gene from *Bacillus thurigiensis* and characterization at molecular level.

Under **Crop Improvement and Management**, 21 varieties and two hybrids (HRI 120: resistant to white backed planthopper and gall midge, and Pusa RH 10: moderately resistant to brown planthopper and rice tungro virus) of rice; four varieties (HUW 533, GW 322, HD 2781 and HW 2045) of wheat; five hybrids/composites (Hybrid Shaktiman 1, JH 3459, Seed Tech 2324, Hybrid Shaktiman 2 and IC 9001) of maize; two direct introductions (Alfa 93 and BCU 73) of barley; one hybrid (CSH 19R) of sorghum; three hybrids (RHB 121, PB 112 and Nandi 35) and one composite variety (Pusa Composite 383) of pearl millet; nine varieties (Chilka, GPU 45 and GPU 26 of finger millet, Meera of foxtail millet, DHPM of proso millet, Kolab and Paiyur 2 of little millet, Jawahar Kodo 48 of kodo millet and VL Madira 181 of barnyard millet) of small millets; one variety (Bundel Berseem: immune to downy mildew and resistant to major insect-pests) at Central and one multicut, high protein variety (COFS 29: resistant to major diseases and insect-pests) of forage sorghum at State level; one early-maturing variety (VG 9521) of groundnut; one low erucic acid variety [TERI (OE) RO 3] of *gobhi sarson*; one variety (JTC 1) of *karan rai*; three varieties (MAUS 61, LSb 1 and Palam Soya) of soybean; two varieties (Shekhar: resistant to powdery mildew, rust and wilt, and NL 97: moderately resistant to powdery mildew, wilt and linseed bud fly) of linseed; one variety (JTS 8) of sesame; one early-maturing variety (Gujarat Niger) of niger; one pedigree



selection (RSG 888: resistant to dry root rot) and a bold-seeded *kabuli* variety (HK 93-134) of gram; two varieties (Laxmi: resistant to sterility mosaic and tolerant to wilt, and AKT 8811: tolerant to fusarial wilt) of pigeonpea; one variety (ML 818: resistant to *Cercospora*, yellow mosaic virus and bacterial leaf spots) of mungbean; one variety (KU 300: resistant to yellow mosaic virus) of urdbean; one selection (IIPR 96-4: resistant to common bean mosaic virus and leaf crinkle) of *rajmash*; one pedigree selection (IPF 27: resistant to powdery mildew and tolerant to rust) of fieldpea; three lines (RLS 1186, IPLY 99-7 and IPLY 99-9: resistant to powdery mildew) of lathyrus; one variety (RMO 435: tolerant to yellow mosaic virus) of mothbean and one variety (RGC 1017) of clusterbean; two varieties (Pratima and CNH 120 MB) and one intra-*hirsutum* hybrid (Bunny) of cotton; three varieties (Co 89029: moderately resistant to red rot, CoSe 95422: moderately resistant to red rot and smut, and CoSe 92493: moderately resistant to red rot) of sugarcane; one fine-quality fibre variety (JRO 128) of tossa jute; and three varieties (Dharla, Abirami and Lichchivi) of chewing tobacco and one variety (CY 79) of flue-cured tobacco were released/identified for various agro-climatic zones of the country.

Other major accomplishments include suitability of thermo-genetic male-sterile line (MLTG 4) of rice for developing two-line hybrids; development to simple technique for evaluating tolerance/sensitivity of wheat genotypes to fusarial toxins; identification of maize genotypes tolerant to diseases, excess soil moisture and drought; first-time development of two-row malt barley (DWR 28); presence of confectionery taste in jaggery prepared from NSS 104 and SSV 84 sorghum; higher returns from intercropping of grain amaranth in long-duration pigeonpea (CO 6); addition of new exotic and indigenous germplasm of forage crops; employment of epicuticular wax load as a selection criterion for drought tolerance in groundnut; optimization of protocol for castor transformation through *Agrobacterium*-mediated gene transfer; significant increase in sesame yield with single superphosphate or element sulphur or gypsum; 50% reduction in *Phytophthora* blight incidence when pigeonpea sown on ridges compared with flat sowing; reduction in pod-borer damage when mungbean and urdbean intercropped with soybean, and in neurotoxic compound in lathyrus *dal* by pre-cooking water soaking; higher profits of potato intercropping in cotton and development of two-row bullock-drawn cotton planter, especially for small

farmers cultivating on Vertisols; first-time development of interspecific tobacco hybrids from a trispecific cross; increase in yield and decrease in pigeonpea nematode under intercropping of pigeonpea with groundnut; development of simple, low-priced, light-weight royal jelly collector; reduction in crop loss on growing *Butea monosperma* on farm bunds; development of an easy and rapid laboratory method for the large-scale screening of antagonists against specific nematodes; and utilization of flag leaf in rice for synchronization of male and female lines through staggered planting.

In **Improvement and Management of Horticultural Crops**, late-ripening mango hybrid (Amrapali × Vanaraj) was promising with attractive fruit colour and good quality for export and internal market. A unique wild-type banana locally called 'Sai Sui' was collected. In citrus, Tenali selection was found promising and tolerant to canker. Commercial production of Nagpur mandarin was started at Nagpur under Revolving Fund Scheme. In guava, Allahabad Safeda, Sardar and Allahabad Surkha gave good yield, and the biological control of spiralling whitefly was possible through parasitoids. In papaya, CO 2, CO 6, CO 7, CO 3 and Pusa Delicious varieties were more prolific for fruits. In sapota, inarching method of grafting during June-July or September-October was ideal. In litchi, 42 accessions were collected. Five different types of jackfruit were collected and characterized. Kernel recovery in BP 4 walnut was better than America's best variety and has potential for export.

In Arid zone fruits, Ber Seb Banarasi Kadaka, Mundia, Dandan, Alwar Desi, Govindgarh Special and Kala Gola proved superior in all aspects, and a genotype that bears fruits twice a year was identified. Major achievements of Post-harvest management of fruits include extension of shelf-life of Kesar mango fruits up to 54 days; excellent marketability of white button mushroom up to 7 days; superiority of small packaging to large packaging in onion to avoid rotting; excellent marketability of cut-rose variety First Red up to 3 days in zero-energy cool chamber at ambient temperature; development of a technology for fruit-based carbonated drinks on the pilot plant scale; standardization of method for apple-pulp preparation; formation of onion powder from its slices; and standardization of drying and dehydration including osmotic concentration for plum, ginger, apple and galgal.

In Vegetable crops, 29 open-pollinated, 8 F₁ hybrids and 3 varieties resistant to diseases were identified for



commercial cultivation in different agro-climatic zones. The F₁ hybrids ARBH 541, PBH 6 (both long) and JBH 1 (round) in brinjal; BSS 20 in tomato (indeterminate); PCUCH 1 in cucumber; NDBH 4 in bottle gourd; RHRBGH 1 in bitter gourd; and DVR 3 in okra were identified for release in all the zones of the country. Varieties DPP 68 and KS 245 of pea (mid-season, resistant to powdery mildew) and VRO 3 of okra (resistant to yellow-vein mosaic virus) were also identified. Radish varieties IIVR 1 (30 days) and IIVR 2 (40-50 days) were developed. Stable CMS lines were developed in chilli for the hybrid seed production. Soil solarization of nursery-beds resulted in 90, 86.7 and 74.2% seedling stand in brinjal, chilli and tomato, respectively, with reduced bacterial wilt and weed population.

In potato, TPS population 92 PT 27 proved better than recommended one for raising commercial crop. The DNA fingerprints of 23 advanced hybrids and TPS parent EX/A 680-16 were prepared. Thirty-four transgenic lines were also produced by introducing *AmA1* gene in 5 Indian varieties to increase protein content. Soil solarization was effective for the control of russet scab, black scrub and tuber cracking coupled with increased tuber yield. A 3-row sub-soiler was designed and developed. A potato digger for potato-sugarcane intercrop was also designed. Seventeen edible processed products (10 non-fried and 7 fried) were prepared on small scale.

A total of 3,968 accessions comprising cassava, sweet potato, yams, aroids and minor tuber crops were maintained at Thiruvananthapuram. Cassava hybrids Sree Rekha and Sree Prabha, with good-cooking quality, were released for cultivation in Kerala. True cassava seed technology was developed to overcome its biological constraints. Cassava hybrids CE 165, CE 328 and CI 301 were found drought tolerant. Active charcoal proved to be an effective medium for mass trapping of rice weevil, a major pest of stored cassava chips. A technology was standardized for the bioconversion of cassava starch factory residues to maltose. And a technique could also be developed for citric acid production from sweet potato residues. Antibacterial and anti-fungal properties of *Dioscorea alata*, *Amorphophallus* and *Curcuma* sp. were established. A drum-type centrifugal granulator for animal feed manufacture from tuber crop flours was fabricated. A low-cost effluent-treatment technology developed for detoxication of starch and sago factory effluents, was successfully transferred to Starch and Sago Industries. Stems of cassava and yams, and vine cuttings of sweet

potato were distributed among farmers and developmental agencies.

In Mushrooms protocols for DNA isolation, purification etc. were standardized to detect genetic variation during storage. Medicinal mushroom, *Ganoderma lucidum*, was successfully cultivated for the first time on saw-dust and wheat-straw substrates. In the case of button mushroom, an improved method of drying was developed for production of excellent mushroom powder, biscuits, nuggets etc.

Salient achievements under Floriculture include release of 9 varieties of rose, 13 of gladiolus and 13 of chrysanthemum for cultivation; and superiority of top cuttings treated with 2,000 ppm IBA for rooting and of stem splits for propagation of anthuriums.

In Plantation crops, the major accomplishments had been the confirmation of half-strength MS medium + 50 mg/litre NAA as best combination for root induction from leaf explant of coconut and the design development of hybrid dryer (capacity 3,000 coconuts/batch, drying time 32 hr) with solar energy as main source of energy and electricity as an alternate source in coconut; 100% control of oil palm beetle by *Metarrhizium anisoplae* developed on broken maize grains; collection of 18 new accessions in cashew and 300% increase in cashew yield with soil conservation, irrigation and coconut husk burial between two rows of cashew; and organization of training programme on vegetative propagation of cashew for benefits of farmers, etc. In Spices, the significant achievements included addition in germplasm conservation of *Piper*, *Elettaria*, *Zingiber* and *Curcuma* spp.; recommendation for release of two high-yielding ginger selections (Coll. 35 and Coll. 117) and a nutmeg line (A 9/4); development of foliar diagnostic norms for nutrient balance assessment and yield for optimum production in cardamom; tolerance of five germplasm lines of black pepper to *Phytophthora capsici*; development of simple disinfection technique to eliminate *Ralstonia solanacearum* from seed rhizomes of ginger; and evolution of low-cost technology for mass multiplication of *Trichoderma* sp. for field application.

In Medicinal and aromatic plants, RAs 22 *ashwagandha* gave the highest root yield per plant (30 g) and safed musli MCB 405, the maximum fleshy roots (2.05 tonnes/ha). In *isabgol* 30 kg N/ha significantly increased the seed yield. Application of 20 kg N/ha through castor-cake would be the best option for getting higher yield of kalmegh.

In the area of **Natural Resource Management**, major accomplishments under soil resource inventory are the



generation of soil map of India on 1:1 million scale; development of regional-level soil-information system for north-eastern region; and preparation of district soil resource atlases, covering at least one district in each state. Under resource conservation and management, salient features are the high yield of soybean from broad bed and furrow; identification of *Acacia nilotica* for rehabilitation of the degraded ravine soils adjacent to river Yamuna; and suitability of *A. nilotica* and *Casuarina equisetifolia* combination for reclamation of saline waterlogged Vertisols. Significant findings under soil fertility and nutrient management had been the improvement in wheat yield and soil organic matter owing to rice-residue incorporation into soil along with phosphocompost application; attainment of higher yield of maize and groundnut on substitution of inorganic fertilizers with farmyard manure; and enhancement of nodulation and seed yield of blackgram and greengram with co-inoculation of *Rhizobium* and antagonistic bacteria along with *Azospirillum/Azotobacter*.

Prediction of rainfall in coastal Orissa using different probability distribution models, and use of CROPWAT (crop water) model for water requirement and irrigation scheduling of pigeonpea and cotton in Gujarat under rainfed and irrigated conditions, are the significant results under water management. Important achievement under soil salinity and coastal ecosystem is the mapping of saline and waterlogged soils of Haryana using remote sensing landsat TM data. Major accomplishments under rainfed research include increase in grain and straw yields of rice by recycling of rice straw along with mushroom spend substrate in rice-based farming system in western coast of Goa; better performance of turmeric (7.32 tonnes/ha) when grown under the shade of 2 years old guava tree; and preparation of an integrated management plan for implementation in Bada Khara Watershed in Bundi, Rajasthan. Higher yield in rice through combined use of NPK and sulphitation pressmud; and identification of eight promising accessions of *Sesbania* and two of *Crotalaria* for green-manure are the highlights of crop production. In area of weed management, *Zygogramma bicolorata* proved to be a safe biocontrol agent of *Parthenium hysterophorus* weed. In farming system research, significant findings include at par performance of feeds based on chicken liver meal and squid meal with high-priced commercial feeds; and extension of storage life of indigenous fruits (bread fruit and bimbli) when packed in 0.4 mm LDPE bags with

0.5% ventilation. Significant results of arid ecosystem comprise rehabilitation of lignite mine degraded land through profile modification and plantation of trees and shrubs; and development of three-in-one solar device for heating water, cooking food and drying fruits and vegetables. The salient features of research under the agroforestry include development of Plant Polar 5 Clone, a multiple tree species, having tolerance to blight and stem-borer, for farmers of tarai area, and of a model for the non-destructive estimation of above-ground biomass of *Eucalyptus tereticornis*.

Under **Livestock and Poultry Improvement and Management**, an information on animal genetic resources of India was made available on internet - <http://nbagr.hry.nic.in>. It may be downloaded free of cost. In the area of survey, evaluation and characterization of breeds, Gir cows showed very low reproductive abnormality. Molecular genetic characterization of indigenous livestock and poultry breeds is under progress. Somatic cell preservation protocol was standardized for buffaloes. Somatic cell lines of sheep and goats were preserved for future use in cloning. A Karan Fries cow gave 46.5 kg milk/day at the NDRI, Karnal. Under Indigenous Breeds Project, performance of Haryana, Ongole, Gir and Tharparkar is being studied. Network Project on Buffalo was expanded to cover more buffalo breeds during the current year. Under the Network Project on Sheep Improvement, the survivability of sheep was improved.

Bharat Merino yielded 2.02 kg annual greasy fleece and has the potential to substitute exotic fine wool sheep. Garole × Malpura crossbred showed 44% twin lambings. Under the AICRP on Goat Improvement, the flock mortality was quite low. In rabbits, period during July-December was found better for growth. Commercial broiler from the CARI, Izatnagar, attained 1,486 g weight at 7 weeks of age and livability of broilers was more than 97.5%. Heat-tolerant major gene, i.e. Naked Neck, was integrated in broiler stock. Homozygote dwarf line was developed. Vanaraj, Grampriya and Krishibro birds gained popularity in rural masses because of their performance under field conditions. Outbreak strains of foot-and-mouth-disease (FMD) virus were sequenced. The National Repository of FMD virus includes 950 well-characterized field isolates. Milk-based ELISA kits could be developed for screening bovine brucellosis and infectious bovine rhinotrachitis (IBR). Recombinant competitive ELISA kit was developed for rinderpest sero-surveillance. The success of Animal Disease Monitoring and Surveillance (ADMAS) led several



Kayamkulam backwater of Kerala revealed that *Penaeus indicus*, *Metapenaeus deobsoni* and *M. monoceros* contributed substantially to the total catch. Identification and cataloguing of potential ornamental fish species was completed in the North-eastern states and West Bengal. A qualitative health assessment index (HAI) was developed for rapid evaluation of fish condition in the field. The general health status of fish populations in river Hooghly was evaluated. Mahseer fishery was developed in a lake in Champawat district of Uttaranchal. A breakthrough was achieved in spawning Asian catfish, *Clarias batrachus* spontaneously. The seed production of gangetic prawn, *Macrobrachium gangeticum* was done successfully. The giant freshwater prawn, *M. rosenbergii* cultured in pens, was installed in beels for 92-95 days and it attained a size of 135 mm/38 g to 148 mm/57 g. Trout *Onchorhynchus mykiss* could be reared in the warmer agro-climatic conditions of Champawat where water quality was not congenial for trout farming. Cage culture experiment of mahseer was conducted. After 150 days of culture the average net weight of *Tor khudree* increased from 106 g to 352 g and that of *T. putitora* from 14.6 g to 52.4 g. A polyculture experiment with stocking density of 38,800/ha (millet, pearlspot, *P. indicus*, *P. monodon*) was carried out. A breakthrough was achieved in the seed production and larval rearing of sea cucumber, *Holothuria spinifera* for the first time in the hatchery. Another breakthrough in successful domestication of the tiger shrimp, *Penaeus monodon* was achieved. Six new designs for eco-friendly and resource-specific demersal trawls were developed. A few peptides from the salivary gland secretions of the *Conus inscriptus* were isolated. These peptides have biomedical importance since they are potent analgesic agents. Genetic characterization of *Labeo* species, viz. rohu, calbasu, bata, fimbriatus, gonius and diochelius, was done using RAPD-PCR profiling. Sperms of wild stocks of prioritized fish *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* and *Labeo dussumieri* were cryopreserved to preserve natural genetic variability.

Under **Agricultural Engineering and Technology**, major achievements had been the modification and commercialization of tractor-mounted till planter; development of self-propelled vegetable planter attachment to self-propelled reaper/power weeder and attachments for riding-type self-propelled reaper windrowers; new power weeder for cotton by upgrading the engine to 3 HP; power tiller-operated multi-crop planter

of 34 kg for maize, soybean and wheat; walk-behind-type self-propelled forage harvester; high-capacity pigeonpea thresher, having automatic chain conveyor-type feeding mechanism to feed only pod portion of stalk; development and commercialization of flail type mower-cum-chopper for fodder harvesting; and design and development of a set-up for measuring the strength parameters of agricultural workers in case of farm implements and machinery. Besides, significant progress was made in prototype feasibility testing in respect of tractor-mounted rotavator and potato planter, light weight power tiller, aeroblast sprayer and self-propelled high clearance sprayer. In post-harvest engineering and technology, the major work includes development of (i) agro-processing centres for 5 states, (ii) an evaporatively cooled hut-type structure for oranges and potato, (iii) green chickpea shelling machine, (iv) fluidized bed dryer for mushroom, (v) machine for production of snowball from tender coconuts, (vi) power tiller-operated mechanical seed extractor for pomegranate, and (vii) aqua filter system to function as external biofilter. Other achievements include construction of evaporatively cooled room for on-farm pre-cooling and storage of fruits and vegetables; development of blender-cum-mixer, betel leaf curing chamber, and technology for producing corrugated roofing panel from crop residues and starch-based edible film. In cotton technology, a cotton stalk puller-cum-chipper was developed and an attempt was made to explore the possibility of producing Avivastra wool cotton by adopting short-staple commercial spinning system. Biological control of lac predators, development of lac varnish for wood and hot melt adhesive for packaging industry and preparation of lac wax-based emulsion formulations for extending shelf-life of fruits and vegetables are the highlights of lac technology. Development of power ribboner of improved design and low-cost jute and jute-blended carpet are the significant findings in case of jute technology. Under renewable sources of energy, some of the salient achievements are the development of large-size natural circulation solar dryer; a system for operation of domestic refrigerator powered with solar photovoltaic panels; natural convection updraft type biomass gas stove for rural household cooking; and a horizontal flow floating drum-type biogas plant for anaerobic digestion of fibrous agro-residues. Under irrigation and drainage engineering, an automated testing facility for pumps and drippers was designed and developed at Bhopal.

Under **Agricultural Human Resource Development**,



kisan gosthies, exhibitions etc. were arranged for dissemination of information. The TTCs organized 229 training courses to 5,513 participants. The KVKs also identified various technologies for on-farm testing to evaluate and assess its impact on specific location. The KVKs produced/distributed to the farmers the seed of cereals, oilseeds, pulses and vegetables; saplings of fruits; seedlings of vegetables, species, forest trees, ornamental and plantation crops; and fingerlings and spawn of fish. Increased yield in cereal, pulse, oilseed, fodder and horticultural crops was shown through the frontline demonstrations. Rice bran and mustard oil-cake showed more growth rate in rohu than poultry litter and cow-dung. The salient findings of the NRCWA include the start of 14 research projects; preference of farm women for Shree Samrat sweet potato on account of its favourable characters; motivation of farm women to start small-scale poultry farm; involvement of 90% women workers in agricultural activities; and design refinement of sitting type-groundnut corticator for women workers. Under Mission Mode Project about 1,730 information on ITK were received through voluntary disclosure on different aspects of agriculture and allied areas. The project is operative through 10 zonal leaders with more than 100 potential co-operating centres.

In **Research for Tribal and Hill Regions**, major accomplishments of the Central Agricultural Research Institute, Port Blair, includes confirmation of ample genetic diversity in the available rice accessions indigenous to Bay Islands; collection of under-utilized plants Malayan apple and durian; induction of *in-vitro* flowering and fruiting in tomato from calli generated from leaf explants; collection and cataloguing of 10 species of orchids; development of quicken hybrid between Nicobari fowl and Japanese quail; collection of 31 species of grouper (important sea-food species); successful induction of one set of putative transgenic rohu; creation of database on crops, livestock, poultry and fisheries and its availability on Institute's website; successful control of humpsore disease; and management of rhinoceros beetle in coconut.

Significant findings of the Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora, had been the release of Vivek Dhan 82 rice for hills of Uttaranchal, Himachal Pradesh and Meghalaya, and the identification of promising lines one each in barnyard millet, garlic, field pea, spring rice, wheat and barley; multiplication of 9.68 tonnes truthfully labeled seeds of improved varieties and their distribution

among hill farmers; existence of congenial environment for growing broccoli, knol-khol, lettuce and parsley; identification of resistance sources against major diseases in rice, wheat, maize and garden pea; confirmation of rockphosphate as a better source of P for cauliflower; and better performance of improved grasses than local ones for fodder production in hills.

Superiority of intercropped ginger to its sole crop; identification of agri-horti-sylvi-pastoral model for north-east region; and preparation of fermented products made from edible shoots of bamboo without preservatives with storage period of six months to two years, are the highlights of the ICAR Research Complex for NEH Region, Umiam.

The **National Agricultural Technology Project**, being implemented by the Indian Council of Agricultural Research (ICAR) and Department of Agriculture and Co-operation (DAC), has three major components, viz. Research, Organization and Management, and Innovations in Technology Dissemination.

In Production system research, 264 subprojects were approved besides 70 IVLP centres. Some of the important achievements in irrigated agro-ecosystem include identification and release of two quality protein maize hybrids Shaktiman 1 and Shaktiman 2; significant increase in seed-cotton yield by wheat-straw incorporation; development of seeder-cutter/planter machine for sowing or planting wheat and sugarcane in single pass of tractor; standardization of process for oilpalm fibre extraction from empty bunches; development of manually operated coconut-splitting device; identification of suitable rice-based cropping system for salt-affected coastal soils; development of broodstock for *Penaeus monodon* and *P. indicus*, rotary ball mill for shaping molluscan and a machine for making feed blocks of residues of different crops are the major findings in coastal agro-ecosystem. Under hill and mountain agro-ecosystem, the salient features are the constructions of gauging stations to monitor run-off and soil loss in small watersheds; adoption of integrated rice-fish-piggery-duckery farming system by tribal farmers; control of nasal schistosomiasis in cross-bred cattle; development of new inoculants technology in the form of liquid rhizobium inoculant; and high regeneration capacity of M 35-1 sorghum in tissue culture. Under mission mode, some of major achievements include collection of 24,599 germplasm of different crops; release of two GMS hybrids in cotton, two varieties and one hybrid in sorghum and four single-cross, early hybrids in maize; establishment



and *Kheti*; and quarterly semi-technical magazines/newsletters, viz. *Indian Horticulture*, *Phal-Phool*, *Krishi Chayanika*, *ICAR Reporter*, *ICAR News* and *ARIS News*. Special issues/accent numbers of periodicals were brought out on the occasions of the World Food Day, International Conference on Sugarcane, National Symposium on Floriculture in the New Millennium, ICAR Foundation Day, Biotechnology and Plant Protection. The DIPA earned about Rs 3.5 million (up to 28 February 2002) through sale of journals/periodicals, priced books and advertisements, and participated in various exhibitions and displayed the publications it brought out. Agricultural Research Information Centre (ARIC) Unit in collaboration with Art Unit digitized the photographs available in Photo Library of DIPA by creating a database in MS-Acess. The ARIC has collected and processed the information on AP Cess Fund Schemes, Research Projects, Indian Agricultural Periodicals, All-India Co-ordinated Research Projects and Crop Varieties released by the ICAR for providing information as and when required, and digitized the Council's document *Vision 2020*. The web page of DIPA was developed and connected to the ICAR website. About 300 scientists and research scholars were benefited through the Selective Dissemination of Information (SDI) services (available at ARIC), viz. AGRIS-CD, CARIS-CD, CAB-CD etc., and document delivery services. About 10,000 readers visited the ICAR Library and consulted various publications available in the library.

Publicity and Public Relations Unit issued material of current importance to various newspapers, agricultural and current affairs magazines and electronic media and the

Council's achievements in agricultural research, extension and education were adequately covered in the media at the national and regional levels. The video films prepared on the activities and achievements of the Council as a whole and on important issues of immediate concern to farmers, were distributed to various ICAR institutes, KVKs, Extension Directorates of SAUs for wide dissemination of information. Also, various exhibitions to display salient achievements of the Council relating to agricultural development, were organized.

The Council has thus, made successful advances in agricultural research, extension and education to address the multiple and interwoven problems associated with food and nutritional security, such as enhancing productivity, sustaining production, protecting environment, conserving natural resources and improving profitability of farming as an occupation. With the meagre financial resources, the Council has exhibited appreciable pace of research in all sectors, viz. crops, horticulture, natural resource management, livestock, fisheries and agricultural engineering, besides strengthening the agricultural extension and education, introducing several organization and management reforms and strengthening the linkages and collaborative efforts with public and private sectors at national and international levels.

(Panjab Singh)
Secretary (DARE) & DG, ICAR

**Salient
Achievements**



2 Salient Achievements

Crop Improvement and Management

PLANT GENETIC RESOURCES

Germplasm Exploration and Collection

A total of 269 explorations have resulted in the collection of 16,597 accessions of cereals (3,485), millets and minor millets (935), pseudocereals (328), pulses (1,223), oilseeds (841), fibres (562), vegetables (1,842), fruits (521), medicinal and aromatic plants (1,324), spices and condiments (456) and others (5,080).

Besides, 15,876 samples of diverse crops from 40 countries and 50,230 samples of international trials from the IRRI, Philippines; CIMMYT, Mexico; Nepal and Thailand; and ICARDA, Syria, were introduced. Introductions include wheat cultivar with high protein content (EC 467720) from the USA; submergence tolerant lines of rice (EC 469575-83) from the IRRI, Philippines; drought-tolerant lines of maize (EC 468257-85) from the CIMMYT, Mexico; stem and leaf rust-resistant line of Triticale (EC 467937) from Canada; early-maturing and drought-tolerant lines of pearl millet (EC 470391-397) from the USA; high-yielding and crown-rust resistant lines of oat (EC 469501-3) from the USA; rust-resistant lines of soybean (EC 473111-38) from Taiwan; vitamin C rich lines in seabuckthorn (EC 468632-3) from Russia; high β -carotene content tomato (EC 4668370-2) with mid-season maturity suited for processing from the USA; heat-tolerant and bacterial-wilt resistant lines in chillies (EC 470358-63) from Taiwan; wild *Catharanthus* spp. (EC 466655-7) from the Netherlands; and a new crop tomatillo (*Physalis ixocarpa*) sweet and sour types (EC467434-62) from the USA. Introduced transgenic materials include, rice (EC 4673496-558) from Belgium, having *cry 1Ab/cry19c* gene; soybean (EC434782-812) from the USA, having *CP4 EPSPS* gene; *Brassica juncea* (EC 463769-921), having *barnase*, *barstar* and *bar* genes, from Australia; chickpea (EC 469461-90) containing polygalactourinase-inhibiting protein gene from Scotland and beans with α -amylase-inhibitor gene (EC469512-3) from Australia.

One hundred and eighty-two samples have been exported to 12 countries. Inland supply comprised 14,684 samples.

Plant Quarantine

Out of the total of 53,922 samples for quarantine clearance, 41,229 were imported and the rest have been exported. One thousand two hundred and forty-nine samples were infested with insects/mites; 121 were infected/contaminated with nematodes and 364 were infected with plant pathogens. Over 1,600 samples were salvaged. Paddy samples, totalling to 5,267, were given mandatory hot-water treatment. Phytosanitary certificates, 178 in number, were issued for consignments meant for export. A total of 6,628 samples of exotic germplasm were grown in Post-Entry Quarantine Glasshouse/Nursery. Pea seed-borne mosaic virus in EC 455038, EC 455042 from Syria and EC 454029 from Nepal has been confirmed.

Germplasm Conservation

In this year, 7,946 accessions have been added to in the long-term conservation in the National Gene Bank, resulting in 204,740 accessions in toto. A total of 642 released varieties have been transferred to long-term storage. Over 1,300 accessions of barley, jute, mustard, sesame and ocimum monitored for seed viability have been

- Total 15,876 samples of diverse crops from 40 countries and 50,230 samples of international trials from the IRRI, CIMMYT and ICARDA have been introduced.
- For consignments meant for export, 178 phytosanitary certificates have been issued.
- Molecular profiles of 79 non-aromatic rice cultivars have been obtained using 48 mapped sequence tagged microsatellite loci.
- A database for storage and for retrieval of DNA fingerprint information is being developed.
- NRC on plant biotechnology has been identified as one of the centres to participate in a global endeavour to sequence rice genome.
- A novel vegetative insecticidal protein *vip 3A* gene has been isolated from *Bacillus thuringiensis* and characterized at the molecular level.



Foxtail millet (*Setaria italica*) variability, collected from Rayalaseema region of Andhra Pradesh



Variability in colocasia (*arvi*), collected from Sirmour (Himachal Pradesh)



High-yielding and long-podded cowpea, collected from Mandi (Himachal Pradesh)

GERMPLASM REGISTERED

Oryza sativa (6), *Triticum aestivum* (6), *Hordeum vulgare* (3), *Ricinus communis* (2), *Solanum tuberosum* (1), *Trigonella foenum-graecum* (2), *Sesbania rostrata* (1), *Cajanus cajan* (7), *Ziziphus mauritiana* (3), *Vigna aconitifolia* (1), *Arachis hypogaea* (4), *Citrullus lanatus* (2), *Glycine max* (1), *Crotalaria juncea* (1), *Coffea arabica* (6), *Papaver somniferum* (1), *Brassica napus* (2), *Brassica juncea* (1)



Capsule variability in mesta (*Hibiscus cannabinus*), collected from the north-coastal region of Andhra Pradesh

found maintaining viability to gene bank standards. Accessions of sorghum (11,112), chickpea (209) and groundnut (341) have been restored from the ICRISAT and 3,876 accessions belonging to over 400 taxa are being maintained in the cryo-bank, which includes 907 accessions of orthodox and intermediate seed species, added this year. Forty-seven accessions have been augmented in *in-vitro* repository, resulting in 1,178 accessions in total.

Germplasm Evaluation

Total of 9,403 accessions of cereals: wheat (3,556), barley (375), triticale (369) and maize (800); of pulses: pea (133), lentil (122), coupe (372), urdbean (372); of oilseeds: rapeseed and mustard (155); of vegetables: brinjal (1,088), tomato (588), ridge-gourd (138), sponge-gourd (25), bottle-gourd (21), bitter-gourd (5), cucumber (9), tinda (16), pumpkin (23), summer squash (9), onion (56), garlic (654); of medicinal and aromatic plants: *Ocimum* (25), *Andrographis* (39), *Withania* (4), *Mucuna* (21), vetiver (130), palmarosa (55), urginia (21) and tinospora (20); of underutilized, faba-bean (188) were grown for characterization, preliminary evaluation and maintenance. Besides 19,254 accessions have been characterized for morpho-agronomic traits and are maintained at the 10 regional stations.

PROMISING ACCESSIONS IDENTIFIED

Brassica spp.

High oil : IC 248988 (46.77%), IC 248990 (46.47%), IC 248987 (46.12%)
Lowest erucic acid : EC 302488 (1.56%)

Chillies

Seed oil : EC 43739, IC 119442
Oleoresin : IC 119640
Colour value : IC 119291, IC 119755
Capsaicin : IC 119708, IC 119731

Pea

Protein content : EC 384137 (27.98%), IC 212132 (27.96%), EC 398591 (27.59%)

Mungbean

Protein content : PLM 445, PLM 468, PLM 666, PLM 350, PLM 340 and EC 251557A (>28%)

Wild collection (IC 212722) of kulthi

High protein percentage(38.37 ± 1.37); more than control lines of kulthi (*Macrotyloma uniflorum*)

DNA Fingerprinting

Cereals and millets: Molecular profiles of 79 non-aromatic rice cultivars have been obtained using 48 mapped sequence tagged microsatellite (STMS) loci. Genetic purity of aromatic rice Pusa Basmati has been tested. Sixty-one aromatic rice cultivars have been fingerprinted using 55 non-linked microsatellite markers. Forty-eight bread-wheat cultivars have been analysed with 22 most informative Amplified Fragment Length Polymorphism (AFLP) primer pairs.

DNA MARKERS REVEAL NARROW GENETIC BASE OF THE LATEST MUNGBEAN AND TOMATO CULTIVARS

Diversity in mungbean and tomato (using DNA markers) has revealed that their modern Indian cultivars are genetically very similar. This finding calls for a shift in breeding strategies, towards greater use of germplasm collections available with breeders and in genebanks.



Pulses: AFLP profiling of 32 released cultivars of mungbean has been completed using six most informative AFLP primer pairs. Twenty-three chickpea accessions and 14 released cultivars analysed with 78 RAPD primers have revealed low genetic diversity among them.

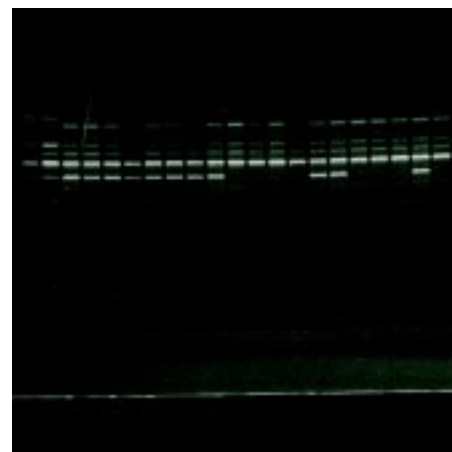
Oilseeds: Forty-eight sesame cultivars profiled with selected 21 RAPD primers have showed high degree of similarity.

Fibre crops: Higher polymorphism was noted in diploids when 7 diploid and 25 tetraploid cotton cultivars were fingerprinted using 26 RAPD primers.

Vegetable crops: Thirty-eight accessions of chillies fingerprinted with 6 AFLP primer pairs could be distinguished independently by each of the primers.

Horticultural crops: Eighteen cashew accessions analysed with 6 selected AFLP primer pairs have showed high degree of polymorphism. Twenty-four mango cultivars with 6 inter simple sequence repeat (ISSR) primers and 15 AFLP primers, and 240 Indian banana and plantain accessions with nine selected AFLP primer pairs have been fingerprinted.

Medicinal and aromatic plants: Seventy Indian neem accessions analysed with 21 random primers have revealed moderate genetic diversity among them.



RAPD profile of 23 chickpea germplasm accessions and cultivars

Plant Biotechnology

A cell culture variant of rice IET 16768 has been promoted to Advanced Varietal Trial-stage II. Another promising double haploid rice (BTC-E23/99) has stood first in the Initial Evaluation Trial, showing yield advantage over checks.

A novel vegetative insecticidal protein *vip3A* gene has been isolated and characterized at the molecular level. A protease inhibitor gene and a lectin gene have also been isolated from cowpea and characterized at the molecular level.

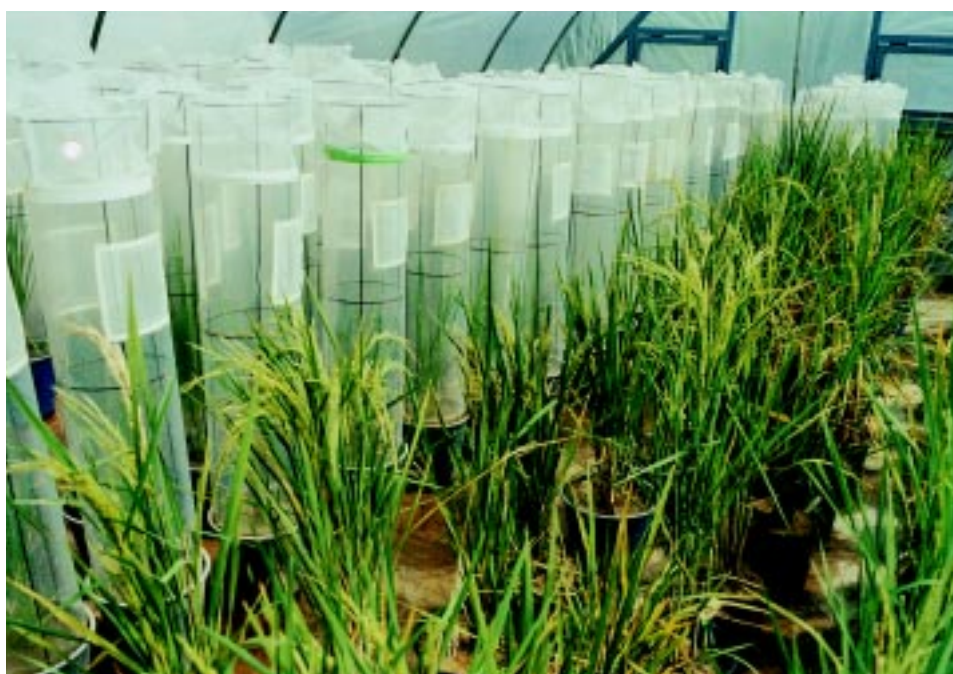
The Bt transgenic rice using *cry1Ac* gene, developed earlier in IR 64 and Pusa Basmati backgrounds, tested in controlled conditions against yellow stem-borer has showed superior performance.

A molecular breeding group has succeeded in developing a CAPS marker for *Ac2* gene in mustard, cloning RGAs (resistance gene analogues) for *Ac2* gene in mustard, extension of molecular map for mustard, using AFLP markers, and deployment of AFLP profiling system for non-aromatic rice, wheat and *Brassica*.

RICE GENOME SEQUENCING

NRC on Plant Biotechnology is one of the centres to participate in a global endeavour to sequence Rice Genome. India has joined the International Rice Genome Sequencing Project (IRGSP), a global consortium, consisting of 11 countries, including US, Japan and China.

Bt transgenic rice, using *cry 1AC* gene, developed earlier in IR 64 and Pusa Basmati backgrounds, when tested in controlled conditions against yellow stem-borer showed superior performance





- Rice MLTG 4 is the most promising thermo-genetic male sterile (TGMS) line for developing two-line hybrids with clear transformation from sterility to fertility and *vice-versa*.
- To overcome low temperature (5-10°C) during boro season in north-eastern region, polythene tunnel method has been developed for raising rice-seed nursery.
- In rice, Almix (a new herbicide) at 0.004 kg a.i./ha along with early post-emergence application of Butachlor at 1.5 a.i./ha has been promising for weed control.
- New fungicide Bann 75 WP has been most effective against blast and new Sheathmar and Rhizocin fungicides against the sheath blight.



Pusa Sugandh 2 (IET 16310) and Pusa Sugandh 3 (IET 16313) are suitable for irrigated areas of Punjab, Haryana, Delhi and Uttaranchal. They show moderate resistance to blast and their grains are long slender

FOOD CROPS

RICE

Crop Improvement

In rice, 21 varieties and 2 hybrids have been released

Rice varieties/hybrids released and notified			
Variety	Grain type	Reaction to pest/ disease abiotic stress	Recommended for
Central releases			
Pant Dhan 16	SB	R: GM 1; MR: Blast, SB	Rainfed uplands as well as irrigated areas of Bihar, West Bengal and Haryana
Vivek Dhan 82	LB	R: Blast, NBL	Hills of Himachal Pradesh, Meghalaya and Uttaranchal
Yamini	LS	MR: Blast, ShR	Basmati, scented culture identified for sodic areas as well as normal soils of Uttar Pradesh, Haryana and Punjab
Krishnahamsa	LS	R: Blast, cold	Boro areas of Tripura, West Bengal and Bihar
Vasumati	LS	MR: Blast, BS	Basmati-growing areas of north-western India
Pusa Sugandh 2, 3	LS	MR: Blast	North-western states, Punjab, Haryana, Delhi, Uttaranchal
HRI 120 (Hybrid)	LS	R: WBPH, GM	Irrigated areas of southern, eastern and western regions
Pusa RH 10 (Hybrid)	LS	MR: BPH, RTV	Haryana, Delhi and Uttaranchal
State releases			
<i>Irrigated</i>			
PR 113	LS	MR: Blast, BLB	Punjab
PR 114	LS	R: BLB	Punjab
PR 115	LS	R: BLB	Punjab
PR 116	LS	R: BLB	Punjab
Harsan Sarai	LS	R: Blast	Uttar Pradesh
Narendra Usar 3	LS	R: BLB	Assured irrigated, saline-alkaline areas of Uttar Pradesh
Bamleshwari	LB	R: BLB, Blast, ShBl	Irrigated areas of Chhatisgarh, Madhya Pradesh and eastern Uttar Pradesh
<i>Rainfed uplands</i>			
Maruteru Sannalu	LS	—	Upland areas of Andhra Pradesh
Danteshwari	LS	MR: Blast	Direct-seeded rainfed uplands of Madhya Pradesh
<i>Deep-water rice</i>			
Hemavati Durga	MS	R: Blast	Lowlands with temporary submergence problem in hill zone of Karnataka
<i>Hill areas</i>			
KHP 5	MB	MR: Blast	Upland direct-sowing situation of hill zone of Karnataka
Palam Dhan	LS	R: Blast	Mid hills of Himachal Pradesh
Irani Basmati	LS	R: Blast	Hills of Himachal Pradesh

R: Resistant, MR: Moderately resistant, BLB: Bacterial blight, BPH: Brown planthopper, BS: Brown spot, GM: Gall midge, NBL: Neck blast, SB: Stem-borer, ShBl: Sheath blight, ShR: Sheath rot, RTV: Rice tungro virus, WBPH: White backed planthopper, LS: Long slender, MS: Medium slender, MB: Medium bold, SB: Short bold.



Hybrid Rice Technology

Variety Identification Committee has identified rice KRH 2, RH 204 and 27 PO2 as suitable for submission for release proposals.

KRH 2, PHB 71 and Sahyadri, high-yielding and widely adapted rice hybrids, have showed yield advantage ranging from 882 to 1,110 kg/ha in *rabi* and 495-665 kg/ha in *kharif*.

New CMS lines developed: Two new CMS lines, CRMS 31A, and CRMS 32A, for developing rice hybrids for both irrigated and shallow lowlands have been developed.

Promising Thermo-Genetic Male Sterile (TGMS) line: MLTG 4 is the most promising Thermo-Genetic Male Sterile (TGMS) line for developing two-line hybrids, with clear transformation from sterility to fertility and *vice versa*.

Biotechnology: The PCR-based sequence tagged site (STS) marker could distinguish A and B lines. In multiplex reaction with another primer pTA 248, 2 A lines, IR 58025A and IR 62829A have been distinguished.

Crop Production

Polythene tunnel method for raising rice seed nursery has been developed to overcome low temperatures, ranging from 5 to 10°C during boro season sowing in the north-eastern regions. This is for ensured seedling growth and also for reduced plant mortality.

Poly rice, a commercial formulation containing NPK along with micronutrients, when applied to leaves at 2% concentration at panicle initiation, one week before and one week after flowering along with the recommended fertilizer dose, applied as soil application, increased grain yield by 24% over recommended fertilizers.

In hybrid rice PA 6201, N was applied at 135 kg N/ha in 4 equal splits: basal, 21 days after transplanting, at panicle initiation and at panicle emergence. This along with 45 kg P₂O₅ and 90 kg K₂O in dry season had resulted in 12% increase in yield over check.

Direct seeding of sprouted seed along with the optimized crop-management package by eight-row drum seeder has recorded comparable grain yield to that of transplanting in Tulasi, Krishnahamsa, IET 9994, IET 9219, IET 9691 and Vikas rice; out of the 23 cultivars/varieties tested.

Almix (a new herbicide) at 0.004 kg a.i./ha along with the early post-emergence application of Butachlor at 1.5 kg a.i./ha was found effective for weed control.

Final growth trend analysis of 10-year study on intensive rice-rice cultivation indicated a low positive growth of *kharif* rice productivity and a decline in *rabi* rice yields by 2% per annum despite sufficient levels of fertilizer applied.

Crop Protection

Promising rice-resistant lines	
Breeding lines	Resistance against
MTU 1036, MTU 1037, MTU 1042, MTU 1048; INRC Nos. 202, 3524, 3526	Planthoppers
JGL 1851, JGL 2813, JGL 3856, JGL 3858, RGL 8896, RYT 2663; INRC Nos. 1531, 1590	Different gall-midge biotypes
IET Nos. 15579, 15581, 16251, 16270, 16362, 16364, 16783, 16848 (among inbreds), 16439, 16440, 16442 (among hybrids) and INRC Nos. 3552, 17425, 17426, 17427, 17450, 17453, 17458, 17519, 17530, 17578, 17587 and 17604	Blast
IET Nos. 16403, 16307, 15588, 16262; INRC 17460	Bacterial leaf blight



Pusa RH 10 is a hybrid for irrigated areas of Haryana, Delhi and Uttaranchal. It has showed moderate resistance to brown planthopper and rice tungro virus

PROMISING RICE CULTURES	
Ecosystem	Promising culture (IET No.)
Rainfed upland	16804, 16806 15164, 15828
Deep water	16847, 16850
Saline/Sodic	16888, 13428
Irrigated	15948, 15949 (E) 16130, 16253 (ME) 16007, 16479, 16075, 16434 (M)
Semi-deep water	16472, 16473
Costal saline	15420, 13428
Boro	12884, 8886, 8883
High altitude area	16468, 16047, 16007, 16479 16457, 16009



KRH 2 is a high-yielding, widely adapted rice hybrid. It shows a yield advantage of 882-1,110 kg/ha in *rabi* and 495-665 kg/ha in *kharif*



RICE TRANSPLANTER

A manual 4-row transplanter, which can be operated in irrigated and rainfed shallow lowlands, has been developed. This machine covers 0.2 ha/day, saving 60% on labour and 55% on cost as compared with rice transplanting done manually. Cost of transplanter is Rs 4,000 and operation cost is about Rs 600/ha.

- Five CHA products have produced acceptable level of male sterility in wheat at the appropriate doses.
- In north-western plains zone, 2 hybrids of wheat HM 99168 and HM 9997 have exhibited more than 12% heterosis over the best check PBW 343.
- A marker-aided selection approach, utilizing PCR-based markers linked to quality traits and disease resistance genes in wheat, is being executed at the Directorate of Wheat Research.
- Diversification of rice-wheat system by berseem or oats for fodder once in 3 years reduced weed infestation.

WHEATS IDENTIFIED

Variety	Production conditions and area of recommendation
HUW 533	Timely sown, rainfed areas of eastern Uttar Pradesh, Bihar, West Bengal, Assam, Orissa
GW 322	Timely sown, irrigated areas of Madhya Pradesh, Gujarat, parts of Rajasthan, Maharashtra, Karnataka
HD 2781	Timely sown, rainfed areas of Maharashtra, Karnataka
HW 2045	Late sown, irrigated areas of eastern Uttar Pradesh, Bihar, West Bengal, Assam, Orissa

Chemical Control

New fungicide formulation Baan 75 WP has been found most effective against blast and Sheathmar and Rhizocin fungicides against sheath blight.

Fresh leaf extract of *Polygonum hydropiper*, at 50 g of leaf in one litre of water emulsified with 5 ml of teepol, controlled brown planthopper infestation and resulted in 66.7% mortality of caseworm in fields.

Integrated use of resistant varieties and fungicidal application was most effective against blast, and resistant varieties and judicious use of nitrogenous fertilizers was most effective against bacterial blight.

Ufra nematode was observed in the endosperm and germ portion of seeds of Vijetha, indicating possibility of seed as the carrier of the nematode.

W H E A T

Crop Improvement

Winter × Spring Wheat Hybridization

With the understanding that introgression of winter wheats may bring in better quality- and yield-contributing genes in spring wheats, a collaborative project was started. In this, 10 winter wheats, KAVKAZ, AGENT, BLUEBOY, HOBBIT, HUSTLER, AGATHA, ARTHUR, AUBURN, BEZOSTAYA and MARTINVASAK 10, selected from the International Winter Wheat Nursery, were crossed with PBW 343, UP 2338, Raj 3765, WH 542 and HD 2687. During 2000-01, 35 F₂ bulks have been selected for distribution to Palampur, Pantnagar, Delhi, Kanpur, Varanasi and Vijapur.

Hybrid Wheat Research

Among 41 different molecules synthesized, 5 chemical hybridizing agent products have produced acceptable level of male sterility at the appropriate doses. Among the 49 wheat entries evaluated over 3 locations in the north-western plains zone, 2 hybrids viz. HM 99168 and HM 9997 have exhibited more than 12% heterosis over the best check PBW 343.

Marker-assisted Selection

A marker-aided selection approach, utilizing PCR-based markers linked to the quality traits and disease resistance genes, is being executed at the Directorate of Wheat Research. So far worldwide 40 or more disease resistant genes in wheat have been tagged; of which *Lr 9*, *Lr 10*, *Lr 24*, *Lr 25*, *Lr 28*, *Lr 29*, *Lr 34*, *Lr 35*, *Lr 37*, *Lr 39*, *Yr 15*, *Yr 17* and *Sr 39* are the important ones.

Germplasm Collection

Total of 189 accessions have been collected from Assam, Madhya Pradesh and Uttaranchal hills. These include huskless (Uua), 2R, 6R, barley and old Lal mishri, Katha, Methi local.

Efficient moisture-harvesting genotypes: In the central zone, wheat WH147 gave

Genetic stock of *Triticum aestivum* identified and registered during 2001

No.	Name	Traits	Centre
0043	KBRL10	Highly resistant to Karnal bunt	PAU, Ludhiana
0044	KBRL13	Highly resistant to Karnal bunt	PAU, Ludhiana
0047	KBRL22	Highly resistant to Karnal bunt	PAU, Ludhiana
0049	WH595	Leaf and stripe resistant, with high protein content	CCSHAU, Hisar
0050	WH712	High sedimentation value	CCSHAU, Hisar



on an average a yield of 2,016 kg/ha under no irrigation and 2,315 kg under limited irrigation; NIAW 215 gave 1,935 and 2,517 kg in the similar conditions.

Genotypes for terminal heat stress in the north-western plains zone: Late-sown crop is invariably exposed to terminal heat stress in the zone. A large number of genotypes were evaluated under rising ambient temperature as well as under continuous heat in plastic houses. HD 2428 was found susceptible to higher maximum temperature whereas NIAW 845, WH 730, CBW 12 were tolerant to terminal hot environment.

Top ranking wheat genotypes in international nurseries/trials				
Pedigree	Yield (tonnes/ha)	Heading (days)	Height (cm)	1,000 grain wt (g)
V763.2312//879.C8	7.5	99	85	40
BCN//TAN/VEE	7.5	100	86	42
PICUS/4/CS5A/5RL	7.2	100	69	40
PV//CAR422/ANA/5/BOW	7.0	99	72	41
ATTILA/3/HUI/CARC//CHEN	7.0	95	70	38
21ST ESWYT				
KAUZ//ALTAR 84/AOS/3/KAUZ	7.2	87	96	34
F60314.76/MRL//CNO 79/3/KA	7.1	92	104	35
SW89.3064/STAR	6.7	92	93	37
18TH SAWSN				
KAUZ/ALTAR 84/AOS	7.0	69	83	40
ALTAR 84/AE. SQUARROSA//	7.0	69	93	39
BAVIACORA M 92	6.8	72	46	40
KAUZ*2/BOW//KAUZ	6.7	70	82	42
32ND IDYN (durum)				
BOOMER 18/LOTUS4	7.1	77	86	44
CADO/BOOMER 33	6.9	79	90	50
PLATA 1/SNM//PLATA9	6.8	81	87	48

Crop Production

Various tillage options were evaluated and perfected in a farmers' participatory approach in three villages around Karnal.

Economics of various tillage options in Karnal					
Tillage options	Tractor operation	Yield (tonnes/ha)	Cost of cultivation (in rupees)	Net returns (in rupees)	Net profit over conventional (in rupees)
Zero tillage	1	5.596	14,848	23,205	4,470
Rotary tillage	1	5.978	15,154	25,496	6,761
FIRB	10	5.323	15,800	20,396	1,661
Conventional (broadcasting)	12	5.275	17,135	18,735	-

Crop Protection

Monitoring Rust Pathotype Flora

In leaf rust, among 12 pathotypes recorded, pts. 77-5 and 104-2 were more widely distributed. Lr 9 virulence was recorded in only 3 samples from Nilgiri hills, indicating not much development of this. Pathotype 104-2 (21R55) carrying virulence for Lr 23 and Lr 26 was frequent in durum and dicoccum wheat areas. In the northern India, there was predominance of 104-2 and 77A, followed by 77-5.

HEAD SCAB - A POSSIBLE PROBLEM OF FUTURE WHEAT

Head scab may become serious with spells of wet weather (warm and humid) at crop anthesis. Such a weather may frequently occur as a consequence of global warming and change in rainfall pattern.

Head scab infected samples of wheat were collected from different locations in hills and foot hills. Five *Fusarium* spp. (*F. graminearum*, *F. oxysporum*, *F. equiseti*, *F. moniliforme* and *F. solani*) have been isolated, purified and identified. A set of differentials has been constituted.

RUSTS' RESISTANT WHEAT GENOTYPES

Stem, leaf and stripe rusts

- (i) +LB, PM, KB, FS VL 796, WH 913, DWR 1006 (d), TL 2877 (t), HPT 6 (t)
- (ii) +LB and KB HS 270, HPW 143, HW 2023, LRG 102 and PDW 215 (d)
- (iii) +LB HS 395, HPW 152, HPW 160, HPW 162, PBW 445, PB 452, HP 1832, HUW 507, MACS 6086, HI 1462, HPW 161, HW 2023, HW 3009, NIAW 129, HPW 147 and K 9441 and HI 8540 (d)
- (iv) + KB Raj 3777

Stem and leaf rusts

- (i) +LB, KB, PM, FS PDW 269 and WH 913
- (ii) +CCN DWR 174
- (iii) +Root aphids HPW 42, TL 2877, UP 2425, HI 8498, DT 8, JNIT 154, NW 1067, MACS 2884 and PBW 342

*Abvn. LB= Leaf blight, PM = Powdery mildew, KB = Karnal bunt, FS = Flag smut, CCN = Cereal cyst nematode



HERBICIDE RESISTANCE IN WEEDS OF WHEAT-CROP

Out of the five herbicides (Sulfosulfuron 25g, Metribuzin 175g, Clodinafop 60g, Fenoxaprop 100g and Tralkoxydim 350 g/ha) tested for control of *Phalaris minor*, two (Sulfosulfuron and Metribuzin) could control the weed. Metsulfuron at 4.0 g/ha and Chlorsulfuron at 25g/ha were effective against the broadleaf weeds. In zero tillage, *P. minor* population was lesser as compared to conventional because seeds lying in lower layers do not come up in the upper layer. Intensification of rice-wheat system by including short-duration vegetable pea or potato, followed by late wheat effectively controlled weed without herbicide application. Diversification of rice-wheat system by berseem or oats for fodder once in 3 years also reduced weed infestation.



Hybrid Shaktiman 1 is a high-quality protein maize with white bold grains. It is recommended for irrigated areas of Uttar Pradesh and Bihar for *rabi* cultivation

- In maize, genotypes resistant/tolerant to downy mildew, maydis leaf blight, post-flowering stalk-rot, turcicum leaf blight, excess soil moisture and to drought have been identified.
- Seed Tech 2324, orange yellow, semiflint type maize has been recommended for *kharif* in irrigated areas of the country.

In yellow rust, 8 pathotypes were observed. The Yr 9 virulence (46S119), which has virulence for both Yr 2 and Yr 9, was most widespread pathotype.

Pathotype 40A was the most frequent pathotype of black rust in the country, and pathotype 295 was recorded from Maharashtra only.

Protein Content in Wheat

The average protein content in Indian wheat is around 11.0%, but there were several grain lots that had even 14% protein. Since the demand for such a wheat (14%) is only 4 to 5 million tonnes. For this demand, after a NIR (Near Infra Red)-based protein scan, which takes only few minutes to estimate protein content, grain lots with acceptable protein can be procured and separately stored for trade and value-addition.

BISCUIT-MAKING QUALITY OF WHEAT

Baking test: The baking test could indicate the availability of some lines with good biscuit-making quality.

WHEAT GERMLASM HAVING GOOD AND POOR BISCUIT-MAKING QUALITY

(Good biscuit lines (Biscuit diameter/thickness) >7.5 and up to 10.0)

HP1856, HPW74, HPW89, HPW114, HPW143, HUW37, HY173, NI5406, CITR4793, TW'S, E839, E4530, E4542, E4812-A, EC378772, EC378773, EC378788, EC378790, EC378793

MAIZE

Crop Improvement

A composite IC 9001 has been identified for irrigated and rainfed areas of Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Delhi, Haryana, Punjab and western Uttar Pradesh.

Released maize hybrids/composites

Cultivars	Maturity/grain colour	Production conditions and salient features	Area of production
Hybrid Shaktiman 1	Full season, white bold grains	Irrigated, for <i>rabi</i> cultivation, with high quality protein	Uttar Pradesh and Bihar
JH 3459	Orange yellow flint	Rainfed and irrigated areas, for <i>kharif</i>	Delhi, Haryana, Uttar Pradesh and Punjab
Seed Tech 2324	Orange yellow semi flint	Irrigated, for <i>kharif</i> cultivation	Across the country
Hybrid Shaktiman 2	Full season	Irrigated, for <i>rabi</i> cultivation, with high quality protein	Bihar

Genotypes for Biotic and Abiotic Stresses

Biotic stresses: Downy mildew. MAH 1067, MAH 1101, MAH 1102, NAH 1046,



NAH 1048, NAH 1051, NAH 1056, NAH 1058, NAH1063, NAH 1056, NAH 1074, NAH 1080, NAH 1081, NAH 1086, NAH 1090, NAH 1091, NAH 1092, NAH 1100, NAH 1101, NAH 1103, NAH 1104, NAH 1108, NAH 1110, NAH 1115.

Maydis leaf blight. SC 24(92)-3-2-1-1, Suwan 1(5)C 11 B-B, CML and SC 7-2-1-2 b-1.

Post-flowering stalk rot. Pop 28, TSR (S2)-13-1# Across 7936, Talatijapan 893, 6-1-3###, Prabhat, Pool Sequia, J 54 MO 17-2-3g-2-2, Pusa Composite 2-2-1-2, L 140, LLPC2, RDBBDE 2-1-3-1-1-2F-j-2#2-19-1-1-+6, MSP1 21-1-1-1-1.

Turcicum leaf blight. NAI 143, NAI 145, NAI 147, NAI 151, NAI 155.

Abiotic stresses: Excess soil moisture tolerant. CML 226, CML 311, CML 327, CML 118 and CM 600.

Tolerant to drought stress. (5406-119P28TSR-(S2)-3-1-2-2 ###-B7, (P43 F95* 21 F219)-1 BBB -#* -4-B3 1-B2 and (CML 159 × CML 144).



JH 3459 maize is promising for rainfed and irrigated areas of Delhi, Haryana, Uttar Pradesh and Punjab for *kharif* cultivation

Crop Production

Sowing baby corn from April to middle of July has been effective. Organic manure placement in seed furrows has proved useful under rainfed farming. FYM (10 tonnes/ha) along with the recommended doses of NPK resulted in significant yield increases of pop corn with 66 cm × 15 cm row spacing and 66.6 thousand plants/hectare. For weed management, intercropping with soybean and use of Alachlor and Pedamenthalin were effective.

BARLEY

Crop Improvement

DWR 28 barley, the first two-row malt barley, has been developed through hybridization programme. So far only the direct introductions, Alfa 93 and BCU 73, have been released.

- DWR 28, the first two-row malt barley, has been developed through hybridization between BCU 73 and PL 172.

Barley variety identified				
Variety	Parentage	Area of adaptation	Production conditions	Salient characteristics
DWR 28	BCU 73/PL 172	North western plains zone	Irrigated, timely sown	Two-row malt barley, highly resistant to yellow rust with better malting quality

- The dual-purpose CSV 15 sorghum of 102 days duration has brought back the phased out chickpea in rotation.
- Two new male sterile lines on A 2 sorghum cytoplasm and 2 new male sterile lines on Maldandi cytoplasm have been developed.
- Jaggery prepared from NSS 104 and SSV 84 sorghum has confectionery taste.

SORGHUM

Crop Improvement

Kharif sorghum: The dual-purpose variety CSV 15 of 102 days duration has made impact on the whole cropping system, and has brought back the phased out chickpea in rotation. Now the farmer can get assured grain yield of sorghum up to 3.5 tonnes/ha with disease-free, stay-green plants up to maturity, and can vacate field 38 days before the time, for enabling early sowing of chickpea to minimize wilt disease due allelopathic effect. SPV 1,474 with 3,826 kg/ha grain yield exhibited 8.4% and 16.5% superiority over improved CSV 15 and CSV 13.

Rabi sorghum: In *rabi*, the earlier released bold grain and shootfly-resistant hybrid CSH 15R is gaining popularity among the farmers. During the year, hybrid SPH 1010 has been released as CSH19R. This yielded highest (3,066 kg/ha) under multilocation trials and was 32.1% superior to M 35-1 (2,321 kg/ha) and 23.8% to CSH 15R (2,475 kg/ha).

SEED PRODUCTION TECHNOLOGY FOR SORGHUM

Hybrids CSH 18 and CSH 19 of sorghum have showed proper synchrony of flowering and highest seed set with staggered sowing. GA spray at 400 ppm on R 354 and 250 ppm on Indore 12 at primordial initiation showed highest seed set. Seed quality traits, field emergence, root length, seedling dry weight and vigour index, differed significantly from 12 to 24 months of storage due to moisture.



JAGGERY FROM SWEET SORGHUM

Jaggery prepared from NSS 104 and SSV 84 has confectionery taste. Maximum jaggery production was with SSV 84, yielding 7.67%.

Diversification of CMS Lines

Two new male sterile lines on A2 cytoplasm and 2 new male sterile lines on Maldandi cytoplasm have been developed and evaluated.

Crop Production

Intercropping of Sorghum

Among the intercrops, pigeonpea with sorghum was found superior to soybean and groundnut in terms of the monetary returns, besides the pure crop.

Crop Protection

Entries with multiple disease resistance are SPV 1531, 1533, SPH 1148, 1250, 1251 and 1268. Parental lines C43 RS 673 and RS 29 are found resistant to grain mold and RS 29 and AKMS 14B to downy mildew. Some lines resistant to shootfly and also showing resistance to grain mold are GMRP 13, SRF 142, SR 770-7 and SRF 133-8. Entries which showed resistant to charcoal rot are SPV Nos. 1380, 15-4, 1457, 1491, 1411 and 1538 and hybrids are SPH 1303, 1302, SPH 1305 and SPH 1314.

Parental lines as resistant to charcoal rot are 27A, CS 3541, 27B and 296 B.

Tolerant sorghum lines against major pests	
Variety	Tolerance level
In kharif season	
SPV 1472, SPV 1489, SPV 1482	Moderate for stem-borer
SPV 1481 and SPV 1487	Moderate for midge, shootbug and headworms from Advanced Varietal Trial
SPH 1148	Moderate for shootfly, stem-borer, and midge from Advanced Hybrid Trial
In rabi season	
PH 1065	Moderate for shootfly and stem-borer
SPV 1504	Moderate for shootfly
SPV 1380, SPV 1413, SPV 1452 and 1491	Moderate for stem-borer and shootbug from Advanced Varietal Trial
SPH 1077 and SPH 1078	Moderate for shootfly from Advanced Hybrid Trial
104A/B, RR 9803, RR9808, RR 9809 and RS 585	Moderate for shootfly from parental line trial

INTEGRATED PEST MANAGEMENT FOR SORGHUM SHOOTFLY

Field experiments were conducted to determine the effect of integrated pest management modules on the incidence of shootfly *Atherigona soccata* Rondani. In all modules, neem spray at 3.0-5.0% effectively repelled egg-laying of shootfly, *Atherigona soccata*, reflecting as low dead hearts' formation. Intercropping of sorghum and pigeonpea in 2:1 row ratio was also useful. A combination of soil application of muriate of potash (30kg/ha) and seed treatment with Imidacloprid at 10-14 ml/kg minimized losses effectively.



PEARL MILLET

Crop Improvement

Three hybrids and 1 composite variety have been released during the year.

- Released 3 hybrid and 1 composite variety of pearl millet, which recorded higher grain yield of 90 kg/ha.

Pearl millet hybrids/varieties released			
Hybrids/varieties	Area of recommendation	Mean grain yield (tonnes/ha)	Salient features
Hybrids			
RHB 121	Rajasthan, Haryana, Punjab, Gujarat, Uttar Pradesh, Madhya Pradesh and Delhi	2.73	Early medium maturity (75-78 days), suitable for rainfed areas, presence of bristles
Nandi 35	Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu	3.01	Medium maturity (80-83 days), suitable for both rainfed and irrigated areas
Composite/varieties			
Pusa Composite 383	Rajasthan, Haryana, Punjab, Gujarat, Uttar Pradesh, Madhya Pradesh and Delhi	2.17	Early medium maturity (76-78 days), suitable for rainfed/areas

Crop Production

Pearl millet-based cropping system productivity could be sustained by applying N 25-50% through FYM/vermicompost or super compost and 75 to 50% through inorganic N fertilizer with recommended dose of fertilizer (RDF) in the succeeding wheat and safflower and 50% RDF in the succeeding soybean and safflower.

Newly developed hybrids RHB 121, NMH 26 and composite MP 383 recorded 8-9% higher grain yield (at 90 kg/ha) over best respective check.

Crop Protection

Hybrids MH 900, MH 901, MH 943, MH 956, MH 960, MH 1014, MH 1019 and MH 1050 have been found with high degree of resistance to downy mildew. And MH 881 and MH 882 possess combined resistance to downy mildew and smut diseases.

SMALL MILLETS

Crop Improvement

Nine varieties of different small millets have been released for cultivation.

Crop Protection*Donors for Resistance*

In the national screening nurseries, finger millet accessions GE 5181, GE 5192, GE 5214, GE 5240 and GE 5253 recorded very low score for neck and finger blast, and can be used as the donors for resistance. Resistant varieties of foxtail millet for sheath blight are SiA 2679 and PS 4; of barnyard millet for grain smut are PRB 9402 and PRB 9602; of kodomillet for head smut are RK 87 and RK 390 and OLM 203; and of little millet for rust are TNAU 89, TNAU 98, CO 2.

- Nine varieties of different small millets have been released.



Small millets' released				
Crop/Variety	Area of recommendation	Yield (tonnes/ha)	Duration (days)	Salient features
Fingermillet				
Chilka	Orissa, Madhya Pradesh, Gujarat, Andhra Pradesh	2.5-30	105-115	It is moderately resistant to finger and neck blast and is suitable for early sowing
GPU 45	Tamil Nadu, Gujarat, Karnataka, Madhya Pradesh, Jharkhand, Maharashtra	2.7-2.9	104-109	It is suitable for normal and late planting
GPU26	Karnataka	3.0-4.0	95-100	It is moderately resistant to finger and neck blast and is suitable for late sown conditions
Foxtail millet				
SR 16 (Meera)	Rajasthan	1.5 -1.7	75	It is suitable for sub marginal, undulating and sloppy lands. It has superior stover quality and has stay-green character at maturity
Proso millet				
GPUP 8 (DHPM 1)	Karnataka	2.5-2.8	85	It is suitable for double cropping and is resistant to brown spot
Little millet				
KOLAB Paiyur 2	Madhya Pradesh, Orissa, Chattisgarh, Bihar, Karnataka, Gujarat	1.5-1.7	75	It is suitable for early and late planting
Paiyur 2	Tamil Nadu	0.7 - 0.8	80-85	It shows field tolerance to grain smut and is adapted to poor fertility soils
Kodo millet				
Jawahar Kodo 48	Andhra Pradesh, Karnataka, Chattisgarh, Gujarat, Madhya Pradesh	2.0-2.5	90-98	It is suitable for timely sowing
Barnyard millet				
VL Madira 181	Bihar, Karnataka, Madhya Pradesh, Tamil Nadu	1.5-1.8	80-90	It is moderately resistant to grain smut

Small millets' promising cultivars	
Millets	Cultivars
Fingermillet	GPU 52, TNAU 946, OEB 14, GPU 53 and TNAU 908
Foxtail millet	SiA 2644 and SiA 2829
Kodo millet	DPS 158 and ICK 769
Little millet	OLM 20
Barnyard millet	VL 158 and VL 182

UNDERUTILIZED CROPS

Crop Production

- Intercropping grain-amarnath in long-duration pigeonpea (CO 6) resulted in higher gross returns of Rs 18,166/ha and higher cost : benefit ratio of 1 : 1.52.

Intercropping grain-amaranth in long duration pigeonpea (cv. CO 6) resulted in higher gross returns (Rs 18,166/ha) and cost: benefit ratio (1 : 1.52).

Application of Alachlor at 1.0 kg a.i./ha resulted in highest grain yield and least production of weed biomass in common buckwheat.



PROMISING ENTRIES IDENTIFIED

Hills

IC 35407 (1.95 tonnes/ha)	: Grain-amaranth
KBB 3 (1.21 tonnes/ha)	: Buckwheat
BRS 1 (normal duration, 1.32 tonnes/ha) and PRR 9301 (1.55 tonnes/ha)	: Rice-bean
H 656 (1.12 tonnes/ha)	: Job's tear
VH 82-1	: Faba-bean
H 1644 (0.7 tonne/ha)	: Perilla
EC340263 (2.4 tonnes/ha)	: Adzuki bean
CHLKW 8 (0.7 tonne/ha)	: Chenopodium

Plains

BGA 2 (1.82 tonnes/ha)	: Grain-amaranth
RBL 36 (9.10 tonnes/ha, normal) and PRR 2 (1.4 tonnes/ha, early)	: Rice-bean
BSH 9 (2.705 tonnes/ha)	: Faba-bean
SKNK 16 (0.5 tonne/ha)	: Kalingada
RMF 37 (4.313 tonnes green fruit/ha)	: Kankoda
GP 59 (0.3 tonne/ha)	: Tumba
GP 233 (gave maximum seed yield in IVT)	: Tumba
GP 255 (Largest fruits in IVT)	: Tumba
AKWB 1 (0.7 tonne/ha)	: Winged bean

Quality Aspects

Protein content in SKNK 7 of grain-amaranth ranged from 11.9 to 15.9% and oil content was high in K 35696 (12.6%), Suvarna (12.5%) and RGA 5 (12.4%).

FORAGE CROPS**Crop Improvement**

During the year, 539 new, exotic and indigenous germplasm of different forage crops have been added at the IGFR and other centres. And 580 accessions have been deposited for the long-term storage at the NBPGR, New Delhi.

Crop Production

Maximum berseem equivalent yield (144.8 tonnes/ha) was observed in guinea-grass + cowpea - berseem sequence in the irrigated areas.

Inoculation of sorghum with *Azotobacter* and berseem with *Pseudomonas* gave yield advantage of 7.1%, besides improving the nutrient status of the soil.

Alachlor at 1.25 kg a.i./ha as pre-emergence weedicide, followed by hand-weeding at 6 weeks showed promise in lucerne.

In rainfed areas, 120 kg K₂O/ha along with 40 kg N/ha, half as urea-N and remaining half as FYM slurry gave a yield advantage of 43% in *Stylosanthes hamata* + *Cenchrus ciliaris* pasture.

FYM and Fertilizers in Fodder-based Cropping System

Sorghum-berseem-pearl millet, fodder-based cropping system, gave higher gross monetary returns of Rs 59,340/ha, compared to sorghum-oats-pearl millet (Rs 27,080/ha) with 75% NPK + FYM at 10 tonnes/ha in *kharif* and *rabi*.

- During the year, 539 new, exotic and indigenous germplasm of different forage crops have been added at the IGFR and other centres.
- Sorghum inoculated with *Azotobacter* and berseem with *Pseudomonas* gave yield advantage of 7.1%, besides improving nutrient status of the soil.



Released forage crop varieties				
Crop/variety	Adaptation region/Agro-ecology	Yield	Duration	Other salient features
Central release				
Berseem : Bundel Berseem 3	For irrigated areas in the eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal, Orissa and Assam	Green forage 50.87 tonnes/ha	Seed to flowering is 155-170 days and seed to seed is 195-210 days (medium to late)	(i) Better than Wardan for green forage, dry matter and crude protein yield
		Dry matter 8.16 tonnes/ha		(ii) Immune to downy mildew and moderately resistant to root-rot
		Crude protein 1.25 tonnes/ha		(iii) Resistant to major insect-pests and moderately resistant to nematodes
		Seed 0.54 tonne/ha		(iv) Non-shattering type, resistant to lodging and responsive to recommended agronomic practices
State release				
Sorghum (Forage): TNFS 9602 as COFS 29	Tamil Nadu irrigated areas	Green forage 75.43 tonnes/ha	Seed to 50% flowering in 65-70 days and seed to seed 100-110 days	(i) Multicut, yields up to 5 cuts per year
		Dry matter 20.42 tonnes/ha		(ii) Tall growing, thin stemmed with profuse tillering (10-15), highly leafy
				(iii) Resistant to major diseases and insect-pests
				(iv) High crude protein content (8.41%)

Crop Protection

The root-rot disease in cowpea and berseem could be effectively controlled with neem cake at 1 tonne/ha and seed treatment with *Trichoderma harzianum* (fungi).

SUCCESS STORY

FORAGES ON BUNDS

Broad farm-bunds occupy about 6-10% of the cultivated lands in Bundelkhand and in many other parts of the country for minimizing run-off losses. This was perceived by many farmers as a net loss in actual cultivated area. Utilization of such bunds through growing of forages in a participatory mode in some villages around Jhansi (Uttar Pradesh) and Dharwad (Karnataka) was undertaken.

It was possible to apply participatory mode for judicious selection of tree and pasture species. The preference was for medium-height trees of fruit value, providing high and quick returns. Similarly, the choice was for a few pasture species; but *Stylosanthes hamata* was the unanimous choice.

PREFERRED SPECIES FOR FARM-BUNDS

Tree species

Jhansi	Dharwad
<i>Carissa carandus</i>	<i>Acharus sapota</i>
<i>Emblca officinalis</i>	<i>Mangifera indica</i>
<i>Psidium guajava</i>	
<i>Ziziphus mauritiana</i>	

Pasture species

Jhansi	Dharwad
<i>Brachiaria</i>	<i>Brachiaria</i>
<i>Cenchrus</i> sp.	<i>Pennisetum</i> TSH
<i>Pennisetum</i> TSH	<i>Stylosanthes hamata</i>
<i>Stylosanthes hamata</i>	



OILSEEDS

GROUNDNUT

Crop Improvement

An early-maturing (107 days), Spanish groundnut variety VG 9521 has been released for Tamil Nadu, Andhra Pradesh, Karnataka, Kerala and southern Maharashtra for *kharif*. VRI(Gn)5 for *kharif* and Co(Gn)4 for *kharif* and *rabi*/summer seasons have been released for Tamil Nadu.

PBS 24004 (tolerant to iron-deficiency chlorosis), PBS 30008 (narrow leaf mutant) and PBS 30017 (lemon yellow leaf mutant) have been registered with the NBPGR.

Crop Production

The epicuticular wax load (EWL) on leaf increased significantly with increase in plant age, and this increase was more pronounced in the crop subjected to protracted moisture deficit stress. Hence, EWL can possibly be used as a selection criterion for drought tolerance.

ICGS 44 withstood membrane injury due to high temperature and water deficit. This genotype would be promising in breeding for resistance to high temperature.

Pigeonpea ICPL 87 was found best for groundnut intercropping at Jalgaon and BDN 2 at Junagadh with higher net returns.

Groundnut+pigeonpea intercropping improved organic carbon content (0.41%), maintained higher available nitrogen (60 ppm) and enhanced activities of free nitrogen-fixing microbes in the soil (50.5×10^4 colony forming units per g of soil) as compared to sole groundnut, in which organic carbon content was 0.38%, nitrogen content was 56 ppm and N_2 -fixing microbes population was 5.1×10^4 .

Crop Protection

Seven advanced breeding lines ICGVs 93197, 92012, 91153, 92195, 92022, ALG 75 and VG 9711 have been found highly resistant to late leaf spot in natural and artificially inoculated conditions.

Mustard cake (50%) aqueous extract, obtained after soaking for 16 hr, inhibited spore germination of late leaf-spot and rust pathogen. Groundnut with pearl millet (3:1) + foliar spray of aqueous extract of mustard cake at 5% at 55 DAS significantly reduced intensity of early and late leaf spot diseases. For controlling late leaf spot and rust, one row of pigeonpea for every 3 of groundnut and one foliar spray of neem seed kernel extract (5% concentration) at 55 days after sowing have been found promising. This gave a cost : benefit ratio of 1 : 5 at Jalgaon.

RAPESEED-MUSTARD

Crop Improvement

Gobhi sarson (*Brassica napus*) TERI (OE) RO3 (TERI UNNAT), with low erucic acid (< 2%), has been identified for release. This also has high oleic acid (59.5%) with average yield of 1,113 kg/ha and its oil content is 41%. It matures in 134 days (9 days earlier than GSL a national check). Karan rai (*Brassica napus*) JTC 1 has been identified for rainfed areas. It gives a mean yield of 1,419 kg/ha and matures in 165 days. And another PC 5-17 has been recommended for rainfed and irrigated agro-ecologies with an average yield of 1,725 kg/ha in irrigated areas and of 1,515 kg/ha in rainfed area, besides oil content of 39.4%.

Crop Production

Guar (*Cyamopsis tetragonoloba*) - taramira (*Eruca sativa*) sequence with 40 kg S/ha to taramira has been found more remunerative than fallow-taramira sequence,

- An early-maturing, Spanish groundnut VG 9521 has been released for Tamil Nadu, Andhra Pradesh, Karnataka, Kerala and southern Maharashtra for *kharif*.
- Epicuticular wax load can be used as a selection criterion for drought tolerance in groundnut.

GROUNDNUT GENOTYPES IDENTIFIED FOR IMPORTANT TRAITS	
Ca-efficient	NRCG 7085-1, 6820, 6919, MOR 161, ICGHNG 88448
P-efficient	NRCG 7085-1, 1308, 6155, PBS 13, PBS 18057, 20016, MOR 204, PBS, 11037, 20016, 20057 and MOR 139
Tolerance to aluminium toxicity	ICG 813, 1001, 1021, 1048, 1056, 1064, 1355, 3606, 10964, 11183
High oil content (> 51%)	ICGV 86590, ICGS 1, ICGS 21, HNG (HPS) 2, GG 12 and CSMG 884

- Gobhi sarson TERI (OE) R 03 with low erucic acid (< 2%) has been identified for release.



and has been recommended for semi-arid eastern plains zone of Rajasthan. Jute (*Corchorus olitorius*)-toria (*Brassica campestris* var. toria), followed by rice (*Oryza sativa*)-toria, with 40 kg S/ha to toria proved remunerative and have been recommended for Assam.

- Soybean MAUS 61 with moderate resistance to soybean rust has been identified for southern Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and other parts of peninsular India.
- Hardee and Punjab 1 soybean showed lowest level of trypsin inhibitor. This trait will enhance food uses of soybean
- A tractor-drawn weeding machine for soybean rotary weeder, an intercrop seed-drill and a conservation seed-drill for soybean have been developed.

SOYBEAN

Crop Improvement

Soybean MAUS 61 with moderate resistance to soybean rust, has been identified for southern Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and other parts of peninsular India. The variety also possesses marginal yield superiority over ruling varieties. Soybean LSb 1 for Andhra Pradesh and Palam Soya for Himachal Pradesh have been released.

The National Active Germplasm Site (NAGS) of the National Research Centre on Soybean maintains nearly 2,500 germplasm lines collected/introduced from diverse sources. Superior breeding lines, Doko (Brazil) for resistance to mechanical damage; EC 391339, EC 394839 (PI 240644), EC 394837 (Sant Maria) for long juvenility; EC 34500 and DS 396 for insect resistance have been identified for use in breeding programmes.

Hardee and Punjab 1 showed lowest level of trypsin inhibitor among Indian varieties. This trait will enhance food uses of soybean.

Fourteen new soybean releases have been conserved at the National Gene Bank for the long-term storage.

Crop Production

In soybean-wheat system, application of FYM at 10 tonnes/ha along with recommended inorganic nutrients gave net returns of Rs 44,346/ha with C : B ratio of 1 : 2.16.

Significant soybean equivalent yield could be obtained in soybean-wheat cropping system than soybean-chickpea and soybean-mustard systems. Soybean-linseed system was comparable with soybean-wheat. Maximum net returns (Rs 23,743/ha) could be obtained in soybean-wheat system and the highest C : B ratio (1 : 3.26) was observed in soybean-linseed. The highest soybean equivalent yield was recorded with minimum tillage. This indicates the possibility of reducing tillage for crop sequence, and thereby minimizing cost of production.

A tractor-drawn weeding machine for soybean rotary weeder, an intercrop seed-drill and a conservation seed-drill for soybean have been developed. To facilitate spreading of organic manure uniformly in shorter time with efficiency, hydraulic

Rotary weeder (power weeder) tractor drawn for soybean



Intercrop seed-drill for soybean





trolley has been provided with a detachable attachment. This attachment facilitates uniform spread of manure. In a day of 8 hours, the machine can spread manure in 4-5 hectares. Food uses of soybean have been promoted through training and demonstrations.

Crop Protection

Bio-pesticide *Beauveria bassiana* formulation at 1 litre/ha before or after the spray of Triazophos (0.05%) has been highly effective in controlling major insect-pests.

Bt formulation (Dipel) has been found compatible with Monocrotophos, Topsin-M, Bayleton and Bavistin and also with a mixture of Monocrotophos and Topsin-M, Bayleton/Bavistin. However, mixture of Monocrotophos and Bayleton had synergistic effect, suppressing growth of Bt.

Seed treatment with Thiomethoxam 70 WS at 3 g/kg of seed, Carbosulfan 25 DS at 30g/kg of seed and soil application with Phorate 10 G (at 10kg/ha) and Carbofuran 3G at 30 kg/ha were highly effective in controlling damage (stem tunnelling) by stem-fly maggots.

Two sprays of Carbendazim or Thiophanate Methyl at 0.05%, at 35 and 50 DAS were effective and economical for management of *Myrothecium*, *Alternaria* and *Cercospora* foliar diseases.



Conservation seed-drill for soybean

- Stable CMS lines with cytoplasm and nuclear genome of Morden have been isolated and their isogenic fertile counterparts identified.

SUNFLOWER

Sunflower accessions DSI 34, DSI 91, DSI 107, Acc 1505, Acc 1485, Acc 179, DCMS 6, DCMS 14, CMS 335A, TUB 346, M 92-4 are found superior for agronomic and physiological performances. And 664, 1254, 1149, 1426, 138, 73 and 69 have been found highly tolerant to *Alternaria* blight; with less than 5% disease incidence.

The accession 866 was free from thrips and 1148, 1139-1, 1439 and EC 399459 had very low population (<1/plant). EC 399514, EC 376211 and EC 399459 are found promising against leaf hopper. White-fly population was nil in EC 399514 and in 864, 1254, 1149, 1464, 916-1, EC 399459, EC 399418, Acc 1142 and Acc 221, there was less than one white-fly/plant.

Stable CMS lines with *arg* cytoplasm and nuclear genome of Morden have been isolated and their isogenic fertile counterparts have been identified.

At Raichur, in sunflower - chickpea cropping sequence for sustainable production, it was possible to substitute 50% P needs of chickpea by seed treatment with phosphorus-solubilizing bacteria along with 5 tonnes/ha of farmyard manure, provided sunflower receives recommended P.

In Marathwada region of Maharashtra (Latur), incorporation of sunflower stalks, treated with cellulosic micro-organisms, was found reducing fertilizer needs of chickpea by 25% besides increasing profitability by Rs 700 to Rs 800/ha in sunflower-chickpea cropping sequence.

Imidacloprid 70WS at 5 g/kg of seed as seed dresser or Imidacloprid 200SL at 0.1 ml/litre of water as foliar spray at 15-20 days interval was observed to be effective against leaf hoppers and thrips besides reducing necrosis disease in sunflower during early stages.

Interspecific sunflower promising derivatives with resistance to *Alternaria*, downy mildew and rust



SAFFLOWER

A non-spiny safflower NARI 6, cross between Co1 and JL 8, has been found tolerant to *Alternaria* and *Cercospora* diseases. It matures in 135 days, and has an average yield of 1,024 kg/ha.

PH 6, a non-spiny hybrid, with 25 and 10% seed yield superiority to non-spiny check JSI 7 and spiny check A 1, has been identified for irrigated areas.

NARI-P 7, JLSF 416, GMU 6943, GMU 6957, GMU 6967, GMU 6968, GMU 6969 and GMU6980 have showed promise against foliar diseases.

- A non-spiny safflower variety NARI 6 and a hybrid PH 6 have been released.



PBNS 12 safflower with 12% yield superiority to national check A 1 has been identified for irrigated areas.

Sulphur fertilization up to 15 kg/ha at Phaltan and 45 kg/ha at Solapur and Tandur through single superphosphate significantly enhanced yield.

Seed treatment with *Azotobacter* or *Azospirillum* at Solapur could effectively substitute 50% N needs of safflower in rainfed areas.

- A protocol for castor transformation through *Agrobacterium*-mediated gene transfer has been optimized.
- Mutants of *Trichoderma viride* B 16 and *T. koningii* B 19 for castor-wilt management are found more virulent than their native isolates.

CASTOR

Three entries of castor RG 2528, RG 2529 and RG 2559 have been found wilt free. And RG 1713, RG 1726, RG 1741, RG 1743, RG 2088, RG 2040, RG 2377, RG 2522, RG 2535, RG 2559 and RG 2580 have showed resistance (<10 capsule infestation) to *Botrytis* in artificial screening.

A protocol for castor transformation through *Agrobacterium*-mediated gene transfer has been optimized. Best response was achieved with a titre of 1:20 and a cocultivation duration of 15 min.

To control castor semilooper, strain 4D21 of *Bacillus thuringiensis* (Bt) multiplied in the fermentor on molasses was tested at Govindhally and Palem in 0.5 acre each with 0.07% Endosulfan and 0.1% commercial *Bt* (HALT) as checks. Feeding cessation of larvae occurred within 2 hours and mortality was observed within 24 hours. Observations recorded at 2 days after spraying showed that *Bt* is on a par with Endosulfan check in terms of its efficacy against castor semilooper.

Mutants of *Trichoderma viride*-B16 and *T. koningii*-B19 have been developed through UV irradiation. They are found more virulent than native isolates and possess tolerance to Carbendazim.

LINSEED

Crop Improvement

Under NATP exploration programme, 88 local land-races have been collected from Orissa, West Bengal, Bihar and NEH region.

During 2000-2001, a total of 8.29 tonnes of breeder seed of 12 linseed varieties was produced against the indent of 4.72 tonnes.

Crop Production

At Raipur, sowing of double-purpose linseed in mid November with 67.5 kg of seed/ha was the best treatment to harvest better yields of seed and fibre.

SUCCESS STORY

FARMERS' PARTICIPATION IN SEED PRODUCTION OF CASTOR

The small and marginal tribal-farmers of Karkalpad, Narlakunta, Eluguralla and Gadamedi hamlets of Amangal Mandal in Mahaboobnagar district of Andhra Pradesh used to grow sorghum, vegetables, castor and rice. Castor is one of the important cash crops of farmers. Farmers being economically poor could not afford good quality seed of improved varieties/hybrids. A team of the scientists of Directorate of Oilseeds Research (DOR), prepared an action plan for production of castor seed by these farmers. Nearly 146 farmers were convinced about the seed-village concept to undertake seed production of DCS 9, a high-yielding castor. In this programme, the Andhra Pradesh State Seed Certification Agency

and M/s Vijayavardhini Oilseeds Growers Federation were associated for Seed Certification and procurement of surplus seeds. The breeder seed of DCS 9 was supplied by the DOR. The net area covered for seed production was 376 acres.

A total of 115 tonnes of seed could be produced, out of which 23 tonnes were procured by M/s Vijayavardhini Oilseed Growers Federation and 10 tonnes by the private companies. About 2 tonnes was kept by the farmers for their own use. Rest of the seeds were sold by farmers in the open market. These farmers have now formed their own Cooperative Society for seed production to extend seed production activities further.



Released linseed varieties				
Variety	Area of adaptation	Average seed yield kg/ha	Days to maturity	Salient features
Shekhar (LCK)	Uttar Pradesh excluding Bundelkhand, Bihar, West Bengal and Assam for irrigated and rainfed areas	1,555 (Irrigated) 920 (Rainfed)	135-140	Resistant to powdery mildew, rust and wilt. Oil content is 43%
NL 97 (State release)	Rainfed areas of Maharashtra	800-1,000	115-120	Moderately resistant to powdery mildew, wilt, linseed bud-fly. Oil content is 42%

LINSEED-RESISTANT GENOTYPES

Wilt :	BAU 927, CI 2227, Coyat, EC 589
<i>Alternaria</i> blight :	Ayogi, BAU 610 A, ES 44, LCK 9816
Powdery mildew :	Ayogi, KL 178, KL 209, LCK 89512, LCK 9211, NDL 97-5
Rust :	KL 178, LCK 9826, RL(U) 6, DPL 14, Nagarkot, Surabhi

Seed rate of 75 kg/ha of double-purpose linseed at Palampur along with 60 kg N/ha gave highest seed and fibre yield of better quality.

Crop Protection

Linseed intercropped with chickpea (3:1) at recommended fertilizer (N 60-80, P 40 kg/ha) and irrigation (two to three), bird perches at 40-50 pegs/ha and a single application of Imidacloprid 200 SL at 100 ml/ha at ET level of 10% bud-fly infestation has been found the best module against bud-fly.

SESAME

Crop Improvement

JTS 8 has been released and notified for cultivation in the arid and semi-arid ecosystems of Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka.

Over 3 tonnes of breeder seed of 24 varieties was produced against the DAC indent of 0.65 tonnes.

Crop Production

Single superphosphate or elemental sulphur or gypsum significantly increased sesame yield.

Sesame + urdbean (3:3) intercropping at Vridhachalam, sesame - clusterbean (4:1) at Tikamgarh, sesame + cotton (3:1) at Amreli, sesame + urdbean (2:2) at Powerkheda have been found the most remunerative systems.

Crop Protection

SI 250 and IC 204137 lines have been found tolerant to *Antigastra*, and IC 205071 has been identified as promising with resistance to *Antigastra* and *Dasyneura*. Two sprays of Endosulfan (0.07%) at 30 and 45 DAS proved most effective, followed by neemgold, neem oil and neem formulation for controlling leaf roller/capsule-borer and bud-fly.

Advance breeding materials i.e. RT 46, RT 54, RT 103, RT 125 and VRI 1 have been found resistant to phyllody and moderately resistant to *Macrophomina* stem/root-rot. RT 325 and PKDS 5 have showed moderate resistance against *Macrophomina* stem/root-rot and phyllody.

- Released JTS 8 sesame for arid and semiarid ecosystems of Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Gujarat, Andhra Pradesh and Karnataka.
- Single superphosphate or elemental sulphur or gypsum at 15 kg sulphur/ha significantly increased sesame yield.
- Identified Gujarat Niger 1, an early-maturing niger, for cultivation in south-western tribal areas of Gujarat.



JNC 6 niger a composite of 7 genetically diverse strains with wide adaptability and resistance to biotic and abiotic stresses has been identified for release at the national level

NIGER

A high-yielding, early-maturing Gujarat Niger 1 has been identified for cultivation in south western tribal areas of Gujarat. JNC 6 a composite of 7 genetically diverse strains with wide adaptability and resistance to biotic and abiotic stresses has been identified for release at the national level.

Over 0.7 tonne of breeder seed of 4 varieties was produced against the DAC indent of 0.36 tonne.

PULSES

CHICKPEA

Crop Improvement

- Identified RSG 888 chickpea for rainfed areas of Punjab, Haryana, Rajasthan and western Uttar Pradesh and HK 94-134 bold-seeded kabuli variety for irrigated areas of eastern Uttar Pradesh, Bihar, West Bengal and Assam.
- Pigeonpea Laxmi for Andhra Pradesh, resistant to sterility mosaic and wilt, and AKT 8811 for Maharashtra, tolerant to *Fusarium* wilt, have been released.
- Pigeonpea sowing on ridges reduced incidence of *Phytophthora* blight by 50% compared with flat sowing.

RSG 888, a pedigree selection from RSG 44 × E 100Y, has been identified for rainfed areas of Punjab, Haryana, Rajasthan and western Uttar Pradesh. The variety showed good level of resistance to dry root-rot and moderate against wilt. It matures in 150-160 days with average yield of 2.1 tonnes/ha.

HK 94-134, a bold-seeded (26.7 g/100-seed) kabuli variety from a three-way cross (H 82-5 × E 100 Ym) × Bhim has been identified for irrigated areas of eastern Uttar Pradesh, Bihar, West Bengal and Assam. It matures in 120-140 days and gives an average yield of 1.5 tonnes/ha.

Some of the promising donors having multiple disease resistance are IPC 97-1 and BGD 12 (wilt, collar-rot, dry root-rot and *Ascochyta* blight); FG 712 (wilt, collar-rot and *Ascochyta*); and IPC 97-7 (wilt and collar-rot).

Chickpea CSJ146, Phule G 92926 and Phule G 93118 are found tolerant to both *Meloidogyne incognita* and *M. javanica*. BG 1033 showed consistently less pod-borer damage.

Of the 45 varieties, 31.23 tonnes of breeder seed have been produced against the DAC indent of 26.27 tonnes.

Crop Production

Use of 2 tonnes of vermicompost significantly improved grain yield of chickpea.



IPC 97-1 chickpea showing wilt resistance in wilt-sick plot. This variety shows resistance to not only wilt but to collar-rot, dry-rot and *Ascochyta* blight



Intercropping chickpea KWR 108 with linseed Neelam in 4:2 ratio gave maximum chickpea equivalent yield with higher net monetary returns.

In chickpea, osmotic adjustment has been positively correlated with drought tolerance and grain yield. Early flowering genotypes ICC 4958, ICCV 92944 and ICCV 94916 have been best adapted to rainfed areas due to their high root biomass, low canopy temperature and maintenance of higher turgor and leaf water potential during terminal drought.

Crop Protection

At least 5 pathotypes of *Fusarium oxysporum* f. sp. *ciceri* are suspected to be present in the country.

Chickpea PG 95007, PBG 126, FG 703, ICC 10149, H 82-2, H 92-71, GNG 1000, ICC 11441, BG 372 and G 91061 have been identified as resistant to wilt. And GCP 9504, H 92-71, FG 711 and FG 712 have showed multiracial resistance against *F. oxysporum* f. sp. *ciceri*.

Trichoderma harzianum has been more effective than *T. viride* in inhibiting growth of isolates of *Fusarium oxysporum* f. sp. *ciceri*.

Seed treatment with Carbosulfan 25 ST at 3% reduced root-knot nematode population.

At IIPR, Kanpur, Lufenuron and Acephate effectively reduced pod damage. β -Cyfluthrin 18.75 g a.i./ha and Koranda are found superior to Endosulfan in controlling *Helicoverpa armigera*.

PIGEONPEA

The year 2000-2001 has not been congenial for pigeonpea due to moisture stress in the central and south India, in spite of moderate infestation of *Helicoverpa* and other pests.

Crop Improvement

Released varieties of pigeonpea				
Variety	Adaptation region/agro-ecology	Yield (tonnes/ha)	Duration (days)	Salient features
Laxmi (ICPL 85063)	Andhra Pradesh	1.8-2.0	175-180	Resistant to sterility mosaic disease and tolerant to wilt disease
AKT 8811	Maharashtra	1.1-1.3	140-150	Tolerant to <i>Fusarium</i> wilt

CMS 288 A and 67 A pigeonpea have proved to be stable across the locations. The notable achievement is the identification of 18 fertility restorer lines against CMS 288A.

Breeder seed of 23.36 tonnes of 29 varieties has been produced against the DAC indent of 8.85 tonnes.

Crop Production

Intercropping pigeonpea in mungbean/urdbean/soybean has proved superior to sorghum or pearl millet, and 2% urea spray at 15 and 45 days after harvest of intercrop could increase yield of pigeonpea.

Zinc sulphate at 15 kg/ha along with the recommended NPKS at (20-18-27-20) increased productivity up to 28%. New strains of rhizobium A-5, A-7, RAU-10, BPR-9804 and 9806 have showed promise.



Pigeonpea KPL 44. It shows resistance against wilt, *Phytophthora* blight and sterility mosaic disease



PIGEONPEA GENOTYPES RESISTANT TO DISEASES IDENTIFIED

MAL 13, RA 6, JKM 1, JKM 169, KPL 143 and KPL 44	<i>Fusarium</i> wilt
OGUK 1, MA 6, KPL 43, KPL 44, MAL 15, Pusa (B) 34, Pusa (B) 35, IPA 98-3 and RA 6	Sterility mosaic
KPL 43, PP 16 K, PP 17 K, PPKL 6 and PSMR 2006 K	Multiple resistance to wilt and sterility mosaic and tolerance to <i>Phytophthora</i> blight diseases

Crop Protection

Pigeonpea sowing on ridges reduced incidence of *Phytophthora* blight by nearly 50% as compared to flat sowing.

MAL 9 was found resistant to pigeonpea cyst nematode (*Heterodera cajani*) and Pusa (B) 35 exhibited tolerance to cyst and root-knot nematodes KPL 43 and GPS 33 also showed resistance to root-knot nematode.

Carbofuran at 2 kg a.i./ha to soil and seed treatment with Monocrotophos at 0.1% for 6 hours increased yield of pigeonpea by 38.9 and 18.6% over control in root-knot nematode infested fields.

MUNGBEAN AND URDBEAN

Crop Improvement

Mungbean ML 818 selected from 5145/87 × ML 267 has been identified for Punjab, Haryana, western Uttar Pradesh and Rajasthan. It is resistant to yellow mosaic virus, *Cercospora* leaf spot and bacterial leaf spot and matures in about 85 days and gives an average yield of 1.25 tonnes/ha.

Urdbean KU 300 developed through pedigree selection from T 9 × 7378/2 has been identified for Punjab, Haryana, western Uttar Pradesh and Rajasthan. It has showed resistance to yellow mosaic virus and is suitable for spring with an average yield of 1.1 tonnes/ha.

Crop Production

Sulphur at 20 kg/ha, half as basal and half as side-dressing increased grain yield by 20% over full dose as basal.

Urea 2% foliar spray at flowering and pod development stages increased grain yield of *rabi* mungbean and *rabi* urdbean in peninsular India.

Crop Protection

Mungbean UPM 98-1, M 267, ML 881 and MH 98-1 have been identified as resistant to mungbean yellow mosaic virus and anthracnose.

- Identified mungbean ML 818, which shows resistance to yellow mosaic virus, *Cercospora* leaf-spot and bacterial leaf-spot, for Punjab, Haryana, western Uttar Pradesh and Rajasthan.
- Intercropping of mungbean and urdbean with soybean or pearl millet reduced pod-borer damage.

Resistant donors identified in mungbean and urdbean

Resistant to	Mungbean	Urdbean
Yellow mosaic virus	UPM 98, UPM 98-1, PMB 63, ML 818	KU 96-3, PLU 63
<i>Cercospora</i> leaf spot	UPM 98-1, HUM 7, PDM 96-262	-
Powdery mildew	UPM 98-1, HUM 7, PMB 63, ML 131	TU 99-852, TU 843
Pod-borer	ML 818, ML 131, Pusa 105, BM 4, HUM 7, Pusa 9771	AKU 18, TU 9814, OBG 16, TAU 2



Two sprays of Carbendazim (0.05%) were effective and economical against web-blight and one was effective against powdery mildew.

Urdbean IPU 91-3, IPU 91-711, IPU 94-1, IPU 94-2, IPU 94-4, IPU 96-123, IPU 97-73, DPU 88-1 and DPU 88-31 are found resistant against mungbean yellow mosaic virus under high disease pressure. And KU 96-3, PLU 277 and PLU 461 are found resistant against MYMV and anthracnose.

Intercropping in pearl millet or soybean reduced pod-borer damage in mungbean and urdbean. λ -Cyhalothrin at 0.04% in mungbean gave maximum pod-borer control. Foliar spray with NSKE (5%) + λ -Cyhalothrin (0.02%) gave maximum control of pod-borer with higher grain yield in urdbean.

LENTIL

For lentil breeding, resistant sources for wilt and root-rot are IPL 128, PL 131, PL 95-16, L 5258 and L 4659 and for collar-rot and rust are IPL 128, IPL 133 and PL 95-16. DPL 25 and DPL 58 have showed consistent resistance against rust.

Even though there is a 16-17% reduction in seed germination, still seed treatment with kerosene oil (2-5%) has been effective in reducing wilt by 31-46% with consequent yield increase of 48-52%. Seed treatment with Carbendazim (Bavistin 50 WP) + Thiram (Thiram 75 DS) at 0.1% each significantly controlled wilt (39-51%) and increased seed yield (86-154%).

Two sprays of zinc sulphate (0.1%) controlled rust to the extent of 54% over unsprayed crop, and resulted in 10% additional yield with cost : benefit ratio of 1:1.75.

RAJMASH

IIPR 96-4, a selection from exotic line ET 8447, has been identified for eastern Uttar Pradesh, Bihar, West Bengal and Orissa. It has 11.4% yield superiority over check PDR 14, and matures in 135-140 days. It has showed resistance against bean common mosaic virus (BCMV) and leaf crinkle. Seeds are medium bold (38 g/100-seed) and are variegated red in colour.

Nimbecidine 0.2%, Ahook 0.5%, neemgold 0.5%, all neem-based pesticides, are superior in controlling major insect-pests.

ET 8497, ET 8430, ET 8411, ET 8416, ET 8447, PJ 164631 and Vermelho 2152 have showed resistance to BCMV.

Rajmash grains infected with *Sclerotinia sclerotiorum* placed at the hypocotyl region of the plant has been found most effective technique for screening resistant genotypes in pot culture.

- IIPR 96-4 rajmash, showing superior yield performance over check PDR 14, has been identified for eastern Uttar Pradesh, Bihar, West Bengal and Orissa.

- Identified IPF 27 fieldpea with a yield potential of 2.8-3.0 tonnes/ha.
- Two sprays of $ZnSO_4$ (0.1%) were effective against rust, besides being highly safe and eco-friendly.

FIELDPEA

IPF 27, a pedigree selection from Rachna × Kiran, has been identified for eastern Uttar Pradesh, Bihar, West Bengal and Assam. Besides resistance to powdery mildew and tolerance to rust, it has yield potential of 2.8-3.0 tonnes/ha. Its seeds are white, round and medium bold (19 g/100-seed).

HUDP 17, HUDP 16, DMR 38, IPF 27, IPF 14, KPMR 569, Pant P 11, DDR 41, DMR 7 and DMR 45 have been identified as donors against rust and DDR 49, DDR 39, HUP 2, HUDP 15 and DMR 38 against pod-borer.

Pendimethalin at 0.75 kg/ha as pre-emergence herbicide coupled with hand weeding 30 days after sowing increased mean yield of dwarf peas by about 30% over control.

JP 9, NIC 20395, DPFPD 62, KPMR 8, JP 181, JP 50 A, K 9, KSP 11, KSP 22, KPMR 65-1 and PM 5 showed stable resistance against rust and powdery mildew.

Two sprays of zinc sulphate (0.1%) were effective against rust in fieldpea, besides being highly safe and eco-friendly.



IPF 27 fieldpea is a pedigree selection from Rachna x Kiran. It shows resistance to powdery mildew and tolerance to rust, with a yield potential of 2.8-3.0 tonnes/ha. It has been identified for eastern Uttar Pradesh, Bihar, West Bengal and Assam



- Pre-cooking water soaking of lathyrus dal for 4-6 hr reduced 27-30% β -oxalyl diamino propionic acid, a neurotoxic compound.

LATHYRUS

Lathyrus lines RLS 1186, IPLY 99-7 and IPLY 99-9 have been identified for resistance against powdery mildew.

Pre-cooking water soaking of decorticated split seed (dal) of lathyrus for 4-6 hr resulted in 27-30% losses of β -oxalyl diamino propionic acid (ODAP), a neurotoxic compound present in lathyrus.

ARID LEGUMES

Crop Improvement

Mothbean RMO 435, maturing in 62-65 days, with yield of about 500 kg/ha has been identified for rainfed areas. It has field tolerance to yellow mosaic virus.

Clusterbean RGC 1017, identified for Rajasthan, Haryana and Gujarat, matures in 92-96 days. It shows 18% higher average yield over national check RGC 936. It contains 34.1% endosperm, 31.0% crude protein and 29.4% galactomannan gum.

Breeder seed of clusterbean RGC 936, RGC 197, RGC 986, RGC 1003 and GAUG 34 have been produced to the tune of 17.4 tonnes, of cowpea C 152, Vamban 1, RC 19 and GC 3 to the extent of 2.88 tonnes and of mothbean RMO 40, RMO 257, RMO 225, IPCMO 912, Jawala, FMM 96 and CAZRI Moth 1 around 4.26 tonnes.

Crop Production

At Bangalore and Pattambi, horsegram PHG 9 with recommended 20 kg N + 25 Kg P_2O_5 + 10 kg K_2O + weed control and plant protection could yield 72.1% higher over recommended dose of fertilizer alone.

On cowpea, spray of 500 ppm thiourea at vegetative and flowering stages proved effective in giving higher yield (19.0%) compared to control at Hisar and Durgapura.

Sulphur at 40 kg/ha increased grain yield of guar by about 33.0% over 20 kg S/ha at Bikaner and Gwalior. Further 50% S through gypsum and 50% through elemental form proved most effective.

Crop Protection

In nutrient-deficient soils, inoculation of *Mycorrhiza*, *Azotobacter* and *Rhizobium* in guar resulted in the best management of root-rot diseases.

In cowpea, Thiram at 3 g/kg of seed, followed by 3 sprays of Carbendazim at 15 days interval, starting from 15 days of seedling emergence, has been effective in decreasing root-rot infection.

Cowpea GC 9714 proved quite resistant to storage grains pest (*Callosobruchus chinensis*).

Quality Aspects

In normal maturing group of cowpea genotypes, V 585 had maximum crude protein (27.3%), lower value of cooking time (16 min.) and *in-vitro* protein digestibility (IVPD) contents (46.5%).

Mothbean RMO 435, CZM 35 and CZM 57 have showed maximum crude protein, to the extent of 27.0%. In IVPD, CZM 35 (53.2%) and RMG 24 (52.8%) were better.

- Mothbean RMO 435, CZM 35 and CSM 57 showed maximum crude protein, to the extent of 27%.
- In nutrient-deficient soils *Mycorrhiza*, *Azotobacter* and *Rhizobium* inoculation to guar helped in management of root-rot diseases.



COMMERCIAL CROPS

COTTON

Crop Improvement

Pratima, a *Gossypium hirsutum* variety, and Bunny, an intra-*hirsutum* hybrid, have been released for commercial cultivation in the irrigated tracts of south zone.

A *G.hirsutum* high-yielding, medium-staple, early-maturing CNH 120 MB has been identified for release in Tamil Nadu, Karnataka and Andhra Pradesh.

Hybrid CSHH 25, resistant to cotton leaf curl virus (CLCuV), has showed an increase of 14.63% 59.59% and 66.93% for seed-cotton yield over hybrids LHH 144, HHH 81 and Raj HH 16. It is proposed for release in Haryana and Rajasthan.

A 'desi' genotype DLSA 17 developed by the CICR, Nagpur, has recorded a seed-cotton yield of 1,955 kg/ha, and has also showed fibre quality characters at a par with *G.hirsutum*.

A new source of cytoplasmic male sterility with *aridum* cytoplasm has been developed at the CICR, Nagpur.

Crop Production

Deep tillage once in 2 years plus conventional tillage had led to significantly higher seed-cotton yield in Faridkot and Sriganaganagar. Use of drip irrigation system in Surat and Dharwad Centres led to higher yields, besides saving in water by 25%. Urea (2%), DAP (2%), KNO₃ (1%), ZnSO₄ (0.5%) and MgSO₄ (1%), when applied to leaves, were superior in enhancing seed-cotton yield by 15-20%.

Pendimethalin, Fluchloralin, Haloxyfop, Roundup and Prometryn were efficient in controlling weeds economically.

Potato intercropping in cotton, a novel approach, gave higher profits in Dharwad. Soybean, mungbean and maize were found profitable for strip-intercropping in cotton in Guntur, Andhra Pradesh. Cotton-wheat, cotton-raya cropping system for north zone and cotton-sunflower and cotton-chickpea for Karnataka in the south zone have been identified as efficient double crop sequences.

A two-row, cotton planter for small farmers of Vidarbha and Marathwada regions of Maharashtra and also for dryland areas of Madhya Pradesh, Karnataka and Andhra Pradesh, especially for vertisols, has been developed at the CICR, Nagpur. The implement weighs 50 kg and is pulled by a pair of bullocks. It can cover 1 hectare in 2 hours. The row-to-row spacing is kept at 60 cm, while seed-to-seed spacing varies from 30 cm to 120 cm.

At Coimbatore, cotton-sorghum produced higher seed-cotton yield with more residual NPK left in the soil than cotton-fallow-cotton sequence.

Crop Protection

Spinosad and Indoxacarb insecticides were effective against bollworms more particularly to *Helicoverpa armigera*. New chemicals Bifenthrin and F 6028 showed high efficacy against bollworms and recorded high seed-cotton yield.

Three RAPD fragments have been sequenced to design primers that are used as SCAR markers in molecular diagnostic kits to detect frequency of pyrethroid resistance in field population of *Helicoverpa armigera*. This is a significant step for developing a field usable, and cheaper technology for detecting insecticide resistance in cotton.

SUGARCANE

Crop Improvement

A total of 28,419.1 g of fluff from 504 crosses has been despatched to 19 centres, representing 5 agroclimatic zones. The National Hybridization Garden 2001 has

- Released Pratima (a *Gossypium hirsutum* variety) and Bunny (an intra-*hirsutum* hybrid) for commercial cultivation in irrigated tracts of south zone.
- Developed a new source of cytoplasmic male sterility in cotton with *aridum* cytoplasm.
- A novel approach of potato intercropping in cotton gave higher profits in Dharwad.
- Developed a two-row, bullock-drawn cotton planter, especially for small farmers cultivating on vertisols.
- New chemicals Bifenthrin and F 6028 showed high efficacy against bollworms and recorded high seed-cotton yield.
- Sequenced 3 RAPD fragments for primers to be used in molecular diagnostic kits to detect pyrethroid resistance in *Helicoverpa armigera* population.

- Co 89029, Co Se 95422 and Co Se 92423 sugarcane, moderately resistant to red-rot, released for commercial cultivation.
- Recommended Co 86032 and Co 8021 sugarcane for iron-deficient soils.



Co 86032 sugarcane is grown in wide rows of 150 cm, and is recommended for cultivation in the iron-deficient soils

Sugarcane varieties released for commercial cultivation

Variety	Area of adaptation	Cane yield (tonnes/ha)	Sucrose (%)	Maturity group	Reaction against disease
Co 89029 (GANDAK)	Eastern Uttar Pradesh, Bihar, West Bengal	70.62	16.29	Early	Moderately resistant to red-rot
CoSe 95422 (RASBHARI)	Eastern Uttar Pradesh, Bihar, West Bengal	67.78	17.66	Early	Moderately resistant to red-rot and smut
CoSe 92423 (RAJBHOG)	Eastern Uttar Pradesh, Bihar, West Bengal	70.11	17.50	Mid late	Moderately resistant to red-rot

been planted with 402 clones, comprising Co canes (87), state clones (263), HR types (2), ISH types (30), foreign hybrids (16) and miscellaneous (4).

A total of 114 mericlones flasks have been supplied to sugar factories of Tamil Nadu, Gujarat and Maharashtra.

Crop Production

Linseed Garima, which required 46 kg N/ha as top-dressing, intercropped in autumn sugarcane CoS 95255 at 75 cm was quite remunerative, as linseed yield of 1.5 tonnes/ha generated Rs 15,000/ha as mid-season income.

Co 86032 and Co 8021 sugarcane were recommended for cultivation in iron-deficient soils.

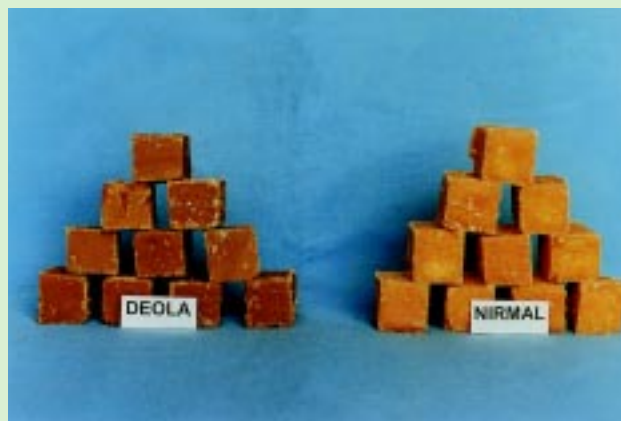
Carbendazim at 0.025% gave maximum control of smut at the majority of the locations. Sprouting of setts and cane yield improved with this. Tilt (0.2%) and Bayleton (0.2%) also effectively controlled smut disease.



Seedlings from sugarcane fluff in the mist chamber



SUGARCANE PRODUCTS



Crop Protection

Indirect-ELISA technique has been standardized for diagnosis of sugarcane ratoon stunting disease bacterium. The technique was sensitive to asymptomatic sugarcane stalks.

Laboratory parasitization rates of *Sturmiopsis inferens* on shoot-borer by Scaramuzza technique gave been generally higher than those noticed by King's method.

JUTE AND ALLIED FIBRES

Crop Improvement

A new high-yielding tossa jute JRO 128 has been developed from a cross between TJ6 and Tanganyika 1, and has been released for general cultivation. It is recommended for sowing in mid-March without the risk of early flowering and can be accommodated in multiple cropping system. The variety produces stronger (26-29 g/tex) and fine quality fibres (2.0-2.5 tex) of TD2 grade.

Tan/X/087 and JRO 524 for fibre percentage, JRO 3352 for base diameter and stick weight and JRO 878 for plant height and stick weight have been identified as good general combiners. Hybrids from Selection 2 × JRO 878, JRO 52 × JRO 524, JRO 52 × JRO 878, KEN/SM/004 × JRO 524 and KEN/SM/024 × JRO 878 have showed positive and numerically higher specific combining abilities, which are carried forward.

In mesta (*Hibiscus sabdariffa*) in advance varietal trial-II, AMT (3.0 tonnes/ha) and AM 4 (2.85 tonnes/ha) outyielded best check at the CRIJAF, and at Amadalavalasa (Andhra Pradesh), AHS 85 (3.61 tonnes/ha) was promising.

In Sunnhemp, IET SH 12 recorded a very high yield of 2.31 tonnes/ha at Coohbehar.

Crop Production

In medium land in waterlogged areas with 22-30 cm water-depth for 50 days (from 60 days after sowing to 110 days of crop harvest), JRO 524 (*olitorius* jute) yielded 1.73 tonnes/ha against Hybrid C (Padma) (*capsularis* jute) recommended for such a situation in north Bengal, Bihar, U.P. and Assam.

For seed production, sowing in mid-June and detopping at 45 days age have been most beneficial for *capsularis* and *olitorius* jutes at Aduthurai (Tamil Nadu)

- Released for general cultivation tossa jute JRO 128 can be sown in mid March without the risk of early flowering.
- Spraying Cofider at 5 ml/litre effectively controlled mealy bug of mesta at Andhra Pradesh.



- Flue-cured tobacco K 326 (NLS 4) produces semi-flavoured, suitable for export, tobacco.
- Developed interspecific hybrids for the first time from a trispecific cross (*Nicotiana benthamiana* - *repanda*) x *N. gossei*.
- In tobacco, damping off could be controlled to the extent of 91.4% with polythene mulching of nursery beds for 4 weeks and soil amendments with neem cake at 0.2%.
- Carcinogenic tobacco specific nitrosamines were below detectable limits in tobacco K 326, Bhavya and Ratna in Karnataka light soils.
- Solanesol, a trisesquiterpenoid alcohol from tobacco, is the starter for anti-cancer drug potentiating agents like N-solanesyl-N, N1-bis ethylene diamine.



Chewing tobacco Abirami (HV 86-5) has been identified for north Bengal, Tamil Nadu and north Bihar



Flue-cured CY 79 has been identified for southern light soils and southern black soils of Andhra Pradesh with conserved soil-moisture

and Rahuri (Maharashtra). At Purulia (West Bengal), 1.1 tonnes of seed per hectare of *capsularis* were obtained. This indicates very good prospect of jute seed production of *capsularis* type in drier tracts.

Crop Protection

Jute seeds when dressed with *Trichoderma* and *Azospirillum* controlled root-rot and sunnhemp dressed with *Bradyrhizobium japonicum* and *Aspergillus niger* strain-27 controlled wilt, besides promoting plant growth.

Spraying Cofider at 5 ml/lit. has been most effective against mealy bug of mesta at Andhra Pradesh.

TOBACCO

Crop Improvement

Chewing tobaccos Dharla (Sel. 8-4-1), Abirami (HV 86-5) and Lichchivi (PS 14) have been identified for north Bengal, Tamil Nadu and north Bihar. Flue-cured CY 79 has been identified for southern light soils and southern black soils of Andhra Pradesh in the conserved soil-moisture areas.

The released flue-cured tobacco K 326 (NLS 4) produces semi-flavoured, suitable for export, tobacco.

Advanced burley breeding line BSRB 2, an interspecific derivative, having resistance to blackshank, introgressed from *Nicotiana plumbaginifolia*, performed well in on-farm trials and bulk trials at the BTRC, Jeddangi. Interspecific hybrids of a trispecific cross (*N. × benthamiana* - *repanda*) x *N. gossei* could be obtained for the first time.

Country cheroot tobacco HV. 97-10 and HV. 97-7 are promising for higher yield and better smoking quality.

Crop Production

Urdbean during *kharif* and FCV tobacco in *rabi* recorded higher net returns with a cost : benefit ratio of 1 : 1.62, closely followed by maize+soybean during *kharif* and chickpea during *rabi* with cost : benefit ratio of 1 : 1.20.

Modified flue-pipe system of tobacco curing designed by TIDE, Bangalore, gave about 25% saving in wood fuel consumption in Karnataka compared to the conventional flue-pipe system.

SUCCESS STORY

SOLANESOL FROM TOBACCO

Tobacco is a rich source of solanesol, a trisesquiterpenoid alcohol, which is the starting material for synthesis of Coenzyme Q9, Coenzyme Q10, Vitamin K2 and anti-cancer drug potentiating agents like N-solanesyl-N, N1-bis (3, 4-dimethoxybenzyl) ethylene diamine.

Raw materials rich in solanesol have been identified. Chewing tobacco Abirami grown in Tamil Nadu, and HDBRG tobacco cultivated in Andhra Pradesh contain 3.20% solanesol. Germplasm lines T1-163 and T1-1112 with a solanesol content of 2.50% have been identified.

A process, developed for extraction of solanesol (95%) with an overall recovery of 72%, has been developed. Addition of reactive linkers to solanesol have helped in hooking functional groups, amines, phenols and alcohols, paving the way for new bioactive compounds.





ECONOMICAL RECOMMENDATIONS FOR FARMERS OF MIDDLE GUJARAT FOR RAISING TOBACCO NURSERY FREE OF *SPODOPTERA LITURA*

- Apply two sprays of neem-based formulations, either NSKS @ 10/kg (ICBR 1 : 399) or Azadex @ 1.0 l/ha (ICBR 1: 236) or Nimbecidine @ 1.5 l/ha (ICBR 1 : 135). First spray is to be given 20 days after germination and second spray 10 days after the first spray.
- Alternatively, one application of Dipel @ 0.75 kg/ha (ICBR 1 : 209) or Bioasp @ 0.75 kg/ha (ICBR 1 : 113) after 30 days of sowing of seeds in nursery; or two sprays (20 and 30 days after germination) of Cypermethrin 0.01% (ICBR 1 : 272) or Polytrin-C 0.0495% (ICBR 1 : 204) or Spark 0.036% (ICBR 1 : 191) or Deltamethrin 0.0028% (ICBR 1 : 185) or Chlorpyrifos 0.04% (ICBR 1 : 175) are recommended.

At Nipani, Napropamide at 1.24 and 1.50 a.i. kg/ha gave significantly higher transplantable seedlings than other treatments. At Anand, Stomp 1.5% in combination with urea (2%) controlled suckers effectively, and thereby increased the yield of bidi tobacco.

Tobacco-groundnut (summer) system realized maximum net returns, followed by castor-groundnut (summer) and cotton-groundnut at the BTRS, Anand.

Crop Protection

On FCV tobacco, spray of Profenofos (0.15%), followed by Leufenuron (0.005%) or Ha NPV (250 LE/ha) or *Bacillus thuringiensis* var. *kurstaki* (1.5 kg/ha) was effective in managing *Helicoverpa armigera*.

Score 10% WP (Difenconazole) effectively controlled anthracnose and frog-eye-spot in tobacco nurseries.

Polythene mulching of nursery beds for 4 weeks and soil amendment with neem-cake at 0.2% controlled damping-off disease to an extent of 91.4% at the Regional Research Station, Shimoga. At Anand, soil solarization with clear LLDPE plastic film (25mm) for 15 days during summer, followed by Metalaxyl MZ at 2.16 kg/ha (Ridomil MZ 72 WP at 3 kg/ha) at initiation of damping-off, followed by Bordeaux mixture at 0.6% (ICBR 1:4.25), showed promise.

Tobacco specific nitrosamines (TSNA) are considered carcinogenic in tobacco. The levels are below the detectable limits in Karnataka light soils in K 326 (NLS 4), Bhavya and Ratna (1 CH6534).

SEED PRODUCTION TECHNOLOGY

BREEDER SEED PRODUCTION

During 2000-2001, a total of 2,379.32 tonnes of breeder seed of different crops have been produced. Major quantities belonged to cereals (954.12 tonnes) and oilseeds (877.83 tonnes), followed by pulses (474.33 tonnes), forages (39.46 tonnes) and fibres (33.60 tonnes).

Seed Technology

Hybrid seed production technology: In rice, results generated have indicated that flag leaf is a good indicator for panicle emergence in A, B and R lines. Hence, it could be used for obtaining synchronization in flowering of male and female lines through staggered planting.

Micronutrient (Borax 0.25-1.00%) and growth regulator (TIBA at 22-75 ppm) spray in sunflower could enhance seed quality as vigour index. Seed hydration combined with 2% urea spray at button formation helped to bring synchronization of flowering (advance flowering by 3-5 days in late parent) in parental lines of sunflower hybrid DSH 1.



Modified flue-pipe system of tobacco-curing, designed by the TIDE, Bangalore, gives about 25% saving in wood fuel consumption in Karnataka compared to conventional flue-pipe system

- Flag leaf in rice indicates panicle emergence in A, B and R lines. This can be used for synchronization in flowering of male and female lines through staggered planting.
- In HHB 94 pearl millet, male: female planting ratio of 2:10 has showed promise for hybrid seed production.
- Economics of hybrid seed production shows cost:benefit ratio of 1:1.8 for cotton (Hyderabad); 1:2.41 for castor (Jamnagar); 1:1.69 for pearl millet (Rahuri) and 1:1.67 for sunflower (Bangalore *rab*).



In pearl millet, a planting ratio of 2:10 (male : female) for HHB 94 at Hisar and 2:16 for hybrid Saburi at Rahuri have been found promising and recommended. Economics of hybrids seed production have showed maximum cost:benefit ratio of 1:1.8 for cotton (Hyderabad); 1:2.41 for castor (Jamnagar); 1:1.67 for pearl millet (Rahuri) and 1:1.67 for sunflower (Bangalore, *rabi*).

Seed storage: Breeder and certified seeds of soybean should be packed in poly-lined jute canvas bags after drying to 9% m.c. to retain its viability during validation period.

Seed health: In the seed of poor storer line 6D-1, the restorer parent of sunflower hybrid KBSH 1, germination can be maintained by proper seed drying at 9% moisture and by packing in 700 gauge polythene bags after treatment with Thiram at 0.2% or Hadron (halogen based leaf powder) at 0.3%. Pre-sowing seed hydration treatment and Thiram dressing at 0.2% was effective in sunflower, wheat, maize and *Cenchrus ciliaris*. Deltamethrin 2.8 EC at 1 ppm (0.04 ml/kg) can be used as seed treatment to protect seed of all field crops from insect infestation.

Tribolium castaneum, an important storage insect pest collected from NSP centres exhibited high degrees of tolerance (>24 times at Faizabad and Coimbatore) to malathion, a commonly used disinfectant in godowns. A high degree positive correlation was found between pairs of pulse beetle and number of adults emerging after first generation and percentage of seed damage.

PLANT PROTECTION

BIOLOGICAL CONTROL

Biosystematic Studies on Indian Predatory Coccinellids

An annotated checklist of the coccinellid fauna of Indian subcontinent comprising about 418 species under 78 genera, 21 tribes and five subfamilies is being prepared. The subfamily Epilachninae, with about 80 species, also has been added to checklist. Two new species, *Microserangium brunneonigrum* and *Pseudaspidimerus infuscatus*, have been described from south India. Two genera *Synonychomorpha* and *Diomus*, and one species *Pseudaspidimerus mauliki*, have been recorded for the first time from India. *Aneleis cardoni* and *A. perrotteti* have been identified as promising predators of spiralling whitefly *Aleurodicus dispersus*, an exotic pest.

Behavioural Studies on Natural Enemies

Tritrophic interactions studies between 15 cotton genotypes, bollworm *Helicoverpa armigera* and egg parasitoids *Trichogramma chilonis* have revealed that allelochemical diversity in cotton genotypes (along with morphological characters) influences parasitization of *Helicoverpa armigera* eggs by *T. chilonis*. Highest parasitization of 42.22% was recorded on DHB 435 and CPD 431.

Campoletis chloridae recorded a higher parasitism of 4-day-old *Helicoverpa armigera* larvae on chickpea when larvae were preconditioned on plants for 24 hr as compared to just released larvae.

Artificial Diets for Host-Insects and Natural Enemies

Aphid lion *Chrysoperla carnea* could be successfully reared for 10 generations on beef-liver plus defatted soybean based artificial diet. The mean percentage survival and adult emergence were 88% and 86%. Biochemical analysis has revealed that the diet is rich in protein and carbohydrate and can be stored for 100 days. *Mallada boninensis* could also be successfully reared on the beef-liver based diet.

Cryptolaemus montrouzieri was reared on a freeze-dried artificial diet based on the beef-liver and egg-yolk. Mean adult emergence of predators reared on artificial diet was 58%.

- Intercropping pigeonpea with groundnut or sesame increased yield and reduced pigeonpea nematode *Heterodera cajani* population.
- Designed and developed a simple, cheap light weight royal jelly collector.
- For hybrid seed production in sunflower, pollination by *Apis mellifera* and *A. cerana* is preferred alternative to hand pollination.
- When *Butea monosperma* is grown on farm-bunds, it attracts many depredatory birds and thus crop losses get reduced.
- Reported for the first time in Jamnagar, ruffs (*Philomachus pugnax*) and black-tailed god wit (*Limosa laponica*) damaging wheat at sowing and at sprouting.
- An annotated checklist of coccinellid fauna of Indian subcontinents is being prepared.
- *Aceria guerreronis*, reported as serious pest of coconut in Kerala, has spread to all coconut-growing areas.
- Developed an easy and rapid laboratory method for large-scale screening of a wide range of antagonists against specific nematodes.



A high temperature-tolerant strain of *Trichogramma chilonis* developed at 36°C and 60% relative humidity after 48 generations of rearing gave 85% parasitism and increased longevity (4 days).

Studies on Entomopathogens

Sulphur and CaSO₄ at all concentrations significantly reduced radial growth of *Beauveria bassiana*, *B. brongniartii* and *Metarrhizium anisopliae* but did not affect spore production. Paraquat was found toxic to *B. bassiana*, *B. brongniartii* and *M. anisopliae*, and glyphosate was more toxic to *B. bassiana* than the other two fungi.

Aceria guerreronis, first recorded as serious pest of coconut in Kerala in 1998, has spread to all the coconut-growing areas of the country within three years.

Fungal and Bacterial Antagonists

Molasses-soy medium, which supports biomass production of *Trichoderma* species, has been standardized for commercial production.

Soil application of *Trichoderma harzianum* and *T. viride* at 5g of powder formulation mixed in 1 kg of farmyard manure (FYM) effectively controlled *Fusarium* wilt and *Rhizoctonia* wet root-rot of chickpea and also gave higher yields. Soil application (10g in 1 kg of FYM) of *T. harzianum* prior to sowing was more effective than seed treatment (10g/kg of seed) in controlling *Fusarium* wilt of pigeonpea caused by *F. udum* and resulted in better plant growth and yield. The bioagents were allowed to proliferate up to 30 days after inoculation. *T. viride* was found effective in controlling root-rot of cotton caused by *Rhizoctonia solani*.

Seed treatment (at 5 g/kg) with talc-based formulations of the bacterial antagonists, *Pseudomonas putida* and *P. fluorescens*, was found promising against *Fusarium* wilt and *Rhizoctonia* wet root-rot of chickpea and *Fusarium* wilt of pigeonpea.

Entomopathogenic Nematodes

Toxins isolated from *Xenorhabdus nematophilus* and *Photorhabdus luimescens* and smeared on the larvae of potato-tuber moth had resulted in absolute mortality.

Steinernema carpocapsae (PDBC EN 6.11) sprayed at 1.25 billion/ha against *Helicoverpa armigera* on pigeonpea gave good control at Tandur, Medak (Andhra Pradesh).

Steinernema carpocapsae and *S. bicornutum* were found effective against *Spodoptera litura*, *Helicoverpa armigera*, *Opisina arenosella*, *Phthorimaea operculella* and *Plutella xylostella* in laboratory. *Galleria mellonella* (final instar) was found most suitable for progeny production of *Steinernema* spp. and *Heterorhabditis* spp. Isolates of *Steinernema bicornutum*, *Heterorhabditis indica* and *S. carpocapsae* were effective at 2.5 billion Ijs/ha against brinjal fruit-borer *Leucinodes orbonalis*.

Wouts medium has been ideal for multiplication of *S. carpocapsae* and *H. indica*, and dog-biscuit+beef extract medium has been found good for mass production of *S. carpocapsae*. Talc + China clay formulation at 15°C retained maximum viability and pathogenicity for 90 days.

Biological Control of Plant Parasitic Nematodes

Growth and sporulation of nematophagous fungi, *Paecilomyces lilacinus* and *Verticillium chlamydosporium*, could be enhanced significantly by supplementation of sorghum grain with calcium carbonate, chitin or both.

An easy and rapid laboratory bioassay method for large-scale screening of a wide range of antagonists against specific nematodes has been developed.

Biological Control of Crop Pests

Commercial crops: Release of egg parasitoid *T. chilonis* at 50,000/ha at 10 days

BIOLOGICAL CONTROL OF SPIRALLING WHITEFLY

The polyphagous spiralling whitefly (*Aleurodicus dispersus*) first reported in 1993 from Kerala has been recorded on 253 host plants in India and the important economic plants include guava, banana, papaya, cucurbits, ornamental crops and shade trees. In an attempt to manage through classical biological control, 2 aphelinid parasitoids, *Encarsia guadeloupae* and *E. sp.nr. meritoria* found in Minicoy, Lakshadweep island in 1999 have been successfully introduced in and around Bangalore and they have now spread to several parts of peninsular India. Two of the important indigenous coleopteran predators *Axinoscymnus puttarudriahi* (Coccinellidae) and *Cybocephalus* sp. (Nitidulidae) have been able to discriminate between parasitized and unparasitized whitefly nymphs and completely avoided feeding on parasitized nymphs.

IMPROVED STRAINS OF TRICHOGRAMMATIDS

In SDS-PAGE profiles 3 new protein bands appeared in the pesticide tolerant *Trichogramma chilonis* as compared to susceptible strain. The insecticide tolerant strains could parasitize *Helicoverpa armigera* eggs even on just sprayed (Endosulfan, Monocrotophos, Fenvalerate, Cypermethrin, Dimethoate and Acephate) cotton-plants, and increased parasitism was noticed 5-7 days after spraying.



interval during July–October reduced incidence of stalk-borer, *Chilo auricilius*, with just 1.36, 4.10 and 12.50% incidence as compared to 6.03, 11.20 and 20.20% in control.

Bt Products (Delfin, Spic-bio) gave effective control of bollworms, supported larger numbers of natural enemies and gave higher yields as compared to untreated control at Coimbatore (Tamil Nadu).

Talc-based formulation of *Steinernema carpocapsae* was compared with S/NPV and Chlorpyrifos for the control of *Spodoptera litura* in tobacco nursery in Rajahmundry and the results indicated that *S. carpocapsae* entomopathogenic nematodes (EPN) at 1, 2 and 4 × 10³ Ijs, EPN at 1 × 10⁵ Ijs + *S. litura* nucleopolyhedroviruses (S/NPV) at 1.5 × 10¹² PIB, S/NPV alone at 1.5 × 10¹² PIB and Chlorpyrifos at 0.05% gave superior protection to tobacco seedlings from damage caused by *S. litura*. The EPN in combination with S/NPV was superior to all the doses of EPN and S/NPV alone in reducing larval population.

Pulse and oilseed crops: *Bt* (1 kg/ha)- HaNPV (1.5 × 10¹² POB/ha)-Endosulfan-*Bt* sequential application recorded lesser larvae and pod damage, and higher yield of 735 kg/ha (compared to 310 kg/ha in farmer's practice) and greater cost : benefit ratio of 1 : 3.29 than farmer's practice 1 : 2.51.

Cereal crops: At Coimbatore, Pune, Ludhiana and Jorhat, release of *Trichogramma japonicum*/*T. chilonis* 3 times, spray of *Bacillus thuringiensis* at 1 kg/ha at 40 and 55 DAT or need-based application of Monocrotophos at 40 and 55 DAT reduced stem borer and leaf folder incidence in rice, increased parasitism of stem-borer and leaf-folder eggs and recorded higher yield.

Tree crops: Releases of *Trichogramma chilostraeae* reduced the fruit damage due to the pomegranate fruit borer *Deudorix isocrates* in Bangalore. Fruit borer, *Deudorix epijarbaseggi* in Solan were parasitized to the extent of 59.2% and among the parasitoids, 93.1% were scelionid, *Telenomus cyrus* and 6.9% were the cupelmid, *Anastatus* sp.nr. *kashmirensis*. *T. chilonis* releases in Bangalore were effective in controlling the larval population of *Papilio demoleus* on citrus in trials.

Field experiment on biological suppression of *Meloidogyne incognita* in papaya using two antagonistic fungi, *Paecilomyces lilacinus* and *Verticillium chlamyosporium*, indicated that their integration with air-dried FYM/oil-cake, followed by light irrigation favoured fungal establishment and parasitization on egg masses of the root-knot nematode.

Chrysoperla carnea could be safely released after 10,7 and 5 days of the spray of Chlorpyrifos, Methyl Parathion and Endosulfan spray. Chlorpyrifos (0.04%), Endosulfan (0.05%), Methyl Parathion (0.05%), Imidacloprid (0.01%, 0.02%) and Thiamethoxam (0.013, 0.0063%) did not affect *Aphelinus mali* over wintering population and parasitoids emerged from mummified aphids.

Vegetable, ornamental crops and potato: Five releases of *Trichogramma pretiosum*, and 3 or 5 sprays of HaNPV were ideal for management of *Helicoverpa armigera* on tomatoes.

Paecilomyces lilacinus grown on sorghum grain and formulated in talc effectively reduced root-knot nematodes in chrysanthemum at 4-6 kg/acre along with neem-cake at 150-200 kg and enhanced flower yield between 18 and 24%.

In Bangalore, *Trichogrammatoidea bactrae* at 2.5 lakh adults per hectare against *P. xylostella* on cabbage (5 releases at weekly intervals) in comparison with Endosulfan 3 sprays at weekly intervals resulted in reduction in larval population and increase in yield. The ICBR realized due to this treatment at Pune (Maharashtra) was 1 : 55 : 64.

Among *Bt* formulations tested, Biobit proved effective in checking on diamond back moth with least mean number of larvae (1,700), followed by Dipel (21.93).

Five sprays of Delfin WG at 1kg/ha were best with least fruit infestation (8.93%) and maximum yield (13.65 tonnes/ha).

Imidacloprid, Cypermethrin, pongamia oil, neem seed kernel, Chlorothalonil, mancozeb and copper oxychloride were found safe to serpentine leafminer parasitoid *Hemiptarsenus varicornis*, Monocrotophos was moderately toxic, up to 21 days

'BIO RICE' AND PDBC INFOBASE AS
READY RECKONERS

The CD version of the expert system 'BIORICE', is now available. In development of a National Information System on Biological Suppression of Crop Pests, a CD version of the software "PDBC INFOBASE" has been developed with fine illustrations and pictures.

An expert system for controlling pests of oilseeds and pulses is under preparation for which keys for identification of the major pests along with their damage symptoms are in progress. A knowledge base system for *Helicoverpa armigera* and its natural enemies is being developed by creating a database in MS-Access on biology of pest, its host plants, distribution and natural enemies.



after spray and Phosphamidon least toxic up to 14 days after treatment and then it is safe.

Releases of *Copidosoma koehleri* at 50,000 mummies/ha in 4 equal doses at weekly interval in perforated plastic vials hung 5-m apart in field 45 days after planting has been the best method. This recorded least damages by *Phthorimaea operculella* and yielded maximum tuber in Pune. Release of *C. koehleri* at 1 mummy/4 kg tubers in country-stores recorded minimum tuber infestation (11.36%) after one month of storage and it was similar to release of *C. blackburni* at 2 pupae/kg tubers.

PESTICIDE RESIDUES

Out of 712 vegetable samples, 61% were contaminated with pesticide residues, and out of which 11% exceeded maximum residual limit (MRL) value. In 378 fruit samples, 53% were contaminated with pesticide residues. In milk, out of 537 samples, 52% were contaminated with DDT and 94% with HCH. However, only 14% samples exceeded the MRL in DDT and 18% in HCH. Residues of Endosulfan were detected in 9% samples of milk and 5% exceeded MRL value. Out of 509 samples of irrigation water (258 groundwater and 251 surface water) analyzed, 60% samples of groundwater and 73% samples of surface water were contaminated mainly with HCH and DDT. Out of 99 spice samples analyzed, 42% were contaminated, and 6% exceeded MRL value. In 102 fish samples, 49% were contaminated with DDT, HCH and Endosulfan, and out of which 9% exceeded MRL value. Out of 234 samples of non-vegetarian diet, 78% and of 235 samples of vegetarian diet, 60% were contaminated with HCH, DDT and Endosulfan.

NEMATODE MANAGEMENT

Rice-wheat cropping system: In rice-wheat system in parts of Punjab, Haryana and eastern Uttar Pradesh, root-knot nematodes (*Meloidogyne* spp.) caused serious damage to nursery and transplanted rice. Their population increased further under wheat. A combination of (i) soil solarization of nursery-beds for 3 weeks and application of Carbofuran at 0.3g m², (ii) summer ploughing of field after harvest of wheat, and (iii) puddling of field before transplanting have been an efficient integrated nematode management package.

Rice: In rice-based cropping systems, *dhaincha*, mungbean, groundnut, cowpea or sesamum were effective in reducing rice-root nematode (*Hirschmanniella oryzae*) population.

Pulses: Ploughing along with treatment of seeds at 3% a.i. w/w Carbosulfan effectively controlled root-knot nematode in mungbean at Jorhat and Udaipur. Intercropping pigeonpea with groundnut or sesame increased yield and reduced pigeonpea nematode *Heterodera cajani* population.

Fibre crops: In cotton, root-knot nematode *Meloidogyne incognita* caused patches of stunted yellowing crop with heavy yield losses in Vadodara in Gujarat and Barwala and Sirsa in Haryana. Seed treatment with carbosulfan 25 ST at 3% a.i. w/w, followed by application of Carbofuran at 1 kg a.i./ha in the main field at the time of sowing have been found best, significantly reducing, reniform nematode population and in increasing cotton yield.

Oilseeds crops: Avoidable yield losses estimated were 14-21% due to *Meloidogyne javanica* and 9.7 to 13.2% due to *M. arenaria* in groundnut. Root-knot nematode *M. arenaria*/*M. javanica* were managed in Gujarat by applying neem/castor cake at 1,000 kg/ha along with nematicide Carbofuran 3G or Sebufos 10G at 2 kg a.i./ha.

WHITEGRUB MANAGEMENT

A management strategy, combining physical and chemical control measures, Phorate 10 G at 25 g and Chlorpyrifos 20 EC at 8 ml per arecanut palm to the soil between

FORECASTED HELICOVERPA ARMIGERA INFESTATION IN PIGEONPEA

In Gulbarga district, Karnataka, it was forecasted that infestation on pigeonpea would be severe in 8 subdivisions during November 2001 to January 2002. This prediction helped for preparedness of the farmers for taking up suitable management measures.

CLIMEX FOR PEST RISK ANALYSIS OF PERONOSPORA MANSHURICA

The CLIMEX model for forecasting favourableness of Indian environment for development and establishment of *Peronospora manshurica*, the causal agent of soybean downy mildew suggests Himachal Pradesh (*khariif*) and Karnataka (*rabi*) favourable for the growth and survival of the pathogen.

IPM VALIDATION IN BASMATI RICE

IPM validation trial was laid out in 160 hectares in Shikohpur, District Baghpat, Uttar Pradesh. It consisted of rice Pusa Basamati 1 green manure and potash at 40 kg/ha, scouting and monitoring of pests and their natural enemies, seed treatment with Carbendazim at 2 g/kg of seed, release of *Trichogramma japonicum*, spray of Carbendazim against sheath blight, streptomycin against bacterial leaf blight, and of Monocrotophos against Gundhi Bug in 4, 2 and 1 hectares. The pesticide application could be brought down to 1 in this village, when the farmers of non-IPM Badka village, District Baghpat, had to use 5-6 applications.



EFFICACY OF *M. ANISOPLIAE* WITH IMIDACLOPRID TO WHITEGRUB

Metarrhizium anisopliae (isolate Ma-4) alone and with 3 doses of Imidacloprid (20, 15, 5 ppm) was tested in soil against the second instar of *Holotrichia consanguinea*. Complete grub mortality occurred within 11 to 17 days when grubs were exposed to *M. anisopliae* treated soil along with 10 and/or 5 ppm of Imidacloprid 70 WS; 26 days were required for causing the same level of mortality when test fungus alone was used.

MEDIUM FOR *METARRHIZIUM* MASS PRODUCTION

A technique for conidial as well as mycelial mass production of *M. anisopliae* has been standardized in Network Unit, All-India Network Project on Whitegrubs and Other Soil Arthropods, at the Agricultural Research Station, Durgapura, Jaipur. For conidial production, crushed maize-grain substrate with 50% moisture, filled in polypropylene bags (PP), was found the best, yielding $2-3 \times 10^9$ conidia/g dry grain substrate. And highest mycelial yield of 21.85 g dry mycelia/litre of Sabouraud's dextrose broth with yeast extract (SDY) was harvested, using shake-culture technique. Propagule size more than 250 μ m that exhibited highest conidiation compared with lower size particles on rehydration.

August and September has been developed against arecanut whitegrub *Leucopholis* spp.

Ecofriendly technology of whitegrub (*Holotrichia consanguinea*) management through beetle control using pheromone, developed by Network Unit of the All-India Network Project on Whitegrubs and Other Soil Arthropods, was successfully demonstrated in Chak Bhairu Karol, Govindpura and Ram Nagaria villages near Jaipur. Spraying only one-third of the total host-trees (one tree within a radius of 15 m) in one hectare with Monocrotophos at 0.05% and loading with pheromone resulted more than 75% killing of beetles.

Efficacy of Fungal Formulations in Field

Metarrhizium anisopliae and *Beauveria bassiana* conidial dust formulation of each when integrated with half of the recommended dose of Chlorpyrifos (1 lit. a.i./ha) have provided better results against many whitegrub species, specially *Holotrichia seticollis* and *Holotrichia coriacea* damaging potato crop at Palampur (Himachal Pradesh) and *Holotrichia longipennis* on upland paddy at Ranichauri (Uttaranchal). *H. seticollis* and *H. sikkimensis* attacking ginger at Gangtok (Sikkim) was also effectively controlled by *M. anisopliae*. The performance of *M. anisopliae* isolate Ma-4 in particular was found outstanding against *H. consanguinea* under laboratory and pot experiment conditions at the Agricultural Research Station, Durgapura.

HONEY – BEE MANAGEMENT

Various types of hives/mating nuclei (tripartitioned langstroth hive, tetra-partitioned langstroth hive, three-frame transportation hive, three-frame baby nuclei of 14.5 cm \times 14.5 cm \times 12.0 cm size and ten-frame langstroth hive) have resulted in 100% queen emergence and 100% mating success, excepting baby nucleus in which it was 50% during April 2001, but it was 33.3, 0.0, 75.0, 75.0 and 100% in tri-partitioned langstroth hive, tetrapartitioned langstroth hive, transportation hive, baby nucleus and 10 frame langstroth hive in May; egg-laying success was 100% in April and 66.7% in transportation hive and 100% in all other hives in May 2001.

Brood rearing and pollen stores in ferocious *Apis mellifera* colonies were higher as compared to moderate and mild colonies.

Bee Diseases, Enemies and Selective Breeding

Almost all jet-black drones of *Apis mellifera* matured sexually between 18 and 22 days, yielded more semen (2 μ l), while golden yellow drones matured after 22 days. The black drone yielded less semen (0.5-1.2 μ l).

Purified Thai Sac Brood Virus (TSBV) of *A. cerana* was found disintegrated/disorganized into circular discs and tubes under electron microscope within six months of storage even at -20°C . Antiserum was prepared with a satisfactory titre (1 : 200) in immuno double-diffusion gel tests.

HIVE PRODUCTS

Royal-jelly production

Artificial (synthetic) plastic royal jelly cell cups pre-coated with bees wax 72 hr after grafting during October-November showed 80.9% mean acceptance of larvae of less than 24 hr age combined with priming with royal jelly.

A simple, cheap and light-weight royal-jelly collector has been designed and developed that works on running tap-water and does not require electricity for operation. Its efficiency of jelly collection is 93.3%.

Propolis production

Maximum deposition of propolis was recorded by scrapping from the upper surfaces of top bars of frames coupled with wooden splinters in between inner cover and brood chamber, followed by in slits of plastic queen excluder used as propolis screens.

Propolis collection was negligible during winter while mean propolis deposition ranged between 1.0 and 13.4 μ g per colony per month.



Small and fresh fish attracted 28-35 wasps/day and big and fresh fish attracted only 14 wasps/day. Rotten fish attracted less number of wasps. When bait was kept in moist condition it attracted more number of wasps than dried pieces of fish.

Pollination Research

The activity of *Apis mellifera* foragers was more in large cages than in smaller ones in fertile and CMS lines of cauliflower for hybrid seed production. Seed set was higher in fertile lines (21.24 to 41.39%) than in CMS lines (2.77 to 11.55%). Seeds per pod of fertile line in large cages were more than those in small sized cages, however, no such correlation was noticed in CMS lines.

Bees of *Apis mellifera* and *Apis cerana* can be used for pollination for sunflower hybrid seed production, as an alternative for hand pollination.

In sweet-orange, percentage increase in fruit-set over self pollination was 24.1, 21.7 and 15.7 in *Apis mellifera* and *Apis cerana* and open pollination. Fruit drop was lowest in *Apis cerana* (16.0%) and *Apis mellifera* (17.5%) compared to 29.6% and 27.8% in self and open pollinations. The decrease in fruit drop over open pollination was 4.30 and 5.86% in *Apis mellifera* and *Apis cerana* pollination.

The highest yield (75 kg fruit/tree) in litchi was obtained from bee-pollinated crop, followed by open pollination (68 kg/tree).

AGRICULTURAL ORNITHOLOGY

BBR and NIVAR are non-lethal botanical pesticides. During *kharif*, BBR at 10 ml/litre of water concentration resulted in higher yield compared to NIVAR at 15ml

Butea monosperma during flowering attracts many depredatory birds, and reduces crop damage by them





Ripe apple fruits damaged by parakeets

and control in the experimental fields. These botanicals acted as potential repellents in reducing bird damage.

BBR and reflective ribbon plot in *kharif* (sorghum) showed higher yield (675 kg/ha) than in *rabi* (510.25 kg/ha). Similarly wrapping and ribbon in maize during *rabi* showed higher yield (790 kg/ha) in the treated plot compared to control (710 kg/ha).

Studies on the effect of pesticidal spray on the migratory bird foraging on wetland cropping systems in Andhra Pradesh have revealed that the insecticides spraying affected the migratory and resident birds such as Brahminy ducks, Pintails, Lesser whistling teal, Comb duck, Spot-billed duck which forage on sprouted paddy seeds in nurseries. Similarly, at Thrissur pesticide poisoning was recorded on pond heron in the rice ecosystem. Residue analysis revealed that presence of low concentration of organochlorides resulted in cumulative affect on these birds.

Around maize, sorghum screen (fodder variety, GS3) was most effective against rose-ringed parakeet, followed by maize screen at Gujarat.

Mulberry trees attracted more insectivorous birds specially Rosy pastors as dominant species (75%). *Butea monosperma* on farm-bunds attracts many depredatory birds and reduces incidence of crop damage during vulnerable stages.

In Jamnagar, ruffs (*Philomachus pugnax*) and black tailed godwit (*Limosa lapponica*) have been reported for the first time damaging wheat during sowing and sprouting stage. Granivorous birds devoured about 74% of the spilled wheat grains from harvested fields and cleared fallow land from weed seeds.

Cattle egrets fed effectively on *Helicoverpa armigera* and *Spodoptera exigua* in groundnut fields.

The use of reflective ribbons in a kinnow-orchard resulted in reduction of fruit damage to the extent of 13% over a period of 15 days at Solan.

Streaked laughing thrust (*Garrulax lineatus*) has been observed for the first time feeding on damaged apple fruits.

At KAU, Thrissur, banana was damaged to the tune of 21% by the small-green barbet (*Megalaima viridis*). Covering branches with polythene cover or with dried banana trashes (especially leaves) gave encouraging results.

RODENT CONTROL

Rodent Damage

Rodent damage to different crops at pre-harvest stage was lesser than last year. Wheat was observed to suffer 1.0-3.0% in Punjab; 5.8-7.3% in Himachal Pradesh and 4.0-5.68% in Gujarat during the year. Wheat near sugarcane fields experienced higher damage in Punjab. In arid areas, damage accounted for 12.7-17.4% at flowering stage. Damage to standing rice was 3.3-5.6% in Punjab and 5.4-8.2% in Himachal Pradesh. Among oilseeds, mustard recorded 11.3-14.9% plant damage by rodents and groundnut suffered to the tune of 3.9-6.4% of plants and 4.0-6.5 of pods. Rodents inflicted higher damage to cabbage heads (12.5%) than cauliflower (3.6-6.3%). Similarly pea and tomato experienced 5.5-8% and 2.2-7% damage in Himachal Pradesh. Nurseries of apple, peach, pecan, mango etc were more prone to rodent infestation, recording a damage of up to 15.6%, and the grown-up trees had damage of 1.5% on apple, 1.6% on pecan and 2.3% on plum tree at Solan. The bandicoots have been observed to hoard on an average 0.866 kg of wheat, 1.249 kg of rice and 1.06 kg of tomato in each of the burrow.

Rodent Management

Studies on resiliency management of rodents at Ludhiana indicated that alpha Chlorohydrin, a male sterilant, was able to cause sperm abnormalities and significantly reduce spermatogenic cells resulting in testicular necrosis in Indian gerbils, *Tatera indica*.

Aluminium or GI sheet collars fixing on stems of mango and coconut trees saved fruit/nuts from rodent attack at Solan and Bangalore, respectively.



INTELLECTUAL PROPERTY RIGHTS ACTIVITIES IN THE ICAR

The IPR related activities in the ICAR include: (i) Protection of Intellectual Property Rights: Patents, (ii) Research collaboration, consultancy and contract research services vis-a-vis IPR, (iii) Subject-matter input for ICAR and inter-ministerial backstopping, (iv) Institutional capability and capacity strengthening, and (v) Linkages and participation.

Protection of IPR

Patenting of technology invented in the ICAR system is being done centrally. A total of 31 patent applications received from scientist(s) through their respective institutes, including the back-logs, were examined for their status - provisional or complete, assignment and various techno-legal components, and applicants were advised to modify/improve application in respect of specifications, claims and other elements, where applicable and as appropriate. The applications complete in all respect, were filed at the Patent Branch Office, Delhi.

In terms of institute-wise filing of patent application, IARI topped with 9 applications, followed by NDRI (4), IVRI and ILRI (2 each) and CMFRI, CPRI, CTRI, CSSRI, NIRJAFT and NCIPM filed one application each.

One patent entitled, "A new bed for mushroom cultivation by utilizing biogas waste slurry and straw for improved mushroom cultivation" has been granted by the Patent Office, Kolkata. This technology has been developed at the NIRJAFT, Kolkata. First examination report has been provided by the Patent Branch Office, Delhi in respect of another patent application "No.3422/DEL/95" submitted by CIAE, Bhopal, for further action.

Research Collaboration, Consultancy and Contact Research Services vis-à-vis IPR

Agreements for IPR component and share in collaborative research: The collaborative project proposals referred by the DARE/various Divisions were examined for IPR component and appropriate comments were offered to suitably reflect Council's intellectual property rights in respect of resource investments and expected technology output. This intervention helped in convincing some of the proposed collaboration partners to agree to file joint applications for patenting of technology generated and are ready to share reasonable royalty with the Council on equal or proportionate basis. Various Memoranda of Understanding (MoU) and Workplans were similarly examined and suitable alterations suggested.

Sharing of royalty within the organization: All matters related to consultancy and contacts for research, training or other services, including the sharing of charges among scientists and institutes, referred by various Divisions were attended and benefit sharing verified/recommended as per ICAR guidelines/Johl Committee Report.

Backstopping/Services on Subjectmatter

Subject-matter inputs for the ICAR and inter-ministerial backstopping included some primary IPR issues on patents, *sui generis* system on protection of plant varieties, geographical indications, biodiversity, traditional knowledge, biosafety, WTO agreement on agriculture and sanitary and phytosanitary aspects, etc.

Institutional Capabilities and Capacity Strengthening

Nomination of IPR nodal officers: The process of nominating IPR nodal officers by all ICAR institutes/Bureau/Project Directorates/National Research Centres was speeded up to facilitate streamlining of IPR matters at the institute level.

Training imparted on 'IPR and WTO Awareness': The IPR nodal officers along with other nominated scientists from the ICAR institutes and SAUs were given 3 days training on various IPR and WTO related developments and issues. In all, nearly 250 ICAR scientists were trained in 4 trainings conducted between June and September 2001 at New Delhi, Hyderabad, Lucknow and Mumbai.

The training module included: (i) patents, process of patenting and management of patents/IPR portfolio, (ii) geographical indications, (iii) *sui generis* protection of plant varieties, (iv) biodiversity management, use and benefit sharing, (v) case studies, (vi) WTO agreements on trade related intellectual property rights, agriculture, and sanitary and phytosanitary conditions, (vii) Developments on concerned national legislations and international negotiations/agreements/convention/undertaking, etc. The module also included practical training on writing and reading/analyzing techno-legal patent documents and filing of applications in the ICAR set up.

Middle level IPR management training to ICAR scientists: A three-day intensive training on 'IPR in relation to agriculture' was given to 6 ICAR scientists at the Indian Institute of Management, Ahmedabad, which covered *inter alia* important topics, such as, valuation of intellectual property, management of IPR portfolio and public-private partnerships.

Linkages and Participation

Council's liaison and linkages were maintained, the notables include CSIR, FICCI/IIPD, CII, ISIL NAAS, etc.



Third generation rodenticide, difethialone (25 ppm) yielded cent per cent mortality in laboratory of *Rattus rattus*, *Bandicota bengalensis*, *Meriones hurrianae* and *Tatera indica* under no choice, and it was 70-80% in choice trials. Field evaluation too resulted 60-70% control success in field crops (wheat, cotton, groundnut, rice, sugarcane etc.) at Ludhiana, Jodhpur, Solan, Junagadh and Bangalore. In sandy-loam soil, aluminium phosphide at 2.4-3.0 g per burrow was highly effective as against 1.2 g/burrow in deltaic alluvial soils of Andhra Pradesh. In rice fields in Punjab, baiting with racumin, followed by zinc phosphide, resulted in 81.5% rodent mortality. The efficacy of this combination was at a par with racumin, followed by bromadiolone. At Solan, integrated approach to rodent management in cauliflower involves fumigation of active burrows before transplantation, (ii) live-trapping throughout crop cycle, (iii) weed control (iv) poison baiting with zinc phosphide and bromadiolone at flowering. The management operation lead to a net cost: benefit ratio of 1:12.43.

AGRICULTURAL ACAROLOGY

Brown-wheat mite *Petrobia latens* infested severely rainfed wheats PBW 175, PBW 299, C 306 and LOK 1 in some districts of Punjab, Himachal Pradesh and Rajasthan. Even irrigated wheats PBW 502, HP 1731, CBW 13, HD 2824, Raj 3077, Raj 3765, Raj 4029 and Raj 4033 were found damaged by this mite; infestation was severe especially in Raj 3765 in Rajasthan.

Two-spotted spidermite *Tetranychus urticae* damaged tomato and muskmelon, bottlegourd and spongegourd during April - June in Ludhiana. In Varanasi, *Tetranychus ludeni* affected cowpea from February onwards, with peak mite population in June and this declined with the onset of monsoon.

In Kalyani, peak population of yellow mite *Polychagotarsonemus latus* on chilli was observed when the mean day temperature was 30.4°C; mite activity was observed between 28.5° and 30.5°C. Yield losses were of 24.9%.

The coconut mite *Aceria gurreronis* was observed to infest and survive on palmyra *Borassus flabellifer* in Thondamattur and Sirugamani in Tamil Nadu; a single fruit harboured as many as 100 mites mostly on tepals. Feeding by the mites caused pale-brown patches on the inner side of the tepals, mild damage symptoms could be seen on the nut surface also. In Coimbatore, spot application of Fenprothrin (3 ml/litre) and Endosulfan (4 ml/litre) resulted in 61-80% and 61-90% reduction in coconut mite population in 15 days.

Of several newer molecules evaluated against mites infesting different crops like cowpea, chilli, okra, rose (both polyhouse and open cultivated), Fenpyroximate (15 to 30 g a.i./ha), Fenazaquin (125 g a.i./ha), Buprofezin (75-150 g a.i./ha), Diafenthiuron (300-600 g a.i./ha) were found promising against chilli yellow mite (Bangalore and Kalyani) and okra mite (Coimbatore and Ludhiana) up to 14 days causing 80-90% reduction in mite population. Fenprothrin (0.02%) against spidermite in polyhouse roses in Navasari and Vertimec (0.042%) against *T.ludeni* on cowpea in Varanasi were also promising. Among the different botanicals screened, azadirachtin (300 and 500 ppm) gave a maximum of 50%-60% mortality of spider mite on okra crop in Varanasi. In Bangalore, commercial neem formulations exercised a maximum of 50-60% control of spidermite on vegetable pendal bean and okra, and these formulations were safe to the associated phytoseiid mite predator *Amblyseius longispinosus*.

Amblyseius longispinosus was found as an efficient phytoseiid predator in okra, groundnut and cotton systems in Tamil Nadu. *Amblyseius longispinosus* and *A. multidentatus* were major predators associated with spidermite on vegetables in Varanasi. *Amblyseius longispinosus* released at 20:1 ratio (prey: predator) brought down the population of *Tetranychus urticae* on carnation in polyhouse in Bangalore in 5 weeks and subsequent spidermite population build-up was minimal.

EFFICACIOUS 'MYCOHIT'—A MYCOACARICIDE

Hirsutella thompsonii, the eriophyid mite-specific fungus, has been developed into a mycoacaricide named 'Mycohit', based exclusively on one of the superior strains-MF (Ag) 5 (ITCC 4962; IMI 385470). This is the first report of its kind. The product has a potency of 2.5×10^8 CFU/g with a moisture content of about 12%. Its 1% concentration and about 2 litres of the spray solution is needed per tree. Up to 125 trees (about 1 ha) can be treated with 2.5 kg of the product. In certain situations such as after a heavy rain, just dusting of the product on the bunches is enough because of the wet microclimate within the crown.

Field investigations have been conducted in more than 20 different places for evaluating performance of Mycohit. In several places, by the 70th day more than 70 and 90% mortality of the mite was observed in nuts sprayed once and twice (two weeks interval).



Improvement and Management of Horticultural Crops

FRUIT CROPS

M A N G O

Germplasm collection was enriched by adding 15 new accessions and 21 seedlings at Vengurle, Periyakulam, Sangareddy, Paria and Mohanpur. Two superior clones of Alphonso and one of Banganpalli were selected at RFRS, Vengurle and FRS, Sangareddy, respectively. At CISH, Lucknow, a late-ripening mango hybrid (Amrapali × Vanraj) was found promising with attractive fruit colour and good quality having potential for export and internal market. Its fruits are 180-200 g in weight with dark yellow, firm flesh having TSS 23° Brix. The hybrid Sindhu produced 'off' season flowering and fruiting at FRS, Sangareddy. The exotic cv. Eldon continued to excel among all the varieties with medium-sized fruits (260 g), good TSS (18.3° Brix), attractive apricot colour peel and better shelf-life (12 days) at room temperature.

Plants propagated by veneer grafting method gave maximum yield at Sabour, Sangareddy and Rewa, while air-layered plants were superior in yield at GBPUAT, Pantnagar. Double hedge row system of planting has given significantly higher yield than the control at most of the centres. At IIHR, Bangalore in Alphonso fruit yield/canopy volume was maximum with Vellaikulamban rootstock which can be used as a dwarfing rootstock for Alphonso for high-density planting. Application of paclobutrazol @ 3-5 ml/m canopy diameter, 90-120 days before bud-burst gave consistently higher yield by regulation of shoot growth and flowering habit in mango.

In mango orchards, use of vesicular-arbuscular mycorrhizae, *Glomus fasciculatum*, increases the availability of P, Zn, Cu, Mn and Fe in soils. One time fertilizer application @ 1,000 g each of N, P and K during July was found to be the best for mango. Widespread B deficiency was observed in Alphonso in Maharashtra and Karnataka which can be corrected by application of 150-200 g Borax/tree besides increasing the fruit set up to 20-25%. Biofertilizer *Azospyrillum* (300 g/tree) with 40 kg FYM has given good results in Deshehari. Exposing of Alphonso fruits to direct sunlight after harvesting, ripening at high humidity or temperature significantly increased the spongy tissue. However, ripening the fruits at 20°C reduced the spongy tissue formation.

The anthracnose disease was effectively controlled by pre-harvest spraying of Benomyl (0.1%) or Carbendazim (0.1%) followed by postharvest hot-water treatment or dipping fruits in 2% sodium chloride solution.

In integrated pest management of mango hopper proper cleaning by ploughing, pruning of overcrowded branches and spraying of Monocrotophos @ 0.05% at panicle emergence followed by 2 sprays at 15 days interval, sprays of Fenitrothion (0.05%) at bud-burst stage, Nimbecidine (0.5%) at fruit set have given best control at BAC, Sabour and BCKV, Mohanpur. Application of Monocrotophos @ 0.72% and Quinalphos @ 0.05% were found effective to control shoot gall psylla at BAC, Sabour.

Mango stone weevil (*Sternochetus mangiferae*) has been recorded for the first time in mango-growing areas of Uttar Pradesh hills with 15.4% infestation in sampled fruits.

- Two superior clones of mango Alphonso and one of Banganpalli were selected
- The National Musa Germplasm Information System has been created at NRC, Banana, Trichy
- A quick diagnostic method for rDNA region of citrus-greening bacterium was developed
- About 42 accessions of litchi collected from various parts were stored in the gene bank at NRC for Litchi, Muzaffarpur



A promising mango hybrid

MANAGING FRUIT FLY

Fruit fly has become a major pest in mango which is a big hindrance in export of Alphonso mango. The IIHR, Bangalore, has made efforts to standardize the technology for control of fruit fly which consists of orchard sanitation, inter-tree ploughing, male annihilation and selected sprays starting 45 days before harvesting followed by postharvest hot-water treatment at 48°C for one hour.



Banana BRS 1 is ideal for dessert and cooking

BANANA

A National Musa Germplasm Information System (MGIS) has been created at NRC, Banana, Trichy. It is a valuable tool for the management of germplasm data which contains 4,122 records. The data will be available on the internet for consultation. A unique wild type of banana locally called as “Sai Su” (*Eusete glaucum*) was collected from deep forest areas of Turial near Aizwal, Mizoram. It does not produce any side suckers and is propagated only through seeds. Fruit has blunt tip and each contained 0-15 black, bold, smooth seeds with thick seed coat. The edible succulent leaf sheaths make a popular vegetable sold in market and its fibres are used for making fancy articles.

At IIHR, Bangalore, foliar spray of 1% urea, 0.5% SOP, 0.2% ZnSO₄, 0.1% boric acid 6 times at monthly interval from fifth month in ratoon crop of banana gave the same yield as in planted crop. About 3-5 ratoons after plant crop can be taken successfully by adoption of this technology. The cost of cultivation has been reduced to Rs 35/plant with increased cost:benefit ratio from 1 : 4 to 1 : 6 for the ratoon crop.

Under AICRP for Tropical Fruits, hybrids BRS 1 and BRS 2 were released for cultivation in Kerala. The Gandevi selection (AAA) with good management recorded higher yield (91.08 tonnes/ha). The clone KB-8 from Dwarf Cavendish consistently recorded higher bunch weight with a yield of 115 tonnes/ha at Kovvur. Planting 3 suckers with a plant spacing of 1.8 m × 3.6 m with 300:90:400 g N : P₂O₅ : K₂O/plant/year, respectively, recorded higher cost:benefit ratio. Planting of Rajapuri (AAB) in June-December, Nendran (AAB) in October-December, Basrai (AAA) in June-August, Tellachakkerakeli (AAA) in June-October was found ideal under Arabhavi, Kannara, Gandevi and Kovvur conditions respectively. Application of 50 g N through organic source (FYM/green manure) and 150 g N through inorganic source enhanced the yield in Kothia (AAB), Grand Naine (AAA), Borhaji (AAA) and Poovan (AAB) at different agroclimatic regions. Covering of bunches with white polythene having 2% ventilation holes improved the finger size and bunch appeal under subtropical conditions during winter season. Tissue-cultured planting material was better in yield and crop duration. Intercropping with knol-khol and elephant-foot yam recorded good yield with higher cost : benefit ratio under Jorhat conditions. Application of fertilizer through drip resulted in a saving of 25% nutrients besides better crop response.

Banana stem weevil, *Odoiporus longicollis*, is one of the most serious pest especially in North-Eastern and South India. Prophylactic spray of neenazol (2.5 ml/litre of water) or chlorpyrifos (2.5 ml/litre of water) on the pseudostem in 5 months old plants prevents egg laying by the weevil. Stem injections of monocrotophos solution (150 ml Monocrotophos + 350 ml of water) at 30 cm and 1.20 m above the ground level at 30° angle in opposite directions is recommended. However, the injection should not be given after flowering.

The seedlings of Nagpur mandarin are ready for transplanting



CITRUS

Tenali selection was found promising and showed tolerance to canker at Tirupati. Rangpur Lime as rootstock both for sweet orange and mandarin was found to be superior to other rootstocks. Rough lemon local was found to be tolerant to Pytophthora.

Nagpur mandarin plants spaced at 6 m × 3 m (555 plants/ha) were found ideal for higher yield at Akola and Rahuri, respectively. Application of 1,200 g N, 400 g P₂O₅ and 400 g K₂O/plant/year for 16 years old Nagpur mandarin recorded highest yield. In old Nagpur mandarin and acid lime orchards, medium pruning (removal of terminal shoots of 15-22 cm) recorded higher yields at Akola. In acid lime cv. Ambia bahar 2 sprays of cycocel @ 1,000 ppm induced maximum numbers of flowers/shoot.

Citrus blackfly was effectively controlled by Monocrotophos (0.05%) or Fenvalerate (0.01%) or neem oil (1%) and lemon butterfly by Fenvalerate (0.01%). Spray of Fenvalerate (0.05%) followed by monocrotophos (0.05%) checked the



citrus leaf miner. Mealybug was effectively controlled by chlorpyrifos (0.05%). Soil drenching and spray of Metalaxyl (0.02%) followed by Bordeaux pasting was effective in checking the spread of *Phytophthora* root-rot in kinnow mandarins.

Hexaconazole (0.4%) with Carbendazim (0.2%) provided effective control of dry root rot in sweet orange. Pruning followed by spraying of streptomycin (100 ppm) and 4 sprays of copper oxychloride (0.3%) at monthly intervals was recommended for the control of canker in acid lime. Pre-harvest stem end rot of fruits was effectively controlled by spraying of carbendazim (0.1%). At NRC for Citrus, Nagpur, commercial production of disease-free planting material of Nagpur mandarin, acid lime and sweet orange has been undertaken under a Revolving Fund Scheme. The planting material is in great demand and goes to the different states like Sikkim, Orissa, Madhya Pradesh and Delhi.

At IIHR, Bangalore, a quick diagnostic method was developed based on PCR amplification of rDNA region of citrus-greening bacterium. This method is suitable for certification and indexing of citrus plant material free from greening bacterium. Spraying of Tetracycline @ 100 ppm with good management (40 kg FYM), 10 kg neem cake, 600 : 300 : 400gN : P₂O₅ : K₂O/plant/year, respectively, along with 2 sprays of micronutrients continued to record good control of greening disease.

GUAVA

Under germplasm maintenance, a total of 100 accessions are maintained at various centres. The germplasm evaluation revealed that cv. Allahabad Safeda; Sardar (L 49) and Allahabad Surkha gave good yield at most of the centres. The maximum yield per plot was found in higher plant densities (double hedge-row system) as compared to the control at FRS, Rewa and BAC, Sabour. Pruning of three-fourths of current shoots gave lowest fruit yield in rainy season but highest yield in winter season at GBPUAT, Pantnagar. Two sprays of 15% urea during April/May gave maximum yield during winter season at BAC, Sabour. Biological control of Spiralling whitefly (*Aleurodicus disperses*) is possible through parasitoids, *Encarsia haitiensis* and *E. guadeloupae*.

GRAPE

A cumulative germplasm collection of 346 accessions have been made at NRC, Grape, Pune. A total of 73 accessions were collected including 30 exotic mainly introduced from Iran and 3 native wild types collected from the forests of upper Konkan region. Fifteen grape varieties were procured from South Korea. A grape hybrid Shweta Seedless (Anab-e-Shahi × Thompson Seedless) has been developed at IIHR, Bangalore. This hybrid grafted on 'Dogridge' yielded very good crop of high quality berries of export standards (large-sized, more than 18 mm, round to oval shaped for European markets). Farmers from Maharashtra have exported 'Shweta Seedless' which was on a par with other grapes in European market. The popular seedless 'Sonaka', a mutant of Thompson Seedless and Kismish Chorni also known as Sharad Seedless can successfully be grown on commercial scale in Southern Karnataka viz. Bangalore and Kolar. The success is attributed to improvement in pruning technology and the use of growth regulating chemicals. Grape cv. Flame Seedless and Pusa Navrang were found suitable for table and juice purpose respectively under Lucknow conditions. The vine growth, canopy development, productivity and the quality were significantly affected by various systems of training tested. The highest mean bunch weight and berry weight were recorded under Bower System of training.

Downy mildew caused by *Plasmopara viticola* could be effectively controlled by sprays of Aliette (0.2%) + Mancozeb (0.2%) and Metalaxyl MZ (0.2%). Pre-harvest foliar spraying of Hexaconazole @ 0.05% and Mancozeb (0.2%) to control mildew should be made 30 and 60 days before harvesting, respectively to dissipate its detectable residual effect.

PLANTING MATERIAL

A total of 15,366 budged plants were supplied at Chethalli; 5,469 Kagzi lime seedlings and 5,562 mosambi grafts were supplied to farmers and Govt. departments at Rahuri.



Shweta Seedless provides export quality grapes



PAPAYA

A total of 49 gynodioecious and 35 dioecious clones of papaya were maintained at Coimbatore. Papaya CO 2, CO 6, CO 7, CO 3 and Pusa Delicious were found more prolific for number of fruits. Foliar spray of $ZnSO_4$ (0.5%) + H_3BO_3 (0.1%) 4 and 8 months after planting significantly improved the fruit latex yield.

Application of neem cake @ 100 g/bag recorded effective control of nematode under pot culture. Drenching with copper oxychloride (0.1%) @ 25 ml/pot was effective to control *Phytophthora* root-rot. Application of 10 kg FYM, 2 kg neem cake, 1 kg Sterameal, 200g N, 250 g P_2O_5 and 100g K_2O , 0.5% $ZnSO_4$ and H_3BO_3 (1%) was found effective for the management of papaya ring spot. Neem oil (1%) and dimethoate (1.5%) also found to give good control. Papaya seedlings pre-immunized with mild strains offered higher protection for papaya ring spot virus.

SAPOTA

A total of 20 varieties at Gandevi, 19 at Arabhavi, 20 at Kovvur and 14 at Periyakulam were maintained and evaluated under AICRP on Tropical Fruits. Spota PKM 1 maintained its superiority in terms of growth and yield. Out of 31 hybrids evaluated at Periyakulam, hybrid progenies of Guthi × Badami showed good growth. Inarching method of grafting in June-July or September-October was found ideal. The softwood grafting was more successful in hybrids PKM 1, PKM 3 and CO 2. Density of 312 plants/ha (8 m × 4 m spacing) recorded higher yield for PKM 1. Application of 600 gN, 200 g P_2O_5 and 200 g K_2O /plant/year in PKM 1 was found ideal under Periyakulam conditions. At Gandevi, application of 25 kg FYM, 400g N, 60 g P_2O_5 and 300g K_2O /plant/year gave higher yields in Kallipatii.

LITCHI

NRC FOR LITCHI

At NRC for Litchi, Muzaffarpur, 42 accessions were collected from different regions for the gene bank. These are being maintained in the nursery for evaluation.

At IIHR, Bangalore, a new tissue culture technique 'transverse thin-cell layer' (t-TCL) was applied to litchi Purbi for developing an alternate micropropagation protocol. Under AICRP, a total of 36 germplasm accessions were maintained at different centres. Litchi Rose Scented produced higher yield comparing to other cultivars at GBPUAT, Pantnagar. Maximum yield per plot was obtained in double-hedged-row system at BAC, Sabour and GBPUAT, Pantnagar. Terminal pruning of 7.5 cm branches during harvesting has been recommended for commercial adoption at BCKV, Mohanpur. The litchi fruit-borer was effectively controlled by 2 sprays of Endosulphan (0.07%) or Carbaryl (0.1%).

Walnut BP 4 is better than hitherto a popular variety Sunland



JACKFRUIT

Five different types were collected and characterized at Mohanpur. At Kannara, 122 trees were characterized and evaluated. Three varieties have been planted besides selecting 11 clones for further planting at Kovvur.

WALNUT

The CITH, Srinagar (J&K) has selected a walnut tree BP 4 having its nut and kernel weight of 19.84 and 10.40 g, respectively. It has kernel recovery of 52.42% which is better than the America's best variety Sunland. It has smooth shell texture with intermediate shell seal and ideal for export purpose. It is expected to reduce its gestation period to about 5 years from about 15 years through vegetative propagation. This will help to raise orchards by its large-scale propagation and country can earn more foreign exchange from its export to 12 countries in the world.



ARID ZONE FRUITS

The CIAH, Bikaner, maintained 318 accessions of ber, 22 of boradii, 150 of pomegranate, 22 of aonla, 105 of cactus pear, 47 of date palm, 32 each of ker and gonda, 558 of kachari, 192 of mateera, 90 of snapmelon, 132 of chilli and 64 of muskmelon. Ber Seb Banarsi Kadaka, Mundia, Dandan, Alwar Desi, Govindgarh Special and Kala Gola were found superior in all aspects. Patch budding success (90.61%) in aonla can be achieved by using perforated polybags of 40 cm × 15 cm size.

At Bangalore, planting of pomegranate Ganesh at 5 m × 5 m spacing and application of 500 g : 250 g : 25 g N, P and K/plant/year respectively resulted in maximum fruit size (250 g) and yield of 5.37 tonnes/ha. Micropropagation of hybrid Ruby has been standardized using shoot tips and nodal explants. Cultivars Ganesh, G 137 and Bassein Seedless were found superior in respect of soft seed, high TSS and pink aril colour. It was found that 625 : 250 : 250 g NPK/plant/year was sufficient for the above 4 years plants under Rahuri conditions. Jalore seedless produced highest yield (16.75 kg/plant), big fruit size and high TSS at Jobner. The fruit cracking can be minimized significantly by spraying of borax (0.2%).

Germplasm collection of 164 custard-apple accessions were made from different regions of Andhra Pradesh. At Faizabad, 2 promising aonla genotypes NA 23 and 24, one ber that bear fruits twice a year and one jamun were identified. The peak fruit-setting period was observed during September–October and highest fruit yield was recorded in ‘Surti’ and ‘Katha’ (45.2 kg/tree) followed by Gola Gurgaon (40.7 kg/tree). At Aruppukottai, February pruning in ber was found best for enhancing yield.

Maximum fruit yield in date palm was recorded at doka stage in Barhee (113.3 kg/tree) followed by Sayar (93.3 kg/tree), Khadrawy (90.5 kg/tree) and Medjool (82.3 kg/tree) at Bikaner. Maximum yield was recorded in Muskat 2 (20 kg/tree) followed by Shamran (18 kg/tree) and Umshock (14 kg/tree) at Jodhpur.

The plants of fig Poona pruned to 6 buds and given a swabbing of 1.5% Dormex resulted in maximum sprouting number of fruits (750) and fruit yield/plant (23.0 kg). Pruning during mid-September found to be the best time at Bangalore. The nutritional requirement was standardized (900 g N, 250 g P, 275 g K/plant/year) at Rahuri.

In phalsa, pruning height should be 20 cm from the ground level. Nutritional requirement for custard apple was standardized as 250 : 125 : 125 g NPK/plant/year.

The synthetic pyrethroids deltamethrin (0.2%) and fenvelarate (0.01%) provided most effective control for ber fruit-borer at Rahuri. At Anantpur, it was controlled effectively by spraying of Profenphos + Cypermethrin followed by Monocrotophos and Quinalphos. Application of Deltamethrin (0.03%) and Carbaryl 50 wp 0.02% as alternate sprays at 21 days interval gave an effective control to anar butterfly. Three foliar sprays of Cypermethrin (0.005%) and endosulphan (0.05%) with onset of monsoon at 15 days interval controlled stem capsule caterpillar in aonla at Jobner.

At Aruppukottai, 2 sprays of carbendazim (0.1%) were found very effective against Isariopsis leaf spot in ber. Leaf and fruit spots of pomegranate in Ambia bahar was controlled by one prophylactic spray at flowering or fruit setting and subsequent 4 sprays at 20 days intervals by Ziram (0.25%) or Bordeaux mixture (1.0%) under Rahuri conditions. Four sprays of Chlorothalonil (0.2%) at 15 days interval was found most effective to control aonla rust under Jobner conditions. The fig rust can be controlled successfully by 4 sprays of Bavistin (0.1%) or Dithane Z-78/M-45 (0.3%) or Chlorothalonil (0.2%) or copper oxychloride (0.4%) at 12 days interval at Rahuri. The fruit rotting in date palm was minimized by 2 sprays of Carbendazim (0.1%) followed by copper oxychloride at Bikaner.



A promising selection CISH-B 2 of bael



The IIVR 1 is an early-maturing radish

VEGETABLE CROPS

In vegetable crops, 29 open-pollinated, 8 F₁ hybrids and 3 varieties resistant to diseases have been identified for commercial cultivation in various agroclimatic zones of the country. The details of varieties and recommended areas are given here.

F₁ hybrids ARBH 541 and PBH 6 in brinjal (long), JBH 1 in brinjal (round), BSS 20 in tomato (indeterminate), PCUCH 1 in cucumber, NDBH 4 in bottle gourd, RHRBGH 1 in bitter gourd and DVR 3 in okra were identified for release for cultivation in all the zones of the country. Disease resistant varieties DPP 68 and KS 245 of pea (mid-season) resistant to powdery mildew and VRO 3 of okra resistant to yellow-vein mosaic virus were also identified for release.

Application of 180 kg/ha N and 120 kg/ha P₂O₅ in capsicum hybrid Bharat; 120 kg/ha N and 60 kg/ha P₂O₅ in french bean Arka Komal at Varanasi and 90 kg/ha N, 60 kg/ha P₂O₅ and 60 kg/ha K₂O in bitter gourd Hirkani at Rahuri gave higher yield of 328 q/ha, 96.5 q/ha and 57.68q/ha with C:B ratio of 1 : 5.15, 1 : 1.38 and 1 : 2.61 respectively. Soil solarization of nursery-beds resulted in 90% seedling stand in brinjal, 86.7% in chilli and 74.2% in tomato respectively with reduction in bacterial wilt incidence and weed populations in nursery-beds.

Vegetable varieties recommended for various states

Crop	Variety	Recommended areas
Brinjal (long)	Punjab Sadabahar	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar, Rajasthan, Gujarat, Haryana, Delhi
Brinjal (round)	NDB 28-2	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar
	D 2-88-6	Madhya Pradesh, Maharashtra, Rajasthan, Gujarat, Haryana, Delhi
Tomato (determinate)	BT 116-3-2	Eastern Madhya Pradesh, Orissa, Andhra Pradesh, Rajasthan, Gujarat, Haryana, Delhi
Tomato (indeterminate)	NDT 3	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra
	KS 118	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar
	DVRT 2	Rajasthan, Gujarat, Haryana, Delhi
	BT 20-2-1	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra
Chilli	NDT 9	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar,
	AKC 86-39	Madhya Pradesh, Maharashtra
	BC 14-2	Eastern Madhya Pradesh, Orissa, Andhra Pradesh, Rajasthan, Gujarat, Haryana, Delhi
Garlic	RHRC-Cluster Erect	Madhya Pradesh, Maharashtra
	VLG 7	Jammu and Kashmir, Himachal Pradesh, Hills of Uttar Pradesh, Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar,
Cauliflower (snowball)	KT 25	Jammu and Kashmir, Himachal Pradesh, Hills of Uttar Pradesh
Bitter gourd	PBIG 1	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar,
Bottle gourd	PBOG 61	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar, Rajasthan, Gujarat, Haryana, Delhi
Cucumber	BG L-C-2-1	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar,
	CHC 2	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar,
Pumpkin	CM 350	Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Kerala
Ridge gourd	NDPK 24	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar, Rajasthan, Gujarat, Haryana, Delhi
	CHRG 1	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar,
	PRG 7	Madhya Pradesh, Maharashtra
French bean (bush type)	IIHR 7	Karnataka, Tamil Nadu, Kerala
	CH 812	Madhya Pradesh, Maharashtra, North-Eastern states, Andaman and Nicobar, Sikkim
French bean (pole type)	CH 819	Jammu and Kashmir, Himachal Pradesh, Hills of Uttar Pradesh
Pea (early)	VRP 2	Rajasthan, Gujarat, Haryana, Delhi
	NDVP 12	Punjab, <i>tarai</i> region of Uttar Pradesh, Bihar
Pea (mid-season)	VRP 3	Jammu and Kashmir, Himachal Pradesh, Hills of Uttar Pradesh
Pea (edible-podded)	Organ Sugar Podded	Rajasthan, Gujarat, Haryana, Delhi



One spray of imidacloprid @ 40g a.i./ha+ 2 sprays of betacyfluthrin @ 18.5g a.i./ha was effective in integrated module of okra jassids and shoot and fruit-borer pest management. Spraying of neem-seed kernel extract (5%) was effective in reducing leaf minor damage in cucumber. Spraying of cypermethrin @ 50 g a.i./ha at 20, 35, 50 and 65 days after transplanting was effective for control of shoot and fruit-borer in brinjal with maximum net income. Three sprays of carbendazim (0.1%) from 50 days after sowing at 10 days interval recorded very low disease incidence (12.65%) of *Cercospora* leaf spot of okra with the highest yield (143.12 q/ha) with C : B ratio 1 : 4 as compared to control i.e. disease incidence 49.78%, yield 90.50q/ha and C : B ratio 1 : 2.8.

- In vegetables, 29 open-pollinated varieties, 8 hybrids and 3 varieties have been identified for release

TUBER CROPS

POTATO

Twelve advanced stage hybrids were included in multilocal trials. Out of large number of TPS populations tested for raising commercial crop, population 92-PT-27 was better than the recommended population TPS-C-3. Population 92-PT-27 has advantage for production of hybrid TPS as its parents flower under short day conditions.

DNA (RAPD) fingerprints of 23 advanced hybrids and TPS parent EX/A-680-16 have been prepared using 10 decamer primers. To differentiate late blight resistant and susceptible clones by RAPD markers, 24 Indian potato varieties were characterized. Dendrogram constructed on the basis of band sharing could separate the 24 clones into late blight resistance and susceptible groups. Five transgenic lines were selected for a large-scale evaluation under glasshouse and field conditions, after testing them for PTM resistance in preferential and forced feeding experiments. Thirty-four transgenic lines were also produced by introducing AmA1 gene in 5 Indian potato varieties to increase protein content.

Treating tubers with boric acid whether accompanied with the soil application of gypsum or not effectively controlled black scurf disease, pre-cold storage treatment being superior. Soil solarization was effective for the control of russet scab, black scurf and tuber cracking coupled with increased tuber yield. Residual beneficial effect of soil solarization up to 18 months was observed. Solarization during May-June was more effective than that during August-October; solarization for 2 weeks during May-June was sufficient to control diseases, while for 6 weeks was required to obtain maximum yield increase. Incorporation of *Parthenium* sp., *Thevetia peruviana*, *Chenopodium album* and *Azadirachta indica* in soil after solarization proved more effective in controlling black scurf, lenticel proliferation and russetting. Soil pulverization during hot weather (May-June), made *Fusarium* and *Rhizoctonia* non-detectable up to 4" of soil depth.

The bio-agents namely, *Bacillus cereus*, *B. subtilis*, avirulent *Ralstonia solanacearum*, when applied as seed treatment controlled bacterial wilt effectively at Hasan and Bhubaneswar with increased tuber yield. IDM or combination of two or more treatments like tuber treatment with boric acid or bio-agent, planting of late blight resistant variety, roguing, fungicide application, dehauling and crop rotation, proved very effective in controlling regional diseases and increasing tuber yield.

The tractor-drawn 2-row mounted type potato digger windrower was modified and provided with attachment to collect the dug tubers in small heaps at 1.5 m interval of 1.5 meters with tuber bruising of 3.02%. The 2-row trailed type potato digger windrower was improved by providing rubber spade to avoid bruising during digging operation.

Design of spring loaded anti-clodding attachment for oscillating type digger was modified to have uniform pressing load on all types of ridges thereby preventing any clod formation. At a speed of 2-3 km/hr, it was found to have effective field with a capacity of 1.75 ha/day and tuber exposure as 85-90%, depending upon soil and field conditions.

VEGETABLE IMPROVEMENT

Radish varieties, IIVR 1 (maturing in 30 days) and IIVR 2 (40-45 days duration) have been developed. In chilli, stable CMS lines have been developed for hybrid seed production. The gynocious lines identified in bitter melon are under testing for hybrid seed production.

- DNA fingerprints of 23 advanced hybrids and a TPS parent of potato have been prepared

FERTILIZER APPLICATION

Soil test based fertilizer models predicted the yields with fair accuracy at 20-23 tonnes/ha yield targets at Modipuram. Kufri Jyoti was more sensitive to nutrient stress. Nitrogen needs of early crops of Kufri Sutlej was higher than main crop at Modipuram. At Shimla, Kufri Giriraj responded to higher doses of fertilizers 180 kg N, 66 kg P and 120 kg K/ha than Kufri Jyoti.



THREE-ROW SUB-SOILER DESIGNED

The 3-row sub-soiler designed and developed with an effective field capacity of 0.55 ha/hr and it required 55-60 HP for 300-500mm deep penetration. A potato digger for potato-sugarcane intercrop was also designed.

Evaluation of traditional potato storage methods like heaps and pits at Jalandhar, Modipuram and Patna revealed that the total storage losses were 14-16% in heaps and 8-13% in pits, after 90 days of storage. The temperature in heaps and pits was lower than the ambient by 11 and 13°C respectively. Potatoes stored in heaps and pits were highly suitable for processing. Kufri Chipsona 2 could be stored for 6 months at 10-12°C with CIPC treatment. Under controlled atmosphere storage conditions sprout number and weight increased at 5 and 10% CO₂ (20+1°C and 90-95% RH). Tuber treatment with combination of boric acid (3%) and rectified spirit (0.5%) resulted in significant reduction in disease incidence. Diphenylamine, Carvone, Mentha oil, Eucalyptus oil and Salicylaldehyde were tried for suppressing sprout growth during storage under room temperature and in ECPS. Significant sprout suppression was observed in all the cases. Rotting was minimum with diphenylamine and Salicylaldehyde but was considerable with others.

At CPRS, Jalandhar, 17 edible processed products including 10 non-fried and 7 fried were prepared from potato on a small scale. Among the non-fried products, instant potato soup mix and potato custard have good shelf-life. These products, if produced on the industrial scale and properly advertised, can become very popular in the Indian markets. Potato biscuits and potato cake are 2 bakery items, which have commercial value and can attract the attention of customers, if properly popularized. Products, like potato jam, sweet pie, candies, potato pickle and potato lollipops can be easily made by housewives. Fried products such as potato-sago papads, dehydrated chips, potato sticks and potato waris can be produced by the cottage industry, which, apart from providing employment can bring remunerative returns to the rural folks. Dehydrated chips and potato sticks contain low fat and are most suited for the calories conscious people.

TROPICAL TUBER CROPS

Germplasm collection of 3,968 accessions comprising cassava (1,635), sweet potato (884), yams (734), aroids (551) and minor tuber crops (164) were maintained at CTCRI, Thiruvananthapuram. A total of 1,464 accessions of tuber crops, viz. cassava (1,026), sweet potato (110), *Dioscorea alata* (75), *D. rotundata* (123), *D. esculenta* (28), *Dioscorea* sp. (28), *Colocasia esculenta* (71) and Chinese potato (3) were transferred to *in vitro* medium term conservation.

Two cassava hybrids, Sree Rekha (48.0 tonnes/ha) and Sree Prabha (42.0 tonnes/ha) with good cooking quality under upland and lowland conditions were released for cultivation in Kerala. True Cassava Seed Technology was developed in order to overcome the biological constraints of cassava like low multiplication rate and bulk of seed material requirement, and to enhance rapid spread of the crop to non-traditional and far-flung poverty-stricken areas. Two sweet potato lines RS III-3 and CIP 4 90056.2 with a yield potential of 25-28 tonnes/ha were promising in on farm trials and are in pre-release stage. Five high-yielding accessions of greater yam (*Dioscorea alata*), 3 of elephant-foot yam (*Amorphophallus paeoniifolius*) and 2 of taro were identified for further evaluation.

Three cassava genotypes, CE 165, CE 328 and CI 301, were drought tolerant with more than 25% extractable starch content and maintained optimum leaf area index (LAI), green canopy and high light interception under drought conditions. In greater yam, non-pruned, non-trailed crop produced comparable yield as trailed crop, pruned at 2m height. Significantly higher tuber yield could be obtained from non-trailed, widely spaced crop as compared to trailed, closely spaced crop. Maximum tuber yield (9.28 tonnes/ha) could be obtained, by planting Chinese potato on flat beds at a spacing of 45 cm × 30 cm in vertical position.

On farm technology validation on sex pheromone impregnated 4 mm ID rubber tubing, conducted at Thiruvananthapuram, Hyderabad, Dapoli, Dholi, Ranchi, Kalyani and Faizabad showed that the septa were effective in the mass trapping of weevils. Survey on white fly (*Bemisia tabaci*) and its natural enemies led to the identification of 2 new parasitoids, viz. *Encarsia* sp. and *E. strenua*, 3 new predators,

- Cassava hybrids Sree Rekha and Sree Prabha were released
- The technology for bioconversion of cassava starch factory residues for maltose was standardized using crushed rice seedlings as amylase
- The low-cost effluent technology of detoxification of starch and sago factory effluents was successfully transferred for commercialization



viz. *Serangium parcesetosum*, an unidentified Coccinellid and a Phytoseiid mite. Host transfer and ovipositional studies on white fly proved the existence of two strains of the insect, viz. cassava strain and sweet potato strain. Maximum nymphal and pupal population of white fly was found on the middle leaves of cassava, whereas adult population was maximum in the lower leaves. Major predators of spiral whitefly were identified as *Axinocymnus* sp., *Scymnus* sp. and *Cybocephalus* sp. and parasitoid was *Encarsia* sp. Petroleum ether extracts of cassava tuber rind and seeds and ethyl acetate extract of cassava leaves were effective in causing very high mortality (77-100%) of the rice weevil (*Sitophilus oryzae*). Active charcoal was found to be an effective medium for mass trapping of rice weevil, a major pest of stored cassava chips.

The entomopathogenic fungi, *Beauveria bassiana* and *Metarrhizium anisopliae*, and nematode, *Steinernema glaseri*, were field tested for their efficacy against sweet potato weevil. *Araecerus fasciculatus* is a major storage pest of yams and aroids and its multiplication is fast at 70-80% RH and ambient temperature (27-30°C). *Thaneroclerus buquiti* is found as an effective predator of this pest. New nematodes were reported in *Xanthosoma* (*Meloidogyne javanica*) and elephant-foot yam (*Radopholoides* sp.).

Survey conducted on tuber rot of cassava in Thammampatty and adjoining areas of Tamil Nadu revealed constant association of *Phytophthora palmivora* with the disease. Regulating irrigation, improving drainage and strict adherence to sanitation were found to help in containing the disease. A leaf blight resistant taro cultivar 'Muktakeshi' was identified. The Integrated Disease Management (IDM) package comprising use of resistant variety, tuber treatment with *Trichoderma viride* and one preventive spray with Mancozeb (0.2%) was developed for the management of taro leaf blight.

The technology for the bioconversion of cassava starch factory residues to maltose was standardized using crushed rice seedlings as the source of amylase. Approximately 2.5 kg residues gave 1.5 kg of maltose syrup containing 13% maltose. Technology for the production of cold water-soluble starch was modified to reduce the requirement of alcohol. Carboxymethyl starch with desirable solubility and viscosity was prepared from cassava starch. Studies on the swelling volume, clarity and pasting properties of cassava starch showed that acids/alum produced detrimental effect by reducing the viscosity, whereas oxidising agents had only marginal effect on these properties. Fried cassava chips with excellent texture and acceptable colour could be obtained from fresh cassava root slices pre-treated with 0.1% acetic acid/citric acid, washed and blanched for 10 min. before deep-fat frying. Performance evaluation of a newly fabricated cassava rasper showed that its capacity of tuber rasping is 385 kg/hr and 360 kg/hr with cassava varieties, H 226 and H 165 respectively. Immobilization of *Aspergillus* sp. on brick powder was effective for detoxification of cassava starch factory effluents

Technique for the production of citric acid from sweet potato residues was developed, the yield being 47.6 mg/ml of the culture filtrate of *Aspergillus niger*. The *de novo* production of sugars was maximum when whole tubers of sweet potato were baked or thick chips sun-dried. Least sugar formation was detected during microwave baking. High anthocyanin types useful for extraction of natural colourants were identified in sweet potato (25-30 mg anthocyanin/100g leaves).

Anti-bacterial and anti-fungal properties of *Dioscorea alata*, *Amorphophallus* and *Curcuma* sp. were established through solvent extraction and using microbial cultures. Mucilage from *Colocasia*, *Xanthosoma*, *Amorphophallus* and edible *Dioscorea* sp. was isolated using 0.1% ammonia and acetone precipitation and the yield ranged from 1.8-3.0% (FWB). An additional advantage was the recovery of starch for other uses. A drum type centrifugal granulator for animal feed manufacture from tuber crop flours was fabricated. Petroleum ether extracts of *Curcuma* sp. were separated by TLC and certain fractions were found to have larvicidal (mosquito larvae) effects.

Under the planting material production programme, 47,220 stems of different high-yielding cassava varieties, 4,368 kg of yams and aroids (1,115 kg *D. alata*, 88



Pheromone trap is effective in collecting weevils on sweet potato

NEW TECHNOLOGY

The low-cost effluent treatment technology developed at CTCRI for the detoxification of starch and sago factory effluents was successfully transferred to M/s Selvakumar Starch & Sago Industries, Thammampatty, Salem. The technology has several attractive features like easy installation and maintenance, extra income from fuel gas, permissible levels of BOD, COD and Cyanide, feasibility for aquaculture or recycling of water etc.



kg *D. esculenta* and 187 kg elephant-foot yam) were produced. Approximately, 10,195 stems of cassava, 820 kg of yams and 150 kg of elephant-foot yam and 5,000 vine cuttings of sweet potato were distributed to farmers and developmental agencies. Under the Revolving Fund Scheme, more than 4.0 tonnes of seed material of elephant-foot yam, *Dioscorea* and *Colocasia* were supplied to developmental agencies

Survey on tuber crop cultivation in the tribal areas of Orissa and Madhya Pradesh showed that sweet potato was the most important tuber crop grown by the farmers, followed by yams and taro. Market surveys on cassava products showed that Pune, Mumbai and Kolkata are the major marketing and consumption centres for sago in India, inflow to the market being from Salem in the former two places and Samalkot in the latter place.

M U S H R O O M

Gene Bank of National Research Centre for Mushroom (NRCM) was enriched by adding 107 fleshy fungi collected from forest areas of Himachal Pradesh. For the conservation of germplasm, different methods were developed. Mushroom cultures could be preserved for a short period when wheat grain was used as substrate/medium and stored at 4°C. For medium storage, higher recoveries were achieved from liquid paraffin storage at room temperature and in glycerol, both at room temperature and at 4°C. For a long-term preservation, cryopreservation was effective and cultures could be stored for more than 2 years.

Protocols for DNA isolation, purification, quantification and amplification were standardized to detect the genetic variations during storage. Of the 43 *Agaricus bisporus* lines comprising commercial strains, wild collection from India and exotic strains evaluated for yield, quality and insect pest resistance to select as parental lines, bran strains from USA produced tough fruit bodies with higher yield at lower temperature (14-16°C) compared to white strains.

The *Morchella vulgaris*, *M. conica* and *M. esculenta* were collected from Himachal Pradesh for domestication.

The compost prepared in newly-constructed phase I bunkers gave 18% higher yields of *Agaricus bisporus*/*A. bitorquis* in 6 weeks of cropping. Post composting supplementation of compost with organic nitrogen containing supplements like soybean/cotton seed at the time of casing showed significant yield increase when added to substrate at 6" depth and whole compost mass. Both soybean and cotton seed proved to be good supplements when applied after formalin treatment.

Coir pith, fine grade garbage compost, coarse grade garbage compost, spent mushroom compost, both alone and in various combinations were promising as casing materials in cultivation of commonly-grown white button mushroom, *A. bisporus*. Medicinal mushroom, *Ganoderma lucidum*, was successfully cultivated for the first time in India on saw-dust and wheat straw substrates.

Disease surveys conducted in mushroom farms of Himachal Pradesh, Haryana and Punjab revealed the maximum incidence of *Mycogone perniciosa*, followed by yellow mould and ink cap. In some areas in Haryana (Morni Hills) 25-30% incidence of wet bubble disease was recorded. Sciarid fly infestation was observed in all the farms surveyed. Integrated management of *Mycogone* disease includes removal of old casing - application of Bavistin (0.1%) spray -recasing of the bed. This reduced the disease incidence significantly and increased the healthy mushroom yield.

Single spray of Bavistin @ 0.1% after casing effectively controlled the disease caused by *Mycogone perniciosa*, *Verticillium fungicola* and competitor mould *Sepedonium chrysospermum* was effectively controlled by spraying of Dithane M-45. Bavistin was also effective for the control of dry bubble (*V. fungicola*) and sporogon was effective against wet bubble (*Mycogone perniciosa*) @ 0.2% spray when applied immediately after casing. Studies on seasonal abundance of mushroom flies using light traps indicated that maximum population of phorids was observed during October, whereas maximum populations of sciarids was observed during May on seasonally grown crops at Solan.



New strain of spring tropical mushroom

- An improved method of drying button mushroom was developed
- The mushroom powder was excellent for making soup, biscuits, nuggets etc.
- Four on-campus and 2-off campus training programmes on mushroom were organized



Improved method of drying the button mushroom (*Agaricus bisporus*) was developed which yielded mushroom powder suitable for production of excellent quality mushroom soup powder, biscuits, nuggets, etc.

NRC for Mushroom, Solan, has organized 4 on-campus and 2-off campus training programmes for trainees from all over the country.

- Gene bank of NRCM was enriched by adding 107 fleshy fungi collected from different forest areas

FLORICULTURE

ROSE

Rose Pusa Gaurav, Pusa Bahadur, Pusa Priya, Pusa Barahmasi, Pusa Viranghana, Pusa Pitamber, Pusa Garima and Dr Bharat Ram were released by IARI, New Delhi. Application of NPK @ 400:300:200 ppm per week has been recommended for Ludhiana and Bhubaneswar regions. In First Red, nutritional dose of 150 ppm N, 50 ppm P₂O₅ and 150 ppm K₂O/day along with 10kg FYM m²/year was best for production of quality cut flowers under polyhouse conditions. Spraying of Kavach 0.2% for the control of powdery mildew, 6 sprays of captan 0.2% or Bavistin 0.2% at 8 days interval for leaf spot/leaf blight, Vertimex 0.25%, or Mavrik 0.4 ml/litre for thrips and Curacron 2ml/litre for borer were standardized.

- New varieties of rose, gladiolus, chrysanthemum, carnation etc. were released

GLADIOLUS

Gladiolus Chandi, Gunjan, Kamini, Mohini, Lohit Rangmahal, Sarang, Shagun, Shringarika, Sukanya, Swapnil, Swarnima, Sunayana and Punjab Dawn were developed and released by Delhi and Ludhiana centres. For the production of quality spikes in gladiolus, 2 sprays of Fe₂SO₄ @ 0.2% at third and sixth leaf stages were recommended for Punjab and adjoining states. Pre-planting and pre-storage treatment of gladiolus corms with carbendazim (0.1%) + Bavistin (0.3%) was recommended for the control of Fusarium wilt and storage rot of corms. A holding solution consisting of sucrose (4%) + Al₂SO₄ (300 ppm) + NaCl (25 ppm) has been recommended for enhancing postharvest life of gladiolus cut spikes.

CHRYSANTHEMUM

Chrysanthemum Arka Ganga, Arka Ravi and Arka Swarna (IIHR, Bangalore); Shanti, Y2K, Kargil, Diana and Sadbhavna (NBRI, Lucknow); Punjab Anuradha and Punjab Gold (PAU, Ludhiana) were released for commercial cultivation. Yellow Gold, Nilima and Co 2 developed by IIHR, Bangalore and TNAU, Coimbatore, were recommended for commercial cultivation under Bangalore region. A spacing of 30 cm × 20 cm, pinching twice 4 and 7 weeks after planting and fertilization with 30 g N and 20g each of P and K/m² was recommended for Bangalore region.

Six sprays of Dithane M-45 (0.2%) at 15 days interval starting from incidence of the disease was the most effective control for leaf spot disease.

CARNATION

Single pinching in carnation Impala hastened flowering, whereas double pinching in Exotica produced highest flower yield and longest stalks at Delhi centre. Planting in October, pinching by Pinch-and-a-Half method and application of 1500ppm of nitrogen produced maximum flower yield at Solan.

ORCHIDS

Gravel was the best medium for epiphytic orchids at Coimbatore. In Dendrobium hybrid Sonia, application of NPK (30 : 10 : 10) at 0.2% weekly twice along with BA (200ppm) was best for maximum growth and flowering.



ANTHURIUM

Top cuttings treated with IBA (2000ppm) was best for rooting in comparison to nodal cuttings and the stem splits were the best for the propagation of anthuriums. Potting medium consisting of FYM and coco-peat was best for its cultivation at Coimbatore. Application of 20 : 20 : 40 NPK @ 0.25% at weekly intervals was recommended at Vellanikkara.

TUBEROSE

Planting in February at Pune, Lucknow and Hyderabad and in March at Kalyani is the best time for tuberose. Application of 200 : 100 : 200 kg/ha of NPK is recommended for Kalyani region.

GERBERA

Two-row planting of Gebera at a spacing of 30 cm × 20 cm under naturally ventilated or tunnel type polyhouse was best in Gebera Sangria at Pune. In Golden Gate, nutritional dose of 100 ppm N, 40 ppm, P₂O₅ and 150 ppm K₂O/day along with 10 kg FYM/m²/year was recommended for maximum production of quality flowers at Pune.

PLANTATION CROPS

COCONUT



An ideal coconut variety for Assam

In tissue culture studies for rapid multiplication of elite genotype in coconut, 15% of the cultures derived from West Coast Tall produced shoots in the medium containing spermine. Half strength MS medium with 50 mg/litre NAA was best combination for root induction from leaf explants.

A large-scale inoculation trial in polybag coconut seedlings was conducted using biofertilizers prepared from local isolates of associative nitrogen fixers. The biofertilizers prepared from *Azocarcus*, *Arthobacter* and *Azospirillum* sp. benefited the plants to the maximum extent. *Azospirillum lipoferum*, *A. brasilense*, *Herbaspirillum frisingense*, *Burkholderia*, *Pseudomonas* and *Bacillus* also improved seedling growth and health.

A hybrid dryer with solar energy as the main source of energy and electricity as the alternate source of energy was designed. It consists of a double pass parallel plate solar collector with UV stabilized high-density polyethylene film used as transmitter and black HDPE film used as absorber sheet. The temperature and humidity inside the drying chamber is 25-30°C higher and 20% lower respectively than the ambient temperature and humidity. When the temperature inside the drying chamber reduced below a pre-set level, the electronic control system activates the electric heaters to maintain the temperature inside the drying chamber. A separate electronic control system is incorporated to switch off the dryer when the drying is completed. The dryer capacity is 3,000 coconuts/batch and the drying time is 32 hours.

Studies on abundance of the Eriophyid mite showed that higher temperature combined with high relative humidity were congenial for rapid multiplication of the mite. Intermittent summer rains followed by dry weather were favourable for the population build-up.

ARECANUT

In arecanut, among the crosses Hirehalli Dwarf × Sumangala and Hirehalli Dwarf × Sreemangala minimum height and maximum stem girth of 2.42 and 2.50 m and 64.99 and 61.11 cm respectively were recorded. Among hybrids, maximum ripe nut yield of 9.14 kg/palm was recorded in the cross HD × Sumangala.



C O C O A

A new disease on cocoa, vascular streak die back or cocoa wilt, was seen in parts of Karnataka with an average incidence of 6.69%. The cocoa plants of 2-5 years old were found to be susceptible to infection under field conditions. The disease appears during September after the south-west monsoon and reaches maximum during October-March and declines to a minimum thereafter. The visible symptoms of the diseased plants are yellowing or browning of leaves, wilting of branches and finally death of the whole plants.

- About 18 cultivars of coconut were analysed for fatty acid profile of oil
- A dryer for coconut with solar energy as main source of energy and electricity as an alternated source of energy was designed
- A new disease on cocoa named as vascular streak die-back was noticed.
- Eighteen new accessions of cashew were collected from different states

O I L P A L M

The compost made from oil palm wastes contains 1.4% N, 0.13% P, 0.63% K, 0.28% Ca and 0.26% Mg in addition to the micronutrients. On per hectare basis, this contributes about 167 kg of N, 37 kg P₂O₅ and 90 kg of K₂O compared to the recommended inorganic fertilizer dosage of 177 kg N, 89 kg P₂O₅ and 177 kg of K₂O. Thus the composted oil palm wastes can meet the fertilizer needs to the tune of 94% N, P₂O₅ and 51% K₂O requirement of the crop.

The effect of different levels of irrigation and fertilizer along with various irrigation methods on the morphological and physiological parameters during the pre-bearing stage of oil palm was studied. The number of leaves did not vary significantly among different irrigation and fertilizer levels. But it varied significantly among different irrigation methods evaluated.

Survey conducted at Krishna, East and West Godavari districts of Andhra Pradesh to ascertain the leaf nutrient status in 1,086 mature oil palm plantations revealed that majority of plantations had optimum leaf nitrogen content except Krishna, where 87.5% of the plantations were deficient in nitrogen. The leaf phosphorus content was deficient in all the plantations surveyed. About 54.6% plantations in West Godavari possessed optimum leaf P content. Regarding potassium content, 50% of the plantations in West Godavari and Krishna possessed optimum level.

CROP IMPROVEMENT

Hybrids had low ratio of saturated to unsaturated fatty acids. Andaman Tall had high concentration of medium chain fatty acids (MCFAs) including high lauric acid concentration. The Chowghat Orange Dwarf × West Coast Tall ranked top when both these criteria were taken into consideration. Laccadive Tall × Ganga Bondam Dwarf had low ratio of saturated to unsaturated fatty acid and high concentration of lauric acid.

C A S H E W

Eighteen new accessions were collected from Maharashtra, Andhra Pradesh, Kerala and Karnataka, taking the total to 451.

The performance of BPP 4 and K 22-1 were found better compared to other varieties in different varietal improvement trials conducted. Processed kernels of released varieties were evaluated for physical and sensory characters such as colour, size, texture and taste using 9-point hedonic scale. NRCC Sel 1 was most preferred, whereas BPP 3 and BLA 139 1 were least preferred.

The tree height increased significantly in high-density plot (500 trees/ha) over low-density plot (156 trees/ha). Effective canopy height was significantly more in low-density plots than high-density plots. Available 'N' in soil up to 1m depth was higher in high-density plots than in low-density plots.

Soil conservation and irrigation, coconut husk burial between 2 rows of cashew resulted in 300% increase in yield. Similarly with irrigation and soil conservation, the yield was 400% of control plot. The extent of egg parasitism (*Telenomus* sp. and *Chaetostricha* sp.) on TMB under west coast was quite prominent (35.6–62.5%) whereas it was least in east coast (0.0–21.6%).

PEST MANAGEMENT

The use of bioagents like green muscardine fungus (*Metarrhizium anisopliae*) culture developed on broken maize grains caused 100% control of the beetle when applied thrice in the farmyard pits continuously at monthly intervals. Symptoms of the fungus were observed as soon it comes in contact with the grub. The infected grub becomes harder 10 days after application and mortality within 30 days. Grubs turn to green and later to gray. All the stages of the beetle were infected by the culture. Pheromone traps using Sime RB oryctalure sachets were not found to be effective for the control of rhinoceros beetle.

S P I C E S

The germplasm conservation at Indian Institute of Spices, Calicut, was strengthened by adding 148 collections of *Piper* species and 3, 15 and 9 collections of *Elettaria*, *Zingiber* and *Curcuma* species, respectively. Four collections of *Vanilla* sp. and 30 collections of tree spices (*Garcinia* sp., *Myristica* sp., *Syzygium* sp. and *Cinnamomum*



SUCCESS STORY

SOFTWOOD GRAFTING

Grafting operation should be done under shade in a grafting shed/polyhouse. On the selected rootstock seedling (about 2-month old; 25-30 cm height) 2 pairs of bottom leaves are retained and other leaves are removed using a sharp grafting knife. At a height of 15-20 cm from collar region, the terminal shoot is decapitated by giving a transverse cut. A cleft of 6-7 cm deep is made in the middle of the decapitated stem by giving a longitudinal cut. A little portion of wood is removed from the inner sides of the cleft at the tip, so that after grafting, the graft joint will be perfect. A matching scion for the

rootstock is selected. The cut end of the scion is mended into a wedge shape of 6-7 cm length by chopping off the bark and little portion of wood from 2 opposite sides taking care to retain some bark on the remaining 2 sides. While preparing the wedge, the gum on the cut surfaces should not be disturbed/soiled by touching with fingers. The tip of the wedge should be as thin as possible. The wedge of scion is inserted into the cleft of the rootstock taking care to align the cambial layers of both the rootstock and scion. If the scion is thicker in girth, then the cambial layers of both the rootstock and scion should be united at least on one side with the help of a finger. Then graft joint is secured firmly with a polythene strip (2cm wide, 30 cm long and 100 gauge thick). A long and narrow polythene bag (20cm × 4cm size and 200 gauge thick) is inserted on the graft plant. This protects the scion from desiccation. After 2-3 weeks of grafting, the polythene caps are removed and the grafts are shifted to open area in the nursery. Freshly prepared softwood grafts may also be maintained in polyhouse without shifting them to open



The technology for softwood grafting in cashew

nursery area. Then grafts are maintained in the nursery till they are sold. Softwood grafts can be prepared almost throughout the year with a mean graft success of 65-70% saleable grafts. However, the best season for grafting would be June-November under Dakshina Kannada weather conditions.

Government of India realizing the viability of the technology, has come forward during the Eight Plan period to establish Regional Nurseries in different cashew-growing states. Today we have 75 units of Regional Nurseries in the country supported by Directorate

of Cashew and Cocoa Development (DCCD), Ministry of Agriculture, Cochin. These nurseries have the production potential of over 80 lakh grafts annually.

Training programme on "Vegetative Propagation of Cashew" is being conducted by NRCC and other Centers of AICRP on Cashew, regularly for the benefit of farmers and nursery assistants from various development departments. The main objective of this programme is to train the interest of farmers and field level functionaries. A total of 31 such training programmes have been conducted so far at NRCC alone and 437

persons were trained.

From 1992-93 to 2000-2001, these Regional Nurseries could produce and supply about 3.77 crores of quality planting material to the farmers and development agencies, covering an area of about 1.70 lakh ha. With the area expansion taking place with high-yielding clones, we will be able to achieve the requirement of one million tonnes of raw nuts for processing in India.

sp.) were also added to the germplasm. The cardamom accessions conserved in the *in vitro* gene bank maintained their genetic stability even after 6 years of conservation.

Evaluation of black pepper hybrids for their yield at Valparai (Tamil Nadu), a high altitude region, indicated that HP 34, HP 105 and HP 813 were promising. Coll. 1041, was tolerant to *Phytophthora* foot-rot and yielded 4.77 kg (green)/vine. Among 150 black pepper germplasm accessions screened for drought, HP 976 and Acc. H 892 were tolerant. Evaluation of promising turmeric lines indicated that highest yield of 34.7 tonnes/ha (fresh) with a dry recovery of 20% was recorded in Selection 585.

Grafting of black pepper of *Piper colubrinum*, a rootstock resistant to *Phytophthora capsici*, indicated that tongue method (56.8%) and double rootstock method (78.2%) of grafting were significantly superior to other techniques. Among wild and related species of *Myristica* evaluated as rootstocks for grafting nutmeg, *M. malabarica* was most compatible.

The cardamom Acc.PS-44 an open-pollinated seedling of PV 1, a Malabar variety, was found promising at Pampadumpara (KAU). Two superior clones, Acc. 8-4-D11 and 7-24-D11, were identified by the Mudigere centre.

Coriander, RCr 441, RCr 435, Rcr 436, UD 446 and UD 684 were resistance to root-knot nematodes at Jobner. Sowing of cumin on 10 November was best to minimize wilt incidence, with higher green yield (3.63 q/ha). Guj. Cumin 3, Acc 1136, Acc 1145, Acc 1165 were moderately resistant to *Fusarium* wilt. The highest volatile oil content in cumin was found in EC 232684 (4.4%) and JC 147 (39%).

- Germplasm collections of various spices were strengthened



SPICES IMPROVEMENT

In ginger, 2 high-yielding selections—Coll.35 and Coll. 117—with yield potential of 22.4 and 23.2 tonnes/ha respectively have been recommended for release. A promising nutmeg line, A 9/4, with an yield potential of 4,800 kg mace/ha and 31,220 kg nuts/ha has been recommended for release.

Kasuri methi (a species related to fenugreek) was found tolerant to powdery mildew. Sowing of fenugreek variety RMt 1 on 31 October and UM 305 up to 15 November at 25-30 cm row spacing is recommended for general adoption under semi-arid conditions.

Evaluation of organic materials as nutrient sources, indicated that coir compost enriched with DAP (0.2kg/m³) can replace farmyard manure in the nursery mixture for raising black pepper cuttings. Application of farmyard manure and vermicompost @ 1.25 kg/pot with 10 kg soil enhanced the yield of bush pepper by 119 and 75% respectively compared to chemical fertilizers. Foliar diagnostic norms for assessing nutrient balance and yield was developed by utilizing Diagnosis Recommendations Integrated System (DRIS) for optimum production in cardamom.

About 18% dry recovery was obtained from ginger Bhaise, Kalimpong and Gurubathani when these were cultivated in plains of Kerela compared to 10-12% at higher altitude (Sikkim). However, volatile oil and oleoresin were higher (2.5 and 7%) at Sikkim compared to Kerala (1.5 and 5%).

The micronutrient application increased the yield in coriander. Foliar application of MnSO₄, ZnSO₄ and CuSO₄ each @ 0.50% and soil application of FeSO₄ @ 5 kg/ha or foliar application at pre-flowering stage @0.125% can be recommended to get higher seed yield of coriander under micronutrient deficient sandy loam soils.

Studies on synthesis of curcumin in turmeric indicated that the activity of phenyl alanine ammonia lyase (PAL), the key enzyme in curcumin biosynthesis was maximum in the mitochondrial fraction compared to microsomal and cytoplasmic fractions. GC profile of volatile oils of turmeric rhizomes, roots and leaves showed that ar-turmerone was the major component in rhizomes, roots (31.5% and 46.8% respectively) while 2- phellandrene (32.6%) was the major component in leaves.

A storage technology for reducing the disease incidence and high recovery of seed rhizome involves storage in sand layered pits mixed with Dithane M-45+ Bavistin (5g+3g/kg of seed) and is recommended for adoption.

Biochemical characterization of *Phytophthora* isolates was initiated using isozyme analysis. The isolates were characterized for catalase (CAT), superoxide dismutase (SOD), malic enzyme (ME) and glucose-6 phosphate dehydrogenase (G6PDH). Up to 10 putative loci were resolved across the 4 enzyme systems studied. The electrophoretic patterns for 4 enzymes revealed that 3 loci each for SOD and ME and 2 loci for G6PDH.

Screening of germplasm of black pepper against *Phytophthora capsici* indicated that HP 105, HP 423, HP 664, HP 756 and HP 780 showed tolerant reaction.

Promising isolates of fluorescent *Pseudomonas* sp. and *Trichoderma* sp. were isolated from rhizosphere of black pepper. Volatile metabolites produced by *Trichoderma* spp. reduced virulence of *P. capsici*. Among 20, *T. harzianum* isolates studied, 6 of them caused more than 50% loss in virulence of *P. capsici*. Among the various *Trichoderma* spp. evaluated for their effect on growth promotion of black pepper seedlings and control of foot rot, *T. aureoviride* P-25 and *T. aureoviride* P-25 + *T. harzianum* P-26 promoted maximum growth of seedlings. Coir compost + sorghum was the best carrier medium for mass multiplication of *Trichoderma*.

An integrated strategy involving pruning of fresh infested shoots (at fortnightly intervals) during July-August and spraying of insecticide (at monthly intervals) during September-October was effective for the management of shoot-borer (*Conogethes punctiferalis*) a major pest of ginger.

Of the 29 isolates of plant growth-promoting Rhizobacteria from roots of black pepper and turmeric, 10 caused 100% mortality of root-knot nematodes in *in vitro* bioassays. Thirteen promising fungal biocontrol agents were evaluated on turmeric in microplots infested with root-knot nematodes, among which *Verticillium chlamydosporium*, *Paecilomyces lilacinus*, *Fusarium* sp., *Aspergillus nidulans* and *Scopulariopsis* sp. suppressed nematode populations significantly. Evaluation of biocontrol agents for the management of root-knot nematode of black pepper in the field indicated significant reduction in nematode populations in plots treated with *Trichoderma harzianum*, *V. chlamydosporium* and *Pasteuriar*.

Acc. 35 is a new recommended ginger variety





A 9/4: a high-yielding nutmeg

SOLARIZATION

A simple disinfection technique to eliminate *Ralstonia solanacearum*, the causal organism of bacterial wilt, from seed rhizomes of ginger was developed. The method involves solarization of ginger rhizomes for 2-4 hours which raised the rhizome temperature to 55°C during summer just before planting which eliminated the seed-borne pathogens from ginger rhizomes.

A promising betelvine



A low-cost technology for mass multiplication of *Trichoderma* sp. for field application has been developed by the Sirsi centre. Survey conducted in the Idukki district of Kerala by the Pampadumpara centre (KAU) reported the occurrence of anthracnose disease and marginal gall thrips in black pepper. A package of plant protection measures was recommended for the management of *Phytophthora* foot-rot in black pepper by the Panniyur (KAU) and Sirsi centres. Two sprayings of either Monocrotophos (0.05%) or Dimethoate (0.05%) at fortnightly intervals after harvesting of berries are very effective in the reduction of black pepper mussel scale *Lepidosaphes piperis* at high ranges of Idukki district and is recommended for adoption.

BETELVINE

In initial evaluation trial, Vasani Kapoori, Shirpurkata and Dindugal produced highest leaf yield compared to local check. Yield increase was 89.4, 33.1 and 41.6% respectively. In hybrid evaluation trial, GN hybrid (Godi Bangla × Kapoori Nasik) showed normal vigour. Hundred per cent replenishment of pan evaporation rate through drip irrigation produced highest leaf yield (27.66 lakhs/ha) but it was at par with 150% replenishment (26.70 lakhs/ha) at JNKVV, Jabalpur. However, at MPAU centre 125% evaporation replenishment produced highest yield (32.09 lakh/ha).

Application of *Trichoderma* inoculated oil cake at quarterly interval was found statistically at par with Bordeaux mixture (4D+8S) treatment in increasing leaf yield and in reducing the disease incidence.

The maximum and minimum temperature and maximum relative humidity had positive correlations on foot-rot disease development, whereas minimum relative humidity had negative correlation in disease development. Step down analysis revealed that 1°C increase in maximum temperature increased 0.88% disease incidence. Similarly, 1% increase in relative humidity increased 0.32% disease incidence. In Sirmurali Bhabna, variety of betelvine minimum temperature, maximum relative humidity and rainfall had positive significant effect on per cent disease incidence of leaf rot, while maximum temperature showed a negative correlation. In Harshpur Bangla, minimum temperature and maximum relative humidity had positive effect on disease incidence of leaf rot, while maximum temperature and rainfall had negative effect.

The important contributing environmental components for leaf-rot disease incidence were maximum relative humidity above 90% and minimum temperature (26-30°C), which seems to have accounted for 22.09 and 11.38% of the total variation in disease incidence, respectively.

Temperature, total rainfall and cloudy days had positive effect, whereas bright sunshine had negative correlation on Anthracnose disease incidence. Maximum and minimum temperature, relative humidity, bright sunshine hours and rainfall had positive correlation, whereas number of rainy days and number of cloudy days had negative correlation effect on bacterial leaf spot disease incidence.

Integrated disease management with sanitation + one soil drenching of Bordeaux mixture + *Trichoderma* application (after one month) + one more soil drenching of Bordeaux mixture significantly reduced *Phytophthora* foot-rot disease incidence and increased leaf yield. Highest cost : benefit ratio was also obtained at AAU (1 : 2.94), JNKVV (1 : 1.40) and MPAU (1 : 3.34).

Application of oil cakes + carbofuran + 3 inoculations of *P. lilacinus* inoculated oil cakes was found to control root-knot nematode and increased leaf yield compared to other treatments.

Tobacco caterpillar and white mites were important pests in Andhra Pradesh observed during first fortnight of October and first fortnight of January. Black fly, aphids, red spider mites and betelvine bug were found serious and widely distributed in Maharashtra. Peak appearance of black fly was in November, aphids in December and betelvine bug in October. In Tamil Nadu, scales and spider mites were observed



as major pests appearing maximum during second fortnight of April and summer months, respectively.

About 18% yield loss due to tobacco caterpillar at ANGRAU, 12% yield loss due to mite at MPKV, and 51% yield loss due to scale insect at TNAU, Coimbatore were observed.

MEDICINAL AND AROMATIC PLANTS

Fifteen gemplasm lines of aswagandha were evaluated at MPUAT. Root yield/plant was maximum in RAs 20 (30g). Total alkaloid yield was highest in RAs 22 (0.61%). In isabgol, 71 genotypes including 3 checks, viz. RI 89, GI 2 and Sel 10 were evaluated. Effective spikes/plant ranged from 4.25 in MIB 125 to 15.90 in AMB 6. The maturity period varied from 100 days in DM 5 to 112 days in P 79. Seed yield/ha ranged between 8,440 kg in DM 11 and 2,331 kg in PB 31. In PB 3-1, swelling factor was 14.25 cc/g. Two strains, PS 19 and HI 1, were found to be immune and strains, PB 62, Palampur 3, P 79 and DM 11 were recorded as resistant to downy mildew. In ashwagandha, application of 100 ppm cycocel enhanced alkaloid content (0.99%) in roots significantly. A combined dose each of 30 kg /ha of N and P emerged as an optimum dose for increasing the root yield of rainfed ashwagandha. Application of Isoproturon at 0.75 kg/ha + hand-weeding 45 DAS emerged as an effective weed control method.

In liquorice, HM 1 recorded highest number of inflorescences/ branch (13.3), pods/inflorescence (5.4) and pod setting (23.7%) was recorded in HM 1. Florets/inflorescence were highest in EC 120170 (26.2).

In vertiver, IC 78651 performed statistically significant over the control in root yield and oil content. However, it was observed that total oil yield was about 3 times lesser than that of NDUAT (15.5 litres/ha).

In safed musli, MCB 405 gave highest yield (2,056 kg fleshy roots/ha). There is a total absence of self-incompatibility in safed musli. The highest percentage of seed germination, increase in shoot length, number of rhizomatous roots and fresh weight of roots was recorded with seed soaking in GA₃ 1000 ppm for 24 hr or in humic acid (0.5%) compared to the control. Removal of the inflorescence enhanced length of leaf and tuber and total weight of tuber per hill. Maximum tuber yield (9.5 tonnes/ha) was obtained with 15 tonnes FYM/ha but it was at par with 10 and 20 tonnes FYM/ha.

Thirty-two accessions of Kawch (*Mucuna pruriens*) were collected and were evaluated for L-DOPA content which varied from 7.43 to 5.4%. Controlled selfing between flowers on the same plant of Glory lily (*Gloriosa superba* L.) gave best result in terms of percentage fruit set, number of seeds/fruit, seed weight and colchicine content.

Application of 3 irrigations 25, 50 and 75 DAS significantly increased growth characters and seed yield compared to 2 irrigations (25 and 50 DAS) in isabgol. Swelling factor of seed was reduced significantly due to 4 irrigations compared to 2 or 3 irrigations. Application of 30 kg N/ha significantly increased seed yield and swelling factor of seed was reduced significantly due to application of higher dose of N (45 kg /ha).

In kalmegh (*Andrographis paniculata*), application of N through organic and inorganic sources enhanced dry herbage yield significantly over control. Application of 20 kg N/ha through castor cake would be the best option for getting higher yield of kalmegh.

In babchi (*Psoralea corylifolia*), application of 40 kg N+20kg P/ha resulted in significantly higher branches/plant, ears/plant, seed yield and psoralin content of seed, 40 cm × 30cm spacing gave 24.20 and 3.12% higher seed yield compared to 30 cm × 30 cm and 60 cm × 30cm respectively.

In isabgol, spraying of mancozeb (0.3%) did not significantly increase the yield though the per cent disease index of downy mildew was significantly lower than the unsprayed control.



Poppy capsules are ready for latex extraction

- Fifteen germplasm lines of Ashwagandha were evaluated

NEW DEVELOPMENT

In opium poppy, Chetak Aphim proved its superiority with respect to latex (97.80 kg/ha) and morphine yield (19.61 kg/ha). At NDUAT, NOP 530, NOP 549 and Kirtiman were found to be superior performers in latex and seed yield.



POSTHARVEST MANAGEMENT

- The fruit-based carbonated drinks are being tested at IARI, New Delhi

VALUE-ADDED PRODUCTS

The technology for fruit-based carbonated drinks on pilot plant scale has been developed. The beverages are being produced on commercial line under the brand name 'Pusa Fruit Drinks'. A method has been standardized for the preparation of apple pulp. The heat process of pulp at 90°C for 5 minutes was suitable to make it free from microorganisms as well as enzymatic browning. The 8-minute conventional blanching treatment of peeled banana and 3-minute microwave blanching resulted in cent per cent activity loss of the enzymes (PPO, POD and PME) are responsible for browning. Onion powder could be prepared from 5 mm thick osmotically-dehydrated onion slices after drying in a cabinet dryer at 60°C for 10 hr, grinding in a laboratory powder mill and sieving with 30 mesh sieve, these could be stored up to 6 months in 400 gauge LDPE or 200 gauge HDPE pouches at 7°C compared to 4 months at ambient condition with better pungency. Drying and dehydration including osmotic concentration have been standardized for plum, ginger, apple and galgal.

Postharvest treatment of mango fruits with chlorine water improved ripening of fruits and also reduced microbial load significantly. Shelf-life of Kesar mango fruits could be extended up to 54 days when treated with combination of waxol (6%)+ carbendazim (0.1%) and stored in cool store followed by 30 days when stored in cool chamber and 58 days when stored at room temperature.

Application of ethrel 500 ppm and storing in zero-energy cool chamber in order to obtain a uniform golden yellow colour could successfully regulate the ripening of banana. Hot benomyl application (500 ppm) and stem-end waxing were found to double the shelf-life of banana Basrai (10 days as against 5 days in control) at ambient condition. The treated banana fruits when packed under modified atmosphere packaging could be stored up to 30 days at 13°C as against 15 days in unpacked control fruits. Bunches of Red Banana covered with 1.0% ventilated blue polyethylene bags reduced the time taken for maturity to 115 days (139.2 days in control), increased bunch weight (12.4 kg), pulp weight, ascorbic acid, total sugars and reducing sugar.

Kinnow fruits dipped in 0.05% Bavistin and 4 fruits packed in each polyethylene bags retained the best quality during storage. Dipping of fruits with 50% stay fresh 960 also proved effective. Mosambi sweet orange and acid lime fruits wrapped in vented polyethylene liner could be stored in evaporative cool chamber up to 42 and 30 days, respectively.

Fumigation of litchi Bombai for 15 minutes followed by dipping in pH 1 solution for 5 min. was most effective to retain red colour of dehydrated fruits up to 45 days.

An innovative postharvest treatment with calcium chloride as vacuum infiltration coupled with modified atmosphere packaging of white button mushrooms resulted in its excellent marketability up to 7 days at ambient condition as against only 1-2 days in commercial practice. Packaging of onion Pusa Red in nylon-net bags and open-weave hessian bags of different sizes from 1 kg to 20 kg indicated that at the end of 2 months of storage at room temperature, there was no rotting in smaller packaging lot of 1 kg and 2 kg in nylon-net bags and highest rotting (6.1%) was observed in 20 kg lots of open-weave hessian bags. Total loss due to PLW and rotting was minimum (8.54%) in 1 kg lot of nylon-net bags and maximum (17.65%) in 20 kg lots of pen-weave hessian bags. Tomato fruits packed in wooden box with dried grass as filling material harvested at breaker stage was found effective in reducing PLW and ripening. It also increased the shelf-life to 12 days as against 10.6 days in control.

Studies on removal of florets from the harvested spikes of gladiolus Sunayana and Vandana revealed increased flower opening and diameter of the 7th floret with reduced longevity of spikes. Radio-isotopic studies on sucrose partitioning by the cut rose First Red revealed that postharvest uptake and accumulation of sucrose in different plant parts are dependent on its concentration in the vase solution. A concentration of 4-5% sucrose in vase solution was found to be the optimum for maintaining postharvest quality of cut rose First Red. Excellent marketability of cut rose First Red up to 3 days were observed in zero-energy cool chamber as against only 1 day at ambient condition.



Natural Resource Management

SOIL RESOURCE INVENTORY

Soil Mapping

Soil map of India has been generated on 1 : 1 m scale using soil polygon data from 1 : 250,000 scale soil maps with necessary categoric and cartographic generalization. The soils in this map belong to 7 orders and 62 great groups. There are 1649 soil units in this map. Similarly, regional level soil information system on 1 : 1 million scale has been developed for the north-eastern region of the country from the 1 : 250,000 scale through cartographic generalization. Several thematic maps useful in spatial analysis of relevant theme and land use planning have also been generated.

District Soil Resource Atlases

The district soil resource atlases covering at least one district in each state as a model, encompassing 30 to 40 different themes of significant importance in the district were generated. Maps pertaining to Aurangabad, Nagpur, Jalna and Ratnagiri (Maharashtra), Jamnagar (Gujarat), Madhubani (Bihar), Bankura and Puruliya (West Bengal), Ganjam (Orissa) and Rajgarh (Madhya Pradesh) have been completed. Five hundred copies of each such atlases have already been sent to district authorities for use by them for planning development work, education, extension, research and other activities. Mapping of Sirsa district of Haryana, Etawah district of Uttar Pradesh, Medak district of Andhra Pradesh and Bardhaman, Hugli and South 24-Parganas districts of West Bengal has also been completed.

Soil Erosion Map

Soil erosion map of Maharashtra state has been prepared. The erosion classes and the ranges of soil loss (tonnes/ha) along with the area affected in percentage of total have been worked out.

Soil erosion classes, ranges and percentage area affected for Maharashtra		
Class	Range of soil loss (tonnes/ha/annum)	Area (per cent of the state)
Very slight	(<5.0)	46
Slight	(5.0-10.0)	20
Moderate	(10.0-15.0)	10
Moderately severe	(15.0-20.0)	06
Severe	(20.0-40.0)	08
Very severe	(40.0-80.0)	05
Extremely severe	(>80.0)	05

Extent of Sulphur Deficiency in Indian Soils and Response of Crops

Extensive surveys revealed that sulphur (S) deficiency in Indian soils ranges from 5-83% with a mean of 41%. Of the 220 districts surveyed about 132 have more than 30% of S deficiency. Map showing S deficiency in different AER has

- Soil map of India has been generated on 1 : 1 million scale using soil polygon data from 1:250,000 scale soil map. The soils belong to 7 orders and 62 great groups
- Regional level soil information system on 1 : 1 million scale has been developed for the north-eastern region of the country
- The district soil resource atlases, covering at least one district in each state as a model encompassing 30 to 40 different themes have been generated



been prepared. Sulphur deficiency has been confirmed in 93 frontline demonstration trials carried out in Bihar, Andhra Pradesh, Gujarat, Madhya Pradesh, Tamil Nadu and Uttar Pradesh where application of 20-40 kg S/ha significantly increased the seed yield by 205 to 790 kg/ha. The economic benefit was Rs 14-26 per rupee spent on sulphur fertilizers.

RESOURCE CONSERVATION AND MANAGEMENT

Tillage Management in Soybean–Wheat and Rice–Wheat Systems in a Vertisol

- The yield of soybean under broad bed furrow was higher than under flat on grade land treatment
- *Acacia nilotica* has been recommended for rehabilitation of the degraded ravine soils located adjacent to river Yamuna at Farah, Mathura. Pearlmillet, barley, bluepanic grass and *Cenchrus ciliaris* were found suitable for cultivation with *Acacia nilotica*
- *Acacia nilotica* and *C. equisetifolia* combination was found suitable for reclamation of saline waterlogged vertisol

Performance of different tillage systems was evaluated on soil quality and crop productivity in soybean-wheat and rice-wheat cropping systems. In soybean-wheat cropping system, the effect of tillage on seed yields of both the crops was not significant. It indicates that conservation tillage can be adopted to realize similar yields of soybean with concomitant savings of energy and valuable time during sowing period in monsoon. Seed yields under 150% and 100% recommended nitrogen were at par and were significantly higher than those under 50% and no N treatments, respectively.

Under rice-wheat cropping system, two tillage systems namely, mechanically transplanted rice and direct dry seeded rice were evaluated. The yield and B/C ratio of direct seeded rice were markedly less compared to mechanically transplanted rice. The higher yield in latter system may be attributed to the favourable soil physical environment in transplanted plots. Grain yield improved with nitrogen levels up to 100% N in both the systems.

Effect of tillage and nitrogen on grain yield (tonnes/ha) and benefit: cost ratio of rice (IR 36) in rice-wheat cropping system

Parameter	Tillage treatment	% nitrogen dose (kg/ha)			
		0	50	100	150
Yield	Mechanically transplanted rice	0.80	3.20	5.50	5.70
	Direct dry seeded rice	0.54	0.72	1.12	1.34
B : C ratio	Mechanically transplanted rice	0.34	1.17	1.82	1.73
	Direct dry seeded rice	0.32	0.40	0.57	0.63

Varying Land Treatments for Irrigation and Nutrient Management

Effect of different treatments, viz. (a) broad bed and furrow (BBF) and (b) flat on grade (FOG) and nutrient management showed that the yields of soybean in all treatments under BBF were higher than those under FOG because of better soil physical conditions. While the runoff was 13% of the seasonal rainfall, the soil loss was 3.3 tonnes/ha in both the land treatments. The dry biomass of nodules was 23% higher in BBF than in FOG. Dry biomass of nodules was better in the treatments having organic(s), i.e. FYM and/or *Gliricidia* as component. The replacement of inorganic nitrogen either fully or partially (50% through organics FYM and/or *Gliricidia*) increased nodule dry biomass from 35 to 130% under different land treatments. Nitrogen supply through organics, i.e. FYM and/or *Gliricidia* improved the synthesis of microbial biomass C and N. This is because applied organics acted as substrate for microbes which resulted in intense microbial activity and corresponding accumulation of nutrients.

Establishing Tree Plantations for Ravine Land Reclamation

Experiments on the degraded ravine soils located adjacent to river Yamuna at Farah, Mathura, (light textured, poor fertility) showed that rehabilitation of the land can be effective by the utilization of underground saline waters (EC 5.7-13.2 dS/m). *Acacia nilotica* has been identified as a promising tree which serves as a good



forage for goats. Pearlmillet-barley were most suited for cultivation with *Acacia nilotica* under agrisilvicultural systems while the blue panic grass was most promising under silvipastoral system followed by locally grown *Cenchrus ciliaris*. Feeding trials with goats showed no adverse effects of saline irrigated forages, rather the goats became physiologically healthy with an increase in their haemoglobin contents and packed cell volume.

Tree/Grass Species for Reclamation of Saline Waterlogged Vertisol

Observations at Gangawati (Vertisol soils) showed that as a consequence of water use by trees/tree+grass combinations, seepage to a drain could be checked to the extent of 80-90%. *Acacia nilotica* followed by *C. equisetifolia* could tolerate the higher levels of salinity. The depth to water table increased in the plantation area despite a rising trend outside the plantation. Both *A. nilotica* and *C. equisetifolia* showed higher magnitude of bio-ameliorative effects through considerable reduction in soil salinity and improvements in organic carbon. Trees along with grass had additive bio-ameliorative effects.

SOIL FERTILITY AND NUTRIENT MANAGEMENT

Rice Residue Management under Rice-Wheat System

Soil incorporation of rice residues along with application of N-enriched phosphocompost three weeks prior to the sowing of wheat improved wheat yields and soil organic matter content. Phosphocompost supplied phosphorus as well as additional nitrogen to overcome the adverse impact of nitrogen immobilization due to rice residue incorporation on wheat crop. Residue incorporation in sandy loam soil (pH 7.8) decreased wheat grain yield from 4.72 tonnes/ha to 4.00 tonnes/ha, whereas addition of N-enriched phosphocompost raised it to 4.95 tonnes/ha. This practice of supplying phosphorus through phosphocompost and residue incorporation *in situ* also increased soil organic carbon content and availability of other nutrients in soils.

Wheat yield as affected by addition of rice residues and phosphocompost		
Treatment	Wheat yield (tonnes/ha)	
	Sandy loam	Alfisol
Residues burnt	4.72	2.16
Residues incorporated	3.95	2.25
Residues incorporated +Cellulolytic fungi	4.00	2.36
Residues incorporated + Phosphocompost	4.95	2.97
Residues burnt + Phosphocompost	5.07	2.47
CD (0.05)	2.0	1.7

- Soil incorporation of rice residues along with application of phosphocompost improved wheat yields and soil organic matter content
- Maize and groundnut gave the highest yields when 50% of the inorganic fertilizers were substituted with farmyard manure
- Co-inoculation of *Rhizobium* and antagonistic bacteria along with *Azospirillum/Azotobacter* enhanced the nodulation and grain yields in blackgram and greengram
- The mycorrhizal inoculation on the improved varieties of aonla recorded higher colonization

Long-term Fertilization and Soil Organic Carbon in Rice-based Cropping System

Long-term effects of fertilizer and manure treatments, viz. control, N, NP,NPK and NPK+FYM on soil organic carbon (SOC) dynamics play an important role in the sustainability of intensive cropping systems in different soils under rice-wheat-jute cropping system as experimented on Inceptisol at Barrackpore, West Bengal. Results showed that active pools of carbon (soil microbial biomass C, water soluble-C and water-soluble carbohydrates) are quite sensitive to changes as a result of long-term fertilizer use and land management practices. Slow pool of carbon increased with decrease in the particle size aggregates. The passive pool of carbon, viz. fulvic acid-C and humic acid-C fractions remained unchanged. Integrated use of NPK and FYM maintained higher levels of active pools of carbon than N alone and unmanured



treatment and also resulted in highest yield of crops. Carbon sequestration was positive under 100% of the recommended NPK and 100% NPK + FYM treated plots. Imbalance fertilizer use particularly N alone could not bring carbon to an equilibrium level even after 29 years of rice based cropping system in an alluvial soil.

ENHANCING RHIZOSPHERE COMPETENCY OF *RHIZOBIUM*

Antagonistic bacteria which are capable of suppressing harmful bacteria and fungi in the rhizosphere of legumes capable of enhancing the performance of *Rhizobium* for nodulation, nitrogen fixation and improved yields upon co-inoculation were isolated and tested in controlled and multi-location field experiments. Competitive rhizobia capable of producing siderophores, with intrinsic resistance to antibiotics and phages were identified and their nitrogen fixing potential was assessed. In field experiments, co-inoculation of *Rhizobium* and antagonistic bacteria (AB 3) along with *Azospirillum/Azotobacter* enhanced the nodulation and grain yields in blackgram/greengram. About 30-50 kg/ha more grain yield was obtained with dual or trio-inoculation.

Soybean and Chickpea Breeder Lines for Higher Biological Nitrogen Fixation

Breeder lines of soybean were screened in a vertisol at Jabalpur for identifying cultivars capable of high nodulation with indigenous rhizobia. The variation in nodulation was from 22-42 nodules/plant (1.9 fold variation), 0.55-2.10 g nodules/plant (3.8 x), 1.02-3.29% plant N (3.22 x) and (3.87-6.66)% grain N (1.72 x). Similarly for chickpea a large range of variation (7 fold) in nodule number and plant biomass and a much larger variation in nodule mass within the same field were observed. Results are indicative of the potential for selecting high nodulation variants among extant genotypes of soybean and chickpea in Madhya Pradesh for hybridization efforts to improve BNF in cultivated varieties by exploiting the indigenous rhizobial populations in areas where it may not be possible to practice inoculation.

Integrated Plant Nutrient Supply (IPNS) System

Integrated plant nutrient supply system (IPNS) on maize (Pioneer) and groundnut (TMV 2) during summer revealed that both maize and groundnut gave the highest yield when 50% of the inorganic fertilizers were substituted with farmyard manure (FYM), followed by substitution of inorganics only to an extent of 25%. However, Soil Test based Crop Response (STCR) approach of fertilizer recommendation was better compared to general fertilizer recommendation and farmers' practice.

Frontline demonstrations conducted on groundnut (TMV 7, JL 24, VRI 2), sunflower (PAC 8699) and gingelly (TMV 4 and VRI 1) on red and lateritic soils revealed that addition of 12.5 tonnes FYM/ha saved 35, 18 and 40 kg/ha of N, P₂O₅ and K₂O, respectively. Soil test based recommendations and IPNS recorded the highest yields of 1,910 kg/ha in sunflower, 2,390 kg/ha in groundnut and 950 kg/ha in gingelly.

Integrated Plant Nutrient System (IPNS) in Soybean-Wheat Cropping System

Under FAO-ICAR-IFFCO collaborative project, soil test based application of chemical fertilizers along with organic manure has been demonstrated in irrigated soybean-wheat cropping system of Malwa region. Soil test based fertilizer recommendations resulted in significant increase in number of pods/plant compared to farmers' practices. Application of 4 tonnes/ha of organics along with STCR based dose of fertilizers was found to produce highest yield of soybean in the region.

Effect of Mycorrhizal Inoculations on *Aonla*

The effect of mycorrhizal inoculations on the improved varieties of *aonla* (*Emblia officinalis*), viz. Kanchan, NA 7, Krishna and Chakaiya recorded 65.8%, 75.2%, 76.3% and 70.12% colonization, respectively. Field patterns at Jhansi, Bundelkhand indicate that lowland *aonla* plants are less mycorrhizal as compared to upland ones. Inoculation of *Ziziphus mauritiana* and *Emblia officinalis* with *Acaulospora denticulata* and *Glomus etunicatum* significantly increased collar diameter and total dry matter yield over control.

WATER MANAGEMENT

Performance Evaluation of Cavity Wells as Recharge-cum-Irrigation Wells

A sand column with two heights (180 and 145 cm) was tested for purification of recharge water was not found effective in removing the pathogens, yet it removed turbidity effectively. The recharge rate from the filter was 16.58 l/s (from a surface of -100 sq m), which reduced to one-half within 2 hours due to clogging. In another



study, the hydraulic conductivity (K) and specific storage of the aquifer was reduced with increase in concentration of clay in the water. Decrease in K was 2.24% for 60 hr of recharge with 200 ppm of clay.

Performance Evaluation of Hydraulic Ram in Hilly Areas

A survey of 375 hydrams was conducted in Kumaun division of Uttaranchal that showed only 269 are in working condition, 97 out of order, and 9 completely abandoned as they have failed and cannot be made operative. Performance evaluation of ten selected hydrams was undertaken and break-down and operational problems were identified. The effect of introduction of hydram irrigation on cropping pattern showed that prevalent rainfed maize and pulses were replaced by rice and vegetables in many commands.

Development of Ground Water Simulation Model for Punjab

Simulation model (based on PLASM model) for ground water behaviour in different parts of Punjab was taken up and data related to the hydraulic properties of the aquifers, hydraulic conductivity, specific yield and aquifer bottom elevation maps have been prepared. The calibration of the model is in progress.

Conjunctive Use in Bargi Command

An optimum water allocation plan has been devised for the cropped area of 1947 ha in the command of Bargi Irrigation Project in Jabalpur. The proposed conjunctive use is expected to increase the benefit cost ratio to 1.90 from 1.59 for the existing irrigation system. It has been observed that water table is continuously decreasing in the command.

Ground Water Modeling for Conjunctive Use

A computer program for module related to estimation of soil moisture in the root zone, actual ET, return flow to the ground water due to irrigation, crop yield and rise in groundwater has been prepared for the command of Mula and Musalwadi Irrigation Project. Thematic/derived maps of the Mula command have been prepared using the GIS and remote sensing data.

Open Well Hydraulics

The study was undertaken at Pantnagar to develop the design criteria for the radial strainers by using the Electrolyte Tank model. Relationship between steady flow rate of different well and aquifer parameters of a radial collector well for one particular set of boundary conditions were developed.

An analytical solution for unsteady flow to steady discharging non-penetrating well of finite diameter with hemispherical bottom (cavity well) in a leaky artesian aquifer of finite thickness was obtained. The flow system was analysed in three dimensions using the solution. Methodology (in the form of curve fitting technique) for determining aquifer parameters using the solution had been devised and demonstrated with an example.

Prediction of Rainfall in Coastal Orissa

Using different probability distribution models, probable rainfall of 4 monsoon months of 3 coastal districts were computed. Results revealed that in the month of June, the observed monsoon rainfall was 223 mm at 80% probability level for Cuttack and all the probability distribution functions predict almost comparable rainfall. In July and August months, the lowest Chi-square values were achieved by Extreme value Type-I distribution, whereas in the month of September it was in Log Pearson Type-III distribution. For predicting September rainfall in Balasore and Ganjam, Log normal distribution is best. For computing one-day maximum rainfall for

- Using different probability distribution models, rainfall in coastal Orissa was predicted
- Water requirement and irrigation schedule of pigeonpea and cotton in Gujrat was worked out both under rainfed and irrigated conditions using CROPWAT model. In pigeonpea and cotton full yield potential can be achieved with supplemental irrigation
- At Faizabad, a variable irrigation schedule of IW/CPE 1.2 up to dough stage produced maximum grain yield (3.90 tonnes/ha) of wheat requiring 6 irrigations of 6 cm depth each
- At chiplima 4 irrigations of 6 cm depth scheduled at IW/CPE 1.0 produced optimum seed yield (0.98 tonne/ha) of rajmash



designing soil conservation and hydraulic structures normal distribution can be used for both Dhenkanal and Kamakhyanager area.

Effect of Irrigation Level in Drip and Surface Irrigation

Studies revealed that application of differential amount of irrigation water significantly influenced fruit yield of brinjal. In drip irrigation system, average fruit yield was 29.8 and 10.2% more than that in surface irrigation method in the first and second year, respectively. Irrigation applied at 100 and 80% of the evaporative demand produced comparable fruit yield. Irrigation with 60 and 40% of the evaporative demand reduced fruit yield by 17.8-20.3% and 26.1-28.7%, respectively. In surface method also, irrigation applied at IW/CPE 1.2 at 7-10 days interval in first year and at 11-18 days interval in second year produced fruit yield at par with irrigation applied at IW/CPE 1.0 with 8-13 day and 13-23 days interval in respective year. Longer irrigation interval in surface method curtailed overall growth of plant and finally reduced the fruit yield. In drip system, irrigation supplied at 100 and 80% of the crop evaporative demand have comparable fruit length, diameter and volume of fruit. Fruit weight however was significantly higher with irrigation at 100% of crop evaporative demand. Beyond this level the fruit weight was adversely affected.

FISH POND-CUM-SECONDARY RESERVOIR FOR MULTIPLE USES OF IRRIGATION WATER

A fish pond-cum-secondary reservoir was constructed for economical and multiple uses of irrigation water in agricultural production system. Results revealed that dissolved oxygen level at 1.6 m below water level decreased continuously up to 6 days after water exchange before stabilizing indicating water to be exchanged after every 5 days for proper growth of fish. If the input cost of fish is minimized, fish pond cum secondary reservoir will be beneficial proposition for small farmers.

Performance of Groundnut as Influenced by Mulching and Irrigation

Both irrigation and mulching significantly influenced the productivity of groundnut. Irrigation at flowering, pegging and pod formation stage recorded significantly higher pod yield (1,310.3 kg/ha) than no irrigation (802.4 kg/ha). Mulching also positively influenced pod and haulm yields of groundnut. Pod yields with water hyacinth mulch (1,152.6 kg/ha) and rice straw mulch (1,152.3 kg/ha) recorded significantly superior yields to that of no mulch control (1,039.8 kg/ha). Similarly, the haulm yields recorded with water hyacinth mulch (2,379.3 kg/ha) and rice straw mulch (2,370.7 kg/ha) were significantly superior to that of no mulch control (2,267.5 kg/ha).

Water Management of Cotton and Pigeonpea in Gujarat

Water requirement and irrigation scheduling of pigeonpea and cotton in Bara tract of Gujarat was worked out both for rainfed and irrigated conditions using CROPWAT model. Yield reduction under irrigated and rainfed (20% less) conditions for both the crops were similar, indicating that even under unirrigated conditions in an average normal rainfall year, 80% of the potential yield of both the crops can be achieved. In pigeonpea, the full yield potential of the crop can be achieved with 258, 331 and 395 mm of supplemental irrigation, respectively for three dates of sowing, viz. June 15, June 30 and July 15, respectively. While in cotton, it can be achieved with 189, 270 and 360 mm supplemental irrigation, respectively.

Tillage and Water Management in Wheat in Heavy Soils

Experiment was conducted at Patna on wheat crop during rabi 2000 to study the effect of various tillage practices such as conventional tillage, zero tillage, and raised bed sowing under 3, 5, 7, 9 cm depth of irrigation. Maximum saving of water was observed in raised bed sowing treatments followed by zero tillage as compared to conventional tillage practices. It was observed that in zero tillage, rate of advancement of water was more and infiltration was less as compared to other tillage practices.

Ground Water Contribution to Crop Water Use

Saturated hydraulic conductivity was highest in Typic Paleustalf and lowest in Aeric Fluvaquent. For 0.09 and 1.50 cm depth of water table, the highest upward flux (18.7 mm/d) was observed in Typic Haplustalf and the lowest (5.5 mm/d) in Aeric Tropaquept. At 1.2 m depth the highest flux (10.7 mm/d) was observed in the



same soil group (Typic Haplustalf) but the lowest (2.8 mm/d) was observed in Aeric Fluvaquept. The results indicated that under shallow and medium depth of water table significant amount of ground water was contributed for crop use.

Percolation Tank in Augmenting the Ground Water Recharge

Recharge from the Shivange percolation tank, Rahuri studied since 1992-93 and analysis of well water level data showed that the influence of percolation tank is up to 750 m. The recharge due to percolation tank was estimated to be 89% of inflow, while the average recharge over the period of seven years was 86%. The total inflow based on curve number technique was computed as 216.0 ha-m. Thematic/derived maps (Land use, soil, ground water potential, slope) were prepared for the study area of Rahuri (comprises of 3,109 ha with two percolation tanks having 69.0 and 21.6 ha-m storage capacity) using remote sensing and GIS technique.

Ground Water Pollution from Agro-Chemicals

The field-testing of nitrogen transport model at Ludhiana showed that the maximum and minimum concentrations of NO_3 in the ground water were respectively 29.81 and 0.16 mg/l in 1998; 39.71 and 0.11 mg/l in 1999 and 34.36 and 0.0 mg/l in 2000 and is below the permissible value of 45 mg/l (WHO). No appreciable difference in NO_3 was reported for pre and post-monsoon samples.

Samples from wells from different parts of the University Campus, Jabalpur and analysed for sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and total dissolved salts (TDS) showed that the water belongs to good quality for irrigation with higher alkalinity in some samples. The water and soil (irrigated with polluted well waters) samples from the area near sugar factory showed that the concentration of ions in well water (Ca^{++} , Mg^{++} , Na^{+} , HCO_3^- , CO_3^{2-} , K, Cl, S, SAR, RSC) were reduced after moonsoon that again accumulated in due course up to next monsoon. The quality of the ground water varied from place to place and season to season with the depth of water table. In Haridwar, water in shallow aquifers is rich in bicarbonates (Ca^{++} , Mg^{++}) and alkaline earth metals.

The study taken up in Ikkadu block, Tamil Nadu to investigate the ground water pollution due to NPK fertilizers showed that the well water falls in medium salinity group that can be used for irrigation with some precautions.

Pollution of Ground Water Sources from Surface Discharge

In the Vellore district of Tamil Nadu, the effect of point sources and surface water pollution on the quality of ground water suggest that the well waters were affected due to effluents from tanneries in Kilvisharam, Pernampet, Vaniambadi and in Ranipet and from Palar river and the water has been contaminated due to the effluents from tanneries.

The study undertaken to assess the distribution of pollution of ground water and soil around sugar factory area in the Trichy district in Cauvery basin showed increasing trend in the values of EC, pH, and TDS that indicates increase in salinity.

Managing Crop with Arsenic Contamination in Ground Water in West Bengal

A comprehensive investigation into the arsenic contamination has been reported in ground water of several districts of West Bengal revealed that the arsenic pollution in ground water in parts of West Bengal is a long-term geological phenomenon. Arsenic was introduced into the clastic sediments forming the aquifer of the affected areas in soluble state carried by the river water of the Ganges. There are safe water zones even within the affected (contaminated) areas. The worst affected is the Baruipur Block (South 24 Parganas) of the state with variable toxic concentrations of arsenic in the surface soils as well as in ground water at shallow depths (15-35 m) of the affected zones. The surface water (ponds, open wells, etc.) and the ground water at higher depths (more than 75 m) usually did not contain toxic level (> 0.05 ppm) of arsenic. Soil availability of arsenic can be influenced by different treatments. Besides

RICE-FISH FARMING FOR HIGHER PRODUCTIVITY

An experimental study on rice-fish integration system was conducted at WTCER Research Farm, Bhubaneswar with productivity of fish and prawn 793.1, 1,024.6 and 1,181.2 kg/ha/4 months in the fields with refuge at 15 cm, 12.5 cm and 10 cm dyke height, respectively at stocking density of 25,000/ha. Growth performance of cultured species improved as the dyke height decreased, probably due to increased spillover water supply to the refuge, thus less fluctuation of physico-chemical parameters and increased availability of nutrients and natural feed. The highest recorded productivity of rice, fish and prawn in the system are 2,870.0 kg, 1,143.7 kg and 37.5 kg/ha, respectively corresponding to total gross return of Rs 41,724/ha (selling price of rice, fish and prawn @ Rs 5, 20 and 120 respectively). The equivalent yield of this low input-based rice-fish integration system, however, corresponds to 8.34 tonnes/ha of rice (rice equivalent). Rice and straw yield increased by 6.3-7.4% and 8.1-10.6% (without using any pesticide, etc.) due to the introduction of fish into the rice field. With increase in dyke height from 10 to 15 cm, the overall grain and straw yield increased significantly ($P < 0.05$), due to increased frequency of locomotory movement of fish.



GANGA DIARA LAND MANAGEMENT

In varietal cum manurial trial at Sabour, Bihar sunflower variety MSFH gave the highest yield of 2.29 tonnes/ha followed by 3302 and PAC 36 whereas pointed gourd variety "Hilly" registered the highest yield of 12.4 tonnes/ha. Blackgram (kalai) forage followed by either wheat or gram in rabi gave significant higher return. Blackgram (grain) + gram with net return of Rs 21,708.15/ha and blackgram + lentil sequences were found to be successful as alternative cropping sequence in Diara Land. In intercropping, sunflower + carrot combination fetched significantly higher return of Rs 51,992/ha with full dose of recommended fertilizer. Two hand weeding at 30 and 40 days after sowing in wheat gave similar yields as of application of weedicide Pendimethylene.

drinking water, consumption of crops and vegetables grown on arsenic contaminated soil may be a potential source of its intake in human/animal body. Edible parts of leafy vegetables and root crops contain higher amounts of arsenic as compared to grain and fruit crops. Arsenic intake in the animal is more from the feed sources than through drinking water. Thus, management of the agricultural system holds the key to mitigate the arsenic menace. Addition of organic manure including green manure as well as zinc sulphate to the soil or growing crops like greengram and groundnut reduced arsenic availability and uptake while phosphate application, submergence and salinity increased it. BGA *Anabena* spp. has been found to absorb more arsenic from the medium indicating thereby its decontamination ability in the rice growing system particularly for the *Boro* rice.

Leaching Requirement of Super Cyclone Affected Coastal Soils of Orissa

Leaching requirements of three super cyclone affected coastal soils of Orissa showed that leaching with 2.50 pore volumes of water removed 96 per cent of total salts and brought down EC below 4 dS/m in 40 cm soil layer of Typic Haplaquept and Aeric Tropaquept, while the same amount of water removed 88% of total salts from Aeric Fluvaquept. To achieve the same level of desalinization, i.e. 96% in Aeric Fluvaquept, leaching with 3.00 pore volumes of water was necessary.

Physio-chemical Analysis of Crop under Waterlogged Situation

Five varieties of rice, viz. Panidhan, Lunishree, Tulasi, Sarala and Durga, were evaluated at Barang Village, Orissa under waterlogged conditions. The variety Lunishree and Durga showed early and better canopy development. At mature post heading stage most of the varieties among themselves did not show much variation. The chlorophyll content of the leaves were significantly higher in both variety Panidhan and Lunishree at 100 DAP to a duration up to 135 DAP. The net photosynthesis rate was lowest in variety Panidhan. In general Lunishree and Tulasi maintained very high CO₂ fixation rate along with high internal CO₂ concentration. The yield of Lunishree (4.37 tonnes/ha) was observed highest in all the dates of sowing along with good chlorophyll content, leaf area for longer duration and fairly higher tiller number compared to other varieties. The variety Durga and Tulasi were also found promising.

Management of Diara Land, Assam

Study has been conducted on the evaluation of five improved semi deep-water rice varieties during *khari*f season at five locations of Lakhimpur district in Assam to find out new plant type for deep water rice with high yield for drained environment. The local cultivars Borjahingia Laodubi and Kuhimari can be replaced by Padmanabh and Panindra (Local CVs) which topped the yield levels. Rice grain yield was observed highest (5.20 tonnes/ha) for JM 50 in Haribor Nahami and the lowest (2.00 tonnes/ha) for KDML 105 at Rangpuria in deep water rice varietal trial. Out of 3 toria varieties, viz. M 27, TS-36, and TS-38 tested under four dates of sowing conditions variety M-27 has registered the highest yield in late sown condition whereas TS 36 and TS 38 performed better in early sowing condition (0.925 to 0.945 tonne/ha). Toria yield was reduced by 60% under December sown condition irrespective of varieties, whereas straw mulch alone and in combination with cycocel spray conserved residual moisture with enhanced yield. On farm study was conducted to assess the effect of cutting management practices with varying phosphorus and nitrogen levels on growth and seed yield of coriander. Highest seed yield (2.56 tonnes/ha) was recorded at single cutting at 30 DAS, while no cutting and 2 cuttings produced lower yield. Maximum plant height (70.5 cm) was recorded in maximum level of phosphorus (45 kg/ha). Maximum plant height (82.5 cm), maximum branches/plant (19.7) and highest yield/ha (4.51 tonnes/ha) was recorded with maximum dose of N at 40 kg/ha. Earlier dates of sowing (during 20th March to 5th May) in Bhindi variety



Pusa Sawani resulted in better vegetative growth and higher yield, which gradually decreased towards later dates of sowing.

Rice Water Management in different Locations

At Bilaspur, in sandy clay loam soils, grain yield (5.26 tonnes/ha) of rice was obtained by scheduling 7 cm irrigation at 1 day after drying (DAD). Transplanted rice proved superior over direct seeding. At Chiplima, in sandy loam soils, continuous shallow submergence of 5 + 2 cm produced maximum grain yield (4.16 tonnes/ha) of summer rice with 180 : 80 : 80 kg NPK/ha. At Faizabad, in silt clay loam soils, 7 cm irrigation at 1 DAD produced 6.19 tonnes/ha optimum yield with 150 kg N/ha as fertilizers and 30 kg N/ha as FYM. At Jorhat, in sandy loam soils, highest grain yield of 3.91 tonnes/ha of summer rice was obtained by scheduling 5 cm irrigation at 3 DAD with response to fertilizers observed up to 80 : 40 : 40 kg NPK/ha. At Pantnagar, in silt clay loam soils, maximum rice grain yield of 5.75 tonnes/ha was obtained by scheduling 7 cm irrigation at 3 DAD requiring 2 irrigations under shallow water-table conditions. At Pusa, maximum grain yield (2.85 tonnes/ha) of early rice was obtained by scheduling 7 cm irrigation at 1 DAD with 100 kg N/ha. While maximum grain yield (3.21 tonnes/ha) of timely sown rice was obtained by scheduling 5 + 2 cm irrigation at 3 DAD requiring 3 irrigations.

Water Management in Wheat

Under rice-wheat cropping system at Faizabad, a variable irrigation schedule of IW/CPE = 1.2 up to dough stage produced maximum grain yield (3.90 tonnes/ha) of wheat requiring 6 irrigations of 6 cm depth each. At Hisar, in sandy loam soils, under shallow water-table conditions, scheduling 6 cm irrigation at 60% depletion of available water requiring 3 irrigations produced 4.07 and 4.03 tonnes/ha wheat yield in PBW 343 and RJ 3765, respectively. Nitrogen schedule of 1/4 N at sowing + 1/2 of remaining at 35 DAS + remaining at 55 DAS was observed most appropriate. Under rice wheat cropping system, in slit clay loam soils at Pantnagar, late sown wheat (Cv UP-2338) receiving 6 cm irrigations at CRI + boot + milk stages of crop growth, produced 4.13 tonnes/ha grain yield under shallow water-table conditions. Favourable response of late sown wheat to nitrogen was observed up to 150 kg N/ha in silt clay loam soils while 4 irrigations each of 6 cm depth to late sown wheat produced 2.76 tonnes/ha optimum wheat grain yield. Application of nitrogen @ 150 kg N/ha was observed to be optimum.

Water Management for other Crops

At Pusa, in sandy loam soils, two irrigations each of 5 cm depth to mustard at IW/CPE = 0.8 produced 1.57 tonnes/ha maximum seed yield with 41.8% oil content. Sulphur application @ 15 kg S/ha was observed to be optimum. At Rahuri, irrigation at 75 mm CPE to summer groundnut (Cv. TG-26) produced maximum pod yield of 3.50 tonnes/ha with 52% oil content. Use of 7 micron plastic mulch with spray of 8 per cent kaoline produced 3.53 tonnes/ha pod yield.

At Faizabad, in silt loam soils, 5 light irrigations each of 3 cm depth besides two common irrigations each of 6 cm scheduled at 50 mm CPE produced 21.55 tonnes/ha fruit yield of tomato (Cv. Narendra-2). Paired planting on raised beds proved better than other configurations.

At Kota, in clay loam soils, 5 post sowing irrigations each of 6 cm depth scheduled at IW/CPE 0.8 besides a common irrigation of 10 cm produced 2.01 tonnes/ha optimum yield of dried red chillies. The crop gave a linear response to nitrogen application up to 160 kg N/ha. At Morena, in sandy loam soils, 7 light irrigations each of 2.5 cm depth scheduled at 30% depletion of available soil moisture produced 25.3 tonnes/ha bulb yield of onion. For higher productivity, onion must be planted in the second week of January. Whereas 8 light irrigations each of 4 cm depth scheduled at IW/CPE = 0.8 to December planted onion, produced 36.9 tonnes/ha bulb

WATER MANAGEMENT IN PULSES

At Chiplima, in sandy clay loam soils, 4 irrigations each of 6 cm depth scheduled at IW/CPE 1.0 produced optimum seed yield (0.90 tonnes/ha) of rajmash. Sowing in the second week of November was observed to be appropriate. At Faizabad, in silt loam soils, 4 irrigations each of 5 cm depth scheduled at IW/CPE = 0.9 produced 2.26 tonnes/ha seed yield of rajmash. Application of 100 kg N/ha along with FYM @ 5 tonnes/ha was observed to be optimum. At Jorhat, in sandy loam soils, 6 m drain spacing produced maximum *kharif* moong seed yield of 0.92 tonne/ha. At Parbhani in medium black soil, 2 irrigations each of 6 cm depth scheduled at flowering and pod development stages produced 1.91 tonnes/ha seed yield of pigeonpea (Cv. BSMR 736). Ridge and furrow after two rows with irrigation in each furrow performed better over other treatments. At Parbhani, 2 irrigations each of 6 cm depth at flowering and pod stages produced 1.64 tonnes/ha seed grain yield of chickpea (Cv. ICCV 2).



yield of onion (Cv N 53) with recommended doses of NPK. In potato 6 irrigations each of 6 cm depth scheduled at fixed 10 days interval produced 30.1 tonnes/ha maximum tuber yield (Cv Kufri Chandramukhi) which performed better over IW/CPE approach. Two post sowing irrigations each of 6 cm depth scheduled at 80 and 120 DAS produced 1.03 tonnes/ha seed and 0.4 tonne/ha root yield of ashwagandha. At Kota one irrigation of 6 cm depth produced 0.82 tonne/ha root yield of ashwagandha with 30 kg N/ha. At Chiplima, 21 irrigations each of 6 cm depth to autumn planted sugarcane scheduled at IW/CPE=1.2 produced 129.4 tonnes/ha cane yield.

Pressurised Irrigation Methods at different Centres

At Belvatagi (loamy clay soil) drip irrigation at 100% PE produced 15.7 tonnes/ha yield of curry leaf under normal planting and scheduling at 75% PE and 60% wetted area consumed about 40.3 water/tree/day producing 14 kg/pomegranate tree (Cv Jyothi) which is 71% higher over surface irrigation method and saved 20% irrigation water.

At Bhavanisagar, drip irrigation to tapioca at 75 mm CPE produced 50.4 tonnes/ha tuber yield requiring 54.3 cm irrigation water and micro-sprinkler irrigation at 80% PE on alternate day, registered maximum pod yield (3.60 tonnes/ha) in summer Groundnut (Cv BS-9706). At Madurai, old coconut plantation produced 180 nuts/tree under drip irrigation at 100% PE. Whereas cane yield of ratoon sugarcane (147 tonnes/ha) was obtained through drip irrigation at 60% PE at an interval of 3 days requiring 114 cm of irrigation water with 29% saving. Summer groundnut scheduled at 100% PE produced optimum pod yield of 2.72 tonnes/ha. At Navsari, drip irrigation to tuberose at 80% PE produced 4.22 lakh spikes/ha, which is 66% higher over surface method. At Rahuri paired row planted cotton produced 3.0 tonnes/ha kapas yield under drip irrigation and saved 26% and produced 21.4 tonnes/ha tuber yield of potato.

- Saline and waterlogged soils existing within Haryana were mapped using remote sensing Landsat TM data
- Wheat yield of 3.62 tonnes/ha was recorded with pre-sowing canal water irrigation and saline water irrigation thereafter

SOIL SALINITY AND COASTAL ECOSYSTEM

Mapping Saline and Waterlogged Soils in Central Haryana Using Remote Sensing and GIS

Extent of saline and waterlogged soils in Haryana were mapped using remote sensing Landsat TM data. Digital image processing techniques for different classes were identified with an average accuracy level of 85.6 per cent. The study showed that surface accumulated white salt crystals are a prominent indicator for the detection and correlation of salinity during the dry season. Waterlogged soils have been mapped into two categories, viz. submerged soils and waterlogged soils. These were identified by dark blue and blue colour respectively in the false colour composite.

Conjunctive Use of Surface and Saline Ground Water

At Bathinda, wheat (Cv PBW 373) yield of 3.62 tonnes/ha was obtained with pre-sowing canal water irrigation and saline water irrigation thereafter. Five years mean data indicate that two saline water irrigations followed by one canal water irrigation produced 2.91 tonnes/ha maximum wheat grain yield.

Managing Saline Black Soils Using Grass Based Land Use System

Salvadora persica, a good source of non-edible seed oil (30.4–34.6%) rich in C12 and C14 fatty acids, was found to grow and yield well on highly deteriorated saline black soils having salinity even greater than 65 dS/m with planting density of 4 m × 4 m. Even at EC 55–65 dS/m, the yield was 1.5 tonnes/ha by fourth year and it yielded 2.5 tonnes/ha at EC 25–35 dS/m respectively. Studies showed *Dichanthium annulatum* as ideal forage grass due to its growth, salt exclusion and yielding ability on such soils.

RECLAMATION OF SODIC VERTISOLS UNDER RAINFED CONDITIONS

The cotton yield remained unaffected but the rice yield increased with increasing ratio of raised and sunken beds due to higher availability of stored water in sunken beds. In a similar study conducted at Tiruchirapalli, bed size of 405×30 cm resulted in higher grain yield of sunflower followed by 270×30 cm. Among the organic amendments tried, FYM and press-mud were better in reducing pH and improving the yield of sunflower in sodic soil under rainfed conditions.



Integrated Agronomic and Nutrient Management of Rice in Saline Coastal Soils

The application of 50 kg N/ha under *dhaincha* treated plots increased rice yield compared to the farmer's practice of using 20 kg N/ha. Without *dhaincha* treatment, when compared with 20 kg N/ha, increase in grain yield was recorded only after application of 100 kg N/ha along with azolla and blue green algae. However, no significant change was observed due to addition of biofertilizers to inorganic N source.

Improving Crop Performance in Saline Soil by Subsurface Drainage

To improve the soil salinity and crop yield in 1200 ha Operational Pilot Project area of Gohana block of Sonapat district in Haryana, subsurface drainage was installed with an average depth of 1.6 m with 60 m drain spacing. Results have shown that drainage installation had facilitated the reclamation of waterlogged saline lands, with varied salt removal in space and time. In this area, decrease in soil salinity in different blocks ranged from 10 to 66% depending upon the period of leaching with an average 53% decrease in salt content and 18% average increase in wheat yield compared to initial yield.

Water and Nutrient Management for Alkali Soils in Uttar Pradesh

For evolving efficient water and nutrient management strategies for sustainability of rice-wheat cropping system in gypsum amended alkali soils of Uttar Pradesh, 100% NPK + 10 tonnes/ha SPMC or 100% NPK with green manure enhanced rice yield besides improving the fertility status of such soils. Further, application of 100% NPK combined with residual effect of green manure or SPMC or Zn significantly increased wheat yield.

Effect of Set Furrow Methods of Gypsum Application on Alkali Soil Reclamation

The experiment was conducted on black alkali soil at Barwaha (Madhya Pradesh). Gypsum (100% of GR) was applied in plough layer either alone or with sand @ 5 tonnes/ha and equivalent quantity of gypsum and sand was applied in strips (60 cm wide) to a depth of 25 cm. The maximum seed cotton yield was recorded when gypsum alone was applied in strips followed by gypsum with sand in strips and gypsum with sand in plough layer.

RAINFED RESEARCH

On-Farm Rainwater Conservation

Live bunds with vetiver or *Pennisetum hohenackeri* in between earthen bunds at 1.0 m vertical interval in finger millet at Bangalore, contour cultivation and compartmental bunding and mulching with stone pebbles in groundnut at Anantapur, sowing across the slope in wheat and maize at Hoshiarpur, disc harrow once in mustard and chickpea at Hisar, interculture operation during the dry spell in linseed at Ranchi and ridges and furrows in *rabi* sorghum at Solapur were found promising 'On-farm rainwater conservation' techniques.

Land Treatments and Tillage Effects on Rainfed Cotton

The seed cotton yields from broad bed and furrow (BBF) with 75% recommended dose of fertilizer and green manure in both conventional and reduced tillage practices were found better than those from flat bed system. The yields from reduced tillage were at par with the conventional tillage. The BBF system with green manures was found to have beneficial effect on soil health.

Rice Based Farming Systems

In rice based farming systems, recycling of rice straw (2 tonnes/ha) along with

COMBINED USE OF ALKALI AND CANAL WATER

Multi-quality waters can be used for irrigation to get optimum economic yields in different crops. Alkali waters (RSC 11.3 me/l, EC 2.3 dS/m) were used along with good quality tube well water (EC 0.5 dS/m, RSC Nil), either by mixing the two waters or alternating their use, for rice - wheat crop rotation. Cyclic modes performed better than their counter mixing modes where the decline in yields ranged between 19-28% in rice and 8-19% in wheat. Use of alkali water for irrigation during *kharif* season resulted in greater reduction in crop yield. The pH and SAR of surface soil increased with the continuous use of alkali water.

ALLEVIATING EFFECT OF ALKALI WATER

Recurring costs of amendments like gypsum demand efficient utilization of alkali water in irrigated soils. Results showed in the experiment of a deteriorated soil (pH 9.4, Ece 3.3 dS/m and ESP 52.8) due to use of alkali water (RSC 9.1 me/l) with rice-wheat and sorghum-mustard sequences the superiority of gypsum addition by its dissolution after passing alkali water through specially designed beds (7-15 cm thickness) in terms of improving crop yields when compared with similar applications directly to the soil. In a similar study conducted at Bikaner, gypsum @ 50% GR proved beneficial in obtaining the optimal yield of pearl millet and mustard.

- In rice based farming system, recycling of rice straw along with mushroom spent substrate in rice showed increase in grain and straw yield in western coast of Goa
- Guava based system developed at Jabalpur revealed that *Curcuma domestica* grown under the shade of 12 year old guava tree performed better with an average yield of 7.32 tonnes/ha
- An integrated watershed management plan was prepared for implementation in Bada Khara watershed in Bundi, Rajasthan



ECONOMICS OF COCONUT BASED FARMING SYSTEMS

Application of 100 per cent inorganics alone has resulted in relatively higher plant height, tillers/clump, number of leaves/plant, leaf length and width, inter-nodal length and forage grass yield (29.62 tonnes/ha) and was followed by treatment of 50 per cent organics+ 50 per cent inorganics (29.18 tonnes/ha) while the minimum growth and yield parameters were recorded in plots receiving 100 per cent organics alone (28.23 tonnes/ha) in NB-21 hybrid napier grass under palm (coconut) based cropping/farming system in Goa.

The hybrid napier PBN-16 and DHN-3 consistently showed better performance in terms of green forage yield, dry forage yield and tillers per clump. The grass intercropping in coconut with dairy unit has added additional net returns to the tune of Rs 7000/cow/year with additional employment potential of 70 man days/cow/year.

mushroom spend substrate (1 tonnes/ha) in rice, continued to show an increased trend in both grain (4.59 tonnes/ha) and the straw yield (5.36 tonnes/ha) in western coast of Goa. Among the rice based cropping systems, rice-cowpea (variety V-118) yield (7.77 tonnes/ha of rice grain equivalent) was consistently higher as compared to rice-brinjal system (8.56 tonnes/ha) under protective irrigated conditions. However, the soil organic carbon build-up was better with the recycling of FYM to rice @ 10 tonnes/ha and rotation with groundnut. Further, the integration with mushroom production @ 1,000 bags/ha added additional component productivity to the tune of 4.95 tonnes/ha equivalent rice grain yield.

Conservation of Minor Fruit, Vegetable and Flower Germplasm

Four types of rose apple, two types of bread fruit, two jack fruit types, three species of *Garcinia* and three varieties of aonla (*Embllica officinalis*) were added to the Institute germplasm during this period from the agroforest areas grown in Goa. In addition, 13 high yielding strains of okra were collected from different vegetable growing areas of Goa and were added to the collection.

Guava Based System for Kymore Plateau and Satpura Hills

Guava based system developed at Jabalpur, revealed that *Curcuma domestica* grown under the shade of 12 year old guava trees var. Lucknow-49 (3.5 to 4.5 m height and 14-24 cm dbh) performed better under 45 × 25 cm spacing with an average yield of 7.32 tonnes/ha. Similarly, *Zingiber officinale* also showed better yield (5.39 tonnes/ha) at 30 × 20 cm spacing. This system is well adopted by the farmers of Kymore plateau and Satpura hills of Madhya Pradesh.

Diversification into New or Less Traditional Crops

Promising new crops of castor at Akola, Anantapur, Solapur, Hisar and Bijapur; amaranthus in Akola and Anantapur; chillies and vegetable pigeonpea in Bangalore; groundnut in Faizabad and Phulbani and sole crop of pigeonpea at Indore are becoming popular with farmers in place of traditional crops at these centers.

Watershed Development

In order to demonstrate and evaluate technological packages for ravine watersheds, an integrated watershed management plan was prepared for implementation in a completely participatory mode in Bada Khera Watershed near Lakheri in district Bundi (Rajasthan). About 55% of 682 ha watershed is under agriculture while 25% is community wasteland and remaining 20% area is ravine. Out of annual average rainfall of 750 mm, about 40-45% is immediately lost through surface runoff with an average erosion rates of 40-42 tonnes/ha. So far about 429 ha land has been treated. The gully control structures have arrested about 10,000 tonnes of fertile top soil. Impact evaluation has indicated reduction in runoff and soil loss by 65% and 53% respectively. The levelling and bunding improved 57% profile moisture during cropping period, resulting in about 90% higher grain yield of rainfed sorghum, soybean and mustard. The improved agronomic package increased crop yields by 39-78% over traditional methods. The project implementation generated 7,473 mandays. The income of self-help group improved by 19-52% over pre-project period. During the summer period of 2001, when the region was facing extreme shortage of drinking water due to preceding consecutive drought years, the village pond of Bada Khera was a continual and only source of water for about 80% of animal population of the village.

GIS based strategies for soil and water conservation, selection of water harvesting sites and identification of artificial recharge sites have been worked out.

RED PALM WEEVIL MANAGEMENT IN GOA

Using food baited pheromone traps, revealed a high incidence of RPW (Red Palm Weevil), *Rhynchophorus ferrugineus* Oliv. throughout Goa. On an average 26.03 weevils were captured per trap during the period. RPW was most active in Goa during September- November while it was least active during May to June. It was observed that for mass trapping programmes the recommended 1 trap/ha can be reduced effectively to 1 trap/3 ha trap density.



CROP PRODUCTION

Cropping Systems Research

To address the ill-effects of continuous rice-wheat cropping, efforts were made to find out suitable alternative cropping systems. At Modipuram, rice-potato-sunflower, rice-wheat-green gram and sugarcane ratoon-wheat were identified as promising alternative cropping systems with annual net returns of Rs 53,613, Rs. 41,196 and Rs 40,034 per hectare, respectively, as against Rs 30,938 per hectare in rice-wheat. Under sub-humid ecosystem, at Pantnagar, rice-vegetable pea-summer rice, at Sabour, rice-potato-sunflower; at Varanasi, rice-maize + field pea-cowpea (F) followed by rice-potato-green gram; at Bhubaneswar, rice-maize-green gram; at Chiplima, rice-tomato-lady's finger and at Sehere, blackgram-chickpea systems were identified as more remunerative. Under humid ecosystem, at Palampur, rice-toria-potato and at Nadia, rice-cabbage-rice followed by rice-potato-groundnut were identified as viable replacement for rice-wheat system. In coastal ecosystem at Thanjavur, rice-rice-pigeonpea and groundnut-rice-blackgram gave higher economic returns. In arid ecosystem at Hisar, soybean-wheat-cowpea (F) was found economically viable. Under semi arid ecosystem at Kanpur, maize-potato-sunflower followed by rice-mustard-sunflower; at Parbhani, soybean-onion; at Rudrapur, soybean-sunflower and at Rajendranagar, marigold-sunflower followed by maize-potato were identified as more remunerative cropping systems.

Sulphitation Pressmud as Organic Manure for Rice-Wheat System

Sulphitation press mud (SPM) is a byproduct of the sugarcane industry and is used as an organic nutrient source to meet the crop demands in intensive rice-wheat system was studied at Modipuram in a long-term experiment initiated in 1993-94. Results of the last seven rice-wheat cycles indicated that combined use of fertilizer NPK (75% of recommended dose) and SPM (to supply 25% of recommended N dose) in rice significantly out-yielded the treatment receiving NPK and Zn solely through fertilizers. SPM also proved to be superior in terms of rice yield compared to other organic materials, viz. FYM, green gram residues or rice/wheat residues, when applied on equal N content basis. Use of SPM during monsoon season with chemical fertilizers proved more advantageous than in winter season.

Raised Bed Planting for Legume Intercropping in Direct Seeded Rice

Efforts were made at Modipuram to introduce, the legumes as intercrops in upland rice based system. Sowing on raised bed planting over flat sowing were tested in a field experiment involving four inter sequential cropping systems (rice-wheat, rice + soybean-wheat, rice + groundnut-wheat, rice + cowpea-wheat). On an average, inter-sequential cropping with the raised bed planting produced higher yields (9% to 16.5%) than the flat sowing.

Sesbania and *Crotalaria* as Green Manuring for Rice-Wheat

Rajender Dhaincha, Hisar local, LJ 36, CO 1, LJ 30, MD (S) 1, LJ 31, EC 95553 were found promising accessions for green manuring traits screened from 58 lines and produce dry matter @ 6 tonnes/ha with a seed yield of 2.9 tonnes/ha. Similarly, genotype PAU (C) 1 out of four local cultivars of *Crotalaria juncea* evaluated, was found most promising followed by NDUAT (C) 2 for green manuring. These two genotypes exhibited fast initial vigour, high biomass accumulation and greater tolerance to yellow mosaic virus and foot rot.

Potential of Boro Rice Seedlings in Waterlogged Areas of Sone Command

Boro rice cultivation in waterlogged lands revealed that rice variety Gautam (Prabhat and RAU 1400) sown in January took more days for germination as against November sown with maximum grain yield of 3.04 tonnes/ha recorded in November

- Combined use of fertilizer NPK and sulphitation press mud in rice gave higher yield than the treatment receiving NPK and Zn solely through fertilizers
- Rajender Dhaincha, Hisar local, LJ 36, Co 1, LJ 30, MD (S) 1, LJ 31, EC 95553 of *Sesbania* and PAU (C) 1 and NDUAT (C) 2 of *Crotalaria* were found promising accessions for green manure

TECHNIQUE FOR RAPID DECOMPOSITION OF RICE-STRAW

Pre-treating rice-straw with aqueous solution of urea (1.25%), ZnSO₄ (1.25%) and CuSO₄ (0.062%) for 48 hours and subsequent composting in a manure pit made rapid decomposition within 21 days and addition of pigeonpea twigs and pod husks in 1:4 ratio enhanced the rate of decomposition and improved the substrate quality of compost. Significant increase in yield of rice-wheat system was obtained through soil application of this material @ 5 tonnes/ha in alternate crops.



sown Gautam which was at par with the yield obtained in same variety of January sown. There was significantly higher yield under continuous ponding (2.96 tonnes/ha) over intermittent ponding (2.7.3 tonnes/ha) but both were at par to intermittent + continuous ponding of water (2.87 tonnes/ha).

WEED MANAGEMENT

- *Zygogramma bicolorata* is a safe biocontrol agent of *Parthenium hysterophorus* weed

Biological Management of *Parthenium hysterophorus*

Parthenium hysterophorus which is commonly known as congress grass is a native of Mexico. Its allelopathic effect coupled with the absence of natural indigenous enemies like insects and diseases were important factors responsible for its rapid spread causing health hazards in human and cattle population. Among biological control studies, in-depth investigations were carried out on the exotic beetle *Zygogramma bicolorata* which was imported from Mexico in 1982 as a biocontrol agent at Bangalore against this noxious weed. After host specificity tests in the quarantine conditions, the insect was released in the field to control *Parthenium*. Based upon biological and biochemical studies and field testing, it was unequivocally proved that *Z. bicolorata* is a safe, cost-effective, self-sustaining and eco-friendly bio-agent and can suppress *Parthenium* effectively. The culture of these insects is available on request from the NRCWS, Jabalpur.

Zygogramma Infests Sunflower

Zygogramma a beetle could be a potential pest as it was reported to feed on sunflower. Developmental studies on sunflower revealed that in spite of completing its life cycle on chemical parthenium collected on sunflower leaves from the parthenium plants growing on bunds/waste lands. Biochemical analysis of sunflower revealed that it contains two compounds *Ayyappin* and *Scopoletin* which act as inhibitors to *Z. bicolorata*, therefore sunflower could never be a preferred host of the beetle.

FARMING SYSTEM RESEARCH

Evaluation of Plantation Crops in Goa

Goa 1 (Balli 2) cashew selection (a local variety) continued to show promising performance by yielding 4.01 kg of raw nuts per tree (at 2 m × 2 m spacing) during the season with a cumulative yield of 25.16 kg/tree at the age of 11 years with 31.24 shelling percentage. The introduced accessions H-1600 and H-1608 recorded nut yield of 5.86 and 4.13 kg/tree, respectively.

Substitution of Poultry, Pig, Rabbit Feed

Brewery dried grain (BDG) with or without kemzyme supplementation on the performance of broiler indicated that broiler chicks fed with 4 per cent BDG and 1.0 g/kg kemzyme performed equally as that of control chicks in respect of body weight and feed conversion efficiency but had less abdominal fat deposit than the control chicks. Kemzyme supplement to the diet containing 8 per cent BDG significantly reduced the abdominal fat in chicks.

Replacing wheat bran with dried cashew apple waste (CAW) to the extent of 20 per cent for pigs (local × Yorkshire crossbred) as feed substitute, indicated that there was no adverse effect on the feed intake and growth rate of the animals when CAW was incorporated at this level. Average dry matter digestibility was 70.78% and 73.90% and the daily weight gain was 167.70 g and 168.35 g in case of experimental and control groups, respectively. Cost of feed was reduced by Rs 1.20/kg (17%).

Incorporation of brewery dried grain waste or cashew apple waste to the extent of 25 per cent in rabbit feed conducted on 18 young crossbred rabbits recorded the average daily weight gain of 17.87 g, 15.06 g and 15.84 g for control, CAW and

- Out of the four formulated ornamental fish feeds tested on gourami for the growth performance, feeds based on chicken liver meal and squid meal, gave results statistically at par
- Foot-and-mouth disease and Ehrlichiosis among cattle prevalent in Goa
- Storage life of bread fruit and bimbli could be extended by packing them in 0.4 mm LDPE bags with 0.5% ventilation



BDG diet, respectively, indicating that brewery grain waste can be used as substitute for wheat bran in rabbit feed to reduce the feed cost by Rs 1.45/kg.

Low Cost Feed for Fish

Out of the four formulated ornamental fish feeds tested on gourami for the growth performance, feeds based on chicken liver meal and squid meal, gave results statistically at par in case of all nutritional indices compared to the commercial diets, viz. brine shrimp flake and tubifex worm which was many fold cheaper than the commercial ones.

Use of probiotics containing different levels of *Lactobacillus* sp. on *Labeo rohita* fry, on the growth performance, nutrient utilization and carcass composition was found to be the best at the probiotic supplement level of 5.0 g [3.0 billion *Lactobacillus* viable CFU/kg of basal diet (40.00% CP). However enzyme based probiotic feed supplement gave the best results at the level of 3 g.

Livestock Disease Management

Staphylococcus aureus and *Streptococcus* sp. were found to be the major causative organisms of mastitis in crossbred cows from field cases. Foot and mouth disease and Ehrlichiosis among cattle are also prevalent in Goa. Total of 3.13 per cent blood samples from cattle revealed positively for brucellosis.

Samples of fresh meat and meat products collected contained fresh meat counts of 10.45×10^4 cfu/g for mesophiles, less than 10^3 cfu/g for psychrophiles and 1.1×10^4 cfu/g for yeast and moulds. In meat products, the mesophilic counts were 7.5×10^4 cfu/g.

Post-harvest Technology of Local Fruits

It was found that most of the processed products from fruits available or grown in Goa region, had storage life of up to six months with traditional recipes and packing. In studies on extending the shelf life of indigenous fruits, viz. bread fruit and bimbli, showed that the storage life could be extended at ambient temperature by packing them in 0.4 mm LDPE bags with 0.5 per cent ventilation. Studies on storage of raw bread fruit pieces in brine solution, revealed that after six months of storage there was not much change in organoleptic attributes, viz. colour, texture and flabbier besides, chemical parameters like TSS and acidity.

ARID ECOSYSTEM

Rainwater Harvesting in Tankas for Drought Management

Water harvesting technology involving land shaping, roof water harvesting and its storage in tankas were great success at Khetasar, Kalyanpur and many other villages near CAZRI, Jodhpur. The harvested water was utilized for meeting drinking water needs of livestock, human beings, establishment of nursery and agroforestry systems and have been widely adopted by Rajeev Gandhi Drinking Water Mission and provided drought proofing and sustainability to the region.

Rehabilitation of Lignite Mine Degraded Lands

Mining of lignite in arid Rajasthan leads to inversion of soil and represents an extreme form of land degradation. Ten hectare land has been rehabilitated by profile modification and plantation of trees and shrubs, viz. *Salvadora oleoides*, *Tecomella undulata*, *Prosopis cineraria*, *Azadirachta indica*, *Colophospermum mopane*, *Acacia tortilis*, *Parkinsonia aculeata*, *Tamarix aphylla* and *Dichrostachys nutans* and *Cenchrus ciliaris* and *Lasiurus indicus* grasses with more than 90% survival rate of all species with profuse development of natural vegetation (silvi-pasture) after three years of efforts. A gypsiferous wasteland in Kawas (Barmer) has been rehabilitated by planting *Cenchrus ciliaris* and *Colophospermum mopane*, *Acacia Senegal*,

- Lignite mine degraded land has been rehabilitated by profile modification and plantation of trees and shrubs
- Sandy soils with shallow soil depth, otherwise unfit for crop cultivation have been rehabilitated by growing grass at the farmers' field



Runoff harvesting in tanka for drinking and silvipasture development at Kalyanpur



Back fill of lignite mined land at Giral, Barmer (*left*); rehabilitated back fill (after 3 years) of lignite mined at Giral, Barmer (*middle*); silvipasture of *C. mopane* and *C. ciliaris* for gypsiferous soil (*right*)

Tecomella undulata and *Prosopis cineraria* through profile modification using a mixture of FYM, pond sediments and sands.

Management of Sandy Soils

Bunding with vegetative barrier of *Cenchrus ciliaris* increased the profile moisture storage by 50-60% and increased the productivity of pearl millet by 100% in low rainfall situation in village Kalyanpur. Minimum tillage by disking the soil only once, application of manure @ 1-2 tonnes/ha and nitrogen (40 kg/ha) increased the productivity of pearl millet (HHB 67) to 1.0 tonne/ha as compared to 0.02 tonne/ha obtained from local variety. Application of tumba cake @ 1.0 tonne/ha improved the productivity of greengram variety PDM 54 by 50% at farmer's field in Manai village in Jodhpur under low rainfall (350 mm) situation.



Vegetative barrier of *Cenchrus ciliaris* grass helps in conserving soil moisture and enhancing production

Rehabilitation of Shallow Sandy Wastes

Unproductive sandy soils with shallow soil depth and high calcium carbonate content, otherwise unfit for crop cultivation have been rehabilitated by growing grass at the farmers field in village Sitli and Bankewas. The successful pasture was developed by using an improved technique of pasture cultivation.

Pasture development on shallow sandy degraded lands



Application of tumba cake @ 1.0 tonne/ha improved the productivity by 50% of greengram variety PDM 54 at farmers' field in Manai Village near Jodhpur under low rainfall situation





AGROFORESTRY

Evaluation of Multipurpose Tree Species and Tree Improvement

'Pant Poplar 5 clone' developed at Pantnagar, exhibited tolerance to blight and stem borer compared to G3, G48 and D121 clones and was recommended to the farmers of the terai area. Among different 9 year old G3, G48, G121 and 72/58 clones of *Populus deltoides* tested at Pusa, G3 was most promising clone followed by G48.

Two hundred seventy six accessions of *Azadirachta indica* have been collected at Jhansi from eight states. Ten selections were identified based on fast growth and high seed yield for mass multiplication and supplying the saplings to users. *Azadirachta siamensis* has been introduced successfully showing quick growth and erectness.

In a provenance study of *Acacia mangium* and *A. auriculiformis* at Bhubaneswar, population of *A. mangium* segregated into pure *A. mangium* and *A. auriculiformis* hybrids in the ratio of 59 and 41 per cent. The overall growth of *A. mangium* hybrids was faster than either parents.

Under partial waterlogged soils at Nagpur, *Terminalia arjuna* recorded 92% survival followed by *Dalbergia sissoo* with 74% survival. The studies conducted at Faizabad, indicated superiority of *Madhuca latifolia* over *M. africana* in terms of tree growth. The three year studies at Kattupakkam, indicated that protein content (19.8%) in *Glyricidia sepium* remained significantly higher when leaves were pruned at 1.5 month interval.

Vegetative Propagation

Air layering in *Hardwickia binata* with 1000 ppm IBA + 500 ppm Kinetin + 50 ppm vitamin B complex resulting in 55% rooting during May was achieved with 100% survival in pots. Air layering was successfully done during March-October which provide sufficient time for producing air layered plants which can be used to establish seed orchards

The studies conducted on vegetative propagation of bamboo at Nagpur revealed that cuttings taken from basal portion of bamboo culms were best in rooting ability with NAA 100 ppm treatment (83.33%). Vegetative propagation studies in 5 and 25 year old *Acacia lenticularis* plants at Pusa, showed that rooting potential of stem cuttings varied with season. In young trees the maximum rooting was recorded during February with IBA 100 ppm (78%) followed by June plantation with IBA 200 ppm (71% rooting).

Growth Model

In order to develop stand yield/growth model, biomass-dbh model has been developed for *Eucalyptus tereticornis* clones to be used for non-destructive estimations of above ground biomass. The fitted model resulted in

$$\text{Biomass} = 1060.22 * [1 + \exp(3.62 - 0.09 * \text{dbh})]^{-1} \text{ with } R^2 (\text{obs vs pred}) = 0.994$$

The proposed model predicted reasonable future biomass growth values with mean 12.5% bias, mean residual of 0.396 kg and absolute mean residual as 15.426 kg with t-test value of -0.134 with p-value = 0.894 ensuring the accuracy of prediction.

Agrisilvicultural System

Studies conducted at Jhansi revealed that under agrisilvicultural system with *Tectona grandis*, *Azadirachta indica* and *Albizia procera* the minimum reduction in intercrop yield (with and without pruning) was recorded in association with *T. grandis* (11.57 and 23.66% in wheat and 18.75 and 28.13% in blackgram) and maximum under *A. procera* (30.99 and 34.50% in wheat and 43.75 and 46.88% in blackgram) over control (3.275 and 0.320 tonnes/ha), respectively.

DEVELOPMENT OF THREE-IN-ONE SOLAR DEVICE

An integrated three-in-one solar device developed at the CAZRI, Jodhpur could be used for either heating water, cooking food and drying fruits and vegetables. The device is capable to produce 40 litres of hot water at 55°C during winter afternoon, could obtain 120°C stagnation temperature for cooking or 2-4 kg fruit and vegetable for dehydration and costs nearly Rs 6,000.



Three-in-one solar device designed and developed at CAZRI, Jodhpur

- Pant Poplar 5 clone, a multiple tree species, developed at Pantnagar was recommended to the farmers of the terai area
- Studies on growth and biomass yield of three *Albizia* species (*A. amara*, *A. lebbbeck* and *A. procera*), *A. procera* produced significantly more leaf fodder and fuel wood as compared to *A. amara* and *A. lebbbeck*



ECONOMICS OF AGRISILVICULTURE - A NEW LAND USE SYSTEM

The teak based agrisilvicultural system developed at Dharwad, revealed that addition of teak and papaya in the system resulted in higher net return (Rs 15,607/ha/year) followed by field crop + teak + papaya + grass (Rs 14,156/ha/year) least being in sole crops. In another system, at the end of 10th year, soybean grain yield was significantly reduced at 1 m and 5 m distance from the tree base of different species compared to sole crop. The lowest reduction was observed with *Prosopis cineraria* (37.9%) and highest with *Terminalia belarica* (66.42%).

In a boundary plantation system of *Dendrocalamus strictus* developed at Pusa, turmeric, ginger and Dinanath grass produced 32.4 to 40.5% relative yield under full light (0% interception) indicating higher yield near the bamboo row compared to away from bamboo. In *Casuarina equisetifolia* based agrisilvicultural system at Faizabad, there was a significant effect of 50% pruning of tree canopy on crop yield. The reduction in crop yield over control was (15.3 and 16.6%, respectively for wheat and rice), whereas reduction was 35% and 32%, respectively for wheat and rice under unpruned conditions.

ECONOMIC ANALYSIS OF THE POPLAR -WHEAT/ SUGARCANE SYSTEM

The studies at Ludhiana, revealed that grain yield of wheat decreased significantly with increase in age of poplar spaced at 4.5 × 4.5 m. The reduction in grain yield increased from 11.05% in one year old plantation to 44.94% in five year old plantation, but this reduction in yield is compensated by poplar growth (height 21 m and DBH 22.5 cm). The economic analysis of the poplar -wheat / sugarcane system revealed 1:4.45 C:B ratio with 400 trees/ha in 8 year rotation.

Performance of Aonla -Blackgram Land Use System

The growth performance and survival of aonla was better under various *in-situ* moisture conservation techniques as compared to control during 4th year at Jhansi. It started fruiting after four years of plantation and yielded 3.90 to 21.77 kg fruits/plant. The 11th year of varietal evaluation of aonla under rainfed conditions indicated that the average fruit yield/plant was 109.67 kg, 88.25 kg, 89.14 kg and 61.40 kg in variety Kanchan, NA -7, Krishna and Chakaiya, respectively. With such high level of aonla production in marginal lands, aonla at 10 m × 6 m spacing (166 plants/ha) can give an yield of 12.0 to 15.0 tonnes/ha of fruits/year at the age of 11 years. Apart from fruit yield of aonla, 0.122 to 0.135 tonne/ha grain yield of intercrop (blackgram) was obtained from the system. The economic analysis of the system resulted in B : C ratio of 1 : 2.24 for 200 tree/ha with blackgram as *kharif* crop with pay back period of 5 years.

Agri-horticultural System of Wheat with Peach at Solan

In an agri-horticultural system developed at Solan, performance of four wheat varieties at three nitrogen levels were studied in association with peach. The wheat yield reduced by 18.45% due to peach over the sole crop, but the application of 25% over dose above the recommended (80 kg/ha) helped in increasing the wheat yield and compensated for 50% reduction in yield. In economic terms, this system gave net return of Rs 43,000/ha over Rs 26,000/ha compared to sole crop.

Silvipastoral System

Studies on growth and biomass production of three tree species *Acacia nilotica* var. *cupressiformis*, *Dalbergia sissoo* and *Hardwickia binata* conducted at Jhansi, during 9th year revealed that the total biomass (7.06 tonnes/ha) obtained in association with *D. sissoo* was higher than other two silvipastoral systems. However, pasture alone gave maximum yield of 7.50 tonnes/ha. Organic carbon and total N for *H. binata* based system varied between 6.5 - 8.2 g/kg and 0.066-0.075% below canopy at 0-15 cm depth while corresponding values for *D. sissoo* were 6.5-7.9 g/kg and 0.059-0.075%, respectively. The studies conducted at Kattupakkam showed that the *Colopogonium*, if integrated as under storey in mango plantation would yield 0.969 tonne of dry fodder, 0.116 tonnes digested protein/ha and can sustain 3-4 number of sheep in one hectare.

Cost: Benefit Ratio of Silvipastoral System

The system resulted in C:B ratio of 1:1.52 in association with *Chrysopogon fulvus* and *Stylosanthes hemata* on 8 year rotation. Studies on growth and biomass yield of three *Albizia* species (*A. amara*, *A. lebbek* and *A. procera*) with 4 pruning intensities (0, 25, 50 and 75% height from ground level) in natural grassland during 5th year showed that *A. procera* produced significantly more leaf fodder (1.34 tonnes/ha) and fuel wood (2.9 tonnes/ha) as compared to *A. amara* and *A. lebbek*. The studies showed that *A. nilotica*, *L. leucocephala* and *Terminalia arjuna* exhibited great potential in terms of nutritive value of pruned foliage. The leafy material contained (kg/DM) medium to high crude protein (93-228 g) and high degradable dry matter, organic matter and crude protein (749 - 881; 771-885; 672-920 g, respectively).

Silvipastoral System and Sand Dune Stabilisation

A *Dichrostachys cinerea* based silvipastoral model has been developed at Fatehpur-Shekhawati. The studies revealed that a biomass yield of 3.42 tonnes/ha/year may be obtained when *D. cinerea* was planted at 5 m row spacing and *Cenchrus ciliaris* grass between the rows with tree component coppiced every year (in November-December) and hold great promise for sand dune stabilization and is found to be most suitable for unculturable lands of arid and semi-arid regions. □



Livestock and Poultry Improvement and Management

ANIMAL GENETIC RESOURCES

Livestock Information System

Information System on Animal Genetic Resources of India (AGRI-IS) developed at the National Bureau of Animal Genetic Resources (NBAGR), Karnal, contains breed-wise information on habitat, characteristics, management practices, farms, references, photographs, habitat maps, etc. This was updated with the data on various breeds of cattle, buffaloes, sheep, goat and camel, and the next version will be released with updated information for all species. Database on livestock census contains age-wise and sex-wise population statistics for all the species and for all the districts of India from 1961 onwards. This databank has latest census figures (1997) for 13 states. Package developed for data entry and analysis of information collected from the field through survey was put up on the internet and can be downloaded free of cost from <<http://nbagr.hry.nic.in>>. An effort was made to develop a database of buffalo genetic resources at the CIRB, Hisar. Scanned images of different buffalo breeds were fixed in bit map graphic files and linked with buffalo database. Various queries were designed in scheme structure to establish the relationship among data tables. Herd data of various livestock farms in Gujarat, Rajasthan, Bihar, Goa, Punjab, Haryana, Andhra Pradesh, Maharashtra, Karnataka, Uttar Pradesh and Madhya Pradesh were appended in the inventory of livestock farms. The State Governments of Uttar Pradesh, Karnataka, Haryana, Jammu and Kashmir, Himachal Pradesh, Gujarat, Bihar and Punjab, nominated nodal officers for collaboration with the NBAGR. Basic data on physiological, biochemical, haematological and hormonal parameters under rest and working conditions of indigenous equine breeds, are being developed.

SURVEY, EVALUATION AND CHARACTERIZATION OF BREEDS

Network Project on Animal Genetic Resources

Survey and conservation work was initiated at 12 survey units, and 9 *in situ* and 8 *ex situ* conservation units. The survey units include Bachaur, Dangi and Amritmahal cattle; Nagpuri buffalo; Arunachali mithun; Mecheri, Deccani and Changthangi sheep; Attapadi goat; Kuchhi camel; Spiti horse; and Ankleshwar poultry. The *in situ* conservation units cover Tharparkar and Sahiwal cattle, Toda and Nili-Ravi buffalo, Magra and Nilgiri sheep, Jamunapari goat, and Spiti horse. The *ex situ* conservation units include Nagauri, Rathi and Kangayam cattle; Pandharpuri and Nili-Ravi buffaloes; Magra sheep; and Beetal and Jamunapari goats.

Gir cattle: The Gir breed of cattle is mainly distributed in the Saurashtra region of Gujarat. The survey was conducted in Junagarh, Rajkot and Bhavnagar districts. Gir accounted for 36.61% of the cattle population of Saurashtra region. Majority of the animals has red coat colour with black horn, skin, muzzle, tail switch and hooves. The forehead is bulging with the horns emerging sideways downward bending sideward and upwards and tips turning inward and downward. The ears are drooping with an average ear length of 30.1 cm. In adult females, the height at wither, body length and chest girth were 166.5, 131.4 and 130.8 cm respectively. The average

- Information on animal genetic resources of India is available on internet - <http://nbagr.hry.nic.in>.
- Gir cows showed very low reproductive abnormality
- Somatic cell preservation standardized in buffaloes
- Somatic cell lines of sheep and goats preserved for use in cloning
- Training to women in goat rearing may bring food security in rural India
- Milk yield of Karan Fries was 46.5 kg/day at the NDRI, Karnal
- Network Project on Buffalo expanded to cover more buffalo breeds
- Survivability of sheep improved
- Bharat Merino has the potential to substitute exotic fine wool breeds
- Garole x Malapura crossbreds had 44% twin lambing
- July to December period better for growth in rabbit

The Gir cattle is mainly distributed in the Saurashtra region of Gujarat, and accounts for 36.61% of the cattle population there





- Commercial broiler from CARI attained 1,486 g weight at 7 weeks of age
- Viability of broilers was more than 97.5%
- Heat tolerant major gene i.e. Naked Neck was integrated in broiler stock
- Homozygote dwarf line developed

body weights at birth, 3 month, 6 month and 12 month of age were 20.8, 48.5, 75.5 and 116.3 kg respectively.

Overall age at first estrus was 34.29 months. Age at first mating and calving averaged 36.57 and 46.08 months. Average service period was 116.50 days. Number of services per conception averaged 1.47. Average calving interval was 409.16 days. Young bulls started mating at an average age of 3.70 years. Reproductive abnormalities in Gir cows were quite low (3.17%). Daily milk yield averaged 7.04 kg and the estimated 300-day lactation yield was 2,113.0 kg. The milk fat% ranged from 4.55 to 4.65 in different districts.

IMPROVEMENT AND IN-SITU CONSERVATION OF JAMUNAPARI GOATS IN THEIR HOME TRACT CHAKARNAGAR, ETWAH

Conservation and improvement of Jamunapari goat in its home tract Chakarnagar, Etawah, UP is being undertaken since 1993 in two adopted villages under the AICRP programme. Study on role of women in goat rearing at Chakarnagar, revealed that women play important role in day to day feeding, preparing special ration for goat during pregnancy and grooming for show purposes. Improvement and enhancement in use of women power in rural sector will bring food security in sustainable and substantial manner. It is essential to provide training to women in different aspects of goat rearing skill and better marketing opportunities that can have direct impact on both household and national food securities.



The Barbari goat has extensively been used under goat development programme

Barbari goats: Barbari goats are believed to have derived their name from its place of origin in Barbara in east Africa. Their migration route to India is not known but in all its probability the traders of the Mediaeval period might have brought them during their business entourage to India. The breed is found in Etah, Aligarh, Agra and Mathura districts of Uttar Pradesh, and adjoining Bharatpur district in Rajasthan. This breed has been adopted and extensively used in the country under goat development programmes, and also for commercial rearing. Animals are medium in size with stout and compact body. The main coat color is brown; some animals have white and black spots. Both the sexes have twisted horns directed upward, backward and outward. Some animals have wattles. The udder is well set and round in shape with conical teats. The average age at kidding ranged between 510-550 days. The average daily milk production was 0.274 kg with the lactation yield of 95.2 kg in an average lactation of 115 days. The flock size ranged from 1 to 25; in 80% of the flocks the number of goats was 1-5, and only in 4% cases more than 15. The animals let to graze for about 8-10 hr. Animals, especially the milking does, are also provided with straw and mineral mixture as supplementary feed.

Conservation and utilization of indigenous fowl: Under the conservation programme at the CARI, Izatnagar, purebred chicks comprising 1,186 Aseel Kagar, 746 Aseel Peela, 1,736 Kadakanath and 734 CARI Red were hatched. Fertility of purebreds ranged from 74.98 to 89.38% that was lowest in CARI Red and highest in Aseel Kagar. Hatchability of both, total egg set (TES) and fertile egg set (FES), was lowest in Aseel Peela (56.89 and 67.84% respectively) and highest in Kadakanath (78.42 and 88.46% respectively).

Graded up chicks comprising 1,634 Naked Neck and 1,525 Frizzle of second generation (graded up with White Leghorn) were hatched. Fertility values in graded Naked Neck and Frizzle were 80.20 and 74.24%, respectively, and corresponding values for hatchability for TES were 61.29 and 76.42%, while these values for FES were 76.42 and 80.79% respectively.

Results of the first generation of grading up of Naked Neck and Frizzle population with White Leghorn showed significant improvement in the part time egg production (40 weeks of age) in both the lines, but significant decrease in egg weight was also observed in both the lines. Mean time egg productions of 101.61 and 99.33 eggs were recorded for second generation graded Naked Neck and Frizzle population,



Hatchability was highest in Kadakanath



which were 12 and 11 eggs more than the previous generation for the respective population. In this generation the egg weight decreased in Frizzle fowl population but not in Naked Neck population.

Mithun: Conservation and improvement of mithun is the second important mandate of the NRC on Mithun, Nagaland. Research programmes on *ex situ* conservation particularly through sperm conservation were carried out during the year.

Yak: Survey on yak genetic resources and their feeding resources was initiated in Ladakh region.

Immunogenetics of Indian Livestock

Cattle: IL-2 in the blood plasma of normal and diseased animals was quantified. Blood samples were collected from Sahiwal, Tharparkar, Karan Fries and Karan Swiss animals. The range of interleukin-2 in the blood plasma of normal animals of Sahiwal, Tharparkar, Karan Swiss and Karan Fries was 400-745.5, 540-772.5, 425-691.5 and 450-500.2 pg/ml, respectively, and in animals suffering from mastitis was 584.7-899.1, 577.6-836.9, 563.2-670.1 and 580.7-780 pg/ml, respectively.

Quantification of IL-2 by ELISA in culture supernatants was also carried out. IL-2 secretion varied from 34 pg/ml in supernatant harvested at 45 min to around 340 pg/ml in supernatants harvested in 24 hr. Cell proliferation for the same number of cells in the culture was higher when supernatant-containing IL-2 was added.

At the National Dairy Research Institute (NDRI), Karnal, a highly specific and sensitive antirabbit IgG (second antibody) was produced indigenously, and is now being routinely used in EIA procedures.

Horses: At the National Research Centre (NRC) on Equines, Hisar, biochemical polymorphic studies and estimation of the gene frequency in Marwari breed of horses were carried out.

Molecular Genetic Characterization of Indigenous Livestock and Poultry

Cattle: At the NBAGR, Karnal, genetic characterization using 25 FAO recommended microsatellite markers was completed in 48 unrelated samples of Sahiwal cattle. Similarly 33 DNA samples of Haryana cattle were analyzed using 12 microsatellite markers. Genotypes of each individual animal were recorded. At the NDRI, Karnal, molecular genetic characterization was carried out involving Krishnavally, Ongole, Amritmahal, Hallikar, Khillari and Malanad Gidda.

Buffalo: At the NDRI, Karnal, a 65-kDa buffalo placental protein suppressed proliferation of lipopolysaccharide-stimulated-buffalo lymphocyte *in vitro* indicating suppression of B-cells.

At the NBAGR, Karnal, out of the 59 polymorphic microsatellite markers that showed polymorphism in buffaloes, number of alleles and allelic range for 40 markers were determined. Genetic characterization of Murrah breed was carried out using selected 25 polymorphic markers for which the number of alleles, allelic size range and heterozygosity were determined.

- Bovine microsatellite sequences showed extensive conservation in bubaline genome. A battery of microsatellite markers was identified to study genetic variability in buffalo populations.
- Allele numbers, size ranges and heterozygosity were documented for 40 polymorphic microsatellite markers that were analysed in buffalo panel of 3 breeds.
- Selected 25 polymorphic microsatellite markers are being analysed in buffalo breeds for genetic characterization.
- Non-radioactive based DNA fingerprinting technique using oligo probes was standardized for genetic diversity study in farm animals.
- At the CIRB, Hisar, DNA was isolated from blood of 30 buffaloes. The quality and quantity of the isolated DNA were evaluated. The establishment of polymorphism through RAPD primers was initiated. Further work is in progress.

IMMUNOGENETIC STUDIES IN GOATS

At the Central Institute for Research on Goats (CIRG), Makhdoom, serum lysozyme was established as a marker for studying disease resistance parameter in goats. Further, milk casein polymorphism was studied in Jamunapari, Barbari, Marwari, Jakhrana and Sirohi goats and extensive polymorphism was observed in a-S1 casein locus. The genotypic frequencies of a S1-Cn in Jamunapari, Barbari, Marwari, Sirohi and Jakhrana goats were 0.96, 0.91, 0.93, 0.81 and 0.90, respectively. The distribution of frequency of aS1-Cn was higher in all the breeds except Sirohi.



- At the IVRI, Izatnagar, for specific identification of breeds, random amplified polymorphic DNA analysis technique was applied that identified 3 potentially informative primers (OPA 14, BG 27, BG 28) on the genome of Murrah buffaloes and 2 primers (OPA 4, BG 15) on Bhadawari buffaloes.



Garole sheep breed is being characterized by using microsatellite primers

Sheep and goat: Microsatellite primer pairs (7) were tested for amplification and assessment of polymorphism in Garole, Nali and Chokla sheep. Microsatellite primers (14) were used to detect the distribution of alleles and to calculate allelic frequencies for each loci in 35 DNA samples of Garole sheep. These markers generated 104 alleles. Overall number of alleles ranged from 5 to 11 with a mean of 7.42/microsatellite marker. The most polymorphic marker was OarHH 47 with 11 alleles.

In Black Bengal goats microsatellite loci and in Pugal sheep 3 microsatellite loci were analysed. Number of alleles, heterozygosity and PIC values for all the loci were studied.

DNA fingerprinting of Indian goats by minisatellite (Bkm) and microsatellite marker: At the CIRG, Makhdoom, genetic fingerprinting profiles were successfully used for establishing biological relationships, linkage analysis and phylogenetic relationship among related species.

Ten microsatellites were standardized, and further characterization of Jamunapari, Barbari, Sirohi, Kutchi, Jhakhrana, Changthangi and Black Bengal goats was taken up.

Camel: Genomic DNA samples of double-humped camel were studied at the NRC on Camel, Bikaner, along with single humped camel, cattle, buffalo, sheep, goat, horse and donkey with a single set of primer. Genomic DNA of double-humped camel revealed a single band of 237 bp whereas in single humped camel 2 bands of 237 bp and 288 bp were amplified.

Pig: At the NBAGR, Karnal, blood samples of desi pigs of Northern India and Assamese pigs were collected and DNA was isolated. DNA samples were amplified at specific microsatellite loci by polymerase chain reaction. The PCR product was resolved on denaturing polyacrylamide gel for alleles. The data were recorded and analyzed for heterozygosity in desi and Assamese pigs for these microsatellite loci.

Equine: At the NRC on Equines, Hisar, molecular characterization was done for studying genetic diversity among Marwari horses. Biochemical polymorphic studies and estimation of the gene frequency was taken up. Basic data for indigenous breeds of equines in respect of physiological, biochemical, haematological and hormonal parameters under rest and working conditions are being collected.

Poultry: Biotechnological approaches for improving traits of importance in broiler and layer populations. At the Project Directorate on Poultry, Hyderabad, genetic characterization of an egg type population vis-à-vis indigenously available homogeneous chicken stocks for quantitative, immunogenic and molecular profiles, was initiated. Molecular analysis of a brown eggger population for its immunogenetic make up at the MHC-Bg region employing fragment length polymorphism techniques using public-domain DNA markers such as Bg-28 and Bg-32.1, was undertaken.

Evaluation of genetic distances among selected and control lines of White Leghorn chicken lines using DNA methods: At the CARI, Izatnagar, the project was initiated to evaluate the genetic biodiversity within and between 4 selected lines of White Leghorn by DNA methods. The genomic DNA from 10-12 birds of each line was taken and evaluated for purity. Only distinct and prominent bands were scored. The presence or absence of band within RAPD pattern was scored as one or zero, respectively, and the genetic identity index (I) or similarity index, band sharing frequency (BSF) and genetic distance were estimated.

RAPD-PCR fingerprints: Most of the random primers yielded scorable polymorphic amplified fragments in the individual of selected and control WLH chicken lines. The size of scorable amplified fragments ranged from 300 to 3,100 bp.

Genetic identity index (I)- The band frequencies data were used to estimate the genetic identity index between lines. The highest genetic identity was observed between IWH and IWI lines.



Microsatellite in double-humped camel (DH), single humped camel (SH), cattle (C), buffalo (B), sheep (S), and goat (G)



Band sharing frequency (BSF): The overall average within the BSF estimates ranged from 0.641 ± 0.072 (IWI) to 0.803 ± 0.049 (IWC). The average BSF estimates between lines ranged from 0.580 ± 0.051 (IWG-IWI) to 0.710 ± 0.037 (IWC-IWJ). The medium to high estimates of BSF between lines represented the genetic relatedness among the lines taken in this study.

Genetic distance (Dxy): A FORTRAN program was developed to estimate within and between lines BSF estimates and also to calculate the genetic distance based on BSF estimates. The D estimates ranged from 0.059 ± 0.025 to 0.122 ± 0.040 .

Introgression of Major Genes associated with Tropical Productive Adaptability using DNA Based Markers

A resource population from the crossing of five heterozygous Naked Neck broiler males and 20 normal feathered White Leghorn birds was generated. A panel of microsatellite markers from the markers placed on chromosome 3 was identified from the chicken genome database available of 'CHICKMAP' (www.ri.bbsrc.ac.uk <<http://www.ri.bbsrc.ac.uk>>). These microsatellite markers were used in a segregating family of 6 randomly picked progenies along with the parents. The results revealed that on 6% native PAGE, the microsatellite markers LEI 166, MCW 0040, LEI 0065 and LEI 113 seemed to be informative.

Fowl: At the NBAGR, Karnal, blood samples of Aseel fowl were collected from Bastar district of Madhya Pradesh and Khaman districts adjoining Andhra Pradesh. Blood samples (60) were processed for DNA isolation and 45 DNA samples were of acceptable quality for further analysis using microsatellite primers. Blood samples from Nicobari fowl (35) were collected and processed for DNA isolation. The PCR product was resolved on denaturing polyacrylamide gel for alleles and data were recorded.

Genetic distancing using allelic frequencies and the dendrograms were produced. The genetic distance revealed by UPGMA method clustered the Aseel and Nicobari fowl together with the genetic distance of 0.5899 (Node 1) while the genetic distance from Miri poultry was 0.8758 (Node 2). The number of loci supporting the node were 6 out of 15 giving a value of 40% while the Node 2 was supported by all the 15 loci. The data were further analyzed using unbiased values and the genetic distances were obtained for Node 1 and 2. The values obtained were 0.5609 and 0.8334 respectively. Six loci supported the Node 1 and all the 15 loci supported the Node 2.

Mithun: At the NRC on Mithun, Nagaland, identification, evaluation and characterization of mithun germplasm resources in the country was taken up. Characterization of the germplasm resources through RAPD technique was carried out in collaboration with the CARI, Izatnagar. Different primers had shown different types of band sharing and band differences indicating that four strains of mithun had genetic differences. Arunachalee mithun showed higher genetic differences with other strains.

Somatic Cell Count in Indigenous, Crossbred Cows and Buffaloes

At the NDRI, Karnal, the basal concentrations of somatic cell count in indigenous, crossbred cows and buffaloes were established, and their variations during different seasons, parity and state of lactation were determined.

Identification, evaluation and characterization of mithun germplasm resources in the country was taken up at the NRC on Mithun





PRESERVATION OF SOMATIC CELL
LINES OF SHEEP AND GOAT

At the NBAGR, Karnal, 24 skin samples from Jaisalmeri sheep and 25 from Parbatsari goats were collected and analyzed. Primary cultures of fibroblast cells from ear pinna of sheep and goats were developed. The cells were re-seeded. The cell survival rate and cell count in each passage were studied. Chromosomal profile of cells was studied after an interval of 3 passages. The representative sample from each passage was cryofreezed at -25°C . The cryofrozen samples were thawed at 39°C and re-seeded in the tissue culture flask to study the cell proliferation rates, and format for database of cryopreserved germplasm was prepared.

At the IVRI, Izatnagar, fibroblast cells from skin of goat could be successfully cultured for use in embryo cloning. Standardization of enucleation, reconstruction and electrofusion of goat oocytes was achieved.

Somatic Cell Preservation in Buffaloes Standardized

At the NBAGR, Karnal, the technique of skin sample collection from live buffaloes and culture to isolate the skin fibroblast cells was standardized. Skin sample ($1\text{ cm} \times 1\text{ cm}$ piece) was taken out from the ear pinna of one male and one female calves from elite Murrah buffaloes from the farmer's herd. The skin tissues were collected in Dulbecco's phosphate buffered saline supplemented with 10% FBS. The samples were processed in DMEM+HF 12 nutrient medium supplemented with 10% characterized foetal bovine serum. The primary cells were obtained from tissue explants and cells were cultured on continuous ninth passage in 25 cm^2 tissue culture flasks.

Cell Proliferation and Viability Tests

The cells were counted by standard Newbar haemocytometer, for each passage, at the time of harvesting of each culture. About 80,000 cells were re-seeded in each flask in 5-ml medium. The cells were stained in trypan blue to find out the ratio of live and dead cells by using haemocytometer. Cells (1×10^6) were taken in freezing media (DME+HF-12 with 10% DMSO) in 2ml cryovials. The cryovials were labeled appropriately and stored at both -30°C as well as at -80°C .

Microsatellite Analysis

Microsatellite markers (20) were used to analyse DNA samples of Kangayam, Ongole and Umblachery breeds of cattle at the Core Laboratory, TANUVAS Chennai. DNA extracted from the blood samples of Jaffarabadi, Mehsana and Pandharpuri buffaloes were subjected to microsatellite analysis at the Core Laboratory, GAU Anand. Microsatellite marker CSSM-013 studied in Jaffarabadi buffaloes revealed that all the buffaloes were heterozygous.

NATIONAL AGRICULTURAL TECHNOLOGY PROJECT

NBAGR, Karnal (Lead Centre): Genetic characterization of various breeds of animal genetic resources is in progress. The microsatellite primers of the camel are being screened using a panel of samples from single humped camels (Jaisalmeri, Bikaneri and Kutchi) and double-humped camels. The selected microsatellite primers shall be used to characterize various camel breeds.

The Tarai and Bhadawari buffaloes, Chegu and Black Bengal goats, and Pugal and Garole sheep breeds are also being characterized using microsatellite primers.

In poultry data generated for 26 microsatellite were used for diversity analysis. Enumeration was completed for Aseel, Miri and Nicobari. The data were analyzed for these populations to test if the populations are in Hardy Weinberg Equilibrium (HWE) with respect to the 26 loci, by using chi square test, likelihood ratio (G2) and exact test.

The data were analyzed on two basis i.e. (i) taking all the genotypes from the sample and (ii) pooling the genotype into three categories—homozygote of the most frequently occurring allele, heterozygote of the most frequently occurring allele, and all other alleles clubbed together (which were less frequently occurring). The clubbing of the data was done keeping in view that all the genotypes would not be available in the sample. Chi-square test, revealed that 10 microsatellite loci were deviating from HW equilibrium at 1% level of significance in Nicobari, 5 in Miri, and 7 in Aseel. The deviation from HWE was for 7, 2 and 4 loci for Nicobari, Miri and Aseel, respectively, when data were analyzed for likelihood ratio, G2 test and pooled genotypes. Chi-square and G2 were significant for pooled genotypes for 7 loci in Nicobari, 2 loci in Miri and 2 loci in Aseel genotype. All the microsatellite loci are polymorphic in their nature. The PIC values for ADL-176 ranged between 0.5046 for MCW2 to 0.8755 for the entire dataset. Three alleles for MCW3 and 10 for ADL-176 and ADL-34 were observed.



Exact test for HW equilibrium: The exact test was performed using Fischer's exact test for smaller contingency tables. The method was applied using Markov chain Monte Carlo method. The analysis using the multilocus genetic data revealed that the values were 0.000 meaning that the null hypothesis is accepted i.e. the populations are in Hardy Weinberg Equilibrium and there is no deviation from HW equilibrium.

Genetic distance and genetic identity: Nei's original measure of genetic identity and genetic distance - Nei's genetic distances between Nicobari and Miri is 0.7546 and between Nicobari and Aseel is 0.8433. The genetic distance between Miri and Aseel is 0.9821. The genetic identity between Nicobari and Miri, Nicobari and Aseel, and Miri and Aseel has been 0.4702, 0.4303 and 0.3745 respectively. The unbiased measures of genetic identity and genetic distance were also calculated. The dendrograms of Nei's 1972, Nei's 1972 unbiased and Nei's minimum distance were prepared.

Linkage disequilibrium: The linkage disequilibrium that represents the association between microsatellite loci or alleles was conducted for the three populations. The LD=1 was found between ADL-102 and ADL-158 in Nicobari population. The LD values were 7 and 6 for Miri and Aseel poultry respectively. At least three values i.e. 2 for ADL-136, 1 for ADL-210 and 2 for ADL-176 showed linkage disequilibrium with MCW-14, HUI-7, ADL-210, ADL-23 and MCW-59.

ANIMAL BREEDING

CATTLE

Crossbred Cattle

Frieswal: Under the Frieswal project the present cattle population consists of 22,744 females including 11,501 Frieswals, 8,567 higher crosses and 2,676 lower crosses located at 43 military farms. Military Farm, Meerut, has the maximum number of Frieswals (1,509). The present strength of elite cows at various military farms is 673. Breeding values of 36 Frieswal bulls was evaluated based on the progeny's first lactation milk yield. The top eight bulls (20% of total) with their breeding values were Nashila (2,915.33 kg), Khan (2,904.36 kg), Gajraj (2,885.24 kg), Karan (2,882.63 kg), Rustam (2,882.37 kg), Hira (2,881.27 kg) and Robila (2,877.42 kg).

The production traits such as lactation yield, 300 days milk yield, lactation length and peak yield of Frieswal cows were $3,146.12 \pm 79.42$ kg, $3,011.31 \pm 73.66$ kg, 317.67 ± 9.15 days and 14.53 ± 0.36 kg, respectively. The average age and weight at first calving, dry period, service period and calving interval of Frieswal cows were 987.71 ± 10.59 days and 360.15 ± 4.24 kg, 110.73 ± 11.23 days, 179.36 ± 13.80 days and 426.86 ± 13.97 days, respectively.

The average daily body weight gain (g) of growing Frieswal bull calves maintained at various levels of feeding 100% P \times 100% E, 100% P \times 120% E, 120% P \times 100% E, 120% P \times 120% E of NRC 1989 and Military Farm feeding scales were 598, 710, 667, 667 and 524 g, respectively. The best result was obtained in feeding of 100% protein and 120% energy levels of NRC 1989.

Field progeny testing: Under this project semen of Frieswal bulls is being used for progeny testing of crossbred bulls under field conditions at 3 different places in India, viz. Ludhiana (PAU), Mannuthy (KAU) and Urukanchan (BAIF). At BAIF, 1,472 pregnancies were confirmed and the conception rate was 42.12%. At the KAU, average age at first calving in the daughters of second set of bulls was $1,013.57 \pm 12.12$ days. The average 305 days milk yield of daughters of the first set of bulls was $1,949.83 \pm 8.00$ kg and in the daughters of second set of bulls $2,042.19 \pm 26.83$ kg.

Three first generation Karan Fries (KF) crossbred cows at the NDRI, Karnal, gave record milk yield of 46.5 kg, 44.8 kg and 46.0 kg day surpassing previous best milk production of 44.2 kg for the Institute herd.



Hariana cow yielded 3.98 kg wet average and 1.95 kg herd average



Indigenous Breeds

Haryana, Ongole, Gir and Tharparkar breeds are being studied.

Haryana: Overall conception rate in heifers and cows was 52 and 59%, respectively. Average number of inseminations/conception was 1.7 in cows. In 5 sets 47 bulls have so far been put to test matings. Daughters (1,060) have so far been born due to 4 sets of test bulls; 47% cows remained in milk and yielded 3.98 kg wet average and 1.95 kg herd average. Average age at first calving and first lactation milk yield was 56.10 month and 816.01 kg, respectively. Average dry period, service period and calving interval averaged 214.36, 160.16 and 443.45 days, respectively.

Bull calves (10) put to training for draught took 36.70 ± 1.08 months to be ready for draught purposes. The mean fatigue score, an index of draughtability for empty cart was 2.00 to 2.50 after 2 hr work and 2.00 to 3.00 after 3 hr work.

Ongole: Overall conception rate in heifers and cows was 55 and 60%, respectively. Average number of inseminations/conceptions was 1.7 in cows. Three sets of 8 each were put to test mating and 1,228 daughters (284+393+551) were born. More than 31,855 doses of semen of test bulls were available on closing date. Round the year 37% cows were in milk and yielded 3.1 kg wet and 0.78 kg herd average. Average age at first calving was 55.14 months. First lactation milk yield averaged 682 kg. Overall lactation yield in 300 days was 654 kg. Average lactation length and peak yield were 216.8 days and 3.26 kg, respectively. Dry period, service period and calving interval averaged 271.68, 198 and 486.34 days, respectively.

Gir and Tharparkar: Livestock Research Station, Beechwal (Bikaner) and Cattle Breed Farms, Junagarh, were identified as germplasm units for Tharparkar and Gir breeds, respectively. The associated herds are yet to be identified.



In Ongole cattle herd three sets of eight each were put to test mating and 1,228 daughters (284+393+551) were born

BUFFALO

Network Project on Buffalo Improvement

Breeding from fifth set of 15 Murrah bulls was completed and from this set 54,087 doses of frozen semen were stored (33,317 doses from 6 bulls at the CIRB, 11,784 doses from 4 bulls at the PAU and 8,986 doses from 5 bulls at the NDRI) for future use. Sixth set of 16 test bulls of Murrah breed (5 CIRB, Hisar, 5 NDRI, Karnal, 4 PAU, Ludhiana and 2 HAU, Hisar) was selected from among the participating herds. Test mating from these bulls started from January 2001 and shall continue up to June 2002. The average age of the bulls at the time of selection was 40.2 months and the average of dam's best lactation (305 day or less milk yield) was 3,055 kg.

The 3 top ranking sires were selected for nominated matings on the basis of their sire index value. First ranking sire number 392 from CIRB, Hisar, has sire index of 2,099 kg based on 10 daughters. Second and third ranking sires (Bull no. 3,108 and 3,567) belonged to the NDRI, Karnal, and their sire index was estimated as 1,953 kg based on 18 daughters and 1,927 kg based on 15 daughters, respectively. Per cent superiority of these 3 top ranking sires over contemporary daughters was estimated as 22.7, 7.1 and 6.2% respectively. Frozen semen of these bulls is being used for elite matings in all the participating herds. At the PAU Ludhiana, HAU Hisar and NDRI Karnal wet average of milk yield during the year increased to 6.7 kg, 6.7 kg and 6.65 kg. Average calving interval during the year at CIRB, PAU, NDRI, HAU and IVRI was recorded as 454 days, 511 days, 408 days, 480 days and 411 days, respectively, indicating improvement at the PAU, NDRI and IVRI over the previous year averages.

During this year the Network Project on buffalo was expended to cover more important breeds of buffaloes in the country by establishing new centres, which include (i) GAU, Junagarh for improvement of Jaffarabadi buffaloes; (ii) MPUAT, Udaipur, for Surti buffaloes; (iii) CIRB Sub campus Nabha for Nili-Ravi buffaloes; (iv) IGFRI, Jhansi for Bhadawari buffaloes; (v) MPKV, Kolhapur for Pandharpuri buffaloes; (vi) ANGRAU, Venkataramanagudem for Godavari buffaloes; (vii) AAU, Khanapara for swamp; and NDUAT, Faizabad, for Murrah buffaloes which will



Network Project of Buffalo was expended and MPKV, Kolhapur centre was established to study the Pandharpuri buffaloes



work in association with the existing centres for Murrah breed. Besides these three more field units for Murrah breed at PAU Ludhiana, NDRI Karnal and CIRB Hisar, were launched.

SHEEP

Sheep for Carpet Wool

Avikalin: Avikalin sheep produced overall annual greasy fleece weight of 1.446 kg with an average of 1.663 kg in rams and 1.229 kg in ewes. Annual tugging and lambing per cent on ewe's available and tugged basis were 98.18, 94.37 and 96.17%, respectively. The survivability in 0-3 month, 3-12 month and adult animals were 95.85, 97.20 and 92.67%, respectively. Ram lambs were selected on the basis of selection index incorporating greasy fleece yield and body weights both at 6 month of age. Least squares means for 3, 6, 9 and 12 months were 3.02, 13.50, 21.63, 23.72 and 26.74 kg in Avikalin.

Sheep for Fine Wool

Bharat Merino: Ram lambs for future breeding were selected on the basis of selection index developed by incorporating GFY and body weight at 6 months of age. The overall annual greasy fleece yield of Bharat Merino sheep was 2.02 kg. Annual lambing per cent on the basis of ewes available was 55.0%. The survivability in 0-3, 3-6, 6-12 and adult age groups was 97.40, 98.15, 98.40 and 89.52%. The average body weight at birth, 3, 6 and 12 month were 2.75, 11.41, 20.11 and 29.72 kg. The strain has the potential to substitute for the exotic fine wool breed of sheep.

Sheep for Mutton Production

Malpura: Malpura is an important breed of Rajasthan. Overall means for birth, 3, 6 and 12 months body weight were 2.93, 13.43, 22.04 and 28.65 kg in Malpura, 3.65, 15.58, 24.30 and 32.13 kg in Awassi × Malpura halfbred, and 2.08, 11.54, 17.80 and 23.40 kg in Garole × Malpura. Malpura ewes were crossed with Garole rams considering the importance of multiple births in sheep breeding. Garole × Malpura halfbred ewes yield encouraging results in terms of twin lambing percentage. Of 34 lambings obtained during 2000-2001 from above mentioned genetic group, 44% were twin lambings, whereas, Malpura gave birth to single lambs except 1-2% twin lambing. Survivability of above genetic groups was almost as in semi arid conditions. Garole crosses have the potential for increased lambing rate. A systematic study on Garole sheep was initiated.

Network Project on Sheep Improvement

Chokla: At the CSWRI, Avikanagar, Chokla sheep is being improved through selection for carpet wool production. Average annual greasy fleece yield was 2.00 kg. Average body weights at birth, 6 month and 12 month of age were 2.53, 16.90 and 22.63 kg, respectively. Overall survivability of the flock was 93%. Annual lambing was 70%.

Marwari: At Arid Region Campus (CSWRI), Bikaner, Marwari sheep is being improved through selection for carpet wool production. Males are selected based on selection index incorporating 6-month body weight and first 6 monthly greasy fleece weight. The average birth, 3, 6, 9 and 12 month weights were 2.76, 10.73, 17.17, 21.95 and 22.69 kg, respectively. Birth weight for spring 2001 was 3.08 kg. Elite lambs had higher body weights than tester lambs at all stages of growth. Tugging was 54.3%. Lambing on available and bred basis was 44.1 and 81.1% in elite animals. In tester ewes tugging was 56.9%. Lambing on ewes available and bred basis was 44.1 and 81.1% in elite animals. Lambing on available and bred basis was 47.1 and 82.6% respectively. Elite animals produced heavier clips as compared to tester animals. Average annual greasy fleece weight for adult animals was 1.00 kg. The



Avikalin sheep produced annual greasy fleece weight of 1.663 kg in rams and 1.229 kg in ewes



Malpura sheep attained 28.65 kg body weight by 12 months of age



Chokla sheep is being improved through selection for carpet wool production



average fibre diameter was 36.23 μ and medullation 42.9%. Average staple length was 4.89 cm. The selection differential for 6 month body weight was 4.7 kg and first 6 monthly greasy fleece weight was 55 g. The heritability estimates for birth weight, 3, 6, 9 and 12 month body weight, first 6 monthly and second 6 monthly greasy fleece weight were 0.307 ± 0.054 , 0.436 ± 0.061 , 0.346 ± 0.056 , 0.399 ± 0.060 , 0.309 ± 0.054 , 0.392 ± 0.059 and 0.307 ± 0.054 , respectively.

Muzaffarnagri: At the CIRG, Makhdoom, Muzaffarnagri sheep is being improved for mutton production through selection. The average birth, 3, 6 and 9 month weights were 3.16, 13.11, 20.79 and 22.25 kg, respectively. The adult annual greasy fleece yield was 1.25 kg. Feed conversion efficiency was 19.55% in males and 16.59% in females. Selection differential for 6-month body weight and wool yield was 5.45 kg and 96 g respectively. Overall mortality was 4.84%.

Deccani: At the MPKV, Rahuri, development of elite flock of Deccani sheep is under progress. Average body weights at birth, weaning, 6, 9 and 12 months of age were 3.06, 14.66, 19.92, 21.62 and 23.64 kg, respectively.

Nellore: At the ANGRU, Palamner, sheep is being improved through selection for mutton production using selection index incorporating body weight at 6 and 9 months of age. The overall means for body weights at birth, 6, 9 and 12 months of age were 2.95, 13.92, 22.39, and 26.61 kg respectively. The overall means for pre-weaning and post-weaning daily were 144 and 34 g, respectively.

Magra: At the RAU, Bikaner, Magra sheep is being improved through selection. This is field based unit. There were 3,454 lambing (74.3%). The average body weights at birth, 6, 12 months and adult stage were 2.79, 21.08, 29.09 and 35.82 kg, respectively. Average greasy fleece weight was higher (940 g) at first 6 months age and lowest (659 g) in adult group. The selection differential for 12 month body weight and greasy fleece weight at this age was 7.1 kg and 102 g, respectively.

Madras Red : At the TANUVAS, Kattupakkam, the Madras Red sheep is being improved through selection for mutton production. Average body weight at birth, 6, 9 and 12 months was 2.86, 14.64, 18.48 and 20.6 kg, respectively.

GOAT

Genetic Improvement and Sire Evaluation of Jamunapari Goats for Milk Production



Jamunapari male selected from farmer's flock at adopted village

Aim of the project is to improve production performance of Jamunapari goats through selective breeding. Index for selection of breeding bucks was developed including 9 months body weight of the individual and 90 days milk yield of their dam. Selected bucks were used to generate progenies. The mean body weight at birth, 3, 6, 9 and 12 months of age were 2.89 ± 0.03 , 9.42 ± 0.16 , 14.38 ± 0.25 , 18.98 ± 0.55 and 24.57 ± 0.67 kg, respectively. The genetic potential of the breed in intensive system of management revealed the body weight of about 13.18 ± 0.44 , 19.66 ± 0.63 , 28.18 ± 0.72 and 34.48 ± 0.77 kg at 3, 6, 9 and 12 months, respectively. The body weight gain in intensive system of management was 94.0 g/day during 6-9 months of age. Heritability estimates for weight at birth, 3, 6, 9 and 12 months of age were 0.23 ± 0.07 , 0.22 ± 0.07 , 0.22 ± 0.07 , $0.0.36\pm 0.08$, respectively. The heritability estimates for 90, 140 days and total milk yield were 0.46 ± 0.18 , 0.55 ± 0.19 and 0.55 ± 0.19 , respectively.

Genetic Improvement of Barbari Goats for Meat and Milk Production

Genetic improvement of Barbari goat for increased meat and milk production has resulted into an improved stock of the breed. There had been marked increase in the overall productivity of the flock over the years.

The least squares means for body weight growth at birth, 3, 6, 9 and 12 months of age were 1.77 ± 0.03 , 7.08 ± 0.18 , 11.52 ± 0.20 , 16.21 ± 0.59 and 20.79 ± 0.55 kg, respectively, which were highest for previous 3 years. Year of birth, sex of kid, type of birth had significant effect on body weight up to 12 months of age. However, season of birth had significantly affected body weight at 9 and 12 months of age



only. The kids born during October-November had higher body weight at 9 and 12 months of age than those born during March-April. Males had higher body weight than females at all the ages. Single born kids had significantly higher body weight than twin and multiple born kids at all the ages.

Year of kidding significantly affected the 90 days milk, 140 days milk yield and lactation yield. Season of kidding affected lactation length, however, lactation order and type of kidding had no influence on lactation traits. Age at first mating was 329 ± 19.78 days, which was lowest and subsequently there was significant reduction in age at first kidding, a positive impact reproduction management.

AICRP on Goat Improvement

Jamunapari flock maintained under farm conditions at the CIRG, Makhdoom, attained body weight of 24.57 ± 0.67 kg at 12 months of age. The feed lot kids attained maximum gain of 92.8 ± 5.88 g/day during 3-6 months of age. The part lactation yields for 90 and 140 days were 64.04 ± 1.59 and 88.24 ± 2.21 kg respectively. Breeding efficiency on the basis of does tugged was 90.73%. Bucks were selected using an index combining 9 months body weight and 90 days milk yield of the dam. Breed improvement of programme was taken up in Jagtoli and Nagla Kadhori villages. The kids attained a body weight of 24.54 ± 1.14 kg at 9 months of age under field conditions. The average daily milk yield of Jamunapari goat was 1.12 ± 0.01 kg/day. The kidding rate and twinning were 1.41 and 50.5%, respectively.

The Barbari flock maintained at the CIRG, Makhdoom, registered a population growth of 76.96%. The kids attained the body weight of 20.97 ± 0.55 kg at 12 months of age. The part lactation yields for 90 and 140 days were 61.78 ± 2.74 kg and 76.25 ± 9.04 kg respectively. The flock mortality was quite low (6.21%) during the period.

Kids at a farm based unit of Sirohi breed at the CSWRI, Avikanagar, Rajasthan, attained a body weight of 20.36 kg at 6 months of age. Their body weight gain was 83 g/day during 3-6 months of age. The part lactation yields for 90 and 150 days were 66.67 and 84.85 kg, respectively. The breeding efficiency was 82.69% on the basis of does tugged.

CAMEL

Age at first calving in Bikaneri, Jaisalmeri and Kachchhi was, respectively, $2,017.93 \pm 87.65$, $2,088.79 \pm 70.78$ and $1,971.33 \pm 200.59$ days. Calving interval was 740.76 ± 10.67 days. The gestation period of Kachchhi females was 385.17 ± 1.53 days, Bikaneri 390.20 ± 0.93 days and Jaisalmeri 389.52 ± 0.98 days. Pedigree information related to herd of centre was created. An informative database on reproductive performance (1992-2000), health (1984-2000), body biometry measurements, hair and milk production of all camels maintained at the Centre was created. Breeding tract database of Jaisalmeri camel was created.

PIG

At the ANGRAU, Tirupati, breeding programme was drawn with boars and sows of 50% LWY group and boars and sows of 75% LWY group. At the AAU, Khanapara, halfbred and Hampshire gilts were mated. Average litter size at birth in the second crop was 7.920 ± 0.57 in 50% H and 9.31 ± 0.33 in 75% H group. At the KAU, Mannuthy, breeding programme was drawn with gilts and boars. Litter size averaged 6.53 ± 0.40 at birth and 6.39 ± 0.39 at weaning. Average litter weight was 7.38 ± 0.71 kg at birth and 51.68 ± 3.44 kg at weaning. In addition to the existing centers two new research centers one each at BAU, Ranchi, Jharkhand, and another at the ICAR Research Complex, Goa, were initiated.

MARWARI GOAT IMPROVEMENT PROGRAMME

Field based centre of Marwari breed under the RAU, Bikaner, has four village centres in the home tract of Marwari goats. The average body weight at 2-4-6 teeth and full mouth were 24.44 ± 0.48 , 28.18 ± 0.035 , 29.43 ± 0.61 and 33.31 ± 0.19 kg, respectively. Milk productions for 30, 60 and 90 days were 55.14 ± 1.12 , 108.43 ± 2.11 and 158.72 ± 2.84 kg respectively. The number of goat breeders having agriculture along with the animal husbandry was highest (82.55%). Breeders having more than 25 goats earned 4% more income than those having less number of goats.



An informative database on camels was created at the NRCC



Breeding stock of Black Brown rabbit was selected with high selection differential

RABBIT

Rabbit for Meat

At Avikanagar, 907 kits were produced during this period from White Giant (WG) (344), Soviet Chinchilla (SC) (533) and Black Brown (BB) (30) breeds. Breeding stock was selected with high selection differential. The selection differentials in 12 weeks were 227.26 g in WG and 203.7 g in SC breeds. Among litter traits, the selection differential for litter size at birth (LSB) was 0.54 in WG and 1.79 in SC for litter size at weaning (LSW), 1.11 in WG and 1.98 in SC. Males were selected on the basis of 12-week body weight while females were selected on the basis of litter traits. The overall means of LSB, LWB, LSW, WKDL achieved this year were 6.08, 337.36, 5.03 kg and 1,733.03 g respectively. Reproductive performance was better than the previous year with respect to LWW and WKDL. LSB and WKDL were better in SC while LWW was better in WG. The overall body weights at 4, 6, 12 and 24 weeks of age were 350.09, 658.38, 1,452.42 and 2,274.63 g, respectively. Higher body weights were recorded in WG and SC in all stages. Season had highly significant effect on body weights. July to December period was better for growth than January to June. Females had significantly higher body weights than males at 24 weeks of age. Adult body weights declined from April to August and increased from September to March. At North Temperate Regional Station, Garsa, Kullu, body weight at 84 days of the different breeds were relatively more than recorded in previous year except in Grey Giant. Daily weight gain was highest in rabbits weaned at 28 days as compared to animals weaned at 35 to 42 days. The kit survivability in different breeds ranged from 94 to 100%.

Angora Rabbit for Wool

The population of German Angora (new) increased with a kit survivability of 97.4%. The average litter size at birth and weaning was 5.01 and 4.88, respectively. The average litter weight at birth was 281.03 g while the average 42 day weaning weight was 683.3 g. The pooled average wool yield of the general flock was 671.4 g and that of breeding flock 685 g.

POULTRY

Poultry for Meat

Under the AICRP on Poultry for Meat the mass selection for 6-week body weight with more emphasis on conformation traits in male line, and egg production and hatchability in female line, continued. The sub lines, SG and SF derived from SML-2 at CARI Centre, Izatnagar, exceeded 1,700 g at 6 weeks and were superior to the controls both at 4 and 6 weeks of age. The estimated genetic and phenotypic responses, respectively, were 46.77 and 47.02 g in SG and 51.86 and 51.95 g in SF line at 6 weeks of age. The feed conversion ratio showed a desirable decline over the last 3 generations, phenotypically. The average body weight at 6-weeks of age in the S-6 generation was 1,640 g. The synthetic dam line at the CARI showed positive genetic response of 15.53 and 38.64 g for body weight in 4 and 6 weeks, respectively. At the OUAT, Bhubaneswar, evaluation and regeneration of the synthetic dam line received from the CARI, Izatnagar, were under progress. The body weight of males and females at 6-weeks of age were 1,355 and 1,148 g with an average feed conversion ratio of 2.29. The average egg number up to 40 weeks of age was 55.28. The body weights of Pb-2 at 4 and 6 weeks exceeded the corresponding body weights of the last generation at the PAU, Ludhiana. At the UAS, Bangalore, evaluation and regeneration of the synthetic Pb-2 line originally received from PAU, Ludhiana, continued and the average body weight

A pair of layer cross





of female pureline was 1,200 g at 6 weeks of age. At the JNKVV, Jabalpur, evaluation of purebred dwarf dam continued.

In the 37 random sample broiler test at Hessarghata, the commercials from the CARI attained 1,195 and 1,486 g body weight with feed efficiency of 1.45 and 1.82 at 6 and 7 weeks of age, respectively, while the first and second entry from the UAS, Bangalore, attained 950 and 1,198 g at 6 weeks of age, with feed conversion ratio of 1.80 and 1.44, respectively, and the same attained 1,244 and 1,437 g body weight at 7 weeks of age with respective feed conversion ratio of 2.09 and 1.88. At another testing centre in Gurgaon, the entries from the PAU, Ludhiana, secured second position in the 17 RSBT by attaining 1,480 and 1,958 g body weight at 6 and 7 weeks of age, respectively. The entries from the CARI closely followed those of the PAU, Ludhiana, in the same test. In yet another random sample test conducted at Bhubaneswar, the lone entry sent by the CARI centre secured second position with a recorded body weight of 1,495 and 1,713 g at 6 and 7 weeks of age with corresponding feed efficiency of 2.2 and 2.4. The per cent livability of broilers sent from different AICRP centres was more than 97.5%.

The heat tolerant major gene i.e. Naked Neck (Na) was introgressed in broiler stock and populations having colour (NNCP) and white plumage (NNWP) were developed. Both the populations completed 5 generations of selection. The body weight of NNCP at 4, 6 and 7 week were 774, 1,408 and 1,573g, respectively. Corresponding weights in NNWP were 786, 1,426 and 1,732g.

Poultry for Egg

Under the AICRP Network programme, intra population selection for egg production up to 64 weeks of age superimposed with independent culling level selection for egg weight at 28 weeks and layer house mortality, was continued. The phenotypic response as a consequence of intrapopulation selection followed a desirable direction for principal traits of selection. The response to selection for enhanced period of 64 week egg production in IWD and IWF lines at the ANGRAU was positive by producing 9 to 20 eggs more than the controls, and by 72 weeks of age this advantage marginally declined to a range of 5-15 eggs. The hen housed egg production at 72 weeks was 268 and 282 eggs for IWD and IWF lines, respectively. Four generations of selection for egg number up to 64 weeks of age did not favour early sexual maturity in the population. At the KAU, Mannuthy, the S-19 generation of IWN and IWP showed an increase of 13 and 17 eggs, respectively, compared to the control by 40 weeks of age. The culling level of selection for egg weight resulted in achieving 50.47 g at 28 weeks and 54.04 g at 40 weeks of age in IWN strain. The corresponding egg weights in IWP strains were 50.2 and 54.14 g respectively. The same lines, maintained at the GAU, Anand, for evaluation of feed efficiency, yielded survivor production of 241 eggs in IWN and 232 eggs in IWP. The per day feed intake was 114 and 106 g, respectively, for IWN and IWP up to 64 weeks of age. A reduction in feed intake by 1.5 g/day per hen was observed in the current generation compared to the earlier S-2 generation in IWN line.

At the CARI, Izatnagar, the phenotypic response of hen house egg production up to 40 weeks in IWG and IWJ strains was estimated as 2.14 and 1.73 eggs, respectively; and in the same order, for the age at first egg was -2.15 and -1.98 days for both strains. A statistically significant realized genetic gain for egg production was 1.80 to 1.37 eggs for IWG and IWJ. The commercial cross of CARI, ILI-80 yielded 276.01 eggs with an average egg weight of 58.4 g in random sample test that is comparable with most of the commercials available in the market.

Various strain and breed crosses were developed, maintained and evaluated for their enhanced part record up to 64 week of age. Among the various strain crosses 4-way cross (JGHI) have produced the maximum number of eggs (238.85) followed by JG (234.07), GHI (229.37), JHI (221.45) and HI (221.31), while the breed cross (IWH × RIR) have produced only 218.11 eggs. The mean egg weight at 40 and 64 weeks of age in the various crosses ranged from 52.17 to 54.64 g and 52.72 to 57.11 g, respectively. At 64th week of age maximum egg weight was observed in



The heat tolerant major gene i.e. Naked Neck (NA) was introgressed in broiler stock

RURAL POULTRY GERMLASM

The need to sustain free-range poultry farming in rural, tribal and backward areas was pursued vigorously utilizing the germplasm developed for the purpose. Vanaraja, a dual purpose bird was the choice in almost all districts of Andhra Pradesh, some parts of Orissa and some north-eastern states besides Port Blair. Grampriya was popular in Kerala and West Bengal as a backyard layer with good egg production and moderate body weight. Krishibro, a commercial, colour broiler with excellent livability and good feed efficiency was provided to the user agencies. Germplasm was made available either as fertile eggs, day-old chicks or parent stock. Day-old chicks of Vanaraja (58,251), Krishibro (3482) and other (2957) were provided to rural masses through Animal Husbandry Departments, KVKs, NGOs, Agricultural Universities etc.



BACKYARD/RURAL POULTRY PRODUCTION



Free range rearing of local birds

of free range rearing under rural/tribal conditions. Two subpopulations carrying genes for high and low antibody titers against sheep RBC were developed and maintained as pedigreed populations in the male line. In addition, a brown egg layer line is being maintained, evaluated and improved for utilizing the same for developing a tinted layer for backyard poultry production in the long run.

Transportation of birds using local basket



The programme on 'Development of Germplasm for Backyard/Free Range Farming for Rural and Tribal Areas' was on priority for Project Directorate on Poultry. The male and female lines were maintained, selected and evaluated for growth and production at different ages. The regeneration of both the lines was aimed at developing colour germplasm by giving emphasis on high immune competence, long shanks, moderate body weight and high egg production to suit the requirements

the breed cross (57.11 g). All the strain crosses matured in the age range of 125.16 to 129.36 days while breed cross matured at the age of 140.50 days.

The replacement stock of S-20 generation of Rhode Island Red (RIR) was reproduced from 40 selected sires mated to 160 dams with 87.65 and 87.66% fertility in RIR selected and control lines, respectively. The selected line produced 4,048 g of egg mass; 72.04 eggs during its 40th weeks of part record with 56.19 g average egg weight. The pullets of the selected line matured at an age of 158.59 days.

Under the programme on 'Development of gene lines with single genes', attempts were made to develop the Naked Neck line as a true breeding broiler population. A homozygote dwarf line was also developed keeping in view its potential as a meat type female parent line for tropical broiler production. The average egg number and egg weight in Naked Neck gene line were 49.82 and 60.95 g at 40 weeks of age and corresponding measures in dwarf line were 66.70 and 56.86 g.

The feed efficiency line has completed S-3 generation of selection, taking residual feed consumption up to 40 weeks of age as a selection criterion. For S-3 generation, the reproductive performance revealed fertility as 90.04%, and hatchability on fertile eggs transferred basis as 73.78%. Comparative performance of the feed efficiency line along with control population revealed that pullets of selected line matured at 153.78 days of age, and produced 95.94 eggs up to 40 week of age with 50.75 g mean egg weight (40th week). Corresponding observations on above traits in control population were recorded to be 166.47 days, 77.88 eggs and 54.30 g, respectively. Feed consumed/dozen eggs and per kg of egg mass were recorded at two stages, viz. 37-40 weeks and 61-64 weeks. FC/kg of egg mass was quite comparable in the selected line in both the stages being recorded to be 2.947 kg and 2.910 kg of feed/kg of egg mass, respectively, more feed consumption per dozen of eggs during 61-64 weeks (2,076.71 g) in comparison to 37-40 weeks (1,787.89g) accounted for better egg size at 2 later stages of egg production (59.56 g > 50.75 g).

Participation in random sample policy performance test centers: The commercial



layer stocks of CARI participated in the various test centres. The age at first egg and age at 50% production were recorded at 115 and 142 days, respectively, at Bhubneshwar centre. Result from Bangalore centre (30th test) revealed maximum egg production (HD) for the pullets maintained in cages (276.01 egg), with maximum egg weight of 58.37 g in deep litter. The feed consumption/dozen of eggs was 2.010 kg and the margin of profit was Rs 33.45 over feed cost.

TURKEY

At the CARI, Izatnagar, for rearing and management practices of turkey under tropical climate, small variety turkey chicks were reared at three floor density (0.75, 1.0 and 1.5 ft²/bird) from day-old to eight weeks reared of age. The poults reared at 1.0 ft² consumed less feed and gave better FCE (51.5%) as compared to other two densities (47.7 and 44.7% for 0.75 and 1.5 ft² respectively).



Rearing and management practices for turkey under tropical climate, are being developed

QUAIL

At the CARI, Izatnagar, the broiler quail chicks hatched during summer and winter were provided floor space of 100, 150 and 180 cm²/bird during brooding period (0-3 weeks). Thereafter, they were reared in the rearing cages until fifth week of age. The birds kept at 180 cm² floor space recorded significantly higher body weight in third week and feed consumption than that of 100 cm² and 150 cm² floor space both during summer and winter. Feed conversion ratio (FCR) during 0-3 weeks were significantly better in 100 cm² than quail provided 150 cm² and 180 cm² floor space. There was no significant difference in mortality at 3 different floor spaces. The birds provided extra floor space during rearing period recorded significantly higher fifth week body weight and 3-5 weeks body weight gain and better FCR. Mortality pattern remained unaffected at 3 floor spaces both during summer and winter. The fifth week carcass parameters were not significantly different at different floor spaces.

GUINEAFOWL

At the CARI, Izatnagar, the guineafowls are being improved for high growth rate and general disease resistance. A replacement stock of 2,168 keets was hatched from the parents selected for high body weight. The 12-week body weight Lavender, Pearl and White varieties was 843.73, 885.10 and 882.79 g, respectively. With the objective of developing the divergent lines for antibody response to sheep red blood cell (SRBC) the S-2 generation of high and low titre lines were generated and evaluated. The high and low titre lines showed significant differences for antibody titre against SRBC.

ANIMAL HEALTH

FOOT-AND-MOUTH DISEASE

The nucleotide sequence data of 500 different FMDV outbreak strains including the vaccine strains recovered from various parts of the country (consisting of serotypes O : 250 isolates, Asia 1 : 130 isolates and A : 120 isolates) during the last 25 years were sequenced. The nucleotide sequences thus obtained are compared with each other, the vaccine virus strain used in the country and the exotic strains of the respective serotypes. The evolutionary relationship of the sequences was calculated. Besides the 1D gene, the complete capsid coding region (approximately 2.2 Kb) of the field isolates (serotypes O: 32 and Asia 1:48) were sequenced and are being used for phylogenetic analysis.

Another non-structural region (L-gene) was also sequenced for 32 serotype O and 30 Asia 1 field isolates of which the capsid coding region is available, and is



- Foot-and-mouth disease virus outbreak strains were sequenced
- National Repository of FMD virus includes 950 well characterized field isolates
- Milk based ELISA kits developed for screening bovine brucellosis, and IBR
- Recombinant competitive ELISA kit developed for rinderpest sero-surveillance
- State modules of india.admas.epitrac developed
- Epidemiological aspects of leptospirosis are being studied
- Prevalence of bovine tropical theileriosis is being studied
- Cattle tick survey covering Rajasthan, Haryana and Himachal Pradesh was conducted
- Vaccine developed for haemorrhagic septicaemia
- Combine vaccine being developed for HS and FMD, and pig pasteurellosis and FMD
- Identification of bluetongue virus-positive animals possible through NS 3 primer pair in any given animal population
- Test developed for detection of anthelmintic resistance in *Haemonchus contortus*
- Urea spray on pasture reduced larval recovery from pasture
- Nematophagous fungi, viz. *Duddingtonia flagrans* and *Arthrobotrys oligospora* isolated from sheep faeces
- Diagnostic procedure for PPR virus detection developed
- PPR vaccine gave immunity up to 18 months
- Ranikhet disease vaccine found useful in birds
- EDS 76 vaccine developed for quails
- One case of glanders reported in Uttar Pradesh

being used for genetic comparison to evaluate the different evolutionary rates acting on different genomic regions of the virus. Antibodies against non-structural proteins (NSP) persist in animals for longer period and their presence in the animal is used as a marker to differentiate between FMDV infected and non-infected animals. An indirect ELISA was developed to detect antibodies against NSP antigens. The test uses *Baculovirus* expressed antigens, and 3,256 random sera samples were tested against all the 5 non-structural (L, 2B, 2C, 3AB3 and 3D) antigens.

A liquid phase blocking ELISA (LPBE) test is being used to determine the protective antibody levels against O, Asia 1, A and C in animals following vaccination. This test procedure will be very valuable for sero-monitoring work to determine the vaccine efficacy and decide the frequency of vaccinations during a control programme.

Generation of monoclonal antibody resistant mutants (MARM) and their sequencing in the capsid-coding region helps in identifying the neutralizable antigenic sites. To this end 29 MARM were generated that helped in identifying 3 distinct antigenic sites on FMD type Asia 1 virus. Out of the three sites identified, 2 are located on VP1 and one on VP2 protein.

A National Repository of FMD viruses is being maintained, and it includes 950 well-characterized field isolates (in the form of BHK₂₁ cell culture adapted) representing the serotypes O, Asia 1, A and C.

ANIMAL DISEASES MONITORING AND SURVEILLANCE

The milk based IBR ELISA kit is an alternative field test for the serum based IBR kit. It is software based and highly sensitive, specific and user friendly. This is developed as replacement for serum ELISA kit for use with the lactating animals. Immunocapture ELISA for the detection of IBR virus in semen was standardized and will be field validated soon.

Recombinant competitive ELISA kit for rinderpest sero-surveillance was developed. This 'cutting edge and novel molecular technology' is being used to develop a veterinary immuno-diagnostic kit for the first time in the country. This was developed jointly with the Indian Institute of Science. It would save the country several crores in foreign exchange and will help declare freedom from rinderpest infection.

Epidemiological aspects of leptospirosis were undertaken and leptospiral serovars from rodents, domestic animals and man were studied. The highest isolation records with primary association of *Leptospira inadai* infection in man and animals were noted. The need to develop local expertise in molecular typing is stressed to understand this emerging disease.

BLOOD PROTISTA

Epidemiological studies on prevalence of bovine tropical theileriosis revealed that the disease is endemic, however, its epidemiology has not been adequately studied in the Western Himalayan Region. Sero-prevalence studies were conducted by using indirect fluorescent antibody test (IFAT) and single dilution enzyme linked immunosorbent assay (SD-ELISA).

The overall prevalence of *Theileria* infection in cattle of Himachal Pradesh was 4.55% as detected by blood smear examination. IFAT detected 15.77% antibodies to *Theileria* and SD-ELISA detected 26.58%. No sex bias was observed in the prevalence of *Theileria* infection when detected by blood smear examination and IFAT, but females showed higher seroprevalence by SD-ELISA. The variation in *Theileria* infection in three agro-climatic zones within Himachal Pradesh was not found significant by the sero-diagnostic tests, but the cattle of lower hills showed higher positivity by blood smear examination. The infection was prevalent more in exotic and their crosses than that in the indigenous cattle. *Haemaphysalis bispinosa*, a tick known to transmit *Theileria orientalis* was widely prevalent, whereas *Hyalomma* species, the tick known to transmit *T. annulata* was rare. The prevalence



of infection was more in organized farms as compared to cattle kept by individual farmers. The overall prevalence of the disease in Western Himalayan region was much lower compared to northern plains and Rajasthan.

Ticks being the vectors of important diseases, demand a constant watch. Cattle tick surveys covering Rajasthan, Haryana and Himachal Pradesh were conducted during maximum tick activity season i.e. April to November in arid, semi-arid, sub-humid, humid and cold arid regions of India. The districts surveyed were Jaisalmer, Jodhpur, Bikaner, Churu (Rajasthan); Hisar, Jind, Kaithal, Karnal, Kurkshetra, Ambala, Panchkula, (Haryana); Sirmaur, Solan, Shimla and Kinnaur (Himachal Pradesh). From Pokaran (Jaisalmer) to Pooh (Reckong Peo) area about 1,200 km was surveyed along main roads. Cattle (2,334) of all age groups, including native and crossbreds, were surveyed and 81.53% of them were found infested with ticks. Dairy farms, individual house holds with a few cattle, *gaushalas* and animal visiting veterinary hospital premises in villages and cities were the survey sites.

Hyalomma anatolicum anatolicum, *H. dromedarii*, *H. marginatum isaaci*, *Rhipicephalus haemaphysaloides*, *Boophilus microplus*, *Haemaphysalis bispinosa*, *Ixodes ovatus* and *Ornithodoros savignyi* were collected from cattle. The prevalence of tick species was described either as predominant (tick species found on > 25% of the infested cattle) or common (tick species found on 5-25% of the infested cattle) or rare (tick species found on < 5% of the infested cattle). The prevalence of *H.a. anatolicum* changed from a predominant tick in Rajasthan to a common tick in Haryana to a non-prevalent tick in Shimla district and beyond in Himachal Pradesh. The prevalence of *B. microplus* changed from a non-prevalent tick in Jaisalmer to a predominant tick in Haryana and Himachal Pradesh. The prevalence of other five ixodid ticks varied with the location. *Hyalomma dromedarii* was a common tick in Rajasthan, rare in Haryana while this was not found during the present survey in Himachal Pradesh. *Haemaphysalis bispinosa* was a common tick in Himachal Pradesh, a rare tick in Haryana, but it was not found in Rajasthan. *Hyalomma m. isaaci* and *R. haemaphysaloides* were also seen rarely on cattle in Haryana and Himachal Pradesh. *Ixodes* sp ticks were only encountered in Shimla and Kinnaur. *Ixodes ovatus* was a common tick in Shimla and a predominant tick in Kinnaur. Amongst the *Argasid* ticks, *O. savignyi* was the only cattle tick found commonly in the animal sheds in all the four districts of Rajasthan and rarely in Hisar district of Haryana.

Boophilus, *Haemaphysalis*, *Rhipicephalus* and *Ixodes* ticks were prevalent in various animal species of Arunachal Pradesh whereas in Assam, *Haemaphysalis* and *Boophilus* were the predominant ticks. On blood smear examination, *Babesia* infection was detected in six cattle, one mithun and one yak in Arunachal Pradesh and Assam.

Theileria annulata exhibited antigenic diversity amongst various isolates prevalent in different parts of the world. Antigenic polymorphism has serious implications for vaccine development. Investigations were carried out by using four *in vitro* propagated *T. annulata* schizont cell lines. Hisar 1 and Hisar 2 were used to generate 2 cell lines. One cell line of each was generated from parasite material collected from Taranagar (Rajasthan) and Ananad (Gujrat).

The viability and non-viability counts showed significant variation among cell lines, days of passages, and interaction between cell lines and days of passages. Hisar-1 differs significantly from Hisar 2, Taranagar and Anand cell lines, and Hisar 2 differs from all the three remaining cell lines. Cell lines did not differ statistically from each other with respect to mitotic index, macroschizont nuclear number and per cent infectivity.

Monoclonal antibodies, viz. 1C7, 1E11, 2G2 and EU- 106, raised against *T. annulata* schizonts (Hisar), were used to study their reactivity with *in vitro* propagated *T. annulata* schizonts of four different isolates by using indirect fluorescent antibody test (IFAT) and indirect immunoperoxidase test (IPT). 1C7 reacted poorly with Taranagar isolate in both tests. It can be concluded that Taranagar isolate was different from other isolates.

A KIT FOR SCREENING BRUCELLOSIS

Milk base ELISA kit for pooled milk screening for bovine brucellosis at village milk co-operative level was developed and field validated. This kit is very user friendly, specific and sensitive for pooled milk samples. As a single test sample, it can detect brucellosis infection in 750 liters of milk. More than 7,000 milk co-operative societies have been screened for brucellosis in Karnataka. The kit is also being used in other states. This kit has a great promise in the conceptualized national programme on Bovine Brucellosis Progressive Control Programme (BBPCP).

INDIA . ADMASEPITRAK

State modules of india.admasEptrak with additional features were developed. This is a comprehensive software that incorporates all the available information of a particular software and application tools required by the state and district level functionaries. Being built on RDBMS, it allows itself to be easily modified and supplemented with any number of "blocks" of information the user needs. Several states are using this module and have successfully updated their respective state data. This was particularly developed for online use with NADRES programme.



Genomic DNA from conserved region of the Tams-1 gene of *T. annulata* was amplified from nucleotide 62–833 bp using polymerase chain reaction with specific primers. Further restriction fragment length polymorphism of this region was analyzed by restriction endonuclease (Rsa-1). Hisar 1, Hisar 2 and Taranagar cell lines revealed similar pattern of digestion while Anand cell lines revealed different pattern of bands. PCR was standardized for early detection of *Theileria annulata* from lymphnode biopsy and blood of carrier cattle using small sub-unit ribosomal RNA gene. The protein profile of *T. annulata* by SDS-PAGE showed at least three major bands exclusively present in piroplasm (98, 32 and 20 kDa) and schizont (71,37 and 34 kDa) antigens. A PCR for detection of *Babesia bigemina* in carrier cattle detected 9 out of 11 normally healthy cattle as positive for babesiosis. A PCR assay using blood samples collected on filter paper was developed for detection of *Trypanosoma evansi*. Out of 47 blood samples of camel examined for trypanosomiasis by PCR, 10 were found positive. Random amplified polymorphic DNA (RAPD)-PCR was standardized for preferential amplification of *Trypanosoma evansi*.

A survey on dogs of different species revealed that 5.51% were positive for *Ehrlichia canis*, 3.86% *Hepatozoan canis* and only 0.37% for *Babesia canis*. A sensitive and reliable nested PCR was developed for diagnosis of *E. canis* in dogs. Out of 170 blood samples of dogs, 109 were found positive by PCR, whereas, only 30 were positive by blood smear examination.

SUCCESS STORY

RABBIT HAEMORRHAGIC DISEASE IN INDIA

Whole blood samples collected from different parts of the country were found negative for rabbit haemorrhagic disease by RT-PCR. Based on the result it is evident that possibly the disease is not prevalent in India.

The blood samples (120) were collected from rabbits imported from Germany and quarantined at Animal Quarantine and Certification Services, New Delhi. Random samples (55) were tested by RT-PCR and 25 samples showed specific amplifications indicating the presence of RHDV infection. Analysis of 130 serum samples collected from the same lot of rabbits showed that 62 of them were positive for RHDV antibodies by indirect ELISA test. Histopathology of 12 morbid tissue samples revealed haemorrhagic changes in lungs and liver. The results were communicated to the Ministry of Animal Husbandry and Dairying, Government of India, which decided to destroy the imported rabbits. Hence all the rabbits were euthanised and incinerated. Possible entry of RHDV infection into the country was prevented.

HAEMORRHAGIC SEPTICAEMIA

Out of 67 suspected *Pasteurella multocida* cultures only 47 were identified as *P. multocida*. Pathogenicity test and drug sensitivity of 35 and 101 cultures were carried out respectively. *P. multocida* serotype B:2 was identified from buffalo, cattle, pig, sheep, goat, poultry, tiger, lion and dog. Besides this, serotypes A:1, A:3, F:3 and F:3,4 were reported from cattle and A:1 and A:3 from buffalo. PM-PCR assay confirmed 150 isolates of *P. multocida*. These further, were confirmed by nested-PCR and multiplex PCR. H S specific PCR (HSB) was also carried out on 46 isolates of *P. multocida* only 24 isolates gave an amplified product of approximately 600 bp. Over and above this HSB-PCR using Brickell primer set were also carried out to develop PCR assay specific for *P. multocida* serotype A.

Under this project a new primer set specific for serotype A was designed. Isolates (90) of *P. multocida* were tested with newly designed PCR primers and 24 isolates gave positive results. Further, it was confirmed by nested PCR for serotype A and also by conventional serotyping methods. *P. multocida* isolates were further characterized by using RE analysis, RAPD and PCR-RFLP.

GASTRO-INTESTINAL PARASITISM

In hot and humid zone, GI parasitism has higher incidence in sheep (80.6%) and goat (82.8%). In cattle and buffalo *Strongyle* infection was more in hill as compared to tarai and plain regions, whereas, in sheep and goat it was noticed reverse.

In cold and humid region, of GI nematodosis occurred only in cattle and pig. In coastal area of Chennai, GI parasitism was more in high rainfall area followed by high altitude and Cauvery delta, whereas, in West Bengal GI parasitism occurred more in sheep followed by cattle, buffalo and goat.

Amongst gastro-intestinal nematodes, haemonchosis caused by *Haemonchus contortus* was predominant infection followed by *Trichostrongylus* sp., *Oesophagostomum* sp. and *Toxocara* sp. in cattle. In the coastal region (Chennai) occurrence of *Mecistocirrus digitatus* was also reported from sheep, goat, cattle and buffalo slaughtered in the abattoir. In pigs, however, the predominant infection was *Strongyloides* sp. followed by *Hylostrongylus* sp., *Oesophagostomum* sp., and *Ascaris* sp. in cold and humid region (Meghalaya).

In preliminary trials, levamisole and doramectin were effective against GI nematodosis in ruminants. Anthelmintic resistance was also observed in sheep and



goat. For determining the phenomenon of drug resistance, larval development assay (LDA) was standardized. Larvae (L3) developed from the resistant strain of *H. contortus* required more concentration of drug as compared to susceptible strain.

Antigens of different GI nematodes were prepared and hyperimmune sera were also raised. Purification and characterization of these antigens are still under progress. Hyperimmune sera raised against somatic antigen of *H. contortus* showed formation of precipitin lines in double immunodiffusion test. Protein of midgut antigen from *H. contortus* revealed 16 predominant bands from 205 kDa to 24 kDa in SDS-PAGE.

BLUETONGUE (BT) DISEASE

Work on isolation of virus from collected samples was initiated at the centres. A total of 16 clinical/morbid materials were processed but none of them, however, could yield any virus. Out of 163 serum samples of sheep, goat, cattle and buffalo received from Uttar Pradesh, Punjab, Jammu and Kashmir, Rajasthan, Maharashtra, Andhra Pradesh and Tamil Nadu, only 52 were found positive for bluetongue antibodies in AGID test. RT-PCR and RNA profiling work was standardized for characterization of BT virus at the IVRI and Hisar centre.

Inactivated vaccines (3) were prepared with most prevalent type 18 of BTV using binary ethyleneamine as inactivant and 3 types of adjuvants, viz. (i) aluminium hydroxide gel, (ii) saponin, and (iii) aluminium hydroxide and saponin. All vaccine preparations elicited good humoral immune response as detected by agar gel precipitation test and serum neutralization test. Cell-mediated immune response was also detected by delayed type hypersensitivity reaction. However, inconsistent results were observed by LTT, which need further exploration.

INDIGENOUS MEDICINES

- Feeding of probiotics, viz. *L. acidophilus* and *S. cerevisiae* in the form of fermented feed, resulted in low incidence and duration of diarrhoea, and improved growth rate in calves. This practice can be used with advantage during the neonatal life of calves, kids and lambs.
- Foot-and-mouth disease virus inactivated polyvalent adjuvant oil vaccine was developed at the IVRI, Bangalore. The vaccine has better syringibility as compared to aluminium hydroxide gel vaccine. Studies on herd immunity in crossbred cattle, pure Jersey cattle and buffaloes revealed that protective level of antibodies remained up to 6 months. Challenge results showed that the vaccine was potent even after storage for 20 months at +4°C.

EXOTIC DISEASES

Bovine Viral Diarrhoea (BVD)

Serum samples collected from cattle and buffalo from different parts of the country, revealed that 24.8% were positive for antibody to BVDV. Oligonucleotide primers flanking different genomic regions of the virus were evaluated for sensitivity and specificity in detecting BVDV RNA in animals by RT-PCR. Many of the primer pairs could detect the viral genome in cell culture samples, only one of them specific for the NS3 genomic region of the virus, was precise and consistent in detecting the viral genome in serum/PBL samples in field cases. This NS3 primer pair was used in detecting the presence of viral genome in RNA samples extracted from serum/PBL/cell culture materials and 40% were found positive. All the amplicons were of expected size and could be detected by 33p-dATP labeled nick translated probe derived from a reference NS3 clone of German origin. The results showed the specificity of the NS3 primer pair and also the suitability of a two-enzyme one-buffer system RT-PCR in identification of BVD virus positive animals in any given animal population.

VACCINES

A low volume saponified haemorrhagic septicaemia vaccine was prepared for cattle and buffalo. It is giving promising results in the preliminary trial in cow calves. A low volume saponified trivalent and quadrivalent vaccine was prepared for sheep and goat. The two vaccines are under study in homologous host.

Further, a combined vaccine against HS and FMD was developed, which is under trial. Similarly, a combined vaccine for pig pasteurellosis and FMD was also prepared, and it is also under trial.



New epidemiological observations were made upon correlation between the antibody status of the animals and results of NS3 RT-PCR. Correlation between the two tests on animals was carried out in identified groups of the animals, viz.

- Antibody positive and virus (NS3 sequence) negative (41; 14%)
- Antibody negative and virus positive (89; 30%)
- Both antibody and virus positive (43; 14%)
- Both antibody and virus negative (125; 42%)

This segregation of animals was significant as it revealed complex epidemiology of BVDV infection in the country. It will be of immense help during implementation of BVD control programmes. Animals in group 3 are possibly persistently infected ones and subsequently exposed to heterologous ncp strain(s) of the virus later in the life, resulting in seroconversion. Moreover, ncp BVD virus could be isolated in EBTr cells from serum of these animals tested at random. Partial nucleotide sequence of selected NS3 amplicons identified two different virus populations in an adult buffalo of this group; and one of these sequences was similar to that obtained from an antibody-negative and virus-positive cattle bull in group 2. This finding supplements the observation that a PI animal can also be antibody-positive due to re-infection with a heterologous ncp strain of the virus. Therefore, the results suggested that during implementation of BVD control programme, antibody positive animal should not be ignored as merely immune ones, as they also could be persistently infected like many antibody negative (immuno-tolerant) animals. The results showed that investigation on prevalence of BVDV infection should not be restricted to serum antibody screening as it could not reflect true status of a herd.

Isolation of the virus was achieved from serum of seven antibody positive and six antibody negative animals at random in BT and EBTr cell lines maintained in horse serum. Propagation of the virus from passage 1 to 5 was checked by NS3 RT-PCR and amplicon concentrations increased gradually with the increase in passage number. Specificity was checked by nick translated probe derived from a reference NS3 clone. Selected NS3 amplicons were cloned into pGEMT/pUC vectors. Five recombinant plasmids from each clone were partially sequenced using 33p-gamma ATP labeled primer. The sequences were aligned with reference exotic sequences. The Indian sequences showed variations with the exotic sequences of NADL and SD-1 strains. However, DNA probes derived from a NS3 clone of German origin could hybridize with the Indian sequences both at 42° and 65°C. Some important observations were made upon comparison of the Indian sequences. Three sequences derived from two NS3 amplicons were compared. One of the sequences originated from a bull in Sabaramati (Gujarat) and the other two sequences were from a buffalo in Bhuj (Gujarat). The two sequences obtained from the same buffalo were much divergent from each other indicating possible presence of two different populations of ncp strain in the animal. One of these sequences matched almost exactly (4.4% divergence) with the sequence obtained from the aforementioned bull. This result showed that, ncp strains differing in the NS3 region are present in the country.

SUCCESS STORY

AVIAN INFLUENZA TYPE A VIRUS INFECTION IN POULTRY

Serum samples (400) were collected/received from the birds with clinical symptoms of respiratory illness from organized poultry farms in Madhya Pradesh, Uttar Pradesh, Chandigarh, Haryana, Andhra Pradesh and Jammu and Kashmir. None of the serum samples was positive for antibodies to avian influenza virus. Total RNA was extracted from 56 tissue samples and subjected to RT-PCR targeting AIV type A specific nucleotide sequences of matrix and nucleoprotein genes, and subtypes specific sequences of haemagglutinin genes of H5 and H7 subtypes. None of the tissue samples was found positive with all 4 sets of primers. Isolation of virus in embryonated chicken eggs and primary chicken embryo kidney cells was attempted but the materials were negative as assessed by HA test.

In August 2001, the pigeon serum samples received from the Chennai Quarantine Station, were tested for avian influenza. The pigeons were imported unauthorized by some personal and had no animal health certificate and previous history. Around 60% of the pigeons were found positive for antibodies to H7 subtype (1 : 16 to 1 : 512 titers) by HI assay. The pigeons were destroyed on the recommendations of the Director, HSADL, Bhopal, to the Department of animal Husbandry and Dairying, Government of India. Efforts were made for isolation of virus using chicken embryos and primary chicken embryo kidney cells from the tissue of the pigeons. The total RNA extracted from 10 tissue samples was tested by influenza virus type A specific RT-PCR and found negative.

Bovine Immunodeficiency Virus (BIV)

DNA samples were tested for the presence of pro viral DNA sequences by southern hybridization using radio-labeled gag probe in the presence of formamide in bovine immunodeficiency disease. Three each of the blood and milk DNA samples were identified positive for the presence of proviral DNA of BIV.

Six DNA samples, which tested positive in hybridization were subjected to PCR using oligonucleotide primers specific for the 'gag', capsid region (p26) and transmembrane (tm) sequences of the BIV strain R 29. Two of these DNA samples yielded amplicons of expected size with all the primer combinations. Selected amplicons were cloned and nucleotide sequence is under determination. The rest four DNA samples are being investigated for possible sequence divergence in the primer binding regions.



Monoclonal antibodies were produced against recombinant gag protein of BIV. Four out of 27 primary clones showed high reactivity and rest showed low reactivity with BIV-gag protein. Isotypes of all the clones were determined. One of the BIV reactive clones showed cross reactivity with caprine arthritis and encephalitis virus (CAEV). Selected clones were inoculated into mice for production of ascites.

Sheep

A test for detection of anthelmintic resistance in *Haemonchus contortus* was standardized and used. The results revealed that more than 80% of eggs incubated and developed to infective larvae when no anthelmintic (thiabendazole) was used. On incorporation of thiabendazole (TBZ) in test system @ 0.078 μ M/ml the development varied from 61.92 to 77.09% with susceptible *H. contortus*. The larval development was significantly inhibited more than 50% at concentration more than 0.078 μ M/ml TBZ.

Use of commercial urea solution prevented egg hatching and 50% eggs failed to hatch at 1.1477 \pm 0.00979 N₂% concentration. The urea nitrogen *in vitro* was also lethal to infective larvae. The incorporation of urea in coproculture reduced the recovery of larvae. Urea spray at 2.72% concentration significantly reduced larval recovery from pasture.

Nematophagous fungi, viz. *Duddingtonia flagrans* and *Arthrobotrys oligospora* were isolated from fresh sheep faeces. *D. flagrans* exhibited excellent capability to trap nematode larvae. *A. oligospora*, grown on corn-meal agar, did not show the nematophagous ability. However, when grown on 2% water agar medium the fungus showed both net-forming capability and trapping of infective *H. contortus* larvae. Trapping efficiency was maximum (66.6%) on the day 6 PI. The addition of fungal conidia in coproculture reduced recovery of larvae. Addition of conidia @ 100, 1,000 and 2,000/g faeces resulted in reduction of larval recovery by 73.7, 78.8 and 84.2%, respectively. However, there was no evidence of survival of conidia of *A. oligospora* after passage through the gastrointestinal tract, as the fungus could not be recovered from faecal cultures following the oral administration of conidia to sheep.

Goat

Monitoring and sero-surveillance of important goat diseases was carried out throughout the country. Comprehensive information on PPR outbreaks from different parts of the country was collected. Identification and evaluation of ethano-medical plants for control of parasitic diseases in small ruminants and development of immuno-diagnostic test for caprine brucellosis are under progress.

The PPR virus was isolated and identified on molecular basis and diagnostic procedure was developed. An effective live attenuated vaccine was also developed, which gave immunity up to 18 months. The vaccine will be useful for the control of this dreaded disease in the country.

Poultry

At the CARI, Izatnagar, flock consisting of 165, 634 layers, broilers, desi fowls, guinea fowls, turkey and quails, was protected against Ranikhet disease, Marek's disease, infectious bursal disease, fowl pox and EDS-76 virus infections, through a suitable vaccination programme. The average cost of the treatment was Rs 1.52/bird. The birds were provided with compound poultry feed devoid of antibiotics and growth promoters.

The overall mortality percentage was 14.19%. There was no outbreak of any major infectious diseases in any flock of the CARI. These birds were free from *Salmonella Pullorum*, *S. Gallinarum*, *Mycoplasma gallisepticum* and *M. synoviae*. The birds were immunologically competent to withstand adverse conditions. A new RD vaccine for guinea fowls was developed, which was effective in controlling the leg problems caused by RD virus. A vaccine against EDS-76 virus infection in



Erosions and ulcers on tongue and lower lip in sheep suffering from PPR



Severe nasal discharge in goat suffering from PPR



quails was developed. Problems of drop in egg production and production of increased level of thin shelled eggs were successfully solved by using this vaccine. Turkeys were protected against turkey-pox infection with the use of fowl-pox vaccine. The egg production and survivability of turkeys improved in comparison to previous years. There was no incidence of coccidiosis in layer and broiler flocks. The bio-security programme was beneficial in controlling disease in poultry flocks.

Equine

Testing of neonate foal sera before suckling colostrum revealed presence of moderate concentration of IgM type of antibodies, indicating the ability of equine foetus to synthesize IgM. However, the absorption of IgG, IgA, IgM and IgG (T) occurred within 24 hr after birth. An experimental batch of outer membrane protein vaccine against *Salmonella* Abrotus-equi infection gave protective level of immune responses in ponies. Therapeutic management of combined cyanocobalamine and anurine hydrochloride for hindquarter paresis in equines provided better ameliorative effect than the individual application of either of the drugs. Younger animals suffer more with renal colic, whereas, older animals mostly suffer with obstructive colic. The change in feed could possibly be incriminated as the predominant cause of colic in older animals. Management of urinary colic by catheterization followed by parental administration of pentazocine sodium and polyionic fluid was very useful.

SUCCESS STORY

CONTROL OF EQUINE INFECTIOUS ANAEMIA

Equine infectious anaemia (EIA), a dreaded disease of horses caused by a virus similar to human immunodeficiency virus (HIV), is manifested in acute, sub acute and chronic forms. The disease is transmitted by blood sucking insect vectors. There is neither any specific cure nor vaccine available for this disease. Horses infected by EIA virus, either die in the acute attack or during subsequent relapses or become inapparent carriers. These carrier horses maintain the virus in the form of persistent viraemia and become source of infection to other horses. Under stress of breeding, work, or immunosuppression, the disease may get precipitated in chronically infected equines.

EIA leads to heavy economic losses to equine owners and the industry, particularly when costly animals of elite group e.g. horse from Turf/Race clubs or Thoroughbred horses get infected. In addition to the direct losses by deaths/elimination, indirect losses are also faced due to restricted movement of in-contact animals.

EIA was detected in Karnataka, India, in February 1987. The disease was suspected on the basis of history and clinical symptoms and confirmed by Coggins' test. This led to the initiation of a surveillance and monitoring programme by the NRCE, Hisar, on EIA. As a result of regular monitoring, the initial cases observed in Karnataka, followed by number of cases detected in Maharashtra, Karnataka, West Bengal, Haryana, Delhi and Punjab, were restricted in a record time. These cases were a part of an outbreak of the disease in India. By and large, EIA has been confined mainly to Thoroughbred population.

Under the surveillance programme in the decade after 1987 more than 53,000 samples from horses, mules and donkeys were screened. The surveillance, monitoring and

control measures adopted were quite effective in keeping the incidence of the disease at a low profile. The spread of the disease could be checked due to strict control and preventive measures adopted on the national basis. Presently, most of the states in India are enjoying a negative status. However, the virus seems to be lurking in northern states as a few positive cases were detected in Western Uttar Pradesh, Haryana and Punjab recently.

As no effective treatment or preventive medicine/vaccine is available for EIA, the only way to control and/or prevent the spread of the disease is to follow 'test and elimination' policy. Surveillance, monitoring of the disease and measures taken to control and prevent the spread of the disease included

- restriction on the movement of positive reactors and in contact horses
- mandatory Coggins' negative certificate for all the horses requiring movement for races, sports, sales or breeding progeny of EIA reactors and mares before covering,
- elimination of positive reactors
- sound management and hygienic practices
- quarantine and testing of imported animals
- isolation of sick animals
- reduction of insect vectors in and around the premises, and use of disposable syringes and needles with the concept of 'One needle - one horse'.

Periodic testing of indigenous population of equine is regularly carried by the NRCE, Hisar, and with continuous surveillance and monitoring system in vogue; we are able to achieve the zero status for this dreaded disease in India.



SUCCESS STORY

EQUINE INFLUENZA: DIAGNOSIS AND CONTROL IN INDIA

Equine owners, stud masters, army, Border Security Force, equine clinicians and administrative authorities were caught unaware when equine influenza broke out in 1987 as over 83,000 equines suffered from the disease.

The disease was noticed in north and central India, viz. Haryana, Punjab, Madhya Pradesh, Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir, Chandigarh and Delhi. A high morbidity (80-100%) was observed in all categories of horses, and donkeys without variation due to age, sex or breed.

Secondary complications were noticed in some of the sick equines which were either not given sufficient rest, adequate therapy or were kept under poor stable hygienic conditions. Bacteriologically, pure culture of *Streptococcus equi* was isolated from the pus material collected from glandular swellings of strangle cases.

The entry of equine influenza in India was attributed to the importation of large contingent of horses from France. These landed at Delhi in last week of December 1986 and January 1987, and were distributed to some of the farms in Northern India. Subsequently, equine sports events held at Delhi during January/February resulted into the spread of the disease to Madhya Pradesh, Uttar Pradesh, Delhi, Haryana, Punjab, Chandigarh and Jammu and Kashmir.

The National Research Centre on Equine, Hisar, acted in time and diagnosed the disease. The equine influenza virus was successfully isolated from a horse and a donkey with clinical manifestations of the disease, and propagated in developing chick embryo. These isolates were identified as A/Equi-2 (H3 N8) type and were designated as A/Equi-2/Ludhiana/87 and A/Equi-2/Bhiwani/87 as per place of their origin.

The measures adopted to curtail the epidemic paid dividend and no fresh case occurred after August 1987, except few sero-conversions in Himachal Pradesh in 1989 and in Madhya Pradesh in 1991.

The NRCE, Hisar, developed a low cost effective equine influenza (A/Equi-2) vaccine. It was safe, potent and immunogenic, and induced satisfactory humoral and protective immunity when administered in 2 doses 4 weeks apart. The vaccine showed effective immune responses in indigenous Kathiawari horses, Thoroughbred horses, ponies and donkeys (exotic and indigenous) after 2-3 vaccinations schedule. The protective level of antibodies persisted from 3-5 months. Sero-surveillance studies revealed a negative status of this virus in almost all the states, except a few animals having positive antibody titre for both A/Equi-1 and A/Equi-2 mostly with a history of vaccination.

Control of equine influenza was achieved by

- bringing awareness throughout the country by advising the line of action
- spot consultancy
- advisory services at farm and state level
- general awakening of public and field veterinarians by providing them with the details of the disease including secondary complication problems, method of treatment, collection, preservation and transport of clinical material for laboratory diagnosis.

The precautions for the control of disease comprised stoppage of movement of all equines for one month from the infected to healthy farm, premises, state or region and vice versa, and ban on the holding of equine fairs, horse shows and race events. Affected animals were given complete rest for 3 weeks along with isolation of sick animals and their attendants, provision of drinking water in separate buckets for individual priced animals. Supportive treatment was invariably given as per clinical condition of animals.

Seromonitoring of horses for equine infectious anaemia, brucellosis and *Salmonella* infection showed no positive animal for any of these infections. A case of glanders was detected in Uttar Pradesh indicating that the disease is still lingering at a low profile and needs formulation of strategies for the control of this disease. Clinicopathological investigation into the causes of reproductive failures in an organized equine stud revealed that 80% cases were due to various infectious causes and the remaining 20% cases were of non-infectious nature. Most of the organisms isolated from these cases were susceptible to ofloxacin and ciprofloxacin. Exfoliative cytological examination conducted on the uterine lavages revealed that these cases were of chronic endometritis. The cellular components were predominantly neutrophils, degenerating polymorphs, some lymphocytes and exfoliated epithelial cells depending upon the stage of endometritis. No indication of any cancerous condition could be observed.

A non-invasive technique of ultrasonographic evaluation of aorta and its quadrification was highly promising in obtaining a definitive diagnosis of iliac thrombosis in horses.



An ultrasonographic scan of iliac anterior showing a thrombus



ANIMAL NUTRITION AND PHYSIOLOGY

ANIMAL NUTRITION

Cattle

- Information available on requirement of feed and nutrients for animals in different states
- Silkworm pupae protein proved good source of bypass protein
- Fungi *Orpinomyces* spp from cattle rumen has the potential to enhance nutritive value of wheat and paddy straw
- New byproducts resources were developed for inclusion in cattle diet
- Fungal zoospores were more on high roughage compared to high concentrate diets
- Defaunation of animals resulted in better nitrogen utilization
- Water-splashing 3-times a day reduced age at first service and age at first calving
- Cheap pelleted feed developed for goats
- Different types of feeders and waters were developed to check feed wastage
- Mustard straw-based complete feed blocks prepared for sheep
- Dietary sodium bicarbonate supplementation improved the nutrient utilization
- Nutritional package of practices for quails by the CARI
- *Guar chara*, *khejri* and urea supplementation resulted in increased fibre digestibility
- Local fodder trees were identified to species level in North east zone
- Rations prepared for mithun
- Soybean-meal completely replaced mustard-meal in broiler rabbit diet
- Area specific mineral supplements developed to overcome the deficiency in that region

A comprehensive relational database on the feed resource availability and requirement in different states of the country was developed. Information on feed resources availability for any particular state, crop, land utilization pattern and the requirement of feed and nutrients for animals in a particular state, is available.

Survey analysis indicated that:

- Overall dry matter availability from different sources has increased
- Availability of greens on dry matter basis has remained almost stagnant (128 million tonnes)
- Crop residues are the major source of dry matter to animals in majority of the states except in Kerala, Mizoram, Nagaland and Union Territory of Andaman and Nicobar Islands.
- Proportionate dry matter contribution from cultivated fodder was maximum in Kerala and contribution from greens of forest source was considerable in Mizoram, Nagaland, Himachal Pradesh and Union Territory of Andaman and Nicobar Islands.

The bypass protein fraction of sunflower extraction was a good source of lysine, and that of rapeseed extraction and rice polish were good sources of both the limiting amino acids. Soybean extraction contained higher levels of these amino acids but was highly degradable in the rumen and hence needs to be protected. For high yielding animals where there are limitations of these amino acids a combination of feed supplements that are good sources of lysine and methionine have to be incorporated in the diet. The silk worm pupae protein was a good source of bypass protein.

Protected fat was prepared from *karanj* oil, *kusum* oil, palm fatty acids, *mahua* oil, acid oil and soap stock using double decomposition method. Protected fat was also prepared by fusion method from *karanj* oil, *kusum* oil, palm fatty acids, *mahua* oil and acid oil. Fermentation pattern and digestibility of dry matter under *in vitro* conditions, were at par wheat straw and concentrate mix in 60:40 ratio at 5% level of supplementation, however, at 10% level these values decreased slightly.

Acid oil and silk worm pupae oil were used in the diet of high yielding dairy cows with different concentrate-roughage ratios. At higher levels of supplementation (10 to 20%) these fat supplements suppressed fibre digestion *in vitro* and hence needs to be protected. Protection using calcium salts showed the desired effect.

The proportion of cellulolytic, proteolytic, amylolytic and lipolytic bacteria was enumerated in the rumen fluid of animals fed on different feeding regimens. The predominant cellulolytic bacteria (*Ruminococcus albus*) were isolated from the rumen fluid, and DNA was extracted for restriction and transformation in *Escherichia coli*.

Anaerobic fungal isolates *Orpinomyces* sp. (C-14), *Piromyces* sp. (C-15), *Anaeromyces* spp (B-6) and *Orpinomyces* sp. (B-13), originally from cow and buffalo rumen, were selected to find out their *in vitro* dry matter digestibility and effect on NDF, ADF, ADL and individual volatile fatty acids to establish a promising fungi to be dozed to animals for higher growth milk production. C-14 (*Orpinomyces* spp from cattle) seems to be a promising fungi to enhance the nutritive value of wheat and paddy straw. *S.cerevisiae* strains 45, 50, 189 and 225, improved the rumen fermentation, as shown by a higher gas production when supplemented @ 10 cfu/vessel. DM and OM degradability improved to 47.16 and 46.08%, respectively, in group supplemented with *S.cerevisiae* 225.

Diets with different cell wall proportions were tested for changes in rumen fermentation pattern in adult animals. The total volatile fatty acid pool in rumen was monitored for 24 hr and concentration of fatty acids was fixed to match with the concentration occurring in rumen under optimum levels of cell wall carbohydrates in diets. A simple compartment model with linear differential equation was developed.



Gossypol content of cottonseed did not affect its protein degradability and feeding of cottonseed maintained the plasma level of β carotene and vitamin E. Growth performance of calves fed either mustard or taramira-cake was comparable. Niacin supplementation at 100 ppm level in *in vitro* studies was beneficial for enhancing TVFA concentration and TCA-ppt N and IVDMD in buffaloes.

BYPRODUCT RESOURCES

New byproducts resources which may become potential feed supplement are under trial in Andaman and Nicobar, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Punjab and Tamil Nadu. Patent was filed on a simple, quick and sensitive method for staining of proteins on nitrocellulose membrane by the NDRI, Karnal. The NDRI, Karnal, has also assessed following technologies for transfer to the field:

- Using local feeds, one low cost concentrate mixture (rice bran 15%, wheat bran 15%, maize 18%, mustard-cake 15%, linseed-cake 15%, gram *chuni* 10%, *masur chuni* 10%, salt 1% and lime 1%) was formulated. It was suitable for sustainable milk production in north Bihar (Patna, Nawda, Gaya, Nalanda, Aurangabad, Bhojpur, Rohtas, Saran, Siwan, Gopalganj, Champaran East and West, Muzaffarpur, Vaishali, Sitamari, Darbhanga, Samastipur, Madhubani, Begusarai, Saharsa, Purnea and Katihar).
- A low cost concentrate mixture (rice bran 25%, wheat bran 5%, maize 18%, mustard-cake 20%, linseed-cake 10%, gram *chuni* 20%, salt 1% and lime 1%) was formulated. It was suitable for sustainable milk production in Santhal Parganas, Hazaribagh, Giridhi, Dhanbad, Ranchi, Palamou and Singbhum (Jharkhand).
- A low cost concentrate mixture (mustard-cake 30%, rice bran 30%, maize 18%, kalai *chuni* 20%, salt 1% and lime 1%) was formulated. It was suitable for dairy cattle for sustainable milk production in the plains of Assam.

Buffalo

The *in vivo*, *in vitro* and *in sacco* experiments revealed that number of biomass (i.e. bacteria and protozoa) increased with amount of concentrate in diet. The fungal zoospores were more on high roughage compared to high concentrate diets. Concentrations of nitrogen metabolites (total N, $\text{NH}_3\text{-N}$, NPN, microbial N) and volatile fatty acids (VFAs) were more on high concentrate diets. A significant population of microbes (between 48 to 55% of protozoa and between 54 to 58% bacteria) was found associated with the particular phase of digesta. Defaunation of animals fed high roughage and high concentrate diets increased synthesis of microbial nitrogen in rumen resulting in better nitrogen utilization. Higher body weight gains were obtained with less DM intake in the defaunated animals as compared to faunated buffalo calves.

Analysis of samples of feeds and fodder collected from the farmers around Hisar, revealed that 30% diets were deficient in Ca and P, and more than 50% in Zn, Mn and Cu. Based on the above findings an area specific mineral mixture was prepared and supplied to the farmers.

Heifers given water splashing 3-times a day during summer performed better in terms of age at first service and calving in comparison to those given water splashing once daily. Water splashing 3-times a day was beneficial in terms of body weight gain (454 g vs 428 g/day) and age at first calving (40.4 vs 42.4 months) without affecting the milk yield in subsequent lactation.

Goat

Studies on mineral status of feed vis-à-vis goat: Tree and bush leaves, *desi babul* (*Acacia nilotica*), *ardu* (*Ailanthus excelsa*), *peepal* (*Ficus religiosa*), *Brij babul* (*Dichrostachys nutans*), *subabul* (*Leucaena leucocephala*), *gular* (*Ficus glomerata*),

LOW-PRICED PELLETTED FEED FOR GOATS

With the main objective of improvement in the existing feeding practices of goat farmers for increased productivity from their animals without putting much financial burden on them and within the feed resources available at their end, three tree leaves based pelleted complete feed was prepared and nutrients availability from such preparation was determined for goats. This feed consisted of 68% dried tree leaves, 30% barley grain, 1% mineral mixture and 1% salt. *Ber*, *pepal* and *siris* tree leaves were used in making pelleted feed. The nutrient intake was as per the recommendations of NRC.



chonkra (*Prosopis cineraria*), neem (*Azadirachta indica*), mulberry (*Morus alba*), ber (*Ziziphus mauritiana*), bargad (*Ficus bengalensis*), hingota (*Balarites aegyptica*), siris (*Albizia lebbek*), jangle jalebi (*Pithocellobium dulce*), khadyar (*Salvadora persica*), heens (*Capparis horrida*), anni (*Chlorodendron phlemides*) and two grasses *anjan* (*Cenchrus ciliaris*) and *dub* (*Demostachys phlemidesy*) were analysed for calcium, phosphorus, magnesium, zinc, copper, iron, and manganese. The samples were collected in winter and summer. All the tree/bush fodders, grasses contained more calcium (>0.7%). Phosphorus was low in all the samples (<0.5). Magnesium in samples was adequate (0.2%) except in *dub* grass (0.14%), zinc (ppm) was adequate (>30) in all the samples analysed. Copper (ppm) was adequate (> 15) only in *desi babul* (17), *anni* (15) and *dub* grass (15) and in rest of the feeds copper was deficient (15 ppm). Iron (ppm) was in excess in all the fodders analyzed (>100). Manganese (ppm) was sufficient (> 30) in *ardu*, *peepal*, *brij babul*, *subabul*, *gular*, *mulberry*, *ber*, *hingota*, *jangle jalebi* and *heens*; and other feeds contained less than 30 ppm. It may be concluded that tree leaves/grasses in and around the CIRG, Makhdoom, appeared to be deficient in phosphorus and excess in iron. Some of the fodders were deficient in copper and manganese. Most of the feed materials were having adequate calcium, magnesium and zinc.

SUCCESS STORY

GOAT MANAGEMENT ASPECTS

There is a wide variation in devices for feeding and watering of goats and sheep. No standard is being followed in feeding and watering appliances. Animals tend to contaminate the feed in designing by voiding the faeces and urine and standing inside the feeder. To overcome waste and soilage feeding and watering devices were tested and recommended for use.

- Rectangular feeder for adult animals consists of a 4 legged angle iron strand, a GI rectangular shaped feeding trough with a triangular pyramid in the middle and a vertical and sloping hayrack mounted on the feeding trough. The upper portion of the rack is covered with GI sheet and the lower portion consists of iron bars. These feeders have provisions for individual or simultaneous feeding of various types of feed materials.
- Hexagonal feeder for adult animals consists of a 6 legged stand on which a hexagonal bottom trough with six faced central cone is fitted. A six-faced cylindrical hay rack was mounted on the feeding trough. The lower portion of this rack had vertical slanting outward iron bars whereas the top portion was made of galvanized iron sheet. This feeder also has provision for individual or simultaneous feeding of various types of feed materials. This can accommodate about 15 animals. Animals can eat from all the sides. The feeding height should be kept as average shoulder point height of the animals. These feeders can be locally fabricated and save space and labour. There is less wastage and no contamination through faeces and urine.
- Kid feeder with roof consists of an adjustable stand, GI feeding trough with a roof to protect the feed materials. The height of feeding trough can be adjusted as per the age of animals. Kids can eat from both the sides. The height of the roof can also be adjusted. This feeder was developed for kids in the age groups of 3-6 months; however, it can be used for kids between 0 to 12 months of age. It is suitable for 8-10 kids of sheep and goat.
- Box type kid feeder consists of a box made of GI sheet with an opening in the length side of the box. This can be fitted at any height on the walls, fencing or on stand. Goats can be fed only

from one side. It meets the requirement of goats and sheep up to one year of age. It can accommodate 4 sheep or 5 goats. This feeder can also be used as hanging type feeder for kids up to 3 months of age.

- Hanging type circular kid feeder was developed for the kids up to 3 months of age. Out of this one feeder was the most suitable. It consists of a joint less aluminum pan (used as feeding trough), a conical storage bin (made of GI sheet) etc. Feed material is kept in the storage bin fixed above the aluminium-feeding trough, from which it flows into the feeding trough. This feeder may accommodate about ten kids of sheep and goat. Animals can take feed from all the sides.
- Adjustable kid feeder with hayrack and watering devices are suitable for the feeding of all types of feed materials. On the width sides of the hayrack, watering devices are attached. It can accommodate 8-10 kids. It is suitable for kids from the day of birth to 12 months of age. There is no contamination of feed. The rate of feed consumption and waste of feed was satisfactory. For kids up to 3 months of age lower feeding trough height (25% less than average shoulder point height) may be more comfortable and will give better performance. After removal of stand and watering devices, this feeder may work as hanging type feeder for kids up to 3 months of age.
- Circular kid watering device consists of aluminum pan from which water may be taken by the goats and sheep, a water storage container is fitted over this pan from which water percolate to the pan to maintain a fixed water level in the pan. The whole device is fitted on an adjustable stand made of GI pipes. Animals can drink water from all the sides. In this device 10 kids can be accommodated.
- Animals drink water from two sides in barrel type kid watering device. A barrel is made of GI sheet and fitted over a water trough of GI sheet. Water is filled in the barrel. The whole device is fitted on an adjustable stand made of GI pipe. It can accommodate one-year of age about 10 animals.



Sheep

Mustard straw-based complete feed blocks enabled utilization of mustard straw in sheep feeding, and with it DMI ranged from 3.23 to 3.78% of the live weight. It checks animal selectivity towards concentrate and stimulates rumen environment for better nutrient utilization. Studies on delignification of mustard straw in solid state fermentation by white rot fungi are in progress. White rot fungi improved protein content, and DM losses were lower to the reported DM losses in wheat straw etc. Adding 15 g sodium bicarbonate per kg composite feed mixture with high concentrate (roughage to concentrate ratio: 25 : 75) improved feed intake, increased growth by 35% and increased cellulose digestibility in lambs. Trans-inoculation of goat rumen liquor into sheep rumen increased DMI (g/day) of *Leucaena* leaves. Animals consumed 495 g DM/day in control and 554 g in trans-inoculated group. Infusion of goat rumen liquor improved ruminal protease, amylase, carboxymethylase and filter paper degrading enzymes.

Dietary sodium carbonate (15 g) supplementation improved the digestibility of structure carbohydrate. The rumen ciliate protozoal populations, total volatile fatty acids, total nitrogen and TCA, ppt-N contents significantly increased and ruminal ammonia concentration decreased by addition of buffer in diet. In weaner lambs the overall growth rate and feed conversion efficiency improved by 12-15% due to incorporation of buffer agent in high concentrate based ration.

Alkaline hydrogen peroxide treatment of mustard straw weakened the ligno-cellulosic bondage of the low grade roughage and improved dry-matter intake and nitrogen retention by sheep.

Poultry

Nursery rearing under confinement is advocated for Vanaraja chicks up to 6 weeks of age to ensure high rate of livability and optimal growth. Feeding Vanaraja chicks with high or low density diets determines the economics of rearing in nursery. Vanaraja chicks needed diets with 2,400 kcal ME/kg and 16% protein to achieve optimal performance. When compared with diet containing 2,800 kcal ME/kg and 23% protein, a net reduction of 15% in dietary energy and 30% in protein could be achieved without any compromise on performance, which implies better nutrient utilization by these birds.

Increased ME content improved body weight, feed conversion efficiency, meat yields and abdominal fat in broiler breeders. But diets with 2,650 kcal ME/kg produced results statistically equivalent to higher ME levels, indicating that these birds reach adequacy in performance with 2,650 kcal ME in feed, which would be cost effective and economical. Low energy favoured better dry matter digestibility and high Ca retention in bone but not phosphorus. The colour synthetic lines responded equally well for body weight and feed conversion efficiency, with all levels of protein tried, but 18.5% protein produced ideal effects also on feed intake and immune competence. Sire and dam synthetic lines of colour broilers performed well even on low plain of nutrition, which have favourable economic implications on feed cost.

The nutritional package of practices developed at the CARI for adoption by the farmers and the industry will help in successful stretching of the quail production to different parts of the country.

Methionine a limiting amino acid in practical diets based on maize-soybean meal, has to be supplemented in diets with synthetic methionine, but is costly and at times not easily available. If methionine and cystine are limiting in the diet an addition of 0.1% sodium sulphate may spare methionine supplementation up to 0.075% in the diet, thus economizing the feed cost substantially.

Dried and powdered egg shells as waste from hatchery (HESW) were a good source of calcium (34%) for laying birds. Supplementation of HESW in fish-meal based layer diet replacing limestone and shell grit and DCP increased egg production and specific gravity without affecting feed intake. Egg shell powder can replace supplemental sources of calcium including dicalcium phosphate if the provision of phosphorus is made from other sources.

TRACE MINERALS IN BROILER NUTRITION

Zn and Cu are the two important trace minerals in broiler nutrition. Maize, soybean, deoiled brans etc. contain Zn as an inherent component, which would be adequate to support optimum growth and feed conversion efficiency of broilers up to 6 weeks of age. But, during early period of growth Zn retention will be high particularly at 3 weeks of age compared to subsequent weeks, necessitating supplementation of Zn in the practical diets to sustain higher mineral concentration in tissues. Zn inclusion at 80 ppm level in diet significantly improved tissue concentration of element and antibody production, minimized stress in birds and helped in higher retention of P and Mn in bone. Bioavailability of Zn from its sulphate salt was consistently better than other forms. Cu requirement in broiler diets is as low as 8ppm, but its supplementation is essential to maintain optimum growth, bioavailability of the mineral and immune competence of the birds. Cu supplementation beyond 128ppm may not have any added advantage. On the contrary, it may lower growth, feed conversion efficiency and immune competence, besides increasing the stress on birds. Higher Cu levels in diets could also adversely affect the uptake of Zn and Mn by tissues. Therefore, low levels of Cu supplementation (98ppm) are desirable to obtain optimal metabolic advantage. Supplementation of Cu from sulphate salt provided better response compared to the oxide or carbonate salts.



SUCCESS STORY

COMPLETE FEED BLOCKS

At the CSWRI, Avikanagar, a machine was developed in collaboration with the IARI, to prepare complete feed blocks (CFB). A 10 horse power hydraulic machine was used to produce the CFBs. The blocks were made of proportionate mixture of wheat bran, rice bran, mustard, groundnut-cake, urea, molasses, minerals and salt. The blocks have dimension of 0.5 cubic feet contain-ing about 13% proteins and 50 to 55% total digestible nutrients. The nutritive value is 33% higher than common feed. This machine is being tested in 5 different locations. The machine costs about 3.5 lakhs.

ADVANTAGES OF COMPLETE FEED BLOCKS

The complete feed pelleting, with little technical expertise has the following advantages:

- Processing of bulky and fibrous complete diets and concentrates of livestock and poultry
- Complete sterilization and gelatinization of feed
- Reduces the processing cost and increases the rate of production compared to conventional pelleting
- Increases bulk density, and reduces wastage, and problems of handling, storage and transport
- Utilizes the otherwise unutilized feed resources
- Reduces the cost of feed per unit of milk production and unit weight gain compared to conventional feeding
- Provides a balanced complete ration in situations of drought and natural calamities
- Do not require green fodder if synthetic vitamin A is being added in complete feed blocks



Animal feed block formation machine

Absorb+, a feed supplement, was partially effective in alleviating the adverse effects of aflatoxin β 1 and methylparathion and fenvalerate. Similarly addition of zeolite @ 1g/kg in diet of quails alleviated the toxin effects of 100 ppm fenvalerate and 6.25 ppm methylparathion.

Camel

Guar chara supplemented with *khejri* leaves showed low fibre digestibility may be due to high lignification of *guar* stem. Supplementation of urea and *khejri* leaves increased crude fibre digestibility because of catalytic effect of supplement on ruminal microbial activity due to proper ammonia used in rumen and other factors. Urea feeding was economical in terms of nutrient availability, which is the main index for productivity.

A camel can easily be sustained on 5.33 ha silvipasture area in arid region for whole year. Grazing behaviour indicated that first preference of camel is lopped *jal* tree leaves followed by *murali*, *tortlis*, *pala* and *phog*. Supplementary feeding of green grammana grass improved milk production (4,980.29 ml). Milk production was higher in morning as compared to evening. Dry matter intake/100 mg body weight, digestible dry matter intake, DCP, TDN and ME were greater in supplemented group as compared to control. Chemical composition of commonly used fodders by bactrian camel was analysed. Crude protein was highest in *Hypophae rhamnoides* followed by *gyalta*, *changna* and alfalfa.

Yak

Some local fodder trees consumed by yaks were identified to species level and a herbarium was prepared. Comparative chemical composition of certain locally available fodder trees was studied. Total fodder production increased to 27,068.70 kg. Fodder maize (African tall) could be grown at 2,750 m amsl.

Toxic factors and crude protein of *bagar*, *domkor*, *phrengpa*, *marma*, *marshing*, *bamlakpa*, *khaksuma*, *suylili*, *blemkar* were estimated.

Mithun

Different combinations of rations incorporating locally available grasses, tree leaves, shrubs etc with rice polish and wheat bran were developed, tested through experimentation and recommended for larger use by mithun farmers. Although suitable feeding technologies were developed for optimizing growth and production in mithun, the same could not be tested at farmers field because the mithuns are still kept by the farmers in semi wild state. The farmer may not use these technologies unless proper domestication and semi-intensive/intensive system of mithun rearing is followed. However, efforts are on to educate the farming community on the need of rearing mithun under confinement system.

Grasses, herbs, shrubs and tree leaves preferred by mithun were surveyed and proximate principles for some of them were analyzed, and out of 70 samples collected 25 were taxonomically classified. *The die* tree leaves contain 31.48% crude protein, so 100 trees were planted in farm of the institute. Feeding of cultivated fodder was practised in the farm animals. Napier grass was relished by the mithun. Mithuns fed on napier grass at vegetative stage, gained a daily average body weight of 500 g/day with a feed conversion ratio of 1:5.32.

Rabbit

Economically viable feeding system for rabbits was developed with soybean-meal, which can completely replace mustard-meal in broiler rabbit diet. Broiler rabbits tolerated 8.4 mg glucosinolate/kg diet in the form of complete pellets. Long term feeding of mustard-meal caused motility in rabbits, and hence not suitable for breeding or wool producing rabbits.

Network Programmes in Animal Nutrition

Network programme on Micronutrients in Animal Production is in operation at



the AAU, Guwahati; KAU, Thrissur; TNUVAS, Chennai; JNKVV, Jabalpur; WBUAFS, Kolkata; and NIANP, Bangalore. Network programme on Agricultural Byproducts as Animal feeds is in operation at the PAU, Ludhiana; CIRG, Makhdoom; BVC, Mumbai; BAIF, Pune; ANGRAU, Hyderabad and GAU, Gujarat. Network programme on Crop Based Animal Production is in operation at the IGFRI, Jhansi, CIRG, Makhdoom; IVRI, Mukteshwar; CSWRI, Avikanagar and NRC on Camel, Bikaner.

Under the Network programme on Micronutrients in Animal Nutrition and Production most of the centres have developed region specific mineral supplements based on the extensive survey work conducted on the micronutrient status of soil, feed, fodder and blood of animals in all the agro climatic zones of Karnataka, Tamil Nadu, Kerala, West Bengal and Assam. These areas have shown major deficiency of calcium, phosphorus, copper and zinc. Majority of the animals having reproductive problems showed improvement in their reproductive efficiency when given area specific mineral supplements. The locally available feeds and fodders were categorized as good and moderate sources based on their mineral content and this helped in strategic supplementation of deficient micronutrients through locally available feed resources to overcome the deficiency in that region. These practical and cost effective technologies are being propagated for adoption at field level through the state Animal Husbandry Department and have achieved considerable success.

Under the Network Programme on Agricultural Byproducts as Animal Feed many unconventional feeds were tested and recommended for their use in livestock ration e.g. mango seed kernel, sal seed-meal, *kusum*-cake, *vilayati babul* pods, tapioca starch waste, *mahua* flowers, molasses, and malt waste as energy source; *babul* seed *chuni*, *kuvadiah* seed, *pilludi*-cake, *isabgul gola* and *lali*, *ambadi*-cake, niger seed, rubber seed-cake, neemseed-cake as protein source. The *mahua*-cake, *babul* pods, *kusum* seeds, subabul seeds, single cell protein, corn steep liquor, *jowar* gluten etc. are good energy and protein sources.

ANIMAL PHYSIOLOGY

Cattle

Conception rate in cows increased significantly on insulin administration in mid luteal phase either in a single dose or in multiple doses over 3 days. A sensitive enzyme immunoassay for bovine leuteinizing hormone (LH) was developed. In indigenous and crossbred cows the basal concentrations of somatic cells count and their variations during different seasons, parity and state of lactation were determined.

Judicious use of available feed resources and restriction on wastage of biological energy are necessary to improve animal productivity. Feeding of chaffed ragi and paddy straw reduced the wastage of biological energy by reducing chewing and rumination activity. Chaffing of straws resulted in higher dry matter intake and energy. The energy thus conserved from these activities could be fruitfully utilized for various productive purposes. Methanolic extract of tamarind was effective in preventing fluorosis, and it can be used to prevent fluorosis in the fluorosis prone areas of the country. Supplementation of *Kaach* (a byproduct from catechu industry) using sheep as a model significantly reduced methane production. Endocrine profiles of catabolic (cortisol) and anabolic (testosterone, T_3 , T_4 , and insulin) status were worked out in growing calves up to puberty in both Sahiwal and crossbreds. Differences in profiles were found among cattle exhibiting different growth rates.

Buffalo

The radioimmunoassay procedures for determination of insulin like growth factor - I (IGFI) were standardized for the first time in buffalo plasma. The basal concentrations of somatic cells count in indigenous and crossbred buffaloes were established and their variations during different seasons, parity and state of lactation

- Insulin administration in mid-luteal phase improved conception rate in cattle
- Chaffed straw utilizes less bioenergy and leaves more energy for productive purpose
- Methanolic extract of tamarind effectively prevented fluorosis
- *Kaach* significantly reduced methane production in sheep
- Milk progesterone level in sheep indicated the reproductive status of buffaloes
- Fibroblast cells from skin of goat were successfully cultured for cloning
- Pregnancy specific protein observed in goats
- Semen preservation technique developed for field use
- Lead and cadmium levels higher than permissible limits observed in water, feed, fodder and blood samples of animals
- Superovulation protocol developed for ewes
- Cervical moulds developed for ewes to develop suitable transcervical catheter
- Draughtability of the donkey was studied
- Cryopreservation of camel semen was attempted
- 25% glucose solution helped weak chicks to survive



determined. A 65-kDa placental protein suppressed proliferation of lipopolysaccharide stimulated-buffalo-lymphocyte *in vitro* indicating suppression of B-cells.

Information on uterine environment changes mainly due to alteration in the biochemical constituents of uterine fluid in buffaloes, is not available. Total protein and RNA content of the uterine fluid varied quantitatively according to stages of the estrus cycle. Two high molecular weight proteins and two low molecular weight peptides were detected in uterine fluid but not found in serum, and relative concentration of different proteins also varied between the two fluids. These changes in the biochemical constituents of uterine fluid may be responsible in the mechanisms involved in signaling between the developing conceptus and dam. Considerable differences in total cytoplasmic progesterone receptors were observed during different stages of estrous cycle. Progesterone receptor levels during the second stage of estrus cycle declined may be due to exposure of uterus to increased level of progesterone and decreased level of estrogen.

At the CIRB, Hisar, addition of hormones (FSH, LH) with sera (foetal calf resume calf serum) in maturation and culture media for buffalo oocytes, resulted in higher rate of maturation (90%) and blastocyst formulation (30%) as compared to hormone deficient media (75% and 20%).

No significant variation in semen volume was recorded in buffalo bulls in different seasons and it ranged from 2.45 ml in rainy to 2.85 ml in summer. On 4 point scale average activity (varied from 1.65 to 1.85), sperm motility (varied from 57.95 to 62.96), and post thaw motility (varied from 38.22 to 40.64) were studied. The frequency of rejection of ejaculates was highest in rainy season followed by summer and lowest in winter indicating winter as favourable season for semen freezing.

Milk progesterone level was used for monitoring reproductive status and fertility improvement of buffaloes at the NDRI, Karnal. Out of 158 estruses analyzed by milk progesterone profiles, 67(42%) were not observed. The incidence of unobserved estrous was highest in May (75%) followed by April (66.6%). The lowest incidence of unobserved estrus was recorded in December (14%). From the 69 animals for which the milk progesterone profiles have been obtained 39 buffaloes were found to be pregnant (57%) and the overall incidence of cyclic non-pregnant animals was 24%.

Lipoprotein and growth hormone profiles in normal cyclic and acyclic repeat breeder buffaloes were studied at the NDRI, Karnal. Their cyclicality was confirmed by determining the plasma progesterone levels.

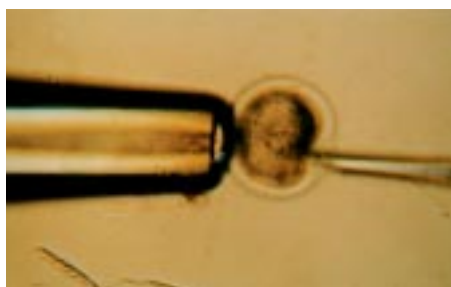
Goat

Fibroblast cells from skin of goat were successfully cultured for use in embryo cloning. Standardization of enucleation, reconstruction and electrofusion of goat oocytes was achieved. A pregnancy marker protein of placental origin of 53 kDa was present in pregnant goat and it was absent in non-pregnant serum, thereby suggesting that it is a pregnancy-specific protein. This protein regressed after parturition. Physiological basis of thermo-adaptability of goats was studied. Goats can be reared successfully under intensive or semi-intensive system of management depending upon resource availability. Automization of semen freezing protocol for high post-thaw motility and fertility in goats is in progress. A field technique of semen preservation was developed and perfected for adoption under field conditions and is ready for commercial exploitation. Thyroid hormone levels during growth were quantified.

Water, feed, fodder and blood samples from animals collected from industrially polluted areas in the per-urban locality of Bangalore, showed that lead and cadmium levels were higher than the permissible limits. The fluoride and nitrate content were within the safe levels.

Sheep

Reproductive efficiency in ewes/does can be improved by exteroceptive



Matured goat oocytes being enucleated for somatic cell nuclear transfer



stimulation through management practices, which would eliminate use of exogenous hormones and their deleterious effects. Preliminary studies on hormonal levels were conducted in Bannur sheep.

The individual variability among donor ewes in response to superovulatory drugs is one of the major constraints limiting the success of embryo transfer technology. Ovagen @ 5.4 mg (8 doses over 4 days) in conjunction with a single dose of PMSG (200 IU) was the best protocol developed for superovulation of ewes. The efficiency of this superovulation protocol was validated in exotic (Rambouillet), crossbred (Bharat Merino and Fine wool synthetic) and native (Kheri and Malpura) ewes. This protocol was successful in inducing superovulation in >70% of treated or programmed ewes with an ovulation rate (ovulation per ewe) ranging from 6-10.

Cervical moulds of adult native ewes were prepared for studying the anatomical features. The silicone moulds represent the potential space within the cervical canal and provided the most useful anatomical information for developing suitable transcervical catheter. Progesterone impregnated vaginal sponges (laboratory made) @ 350 mg P4 showed higher estrous response (81%) as compared to 300 mg P4 (69%) and without P4 (36%) during spring. While during autumn the lower dose level of 300 mg showed better response. Progesterone treatment improved ovulation and lambing in native and crossbred ewes. An attempt was made to design and fabricate simple device suitable for enrichment of ram semen into X- and Y-bearing fractions. Initially the sperm motility and density of the upper portion was less but later on these increased. The sperm motility and density were more at the bottom of the column. Optimization of this technique is in progress.

Equine

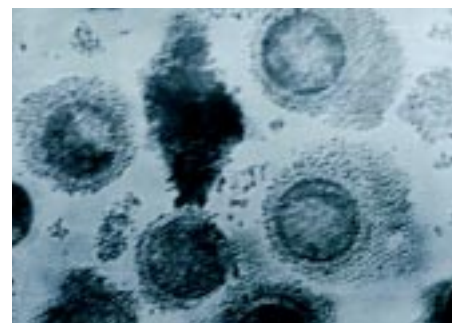
Effect of both age and sex was observed on thyroid hormone levels, haematological and biochemical indices in healthy Kathiawari horses. In females, haemoglobin level was significantly lower in yearlings than adult animals while TLC was higher in yearlings than equids of other age groups. Sex had effect only on TEC, MCHC and MCH in animals of 1-3 years age group (young stock), while PCV affected adults of both female and male equids. Age and sex influenced activities of enzymes. CK, GGT, GOT, GPT and LDH activities were significantly higher in young and adult equids than animals of other age groups in Kathiawari horses while activity of alkaline phosphatase was significantly high in yearlings than equids belonging to other age groups in both males and females. However, activity of SDH was unaltered due to both sex and age factor. Albumin, BUN, BIL, cholesterol, creatinine, protein, triglyceride and uric acid were statistically different in various age and sex groups of horses. Calcium, magnesium and chloride were almost same in various age groups of male horses. Significantly higher levels of T_3 and T_4 were observed in both male and female yearlings as compared to equids of other age groups in both the sexes.

Draughtability studies were carried out with indigenous donkeys carrying pack load equal to 40%, 50% and 66% of their body weight for different time intervals under work-rest-work cycle. Physiological, biochemical, hematological indices, blood gases levels were evaluated during this study. Work-rest-work cycle is better than continuous work plan for more and efficient utilization of donkey's draught capacity; and the total work hours could be extended under this work-rest-work cycle.

Projects on perfection of technology for production of pregnant mare serum gonadotropin (PMSG) indigenously and development/standardization of pregnancy diagnostic kit are in operation at the NRCE, Hisar.

Camel

The reproductive efficiency of farm camel herd during regular breeding season indicated significant improvement of 10 to 12% in overall per cent conception due to adoption of improved research techniques. Cryopreservation of camel semen was done successfully by using programmable LN₂ freezer. Tremendous variability was observed in freezability of semen from different males. Based on post-thaw



Morphology of frozen thawed freshly collected goat oocytes



Microphotograph of camel sperm is almost liquified coagulum



Sonograph of ovarian follicle of female camel

motility test, overall success rate of cryopreservation of semen was adjudged to be 44.26%. Sonographic monitoring of female camels for ovarian follicle was done and one female was successfully impregnated through artificial insemination using frozen thawed semen.

Race-rest cycle was evaluated using biochemical markers in females of Bikaneri and Jaisalmeri breed. Average race speed of Jaisalmeri and Bikaneri females was recorded as 18 ± 1.4 and 16 ± 1.7 km/hr respectively. Cardinal responses after race indicated significant increase in pulse and respiration. Blood pO_2 , pCO_2 , glucose, cortisol and lactate significantly increased due to race stress. Jaisalmeri females revealed faster recovery of blood biochemicals towards normalcy as compared to Bikaneri female camels.

Poultry

The age of first egg was advanced with estradiol treatment. The egg laying was apparently high in 13 to 14 week treated group as compared to non-treated group. The frequency of double yolk eggs was more in 12 to 13 and 12 to 16 weeks treated group in first month of lay as compared to non-treated groups. The maturation of reproductive system could be modulated through estrogen treatment favourably at a critical pre puberty phase.

MATURATION OF GASTROINTESTINAL TRACT IN BROILERS

At an early age, the development rate of GIT is faster in birds particularly in broilers. A particular trend was observed in development of small intestine—the duodenum weight increased up to 11 days, jejunum up to 23 and ileum up to 32 days after hatch. This signifies that lower segment of small intestine takes longer time to get matured. Individual variations in development pattern of GIT in birds were also observed. Some nutrients/electrolytes in solutions (glucose, oral dehydration solution RS and sodium bicarbonate) were also fed to broiler chicks at early age (up to 5 days age), but these solutions did not produce appreciable impact on preponing the maturation of GIT. However, glucose solution of 25% strength helped weak chicks in reducing their mortality rate and attaining comparable body weights at marketing age.

T_3 and T_4 levels were noted higher in those birds that died during the summer as compared to those who survived. Level of testosterone in plasma, testicular size, area of cloacal gland and foam production all were found positively correlated with the fertilizing ability of male Japanese quail. Therefore, when males were investigated for reproductive functions, the area of cloacal gland or foam production may be considered as a simple and effective tool for screening the infertile males from the breeding flocks of Japanese quail.

Immunization of prolactin in White Leghorn birds with bromocryptine improved egg production by suppressing the prolactin level in birds and increasing sequence length and reducing pause days. Bromocryptine administration had an effect on prolactin levels, which in turn interfered synthesis of estradiol- 17β and progesterone thus showing a definite correlation with egg production. Oral administration of bromocryptine through feeds increased egg production up to 40 weeks.

Mithun

Conservation and improvement of mithun is the second important mandate of the Institute. Research programmes on *ex situ* conservation particularly through the conservation of sperm was carried out during the year. Mithuns were trained for semen collection using cattle AV as well as through rectal palpation method. It is the first attempt in the country to collect mithun semen artificially. Average volume of semen, concentration and percentage of live spermatozoa in the semen samples were 3.12 ml, 710.83 mill/ml and 71.73% respectively.



Among the four body tissues, highest moisture and fat content of 84.85% and 8.70% were recorded in kidney while the skin recorded a higher level of CP (27.89%). The water intake in female was higher than male (2.241 vs 0.218 litre/W^{0.28} kg/day). Mithun drank more water when managed in semi-intensive condition than under free-range condition. Total water intake in growing mithun calves was higher in pre-monsoon but the feed and water intake was comparatively higher in post-monsoon season. Total water intake in growing mithun calves was 19.75 litre/day and the faecal water loss was 4.08% of their body weight. Hb, PCB, RBC counts in mithun were influenced by the seasons—rainy season showing higher values than that in summer and winter. Mithun calves had highly significant higher values for PCV, ESR, WBC, RBC, GOT and alkaline phosphate. Significant difference in protein count was also observed.

Fresh and stored blood samples indicated RBC osmotic stability up to 0.5% buffered saline concentration after which cells ruptured and complete haemolysis was recorded at 0.2% of buffer saline concentration. Mithun RBC maintained the osmotic resistance up to a saline concentration of 0.35% while cattle and swamp buffalo RBCs could maintain it up to 0.45% and 0.5% respectively. The osmotic fragility test of cattle and mithun calves also indicated that RBCs of mithun calves could maintain the resistance up to a saline concentration of 0.50% while cattle calves up to 0.07%.

Yak

Estradiol-17 β and progesterone at a ratio of 1:2.5 successfully induced lactation in 3 out of 5 yaks. Estradiol, progesterone, cortisol, testosterone, T₃ and T₄ were estimated during estrous cycle and seasonal anestrous period. During estrous cycle and anestrous period, Ca, P, Fe, Zn, Cu, Mn, Co, total protein, cholesterol, glucose, and VFA were also estimated. Three out of five randomly cycling female yaks came into heat after 48-50 hr of single injection of PGF₂ analogue in the luteal phase. Semen was successfully collected from yak bull of the farm for the first time.

Rabbit

A highly specific and sensitive anti rabbit IgG (second anti-body) was produced indigenously and is now being routinely used in EIA procedures.

Embryo Transfer Technology

Network Programme on Embryo Transfer Technology in Animal Production is in operation at 11 centers across the country with significant progress. Buffalo follicular fluid replaced the maturation medium by 100%, thus making IVM more economical and feasible. PMSG at 40 IU/ml was more effective hormone supplement in maturation medium than estradiol or the combination of PMSG and estradiol. Epidermal growth factor (EGF) alone at 10 ng/ml added to TCM-199 resulted in good maturation of oocytes without any other hormonal supplements. Somatic cells monolayer had no beneficial effect on maturation rate when serum and gonadotrophin were supplemented in oocyte culture media. Trypan blue (0.05%) staining of oocytes for 2 min can be used to differentiate live and dead oocytes with no deleterious effect on maturation rate. Cleavage rates of over 50% were observed in oocytes matured in TCM-199 + SS (10%) + PMSG (40 IU/ml) and fertilized in BO medium (9-10 \times 10⁶ spermatozoa/ml) along with buffalo oviductal epithelial cells. It was the best complex and defined maturation media in terms of embryo yield in buffaloes.

Use of FSH-P for production of embryos was costly. Pretreatment of animals with low dose of human chorionic gonadotrophin (hCG) followed by estradiol-17 β and superovulation with pregnant mare serum gonadotrophin (PMSG) produced viable transferable embryos with lower cost of production.

Culture medium for *in vitro* maturation and fertilization of oocytes collected from buffalo ovaries and culture of resultant embryos were made cost effective by



Semen was successfully collected from yak bull for the first time



TECHNOLOGIES ASSESSED AND TRANSFERRED

- The efficacy of twin apron conveyor system for making *chhana* and the kneader was demonstrated to the interested users for its adoption.
- A *Palada Payasam* Instant Mix was developed at Southern Regional Station, Bangalore under the Network Project, and commercialized by transferring the technology to Malabar Milk Producers Union (MILMA) in Kerala.
- Hansa test serum to detect adulteration cow milk with buffalo milk was produced and supplied to various dairies from time to time.

replacing costly follicular stimulating hormone (FSH) by locally available pregnant mare serum gonadotropin (PMSG) and steer serum.

A simple laprascope aided method for embryo recovery from sheep was standardized without the need of inflating abdomen. In Kheri ewes 89% embryo recovery was achieved in laparoscope aided method and 50% through surgical procedure. The overall recovery of embryos was 73%. A superovulatory protocol consisting of PMSG (200 IU) and ovagen (5.4 mg) in Kheri ewes, synchronized with lutayse (two 10 mg doses, 10 days apart), gave a good ovarian response.

DAIRYING AND ANIMAL PRODUCTS TECHNOLOGY

MILK AND MILK PRODUCTS TECHNOLOGY

Milk Processing Technologies

- Technology for the manufacture of non-dairy coffee whitener was developed.
- Shelf stable tomato - whey soup was developed.
- Incorporating sugar partly in caramelised form could reduce manufacturing time of *kunda* as well as energy consumption. The results indicated that the manufacture time could be reduced by 25 - 45% and the energy requirement by 45% by adopting this method.



Incorporating sugar partly in caramelised form could reduce manufacturing time of *kunda* as well as energy consumption

acid+whey, 75:25) and sodium chloride, each at 0.05% and fermented skim milk (15% w/w), was standardized.

- A *Palada Payasam* dry mix was developed at the SRS, NDRI. The Malabar Co-operative Milk Producers Union Ltd., procured the technology for commercial production of *Palada Payasam* in Kerala.
- Pronounced immunomodulatory effect was observed in bioactive peptides derived from casein.
- Antimicrobial spectrum of purified buffalo milk lysozyme was established.
- *Lactobacilli* exhibiting good probiotic properties, viz. survival at pH 1-3 in the presence of 2-4% bile and higher cell surface hydrophobicity and adsorption to epithelial cells, were isolated.
- The process of making good quality skimmed milk powder by using a combination of coagulant (citric

Camel Milk

Physico chemical and gross chemical composition of camel milk was studied. Camel milk is opaque white in colour with normal odour and salty sweet in taste. Milk samples were analyzed for protein, fat, lactose, SNF, ash, moisture, vitamin C, pH, acidity, specific gravity and viscosity. Camel milk was evaluated for shelf life for 8 hr at 37°C and refrigerated temperature. Postpartum changes in gross chemical composition of camel colostrum/milk acidity and pH ranged from 0.29 to 0.3 and 6.35 to 6.61 respectively, fat increased from 0.1 to 3.78%, and protein deviated from 17.62 to 2.66%. An increase in pH and decrease in acidity in milk with time of calving was observed.

Goat Milk

The milk yield was highest (0.770 ml/day) in Jakhana and lowest (0.500 ml/day) in Marwari. Similar trend was observed for fat content. The pH value was higher for Sirohi (6.64), followed by Jakhana, Marwari and Kutchi. Kutchi milk

PATENTS FILED

- A cream separator attachment for mixies and food processors
- Instant Makhana Kheer Mix
- A simple quick and sensitive method for staining of proteins on nitrocellulose membrane
- The Model Dairy Plant was granted Quality Certification **ISO 9002: 1994** and **Food Safety (IS 15000:1998) HACCP** by the Bureau of Indian Standard on 12 September 2000



having lowest pH had significantly higher titrable acidity. Parity has significant effect on milk yield and milk pH. Animals in second and fifth parity yielded higher milk/day. As the parity advanced, the milk pH increased. Rest of the milk traits remained unaffected due to parity of animals. The highest milk yield was recorded in second week of lactation. As the lactation period advanced, fat content and pH steadily increased whereas casein content declined. Total solids content was highest in last stage of lactation, but SNF, ash and TA remained unaffected.

MEAT AND POULTRY BYPRODUCTS

Meat Production and Carcass Quality

Heavier Jamunapari goat carcass weight classes within each age category having higher loin eye area produced higher back fat and breast fat thickness and higher dressing percentage. The carcass and non-carcass fat decreased with increase in age. Goat meat could safely be preserved for 3 months under frozen ($-18\pm 2^{\circ}\text{C}$) conditions without significant loss in eating quality. Recovery of coliforms and faecal streptococci was better by pour plate method in comparison to resuscitation method. Frozen storage arrested the multiplication of viable faecal indicator organisms. Effect of dietary sodium bicarbonate levels on carcass and meat quality of sheep indicated that the loin eye area as an index of muscle growth was also lower in control compared to groups supplemented with sodium bicarbonate. The growth rate and dressing yield improved by supplementing sodium bicarbonate. Carcass and meat quality characteristics of sheep and goat maintained on 50:50 roughage: concentrate ration indicated that the dressing yield and muscle growth of yearling sheep were higher than goats. Further, under similar feeding regimen the sheep deposited more carcass and depot fat than goats, whereas, the meat acceptability score was similar for the two species. Replacement of soya-meal substitution with mustard-cake as protein source even up to 100% did not have visible impact on carcass traits of finisher kits slaughtered at 12 weeks of age. The smaller the number of animals/cage the better the carcass yield and quality.

Quality aspects: Status of carcass contamination, decontamination with lactic acid and storage stability at chilling indicated that live animals themselves and ruminal surface were most contaminated part. However, during slaughter decontamination of carcass with 1% lactic acid significantly reduced carcass contamination.

Meat Products

Buffalo meat products: Smoking and cooking schedule techniques were standardized at Livestock Products Technology Division, IVRI, Izatnagar, to produce low fat buffalo meat sausages. Direct smoking (without the stage of pre-drying the product) significantly reduced skin formation on the surface of low fat sausages.

Chicken Meat Products

Role of phytoproducts in extending shelf-life of minced chicken meat: This investigation was carried out to elucidate the antimicrobial property of some phytoproducts in extending shelf-life of minced chicken meat both at ambient ($28^{\circ}\text{--}30^{\circ}\text{C}$) and refrigerated ($5^{\circ}\pm 1^{\circ}\text{C}$) temperatures. Under ambient storage, incorporation of garlic extract (GE) in the minced chicken meat at 4.0 or 8.0% (v/w) level reduced aerobic and anaerobic bacterial counts by one log scale and extended its shelf-life by more than 6 hr as compared to that of untreated control. Similarly, under refrigerated storage both these levels of GE significantly reduced aerobic bacterial, coliforms, yeast and moulds and anaerobic counts and extended shelf-life of meat by more than one day as compared to that of untreated control. Cinnamon powder incorporation at 2.0 or 4.0% (w/w) level in minced chicken meat produced a marked inhibitory effect on the bacterial multiplication as compared to control during ambient storage. Thiobarbituric acid (TBA) values in treated meat samples were also lower

PALADA PAYASAM INSTANT MIX

Palada Payasam is a popular sweet delicacy in Kerala. The traditional method of its preparation is laborious and time consuming. Process modifications reduced the time of preparation of the product by accelerating the release of Maillard reaction products to provide the desired colour and flavour. A dry mix, having shelf life over 6 months at ambient temperature, was developed to prepare the *Payasam* in a convenient way. The *Payasam* prepared by using the mix had organoleptic characteristics similar to those of the traditional product. Encouraged by the market response during consumer acceptability studies of the product, a milk producers' union in Kerala, procured the technology. The product is being marketed in Kerala.

EGG ROLL—A VERSATILE PRODUCT DEVELOPED FOR INDIAN FAST FOOD MARKET

Egg roll being a highly nutritious, tasty and convenience egg product offers a potential market at fast food outlets. Organoleptically, the egg roll containing 80% scrambled egg with 20% chicken sausage was rated the best in flavour and texture. Survey conducted during refrigerated ($5^{\circ}\pm 1^{\circ}\text{C}$) storage of the most acceptable blend indicated a shelf-life of 8 days in vacuum and 6 days in aerobic packaging. The cost of ingredients formulating an egg roll weighing about 145 g was calculated to be approximately Rs 10.00.



PET FOOD FROM POULTRY PROCESSING WASTES

Recycling of poultry processing wastes, constituting about 25 to 35% of live weight, as a valuable source of pet feeding is highly desirable from economic and pollution control view point. Process was standardized for the preparation of poultry by-product meal (PBPM), formulation of PBPM based pet food, and evaluation of its nutritive value and storage stability. Processing of all the inedible broiler by-products, excluding feathers at 1.1kg/cm pressure for 30 min followed by homogenization and oven-drying (70° C; 16 hr) appeared optimum to reduce moisture content of PBPM below 5% without affecting its nutritive value. The PBPM contained 61.7% crude proteins, 26.1% ether extract, 3.1% calcium, 1.7% phosphorus, 2.8% FNDB-available lysine, 1.1% methionine and 6.5 kcal gross energy/g.

Rectangular pet food biscuits of about 1.5cm thickness prepared from PBPM (15%) in combination with leaker eggs, bakery waste, cereal and cereal by-products, soy flour, permitted food additives, vitamins and mineral mixture had high pepsin digestibility (69.7-71.4%), and were a good source of crude proteins (22.9-23.7%), calcium (0.74-0.77%), phosphorus (0.67-0.70%), available lysine (0.80-0.82%), methionine (0.47-0.51%) and ME (4.17-4.24 kcal/kg). The product remained microbiologically safe without any off-odour throughout the 60 days of ambient (31°C) storage. Feeding 100 g of these foods to adult pet dogs weighing about 10kg could meet 50 to 65% of their daily maintenance requirement for ME, CP, Ca, P, available lysine and methionine. The product was highly palatable to pet dogs without any ill effects. The material cost of production of PBPM based pet foods is Rs 15/kg.

as compared to control. Both the used levels of cinnamon powder appeared effective in extending shelf-life of minced chicken meat by more than 6 hr as compared to that of control group. Under refrigerated storage, cinnamon at both the levels exerted higher antimicrobial property leading to extension of shelf-life of minced chicken meat by more than 3 and 4 days, respectively, as compared to that of control. Phytoproducts are useful in improving the microbial quality and shelf-life of minced chicken meat both at ambient and refrigerated temperatures.

Dehydrated chicken meat stock: Cooked (1.1 kg/cm; 15min) and oven-dried (70°±1°C; 12 hr) spent hen meat, edible byproducts (skin, gizzard and heart) in natural proportion, separable fat and cook-out exudates from carcass frame, shank and head (without beak and eyes) together yielded approximately 39% dehydrated chicken meat stock (CMS). Incorporation of 0.5% sodium tripolyphosphate in CMS followed by vacuum packaging in PFP laminated pouches was highly effective in inhibiting lipid oxidation as indicated by consistently low thiobarbituric acid (TBA) values during storage. Both aerobic (10g 2.0-3.3/g) and anaerobic (10g 1.0-1.6/g) bacterial and yeast and mould (10g 1.0-1.8/g) counts remained fairly low. Neither any coliforms of staphylococci nor any off-odour was evident during storage, suggesting that dehydrated cooked chicken meat stock could be safely stored for 90 days at mean ambient temperature (26°C) without much loss of its quality for the preparation of chicken soup and other food usage.

Chicken gizzard snacks: Vinegar medium garlic extract (VMGE) was more effective in containing the microbial counts as compared to water medium garlic extract (WMGE). But, in view of the impaired acceptability of VMGE product WMGE was preferred for processing gizzard snacks. In none of the samples, coliforms or staphylococci were detected during 14 and 28 days of refrigerated (4°±1°C) and frozen (-18°C) storage respectively. It is inferred that 8% level of water medium garlic extract rendered better quality product. The proximate analysis and sensory evaluations also suggested processing of gizzard snacks with 8% level of water medium garlic extract.

Chicken cutlets: Storage quality changes in chicken cutlets again suggested that incorporation of SMGE at 8% level could render microbiologically safe and better acceptable product till 14 and 28 days of refrigerated and frozen storage respectively.

Shami chicken kababs: Incorporation of 0.1% (w/w) black pepper extract in shami chicken kabab was able to offer cost effective shelf stable product. Such product could safely be utilized till 2 and 4 weeks of refrigerated (4°±1°C) and frozen (-18°C) storage respectively. Effect of 0.2% (w/w) level of turmeric extract was adjudged best and the product retained its acceptability till same period under respective conditions of storage.

Rabbit Meat Products

Storage stability of rabbit pickle at ambient temperature revealed that a fairly acceptable rabbit pickle (meat and liver) can be prepared and safely stored for two months. Decontamination of carcass with 1% lactic acid significantly reduced carcass contamination.

Sheep and Goat Meat Products

Effect of meat particle size on quality attributes of restructured mutton steaks indicated that restructured mutton steaks was better when prepared from minced meat of smaller particle size.

W O O L

Development of Wool-equine Products

Equine fibre collected from the NRCE is classified into different groups according



CAMEL HAIR PRODUCTS

Bikaneri breed produces maximum hair yield, followed by Jaisalmeri and Kachchhi breed. When compared to Bikaneri females, males produce more hair yield. Similar trend was observed in Jaisalmeri and Kachchhi breed. Male camel produces more camels hair yield as compared to female. The average hair production for male and female camels was 807.77 ± 18.20 g and 717.24 ± 16.45 g, respectively. Camel aged 3 years produced maximum hair yield followed by 2, 4-6 years, 1 year and above 6 years age group. The hair is widely used in village cottage industry for preparation of floor covering, bags, ropes and other blend products.



to its fibre diameter, length and colour. These classified equine fibres were blended with fine wool to develop diversified products. The equine fibre was blended with fine wool up to 30% with satisfactory performance. The yarn of 5 Nm with a 60 TM was developed for the preparation of blanket/furnishing fabric and carpets. Equine yarns are weaker than camel and rabbit hair blended yarn. Various blended yarns were converted into blankets using pure woolen yarn in wrap and blended yarns in weft. The furnishing fabrics are also developed using cotton yarn as wrap and blended yarn as a weft. The developed fabrics were given scouring, dyeing, milling, strengthening etc.

Dyeing Technique of Wool-Cotton Blend with Reactive Dye

A new technology was developed to dye wool-cotton blended fabric using single dye bath instead of conventional technique in which two dye baths with different dyes are used to dye cotton and wool separately. A cotton reactive dye (Drimarene PRBI) was used to dye wool cotton. The dyeing of blend was carried out in such a way that both wool and cotton could be dyed with cotton reactive dye. The dye bath of desired level shade is prepared and the blended fabric is inserted into dye-bath for dyeing of cotton component under optimum dyeing conditions. When cotton component is dyed up to desired level of shade then soda ash is added in the dye bath and boiled which hydrolyzes the dye partially and converts it into an acid dye. The partially hydrolyzed acid dye facilitates the dyeing of wool component and gets fixed under suitable conditions of dye bath. The optimum conditions of dyeing are pH 9.5, temperature 40°C and time 30 min for cotton; and pH 5.5, temperature 90°C from dye bath which produces uniform shade on wool-cotton blended fabric. Different shades of red were developed on wool-cotton blend using different concentrations of dye. The colour fastness properties such as light fastness, washing fastness and rubbing fastness of dyed fabrics were very good.



Fish Production and Processing

- The marine fish productions in India was estimated at 2.7 million tonnes
- Fish yield assessment of five reservoirs of southern Rajasthan was conducted. The fish yield in the reservoirs ranged from 23.0 to 172 kg/ha with dominance of major and minor carps
- The fishery and biology of prawns in Kayamkulam backwaters of Kerala were studied. *Penaeus indicus*, *Metapenaeus deobsoni* and *M. monoceros* contributed substantially to the total catch
- Identification and cataloguing of potential ornamental fish species have been done in the north-eastern states and West Bengal
- A qualitative health assessment index (HAI) for rapid evaluation of fish condition in the field was developed. The general health status of fish populations in river Hooghly was evaluated
- Mahseer fishery was developed in a lake in Champawat district of Uttaranchal
- A breakthrough has been achieved in spawning Asian catfish, *Clarias batrachus* spontaneously
- The seed production trials of Gangetic prawn, *Macrobrachium gangeticum* were carried out
- The giant freshwater prawn, *M. rosenbergii* cultured in pens installed in beels for a period of 92-95 days attained a size range of 135 m/38 g to 148 mm/57 g
- Trout *Onchorhynchus mykiss* was reared in the warmer agro-climatic conditions of Champawat where water quality was uncongenial for trout farming
- Cage culture experiment of mahseer has been conducted. After 150 days of culture the average net weight of *Tor khudree* increased from 35.2 g to 106 g and the average net weight of *Tor putitora* from 14.6 g to 52.4 g

CAPTURE FISHERIES

MARINE SECTOR

Estimation of Marine Fish Production

The marine fish production in India during the year 2000 was estimated at 2.7 million tonnes registering a 10.3% increase over the previous year. The data were made available to different interested agencies. Oil sardine landings recorded an all time high of 367,500 tonnes which was about 53% higher than the previous year. Ribbonfish landings were 183,000 tonnes with an increase of 47% over the last year. There was a decline of about 35% in the landings of mackerel; the landings during 2000 being 135,600 tonnes. The penaeid prawns showed an increase of 17% over the previous year with the landings to the tune of 204,500 tonnes during 2000. A marginal increase of about 3% was noticed in Bombayduck landings which were about 96,700 tonnes in the year 2000. The non penaeid prawn landings during 2000 were about 151,500 tonnes which was about 2-4% more than the previous year. An increase of 22% was noticed in the landings of catfish which was about 57,600 tonnes during the year 2000.

Status of Deep Sea Prawn Resources

Exploitation of the deep sea prawns was continued along the south-west coast of India at depths ranging from 175-400 m by shrimp trawlers. The total catch declined from 25,247 tonnes at a catch rate of 53 kg in 1999-2000 to 10,042 tonnes at a catch rate of 31 kg/hr during 2000-01. Contribution of pandalid prawns to the fishery

Deep sea prawn landings





declined from 78% to 49% during the current year. While adults represented the fishery during 1999-2000, juveniles contributed more in 2000-01. Unlike the coastal species, the deep sea prawns are highly susceptible to overexploitation due to their long life span, slow growth rate and low fecundity. Restriction on exploitation by introducing catch quota system or limited entry of fishing vessels are the various management measures to be considered for implementation.

Revalidation of Potential Yield Estimate in the Indian EEZ

The potential yield estimates of marine fishery resources in the Indian EEZ were revalidated by using recent data. The revalidated estimates is 3.934 million tonnes consisting of 2.017 million tonnes of demersal resources, 1.673 million tonnes of pelagic resources and 0.244 million tonnes of oceanic resources. The potential yield estimates were made for 68 species for the first time.

INLAND SECTOR

Assessment of Productive Potential of Wetlands by Satellite Imagery

Satellite USS-III images of IRS-IC/ID in respect of West Bengal were analysed for estimation of size and shape of the water bodies in different districts. Water temperature, pH, salinity, nitrate, total nitrogen, calcium, gross primary production and respiration were analysed in selected water bodies and the results indicated that these parameters can be estimated using properties of satellite images pertaining to the water body. GIS was created on the basis of data collected from the field. Based on the information extracted from the satellite image of West Bengal, a geographical information system (GIS) has been developed in respect of water bodies more than 50 ha in size to help the planners and decision makers in advocating the optimum management policies.

Fish Yield Assessment of Reservoirs

Ecological investigations of five reservoirs of southern Rajasthan were conducted. They were shallow reservoirs with alkaline water. The fish yield in the reservoirs ranged from 23.0 to 172 kg/ha with dominance of major and minor carps. Based on the production potential ranging from 350 in Kothari to 500 kg/ha in Khari and Udaisagar, these reservoirs can be categorised as highly productive. Stocking of Indian major carps @ 150 fingerlings in Kothari to 1500 fingerlings/ha in Khari and Udaisagar reservoirs have been suggested.

Fishery Status of Kerala Backwaters

The fishery and biology of prawns in Kayamkulam backwater of Kerala were studied. *Penaeus indicus*, *Metapenaeus dobsoni* and *M. monoceros* contributed substantially (831 tonnes) to the total catch. These species fished with fine mesh, seine nets and gill nets are subjected to both recruitment overfishing and growth overfishing. Strict regulation of exploitation by enhancing the mesh size of seine nets has been suggested.

Identification and Cataloguing of Ornamental Fishes of North East Region

Identification and cataloguing of potential ornamental fish species have been done in the north-eastern states and West Bengal. Breeding of ornamental fishes is being standardized.

Development of Fish Health Assessment Method

A qualitative health assessment index (HAI) for rapid evaluation of fish condition

- A polyculture experiment with stocking density of 38,800 nos/ha (mullet, pearlspot, *P. indicus*, *P. monodon*) was carried out in 0.05 ha. A total quantity of 78.2 kg of fish and shrimp was harvested
- A breakthrough has been achieved in the seed production and larval rearing of sea cucumber, *Holothuria spinifera* for the first time in the hatchery
- A major breakthrough in successful domestication of the tiger shrimp, *Penaeus monodon* has been achieved
- Six new designs for eco-friendly and resource specific demersal trawls were developed
- A few peptides from the salivary gland secretions of the cone, *Conus inscriptus* were detected. These peptides have biomedical importance since they are potent analgesic agents
- Genetic characterisation of *Labeo* species, viz rohu, calbasu, bata, fimbriatus, gonius and diochelius was done using RAPD-PCR profiling
- With the aim to preserve natural genetic variability, sperms of wild stocks of prioritized fish species *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* and *Labeo dussumieri* were cryopreserved



DEVELOPMENT OF MAHSEER FISHERY
FOR SPORT FISHING IN
KUMAON LAKES

The NRC on Coldwater Fisheries initiated to develop mahseer fishery in an upland lake, Shyamalatal situated at an altitude of 1290 above mean sea-level near Sukhidang in Champawat district of Uttaranchal State, both for brood stock rearing and consequent angling. In all 6000 fingerlings of golden mahseer (35-90 mm) were released in the lake. The first monitoring revealed that the fish has adjusted in the new environment and growth was quite satisfactory. Within a period of 2-6 months the mahseer (*Tor putitora*) fingerlings registered growth to a size range of 85-150 mm. This lake has a potential to be developed as sport fishing activity and generate income to local community in this remote area.

in the field was tried successfully to evaluate the general health status of fish populations in river Hooghly from a polluted and non-polluted site. It revealed higher HAI (61.5) in polluted site compared to non-polluted site (26.5) in fish *R. rita*.

COLDWATER SECTOR

Environmental Status of Nainital Lake (Uttaranchal)

The winter fish kill in Nainital lake is very common. Therefore investigation was conducted to know the reason. It was observed that due to intense nutrient loading the oxygen cycle has been adversely affected in the lake. The presence of toxic substances like ammonia and hydrogen sulphide was recorded at bottom. In Nainital lake, the fishes are facing acute stress condition due to low oxygen level at surface as well as bottom of the lake.

Survey of High Mountain Lakes in Central Himalayan Region

A survey was conducted in high altitude lakes of the Central Himalayan region of Garhwal to evaluate their ecological features, biodiversity and fisheries. Most of these lakes have religious sanctity and serve as biodiversity sanctuaries.

The survey has revealed that these coldwater lakes are oligotrophic in nature.

Ecological features of high altitude lakes

Parameters	Deorital	Gandhisarovar	Dailyatal	Vasukital	Hemkund Sahib
Location altitude (masl)	3255.00	3970.00	4275.00	4300.00	4329.00
Water temp. (°C)	22.50	11.00	8.00	8.00	7.00
Turbidity (m)	1.60	1.20	1.85	2.40	1.80
pH	7.20	6.20	6.20	6.20	6.80
D. oxygen (ppm)	7.40	7.24	7.20	7.20	7.00
Specific conductivity (umhos/cm)	40.00	80.00	74.00	70.00	16.50
P. Production (mg C m ³ h ⁻¹)	31.25	16.50	14.50	12.50	28.50

CULTURE FISHERIES

FRESHWATER AQUACULTURE

Spawning of Asian Catfish, *Clarias batrachus*

A breakthrough has been achieved in spawning Asian catfish, *Clarias batrachus* spontaneously. With the manipulation of hormone dose, latency period and brood stock feed, the fishes breed without stripping male and female and spawn spontaneously following hormone injection.

Seed Production of Gangetic Prawn, *Macrobrachium gangeticum*

The seed production trial of gangetic prawn, *Macrobrachium gangeticum* (Bate) synonym *M. birmanicum choprai* (Tiwari) were carried out in plastic pool following air-lift biofilter recirculatory system. The larvae were reared in brackishwater of 12-14 ppt salinity. The larvae passed through eleven larval stages with 16-18 molts. The first few post larvae occurred on 22nd day. A record production of 13,043 post larvae @ 43 PL/I was achieved with about 90% metamorphosis during 45 days of rearing cycle.



Culture of Freshwater Prawn in Pens

The giant freshwater prawn, *M. rosenbergii* cultured in pens installed in beels for a period ranging from 92-95 days attained a size range of 135 mm/38 g to 148 mm/57 g at a stocking density ranging from 21,000 to 25,000 nos./ha. A yield of 484 to 588 kg/ha was obtained in 92-95 days of culture.

Evaluation of Dairy Effluents for Aquaculture Activity

To evaluate the potential of dairy effluents for aquaculture, a pen enclosure (0.011 ha) was constructed in the lagoon near the discharge point of dairy plant effluent. The pen was stocked with fingerling of Indian major and minor carps (catla, rohu, mrigal, silver carp and bata) at 5000 nos./ha. The fishes were reared for 6 months. All the species stocked exhibited very good growth indicating the potential of dairy effluent for aquaculture. The estimated productions of fish within six months was 3.5 tonnes/ha.

Development of Phosphatase Producing Bacterial Biofertilizers for Aquaculture

Bacterial isolates were collected and screened for phosphatase activity from both pond water and sediments. Out of the total 1079 bacterial isolates collected one hundred were found to be potential alkaline phosphatase enzyme producers. The study has indicated the possibility of using bacterial biofilter in fish farming activities in the country.

BREEDING ENDANGERED FISHES

Induced breeding was successfully achieved in three endangered and food fishes namely *Horabagrus bachysoma*, *Labeo dussumieri* and *Ompok malabaricus*. Two prioritised ornamental species of Western Ghats namely *Danio malabaricus* and *Puntius melanopyx* were successfully bred in captivity. Breeding technique for *H. brachysoma* and *O. malabaricus* were standardized for the first time in the country.

COLDWATER AQUACULTURE

Trout Culture at Champawat

Experiments were conducted to rear rainbow trout *Onchorhynchus mykiss* in the warmer agro-climatic conditions, where for nearly ten months the minimum water temperature remains above 10°C and the maximum ranges between 20-22°C, even the pH values always range between 8.0 to 8.2 and lower levels of dissolved oxygen drop to 5.0 ppm. The water quality was uncongenial for trout farming. The water quality was monitored and scientific package of practices for farming of rainbow trout was adopted. The result was very encouraging and the fishes attained the table size in the warmer agro-climatic condition of Champawat. These prized fishes were sold to the local people. This has opened up a great opportunity to local people to take up the trout farming which commands high price and has good demand in big metropolitan cities.

Cage Culture of Mahseer in Reservoir

Cage culture experiment for culture of mahseer has been conducted in the Walwan reservoir. The nylon cages (2 to 5 mm and 2 to 15 mm) were stocked with commercially important mahseer at a depth of 2 metre in the reservoir. Encouraging results were obtained and after 150 days of culture the average net weight of *Tor khudree* increased from 35.2 g to 106 g and the average net weight of *Tor putitora* from 14.6 g to 52.4 g. The rate of survival of mahseer in these cages were approximately 98%.



Experimental cages in Walwan reservoir



Stocking of cage in progress

BRACKISHWATER AQUACULTURE

Polyculture of Brackishwater Finfishes and Shellfishes

A polyculture experiment with stocking density of 38,800 nos./ha (mullet 16,000; pearlspot 3,800; *P. indicus* 12,000; *P. monodon* 12,000), was carried out in a 0.05 ha. perennial tide-fed pond at the Narakkal. A total quantity of 78.2 kg of fish and shrimp was harvested at the end of a culture duration of 6 months for fishes and 3-4 months



for shrimps. The total production rate works out to 1,564 kg/ha. From an initial size of 25 mm/0.16 g for mullets, *M. cephalus* reached 250 mm/155 g and *L. parsia* 162 mm/36 g. *E. suratensis* attained 178 mm/134 g from an initial size of 58 mm/8 g. In the case of shrimp, PL20 reached a size of 152 mm/29 g for *P. monodon* and 101 mm/5 g for *P. indicus*.

MARICULTURE

Seed Production of Sea Cucumber

A breakthrough has been achieved in the seed production and larval rearing of sea cucumber *Holothuria spinifera* for the first time in the hatchery by Tuticorin Centre of CMFRI, Cochin. The large scale ranching can augment their natural resource in our coastal waters thus increasing the production of *Beche-de-mer* and export quality product of the sea cucumber.



Seed production and larval rearing of sea cucumber, *Holothuria spinifera* has been carried out in the hatchery for the first time

Ornamental Fish Breeding and Seed Production

The experiment has been taken to breed marine ornamental fish species *Pomacentrus pavo* (Peacock damselfish) in captivity. It was observed that the species spawns (in onshore FRP tanks with seawater) several times in a year laying about 1500-5000 eggs in each spawning. The larvae thrived well on bivalve eggs and, *Artemia nauplii* and mussel meat later.



Ornamental fish peacock damselfish (*Pomacentrus pavo*) has been bred in captivity

DETECTION OF SLEEPER PEPTIDES IN MARINE CONE SNAILS

A significant achievement has been made by the CIFE, Mumbai to detect few peptides from the salivary gland secretions of the cone *Conus inscriptus* that induce sleep in mice models upon intraperitoneal injection. The detection and isolation of these peptides, popularly known as "sleeper peptides" is of considerable biomedical importance since they are potent analgesic agents. Sleeper peptides from *C. magus* are undergoing clinical trials in USA as analgesic agents.



Conus inscriptus, the venomous marine gastropod from which "sleeper peptides" have been isolated

Tissue Culture in Pearl Oyster

Remarkable progress was achieved in tissue culture of abalone, pearl oyster and windowpane oyster. Achievements were made in the cryopreservation of excess cells produced during *in vitro* culture and their subculture.

Domestication of the Tiger Shrimp, *Penaeus monodon*

A major breakthrough in successful domestication of the tiger shrimp, *Penaeus monodon* has been achieved. The F1 generation of hatchery produced and farm grown shrimps were induced to mature and spawn by artificial insemination and eyestalk ablation, giving rise to second generation population. Subsequently third and fourth generation population was produced from domesticated shrimp. This achievement in domestication is important in developing pathogen free and genetically improved stock through selective breeding programmes.

FISHERIES TECHNOLOGY

New Designs of Demersal Trawl

Six new designs of eco-friendly and resource specific demersal trawls were developed. Trials carried out have shown that with proper rigging, none of the designs



dragged bottom debris and benthos, preserving the bottom ecology of the trawling grounds.

Preservation of Rubberwood

Rubberwood treated with dual preservative—copper creosote and arsenical creosote—showed maximum increase in compression stress and least reduction in strength even after exposure for nearly three years in seawater. The latter indicates least intensity of internal attack.

Characterization and Refinement of Fish and Fishery Products

The CIFE, Mumbai has isolated compounds responsible for aroma in fish such as hydrocarbons, aldehydes, alcohols, ketones, fatty acids. These compounds are being correlated are precursors.

Preparation of Value Added Products

Method was developed for production of chilly fish by modifying the recipe used for preparation of chilly chicken. The procedure was standardized and the product packed in polythene sheets and stored at -20°C remained in good condition with respect to appearance, flavour and texture even after one year of storage. Method for preparation of battered and breaded products from cuttlefish fillets was standardized with respect to batter composition, breadcrumb size, etc. The samples were acceptable up to 15 months of storage.

Packaging of Value Added Fish Products

Indigenously available thermoformed containers made of PVC and polystyrene were found suitable for packing value added fish products. They were seen to be as good as the imported HDPC containers.

The method developed for production of PUFA (Polyunsaturated fatty acid) concentrate was modified to reduce the consumption of water by about 15% without affecting the quality or yield of the product.

Qualitative Determination of Metabisulphite Residues in Prawns

A spot test for qualitative determination of metabisulphite residues in prawns was developed and is being perfected. This method is superior to the commonly employed malachite green test which responds to even untreated samples.

FISH GENETICS RESOURCES

Genetic Characterisation of *Labeo* Species

Genetic characterisation of six *Labeo* species, viz. rohu, calbasu, bata, fimbriatus, gonius and diocheliu was done using RAPD-PCR profiling. Intra and inter-species genetic similarities (GS) were evaluated and species specific RAPD fingerprints generated. High intra-specific genetic similarity co-efficients were found in all the species. Inter-specific genetic similarity estimates were used to hypothesize phylogenetic relationship among six species. The cluster analysis showed two main clusters one with bata, rohu, calbasu and diocheliu and another fimbriatus and gonius indicating that members of each cluster are genetically close to each other. The present result is based, initially, on six random primers which indicates that RAPD-PCR profiling may be used as a molecular tool for assessing carp genetic diversity at species level identifying the taxonomic units and determining species distinctiveness.

Gene Banking

Under the gene banking programme, sperm cryopreservation protocol for

POPULATION CHARACTERIZATION OF *LABEO ROHITA*

Management of fish germplasm resources requires information on population genetic structure of species. Studies were conducted with random amplified polymorphic DNA markers and it was observed that populations of *Labeo rohita* in Kalibain and Satluj are genetically similar, whereas populations in Rapti and Mahanadi are equidistant from them.

Stocks of important commercial fish *Catla catla* are prone to mixing with farmed gene pools due to straying, stocking and transplantation programmes. This can lead to the loss of genetic variability in the species. In studies undertaken to address this issue, out of twenty four allozyme loci screened, five, viz. *EST1**, *EST2**, *α GPDH**, *ODH2** and *ACP**, were found to be polymorphic. It was also found that allele *α GPDH* 109* is present in the rivers of Ganga system only. This allele can be a useful marker to assess the mixing of stocks of this important fish species.



TURTLE EXCLUDER DEVICE (TED) FOR CONSERVATION OF MARINE TURTLES

Marine turtles are an endangered species, protected under international conventions such as CITES (Convention on International Trade on Endangered Species of Wild Flora and Fauna) and CMS (Convention on Migratory Species) to which India is a signatory and under Schedule 1 of the Indian Wildlife Protection Act 1972 and its amendment of 1991.

Normally, the sea turtles get caught in large numbers in fishing nets, especially trawl nets, during the mass-nesting season, resulting in mass mortality. In India, this problem is very acute along Orissa and West Bengal coast. It was against this background that the Central Institute of Fisheries Technology (CIFT) took up the design, fabrication, field testing and popularization and training of the fishermen in its fabrication and use.

The device permitted 100% escapement of the Olive Ridley turtles while keeping escapement of total catch between 0.24 and 1.2% and shrimp alone between 0 and 0.62%. Demonstration of fabrication

and operation of CIFT-TED was carried out at Bhubaneswar, Paradeep and Dhamra in Orissa during the mass nesting season of the Olive Ridley Turtles, at Shankarpur and Frasergunj fishing centres in West Bengal and at Visakhapatnam in Andhra Pradesh. Officials from State Fisheries Departments, Forest Department, State Institute of Fisheries Technology (Kakinada), Marine Products Export Development Authority, representatives from Boat Owners Association, NGOs, Garware Wall Ropes Ltd., trawler fishermen and net makers were benefited by the workshop-cum-training initiatives.

The use of TED, combined with other elements of an integrated turtle conservation, can stop the decline in sea turtle population and will, over a period of time, lead to their recovery. An Expert Scientific Panel in a report submitted to the Ministry of Agriculture, Government of India, has recommended the mandatory use of TEDs by all mechanized trawlers operating in areas where higher incidental mortalities of marine turtles have been recorded in Indian waters.

endangered and endemic fish *Horabagrus brachysoma* was successfully developed and this species was added to the NBFGR mini gene bank. With the aim to preserve natural genetic variability, sperms of wild stocks of prioritised fish species *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala* and *Labeo dussumieri* were cryopreserved.

DNA retrieved from tissues can provide valuable genetic information and offers tremendous scope for utilizing biotechnological tools in future. Therefore, to ensure access to genetic information on a long-term basis or for specific situations, DNA was successfully isolated from the cryopreserved spermatozoa of *Labeo rohita* and *L. dussumieri*. This has added a new dimension to the gene banking programme.

HUMAN RESOURCE DEVELOPMENT

The CIFE, Mumbai is the nodal institution for fisheries education in the country. The institute is conducting academic programmes at Masters and Doctoral level. During the year, 38 students successfully completed the various M.F.Sc. programmes. Under the Ph D Programme, the degree was awarded to 6 in Mariculture and 5 in the Inland Aquaculture. Under the P.G. Certificate in Inland Fisheries and Administration, 28 trainees completed programme. Training Programme were conducted under the auspices of CAS in Fishery Science in which a total of 48 participants were trained. A Summer School on Environmental Impact Assessment and Management of Coastal Zones : An Integrated Approach were organized from 7 to 27 August 2001 in which 24 persons have participated. Eight short-term training programmes were conducted for different durations were organized by the CIFE.

During the current academic programme, the CIFE has introduced new post-graduate programme (M.F.Sc.) Fish Genetics and Bio-technology, Fish Pathology and Microbiology, Fish Nutrition and Biochemistry, Post-harvest Technology.



FARM IMPLEMENTS AND MACHINERY

Tractor-mounted Raised Bed Planter

The PAU, Ludhiana Centre of AICRP on FIM has modified the design of tractor-mounted raised bed planter which makes 2 beds of 68 cm base width, 35 cm top width and 20 cm slant height with the help of 3 furrow openers (double-mould board type). It has a spring-loaded leveller to level the soil before sowing and bed shaper to give proper shape to beds after sowing. Two to three rows of wheat can be sown on each bed. Seed metering is done with the help of fluted rollers. Fertilizer metering is done by gravity feed. Feasibility testing of the raised bed planter was carried out at CIAE, Bhopal and PAU, Ludhiana Centre of AICRP on FIM in 6 villages covering more than 50 ha area. Thirty units have been manufactured and supplied to different centres by the PAU, Ludhiana Centre for feasibility testing. The main advantages of this planter are: (i) it reduces cost of cultivation, (ii) reduces weed infestation and mechanical weed control is possible in furrows, and (iii) saves irrigation water by about 30%.

Tractor-mounted Till Planter

A tractor-mounted till planter developed earlier was modified and commercialized at the PAU, Ludhiana Centre of AICRP on FIM. The modified machine has 9-row seed-cum-fertilizer drill mounted on a 1.6 m wide rotavator. The seed metering is done by using fluted rollers and fertilizer is placed by gravity with adjustable holes and an agitator. The drive to the metering mechanism is given by the ground wheel through chain and sprockets. Furrow openers for the placement of seed and fertilizer are mounted at the rear of rotavator in 2 rows in a staggered manner. The rotavator has 36 blades (L-type) mounted on 6 discs that are driven through gears and PTO shaft of the tractor. Field evaluation of the planter was done for sowing wheat after harvesting of rice crop by combine in different stubble conditions in sandy loam soil and silt clay loam soil of Punjab. Two treatments were selected for the sandy loam soil:

- T1 (partial burning of rice straw + pre-sowing irrigation + till planter for wheat sowing).
- T2 (stubble shaver + complete burning of rice straw + pre-sowing irrigation + till planter for wheat sowing)

In silt clay loam soil, treatments selected were:

- T3 (partial burning of rice straw + pre-sowing irrigation + till planter for wheat sowing.)
- T4 (partial burning of rice straw + pre-sowing irrigation + one disc harrowing + till planter for wheat sowing).

The performance of the machine was better in completely burnt rice fields than partially burnt fields. The cost of operation (Rs/ha) along with tractor was 247 for disc harrow, 190 for stubble shaver and 1,015 for till planter. Local manufacturers in Ludhiana have started manufacturing of this machine.



Tractor-mounted raised bed planter saves 20% in seed rate, about 30% in fertilizer and 34% in irrigation water requirement besides getting higher yields

- Tractor-mounted till planter developed earlier modified and commercialized at PAU, Ludhiana Centre of AICRP on FIM
- Vegetable planter attachment developed at TNAU, Coimbatore Centre of AICRP on FIM
- Attachments for riding type self-propelled reaper windrower developed at CIAE, Bhopal to make it a multi-purpose machine
- A new power weeder made at CIAE, Bhopal
- Power tiller-operated multi-crop planter weighing 34 kg developed at HPKV, Palampur Centre of AICRP on FIM



Tractor-mounted till planter performs better in silt clay loam soil where one pass of tractor-mounted disc harrow is added in the treatment

Self-propelled Vegetable Planter

The TNAU, Coimbatore Centre of AICRP on FIM has developed a vegetable planter attachment to the self-propelled reaper/power weeder. It consists of a simple frame on which the seed box, hitch bracket, handle, clutch mechanism and 3 no. of shoe type furrow openers are mounted. The provision of spoon/cup feed type mechanism facilitates metering of small onion bulbs/seeds without breakage. Provision of a clutch facilitates stopping of seed dropping at headlands. A square bar is provided at the rear end of the unit to cover the seeds and can be lifted in case of accumulation of trash and row-to-row distance can be adjusted. There is provision to change the spoon or cups welded on a ring that fits on the disc for sowing small onion bulbs and lady's finger seed accordingly. The planter was tested for its performance on the TNAU, Coimbatore farm for sowing small onion and lady's finger in red sandy loam soil in comparison with manual dibbling method. The field capacity was found to be 0.06 and 0.09 ha/hr in onion bulbs and lady's finger seed, respectively. The cost of sowing with planter was Rs 740/ha as compared to Rs 1, 200/ha by conventional method.

Attachments for Riding Type Self-propelled Reaper Windrower

Seed drill: A 5-row unit of seed drill attachment has been developed at CIAE, Bhopal for operating with self-propelled riding type reaper. The seed drill has provision for varying row-to-row spacing from 225 to 300 mm. During *kharif* season, soybean variety JS 335 was sown on 0.43 ha area at a row spacing of 300 mm. The average field capacity was 0.27 ha/hr at a forward speed of 2.78 km/hr. During *rabi* season, Bengalgram was sown at a row spacing of 300 mm. The average field capacity was 0.332 ha/hr at a forward speed of 2.84 km/hr.

Weeder: A weeding attachment was developed and evaluated at CIAE, Bhopal for weeding operation in soybean (JS 904) grown at 350 mm row spacing. The performance of weeder was satisfactory. Its field capacity was 0.288 ha/hr.

Sprayer: A twin blower type spraying attachment was developed at CIAE, Bhopal. Power to spraying attachment was given through a V-belt and pulley arrangement from engine by stepping up the speed to achieve required speed of blower. Initial test results showed 1.2 l/min. of discharge, 2.7 m width of coverage, 0.88 ha/hr of field capacity and 88.5% of field efficiency. Application rate was found as 77.5 litres/ha.

Self-propelled Power Weeder

A new power weeder was made at CIAE, Bhopal by upgrading the engine to 3hp petrol-start kerosene-run engine. The weeder was tried for weeding operation of cotton crop sown at the Institute farm at 90 cm row-to-row spacing. The weeding operation was performed with 3 sweeps of 150 mm size as a single row machine. Evaluation of the power weeder indicated the mean values of effective field capacity; forward speed and weeding efficiency were 0.14 ha/hr, 2.10 km/hr and 80.7%, respectively without plant damage in cotton crop.

By using power tiller-operated multi-crop planter 3 rows of wheat, 2 rows of maize and 2 rows of soybean can be sown



Power Tiller-operated Multi-crop Planter

The HPKV, Palampur Centre of AICRP on FIM has developed a power tiller-operated multi-crop planter, which weighs 34 kg. This machine was extensively evaluated with Mitsubishi power tiller (12 hp) on HPKV farm in silty clay loam soil and at farmers' fields. The performance of this planter was compared with manual multi-crop planter and traditional method of sowing (seed dropping behind indigenous plough) for sowing maize, soybean and wheat crops in small plots of 10 m × 5 m. Field capacity (ha/hr) with the 3 systems was 0.18, 0.09 and 0.03 for maize, 0.16, 0.05 and 0.03 for soybean, and 0.09, 0.03 and 0.02 for wheat, respectively. In the traditional method cost of operation was 71% higher for maize, 65% for soybean and 56% for wheat crop over power tiller-operated multi-crop planter.



Self-propelled Forage Harvester

A walk-behind-type self-propelled forage harvester (1.6 m cutter bar) was developed at PAU, Ludhiana Centre of AICRP on FIM. The cutting mechanism is mounted at the centre of the power unit. Power from the engine to the cutting mechanism is given through belt and pulleys. The machine has 2 end shoes and one guard in the centre of cutter bar to avoid falling of harvested crop on the engine. Preliminary trials of machine on maize, sorghum and pearl millet indicated that the cutting of crop was good. Provision of middle crop divider has stopped falling of harvested stalks haphazardly and thus choking of entire system is eliminated.

Tractor-mounted Fodder Harvester

The PAU, Ludhiana Centre of AICRP on FIM has developed and commercialized a flail type mower-cum-chopper for fodder crop harvesting. The machine consists of a rotary shaft mounted with blades named as flail to harvest the crop, auger for conveying the cut crop, cutters for chopping and conveying chopped fodder through outlet into the trailer. The blades on the rotary shaft are staggered in 3 lines of 13 blades on each row on a horizontal axis perpendicular to the direction of motion. After the crop is cut by the blades, it comes in the auger, which conveys it to the chopping mechanism. The chopping mechanism having 3 blades cut the crop into pieces and chopped material is thrown out with a high speed and is filled into the hitched trailer to the machine. The machine was operated by a 55 hp tractor and at PTO speed of 1,000 rpm.



Tractor-mounted fodder harvester in a single operation can harvest, chop and load the chopped fodders like maize, pearl millet, oat etc. in the trailer attached to the machine

High Capacity Pigeonpea Thresher

The CIAE, Bhopal has developed a high capacity pigeonpea thresher, having automatic chain conveyor type feeding mechanism to feed only pod portion of the stalk. The machine was field evaluated. Run by a 7.5 kW motor or 20-22 kW tractor PTO the throughput capacity of 2,112 kg/hr, output of 436 kg/hr, threshing efficiency 98.5% and cleaning efficiency of 98.2% were observed with pigeonpea crop having grain to straw ratio as 0.4.

Heart Rate Responses of Women Workers in Operation of Farm Machinery

A study was conducted to compare the heart rate responses of women workers while working with groundnut decorticator under different climatic conditions. The parameters used for comparison were heart rate (for evaluation of workload), output (kg/hr) and the muscular effort required for handle operation (kgf). Four women subjects participated in the experiment. Each trial was 30 min. duration, after which a rest of 15 min. was given to the subject. Data on heart rate were taken with the help of polar heart rate monitor during each trial. Data on strokes/min., force applied, quantity of groundnuts/batch, broken, unshelled/partially-shelled pods, damaged, foreign matter were noted.

During decortication, the kernel output with sitting and standing type decorticators were 26 and 33 kg/hr as against 1.1 kg/hr by traditional method. The mean working heart rates were 85.5, 111.0 and 121.8 beats/min. for traditional method, sitting type decorticator and standing type decorticator, respectively. The mean values of force required to operate the handle at the start of the batch was 4.8 kgf for standing type groundnut decorticators.

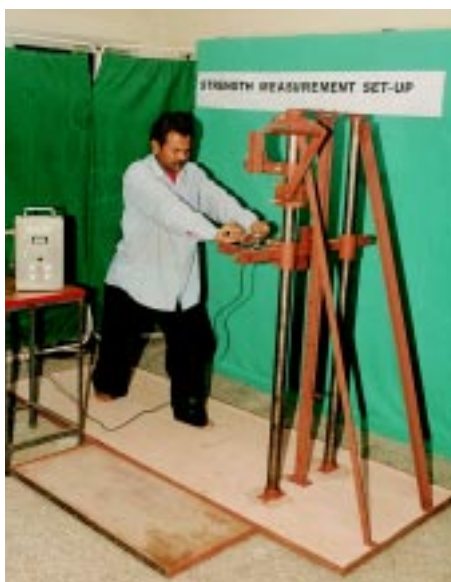
Similar study was also conducted with hand-operated maize shellers, viz. rotary disc type maize sheller and tubular maize sheller and compared with local method of maize shelling. Each trial was of 1 hr duration. For rotary disc type maize sheller, trial duration was of 30 min. The results indicated that the working heart rate for rotary disc type sheller, tubular sheller and traditional method (with sickle) were 114, 93 and 88 beats/min. and increase in heart rate over rest were 36.3, 15.7 and 11.6 beats/min., respectively. The rotary disc type maize sheller had the maximum output of 73 kg/hr, followed by tubular maize sheller (27 kg/hr) and traditional

- A walk-behind-type self-propelled forage harvester developed at PAU, Ludhiana Centre of AICRP on FIM
- A flail type mower-cum-chopper developed and commercialized at PAU, Ludhiana Centre of AICRP on FIM for fodder crop harvesting
- A high capacity pigeonpea thresher having automatic chain conveyor or type feeding mechanism developed at CIAE, Bhopal
- A set-up for measurement of strength parameters of workers developed by the Bhopal Centre of AICRP on Human Engineering and Safety in Agriculture



Overview of agricultural accidents in Madhya Pradesh, Orissa and Tamil Nadu

Particulars	States		
	Madhya Pradesh	Orissa	Tamil Nadu
Survey varied by	CIAE, Bhopal	OUAT, Bhubaneswar	TNAU, Coimbatore
Number of villages surveyed	8 villages from 8 districts	12 villages from 12 districts	12 villages from 9 districts
Total number of accidents reported during 1995-99	76	131	373
Fatal	7 (9.2%)	27 (21%)	16 (4.3%)
Non-fatal	69 (90.8%)	104 (79%)	357 (95.7%)
Overall accident incidence rate/1000 workers/year	1.25	1.77	2.81
Category-wise accidents			
Farm machinery	60 (79.0%)	52 (39.7%)	334 (89.5%)
Hand tools	9 (11.8%)	28 (21.0%)	36 (9.7%)
Others (snake bites, animal bites, fall in wells, lightning, heat stroke etc.)	7 (9.2%)	51 (39.3%)	5 (1.3%)
Category-wise accident incidence rates			
Farm machinery (1,000 machines/year)	2.95	2.85	18.66
Hand tools (1,000 hand tools/ year)	0.08	0.39	0.20
Others (1,000 workers/ year)	0.13	0.88	0.35
Category-wise estimates for agricultural accidents/year			
Total	17,500	18,300	94,500
Fatal	2,100	3,500	4,101
Non-fatal	15,400	14,800	90,400



Strength measurement set-up with both hands (top), in paddle operation in sitting posture (bottom)

method with sickle (17 kg/hr). Hand-operated rotary disc type sheller could not be operated beyond 30 min. due to muscular fatigue involved in the operation. After every 30 min. a rest of 15 min. is must to restart the work. It was also observed that in the traditional method there was a high probability of injury of finger during operation.

MEASUREMENT OF STRENGTH PARAMETERS OF AGRICULTURAL WORKERS

A set-up for measurement of various strength parameters of workers useful for ergonomic design of agricultural equipment and machines has been designed and developed by Bhopal Centre of All-India Co-ordinated Research Project on Human Engineering and Safety in Agriculture. The strength parameters which can be measured by the set-up are push and pull forces by one or both the hands in sitting and standing posture, leg and foot strength of right and left leg in sitting posture, steering force which a tractor operator can apply on a steering wheel with one or both hands in clock-wise or anti clock-wise direction and cranking force with one or both the hands during push or pull mode in standing posture. For accurate and reliable measurement of strength parameters, the set-up uses a strain gauge type load cell with indicator which could be mounted with appropriate fixtures provided for the purpose. The indicator also has a provision for analogue output for recording of the data with a suitable recorder. The set-up is portable and can be dismantled into different components for easy transport from place to place.



Source-wise classification of accidents in agriculture			
Source	Per cent of total accidents due to various sources		
	Madhya Pradesh	Orissa	Tamil Nadu
Farm tools and machinery-related accidents			
Tractors	46.1	8.4	27.4
Power tillers	-	2.3	-
Animal-drawn puddlers	-	3.1	-
Threshers	14.5	0.8	18.2
Electric motors and pump sets	7.9	6.9	-
Sprayer	2.6	12.2	25.7
Spade/ pickaxe	1.3	9.2	3.0
Sickle	10.5	6.1	6.7
Chaff cutters	4.0	0.8	5.9
Cane crusher	-	0.8	11.8
Winnowers	-	0.8	-
Rice hullers/grain mill	2.6	7.6	-
Other tools and machinery	1.3	6.0	-
Sub-total	90.8	65.0	98.7
Accidents related to other sources			
Snake/animal bites	5.2	14.4	1.3
Fall in wells	4.0	-	-
Lightning	-	11.4	-
Sun stroke	-	9.2	-
Sub-total	9.2	35.0	1.3
Total	100	100	100

PROTOTYPE FEASIBILITY TESTING

Tractor-mounted Rotavator

The JNKVV, Jabalpur and PDKV, Akola Centres of AICRP on FIM carried out feasibility testing of tractor-mounted rotavator of 1,250 mm size. Testing of the rotavator was carried out for preparation of puddle bed for rice in 11 ha and seedbed for wheat in 24 ha at JNKVV, Jabalpur and 61 ha at PDKV, Akola for cotton crop. Use of rotavator reduced the number of operations, thereby increasing the overall field capacity and reducing the time required for seedbed preparation. The seedbed quality obtained was better than that with conventional practices and the rice stubbles were also incorporated in the soil.

Tractor-mounted Potato Planter

A tractor-mounted potato planter was field evaluated at AADU, Allahabad Centre of AICRP on FIM, at recommended seed rate (2.5 tonnes/ha). At row spacing of 560 mm and average seed-to-seed spacing of 127 mm the machine was tested for forward speed of 1.29 to 1.65 km/hr. The field capacity varied from 0.08 to 0.14 ha/hr with corresponding field efficiency varying from 55% to 73%. The plant population/m row and yield varied from 0.8 to 1.0 and 29.5 to 31.3 tonnes/ha, respectively. Farmers accepted the machine for timeliness of operation and higher output. The machine was used on 13 farmers' fields covering a total area of 34.25 ha.

At NDUAT, Faizabad a 2-row tractor-mounted semi-automatic belt type potato planter with fertilizer placement device was tested for its feasibility. The system required total of 4 persons for its continuous operation, one for operating the tractor with machine, two sitting on the machine for removing excess tubers, filling vacant cups and one for carrying and filling tubers and fertilizers in the machine during



operation. The machine was demonstrated in 26 ha area on different farmers' fields. Potato planter saved 77 m-days/ha in earthing, 28 m-days/ha in interculture and 98 m-days/ha in seeding operation in comparison to conventional method.

Light Weight Power Tiller

The RAU, Pusa Centre of AICRP on FIM carried out prototype feasibility testing of light weight power tiller for interculture operation in sugarcane, maize, tobacco and vegetable. The lightweight power tiller was found suitable for weeding with 40 cm rotavator and cutter wheel (other available size was 80 cm). The interculture operation was conducted in 9 ha area of sugarcane, 4.5 ha area of maize and 2 ha area of tobacco. There was a net saving of approx. Rs 1,000/ha with the use of lightweight power tiller in comparison to the traditional method of interculture. Timeliness of the operation was another beneficial factor. Sugar mill authorities have distributed 5 units of light weight power tiller to the cane growers of the region after seeing its demonstration.

Aeroblast Sprayer

Feasibility testing of a tractor-mounted aeroblast sprayer was carried out by PAU Centre of AICRP on FIM on cotton crop. The machine is useful for spraying on horticultural plants and tall crops like cotton and sunflower. Field capacity of the machine varied from 2 to 3 ha/hr. Droplets were deposited on both sides of the leaf due to air blast. A total area of 12.5 ha was covered with the machine during prototype feasibility testing by the PAU, Ludhiana Centre. The farmers of 10 villages surveyed, used it for 3,484 ha (in cotton crop 6-7 times spraying is done).

Self-propelled High Clearance Sprayer

The Akola Centre of AICRP on FIM has carried out prototype feasibility testing of PAU self-propelled high clearance sprayer in cotton crop at the university farm in 12 ha and in 5 farmers' fields in 16 ha. It was observed that the self-propelled high clearance sprayer could be easily operated in the cotton fields where the row-to-row spacing varied from 60 to 75 cm. The height of the crop was 65-110 cm. The boom height was adjusted according to the height of the crop, which varied from 0.85 to 1.30 cm. The sprayer was operated at a system pressure of 5 kg/cm², which could operate 16 nozzles giving a desirable spray to be deposited on the cotton. A swath of about 11 m was obtained during the spraying. The fuel consumption was 1.33 litres/ha. The volume of chemical solutions sprayed/hr varied from 176-200 litres/ha. The effective field capacity obtained was 2.52 ha/hr. During the spraying operation it varied from 2.15 to 2.89 ha/hr. The cost of operation varied from Rs 50.90 to Rs 68.40/ha. Self-propelled high clearance sprayer can achieve a time saving of 98.10% and a saving in cost of 82.27% when compared with manually-operated knapsack sprayer.

Lowland Rice Seeder

The TNAU, ANGRAU, and IIT Centres of the AICRP on FIM carried out prototype feasibility testing of the manual pre-germinated rice seeder in farmers' fields. Large-scale farm trials were conducted to assess the performance of lowland rice seeder in comparison with transplanted rice and broadcasting method. Grain yield was higher in the case of rice seeder at most of the locations.

The TNAU, Coimbatore and IIT, Kharagpur Centres of AICRP on FIM covered 133 and 100 ha area on farmers' field under prototype feasibility testing, respectively under large scale-testing. The field capacity of the device at 3 Centres varied from 0.08 to 0.14 ha/hr. The average field efficiency was 75%. The initial cost of the machine is Rs 2,500 and its cost of operation is Rs 600/ha. The machine is commercialized at TNAU Centre and 227 units sold. The ANGRAU, Hyderabad and IIT, Kharagpur Centres have also commercialized the unit.

Lowland rice-seeder is used for sowing pre-germinated rice in puddled field





Field performance of lowland rice seeder in different agro-climatic zones of Tamil Nadu							
Location	Variety	Plant population (no./m ²)			Grain yield (tonnes/ha)		
		T1	T2	T3	T1	T2	T3
Coimbatore	ADT 38	54	112	76	5.16	4.55	5.55
Aduthurai	ADT 38	50	72	64	5.09	5.25	5.72
Ambasamudram	ASD 16	50	72	70	4.04	4.02	4.27
Tanjore	ADT 36	47	55	51	5.60	5.80	7.60
Madurai	ADT 36	50	58	53	4.58	4.50	4.66
Bhavanisagar	ADT 38	51	68	65	8.58	7.45	8.65

T1, Transplanting; T2, broadcasting; T3, rice seeder

POST-HARVEST ENGINEERING AND TECHNOLOGY

Model Agro Processing Centres

Agro Processing Centres (APC) were developed under AICRP on PHT for Punjab, Karnataka, Gujarat, Tamil Nadu and Uttar Pradesh. These are multi-product processing units working on job shop concept for round-the-year operations in rural areas utilizing local skills. A typical APC in Karnataka designed for a cluster of 2-3 villages comprises a multi-crop cleaner and grader, rice sheller, polisher, grain pearer, *atta ckakki* (for *ragi*), a hammer mill for spices and condiments, mechanical oil expeller and filter press, a mini *dal* mill, *papad* press, tamarind deskinning, deseeding and sheeting machine, weighing balances, and packaging machinery, besides a potato chip making unit. The entire machinery costs about Rs 4 lakh. Space requirement is about 16 m × 5 m. The unit provides employment to 6-8 persons round-the-year. The returns on investment of such unit is 15-20%. The APCs established in Aradeshalli and Banawadi villages near Bangalore, Ferina village in Dhoraji Taluka of Rajkot (Gujarat), and Mota Haldu village near Haldwani in Uttaranchal have been the leading centres. In Punjab, models evolved by the PAU, Ludhiana Centre of the AICRP on PHT have been widely adopted at the Government and private level. About 100 APCs have been established during the IX Plan in the state. In view of the success of such units, the World Bank has offered to provide funding for 600 such APCs to be established in different locations in Karnataka. The AICRP on PHT Centre at UAS, Bangalore has been assigned responsibility for detailed planning.

Insect Trap Bin for Reduction in Storage Losses

Wondering behaviour of insects was successfully utilized in developing metal bins with perforated ducts installed inside the bin called insect trap bins. Technology developed earlier at TNAU, Coimbatore under A P Cess Fund project was field tested under the AICRP at Junagadh Centre with scaled-up farm level conditions. For metal bins of 100 kg capacity, storage losses in wheat were reduced by 50% to that of control (metal bins without perforated ducts and fumigation). For groundnut, this technology was not found effective against insects, viz. bruchid (*Caryedon serratus* Fab.), rust red flour beetle (*Tribolium castaneum* Hb.) and corcyra (*Corcyra cephalonic* Stanton).

Evaporatively Cooled Structure for Oranges and Potato

For on-farm storage of freshly harvested oranges up to 10 days and potatoes up to 3 weeks, an evaporatively cooled hut type structure has been developed at PKV, Akola Centre of the AICRP on PHT. The concept of the IARI designed Zero Energy

- Agro Processing Centres developed for 5 states under AICRP on PHT
- An evaporatively cooled hut type structure for oranges and potato developed at PKV, Akola Centre of AICRP on PHT
- Green chickpea shelling machine developed at JNKVV, Jabalpur Centre of AICRP on PHT
- A fluidized bed drier for mushroom developed at TNAU, Coimbatore Centre of AICRP on PHT
- A drier of 3,000 coconuts/batch capacity developed at CPCRI, Kasaragod Centre of AICRP on PHT
- A machine for production of snowball from tender coconuts developed at CPCRI, Kasaragod Centre of AICRP on PHT
- A power-operated mechanical seed extractor for pomegranate developed at MPKV, Rahuri
- A demand feeder designed at CIFA, Bhubaneswar.
- Aqua filter system designed at CIFA, Bhubaneswar to function as external biofilter



Cool Chamber was used here to develop a structure of much larger capacity for use by the farmers and traders. The structure has a capacity of 1.5-2.0 tonnes, costs about Rs 15,000 and helps reducing temperature and increasing humidity for enhanced shelf-life through evaporative cooling and humidification.

Evaporatively Cooled Room for On-farm Pre-cooling and Storage of Fruits and Vegetables

Evaporatively cooled (EC) room ($3 \times 3 \times 3$ m) of about 2 tonnes capacity has been constructed at CIPHET, Ludhiana for on-farm storage of fruits and vegetables. It is double-walled 11.3 cm thick each of bricks with an 11.3 cm sand filled in between. Its floor is made of cement concrete, and the roof is of reinforced brick concrete. At the top of sand fill, just below the roof, a drip irrigation pipe is laid out all around and connected to an overhead PVC water tank. The water keeps dripping over sand, which, in turn, keeps the outer and inner walls wet. While evaporation from outer wall keeps the room cool, the indoor wall keeps high humidity due to evaporation. An air inlet at door bottom and air outlet at roof provides conditions for natural ventilation to minimize possible development of microbes on stored produce. The EC room costs about Rs 35,000.

During preliminary trials in early January and late February kinnows, cauliflower and tomatoes were stored. Small-scale trials were conducted for a load varying from about 100 to 200 kg fruits/vegetables kept in stackable plastic trays. Trials showed a definite advantage for enhancing shelf-life of these fruits and vegetables mainly due to maintenance of high (>85%) relative humidity (RH) throughout the day inside the EC room. Compared on the basis of 10% physiological loss in weight, the shelf-life inside the EC room was 34 days for early kinnows, 23 days for late kinnows, 11 days for cauliflower and 19 days for tomatoes. It was 21, 11, 3 and 7 days, respectively for these fruits/vegetables stored in an ordinary room at the same time.

Green Chickpea Shelling Machine

For use of green chickpea as salad, blanched and salted snack food, vegetable ingredient etc., a green chickpea shelling machine has been developed at JNKVV, Jabalpur Centre of AICRP on PHT. It has a capacity of 50 kg/hr of pods, requires 0.4 kW electric motor and one operator. The machine costs Rs 20,000. The green chickpea grains obtained from the machine could be packed in LDPE packs and cold stored for longer shelf-life.

Betel Leaf Curing Chamber

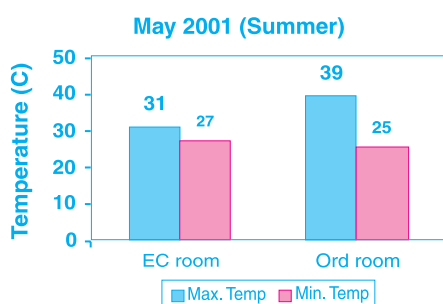
For reducing the time of betel leaf curing and better uniformity in quality of cured leaves, a betel leaf curing chamber for 10,000 leaves/batch has been developed at Bhubaneswar Centre of the AICRP on PHT. It has distinct advantages over the traditional VAT system in overall economy and better quality. The Chamber is constructed from stainless steel and mild steel components. It resembles a BOD incubator and has arrangements for controlling the temperature and ventilation. It costs Rs 40,000.

Modification of Arecanut Dehusker

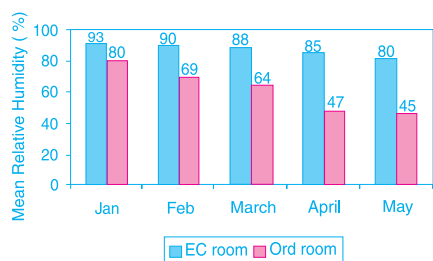
The capacity of traditional knife (popularly known as *Adikemane*) to dehusk arecanuts is about 7.5 kg/hr per person. An arecanut dehusker (manual) has been designed and developed at UAS, Bangalore Centre of AICRP on PHT. It can be operated simultaneously by 4 persons on a common working table. It has a capacity of 80 kg/hr by 4 persons. Besides time saving, it reduces drudgery and fatigue of workers.

Mushroom Drier

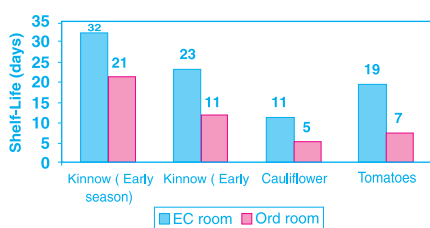
A fluidized bed drier for mushrooms having capacity of 5 kg/batch has been



Comparison of maximum temperature inside evaporatively cooled room and ordinary room



Comparison of relative humidity (mean) inside evaporatively cooled room and ordinary room



Increase in shelf-life of fruits and vegetables stored in evaporatively cooled room and ordinary room



developed at the TNAU, Coimbatore Centre of AICRP on PHT. Large-scale field evaluation of the drier was conducted at the District Women and Children Rural Development Agency (DWCRA) and Amman Mushrooms Farm at Sengulam, Erode District for oyster and milky mushrooms. It uses 46-54°C hot air and dries mushrooms in 2 hr against 7-9 hr by sun drying at 35 m³/min. of air flow rate to 10% moisture content. A cabinet type mushroom drier using hot air coupled with a centrifugal spin (blanch water draining) system costing Rs 15,000 has also been developed at CIAE, Bhopal Centre of the AICRP on PHT.

Drier for Coconuts Using Combination of Solar Energy, Electricity and Agricultural Wastes

For drying coconuts, a drier of 3,000 coconuts/batch capacity using combination of solar energy, electricity, and agricultural waste has been developed at the CPCRI, Kasaragod Centre of the AICRP on PHT. It takes about 33 hr to dry the coconuts and saves considerable amount of time over traditional sun drying. The dryer has facility for an electrical back-up controlled by electronic switching circuits. Electric heaters of 2 kW capacity each (6 nos.) are switched on only when the temperature inside the drying chamber is less than 55°C and switched off when the temperature exceeds 70°C. A separate control circuit is also incorporated to switch off the heating system once the drying is complete. This is done by monitoring the exhaust temperature using thermistor sensors.

Development of Solar Tunnel Drying System for Agricultural Produce

Solar tunnel dryer (STD) with 3-tier drying chamber has been developed under an ad-hoc scheme at IIT, Delhi. The division of drying chamber in 3-tier has made it thermally more efficient (by reducing heat wastage) and economically viable (by reducing length of the dryer). The solar tunnel dryer has the capability to dry about 2,000 kg low moisture crop, e.g. barley within 2 days. This modification enhances drying rate and reduces drying time. The length and diameter of STD are 6 m and 1.5 m, respectively. Experiments were also conducted on tomatoes. The observed initial moisture content of tomatoes was 94% (wb) and the final about 6%. The rate of drying is much faster inside the drier than in open under the sun.

Snowball Tender Coconut Machine

A machine for production of snowball from tender coconuts has been developed at CPCRI, Kasaragod Centre of AICRP on PHT. It has a capacity of 20 nuts/operator/hour. The machine is operated by 0.75 kW electric motor. Packaging technology for the snowball tender nuts has also been developed. Briquettes are also prepared from the pith and shell pieces of tender coconuts. Thus, whole of the coconut is used in this value-addition process without any part going as waste.

Development of Intermediate Moisture Coconut Chips

Process for production of intermediate moisture coconut chips has been developed at CPCRI, Kasaragod Centre of the AICRP on PHT using osmotic dehydration. The maximum rate of dehydration and best colour of the chips were obtained at 55–63° Brix. Agitation is not required but stirring of the syrup once every 10 min. was found best. The sweet coconut chips prepared by using 55-63° Brix sugar syrup strength with salt concentration of 3-4% with respect to syrup volume followed by hot air drying at 50°C is recommended for use of the product as snack food.

Refined Technology for Bottling of Sugarcane Juice

A process has been developed at TNAU, Coimbatore to preserve sugarcane juice up to 120 days in glass bottles using sodium benzoate (125 ppm) and pasteurization of filled bottles. The process costs less than Rs 2/180 ml bottle. Feasibility report of the project has been prepared for the benefit of the potential entrepreneurs.

PRE-GRINDER FOR OILSEEDS

This machine consists of 2 mild steel rollers having 45 cm length and 20 cm diameter. These two rollers rotate in opposite directions at 400 rpm. The gap between the rollers can be adjusted from 1 to 10 mm. This machine is operated by 1 hp 3-phase motor. The ground material is fed to the expeller, which facilitates easy expelling of oilseeds that results in less number of passes required for oil extraction in a mechanical expeller.



A pre-grinder for oilseeds of 100 kg/hr capacity has been developed at CIPHET, Ludhiana



BLENDER-CUM-MIXER

For uniform mixing of an enzyme/water with an oilseed as a pre-treatment, a blender-cum-mixer has been designed and developed at CIPHET, Ludhiana. This mixer consists of a cylindrical drum of mild steel having 100 cm length and 48 cm diameter. It is mounted on a central shaft having 12 fan blades for uniform mixing. This mixer is manually as well as power operated. It can be operated by 1 hp 3-phase motor. It is a batch type of mixer with 40-50 kg batch capacity.



Blender-cum-mixer has been developed at CIPHET, Ludhiana for enzymic treatment of oilseeds under controlled conditions

Technology for Producing Corrugated Roofing Panel from Crop Residues

Fibre board and roofing panels have been prepared at JNKVV, Jabalpur from soybean straw with phenol formaldehyde (PF) resin in the concentration range of 10-12%. Cement bonded soybean boards and corrugated roofing sheets were made and tested for various physical parameters, viz. water absorption, mass density, tensile and compressive strength etc. Cement-bonded soybean straw particle boards in the ratio of 12:88 have shown good mechanical properties and fire resistance. Corrugated cement-bonded straw sheets have shown good prospect as a roofing substitute to G I sheets and asbestos sheets. Test specimen of cement-bonded corrugated sheets and tiles have also been developed.

Mechanical Seed Extractor for Pomegranate

A power-operated mechanical seed (arils) extractor for pomegranate has been developed at MPKV, Rahuri. The machine consists of main frame (made of mild steel), shaft with knife, concave, feeding chute and power transmission. Fruits are fed one by one through the feeding chute and are cut into pieces by the knives fitted on the shaft rotating at 300 rpm. The knives are mounted on the shaft 50 mm apart at 90°. The seed separation efficiency of the machine was observed to be 96%. The capacity of the machine varies between 140 and 160 kg/hr of pomegranate. Seeds separated by the machine have 97% purity. Preservation studies revealed that juice could be stored up to 270 days at 5±1°C after pasteurization with 100 ppm KMS as preservative. Juice can also be stored up to 120 days at room temperature. The rind of pomegranate has been dried at 80°C temperature for 5 hr to obtain powder. Hammer mill with 100-mesh sieve gave fine powder. The pomegranate seeds are dehydrated to prepare *anardana*.

Technology for Smoking of Buffalo Meat

Process for smoking of buffalo meat and preparation of value-added products have been standardized at AMU, Aligarh. The curing solution contained salt, sugar and sodium nitrate while the anti-oxidant used were sodium ascorbate (500 PPM) and sodium hexa meta phosphate (SHMP). The meat samples were stored at 0°C and 5°C temperature in LDPE/HDPE/PP bags and aluminium-foil. Smoking for 8 hr at temperature ranging between 50 and 60°C caused significant increase in pH of raw meat, which increased up to 6.25 (initial value 5.85). It also improved the colour, texture, and odour with respective score values of 7.33, 7.67 and 7.33 and caused reduction in microbial population. The shelf-life of smoked meat samples packed in LDPE bags was 46 days at 5°C storage temperature. Curing followed by smoking for 9 hr at temperature ranging between 50 and 60°C made remarkable improvements in pH and as well as developed desirable functional properties in meat samples. Value-added products namely, *Shami kabab* and fresh *kabab* were prepared by frying, tandoor cooking and microwave oven processing; packed in LDPE and HDPE bags and stored at 0 and -10°C temperature for one month. Among various cooking methods, microwave processing was found to be the best, as it caused minimum cooking losses (27%) as compared to fried *kabab* (28.5%) and *tandoor kabab* (31.7%).

Development of Starch-based Edible Film

Considering the end of use of the films, and expected functional behaviour of different biopolymers, plasticisers, cross-linking agents and other additives, about 1,500 films have been cast using various compositions at IIT, Kaharagpur. Biopolymers included amylase, cellulose derivatives, alginate and gelatin; plasticisers included di- and tri-hydroxy alcohols. Almost all these films are transparent (opacity 4-6%), thin (0.06-0.11 mm thickness), light (density 1,100-1,300 kg/m³) and remain flexible for a wide range of temperature. The maximum values of ultimate tensile strength, tear strength and puncture strength of the films so far obtained with few compositions are 35 MPa, 20 N/mm and 14 N, respectively. The films become soggy



and tender when put in water at normal temperature, and preliminary investigation indicated that 10 layers of such films piled together could be crushed with a force as low as 5.9N. This implies that the films could be easily dispensable in water under mild mechanical action. The dry films of certain blends showed oil absorption of about 6%, thus, suggesting good oil barrier property. It is observed that all films could be stored without any visible deterioration at normal atmospheric condition except in rainy season. Incorporation of some antimicrobial agents in the blends and testing showed substantial extension in shelf-life to 29 days from 3 days in control under average monsoon simulated condition (35°C, 95% RH). Test with the adult insects of *Sitophylus oryzae* showed no visible damage to the films.

SOYBEAN PROCESSING

Use of Alternate Solvents

Studies on the use of alternate solvents for extraction of soybean oil revealed that the extraction temperature was directly correlated to oil recovery. Hexane was found to give highest oil recovery of 99.5% while heptane gave 99.0% recovery. The aqueous solvents showed same trend but the required temperature and time for attaining 99% recovery were higher. The proportion of water added was found to adversely affect the recovery of oil. Use of azeotropes was found to be efficient in the extraction but the time required to attain 99% recovery of oil was more than 10 hr as against 7 hr with pure solvent. The advantage of using azeotropes lies in the facts that the residual solvent in oil as well as in desolventized soybean meal was considerably less and the time and temperature required for extraction of oil were also less because of lower boiling point.

Characteristics of Solvent-extracted Meal

The solvent-extracted meal was found to contain more than 50% protein in all cases irrespective of the solvents used for oil extraction. The residual oil, fibre and ash content were also almost of similar levels. The NSI and oil content were low and urease activity was nil. The meal was found to have low total bacterial and fungal counts and was thus well within the permissible limits recommended by BIS. The meal was found to be free from indicator pathogens, viz. Coliforms and Salmonella. The residual solvent was also within the permissible limits of 170 ppm.

Production of *shrikhand* from Soy Milk

Preliminary experimentation showed that curd formed with soymilk was quite loose, as soy milk contained only about 2.5% fermentable sugars that too in the form of oligosaccharides. These are normally not fermented by all lactic acid bacteria. The titrable acidity developed in raw soy milk and thereby curd formation was considerably poor. Also incomplete fermentation of soymilk was observed. By the addition of 2.0% glucose, the yields of *chakka* and *shrikhand* were increased by 1.5 folds. Highest increase of 199 g in *chakka* and 389 g in *shrikhand* was obtained with 3.0% glucose supplementation with excellent quality of curd and *chakka*.

Shrikhand Prepared from Soy Milk and Cow Milk Blend

The *shrikhand* was also prepared from soy milk blended with cow milk in different combinations of 0, 25, 50, 75 and 100% of cow milk. The yield of *chakka* with cow milk alone was 220.50 g/litre while with 50% soy milk it rose to 284.50 g/litre of milk blend. *Shrikhand* prepared from standard milk and soy milk blends also showed the similar trend for yields of *chakka* and *shrikhand*, i.e. the yield of *shrikhand* was almost 2 folds higher than the yield of *chakka*.

The total solids were found to have increased with increase of soy milk concentration in the milk blends. With 25 and 50% soy milk supplementation, *shrikhand* yields were 560.50 g and 566 g/litre of the blend, respectively. The quality

VALUE-ADDED PRODUCTS FROM SORGHUM

The processes for preparation of *sev* and *papad* from sorghum were developed and evaluated in laboratory. The processes were standardized. Soyflour (10%) was added in the sorghum flour for nutritional enrichment of *sev*. For quality product with nutritional enrichment, Bengalgram flour in the proportion of 10, 20, 30, 40 and 50% was added in sorghum flour with 10% soyflour for preparation of *sev*. From the sensory evaluation it was revealed that the product prepared from addition of Bengalgram flour @ 40% and 50% in sorghum flour with 10% soyflour are on par with each other and significantly superior over products prepared with sorghum flour + 10% soyflour, sorghum flour + 10% soyflour with 10, 20, 30% Bengal gram flour. In *papad*, the soybean flour was mixed with sorghum flour in the proportion of 0, 5, 10, 15 and 20% for nutritional enrichment. It was revealed from sensory evaluation that the product prepared with 10% soyflour is significantly superior over products prepared with 0, 5, 15 and 20% soyflour. The study revealed that mixing of Bengalgram flour 40% in sorghum flour and 10% soyflour is better for preparation of *sev* and addition of soyflour up to 10% with sorghum flour is acceptable for preparation of *papad*.



PRODUCTION OF DIETARY FIBRE FROM SOY HULL AND OKARA

Soy hull was first treated with an acidic solution (0.01N HCl) to solubilize the protein component that is soluble under acidic conditions. The fibre was subsequently filtered and washed with alkali (0.01N NaOH) to get rid of proteins, which were soluble in alkaline solution. Subsequently, the hull was filtered and washed thoroughly with water till no colour was seen with phenolphthalein indicator in the washed water. The colour of the product was greenish. In the next series of experiments, alkali treatment was eliminated. This resulted in improvement in colour, which was slightly creamish. The hull and the products obtained were analyzed for protein, fat, crude fibre, neutral detergent fibre, acid detergent fibre, hemicellulose, cellulose and lignin. The treatments were effective in reducing the protein contents and increasing the ADF fraction, thereby reducing the hemicellulose fraction.

of *shrikhand* was in accordance with the recommended levels of the different constituents as per BIS standard. Sensory evaluation revealed that *shrikhand* prepared with soy milk supplementation up to 50% (v/v) was acceptable.

Preparation of Soy-fortified Doughnuts

Doughnuts were prepared using full fat soy flour with 10, 20 and 30% blends in the basic formula. On the basis of the dough consistency data, it was concluded that as the level of soy substitution increased, amount of water due to increased water absorption by the flour required for developing the desired dough, sheetable consistency increased. The doughnuts prepared by 20% soy substitution fried at 170°C indicated increase in frying time, lipid content and oil uptake (24.7%). However, the lipid content and oil uptake by these soy-fortified doughnuts were always lower than the control (33 and 31%, respectively). Hence, 20% soy substitution level was judged the best. The lipid content and oil uptake for 30% soy substitution were 39 and 32%, respectively. It was observed that the moisture loss of the sample with 20% soy substitution was minimum. This finding is further corroborated by another result, i.e. final moisture content, which again is highest in case of the same sample. On the basis of oil uptake and acceptability score it was observed that doughnuts with 20% of soyflour substitution were much better than the control sample.

PLASTICS IN AGRICULTURE

A demand feeder using transparent acrylic plastics material was designed at CIFA, Bhubaneswar for pond culture systems to feed the fishes. Feed drops by gravity onto an adjustable 100 mm diameter circular acrylic feed platform, which was positioned below the tube and above water level. When fish activates the rod, which is suspended from the conical tube on V-shaped steel wire, feed pellets from hopper falls on the platform and are retained on it.

Closed Loop Water Filtration for Aquarium

An aqua filter system was designed at CIFA, Bhubaneswar to function, as an external biofilter, made of plastics suitable for using in big aquariums with a back-washing facility. It can be operated continuously with two sets of aerators under the control of 1 hr sequential timer. It has a provision for controlling the inlets/outlets water and back-washing facilities using valves. It also has the facility to fill and drain water to the aquarium through filter. The system has been found working efficiently on a continuous basis. Study on the bacterial density with reference to the total heterotrophs was estimated to be 90/ml in the inlet water of the system.

Floriculture Under Polyhouse

Five cultivar varieties of gladiolus, viz. Trader Horn, Rose Supreme, Jackson Gold, Fedello and Wind Song were planted in Polyhouse as well as in open field condition at CIPHET, Abohar. Of the five cultivars of gladiolus tested, Trader Horn and Rose Supreme proved better than the other cultivars when grown inside the polyhouses in respect to spike length and number of florets. Number of florets were found significantly higher to the tune of 3.8 and 4.3 respectively in Trader Horn and Rose Supreme cultivars. Earliness of 28 days was achieved by growing gladiolus inside the polyhouses. Maximum vase life of 9 days was observed for Rose Supreme and Trader Horn grown inside the polyhouses. Cultivars Rose Supreme and Trader Horn were found best-suited for the agro-climatic conditions of Abohar when grown under polyhouse cultivation.



Closed loop water filtration for aquarium. This system is beneficial for the ornamental fish growers, hobbyist, small and marginal farmers



COTTON TECHNOLOGY

Force Requirement for Cotton Picking, Stalk Uprooting and Stalk Cutting

Cotton picking, stalk uprooting and stalk cutting forces were measured at the GTC of CIRCOT at Nagpur by using a recently developed test rig. Among CNH 36, Anjali, LRA 5166, AKA 8401 and AKH 4 tested, the variety Anjali was found to require a maximum picking force of 0.598 N/gm of *kapas* followed by AKH 4, LRA 5166, AKA 8401 and CNH 36 in that order. The maximum uprooting force of 930 N was measured for AKA 8401 and the minimum of 430 N uprooting force was noted for CNH 36. The maximum cutting force was measured (1500 N) for cotton stalk of diameter 14 mm with a moisture content of 64.7% (db). Based on these findings, a cotton stalk puller-cum-chipper has been designed.

Short Fibre Content and Yarn Imperfections

Spinning trials at CIRCOT on cotton having the same fibre quality as indicated by 2.5% span length, micronaire and fibre strength showed that yarns spun to the same count from the above cottons although had the same strength but differed considerably in imperfections. The results brought out the influence of short fibre content and presence of the fine foreign matter consisting of micro dust and trash in lint on yarn uniformity.

The study highlighted the need to: (i) estimate/measure additional fibre qualities to ensure more uniform yarn production at spinning stage, and (ii) to minimize such factors as generation of short fibres and foreign matter during ginning and handling.

Variable Speed Gin

To improve the productivity and bring down cost of ginning, an attempt was made at CIRCOT, Mumbai to modify a commercial DR gin by independently controlling the speeds of both roller and beater by changing the driving mechanisms of the two most important parts of the machine. This modified machine yielded 50-80 kg of lint/hr on an average, with no extra demand on the power as against conventional gins which give an out-put of 35-40 kg/hr. More than 3,000 factories employing over 30,000 DR gins can benefit by this modification, as this can bring in an annual saving over Rs 80 crore at the present rate of raw cotton (Rs 15,000/100 kg).

Spinning of Indigenously Developed Short Wool in Blends with Cotton on Short Staple Spinning Systems

An attempt was made at CIRCOT to explore the possibility of producing Avivastra wool-cotton blended good quality yarns by adopting short staple commercial spinning systems. It was found that Avivastra wool can be blended to the extent of 40% for production 16s and 20s Ne yarns on ring spinning system and up to 30% for production of 16s Ne yarns on rotor spinning system. Ring yarns had relatively better lea CSP and single thread tenacity, higher unevenness (U%) imperfections and hairiness as compared to rotor yarns. Through this study, CIRCOT has identified several factors for successful processing and production of Avivastra wool-cotton blended yarns.

Spinning and Weaving Trials on Naturally Coloured Cottons

Detailed bulk scale spinning and weaving trials on indigenously-grown naturally coloured cottons undertaken at CIRCOT revealed that coloured cottons are more amenable to cleaning and mechanical processing than the normal white cotton. The fabrics prepared from coloured cotton showed better fastness properties to washing, perspiration, rubbing and light and possess good handle value. Coloured cottons could be best utilized in combination with white cottons to produce attractive fabrics and garments and their eco-friendliness could give an added advantage for promotion even in International markets.



Sweet pepper in polyhouse

VEGETABLE WITH POLYHOUSES

Studies were carried out for determining vegetable sequence under round-the-year vegetable production using greenhouse technology at Choudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur and CIPHET, Abohar. Capsicum-cabbage-green onion was found to be most suitable with benefit : cost ratio of 2.7 at Palampur, whereas spinach (one cut)-broccoli-sweet pepper was most remunerative with benefit : cost ratio of 5.1 for Abohar region. The average temperature inside the greenhouse was 5-8°C higher, the relative humidity 4-12% higher and the evaporation was 1.5-2.5 mm/day higher compared to outside.

- A cotton stalk puller-cum-chipper developed at CIRCOT, Nagpur
- Attempt made at CIRCOT to explore the possibility of producing Avivastra wool cotton by adopting short staple commercial spinning system



STRAWBERRY CULTIVATION IN ABOHAR REGION

Mr Nachatar Singh, a progressive farmer of Nandgarh village of Muktsar district was very eager to grow high-value crops and after coming in contact with the CIPHET, Abohar got the motivation to grow strawberry, which is not grown traditionally in that area. After attending training programme on strawberry cultivation and with the help of AICRP on APA Centre, Abohar, he planted strawberry on 0.8 ha for which about 50,000 strawberry runners of chandler cultivars were brought from Himachal Pradesh and Maharashtra. The runners were transplanted in October and micro-irrigation system was used for irrigation and fertigation on which about Rs 1.8 lakh were spent. Mr Nachatar Singh obtained strawberry yield of approximately 34.0 tonnes/ha. The fruits were sold in the markets of Delhi, Chandigarh, Amritsar, Muktsar, Bathinda, Faridkot, Malout, Abohar, Moga, and other cities at rate ranging from Rs 40 to 200/kg. He earned a profit of Rs 2.5 lakh/ha. Now he plans to export strawberry fruits to Middle East and some European countries.

Eco-friendly Azo Dyes

Research findings have identified many of the aromatic amines that are employed in the production of azo-dyes as carcinogens. These findings have led to the ban on certain azo-dyes both in India and many European countries, necessitating research on finding out alternate safe dyes.

Studies carried out at CIRCOT employing a few non-carcinogenic aromatic amines and a series of safe coupling agents have yielded 20 non-carcinogenic dyes. Few of the above dyes were further chemically modified and new reactive dye (cold brand) was synthesized. The new dyes have good dyeability with satisfactory fastness characteristics. Large-scale preparation at laboratory was successful with good yield potential.

Natural Dyes

The CIRCOT, working in collaboration with several organizations, has identified potential dye-yielding plants from the western Maharashtra. Forty-two plant materials were studied to standardize their application techniques on cotton. Different conditions were tried to extract the dye from powered plant materials. Fabric samples were dyed with these extracts under different dyeing conditions. Best extraction and dyeing recipes for each plant material were selected on the basis of visual assessment of dyed samples and also by comparing colour strengths. By changing the dyeing/extraction conditions, different shades were obtained for the same plant material. The dyed fabrics were also tested for light and wash fastness. On the basis of colour obtained on dyed fabrics and its fastness properties, plant materials were classified into high, medium or low priority category. Out of the 42 plant materials tried, about 20 plants yielded good colour on cotton with moderate to good fastness properties and were placed in high priority category.

LAC TECHNOLOGY

Biological Control of Lac Predators by Insect Parasitoids under Field Condition

Field release of *Trichogramma chilonis*, *T. pretiosum* and *T. brasiliensis* (by means to trichocards) carried out on lac crops grown on *Butea monosperma* (*palas*), *Flemingia macrophylla* (*bhalia*) and *Schleichera oleosa* (*kusum*) showed 50-91% control of lepidopterous predators of lac insect and more than 2 times broodlac yield over control. The recent findings have opened a new vista in the management of the serious predators of lac insects on one hand, and boosting the eco-friendly lac production, on the other.

Development of Lac Varnish for Wood and Hot Melt Adhesive for Packaging Industry

Shellac-based spiritless wood varnishes MSV 001 and MSV 005 were compared with touchwood, melamine coating and french polish on plywood and observed that MSV 005 is better in respect of gloss, good brushability, good clarity and acceptable smell over market formulations and is economical as compared to other products. Hot melt adhesive was found very good for carton, book binding, leather to sole, copper to copper and wood to wood as a packaging material which is prepared in 2 kg/lot.

Lac Wax-based Emulsion Formulations for Extending Shelf-life of Fruits and Vegetables

Lac wax was used to prepare emulsion for coating of fruits and vegetables. Several formulations with different compositions were prepared and tested on Mango (cv. Dushheri). Fully matured unripened mangoes were coated with these emulsions



and stored at ambient temperature and humidity (20-30°C and 72-90% RH). The physiological loss in weight and the changes in firmness, titratable acidity, total sugar, total soluble solid content and the organoleptic characteristics of the coated and uncoated (control) samples were determined periodically.

JUTE TECHNOLOGY

Fungal Culture as Processing Aid in Jute Industry

The NIRJAFT has developed an eco-friendly microbial method for softening and upgrading of barky jute/root cutting using fungal culture, *Penicillium corylophilum*. Study of 3 main enzymes has shown that the fungus has high pectinase but low cellulase activity. This property has attributed towards the suitability of the culture as a softening agent for barky jute/root cuttings, without any adverse effect on fibre strength. Pilot plant trial conducted at industry level has proved the efficiency of this culture as a processing aid in jute industry.

- Power ribboner of improved design developed by NIRJAFT, Kolkata
- Low-cost jute and jute-blended carpet developed by NIRJAFT, Kolkata

Mechanical Extraction of Fibre

There is acute shortage of adequate water for conventional plant retting. Hence, NIRJAFT evolved alternative method for extraction of green bark from the harvested plant by ribboner and retting the ribbons thus extracted in comparatively much less volume of water.

For manual extraction of green bark, ribboners of two different designs were fabricated in the Institute, one as horizontal type single roller and the other as vertical type double roller. During the last jute harvesting season in August a field trial and demonstration of such ribboners were conducted at Uttar Dinajpur, West Bengal. The extraction of ribbon by single roller and double roller manual ribbons was demonstrated to a group of about 50 jute farmers at 3 sites. An appropriate power ribboner of improved design has also been developed by NIRJAFT which can extract ribbons without breaking the sticks unlike the existing power ribboner of decorticator so far developed in the country or abroad. Two prototypes of such ribboners, one of laboratory model and the other of field scale model were designed and fabricated at the Institute. The field-scale ribboner has been provided with a motor as well as an oil engine of 2 HP capacity as alternative power. Besides, the ribboning capacity can well be enhanced during the operation as the said ribboner may also be used by two operators simultaneously in feeding the plant stems from both sides of the machine. Large-scale laboratory trials were conducted for extraction of ribbons from green plants by both the laboratory model and field-scale power ribboner when 135 of *Oltorius* and 90 of *Capsularis* plant stems were ribboned continuously. The observation on the functional operation of the machine showed that the ribboning was trouble-free and the sticks separated in full length were almost without any bark throughout the whole length unlike the extraction by manual ribboners.

PC-interfaced Jute Yarn Hairness Meter

An instrument has been developed by NIRJAFT, Kolkata to handle the problem of hairness of jute yarns and suggest measures for its control. The instrument counts the number of protruded fibres (hairs) on a pre-determined length at a particular distance from the yarn surface by a silicon photo-transistor and expresses the results digitally. The instrument has been interfaced with a computer to collect, store and analyze data to give various statistical calculations and graphical representations along with print-outs of the results. The software developed renders automation of the instrument to control the driving motor, preset length of the yarn, the test-time and many other attributes. Though the instrument is developed for jute yarn in particular, it can be used for more coarse yarns as well as finer cotton yarns of 60's count or so.



Low-cost Jute Blended Carpet from Non-woven Textiles

Low-cost jute and jute-blended carpet from non-woven jute and its blends for floor covering using screen-printing process were developed by NIRJAFT, Kolkata. The top surface of the carpet has been printed with decorative design by application of pigment. The bottom surface of the carpet was finished by spraying some biodegradable adhesive. The application of resin helped prevent the shedding of jute fibre from the surfaces. The design printed in the carpet was similar to those of Persian style. Some of the jute industries have already shown interest to commercialize the product after visiting NIRJAFT.

Bio-pulping of Jute Stick

Mutation of fungi has been employed in the biopulping process of jute sticks by ultraviolet and X-ray irradiation at NIRJAFT, Kolkata. When UV rays were used as mutagen both *P. chrysosporium* and BP 8 enhanced the lignolysis, whereas there was a decrease in cellulolysis. Paper sheets made in the chemi-microbial process mutated fungi showed satisfactory properties and bleaching of the sheets gave even better results in respect of strength. Improvement in strength may be due to removal of materials not contributing to tensile properties. Bio-bleaching was also made with the crude enzyme preparation of the fungus BP 2. Brightness index improved to a significant extent. The properties of the paper sheets produced through this process compared well with those of hand-made paper available in the market.

ENERGY IN AGRICULTURE

Trend in Energy Requirement in Crop Production

- A repeat energy audits of crop production systems in different agro-climatic zones made under the AICRP on ERAS

Under the AICRP on ERAS energy audits of crop production systems in different agro-climatic zones have been undertaken to capture the energy-use patterns and its dynamic behaviour with changing cultivation practices. Studies indicate that in intensive agriculture practised in Punjab, the major change in energy-use pattern was that the use of animal power was almost dispensed with for field operations. Use of machinery energy has increased due to use of tractor with associated machinery. In some areas use of tractor have shown slight decline and consequently energy investment in diesel has slightly reduced. The results also indicated that fertilizer energy consumption rate for wheat cultivation was higher than recommended doses by 7.6-24% in different agro-climatic zones. Energy consumption over a period of time for wheat cultivation has shown variation to the extent of 10-15% due to change in energy resources.

In West Bengal, it has been observed that while traditional bullock-operated implements are in use, some areas have shifted to power tiller use. The recent adoption of power tillers has helped in reducing the use of human energy by 12% and animal energy by 97%. The total energy consumption has increased by 22% resulting in increase in crop yield from 1.6 tonnes/ha to 2.4 tonnes/ha. The specific energy consumption in traditional agriculture has increased by 13%, while it decreased by 12% with adoption of power tillers.

Studies conducted in Tamil Nadu indicated that energy saving was possible through proper utilization of the resources. In Kanya Kumari district (high rainfall zone), 49% higher yield of *kharif* rice was obtained using present practices through proper crop management and 10% higher investment in animal energy and 21% higher diesel energy. Similar trend was also observed in North Area to Thanjaur, Tuticorin and Coimbtore districts with some variations in percentage.

In areas practising soybean-wheat crop rotation in Madhya Pradesh, optimal energy resource allocations using improved cultivation practices provided maximum yield of 2,274 kg/ha of soybean, 5,464 kg/ha of wheat (tractor farm) and 5,511 kg/ha of wheat (mixed farm) with increase in energy productivity from 0.18 to 0.30 kg/MJ for soybean, 0.20 to 0.30 kg/MJ for wheat tractor farm and 0.22 to 0.32 kg/MJ for wheat mixed farm.

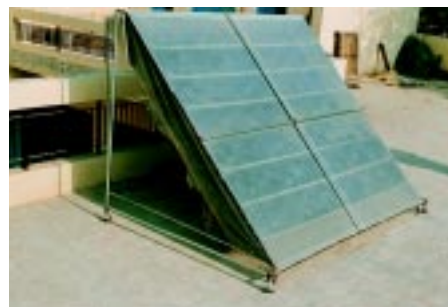


Studies indicated that on an average only about 10-15% of farmers were using energy resources properly. Optimal resource allocations with improved practices provide opportunity of savings in direct commercial energy sources and better use of animal energy.

RENEWABLE SOURCES OF ENERGY

Portable Farm Solar Dryer

The PAU, Ludhiana Centre of AICRP on RES has developed a large-sized natural circulation solar dryer. This new design of greenhouse type dryer has an option of drying the product under shade or without shade as per the requirement. It can be used to dry any agricultural produce in the form of small solid pieces or leafy products, e.g. garlic, turmeric, onion, chillies, ginger, fenugreek leaves, mangoes, grapes etc. The maximum temperature that was obtained inside the dryer was around 60°C. About 20-30 kg of product could be loaded at a time and dried in 2-3 sunny days. As compared to other designs of greenhouse type dryers, this dryer is more efficient due to less heat loss area, better back insulation, easy trading and unloading and better heat transfer because of air flow through the product. Its cost is also less due to lesser material requirement. The dryer was used by a farmer at village Jhande, district Ludhiana to dry fresh red chillies, who was satisfied with the quality of dried chillies which were sold at a price of about 85% higher than the chillies dried in open sun.



Portable farm solar dryer can be used at farms or remote places as no electricity is required for its operation. It costs Rs 3,000

High Performance Domestic Solar Dryer

The PAU, Ludhiana Centre of AICRP on RES has developed a small solar dryer suitable for domestic use. It is a natural circulation, integral, direct/indirect type solar dryer having solar interception area of 0.37 m². The efficiency of this dryer is high because of solar energy interception on inclined aperture and better utilization of the hot air by the trays positioned at different levels. Maximum stagnation temperature of 90-100°C and the working temperature of 50-60°C have been recorded. The products can be dried under shade or without shade as desired. The dryer has simple provision for changing inclination of the aperture by 15 E to capture more solar energy in different seasons. The drier was used for dehydration of garlic, turmeric, ginger, coriander leaves, fenugreek leaves and red chillies. Normally 2-3 kg of the product having initial moisture content of 85-95% was loaded at a time which got dried to a moisture content of around 5-7% in 2-3 sunny days.



The efficiency of the high performance domestic solar dryer is almost double than the conventional cabinet type solar dryers

Solar Photovoltaic-based Refrigerator

The SPRERI, Vallabh Vidyanagar Centre of AICRP on RES has successfully developed a system for operation of domestic refrigerator powered with solar photovoltaic panels. The system consists of an imported 73-litre capacity vapour-compression refrigerator equipped with 12 volts/24 volts DC compressor, SPV array of 180 Wp capacity, charge controller of 24 volts and 10 A rating and a battery bank of 24 volt and 130 A-h capacity. The power consumption of the refrigerator was 60 W. The system has provision to operate as bottle cooler, refrigerator and deep freezer by changing the thermostat settings. The refrigerator consumes 400 to 600 W-h of electricity/day depending on the mode of operation.

Step Type Solar Cocoon Stifler

A 2 m² solar collector was developed at CIAE, Bhopal and installed at Silk Reeling Centre, Hoshangabad for heating of shifting of cocoons. Peak stagnant temperatures in the solar cocoon stifler were observed 95°C and 120°C during typical sunny days in the winter and summer months, respectively under no load conditions. Fresh cocoons were loaded in the layers on the specially designed trays for placement



Step type solar cocoon stifter was found to be at par to stifled cocoons in the conventional ovens

in the stifter. It was possible to stifle about 60 kg green cocoon on a clear sunny day in March in 6 batches each of 10 kg. Stifling time for a batch of 10 kg cocoon varied from 45 min. to 90 min. as per the intensity of the sun. The average shell ratios of the green cocoons were 21. The stifled cocoons were reeled and the rendita (cocoon to silk ratio) obtained was 7.73 which was equivalent to stifled cocoons in the conventional electric oven.

Stand-alone Wind-diesel Hybrid Power System

A large number of wind farms employing high capacity wind generators (250-600 kW) have been installed on commercial scale in the country during the last few years. All these wind farms normally supply power into the state electricity grid which, in turn, is utilized for industrial applications either by the promoter of the wind farm or by third party(s) through arrangement with the State Electricity Board. Techno-economic feasibility of a small stand-alone wind-diesel hybrid power system of 3.6 kW capacity was studied. The system was installed in a mini housing complex of National Dairy Development Board (NDDB) at Gandhidham. It consisted of a 5 m diameter wind rotor-cum-generator mounted on a 23 m tall steel tower, a battery bank having 24 lead-acid deep discharge batteries, an inverter for converting AC to DC power and a standby diesel generator of 6 kW capacity for maintaining uninterrupted power supply when wind power generation falls short of the actual demand. The operation of the diesel gen-set was automatic and was set at 30% discharge level of the fully charged battery bank. The system withstood the severe earthquake experienced in Anjar, Gandhidham and Bhuj region of Gujarat on January 26, 2001. It continued supplying power to the mini NDDB housing complex at Gandhidham while the State Electricity Board power supply remained disrupted for many days. Such a system may be a very good option for uninterrupted electricity supply to remote villages not connected with state power supply grid and are located in windy regions. The power may be used for domestic, community and industrial applications.

Biomass Gas Stove

The TNAU, Coimbatore Centre of AICRP on RES developed a natural convection updraft type biomass gas stove for applications in rural household cooking, cottage industries and small commercial and community applications. The biomass gas stove consists of a hollow cylindrical body with its top open and bottom closed. The bottom is provided with an air opening and a shutter-cum-ash removal door. The top of the cylinder has provision for placing the vessel for cooking. The main fuels used were arecanut husk, casurina logs and coconut branches. The duration of flame obtained by loading 6 kg of arecanut husk and pieces of caesarean log and coconut branches were 75 min., 135 min. and 85 min., respectively. The study revealed that the time saved in cooking operation was around 40%. The saving in fuel consumption varied between 20 and 30%.

Generation and Purification of Hydrogen from Biomass and Evaluation with Alkaline Fuel Cell

At CIAE, Bhopal a 2.5 kW capacity down draft gasifier was used to generate producer gas for conversion of CO and H₂O into H₂. An experimental set-up was developed for optimizing the steam and gas flow rate in high temperature shift reactor for conversion. The reactor of 700 mm height and 30 mm diameter was fabricated with the provision to measure the temperature of reactor at different stages. The heating of reactor was accomplished by wrapping with 2.0 kW electric heating coil. The reactor was insulated using glass fibre of 50 mm thickness. The temperature of the reactor was controlled by changing the potential (v) in the heating element. The voltage was optimized to 65 V to 100 V to maintain the temperature of HT reactor, and the variation of voltage from 65 V to 100 V was sufficient in maintaining the reactor temperature in the range of 250° to 350°C. A commercial pressure vessel

- Large-sized natural circulation solar dryer developed by the PAU, Ludhiana Centre of AICRP on RES
- The SPRERI, Vallabh Vidyanagar Centre of AICRP on RES developed a system for operation of domestic refrigerator powered with solar photovoltaic panels
- A natural convection updraft type biomass gas stove developed by the TNAU, Coimbatore Centre of AICRP on RES
- The MPUAT, Udaipur Centre of AICRP on RES designed and developed a horizontal flow floating drum type biogas plant



was modified to generate steam required for supply to HT reactor. The output and steam temperature was monitored at different pressure. The optimum flow observed was 8.4 to 9.7 l/min. The initial experimental results shows that production of H_2 in above experimental set-up varied from 59.2 to 67.1% with gas steam flow ratio of 1 : 3.

ORP Trials on Improved *Chulha*

The PDKV, Akola; MPUAT, Udaipur and SPCW, Courtallam Centres of AICRP on RES carried out ORP trials on improved models of fixed type smokeless *chulhas*. The study revealed that selection of appropriate model of the improved *chulha* in keeping with the requirements of the family, different types of fuels commonly available in the village and the type of cooking appliances used in the region was found to be the most important factor in adoption of the improved *chulhas*. Savings in fuel consumption, ease of operation and maintenance and lower smoke level were found to be other important considerations for the users. Many of the rural families, who found that the new *chulha* was suitable for cooking all their dishes, saved significant quantity of fuels (25% or more) and emitted lower smoke, began using the improved *chulha* regularly and subsequently dismantled their traditional *chulha*.

BIOGAS GENERATION FROM KITCHEN WASTE

The MPUAT Udaipur Centre of AICRP on RES has designed and developed a horizontal flow floating drum type biogas plant for anaerobic digestion of fibrous agro-residues such as water hyacinth, kitchen waste, vegetable market waste and other farm

residues. The plant consists of a digester, a floating steel gas holder, an inlet and an outlet provided along the length of the digester and a manual stirrer for mixing the slurry inside the digester. On an average, a gas

yield of around 180 l/kg dry mass (varying between 150 and 210 l/kg dm) was obtained. No problem was encountered in operation of the plant during the period. A scaled-up plant of this design to produce on an average 9 m³ of biogas/day has been designed and installed at the Training Centre of Western Railway at Udaipur. About 80-100 kg waste from the kitchen and dining hall comprising uncooked and



cooked vegetables, *chapatis*, rice, pulses, etc. are fed into the plant everyday. The plant has been provided with a mechanical shredding unit for pre-treatment of the substrate before feeding into the plant. After its operation was stabilized, the

substrate was changed to the kitchen waste. Around 90 kg of the waste along with equal quantity of water, mixed thoroughly by the shredder is charged into the digester through the inlet chamber. The contents of the digester is

stirred by rotating the handle manually in both directions for 5-10 min. in the morning and evening everyday. The initial solids concentration of the substrate was kept between 8 and 10%. Average biogas production of 195 l/kg dry matter has been recorded. The average NPK content of the digested slurry have been reported to be 1.88%, 1.48% and 0.21%, respectively.

ANIMAL ENERGY

The ORP trials on improved yokes and animal-drawn equipment were conducted at different centres of AICRP on UAE. Two hundred Nagpuri yokes were distributed to farmers by Bhopal and Allahabad Centres to have feedback information from the farmers. Farmers liked the Nagpuri yoke as it increased the draughtability of their



animals and gave about 10-15% greater area coverage in field operations in comparison to the local yoke.

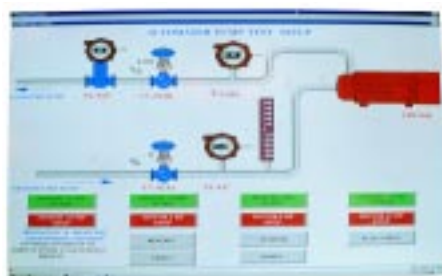
Single- double- and three-row wedge plough, increase sizes of *bakhar*, MB plough and cultivators matching to draught capacity of the animals were given to farmers for use. They reported that on an average about 25% increased area coverage was obtained by them using matching implements.

The ORP trials on use of donkeys for light field operations at Raichur Centre showed that a pair of donkeys weighing between 165 and 180 kg/pair could do the field job of a medium pair of bullocks. The average speed of working in field operation was about 3 kmph. A donkey could easily transport a pay load of about 0.5 tonne in donkey cart and 6-7 passengers in donkey *tonga* to a distance of about 5-6 km at one stretch without rest.

An improved gear drive system for operation of animals in rotary mode for operating an electric generator and many other agro-processing equipment has been developed under an ad-hoc scheme at BHU, Varanasi. The efficiency of this system is very high as compared to the existing rotary units available in the market. The system is being extensively evaluated.



Automatic pump and dripper testing facility are operated by the SCADA



SCADA with software RS VIEW 32 in which animated screens of testing set-up can be created with control buttons

IRRIGATION AND DRAINAGE ENGINEERING

Irrigation Equipment and System Testing Facilities

An automated testing facility for both pumps and drippers has been designed and installed at CIAE, Bhopal. The pump testing set-up includes Programmable Logic Controller (PLC), pressure transmitter for both suction and delivery pressures, discharge sensor with auto control valves, torque-sensor-cum-transmitter, speed sensor etc. for automatic measurement of various parameters. The dripper testing includes 25 tipping buckets with electronic counter for discharge measurement, PLC for automation, differential pressure transmitter across the filter, absolute pressure transmitter for measuring inlet pressure, submersible pump (0.25hp), pump regulating drive for changing rpm of the pump to maintain set pressure in the inlet. These two systems are operated by Supervisory Control and Data Acquisition (SCADA) using software RS VIEW 32. The SCADA acquires the data from the testing set-ups through PLC in the form of 4-20 mA signal received from the sensor-cum-transmitters. Historical trends and real trends of each measuring parameter in the system are plotted in real time using SCADA. Data acquired through automation are analyzed in MS EXCEL package. The system has Ethernet card facility to assess the information through LAN or Internet etc.

Automation of Surge Flow Irrigation System in Vertisols

A study was carried at the research farm of CIAE, Bhopal with different combinations of stream sizes (1.5, 2 lps), cycle times (5, 10, 15 min.) and cycle ratios (0.25, 0.50, 0.75). From the stimulated field experiments, it was observed that water front advance was more for all the cycle times and cycle ratios in both 1.5 and 2 lps stream sizes, when compared to continuous flow irrigation. While comparing the surge effect among the stream sizes, it was found that the combination of 1.5 lps stream size, 15 min. cycle time and 0.5 cycle ratio was better in view of more distribution uniformity co-efficient (92.3%), better water front advance and average moisture content at head, middle and tail of furrow reaching almost field capacity (28-31%) in irrigated furrows. For this combination, an increase of 28.33% and 7% in water front advance and distribution uniformity co-efficient, respectively, were observed over the continuous furrow irrigation.

Gabion Structures

A total of 9 gabion structures were constructed, installed and evaluated in 2 micro-watersheds of respectively, 169 and 193 ha area, in Pipilyahana and Umariya



Khurd near Indore city, where extensive gullies had formed. In one location in Pipliyahana, the gabions were of uniform size: 1×1×1m and the remaining 8 were of varying sizes. Prior to the constructions of these structures, there was no water storage as the run-off was flowing unhindered carrying silt with it and gradually deteriorating the gully. After construction, in one of the structures where detailed monitoring was done, the water storage capacity of about 400 m was achieved. An economic evaluation of the water harvesting structure equipped with gabions for sedimentation control at the Pipilyahana micro-watershed revealed an average benefit : cost ratio of 1.53 when the harvested water was used for irrigation. For identical gullies, the cost of conventional masonry gully controls structure was Rs 2,00,000 and for the gabion structure, it was Rs 40,000.

Sub-surface Drainage

Sub-surface drainage in the acid sulphate soils in the Kuttanad region of Kerala were evaluated in terms of its impact on the important soil chemical properties and the crop yield and a comparison was made with the conventional surface drainage system adopted by the local rice-growing farmers. The sub-surface drainage always resulted in a better soil chemical environment in terms of several soil chemical parameters and also crop yield. The sub-surface drainage effluent had much higher concentration on dissolved salts and onions as compared to the surface drainage water.

- An automated testing facility for pumps and drippers designed and installed at CIAE, Bhopal
- Field demonstrations of self-propelled rice transplanter, reaper harvester and zero-till drill conducted in Bihar

TRANSFER OF TECHNOLOGY

Technology Transferred to Government of Assam

Government of Assam was provided technical assistance for procurement of agricultural machinery, namely 8-row rice transplanter, manual rice thresher, self-propelled walking reaper, and riding type vertical conveyor reaper.

Rice Transplanter Demonstrations in Bihar

Field demonstrations of self-propelled rice transplanter at KVK, Harnaut, Brijwan Farm, Bihar Sharif and Mitthapur Farm - ARI, Patna were conducted in co-operation with Bihar Agricultural College, Sabour; RAU Agricultural Research Institute, Patna and District Agricultural Officer, Nalanda to demonstrate the benefits of mechanized transplanting of rice to farmers of traditionally rice-growing areas of Bihar.



Around 800 farmers from 65 villages and 100 Government officials of Bihar participated in the rice transplanter demonstration conducted at 3 locations

Demonstration of Reaper Harvester and Zero-till Drill in Bihar

Field demonstrations were organized at Barh, Harnaut, Mokama villages of Bihar. The then hon'ble Union Minister of Agriculture, Shri Nitish Kumar witnessed the demonstration of self-propelled reaper at Badaura village and zero till demonstration at KVK farm, Harnaut.

Supply of Prototypes to NEH Region

The CIAE, Bhopal supplied 1,242 prototypes costing Rs 8,45,129 to ICAR Research Complex for NEH region, Barapani, Shillong for demonstration in the Region under multi-location trial purpose.

HUMAN RESOURCE DEVELOPMENT

Summer School

A Summer School on *Energy Management in Agriculture* was organized by CIAE, Bhopal. Seventeen participants from various SAU/ICAR Institutes attended the programme. The School focused on the technological advancements made in different



- Summer and winter schools organized by CIAE, Bhopal
- Trainers' Training Centre, CIAE, Bhopal organized 42 training courses

facets of energy management in agriculture including mechanization trend and its impact on source-wise energy-use pattern; energy conservation technologies; use of renewable energy sources in Indian agriculture and energy modelling and forecasting.

Winter School

Winter School on *Advances in Manufacturing Technology of Agricultural Equipment* was organized by CIAE, Bhopal for teachers, researchers, extension-workers, manufacturers to facilitate quality manufacturing of farm machinery. Twenty-one participants interacted and exchanged experiences with professionals during this school. The course covered 8 areas, viz. CAD/CAM, casting/moulding, material removal, joining process, quality control, materials and their quality upgradation, industrial engineering, critical components and case studies on agricultural equipment.

Training Advances in Farm Equipment Manufacturing

Eleven participants comprising university teachers, researchers and extension-workers were provided training to upgrade their knowledge on quality manufacturing of agricultural implements in a 3-week training course on *Advances in Farm Equipment Manufacturing*, organized during February 1-20, 2001. An engineer from Sri Lanka also joined this advance training course. The course covered 8 critical areas of manufacturing, viz. CAD/CAM, casting/moulding, material removal/forming, joining process, quality control, material and their quality upgradation, industrial engineering, critical parts and case studies on agricultural equipment.

Training on Fabrication of Improved Agricultural Equipment for Unemployed Rural Youths

In collaboration with Entrepreneurship Development Institute, Lucknow, an entrepreneurial training programme on *Fabrication of Improved Agricultural Equipment* for unemployed rural youths was conducted at Raipur on payment basis. It was attended by 23 participants. The trainees fabricated CIAE grubber weeder, local design of 3-tyne weeder, tubular maize sheller, low lift water pump etc. Besides they learnt improved fabrication techniques. Post-training follow-up has resulted in establishment of workshops by 10 participants funded by commercial banks.

Manufacturing of Agricultural Implements

A training programme on *Manufacturing of Agricultural Implements* was organized for 20 village artisans.

Trainings for Women Scientists

The Sub-centre of National Research Centre for Women in Agriculture at CIAE, Bhopal conducted a training programme on *Women Friendly Farm Technologies* for scientists of All-India Co-ordinated Research Project on Home Science (Family Resource Management Unit). Eighteen participants from 9 centres attended the training.

Training for Women Farmers under Swashakti Project

Three training programmes for the women farmers of the self-help groups was sponsored by Swashakti Project of the *Mahila Arthik Vikas Nigam*, Madhya Pradesh, Bhopal. Fifty-eight participants of which 37 were SC/ST farmers, were imparted training on cultivation of vegetable and food crops.

Training of Upcoming Entrepreneurs for Production of Soy Milk and Soy Paneer

Soybean Processing and Utilization Centre conducted 7 training programmes. A total of 71 participants attended these 6-day programmes and revenue generated through fees was Rs 71,000.



Training Achievements of Krishi Vigyan Kendra at CIAE, Bhopal

Krishi Vigyan Kendra, CIAE, Bhopal organized vocational training programmes for farmers, farm women, rural youth, school drop-outs and *anganwadi* workers in crop production, home science, broiler raising, dairy, plant protection, tractor and farm machinery, electrical motor winding, etc. A total of 102 trainings were organized in which 206 females and 2,511 males were trained.

Training Achievements of Trainers' Training Centre at CIAE, Bhopal

The Trainers Training Centre, CIAE, Bhopal organized 42 training courses in which 562 participants attended specialized training courses on agricultural engineering. The participants included Subject-Matter Specialists, KVK Trainers, Officers of State Agricultural Department, Teachers and Students of Agricultural and allied engineering disciplines.

Training on Cotton Quality Evaluation

The CIRCOT, Mumbai organized training courses in Cotton Quality Evaluation and also on specialized instrument operation like H VI and AFIS. The training at the headquarters comprise informative lectures and a series of practical demonstrations along with visits to the Textile Industries to get practical knowledge on the subject. During the period 64 trainees received training on Cotton Quality Evaluation in 8 batches. There was also a specialized training course in HVI and AFIS in which there were 9 trainees in 2 batches apart from thirty-two trainees from Madhya Pradesh Agricultural Marketing Board, Bhopal who attended the course in 3 batches. Training was imparted to a cotton specialist from South Africa during the current year.

Training on Ginning

At the Ginning Training Centre, Nagpur training was imparted to gin fitters, operators and managerial staff on gin operation. During the period there were over 200 sponsored personnel from ginning factories and cotton trade organizations who benefited from the ginning training. This training also had field visits to the ginning and pressing factories to give the trainees first hand information on the problems in the ginning factories and their possible remedies.

Training on Automation of Pressurized Irrigation System

A training on *Automation of Pressurized Irrigation System* was organized. A total of 24 participants from ICAR Institutes, SAUs, State Departments and CIAE participated in the programme. Subjects like automation of irrigation systems, hydraulics of pressurized pipes, soil-plant-water relationships, crop water requirement, design of drip and sprinkler systems, fertigation and filtration, crop monitoring, irrigation accessories and water quality were dealt with in detail through lectures and audio-visual aids.



Training of farm women scientists on operation of rice transplanter at Bhopal



Agricultural Human Resource Development

- Based on the All India Competitive Examination, 1084 students in 10 disciplines of UG programme and 1051 in 70 disciplines of PG programme sought admission to State Agricultural Universities and Deemed Universities on merit and counselling. At PG level all students were moved to other universities to reduce inbreeding

- KAU, Thrissur ranked first with 62 JRF while TNAU, Coimbatore with 52 and GBPUAT, Pantnagar with 40 rated second and third in ICAR Entrance Test for the academic session 2001-2002

VCs' Conference



CAPACITY DEVELOPMENT

STATE AGRICULTURAL UNIVERSITIES

Aligarh Muslim University

- Course contents and syllabus of all the programmes have been revised and updated during 2000-2001.
- Teachers of Department of Agricultural Economics and Business Management have brought out useful study materials.
- Linkages have been developed among different departments of Agriculture Education of the University and other organizations for better developmental interaction.

Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST) Jammu

- Under-graduate programme is carried out at Faculty of Agriculture, Wadoora for Agriculture and Forestry and at Faculty of Veterinary Science and Animal Husbandry for Veterinary Sciences.
- Faculty sponsors candidates under Faculty Improvement Programme of the University for M.Sc. and Ph.D programmes in sister universities outside the State in the disciplines where programmes have not yet been developed by the university, particularly in the field of Veterinary Science and Forestry.

University of Agricultural Sciences, Dharwad

- Procured high quality laboratory equipment such as seed measuring equipment, hot air oven, spectrophotometer, trinocular microscope, electronic balance, double distillation unit, ergo cycle tread mill, psychological tools, creativity material, microwave oven digital lux meter, galvanised containers, creel machine and seed germinator for UG and PG teaching in all the teaching campuses.
- Networking through LAN connectivity and providing internet facility out of ICAR grants have helped the students access information from across the globe.
- Modernization of laboratories, construction of Examination halls, Workshops, Cattle sheds, and students seminar halls has been taken up with full vigour.
- Developed teaching aids, establishment of Instrumentation Centre, Communication facilities such as EPABX and medical facilities to students.

CENTRAL AGRICULTURAL UNIVERSITY, IMPHAL

- The College of Horticulture, Pasighat in Arunachal Pradesh started functioning w.e.f. March,2001. Eighteen students were admitted in first batch



AGRICULTURAL HUMAN RESOURCE DEVELOPMENT

and 13 students in second batch for B.Sc.(Horticulture) programme.

- Since the establishment of the University in 1993, 202 B.Sc.(Ag.) and 63 M.Sc.(Ag.) students successfully completed their degree requirements. At present, a total of 209 students are on roll in College of Agriculture, Imphal, 169 in B.Sc.(Ag.) and 40 in M.Sc. (Ag.). Sixty-one students for B.V.Sc. and A.H. and 45 students for B.F. Sc. have been enrolled so far.
- Seven B.Sc.(Ag.) students of College of Agriculture, Imphal had been selected for admission, to PG programme in All-India Entrance Examination, 2001 conducted by ICAR and admitted in different SAUs.
- The construction of two campuses viz., College of Veterinary Sciences and Animal Husbandry Selesih (Mizoram) and College of Fisheries, Lembucherra (Tripura) had been completed during the year. The Veterinary College campus was inaugurated on 17 October, 2001 by Shri Ajit Singh, Hon'ble Minister for Agriculture, Government of India.
- The University had issued appointment orders for statutory and teaching positions of its four constituent Colleges. One Dean, 5 Professors, 4 Associate Professors and 39 Assistant Professors joined the University.
- A total of 7 NATP and 4 AICRP Projects have so far been sanctioned to the University and these projects are continuing.

- In VCs' Conference, apart from transaction on regular agenda on educational reforms, discussions centered around approach towards X Plan, Expectations of SAUs, Financial constraints in SAUs—ways and means to improve financial health of SAUs; Efficient University Governance; and three Committees constituted to bring out a document on these issues

DEEMED-TO-BE-UNIVERSITIES

National Dairy Research Institute, Karnal

- A Model Dairy plant with facility to process 60,000 litres of milk per day has been established with modern equipment for scaling up, testing of research results and for training of students and industry personnel.
- The Institute has provided centralised facilities for electron microscopy, molecular biology and several fine instrumental laboratories. The free access to these facilities motivates the scientists to carry out quality research and teaching.
- For innovative teaching, modern audio, video and visual equipment facilities have been provided to the various divisions. Sufficient number of personal computers are provided for use in research and teaching.
- Software packages have been developed for various dairy and farm operations, their management and analysis.

- Faculty wise Veterinary college, GBPUA&T and Horticulture College, Velanikkara, KAU ranked first with 23 JRF each while for Agriculture, Agriculture College, Vellayani, KAU and Agriculture College, Coimbatore earned 17 and 15 JRF respectively

AGRIUNIFEST



- Third Agricultural University Youth Festival (AGRIUNIFEST) was organized at KAU, Thrissur, Kerala from January 19 to 25, 2002, where 12 SAUs participated. KAU ranked first and AAU, Jorhat was adjudged second in the competition



- Special computer courses have been developed for dairying students.
- Scientists have prepared books, monographs and bulletins to supplement their teaching efforts.
- Scanning facility to about 35 to 40 research institutes/universities around the country are available at the Institutes computer centre which would shortly provide access to the information super high ways through satellite link to its user.
- Course contents and syllabi of all the programmes have been revised and updated during 2000-2001.
- Teachers of Department of Agricultural Economics and Business Management have brought out useful study materials.
- Linkages have been developed among different departments of Agriculture Education of the University and other organizations for better developmental interaction.

- Third All India Games and Sports Meet was organized at Rajasthan Agricultural University, Bikaner on November 3-8, 2001. A record number of (29) State Agricultural Universities participated

MANPOWER DEVELOPMENT

Agricultural Human Resource Development Project

Implementation of the Agricultural Human Resources Development (AHRD) Project with World Bank Credit which assisted India's drive to modernize its agriculture sector through improved agricultural education system was completed on December 31, 2001. This project was initiated in 1995 with the financial assistance from the World Bank and besides ICAR, it was implemented by the States of Andhra Pradesh, Haryana and Tamil Nadu in their development departments and SAUs. The AHRD Project covers only four universities i.e. CCS Haryana Agricultural University, Hissar; Tamil Nadu Agricultural University, Coimbatore; Acharya N. G. Ranga Agricultural University, Hyderabad and Tamil Nadu Veterinary & Animal Sciences University, Chennai, yet it is a matter of great satisfaction that the educational reforms made under the project have spread to non-AHRD Project participating SAUs also. The major initiatives taken under the AHRD project by ICAR include establishment of Accreditation Board and new accreditation procedure for education quality assurance, reducing inbreeding through All-India Competitive Entrance Examination for admission in SAUs, uniformity in UG and PG regulations, major revision of course curriculum at UG and PG levels, introduction of sabbatical leave, development of instructional material, faculty training for improving competence as a teacher, infrastructure development, modernization of laboratories and lecture halls, library strengthening and access to information through internet and delegations, women technological empowerment and bringing global competitiveness. In the project participating States initiatives put in place by the Development Departments included trainers training, establishment of Human Resource Management and Human Resource Development cells, establishment of Human Resource Management and Human Resource Development cells, establishment of Manpower Advisory Council, infrastructure development for trainings and transfer of technology to end users.

AHRD Projects-CAD courses organized:

1. Graphic and Multimedia Production at IARI, New Delhi.
2. Computer Aided Interior Designing and Landscaping at Hyderabad
3. CAD - Fashion and Textiles at Lady Irwin College, New Delhi.
4. Graphic and Computer Applications in Food Science and Nutrition Management at College of Home Science, Madurai.

Accreditation of Agricultural Universities

The Accreditation Board approved the accreditation of four SAUs with their 32 constituent colleges out of 35 colleges. The accreditation status has been accorded

- The recommendations of Dr Kirti Singh Committee to support the institutions and Colleges outside the State Agricultural University system were published and sent to all State Agricultural Universities and private Agricultural Colleges throughout the country



for a period of 5 years extendable by two more years within which the universities should get themselves re-accredited. The accredited universities are ANGRAU, Hyderabad; CCS HAU, Hisar; TNAU, Coimbatore and TNVASU, Chennai.

In the continuing process of accreditation, seven Agricultural Universities and one Deemed University are undergoing the process of Accreditation. The Universities are Punjab Agricultural University, Ludhiana; University of Agricultural Sciences, Bangalore; University of Agricultural Sciences, Dharwad; Kerala Agricultural University, Thrissur; KKV, Dapoli; Himachal Pradesh Krishi Viswavidyalaya, Palampur; Dr Y S Parmar University for Horticulture and Forestry, Solan and CIFE, Mumbai. These universities have submitted their Self Study Report and Peer Reviews Teams are visiting the Universities for on the spot assessment and interactions with different constituents of the concerned University. Accreditation process has also been initiated in eight more SAUs and three DUs.

Revision of Curricula and Syllabi

The gigantic exercise of restructuring of PG program is nearing completion with revision of curricula for 6 more Master's degree programs. With this, the total number of PG Programs for which syllabi have been revised has gone up to 42. So far, eight course catalogues containing 25 Master's degree programs in eight Broad Subject Matter Areas have been published for circulation.

Hands-on Training on Preparation of Self Study Report

Two trainings were organized during the year at CSAUAT, Kanpur and JNKV, Jabalpur to provide hand-on experience in conducting Self Study and preparation of Self Study Report for Accreditation. A total of 57 senior officers including Vice Chancellors, Directors and Deans of eight Agricultural Universities and three Deemed Universities participated.

Accreditation System and Financial Support to Private Institutions

The Council has identified 11 institutions outside the ICAR-SAUs System, which are fulfilling more or less the ICAR norms and standards for higher agricultural education, for financial support, subject to their accreditation. A committee under the Chairmanship of Dr G.B.Singh, the Vice Chancellor, of JNKV, Jabalpur recommended that the new system of accreditation adopted for SAUs, DUs and CAU is quite comprehensive and suits very well, and can be applied for accreditation of private institutions. The committee also suggested eligibility criteria and pattern of financial assistance which have been accepted by the Council.

Fellowships/Scholarships

The ICAR conducts competitive examinations every year for pursuing studies in B.Sc./M.Sc./Ph.D. in State Agricultural Universities in various courses in Agriculture and allied subjects. During the year, 200 SRFs, 470 JRFs and 220 National Talent Scholarships have been provided to meritorious students. Merit-cum-Means Scholarships have been awarded to 7.5% of the intake capacity in different colleges of SAUs. The SC/ST students have been provided scholarships/fellowships to the extent of 15% and 7.5% of the total intake.

RAWE has been made integral component of all degree programmes in Agriculture and allied sciences. During the period, students undergoing RAWE are paid stipend of Rs. 500 per month by ICAR and Rs 250/- by the State. In addition, Rs.250 per student per month are paid by ICAR to the institutes for operationalising the scheme.

About 5,000 ventures on Agri-clinics and Agri-business would be set up every year on individual or joint/group basis. It is proposed to provide 25% of the project costs in the form of back-ended capital subsidy by the Government.

- The Rural Agricultural Work Experience (RAWE) is now effective in all the State Agricultural Universities with the objective of experimental learning and to acquaint students with various agricultural based farm operations, expose them to actual work situation, help in collecting information on ancient wisdom, and to develop competence and confidence for problem solving situations related to agriculture, by being with the farmer



Accreditation Board Meeting in session

- Establishing Agri-clinics/Agri-business is a part of New Agricultural Policy for providing entrepreneurial support to agriculture pass-outs as technological agents in the public sector. The primary objective of the scheme is to upgrade the variety of technical and support service to farmers through agri-clinic and agri-business Centres with the involvement of agriculture graduates supplementing the efforts of the Government and public sector agencies



- Four SAUs namely ANGRAU, Hyderabad; CCSHAU, Hisar, TNAU, Coimbatore and TNVASU, Chennai; with their 32 of 35 colleges were accredited
- Fifteen SAUs, and four DUs are at various stages of accreditation.
- The revision of PG syllabi have been completed in 13 Broad Subject Matter Areas, covering 43 master's degree programs

Foreign Students Admission

One hundred foreign students were admitted in M.Sc. and Ph.D. Programmes in different SAUs from Ethiopia, Nepal, Indonesia, Vietnam, Sudan, Iran, Bhutan, Bangladesh, Yemen, Egypt, Myanmar, Syria.

Besides developing human resource for SAARC, Africa and Middle-East countries, this has helped in developing resources for institutions imparting such training programmes.

Summer School/Winter School/Short Course

Recognizing the need for training of large number of Scientists, Council has increased the number of training programmes. By the end of IXth Plan it is planned to train 20% of the faculty and scientists each year. A total of 75 Summer/Winter School and Short Courses in the field of Agriculture/Veterinary and Animal Sciences/Home Science/Engineering/Fisheries have been organized for the benefit of teachers, research workers and extension-workers particularly the subject-matter-specialist. The main objective of these in-service training courses are to acquaint the trainees with the latest technological advances in the subject, impart newer skills, proficiency in selected, new emerging areas so that competence of faculty and scientists are improved.

CENTRES OF ADVANCED STUDIES

The Centres of Advanced Studies (CAS) scheme was launched to improve the quality of teaching in State Agricultural University (SAUs) and Deemed Universities of ICAR. The objective of the scheme is (i) to identify the major discipline/department of SAUs/DUs which have developed facilities and faculty in the area of specialization and (ii) to provide need based financial assistance for further refinement of programmes of identified disciplines/departments to make them capable of undertaking advanced teaching, research and extension activities. Presently 35 CAS are existing in various SAUs/DUs of ICAR. These centers have helped in training of the faculties of other universities/institutes in enhancing their capability in use of educational innovations, modern teaching and research methodology and served as repository of ideas and information in concerned discipline. During the year 2000-2001, seventy two training programmes were organized in which 1190 scientists were trained and 25 new manuals were prepared. Quinquennial Review Team (QRT) under the chairmanship of Dr M. V. Rao reviewed the CAS scheme for the period 1995-1999. The QRT suggested several new areas for CAS which include Environmental Pollution and Pesticide Residues, Post Harvest Technology and Product Development for Agriculture, Horticulture, Animal, and Fisheries products, Medicinal and Aromatic Plants, Feed Technology for Cattle Poultry and Fish, Wildlife Management, Fish Pathology, Fish microbiology, Tea, Taxonomy of plants, animals, insects, micro-organism, International agriculture, trade and marketing.



Inaugural function at the Centre of Advanced Studies, TNAU

PROFESSIONAL EXCELLENCE RECOGNITION

Best Teacher Award

Following Scientists were awarded Best Teacher Awards for three subsequent years viz. (1997-98) Dr J M Kataria, Dr V Ravi Prakash, and Dr N N Pandey; for the year (1998-99) Dr S K Das, Dr A S R Anjaneyulu, and Dr J R Rao and for the year (1999-2000) Dr M R Ansari, Dr R P Moudgal, and Dr A A Kumar from IVRI, Izatnagar. Dr N Wandaswamy from TNVASU, Chennai, Dr R C Gautam, Dr (Mrs) Malvika Dadlani, Dr V V Ramamurthy, Dr (Mrs) Swarn Dhingra and Dr (Mrs) Anita Jhamtani (all from IARI), Dr K G Umesh and Dr B A Shamasunder from UAS, Bangalore and Dr B V Patil from UAS, Dharwad were the other awardees.



Book Writing Scheme

In the year under reference 33 titles were finalized for book writing based on revised curricula of which 18 Textbooks have been submitted by various reputed scientists.

National Professor and National Fellow Scheme

- In order to standardize leaf-sampling techniques in grapes, different factors contributing variation in tissue nutrient contents like seasonal variation, position, type of tissue, fruiting and non-fruiting canes and sample size were studied by Prof. K L Chadha at IARI. A pronounced decrease in N, P, K and S concentration was observed with the advancement of the sampling period, while Ca, Mg, Mn increased regularly throughout the season. Copper and Zn however, showed irregular trends throughout the season. The nutrients in petioles opposite to clusters were found to be most stable during May and June, which would perhaps be the suitable time of petiole sampling. N, P, K and Zn contents tended to decrease in Perlette grape petioles with age. However, Ca, Mg, S, K, Cu and Mn levels were increased with age. Leaf petiole number 4 and 5 from the base was found to be the most suitable sampling tissue. A survey was conducted to find out the variation in nutrient status of Perlette grape vineyards in Baghat and Muzaffarnagar district of Uttar Pradesh. Variation in soil nutrient contents was found non-significant for N, P, K, Fe, Cu, Mn and Zn, while significant variation was observed in case of Ca, Mg and S. Vineyards with low yield records significantly higher pH, Ca and Mg and low organic carbon, P, K and Zn varied significantly with yield levels of vines. Petiole composition for the highest yielding vines, were 0.99% N, 0.40% P, 2.88% K, 1.35% Ca, 0.71% Mg, 0.29% S, 92 ppm Fe, 10.35 ppm Cu, 226 ppm Mn and 35 ppm Zn, which seems to be optimum for higher productivity. The effect of five graded doses each of nitrogen (N), phosphorus (P), and potassium (K) fertilization were investigated in the field trial with *Vitis vinifera* L. cv. Perlette. Application of higher doses of N (1000g N/Vine) resulted in excessive vine growth in terms of trunk girth and shoot length. However, application of higher doses of P and K reduced the vine growth.
- The cox 1 gene was cloned from *B. juncea*, via PCR on the basis of sequence information of soybean, sugarbeet and pea cox 1, and was used as a probe in Southern hybridization by Prof. V L Chopra. Comparison of the Southern patterns of CMS line and parents, showed that the CMS-line carried an extra copy of cox I gene. The normal and the additional cox I genes from CMS line were isolated from mitochondrial genome library. The cox I gene was also isolated from mt-genome library of *B. juncea* cv. Pusa. Restriction analysis of the cloned fragments involving cox I gene indicated differences between the two copies of cox I present in the CMS line. Sequencing of the two clones revealed that while the coding region of the two cox I genes in the CMS line was identical but there were differences at the 5' region, which included a duplication and an inversion. Somatic hybrid *Diplotaxis Gomez-campoi* (2n=18) + *Brassica nigra* (2n=16) was synthesized following protoplast fusion for transferring resistance to fungal disease white rust and cytoplasmic genes for inducing male sterility. Hybridity was confirmed through isozyme analysis, RAPD markers and chromosome studies. The hybrids have, in general, intermediate morphology, and are characterized by regular meiosis. The norm is formation of 17 bivalents. The T1 seeds of mustard transgenics for FAE 1 gene (in antisense and sense orientation), which were showing wide variation in erucic acid content were germinated on kanamycin medium and its molecular analysis for the npt II gene has been done. The T2 progenies were grown to maturity under glasshouse

- A Book entitled "Agricultural Education - A Career Guide" has been published which serve as a ready recknor for the students seeking admission in State Agricultural Universities. This Book includes the information and full details regarding all SAUs, their system of admission, duration of courses, subject accredited, hostel facilities, fee structure, number of seats available and site of the campuses under the universities

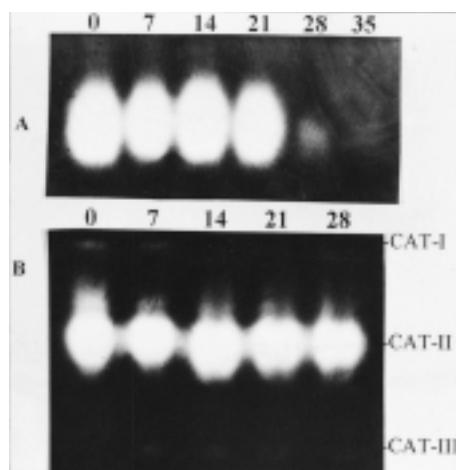
- Leaf lamina in perlette grape was found to be most suitable for analysis of N, Ca, S, Fe, Cu and Zn, while petioles were found to suitable for P, K, Mg & Mn. Petioles from non-fruiting canes had more concentration of N, P, S, Fe & Zn but less of K, Ca, Mg, Mn & Cu. A sample size of 50-75 leaf petioles and/or 30-40 leaves was ideal for the nutrient analysis and indexing in grape variety Perlette

- The knowledge of the CMS-specific gene region has enabled design of a robust and rapid PCR-based molecular marker for the identification of this CMS-line. This marker will be of great practical significance for establishing proprietary right and for checking the genetic purity of the material in hybrid seed lots



conditions and determination of fatty acid profile of these seeds is in progress.

- Realizing the need to develop 'all fish' gene constructs for growth acceleration of Indian fishes, the GH encoding cDNA from Indian major carps and Indian catfish have been cloned and characterized for the first time at Madurai Kamaraj University under ICAR National Professor project by Prof. T J Pandian. The nucleotide sequence of rohu is 1180 bp in length (Gen Bank Acc. No. AF134200) and the deduced peptide sequence shows 90% homology with other catfishes. The sequence has a single N-glycosylation site at the carboxyl terminal (195th position). For the first time, several indigenous expression vectors were constructed. The inclusion of Internal Ribosomal Entry Site (IRES) element in between fish GH cDNA and reporter gene Enhanced Green Fluorescent Protein (EGFP) facilitates the cap-independent translation of the EGFP, and overcomes the hurdle of lack of biological activity of the fusion protein. In rohu, the gene transfer was carried out by electroporation of sperm cells with the vector (prGH-IRES2-EGFP), which was followed by normal fertilization of the eggs. In putative transgenic rohu, growth acceleration of upto 6-7 times more than their siblings was observed. In the catfish, gene transfer was carried out by electroporation of the eggs with the vector p β a-cGH. Observation on the sperm of *Heteropneustes fossilis*, preserved (immediately following death) at -20°C for 140 days, showed that the sperm were still viable, as indicated by motility; the motility lasted for a period of 240 minutes at 28°C. Interestingly, sperm from the restored (at 4°C for 3 days) testes also showed slow motility, which could be enhanced using 1.5% Na₂SO₃ or 0.56% KCl or 0.5% NaCl. In sequential hermaphrodites like the sea bass and grouper, natural sex reversal is a prolonged process (2 or 3 years) and occurs in fishes of 7-10 years of age, making it difficult to undertake short-term laboratory studies to understand the process of sex differentiation. *Macropodus opercularis*, a fresh water fish, is unique in that it is known to complete density-dependent sex reversal in less than 30 days.
- Prof. Renu Khanna Chopra studies on antioxidant enzymes in the flag leaf of wheat during grain development at IARI showed that activities of superoxide dismutase (SOD) and catalase (CAT) declined 21 days after anthesis. The major Cu/Zn isoforms (cytosolic) of SOD declined in activity, whereas low abundance mitochondrial MnSOD isoforms increased in their activity. Senescence induced new isoforms of catalase in the peroxisomes and showed decline in the activity of the major isoform only in the crude fractions at later stages. The presence of FeSOD was found in the mitochondria for the first time in the leaves of a senescing wheat plant.
- Prof. D C Uprety studied effect of elevated CO₂ in the leaf anatomy of *Brassica juncea* at IARI, demonstrated that the changes in leaf ultra structures reflected an optimization strategy due to high CO₂ that allows the loading of chloroplast with excessive oval starch grains to meet the adverse effect of drought on these components. Also, in the case of rice varieties there was a significant variability in the responses to elevated CO₂. The response of rice variety Basmati-1 was significantly better than that of Pusa-677 for photosynthesis, growth and productivity.
- A study on the identification and quantification of phosphatase hydrolysable organic P sources for plant nutrition and refinement of a non-destructive technique for phosphatase estimation was conducted at CAZRI by Prof. J C Tarafdar. This showed that the acid phosphatase generated from plant and fungal sources is different and microbial acid phosphatase showed three times greater efficiency in hydrolysis of phytin, two times greater efficiency in hydrolysis of lecithin than plant phosphatase. Both sources were at par in hydrolyzing glycerophosphate. The acid phosphatase secreted by two weeks old wheat plant increased with increase in organic P concentration up to



Activities of superoxide dismutase (SOD) and catalase declined 21 days after anthesis during the studies on antioxidant enzymes in the flag leaf of wheat during grain development



75 μ M in soil solution. The maximum rate of organic P hydrolysis per plant was 2.3×10^{-14} mol cum $^{-1}$ s $^{-1}$ that varies from 1.0×10^{-14} mol cum $^{-1}$ s $^{-1}$ to 2.3×10^{-14} mol cum $^{-1}$ s $^{-1}$ depending on organic P concentration in soil solution. The rate of hydrolysis was constant with time.

- Prof. B R Yadav reported that the average within breed band sharing frequencies were 0.739 ± 0.032 in Nagpuri and 0.669 ± 0.035 in Murrah breeds. The between breeds band sharing was lower 0.490 ± 0.062 than the within breeds band sharing. The genetic distance determined on the basis of band sharing frequency estimates, was 0.464 ± 15 between Nagpuri and Murrah breeds, indicating the genetic divergence. The genetic identity index calculated on the basis of band frequency was 0.632 ± 0.076 between Nagpuri and Murrah breeds.
- Prof. B R Singh conducted a study on genetic manipulation and breeding of broiler stocks with different scientific applications for economic efficiency in tropical climate at CARI, and world's first embryo culture guinea fowl chick was successfully produced, after having a breakthrough with successful hatching of first millennium chick at the Central Avian Research Institute. The protocol for the embryo culture system was fully developed at CARI. The alterations in the transfer of embryo were done on the basis of its incubation period i.e., 28 days; the second transfer being done on 1st day and third transfer on 5th day. Also, Caribro - Mritunjai (Naked Neck commercial broiler) was introduced in the market for the first time in India. This stock was designed genetically to overcome the problems of tropical heat. The naked neck gene (Na) has been introduced for general reduction of feathers (14 to 20%), rapid growth, efficient feed conversion, excellent livability and competitive yield of lean meat.

- In a study on genome analysis of indigenous breeds of cattle, buffalo and goats using molecular markers conducted at NDRI in four breeds of buffalo (Murrah, Nagpuri and Jaffrabadi) and two three breeds of cattle (Sahiwal, Malwi and Nemari) and some problem breeding cross bred/Sahiwal animals, the band sharing frequency was higher within breeds as compared to between breeds

- CARI has a place of pride to have the World's first embryo culture Guinea fowl chick hatched by *Ex-vivo* Double Window Embryo Culture System. The new findings made it possible to have a more thorough analysis of embryonic development and physiology

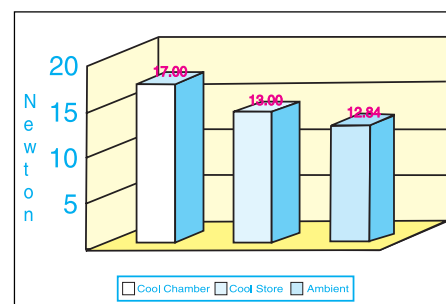
Emeritus Scientist

- Prof. S K Roy studied water chestnut, which has a very short shelf-life therefore it needs to be marketed immediately after harvesting. In a study on the integrated post harvest management of horticultural crops, fresh water chestnuts stored in an environment friendly cool chamber developed based on the principle of evaporative cooling (19-22°C and RH 94-95%) by the IARI, retained freshness up to 7 days while they became unmarketable within 2 days under ambient room temperature (21-27°C and RH 73-80%) and 4 days under cool storage condition (7-9°C and RH 75-85%). The water chestnut kernels stored in new cool chamber were fresh, firm and crispy while both the ambient and cool stored samples were desiccated, soft and mealy. This was also evident from the texture value measured with the help of Instron and expressed in terms of Newton.
- Diversification of cytoplasmic base of hybrid seed parents would greatly facilitate the diversification of nuclear genotypes of elite hybrid parental lines, and thus reduce the genetic vulnerability of such hybrids to disease and also help in producing high yielding hybrids. At present the entire pearl millet hybrid seed industry in India is based on A1 cytoplasm, which has its own demerits. Under a study on diversification of cytoplasmic male sterility and pollinator lines in pearl millet conducted at IARI, by Prof. O P Govila, a new A4 cytoplasmic nuclear male sterility system has been made available from wild species *Pennisetum monodii* that is highly stable. Following important results have been obtained utilizing A4 CMS system.

Pusa 23 is one of the present day most important hybrid of the country, which is based on A1 CMS. In the seed production plots, the seed parent 841 A1 has been found to throw pollen shedders due to mutations and modifiers thus lowering the quality of hybrid seed. In the present investigation when 841 B1 was crossed to 81 it showed perfect maintenance. By



Condition of Water chestnut under different storage conditions after 7 days





backcrossing programme CMS 841 has been converted into A_4 background. The CMS line is completely stable and does not throw any pollen shedders. Thus the commercial F_1 seed will now be genetically pure. A large number of crosses were made between 81 A_4 X inbred lines. It was observed that the F_1 crosses showed both restoration and maintenance. The crosses involving inbred which showed maintenance is being utilized to convert into CMS lines by backcrossing method. Two inbreds M-46 and inbred 5 (PPMI- 362 X IP 1249-2149-2- are highly promising and produce high yielding hybrids.

- Different vegetative propagation methods were tried for commercial production of good quality pods, true-to type planting material raised from elite trees identified to produce sweet, fibreless, tender, small seeded, green and long pods. Excellent success was obtained in propagation by patch budding

- Khejri, *Prosopis cineraria* (L.) Druce, is a highly drought tolerant tree adapted to desertic environment. The tree bears edible pods rich in protein (18%), carbohydrates (56%), phosphorus (0.4%), calcium (0.4%) and iron (0.2%) in immature pods used as vegetable. The ripe pods containing 9-14% crude protein and 6-16% sugar are powdered and used to prepare bakery items such as biscuits and cookies. The quality of immature pods collected from the seed propagated trees differ greatly with respect to taste (flat, bitter, acrid, sweet), tenderness (tender, semi-hard, hard), fibre content (fibrous, fibreless), length (6 to 39 cm), thickness (0.20 to 0.27 cm) and seed number (2 to 30 per pod), seed size (20-50 mg) and contents of protein and minerals.

During May-September under a study conducted by Prof. O P Pareek at CAZRI, out of four rootstocks, viz. *P. cineraria*, *P. juliflora*, *P. alba* and *P. nigra* used for budding scion buds of *P. cineraria*, the best was *P. cineraria*. The technique has been successfully used for *in situ* budding on rootstocks of over 2 years. On an average, 76% success has been achieved. The method can be used to convert the old seedling trees into trees yielding good quality pods and a farmer can earn at least Rs. 2000 per year from an yield of about one quintal green pods per tree.

- Prof. N M Ramaswamy conducted the biotechnological experiments at TNAU for neem improvement with various media combinations and reported that the callus induction frequency in cotyledons of *Azadirachta indica* was high (60%) on MS+2,4-D (2.0mg/l) + Kn (0.5 mg/l) and it was low (1%) in *Melia azedarach*. The young leaf explants of *Azadirachta excelsa* recorded 12% callus induction in the above media combination. The response of anthers of *Azadirachta indica* was poor (0.5%) for callus induction on MS+NAA (2.0 mg/l)+BAP (1.0 mg/l). Irradiation of fruits of *Melia azedarach* with gamma rays (50 krad) indicated the stimulatory effect on the germination and the growth of M1 seedlings.

HOME SCIENCE

Database on Rural Women and Indigenous Knowledge

- Special allocations were made for Home Science and fishery colleges for infrastructural development during the IX Plan

- Participation profile of rural women showed intensive participation seeds selection, weeding, transplanting, post-harvest and livestock management activities along with anchoring participation in all homestead activities.
- The time use pattern confirmed that women spent 16-18 hours per day for daily chores.
- A large wealth of indigenous knowledge on practices, methods and tools related to various aspects of maternal health and care has been identified, validated and documented.
- Technology kits containing communication media-mixes have been developed for empowering technology trainers and grassroot level field functionaries.

Ergonomic Management of Drudgery

- The physiological stresses on the body were very high and severe for farm



activities performed by rural women due to faulty postures, during task performance.

- The physiological and muscular stresses were found to be high and above the permissible limits for performing dairy related tasks and household activities like fetching water, collecting fuel, mud plastering of the house and washing clothes.
- The workload carried by women was beyond the permissible limits, which adversely affected their health, and majority of the sampled women fell in the category of normal or average health status.
- The activities performed by women either in squatting or bending or standing cum bending postures increased body stresses and decreased work output in absence of use of ergonomic friendly tools and implements.

- The women emerged as the joint decision-makers in all spheres of activities with variation in decision-making roles with male or female members that are governed by the nature of activity

Nutritional Security for Human Health in Agrarian Ecosystem

- The crystalline salt that is used in rural home is devoid of adequate amount of iodine.
- The locally available samples of indigenous foods that are used in rural homes have been analyzed and found to be rich sources of β -carotene and ascorbic acid.
- Wide variations were observed in retinal content of milk and milk products (60 fold) and meat/fish and poultry (6 fold) indicating effect of cooking/processing conditions on retinal content.

Comprehensive Child Care through Farm Creche

- The intervention provided to infants as stimulation program and supplementary feeding in creche and nutrition education imparted to mothers brought about a significant improvement in the psycho-motor and mental development of infants.
- A significant improvement took place in weight of the infants through supplementary feeding in creche in experimental group as compared to control group.
- A significant improvement in home environment was also observed with a significant increase in number of toys and play material provided to infants for stimulating their development.
- The feeding habits and quantum/quality of nutritious foods consumed was significantly better in the group that participated in intervention programme.
- The efficacy of intervention programme proved to be effective in optimizing the physical, psycho-motor, mental, language and socio-emotional development of infants.
- A module for establishment and management of creche as an early childhood cost effective program has been developed.

Value Addition to Agro and Animal based Fibres

- Each unit has optimized the dyeing conditions, namely dye material extraction time, dye material concentration, dyeing time, mordant concentration and mordanting method for four natural dyes selected on the basis of local availability.
- A total of 1944 new shades have been developed and documented through shade catalogue.
- The optimum dyeing conditions by prescribed methods have revealed satisfactory colourfastness to washing, light, rubbing and perspiration. These are now ready to be taken up as entrepreneurial activities by farm women.

Dyes used on wool yarn. Flowers of Dhawadi (*left*). Flowers of Kesula (*right*)



NATP PROJECT on Empowerment of Women in Agriculture has been launched this year. Dr (Mrs) Tej Verma, ADG (Home Science) is the Mission Leader and



Dr (Mrs) Pushpa Gupta, Dean, College of Home Science, Maharana Pratap University of Agriculture and Technology, Udaipur is the Principal Investigator. The Project is operative in seven states including SAUs and ICAR Institutes for the period of two and half years with budget allocation of Rs. 3.65 crores.

NATIONAL ACADEMY OF AGRICULTURAL RESEARCH MANAGEMENT, HYDERABAD

National Academy of Agricultural Research Management is the lead Centre in providing the human resource development back up to the NARS and policy support to the Indian Council of Agricultural Research (ICAR). In pursuance of its HRD activities, a variety of training programmes were organized by the Academy for the benefit of scientists/teachers from the ICAR and the State Agricultural Universities (SAUs) within the country as well as from developing country NARS in Asia and Africa. 981 participants were benefited from the Academy's programmes in the areas of agricultural scenario, research project management, personality



International training programmes witnessed a spurt at NAARM in the year under report. A Srilankan team at the NAARM

development, administration and financial management, information and communication technology, stress management, creativity, team work, and participatory methods.

Retreat Programme for the top 20 senior executives of ICAR was organized by the Academy under NATP, at the Indian Institute of Management, Ahmedabad to sensitize them on macro-economic transformations occurring in the global scenario with special emphasis on agriculture and the challenges confronted by ICAR in achieving its vision 2020.

The year witnessed a spurt in the international training programmes. Five International Training Programmes organized during the year led to capacity building of 31 participants from Sri Lanka, Tanzania and Yemen in the areas of agricultural research management.

On the research front, various institutional and externally funded projects were pursued actively. Important research achievements of the year include:

- In collaboration with MANAGE, the Strategic Research and Extension Plan



AGRICULTURAL HUMAN RESOURCE DEVELOPMENT

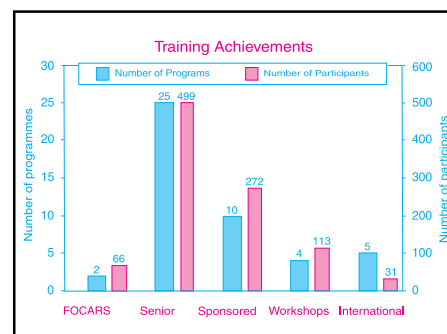
(SREP) guidelines were developed and utilized for developing SREPs in seven districts of Andhra Pradesh, Bihar, Himachal Pradesh and Maharashtra states.

- A basic framework for assessing the performance of agricultural research organizations towards ensuring their accountability was developed in collaboration with ISNAR.
- Based on training need assessment, manpower development strategy was developed for training of ICAR headquarters staff.
- A Web site - Agricultural Gateway of India with extensive links to important sites related to agricultural R and D was developed.

Policy Support

The institute continued to extend policy support to the ICAR by developing the following policy document.

- A Comprehensive Purchase Manual for ICAR.
- Constitution, Structure, Financial and Administrative Powers of Institute Management Committee
- Human Resource Development Strategy for scientists, administrative and finance officers of ICAR.
- Guidelines on Research Project Budgeting and Time Management were developed for ICAR.





- Allocation of livestock research resources across regions and species was assessed
- Considerable scope to raise rice and wheat yield in Indo-Gangetic plains
- Appropriate tariffs to be imposed to regulate unwanted imports
- Livestock sector should get half of the research resources

AGRICULTURAL ECONOMICS

Prioritizing Livestock Research

India's livestock sector is experiencing fast growth. Output growth of the sheep, goat and buffalo is largely number driven. A technological breakthrough is yet to take place in these species. This study provides quantitative assessment of allocation of livestock research resources across regions and species to achieve the goals of efficiency, equity, nutritional security and sustainability. The regional pattern of suggested allocation of livestock research resources indicated highest allocation to Uttar Pradesh (14.4%), followed by Maharashtra (12%), Bihar (10.3%), Andhra Pradesh (9.6%), Rajasthan (7.7%) and Madhya Pradesh (7%). In terms of species, maximum resources should be allocated to buffalo (40.2%), followed by cattle (37.6%), poultry (10%), goat (7.9%) and sheep (1.8%). In cattle 78% of research resources should be earmarked for milk production research and 17% for draught power. Milk production research should claim most of the buffalo research resources (93%). Goat research should emphasize for meat research (57%) followed by milk (34%), while more than three-fourths of sheep research resources should be targeted to meat research. Poultry research resources should be allocated between meat and egg research in a ratio of 2 : 1.

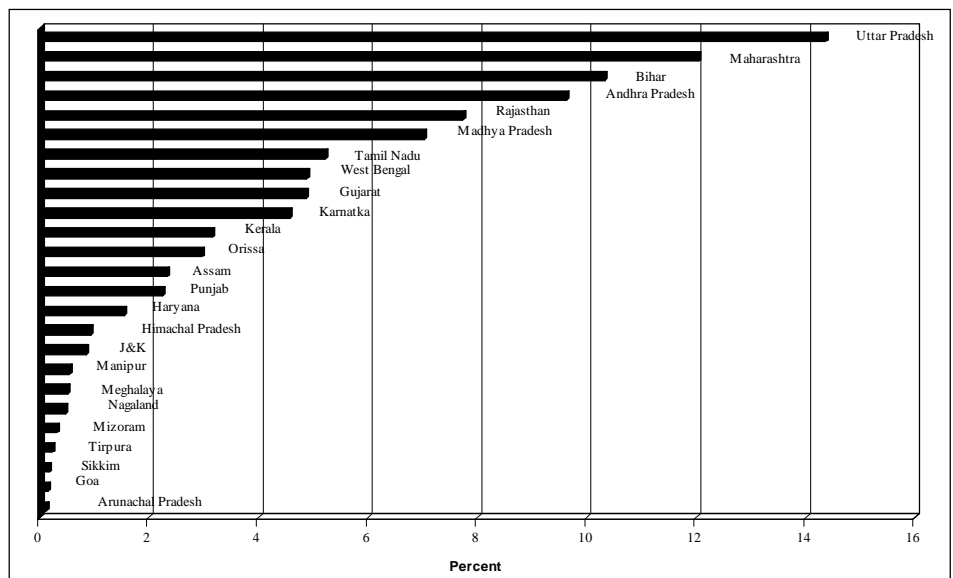
Existing and normative allocation of research resources by species (%)

Species	Existing	Normative
Cattle	29.9	37.6
Buffalo	21.2	40.2
Goat	14.2	7.9
Sheep	11.9	1.8
Pig	1.9	1.0
Poultry	12.9	10.1
Camel	2.2	Neg
Equine	4.2	1.5
Others	1.6	-
Total	100	100

Equity Driven Trade Policy and Strategies for Indian Agriculture

India has emerged as a major exporter of rice and its share in global rice trade has reached about 20% in some years because of liberalization of exports. The trade in wheat shows violent year-to-year fluctuations. In some years, country exported

Regional Priorities in Livestock Research



huge quantity, while in others, it had to go for massive imports. The study showed that export surpluses of wheat were of very transitory nature and their disposal as export necessitated huge imports subsequently, to stabilize domestic prices and to meet domestic requirement.

In recent years, international prices of agricultural commodities have plummeted to a very low level hitting agricultural exports of India, which had been rising at a fast rate after initiation of economic reforms programme. International prices show very high volatility. Transmission of such shocks to farm level would destabilize cropping pattern and cause uncertainty in farm income. Since vast majorities of Indian farmers are either small or marginal, they do not have resources and capability to swiftly shift from one kind of crop pattern to another. Under WTO obligations, it is difficult to check such temporary imports and shocks through quantitative restrictions (QRs). There is a need for alertness to impose appropriate tariffs to regulate unwanted imports.

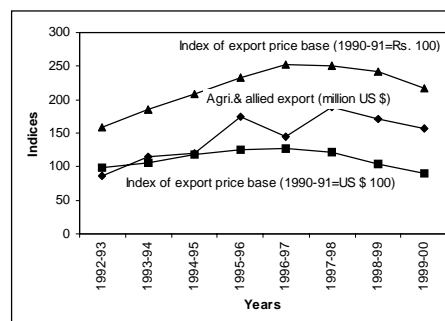
Demand for Livestock Products in India

Consumption of livestock products in India has been increasing over the past 20 years. Sustained economic growth and attendant increase in per capita incomes are expected to further boost livestock product demand substantially. Demand for livestock products for the year 2020 was estimated on the basis of the actual consumption in the year 1993. The expenditure elasticity of livestock products is high particularly in rural areas compared to urban areas implying thereby acceleration in demand for livestock products in rural areas with rising per capita incomes. Further, the expenditure elasticity of livestock products is higher than elasticity of other food expenditures. This implies that there would be a shift in consumption pattern towards livestock products. This is evident from the demand projections for 2020. Demand for milk and meat is estimated to be 147 and 14 million tonnes, respectively.

Demand projections of livestock products towards 2020					
Product	1993	2000	2010	2020	Per cent annual growth rate (1993-2000)
Milk	46.18	60.77	94.30	147.21	4.77
Mutton and goat meat	0.83	1.36	3.81	12.72	13.25
Beef and buffalo meat	0.49	0.61	0.84	1.15	3.39
Chicken	0.25	0.33	0.52	0.81	4.67
Eggs	9.62	13.88	24.90	44.06	6.02
All products in million tonnes except eggs (billion no.).					

Sustainability Implications of Tank Irrigation in Andhra Pradesh

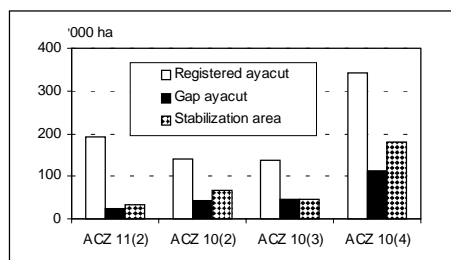
Tank irrigation system infrastructure in south India is continuously deteriorating, which has equity and sustainability implications. For instance, for Andhra Pradesh as a whole, gap Ayacut (no irrigation) and stabilization areas (partial irrigation) constitute 2/3rd of the registered Ayacut in the 90's. Within the state, only 1/5th to 1/3rd of registered ayacut gets assured irrigation in Rayalseema and Telengana regions. These regions are drought prone; account for 4/5ths of the mandals with more than 85% groundwater exploitation; highlighting the sustainability implications of deteriorating tank irrigation infrastructure. Notably, farms in tank irrigated command are predominantly small in size; 40% in less than 0.5 ha category, 60% in less than 1 ha size and 80% in less than 2 ha size, highlighting the equity implications of deteriorating tank irrigation infrastructure. Currently, loss in tank irrigated area has reached around 1/4th of the net irrigated area in the state. There is urgent need



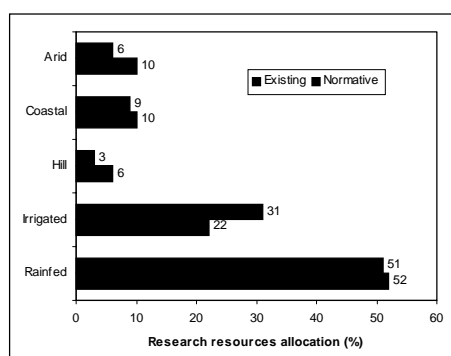
Indices of India's agricultural export in US\$

SUSTAINABILITY OF RICE AND WHEAT IN INDO-GANGETIC PLAINS

A larger area under rice and wheat in the rice-wheat cropping system in Indo-Gangetic Plains (IGP) is showing clear signs of unsustainability. It is estimated that about 62 % of the rice area and 53% of the wheat area was not sustainable in 1990s. It may be mentioned that the unsustainable sub-regions contribute about 55% to both rice and wheat production in IGP. Their share in increased rice and wheat production since introduction of green revolution technologies has been nearly 50%. The production increase has now been constrained due to plateauing of rice and wheat yields and limited scope of area expansion. In Trans-Gangetic and Upper-Gangetic plains, overexploitation of groundwater and declining biodiversity are responsible for unsustainability. Nonetheless, there exists considerable scope to raise yield levels in the Middle and Lower Gangetic plains through technological interventions and management of natural resources.



Deteriorating minor irrigation tank infrastructure in Andhra Pradesh 1990's



Existing and normative allocation of resources (%)

for rehabilitating tank infrastructure and ensuring its physical and financial sustainability through beneficiary involvement in its maintenance and management.

Aggregate Level Priority Setting for Optimum Resource Allocation

An attempt was made to allocate research resources more objectively across agro-ecoregions and production systems. The proposed allocations are based on congruence approach, which takes into consideration the multiple research objectives of efficiency, equity and sustainability. The results suggested reallocation of the NATP research resources across various agro-ecoregions. Irrigated agro-ecoregion should get 9% more of the research resources. Further, results suggested that about one-half of the research resources should be allocated to livestock sector in arid agro-ecoregion. Similarly, about 30% of research resources should go to horticultural crops in coastal agro-ecoregion.

Research resource allocation across agro-ecoregions and commodity groups (%)

Commodity	Agro-ecoregions					Overall
	Arid	Coastal	Hill	Irrigated	Rainfed	
Cereals	17	37	38	38	26	31
Pulses	4	1	neg.	3	6	4
Oilseeds	24	5	2	4	13	10
Livestock	51	21	44	39	34	36
Horticulture	2	30	10	8	11	11
Other crops	2	6	5	8	10	8

WORKSHOP ON INTEGRATED PEST MANAGEMENT IN INDIAN AGRICULTURE 2-3 AUGUST, 2001

The salient recommendations of the workshop organized jointly by NCAP and NCIPM on 2-3 August 2001 are:

- Evolve suitable methodologies for estimation of crop losses due to insects, pests, weeds and diseases, and estimate losses by crops and regions
- Prioritize regions and crops for implementation of IPM programmes
- Strengthen pest monitoring and forecasting systems
- Encourage private investment in bio-pesticides through price and non-price incentives
- Ensure quality control of bio-pesticides
- Positioning of a nodal officer for IPM in each state
- Publicize widely the success stories
- Emphasize on collective action approach

AGRICULTURAL STATISTICS AND COMPUTER APPLICATION

Vegetables are short duration crops with multiple pickings and estimation of extent of their cultivation and production poses several methodological problems. Realising the need of the methodology, the IASRI, New Delhi, had conducted series of pilot sample surveys and the methodology for estimation of area and production at district level was developed. In these surveys, the data for yield were collected for all the pickings of the selected plots. This necessitates the presence of enumerator in limited number of selected villages, as frequent visits are needed for attending every picking in the selected fields. This is cost prohibitive, therefore, an alternate procedure was investigated in which yield is estimated on the basis of partial harvest. Area and



production of important vegetable crops, on the basis of partial harvest, were estimated in two phases. In the first phase, the problem was tackled by sampling from two dimensional populations where, in one dimension selection of sampling units was considered and in the other dimension sampling was spread over time in which the selected units were observed. An approach for a variety of sampling designs associated with sampling overtime was developed using the varying probability sampling methods. This method was tested on secondary data in which different duration of time intervals—on which the data were to be collected and also the periodicity for the systematic sampling interval—were tackled. A span of 7 days in a gap of 14 days was a suitable plan for observing partial harvest data for different vegetable crops. In the second phase, a survey was conducted in rural areas of Delhi during 1995-96, through which the methodology developed for estimation of vegetable production based on partial harvest was demonstrated. This method will be useful for the State Agriculture departments that are providing statistics of production of vegetable crops to the Ministry of Agriculture, Government of India.

- A need was felt to estimate, with reliable precision, the quantum of intake by animals through grazing. The IASRI, New Delhi, conducted studies to evolve technique for determination of intake through grazing and gave precise estimates of intake. The total intake by an animal is through stall feeding and grazing. On an average intake of a cattle per day was 3 kg green, 6 kg dry fodder, about 1 kg concentrates and 6.3 kg herbage through grazing; and intake of buffalo was 3 kg green, 7 kg dry, 3 kg concentrates and 8.4 kg herbage through grazing. The technique evolved for estimation of intake through grazing is based on statistical principles. The findings of the technique were encouraging. The results would be useful for to the dairy planners and other agencies involved in animal husbandry activities.
- A fatigue score card based on qualitative and quantitative physiological characteristics of camel was developed in collaboration with Krishi Vigyan Kendra, Rewari, under the aegis of the All India Co-ordinated Research Project on Utilization of Animal Energy. This fatigue score card is very useful for the farmers, military, farms, etc. Suitable work cycles were also obtained for various draughts.
- A linear programming approach was developed for estimating/projecting the energy requirement in agricultural sector. The approach uses the maximization of yield subject to the constraints on the availability of energy

- Methodology developed for estimation of area and production of vegetable at district level
- Technique developed to estimate animal intake through grazing
- Sampling design proposed for drawl of fertilizers samples from ship hatches
- A fatigue score card developed for camel
- Estimation/projection of energy requirement in agriculture is now possible
- Consultancy and advisory services available for sophisticated statistical techniques
- Model developed for forecasting the onset of powdery mildew in mango
- Agricultural income influences the leased-in-area
- Constraints in marketing of onion affects onion production

SAMPLING PROCEDURE FOR SELECTION OF REPRESENTATIVE SAMPLES OF FERTILIZERS FROM SHIP

A suitable procedure is necessary to check whether the imported fertilizer is as per specifications given in the supply order. The ICAR ad-hoc scheme entitled "Sampling Procedure for Selection of Representative Samples of Fertilizers from Ship" was undertaken to review the existing methodology of drawl of samples of fertilizers from vessels arriving at the Indian ports, and to develop a sampling methodology for selection of representative samples of fertilizers from ships for quality checking. The primary data were collected from two ports—one major port (Kandla) and one minor port (Kakinada). A systematic sampling design was proposed for drawl of fertilizer samples from ship hatches. At minor ports, the ship is anchored mid sea accordingly the above sampling procedure was suitably modified. The data were analyzed to test for significance of difference of means and variances of the hatches, in respect of physical parameters of fertilizer, namely, moisture content and particle size. It revealed no significant difference between hatch-wise means and variances for fertilizer samples of diammonium phosphate (DAP) and murate of potash (MOP) collected at the Kandla port and Kakinada port respectively. The optimum values of the sample size worked out to be 14 for diammonium phosphate and 30 for murate of potash for both the physical parameters.



FORECASTING OF POWDERY MILDEW AND ANTHRACNOSE

In a study entitled 'Epidemiology and Forecasting of Powdery Mildew and Anthracnose', early warning models were developed for Kakori and Malihabad mango belt of Uttar Pradesh, using logistic regression models by describing the relationship of weather parameters upon epidemic status of powdery mildew in mango. While validating these models it was found that the results obtained compared well with the observed responses. Thus, forewarning probabilities of occurrence of powdery mildew disease are obtained 3-4 days before the usual onset of epidemic i.e. third week of March, for taking timely remedial measures for prevention of powdery mildew in mango.

LAND HOLDING STRUCTURE IN INDIA

Study of land tenancy structure in Indian agriculture revealed that wholly owned and self operated holdings account for more than 90% of the holdings and operational areas in the country. The proportion of wholly leased-in holdings is declining over time in all the states. Greater proportion of marginal holdings was found wholly leased-in various states. For the country as a whole, for the total leased-in area, the largest share was accounted for by the share of produce, followed by fixed money and fixed produce. Agricultural income influenced the leased-in-area positively, whereas, the level of poverty in a state had negative impact on tenancy.

AGRICULTURAL RESEARCH DATA BOOK 2001

The Indian Council of Agricultural Research being an apex scientific organization at national level, plays a crucial role in promoting and accelerating use of science and technology programme relating to agricultural research and education. It also provides assistance and support in demonstrating the use of new technologies in agriculture. Information pertaining to agricultural research, education and related aspects available from different sources is scattered over various types of published and unpublished records. The Agricultural Research Data Book 2001, which is fifth in the series is an attempt to put together main components / indicators of such information. The Data Book comprises 160 Tables. It includes 11 sections namely, Natural Resources, Environment, Agricultural Inputs, Fisheries, Horticulture, Production and Productivity, Produce Management, Export and Import, Indian Position in World Agriculture, Investment in Agricultural Research and Education and Human Resources under National Agricultural Research System (NARS). It also contains at the end, list of important National and International Institutions associated with agricultural research and education along with their addresses and contact points.

from human labour, animal labour, diesel, electricity, seed rate, farmyard manure (FYM), fertilizer, chemicals, machinery, total energy, etc. The procedure was also used for minimization of total energy for obtaining a given level of yield. The concept of energy use efficiency was also introduced. This technique is being exploited by the All India Co-ordinated Research Project on Energy Requirement in Agricultural Sector, at the Central Institute of Agricultural Engineering, Bhopal.

- The consultancy and advisory services were taken up rigorously at the institute. The actual problems of the experimenters in terms of the design to be used, generation of randomized lay out of the design, actual analysis of data already generated by using modern sophisticated statistical techniques etc. were taken up.
- Economic analysis of onion production in Nasik District, revealed that the major constraints in onion production, are the non-availability of credit in time, non-availability of season specific high yielding varieties of onion, lack of storage facilities, and malpractices in marketing of produce.
- Institute organized training programmes/courses in computer application for the officials of SAUs, ICAR Institutes and others.

Software and Information System Development

Project Information and Management System (PIMS) -standalone version under Institutionalization of Research Priority Setting, Monitoring and Evaluation and Networking of Social Scientists (Sub-project under NATP, O and M) was developed and implemented.

The following Softwares are under development stage

- PIMS Internet version PIMSNET under Institutionalization of Research Priority Setting, Monitoring and Evaluation and Networking of Social Scientists (Sub-project under NATP, O & M)
- National Information System on Agricultural Education (On-line Version)
- Development of software for Online Information on Personnel Management in ICAR System
- Development of SPAR2.0 (Windows version of SPAR1)



Technology Assessment, Refinement and Transfer

The activities of Division of Agricultural Extension include technology assessment, refinement, and its dissemination. The council have established one National Research Centre for Women in Agriculture (NRCWA) at Bhubaneshwar (Orissa). At present, there are 261 KVKs, 8 TTCs, 70 IVLP Centres, 60 Centres of Technology Evaluation and Impact Assessment, and 40 ATICs in State Agricultural Universities and ICAR Institutes under frontline extension programmes. The council have also strengthened 53 Zonal Agricultural Research Stations (ZARSs) to take up the additional functions of KVKs.

KRISHI VIGYAN KENDRAS

The activities of KVK include skill training of farmers; on-farm testing; in-service training of extension personnel; and organizing frontline demonstrations to establish production potentials on farmers' fields and provide feed back.

Farmers' Training

Training courses (13,884) benefiting 0.3.5 million farmers and farm women were organized in various aspects of crop production, horticulture, plant protection, livestock production and management, home science, agricultural extension, agricultural engineering, fisheries, agro-forestry, etc. These courses include 398 sponsored programmes funded by various other agencies.

Training courses for farmers and farm women				
	No. of courses	No. of beneficiaries		
		Male	Female	Total
Agril extension	1,473	34,536	13,609	48,145
Agril engineering	472	7,473	3,023	10,496
Agroforestry	139	2,267	326	2,593
Livestock production and management	1,834	29,144	10,773	39,917
Crop production	3,622	88,959	21,007	1,09,966
Fisheries	234	3,933	490	4,423
Home science	2,122	4,958	42,223	47,181
Horticulture	2,460	45,245	13,858	59,103
Plant protection	1,297	26,864	4,533	31,397
Soil fertility	167	3,526	448	3,974
*Others	64	883	472	1,355
Total	13,884	2,47,788	1,10,762	3,58,550

*Mushroom production, apiculture, rural crafts and sericulture

Vocational Training for Rural Youth

The training courses for rural youths were organized in agricultural extension, agricultural engineering, agroforestry, animal science, apiculture, crop production, fishery, home science, horticulture, agri-business, mushroom production, plant protection, rural crafts and other income generating activities. A total of 3,011 vocational and skill-oriented training courses were organized for 59,422 rural youths.

- KVKs organized 13,884 training courses for farmers, 3,011 vocational and skill-oriented training courses for rural youth, and 1,480 training programmes for in-service personnel
- KVKs organized 10,182 extension activities to accelerate dissemination of technologies
- KVKs staff delivered 1,494 radio and TV talks on the latest technologies for the benefit of the farmers, farm women and rural youth
- Most KVKs started publication of quarterly newsletters in local languages.
- KVKs produced 1607.7 tonnes of seed of cereal crops, 163.4 tonnes of oil-seeds, 382.30 tonnes of pulses and 57.7 tonnes of vegetables. In addition, also produced 0.77 million fruit saplings, 1.19 million vegetable seedlings, 5.8 thousand spices seedlings and other 0.47 million seedlings of forest species mulberry, ornamental and other plantation crops, besides fish fingerlings and spawn.
- Yield increased in oilseeds, pulses, cereals, fodder and horticultural crops through frontline demonstrations
- KVKs identified various technologies for on-farm testing to evaluate and assess its impact on specific locations

Training on repair of spray pumps for rural youth at KVK, Banswara (Rajasthan)





Training on craft for rural women at KVK, Udaipur

Training courses for rural youth				
	No. of courses	No. of beneficiaries		
		Male	Female	Total
Agril extension	226	3,863	1,863	5,726
Agril engineering	127	2,046	179	2,225
Livestock production and management	424	5,891	2,322	8,213
Apiculture	50	1,186	63	1,249
Crop production	477	7,901	2,283	10,184
Fisheries	107	2,008	151	2,159
Home science	707	1,492	11,360	12,852
Horticulture	568	7,109	3,124	10,233
Mushroom production	51	923	283	1,206
Plant protection	191	3,399	793	4,192
*Others	83	418	765	1,183
Total	3,011	36,236	23,186	59,422

* Bio-fertilizer, bio-pesticide, medicinal plants, sericulture and soil fertility.

Training Programmes for In-service Personnel

Training programmes (1,480) were conducted covering 35,031 participants. The training was imparted through participatory training methodologies, field visits and other interactive methods.

Extension Activities

KVKs organized 10,182 extension activities. These include kisan melas (246), field days (1,215), kisan goshies (1,043), radio & TV talks (1,494), film shows (761), exhibitions (170), newspaper coverages (2,192) and others activities (3,061) like publication of extension literatures, diagnostic surveys, ex-trainees sammelans, etc.

Most KVKs have started publication of quarterly newsletters in the local languages covering the success stories, current agricultural operations to be undertaken by the farmers, and the list of the programmes scheduled during the coming quarter. The



Training on the use of paddy-drum seeder for rural youth at KVK, Bidar



TECHNOLOGY ASSESSMENT, REFINEMENT AND TRANSFER

Extension activities									
	Kisan melas	Field days	Kisan gosthies	Radio & TV talks	Film shows	Exhibitions	Newspaper coverages	*Others	Total
Zone I	19	110	109	107	85	69	559	24	1,082
Zone II	35	170	39	202	456	13	49	1,509	2,473
Zone III	5	27	14	18	9	5	12	18	108
Zone IV	28	101	86	50	17	21	158	189	650
Zone V	77	195	72	554	139	18	373	115	1,543
Zone VI	18	135	53	157	15	11	215	820	1,424
Zone VII	15	348	20	357	18	14	427	277	1,476
Zone VIII	49	129	650	49	22	19	399	109	1,426
Total	246	1,215	1,043	1,494	761	170	2,192	3,061	10,182

*Popular articles, extension literature and advisory services

Training courses for in-service personnel				
	No. of courses	No. of beneficiaries		
		Male	Female	Total
Agril extension	289	5,736	591	6,327
Agril engineering	42	737	54	791
Agroforestry	15	212	112	324
Livestock production and management	117	1,952	231	2,183
Crop production	391	9,886	515	10,401
Fisheries	91	1,727	68	1,795
Home science	156	633	2,881	3,514
Horticulture	219	4,519	562	5,081
Plant protection	116	3,032	115	3,147
Soil fertility	28	792	54	846
*Others	16	155	467	622
Total	1,480	29,381	5,650	35,031

*Agril business, apiculture ,medicinal plants, mushroom production, rural crafts and sericulture

KVKs also adopted group approach for dissemination of technologies by organizing youth clubs and mahila mandals for dissemination of information.

Frontline Demonstrations

The Frontline demonstrations (FLD) were conducted to demonstrate the production potential of the newly released production technologies in a given farming system. The training and field days were organized for extension workers and farmers for dissemination of technologies.

Oilseeds: During the year 12,132 demonstrations were conducted covering 4,488.18 ha on major oilseed crops including soybean, linseed, safflower, mustard, groundnut, sesame, castor and niger. The percentage increase in yield varied from 19.80 in castor to 80.60 in niger.

Pulses: The demonstrations were conducted on lentil, mothbean, redgram, blackgram, bengalgram, greengram, rajmash and field pea. A total of 2,404.13 ha was covered with 7,737 farmers. The percentage of increase in yield varied from 31.60 in rajmash to 52.0 in mothbean.

Other crops: The KVKs organized FLDs on cereals, fodder and horticultural crops covering 1,119.2 ha benefiting 3,026 farmers. The demonstration yield vis-à-vis local check are indicated.

FLD on mustard showed 42.9% increase over local yield in Nimpith KVK adopted village in Sunderban





Frontline demonstration on oilseeds					
Crops	No. of demonstrations	Area (ha)	Demonstration yield (tonnes/ha)	Local yield (tonnes/ha)	Increase (%)
Castor	303	147.40	1.63	1.36	19.8
Groundnut (<i>kharif</i>)	1,874	678.00	1.45	0.99	46.5
Groundnut (<i>rabi</i>)	1,466	536.70	1.88	1.21	55.4
Niger	642	153.10	0.32	0.18	80.6
Sesame	811	310.40	0.64	0.27	61.2
Soybean	1,655	584.98	1.53	1.13	34.5
Sunflower	688	339.80	1.57	1.15	36.5
Linseed	177	78.00	0.89	0.50	78.0
Mustard	4,469	1,629.80	1.40	0.98	42.9
Safflower	47	30.00	0.64	0.43	48.8
Total	12,132	4,488.18	–	–	–



Assessment of basmati varieties, Haryana Basmati 1 and Tarawari, under IVLP programme at farmer's field

Frontline demonstrations on pulses					
Crops	No. of farmers	Area (ha)	Demonstration yield (tonnes/ha)	Local yield (tonnes/ha)	Increase (%)
Blackgram	1,501	390.05	0.79	0.53	49.0
Greengram	1,013	362.20	0.76	0.55	38.2
Mothbean	98	45.00	0.49	0.32	53.0
Redgram	1,192	400.10	1.15	0.85	35.3
Bengalgram	2,614	873.70	1.47	1.05	40.0
Lentil	767	203.43	1.35	0.89	51.7
Pea	552	129.65	1.87	1.23	52.0
Total	7,737	2,404.13			



Frontline demonstrations on other crops			
Crops	Average yield (tonnes/ha)		Increase (%)
	Demonstrations	Local check	
Jowar	2.18	1.94	12.4
Maize	4.26	2.83	50.5
Paddy	4.23	3.15	34.3
Wheat	3.79	3.20	18.4
Pearlmillet	1.34	1.03	30.1
Barley	4.53	3.71	22.1
Chillies	21.47	16.04	33.8
Sugarcane	83.00	75.00	10.6
Turmeric	20.60	15.25	35.1
<i>Bhindi</i>	4.89	3.26	50.2
Bitter gourd	13.32	8.00	66.5
Brinjal	17.99	12.94	39.0
Cabbage	25.02	16.22	54.2
Clusterbean	2.01	1.42	41.5
Fennel	1.10	0.79	39.2
Onion	24.50	19.20	27.6
Pea	15.00	9.80	53.1
Potato	31.05	17.80	74.4
Tomato	20.19	11.82	70.2
Marigold	7.42	5.40	37.4



MAT type paddy nursery bed preparation for machine transplanting at JSS KVK, Karnataka

On-farm testing

Various technologies were identified for on-farm testing by the KVKs to evaluate and assess its impact on location-specific basis.

Increasing growth rate of rohu in farmers' ponds: The trials were conducted on different feeds such as cow dung, poultry litter, rice bran+mustard cake (1:1) in four ponds measuring 0.20 ha each in Jamui districts of Bihar. The pH value of all the ponds ranged from 7.4-8.8. Cow dung and poultry litter were used @ 40-50 kg/ha and rice bran+oil cake @ 1:1. The results based on the body weight of fish taken at



3-months intervals indicate that the maximum body weight of fish from the pond with rice + mustard oil cake was 248.2 gms followed by poultry litter (223.8 gms) and cow dung (203.5 gms), against 123.5 gms without feeding. Similar growth rate was also observed in next 6th month and 11th month. Thus rice bran + mustard oil cake gave best result than poultry litter and cow dung. However, poultry litter and cow dung could be used as fish feed to get additional production where the farmers can not provide rice bran + oil cake.

Growth rate of rohu in farmers' ponds with locally available feeds				
Feed ingredients	Body weight (gms)			
	3 months	6 months	9 months	11 months
Cow dung	203.5	385.8	605.5	700.5
Poultry litter	223.8	400.5	626.7	750.0
Rice bran + mustard oil cake. (1:1)	248.2	415.6	653.8	810.0
No feed	123.5	218.5	350.0	490.0

Instability in productivity of rabi cotton under different micro-farming situations: The cultivation of *rabi*-summer cotton has been gradually increasing during the last two decades in Sundarbans areas of South 24 Parganas district of West Bengal. In coastal saline region of the district, cotton is grown in 10 micro-situations following similar cultural practices irrespective of the micro-farming situations. On the basis of availability of irrigation, land situations (medium and low land), and the extent of soil salinity; 10 micro-situations in 4 villages under two blocks were identified. To augment the productivity of cotton the agronomical practices were reformulated by using higher or lower plant population, fertilizer dose and method of application. The farmers' practice was use of 80:40:40 (NPK)/ha and planting with 60x45 cm spacing. The results of on-farm trial indicate 17.30 to 92.41% increase in yield in various micro-farming situations.

Productivity of <i>rabi</i> cotton under different micro-farming situations			
Treatment	Seed cotton yield (kg/0.1 ha)		Increase (%)
	Mean yield	Farmers' practice	
Rainfed medium land			
Moderately saline	88.1	52.0	69.42
Highly saline	76.0	39.5	92.41
Rainfed low land			
Slightly saline	74.1	55.2	34.24
Moderately saline	82.0	48.3	69.77
Highly saline	60.1	35.1	71.23
Partially irrigated medium land			
Moderately saline	91.3	67.2	35.86
Highly saline	68.4	45.9	49.02
Partially irrigated low land			
Slightly saline	95.6	71.8	33.15
Moderately saline	73.9	63.0	17.30
Highly saline	72.2	42.3	70.69

Raising vegetable nursery (hybrid chilli and tomato) under polyhouse: On-farm trial was conducted in Nawanshahar district, Punjab for raising seedlings of hybrid tomato under low tunnel polycover/polyhouse during night hours, and without



Performance of off-season hybrid tomato nursery under polyhouse												
Observations	Date of sowing of nursery and its raising technology											
	25 October			15 November			30 November			1 February		
	Poly house	Poly cover	No cover	Poly house	Poly cover	No cover	Poly house	Poly cover	No cover	Poly house	Poly cover	No cover
Days to 50% emergence	9	12	21	15	24	35	14	21	29	14	17	20
Per cent emergence	97	97	90	94	94	78	93	95	82	96	95	86
Days taken by nursery for transplanting	23	45	70	41	72	85	53	70	80	38	43	52
Survival after transplanting (%)	89	90	90	98	97	98	95	95	96	82	84	85
Early yield (up to 20th May) (tonnes/ha)	24.6	13.5	14.4	17.4	15.4	6.3	11.2	7.9	4.1	9.8	8.0	3.6
Total yield (tonnes/ha)	43.4	42.9	44.0	46.6	46.2	21.9	44.2	37.7	16.6	36.4	31.3	15.7

Performance of off-season hybrid chilli nursery under polyhouse												
Observations	Date of sowing of nursery and its raising technology											
	25 October			15 November			30 November			1 February		
	Poly house	Poly cover	No cover	Poly house	Poly cover	No cover	Poly house	Poly cover	No cover	Poly house	Poly cover	No cover
Days to 50% emergence	16	20	29	19	23	38	23	28	50	18	21	30
Per cent emergence	68	61	48	66	54	34	65	38	12	70	63	32
Days taken by nursery for transplanting	70	92	120	87	90	128	82	102	113	71	78	88
Survival after transplanting (%)	86	81	93	86	90	89	94	91	57	80	82	80
Early yield (up to 20th May) (tonnes/ha)	3.5	1.6	NIL	3.6	2.0	NIL	3.7	NIL	NIL	NIL	NIL	NIL
Total yield (tonnes/ha)	17.2	17.4	12.8	20.8	20.8	16.1	18.9	17.9	14.3	16.1	16.2	16.1

polycover, with variation in date of sowing. It was found that irrespective of date of sowing, the tomato nursery raised under polyhouse compared with other two methods, had early emergence, highest number of transplants per unit area, and early fruit harvest.

Similar trial was also conducted on chilli and it was found that irrespective of date of sowing, chilli raised under polyhouse when compared with other two methods, was early by 25-55 days, with highest number of transplant per unit area and early fruit yield.

Performance of zero-till-seed-cum-fertilizer drill: The results of zero-till-seed-cum-fertilizer drill are given below.

Increased yield. Zero-tillage trials were conducted by a number of KVKs with the objective to make the farmers aware of the use of zero-till-seed-cum-fertilizer-drill for sowing of wheat early and to reduce the expenditure on land preparation.



The performance of the trials conducted in different districts of Haryana and Punjab indicate an average increase of 6.83% of yield due to its early sowing, besides reduction in cost of land preparation.

Performance of zero-tillage in wheat at different locations of Haryana and Punjab						
Location of KVK	Year	No. of farmers	Area (ha)	Average yield (tonnes/ha)		Per cent increase over conventional
				Zero tillage	Conventional tillage	
Haryana						
Kurukshetra	1998-99	203	105.0	5.24	4.73	10.00
Kaithal	1999-01	32	39.4	46.56	4.30	8.17
Panipat	1999-2000	8	7.5	5.10	4.88	4.50
Punjab						
Ferozepur	2000-01	10	3.2	5.13	5.03	2.0
Gurdaspur	2000-01	11	10.5	4.55	4.71	-
Kapurthala	1999-01	22	16.3	4.79	4.85	-
Patiala	1999-01	33	43.0	4.73	4.62	2.35
Total		319	224.9	4.97	4.65	6.83

Reduction in density of <i>Phalaris minor</i> in wheat at different locations				
District	Year	Population of weeds/m ²		% of reduction in weed density over conventional method
		Zero tillage	Conventional method	
Haryana				
Kurukshetra	1998-99	484	706	31.4
Kurukshetra	1999-2000	424	653	35.1
Kurukshetra	1999-2000	620	785	21.1
Kurukshetra	2000-01	487	693	29.7
Panipat	1999-2000	780	1140	31.6
Punjab				
Ferozepur	2000-01	200	500	60.0
Kapurthala	1999-2000	12	87	86.2

Reduced weed population. The trials conducted in Kurukshetra district of Haryana indicated that sowing with zero-tillage drill reduced the population of *Phalaris minor* in wheat ranging from 21.1 to 35.1% compared to broadcasting. The decrease in population of weed was lower under late sown conditions (21% during 1999-2000). In Panipat district of Haryana, the reduction of weed was 31.6% under zero-tillage seed drill. Whereas in Ferozepur and Kapurthala, the reduction in weed population was 60.0 and 86.2% less respectively under zero-tillage as compared to conventional method.

Impact of frontline demonstrations on oilseeds: The KVK, Tikamgarh, Madhya Pradesh, conducted frontline demonstrations on mustard since 1991-92. The demonstration yield varied from 1.22 tonnes/ha in 1997-98 to 1.77 tonnes/ha in 2000-01. Variation in yield obtained with farmer's practice was 0.4 to 1.02 tonnes/ha. Increase in yield under demonstration over the yield of farmers' practice (local check) ranged from 48 to 206% over the years. District average yield ranged between 0.20 tonne/ha and 0.43 tonne/ha from 1991-92 to 1999-2000.



Increase in local check due to demonstration conducted on mustard						
Year	No. of demonstration	Area (ha)	Average yield (tonnes/ha)		% increase in yield over local check	% increase in yield of local check over
			Demonstration	Local check		
1991-92	50	39.2	1.43	0.49	190	-
1991-92 to 1993-94	107	64.2	1.47	0.57	159	15.8
1992-93 to 1994-95	82	350	1.57	0.72	117	46.8
1993-94 to 1994-95	69	30.0	1.60	0.76	109	55.6
1994-95 to 1995-96	68	30.0	1.71	0.76	123	54.1
1995-96 to 1996-97	68	30.0	1.58	0.62	152	27.2
1996-97 to 1997-98	74	30.0	1.60	0.64	148	30.8
1997-98 to 1998-99	75	30.0	1.50	0.74	102	50.9
1998-99 to 2000-01	75	30.0	1.68	0.88	91	79.3

Under demonstration the yield increased from 1.43 tonnes/ha in 1991-92 to 1.68 tonnes/ha in 1998-99 to 2000-01 over the local check. During the same period the local check increased from 0.49 tonnes/ha to 0.88 tonnes/ha; resulting in decline in the percentage of increase over local check from 190 to 91%. Overall the percentage of increase of local check increased from 15.8% during 1991-92 to 1993-94 to 79.3% during 1998-99 to 2000-01 over the base year of 1991-92.

TRAINERS' TRAINING CENTRES

There are eight Trainers' Training Centres. In these centers, training is imparted through work experience, lectures, field visits, demonstrations and discussions. During the year, 229 training courses were organized benefiting 5,513 participants. During the year, two more TTCs in the areas of vegetables and citrus will be established.

MONITORING MECHANISM

The Project is monitored through 8 Zonal Co-ordinating Units, located at Ludhiana (Zone I), Calcutta (Zone II), Shillong (Zone III), Kanpur (Zone IV), Hyderabad (Zone V), Jodhpur (Zone VI), Jabalpur (Zone VII) and Bangalore (Zone-VIII). The Zonal Units monitor the frontline extension programmes by organizing Workshop at State level and Zones, Scientific Advisory Committee Meeting and visits. During the year 8 Zonal Workshops were organized with the participation of the Incharges of all the KVKs to review the work done during the year and formulation of action plan for the next year. Similarly, 32 state-level workshops were organized in order

Training in vegetable seed production at KVK farm



- TTCs organized 229 training courses, benefiting 5,513 participants. Two more TTCs in the areas of vegetables and citrus to be established
- Joint Project of Division of Crop Sciences and Agricultural Extension evaluated 10 wheat varieties and 15 sunflower cultivars

TECHNOLOGY EVALUATION AND IMPACT ASSESSMENT PROJECT

The Division jointly with the Division of Crop Sciences has been implementing an All India Co-ordinated Crop Improvement Project for multi-locational trials across various crop production ecologies in different parts of the country to identify superior yielding varieties. During the year, at different locations trials on wheat under irrigated conditions were laid to evaluate 10 wheat varieties. The results at KVK, Faridabad indicated highest yield of wheat (7.21 tonnes/ha) from WH 542 and lowest (5.85 tonnes/ha) from PBW 495. Whereas under rainfed conditions at KVK, Chamba trial of 16 varieties of wheat with four replications indicated that varieties of HS 240, HS 418, VL 822 and VL 804 were superior to others. For advanced hybrid trials of sunflower at KVK, Kapurthala, 15 cultivars were included. The results indicated different cultivars reached at flowering stage varying from 54 to 67 days and bore 50% flowers within a period of one week. All cultivars took 104 to 108 days to mature.



SEED/PLANTING MATERIAL

The KVKs produced 1,607.7 tonnes of seed of cereal crops, 163.4 tonnes of oilseeds, 382.3 tonnes of pulses and 57.7 tonnes of vegetables. In addition, also produced 0.77 million fruit saplings, 1.19 million vegetable seedlings, 5.8 thousand spices seedlings, and other 0.47 million seedlings of forest species, mulberry, ornamental and other plantation crops, besides fish fingerlings (15,16,000) and spawn (27,75,000).

Production of seeds

Particulars	Quantity (tonnes)
Cereals	1607.7
Oilseeds	163.4
Pulses	382.3
Vegetables	57.7
Others	29.6
Mushroom spawn	0.4

Production of saplings/seedlings of fruit/vegetables/forest species

Particulars	Saplings/ Seedlings (No.)
Fruits	7,71,475
Vegetables	11,97,285
Spices	5,800
Forest species	89,099
Mulberry	50,000
Ornamental	31,595
Other plantation crops	3,01,307

TRAINING ON WOMEN IN AGRICULTURE

A five-days training was organized for Home Scientists of KVKs of Andhra Pradesh and Maharashtra in collaboration with ANGR Agricultural University, Hyderabad. In all 35 scientists participated in this programme.

to review the frontline demonstrations on oilseeds and pulses. A two-day workshop for the KVKs of Eastern India was organized at KVK, Jamui (Bihar) which was inaugurated by the then Union Agriculture Minister, Shri Nitish Kumar. The workshop was attended by the Vice-Chancellors, Directors of Extension and Directors of ICAR Institute of the region.

NATIONAL RESEARCH CENTRE FOR WOMEN IN AGRICULTURE

The Council has established NRC on Women in Agriculture (NRCWA) at Bhubaneswar (Orissa) to develop methodologies for identification of gender implications in farming systems approach and to develop women specific technologies under different production systems. The salient achievements are given below.

The centre has launched 11 research projects, viz. Identification and improvement of farming systems; Improvement in backyard poultry for farm women; Gender study on agriculture and household economy of tribals of Orissa; Development and testing of extension methods, Studies on technological need for empowering women; Measurement of physiological cost during operation of seed treatment drum; Design refinement in sitting type groundnut decorticator for women workers; Occupational health hazards of farm women; Standardization of women specific field practices in rice; Identification and evaluation of interactive learning modules; and Improvement in storage practices of seeds and grains of important crops. The Centre has also launched three new research projects, viz. (i) Improving livelihood, poverty alleviation and income generation in coastal eco-systems; (ii) Empowerment of women in agriculture; and (iii) Women in agriculture in India with special reference to crop production.

First year's result of the experiments conducted indicated that sweet potato variety Sree-Samrat was preferred by the farm women on account of suitability for roasting, usability in festive occasions, its size, yield, sweetness, longer shelf-life, providing bulk to the curry, and suitability of growing in marginal land.

The backyard poultry project with active involvement of rural women of different social strata has resulted in motivating the women farmers (a) to rear improved strains of poultry under backyard conditions and hatching their eggs for the maintenance of the flock, (b) to make use of backyard poultry for family food security, and (c) to start small-scale poultry farm for supplementary income.

In a gender study on agriculture and household economy among the tribals of Orissa, it was found that work participation rate among the tribals was 57.28% marginally higher than that of male counter part. Proportionately more number of women below 15 years and above 60 years were engaged in economic activities as compared to men. It was also revealed that 90% of women workers were involved in agricultural activities.

The preliminary data obtained from the research study on technological need for empowering women in rural aquaculture revealed that 85% of the rural women having backyard ponds were interested in fish culture and found to have high level of motivation. Women trained on fish breeding during the last season took up happa breeding of carp in their backyard pond under close supervision of fishery scientist of the Institute which fetched 12 litres of fertilized eggs from three sets. Nursery management by women groups was also studied.

At sub-centre of NRCWA, CIAE, Bhopal, the experiment conducted to measure the physiological cost during operation of seed treatment drum with 25 kg seeds of soybean and pigeonpea revealed that during six minutes (required time to mix the seed), the values for 'mean working heart rate' and 'increased in heart rate over rest' were 114.7 beats per minute and 30.5 beats per minutes respectively.

The women workers found sitting type groundnut decorticator comfortable and easy to operate. Efforts have been made to design refinement in sitting type groundnut decorticator for women workers. The modified unit is under fabrication and will be again tested for its performance.



To sensitize the scientists/extension functionaries on application of appropriate technologies in agriculture and allied field for the women farmers, eight specialized training courses were organized during the year benefiting 70 scientists/extension workers. Under farm women training programme, 3 specialized training courses were organized benefiting 90 farm women. 'International Women's Day' and 'World Food Day' were organized involving farm women of adopted villages in which the emphasis was given on health, nutrition, food security and environmental sanitation.

NEW INITIATIVES

Agricultural Technology Information Centres (ATICs)

One orientation programme was organized for sensitizing the ATIC Managers and Directors of Extension Education/Directors of ICAR Institutes in concept and operation of these centres. Two training courses in designing and developing of Web page were also organized.

During the year, 0.15 million lakh farmers visited these centres out of which 0.02 million were provided with diagnostic services. The centres have provided 1132.4 tonnes of seeds of improved varieties of cereals crops, 0.65 million planting material of vegetable and fruits, 2.207 tonnes of biofertilizers, 0.25 tonnes of biopesticides, 9,354 farm implements besides processed products. The diagnostic services provided by these centres included 6,684 samples for soil and water testing, 8,900 specimens of crop plants infested by diseases/insects, besides diagnosis of 8,353 animals. The information material printed and provided included 0.11 million leaflets/pamphlets/bulletins, 360 audio/video learning modules and 58 computer based information sheets to the farmers. The centres have generated a gross income of Rs 96.53 million since their inception.

Remanded ZARs to KVKs

All the 53 centres have taken up additional functions of KVKs including vocational training of farmers, on-farm testing, frontline demonstration and in-service training of extension personnel. Two days orientation course was organized to review the activities of the centres. Training programmes (814) were organized benefiting 21,651 participants. These courses included 237 on crop production, 165 on horticulture, 93 in each home science and animal science, 78 on fishery, 56 on natural resource management, 35 on farm machinery and implements and 57 on agricultural extension. Besides, 504 front-line demonstrations in oilseeds, pulses and other crops and 71 on-farm trials were conducted. The extension activities include 65 farmers' fair, 160 field days, 929 meeting with the farmers in the different villages, 221 radio programmes, 409 newspaper coverage and 183 extension literatures.

Integrated Piggery Development Programme

The division has identified 10 KVKs for undertaking Centrally Sponsored Scheme on Integrated Piggery Development Programme financed by the Department of Animal Husbandry and Dairying, Ministry of Agriculture. All the KVKs except two have constructed the building to initiate the programme soon.

IVLP at KVK Level

Fifty KVKs have initiated for implementation of IVLP during *rabi* 2001-2002. Two training programmes of ten days duration of these KVKs were organized to orient participants about the methodology of the programme.

Intensive Cotton Development Programme (ICDP Cotton)

FLD (730) on cotton were conducted during 2001 in 35 KVKs in cotton growing area funded by Centrally Sponsored Scheme of Intensive Cotton Development

MISSION MODE PROJECT UNDER NATP

Project on collection, documentation and validation of Indigenous Technical Knowledge (ITK), has been taken up with the objectives: (i) to document information on ITK and development of an information system, and (ii) to validate the ITK practices for determining its efficiency. Till 30 September, 2001, 1734 information on ITK have been received through voluntary disclosure on different aspects of agriculture and allied areas. Information on ITK have also been collected from published/documented articles. The project is operative through 10 zonal leaders with more than 100 potential co-operating centres across the country.

Seven KVKs have been implementing Mission Mode Project on 'Validation and Promotion of IPM Technology in selected crops in Different Agro-ecological Regions'. The objectives of the project are to validate and refine the IPM module and evaluate its impact, and to develop a mechanism for creating an interface between IPM technology generation, verification and dissemination at village level among all the stakeholders. The co-operating centres include the KVKs located at Bhatinda (Punjab) and Fatehabad (Haryana) for irrigated cotton; Dausa (Rajasthan) for groundnut; Gulbarga (Karnataka) for pigeonpea; Kota (Rajasthan) for chickpea, Ranchi (Jharkhand) for tomato and cabbage, and Rohru (Himachal Pradesh) for apple.

ENERGY PARKS

The division has identified 10 KVKs for undertaking scheme to set up Energy Parks sponsored by the Ministry of Non-conventional Energy Sources.



Watershed development activities in selected KVKs			
Particulars	KVK		
	Satna	Ratlam	Guna
Total Area (ha)	12,536	4,566	3,136
Major soil and water conservation activities	Loose boulder checks, contour trenches, stone dike, earthen nala bund, ponds, mini percolation tanks, gabiyan structure, afforestation (84 ha), pasture development (24 ha), protected pasture (150 ha), and plant nursery (1,28,000)	Stop dam, earthen plug, boulder check, percolation tank, water harvesting tank, continuous contour trench, cattle protection trench and afforestation with 1,42,089 saplings	Nala bund, graded bunding, continuous contour trench, cattle protection trench, percolation tank, afforestation with 30,000 saplings, and vegetable measures
Training	15 programmes for 966 participants	169 programmes for 2,189 participants	25 programmes for 969 participants
Area (ha) under irrigation			
Before	66	2,030	490
After	1,503	2,036	1,250
Cropping intensity (%)			
Before	-	169.0	100
After	-	177.6	150
Change in productivity of crops (tonnes/ha)	Paddy 1.03 to 1.54 Sorghum 0.6 to 0.7 Pigeonpea 0.74 to 0.88 Chickpea 0.81 to 1.13 Wheat 1.58 to 2.15 Mustard 0.5 to 0.7	Soybean 1.32 to 1.40 Maize 1.10 to 1.55 Wheat 2.98 to 3.21 Mustard 1.02 to 1.15	Soybean 0.8 to 1.50 Chickpea 0.9 to 1.50 Wheat 1.0 to 3.5
Increase in Water levels in wells	0.93 m (May) and 1.80 m (December) during 1996 to 3.09 m (May) and 4.36 m (December) during 2000	7.00 m (May) and 6.5 m (December) during 1999 to 10.0 m (May) and 6.5 (December) during 2000	0.0 m (May) and 5.0 m (December) to 2.0 m (May) and 6.5 m (December) during 2000
No of Self-help groups	67	77	10

Programme under Mini-Mission-II of Technology Mission on Cotton. Two orientation training programmes were also organized for imparting details about the project to the Incharges of KVKs.

INSTITUTION-VILLAGE LINKAGE PROGRAMME (IVLP)

Out of 70 IVLP centres, 24 are located in Rainfed Zone, 19 in Irrigated Zone, 13 in Coastal Zone, 12 in Hills and Mountain Zone and 2 in Arid Zone. There were 2,146 technological interventions including 1,118 on crops, 381 on livestock, 449 on horticulture, 30 on forestry, 48 on fisheries, 21 on gender implications, and 61 on other related areas. During the year, 60,290 farmers in 246 villages were covered. An orientation workshop was also organized.

Training-cum-workshop on Watershed development

A number of KVKs have taken up Watershed Development Programme with the financial support of the respective State Governments. An orientation training-cum-workshop was conducted at Central Soil and Water Conservation Research and Training Institute, Dehradun for providing technical backstopping to the participants. A programme was conducted at KVK Satna (Madhya Pradesh) with the participation of 13 KVKs for further exposure to the participants on the methodologies of data collection and evaluation of its impact.

Training on WTO

An orientation training programme of two-days duration was organized for all the KVKs of Andhra Pradesh on WTO by the Zonal Co-ordinating Unit in collaboration with ANGR Agricultural University, Hyderabad.



3. Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through the Central Agricultural Research Institute (CARI), Port Blair, the Vivekananda Pravatiya Krishi Anusandhan Sansthan (VPKAS), Almora, and the ICAR Research Complex for North-Eastern Hills Region, Umam, Meghalaya, evolves technologies to meet the needs of tribal farmers in hilly areas.

These technologies are intended to improve the socio-economic status of the target group, and will help them to acquire special skills through vocational training in traditional and non-traditional crops, agroforestry, apiculture, sericulture, horticulture, animal husbandry, poultry and fisheries.

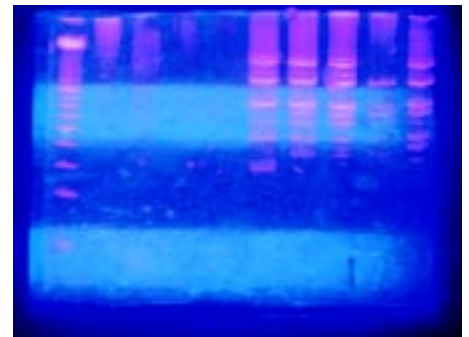
- Average linkage dendrogram confirmed ample genetic diversity in available accessions of the rice indigenous to Bay Islands
- Under-utilized fruits Malayan apple and durian collected

CENTRAL AGRICULTURAL RESEARCH INSTITUTE,
PORT BLAIR

Rice

The RAPD-PCR involving eight arbitrary decamer primers was done to discriminate the cultivars based on the extent of polymorphism in the form of discernible amplicons. A large number of bands of varied molecular weight indicated that a majority of them were polymorphic. Amplified DNA was of 0.30-1.0 kb. All the genotypes were found uniquely distinguished. Dendrograms grouped 19 genotypes into three major clusters. The average linkage dendrogram based on genetic distances confirmed the existence of ample genetic diversity in the available accessions indigenous to Bay Islands. The rice varieties found promising were Quing Livan No.1, Miliyang 55, PAC 831 and HRI 120.

In long-duration C 14-8, the maximum grain yield (3.0 tonnes/ha) was recorded with 75% of recommended N dose + *Azospirillum*. However, further reduction in N dose significantly reduced the yield. In medium (IET 6314)- and short-duration



RAPD-PCR of rice cultivars indigenous to Bay Islands

Quing Livan No. 1, is a semi-tall, medium-duration rice with moderately bold grains and good-cooking quality characters



Promising rice variety Miliyang 55 is suitable for Bay Islands. The variety possesses moderate tolerance to bacterial leaf blight, sheath blight etc. and moderate bold grains and good-cooking quality characters





- *In-vitro* flowering and fruiting induced in tomato from calli generated from leaf explants in Pant 11
- In orchids 10 species collected and catalogued
- Varieties/hybrids/types introduced from mainland: 5 of orchids (*Dendrobium* group), 14 of *Anthurium*, 23 of foliage plants, 10 of flowering plants



In-vitro flowering and fruiting were induced in tomato from calli regenerated from leaf explants of Pant 11



Tilak, a variety of gladiolus produces, 11.5 florets/spike and bigger size flowers (9.14 cm)

varieties, though the maximum grain yield was recorded with full recommended N dose, it was on a par with 75% of recommended N dose + *Azospirillum*. *Azospirillum* significantly increased the growth and yield by 17.6-52.4% in these Islands.

Broad-bed and furrow system of land manipulation for growing fodder and vegetables in rice fields showed the maximum net returns from *Amaranthus*-okra-ratoon okra, followed by growing turmeric and fodder as annual crops on the beds. Among the other vegetable sequences, the performance of brinjal-french bean-cowpea, tomato-cowpea-fallow and cowpea-brinjal-fallow was found good. In comparison to different annual crops and vegetable in sequences, performance of rice as sole crop was found below par and recorded net returns of Rs 18,900 only.

Fruits

In papaya, 25 fruits/plant were recorded in CO 3 followed by 20 fruits/plant in Sunrise Solo, 150 days after planting. Under-utilized fruits, Malayan apple and durian, were collected and planted in the field. Six-year-old sour sop selection planted gave 40 fruits/tree.

Vegetables

Of the eight varieties of cauliflower, Indam 9803 gave the highest yield (15.83 tonnes/ha), followed by Indam 19 and Indam Early (12.62 and 12.15 tonnes/ha). Among the 10 varieties of ridge gourd, Arka Sujat provided the maximum yield (21 tonnes/ha). Out of Pusa Kiran, Arka Suguna, Indam Green, Kanka Red and Katwa Sag (local) amaranths, Indam Green yielded the highest (20.84 tonnes/ha) during the rainy season.

In case of varietal evaluation with 17 varieties, KAU Hybrid 2 brinjal (21.4 tonnes/ha) performed well, followed by CH 157-16-4 1 (20.3 tonnes/ha). Similarly, in case of bacterial wilt-resistance trial with 16 varieties, BB 45 C brinjal (43.94 tonnes/ha) performed well, followed by BB 46 (35.3 tonnes/ha).

Maximum yield (tonnes/ha) of green chillies was recorded in Surakta (17.7), followed by PP 977635 (15.2), Pb. Guchhedar (14.62), PP 977122 (14.4) and LCA 334 (13.4).

In-vitro flowering and fruiting were induced in tomato from calli generated from leaf explants in Pant 11. MS with 2 mg/litre BAP displayed the best response. Flower buds/explants were 10.8. Maximum pollen fertility was 71.4% (average pollen diameter, 0.52 mm). Fruit setting was recorded within 162 days following self-pollination. In another study, all the varieties produced buds *in vitro*, earliest being KS118 within 58 days of culture.

The experiments conducted to standardize the optimum plant and fertilizer requirement for the intercrops (cucumber, ridge and sponge gourd) grown in interspaces of coconut garden showed that spacing of 100 cm × 45 cm resulted in significantly higher yields than 150 cm × 60 cm. In ridge and sponge gourd spacing of 150 cm × 60 cm resulted in significantly higher yields than 180 cm × 90 cm spacing. In all the three intercrops, an application of 12.5 tonnes FYM along with 50% of the recommended inorganic dose for the intercrop resulted in significantly higher yields.

Floriculture

Ten species of orchids were collected and catalogued. Species such as *Dendrobium crumenatum* and *D. aphyllum* are fragrant with white flowers. Five varieties/hybrids of orchids (*Dendrobium* group); 14 varieties of *Anthurium*; 23 types/varieties of foliage plants from 26 genera and 10 types/varieties of flowering plants from 13 genera were introduced from mainland.

Of the six varieties of gladiolus evaluated, Dhiraj produced the maximum number of spikes/corm (3.15) with maximum florets opened at a time (5.82 florets), and had maximum vase life (7.5 days). Tilak gladiolus had the maximum florets/spike (11.5) and bigger flower size (9.14 cm).



Plantation Crops

Among the indigenous germplasm collection of coconut, KD 8-113 gave the maximum yield (74 nuts/palm/year), followed by KD 27-72 (70). In arecanut, highest yield (328 nuts/palm/year) was obtained in Samruddhi, followed by Calicut 31 (207). In arecanut garden (0.4 ha), yield of 157,300 arecanuts, 10 kg of black pepper and 14.10 kg of cinnamon was obtained. In this intercropping, gross returns of Rs 56,000 and net returns of 41,000 were realized.

Natural Resource Management

In an acid soil in basin of oilpalm plantation, application of rockphosphate in combination with fresh poultry manure and farmyard manure to soils with earthworms significantly increased Bray-P (available P), P fractions and enzyme activity in soils and casts. The relative erosion potential of soils of Andamans and site suitability of soils of various islands for growing coconut, arecanut, tree spices and black pepper were determined and mapped.

Animal Sciences

Japanese quail (*Coturnix coturnix japonica*) is a recent introduction in Andaman and Nicobar Islands. An inter-species hybrid 'Quicken' was developed between Nicobari fowl and Japanese quail. The strain, *Lactobacillus acidophilus* N.C.D.C 014 was found to be more efficient, in augmenting the growth rate in Japanese quails in hot humid tropics of these Islands, than other strains of *Lactobacillus* and may be included in feed as a probiotic supplement.

Fisheries

Grouper is an important seafood species in Andaman. A total of 31 species of grouper were recorded, of which the most abundant species was *Epinephelus areolatus*, constituting 25% of the catch.

The breeding and larval rearing in *Macrobrachium rosenbergii* resulted in harvest of 8,000 post larvae in three successive batches for stocking in the experimental ponds.

Polyculture experiment of *M. rosenbergii* with other Indian major carps, i.e. *Labeo rohita* and *Catla catla*, in a 0.08 ha pond showed production of 546.2 kg prawns/125 days and 2,380 kg carps/350 days with 67.9 and 88.5% survival respectively. In fish-crop farming system, growth of prawns was recorded as 97.6 mg and 0.52 mg/day in a stocking density of 50,000 no./ha, showing a productivity of 627.5 kg/ha in 212 days with survival of 60.6% in a water area of 0.04 ha.

Putative transgenic rohu developed through sperm electroporation technique were reared to matured stages. One set of putative rohu was successfully induced bred and 5,000 seeds were produced. The fingerlings reared in the nursery pond showed satisfactory uniform growth, average length 124 mm and weight 24.3 g, which is higher than of catla, rohu F₁ hybrid backcrossed F₂ (with rohu).

In fish-crop-farming system, 627 kg prawn/ha was obtained in 210 days, with prawn attaining 20.7 g showing 61% survival. Rice (C 14-8) grown in rice field with zero management and without insecticides and pesticides, yielded 1 tonne/ha. The embankments of the fish-crop farming plot used for growing banana, papaya, bottle gourd and bitter melon gave 30 kg bottle gourd and 21 kg bitter melon.

Survey carried out in different locations on marine ornamental fishes revealed that 15 species of *Amphiprion* were harbouring in Andaman Islands. *Amphiprion* species are always found in association with sea anemone. Survey recorded around 10 species of sea anemone in these Islands which were having symbiotic relationships with the anemone fishes.

Breeding potential of tiger prawn, *Penaeus mondon*, collected from Middle Andaman coastal waters and reproductive behaviour of two edible oysters (*Crassostrea rivularis* and *Saccostrea cucullata*) were studied.

- An inter-species hybrid (Quicken) developed between Nicobari fowl and Japanese quail
- 31 species of grouper (important seafood species) recorded
- Polyculture of *Macrobrachium rosenbergii* with *Labeo rohita* and *Catla catla*, in 0.08 ha pond, produced 546.2 kg prawns/125 days and 2,380 kg carps/350 days, with 67.9 and 88.5% survival



A unique inter-species hybrid Quicken was developed between Nicobari fowl and Japanese quail

Grouper is an important seafood species in Andaman and is one of the most desired variety for export-oriented cage culture





- One set of putative transgenic rohu successfully induced bred
- 15 species of *Amphiprion* harbouring in Andaman Islands
- Database created on crops, livestock, poultry and fisheries, and available on institute's website
- Disease spread of humpsore successfully controlled
- Rhinoceros beetle managed in coconut

Social Science and Extension

Two in-service training programmes, one on improved pulse and oilseed production technology and another on health management of bovines were organized to the benefit extension personnel.

Frontline demonstrations, 7 on rice, 35 on pulses, 27 on oilseeds, 5 on quail farming and 10 on Nicobari fowl, were conducted and significant results were obtained.

Strain Hubbard gave an average income of Rs 12/bird, followed by Arambagh (Rs 11) and rainbow coloured broiler (Rs 8) in field.

Technology assessment and refinement through institution-village linkage programme (TAR-IVLP): Significant achievements were made through 12 technologies encompassing 141 farm families. The technologies including rice, arecanut, vegetable (bitter gourd, sweet potato, cowpea, okra, water melon), Nicobari fowl and humpsore control in cattle were assessed for their performance under different micro-farming situations in the village.

Five farmers' training programme on management of vegetable crops, poultry farming, humpsore disease, insect-pest and water-stress management of vegetable crops were conducted. A total of 116 farmers attended the training programme.

A good ATIC nursery was developed at the Institute for raising the seedlings of recommended variety of vegetables and plantation crops. Database created on agricultural crops, livestock, poultry, fisheries is available on website of the Institute.

SUCCESS STORY

CONTROL OF HUMPSORE IN ANDAMAN AND NICOBAR ISLANDS



Control of humpsore disease in Andaman and Nicobar Islands. *Left*, at 0 day; *right*, at 15 days

About 55% of local cattle and 10% buffaloes carry the disease of humpsore caused by *Stephanofilaria assamensis*. Etiology of the disease, life-cycle of *S. assamensis*, seasonal variability in sore characteristics and development of suitable chemotherapy and control measures were extensively profiled. This parasite completes its life-cycle in bovines and in a fly (*Musca conducens/Musca autumnalis*). The spread of the disease was successfully controlled. The infected animals were given following treatments:

- Levamesol (1 ml/15-20 kg body weight) sub-cut and application of zinc oxide ointment on the wound for 10 days.

- Diethyl carbomezine citrate (20% solution) 20-25 ml under the skin around the wound with application of zinc oxide ointment.
- Ivermectin (1 ml/50 kg body weight) sub-cut 4 times after every 28 days.

Cleanliness near the cattle sheds, application of insecticides for the control of flies, application of neem oil on the body of cattle, immediate treatment of wounds etc. are some preventive measures.



SUCCESS STORY

FISH CULTURE IN SOUTH ANDAMAN

Guptapara, Manglutan and Manpur are the three backward villages which maintain their livelihood on fisheries, where a large population consists of settlers from Bangladesh, Tamil Nadu, Andhra Pradesh and Bihar. After conducting benchmark survey about the irrigation of ponds owned by the farmers in these villages, a strategy for technological intervention to increase the productivity of the pond was adopted. The farmers were contacted and enlightened about the potential of using their ponds as income-generating avenue by adopting scientific fish culture. By replacing age-old stock with appropriate densities of carp fish seed of catla, rohu, mrigal etc. and by managing the pond environment appropriately, they could get maximum benefit from periodical and enhanced harvests. Thus, interest was generated for additional income through scientific fish culture, which might generate self-employment.

The villages had a total of 15 ponds of size 0.03 to 0.06 ha and all had mixed fish stocks, which were infested with weeds and *Tilapia*. Six new ponds were dug in these villages with the aid from agriculture department for irrigation and fertility.

The farmers were given training on efficient management technique and taught about stocking density and stocking ratio, quality of seed, feed and feeding and fish-health care. Adoption of improved mixed carp farming techniques could increase the production from nil to 2,500- 4,300 kg/ha. The income generation ranged from Rs 1,800 to 19,500/year from the available water area, depending on the size of the fishes harvested, types of pond management and care taken during fish culture activities.

This had tremendous impact on farmers' household economy in the villages. Special interest was created to transfer technology of induced fish breeding and seed production in these villages to solve the problem of fish seed procurement and get the advantage of entering into fish seed business for boosting income through seasonal activity.



Freshwater fish production in a village pond under composite fish culture

SUCCESS STORY

MANAGEMENT OF RHINOCEROS BEETLE IN COCONUT

The search for an eco-friendly, yet potential, method of management of rhinoceros beetle pest led to employ baculovirus, a potential bio-control agent. The virus causes disease in other adults and grubs (young stages) and ultimately kills the pest in a short period. The release of virus through artificially infected beetles was taken up in a few pockets in South Andaman during 1987. The spread of the



Control of rhinoceros beetle's grub by infecting with baculovirus. *Left*, healthy grub; *right*, baculovirus-infected grub

disease and the beetle population was suppressed and palm damage was brought down to insignificant levels. However, the damage level crossed ETL in Bambooflat during 1994 and in Sippighat in 1997 warranting further release of the virus. Accordingly, the virus was released in Bambooflat and Sippighat during 1999. The damage level assessed in Viper Island in 2000 was well within ETL. The virus release effected during 1999 in Sippighat and Bambooflat resulted in decline of palm damage in those areas.



VIVEKANANDA PARVATIYA KRISHI ANUSANDHAN SANSTHAN, ALMORA

Crop Improvement

A high-yielding (4.9 tonnes/ha) rice variety Vivek Dhan 82 was released for irrigated, transplanted conditions of hills of Uttaranchal, Himachal Pradesh and Meghalaya. In addition, six promising lines identified for release are VL Madira 181 barnyard millet for Bihar, Karnataka, Madhya Pradesh and Tamil Nadu; VLG 7 garlic for Uttaranchal, Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh, Punjab and Bihar; VL Matar 40 field pea; VR 431 spring rice; VL 798 wheat; and VLB 56 barley for Uttaranchal.



Vivek Dhan 82, an early-duration (120-125 days), blast-tolerant, long, bold-grained rice gives 47.3 and 45.5% more yield than national check K 39 and zonal check K 448-1-2

Seed Production

During the year 12.81 tonnes of breeder seed (wheat and barley 7.2 tonnes, rice 0.5 tonne, maize 0.22 tonne, small millets 0.3 tonne, pulses 0.44 tonne, oilseeds 3.0 tonnes and vegetables 0.29 tonne) of improved crop varieties for hills was produced. Besides, 9.68 tonnes of truthfully labelled seeds of improved varieties were also multiplied and distributed among the hill farmers.



Breeder seed production plots in wheat

- Vivek Dhan 82 rice variety released and 6 promising lines identified for release (1 each in barnyard millet, garlic, field pea, spring rice, wheat and barley)
- 9.68 tonnes truthfully labelled seeds of improved crop varieties for hills multiplied and distributed among hill farmers
- Uttaranchal hill has congenial environment for growing broccoli, knolkhol, lettuce and parsley
- Resistance sources identified against major diseases in rice, wheat, maize and garden pea
- Rockphosphate proved better source of P for cauliflower
- Improved grasses performed better than local ones for fodder production in hills

Identification of Resistant Sources

Several lines of field crops were found resistant against major diseases in different crops. These include VL 93-3613 and VL 95-3623 for blast; VL 97-3861 and VL 97-3678 for brown spot, sheath rot and tungro diseases in rice; VL 818 for leaf blight and VL 616 and VL 804 for foot rot in wheat; V 217, V 324, V 336, V 338 and V 339 for turcicum and maydis blights in maize; and VP 9211 for powdery mildew in gardenpea. Besides, FC 1, DPP 9411, and JP 585 garden pea also showed consistency in resistance to powdery mildew disease.

Similarly, three rice lines (VL 97-3652, VL 97-3653 and VL 97-3656) have shown resistance against major insect-pests (stem-borer, leaf folder, planthopper and gall midge).



European Vegetables

KTS 2, a variety of broccoli was found promising for curd size ranging from 150 to 300 g (average 250 g/plant). It can be harvested in 60-65 days after transplanting, yielding 10-15 tonnes/ha. White Vienna, a short-duration knol-khol, can be harvested in 40-50 days after transplanting. Its average knob size is 200-300 g/plant and can produce 20-25 tonnes/ha.

Rockphosphate, a Better Source of Phosphorus for Cauliflower

The yield of cauliflower was 15.96 tonnes/ha when rockphosphate (RP) was used as source of P and it was on a par with that obtained with single superphosphate-treated plots. This indicates that rockphosphate, a cheap and readily available source of P fertilizer, could be a better option for cauliflower.

Exploitation of Forest Run-off as a Source of Irrigation for Plant Nutrition

Utilization of run-off from pine and oak forest ecosystems in Uttarakhand showed an enhancement of yield in garden pea. The highest seed yield of pea was in the treatment that received run-off water + recommended dose of NPK. The contribution of the run-off from pine and oak forest on pea yield was 31 and 24% respectively. Besides, organic carbon content of the soil improved considerably by the run-off water treatment. Efforts are on to collect this run-off in water-harvesting structures like LDPE-lined farm ponds to utilize this nutrient-rich natural resource in crop production. The run-off contained NO_3^- , P and K 1.45, 0.12 and 4.50 mg/litre respectively in pine and 1.20, 0.24 and 2.80 mg/litre in oak vegetation.

Long-term Fertility Management

In order to study the long-term effect of organic manuring and chemical fertilization on production sustainability and soil health, a long-term experiment involving continuous soybean-wheat rotation was initiated in 1973 under rainfed condition. Based on 27 years production data, it was concluded that inclusion of a legume is essential in crop rotation (soybean-wheat) and application of FYM is essential in addition to recommended dose of NPK. Biomass recycling in addition to FYM application is also an important factor in maintaining soil organic matter. Addition of K in soils of Almora region of Uttarakhand is necessary for fertility management on long-term basis.



Knol-khol, a potential vegetable for hills. It is very remunerative and free from any serious disease



Broccoli – a successful temperate vegetable for hills of Uttarakhand



Experimental field for long-term fertility management

SUCCESS STORY

CHEMICAL WEEDICIDES – A SUCCESSFUL WAY TO CONTROL WEEDS

Heavy infestation of weeds causes significant yield loss in hills. The traditional practice of controlling weeds through hand-weeding is not only a time-consuming affair but also adds to the drudgery of the women, who are the backbone of the hill agriculture. Use of weedicides is an effective way to control the weeds. To demonstrate the efficacy of the weedicides in controlling *Ranunculus*, a major weed of irrigated wheat, Isoproturon was sprayed @ 1.0 kg a.i./ha in the farmers' fields of adopted villages under IVLP programme of the Institute. This weedicide not only effectively controlled the weeds but also resulted 32 and 30% higher grain and straw yields, respectively, compared with hand-weeding. Similarly, in irrigated rice, spraying of Butachlor was found effective in controlling the weeds and helped in harvesting more grain and straw yields. Likewise, in soybean Alachlor @ 2.0 kg a.i./ha was found effective in controlling the weeds. Having seen the benefits of weedicides in terms of higher yield and reduction in the drudgery of the women, the hill farmers now prefer to use weedicides in controlling weeds.



SUCCESS STORY

PERFORMANCE OF VL DHAN 206

In hill districts of Uttaranchal, rainfed rice occupies about 80-85% of total area under rice. Traditionally, hill farmers grow spring rice, locally known as *chaiti dhan*, using traditional cropping system. Spring rice is direct-seeded during March-April under rainfed upland condition. Usually farmers grow low-yielding traditional varieties.

VL Dhan 206 is an improved rice variety developed at this Institute for cultivation in the spring season. It was sown at farmers' fields of the villages adopted under IVLP programme of the Institute. This variety yielded 32% higher (with average 2.19 and 4.03 tonnes/ha of grain and straw yields respectively) than local cultivars. Having seen the good performance of VL Dhan 206, majority of the farmers adopted it, and nearby villagers have accepted this variety as replacement for the local cultivars.

SUCCESS STORY

AGROFORESTRY SYSTEM DEVELOPMENT FOR NORTH-WEST HIMALAYAS

As there is an acute shortage of fodder round the year in hills, a sizeable areas available under forests and wastelands can be utilized to boost up fodder production. Presently, low-yielding natural grasses generally cover these areas. Improved grasses may have their preference for a particular type of land site, depending on their nature of growth. Therefore, two improved grasses (*Pennisetum purpureum* and *Thysanolaena maxima*) were tested under slopping and marshy land and under deodar tree along with local grasses. The *P. purpureum* produced highest green forage (55.60 tonnes/ha) under deodar tree, followed by slopping land (52.50 tonnes/ha). In case of marshy land, establishment of *P. purpureum* and *T. maxima* was poor during the first year compared with that under slopy land and under deodar tree. Local grasses did not perform well in all these places.



Cultivation of forages is rarely practised in hills due to small land holdings, difficult terrain and poor socio-economic conditions of farmers, leading to acute fodder shortage. Improved grass *Pennisetum purpureum* was grown under deodar tree which gave green forage of 55.60 tonnes/ha



Transfer of Technology

The Institute carried out this programme in three villages of Hawalbagh block of Almora district. Cultivation of improved varieties at farmers' fields showed 150-200% increased yield.

The FLDs on rice and wheat showed significant results. Demonstration on weed control was one of the very successful interventions. Isoproturon was found very effective in controlling *Ranunculus* — a menacing weed of wheat in the hills. Use of weedicide helped in reducing the drudgery of the women of the area to great extent.

The Institute adopted a cluster of three villages in Garur block of district Bageshwar in Uttaranchal under 'Technology Assessment and Refinement' Project through Institution-Village Linkage Programme of the NATP. The project envisaged diversified activities such as crop husbandry, poultry, animal husbandry and fodder management. In addition to demonstrations and on-farm trials, the farmers were also given training on various aspects of agriculture at Almora, Pantnagar and Pashulok, Rishikesh.

ICAR RESEARCH COMPLEX FOR NEH REGION, UMIAM

Farming System Research for North-Eastern Region

Economic analysis of two potential agro-forestry system, viz. agro-horticulture system and multi-purpose tree species-based system, in north-eastern region showed that net present value and benefit : cost ratio from the agro-forestry systems were always higher than those of tree components. Ginger as an intercrop was more profitable than its sole crop. Agri-horti-silvi-pastoral model was identified as the most viable alternative to shifting cultivation, with a ratio of 1:48. Comparison between shifting cultivation and agro-forestry systems showed that agro-forestry system was 15 times more lucrative than that of shifting cultivation. A benefit : cost ratio of 2.94 also indicated the financial viability of the system.

Edible Bamboo

A survey of priority species for edible bamboo shoots in Arunachal Pradesh showed that about 50 bamboo plant species are being used for edible purposes, but use of 15 bamboo species are most prevalent. In respect of delicacy, *Bambusa arundinacea*, *B. tulda*, *Dendrocalamus giganteus*, *D. hamiltonii* and *D. membranaceus* were preferred. The *D. hamiltonii* ranked first as per the availability. Survey of traditional dishes made out of fresh and fermented edible shoots revealed that largely fermented edible shoots are being used as flavouring ingredients in various vegetarian and non-vegetarian dishes. Fermented products were made without any preservatives which can be stored for a period of six months to two years.



A good crop of Vivek Dhan 62 at farmer's field

- Intercropped ginger proved more profitable than its sole crop
- Agro-forestry system proved 15 times more lucrative than shifting cultivation
- Fermented products made from edible shoots of bamboo without preservatives could be stored for six months to two years



4 National Agricultural Technology Project

The National Agricultural Technology Project (NATP), a World Bank-aided project, is being implemented by the ICAR and the Department of Agriculture and Cooperation (DAC) since November 1998. It has three major components, viz. Research, Organization and Management Systems and Innovations in Technology Dissemination.

RESEARCH

PRODUCTION SYSTEM RESEARCH

- Total 264 subprojects and 70 IVLP centres approved in PSR
- Two quality protein maize Shaktiman 1 and Shaktiman 2 identified and recommended for release in Bihar

The research projects under Production System Research (PSR) are mostly location specific. The research is being carried out with 14 production systems under 5 agro-ecosystems, viz. Irrigated, Coastal, Arid, Hill and Mountain and Rainfed. A total of 264 subprojects have been approved at a cost of Rs 2,654.2 million. In addition, 70 IVLP centres have also been approved at a total cost of Rs 238.6 million.

The salient results achieved during 2001 are:

Irrigated Agro-ecosystem

Rice-wheat production systems

- Zero Till Drill (ZT) method proved better than conventional practices of wheat sowing in rice-wheat areas. Surface seeding of wheat has shown great promise in *Chor* areas, which remain fallow during *rabi* around Patna.
- Wheat planted on beds gave almost similar to better yields than conventionally planted wheat. Substantial saving in wheat seed for sowing and irrigation water was recorded with bed planting.
- Puddling improved the water-use efficiency and proved beneficial in reducing the weed infestation. High puddling intensity also increased the nitrogen-use efficiency.
- At Pantnagar 25% recommended N dose for rice can be substituted through farmyard manure or greengram straw and at Varanasi the maximum wheat grain yield (5.91 tonnes/ha) was obtained where one-third N was supplied through digested sludge + one-third N as pressmud + one-third N as carpet waste.
- Studies on carry-over pests showed that the stem-borer damage was higher in zero-tillage plots, while false-smut incidence was low in furrow-irrigated raised beds (FIRBS) and relatively lower in zero tillage than conventional tillage plots. Stem-borer incidence was more in zero tillage and powdery mildew was higher under FIRBS.
- In Punjab and Haryana 10.7 and 2.5 million tonnes of machine harvested rice straw is burnt annually. In *tarai* region of Uttar Pradesh 55% rice straw is machine harvested and whole of it or part is burnt. A substantial amount of wheat straw is also burnt, i.e. 3.1, 1.3 and 4.2 million tonnes, in Punjab, Haryana and eastern Uttar Pradesh respectively. This huge amount of residue burning causes great loss of soil organic matter and plant nutrient and also causes environmental pollution.

ECONOMIC ANALYSIS OF TOTAL FACTOR PRODUCTIVITY

An annual growth in input use was the maximum (2.68%) in trans-gangetic plain zone. However, the output growth rate was highest in lower gangetic plain zone (5.42%). The total factor productivity growth rate was higher in lower gangetic plain zone (3.08%), followed by trans-gangetic plain zone (1.40%), upper gangetic plain zone (0.89%) and middle gangetic plain zone (0.37%).



- Two quality protein maize (QPM), viz. Shaktiman 1 (three-way hybrid) and Shaktiman 2 (single-cross hybrid), in white grain colour were identified and recommended for release in Bihar.

Cotton-based production system

- The major biophysical constraints in cotton production were identified. Socio-economic constraints comprised non-release of canal water in time, erratic power supply, non-availability of quality seed, high cost of plant-protection measures, non-availability of labour during the peak season and price risk.
- The trend and growth of cotton production in Haryana and Rajasthan since 1960-61 showed a fall of 18% in cotton area in the small farms over the last 10 years against 7 and 11% increase in medium and large farms, while the wheat area showed increase of 3.10 and 26% respectively.
- Deep ploughing before cotton sowing once in two years plus reduced tillage with rotavator plus herbicides application for early-season weed control gave significant cotton yield (2.13 tonnes/ha). Incorporation of wheat straw @ 6 tonnes/ha increased the seed-cotton yield significantly.
- LH 1556 and H 1098 cotton performed better at Ludhiana and Hisar, and LH 900 outyielded other varieties at Karnal.
- Intercropping of greengram for seed and green-manuring significantly increased the grain yield of wheat over cowpea intercropping and cotton alone.
- Cotton yield was best with seed treated with *Azospirillum*, followed by *Azotobactor* and *Acetobactor*.
- Imidacloprid reduced the incidence of leaf curl, though the reduction in whitefly population was not much.

- Wheat-straw incorporation significantly increased seed-cotton yield

Sugarcane-based production system

- Non-availability of seed material of appropriate sugarcane varieties, poor tillering, waterlogging, heavy infestation of insect-pests, diseases and weeds, paucity of labour, non-availability of credit facilities, high input costs, non-availability of coupon in time and delayed planting of sugarcane after wheat harvest are some of the major production constraints for low productivity of sugarcane.
- Seeder-cutter/planter machine and an inter-row tillage equipment were developed. With the help of the machine, wheat and sugarcane can be sown or planted in single pass of the tractor.
- Sugarcane + greengram (1:2) appeared promising; cowpea (Pusa Komal) for green pods in sugarcane planted in March in subtropical zone and groundnut in February planted cane in tropical zone also appeared promising intercrops for suppressing weeds and effecting nitrogen economy in sugarcane-based intercropping system.

- Developed seeder-cutter/planter machine could sow or plant wheat and sugarcane in a single pass of tractor

Coastal Agro-ecosystem

Agri-horti production system research

- The red palm weevil management using pheromone traps was standardized for Goa, Tamil Nadu, Andaman and Nicobar Islands and Kerala.
- Economical methods of mass multiplication of green muscardine fungus *Metarrhizium anisopliae* were developed for the control of rhinoceros beetle.
- Coconut cultivars like ECT, VHC 1 and VHC 2 were more susceptible to basal stem rot disease. Copper oxychloride, Tridemorph and zinc sulphate were found effective in the control of basal stem rot in plantation crops.
- The farming system in coconut involving fodder grass–banana–pepper–milk cows–poultry birds–fishery–and sericulture in 1 ha could give a net economic return of Rs 85,000 to 90,000 per year.

- Economical methods of mass multiplication of green muscardine fungus developed for rhinoceros beetle control
- Process standardized for oilpalm fibre extraction from empty bunches
- Manually operated coconut splitting device developed



- Suitable rice-based cropping systems identified in salt-affected coastal soils
- Broodstock feed developed for *Penaeus monodon* and *P. indicus*
- Rotary ball mill developed for shaping molluscan

- Process for oilpalm-fibre extraction from empty bunches was standardized.
- Production of cold water-soluble starch, glutamic acid and maltose from cassava starch and citric acid production from starch/sago industry residue were also standardized.
- A manually operated coconut-splitting device was developed.

Crop sciences

- A detailed report was brought out on the coastal economy of Tamil Nadu, Kerala, Andhra Pradesh and Maharashtra, covering factors (soil, rainfall, population, land-use pattern, cropping pattern) affecting economy.
- Suitable rice-based cropping systems were identified at different centres in the salt-affected coastal soils.
- In cotton, the desi hybrids G.Cot Hy. 7 and G.Cot. Hy. 9 showed 100% increased yield at each centre over the *herbaceum* varieties.

Natural resource management

- Survey of 20,000 ha areas in Bapatla and Guntur districts of Andhra Pradesh indicated the presence of 100 m thick nearly impermeable soil layer below 70 to 90 cm depth below the surface conducive to freshwater storage from precipitation which can be used for irrigation at shallow depths.
- Simple and low-cost vegetative barriers and mechanical engineering measures such as bunding, terracing along with bioengineering measures were developed and demonstrated at all the centres for plantation and annual crop production systems.

Fisheries

- Broodstock of *Penaeus monodon* and *P. indicus* was raised and broodstock feed was developed.
- Pearl production through tissue culture of *P. fucatea* mantle has been initiated. A rotary ball mill for shaping molluscan shell beads was designed, developed and fabricated.

Arid Agro-ecosystem

There are 25 subprojects (research) and 2 on IVLP under this agro-ecosystem. Salient achievements under some projects are as follows:

- A machine developed for making feed blocks of residues of different crops

- The seed-cotton yield under field bunding increased by 10.66% over micro-catchment. Field bunding increased the dry fodder yield of sorghum by 17.61% over micro-catchment.
- A machine was developed at the IARI, New Delhi, for making feed blocks of the crop residue of gram, mustard, sorghum, barley, wheat, maize grains, groundnut straw, tree leaves and paddy straw. Nearly 30-40 blocks of 100-150 kg can be made per hour. The cost of product is Rs 360/tonne. The cost of machine that runs with 10 HP motor is approximately Rs 0.4 million.
- Estrus in ewes was detected with the aid of apron rams of high sexual vigour at 6-hr intervals. Ewes standing to be mounted by the apron ram were recorded as in estrus and mated 12-hr interval with a ram (Bharat Merino) of proven fertility.

Hill and Mountain Agro-ecosystem

Agri-horti production system research

- Gauging stations to monitor run-off and soil loss constructed in small watersheds

- Fifty-seven promising elite trees of walnut and five of almond identified in Kashmir valley are being propagated vegetatively.
- Survey, tabulation and part analysis of data from 10 watersheds at Uttaranchal, Himachal Pradesh, Jammu and Kashmir and NEH region have



been completed to determine the methodologies for the development and analysis of watersheds and decision-support systems for interventions.

- Characterization of morphological parameters, land use, land-capability classification and socio-economic aspects in selected watersheds in Dehra Dun, Palampur, Almora and Meghalaya have been completed. Various conservation measures are being imposed and gauging stations to monitor run-off and soil loss etc. have been constructed.

Livestock and fish production system research

- Four breeds of rabbit for wool and broiler were procured, and three different feeds were tested for their growth and productivity at Mukteshwar.

Rainfed Production System

During this period 98 subprojects were implemented with a total number of 442 PIs/CCPIs in more than 150 rainfed target districts across the country. The institutions covered are SAUs, ICAR, GOI, NGOs, general or traditional universities, Government Departments, CGIAR institutes etc.

Rice-based production system

- Integrated rice-fish-piggery-duckery farming system showed good adoption among the tribal farmers at Ranchi.
- Growing maize and cowpea together have shown promise for higher fodder yield and improving nutrition.
- In cross-bred cattle, treatment with the Zycloz @ 10 mg/kg body weight at weekly intervals for 3 weeks proved most successful for control of nasal schistomomiosis.
- In rainfed uplands of Orissa, the intercropping of groundnut + pigeonpea (4:1) proved promising (1.03 tonnes/ha groundnut + 0.46 tonne/ha pigeonpea).
 - The rice + pigeonpea intercropping was found judicious and beneficial at Ranchi (Jharkhand) and Bhubaneshwar (Orissa).
 - Integrated weed management (Butcholor @ 1.0 kg/ha) followed by interculture at 30 days proved more economical than the farmers' practice (twice manual weeding) for this intercropping system.
- Soybean at JNKVV (Jabalpur), maize (cobs) at WTCER, groundnut at Ranchi and pigeonpea at Darisai appeared suitable options for substitution of rice in upland situation.

- Integrated rice-fish-piggery-duckery farming system showed good adoption among tribal farmers
- Zycloz @ 10 mg/kg body weight successfully controlled nasal schistomomiosis in cross-bred cattle
- Groundnut + pigeonpea (4 : 1) proved promising in rainfed uplands of Orissa
- A new inoculant technology in form of liquid *Rhizobium* inoculant developed

Oilseeds-based production system

- In castor, IPM module involving wilt-resistant Jyothy (DCS 9), removal of alternate hosts, keeping bird perches, hand picking of egg masses and early and late stage larvae of *Spodoptera litura*, spraying of Monocrotophos (0.05%) and Carbendazim (0.05%) against castor semilooper and *Botrytis*, respectively, were found promising in keeping pest and disease incidence below the threshold level.

Pulses-based production system

- The pulses treated with neem seed powder showed a better plant growth in the nematode-infested soils.
- A new inoculant technology was developed in the form of liquid *Rhizobium* inoculant (LRI) to overcome the problems of short-life, poor quality, high contamination and inconsistent field performances. The LRI was found to be superior to the carrier-based *Rhizobium* inoculant (CRI) in quality, shelf-life, field efficacy and commercial viability.
- In an on-farm experiment on integrated nutrient management, the results have shown promise.



- Balanced nutrition with or without inorganics resulted in higher yield of soybean, gram and lentil at the farmers' fields than farmers' practice.
- Integrated nutrient management in soybean as well as in rice showed significant yield improvement over farmers' practice.

Cotton-based production system

- Efforts were made to promote quality of *Gossypium arboreum* having productivity at par with *G. hirsutum* and tolerance to biotic and abiotic stresses. In trials conducted on marginal farmers' fields, *G. arboreum* PA 255 showed 67% higher seed-cotton yield over *G. hirsutum* NH 452 and 127% over hybrid NHH 44.
- Broad bed and furrow (BBF) system proved superior to flat bed (FB) system of planting for seed-cotton yield.

Nutritious cereal-based production system

- M 35-1 sorghum showed high regeneration capacity in tissue culture

- M 35-1 sorghum proved the most suitable genotype, having high regeneration capacity in tissue-culture response.
- Early-sown sorghum (first fortnight of July) escaped the blast diseases. Resistant varieties showed increased activity of phenyl alanine ammonia lyase (PAL) and peroxidase and increased level of phenol compared with the susceptible ones. Total chlorophyll content was more in resistant varieties.
- Growing cowpea as an early-season crop either for vegetable purpose or for incorporation into the soil, followed by second crop of transplanted finger millet later in the season was found as a profitable crop sequence at Bangalore, Berhampur and Coimbatore.

MISSION MODE PROGRAMMES

Three more subprojects have been approved under the mission mode (MM,) making a total of 41 subprojects at the cost of Rs 1,771.6 million.

The achievements under Mission Mode are as follows:

Crop Sciences

- Three more subprojects approved, making a total of 41
- Exploration surveys resulted in collection of 24,599 germplasm of different crops
- Two GMS hybrids in cotton, 2 varieties and 1 hybrid in sorghum and four single-cross, early hybrids in maize released
- Standard protocols established for isolation of protease inhibitor proteins from chickpea, cowpea and pigeonpea
- Putative molecular markers identified for *Lr 19*, *Lr 32* and *Lr 28* genes
- In FLDs 5,250 plants of litchi, 928 of mango, 1,000 seedlings of acid lime and other crops produced for distribution among farmers

- About 411 exploration surveys resulted in collection of 24,599 germplasm lines of different crops including 1,651 herbarium specimen. A total of 8,929 germplasm were assigned IC number and stored for mid-term storage. The number of field gene banks with CCPIs is 15,670.
- Two GMS hybrids in cotton (AAHI and PKHVV 5), two varieties and one hybrid in sorghum (CSV 216 R, RSLG 262 and SPH 1010), four single-cross, early-maturing maize hybrids released for higher productivity. Male-sterile genotypes (CMS, GMS) and R lines resistant to cotton leaf curl virus and tolerant to bollworm were identified in cotton. Two CMS (GT 288A and 67A) along with 20 fertility restorers were developed in pigeonpea.
- Substantial progress was made in synthesizing the three Bt genes (*cryIF*, *cryIAa* and *cryIIA5*) to make them suitable for plant expression.
- Standard protocols for isolation of protease inhibitor proteins from chickpea, cowpea and pigeonpea were established; transformation and regeneration protocol for pigeonpea and *Brassica* was standardized and being further refined. Simultaneous isolation of protease inhibitor gene from indigenous legumes was accomplished.
- The putative molecular markers for genes *Lr 19*, *Lr 32* and *Lr 28* were identified.
- The process for the manufacture of azadirachtin was refined; technical know-how for the preparation of dihydroazadirachtin was developed (patent has been filed); Azadirachtins A, B and H were separated by medium pressure liquid chromatography and characterized spectroscopically; and some potential stabilizers capable of stabilizing azadirachtin were identified.



Household food and nutritional security

Production of quality seed and planting material was taken up in mango, litchi, seedless lime, kagzi lime, coorg mandarin, arecanut and black pepper. In front-line demonstration of improved technologies, 5,250 plants of litchi, 928 plants of mango, 1,000 seedlings of acid lime and other crops were produced for distribution to the farmers.

Scientific carp polyculture was adopted in 44 ponds, covering a water area of about 33 ha to popularize pen culture. The pen material and pen design were standardized taking into account the local conditions. A total of 50 pens, built with split bamboo, were constructed in the 5 selected beels. Stocking densities varied from 5,000 to 6,000/ha fish of catla, rohu and mrigal.

Under the programme on value addition and post-harvest management, 30 villages were selected to popularize Agro/soybean processing technologies. The rural women entrepreneurs are being promoted to supply sweetened and soymilk to village school. A 3-day training was held on zero-energy cool chamber and construction of a cool chamber by the trainees.

Under Impact Assessment of Technology Interventions and Crop Diversification a base-line survey with appropriate survey instruments was undertaken to get an idea about existing food security and socio-economic conditions of the targeted population and the objective was achieved by studying 18 districts, 113 villages and 1,232 household.

Horticulture

- Parental lines and hybrids resistant to multiple diseases were developed in tomato, brinjal, chillies and onion. Male-sterile lines were also developed and maintained.
- Achievements of project on protected cultivation of vegetables and flowers in plains and hills showed that growing medium determines the productivity and profitability of the greenhouse grown crops; pruning and pinching to modify the plant architecture is an important management activity of the greenhouse crop production; monitoring the nutrient levels in fertigation solution holds the key for effective crop management in greenhouse, and botanicals and biological agents hold promise for developing IPM strategies for greenhouse crops.
- The protocols for purification of citrus ringspot, citrus mosaic, potato virus Y and potato leaf roll virus were standardized and polyclonal antibodies prepared. Detection of citrus tristeza virus by RT-PCR was achieved. Viroids in citrus and potato could be diagnosed by R-PAGE and PCR techniques.

- Parental lines and hybrids resistant to multiple diseases developed in tomato, brinjal, chilli and onion

Natural Resource Management

- PRA in Almas watershed (Dehra Dun) has been completed.
- Under the project on Use of Urban and Industrial Effluent in Agriculture, the results showed that the treatment improved the sewage quality parameters except for Ca, Mg and DO. Higher uptake of Cd content > 50-75 ppm in Vertisols significantly reduced the yield of cabbage, cauliflower, spinach and fenugreek; and use of different dilutions with distillery effluent at pre-/post-sowing stages delayed the growth of mustard and wheat.

Agricultural Engineering

- The production design for most of the selected implements has been completed and this will help in commercialization, as the production manuals can be taken by the small scale manufacturers for batch production.
- Mechanized transplanting of rice including mat nursery raising and puddling was standardized. Its production economics showed 20-25% higher grain yield, 65-70% higher net income, 15-20% lower energy use and 40-45%

- Mechanized transplanting of rice including mat nursery raising and puddling standardized



higher benefit : cost ratio than manual system. Direct drilling and minimum tillage sowing of wheat offered higher advantages over the conventional practices. Adaptive trials of mechanized transplanting of rice and zero-till drilling of wheat after harvest of rice on farmers' fields showed that the farmers earned more net income of 46.8% in rice and 25.9% in wheat compared with their conventional practices, besides saving in operational time, labour and energy.

- Water-resistant composites using surface-modified jute fibres and neat or modified polyester resin matrix; laminates of different thickness (2-4 mm); and sandwich composite samples using jute laminates as face and rigid foam as core materials were prepared.

Animal Sciences

- DNA repository established for Garole sheep, Pugal sheep, Bengal goats, Jaisalmeri camel, Aseel poultry, Nicobari fowl, Miri poultry, Bhadwari buffalo and *Tarai* buffalo
- Monoclonal antibodies to an Indian isolate of PPR virus produced and characterized
- Relational Database shell of various diseases developed

- DNA repository was established in respect of Garole sheep (56), Pugal sheep (34); Bengal goats (48); Jaisalmeri camel (55); Aseel poultry (38); Nicobari fowl (36); Miri poultry (20); Bhadawari buffalo (52); and *Tarai* buffalo (60).
- The methods to assess microbial and antimicrobial titre, hormonal and pesticide residues, adulterants in food from livestock and poultry were standardized. Bioassay for microbials in various animal tissues revealed maximum number of positive samples in buffaloes, followed by cattle, pig, sheep, goat and poultry. Kidney showed the maximum positive samples than liver and meat.
- Monoclonal antibodies to an Indian isolate of peste des petits ruminants (PPR) virus (PPR virus sungri) were produced and characterized. One of these MABs designated as 4B11 was found to be suitable for PPR virus antibody detection in a competitive ELISA developed. NSI gene based RT-PCR was evaluated for detection of blue tongue virus. Canine parvo virus was isolated in cell culture.
- Somatic antigen of bubaline origin *Fasciola gigantica* flukes (AFF-FSAg) was purified. This antigen could detect 14-day-old infection in animals. Epidemiological data on fasciolosis, schistosomosis and paramphistomosis revealed varied prevalence rate in different livestock species of different agroclimatic zones of India.
- The livestock- and disease-related databases were disseminated to all the co-operating institutions with hands-on training, by providing GIS-supported India.Admas.Epitrak software under "Weather Based Animal Disease Forecasts" subproject.
- Relational Database shell (RDB) of various diseases has been developed. On receipt of data from various co-operating centres, the RDB of livestock diseases is being updated and considerable progress has been made. Extension and information bulletins were produced and circulated to all the co-operating institutions.

Fisheries

- Six new species of fishes identified from Manipur and adjacent areas of Nagaland
- Significant headway made in utilization of low-value fishes

- The salient achievements of the project on Fish Biodiversity are: Six new species of fishes were identified from Manipur and adjacent areas of Nagaland. Breeding technology for endangered and endemic fish (*Horabagrus brachysoma*) of Kerala and *Ompok malabarius*, a highly priced fish of Tamil Nadu, has been perfected. Breeding technology for two endemic ornamental fishes (*Danio malabaricus* and *Puntius melanampyx*) were also perfected. Sperm cryopreservation technique was developed for endangered and commercially important yellow catfish (*Horabagrus brachysoma*). Microsatellite markers were also developed for six prioritized fish species through cross-species amplification method using sequence primer sequence information from related species.
- In the area of fish technology development for utilization of miscellaneous



varieties of low-value fishes, which constitute 30% of the total fish produced, a significant headway has been made. Rohu curry in Kerala style fish curry medium packed in indigenous retort pouch having three layer configuration has been processed in over-pressure autoclave.

TEAM OF EXCELLENCE

A total of 28 subprojects with a total allocation of Rs 379.149 million were approved under this mode. Achievements under Team of Excellence are as under:

- Growth models of rice and wheat calibrated and validated for several Indian agro-environments. The pest situation in rice and wheat under rice-wheat system during the last 30 years was analysed, and important pests of these crops determined.
- Information on adult plant response of selected *Lr* genes was generated.
- Preliminary investigation on DNA polymorphism indicated the existence of variation at DNA level in pathotypes of different wheat rusts.
- In pollination study of CMS parents of hybrid rice, an application of GA @ 135 g/ha in 58025A, the most common female parent of released rice hybrids, resulted in higher yield. The GA application promoted better panicle exertion, higher flag leaf angle and angle of spikelet opening and more stigma exertion.
- Seed invigoration treatments using different priming agents enhanced the field emergence and days to flowering in parental lines of sunflower and maize.
- A simple equipment, involving water-vacuum pump, for extraction of royal jelly was designed, developed and evaluated.
- The viral RNA from very virulent IBDV-infected bursa could be isolated. For DNA vaccine against rabies, the viral RNA was isolated and rabies virus glycoprotein gene was amplified and cDNA was made by using primers F and primers B. The PCR product was purified and kept for further studies.
- Field samples were tested using reference infectious bursal disease antiserum. A total of 81 idomas were screened by testing the supernatant by ELISA. Though 20 clones were positive, the titre values were low.
- Infectious bronchitis virus (IBV) isolation was attempted with 102 field samples collected from suspected birds, resulting in three isolates. IBV 'S' gene specific primers were selected and used for screening field samples by polymerase chain reaction.
- A method for isolation of good-quality RNA with satisfactory yields from mango and banana fruits (ripe and unripe) was standardized.
- Nucellus cultures of polyembryonic Vellaikolumban mango were established to induce callus and somatic embryos. Modified MS medium and dark incubation were ideal for induction and proliferation of callus. Bulking up of callus was achieved and proliferative secondary somatic embryogenesis induced.

- Information generated on adult plant response of *Lr* genes
- DNA polymorphism indicated variation at DNA level in pathotypes of different wheat rusts
- A simple equipment developed for royal jelly extraction
- Method standardized for isolation of good-quality RNA with satisfactory yield from mango



Shoot emergence in germinating somatic embryo Vellaikolumban mango

Under NATP, nine subprojects were approved for developing Human Resource Development in the field of Plant Genetic Resource Management, Plant Genetic Engineering and Molecular Breeding, Plant Virology, Seed Technology, Biofertilizers, Veterinary Biotechnology and Immunology, Micropropagation of Horticultural and Forest Spices, Biological Control and Sustainability of Rice-wheat Cropping System. Suitable training materials of these subprojects have been developed for distribution among the participants.

A subproject on referral laboratory on Pesticide Residues was approved to be established in the Division of Agricultural Chemicals, IARI, New Delhi.

COMPETITIVE GRANT PROGRAMME

The Competitive Grant Programme (CGP) was started in July 1999 under the NATP.



- Transgenic tobacco plants carrying *PA* gene developed
- cDNA libraries made using RNA isolated from heat-shocked as well as control tissue of Pusa 169 rice

Till date two rounds have been successfully completed. In the first round 79 research projects and in the second round 190 projects were approved by the RPC and sanctioned. The third round of CGP is in progress in which about 3,788 concept notes have been received.

Some of the salient findings of the ongoing subprojects under CGP are:

- *PA* gene was PCR amplified using suitable primers out from pXO1 plasmid-A 184 Kb plasmid that carries the genes for three components of anthrax toxin, viz. PA, LF and EF, by using appropriate primers. Suitable restriction sites were generated on both ends of *PA* gene to facilitate cloning. The primers used were Forward Primer: 5' GGC GCG GTA CCG AAG TTA AAC AGG AGA AC 3'; and Reverse Primer: 5' ATT TAA AAG GAT CCT AGA ATT ACC TTA TCC 3'.
- Transgenic tobacco plants carrying *PA* gene were developed. Tobacco leaf explants were infected with *Agrobacterium tumefaciens* carrying a vector in which *PA* gene was cloned under the control of CAMv 35 S promoter. After co-cultivation, tobacco explants were regenerated/selected on MS medium containing benzyladenine, naphthalene acetic acid (NAA), Kanaycin and cefotaxime.
- The cDNA libraries were made using RNA isolated from heat shocked (42°C, 2 hr shoot) as well as control (un-induced shoot) tissues of Pusa 169 rice cultivar. RNA from the control and stressed seedling was isolated by modified method of Logemann. The modification was the omission of the LiCl as RNA precipitating agent, as LiCl is a known inhibitor of reverse transcriptase. After checking the quality of RNA on a MOPOS-formaldehyde gel 1.2 mg of total RNA was used for isolation of mRNA using biotin-dt and streptavidin paramagnetic.

Financial outlay of NATP

	2000–01 Release/ PIU Exp.	2001–02			
		EFC Provision	BE	(Release/ PIU Exp. (up to Nov. 2001)	RE (proposed)
Research component	4.70	17.42		6.41	
O&M reforms	113.23	113.83		115.57	
ITD	10.48	35.18		1.34	
Price contingency	—	23.83		—	
Total	128.41	190.26	137.22	119.32	293.60

- Research priorities for main production system finalized
- Guidelines for prioritization of research proposals for CGP prepared and widely circulated

ORGANIZATION AND MANAGEMENT SYSTEMS

- As a result of the congruence analysis approach adopted by the NCAP, the research priorities for the main production systems were finalized and are now encompassed in an integrated research effort under the Production System Research, Mission Mode, Team of Excellence (ToE) and Competitive Grant Programme.
- The micro-level priority setting was done in 6 participating states for ITD component through preparation of participatory strategic research and extension plan (SREPs) with the assistance of National Institute of Agriculture Extension Management and NAARM. The NAARM has prepared revised guidelines for SREP preparation.



- Seven institutes of the ICAR were reviewed for the institutional efficiency through a consultancy firm. The final report is being refined with a view to bring O&M reforms in the ICAR.
- Guidelines for prioritization of research proposals for Competitive Grant Programme prepared and widely distributed.
- Project Information Management System (PIMS) was finalized for monitoring and concurrent evaluation. Off line PIMS (stand alone version) was implemented at all the pilot sides. The reports can be generated from data that have been entered at pilot sides.
- A retreat for the ICAR's top 20 executives was organized at Indian Institute of Management, Lucknow, with a planned follow-up programme.
- Computers and related equipments were procured for networking and establishing connectivity down to the divisional level with ICAR institutes, SAUs, ZRSs, Directorates of Extension, MANAGE and the ITD states/ Agriculture Technology Management Agency districts.
- Six centres were identified as the hubs for the main libraries in upgrading the library information system by establishing international data bases on existing information available in India, new data bases on Indian agriculture, and access to databases through world-wide web.

INNOVATIONS IN TECHNOLOGY DISSEMINATION (ITD) – ICAR COMPONENT

Under ITD-ICAR component four activities, viz. Strengthening of Zonal Co-ordinating Units, Strengthening of Directorates of Extension Education, Establishment of Agricultural Technology Information Centres and Remandating of Zonal Agricultural Research Stations, to take-up the additional function of Krishi Vigyan Kendras were undertaken.

Strengthening of Zonal Co-ordinating Units (ZCUs) and Directorates of Extension Education (DEEs) in State Agricultural Universities (SAUs)

All the 8 ZCUs and 29 DEEs in various SAUs were strengthened by providing modern information technology (IT) facilities for better co-ordination, and for making them more effective in carrying out extension activities respectively.

Establishment of Agricultural Technology Information Centres (ATICs)

The progress of establishment of 40 ATICs was reviewed. Except a few, all the ICAR Institutes/SAUs have started construction activities which will be completed by 31 March 2002. The PMC has approved four more ATICs to be established at Udaipur, Bhubaneshwar, Ranchi and Varanasi.

Remandating of Zonal Agricultural Research Stations (ZARSs) to take-up Additional Function of KVKs

At present 53 ZARSs located in the districts, which do not have KVKs, have been remandated. Approval has been granted to construct hostel facilities in 28 ZARSs. The progress of the remandated ZARSs was reviewed.

- Eight Zonal Co-ordinating Units and 29 Directorates of Extension Education strengthened by providing modern IT facilities
- Four new Agricultural Technology Information Centres approved
- Approval granted to construct hostel facilities in 28 Zonal Agricultural Research Stations



5 Organization and Management

DARE

The Department of Agricultural Research and Education (DARE) was established in the Ministry of Agriculture in December 1973. Subjects allotted to the DARE are as per the Government of India (Allocation of Business Rules) and are specified in Appendix I of DARE.

The Indian Council of Agricultural Research (ICAR) is an autonomous body under the Department of Agricultural Research and Education. The Secretary to the Government of India in the DARE functions as the Director-General of the ICAR. The Financial Adviser, DARE, is the Financial Adviser of the ICAR. Generally single-file system is followed between the DARE and the ICAR.

The DARE has 14 Group A, 10 Group B, 14 Group C and 6 Group D employees. The recruitments to the posts in Group A, B, C are made centrally, either through the Department of Personnel and Training or through the Department of Agriculture and Co-operation, depending on the level of the post. The DARE makes direct recruitment only to Group D posts, and such recruitments are made according to the orders of the Government of India regarding reservations for scheduled castes, scheduled tribes and other backward classes. Presently, the DARE has 7 scheduled caste employees.

A detailed break-up of the posts and names of the important functionaries is given in Appendix II of the DARE. The financial requirement (Grant No. 2) includes budget estimates (BE) and revised estimates (RE) of the DARE and the ICAR (Plan and Non-Plan) 2000-2001. The detailed break-up of these financial figures is given in Appendix III of the DARE.

ICAR

The Indian Council of Agricultural Research is the apex organization at the national level for promoting science and technology programmes in the agricultural research and education.

The ICAR was set up on the 16 July 1929 as the Registered Society under the Societies Registration Act 1860; on the recommendations of the Royal Commission on Agriculture. It was reorganized twice, in 1965 and in 1973. The headquarters of the ICAR is located at the Krishi Bhavan, New Delhi.

The Minister for Agriculture is the President of the ICAR, and the State Minister for Agriculture is Vice-President. The principal executive officer of the ICAR is Director-General, who is also the Secretary to the Government of India in the Department of Agricultural Research and Education.

The General Body of the ICAR Society is the supreme authority of the ICAR. And the Minister for Agriculture, Government of India, heads it. The members for this are the Ministers for Agriculture, Animal Husbandry and Fisheries, and the senior officers of various state governments, representatives of Parliament, industry, educational institutes, scientific organization and farmers (Appendix 1).

The Governing Body (Appendix 2) is the chief executive and decision-making authority of the ICAR. It is headed by the Director-General. It consists of eminent agricultural scientists, educators, legislators and representatives of farmers. It is assisted by the Standing Finance Committee, Accreditation Board, Regional Committees, Policy and Planning Committee, several Scientific Panels and Publications Committee.





ORGANIZATION AND MANAGEMENT

RESERVATION OF POSTS FOR SCHEDULED CASTES , SCHEDULED TRIBES AND OBC			
Direct recruitment on the All-India basis	SC	ST	OBC
(a) By open competition (i.e. through the UPSC or by means of open competitive test held by any other authority)	15%	7.5%	27%
(b) Other than at (a) above	16.66%	7.5%	25.84%
Scheduled Castes/Scheduled Tribes and Other Backward Classes in the ICAR Headquarters and its Research Institutes/National Research Centres/Project Directorates in 2000-2001.			
Category	(%) SCs	(%) STs	OBCs
Scientific posts	8.19	0.91	5.27
Technical posts	19.93	5.73	8.28
Administrative posts	19.66	5.54	6.58
Supporting staff (excluding <i>safaiwalas</i>)	26.74	6.41	6.58
Supporting staff (<i>safaiwalas</i>)	92.64	2.35	3.52
Auxiliary posts	28.68	4.09	14.75

In the scientific matters, the Director-General is assisted by 8 Deputy Directors-General, one each for (i) Crop Sciences, (ii) Horticulture, (iii) Natural Resource Management, (iv) Agricultural Engineering, (v) Animal Sciences, (vi) Fisheries, (vii) Agricultural Education, and (viii) Agricultural Extension. The DDGs are responsible for the Institutes, National Research Institutes and Project Directorates in their respective fields. The senior officers posted at the ICAR (Headquarters) are listed in Appendix 3.

The ICAR receives funds from the Government of India and from the proceeds of the Agricultural Produce Cess.

The ICAR develops technologies and disseminates knowledge to farming community not only for increasing yields of crops and maintaining natural resources but also for elevating community's economic status.

The earlier Publications and Information Division of the ICAR has now been upgraded to Directorate of Information and Publications of Agriculture.

The Research set up of ICAR includes 47 Central Institutes (Appendix 4), 4 National Bureaux (Appendix 5), 11 Project Directorates (Appendix 6), 29 National Research Centres (Appendix 7), and 82 All-India Co-ordinated Research Projects (Appendix 8). Besides ICAR finances research scheme; and through the United States-India Fund, 12 externally-aided projects are also in operation.

The ICAR promotes research, education and extension education in 34 state agricultural universities and 1 Central Agricultural University for the North-Eastern Hills Region by giving financial assistance in different forms (Appendix 9).

For effective communication of research findings among farmers, the ICAR maintains an effective network of 261 Krishi Vigyan Kendras and 8 Trainers' Training Centres along with 8 Zonal Co-ordinating Units.

The total sanctioned as well as existing strength of the employees of the ICAR system, including scheduled castes, scheduled tribes and other backward classes, is given in Appendix 10.

Thus with an extensive network of research infrastructure, backed by the excellent teams of scientists and other employees, the ICAR is making rapid strides in agricultural research, and provides support to the national efforts towards achieving food security and self-sufficiency.



Gazetted posts sanctioned/filled/vacant in the ICAR as on 22.1.02								
Posts	Scale of pay	No. of posts sanctioned	Filled	Vacant	No. of SC	No. of ST	No. of OBC	Remarks
Director (P)	Rs 14300-400-18300	01	01	–	–	–	–	
Director (F)	Rs 14300-400-18300	02	02	–	–	–	–	
Director (OL)	Rs 12000-375-16500	01	–	01	–	–	–	
Deputy Secretary	Rs 12000-375-16500	06	05	01	02	–	–	
Deputy Director (P)	Rs 12000-375-16500	02	02	–	–	–	–	
Deputy Director (F)	Rs 12000-375-16500	02	02*	–	–	–	–	*excludes one post of DD(F) at NATP as the same has been temporarily shifted from IVRI, Izatnagar
Deputy Director (OL)	Rs 12000-375-16500	01	01	–	–	–	–	
Controller of Examination	Rs 12000-375-16500	01	01	–	–	–	–	
Under Secretary	Rs 10000-325-15200	14	14	–	02	01	–	
SA to Chairman, ASRB	Rs 10000-325-15200	01	01	–	–	–	–	
Sr. Fin. & Accts Officer	Rs 10000-325-15200	01*	–	01	–	–	–	*excludes one post of SF&AO at NATP as the same has been temporarily shifted from CPRI, Shimla
Legal Advisor	Rs 10000-325-15200	01	01	–	–	–	–	
Fin. & Accts Officer	Rs 8000-275-13500	06	06	–	01	–	01	
Asstt. Legal Advisor	Rs 6500-200-10500	02	02	–	–	–	–	
Asstt. Director (OL)	Rs 6500-200-10500	02	02	–	–	–	–	
Junior Analyst	Rs 6500-200-10500 + Dep. Allowances	02	02	–	–	–	–	
Desk Officer	Rs 6500-200-10500 + Spl. Allowances	06	06	–	01	–	–	
Protocol Officer	Rs 6500-200-10500	01	01	–	–	–	–	
Asstt. Fin. & Accts Officer	Rs 6500-200-10500	06	05*	01	–	–	–	*includes one AF & AO who is presently on deputation with Dy. Speaker (Lok Sabha) on co-terminus basis



(continued from previous page)

Posts	Scale of pay	No. of posts sanctioned	Filled	Vacant	No. of SC	No. of ST	No. of OBC	Remarks
Section Officer	Rs 6500-200-10500	81-2*=79	75	04	12	07	01	*2 posts kept in abeyance for creation of posts under NATP
Private Secretary	Rs 6500-200-10500	30	30	–	03	–	–	

ADMINISTRATION

Recruitment Rules

Recruitment Rules for the posts of Deputy-Secretary, ICAR, Secretary, ASRB and Joint Director (Adm.), IARI, Chief Administrative Officer and LDC are being updated. Schemes and syllabi for the Limited Departmental Competitive Examination for section officers/assistant administrative officers have been revised/formulated.

Filling up of Vacant Posts

Vacant posts of Director (P), Deputy-Secretary, Under-Secretary, Senior Administrative Officer, Administrative Officer, Senior Finance and Accounts Officer, Finance and Accounts Officer, Assistant Finance and Accounts Officer, Section Officer, Junior Analyst (WS), Assistant Director (OL) and Personnel Secretary, Assistants/UDCs/Supporting Staff Grades/PAs/Stenos have been filled up. For the filling up of the posts of Deputy-Secretary, Chief Administrative Officer, Senior Administrative Officer, Administrative Officer, Section Officer, which have fallen vacant recently, meetings of the Departmental Promotion Committees are being arranged. Similarly for filling up of the posts under Limited Departmental Competitive Examination Quota of the assistants/section officers, the competitive examinations are being organized by the Agricultural Scientists' Recruitment Board.

Probation/Confirmation

Clearance of Probation Period/Confirmation of section officers, administrative officers, finance and accounts officers/assistants/stenos have been taken up.

POLICY AND PERSPECTIVE PLANNING

Organization and Management

Improvement in the Organization and Management (O and M) of an organization contributes greatly to its growth. It enhances the productivity of the human capital in the organization.

The ICAR has taken a number of initiatives on O and M reforms to improve working environment and for orientation of need-based, effective, efficient and result oriented research under the National Agricultural Technology Project (NATP). Even outside NATP, the Council has initiated a number of steps. The important activities organized under the O and M component of the NATP are as follows:

Organization and Management (O&M) Task Force

The Task Force on the O and M reforms has emphasized on the importance of relevant and effective trainings for all categories of staff, including the top 20 executives of the ICAR. It has also deliberated on the issues of autonomy in the

HIRING CONSULTANCIES

- For reviewing personnel policies, M/S Ferguson and Co. is being considered
- A consultancy on Financial Management System of the ICAR has been awarded to the National Institute of Financial Management (NIFM), Faridabad. The draft report has been submitted by the NIFM which would be discussed in the next meeting of the Task Force.
- The report on the Purchase Manual for the ICAR has been submitted by the NIFM and report would be discussed in the next meeting of the Task Force.
- The proposal regarding hiring of consultancy of PME was negotiated with the International Food Policy Research Institute (IFPRI) and the International Service for National Agricultural Research (ISNAR). The ISNAR has been approached to take up this assignment, after unwillingness expressed by IFPRI.



Non-Gazetted Posts sanctioned/filled/vacant in ICAR as on 22.1.02								
Posts	Scale of pay	No. of posts sanctioned	Filled	Vacant	No. of SC	No. of ST	No. of OBC	Remarks
Assistant	Rs 5500-175-9000	175	141	34*	27	09	06	*27 UDCs working as Assistants on ad-hoc basis against these 34 posts
P.A. Grade II	Rs 5500-175-9000	56	37	19*	05	–	01	*5 Steno. Gr. III working as P.A. on ad-hoc basis against these 19 posts
Sr. Research Asstt.	Rs 5500-175-9000 + Dep. Allow.	01	–	01	–	–	NA	
Junior Law Officer	Rs 5500-175-9000	02	–	02	–	–	–	
Junior Accounts Officer	Rs 5500-175-9000	04	03	01	–	–	NA	
Data Collector and Assessor	Rs 4500-125-7000	02	02	–	–	–	NA	
Steno Grade III	Rs 4000-100-6000	54	53	01	06	02		
UDC	Rs 4000-100-6000	188	188	–	37	12	NA	
Sports Assistant	Rs 4000-100-6000	01	–	–	–	–	–	Kept in abeyance
Confidential Assistant (Awards)	Rs 5500-175-9000	01	–	–	–	–	–	Kept in abeyance
Programme Officer	Rs 5500-175-9000	01	–	–	–	–	–	Kept in abeyance
Sr Sales Assistant	Rs 5500-175-9000	05	04	–	–	–	–	1 post kept in abeyance
Jr Sales Assistant	Rs 4500-125-7000	02	01	–	–	–	–	1 post kept in abeyance
Conf. Assistant with A.M.	Rs 5500-175-9000	01	–	01	–	–	–	
Language P.A. with A.M.	Rs 5500-175-9000	01	–	01	–	–	–	
LDC	Rs 3050-75-3950-80-4590	164	137	27	27	07	09	
Peon	Rs 2550-55-2660-60-3200	118	91	27	28	04	08	
Farash	Rs 2550-55-2660-60-3200							
Chowkidar	Rs 2550-55-2660-60-3200	02	02	–	–	01	–	
Mali	Rs 2550-55-2660-60-3200	06	06	–	–	–	–	



ORGANIZATION AND MANAGEMENT

<i>(continued from previous page)</i>								
Posts	Scale of pay	No. of posts sanctioned	Filled	Vacant	No. of SC	No. of ST	No. of OBC	Remarks
Packer	Rs 2550-55-2660-60-3200	12	10	02	01	–	04	
Studio Attendant	Rs 2550-55-2660-60-3200	01	01	–	–	–	–	
Store Attendant	Rs 2550-55-2660-60-3200	01	01	–	–	–	–	
Safaiwala	Rs 2550-55-2660-60-3200	16	15	01	15	–	–	
Daftry	Rs 2610-60-2910-65-3300-70-4000	45	45	–	17	03	01	
Jamadar	Rs 2610-60-2910-65-3300-70-4000	08	08	–	05	–	–	
Head Packer	Rs 2610-60-2910-65-3300-70-4000	01	01	–	–	–	–	
Jr Gestetner Operator	Rs 2610-60-2910-65-3300-70-4000	02	02	–	02	–	–	
Franking Machine Operator	Rs 2610-60-2910-65-3300-70-4000	01	–	01	–	–	–	
Record Keeper	Rs 2750-70-3800-75-4400	01	01	–	01	–	–	
Library Attendant	Rs 2750-70-3800-75-4400	03	02	01	–	–	01	
File Attendant	Rs 2750-70-3800-75-4400	01	–	01	–	–	–	
Despatch Rider	Rs 3050-75-3950-80-4590	01	01	–	01	–	–	
Sr Gestetner Operator	Rs 3050-75-3950-80-4590	02	02	–	–	02	–	

ICAR on various matters. Sub-Committees under the Task Force have been constituted to look into administrative, personnel, financial and audit matters; incentives and rewards for administrative and finance officials; review of the nomenclature of the ICAR institutes and for reviewing extension programmes. The Sub-Committees on the administrative matters and for reviewing extension programmes have submitted their final reports, which are being processed for consideration/approval of the Task Force.

A contract for consultancy services for Review of 7 National Institutes was awarded to M/s JPS Associates, New Delhi. This was to undertake a detailed study and review of O and M issues of 7 institutions within NATP framework in keeping with the earlier reviews of the functioning of the ICAR system and its Vision - 2020 statement. The consultants have submitted the draft of the final report.



COMMERCIALIZATION OF EARNINGS FROM THE PRODUCTS AND TECHNOLOGY

The Council has received 73 expressions of interest (EOIs). From these, a committee under the Chairmanship of the National Director (NATP) with ADG (P) as Member-Secretary has short-listed 6 firms for purpose of inviting quotations.

ICAR-Industry Interface

The ICAR has constituted 5 functional groups, based on the major recommendations of the brain-storming workshop held on 2 April 1998. These indicate that both government and non-government organizations are an integral part of each other's functioning, and their liaison will bear fruits for both.

A periodic review is being conducted by the committee with ADG (P) as Member-Secretary. The latest review meeting was held on 23 February 2001. Action is being taken by the functional groups on various issues, and possibility of separate interface with private sector for each functional group is being explored.

INTERNATIONAL AGRICULTURAL RESEARCH PARTNERSHIP (ICAR-ACIAR CONSULTATION)

A high-level consultation between ICAR and Australian Centre for International Agricultural Research (ACIAR) was held during 10-11 September 2001 at New Delhi. The Director of the ACIAR, Dr Bob Clements, with his team discussed prospects of research collaborations with the ICAR.

Consensus was achieved on several over-arching issues, including the need to ensure that agricultural production is sustainable through better natural resource management; manage scarce water resources efficiently through collaboration on policy instruments and on-farm management; research agricultural interventions for rehabilitation of degraded or contaminated agricultural lands; ensure technical and economic research addresses storage and distribution of chain efficiencies for major crops; address increased demand for livestock and fish products arising from increased incomes; raise farmers' incomes and improve nutrition through agricultural diversification; raise quality of agricultural products and opportunities raised through collaboration on products processing; embrace opportunities offered by collaboration on applications of biotechnologies and new information technologies; and link results of research into existing and emerging extension networks.

The indicative priorities will go a long way in developing proposals for research in collaboration in (i) Agricultural Economics and Agricultural Development Policy, (ii) Crop Sciences, (iii) Animal Sciences, (iv) Agroforestry, (v) Fisheries, (vi) Land and Water Management, and (vii) Post-harvest Technology.

- To assess progress of Hindi at the Council Headquarters as well as its institutes, 14 offices were inspected and suggested were given to improve shortcomings
- The 4th issue of 'Rajbhasha Alok' has been published
- Most of the computers at the ICAR Headquarters are bilingual and on some of the computers 100% work is being done in Hindi only
- Parliament, General Body, Standing Finance Committee, Parliamentary Committee of Agriculture Ministry, AGM of ICAR society including many other meetings materials were prepared bilingually. The draft of speeches of Hon'ble Union Agriculture Minister were prepared originally in Hindi

PROGRESSIVE USE OF HINDI

DARE

The DARE has an Official Languages Section for compliance and implementation of the Official Language Policy of the Government of India. It consists of one post each of Assistant Director (Official Language), Junior Hindi Translator, Hindi Steno and Hindi Typist. Besides the Hindi Translation of the budget, this section attends works related to Annual Report of the Department, of Hindi Workshops, meetings, reports and organizing Hindi week, to encourage employees for doing their official work in Hindi.

ICAR

During 2000-2001, one Centre of the Council was notified in the Gazette of the Government of India under rule 10(4) of the Official Language Rule 1976. Thus now, there are 53 offices of the Council which have so far been notified in the Gazette of the Government of India.

Joint Official Language Implementation Committee of the DARE and the ICAR working under the chairmanship of the Additional Secretary, DARE/Secretary, ICAR, met regularly. Similarly, Official Language Implementation Committee constituted at 78 Institutes/Centres held their meeting regularly. Remaining Institutes have been instructed to constitute such committees immediately.



ORGANIZATION AND MANAGEMENT

Proceedings of the Official Language Implementation Committee meetings held by the Institutes as well as the quarterly progress reports regarding use of Official Language Hindi from various institutes were reviewed, and remedial steps have been suggested to overcome shortcomings in the proceedings and reports.

Rosters have been maintained for imparting training in Hindi. Hindi typing and Hindi stenography officials were deputed accordingly for training. This year, 8 stenographers and 10 typists were nominated for Hindi stenography and typing.

This year also Hindi 'Chetna Maas' was celebrated. During this various programmes and competitions were organized. On the occasion, a message of Hon'ble Minister for Agriculture was issued and Secretary, ICAR, also had issued an appeal requesting officers/staff for doing their maximum official work in Hindi. At the ICAR Headquarters 'Hindi Chetna Maas' was observed from 1 October 2001.

During the year 3 Hindi workshops were organized for officers/staff.

Under the 'Rajarshri Tandon Rajbhasha Puruskar', Indian Agricultural Research Institute, Pusa, New Delhi, received the first prize in the category of National Institutes. In other Institutes category, Central Institute for Sub-tropical Horticulture, Lucknow, got first prize and the National Research Centre for Mushroom, Solan, received the Second prize and in category of 'C' region, Central Institute for Fisheries Technology, Kochi, received a special prize.



FINANCE AND AUDIT

Activity Programme Classification

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan, Non-Plan) for 2000–2001 are Rs 14045.50 million and Rs 13250 million respectively and BE for 2001–2002 (Plan and Non-Plan) is Rs 13890.50 million.

Budget estimates and revised estimates of DARE and ICAR						
(Rupees in lakhs)						
Item	Budget Estimates 2000-2001		Revised Estimates 2000-2001		Budget Estimates 2001-2002	
	Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
A. Secretariat Economic services						
Major Head '3451'						
A-1 Secretariat						
Major Head '2415'	–	98	–	92	–	100
International Co-operation						
(01) -India's membership contribution to Commonwealth Agricultural Bureau	–	10	–	10	–	10
(02) -India's membership contribution to Consultative Group on International Agricultural Research	–	338	–	338	–	338
(03) -Other Programmes	60	–	50	–	60	–
(04) -India's contribution to Asia Pacific Association of Agricultural Institutions	–	10	–	10	–	10
(05) -India's contribution to NACA	–	9	–	9.5	–	9.5
(06) -India's contribution to CGPRT	–	5	–	5	–	5
(07) -India's contribution to Seed Seed Testing Association	–	1	–	1	–	1
(08) -ISHS Belgium	–	–	–	1.5	–	1.5



Audit Observations

A total of 253 Audit Reports with 1,274 Audit Paras relating to 84 ICAR Institutes, including its Head Office, were outstanding as on 31 March, 2001. The zone-wise break-up details of the outstanding Audit Reports/Audit Paras are as follows.

Zone	Number of institutions	Number of audit reports	Number of audit paras
West Zone	07	23	135
South Zone	22	62	284
East Zone*	14	72	213
North Zone	41	96	642
Total	84	253	1274
*Position as on 30.9.2001			

Directors/Project Directors of the various Institutes/NRCs/PDs have been urged to make special efforts to ensure speedy clearance of these pending Audit Reports/Paras on priority.

ICAR AWARD CEREMONY 2001



The ICAR Award Ceremony was held on 16 July 2001. During the year, 55 awards under 11 different categories were approved, honouring 3 institutions and 48 scientists and 10 associates. Two agricultural journalists were honoured for the first time through a joint award instituted this year. Similarly, a new award for the farmer was finalized this year as the N G Ranga Farmer Award for the Diversified Agriculture. And the prize money for the life-time achievement award under the most prestigious Rafi Ahmed Kidwai Award has been increased from Rs 0.1 million to Rs 0.3 million from this year. Recognizing the contributions of the AICRPs in the development of agriculture a new award, Choudhary Devi Lal Outstanding AICRP Award, has been instituted from this year. The ICAR Young Scientist Award has been renamed as Lal Bahadur Shastri Young Scientist Award and the Outstanding Extension Scientist/Worker Award, as Swami Sahajanand Saraswati Extension Scientist/Worker Award.

Two Jawaharlal Nehru Award winners belonged to traditional universities in Hyderabad and Pondicherry.

This year, the Best Institution Award has gone to the University of Agricultural Sciences, Dharwad, for excellence in region-specific agricultural research and agricultural education. The other awarded institute is the Central Institute of Fisheries Technology. And still other is the Vivekananda Parvatiya Krishi Anusandhan Sansthan, which is a premier agricultural research institute dedicated to the services of the farmers of the north-western Himalayas. Jawaharlal Nehru Awards were given away for 18 Ph.D. Theses. Ten Lal Bahadur Shastri Young Scientist Awards have been finalized, with the research grants ranging from 0.13 million to Rs 2.3 million through *ad-hoc* schemes for launching investigations in the frontier areas of the chosen fields in a time-bound manner.

The Panjabrao Deshmukh Woman Agricultural Scientist Award has been given for research contributions in molecular biology and genetic engineering in horticultural crops, in sugarcane varietal improvement and for developing and commercializing enteral foods for terminally-ill patients. This year 4 Hari Om Ashram Trust awards have been given. Three Extension Scientists/Workers have been chosen for Swami Sahajanand Saraswati Extension Scientist/Worker Award for outstanding extension education activities.

The Vasantrao Naik Award for Dryland Agriculture has gone for outstanding research contributions in Water Conservation and Dryland Farming.

Life-time achievement awards under the prestigious Rafi Ahmed Kidwai Awards



have gone for breeding wheat, pearl millet and maize; for developing eco-friendly pesticide formulations based on neem; for management of saline lands in Haryana; for developing land and water management systems in Bihar; for controlling bacterial wilt and diseases in potato; for diagnosis and treatment of mycoplasmal mastitis, pneumonia and genital mycoplasmosis in livestock; for developing new techniques of artificial insemination in poultry birds; and for developing freshwater prawn culture.

The Jagjivan Ram Kisan Puruskar has been awarded to a farmer from village Jajanpur, Dist Kaithal, Haryana, for organic/natural farming of 6 vegetables with cost-saving cultural practices. The first N G Ranga Farmer Award has been given away for development of diversified agriculture for small and marginal tribal farmers of Maharashtra (Appendix 11).

TECHNICAL CO-ORDINATION

Financial Support to Scientific Societies

Financial assistance with the approval of the Standing Finance Committee has been provided to 51 scientific societies for publication of journals to 23 societies and academic universities for holding national seminars/symposia/conferences and to 3 societies for holding International Seminars/Symposia/Conferences. A meeting for evaluation/review of grading of scientific journals was organized.

Research Advisory Committee

Constitution of Research Advisory Committee (RAC) was co-ordinated and the proceedings of the RAC meetings were reviewed for obtaining approval of the Director-General, ICAR.

Assistance and monitoring DARE/ICAR Annual Report 2001-02 and Highlights of achievements of A.P. Cess Fund Supported Schemes

Manuscript pertaining to DARE/ICAR Annual Report 2001-02 and significant achievements of A.P. Cess Fund supported schemes have been co-ordinated between the corresponding scientists and the DIPA.

Monthly Summary

Complied monthly summary on major research achievements, exports, import and other related matters of all the Institutes/Project Directorates was submitted to Cabinet, Government of India, and other related departments.

Support to DSIR

Evaluated, processed and provided comments on various proposals submitted by the private organizations to the Department of Scientific and Industrial Research (DSIR), Government of India, for recognition of Research and Development Units of private organizations related to agriculture.

Best Annual Report Awards

The award of 'Best Annual Report Awards' for 1999-2000 to the ICAR Institutes has gone to Institute of Agricultural Engineering, Bhopal and National Centre for Agricultural Economics and Policy Research, New Delhi.

ICAR International Training Programmes

ICAR's International Training Programmes - 2002 document material has been collected from all ICAR Institutes and SAUs, compiled, collated and co-ordination is being done with the DIPA for its publication.



6. Partnership and Linkages

- Work Plans between India and Cuba and between the ICAR, New Delhi and National Agricultural Research Institute, Lima, Peru, were extended
- The ICAR, New Delhi and the CNSTR, Burkinafaso, signed a Work Plan for Co-operation in Agricultural Research and Education
- The Council has 5 foreign collaborative projects, each one under Indo-UK Project, Indo-the Netherland Project, Indo-Swiss Project, Indo-FAO Project and Indo- USA Project
- About 50 Indian scientists were sent abroad for training or on deputation
- Training courses were also organized for foreign students
- Under Protocol activities 13 foreign delegations visited India
- About 120 Indian delegations visited foreign countries
- Counsellors' Meet of the Counsellors In-charge of Agriculture of different Embassies/High Commissions was the major event of the year



Agreement for cooperation in conservation of plant genetic resources



Research collaboration between ICAR and ICLARM

International co-operation

The International Cooperation in the ICAR/DARE has been operating through the MoU/Work Plans signed with various countries/international organizations with ICAR/DARE as a Nodal Department and through participation of ICAR/DARE in MoUs/Work Plans signed by the Department of Agriculture and Cooperation as Nodal Department. In addition, Ministry of Science and Technology has developed programmes of co-operation with various countries and international organizations in which ICAR/DARE is the participating agency in the field of agricultural research. Above all, the Joint Commissions constituted by the Ministry of External Affairs and the Ministry of Commerce have the component of agriculture/agricultural research from the ICAR/DARE directly or through the Department of Agriculture and Co-operation.

MoU/Work Plans

- An agreement for extension of Work Plan up to December 2001 was signed on 24 April 2001 between Indian Council of Agricultural Research and National Agricultural Research Institute, Lima, Peru
- A Work Plan for 2001-2002 was signed on 23 April 2001 between Indian Council of Agricultural Research and CNSTR, Burkinafaso, for co-operation in Agricultural Research and Education
- A fresh Work Plan was signed on 25 July 2001 between Indian Council of Agricultural Research and International Plant Genetic Resources Institute (IPGRI). Earlier it was signed on 19 July 1996
- An agreement was signed on 30 August 2001 between India and Cuba for extension of Work Plan up to 31 March 2003

INTERNATIONAL LINKAGES

Following foreign collaborated projects were approved during 2001-2002 for implementation.

Indo-UK Project

The collaborative project "Livelihoods improved through improved crop and soil management in Bihar and Uttar Pradesh" is being implemented through ICAR Research Complex for Eastern Region, Patna for 4 years from October 2000. Assistance from DFID will be £ 48,472 UK.

Indo-Netherlands Project

The collaborative project "Improvement of water productivity in irrigated cropping system at regional scale using remote sensing and simulation of crop growth, soil, water and salt transport (WATPRO) model" was signed between the CCS Haryana Agricultural University (HAU), Hisar, and Wageningen University and Research Centre, Netherlands, for 3 years with foreign assistance of ECU 128, 856.

Indo-Swiss Project

The Indo-Swiss Biotechnology (ISCB) Project, "Development of transgenic chickpea for insect resistance and abiotic stress tolerance" is being implemented at



the Indian Agricultural Research Institute (IARI), New Delhi. On behalf of the Government of Switzerland the Swiss Agency for Development and Cooperation (SADC) will give an assistance of Swiss Francs 160,000. It is equivalent to Rs 4,000,000 the contribution from Department of Biotechnology, Government of India.

Indo-USA Project

The Thematic programme Networking (TPN-2) Project on "Agroforestry and soil conservation" by Ministry of Environment and Forests is being implemented at the Central Arid Zone Research Institute (CAZRI), Jodhpur, for 5 years with the assistance of US \$ 50,000 from Global Mechanism, Washington, USA.

TRAINING COURSES

Indians to Foreign Countries

Fifty (50) cases of deputation/training abroad of Indian scientists were approved during 2001-2002. Out of these, the following officers were of the rank of ADG and above:

1. Dr B N Singh ADG, (Fisheries), ICAR Krishi Bhavan, New Delhi visited Siem Reap, Cambodia, to participate in the Technical Advisory Committee (TAC) Meeting of Network of Aquaculture Centres in Asia-Pacific (NACA) from 16 to 18 May 2001.
2. Dr C L Acharya, Director, Indian Institute of Soil Science, Bhopal, visited Australia from 2 to 8 July under the ICAR-Australian Centre for International Agricultural Research (ACIAR) Project, Survey of potential of manure for meeting crop nutrient needs with integrated nutrient management in Madhya Pradesh, India.
3. Dr N K Tyagi, Director, Central Soil Salinity Research Institute, Karnal visited the project site in China from 4 to 12 September, 2001 under the European Commission (EC) project, Policies for water savings in Yellow River Basin: A DSS applied to Nigxia and Shandong.
4. Dr K Gopa Kumar (DDG, Fisheries), ICAR, Krishi Bhavan, New Delhi, visited Norway from 10 to 20 September, 2001 under the Indo-Norwegian Project on Selective breeding of rohu.
5. Dr B R Sharma (ADG, Irrigation and Water Management), ICAR, Krishi Bhavan, New Delhi visited Seoul, South Korea from 16 to 23 September 2001 under the Indo-Dutch Network Operational Research Project on Drainage and water management for salinity control in canal commands.
6. Dr K K Vass, Director, National Research Centre on Cold Water Fisheries (NRC CWF), Nainital, participated in the first meeting of the Asian Regional Advisory Group on Aquatic Animal Health (AGM-1) at Network of Aquaculture Centres in Asia Pacific (NACA) Headquarter, Bangkok, Thailand, from 7 to 9 November 2001.
7. Dr S Ayyappan, Director, Central Institute of Fisheries Education (CIFE), Mumbai, visited Hanoi, Vietnam from 12 to 14 November 2001 for participation in the meeting of Aquaculture Education Consortium (AEC) under Network of Aquaculture Centres in Asia-Pacific (NACA).
8. Dr J S Samra, DDG, (National Resource Management), ICAR, Krishi Bhavan, New Delhi, was deputed to Egypt and the Netherlands for a study tour from 15 to 26 December 2001, under the Indo-Dutch Network Operational Research Project on Drainage and water management for salinity control in canal commands.

Major Event

The major event of the year was organizing a Counsellors' Meet of the Counsellors-in-Charge of Agriculture of different Embassies/High Commissions on 12 July 2001, to give them an idea about the training facilities available with the National Agriculture Research System.

INDO-FAO PROJECT

The FAO project, Mass Production of Planning Material of Date Palm was forwarded to Food and Agriculture Organization on 30 October 2001 for 3 years with a total cost of US \$ 261,000 on 100% funding basis by the FAO. Ministry of Agriculture (Department of Agriculture and Co-operation) is the nodal department.

FOREIGN VISITORS IN INDIA

- Bistok Hasihalan and Roudiganto two Indonesian experts visited for a training at Directorate of Wheat Research, Karnal, in the field of seed production techniques for 6 weeks from 16 April 2001
- Nadykta Vladimir, Director, and Dr Ismailov Vladimir, Deputy Director, All-Russian Biological Control Institute, Krasnodar, visited Project Directorate of Biological Control, Bangalore, from 18 to 25 April 2001



Chinese delegation visits ICAR

WORLD BANK ASSISTED PROJECT ON AGRICULTURAL HUMAN RESOURCE DEVELOPMENT (AHRD)

The validity of the Agricultural Human Resources Development (AHRD) Project period was extended up to 31 December 2001. During the current calendar year 12 cases of study visits and 1 proposal of overseas training from the line departments, state agricultural universities concerned and from the ICAR (Hqrs.) were approved under the AHRD project.



PROTOCOL ACTIVITIES

Foreign Delegations to India

- H E (Prof.) M A Qaddus, Minister of State for Fisheries and Livestock, Government of Bangladesh accompanied by his Private Secretary, Mr. Khairul Monir visited India from 30 March to 8 April 2001.
- Dr Meryl Jean Williams, Director-General, ICLARM, Manila visited during 11-14 April 2001.
- Dr William D. Dar, Director-General, ICRISAT, Hyderabad visited New Delhi on 28 April 2001.
- A 13-member delegation from the National Livestock Development Project, Ministry of Agriculture, Government of the Federal Republic of Ethiopia visited IARI, New Delhi; NBPGR, New Delhi; CCS HAU, Hisar; NDRI, Karnal; HPKV, Palampur and IGFRI, Jhansi during 13 May to 11 June 2001.
- Dr Denis Blight, Director General, CABI, UK visited India on 8 May 2001.
- H E Mr. Hemakumar Nayakkara, Member of the Sri Lankan Parliament visited IARI, New Delhi on 14 May 2001.
- Members of Parliament, Australia, visited CSSRI, Karnal on 6-7 June 2001.
- Dr Emil Javier, Chairman, Technical Advisory Committee, CGIAR visited India on 29 June 2001.
- H E Mr. Arefaine Berhe, Minister of Agriculture, Eritrea visited IARI, New Delhi; CRIDA/NRCS/ANGRAU, Hyderabad, and IIHR, Bangalore from 24 June to 2 July 2001.
- Dr Geoffrey C. Hawtin, Director-General, IPGRI, Italy, Rome visited India from 14 to 19 July 2001.
- A Kazakh delegation led by Dr Satybaldin, Director-General visited India on 14 August 2001.
- The Agriculture Minister, Livestock Minister and Director of Agriculture from the Ministry of Agriculture, Tanzania visited NRC for Grapes, Pune, on 24 September 2001.
- Dr R D Singh (Sr. Scientist, IARI, New Delhi), and Dr S K Routray, (Scientist, CRRI, Cuttack) visited Egypt from 14 to 19 July 2001 for study in the field of Maize, Rice respectively under Indo-Egypt Work Plan.
- Dr J C Katyal (Director, NAARM, Hyderabad) and Dr T Balaguru, Agricultural Research Mechanism visited Sri Lanka from 3 to 5 September 2001.
- Dr P Das, (DDG, Agricultural Extension) visited Lao PDR for 6 days from 17 to 22 September 2001 to study in the field of Agricultural Extension Management under the Work Plan between India and Lao, PDR, 2000-2001.
- Dr Mangala Rai, DDG (Crop Science) ICAR, visited Spoleto, Italy from 22 to 28 April 2001.
- Dr P S Datta (Principal Scientists, IARI, New Delhi), visited Vienna, Austria from 23 to 27 April 2001.
- Dr A K Verma (Scientist (SS), IVRI, Izatnagar), deputed to Aberdem, UK for 2 years
- Dr A K Srivastava (Joint Director IASRI, New Delhi) visited FAO (Hqrs. Rome) from 4 to 8 June 2001.
- Dr H P Singh (Director CRIDA, Hyderabad) visited Chingmai, Thailand from 12 to 15 June, 2001.
- Dr B S Dhankar (ADG, Technical Co-ordination, ICAR) visited Bangkok from 3 to 8 June 2001.
- Dr S R Sharma (Sr. Scientist (H), IARI, New Delhi) visited Bangkok from 3 to 8 June 2001.
- Dr K Madhavi Reddy, Sr. Scientist (H), Dr Girija Ganeshan (Sr. Scientist), Dr A T Sadashiva Sci (SS), Dr M Krishna Kumar, (Senior scientist), Dr N K Krishna Kumar (Senior), Dr N K Srinivasa Rao (Senior Scientist, PP), and Dr P Parvatha Reddy, (Director) all from IIHR, Bangalore visited Bangkok from 3 to 8 June 2001.
- Dr Bhuphinder Singh (Sr. Scientist & Incharge, IVRI, Regional Station, Palampur) visited Institute of Animal Husbandry and Veterinary Science, Yezin, Myanmar from 25 June to 13 May 2001
- Dr B S Dhillon (Director, NBPGR, New Delhi) visited Rome twice from 24 to 30 June 2001 and 2-4 July 2001.
- Dr D C Uprety (Senior Scientist, IARI, New Delhi) visited the Netherlands from 10 to 13 July 2001.
- Dr O P Sharma (Senior Scientist, PP, NCIPM, New Delhi), visited CABI, London from 3 to 4 August 2001.
- Dr D K Aggarwal (Senior Scientist), Dr C S Singh (Senior Scientist) and Dr Ashok Gauri (Scientist), all from IARI, New Delhi visited CABI, London, from 3 to 24 August 2001.
- Dr K V B R Tilak and Dr B D Kaushik (both Principal Scientist) from the IARI, New Delhi visited Mymensingh and Dhaka from 19 to 23 August 2001.
- Dr R D Rawal and Dr Abraham Verghese (both from IIHR, Bangalore) visited Oman from 8 to 14 September 2001.
- Dr Himanshu Pathak (Scientist, Sr Scale, IARI, New

Indian Delegations to Foreign Countries

- Dr P Das (DDG, Agricultural Extension), ICAR visited Sri Lanka from 8 to 29 June 2001 for Study in the field of general study on Agricultural Extension System at CARP, Sri Lanka under ICAR-CARP Work Plan.
- Dr Nirmal Singh, (Sr. Testing Engineer, PAU, Ludhiana) visited Egypt from 23 June to 4 July 2001 for study in the field of Mechanization of Cotton Cultivation at Agricultural Research Centre, Egypt under Indo-Egypt Work Plan.
- Dr K E Lawande, (Director, NRC for Onion and Garlic, Pune) visited Egypt from 7 to 2 July 2001 for study in the field of Onion and Garlic under Indo-Egypt Work Plan.
- Dr K R Solanki, Director, NRC on Agro-forestry, Jhansi visited Egypt from 14 to 19 July for study in the field of Agro-Forestry under Indo-Egypt work Plan.



- Delhi) deputed to IRRI, Manila for 3 months.
- Dr M S Sachdev (Sr. Scientist & National Fellow) IARI, New Delhi) visited Vienna, Austria from 24 to 28 September 2001.
- Dr R P Moudgal (Principal Scientist, CARI, Izatnagar), deputed to Alemaya University of Agriculture, Ethiopia for 1 year and 10 months.
- Dr Sanjeev Kumar Srivastava (Scientist, NBPGR), Delhi visited ICLARM, Phillipines from 2 to 11 April 2001.
- Dr R S Paroda, Secretary (DARE) and DG, ICAR, visited GFAR, South Africa from 16 to 24 May 2001.
- Dr E A Siddiq (National Professor, DRR, Hyderabad) visited IRRI, Philippines from 4 to 6 April 2001
- Dr Arvind K Shukla, (Scientist,) PDCSR, Modipuram, visited IRRI, Philippines from 12 March to 6 April 2001.
- Dr N N Singh (Project Director, Maize), Dr P H Zaidi (Scientist), and Dr B M Parsanna (Scientist) all from Directorate of Maize Research IARI, New Delhi visited IRRI, Philippines from 7 to 15 May 2001.
- Dr P K Joshi (Principal Scientist) NCAP, Pusa New Delhi visited CIMMYT, Nepal from 4 to 8 June 2001.
- Dr B Mishra (Project Director, DRR, Hyderabad), visited IRRI, Thailand from 17 to 20 July 2001.
- Dr L V Rao (Scientist, DRR, Hyderabad) visited IRRI, Philippines from 14 to 18 May 2001.
- Dr R N Pal (DDG (Horticulture, ICAR) visited COGENTO/IPGRI, Tanzania from 11 to 17 June 2001.
- Dr P K Aggarwal (Senior Scientist, IARI, New Delhi) visited IRRI, Netherlands from 18 to 24 June 2001.
- Dr Ajay Kumar Upadhyay (Scientist, CPCRI, Kasaragod) visited ICRAF, UK, from 30 June to 5 July 2001.
- Dr N N Singh (Project Director, DMR, IARI, New Delhi) visited CIMMYT, Mexico from 14 to 19 July 2001.
- Dr Lalitha Anand (Head, Division of Biotechnology, IIHR), Bangalore visited INIBAP, USA, from 17 to 20 July 2001.
- Dr A K Mishra (Head, Division of Soil Physics, IISS, Bhopal), and Dr K V Vittal (Head Division of Resource Management CRIDA, Hyderabad) visited ICRISAT, Thailand from 26 to 31 July 2001
- Dr E A Siddiq (National Professor, DRR, Hyderabad) visited IRRI, Cambodia, from 12 to 15 September
- Dr Anjani Kumar (Scientist, NCAP, Pusa New Delhi), Dr N Gopakrishna, Pillai (Head, Division of Pelagic Fisheries, CMFRI, Cochin) and Dr Pradeep Kathia (Scientist, CICFRI, Barrackpore) visited ICLARM, Malaysia from 26 to 25 August 2001.
- Dr S Mruthyunjaya (Director, NCAP) and Dr P K Joshi (Principal Scientist, NCAP) visited ICLARM, Malaysia from 20 to 25 August 2001.
- Dr Bir Pal Singh (Joint Director, CPRS, Modipuram) visited CIP, Sri Lanka from 26 to 28 September 2001.
- Dr Arvind Kumar Shukla (Scientist, PDCSR, Meerut) visited CIMMYT, Bangladesh, from 10 to 22 September 2001.
- Dr J P Singh (Principal Scientist, CPRS, Jalandhar), visited CIP, Ecuador for 3 weeks w.e.f. 13 September 2001.
- Dr C S Praharaj (Scientist, CPRS, Patna) visited CIP, Bangladesh, Nepal from 10 to 22 September 2001.
- Dr R N Pal (DDG (Horticulture), ICAR) visited INIBAP, Sri Lanka from 11 to 14 September 2001.
- Dr Subba Rao (Senior Scientist, DRR, Hyderabad) visited IRRI, Philippines from 2 to 24 August 2001.
- Dr E A Siddiq (National Professor, DRR, Hyderabad) visited Cambodia from 12 to 15 September 2001.
- Dr R N Pal (Acting, DDG, Horticulture, ICAR) visited INIBAP/ASP NET Colombo, Sri Lanka from 11 to 14 September 2001.
- Dr C S Praharaj (Scientist, CPRS, Patna) and Dr Arvind Shukla (Scientist, PDCSR, Modipuram), visited CIMMYT, Nepal and Bangladesh from 10 to 22 September 2001.
- Dr J P Singh (Scientist, CPRS, Jalandhar) visited CIP, Quito, Equador for 3 weeks w.e.f. 13 September 2001.
- Dr Bir Pal Singh (Joint Director, CPRS, Modipuram) visited CIP, Sri Lanka, from 26 to 28 September 2001.
- Dr Mangala Rai, (DDG, Crop Science, ICAR) visited CIMMYT, Netherlands from 1 to 4 October 2001.
- Dr D P Singh (Senior Scientist, DWR, Karnal) visited CIMMYT, Belgium, for 1 week w.e.f. 1 October 2001.
- Dr J S Samra (DDG, Natural Resource Management), visited CIMMYT, USA from 21 to 25 October 2001.
- Dr Ramesh Chandra (Principal Scientist, CISH, Lucknow), visited IPGRI, China, from 11 to 23 October 2001
- Dr R V Nair (Principal Scientist, CPRI, Kayangulam) and Dr P Rajan (Scientist, CPCRI, Kasaragod) visited COGENT (IIPGRI), Bangladesh from 16 to 30 October 2001.
- Dr Panjab Singh (DG, ICAR/Secretary, DARE) visited USA from 29 October to 2 November 2001.
- Dr Jai Gopal (Scientist, CPRI, Shimla) deputed to Lima, Peru for availing TWAS Associateship Scheme under TWAS UNESCO Associateship Programme w.e.f 1 April to 30 June 2001 and again he will be there from 1 April to 30 June 2002.
- Dr E Dhanwanthari, (Scientist, CMFRI, Cochin) deputed to Japan, for 1 year and 6 months for higher studies leading to the award of Ph.D. at the Tokyo University of Fisheries, Tokyo w.e.f. 1st week of April 2001.
- Dr C R Mehta (Scientist, SS), CIAE, Bhopal visited Japan to attend group graining course on Farm Machinery Management utilizing Micro-computers in Japan from 23 to 27 April 2001.
- Dr N A Shakil (Scientist, IARI, New Delhi) deputed to Lowell, USA to carry out a portion of his Ph.D. Research at the Department of Chemistry, University of Massachusetts, Lowell, USA for 9 months w.e.f.



1 November 2001.

- Dr Ravi V. Hunje, (Assistant Professor, UAS, Dharwad) deputed to Germany to attend short-term training course on Organization and Management of formal and informal seed programme in Germany from 18 June to 20 July 2001.
- Dr C Viswanathan (Scientist) WTC, IARI, New Delhi) deputed to USA to avail BOYSCAST fellowship award in the USA for advance research in his areas of specialization from first half of June, 2001 for 12 months.
- Dr M Ramakotti Reddy, (Scientist PDP, Hyderabad) deputed to Australia for higher study leading to the award of Ph.D. at the University of Melbourne, Australia for 3 years w.e.f. July, 2001.
- Dr Raj Kumar (Scientist, SS, DWR, Karnal) visited Germany to attend training on management of formal and informal seed programme in Federal Republic of Germany from 18 June to 21 July 2001.
- Dr C Aswath (Scientist, IIHR, Bangalore) deputed to Korea to work as researchers on Transformation of Ornamental Crops at Konkuk University, Seoul from 1st July 2001 for 2 years.
- Dr B Sivasubramanian (Scientist, CRRRI, Cuttack) deputed to USA for availing Pre-doctoral Research and Training at the University of Baltimore Law School, Maryland, USA for 6 months w.e.f. 15.8.2001.
- Sh. Vijay Garg, (Scientist, (SS) CIAE, Bhopal) deputed to USA for pursuing higher study leading to Ph.D. programme at Oklahoma State University, USA for 3 years w.e.f. August 2001.
- Sh. Rupal Choudhary (Scientist, NDRI, Karnal) deputed to USA for pursuing higher studies leading to Ph.D. programme at Okalhama State University, USA, for 3 years w.e.f. 9 August 2001.
- Dr P K Sahoo (Scientist, CIFA, Bhubaneswar) deputed to UK to avail Bio-technology Overseas Associateship (Longterm) award in U.K. under DBT Programme for 12 months w.e.f. 5 September 2001.
- Sh. Dharmendra Saraswat (Scientist, CIAE, Bhopal) deputed to USA for pursuing higher study leading to Ph.D. programme at the Ohio State University, USA for 3 years w.e.f. 25 August 2001.
- Dr O P S Kholia (Sr. Scientist. CSWCR&TI, Dehra Dun) deputed to Sweden to attend SIDA advanced training on "Sustainable Agriculture in an Environmental perspective, 2001" in Sweden from 9 September to 19 October 2001.
- Dr A G Ponniah (Director, NBFGR, Lucknow) visited Malaysia to attend the interview for the post of Programme Leader, Sr. Scientist Biodiversity Genetics at ICLARM, Malaysia from 22 to 27 August 2001.
- Dr S K Anand, (Sr. Scientist), NDRI, Karnal) deputed to Canada to avail Bio-technology Overseas Associateship (Short-term) award at the University of Gulph, Canada for 6 months w.e.f. 11 November 2001.
- Dr Arunava Datta, (Technical Officer, NRC for Agroforestry, Jhansi) visited Singapore from to attend 2 days training on scientific equipment HPLC system at M/S SPINCO Biotech. Pvt. Ltd., Singapore from 5 to 6 October 2001.
- Dr A K Patra, (Sr. Scientist, IARI, New Delhi) deputed for availing Post-Doctoral Research fellowship by INRA under the French Research Ministry at the University of Claude. Bernard. Lyon, France for 12 months w.e.f. 1 September 2001.
- Dr Dinesh Kumar, (Scientist, IGFRI, Jhansi) deputed to China for availing Chinese Government Scholarship for higher studies at South China Agricultural University, China w.e.f. from September, 2001 to July, 2002.
- Dr Boby Ignatius, (Scientist, CMFRI, Regional Station Mandapam) visited Phillipines to attend the Training course on responsible aquaculture development at SEAFDEC, Phillipines from 4 September to 29 October 2001.
- Ms Sonali Das (Scientist, IASRI, New Delhi) deputed to USA for higher studies leading to Ph.D. programme at the University of Connecticut, USA for 3 years w.e.f. 7 September 2001.
- Dr A Panigrahi (Scientist, CIBA, Chennai) deputed to Japan for availing award of Japanese Government Scholarship for higher studies t the University of Tokyo, Japan for 1 year and 6 months w.e.f. 1.10.2001.
- Dr Sanjay Kuamr Jain, (Scientist, DWR, Karnal) deputed to Germany, for pursuing higher studies leading to Ph.D. programme at the University of Justis Liebig Unviersity Giesson Germany for 3 years w.e.f. 1st week of November 2001.
- Dr S N S Chaurasia, (Scientist, IIVR, Varanasi), and Dr T Jankairam, (Scientist, IIHR, Bangalore) visited Israel to attend Training Course on "Research and Development in Protected Crop Technology in Israel from 30 October to 4 December 2001.
- Dr (Mrs) G Santha Lakshmi (Technical Officer, SBI, Coimbatore), and Shri Bir Singh, (Technical Officer, VPKAS, Almora) visited Phillipines to attend Training refresher course on IPM/ICRE under Netherlands Fellowship Programme in Phillipines from 4 to 16 November 2001.
- Smt Archana Sharma (Technical Officer (T-5), CARI, Port Blair) visited Phillipine to attend a refresher course on Extension Development for IPM in Phillipines under the Netherlands Government Fellowship Programme wef 5 to 16 November 2001.
- Dr B N Rao, (Technical Officer, CTRI, Rajahmundry) and Dr Sri Dhar, (Scientist, V.P.K.A.S) visited Thailand to attend a refresher course on Integrated Quality Management in Thailand from 5 to 17 November
- Dr Ajay Arora, (Scientist, IARI, New Delhi) deputed to Japan for availing JSPS Post-doctoral fellowship programme for Foreign researchers in Japan 24 months w.e.f. 1 November 2001.
- Dr D Sarkar, (Scientist, CPRI, Shimla) visited



- Germany from for availing Alexander Von Humboldt (AvH) Foundation fellowship for advance research in Germany 1 January 2002 to 28 February 2003.
- Dr Sanjay Kumar, (Scientist, NRC on Equine, Hisar) deputed to Japan for availing JSPS Post-doctoral fellowship programme for foreign researchers in Japan from 15 November 2001 to 14 November 2003.
 - Dr N K Prahraj (Sr Scientist, Project Directorate on Poultry, Hyderabad) deputed to France for availing 1 year Post-Doctoral Fellowship at INRA, France w.e.f. December 2001.
 - Dr R Madhusudhana, (Scientist, NRC for Sorghum, Hyderabad) deputed to UK for availing BOYSCAST Fellowship award at Institute of Grassland and Environmental Research, Aberystwyth, UK, under DST's sponsorship for 12 months w.e.f. January 2001.
 - Dr A Sarangi, (Scientist, IARI, New Delhi) deputed to Canada for availing Post-Doctoral Fellowship on Sustainable Agriculture at Mc.Gill University, Canada for 24 months w.e.f. 3 January 2002.
 - Dr Dheer Singh, (Scientist, NDRI, Karnal) deputed to USA for availing 12 months BOYSCAST Fellowship award at University of South Carolina, School of Medicine, Colombia, USA, w.e.f. 1 January 2002 under DST's sponsorship.
 - Sh Gorakh Mal (Scientist, NRCC, Bikaner) deputed to UK for pursuing higher studies leading to the award of Ph.D. at the University of Shaffield, UK for 3 years w.e.f. 1 January 2002.
 - Dr V C Mathur (Senior Scientist, IARI, New Delhi) visited Thailand for participation in UNCTAD Regional Workshop from 3 to 5 April 2001.
 - Dr M L Choudhary (Head, Division of Floriculture & Landscaping, IARI, New Delhi) visited Nepal for participation in the 1st International Floriculture Trade Fair from 27 to 30 April 2001.
 - Dr (Mrs) P Ranjitha, (Scientist, IGFRI, Jhansi) visited South Africa to act as an external reviewer for an International Centre for Development Oriented Research in Agriculture (ICRA) field study from 9 to 26 May and 17 June to 8 July 2001.
 - Dr R K P Singh, (Scientist, ICAR Research Complex for NEH Region, Meghalaya) visited Nepal from 21 to 24 May 2001 for participation in the International Symposium on Mountain Agriculture in the Hindukush Himalaya Region.
 - Dr Y S Ahlawat, (Principal Scientist, IARI, New Delhi) visited Bhutan as a resource person for Citrus Training from 21 to 28 May 2001
 - Dr J C Tiwari, (Senior Scientist, CAZRI, Jodhpur) visited Australia for participation in the ACOTONC 2001 conference from 13 to 20 April 2001.
 - Dr P R Kumar (Director, NRC on Rapeseed and Mustard, Bharatpur) visited Poland for participation in the GCIRC Technical Meeting from 5 to 7 June 2001
 - Dr R K Singh (Senior Scientist, CSWCR&TI Regional Station, Kota) visited Mongolia for participation in the 3rd Asia Africa forum on combating Desertification and fourth Asia Regional Meeting of the CCD focal point in Asia from 21 to 27 June 2001.
 - Dr P K Joshi (Principal Scientist, NCAP, Pusa, New Delhi, visited Japan for participation in APO Sponsored study meeting on Agricultural diversification and International Competitiveness from 16-23 May 2001.
 - Dr S Nagarajan (Project Director, DWR, Karnal) visited France for participation in the International Seminar on Prospects for the development of Wheat in the 21st Century from 27-29 June 2001.
 - Dr C T Jose (Scientist, CPCRI Regional Station, Vittal) visited Korea for participation in the 53rd Session of International Statistical Institute from 22 to 29 August 2001
 - Dr A K Singh (Head, Germplasm Conservation Division, NBPGR, New Delhi) visited UK for participation in Seed Conservation- Turning Science into Practice: Kew International Workshop from 26 to 31 July 2001.
 - Dr Alok Jha (Scientist, NDRI, Karnal) visited Norway for participation in International Dairy Conference from 27-29 June 2001.
 - Dr Edward Raja (Senior Scientist, IIHR, Bangalore) visited Bonn, Germany, for participation in the Bonn 2001 international workshop from 23-27 July 2001.
 - Dr Man Singh (Scientist, IARI, New Delhi) visited Italy for participation in the international conference on Sustainable soil management for environmental Protection Soil Physical Aspects from 2 to 7 July 2001.
 - Dr B Ramakrishnan (Scientist, CRRI, Cuttack) visited the Netherlands for participation in the 9th International symposium on Microbial ecology from 26 to 31 August 2001.
 - Dr S P Tiwari (Director, NRC for Soybean, Indore) visited China for participation in Regional Technical Meeting for Asian Plant Variety Protection System and Workshop on the Principles of Technical Examination from 23 to 26 July.
 - Dr K M Manjaiah, (Scientist, IARI, New Delhi) visited Canada for participation in the International Conference on Biochemistry from 29 July to 3 August 2001.
 - Dr (Mrs) Sudershan Ganguly (Senior Scientist, IARI, New Delhi) visited USA for participation in the 3rd Annual Symposium on Entomopathogenic nematodes and Bacteria from 6 to 11 August 2001.
 - Dr Kiran Singh (DDG (Animal Science, ICAR, New Delhi) visited Vietnam for participation in the international workshop on 'Development strategies for genetic evaluation for beef production in developing countries' from 23 to 28 July 2001.
 - Dr J S Samra (DDG, National Resource Management, ICAR, New Delhi) visited UK for participation in the NRSP workshop entitled "Common Pool Resources Developing Management, Strategies that can benefit



the Poor from 2 to 5 October 2001.

- Dr P S Vimala Devi, (Scientist DOR, Hyderabad) visited Kenya for participation in the international symposium on Biotechnology from 2 to 5 Sept. 2001.
- Dr K V Rajendran (Senior Scientist, CIFE, Mumbai) visited Ireland for participation in the European Association of Fish Pathologists 10th International Conference on 'Disease of Fish and shellfish from 10 to 14 September 2001.
- Dr S D Kulkarni (Head, APD, CIAE, Bhopal) visited China for participation in China international fruit and vegetable fair from 11 to 14 October 2001.
- Dr C Balagopalan, (Head, CUBT, CTCRI, Kerala) visited Brazil for participation in IV Latin American Symposium on Food Science from 12 to 15 November 2001.
- Dr Sangeeta Srivastava, (Scientist, IISR, Lucknow) visited Bangladesh for participation in the 4th International Plant Tissue Culture Conference from 1 to 3 November 2001
- Dr S D Sharma (Director, IASRI, New Delhi) visited China for participation in the international conference on The Development of Agricultural Information Management Technology and Markets in the 21st century from 4 to 6 November 2001.
- Dr (Mrs) G Padmaja, (Principal Scientist), Dr T Makeshkumar (Scientist), Dr (Mrs) M T Sreekumari (Senior Scientist), Dr Mathew George (Principal Scientist), Dr K Abraham (Principal Scientist), Dr R Radhakrishnan Nair (Principal Scientist), Dr M Anatharaman (Principal Scientist) and Dr T Srinivas (Scientist), all from the CTCRI, Thiruvananthapuram, Kerala visited USA for participation in the V International Scientific Meeting on Cassava Biotechnology Network (CNB-V) from 4 to 6 November 2001.



7. Agricultural Scientists' Recruitment Board

The analytical information pertaining to the major initiatives and achievements of the Agricultural Scientists' Recruitment Board (ASRB) from 1 April 2000 to 31 March 2001 is given here.

RECRUITMENT BY EXAMINATION

Examination held during 2000-2001

No examination was held during the 2000-2001. However, the incomplete work of the examination held during 1999-2000 was completed during 2000-2001. Salient features of the same are:

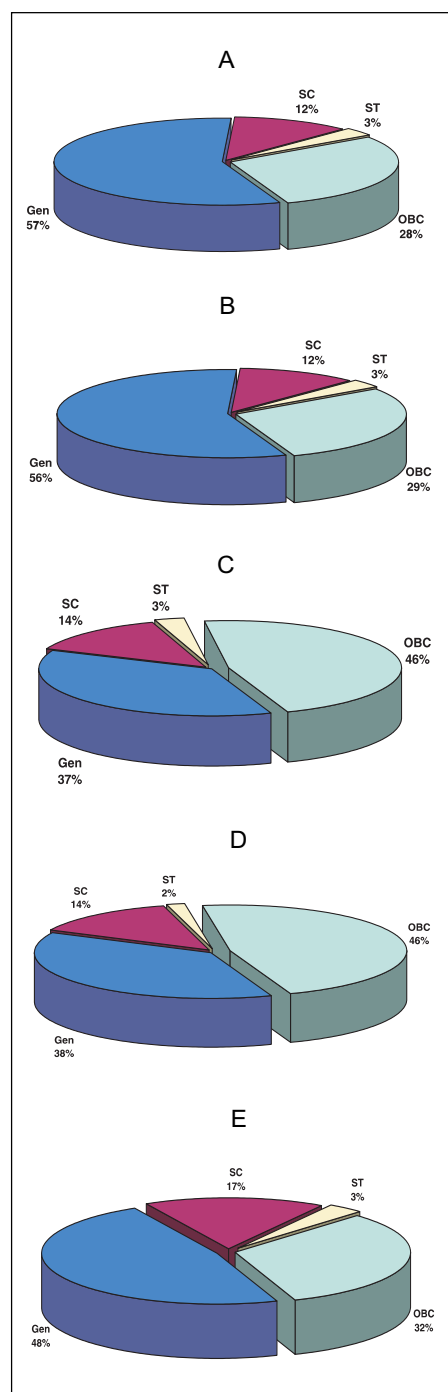
- The recommendations of the Board for appointment as Scientists in the Agricultural Research Service (ARS) on the basis of examination conducted by the Board in December 1999 was sent to the Council on 26 April 2001 after the viva-voce of the qualified candidates was completed. Of the 90 candidates recommended, 14 belonged to SC, 9 to ST and 29 to OBCs.
- Of the 2,305 applicants, 1,224 appeared at the written examination. A total of 342 candidates qualified for being called for interview and finally 90 candidates were recommended for appointment as Scientists in ARS.

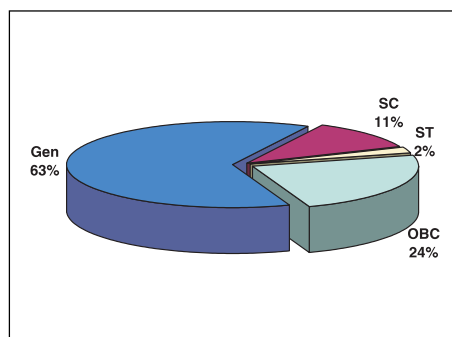
Candidates	General	SC	ST	OBCs	Total
A. Applied	1,307	283	59	656	2,305
B. Appeared in examination	690	141	35	358	1,224
C. Called for viva-voce	126	47	9	160	342
D. Appeared in viva-voce	118	43	5	147	313
E. Candidates finally selected for ARS	43	15	3	29	90

- As a result of combined examination, 2,313 candidates were declared to have qualified the National Eligibility Test for appointment as Assistant Professors/Lecturers in State Agricultural Universities.
- The list of successful candidates was sent to all the State Agricultural Universities and result was notified in the *Employment News*.
- The recommendation regarding award of Senior Research Fellowship as a result of the combined examination was communicated to the Council on 14 May 2001. Of the 176 candidates recommended for award of fellowship, 27 belonged to SC, 9 to ST and 31 to OBCs.

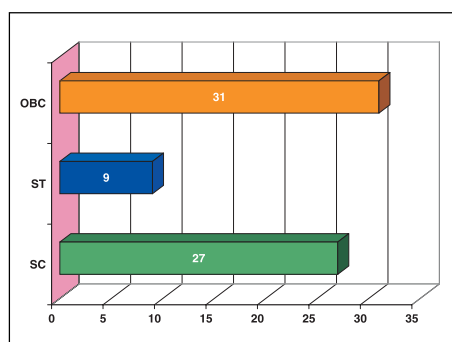
Open Competitive Examination for Recruitment of Finance and Accounts Officers at the ICAR Headquarters

The competitive examination for recruitment to the post of Finance and Accounts Officer in the pay scale of Rs 8,000-13,500 was held in December 1999. Out of 599 candidates applied for examination, 179 candidates appeared in the examination, 17 called for interview, 14 appeared in interview and finally 4 selected (2 General and 2 OBCs). The result was declared on 23 October 2000.

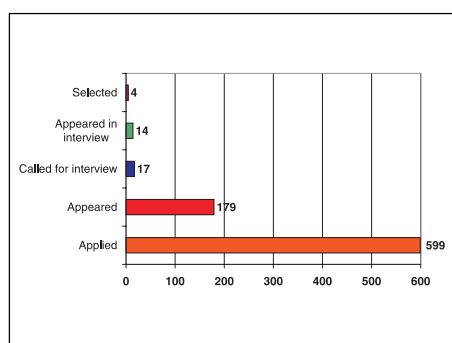




National Eligibility Test



Award of Senior Research Fellowship



Recruitment of F and AO

LIMITED DEPARTMENTAL EXAMINATION FOR RECRUITMENT OF STENOGRAPHER GRADE II

The Limited Departmental Examination for Stenographer Grade II was held in September 1999. Of the 38 candidates, 32 appeared in the examination, 27 called for shorthand test and 2 selected (1 for Hindi and 1 for English). The result was declared on 7 July 2000.

RECRUITMENT BY INTERVIEW

Quantum of Work

The Board issued 5 advertisements for 241 posts during the year. It received requisitions for 358 posts during the year and cases involving 38 posts were carried-over from the previous year. Against a total number of 241 posts, recruitment process could be completed for 200 posts. Requisitions for 11 posts were withdrawn by the ICAR and Board issued corrigenda for change of qualifications on the request of the Council for 2 posts. In 2 cases, no candidate was found eligible after interview. In other 2 cases, no candidate came to attend the interview. In 33 cases, no candidate was found eligible at the screening stage. At the end, there was a balance of 155 posts for which requisitions were received during the last quarter of the year.

The category-wise break-up of these posts is follows:

(a) Scientific

(i) Deputy Director-General and Director of National Institute	2
(ii) Assistant Director-General, Directors of Institutes, Project Directors and Joint Directors of National Institutes	21
(iii) Project Co-ordinators and Zonal Co-ordinators	3
(iv) Heads of Divisions/Regional Stations	33
(v) Principal Scientists	42
(vi) Senior Scientists	139

(b) Technical

(i) Technical	1
Total	241

Interview and Selection

For the 200 posts, for which recruitment process was completed, 2,324 applications were received. Of the 1,505 called for interview, 1,000 appeared.

The category-wise break-up of posts is follows:

(a) Scientific

(i) Deputy Director-General and Director of National Institute	2
(ii) Directors, Joint Directors of National Institutes, Assistant Directors-General, Project Directors	26
(iii) Zonal Co-ordinators, Project Co-ordinators, Joint Directors of Institutes other than National Institutes	6
(iv) Head of Divisions, Officers In-charge	41
(v) Principal Scientists	34
(vi) Senior Scientists	87

(b) Technical

(i) Technical	4
Total	200

Shortage of Suitable Candidates

The Board was unable to find suitable candidates for appointment to 5 posts. For 33 posts no candidates was found eligible to be called for interview.



Reforms

With a view to sharp focus discussion during interview and to gauge the candidates in their areas of strength, the concept of asking Work Plan for next 5 years has been further strengthened and revised, and the candidate is asked to submit:

- A brief note (not more than one page) reviewing the work done by the candidate during the last 10 years, highlighting the achievements and accomplishments during the period including technology developed, project completed, contribution to physical and infrastructural development, inter-disciplinary programme formulation and participation in research activities, mobilization of external funding for projects etc.
- A Work Plan (not more than three pages) on how the candidate proposes to organize the activities of the post for which he or she is an applicant. The information provided may include new research projects/thrust areas of work that he or she proposes to introduce, physical and infrastructural facilities proposed to be developed, linkages with other research units and development departments proposed, as well as the expected outcome from these changes. The plan should be practical and realistic in nature and should be achievable within five years and feasible within the available resources of the institutes. In preparing this plan, the past and present achievements as well as technology development may be critically reviewed and the critical gaps identified. The annual report, department as well as project reports, may be consulted for developing this plan.

RECRUITMENT RULES AND SERVICE RULES

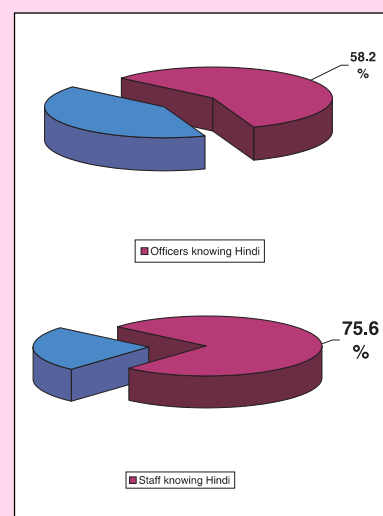
Eight proposals were received during 2000-2001 for framing/amendment of Recruitment Rules, and decisions taken were communicated to the ICAR in respect of Legal Advisor, ICAR; Deputy Secretary, ICAR; Studio Attendant G-D4; Record Keeper (Grade-C); Lower Division Clerks Examination Grade C; File Attendant; and Technical Officer.

ASSESSMENT, REVIEW OF ASSESSMENT AND INDUCTION IN THE ARS

No proposal for Assessment under ARS rules was received during the year relating to Scientists Grade S-I. Four cases of induction relating to Scientists, and Research Management Positions were considered during the year and recommendations were sent to the ICAR. One proposal for review of assessment result was considered during the year.

USE OF HINDI

- Adequate arrangements were made to promote progressive use of Hindi in the office of the Board. To ensure compliance of Official Language Policy of the Central Government/ICAR and to fulfil the target fixed in the annual official language programme, a Technical Officer in Group B service is exclusively attending to the related work.
- About 58.2% of Officers and 75.6% staff working in the Board have acquired working knowledge of Hindi.



- Representative of the Board participates in the quarterly meeting of the Official Language Implementation Committee of the ICAR headquarters where the progress made in the use of Hindi in the official work of the Board is reviewed.
- Examination rules, notice, syllabi, instructions to candidates, admission certificate, test booklets, answer sheets, application forms, attendance sheets and attendance lists, etc. were printed both in English and Hindi simultaneously.
- All the advertisements issued by the Board were prepared and published both in Hindi and English in the leading newspapers of the country including *Rozgar Samachar*.
- Hindi version of this annual report of the Board is also being published.



8 Publications and Information

Dissemination of latest information to the farmers on the new crop varieties released and the new technologies developed in the field of agriculture and related subjects is the prime task of the Indian Council of Agricultural Research. Keeping this in view, the ICAR brings out a number of periodicals i.e. newsletters, bulletins, brochures and reports through the Directorate of Information and Publications of Agriculture.

The publications brought out by the DIPA are of high standard both in quality and content and cater not only to the needs of the farming community but also students, extension workers, progressive farmers and the general public.

The DIPA is now giving more thrust on electronic publishing. It has also created a database and has developed digital publication of documents. Recently, it has organized a workshop on DATABASE in collaboration with CABI.

PUBLICATIONS

English Editorial Unit

During 2001-2002, the ICAR brought out 30 publications in English including (i) Handbook of Horticulture (ii) Minor Spices and Condiments (iii) Odyssey of Sandalwood Tree (v) Textbook of Food Science and Technology (vi) Animal Genetic Resources of India (vi) Vegetables, Tuber Crops and Spices (vii) Protozoa and Protozoan Diseases of Domestic Livestock. Besides, DARE/ICAR Annual Report 2000-2001, four periodicals, viz. *The Indian Journal of Agricultural Sciences*, *the Indian Journal of Animal Sciences*, *Indian Farming* and *Indian Horticulture*, and three quarterly newsletters, viz. ICAR News, ICAR Reporter and *ARIS News* were also brought out regularly.

The two scientific journals—*The Indian Journal of Agricultural Sciences* and *The Indian Journal of Animal Sciences*—which are indexed and abstracted internationally were brought out on time. *Indian Farming*, a popular monthly magazine, brought out two Special Numbers—one on the occasion of World Food Day and the other on Biotechnology. In addition, it also brought out an accent number on 'Organic Farming'. *Indian Horticulture*, a semi-technical magazine of the Council, brought out a special number on the occasion of national symposium on Floriculture in the New Millennium, ICAR News, a quarterly newsletter, mainly deals with dissemination of information by publishing agricultural innovations made, and the new technologies developed both at the headquarters and the institutes. It also covers the profiles of the institutes which give an insight into their functioning. It is widely circulated both in India and abroad. *ICAR Reporter*, an in-house newsletter covers all important activities of the Council such as reports, reforms, personnel, international linkages, etc at the ICAR headquarters and the institutes. The Council also brings out *ARIS News*, a quarterly magazine on information and communication technology. In addition, a number of miscellaneous and *ad-hoc* publications were also brought out.

Hindi Editorial Unit

During the year under report, Hindi Editorial Unit brought out 20 publications and three periodicals, i.e. *Kheti* (monthly), *Phal Phool* (quarterly) and *Krishi Chayanika* (quarterly). In addition, a number of books, bulletins and reports were also published. *Kheti* and *Phal Phool*, are the two popular magazines which publish



The latest ICAR publications brought out by the Directorate of Information and Publications of Agriculture both in English and Hindi



articles relating to agriculture, including fisheries and animal husbandry and on fruits and vegetables, respectively.

Krishi Chayanika, the quarterly magazine has been revamped from July-Sept 2001 issue. Significant changes in selection of articles, layout as well as the size have been changed. The rationale behind this revamp is to give a better look and to make it a source of knowledge bank for progressive farmers and extension workers.

Kheti published 6 special issues on the occasion of Environment Day (June), ICAR Foundation Day (July) World Food Day (October) Biotechnology (January) Sugarcane (February) Plant Protection (March).

Phal Phool brought out a special issue on Bio-tech Horticulture (July-Sept).

In addition to DARE/ICAR Annual Report 2001-2002, some of the important publications brought out by the Hindi Editorial Unit include books such as, *Gulab, Biogas, Bharat Mein Sankar Dhan, Phal Vigyan, Himalayan Ke Vanya Pashu, Ghar Ki Bagia, Moti Somvardhan, Bhed Avom Bakri Palan Mein Nasal Sudhar, Madhya aur Aadhunik Kalin Bharat Mein Pashu Palan Avom Pashu Chikitsa Vigyan*, etc.

Production Unit

The Production Unit, being responsible for administrative management of printing and publishing books and journals including urgent and time-bound publications for the headquarters of the Council, continued to play an important role in the functioning of the DIPA. All the monthly journals (3 in English and 1 in Hindi) were printed well on time maintaining the desired print quality. Council's prestigious quarterly newsletters "*ICAR News*", "*ICAR Reporter*", and "*ARIS News*" were printed well in time using the best paper, as required, and the state-of-art print technology to achieve the best print quality, keeping in view their national and international usage. Besides 30 publications in English, 20 in Hindi were printed maintaining the high class print standards.

Special care is taken for the printing of annual publications of the Council required for AGM of ICAR Society such as DARE/ICAR Annual Report in English and Hindi, Agenda Notes, Speeches of Agriculture Minister and DG, ICAR, ICAR Budget Book, etc. and other publications assigned to the Unit. The time-bound publications/certificates/citations/invitation cards meant for ICAR Award Ceremony were also produced nicely within the given short-time during the reported period.

The selected important publications brought out in English were Handbook of Horticulture Research, 'Odyssey of Sandalwood Tree', 'Minor Spices and Condiments', 'ICAR Telephone Directory 2001', 'Textbook of Food Science and Technology', 'Vegetables, Tuber Crops and Spices', 'Animal Genetic Resources of India', 'Fish Gear and Craft Technology', In Hindi, *Rajbhasha Aalok-2001*, '*Masalon Ki Kheti*', '*Phaloupadan Arthsastra*', '*Mein Hoon Sankar Dhan*', '*Moonga Resham 2001-2002*, Poster for Hindi Week, etc. were printed. Assistance was provided to NATP in production of various publications brought out by them during the year. Education Division was also assisted in the production of various curricula. For Hindi Section of the Council's various certificates and citations were designed and produced in Hindi. The Unit continued participating in the important activities of the DIPA.

Sales and Advertisements

Business Unit plays a key role in distribution and marketing of the publications brought out by the Council among students, scientists and researchers, etc. It participates in exhibitions and fairs and displays books, journals, periodicals brought out by the Directorate of Information and Publications of Agriculture of ICAR. During 2001-2002, the Business Unit promoted the sale of books and periodicals both in English and Hindi and earned a revenue of about Rs 35 lakh (up to 28 February, 2002).



Shri Shripad Y Naik, MoS for Agriculture, signing in the visitors' register at the sales counter of DIPA at the India International Trade Fair held from 14-27 November 2001 at Pragati Maidan, New Delhi



ICAR Publications Stall during XV World Book Fair, New Delhi, 2002.



Art and Photography

Art Unit has played an important role in enhancing the image of the ICAR by designing and illustrating all the publications and publicity material brought out during the period.

Art Unit has successfully adopted the Digital Designing process for all its publications, which has improved the quality of designs in conformity with the new development in printing industry. In collaboration with ARIC (DIPA), Art Unit has digitalized with database all the photographs available in the Photo Library (DIPA) for the purpose of printing the photographs on WEB page of ICAR. The Unit has also started sending photographs by electronic media to international organizations (FAO), as per their requirements.

Apart from regular job, a number of special issues of journals were brought out during this period on different subjects for students, scientists, agricultural community, as well as for general public. All the designs created by the Art Unit were highly appreciated in the Council and also by several international organizations.

The Photography Unit provided photographs, colour transparencies for various publications of the ICAR. It covered other activities of the ICAR including visits of dignitaries from other countries and press conferences of the Union Minister of Agriculture and the State Ministers of Agriculture.

I N F O R M A T I O N

Agricultural Research Information Centre (ARIC)

Agricultural Research Information Centre (ARIC) is the central source of research information of ICAR. During the period under report, it collected and processed the information on A P Cess Fund Schemes, Research Projects (RPFs), Agricultural Colleges, Indian Agricultural Periodicals, All-India Coordinated Research Projects (AICRPs), Deputation Reports, Retired ICAR Scientists, Crop Varieties released by ICAR and National Agricultural Research Database.

ARIC is the National Input Centre for the International Information System for Agricultural Science and Technology (AGRIS) and Current Agricultural Research Information System (CARIS) Projects of Food and Agriculture Organization (FAO), the largest bibliographical information system in the world. Selective Dissemination of Information (SDI) services are available at ARIC through AGRIS-CD, CARIS-CD, CAB-CD, Food and Human Nutrition - CD of AGRIS and FAOSTAT Database. SDI and document delivery services were provided to 350 scientists and research scholars.

ARIC brought out the biannual publication "Directory of Conferences, Seminars, Symposia, Workshops in Agriculture for the users of ICAR and SAU system and ICAR Telephone Directory - 2001.

ARIC has developed digital publication of Vision 2020 document of ICAR. All the photographs available in Photo Unit of DIPA were also digitized by creating a database in MS-Access and scanning 8,500 photographs. This database on CD was made searchable by using Visual Basic at front end for the use of editors, scientists and other users for selecting the photographs. About 1,850 Research Projects of ICAR Institutes (RPFs) were also digitized in MS-Access and will be made available on CD with searching facilities through visual basic at front end. Web page of DIPA was developed and connected to the ICAR Website.

ICAR Library

ICAR library has been renovated and was opened for readers by Dr R S Paroda, former DG, ICAR in August, 2001. The modern layout plan has been appreciated by the Senior Officers and outsiders. During this period, efforts were made to extend information support exploiting databases of CABI (Centre for Agriculture and Bio-Sciences International).



The Hindi Library at the headquarters operated separately from the main library. The library added 250 Hindi books and subscribed to Hindi magazines and also issued 10,000 publications to readers.

All electronic services like e-mail, Internet, Delnet, CD-ROM Service will be provided to the readers very soon.

Publicity and Public Relations Unit

The Publicity and Public Relations Unit plays a pivotal role in dissemination of information pertaining to agriculture and allied subjects, policy decisions and achievements of the research set-up of the ICAR, i.e Central Institutes, National Bureaux, Project Directorates, National Research Centres and All-India Co-ordinated Research Projects, etc. to the print and electronic media. For effective communication of research findings among the farmers and public the PR Unit maintains an effective liaison with the media persons. It is responsible for publicizing the achievements of ICAR in the country and abroad. It also organizes press conferences/briefings addressed by the Union Agriculture Minister, Minister of State for Agriculture, DG (ICAR), DDG's and Directors of various research institutes and projects.

The PR Unit broadly performs the following functions:

Liaison with print and electronic media: The Unit issued material of immediate value to various newspapers, agricultural and current affairs magazines and electronic media from time to time to give a wide publicity to the events. Such material received adequate coverage in the media at national and international level. This unit also runs a feedback service for senior officials of the ICAR. The Unit keeps close eyes on the print media and provides relevant newspaper clippings to the DG (ICAR) and other senior officers of the Council, etc. on daily basis.

The ICAR participated in the following exhibitions

Exhibition	Venue	Period
Science, Agricultural and Cultural Fair	Chabdaha Maidan, Nadia, West Bengal	4-15 July, 2001
Agri-Intex 2001	Coimbatore	1-7 August, 2001
World Food Day Exhibition	New Delhi	16 October, 2001
India International Trade Fair 2001	Pragati Maidan, New Delhi	14-27 November 2001
All-India Agril., Science and Industrial Expo-2002	Murshidabad, West Bengal	23 January to 3rd February 2002
National Fair of Cattle and Trade and Trade (Harihar Nath Chetra Mela)	Sonepur, Bihar	29 November to 29 December 2001
Agriculture Exhibition*	Baraut (Bagpat)	20 December, 2001
Krishak Mela	Meeut, Uttar Pradesh	23 December, 2001
Agri. Tech. 2002 (Indian Science Congress)	Lucknow, Uttar Pradesh	3 to 7 January 2002
Kisan Mela-cum-Awareness Campaign	CIRG, Makhdoom, Uttar Pradesh	4 January 2001
Krishi Expo 2002	Pragati Maidan, New Delhi	27 February to 5 March, 2002

*ICAR institutes also participated in various Kisan Mela-cum-Awareness Campaigns during the period.



Shri Ajit Singh, Union Agriculture Minister, visiting the Agriculture Exhibition organized at Baraut (Bagpat) on 20 December, 2001



Dr Panjab Singh, Director-General, ICAR looking at the exhibits at the India International Trade Fair, Pragati Maidan, New Delhi

Publicity through print and electronic media: This includes issuing of press releases and articles, organizing press conferences and conducting press tours to various ICAR projects and institutes to disseminate information relating to their activities and achievements. This unit also undertakes development of video films on the activities and achievements of ICAR as a whole and on important issues pertaining to agriculture of immediate concern to farmers. These films are distributed to various ICAR institutes, KVKs, Extension Directorates of SAUs for dissemination of information to farmers.

Visits of media persons: PR Unit arranged visits of media persons to various ICAR institutes to highlight the achievements and to make success stories of the institutes. Also, provided essential facilities to the print and electronic media for proper and impressive coverage of the events. A demonstration will only be attended by a small number of farmers, but results will reach many more if they are reported in newspapers and radio or television. Various visits of media persons were organized during the period. They visited CIBA (Chennai), NDRI Centre, PDBC & IIHR (Bangalore), CAZRI (Jodhpur) DWR, (Karnal), etc.

Participation in exhibitions at regional, national and international level: Organizing exhibitions is another focal point of publicity activities of the PR Unit. The promotion of new technologies cannot be accelerated unless a climate of receptivity and awareness of the importance of new technologies in the field of agricultural science are created among the farmers, scientists and public. The Unit organized exhibitions and displayed important items relating to agricultural development in an interesting manner to spread awareness of new ideas, varieties, technologies, etc and also advised the institutes on exhibition-related issues. Nearly 20 ICAR institutes took part in the 14-day IITF 2001 exhibition at New Delhi (November 14-27, 2001), for the first time, ICAR organized ATIC and display-cum-sale of floriculture and ornamental plants in this exhibition under ICAR pavilion.

Reception and Monitoring of Public Grievances: The CP&PRO functions as Staff Grievances Officer under the direct supervision of Secretary, ICAR. Necessary instructions are issued from time to time to all the concerned officials for speedy disposal of the grievances. To cater to the in-house grievances of the employees, the ICAR has an Internal Grievances Committee.

NICNET-based Public Information and Facilitation Centre: In pursuance of Government's commitment to bring greater transparency through better access to information, a NICNET-based Public Information and Facilitation Centre has been established jointly by the three departments of the Ministry of Agriculture - DARE/ICAR, Department of Ministry of Agriculture and Cooperation and Department of Animal Husbandry and Dairying at Krishi Bhavan (Room No. 19A). The centre provides information of State and Central Government agencies, economists, consultants, scientists, farmers and general public. CP&PRO is the nodal officer coordinating with the centre.

National Agricultural Science Museum: This is a new and prestigious activity of the PR Unit. A National Agricultural Science Museum is being established at the Chaudhary Devi Lal National Agricultural Science Centre in IARI Pusa Campus. The work of first phase is almost completed. The work is being carried out by the National Council of Science Museums, Kolkata in consultation with P R Unit. After completion of the second phase, this will be opened to farmers, general public, scientists and various delegations from all over the country.

Appendices

(A) DEPARTMENT OF AGRICULTURAL RESEARCH AND EDUCATION

APPENDIX I

The Government of India (Allocation of Business) Rules
The Second Schedule
(Rule 3)

- (A) Distribution of Subjects in the Department (*Vibhag*),
Ministry of Agriculture (*Krishi Mantralaya*)
- (B) Department of Agricultural Research and Education
(*Krishi Anusandhan aur Shiksha Vibhag*)

PART I

The following subjects which fall within List I of the Seventh Schedule to the Constitution of India.

1. International co-operation in the field of agricultural research and education including relations with foreign and international agricultural research and educational institutions and organizations, including participation in international conferences, associations and other bodies dealing with agricultural research and education and follow-up of decisions at such international conferences, etc.

2. Fundamental, applied and operational research and higher education including co-ordination of such research and higher education in agriculture including agroforestry, animal husbandry, dairying and fisheries, including agricultural statistics, economics and marketing.

3. Co-ordination and determination of standards in institutions for higher education or research and scientific and technical institutions insofar as it relates to food and agriculture including animal husbandry, dairying and fisheries.

4. Cesses for financing to the Indian Council of Agricultural Research, and the Commodity Research programmes other than those relating to tea, coffee and rubber.

5. Sugarcane research.

PART II

For Union Territories the subjects mentioned in Part I above so far as they exist in regard to these territories and in

addition the following subject which falls within List II of the Seventh Schedule of the Constitution of India.

6. Agricultural education and research.

PART III

General and consequential:

7. All matters relating to foreign aid received from foreign countries and International Organizations insofar as agricultural research and education and allied subjects are concerned, including all matters relating to assistance afforded by India to foreign countries in the field of agricultural research and education and allied subjects.

8. Plant introduction and exploration.

9. All-India Soil and Land-Use Survey relating to research, training, correlation, classification, soil mapping and interpretation.

10. Financial assistance to state governments and agricultural universities in respect of agricultural research and educational schemes and programmes.

11. National Demonstrations.

12. Indian Council of Agricultural Research and its constituent research institutes, stations, laboratories and centres.

13. Offences against laws with respect to any of the subjects allotted to this Department.

14. Enquiries and statistics for the purpose of any of the subjects allotted to this Department.

15. Fees in respect of any of the subjects allotted to this Department except fees taken in a court.

APPENDIX II

Total Number of Posts and Names of Important Functionaries

Group	Designation	Scale of pay (in rupees)	Santioned strength
A	Secretary	26,000 (Fixed)	1
A	Additional Secretary (DARE)/Secretary, ICAR	22,400 – 24,500	1
A	Financial Adviser and Additional Secretary	22,400 – 24,500	1
A	Director	14,300 – 18,300	1
A	Deputy Secretary	12,000 – 16,500	1
A	Sr Principal Private Secretary	12,000 – 16,500	1
A	Under Secretary	10,000 – 15,200	7
A	PPS	10,000 – 15,200	1
B	Private Secretary	6,500 – 10,500	1
B	Assistant Director (Official Language)	6,500 – 10,500	1
B	Assistant	5,500 – 9,000	4
B	Personal Assistant	5,500 – 9,000	4
C	Junior Hindi Translator	5,000 – 8,000	1
C	UDC-cum-Cashier	4,000 – 6,000	1
C	UDC	4,000 – 6,000	2
C	Steno Grade 'D'	4,000 – 6,000	5
C	UDC-Hindi Typist	4,000 – 6,000	1
C	Staff Car Driver	4,000 – 6,000	1
C	LDC	3,050 – 4,590	3
D	Daftry	2,550 – 3,540	1
D	Peon	2,440 – 3,200	5
Total			44

Names of the Important Functionaries

S.No.	Name	Designation
1.	Dr Panjab Singh	Secretary, DARE/DG, ICAR
2.	Ms Shashi Mishra	Additional Secretary, DARE/Secretary, ICAR
3.	Mr P Sinha	Additional Secretary/Financial Adviser, DARE
4.	Dr Harsh Mitter	Director, DARE
5.	Mr T K Murugan	Deputy Secretary
6.	Mr R S Bhandari	Senior Principal Private Secretary
7.	Mr G Chandra Sekhar	Under-Secretary
8.	Mr Vijay Kumar	Under-Secretary
9.	Ms Vandana Sharma	Under-Secretary
10.	Mr B J Bhattacharya	Under-Secretary
11.	Mr Satwant Singh	Under-Secretary
12.	Mr Jarnail Singh	Under-Secretary
13.	Mr Madan Lal	Under-Secretary
14.	Ms Geeta Nair	PPS

APPENDIX III

Activity Programme Classification

The Budget Estimates (BE) and Revised Estimates (RE) of DARE and ICAR (Plan, Non-Plan) for 2000-2001 are Rs 1404.55 crores and Rs 1325 crores respectively and BE for 2001-2002 (Plan and Non-Plan) is Rs 1389.05 crores. The detailed break-up of these financial figures are given below in Tables 1 and 2.

Department of Agricultural Research and Education (DARE): The details in respect of BE and RE for 2000-2001 and BE for 2001-2002 are given in Table 1. This excludes the payment to the ICAR.

Table 1 Budget estimates and revised estimates of DARE and ICAR

(Rupees in lakhs)

Item	Budget Estimates 2000-2001		Revised Estimates 2000-2001		Budget Estimates 2001-2002	
	Plan	Non-Plan	Plan	Non-Plan	Plan	Non-Plan
A. Secretariat Economic services						
Major Head '3451'						
A-1 Secretariat						
Major Head '2415'	-	98	-	92	-	100
International Co-operation						
(01) -India's membership contribution to Commonwealth Agricultural Bureau	-	10	-	10	-	10
(02) -India's membership contribution to Consultative Group on International Agricultural Research	-	338	-	338	-	338
(03) -Other Programmes	60	-	50	-	60	-
(04) -India's contribution to Asia Pacific Association of Agricultural Institutions	-	10	-	10	-	10
(05) -India's contribution to NACA	-	9	-	9.5	-	9.5
(06) -India's contribution to CGPRT	-	5	-	5	-	5
(07) -India's contribution to Seed Seed Testing Association	-	1	-	1	-	1
(08) -ISHS Belgium	-	-	-	1.5	-	1.5

Table 2 Details of Financial Outlay

Demand No. 3. Department of Agricultural Research and Education

(Rupees in crores)

	2000-2001 Budget			2000-2001 Revised			2001-2002 Budget			
	Plan	Non-Plan	Total	Plan	Non-Plan	Total	Plan	Non-Plan	Total	
A. Budget Allocation, net of recoveries										
Revenue	629.55	775.00	1404.55	550.00	775.00	1325.00	684.00	705.05	1389.05	
Capital	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Total	629.55	775.00	1404.55	550.00	775.00	1325.00	684.00	705.05	1389.05	
Major Head	0.00	0.98	0.98	0.00	0.92	0.92	0.00	1.00	1.00	
1. Secretariat - Economic Service 3451										
2. Crop Husbandry										
2.01 Payments of net proceeds of cess under Agricultural Produce Cess Act, 1940 2415										
	0.00	5.00	5.00	0.00	9.60	9.60	0.00	40.00	40.00	
2.02 Other Programmes of Crop Husbandry 2415										
Total-Crop Husbandry	†473.05	**658.63	1131.68	†405.11	**654.07	1059.18	†513.00	542.99	1055.99	
Total-Crop Husbandry	473.05	663.63	1136.68	405.11	663.67	1068.78	513.00	582.99	1095.99	
3. Soil and Water Conservation 2415										
	2.90	6.10	9.00	2.90	6.10	9.00	3.58	6.70	10.28	
4. Animal Husbandry 2415										
	45.10	41.31	86.41	44.64	41.31	85.95	58.00	45.44	103.44	
5. Dairy Development 2415										
	6.90	20.22	27.12	6.90	20.22	27.12	7.00	22.24	29.24	
6. Fisheries 2415										
	27.00	27.60	54.60	25.34	27.60	52.94	30.00	30.36	60.36	
7. Forestry 2415										
	11.00	11.43	22.43	9.61	11.43	21.04	11.82	12.57	24.39	
8. Grants-in-aid 2552										
lump-sum provision for North East region	63.00	0.00	63.00	55.00	0.00	55.00	60.00	0.00	60.00	
Total-Payments to ICAR	628.95	770.29	1399.24	549.50	770.33	1319.83	683.40	700.30	1383.70	
9. Other Programmes 2415										
Total-Agricultural Research & Education	0.60	3.73	4.33	0.50	3.75	4.25	0.60	3.75	4.35	
Grand Total	629.55	774.02	1403.57	550.00	774.08	1324.08	684.00	704.05	1388.05	
	629.55	775.00	1404.55	550.00	775.00	1325.00	684.00	705.05	1389.05	
B. Plan Outlay										
	Head of Div.	Budget support	IEBR	Total	Budget support	IEBR	Total	Budget support	IEBR	Total
1. Agricultural Research Education 12415										
	629.55	0.00	629.55	550.00	0.00	550.00	684.00	0.00	684.00	
C. Major Head-wise Total										
Total	629.55	775.00	1404.55	550.00	775.00	1325.00	684.00	705.05	1389.05	
2415	629.55	774.02	1403.57	550.00	774.08	1324.08	684.00	704.05	1388.05	
3451	0.00	0.98	0.98	0.00	0.92	0.92	0.00	1.00	1.00	

†Including EAP component of Rs 147.00 crores in the BE 2000–2001 and Rs 6.00 crores in 'MH 2552', Rs 129.30 crores in the RE 2000–2001 and Rs 160.00 crores in the BE 2000–2001.

**Including Rs 165.00 crores for payment of arrears of 5th CP Report of Teaching Staff including SAUs in the Plan-BE/RE 2000-2001.

**Including Rs 12.47 crores on account of matching grant.

The decrease in the non plan expenditure for 2001–2002 is due to non inclusion of demand for payment of arrears into the teaching staff working in SAUs.

(B) INDIAN COUNCIL OF AGRICULTURAL RESEARCH

APPENDIX 1

INDIAN COUNCIL OF AGRICULTURAL RESEARCH SOCIETY

The Society shall have the following *Ex-Officio* Members:

(i) *Minister-in-charge of the portfolio of Agriculture in the Union Cabinet, President of the Society*

1. Mr Ajit Singh
Minister of Agriculture
Government of India, Krishi Bhavan
New Delhi 110 001

(ii) *Minister of State in the Union Ministry of Agriculture, dealing with the ICAR, Vice-President*

2. Minister of State for AHD&DARE
Government of India, Krishi Bhavan
New Delhi 110 001

(iii) *Union Ministers holding charge of Finance, Planning, Science and Technology, Education and Commerce (in case the Prime Minister is holding any of these portfolios, the Minister of State in the Ministry/Department concerned)*

3. Mr Yashwant Sinha
Minister of Finance, Government of India
New Delhi 110 001
4. Mr Arun Shourie
Minister of State for Planning and Programme
Implementation, Yojana Bhawan, Government of India
New Delhi 110 001
- 5,6 Dr Murli Manohar Joshi
Minister of Science & Technology, and
Human Resource Development
Government of India, Shastri Bhawan
New Delhi 110 001
7. Mr Murasoli Maran
Minister of Commerce, Government of India
Udyog Bhawan, New Delhi 110 001
- (iv) *Other Ministers in the Union Ministry of Agriculture*
 8. Minister of State for Agriculture
Government of India, Krishi Bhavan,
New Delhi 110 001

(v) *Ministers in the States/Incharge of Agriculture/Animal Husbandry/Fisheries*

Andhra Pradesh

9. Mr V S Rao
Minister for Agriculture
Government of Andhra Pradesh
Hyderabad (Andhra Pradesh) 500 022
10. Mr N Krishnappa
Minister of Animal Husbandry and Fisheries
Government of Andhra Pradesh
Hyderabad
(Andhra Pradesh) 500 022

11. Mr N Narsimha Rao
Minister of Fisheries
Government of Andhra Pradesh
Hyderabad 500 022
12. Minister for Horticulture
Government of Andhra Pradesh
Hyderabad 500 022

Arunachal Pradesh

13. Mr Tako Dabi
Minister for Agriculture
Government of Arunachal Pradesh
Itanagar (Arunachal Pradesh) 791 111
14. Mr Kahfa Bangia
Minister for Animal Husbandry and Dairy Development
Government of Arunachal Pradesh
Itanagar (Arunachal Pradesh) 791 111
15. Mr Kameng Dolo
Minister for Fisheries
Government of Arunachal Pradesh
Itanagar 791 111
16. Mr Zapu Deru
Minister for Horticulture
Government of Arunachal Pradesh
Itanagar 791 111

Assam

17. Dr Ardhendu Dey
Minister for Agriculture, Government of Assam
Janta Bhavan, Guwahati (Assam) 781 006
18. Mr H P Narayan
Minister for Veterinary and Animal Husbandry
Government of Assam, Janta Bhavan
Guwahati (Assam) 781 006
19. Dr (Ms) Hemoprabha Saikia
Minister for Fisheries and Employment
Government of Assam, Janta Bhavan
Guwahati (Assam) 781 006
20. Minister for Horticulture
Government of Assam
Janta Bhawan
Guwahati 781 006 (Assam)

Bihar

21. Mr Gulam Sarwar
Minister for Agriculture
Government of Bihar, Patna (Bihar) 800 015
22. Mr Rama Ashray Sahn
Minister for Animal Husbandry and Fisheries
Government of Bihar, Patna (Bihar) 800 015

23. Minister for Horticulture
Government of Bihar
Patna 800 015

Chhatisgarh

24. Dr Prem Sahi Singh
Minister for Agriculture, Animal Husbandry & Fisheries
Government of Chhatisgarh
Raipur (Chhatisgarh)
25. Minister for Horticulture
Government of Chhatisgarh
Raipur (Chhatisgarh)

Delhi

26. Minister for Agriculture
Development and Food
National Capital Territory of Delhi, Delhi
27. Minister for Horticulture
Government of National Capital
Territory of Delhi
Delhi

Goa

28. Mr Ramarao Dessai
Minister for Agriculture
Government of Goa, Panaji (Goa) 403 001
29. Mr Ravi Naik
Minister for Animal Husbandry
Government of Goa, Panaji (Goa) 403 001
30. Mr Manohar Parrikar
Chief Minister and holding the charge of Fisheries
Government of Goa Secretariat
Panaj 403 001 (Goa)
31. Minister for Horticulture
Government of Goa
Panaji 403 001

Gujarat

32. Mr Bechar Bhai Bhadani
Minister for Agriculture
Government of Gujarat
Gandhinagar, (Gujarat) 382 010
33. Mr Kiritsinh Jitubhai Rana
Minister of State for Animal Husbandry
Government of Gujarat, Gandhinagar, (Gujarat) 382 010
34. Mr Babu Bhai Bokhiriya
Minister for Fisheries, Government of Gujarat
Gandhinagar (Gujarat) 382 010
35. Minister for Horticulture
Government of Gujarat
Gandhinagar 382 010

Haryana

36. Mr Jaswinder Singh Sandhu
Minister for Agriculture
Government of Haryana, Chandigarh
(Haryana) 160 001

37. Mr Mohammed Ilyas
Minister for Animal Husbandry and Fisheries
Government of Haryana, Chandigarh
(Haryana) 160 001
38. Minister for Horticulture
Government of Haryana
Chandigarh 160 001

Himachal Pradesh

39. Mr Vidya Sagar Chaudhary
Minister for Agriculture
Government of Himachal Pradesh
Shimla (Himachal Pradesh) 171 002
40. Mr. Ram Lal Markande
Minister of State for Animal Husbandry and Fisheries
Government of Himachal Pradesh
Shimla 171 002
41. Minister for Horticulture
Government of Himachal Pradesh
Shimla 171 002

Jammu and Kashmir

42. Mr Ch. Mohammad Ramzan
Minister for Agriculture, Animal Husbandry,
Rural Development and Fisheries
Government of Jammu and Kashmir
Srinagar (Jammu and Kashmir) 190 001
43. Minister of Horticulture
Government of Jammu & Kashmir
Srinagar (Jammu & Kashmir) 190 005

Jharkhand

44. Mr Deo Dayal
Minister for Agriculture
Government of Jharkhand
Ranchi (Jharkhand)
45. Mr Devidhan Besra
Minister for Animal Husbandry and Fisheries
Government of Jharkhand
Ranchi (Jharkhand)
46. Minister for Horticulture
Government of Jharkhand
Ranchi (Jharkhand)

Karnataka

47. Mr T B Jayachandra
Minister for Agriculture,
Government of Karnataka
Bangalore
(Karnataka) 560 001
48. Mr A Krishnappa
Minister for Animal Husbandry and Fisheries
Government of Karnataka, Bangalore
(Karnataka) 560 001
49. Minister for Horticulture
Government of Karnataka
Bangalore
(Karnataka) 560 001

Kerala

50. Ms K R Gouri Amma
Minister for Agriculture, Animal Husbandry,
Government of Kerala
Thiruvananthapuram (Kerala) 695 001
51. Prof K V Thomas
Minister of Fisheries
Government of Kerala
Thiruvananthapuram (Kerala) 695 001
52. Minister for Horticulture,
Government of Kerala
Thiruvananthapuram (Kerala) 695 001

Madhya Pradesh

53. Mr Mahendra Singh
Minister for Agriculture
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
54. Hira Silawat
Minister for Fisheries
Government of Madhya Pradesh
Bhopal (Madhya Pradesh) 423 006
55. Mr K P Singh
Minister for Animal Husbandry
Government of Madhya Pradesh
Bhopal 423 006
56. Minister for Horticulture
Government of Madhya Pradesh
Bhopal 423 006

Maharashtra

57. Mr Rohit Das Patil
Minister for Agriculture and Animal Husbandry
Government of Maharashtra
Mumbai (Maharashtra) 400 032
58. Mr Anand Rao Deoka
Minister for Fisheries and Dairy Development
Government of Maharashtra
Mumbai 499 932
59. Minister for Horticulture
Government of Maharashtra
Mumbai 400 032

Manipur

60. Minister for Agriculture
Government of Manipur
Imphal (Manipur) 795 001
61. Minister for Animal Husbandry
Government of Manipur
Imphal (Manipur) 795 001
62. Minister for Fisheries
Government of Manipur
Imphal (Manipur) 795 001
63. Minister for Horticulture
Government of Manipur
Imphal (Manipur) 795 001

Meghalaya

64. Mr J D Rymbai
Minister for Agriculture
Government of Meghalaya
Meghalaya Secretariat
Shillong (Meghalaya) 793 001
65. Dr A D Marak
Minister for Animal Husbandry, Veterinary and Soil
Conservation
Government of Meghalaya, Meghalaya Secretariat (C)
Shillong (Meghalaya) 793 001
66. Mr M Marak
Minister of Fisheries, Government of Meghalaya
Meghalaya Secretariat, Shillong 793 001

Mizoram

67. Mr Aichinga
Minister for Agriculture
Government of Mizoram
Aizwal (Mizoram) 796 021
68. Mr J Lalrinchhana
Minister for Animal Husbandry
Government of Mizoram
Aizwal (Mizoram) 796 001
69. Mr H Vanlalauva
Minister for Fisheries
Government of Mizoram
Aizwal (Mizoram) 796 001
70. Mr Zoram Thanga
Minister for Horticulture
Government of Mizoram
Aizwal (Mizoram) 796 001

Nagaland

71. Mr Nyamnyei Konyak
Minister for Agriculture
Government of Nagaland
Kohima (Nagaland) 797 001
72. Mr T Sentichuba
Minister for Animal Husbandry
Government of Nagaland
Kohima (Nagaland) 797 001
73. Mr Kakhedo
Minister for Fisheries, Government of Nagaland
Kohima (Nagaland) 797 002
74. Mr K Yamakam
Minister for Horticulture
Government of Nagaland
Kohima (Nagaland) 797 001

Orissa

75. Mr Amar Prasad Satpathy
Minister of Agriculture, Government of Orissa
Bhubaneswar (Orissa) 751 001

76. Mr B B Harichandan
Minister of State for Animal Resources Development
and Fisheries
Government of Orissa
Bhubaneswar (Orissa) 751 001
77. Minister for Horticulture
Government of Orissa
Orissa Secretariat
Bhubaneswar
(Orissa) 751 001

Pondicherry

78. Mr A Kasilinga
Minister for Fisheries
Government of Pondicherry
Pondicherry 605 001
79. Mr N Rangasamy
Minister for Agriculture and Horticulture
Government of Pondicherry
Pondicherry 605 001
80. Mr C Jaya Kumar
Minister for Animal Husbandry
Government of Pondicherry
Pondicherry 605 001

Punjab

81. Mr Rattan Singh Ajnala
Minister of Animal Husbandry, Fisheries
and Dairy Development
Government of Punjab
Chandigarh (Punjab) 160 001
82. Mr Gurudev Singh Badal
Minister for Agriculture
Government of Punjab
Chandigarh (Punjab) 160 001
83. Minister for Horticulture
Government of Punjab
Chandigarh (Punjab) 160 001

Rajasthan

84. Mr Tayab Hussain
Minister of State for Agriculture and Ground Water
Government of Rajasthan
Jaipur (Rajasthan) 302 005
85. Mr Hari Singh Kumar Kumher
Minister for Livestock and Dairy Development
Government of Rajasthan
Jaipur (Rajasthan) 302 005
86. Mr Kishan Motwani
Minister for Fisheries
Government of Rajasthan
Jaipur (Rajasthan) 302 005
87. Minister for Horticulture
Government of Rajasthan
Jaipur (Rajasthan) 302 005

Sikkim

88. Mr G M Gurung
Minister for Agriculture, Horticulture, Irrigation and
Flood Control
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 101
89. Mr P S Tamang
Minister for Animal Husbandry
Government of Sikkim
Secretariat, Gangtok (Sikkim) 737 001

Tamil Nadu

90. Mr P C Ramaswamy
Minister for Agriculture
Government of Tamil Nadu
Chennai, (Tamil Nadu) 600 009
91. Mr K P Rajendra Prasad
Minister for Animal Husbandry and Fisheries
Government of Tamil Nadu
Chennai (Tamil Nadu) 600 009
92. Minister for Horticulture
Government of Tamil Nadu
Chennai, (Tamil Nadu) 600 009

Tripura

93. Mr Aghore Debbarma
Minister for Agriculture
Civil Secretariat, Government of Tripura
Agartala (Tripura) 799 001
94. Mr Naryan Rupini
Minister for Animal Resources and Development
Government of Tripura
Agartala (Tripura) 799 001
95. Mr Sukumar Barman
Minister for Fisheries
Government of Tripura, Agartala (Tripura) 799 001
96. Minister for Horticulture
Government of Tripura
Civil Secretariat
Agartala (Tripura) 799 001

Uttaranchal

97. Mr Vanshidhar Bhagat
Minister for Agriculture, Animal Husbandry and Fisheries
Government of Uttranchal
Dehradun (Uttranchal)
98. Minister for Horticulture
Government of Uttranchal
Dehradun (Uttranchal)

Uttar Pradesh

99. Mr Diwakar Vikram Singh
Minister for Agriculture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001

100. Mr Phagu Chauhan
Minister for Animal Husbandry and Fisheries
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
101. Minister for Horticulture
Government of Uttar Pradesh
Lucknow (Uttar Pradesh) 226 001
- West Bengal**
102. Mr Kamal Guha
Minister for Agriculture, Government of West Bengal
Writers' Building
Calcutta (West Bengal) 700 001
103. Mr Anisur Rahman
Minister for Animal Resources Development
Government of West Bengal
Calcutta, (West Bengal) 700 001
104. Mr Kironmoy Nanda
Minister for Fisheries, Agriculture and Aquatic Resources
and Fishing Harbours
Government of West Bengal
Calcutta (West Bengal) 700 001
105. Minister for Horticulture
Government of West Bengal
Writers Building
Calcutta (West Bengal) 700 001
- (vi) *Member of Planning Commission, Incharge of Agriculture*
106. Mr Som Pal
Member (Agriculture), Planning Commission
Yojana Bhavan,
New Delhi
- (vii) *Six members of Parliament (Four elected by Lok Sabha
and two elected by Rajya Sabha)*
107. Mr Oscar Fernandes 3.5.2003
Member of Parliament (RS)
Doris Rest Haven, Ambalpadi
Post Brahmagiri
Udupi, Karnataka and
B-202, M.S. Flats
Baba Kharag Singh Marg
New Delhi 110 001
108. Mr S S Ahluwalia 3.5.2003
Member of Parliament (RS)
Boring Canal Road
Ward No. 4
P S Shri Krishna Puri
P.O.-G.P.O., Patna
Patna (Bihar), and
10, Gurudwara Rakab Ganj Road
New Delhi 110 001
109. Mr Jagannath Mallik 15.12.2002
Member of Parliament (Lok Sabha)
At Mohanti Patna
P.O. Jajpur,
Jajpur (Orissa) and
32, Mahadev Road,
New Delhi
110. Mr Shivaji Mane 15.12.2002
Member of Parliament (Lok Sabha)
At. Khemegaon, P.O. Shiwala
Tal. Kalmanuri
Distt. Hingoli (Maharashtra), and
68 North Avenue, New Delhi
111. Mr Uttamrao Patil 15.12.2002
Member of Parliament (Lok Sabha)
11 Mahabali Layout Wadgon
Yavatmal (Maharashtra), and
AB-17, Tilak Marg
New Delhi
112. Mr Jagdambi Prasad Yadav 15.12.2002
Member of Parliament (Lok Sabha)
Village & P.O. Ekashi,
Via. Bariarpur
Distt. Munger 811 211 (Bihar), and
4, Dr Bishamber Das Marg
New Delhi
- (viii) *Director-General, ICAR*
113. Dr Panjab Singh
Director-General, ICAR
Krishi Bhavan, New Delhi 110 001
- (ix) *All Secretaries in the Ministry of Agriculture*
114. Mr J N L Srivastava
Secretary (Agriculture and Co-operation)
Ministry of Agriculture, Department of Agriculture,
Krishi Bhavan, New Delhi 110 001
115. Mr D K Biswas
Secretary (Animal Husbandry and Dairying)
Krishi Bhavan, New Delhi 110 001
- (x) *Secretary, Planning Commission*
116. Mr N C Saxena
Secretary, Planning Commission
Yojana Bhavan, New Delhi 110 001
- (xi) *Chairman, University Grants Commission*
117. Prof. Hari Gautam
Acting Chairman, University Grants Commission
Bahadur Shah Zafar Marg, New Delhi
- (xii) *Chairman, Atomic Energy Commission or Director, Bhabha
Atomic Research Centre, if nominated by the Chairman, Atomic
Energy Commission*
118. Mr R Chidambaram
Chairman
Atomic Energy Commission and
Secretary to the Government of India
Department of Atomic Energy
Anushakti Bhavan, Chhatrapati Shivaji Maharaj Marg
Mumbai 400 039
- (xiii) *Member, Finance (Secretary/Additional Secretary in the
Ministry of Finance), Government of India*
119. Mr B P Misra
Additional Secretary to the Government of India
Ministry of Finance, Department of Expenditure
New Delhi 110 001

<i>(xiv) Four Vice-Chancellors of the Agricultural Universities nominated by the President</i>			
		<i>Up to</i>	
120. Vacant			
121. Dr G L Kaul	30.03.2002		
Vice-Chancellor Assam Agricultural University Jorhat, Assam 785 013			
122. Dr J B Chaudhary	25.07.2003		
Vice-Chancellor Govind Ballabh Pant University of Agri. and Technology, Distt. Udham Singh Nagar Pantnagar (UP) 263 145			
123. Dr M H Mehta	25.07.2003		
Vice-Chancellor Gujarat Agricultural University Sardar Krushinagar, Distt. Banaskantha Gujarat 385 506			
<i>(xv) Five technical representatives, namely Agricultural Commissioner, Horticultural Commissioner, Animal Husbandry Commissioner, Fisheries Development Commissioner from the Union Ministry of Agriculture and Inspector-General of Forests, Government of India</i>			
124. Dr C R Hazra	Ex-officio		
Agricultural Commissioner Department of Agriculture and Co-operation Krishi Bhavan, New Delhi 110 001			
125. Dr H P Singh			
Horticultural Commissioner, Department of Agriculture, Krishi Bhavan, New Delhi 110 001			
126. Dr. V K Taneja			
Animal Husbandry Commissioner Department of Agriculture, Krishi Bhawan, New Delhi			
127. Mr M K R Nair	Ex-officio		
Fisheries Development Commissioner Department of Agriculture, Krishi Bhavan New Delhi 110 001			
128. Mr C P Oberai	Ex-officio		
Inspector-General of Forests, Government of India Department of Environment and Forests CGO Complex, Lodi Road, New Delhi 110 003			
<i>(xvi) Fifteen scientists from within and outside the Council, including one from the Indian Council of Medical Research nominated by the President</i>			
129. Dr S S Katiyar	25.07.2003		
Vice-Chancellor General President Elect. ISCA Chhatrapati Sahu Ji Maharaj University Kanpur 208 024			
130. Dr J S Kanwar	25.07.2003		
Dy. Director General (Emeritus) ICRISAT, 17, Krishi Nagar Colony Phase II, Hashmetpet Road Secunderabad (A P) 500 009			
131. Dr D N Borthakur			25.07.2003
Retd. Vice-Chancellor Assam Agricultural University 'SWAPANAALAYA' Apartments Narikel Basti, Guwahati (Assam) 781 024			
132. Mr Sidhir Bhargava			25.07.2003
Director Agroman System Pvt. Ltd. 25/2, Tardeo Ac Market Mumbai 400 034			
133. Dr M S Gangwar			25.07.2003
Professor & Head Soil Science, Faculty of Agriculture G.B.P.N.U., Nainital (U P) 263 145			
134. Mr Chander Bhushan Prasad			25.07.2003
University Professor of Micro Biology Bihar College of Veterinary B-45, Indira Puri Colony Patna (Bihar) 800 014			
135. Prof M R Verma			25.07.2003
Dean Dept. of Agricultural Engineering Narendra Deva University of Agriculture & Technology Narendra Nagar P.O. Kumarganj (U P) 224 229			
136. Dr A S Khera			25.07.2003
Ex. Vice Chancellor (PAU) 983, Phase 3 B-2 Mohali (Punjab) 160 060			
137. Padmashree Dr N Balakrishnan Nair			25.07.2003
Ex-Chairman Science & Technology Kerala State 'Swathi' Residency Road Thycad, Trivandrum 695 014			
138. Dr N A Jan			25.07.2003
Commissioner of Fisheries J&K State Tourist Reception Centre, Deptt. of Tourism, Srinagar (J&K)			
139. Dr S P Arora			25.07.2003
Former Professor Eminence Retd. Addl. Dir. Res. (H.P.K.V.) Formerly Head, Nut & Phys (NDRI) H.No. 48, Secvtor 13, Urban Estate Karnal (Haryana) 132 001			
140. Prof N Panda			25.07.2003
Former Vice-Chancellor Sambalpur University Ex-Dean of Agriculture & Orissa University of Ag. & Tech. 62/63, 1st Floor, Opp. Unit 8, Boys High School Bhubaneswar 751 003			
141. Dr D K Dasgupta			25.07.2003
Former Vice-Chancellor BCKVV, 32, Serryghat Street Telinipara Hooghly (West Bengal) 712 215			

142. Dr P C Keshavan DAE, Homi Bhabha Chair and Executive Director M.S. Swaminathan Research Foundation Third Cross Road, Taramani Institutional Area Chennai 600 113	25.07.2003	152. Dr S A Khanvilkar Sheetal Niwal Post Dhutroli Tehsil Mandangad 415 203 Distt. Ratnagiri (Maharashtra)	25.7.2003
Representatives of the ICMR			
143. Dr Sarla Subba Rao Director, Malaria Research Institute Indian Council of Medical Research 22, Sham Nath Marg, Delhi 110 054	30.5.2000	153. Dr George Paul Synthetic Industrial Chemical Ltd. Ajay Vihar, M.G. Road Cochin (Kerala) 682 016	25.7.2003
(xvii) <i>Three representatives of Commerce and Industry, nominated by the President</i>			
144. Mr Suresh Neotia 7/21, Queens Park, Calcutta 700 019	3.10.2003	154. Mr Rajendra D Pawar Chairman Baramati Agricultural Trust Baramati Distt., Pune (Maharashtra)	23.12.2003
145. Mr Nikhil Gandhi Group Chairman SEAKING Infrastructure Ltd PIPANAV House 209 Bank Street, Cross Lane, Fort Mumbai 400 023 and Sagar Villa 38, Bhulbhai Desai Road Mumbai 400 026	3.10.2003	Representatives of Rural Interest	
146. Mr Jugeshwar Pandey Lalji Tola, Patna GPO Patna (Bihar) 800 001	3.10.2003	155. Mr D P Tripathi B-2/2041, Vasant Kunj New Delhi 110 070	25.07.2003
(xviii) <i>One farmer from each region of the country as mentioned in Rule 60 (a) and four representatives of rural interest, nominated by the President</i>			
147. Shri Major Jai Pal Singh Village and Post Jaspur Uddham Singh Nagar (Uttaranchal)	25.07.2003	156. Mr Lawrence V Fernandes No. 30, Old No.3, Leonard Road, Richmond Town Bangalore (Karnataka) 566 025	25.07.2003
148. Mr Thenucho Former Speaker Old Minister's Hill Kohima (Nagaland) 797 001	25.7.2003	157. Mr Bibhuti Bhushan Pradhan Village & P.O. Pangatira Via-Parganj Distt. Dhenkaral (Orissa)	25.07.2003
149. Prof Janardan Prasad Singh Quarter No. 4, HIG Housing Colony Block-8, Sector-7 (West) Bahadurpur, Patna (Bihar)	25.7.2003	158. Mr Sant Kumar Chaudhary Ved Kutir 141, Sukhdev Vihar, Mathura Road New Delhi 110 025	25.07.2003
150. Mr Suresh Pujari Sakhipura, P.O. Distt. Sambalpur Orissa	25.7.2003	(xix) <i>Four Directors of the ICAR Research Institutes, nominated by the President</i>	
151. Mr Gopal Pacharwal Ex-Member of Parliament "Keshav Rao Patan" Distt. Bundi (Rajasthan)	25.7.2003	159. Vacant	
		160. Dr M P Yadav Director Indian Veterinary Research Institute Izatnagar 243 122 (Uttar Pradesh)	25.07.2003
		161. Dr B N Mathur Director National Dairy Research Institute Karnal 132 001 (Haryana)	25.07.2003
		162. Dr S Ayyappan Director Central Institute of Fisheries Education Mumbai 400 058 (Maharashtra)	25.07.2003
		(xx) <i>Secretary, Indian Council of agricultural Research</i>	
		163. Ms Shashi Misra Member-Secretary Indian Council of Agricultural Research Krishi Bhawan, New Delhi 110 001	

APPENDIX 2

GOVERNING BODY

Chairman

1. Dr Panjab Singh
Director-General
Indian Council of Agricultural Research, Krishi Bhavan
New Delhi 110 001

Ex-officio Members

Member-Finance

2. Mr B P Misra
Additional Secretary to the Government of India
Ministry of Finance, Department of Expenditure
New Delhi 110 001

Secretary, Planning Commission

3. Mr N C Saxena
Secretary
Planning Commission
Yojna Bhavan, New Delhi 110 001

Secretary, Agriculture

4. Mr J N L Srivastava
Secretary (Agriculture and Co. op), Government of
India Ministry of Agriculture, Department of
Agriculture, Krishi Bhavan, New Delhi 110 001

Chairman, University Grants Commission

5. Prof. Hari Gautam
Chairman
University Grants Commission
Bahadur Shah Zafar Marg, New Delhi

Chairman, Atomic Energy Commission or Director, BARC, if nominated by Chairman (AEC)

6. Mr R Chidambaram
Chairman, Atomic Energy Commission and Secretary,
Government of India, Department of Atomic Energy
Anusakti Bhawan Chatrapatishivaji Marg, Trombay,
Mumbai 400 039

Members

Four scientists (including one Management Expert) who are not employees of the ICAR and are nominated by the President

Management Expert

Up to

7. Mr Sudhir Bhargava
Director
Agroman Pvt. Ltd.
25/2, Tardeo Market, Mumbai 400 034

Scientists

8. Dr S S Katiyar
Vice-Chancellor and
General President Elect. ISCA
Chhatrapati Sahu Ji Maharaj University
Kanpur 208 024

9. Dr J S Kanwar
Deputy Director-General (Emeritus)
ICRISAT
17, Krishi Nagar Colony
Phase II, Hashmetpet Road
Secunderabad (AP) 500 009
10. Dr D N Borthakur
Former Vice-Chancellor
Assam Agricultural University, Jorhat
'SWAPANALAYA' Apartments
Narikel Basti, Guwahati (Assam) 781 024

Three Vice-Chancellors

11. Vacant
12. Dr G L Kaul
Vice-Chancellor
Assam Agricultural University
Jorhat, Assam 785 013
13. J B Chaudhary
Vice-Chancellor, GB Pant University of Agriculture
and Technology
Pant Nagar 263 145

Three Members of Parliament (Two from Lok Sabha and one from Rajya Sabha) nominated by the President

14. Mr Jagannath Mallik
Member of Parliament (Lok Sabha)
At. Mohanti Patna
P.O. Jajpur, Jajpur (Orissa) and
32, Mahadev Road New Delhi
15. Mr Shivaji Mane
Member of Parliament (Lok Sabha)
AT. Khemegoan
P.O. Shiwala, Tal. Kalmanuri
Distt. Hingoli (Maharashtra) and
68 North Avenue, New Delhi
16. Mr S S Ahluwalia
Member of Parliament (Rajya Sabha)
Boring Canal Road
Ward No. 4, P.S. Shri Krishna Puri, P.O., GPO Patna and
10, Gurudwara Rakas Ganj Road
New Delhi 110 001

Three Farmers

17. Mr D P Tripathi
B-2/2041, Vasant Kunj
New Delhi 110 070
18. Mr Lawrence V. Fernandes
No. 3 (Old No. 3)
Leonard Road, Richmond Town
Bangalore 566 025 (Karnataka)

19. Prof. Janardan Prasad Singh
Qr. No. 4, HIG, Housing Colony
Block 8, Sector 7 (West)
Bahadurpur, Patna, Bihar

25.07.2003

22. Dr B N Mathur
Director
National Dairy Research Institute
Karnal 132 001 (Haryana)

25.07.2003

Three Directors

20. Vacant

21. Dr M.P. Yadav
Director
Indian Veterinary Research Institute
Izatnagar 243 122 (Uttar Pradesh)

25.07.2003

Member-Secretary

23. Ms Shashi Misra
Secretary, Indian Council of Agricultural Research
Krishi Bhawan, New Delhi 110 001

APPENDIX 3

SENIOR OFFICERS AT THE HEADQUARTERS OF THE ICAR

1. Dr Panjab Singh, Director-General, ICAR, and Secretary to the Government of India
Department of Agricultural Research and Education
2. Ms Shashi Misra, Secretary, ICAR and Additional Secretary to Government of India, Department of Agricultural Research and Education

Deputy Directors-General

1. Dr Puranjan Das (Agricultural Extension)
2. Dr J C Katyal (Education)
3. Dr Kiran Singh (Animal Sciences) upto 31.01.2002
- 3(a) Arun Varma (Animal Sciences), *Officiating*
4. Dr J S Samra (Natural Resource Management)
5. Dr G Kalloo (Horticulture)
6. Dr Mangala Rai (Crop Sciences)
7. Dr K Gopakumar (Fisheries)
8. Dr A Alam (Agricultural Engineering)

Assistant Directors-General

Crop Sciences

1. Dr O P Dubey (Plant Protection)
2. Dr N B Singh (Oilseeds and Pulses)
3. Dr K C Jain (Commercial Crops)
4. Dr S P Tewari (Seeds)
5. Dr S N Shukla (Food and Fodder Crops)

Horticulture

1. Dr R N Pal (Plantation Crops)
2. Dr B S Dhankar (Vegetable Crops)
3. Dr D S Rathore (Horticulture)

Natural Resource Management

1. Dr G B Singh (Agronomy)
2. Dr P D Sharma (Soils)
3. Dr B R Sharma (Integrated Water Management)
4. Dr K R Solanki (Agroforestry)

Engineering

1. Dr R P Kachru (Post-Harvest Engineering)
2. Dr N S L Srivastava (Engineering)

Animal Sciences

1. Dr S C Chopra (AP&B)
2. Dr Sushil Kumar (DAP&T)
3. Dr Lal Krishna (Animal Health)
4. Dr Arun Varma (Animal Nutrition)

Fisheries

1. Dr A D Divan (Marine Fisheries)
2. Dr B N Singh (Fisheries)

Education

1. Dr N L Maurya (Accreditation)
2. Dr J S Bhatia (EPD)
3. Dr Tej Verma (Home Science)
4. K S Nainawatee (AHRD II)
5. Dr G C Tiwari (AHRD) (Officiating)

Extension

1. Dr B N Choudhary (Agril. Extn.)
2. Dr A N Shukla (Krishi Vigyan Kendras)
3. Dr B S Hansra (Extension)

Others

1. Dr R C Maheshwari (Technical Co-ordination)

2. Dr S Kochar (Intellectual Property Rights)
3. Dr J P Mishra (Planning and ESM)

Principal Scientists

Crop Science

1. Dr A K Sharma (Food Crops)
2. Dr Jagmall Singh (Oilseeds and Pulses)
3. Dr C P Singh (Seeds)
4. Dr S Mourya (Commercial Crops)
5. Dr (Ms) P Kaur (Plant Protection)

Horticulture

1. Dr P S Bhatnagar (Seeds)
2. Dr K C Garg

Natural Resource Management

1. Dr D K Paul (Engineering)
2. Dr O P Sharma (Agronomy)

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1. Dr P P Bhat (Animal Genetics)

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Project Co-ordinator (Biological Nitrogen Fixation)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
 45. Dr Biplab Saha
Project Co-ordinator (Diara Lands)
Directorate of Water Management Research
WALMI Complex, Phulwari Sharif P.O.
Patna (Bihar) 801 505
 46. Dr K P R Vittal
Project Co-ordinator (Dryland Agriculture)
CRIDA Campus, Santoshnagar
Hyderabad (Andhra Pradesh) 500 659

47. Dr Anand Swarup
Project Co-ordinator (Long-term Fertilizer Experiment)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
48. Dr Mohan Singh
Project Co-ordinator (Microbiological Decomposition)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
49. Dr. M V Singh
Project Co-ordinator (Micronutrients and
Secondary Nutrients and Pollutant Elements)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 018
50. Dr A Subba Rao
Project Co-ordinator (Soil Test and Crop Response)
Indian Institute of Soil Science, Nabi Bagh
Bhopal (Madhya Pradesh) 462 038
51. Dr D K Painuli
Project Co-ordinator (Soil Tillage)
Indian Institute of Soil Science
Bhopal (Madhya Pradesh) 462 038
52. Dr P S Minhas
Project Co-ordinator (Use of Salt-affected
Soils and Saline Water)
Central Soil Salinity Research Institute
Karnal (Haryana) 132 001
53. Dr R K Batta
Project Co-ordinator (Water Management)
ICAR Co-ordinating Unit
Mahatma Phule Krishi Vidyapeeth
Rahuri (Maharashtra) 431 722
54. Dr N T Yaduraju
Project Co-ordinator (Weed Science)
National Research Centre for Weed Science
PB 13, M.P. Housing Board Colony, Maharajpur
Adhartal, Jabalpur (Madhya Pradesh) 482 004
55. Dr P R Bhatnagar
Project Co-ordinator (Ground Water)
Directorate of Water Management Research
WALMI Complex, Patna (Bihar) 801 505
56. Dr Y S Ramakrishna
Project Co-ordinator (Agricultural Meteorology)
CRIDA Campus, Santoshnagar
Hyderabad (Andhra Pradesh) 500 659
59. Dr M M Pandey
Project Co-ordinator (Farm Implements
and Machinery)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road, Bhopal
(Madhya Pradesh) 462 038
60. Dr L P Gite
Project Co-ordinator (Human Engineering
and Safety-Studies in Agriculture)
Central Institute of Agricultural Engineering
Bhopal (Madhya Pradesh) 462 038
61. Dr Ashwani Kumar
Project Co-ordinator (Application of Plastics in
Agriculture)
Central Institute of Post-Harvest
Engineering and Technology
Ludhiana (Punjab) 141 004
62. Dr B S Bisht
Project Co-ordinator (Post-Harvest Technology)
Central Institute of Post-Harvest Technology
Ludhiana (Punjab) 141 004
63. Dr R K Verma
Project Co-ordinator (Power Tillers)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road, Bhopal
(Madhya Pradesh) 462 038
64. Dr Jaswant Singh
Project Co-ordinator (Processing, Handling and Storage
of Jaggery and Khandsari)
Indian Institute of Sugarcane Research
Lucknow (Uttar Pradesh) 226 002
65. Dr M Shyam
Project Co-ordinator (Renewable Energy Sources)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road
Bhopal (Madhya Pradesh) 462 038
66. Dr G C Yadav
Project Co-ordinator (Utilization of Animal Energy)
Central Institute of Agricultural Engineering
Nabi Bagh, Berasia Road, Bhopal
(Madhya Pradesh) 462 038

Animal Sciences and Fisheries

Engineering and Technology

57. Dr A K Bhattacharya
Project Co-ordinator (Agricultural Drainage)
Water Technology Centre, Indian Agricultural Research
Institute,
New Delhi 110 012
58. Dr Dipankar De
Project Co-ordinator (Energy Requirements
in Agricultural Sector), Central Institute of Agricultural
Engineering, Nabi Bagh, Berasia Road
Bhopal
(Madhya Pradesh) 462 038
67. Project Co-ordinator (Animal Genetic Resources)
National Bureau of Animal Genetic Resources
PB 129, Karnal
(Haryana) 132 001
68. Dr R K Sethi
Project Co-ordinator (Buffalo Breeding)
Central Institute for Research on Buffaloes
Hisar (Haryana) 125 001
69. Dr K P Pant
Project Co-ordinator
(Crop Based Animal Production Systems)
Central Institute for Research on Goat
Mathura, Makhdoom (Uttar Pradesh) 281 122

70. Dr Arun Varma
Project Co-ordinator (Embryo Transfer)
Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001
71. Dr K C Pant
Project Co-ordinator (Goats)
Regional Research Centre of CIRG
Avikanagar (Rajasthan) 204 501
72. Dr G L Kaul
Project Co-ordinator (Pigs)
Indian Veterinary Research Institute
Izatnagar (Uttar Pradesh) 243 122
73. Dr B U Khan
Project Co-ordinator (Sheep Breeding)
Central Sheep and Wool Research Institute
Arid Region Campus
Bikaner (Rajasthan) 334 002
74. S K Bandyopadhyay
Project Co-ordinator (Foot-and-Mouth Disease)
Division of Epidemiology
Indian Veterinary Research Institute
Mukteshwar Campus (Uttar Pradesh) 263 138
75. Dr M C Goel
Project Co-ordinator (Haemoprotista Disease)
College of Veterinary Science
CCS Haryana Agricultural University
Hisar (Haryana) 125 004
76. Project Co-ordinator (Organic Waste in Aquaculture)
Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001
77. Dr M Rajshekhar
Project Director (Animal Diseases Monitoring
and Surveillance)
Institute of Animal Health and Veterinary Biology
Hebbal, Bangalore (Karnataka) 560 004
78. Dr V P Singh
Project Coordinator
(Network on Haemorrhagic Septicaemia)
IVRI, Izatnagar, Uttar Pradesh 243 122
79. Dr V K Srivastava
Project Co-ordinator
(Network on Gastro-intestinal Parasitism)
IVRI, Izatnagar
(Uttar Pradesh) 243 122
80. Dr M L Mehrotra
Project Co-ordinator
(Network on Blue Tongue)
IVRI, Izatnagar
(Uttar Pradesh) 243 122
81. Dr Arun Verma
Network Programme on Micronutrients in Animal
Nutrition and Production
Krishi Bhawan
New Delhi 110 001

Education

82. Dr (Mrs) Tej Verma
Project Co-ordinator (Home Science)
ICAR, Krishi Anusandhan Bhavan
Pusa, New Delhi 110 012

APPENDIX 9

AGRICULTURAL UNIVERSITIES AND THEIR VICE-CHANCELLORS

1. Dr I V Subba Rao
Acharya N G Ranga Agricultural University
Rajendranagar, Hyderabad (Andhra Pradesh) 500 030
E-mail: root@apau.ap.nic.in
2. Dr G L Kaul
Assam Agricultural University, Jorhat (Assam) 785 003
E-mail: vcc@aacc.ren.nic.in
3. Prof Debarata Das Gupta
Bidhan Chandra Krishi Vishwa Vidyalaya
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4. Mr R P Roy Sharma
Birma Agricultural University
Ranchi (Bihar) 834 006
E-mail: root@bau.bih.nic.in
5. Dr S B Singh
Chandra Shekhar Azad University of Agriculture
and Technology,
Kanpur (Uttar Pradesh) 208 002
E-mail: hau@hau.hry.nic.in
6. Mr Vinay Kumar
Chaudhary Charan Singh Haryana Agricultural University
Hisar (Haryana) 125 004
E-mail: root@hau.pnp.nic.in
7. Dr M L Madan
Dr Punjabrao Deshmukh Krishi Vidyapeeth
Akola (Maharashtra) 444 104
8. Dr R P Awasthi
Dr Yashwant Singh Parmar University of
Horticulture and Forestry
Nauni, Distt Solan, (Himachal Pradesh) 173 230
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9. Dr J B Chaudhary
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and Technology
Pantnagar (Uttar Pradesh) 263 145
E-mail: root@gbpuat.ernet.in
10. Dr M H Mehta
Gujarat Agricultural University
Sardar Krushinagar, Distt Banaskantha
(Gujarat) 385 506
11. Dr Tej Pratap
Ch Sarwan Kumar Himachal Pradesh
Krishi Vishvavidyalaya
Palampur (Himachal Pradesh) 176 062
12. Dr V K Patil
Indira Gandhi Krishi Vishwavidyalaya
Raipur
(Madhya Pradesh) 492 012
13. Dr G B Singh
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur (Madhya Pradesh) 482 004
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14. Dr K V Peter
Kerala Agricultural University
Vellanikkara, Distt Thrissur (Kerala) 680 654
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15. Dr S S Magar
Bala Sahib Sawant Konkan Krishi Vidyapeeth
Dapoli (Maharashtra) 431 712
16. Dr S N Puri
Mahatma Phule Krishi Vidyapeeth
Rahuri (Maharashtra) 431 722
17. Dr V M Pawar
Marathwada Agricultural University
Parbhani (Maharashtra) 431 402
E-mail: mau@ren.nic.in
18. Dr V B Singh
Maharana Pratap
University of Agriculture and Technology
Udaipur 313 001
19. Dr B B Singh
Narendra Deva University of Agriculture
and Technology,
Faizabad (Uttar Pradesh) 224 001
20. Mr Sahadeva Sahoo
Orissa University of Agriculture and Technology
Bhubaneswar (Orissa) 141 004
E-mail: root@uat.cri.nic.in and snp@uat.cri.nic.in
21. Dr K S Aulak
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E-mail: root@pace.chd.nic.in and issahal@pau.chd.nic.in
22. Dr C P S Yadav
Rajasthan Agriculture University
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E-mail: root@raub.raj.nic.in
23. Dr V P Gupta
Rajendra Agricultural University
Samastipur, Pusa (Bihar) 848 125
E-mail: rau@bih.nic.in
24. Dr M Y Kamal
Sher-e-Kashmir University of Agricultural Sciences
and Technology
Srinagar (Jammu and Kashmir) 191 001
25. Mr H Khan
Sher-e-Kashmir University of Agricultural
Sciences and Technology
45-B, Gandhinagar, PB 37
Jammu Tawi (Jammu and Kashmir) 180 004

26. Dr S Kannaiyan
Tamil Nadu Agricultural University
Coimbatore (Tamil Nadu) 641 003
E-mail:root@tnau.tn.nic.in
27. Dr R Kadirvel
Tamil Nadu Veterinary and Animal Sciences
University, Chennai (Tamil Nadu) 600 007
E-mail: root@tnasu.tn.nic.in
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28. Dr A M Krishnappa
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E-mail:root@usab.kar.nic.in
29. Dr S A Patil
University of Agricultural Sciences
Dharwad (Karnataka) 580 005
E-mail:root@usad.kar.nic.in
30. Dr A K Bhattacharya
West Bengal University of Animal and
Fishery Sciences, Belgachia, Calcutta (West Bengal)
31. Dr A S Faroda
Rajasthan Agricultural University
Udaipur (Rajasthan) 313 001
32. Prof P K Srivastava
Dean
Faculty of Agriculture
Aligarh Muslim University
Aligarh 202 002

33. Dr Y C Simhadri
Banaras Hindu University
Varanasi 221 005
34. Dr S K Basu
Viswa Bharati, Santiniketan
West Bengal

Central University

35. Dr S S Baghel
Central Agricultural University
Imphal (Manipur) 795 001

Deemed-to-be Universities and their Directors

1. Dr P K Singh
Indian Agricultural Research Institute
Pusa, New Delhi 110 012
2. Dr M P Yadav
Indian Veterinary Research Institute
Izatnagar (Uttar Pradesh) 243 122
3. Dr B N Mathur
National Dairy Research Institute
Karnal (Haryana) 132 001
4. Dr S Aiyappan
Central Institute of Fisheries Education
Jaiprakash Road, Seven Bungalows, Versova
Mumbai (Maharashtra) 400 061
5. Prof R B Lal
Allahabad Agricultural University
Allahabad (UP)

APPENDIX 10

TOTAL NUMBER OF EMPLOYEES IN THE ICAR AND ITS RESEARCH INSTITUTES AND NUMBER OF SCHEDULED CASTES, SCHEDULED TRIBES AND OTHER BACKWARD CLASSES

Sl.no.	Class of posts	Total posts sanctioned	Total employees in position	Total scheduled castes among them	Percentage to total employees	Total scheduled tribes among them	Percentage to total employees	Total OBC	Percentage total employees
1.	Scientific Post								
	Scientist	3745	2972	268	9.01	28	0.94	172	5.78
	Senior Scientist	1587	1212	89	9.34	13	1.07	62	5.11
	Principal Scientist	661	523	34	6.50	2	0.38	13	2.48
	RMP Scientist	107	89	2	2.24	1	1.12	6	6.74
	Total	6100	4796	393	8.19	44	0.91	253	5.27
2.	Technical Posts								
	Category I	4744	4158	872	20.97	278	6.68	364	8.75
	Category II	3489	3089	581	18.80	144	4.66	238	7.70
	Category III	664	512	94	18.35	23	4.49	41	8.00
	Total	8897	7759	1547	19.93	445	5.73	643	8.28
3.	Administration Posts								
	(a) Directors/ Under Secretaries/ Sr. Admn. Officer/ Sr. Accounts Officer/Admn. Officer/F&AO/Legal etc.	301	262	55	20.99	18	6.87	14	5.34
	(b) Asstt. Fin. & Accounts Officer/Accounts Officer/Section Officer/Hindi Officer/Desk Officer/PRO/	607	556	104	18.70	30	5.39	16	2.87
	(c) Assistants	1279	1198	208	17.36	66	5.50	48	4.00
	(d) Stenographers	863	737	110	14.92	27	3.66	33	4.47
	(e) UDC/Senior Clerk	1343	1310	270	20.61	77	5.87	80	6.10
	(f) LDC/Junior Clerk	1233	1098	268	24.40	68	6.19	149	13.57
	Total	5626	5161	1015	19.66	286	5.54	340	6.58
4.	Supporting Staff								
	Grade I	5613	4423	1164	26.31	277	6.26	484	10.94
	Grade II	3377	3386	930	27.46	168	4.96	106	3.13
	Grade III	1991	1950	501	25.69	151	7.74	58	2.97
	Grade IV	970	960	272	28.33	92	9.58	31	3.22
	Total	11951	10719	2867	26.74	688	6.41	679	6.33
5.	Supporting Staff (Safaiwala)	347	340	315	92.64	8	2.35	12	3.52
6.	Auxiliary Posts	155	122	35	28.68	5	4.09	18	14.75

APPENDIX 11

AWARDS

AWARD	AWARDEES
Sardar Patel Outstanding Institution Award (2000)	<i>State Agricultural University</i> University of Agricultural Sciences, Dharwad <i>ICAR Institutes</i> (i) Central Institute of Fisheries Technology, Cochin (ii) Vivekananda Parvathiya Krishi Anusandhan Sansthan, Almora, Uttaranchal
Jawaharlal Nehru Awards for Outstanding Post-graduate Agricultural Research (2000)	<i>Crop Sciences and Crop Improvement</i> (i) Dr Rajiv Srivastava, JNKVV, Jabalpur (ii) Dr Girish Kumar, Krishna, J.K. Agri-genetics, Secunderabad <i>Biotechnology relating to Plants, Animals or Fisheries</i> (i) Dr (Ms) Ambica Baldev, NBPGR, New Delhi <i>Crop Protection</i> (i) Dr Prabhuraj A, College of Agriculture, Raichur (ii) Dr(Ms.) Sharmistha Barthakur, IARI, New Delhi <i>Natural Resource Management and Agroforestry</i> (i) Dr (Mrs) Uma Bagavathi Ammal, J.L.N. College of Agriculture and Research Institute, Pondicherry (ii) Dr V K Bhosekar, College of Agriculture, Hyderabad <i>Horticulture</i> (i) Dr (Mrs) Archana Mukherjee, Regional Centre of CTCRI, Bhubaneshwar (ii) Dr Gandra V S Sai Prasad, IIHR, Bangalore <i>Engineering and Technologies (Dairy Food and Post-Harvest Technology)</i> (i) Dr R Rajendra Kumar, Thrissur (ii) Dr Ashutosh Upadhyaya, DWMR, Walmi Campus, Patna <i>Animal Production, Health and Nutrition</i> (i) Dr Rajendra Kumar, NRCC, Bikaner (ii) Dr Minakshi, HAU, Hisar (iii) Dr U K Mukhopadhyay, NDRI, Karnal <i>Fisheries</i> (i) Dr Leela Edwin, CIFT, Kochi <i>Social Sciences</i> (i) Dr G Bhubaneshwari, UAS, Dharwad (ii) Dr K N Ramanna, UAS, Bangalore (iii) Dr M A Shanmughan, SIMA, Cotton Development and Research Association, Coimbatore (<i>Jointly</i>)
Swami Sahajanand Saraswati Extension Scientist/ Worker Award (1999-2000)	<i>Livestock Production</i> (i) Dr J C Markanday, NDRI, Karnal 132 001 <i>Resource Management</i> (i) Dr U S Gautam, DWMR, Phulwari Sharif, Patna, Bihar 801 505 <i>Home Science</i> (i) Dr (Mrs) Manju Dutta Das, Assam Agricultural University, Jorhat 13

AWARD	AWARDEES
Rafi Ahmed Kidwai Award for the Biennium (1999-2000)	<p><i>Crop Improvement and Crop Protection</i></p> <p>(i) Dr G S Nanda, Punjab Agricultural University, Ludhiana (Punjab)</p> <p>(ii) Dr R Sai Kumar, Agricultural Research Station, Hyderabad 500 013</p> <p><i>Natural Resource Management</i></p> <p>(i) Dr Balraj S Parmar, Indian Agricultural Research Institute, Pusa, New Delhi 110 012</p> <p>(ii) Dr S K Gupta, Indo-Dutch Network Project, Salinity, Karnal (Haryana)</p> <p><i>Engineering and Technology</i></p> <p>(i) Dr S R Singh, Directorate of Water Management Research, Patna, Bihar 801 505</p> <p><i>Horticulture</i></p> <p>(i) Dr G S Shekhawat, Central Potato Research Institute, Shimla (HP)</p> <p><i>Animal Sciences</i></p> <p>(i) Dr P P Gupta, Punjab Agricultural University, Ludhiana 141 004</p> <p>(ii) Dr Jag Mohan, Central Avian Research Institute, Izatnagar 243 122</p> <p><i>Fisheries and Aquatic Sciences</i></p> <p>(i) Dr K J Rao, Central Institute of Freshwater Aquaculture, Bhubaneshwar 751 002</p> <p>(i) Shri Randhir Singh Sheokand, Village Jajanpur, Dist. Kaithal, Haryana</p>
Jagjivan Ram Kisan Puruskar (2000)	
Lal Bahadur Shastri Young Scientist Award (1999-2000)	<p><i>Crop Sciences (Crop Improvement and Protection)</i></p> <p>(i) Dr Supriya Chakraborty, Indian Institute of Vegetable Research, Varanasi 221 005 (UP)</p> <p>(ii) Dr Suman Gupta, Indian Agricultural Research Institute, New Delhi 110 012</p> <p><i>Soil Science, Agronomy, Agroforestry</i></p> <p>(i) Dr S K Nag, Indian Grassland and Fodder Research Institute, Jhansi 284 003</p> <p>(ii) Dr D Damodar Reddy, Indian Institute of Soil Science, Bhopal (MP) 462 038</p> <p><i>Horticulture</i></p> <p>(i) Dr Debasis Pattanayak, Central Potato Research Institute, Shimla 171 001</p> <p><i>Engineering</i></p> <p>(i) Dr Ashutosh Upadhyaya, Directorate of Water Management Research, Patna 801 505, Bihar</p> <p><i>Animal Sciences</i></p> <p>(i) Dr Shrikrishna Isloor, Project Directorate on Animal Disease Monitoring and Surveillance (PD-ADMAS), Hebbal, Bangalore 560 024</p> <p>(ii) Dr. U K Mukhopadhyay, National Dairy Research Institute, Karnal, Haryana 132 001</p> <p><i>Fisheries Aquatic Life Sciences</i></p> <p>(i) Dr B K Das, Central Institute of Freshwater Aquaculture, Kausalayaganga, Bhubaneshwar 751 002</p> <p><i>Social Science and Home Science</i></p> <p>(i) Dr Seema Jaggi, IASRI, New Delhi</p>
Hari Om Ashram Trust Award (1999-2000)	<p><i>Crop Sciences</i></p> <p>(i) Dr B N Narkhede, Mahatma Phule Krishi Vidyapeeth, Rahuri 413 722</p>

AWARD	AWARDEES
	(ii) Dr C B Salunkhe (iii) Dr M S Shinde, MPKV, Rahuri
	<i>Horticulture</i> (i) Dr P S Sirohi, IARI, New Delhi
	<i>Resource Management</i> (i) Dr Geeta Mahale (ii) Mr Sunanda Kalkannavar (iii) Dr Sakshi, UAS, Dharwad
	<i>Animal Sciences</i> (i) Dr P K Vij (ii) Mr Avinash Kumar (iii) Dr A E Nivasarkar, NBAGR, Karnal
N.G. Ranga Farmer Award (2000)	(i) Mr Pradeep J Patil, Bordi, Dist. Thane 401 701
Panjabrao Deshmukh Women Scientist Award (2000)	(i) Dr Akella Vani, Indian Institute of Horticultural Research, Bangalore 560 089 (ii) Dr K V Bhagyalakshmi, Sugarcane Breeding Institute, Coimbatore 641 003 (iii) Dr(Ms) Meera Chakravarty, Assam Agricultural University, Jorhat 785 013
Vasandrao Naik Award (2000)	(i) Dr J S Samra & Associates, Dehradun 248 195 (UP) (ii) Dr V N Sharda (iii) Dr A K Sikka (iv) Dr P Samraj (v) Dr V Lakshmanan
Chaudhary Charan Singh Award (2000)	(i) Mr Devinder Sharma, New Delhi (ii) Dr Venkatramani, Chennai
One Time Special Award	(i) Dr S K Bandyopadhyay (ii) Dr R P Singh (iii) Dr B P Sreenivasa (iv) Dr P Dhar (v) Dr R N Roy (vi) Dr Rishendra Verma (vii) Dr T N Jaiswal

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Acronyms

AADU	: Allahabad Agricultural Deemed University	CIFT	: Central Institute of Fisheries Technology
AAU	: Assam Agricultural University	CIMMYT	: Centro Internacional de Mejoramiento de Maize Trigo
ACIAR	: Australian Centre for International Agricultural Research	CIPHET	: Central Institute of Post-harvest Engineering and Technology
ADMAS	: Animal Disease Monitoring and Surveillance	CIRCOT	: Central Institute for Research on Cotton Technology
AER	: Agro-ecological Region	CIRG	: Central Institute for Research on Goat
AESR	: Agro-ecological Subregion	CISH	: Central Institute for Sub-tropical Horticulture
AFLP	: Amplification Fragment Length Polymorphism	CITH	: Central Institute of Tropical Horticulture
AHRD	: Agricultural Human Resource Development	CMFRI	: Central Marine Fisheries Research Institute
AICRP	: All-India Co-ordinated Research Project	CMS	: Cytoplasmic Male Sterile
AICRPDA	: All-India Co-ordinated Research Project on Dryland Agriculture	CPCRI	: Central Plantation Crops Research Institute
AMU	: Aligarh Muslim University	CPRS	: Central Potato Research Station
ANGRAU	: Acharya N G Ranga Agricultural University	CRN	: Controlled Release Nitrogen
APEDA	: Agricultural Products Export Development Agency	CSSRI	: Central Soil Salinity Research Institute
ARI	: Agricultural Research Institute	CSWRI	: Central Sheep and Wool Research Institute
ARIS	: Agricultural Research Information System	CTCRI	: Central Tuber Crops Research Institute
ARS	: Agricultural Research Service	CZ	: Central Zone
ASRB	: Agricultural Scientists' Recruitment Board	DAC	: Department of Agriculture and Cooperation
ATIC	: Agricultural Technology Information Centre	DAD	: Days After Drying
ATMA	: Agriculture Technology Management Agency	DAP	: Days After Plantation
AVRDC	: Asian Vegetable Research and Development Centre	DARE	: Department of Agricultural Research and Education
AVT	: Advance Varietal Trial	DAS	: Days After Sowing
BAIF	: Bhartiya Agro-Industries Foundation	DEE	: Directorate of Extension Education
BBF	: Broad Bed and Furrow	DST	: Department of Science and Technology
BE	: Budget Estimates	DUs	: Deemed-to-be Universities
BPH	: Brown Plant-hopper	DWR	: Directorate of Wheat Research
BSMCs	: Broad Subject Matter Committees	ELISA	: Enzyme-linked Immuno Sorbent Assay
BVD	: Bovine Viral Diarrhoea	ESP	: Exchangeable Sodium Percentage
CABI	: Centre for Agriculture and Biosciences International	ETL	: Economic Threshold Level
CARI	: Central Avian Research Institute	ETT	: Embryo Transfer Technology
CAZRI	: Central Arid Zone Research Institute	FAO	: Food and Agriculture Organization
CCN	: Cereal Cyst Nematode	FCV	: Flue Cured Virginia
CCSHAU	: Chaudhary Charan Singh Haryana Agricultural University	FIM	: Farm Implements and Machinery
CEC	: Cation Exchange Capacity	FIRB	: Furrow Irrigated Raised Bed
CGP	: Competitive Grant Programme	FLDs	: Frontline Demonstrations
CIAE	: Central Institute of Agricultural Engineering	FMD	: Foot-and-Mouth Disease
CIAH	: Central Institute of Arid Horticulture	FYM	: Farmyard Manure
CIBA	: Central Institute of Brackishwater Aquaculture	GAU	: Gujarat Agricultural University
CIFA	: Central Institute of Freshwater Aquaculture	GBPUAT	: Govind Ballabh Pant University of Agriculture and Technology
CIFE	: Central Institute of Fisheries Education	GDD	: Growing Degree Days
		GIS	: Geographical Information System
		GOI	: Government of India

GTR	: Guided Tissue Generation	NBFGR	: National Bureau of Fish Genetic Resources
HAI	: Health Assessment Index	NBSS&LUP	: National Bureau of Soil Survey and Land Use Planning
HPKV	: Himachal Pradesh Krishi Vishwavidyalaya	NCAP	: National Centre for Agricultural Economics and Policy Planning
HRD	: Human Resource Development	NDRI	: National Dairy Research Institute
HYV	: High-yielding Variety	NDUAT	: Narendra Deva University of Agriculture and Technology
IARI	: Indian Agricultural Research Institute	NEH	: North-Eastern Hills
IASRI	: Indian Agricultural Statistics Research Institute	NEPZ	: North-Eastern Plains Zone
ICAR	: Indian Council of Agricultural Research	NET	: National Eligibility Test
ICARDA	: International Centre for Agricultural Research in Dry Areas	NGOs	: Non-Government Organizations
ICAR-RC-NEH	: ICAR Research Complex for North-Eastern Hills Region	NIRJAFT	: National Institute of Research on Jute and Allied Fibre Technology
ICRISAT	: International Crops Research Institute for the Semi-Arid Tropics	NRCAF	: National Research Centre on Agroforestry
IGKVV	: Indira Gandhi Krishi Vishwa Vidyalaya	NRCC	: National Research Centre on Camel
IIHR	: Indian Institute of Horticultural Research	NRCE	: National Research Centre on Equines
IIPR	: Indian Institute of Pulses Research	NRCWA	: National Research Centre for Women in Agriculture
IISR	: Indian Institute of Sugarcane Research	NRCWS	: National Research Centre for Weed Science
IIT	: Indian Institute of Technology	NRSA	: National Remote Sensing Agency
ILRI	: Indian Lac Research Institute	O&M	: Organization and Management
INM	: Integrated Nutrient Management	OBCs	: Other Backward Classes
IPM	: Integrated Pest Management	OL	: Other Languages
ITD	: Innovations in Technology Dissemination	OUAT	: Orissa University of Agriculture and Technology
ITK	: Indigenous Technical Knowledge	PAGE	: Polyacrylamide Gel Electrophoresis
IVLP	: Institution-Village Linkage Programme	PAU	: Punjab Agricultural University
IVRI	: Indian Veterinary Research Institute	PCR	: Polymerase Chain Reaction
JNKVV	: Jawaharlal Nehru Krishi Vishwa Vidyalaya	PDCSR	: Project Directorate for Cropping Systems Research
JRF	: Junior Research Fellowship	PDKV	: Dr Punjabrao Deshmukh Krishi Vidyapeeth
KAU	: Kerala Agricultural University	PEQN	: Post Entry Quarantine Nursery
KKV	: Konkan Krishi Vidyapeeth	PFP	: Partial Factor Productivity
KVKs	: Krishi Vigyan Kendras	PMC	: Project Management Committee
LE	: Larval Equivalent	PPR	: Peste des Petitis Ruminants
LER	: Land Equivalent Ratio	PRA	: Participatory Rural Appraisal
MABM	: Master of Agri-business Management	PSB	: Phosphate Solubilizing Bacteria
MM	: Mission Mode	PSR	: Production System Research
MoA	: Memorandum of Agreement	RAPD	: Random Amplified Polymorphic DNA
MoU	: Memorandum of Understanding	RAU	: Rajendra Agricultural University/Rajasthan Agriculture University
MPKV	: Mahtma Phule Krishi Vidyapeeth	RAWE	: Rural Agricultural Work Experience
MPTC	: Multipurpose Tree Species	RE	: Revised Estimates
MRL	: Maximum Residue Limit	REP	: Relative Erosion Potential
MRP	: Mussoorie Rockphosphate	RFLP	: Restricted Fragment Length Polymorphism
MS	: Male-sterile	RSC	: Residual Sodium Carbonate
NAA	: Naphthalene Acetic Acid	SAARC	: South Asian Association for Regional Co-operation
NAARM	: National Academy of Agricultural Research and Management	SAP	: Scientific Advisory Panel
NAP	: National Agricultural Policy	SAR	: Sodium Absorption Ratio
NARP	: National Agricultural Research Project	SAUs	: State Agricultural Universities
NARS	: National Agricultural Research System	SHGs	: Self-help Groups
NATP	: National Agricultural Technology Project	SPM	: Sulphitation Press Mud
NBAGR	: National Bureau of Animal Genetic Resources	SRF	: Senior Research Fellowship

STCR	: Soil Test-based Crop Response	TTCs	: Trainers' Training Centres
STMS	: Sequence Tagged Micro Satellite	UAS	: University of Agricultural Sciences
TAR	: Technology Assessment and Refinement	UGC	: University Grants Commission
TC	: Technical Co-ordination	USIF	: United States India Fund
TDS	: Total Dissolved Salts	VPKAS	: Vivekananda Parvatiya Krishi Anusandhan Sansthan
TFP	: Total Factor Productivity	WSBV	: White Spot Disease Baculo-Virus
TNAU	: Tamil Nadu Agricultural University	YSPUH&F	: Dr Yashwant Singh Parmar University of Horticulture and Forestry
TNUVAS	: Tamil Nadu University of Veterinary and Animal Sciences	ZARS	: Zonal Agricultural Research Station
ToE	: Team of Excellence	ZCU	: Zonal Co-ordinating Unit



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