वार्षिक प्रतिवेदन
Annual Report
2011-12

भाकृअनुप
ICAR

केन्द्रीय उपोष्ण बागवानी संस्थान
रहमानखेड़ा, लखनऊ
Central Institute for Subtropical Horticulture
Rehmankhera, Lucknow

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Central Institute for Subtropical Horticulture
Rehmankhera, Lucknow-226 101 (U.P.), India

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Front Cover : Fruiting in high density planting of mango

Back Cover : Laboratory-cum-administrative building and panoramic view of the experimental farm

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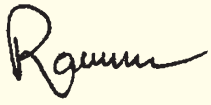
PREFACE

The insatiable and innate urge of the mankind over generations to offer the very best for fulfilling the basic human needs has attained the desired results with tremendous upsurge in crop yield across the globe resulting in quantum jump in agri-horticulture production and productivity mediated through improved technologies evolved, refined and filtered via mission mode scientific pursuits. The zealous attempts rendered, howsoever, side tracked the core issues of ecological balance fine tuned through a natural course operative in the system. The nature though to a great extent could absorb and offset the shocks manifested largely in the form of yield plateau attainment and disintegration of delicate ecological fabric but the input gradient continuum cover over the years has started displaying the telling impacts on the biosphere at large and sustainability and profitability of agri-horti-ecosystem in particular. Advent of global warming and the disastrous consequences are the manifestations of 'poor concern approach' of researchers towards seminal principle of eco-balance required for the eco-system sustainability. Agri-horticultural production systems in the contemporary arena have shed the age-old traditional concept of horticulturist. In the contemporary arena, the fruit production, productivity, quality and profitability have acquired larger dimensions getting impressive inputs and need based harmonious amalgam from basic scientific tools including biotechnology, biochemistry, physics, etc., for unraveling the basic mechanism(s) of plant system so essentially desirable to understand and develop viable and effective technologies.

Climate variations with an array of negative productivity factors mediated through serious weather aberrations quite often are found emerging in the form of rise/ fall in temperatures, unprecedentely long dry/hot/ winter spells, shifts in rainfall patterns over temporal and spatial scale, out breaks / unprecedented surges of array of pests / diseases, negative impacts on beneficial biota and the consequent impacts on yields, have become a cause of global concern. Mandate crops of the Institute including mango, guava, aonla, bael, papaya, etc., also were found vulnerable with discernable yield reductions through distinct impacts on phenophases.

Furthermore, the researches having direct bearing on the economic wheel and the human welfare are no larger merely an instrument of developing high yielding varieties. Changing phase of global economy demand paradigm shifts in the pattern of researches having abiding concern of all the stackholders including farmers, consumers, entrepreneurs and above all, the environment. Keeping in view, the emergence of challenges in the contemporary research arena the Institute had organized a Global Conference on Augmenting production and utilization of mango: biotic and abiotic stresses, stakeholder's consultative meeting, scientists-farmers' interaction meet to redefine the priorities, reorient and execute the research programmes through team and problem solving approaches. Research focus on off-season production, understanding the flowering/ fruiting behaviour, canopy architecture management, ameliorating nutrient deficiencies, microbial dynamics, monitoring of pests/diseases and their crucial linkages with environmental factors, development of disease diagnostic kits, cost effective production through efficient utilization of surplus horticultural produce etc. are the outcomes of the churning process undertaken during the period.

I whole heartedly congratulate all the Institute staff for showing sustained extraordinary patience and cautious indulgence even with the roaming of wild cat in the Rehmankhera campus for nearly 108 days from January-April, 2012 and tide over the crisis. Help rendered by Dr. B.K. Pandey in framing cover design and Shri Prashant Tiwari for computer type setting is also gratefully acknowledged. The painstaking efforts of the publication committee, all the Heads of Divisions and scientists of the Institute and encouragement and support received from the Honorable Secretary, DARE and Director General, ICAR and SMD during the period are gratefully acknowledged.



Lucknow
September, 2012

(H. Ravishankar)
Director

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1. EXECUTIVE SUMMARY

Research Accomplishments

The Central Institute for Subtropical Horticulture, Lucknow has research projects on five focused themes based on its mandates wherein twenty five research projects were in operation during the year. Apart from these projects Institute had nineteen externally-aided projects and two projects with foreign funding. The research achievements made under the targeted areas of genetic resources management and crop improvement, development of modules for improved water and nutrient use efficiency, integrated pests and diseases management, food safety, integrated pre- and post-harvest management, fruit utilization through value addition and waste management, market analysis and identification of gaps in transfer of technology to stakeholders are summarized herein. Other farmer oriented activities carried out by the Institute have also been incorporated.

Genetic resources management

The Institute has the largest germplasm collection of mango in the world having 742 accessions in its field gene bank. Besides, the Institute also has accessions of other subtropical fruits including underutilized fruits.

Twenty one accessions of mango were collected from Kushinagar, Barabanki and Goa areas and thirty four accessions were added to the field gene bank maintaining a total of 742 accessions. About 187 mango accessions were evaluated for fruit characteristics and 55 accessions were characterized from DUS point of view including inflorescence characteristics. Among seven mango varieties/hybrids evaluated for the preparation and storage of pulp, Amin Khurd was the best. Ten cross combinations were used to cross 23188 flowers on 5423 panicles for developing varieties with specific traits like regular bearing, peel colour, dwarfing, etc., Nine hundred hybrid seedlings were evaluated for fruit weight, length, width and thickness, peel weight, stone weight, pulp per cent, stone length, width, thickness and TSS.

Organelle DNA and total RNA isolation protocols were optimized for mango. The presence of the *Constans* gene, a zinc finger transcription factor regulating flowering, was validated in 48 mango cultivars using PCR assay and sequence characterized that revealed highly conserved regions. Sequence characterization of *trn*L and *trn*F genes in 8 mango cultivars has revealed the presence of indels and SNPs. Twenty mango cultivars were characterized for *rbc*L and *rca* genes and used for sequence characterization. The physical positions of five chloroplast genes, *viz*., *trn*L, *trn*F, *pet*B-*pet*D and *atp-rbc*L, were mapped onto partial chloroplast genome. Ten polyembryonic mango cultivars/accessions were molecular characterized using 10 random primers. A catalogue of Indian mango varieties Volume I (184 varieties) was published and CD: Catalogue of Indian mango varieties Vol I. (184 varieties) including an e publication was released in February 2012.

Twenty accessions of guava which consisted of 9 from Rewa, 6 from Satna, 5 from Jhansi were collected and sixteen accessions were planted in the field gene bank. One hundred and twenty accessions including six *Psidium* species were maintained in the field gene bank. For consolidation and maintenance of field gene bank, 31 accessions were propagated on the interspecific wilt resistant hybrid rootstock. Twenty six accessions were characterized for fruit characteristics. A total number of 409 recombinanats representing the cross combinations of Lalit x Purple (305), Shweta x Lalit (56) and Shweta x Purple (48) were planted in the field.

SSR marker system was utilized for mapping the progeny among cultivars (Shweta, CISH G-2 and Lalit crossed with Purple). One SSR primer was designed using websat tool from 58 sequences of *Psidium* spp, which amplified products of size (190 to 200 bp) and validated in hybrid progeny of Lalit x Purple. Recovery of Purple type alleles in the crosses indicated operation of a mechanism favouring these alleles which were supported by the phenotypic expression. Chloroplast genes, viz., *trn*L, *pet*B, *pet*D, *rbc*L and *trn*M from *Psidium guajava* were mapped in the circular cpDNA of *Syzygium cumini*, generating a preliminary chloroplast genome map of *Psidium guajava*. Comparative analysis showed synteny with citrus and grapes cpDNA. Shoot tips of guava were transformed with *endochitinas*e gene. The transformants were characterized for presence of npt-II gene. The kanamycin resistant, acclimatized plantlets of guava generated were challenged with *Fusaruium oxysporum* under *in vitro* condition to screen the resistant ones.

Papaya seeds were produced by controlled pollination to maintain genetic purity of identified lines. 12 cultivars/accessions of elite types were sibmated for production of true to type seeds of individual cultivars/accessions. In the genetic transformation study for PRSV resistance, a total number of 3127 embryonic explants were infected with *Agrobacterium tumefaciense* harbouring *coat protein a*nd *replicase* gene followed by co-cultivation. The kanamycin resistant embryos were converted into plantlets. A total number of 14 plantlets were regenerated, acclimatized and transferred under containment facility for further evaluation.

In aonla, out of twenty one accessions maintained in the field gene bank, nine accessions came into fruiting this year. Maximum fruit yield (6.41 kg tree $^{-1}$) was recorded in CISH-A-13 while it was minimum yield (2.92 kg tree $^{-1}$) in NA-6. The physiochemical and nutraceutical properties were analyzed among the different accessions. In bael, twelve accessions came into to fruiting for the first time and were analyzed for proximate principles

Diversity analysis of 20 accesions of litchi based on 187 markers including ISSR and SSR loci, grouped cultivars into four clusters Shahi, China, Bedana and Longia group. In jamun, two bioactive compounds SC-01 (Maslinic acid) and SC-02 oily compounds were isolated by using bioactivity guided fractionation. New ellagic acid derivative (SC-03) has been isolated (*via* aldose reductase and PTP-1B assay). Eight elite accessions were molecular characterized using 8 random primers.

Improved crop production technologies

The highest fruit yield (16.0 MT ha^{-1}) was recorded in medium density (400 plants ha^{-1}) followed by 10 MT ha^{-1} in density of 267 plants ha^{-1} in 19 years old Dashehari. The direct radiation above canopy in medium density (400 plants ha^{-1}) was higher (17752 mol m^{-2} yr^{-1}) as compared to 8255 mol m^{-2} yr^{-1} below canopy throughout the year. Diffused radiation below the canopy was maximum (1153 mol m^{-2} yr^{-1}) in the density of 100 plants ha^{-1} which reduced as the plant density increased progressively. The south-east quadrant of canopy was more productive (32.41% of total production), while north-west was the least (18.75% of total production). The double hedge row system of planting in Dashehari was the most effective as the yields were higher (8.4 MT ha^{-1}) in comparison to hedge row and square system.

In non-bearing Dashehari orchard, substrate manipulation through FYM, NPK, PSM, *Azotobacter*, *Trichoderma harzianum* and organic mulch effected an increase in the content of organic carbon from 0.34 to 0.47 per cent. The contents of macro- and micro-nutrients in leaves were above the critical limits in all the treatments. In bearing orchard the highest yield (15.85 MT ha^{-1}) was recorded under NPK+Cu+B. Higher soil moisture content and higher fruit yields were recorded in Dashehari and Langra with the application of NPK fertigation during the months of September and second week of May, which coincided with the phenological stages of bud differentiation and fruit development.

The main vegetative flushing in irregular bearing Dashehari was March to August with a peak in June (80%), while in regular bearer cv. Amrapali new vegetative growth even up to March. In Dashehari, 75 to 85 per cent of flower buds differentiated in the earlier emerged shoots (before June), whereas in Amrapali flowering was noted even in new vegetative flush produced up to March. The photo-oxidation of PS-II in young leaves of Dashehari was minimum at higher light intensities (> 35 °C) as new flushes recorded higher anthocyanin content. *Rubisco* activity was higher (5.0 g m^{-2}) in mature green leaves as compared to young leaves (1.5 g m^{-2}). Standardization of PCR conditions and validation of primers for *constans* gene in a set of 24 mango cultivars produced the amplicons of desired sizes of 449 bp for Con F_1/R_1 primer pair.

Substrate manipulation through FYM, NPK, *Azaotobacter*, PSM, *Trichoderma harzianum* and organic mulch in guava cv. Shewta resulted in higher yields (43.8 kg tree^{-1}) with bigger sized fruits in the third year of fruiting. The organic carbon content in soil also increased from 0.29 to 0.53 per cent through substrate manipulation. Further, the soil physical properties also improved with this amendment. Spatio-temporal variations in soil moisture and temperature in high density 19 year old Allahabad Safeda orchard indicated low moisture retention and higher temperature in soil of high planting density as compared to low density plantations. The dehydrogenase activity in soil was maximum in the months of July and November in all the densities (1.5x3, 3x3, 3x6 and 6x6 m) of Allahabad Safeda plantation.

Pests and diseases management

The emergence of mango mealy bug, *Drosicha mangiferae*, was recorded on January 10, 2012 when temperature and relative humidity ranged between 8.7 to 17.9 °C and 78-100 per cent. Its population remained low up to the last week of March. The emergence of hopper on panicles was recorded during the second week of February; its population was also noticed on new leaves during the third week of July. Imidacloprid (0.005%) was the most effective in controlling to the extent of 98 per cent population up to 21 days after spray. Thiamethoxam (0.005%) was found effective in managing thrips whose population was recorded during April-May. The population of fruit fly, *Bactrocura dorsalis*, and *B. zonata*, reached peak during 30th and 31st standard weeks in mango and guava orchards, respectively. Its population could be correlated positively with minimum temperature, minimum RH and rainfall and negatively with sunshine hours.

Diversity analysis of 51 isolates of *Colletotrichum gloeosporioides* based on Euclidean Distance indicated their clustering into two groups, *viz.* Cluster I comprising 78.4 per cent of isolates representing regions of Andhra Pradesh and UP, and Cluster II comprising 21.5 per cent of isolates representing location of Maharashtra, Tamil Nadu and Bihar. Taxonomic correlation of the isolates proved that all the isolates were more related to *C. gloeosporioides* and related to *Glomerella cingulata* perfect stage of *C. gloeosporioides*. *Botryodiplodia theobromae* was found to be the fungi (85%) associated with declining and wilting of mango trees. The soil samples of the wilted trees also showed the presence of nematodes, *viz*. *Hemicriconemoides mangifera* and *Hoplolamius* sp. Graft rot of mango was managed by the sprays of thiophenate methyl (0.05%).

The soil samples of healthy and wilted guava plants collected from different locations showed the occurrence of nematodes *viz*. *Helicotylenchus dihystera*, *Rotycenchulus* reniformis, *Hoplolamius indicus*, *Pratylenchus* sp., *Meloidogyne* sp., *Criconemoides* sp., *Longidorus* sp., *Xiphinema* sp., and nematodes of Tylenchid and Dorylaimus groups. The nemic density varied with location and plant health status. The higher population of *Fusarium oxysporum* was recorded with wilt affected plants. A diagnostic technique for the detection of *Fusarium oxysporum* f. sp. *psidii* using multiplex PCR was standardized.

Post-harvest management and value addition

Amrapali fruits treated with *Saccharomyces cerevisiae* were of superior quality in terms of TSS (19.4 ^{0}B), acidity (0.14%) and total carotenoids (5.83mg 100 $^{-1}$) and had least spoilage after 8 days of ambient storage. Chausa treated with spermine (0.01%) for 10 minutes and stored in cold storage (10^{o}C, 85 ±5% R.H) exhibited higher firmness and acidity and low TSS, total carotenoids and spoilage after four weeks of withdrawal. Among four hybrids evaluated for pickle in oil, H-2108 was organoleptically the best after six months of storage. Out of six hybrids and one variety evaluated for preparation of pulp and beverage, cv. Amin Khurd had the highest pulp content (71.3%) followed by hybrid H-2251 (70.5%). The RTS beverage prepared from cv. Amin Khurd was the most acceptable organoleptically at zero day as well as six months stored pulp. Mango pulp (H-1912) was preserved with 1000 ppm SO_2 up to 18 months under ambient conditions without any microbial spoilage though titratable acidity and reducing sugars increased, while the organoleptic quality of beverage prepared from it decreased marginally. Sensory evaluation of raw mango cider prepared from Totapuri, Chausa, Langra and Dashehari revealed the highest preference for spiced Totapuri cider, (8.32), followed by plain Totapuri and spiced Dashehari ciders. The optimum pasteurization temperature for cider was 60 ^{o}C. Sediment obtained from raw mango cider could be utilized for the preparation of chutney and sweet and spiced squash. Bio-fuel (94% ethanol) was produced from waste (spoiled) fruits using *Saccharomyces cerevisiae*. Enzymes pectinase and cellulase were obtained from peel, while amylase from kernel, through microbial fermentations. Response surface methodology was followed for enhanced production of pectinase using peel pectin as substrate using *Aspergillus niger*. A 17.35 folds increase in pectinase activity (750.26 Ug $^{-1}$ substrate) was observed as compared to non-optimized environmental factors in the basal medium

A prototype of low cost foldable fruit ripening chamber was designed, developed and evaluated. The residue level of carbaryl was below detectable limits (0.01µg g $^{-1}$) in pulp of Dashehari fruits after 16 days of spraying with 3 gl^{-1} cabaryl. Pulp samples of Dashehari fruits, collected from three different markets of Lucknow, were free from the residues of

imidacloprid, thiamethoxam, chlorpyriphos, monocrotophos, dimethoate, cypermethrin, deltamethrin, carbosulfan, carbaryl, endosulfan and DDT. Out of 30 soil samples collected from parks of Gomti Nagar and Indira Nagar areas of Lucknow, 18 samples were found contaminated with chlorpyriphos residue.

Allhabad Safeda fruits treated with *Bacillus subtilis* exhibited less disease incidence on the 8th day of storage. Selections/varieties, evaluated for processing potential, ascorbic acid content varied from 81 to 164 mg 100g $^{-1}$, while acidity ranged between 0.29 to 0.51 per cent. The best RTS beverage was obtained from Allahabad Safeda Seedling selection. Acceptable quality cider was prepared from over-ripe guava fruits.

Bael selections CISH B-1 and B-2 were sampled at different stages of fruit development and analyzed for marmelosin, psoralen, polyphenols and tannic acid contents. Both marmelosin and psoralen contents decreased gradually in B-1 as the fruit growth advanced, whereas in B-2 a variation was observed. Polyphenols content in B-1 ranged between 1.27 to 1.76 per cent, whereas in B-2, it ranged between 1.30 and 1.75 per cent. Tannic acid content in B-1 and B-2 ranged between 1118 to 1651 and 1323 to 2014 mg100g $^{-1}$.

Maximum retention of ascorbic acid (2442 mg 100g^{-1}) and minimum non-enzymatic browning (0.037 OD) was recorded in aonla powder packed in laminated aluminum foil pouches after six months of storage as compared to powder stored in 100 or 200 gauge LDPE pouches. The contents of anthocyanins and total carotenoids increased in spray dried aonla powder prepared from blended aonla juice with 10 per cent beet or carrot juice at the time of preparation. During storage of blended powder up to 6 months in laminated foil pouches, increase in anthocyanins and NEB values were noted, while total carotenoids and ascorbic acid decreased.

The fission yeast isolated from spoiled litchi juice could tolerate heating at 90 ^{0}C for 6 minutes. The yeast had alcohol dehydrogenase activity. Mulberry-aonla blended RTS beverage and wine were developed. RTS and wine prepared from red coloured mulberry MI-497 had attractive red colour, higher anthocyanin and antioxidant values and better sensory properties throughout the storage period of 9 months.

Market analysis and export

The disposal of mango from Lucknow region was 63.12 thousand MT during the year 2011, which was lower by 5.74 thousand MT than previous year. The major markets Delhi, Punjab and Maharashtra accounted for 30.7, 12.6 and 11.7 per cent, respectively, of mangoes disposed from Lucknow. The total arrival of mangoes in Lucknow market was around 70.48 thousand MT during 2011, lesser than previous year by 19 per cent. The total trading of Dashehari, Langra, Chausa, Banganapalli and Totapuri fruits in all the markets of the country were found to be 188.68, 25.7, 47.16, 183.19 and 69.26 thousand MT, respectively. The average weighted price of Dashehari and Banganapalli in all the markets taken together were Rs. 2601 and 4399 q^{-1}, respectively. The exports of mangoes declined from 74.46 to 59.22 thousand MT realising only Rs. 162.92 crores as against Rs 200.54 crores previous year. The export of mango products also declined during 2011, the country exported 218.66 thousand MT worth Rs. 1066.52 crores as against 236.34 thousand MT last year.

The total arrival of guava in the market during 2011-12 was 1.915 thousand MT, which was highest during the last 6 years. The entire year weighted average wholesale price of guava was Rs. 685 q^{-1}. The export of guava from the country declined from 520 MT worth Rs. 11.34 crores to 286.31 MT worth Rs. 0.633 crores during 2010-11. The export of guava products, mainly guava jelly and RTS beverage, were 6.5 thousand MT accounting for Rs. 158.32 lakhs. The Lucknow market received 9.54 thousand MT of papaya during the year, which was around 14.3 per cent higher than previous year. The weighted average price of papaya during the entire period of 2011-12 was Rs. 598 q^{-1}, highest in the last five years.

Technology Transfer

Besides the targeted research in the sphere of crop improvement, crop production, crop protection and post-harvest management, transfer of technology related steps were taken in the mandated crops. The Institute organized different theme oriented programmes wherein 300 farmers/trainers were sensitized. The Institute also organized 22 on-farm trainings sponsored by District Horticulture Mission, technologies mission, state saghan bagvani mission and RKVY (Horticulture Division) and ATMA from

states like Uttar Pradesh, Uttrakhand, Maharastra, Andhra Pradesh, Tamil Nadu, Rajasthan, Odisha, West Bengal, Haryana, etc., wherein 3200 farmers and government officials participated. The Institute also participated in several state and national level events and addressed the problems of farmers through Improved technology capsules. Technology showcasing through demonstrations, scientists-farmers' interactions, exposure visits for the benefit of farmers, extension workers/students, counseling, postal queries, farmers helpline call, training programmes and TV/radio talks were undertaken.

Meetings

Sixteenth Research Advisory Committee (RAC) Meeting of Central Institute for Subtropical Horticulture, Lucknow was conducted under the Chairmanship of Dr. D. P. Ray Vice Chancellor, Orissa University of Agriculture and Technology, Bhubaneshwar, Odisha from June 24-25, 2011. The 30th and 31st Institute Research Committee (IRC) meetings of CISH were held during May 16 and 18 to 20, 2011 and August 11, 12, 16 to 20, 23 to 26, 2011 under the Chairmanship of Dr. H. Ravishankar, Director to review the progress made in the ongoing research projects during 2010-2011 and approval of the technical programmes for the following year.

Awards and Recognitions

Scientists of the Institute received awards and recognitions from different scientific/ developmental agencies and societies. Director/Scientists of the Institute also acted as chairman, co-chairman, convener, rapporteur and member in different seminars/symposia/conferences/workshops/ meetings. Udyan Rashmi, the Rajbhasha Patrika of the Institute was conferred with 2nd prizes twice by the Town Official Language Implementation Committee. The Institute also got 10th prize for carrying out Rajbhasha implementation policy at the Institute.

Linkages and Collaboration

The Institute has in place MOUs with various National and International organizations such as DAC-NCPAH, Ministry of Agriculture, DBT, DST, NMPB, PPV & FRA, UPCST, UPCAR, NAIP, AMAAS, NICRA, Sultanate of Oman and UNEP/GEF. The Institute has in place MoUs to facilitate capacity building initiatives with Amity University, Lucknow; Lucknow University, Lucknow; Babasaheb Bhimrao Ambedkar Agricultural University, Lucknow; Integral University, Lucknow; Sam Higginbotham Institute of Agriculture, Technology and Science, Allahabad; SVPUA&T, Meerut and Bundelkhand University, Jhansi for pursuing B.Tech., M.Sc. and Ph.D degrees of students.

AICRP/PFDC

The Project Coordinator's Cell of All India Coordinated Research Project on Subtropical Fruits is located at the Institute. It has 18 centres working on mango, guava, litchi and grapes, out of these 5 centres are based at different ICAR institutes, 12 in SAUs and one in a non-government agency. The Precision Farming Development Centre (PFDC) was established through National Committee on Plasticulture Application in Horticulture (NCPAH) at the Institute during 2001-2002. The main activities of the centre include technology development and refinement in hi-tech horticulture, technology dissemination and validation, micro-irrigation, plastic mulching, greenhouse technology publication of scientific literature and organizing workshop and trainings for state officials and farmers. The PFDC organized four training programmes in four districts of Uttar Pradesh and 22 on-farm trainings wherein 3200 farmers and government officials participated.

Other Activities

The Institute in collaboration with the Society for Development of Subtropical Horticulture and the International Society for Horticultural Science (ISHS), Belgium organized a four-day Global Conference on Augmenting Production and Utilization of Mango : Biotic and Abiotic stresses from June 21-24, 2011 at the Lifestyle Hotel Pvt. Ltd., Lucknow. The theme of the Conference was 'Mango for Health Care and Livelihood'. The Conference, inaugurated by Dr. H.P. Singh, DDG (Hort.), was attended by over 350 persons representing scientists, farmers and students from India and abroad. A Mango Diversity Show exhibiting over 800 varieties was also organized on this occasion.

Field day on Harvesting, post-harvest management and marketing of mangoes was organized on June 4, 2011 at Au Mau village in Mall block, Lucknow under NAIP project on 'A value chain on mango and guava for domestic and export markets' to appraise the farmers about latest techniques. The Institute organized Showcasing of Agricultural Technologies and Media Meet with a theme of

'Diversified agriculture for augmenting income and livelihood security' on March 22, 2012 at village Thawar, Mall, Lucknow in collaboration with M/S Bayer Crop Science Ltd. Around 700 farmers from mango growing belts of Kakori, Malihabad and Mall blocks participated in the programme in which problems/queries related to horticultural crops production, protection and post harvest management besides credit and marketing were discussed and solution provided.

The fourth Consortium Advisory Committee meeting to review the progress of NAIP subproject on 'A value chain on mango and guava for domestic and export markets' was held on July 25, 2011 under the chairmanship of Dr. D.S. Rathore, ex-VC, CSKHPKV, Palampur. A Stakeholders' Consultative Meet was organized by the Institute under the Chairmanship of Dr. H. Hanumaiah, Hon'ble VC, BBAU, Lucknow on 19th December, 2011 with an aim to engage new batch of stakeholders in order to assess the horticulture potential, appraise the constraints and develop roadmap for the integrated development of horticulture in the region. About 100 farmers from different districts of the state apart from entrepreneurs, KVKs, state department of horticulture and financial institutions interacted with experts and subject matter specialists on range of issues.

Revenue Generation

A total of Rupees 63.33 lakhs was generated by the Institute during the financial year 2011-12.

2. INTRODUCTION

The Institute

The Central Institute for Subtropical Horticulture (CISH) was started as Central Mango Research Station on September 4, 1972 under the aegis of the Indian Institute of Horticultural Research, Bangalore. The Research Station was subsequently upgraded to a full-fledged Institute and named as Central Institute of Horticulture for Northern Plains on June 1, 1984. The Institute was later renamed as Central Institute for Subtropical Horticulture (CISH) on June 14, 1995 which is serving the nation on different research and development aspects on mandated subtropical fruits. The Institute has two experimental farms located one each at Rehmankhera, approximately 25 km away from the city, and at Rae Bareli (R.B.) Road, right in the city of Lucknow. The experimental farm at Rehmankhera has an area of 132.5 Ha comprising 4 blocks (block I-15.5 Ha, block II-35.5 Ha, block III-37.42 Ha & block IV- 44.08 Ha), while the R.B. Road campus has an area of 13.2 Ha. The Institute shifted to its present laboratory-cum-administrative building at block-II at Rehmankhera during May, 1999 where it also houses the Project Coordinator Cell of AICRP on Subtropical Fruits earlier established in September, 1972. The Institute has modern nursery facilities, well established orchards and equipped laboratories to meet the emerging challenges in the niche areas of research on subtropical fruits. The established scientific nursery unit of the Institute is producing quality planting materials of mango, guava, aonla and bael with traceability incorporated for supply to farming communities and backstopping of Krishi Vigyan Kendra for establishing mother blocks. Simultaneously, concerted endeavours for human resource development through capacity building are also going on.

Recognising the importance of capacity building and in harmony with ICAR focus 'Student Ready' he Institute has in place MOUs with Integral University, Lucknow, Sam Higginbottom Institute of Agriculture, Technology and Science, Allahabad, Babasaheb Bhimrao Ambedkar University, Lucknow, Bundelkhand University, Jhansi and Lucknow University, Lucknow for pursuing M.Sc. and Ph.D. degrees of their students at this Institute. Institute has also been recognized by IGNOU, New Delhi as one of the study centres for offering one year Diploma course on Value added products from fruits and vegetables and a Certificate course on Organic farming. National Horticulture Mission has also identified the Institute as a nodal centre for imparting training on rejuvenation of old and unproductive mango orchards and high density planting in guava. The Institute renders other quality services to the growers, *viz.*, responding to querries on orcharding problems through phone-in-live programme (0522-2841082 every Friday from 10.30 am to 4.00 pm), site-specific diagnostic services of soil and nutrient constraints, pests and diseases problems, on-farm visits, production and supply of bio-control agents, hand holding of KVKs and other agricultural/ horticultural universities including the one in Nagaland and other multi stakeholders. The Institute has been actively partnering with the National Horticulture Mission and National Horticulture Board units for its outreach activities of promoting integrated development of horticulture in the region.

A Global Conference on 'Augmenting Production and Utilization of Mango: Biotic and Abiotic Stresses' was organized by the Institute in collaboration with International Society for Horticultural Science (ISHS), Belgium to review the status of research on different aspects plaguing mango productivity and quality and focus on new and emerging challenges. The theme of the global conference was 'Mango for health care and livelihood'.

Vision

Augment the share of agriculture sector in general and horticulture in particular in the GDP of the country and its export basket.

Mission

Conduct basic and strategic research to develop cost effective and viable technologies for production of subtropical fruit culture as a component of integrated farming strategy.

Mandate

- Undertake basic and applied research to enhance productivity and develop value chain for major and minor subtropical fruits.
- Act as national repository of above fruit crops.
- Act as a centre for human resource development and provide consultancy to stakeholders.

- Develop linkages with national and international agencies to accomplish the above mandate.

Objectives

- Management of genetic resources of mandate fruit crops and their conventional and molecular characterization.
- Crop improvement through breeding and genetic engineering.
- Enhancing productivity through improving quality of planting materials using modern propagation techniques and rootstocks, precision farming practices including mechanization and management of biotic and abiotic stresses.
- Reduction in post-harvest losses through improved post-harvest management practices, value addition and diversification of products.
- Human resource development, transfer of technology and evaluation of its socio-economic impact.
- Data storage and retrieval on all aspects of mandate crops.

Significant Achievements

Crop Improvement and Biotechnology

- The Institute is conserving the world's largest germplasm collection of mango numbering 742 accessions, collected from different indigenous and exotic sources.
- A regular bearer mango hybrid CISH-M-1 (Amrapali x Janardhan Pasand) was released as 'Ambika'. The fruits have yellow colour with red blush, firm pulp and scanty fibres. It has good potential for domestic and export markets.
- Another regular bearing mango hybrid H-39 (Amrapali x Vanraj) having yellow peel colour with red blush, firm pulp and high TSS (24^0B) and carotenoids contents was released as 'Arunika'.
- Mango hybrid H-1084 was found promising which is presently under evaluation.
- Mango cv. Elaichi, free from floral malformation, is being used in trait specific breeding programme.
- Molecular characterization of 150 mango cultivars indicated that the germplasm accessions could be categorized into 3 broad groups, *viz.* northern, eastern and other representatives both northern and eastern.
- Three primers, FMID073, HMID074 and FMID2007, could resolve the varietal differences and establish homogeneity among mango mother block entries.
- A South Indian mango cv. Totapuri was found regular bearer and good yielder under Lucknow conditions.
- One hundred and thirty one accessions of guava and 7 *Psidium* spp. are conserved in the field gene bank.
- Two open pollinated seedling selections of coloured guava, CISH-G-3 and CISH-G-4, have been released as 'Lalit' and 'Shweta' for commercial cultivation. Fruits of cv. Lalit are attractive, saffron yellow with red blush in colour, medium size and firm with pink pulp. It has 24 per cent higher yield than the popular variety Allahabad Safeda. Shweta has subglobose fruits with attractive pink blush, white pulp, few soft seeds, high TSS (14^0B) and good yield potential.
- Institute has 36 accessions of bael conserved in the field gene bank. Two promising selections 'CISH-B-1' and 'CISH-B-2' have good table and processing qualities.
- The Institute has also conserved germplasm accessions in the FGB of banana(7), papaya(32),litchi(35) and underutilized fruits representing aonla(22), karonda (30), jamun(35), khirnee(38), tamarind(24), mahua(30), chironji(8), woodapple(17), mulberry(10), cape gooseberry(3), custard apple(8), carambola(2), lasora(3), and roseapple(2).

Crop Production

- The propagation techniques under polyhouse conditions for some underutilized fruits like Jamun, Karonda, Khirnee were standardized.
- High density planting (400 plants ha^{-1}) in Dashehari mango increased the yield by about 3 folds (15 tonnes) over conventional planting (100 plants ha^{-1}) of 6.0 tonnes.
- Crown thinning in mango resulted in higher yield (80 kg $plant^{-1}$) in Mallika in the following year as compared to 55 kg in control.
- Rejuvenation techniques for old and unproductive mango and guava trees have been standardized and demonstrated in farmers' fields.

- Techniques for high density planting and canopy management in guava have been standardized, recommended and popularised.
- Mango based cropping system has been developed and cowpea-potato system gave higher monetary returns in 10 years old orchard.
- Soil application of paclobutrazol @ 4 g tree^{-1} (3.2 ml m^{-1} canopy diameter) was found to manage the problem of irregular bearing in mango cv. Dashehari resulting in increased flowering and fruiting during the expected off year. Mulching along with application of paclobutrazol (1.6 ml m^{-1} canopy diameter) was also found effective in improving yields.
- Soil application of 1kg each of N, P and K (tree^{-1} year^{-1}) to 10 year old Dashehari mango trees increased the yield. Trench application of fertilizers around the tree in July was found efficient.
- Planting of papaya at a spacing of 2 x 1.8 m in the month of September produced the highest yield (55 kg per plant) with good quality fruits in Pusa Delicious.

Crop Protection

- IPM modules for mango insect pests and diseases have been developed and standardized. Entomogenous fungus, *Verticillium lecanii*, egg parasites, *Agrostocetus* spp., *Gomatocerus* sp., and *Polynema spp*., and predators, *Chrysopa lacciperda*, *Mallada boninensis* and *Coccinella septumpunctata* were found potential bio-control agents against mango hoppers.
- Critical limits of weather parameters (temperature and relative humidity) were — — for forecasting the epidemics of mango oppers and powdery mildew.
- Mango bacterial canker disease (MBCD) could be checked by target spraying of streptocyline (200 ppm) at 10 days interval. Antagonists *Bacillus coagulans*, *Pseudomonas spp*. and *Acenetobacter* spp. were found potent bio-control agents for MBCD pathogen.
- Post-harvest diseases of mango, *viz*., anthracnose and stem end rot, could be controlled by dipping the fruits in 0.025 per cent carbendazim in hot water (52±1°C) for 15 minutes.
- *Gliocladium roseum* though was found frequently associated with guava wilt disease, however, *Fusarium oxysporum f.spp.psidii* was found more potent in inciting epidemics.
- *Aspergillus niger* (AN17), *Trichoderma harzianum*, *T. viride* and *Penicillium citrinum* were found effective in integrated management of guava wilt. *Aspergillus niger* (AN 17) presently is brief used in the Institute's nursery for substrate fortification.
- A cross (F_1) between *Psidium molle* x *P. guajava* was identified as resistant rootstock against guava wilt. Demonstration trials using the innovation is underway in wilt endemic areas.
- Four endophytic bacteria and lac based compounds were found effective against rootknot nematode, whereas the potency of entomopathogenic nematode has been demonstrated against insect pests under *in vitro* conditions.
- A multiplex PCR with four sets of primers for *Colletotrichum gloeoporioides* has been optimized.

Post-harvest Management

- Maturity indices for commercial mango cvs Dashehari, Langra, Mallika, Amrapali and Chausa were optimized.
- Low cost mango, guava and bael harvesters have been fabricated.
- A low cost foldable ripening chamber has been designed and developed. Evaluation of the same is under progress.
- Three temperature gradients for storage, *viz*. 12, 15 and 10^{0}C, were worked out to enhance the shelf life of Dashehari, Langra and Chausa mango fruits up to 3, 2 and 3 weeks, respectively.
- Uniform ripening of mangoes could be achieved by dipping of the fruits in 250 - 750 ppm ethrel in hot water (52 ± 2 ^{0}C) for 5 minutes depending upon maturity.
- Pre-harvest sprays of calcium chloride di-hydrate (2%) at 10 days interval were found effective to reduce the jelly seed formation in mango.
- Corrugated fiber board (CFB) boxes of 2 and 4 kg capacities were fabricated for packaging and transportation of mango and guava fruits.
- A protocol for export of mangoes through sea transport has been optimized which was tested for export of 'Dashehari' from Malihabad to UAE by CISH in partnership with NHB.
- Guava fruits cv. Allahabad Safeda could be stored for 28 days at 5^{0}C in 0.25 per cent ventilated LDPE bags.

- Methodologies for preparation of raw mango squash (panna) and instant mango panna powder have been standardized and optimized.
- The technologies for freeze drying of mango and aonla slices, osmo-freeze drying of mango slices and spray drying of aonla juice have been developed.
- Recipe for oil-less mango pickle and sweet papaya chutney have been developed with shelf life of nine months.
- The techniques for preparation of sweetened and brined (salted) aonla segments have been optimized.
- Protocols for the preparation of *mahua* (*Bassi latifolia*) and mango wine, and aonla and guava cider were developed.
- Mango peel could be utilized for the production of compost, fibre, pectin, vinegar and pectinase and cellulase enzymes.

Transfer of Technology

Institute implemented 14 sponsored training programmes on production, protection and postharvest management of subtropical fruits for the benefit of orchardists and extension workers of different State Departments. Institute also provided training (on and of campus) on different aspects of improved crop production technology in mango and other mandated fruit crops for scientists and development workers. Four specialized training programmes on drip irrigation, polythene mulching and protected cultivation were organized under PFDC at different locations of UP. Three training programmes were organized for farmers, officers and extension functionaries in the North Eastern hill region of Assam, Mizoram and Sikkim under Technology Mission for Integrated Development of N-E states, JK, HP and Uttarakhand. Exposure visits of the farmers, farm women, students and officials from different parts of the country were organized for creating awareness about the technologies developed by the Institute. A scientific nursery programme with traceability issue integrated is being pursued and target groups were sensitized about different aspects of quality planting materials production. Institute organized gosthies and participated in state and national level events to disseminate its developed technologies. Field demonstrations, counseling, postal queries, phone-in-live and TV/Radio talks were also undertaken. Thematic technical folders on pre and harvest protocols for enhancing production, productivity and quality of mangoes in UP and Uttarakhand were brought out.

The Institutes' technologies were showcased by organizing scientists-farmers' and media meets at farmers' doorsteps in harmony with ICAR focus 'Farmer First'. Stakeholders' consultative meet was organized to identify and document the issues and problems in order to profile agenda for research and transfer of technology initiatives.

AKMU (Agriculture Knowledge Management Unit)

The Institute has a well developed AKMU cell. The Institute website (www.cishlko.org) has been developed and consolidated to provide contextual information about its users friendly activities to the public. The website contains detailed information on its organizational set-up, cadre, staff, pay scales, immovable property status of employees, ongoing research projects, achievements made, facilities available, package of practices developed for nursery management and higher productivity, technologies perfected, services offered and e-governance. Besides general information, it also contains media resource section where CISH technologies, farmers' advisories and alerts, videos on mango technologies and press releases are uploaded for the use of media persons and farmers/entrepreneurs/students and other stakeholders. The website is regularly updated with the contextual information and is found visited by people both nationally as well as internationally.

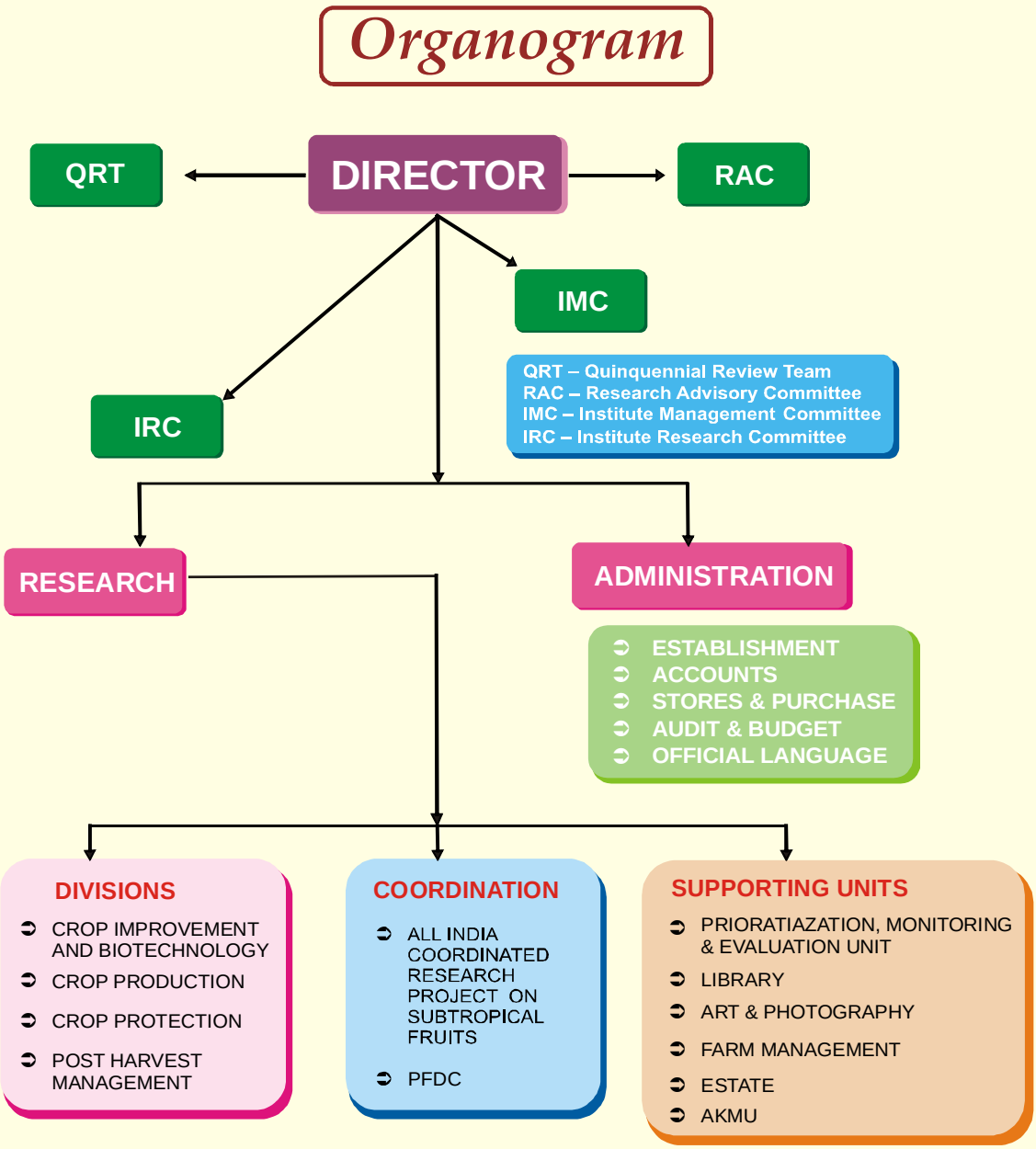
Library

The library of the Institute is catering to the requirements of the scientists, research workers and students of M.Sc./Ph.D. It is well equipped with books, periodicals, reports, reprints and CD ROMs pertaining to different aspects of subtropical horticulture along with computer, internet surfing and reprographic facilities. The facility for database search has been provided through Hort. CD of CABI, AGRIS, etc., and has been automated through LSEASE software of Lybsis. The existing collection (3404) of scientific and technical books was further enriched by the addition of 80 books during the period under report. At present Institute's library subscribes to 62 National and International journals, out of which 20 are

International and 42 National journals, after accessing CeRA platform 27 National and 21 International journals were discontinued for subscription, as they are accessible through CeRA. More than 200 annual reports are being received from ICAR Institutes/ universities/international Institutes on exchange basis. Connectivity for accessing CeRA is in place.

Organizational Set-up

The Institute's functioning is organized through three Divisions, *viz.* Crop Improvement and Biotechnology, Crop Protection and Post Harvest Management. A proposal for creation of new Division of Crop Production is under the consideration of the Council. All India Coordinated Research Project on Subtropical Fruits functions and facilitates at the Institute its activities. The Institute also has a Precision Farming Development Centre (PFDC) for promoting aspects of high-tech horticulture. The organizational set-up of the Institute is shown in organogram. Besides focusing on thematic research areas, interdisciplinary / inter Institute collaboration team approach is being harmonized for optimizing outputs.



Financial Set-up

Budget Allocation & Expenditure (2011-2012)

(Rs in Lakh)

S. No.	Head	Non-Plan		Plan		AICRP (STF)		AP Cess Fund projects		Externally aided projects		Revolving Fund		NAIP Sub projects	
		Budget	Expn.	Budget	Expn.	Budget	Expn.	Budget	Expn.	Budget	Expn.	Budget	Expn.	Budget	Expn.
1	a. Estt. charges	1085.00	1044.03	0.00	0.00	606.92	606.92								
	b. wages	24.00	23.95	0.00	0.00										
	c.OTA	0.15	0.15	0.00	0.00										
2	T.A.	6.00	5.64	14.00	13.68	5.56	5.56								
3	HRD	0.00	0.00	9.00	8.67										
4	Other charges														
	a.Capital	2.50	2.25	90.00	85.38										
	b. Revenue	106.35	73.27	147.00	144.66	44.52	42.10	1.98	1.98	191.56	114.77	18.20	16.63	42.46	38.42
5	Minor works	5.00	4.41	0.00	0.00										
6	Major works	0.00	0.00	90.00	89.52										
7	AR&M building														
	a.Office building	10.00	9.53	0.00	0.00										
	b. Residential building	7.00	6.99	0.00	0.00										
	Total	**1246.00**	**1170.22**	**350.00**	**341.91**	**657.00**	**654.58**	**1.98**	**1.98**	**191.56**	**114.77**	**18.20**	**16.63**	**42.46**	**38.42**
8	**Pension &retirement benefits**	**210.00**	**162.22**												

(Rs in Lakh)

Revenue Receipts (2011-2012)

S.No.	Particulate	Target	Achievement
1	Farm produce		29.11
2	Sale of products		0.04
3	Sale of publications/Tender form etc.		0.79
4	Guest house charges/License fee/Rent		3.72
5	Training/Consultancy		0.40
6	Interest on P-loans		5.31
7	Interest on TDRs		10.09
8	Electric and water charges		1.73
9	Transport charges		8.08
10	Miscellaneous receipts		4.06
	Total	**42.00**	**63.33**

Staff Position (as on 31.03.2012)

Sl. No.	Category	Sanctioned	Filled	Vacant
1.	RMP	1	1	-
2.	Scientific	48	37	11
3.	Technical	56	50	06
4.	Administrative	24	20	04
5.	Skilled Supporting Staff	44	32	12
	Total	173	140	33

Staff Changes

Promotion

Scientific

1. Dr. S. Rajan, Principal Scientist (Hort.) appointed to the post of Head, Crop Improvement and Biotechnology w.e.f. 06.05.2011.

Technical

1. Shri Ganga Saran, T-4 granted merit promotion to the post of T-5(T.O.) w.e.f. 01.01.2009.
2. Smt. Priti Sharma, T-4 granted merit promotion to the post of T-5(T.O.) w.e.f. 30.06.2009.
3. Shri Ram Dayal, T-3 granted merit promotion to the post of T-4 w.e.f. 01.07.2009.
4. Shri J.K. Khare, T-4 granted one additional advance increment (Total three) w.e.f. 01.01.2007.

Administrative

1. Shri Ram Naresh, Personnel Assistant promoted to the post of Private Secretary w.e.f. 01.04.2011.
2. Shri A.K. Talwar, Ex. Assistant granted IIIrd MACP to the next higher grade pay w.e.f. 01.09.2008.
3. Shri Devi Dutt, Assistant granted IIIrd MACP to the next higher grade pay w.e.f. 24.07.2009.
4. Shri Satya Dev Prasad Dixit, Assistant granted IIIrd MACP to the next higher grade pay w.e.f. 06.12.2009.
5. Shri G.P. Misra, Steno granted IInd MACP to the next higher grade pay w.e.f. 01.09.2008.
6. Km. Neelam Dhami, Jr. Steno granted IInd MACP to the next higher grade pay w.e.f. 01.09.2008.
7. Shri Vidya Sagar, Sr. Clerk granted IInd MACP to the next higher grade pay w.e.f. 01.09.2008.
8. Shri Vijendra Singh,Sr. Clerk granted IInd MACP to the next higher grade pay w.e.f. 01.09.2008.
9- Shri Ram Gopal, Jr. Clerk granted IInd MACP to the next higher grade pay w.e.f. 01.09.2008.
10- Shri Parmeshwar Deen, Jr. Clerk granted IIIrd MACP to the next higher grade pay w.e.f. 01.09.2008.

Transfer

Scientific

1. Dr. A.K. Singh, Principal Scientist (Pl. Patho.) transferred to IISR, Lucknow w.e.f. 09.09.2011.

Administrative

1. Shri Anand Mohan Srivastava, AAO repatriated to IISR, Lucknow w.e.f. 28.04.2011.
2. Shri Ravi Badhra, AF & AO, transferred to NBFGR, Lucknow w.e.f. 30.06.2011.

Superannuation

Scientific

1. Dr. Ramesh Chandra, Principal Scientist (Eco. Bot.) superannuated on 29.02.2012.

Technical

1. Shri Prem Kumar, T-6 superannuated on 30.04.2011.
2. Shri Daya Shankar, T-3 superannuated on 31.10.2011.
3. Shri R.P. Mishra, T-5 superannuated on 29.02.2012.

Administrative

1. Smt. Satyawati Verma, Sr. Clerk superannuated on 31.08.2011.

Supporting

1. Shri Kewal Prasad, Skilled Support Staff superannuated on 31.10.2011.
2. Shri Hari Prasad s/o Shri Ram Charan, Skilled Support Staff superannuated on 31.07.2011.
3. Shri Mishri Lal Rawat, Skilled Supporting Staff superannuated on 29.02.2012.

Obituary

1. Shri Ram Chandra S/o Janaki, Skilled Support Staff expired on 07.05.2011.
2. Shri Nanha Lal S/o Durjan skilled support staff expired on 13.08.2011.

3. RESEARCH ACHIEVEMENTS

Crop Improvement and Biotechnology

Mango (*Mangifera indica* L.)

Germplasm collection, characterization, evaluation and documentation

Collection: Twenty one trait specific germplasm accessions of mango were collected from Kushinagar, Barabanki and Goa. Thirty four accessions, *viz.* Ali Bux, Aman, Babul Pasand, Baramasi CISH, Baramasi, Bhari, Burhanguti, Gopal Bhog, Jagatramani, Kalam-e-Hindustan, Kaccha Mitha, Musharad, PFN-10, Peanfuly, Sada Bahar and nineteen promising mango hybrids, were planted in the field gene bank. A total of 742 accessions are presently in the field gene bank.

Characterization: One hundred and eight seven accessions were evaluated for fruit characteristics. Fifty five accessions were also characterized for DUS parameters that also included inflorescence characteristics.

Molecular Characterization

SSR characterization: Six SSR primer pairs (di, tri and tetra nucleotide motifs) were evaluated for their discrimination potential. Forty eight mango accessions were analyzed by fragment analysis for loci *Mi*SHRS 1, 4, 18 , 23, 26 and 29 which generated alleles ranging from 100-275 bp.

Characterization using trnL-F regions: Chloroplast genes were used as markers for studying molecular evolution and development of barcodes. *trn*L and trnF consensus primers for amplification of genes representing transfer RNA for leucine and phenyl-alanine, respectively, were evaluated for detection of intra-specific variations and cultivar identification in mango cultivars. Standardization of PCR conditions and reaction composition were carried out to amplify 600 bp and 400 bp products, respectively. Sequence characterization of *trn*L and *trn*F genes in 8 mango cultivars revealed indels and SNPs based on multiple sequence alignment and phylogenetic analyses by ClustalW (Fig. 1). Parentage and ancestry could also be confirmed as seen in phylogenetic tree (Fig. 2). Transcript sequences of expressed and sequence characterized trnL and trnF genes were annotated and secondary structures were predicted. Unique base sequence was identified to be varying in 8 mango cultivars forming a stem-loop configuration in tRNA-leucine (Fig. 3).

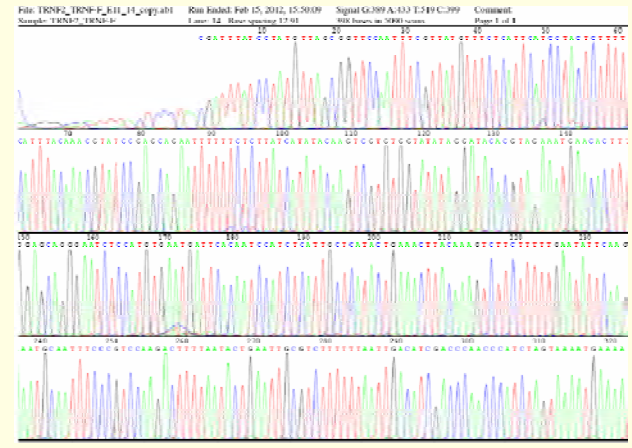


Fig. 1: Sequencing of *trn*F gene in mango cv. Dashehari.

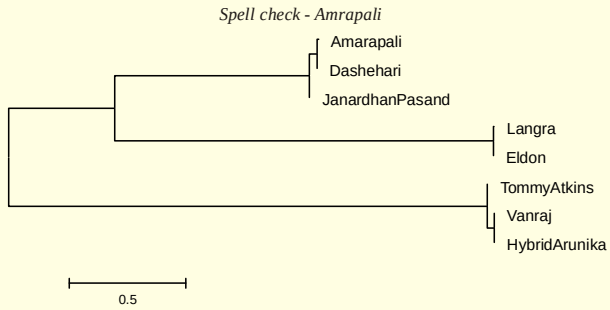


Fig. 2: Phylogenetic tree of nucleotide sequences of trnF gene in 8 mango cultivars.

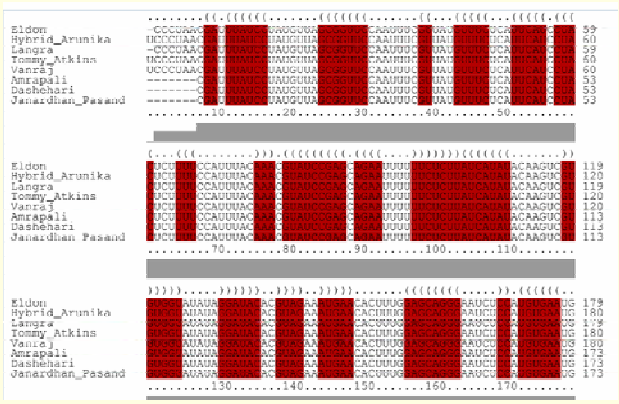


Fig. 3: Multiple sequence alignment of RNA sequence of tRNA-Leu in 8 mango cultivars.

Development of isolation protocol for chloroplast DNA. A new protocol for isolation of chloroplast DNA involving a special step of organelle isolation after which the genomic DNA was isolated from mango

was developed. The protocol provided an yield ranging between 100-150 ngµl^{-1} from 100g of leaf tissues, which was validated in other fruit crops like guava, jamun and litchi. The quality of the DNA was also observed on 0.8 per cent agarose gel from 8 mango cultivars using this protocol (Fig. 4). The quatity of template used for characterization of mango cultivars using chloroplast genes was minimized to 1/4th for PCR reactions of chloroplast genes. PCR conditions were optimized to be 3mM MgCl2, 0.2 mM dNTP, 50 ng DNA, 0.5 µM primers and 0.5 U *Taq* DNA polymerase. PCR conditions for amplification of *trn*L and trnF genes were optimized at 51.8 and 49.9 ^{0}C annealing temperatures.

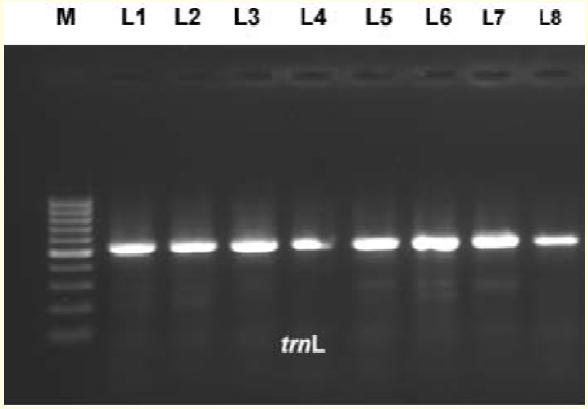


Fig. 4: Agarose gel profile of amplification of trnL gene using cpDNA as template.

L1: Amrapali, L2: Dashehari, L3: Langra, L4: Tommy Atkins, L5: Eldon, L6: Vanraj,

L7: Janardhan Pasand and L8: Arunika.

Physical mapping of chloroplast genes: Mapping the physical positions of certain chloroplast genes, *viz. trn*L, *trn*F, *pet*B-*pet*D and *atp-rbc*L, using partial chloroplast genome reported in mango for sequence alignment and then positioning the genes was undertaken. The partial chloroplast genome consisted of a partial LSC, complete IR and SSC regions. The conserved domains were used as the motif to align the genes and positioning them exactly on the mango partial chloroplast genome. The linear map of chloroplast could position the inverted regions A and B flanked by *trn*L and *trn*F on the two sides (Fig. 5). Two other genes, *viz. pet*B-*pet*D and *atp-rbc*L, were placed ahead of trnL. This mapping was an effort towards understanding of the molecular phylogeny using cpDNA markers and is expected to be a valuable tool for developing sequence based markers for cultivar identification.

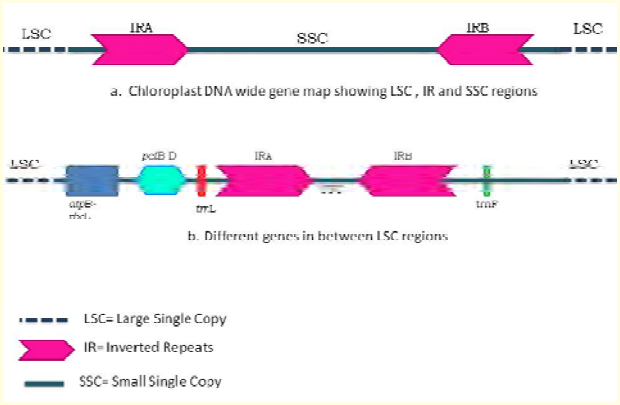


Fig. 5: Physical map of trnL, trnF, petB-petD, atp-rbcL genes on chloroplast DNA.

Development of RNA extraction protocol for transcriptome analysis: Total RNA isolation protocol was optimized from tissues of leaf, inflorescence and fruit at different phenological stages in mango by Trizol method, which yielded 300-500 ngµl^{-1} RNA. The purity index (A_{260}/A_{280}) was found to range between 1.9-2.0 using UV-spectrophotometry. The quality of RNA at different phenological stages on agarose gel is shown in Fig. 6. RAflex kit yielded high quality and quantity of RNA within 4 h. The purity of RNA was affirmed from RIN values (>7.0) for Real time PCR and transcriptome analysis.

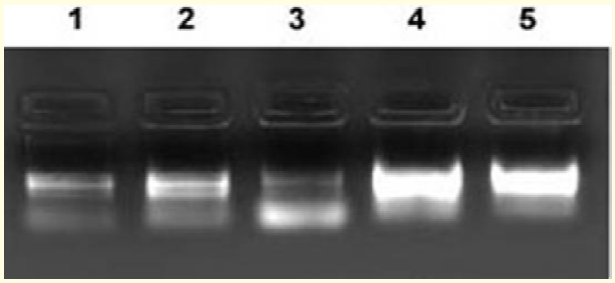


Fig. 6: Quality of RNA at different phenological stages.

1. RNA from flowers with late inflorescence, 2. RNA from leaves of plants with late inflorescence, 3. RNA from leaves of new flush/shoots, 4. RNA from leaves of shoots which had flowering but no fruit set, 5. RNA from leaves of shoot under fruiting.

Identification of genomic regions for peel colour: Studies of different key biosynthetic pathways in plants have linked biochemical variability to cloned structural and regulatory genes. This strategy was utilized for confirming presence of genomic regions responsible for phenotypic expression of mango fruit peel colour. Anthocyanin pigmentation is responsible for peel colouration in coloured mango cultivars with chalcone synthase (*CHS*) and anthocyanidin synthase (*ANS*) genes functionally active/operative at precusor and penultimate steps of flavonoid biosynthetic pathway.

Three primers were synthesized for *ANS* gene of which primer pair ANSF2/ANSR2 could be validated in a set of 8 mango samples. Two primer pairs of anthocyanidin synthase and chalcone synthase were designed using online bioinformatics tools and PCR conditions were optimized and validated for the amplification of these genes. Even though primers targeting *ANS* genes were designed using consensus sequences from Sapindales, the amplified fragments could not be sequence characterized due to heterogeneity of cloned fragments. Variations in chalcone synthase also could not be identified due to small size of sequenced fragment (Fig. 7).

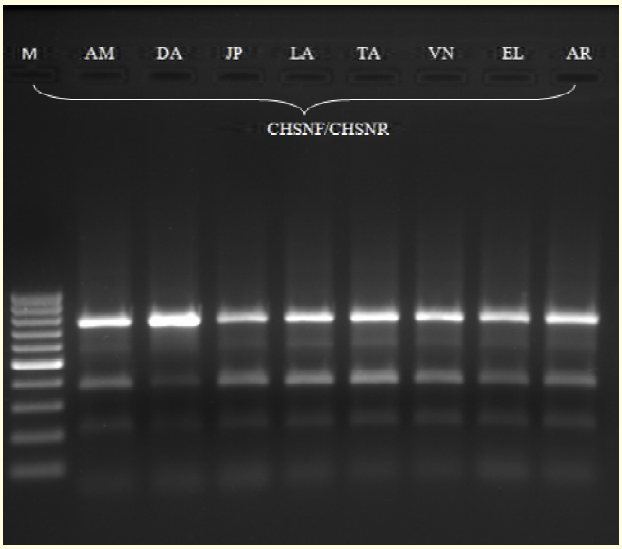


Fig. 7: PCR validation for CHS gene.

M: Marker; AM: Amrapali; DA: Dashehari; JP: Janardhan Pasand;

LA: Langra; TA: Tommy Atkins; VN: Vanraj; EL: Eldon and AR: Arunika.

Identification of regulatory genes controlling flowering: Constans (CON), leafy (LFY) and flowering time (FLT) are the reported major transcription factors controlling flowering in different crop plants. Two primer pairs (*CON* F1/R1 and *CON* F2/R2) were designed using *CONSTANS* gene information of Zihua mango. The presence of the gene was validated in 48 mango varieties using *Con*F1-R1 primer pair, confirming its role in flowering regulation. PCR products were gel eluted, purified, sequence characterized and confirmed by blast analysis. Sequence of CON gene of mango cv. Amrapali is shown in Fig. 8. Similarly, primers for *LFY* and *FLT* genes were designed using sequence information from order Sapindales and validated in 5 mango varieties.

Structural modelling of 5 mango leafy proteins from the amino acid sequences available in NCBI was carried out using leafy protein template of *Arabidopsis*. The structural modelling revealed unique domains in leafy proteins, which could be attributed to their regulatory function in flowering.

Fig. 8: Leafy protein structure.

Molecular characterization of mango varieties for Rubisco and Rubisco activase genes: Rubisco and Rubisco activase are the important enzymes involved in carbon dioxide fixation and of late ascribed to climate resilience. The gene for larger subunit of Rubisco is present in chloroplast while the smaller subunit lies in the nucleus. Two primer pairs for amplification of rbcL (*rbc*LF1/R1, *rbc*LF/R) gene in mango were designed using sequence information in fruit crops for Rubisco larger subunit. The *rbc*L primer pairs (*rbc*LF/R, *rbc*LF1/R1) amplified 600 to 750 bp

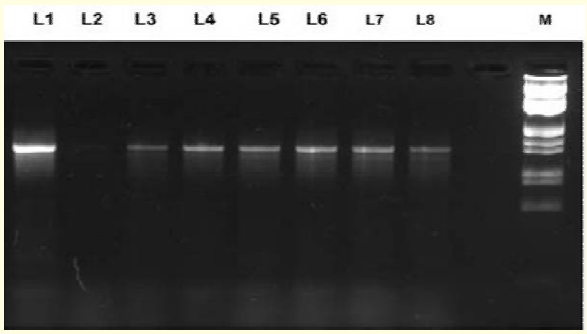


Fig. 9: Agarose gel profile of amplicons of rbcL in 8 mango cultivars using rbcLF1/R1 primer pair.

M: Marker (Lambda DNA/Eco RI/Hind III double digest)

L1: Amrapali, L2: Dashehari, L3: Langra, L4: Tommy Atkins, L5: Eldon, L6: Vanraj,

L7: Janardhan Pasand, L8: Arunika.

fragments (representing partial *rbc*L gene) and new set of primers (*rbc*F2/R2) were designed for amplifying complete fragment of rbcL gene (Fig. 9). Another primer pair (rcaF/R) was designed for amplification of Rubisco activase (*rca*) genes. Twenty mango varieties were characterized for rbcL and rca genes, which produced amplicons of 1200 and 1500 bp, respectively and were used for sequence characterization to detect sequence based variations.

Evaluation: Among seven mango varieties/hybrids evaluated for the preparation and storage of pulp, Amin Khurd was found the best followed by H-2113 and H-2154 for preparation of RTS beverage after 6 months of pulp storage. Four hybrids were evaluated for pickle in oil over 6 months storage, H-2108 followed by H-1394 was found better organoleptically.

Hybridization and evaluation of progenies

Hybridization: Ten cross combinations using known described donors were adopted to cross 23188 flowers on 5423 panicles for developing varieties with specific traits like regular bearing, peel colour, dwarfing, etc. (Table 1). A total number of 1062 seeds of mango hybrids were obtained from the crosses made during 2010-2011 and 708 recombinants obtained. However, fruits could not be obtained from four cross combinations (Table 2).

Table 1: Parental combinations involved in hybridization during the year 2011-2012

Sl. No.	Cross combination	Panicles (No.)	Flowers (No.)
1	Amrapali x Sensation	1150	5440
2	Amrapali x Tommy Atkins	0750	3545
3	Dashehari x Ambika	0300	1361
4	Dashehari x Arunika	0600	2236
5	Dashehari x Sensation	0350	1577
6	Dashehari x Tommy Atkins	1000	3838
7	Dashehari x Vanraj	0500	1802
8	Neelum x Arunika	0200	1000
9	Neelum x Sensation	0100	0334
10	Neelum x Tommy Atkins	0473	2055
	Total	**5423**	**23188**

Establishment of hybrids: One hundred and fifty two hybrid seedlings raised from 21 hybrid combinations attempted in 2009-10 were planted in the field for evaluation of F1 progenies, targeting improvement of

Table 2: Raising of hybrid seedlings for evaluation from crosses of 2010-11

Sl. No.	Cross combination	Panicles used (No.)	Flower crossed (No.)	Fruit harvested (No.)	Stone germinated (No.)
1	Amrapali x Arunika	0530	2325	013	005
2	Amrapali x Sensation	1055	4915	152	134
3	Amrapali x Tommy Atkins	0245	1114	003	002
4	Arunika x Chausa	0304	1265	009	001
5	Dashehari x Ambika	0409	1884	072	041
6	Dashehari x Arunika	2353	9578	114	058
7	Dashehari x Sensation	1206	4371	191	123
8	Dashehari x Tommy Atkins	1590	5422	181	124
9	Dashehari x Vanraj	1600	6292	086	060
10	Elaichi x Arunika	0753	2571	136	093
11	Elaichi x Tommy Atkins	0197	0640	050	031
12	Mallika x Arunika	0236	0958	000	000
13	Mallika x Tommy Atkins	0151	0584	011	002
14	Neelum x Sensation	0200	0757	005	003
15	Neelum x Tommy Atkins	0200	0873	018	018
16	Neelum x Vanraj	0174	0711	021	013
17	Totapuri x Vanraj	0077	0235	000	000
18	Totapuri x Arunika	0170	0472	000	000
19	Totapuri x Tommy Atkins	0150	0470	000	000
	Total	**11600**	**45437**	**1062**	**708**

few traits, *viz.* quality, peel colour, dwarfing, abiotic resistance in rootstock and malformation resistance.

Evaluation of hybrids: Nine hundred hybrid seedlings were evaluated for fruit weight, length, width and thickness, peel weight, stone weight, pulp per cent, stone length, width and thickness and TSS.

Rootstock standardization

One hundred and forty seedlings of 32 polyembryonic mango germplasm accessions were raised in polybags. Chloride salinity gradients (1, 2, 4 and 6 EC dSm^{-1}) using NaCl were created. The polyembryonic mango seedlings, *viz.* Bappakai, Goa, Kurukkan, Mylepelian, Muvandan, Nekkare and Vellaikulamban, were evaluated for morphological and physiological parameters. Nekkare and Kurukkan showed maximum membrane stability index as compared to other polyembryonic mango cultivars up to 91 to 94. The chlorophyll fluorescence (Fv/Fm) was also maximum in Nekkare. Root and shoot weight were maximum in Nekkare and minimum in Bappakai. Nekkare and Kurukkan also showed maximum tolerance to salinity stress and survived up to 2 dsm-1 level. Leaf water potential decreased in all the germplasm accessions gradually with increasing salinity levels.

Cataloguing of Indian mango varieties

A catalogue of 184 indigenous mango varieties (volume - 1) giving morphological descriptions of tree, leaf, fruit together with DNA barcode and details of curators was brought out both in hard and soft copies; the full information of which is also available in www.cishlko.org in the public domain.

Guava (*Psidium guajava* L.)

Germplasm collection, characterization and evaluation

Twenty trait-specific accessions, nine from Rewa, six from Satna, five from Jhansi were collected. Sixteen accessions were planted in 2011 raising the status of FGB to one hundred and twenty accessions that also included six *Psidium* species. AC-3, Bar of Khan, Chittidar, CISH-GS-9, K G Guava, Oval Pink, Portugal, R-2-13, R-2-31, Sangam, Sindh, Sindhu, Spear Acid, Superior, T-42/2 and Waikea were added to the field gene bank during the period. For consolidation of field gene bank, 31 accessions were propagated on the interspecific wilt resistant rootstock (*P. guajava* x *P. molle*). Twenty six accessions were characterized for fruit characteristics. Flowering characters of 12 accessions were evaluated on the basis of DUS guidelines. Four guava selections were evaluated for the preparation of pulp and RTS beverage. Allahabad Safeda seedling contained higher ascorbic acid (164 mg $100g^{-1}$) and the beverage prepared from it was the best organoleptically.

Molecular characterization

SSR markers were utilized for mapping of the progenies obtained (Shweta, CISH G-2 and Lalit crossed with Purple Guava). One SSR primer was designed using websat tool from 58 sequences of *Psidium* spp, which amplified products (190 to 200 bp) and validated in hybrid progeny of Lalit x Purple Guava (Fig. 10). Primers, *viz.* m*Pg*CIR7, 9, 16 and 19, were found polymorphic yielding polymorphic profiles for the mapping population. Recovery of Purple Guava type alleles in the crosses indicated operation of a mechanism favouring these alleles which were

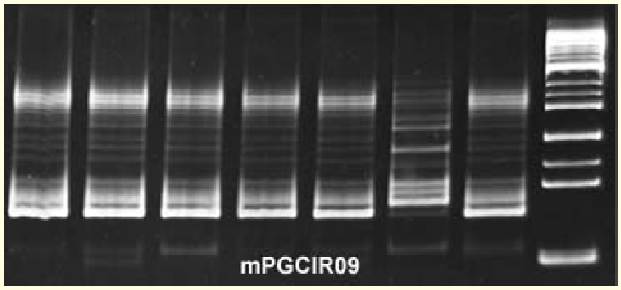


Fig. 10: Purple Guava hybrids with G2 characterized with m*Pg*CIR 09 marker.

supported by the phenotypic expression. A maximum of 3 alleles could be amplified by 7 SSR loci (Table 3).

Physical mapping of chloroplast genome: Eighteen chloroplast gene sequences of *Psidium* species were retrieved from NCBI and multiple sequence alignment was performed with *Syzygium cumini* complete cp genome, in order to locate the physical position of the genes. Chloroplast genes *trn*L, *pet*B, *pet*D, *rbc*L and *trn*M were mapped in the circular map using DNA Plotter (Fig. 11). Comparative analysis showed synteny with citrus and grapes cpDNA.

Table 3: SSR loci polymorphism in Lalit x Purple Guava mapping population

SSR Locus	Allele (No.)	Observed Allele size (bp)	Expected Allele size (bp)	Type of Allele	Genotype configuration						Elite band
					L	PG	H1	H2	H3	H4	
m*Pg*CIR05	2	250-270	224-280	ab	ab	ab	ab	ab	ab	ab	-ve
m*Pg*CIR07	2	150-170	148-160	ab	ab	ab	ab	ab	ab	ab	-ve
m*Pg*CIR09	3	150-190	156-176	abc	bc	ab	ac	ab	ac	ac	+ve
m*Pg*CIR10	2	240-290	262-320	ab	ab	ab	ab	ab	ab	ab	+ve
m*Pg*CIR11	3	290-320	298-314	abc	ac	ab	ac	ab	ab	bc	+ve
m*Pg*CIR16	3	290-310	268-296	abc	ac	ab	ab	ac	ac	ab	+ve
m*Pg*CIR19	3	250-450	258-280	abc	ac	ab	ab	ab	ab	ac	+ve

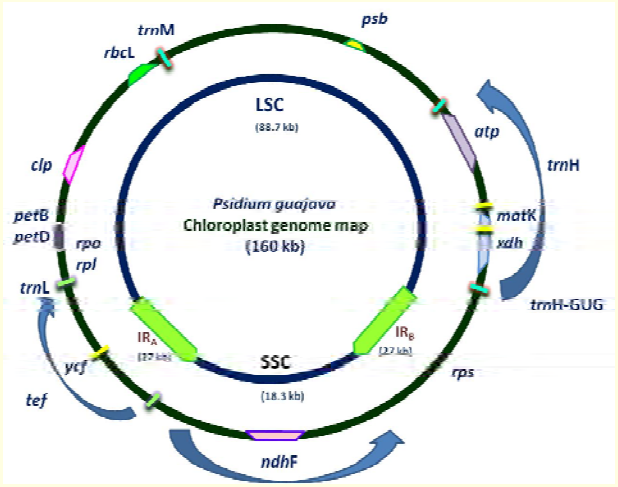


Fig.11. Circular chloroplast genome map of *Psidium guajava.*

Hybridization and evaluation of progenies

In order to integrate genes responsible for anthocyanin synthesis in pulp matrix eight cross combinations, *viz.* CISH-G-1 x Purple Guava, CISH-G-5 x CISH-GS-9,CISH-HG-410 x CISH-G-1,CISH-HG-415 x Lalit, Lalit x CISH-G-1, Lalit x CISH-GS-9, Lalit x Purple Guava and Shweta x Lalit were attempted. A total number of 409 hybrid plants comprising the cross combinations of Lalit x Purple Guava (305), Shweta x Lalit (56) and Shweta x Purple Guava (48) were planted in the field. One hundred and forty six hybrids of guava were characterized for fruit weight, TSS, skin and pulp colour and yield. Crosses from Lalit and Purple Guava produced majority of the hybrid progenies with pink pulp. The pulp colour since is linked to seed hardness, hybrid progenies segregated for seed hardness. Out of 146 hybrids, hardness of the seeds in 6 hybrids ranged between 8.11 -9.45 kg cm^{-2}.

Genetic transformation of guava

Assessment of lethal dose of kanamycin: The data revealed that complete mortality of guava plantlets was observed in 200 and 300 mg l^{-1} of kanamycin in 8 weeks. However, at lower kanamycin concentration (50 mg l^{-1}) about 50 per cent plantlets survived till 8 weeks. There was no difference in lethality effect between 200 and 300 mg l^{-1} kanamycin on guava explants. Two hundred mg l^{-1} kanamycin was ideal for selection of guava transformants for 8 weeks.

Genetic suitability of explant for genetic transformation: The of 908 explants of guava (callus and shoot tips) subjected to genetic transformation, only 445 explants survived after *Agrobacterium* infection. The callus targeted with *Agrobacterium* harbouring *endochitinase* gene gave rise to 12 independent transformants. However, gene integration was found lower in shoot tips (06). The explants were wounded with 100 mg carborendum for five minutes prior to infection with *Agrobacterium* harbouring *endochitinase* gene for 45 minutes followed by co-cultivation for 72 hours under dark conditions. All the explants were selected in 100 mg l^{-1} kanamycin for 2 months. A total of 300 explants survived at this concentration. When selection pressure was enhanced to 200 mg l^{-1} kanamycin for one month only 60 explants survived and rest of the explants bleached out. Upon further elevated selection pressure (300 mg l^{-1}), only 18 plants could survive accounting for both type of explants. These plants were rooted and acclimatized (Fig. 12). The kanamycin resistant acclimatized plantlets of guava are being challenged with *Fusarium oxysporum* under in vitro condition to screen the resistant plantlets.

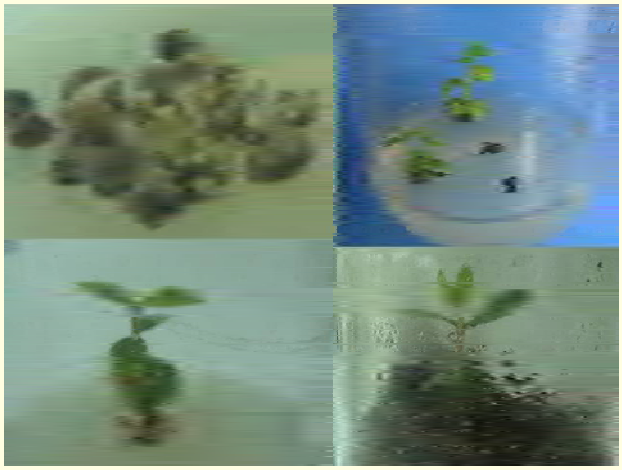


Fig.12: Genetic transformation of guava with *endochitinase* gene.

Micro-propagation of wilt resistant guava: Efforts were made to collect and inoculate nodal shoot explants of hybrid guava rootstock (*Psidium guajava* x *P. molle*) each month which revealed (Fig.13) that explants obtained during April to June showed less oxidative browning (20%), lower fungal infection (25%), higher expalnt survival (55%) and higher explants induced buds (54%) under *in vitro* conditions. The least responsive

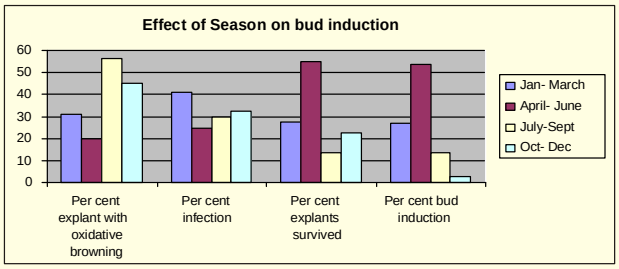


Fig.13: Effect of season of explant collection on micro-propagation of wilt resistant hybrid rootstock

months for explant collection were October to December and only 3 per cent of explants collected induced buds under *in vitro* conditions (Fig. 14). Proliferation ability of hybrid guava rootstock was found low. The best response was observed when shoots were inoculated on MS medium fortified with 4 mg l^{-1} benzyleaminopurine, which gave rise to 2.7 micro shoots per explant. Five micropropagated plants of wilt resistant guava rooted and were acclimatized as nurse culture for further micropropagation studies.

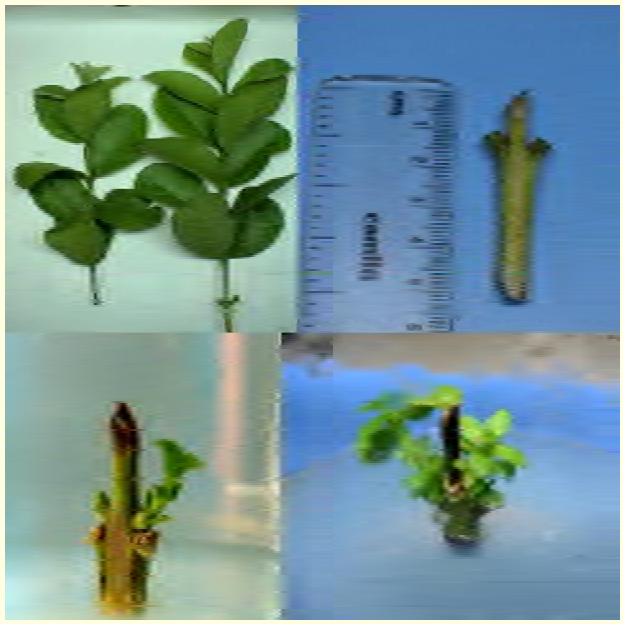


Fig. 14: *In vitro* bud induction from shoot explants derived from March flush.

Papaya (*Carica papaya* L.)

Germplasm evaluation and characterization

Sibmating of candidate/elite plants: Papaya seeds were produced by controlled pollination to maintain genetic purity of identified lines. 12 cultivars/accessions of elite types were sibmated for production of true to type seeds of individual cultivars/accessions. Out of 567 flowers sibmated 285 flowers set fruits (50.26 %). Seed weight varied from 8.649 to 2.216 g^{-1} fruit. The seeds were extracted and stored in airtight containers at low temperature.

Growth and fruiting behaviour: The maximum plant height (2.55 m) was recorded in accession Samrat followed by Farm Selection (2.45 m) and the plant girth was maximum (0.50 m) in accession Samrat followed by Red Lady (0.45 m). The canopy spread in N - S (2.25 m) and E - W (2.55 m) direction were maximum in CO-7. The minimum height at first fruiting was 0.50 m in Pusa Nanha followed by 0.56 m in Pusa Delicious.

Fruit yield and quality: Maximum fruit yield (67.82 kg $plant^{-1}$) was recorded in cv. Pusa Delicious. The average fruit weight was maximum (2.950 kg) in Pusa Delicious followed by CO - 7 (2.845 kg). Maximum TSS (12.2^{0}Brix) was recorded in fruits of Pusa Delicious followed by Arka Prabhat (12.0^{0}Brix). The maximum seed cavity was noted in accession Samrat (10.55 cm), while it was minimum (6.50 cm) in Arka Prabhat. These results are the outcome of first generation submitting.

Genetic transformation for PRSV resistance

Transgenics development: A total number of 3127 embryonic explants infected for 30 min with (*Agrobacterium tumefaciense* harbouring *coat protein* and *replicase* gene) followed by co-cultivation for 72 hours under dark in the presence of 100 µM acetosyringone and pretreatment with 1mM spermidine gave 252 kanamycin (150 mg l^{-1}) resistant plants. *Agrobacterium* was controlled using 250 mg l^{-1} cefotaxim and 250 mg l^{-1} streptocyclin. The kanamycin resistant embryos were converted into plantlets. A total number of 14 plantlets were regenerated, acclimatized and transferred under containment facility for further evaluation.

Evaluation: Five T1 plantlets were screened under containment facility for resistance to PRSV. The plantlets were challenged four times with local strain of PRSV using sap flow transmission. Almost all the T1 showed delayed symptoms of PRSV than control. The expression of PRSV was delayed by 3 - 4 months in all the transgenic lines. However, broad spectrum resistance against PRSV could not be achieved.

Litchi (*Litchi chinensis* sonn.)

Molecular phylogeny and fingerprinting

Twenty litchi germplasm accessions received from NRC Litchi, Muzaffarpur were characterized using 6 SSR primers Lit 23, 24, 25, 27, 28 and 30, which generated alleles in the range of 118 -241bp and this information was used for diversity analysis. Diversity analysis, based on 187 markers including ISSR and SSR loci, revealed grouping of cultivars in to four clusters Shahi, China, Bedana and Longia group (Fig. 15 and 16).

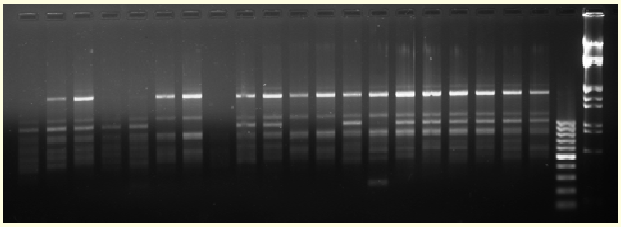


Fig. 15: Agarose gel profile of 20 litchi cultivars by ISSR13.

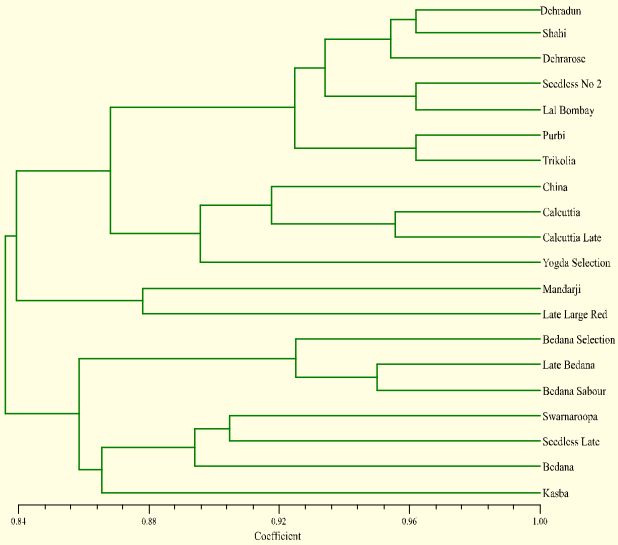


Fig. 16: Phlyogenetic tree of 20 litchi cultivars

Aonla (*Emblica officinalis* Gaertn.)

Germplasm management and Evaluation

Evaluation of twenty two accessions of aonla collected from different parts of Madhya Pradesh field planted along with five known commercial check varieties, *viz*. NA-7, NA-6, Krishna, Kanchan and Lakshmi-52, was carried out. Maximum plant height (6.16m) was attained by CISH-A-4 followed by CISH-A-15 (6.12m), while minimum plant height (1.85m) was noted in check NA-6. The maximum plant girth (65.0cm) was recorded in CISH-A-30 while minimum (20.0cm) in cv. NA-6. Maximum plant spread (7.0m and 8.2m) in both the directions was recorded in accession CISH-A-12, while minimum (2.09m and 2.01m) in CISH-A-24.

Out of the twenty two accessions, nine accessions came into fruiting. Maximum fruit yield (5.64 kg tree-1) was recorded in CISH-A-4 followed by CISH-A-12 (5.45 kg $tree^{-1}$), while minimum (2.42 kg $tree^{-1}$) in CISH-A-12 during the second year of fruiting. The fruit weight varied from 27.60 to 35.10 g among different accessions, being maximum in CISH-A-12. Higher fruit weight in accessions CISH-A-1 (32.5 g), CISH-A-2 (34.4 g), CISH-A-13 (34.5g) was recorded. Variations in fruit length (3.82 to 4.63cm), fruit breadth (3.45 to 4.10cm) and stone weight (1.38 to 1.60g) were recorded in different accessions. The TSS content ranged from 9.2 to 10.8^{0}B, acidity from 1.84 to 3.07 per cent and ascorbic acid from 239.1 to 629.8 mg $100g^{-1}$, polyphenols from 1.35 to 3.99 per cent and antioxidant activity from 110.9 to 121.3 mg g-1 (FRAP) activity among the different accessions analyzed. Maximum ascorbic acid content was recorded in CISH-A-19 followed by CISH-A-1 which showed that these accessions are potential genetic resources for development of aonla cultivars for higher nutraceutical values.

Bael (*Aegle marmelos* Correa.)

Germplasm management and evaluation

Thirty six clonally multiplied bael accessions were planted in the field gene bank for evaluation. Plant height varied from 2.15 to 3.99 m, stem girth from 21.00 to 41.0 cm and plant spread in E-W direction from 1.52 to 3.15 m and N-S direction from 1.56 - 3.19 m. Twelve accessions came to fruiting and fruits were analyzed for physico-chemical parameters. The variations in fruit weight (0.67 to 2.30 kg), fruit size (7.7 to17.5 and 29 to 61cm), number of seeds per fruit (33 to 200), number of seed sacs (9 to 20), shell weight (0.10 to 0.53kg), shell thickness (2.0 to 4.8mm), TSS (26 to 440B), acidity (0.30 to 0.56%), vitamin C (5 to 18 g 100 g-1 pulp), total carotenoids (1.38 to 2.72 mg 100g-1 pulp), total sugars (13.58 to 25.53%) and tannins (2.01 to 4.53%) were recorded among different accessions.

A total number of 151 seedlings raised from promising bael germplasm collected from U.P., Bihar and Jharkhand were planted during the year 2003. These seedlings were evaluated for their growth characteristics. The plant height varied from 2.40 to 7.10m, girth from 12.00 to 63.0 cm and tree volume from 6.17 to 16.80m. Fifteen accessions came to fruiting and fruit number varied from 14 to 54 fruits per tree.

Jamun (*Syzigium cumini* Skeel)

Germplasm management and evaluation

Genetic variability assessment: Genetic diversity among the twelve jamun accessions was assessed by PCR-based markers (RAPD, SSR and DAMD). Nineteen different RAPD primers of the OPA, OPB, OPX, OPD and OPG series were used initially to amplify the genomic DNA and 10 selected for further analysis as they presented clear and unambiguous pattern. A total of 110 fragments were generated, and out of these 86 were polymorphic. The number of bands produced by each primer varied from 6 (OPB-12 and OPG-13) to 17 (OPG 3) with an average of 11 per primer. Jaccard's genetic distance coefficient analysis and similarity among accessions ranged between 0.612 (CISH J-42 and PKM) to 0.903 (J -34, J-37 and PKM). The dendogram separated the genotypes into three main clusters according to their geographic origin (Fig. 17). CISH J-37, CISH J-23 and J-34, which are selections from Lucknow region, share high similarity while Konkan bahadoli (KB) and Godhra (GS) are

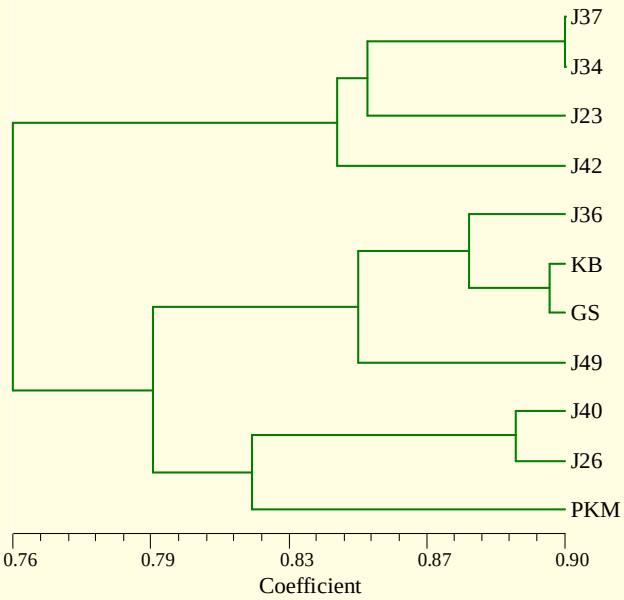


Fig. 17: Phylogenetic tree of selected jamun accessions based on RAPD markers.

selections from western India having 89% similarity, indicating common gene pool of origin.

Evaluation: Thirty five accessions were collected from different parts of the country and planted in FGB. Morphological studies on fruits among eight accessions of jamun showed that CISH J-37 recorded maximum fruit weight (24.35 g), fruit length (3.95 cm), fruit breadth (2.86 cm), pulp content (92.50 %) which was next to CISH J-42 (97.60 %) which also recorded the highest pulp content. Total soluble solids in different accessions varied from 8.00 to 20.400Brix. Methanolic extracts of Syzygium cuminii seed was found to be bioactive. Two bioactive compounds SC-01 (Maslinic acid) and SC-02 (Oily compound) were isolated by using Bioactivity guided fractionation. New Ellagic acid derivative (SC-03) has been isolated (via Aldose reductase and PTP-1B assay).

Crop Production

Mango (Mangifera indica L.)

Planting density

Effect of planting density on vegetative growth and fruiting: In a 19-year old Dashehari orchard planted at different densities (1600, 800, 400, 266, 178 and 100 plants ha^{-1}), observations on vegetative growth parameters showed maximum tree height (5.55 m) in

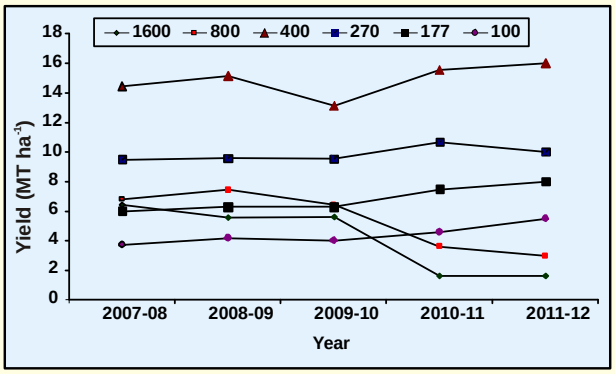


Fig. 18: Yield pattern in high density planting of mango cv. Dashehari.

the highest planting density (1600 plants ha^{-1}) followed by 5.45 m in 800 plants ha^{-1} and minimum (4.90 m) in the conventional density (100 plants ha^{-1}). Maximum fruit yield (16.0 t ha^{-1}) was recorded in medium density (400 plants ha-1) followed by 10.0 MT ha^{-1} of 267 plants ha-1 and the least (5.5 MT ha^{-1}) in conventional density (100 plants ha -1). Yield pattern in different densities during last five years is depicted in Fig. 18.

Effect of planting density on interception of solar radiation : Solar radiation interception below the canopy was maximum (1153 mol m^{-2} yr^{-1}) in 100 plants ha^{-1} while it was 990 mol m^{-2} yr^{-1} in 400 plants ha^{-1} and minimum (768 mol m^{-2} yr^{-1}) in density of 1600 plants ha^{-1}. A high degree of negative correlation (r = -0.76) between LAI and total radiation below canopy was computed. Radiation interception above canopy in medium density (400 plants ha-1) was higher (17752 mol m^{-2} yr^{-1}) as compared to 8525 mol m-2 yr-1 below the canopy.

Light interception as influenced by branch angle within the canopy in relation to fruit yield: Observations on the fruit production in canopy quadrants revealed that South-East (S-E) quadrant of canopy was more productive (32.41 % of total production) as compared to other quadrants (N-W, 18.75 %; S-W, 24.73 % and N-E, 24.09 %). Production potential of canopy quadrants was correlated with gap fraction and it was observed that diffused radiation below canopy was highest, while LAI was the least at 135-180o azimuth angles.

Effect of planting systems: The experiment on high density-cum-planting system in cv. Dashehari with 5 planting systems, *viz.* square, hedge row, double hedge row, paired and cluster system of planting, showed maximum tree height (2.90 m) in double hedge row system followed by hedge row system (2.85 m) and minimum (2.70 m) in square system. Similarly, the highest fruit yield (8.40 MT ha^{-1}) was also recorded in double hedge row system followed by hedge row system (6.50 MT ha^{-1}) and minimum (4.10 MT ha^{-1}) in the square system.

Integrated plant nutrient management

Non-bearing orchard: The experiment on integrated nutrient management in mango cv. Dashehari comprising 18 treatments was started during 2007 and was in the sixth year of progress. Maximum plant height (3.3 m) was recorded in 5 kg FYM + 5 kg vermicompost + 100, 50,100 g N, P, K $tree^{-1}$ $year^{-1}$ of age + *Azotobacter* + PSM + *Trichoderma harzianum* + organic mulch, while maximum canopy spread (4.2 m E-W) and stem diameter (14 cm) were recorded in 10 kg FYM + 50 g N + 25 g P + 50 g K $tree^{-1}$ $year^{-1}$ of age. The fruiting was observed in the fifth year, however, the yield was very low and non-significant. Organic carbon content was low (0.34 to 0.47 %) in all the treatments irrespective of organic matter addition. Maximum organic carbon buildup (0.47%) was recorded in the treatment 10 kg FYM + 100, 50,100 g N, P , K $tree^{-1}$ $year^{-1}$ of age + *Azotobacter* + PSM + *Trichoderma harzianum* + organic mulch as compared to where FYM or vermicompost was added (0.34%). Available N was also low (44.8 to 61.7 ppm) in all the treatments because of coarse textured and low organic carbon content nature of the soil. Available P was in medium to high range (15.6 to 25.8 ppm) in all the treatments. The lowest available P was recorded in the treatment where P was not applied. All the micronutrients, Fe, Mn, Zn and Cu, were observed in sufficient range in all the treatments. Treatments having FYM or vermicompost recorded higher amounts of micronutrients. DTPA extractable Fe, Mn, Zn and Cu contents were the lowest (4.9, 5.4, 0.63 and 0.87 ppm) in the treatments where no organic matter was supplemented. Both macro as well as micronutrient contents increased in the treatments which received FYM and / or vermicompost and NPK. The analysis of leaf samples showed that N, P, K, Fe, Mn, Zn and Cu contents in leaves under various treatments were in the optimum range and above the critical limits.

Bearing orchard: Effect of different integrated plant nutrient component was studied on cv. Dashehari in order to find out their effects on fruit yield, quality and leaf and soil nutrient status. The highest fruit yield of 15.85 MT ha^{-1} was recorded in the treatment NPK + Cu + B over control (8.25 MT ha^{-1}) indicating the essentiality of application of two micronutrients, *viz.* Cu and B, along with NPK for higher production. The

percentage of 'A' grade fruits (>250 g) increased significantly in the treatment NPK + Zn + B + Cu which are also very important from the market point of view and enhanced profitability. TSS and ascorbic acid contents were the highest (19.5 0 B and 40.5 mg 100 g^{-1}) in the treatment green manuring + NPK + Zn + Cu + Mn + B over the control (18.7 0 B and 25.5 mg 100 g^{-1}), however, the titratable acidity was not affected by any of the treatments.

Organic carbon content and available N build up in the soil under different treatments varied in a narrow range (0.52 to 0.64 % and 52.5 to 75.1 ppm). The treatment FYM + NPK + Zn + Cu recorded the highest organic carbon and available N in the soil. Available P and K were in medium to high range in the surface soil (0 to 30 cm) in all the treatments. Highest available K content (156.5 ppm) was recorded in the treatment ½ NPK + FYM + Bio. + Zn + Cu + Mn + B. DTPA extractable B, Zn, Mn and Cu contents in the surface soil of the tree basins were above the critical limits in all the treatments. The sub-surface soil recorded lower levels of all the macro- and micronutrients and organic carbon. The leaf tissue analysis showed that N, P, K, Fe, Mn, Zn and Cu contents of the leaves were in the optimum range in all the treatments, however, the concentration or the nutrient was higher wherever the respective nutrent treatment was applied.

Integrated water and nutrient management

Fertigation: A fertigation experiment was conducted to assess the spatio-temporal variations in soil water content and productivity of drip irrigated mango cv. Dashehari and Langra comprising of 5 treatments of NPK fertigation at different crop phenological stages. Higher moisture content was recorded in the surface layer (0 to 15 cm) and it decreased with the depth of soil. Higher moisture retention was observed in the treatment where fertigation was applied from September to second week of May, which coincided with the reproductive/vegetative crop phenological stages including fruit development. Statistically highest fruit yield (7.2 MT ha^{-1}) was obtained in fertigation with NPK from the beginning of September to the second week of May as compared to basin application (2.8 MT ha^{-1}).

Highest SOC and soil nutrients contents were observed in the NPK fertigation from the beginning of September to second week of May in cv. Langra. Organic carbon content ranged from 0.46 to 0.51 per cent at 0-25 cm soil depth and decreased to 0.24 per cent in 25 to 50 cm. Available P and K varied from 11.37 to 22.4 and 90 to 183 ppm, respectively. Zn, Cu, Fe and Mn concentrations were significantly higher in the fertigation treatment during the passage of major crop phonological stages as compared to the fertigation during the time of flowering and fruiting. The highest fruit yield (6.1 MT ha^{-1}) was obtained in fertigation with NPK from the beginning of September to second week of May as compared to basin application (3.6 MT ha^{-1}). TSS ranged from 17.6 to 18.50 B in ripe Langra fruits.

Understanding the mechanism of flowering

Dynamics of vegetative shoot in relation to flowering: In the dynamics of vegetative shoots associated with flowering, the vegetative flushing pattern varied widely during the year (2011-12) and the main flushing period was March to August with a peak in June (80%) in cv. Dashehari. In the flushes, it was noted that the earlier (before June) emerged shoots differentiated flower buds during the season in the range of 75 to 85 per cent. However, in Amrapali, a regular bearing hybrid, new vegetative growth was produced even up to March 2012 along with flowering which appear to contribute significantly to its regular bearing feature (Fig. 19). Maximum soil moisture content (28.60 to 29.33 %) was recorded at the soil depth of 30 to 60 cm, however, least fluctuations in the moisture content was recorded from the depth of 80 to 100 cm. Decreasing trend of soil moisture was noticed after the rainy season, *i.e.,* from the last week of September to December. Mineral composition of different vegetative flushes indicated that the content of Mg (0.2 to 0.45%), Fe (230 to 296 ppm), Mn (77 to 88 ppm) and Zn (15 to 34 ppm) increased progressively with leaf maturity and their levels were maximum during fruit bud differentiation. However, non-significant variations in leaf K and differentiative patterns in N content were brought out.

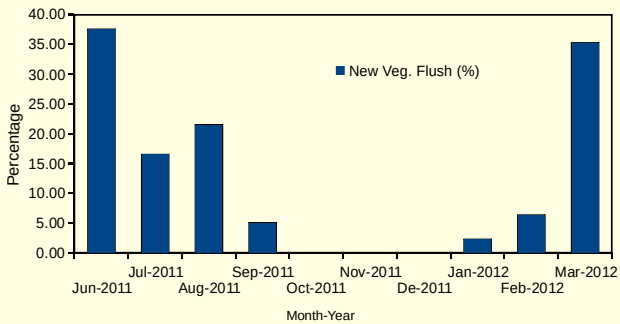


Fig.19: Percentage of new vegetative flush in mango cv. Dashehari.

Physiological and biochemical factors associated with flowering : Chlorophyll fluorescence (Fv/Fm), PSII and electron transport rate (ETR) measured from dark adapted leaves of Amrapali and Langra mango at different stages of flowering were substantially lower in the leaves proximal to flower buds than in leaves of vegetative terminals. The observed variations might be due to the differential water status of leaves (Fig. 20 & 21). Chlorophyll fluorescence was also measured at different stages of leaf development at different light intensities in Dashehari. The photo-oxidation of PS-II was minimum in young leaves at higher light intensities (>35 ^{0}C), which might be due to high concentration of anthocyanin as it might have protected the PS-II from the possible photo damage. Thus, the availability of new flushes with high anthocyanin content during high temperature periods might turn out to be useful to mango. Rubisco activity was higher (5.0 g m^{-2}) in mature green leaves as compared to the young leaves (1.5 g m^{-2}). The data of Rubisco indicated that while anthocyainin remained in the leaves, Rubisco protein content were very low, and when the leaf reached maturity, Rubisco protein content increased.

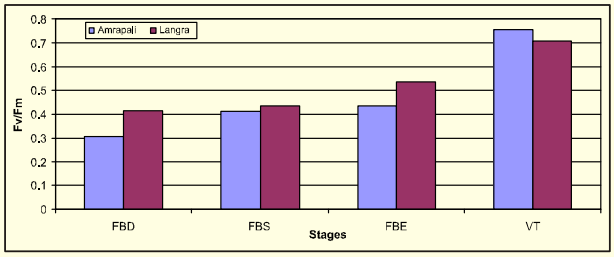


Fig.20: Chlorophyll fluorescence (FV/Fm) in the leaves of flowering and vegetative shoots of mango cv. Langra and Amrapali during different reproductive phases.

FBD: Flower bud differentiation, FBS: Flower bud swollen, FBE: Flower bud elongation, and VT: Vegetative terminal.

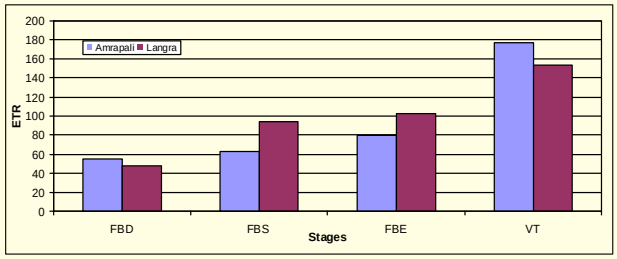


Fig.21: Electron transport rate (ETR) in the leaves of flowering and vegetative shoots of mango cv. Langra and Amrapali.

FBD: Flower bud differentiation, FBS: Flower bud swollen, FBE: Flower bud elongation and VT: Vegetative terminal

The level of cytokinins increased in the differentiating flower buds (750.0 to 801.0 ng g^{-1} FW) with paclobutarazol, whereas there was no significant change (318 to 345.74 ng g^{-1} FW) in the leaves of cv. Langra. The level of non-structural carbohydrate (NSC) fraction in the roots of Langra tree was higher (5042.52 µg g^{-1} FW) during the expected 'Off' year as compared to 'On' year (3812.38 µg g^{-1} FW) at early stages of flowering, whereas the difference in their levels reduced drastically (4135.0 to 4624.75 µg g-1) following fruit harvest. The differences in NSC was narrow in regular bearing hybrid Amrapali.

Effect of paclobutrazol: Long term effects of paclobutrazol application was evaluated in cv. Langra. The trees applied with paclobutrazol (3.2 ml m-1 canopy diameter) during 2008-2011 were kept untreated during the year (2011-12). It was observed that untreated trees also flowered to the extent of 80-100 per cent showing that the residue of paclobutrazol in the soil (0.572 µg g^{-1}) was sufficient enough to induce flowering.

Designing PCR and validation of primers for constans, leafy and flowering time genes: Sequences were retrieved from NCBI database for genes, viz. *constans, leafy* and *flowering time* (*FLT*), and using the sequence information, primers were designed for mango. Standardization of PCR conditions and validation of primers for constans gene was carried out and the gradient PCR was run for six randomly chosen DNA samples from the stock of 48 mango cultivars for optimization of annealing temperature, $MgCl_2$ concentration and primer concentration. From this, the amplicons of desired sizes of 449 bp for *Con*F1/R1 primer pair was obtained and was validated in a set of 24 cultivars.

Development of mango based cropping system

An experiment for evaluation of different intercrops viz. coriander, fenugreek, fennel, nigella, ajowain, marigold, gladiolus, onion and garlic under Dashehari mango orchard (35 year old) was initiated. Performance of all the inter crops in terms of growth parameters was significantly poor in mango orchard than under open conditions. Coriander and marigold gave leaf yield of 2667 kg ha^{-1} and flower yield of 4300 kg ha^{-1}, respectively. Solar radiation availability in experimental plots was in the range of 8000 to 11000 mole m^{-2} y^{-1}.

Optimization of sample size and yield estimation

It was estimated that at 95 per cent confidence level with margin of error within 5 and 10 per cent, the sample size would be 68 and 35 trees for Langra orchard (100 plants) with mean yield of 79.04 kg tree^{-1} and variance of 1703.12. However, at 99 per cent confidence level with margin of error within 5 and 10 per cent the sample size will be 82 and 54 trees.

It was estimated that at confidence level of 95 per cent with margin of error at10 per cent and sample size of 35 trees taken randomly from the Langra orchard of 100 trees, the fruit yield would be in the range of 65.37- 92.71 kg tree^{-1} as per Z-test, while for confidence level of 99 per cent with margin of error at 10 per cent and sample size of 54 trees, the fruit yield would be in the range of 61.04 to 93.53 kg tree^{-1}. Since both the sample size contained predicted population mean, hence minimum sample size based prediction was preferred.

Guava (*Psidium guajava* L.)

Integrated plant nutrient management

Effect on tree growth, fruit yield and quality: The integrated plant nutrient management experiment on guava cv. Shweta was in the fifth year of progress. Plant height ranged between 3.1 and 5.1 m and stem girth between 29.0 and 40.7 cm. The canopy spread in N-S was between 4.10 and 5.57 m, while, it ranged between 4.23 and 5.27 m in E-W direction. The highest fruit yield (17.52 MT ha^{-1}), TSS (12.20 B), vitamin C (234.9 mg 100^{-1} g), total sugars (9.3%) and minimum acidity (0.22 %) were recorded in the treatment 40 kg FYM + 480, 240, 200 g N, P, K tree^{-1} + *Azotobacter* + PSM + *Trichoderma harzianum* + organic mulch. The fruit yield, fruit weight and TSS varied from 25.9 to 43.8 kg tree-1, 138.7 to 262.5 g and 8.0 to 12.30 B.

Effect on soil physical parameters: Bulk density, particle density and water holding capacity of soil ranged from 1.2 to 1.47 Mg m^{-3} , 2.4 to 2.7 Mg m^{-3} and 19.2 to 24.6 per cent, respectively. Mechanical analysis revealed that the soil was coarse textured in nature with 1.6 to 3.1 per cent clay and 58.9 per cent sands. Soil pH (6.97 to 7.18) did not vary significantly among different treatments, however, a marginal decrease in vermicompost, biofertilizers and mulching treatment was observed over NPK+ FYM treated soil. Soil moisture and soil temperature values at the time of harvesting showed that the soil treated with organic sources had higher moisture content. Moreover, the plots that received biofertilizer and mulching had significantly improved moisture retention over those treated with NPK+FYM. Soil temperature varied from 16.3 to 20.3^{0}C among different treatments, however, pooled temperature data ranged from 16.5 to 19.9^{0}C. The plots receiving mulching as a component recorded higher soil temperature as compared to other treatments.

Nutrient status of soil and leaf: Organic carbon content of the soil was low and ranged between 0.29 and 0.53 per cent in surface soil. Maximum (0.53%) organic carbon buildup was recorded under the treatment 10 kg FYM + 100, 50,100 g N, P, K tree^{-1} year^{-1} of age + *Azotobacter* + PSM + *Trichoderma harzianum* + organic mulch over 0.29 per cent where no FYM, vermicompost or mulching was applied. Available N was low (50.4 to 75.6 ppm), while available P was medium to high (17.9 to 25.0 ppm) and available K was high (180.9 to 267.5 ppm) in surface soil in all the treatments. DTPA extractable Fe and Cu contents were low, whereas Mn and Zn were in normal range in all the treatments. The treatments did not show any significant effects on the soil nutrient status. N, P, K, Fe, Mn, Zn and Cu contents of the leaves were in the sufficiency range in all the treatments without any significant differences.

Soil properties of high density orchards

Soil physical parameters: Periodical assessment of soil moisture, soil temperature and SOC content at 0.5 and 1.0 m from the tree trunk were conducted in different planting densities of guava cv. Lalit (555, 277 and 5000 plants ha^{-1}), Shewta (5000 plants ha^{-1}), and Sardar (5000 plants ha^{-1}). Significantly lower moisture content was observed in higher planting densities as compared to normal density of 277 plants ha^{-1}. Soil temperature varied from 14 to 30 ^{0}C among different densities and cultivars. SOC content varied from 0.2 to 0.8 per cent across different depths and densities in different cultivars.

Spatio-temporal variations in soil moisture and soil temperature: Seasonal variations in soil moisture and soil temperature were monitored at active root zone depth of 15 cm at 0.5 and 1.0 m radial distance from tree trunk in twenty years old Allahabad Safeda orchard planted at four different spacings (1.5 × 3, 3 × 3, 3 × 6 and 6 × 6 m). In-situ soil moisture dynamics over space and time scale existed in the high density guava orchard ecosystem and the variability was

mainly governed by the climatic factors particularly rainfall, evaporation, temperature and wind speed. Soil water content was in the range of 3.0 to 13.9 per cent during January to May. However, with the advancement of monsoon season (June to September) average moisture content increased to 22 to 32 per cent. During winter season, soil moisture content decreased to less than 10 per cent. Statistically lower moisture retention in soil was observed in higher densities as compared to low density plantations because of the root zone competition in closely spaced plants. Temporal variations in soil temperature revealed that it ranged between 12 and 18.3 ^{0}C during winter months (November to February) and 23.6 to 33.0 ^{0}C during March to October.

Soil microbial activity in high density guava orchard: Microbial activity in terms of dehydrogenase activity in the soil at 0.5 and 1.0 m from the tree trunk in different densities of guava cultivars Allahabad Safeda and Lalit orchards (2220, 1110, 555, and 277 plants ha^{-1}) with respective spacings of 1.5 x 3, 3 x 3, 3 x 6 and 6 x 6 m exhibited highest values in the month of July and November in all planting densities of Allahabad Safeda (Fig. 22). In cv. Lalit, the highest dehydrogenase activity was found in soil at 0.5 m radial distance from the tree trunk in densities of 555 and 277 plants ha-1 in the month of July and in the density of 5000 plants ha-1 in the month of June, whereas it was the highest in the

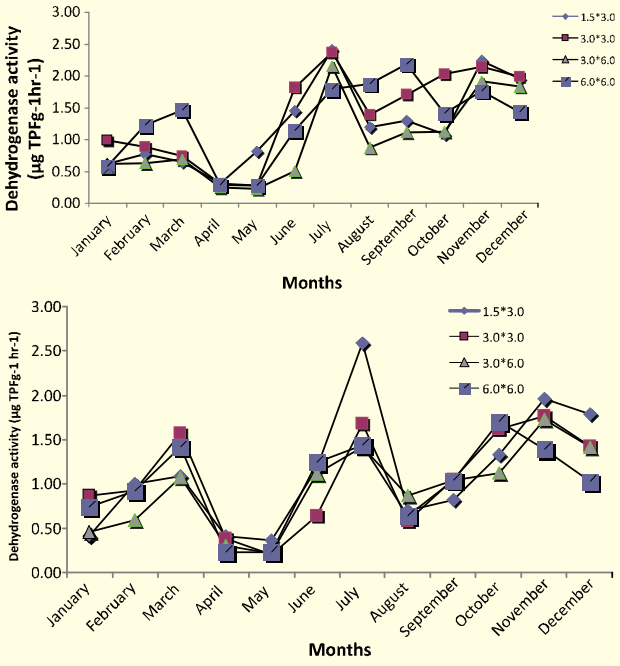


Fig. 22: Dehydrogenase activity in soil of high density guava cv. Allahabad Safeda orchard, (a) 0.5 m and (b) 1.0 m from tree trunk.

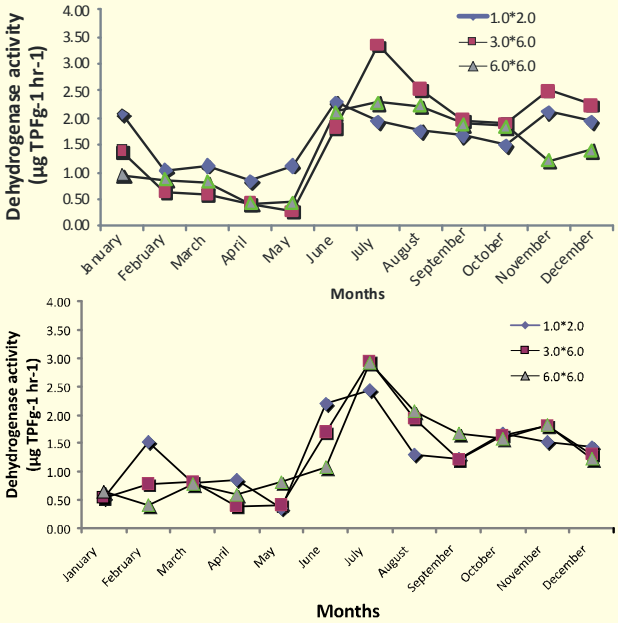


Fig. 23: Dehydrogenase activity in soils of high density guava cv. Lalit orchard, (a) 0.5 m and (b) 1.0 m from tree trunk.

month of July irrespective of planting densities (Fig. 23).

Microbial activity of humic acid amended soil: An experiment was conducted to study the effect of humic acid on microbial activity and nutrient status of soil in

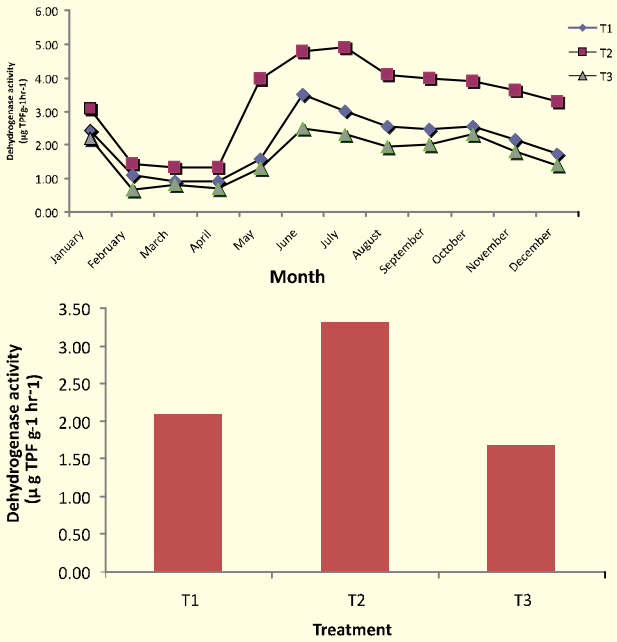


Fig.24: Dehydrogenase activity (a. monthly, b. pooled) in soil of guava cv. Shweta orchard.

T1: control (no humic acid), T2: humic acid @ 20 kg ha^{-1} and T3: humic acid @ 50 kg ha^{-1}.

guava orchard of cv. Shweta. Microbial activity as estimated in terms of dehydrogenase activity was found higher in the soil treated with humic acid (20 kg ha-1) as compared to the soil that received higher dose of humic acid (50 kg ha-1). Dehydrogenase activity was higher during summer months (Fig.24). Consistently high dehydrogenase activity from the month of May to December was observed in soil amended with humic acid (20 kg ha-1). There was no significant effect of humic acid treatment in soil on available N, P, K and DTPA extractable Zn, Cu, Mn, and Fe contents.

Crop Protection

Mango (*Mangifera indica* L.)

Insect pests

Fruit fly

Population dynamics: The population of fruit fly was monitored in mango and guava orchards in experimental blocks of the institute at Rehmankhera using wooden block methyl eugenol traps. The population of *Bactrocera dorsalis* and *B. zonata* started increasing from the 17th standard week and reached the peak in 30th standard week in mango (Av. 2357 flies trap^{-1} week^{-1}) and 31st standard week in guava (Av. 4195 flies trap^{-1} week^{-1}) orchards. The population was higher from 17th to 37th week in mango (Av. 36 to 2357 flies trap^{-1} week^{-1}) and 17th to 51st in guava orchards (16.3 to 4195 flies trap^{-1} week^{-1}). The fly population was positively correlated with minimum temperature (r = 0.51 in mango and 0.64 in guava), minimum RH (r =0.60 in mango and 0.73 in guava), rainfall (0.53 in mango and 0.65 in guava) and negatively correlated with sunshine hours (r = - 0.53 in mango and 0.65 in guava). There was no fruit fly catch between third week of January to last week of March, 2012.

Mealy bug

Population dynamics: The emergence of mango mealy bug (*Drosicha mangiferae*) was recorded on 10th January, 2012 on weed *Clerodendron infortunatum* under the weather conditions of minimum temperature (8.7^{0}C), maximum temperature (17.9^{0}C) and relative humidity (morning 100% and afternoon 78%). The emergence was influenced by weather factors minimum temperature (11.2^{0}C), maximum temperature (18.7^{0}C), RH (morning 94.2% and afternoon 76.1%), rainfall (8 mm) and soil temperature (9.3^{0}C). Its population was very low up to second week of February (2-3 bugs panicle^{-1}) and started increasing during lag week, *i.e.*, from the 3rd week of February, but remained low up to last week of March (2-6 bugs panicle^{-1}).

Bioefficacy of entomopathogenic nematode, Steinernema sp. against mango mealy bug: Steinernema sp. (CISH-M1) was isolated from a soil sample, out of the total 25 samples collected from mango orchards of Rehmankhera farm during September-October, 2011. Its pathogenicity was evaluated against last instar nymphs of mango mealy bug, Drosicha mangiferae under *in vitro* conditions. Two inoculum levels, viz. 50 and 500 infective juveniles (IJs), were used per nymph. No mortality was observed at lowest density (50 IJs), even after one week of inoculation. However, 10 per cent mortality was noticed at highest density after 96 hours of inoculation.

Hopper

Population dynamics: The emergence of mango hopper, Idioscopus nitidulus, was observed on 15th February, 2012 on panicles when minimum temperature, maximum temperature and RH were 11.2^{0}C, 24.9^{0}C and 98 per cent (morning), 45 per cent (afternoon), respectively. Its population was influenced by weather factors, viz. minimum temperature (9.25^{0}C), maximum temperature (23.4^{0}C), RH (morning 85.1%, afternoon 40.2%) and no rainfall during lag week. The population of hopper was very low up to last week of March (1-2 hoppers panicle^{-1}). Its population was recorded during the third week of July on new leaves (Av. 0.6 hopper leaf^{-1}) and continued up to last week of December (Av. 0.1 to 1.2 hoppers leaf^{-1}). In general, hopper population was very low during the year 2011-2012. The population of *Amritodus atkinsoni* was recorded from first week of April on trunk (Av. 0.20 hopper 10 cm^{-2}) and continued throughout the year averaging from 0.1 to 3.1 hoppers 10cm^{-2} trunk. Imidacloprid (0.005%) was highly effective against mango hopper registering more than 98 per cent reduction in its population up to 21 days after spray.

Thrips

Population dynamics: The emergence of thrips was recorded in first week of April, 2011 (Av. 1-2 thrips leaf^{-1}) and remained active up to last week of May, 2011 (Av. 0.2 to 1.71 thrips leaf^{-1} fruit^{-1}). There was no population from first week of June to last week of

August. Its population was recorded again from first week of September (Av. 0.4 thrips leaf^{-1}) until third week of December (Av. 0.2 to 0.6 thrips leaf^{-1}). Thiamethoxam (0.005%) was found most effective in managing thrips on mango registering more than 95 per cent reduction in thrips population up to 21 days after sprays.

Leaf webber

Among two hundred and two mango varieties / accessions screened against mango leaf webber (*Orthaga euadrusalis*), 12 varieties, *viz*. Safeda Mulgoa, Aswina, Sunder Pasand, Neelum Madrasi, Pathar, Baramasi Creeping, Sharab Sah, 1000 SL, Amin Dofasa, Kalapaddy, Gola Nekhnour and Nabdar, were free from its infestation.

Diseases

Anthracnose

Diversity analysis: Diversity analysis of 51 isolates of *Colletotrichem glocosporioides,* collected from different agro-climatic regions of India, showed diversity among themselves on the basis of morphological and cultural characteristics. Based on this data Euclidean Distance matrix was constructed (Fig. 25), the major Cluster I comprised of 78.4 per cent of the isolates (40 nos) representing geographical locations of Andhra Pradesh and Uttar Pradesh.

Remaining isolates comprising of 21.5 per cent of isolates (11nos), representing geographical locations of Maharashtra, Tamil Nadu and Bihar, were clustered into Cluster II. Clustering pattern followed the media, pH and temperature optima, sensitivity towards different systemic and non-systemic fungicides and their reaction towards different bioagents for the growth of *Colletotrichum gloeosporioides*.

The sequence information obtained, were analyzed by local alignment tool using BLASTn (Fig. 26a). The results showed a 99 to 100 per cent homology with DNA sequences from other *C. gloeosporioides* strains deposited in the genebank. Taxonomic correlation of the isolates proved that all the isolates were more related to *C. gloeosporioides* and similar to *Glomerula cingulata* perfect stage of *C. gloeosporioides* (Fig. 26 b).

Management: Two sprays at 15 days intervals of seven fungicides, *viz*. carbendazim, thiophanate methyl, tricyclazole, mencozeb, chlorothalonil, azoxystrobin and difenconazole, at different doses were done for the management of anthracnose leaf spot disease of mango for consecutive 3 years. Per cent disease index (PDI) were calculated on the basis of disease severity

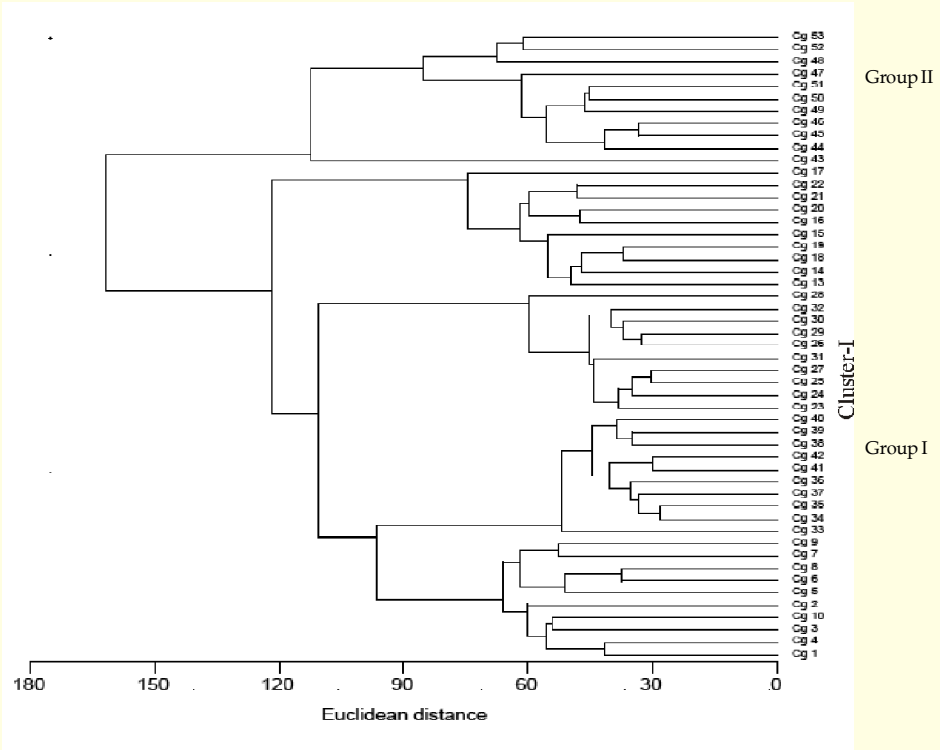


Fig. 25: Euclidean distance tree showing diversity among *Colletotrichum gloeosporioides* isolates.

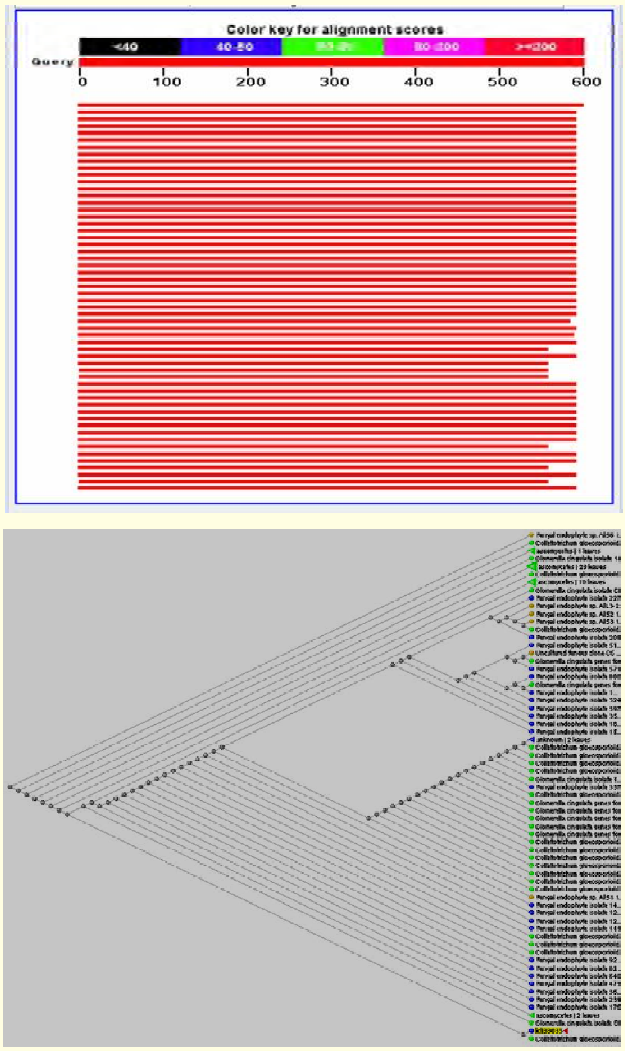


Fig. 26: (a) NCBI web-page for sequence based similarity obtained through sequencing during BLASTn of *Colletotrichum gloeosporioides*, and (b) Taxonomic representation of ITS-sequence data of Colletotrichum *gloeosporioides* isolates obtained from NCBI blast.

on 1-5 scale (Table 4). The fungicide difenconazole was found most effective in managing the diseases followed by azoxystrobin, carbendazim and thiophanate methyl.

Mango wilt

Surveys were conducted in Dehradun, Bijnor, Haridwar, Saharanpur, Barabanki, Faizabad, Kanpur, Lucknow, Sultanpur and Unnao districts for identification of pathogenic fungi associated with wilt disease of mango. *Botryodiplodia theobromae, Fusarium* spp., *Rhizoctonia solani* and *Sclerotium rolfsii* were

Table 4: Efficacy of different fungicides for management of mango leaf spot

Treatments	Dose (%)	Per cent disease index (PDI)			Pooled PDI
		2009	2010	2011	
Carbendazim	0.1	7.20 (15.42)	10.13 (18.53)	6.93 (15.24)	8.08 (16.39)
Thiophanate methyl	0.1	8.53 (16.95)	9.60 (18.04)	6.93 (15.23)	8.35 (16.74)
Tricyclazole	0.1	15.73 (23.95)	12.53 (20.72)	10.13 (18.55)	12.79 (21.07)
Mencozeb	0.2	13.86 (21.81)	17.06 (24.40)	12.53 (20.73)	14.48 (22.31)
Chlorothalonil	0.2	17.33 (24.54)	11.73 (18.04)	9.86 (18.30)	12.97 (20.29)
Azoxystrobin	0.05	7.25 (15.51)	9.60 (18.04)	7.20 (15.42)	8.02 (16.32)
Difenconazole	0.1	6.93 (15.23)	8.53 (16.95)	6.93 (15.23)	7.46 (15.80)
Control	-	59.46 (47.13)	48.00 (43.85)	35.73 (36.70)	47.73 (42.56)
CD at 5%		5.310	1.396	1.202	2.642

* Figures in parentheses are Arcsine transformed values

isolated and identified from stem wood and bark, and root samples of affected trees. *B. theobromae* was found to be present in 85 per cent samples of stem bark of declining and wilting trees.

Soil samples were collected from mango orchards of Malihabad, Mall, Kakori, Sarojininagar, Bakshi ka Talab blocks of Lucknow, Barabanki, Unnao and Faizabad districts for the isolation of plant parasitic nematodes. Microscopic examination revealed the presence of ectoparastic nematodes, *viz. Hemicriconemoides mangiferae, Hoplolaimus* sp., *Tylenchorhynchus* sp., *Helicotylenchus* sp., *Tylenchus* sp., semi-endoparasitic nematode, *Rotylenchulus reniformis* and endoparasitic nematode, *Pratylenchus* sp. from rhizospheric soil samples. However, *H. mangiferae* and *Hoplolaimus* sp. were found widespread in occurrence as they were observed in 95 per cent of the soil samples.

Graft Rot

Management: A trial was conducted to manage dry rot of fresh Dashehari grafts using three fungicides at three different concentrations (0.05, 0.1 and 0.2%) and two bio-control agents (*Trichoderma harzianum* and *Trichoderma viride*) at two different concentrations. The soil of saplings in polybags was drenched with bio-control agents or fungicides during the month of July and the same treatments were applied to scion sticks before grafting in the month of August. The grafts were

sprayed after the removal of caps in the month of September. Maximum healthy grafts (52%) were produced with Thiophanate methyl (0.05% a.i.) followed by 48 per cent in propiconazole (0.1% a.i.), 46 per cent in *Trichoderma viride* (10g l^{-1}) and per cent in difenoconazole (0.05% a.i.), while in control only 20 per cent graft survived.

Guava (*Psidium guajava* L.)

Diseases

Guava wilt

Nematode population in wilt affected orchards: Soil samples were collected from the orchards of healthy and wilted guava plants growing in the regions of Lucknow, Pushkar and Muzaffarnagar during the months of April, June, August and September. The occurrence of plant nematode species, *viz. Helicotylenchus dihystera, Rotycenchulus reniformis, Hoplolaimus indicus, Pratylenchus* sp. *Meloidogyne* sp. *Criconemoides* sp., *Longidorus* sp., *Xiphinema* sp. and a number of other nematode belonging to tylenchid and dorylaimus group, were recorded. The nemic population density, however, exhibited a variation with respect to locale and plant health status. Total nematode population from the samples collected during the month of August from the orchards of healthy guava plants growing in Pushkar ranged from 20 to 150 per 50 cc soil sample, as compared to 44 to 300 and 140 to 450 per 50 cc soil sample from the plants exhibiting 50 and 90 to 100 per cent wilting, respectively. Total nematode population in the soil samples collected from healthy guava orchards located in Muzaffarnagar ranged between 110 to 312 per 50 cc soil as compared to nemic population range of 325 to 400 per 50 cc soil from the plants displaying 50 per cent wilt.

Variation in nematode populations in different months: Composite soil samples were collected from the guava orchards located at R.B. Road and Rehmankhera campuses of the institute during the months of August, September, October, December, January and February. The nematode population ranged between 132 to 154 in the soil samples of healthy plants as compared to 120 to 150 and 100 to 250 from the soil samples of plants exhibiting 50 and 75 per cent wilt, respectively, during the month of August.

Population in healthy guava plants ranged between 112 to 280 as compared to 120 to 240 and 44 to 105 in plants exhibiting 50 per cent and 75 per cent wilt during September. Population variation during the month of October was quite distinct with respect to the health status of plants. Nematode population ranged between 38 to 64 per 50 cc soil sample in healthy plants.

Nematode population during the month of December was found to be very low. Healthy plants harboured a range of 11 to 44 nematode per 50 cc soil, sample. Conversely samples from the plants exhibiting 10 to 15 per cent, 50-60 per cent and 75 per cent harboured a population range of 37 to 43, 40 to 44 and 12 to 31 respectively. Population variation trend was relatively distinctly low in the month of January Samples were also subjected to analysis for fungal population. The population of *Fusarium oxysporum* exhibited higher population density in wilt affected plants.

Effect of different soil amendments: Eighteen treatments comprising of bio-agent ***Trichoderma harzianum,*** oil cake (neem) and FYM alone or in combination were imposed at different time intervals (December, February and March). Soil samples were collected prior and post treatments during December and February for analysis of fungal and nematode population and health status of plant. Data on initial population of nematodes showed very low population of *Rotylenchulus reniformes, Helicotylenchus dihystra, Hoplolaimus indicus* and *Meloidogyne* sp. Observations recorded on plant health status revealed a relatively higher degree of plant mortality in the plants subjected to *FYM* alone.

Comparative analysis of nematode fauna: The occurrence of reniform, besin, lance and spiral nematodes were recorded in the soils samples collected from wilt susceptible (Shewta on seedling root stock) and wilt resistant (Shweta on *Psidium molle* x *Psidium guajava* root stock) guava plantations. However, nematode population configuration could not display any distinct trend in the soils from resistant and susceptible root stocks.

Molecular diagnosis: Detection of *Fusarium oxysporum* f. sp. *psidii* isolates was achieved with a newly designed species specific primer pair BKP-1 / BKP-2. The specificity of the primers was assessed against 21 isolating *F. oxysporum* f. sp. *psidii*. The primer pair BKP-1 / BKP-2 was able to amplify a DNA fragment of approximately 183 bp uniformly in all of isolates *F. oxysporum* f. sp. *psidii* from different agro-climatic zones of guava cultivation of the country (Fig. 27).

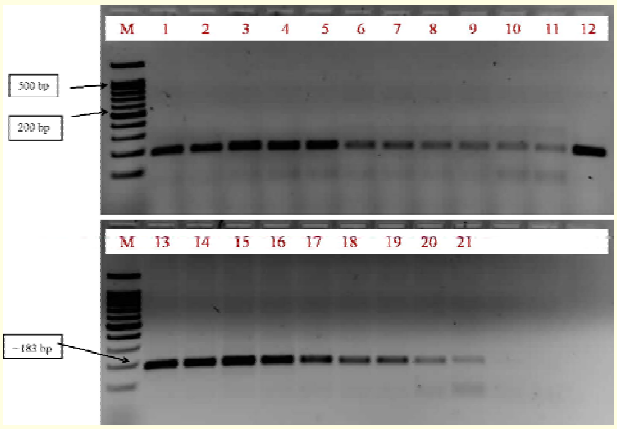


Fig. 27: PCR amplification of 183 bp of ITS region with species specific primer BKP-1/BKP-2 Lane 1 - 21: *F. oxysporum* f. sp. *psidii* isolates, M: 100 bp DNA Ruler.

Diagnostic kit using specific developed primers BKP-1 and BKP-2 were validated for detection of *F. oxysporum* f. sp. *psidii*. *Four species of Fusarium, viz. F. oxysporum* f. sp. *cubense, F. oxysporum* f. sp. *ciceri, F. solani* and *F. moniliformae,* and one isolate of *Colletotrichum gloeosporioides* were included for the validation of kit. This kit could only detect *Fusarium oxysporum* f. sp. *psidii* isolates by amplification of 183 bp product (Fig. 28).

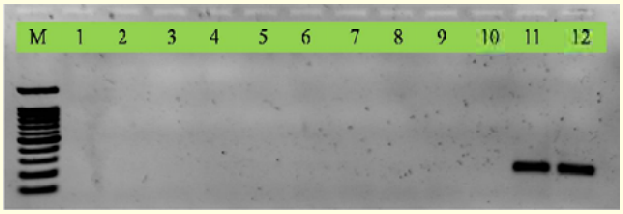


Fig. 28: PCR amplification of ITS region with specific primer BKP-1/BKP-2.

Lane 1-2: *Fusarium oxysporum* f. sp. *cubense,* Lane 3-4: *Fusarium oxysporum* f. sp. *ciceri,* Lane 5-6: *Fusarium moniliformae,* Lane 7-8: *Fusarium solani,* Lane 9-10: Negative control (dH2O), Lane 11 -12: *Fusarium oxysporum* f. sp. *psidii* isolates, M: 100 bp DNA Ruler.

Colony-PCR assay developed was evaluated using mycelium of *Fusarium* spp. directly as the template, without any DNA extraction and purification. DNA template was prepared by suspending portions of fungal mycelium in 50 µl of 1x Trix - EDTA buffer. Amplification was performed using species specific primer BKP-1 and BKP-2 with a Thermal Cycler PCR by 34 cycles of denaturation at 94^{0}C for 60s, annealing at 54^{0}C for 60s, and extension at 72^{0}C for 1.5 min with an initial denaturation of 5 min at 94^{0}C before cycling and final extension of 5 min at 72^{0}C after cycling. Amplicon of 183 bp in all the isolates of *F. oxysporum* f. sp. *psidii* was obtained (Fig. 29). This could be used as a quick diagnostic technique for detection of *Fusarium oxysporum* f. sp. *psidii*.

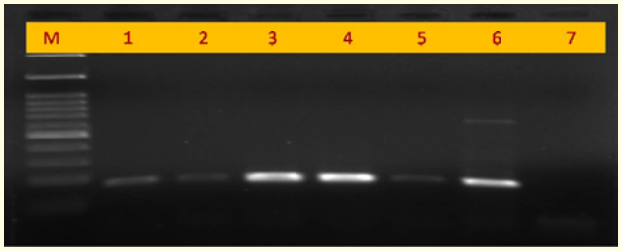


Fig. 29: PCR amplification of ITS region with specific primer BKP-1/BKP-2.

Lane 1 - 6: *F. oxysporum* f. sp. *psidii* isolates, Lane 7: Negative control, Lane M: 100 bp DNA ruler.

Papaya (*Carica papaya* L.)

Nematode pests

Effect of Paenobacillus polymyxa on root -knot nematode: Centrifuged and ultra-filtered supernatants of *P. polymyxa* were imposed on papaya plants inoculated with second stage juveniles of *Meloidogyne incognita* (500 juveniles) in single and double dose treatments. Treatment imposed only once (single dose of 10 ml) could not impact the population build up of root-knot nematode negatively. However, the treatments imposed twice (10 ml two times) was found to cause a moderate level (25-35 %) of reduction in nematode population.

Bael (*Aegle marmelos Correa*)

Diseases

Management of stalk end rot and fruit drop: A field trial was carried out during July 2011 to March 2012 for the management of stalk end rot and fruit drop. Treatments were applied either as soil drench during June or spray during July. Minimum fruit drop (63.8%) was recorded in trees sprayed with difenoconazole (0.05%) followed by 65.9 per cent in soil application of ***Trichoderma harzianum*** (50g tree^{-1}) with 10 kg FYM.

Post Harvest Management

MANGO (*Mangiferra indica* L.)

Mechanization

Design and development of fruit ripening chamber: A prototype of low cost foldable ripening chamber made

of 400 micron polyethylene film of 3 x 1.2 x 1.5 m (LXBXH) having a volume of 5.4 m^3, with four small openings (6 mm dia.) at 1.0 m height, was developed for safe ripening of fruits using ethylene gas. The cost of this structure has been worked out at around rupees two thousand. In a preliminary trial, 200 kg mature *Dashehari* fruits were kept in the chamber for ripening. Ethylene gas (130 ppm) was injected into the chamber from the canister gas. After 16 h of treatment, fruits were taken out and kept for 2 hrs in the open to eliminate surface moisture. The fruits were packed in 5 kg CFB boxes and kept at ambient temperature. The fruits achieved uniform ripening in 5 days.

Storage

Pre-harvest sprays for extending shelf-life: Single, double and triple sprays of 2 per cent calcium chloride (dihydrate) were carried out at 10 days interval starting from the first week of May. Mature Dashehari fruits harvested after 10 days of last spray were washed, surface dried and stored at 12 ± 1^{0}C and 85 ± 5% RH for 3 weeks. Among different treatments, fruits of three pre-harvest sprays of calcium chloride exhibited minimum physiological loss in weight (PLW) as compared to two or single sprayed trees including control throughout the storage period. The slow development of TSS and maintenance of higher levels of titratable acidity in fruits sprayed thrice with calcium indicated delayed ripening. The spoilage was only 10 per cent in these fruits as compared to other treatments where spoilage was more than 15 per cent.

Bagging of mangoes for quality fruits : Uniform sized Dashehari fruits were bagged with brown paper bags in the month of May, four weeks before harvesting. After harvesting, fruits were kept at room temperature for ripening. Quality attributes *viz.* appearance, spoilage, TSS, titratable acidity, and total carotenoids of fruits were determined at regular intervals. Results indicated that bagged fruits uniformly ripened with attractive yellow colour, free from blemishes and had 20 per cent spoilage as compared to unbagged fruits having 40 per cent spoilage after 8 days of storage.

Effect of herbal wax and bio-agents on shelf life: Preliminary trails on herbal wax and herbal wax containing Saccharomyces cerevisiae were applied to mature Amrapali fruits. After 8 days of storage under ambient conditions (32 ± 2^{0}C and 85±5% RH) fruits treated with herbal wax+ Saccharomyces cerevisiae were of desired parameters *viz.* low TSS (19.4^{0}B), titratable acidity (0.14%) and total carotenoids of (5.83 mg100 g^{-1}), and had the least spoilage in comparison to the fruits treated with only herbal wax.

Low temperature storage: Fruits of cv. Chausa treated with 250 ppm ethrel for 5 minutes in hot water at 52 ± 2^{0}C, and were stored in cold storage (10 ± 2^{0}C and 85 ± 5% RH). The fruits were withdrawn at weekly intervals and assessed for ripening parameters. The firmness of fruits declined to 0.36 kg cm^{-2} and the spoilage was 20 per cent in ethrel treated fruits as compared to 30 per cent spoilage in control fruits after 4 weeks of storage.

Effect of polyamines : Mature Chausa fruits were treated with 0.01 percent spermine for 10 minutes, packed in brown paper bags and stored in cold storage (10 ± 2^{0}C and 85 ± 5% RH). The fruits were withdrawn at weekly intervals and assessed for physico-chemical parameters. The spermine treated fruits exhibited higher degree of firmness (1.1 kg cm^{-2}), titratable acidity (0.3%), TSS (20 ^{0}B), total carotenoids (1.20 mg100 g^{-1}) and low spoilage (10%) after four weeks of withdrawal from storage.

Effect of bio-agents on storage behaviour: Mature Amrapali fruits were subjected to post harvest dip treatments with bio-agent (*Saccharomyces cerevisiae*) at concentrations of 10^8, 10^6, 10^4 cells ml^{-1} for 10 min. The fruits were packed in brown paper bags and stored under ambient conditions (32 ± 2^{0}C and 85 ± 5% RH). There was non-significant difference in quality parameters of treated and untreated fruits after 9 days of storage. However, the disease incidence was the least in fruits treated with bio-agent @10^8 cells ml^{-1} on the 9th day of storage thereby increasing the marketability and shelf-life. In the case of bio-agent treated fruits, *Saccharomyces cerevisiae* was the dominant surface micro flora.

Value addition

Instant raw panna powder: A recipe for instant raw mango panna powder was developed. Raw mango pulp was dried using a cabinet dehydrator, first at 80^{0}C for 2 h and then at 60^{0}C for 6 h to a moisture level of 2 to 4 per cent and pulverized into fine powder. Powdered cumin seeds and mint leaves along with sugar and salt in a predetermined proportion were mixed with mango powder. Final preparation of instant raw mango panna powder was made by adding stabilizer (INS 1400), acid regulators [INS 330 and 331(III)], emulsifiers (INS 464 and 415), antioxidant (INS 300), colour (INS 143) and anticaking agent [INS 341(III)] as per PFA description. Addition of these materials enhanced the solubility, consistency, flavour, free-flowing capacity and shelf-life of panna powder.

The overall organoleptic acceptability of panna powder (as drink) was high (8.0). For one instant serving, 10 g of the panna powder should be dissolved in 150 ml of chilled water.

Evaluation of varieties/hybrids for pickles: Four mango hybrids were evaluated for pickle in oil. Fresh fruit analysis indicated a variation of 181 to 353 g in average weight, 7.5 to 9.6^{0}B TSS, 0.94 to 2.38 per cent titratable acidity and 0.59 to 1.44 per cent reducing sugars. Maximum acidity (2.38%) was noticed in H-2108 and minimum (0.94%) in H-1394, while H-2108 recorded minimum TSS (7.5 ^{0}B) and H-1655 maximum TSS (9.6 ^{0}B). A decreasing trend in TSS, titratable acidity and reducing sugars were observed in pickles stored up to 6 months. Organoleptically, pickle from hybrid H-2108 was found the best after 6 months of storage.

Evaluation of varieties/hybrids for pulp and beverage: Out of six mango hybrids and one variety evaluated for preparation of pulp and beverage, cv. Amin Khurd had the highest pulp content (71.3%) followed by hybrid H-2251 (70.5%). TSS (20.13^{0}B), titratable acidity (0.32%) and ascorbic acid (19.3 mg 100 g^{-1}) were maximum in H-2416, while beta-carotene (3.32 mg 100g^{-1}) and reducing sugars (9.03%) were maximum in Amin Khurd. Though TSS and titratable acidity of pulp did not change significantly during 6 months of storage, a slightly decreasing trend in total carotenoids and a significantly increasing trend in reducing sugars were noticed. The RTS beverage prepared from cv. Amin Khurd was the most acceptable one organoleptically at zero day as well as the one prepared from the pulp stored up to six months.

Long term storage of pulp: Mango pulp from hybrid H-1912 was preserved with 1000 ppm SO_2 up to 18 months under ambient conditions. Titratable acidity and reducing sugars increased from 0.54 to 0.69 and 2.07 to 8.67 per cent, respectively, while organoleptic quality of RTS beverage prepared from it decreased from 6.3 to 5.0. However, no microbial spoilage and significant change in the content of total carotenoids were noticed in the pulp during 18 months of storage.

Evaluation of varieties for preparation of raw cider : Mango cider containing 5-6 per cent alcohol was prepared from raw (unripe) pulp of four commercial cultivars, *viz*. Dashehari, Langra, Chausa and Totapuri, using *Saccharomyces cerevisiae*. Prepared ciders were flavoured with extracts of Indian spices including roasted cumin seeds and black pepper, in addition to common and black salts. The total soluble solids of cider ranged between 14.8 to 16.5^{0}B, while titratable acidity varied from 0.67 and 0.74 per cent. The ascorbic acid content was maximum in Langra (20.1 mg 100 ml^{-1}), followed by Chausa (4.5 mg 100 ml^{-1}). Cider from Langra was also higher in polyphenols (61.1 mg 100 ml^{-1} in non flavoured and 54.8 mg 100 ml^{-1} in spiced cider) and total anti-oxidant (20.6 mM ml^{-1} in non flavoured and 20.7 mM ml^{-1} in spiced cider). The reducing sugars of ciders ranged from 4.10 to 4.92 per cent. Sensory evaluation of cider revealed maximum liking for Totapuri cider with spices, followed by plain Totapuri and Dashehari spiced cider (7.78). Ciders flavoured with spices were preferred over non flavoured ones.

Standardization of pasteurization temperature for raw cider : Raw cider prepared from cv. Dashehari and packed in glass bottles was pasteurized at 55, 60 and 65^{0}C for 5 minutes in hot water bath. The samples collected immediately after pasteurization were streaked on yeast extract potato dextrose agar (YEPDA) plates and kept in an incubator at 35^{0}C. The samples pasteurized at 60 and 65^{0}C developed no microbial colonies. Hence, pasteurization temperature of 60^{0}C was found optimum for safe packing and storage of cider.

Microbial quality assurance of processed products : Microbiological examination of stored freeze dried samples of mango slices revealed presence of *Bacillus sp.*, an actinomycete and a gram negative bacterium belonging to *Coliform gp*. in some of the treatments.

Waste utilization

Utilization of raw cider sediments for preparation of value added products : The sediment obtained after preparation of raw cider was used to develop different value added products, *viz*. sweet squash, spiced squash and chutney. Sweet squash had 50^{0}B TSS and 0.9 per cent acidity was preserved with 200 ppm SO_2. Spiced squash having salt (10%), mint leaves (10%) and cumin powder (2%), in addition to sugars and acid was developed. Sweet and spiced squashes were served chilled with three volumes of water. A combination of different spices and sugars was used for the preparation of sweet-sour chutney. All the products had good acceptability.

Development of bio-fuel from wastes: Spoiled and discarded mangoes were used to produce bio-fuel (ethanol) using *Saccharomyces cerevisiae*. The recovery of ethanol (180^0 Proof) was 1 litre 117 kg^{-1} waste fruits resulting in 57 per cent fermentation efficiency.

Enhanced production of pectinase using mango peel pectin : Production of polygalacturonase (PG) under

submersed fermentation condition by *Aspergillus niger* NAIMCC-F-02958 was investigated using the 23 factorial design with central composite rotatable experimental design (CCRD) of response surface methodology (RSM). The optimum variable tested were pH 4-6, temperature 30-50 ^{0}C and 1-5 ml of inoculums. The maximum production of 723.66 U g^{-1} was found under optimized condition by response surface method. Determination coefficient (R^2= 0.66) indicated that 66.88 per cent of the variability in the response could be explained using the model (Fig. 30). The results might be useful for pilot scale production of polygalacturonase using mango peel as substrate.

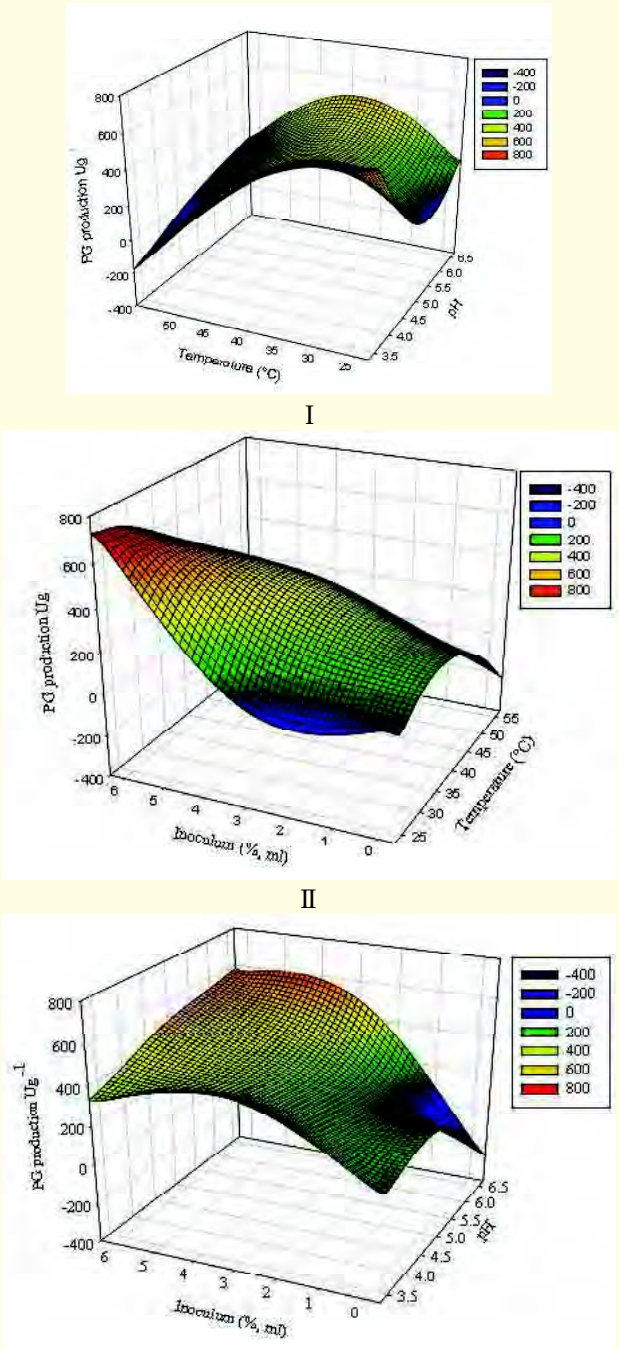


Fig. 30 : Response plot of the effects of contour plots 2D and 3D (i) pH and temperature, (ii) inoculum size and temperature, (iii) inoculum size and pH for optimum PG production using A. niger NAIMCC-F-02958 on mango peel as substrate.

Clarification of juice using fungal cellulase from peel residue : Fungal cellulases, *viz.* CMCase and ?-glucosidase, were produced by *Aspergillus niger* using mango peel residue (1% w/v) as substrate. The enzyme extract having 2.6 U ml^{-1} cellulase activity was used to clarify mango juice for different period of time (0 to 12^0 min) and temperatures (20 to 40 ^{0}C) and compared with commercial enzyme. Enzyme extracted from mango peel residue clarified the juice better than commercial enzyme in terms of reduction in viscosity. The viscosity of enzyme (from mango peel) treated juice at 30^{0}C decreased from an initial of 0.86 mPas to 0.31 mPas after 120 min of treatment, while in case of commercial enzyme, the values decreased from 0.87 mPas to 0.47 mPas under similar conditions of temperature and time. Thus, mango peel enzyme treatment resulted into 64 per cent reduction in the viscosity of juice as against 45 per cent reduction from commercial enzyme treatment (Fig. 31).

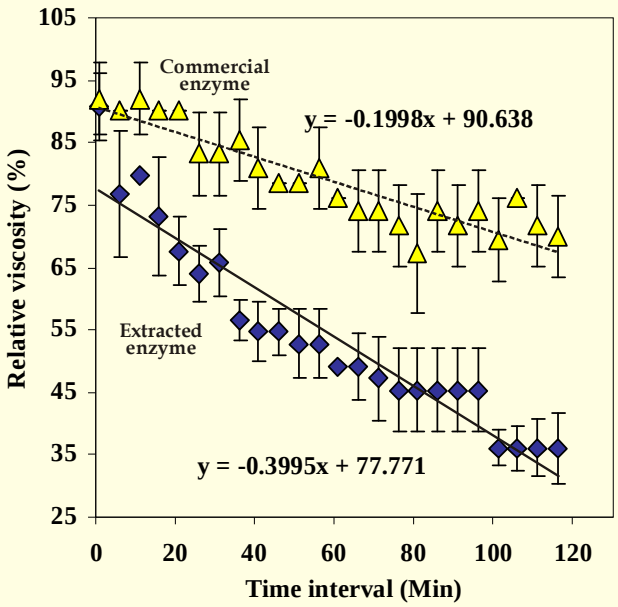


Fig. 31: Reduction in nango pulp viscosity by cellulase treatment.

Extraction of intracellular amylase from germinating kernel Amylase activity of crude extract obtained from partially germinated mango seeds was determined with reference to varied pH and temperature conditions. Amylase activity of the crude extract was measured by monitoring the amount of starch hydrolyzed by the crude enzyme over a time period. The optimum pH and temperature of the crude enzyme were 8.0 and 35^{0}C with an activity of 0.37 ± 0.01 U ml^{-1} and 1.66 ± 0.27 U ml^{-1}, respectively. The content of reducing sugars increased 1.6 folds in germinated mango seed within 24h. The study indicated that germinating mango seeds could be used for ethanol production by reducing the hydrolysis cost of substrate.

Production of extracellular pectinase using peel as substrate: Extracellular pectinase mass produced by Aspergillus niger using mango peel as substrate was immobilized in calcium alginate beads through entrapment technique. Maximum enzyme immobilization efficiency was achieved in 2 mm size beads formed by 7.0 per cent (w/v) of sodium alginate in 2 per cent (w/v) calcium chloride. The catalytic properties of the immobilized pectinase were assessed in comparison with the free enzyme (soluble). The activity yield of the immobilized enzyme was 81per cent of the free enzyme. The immobilized enzyme showed optimum activity at 5.0 pH and 45^{0}C temperature. Thermal stability of the immobilized enzyme after heat inactivation at 60^{0}C was found higher than the free enzyme over a long time interval. The immobilized enzyme retained activity up to 20 per cent of optimum even after 180 min. but the activity of the free enzyme was less than 20 per cent after 60 min, which reached zero by 120 min. The kinetic constants, *viz.* K_m, V_{max} and activation energy of the immobilized enzyme, were affected by immobilization, which influenced the substrate utilization negatively. The immobilized enzyme showed higher stability over a wider pH and temperature ranges. The immobilized pectinase in calcium alginate beads could be stored for longer periods.

Identification of isoforms of pectinase: Isoforms of pectinase, *viz.* polygalacturonase, pectin methyl esterase and pectin lyase, were identified from *Aspergillus niger* multiplied on pectin (extracted from mango peel) using gene specific PCR. A touch down protocol of PCR was developed for the degenerate primers designed, the amplification products were sequenced and primers were redesigned for the specific genes, pectin methyl esterase and pectin lyase. A typical agarose gel profile of partial gene of pectin methyl esterase (400 bp) polygalacturonase (450 bp) and pectin lyase (220 bp) were obtained (Fig. 32 and 33).

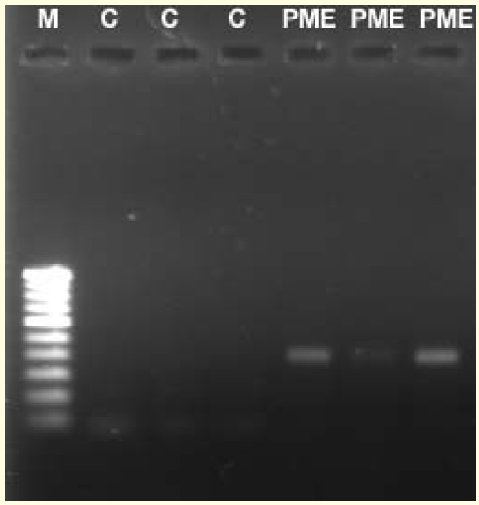


Fig.32: Agarose gel profile of pectin methyl esterase (partial gene) from *Aspergillus niger*. M- 100bp ladder, C- Control, PME- Pectin methyl esterase.

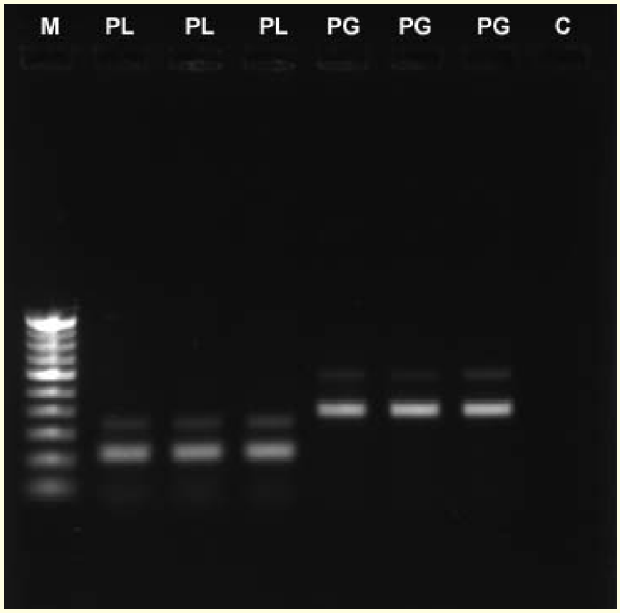


Fig.33: Agarose gel profile of pectin lyase and polygalacturonase genes from *Aspergillus niger* M- 100 bp ladder, PL- Pectin lyase and PG- Polygalacturonase, C- Control.

Food Safety

Pesticide residue analysis

Carbaryl : Carbaryl was sprayed @ 3.0 gl-1 of water on Dashehari trees during the first week of June

to control fruit borer. Carbaryl dissipated in fruit pulp from 1.50 µgg-1 after 12 h to 0.052 µg g^{-1} after 12 days of spraying. The residue level of carbaryl was found below detectable limits (0.01 µg g^{-1}) in pulp after 16 days of spraying. It could not be detected in pulp of ripe mango after 24 days of spraying. The MRL value of carbaryl in mango was 0.05 µg g^{-1} (Fig. 34) .

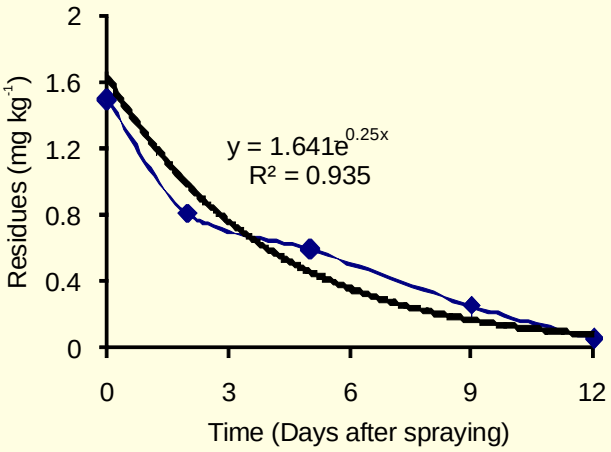


Fig. 34: Dissipation of carbaryl residues in mango pulp after pre-harvest spray.

Residue analysis in market samples: Ripe Dashehari mango fruits collected from three fruit markets located at different places in Lucknow were found free from residues of imidacloprid, thiamethoxam, chlorpyriphos, monocrotophos, dimethoate, cypermethrin, deltamethrin, carbosulfan, carbaryl, endosulfan, endosulfan sulfate and DDT.

Residue analysis in park soil samples : In compliance of directives of High Court Bench, Lucknow soil samples of some parks were analyzed for pesticide residues. Out of 30 soil samples collected from different parks located at Gomti Nagar and Indira Nagar areas of Lucknow, 18 samples were found contaminated with chlorpyrifos ranging between 0.063 to 2.318 µg g^{-1}. Among the contaminated eighteen soil samples, three samples contained considerable amounts of (> 1.50 µg g^{-1}) chlorpyrifos which could leach to the ground water.

Market analysis

Disposal, arrival and prices : The disposal of mango from Lucknow region was 63.12 thousand MT during the year 2011 as against the all time high disposal of 68.86 thousand MT during the previous year. However, even with this marginal decline of 8 per cent, the mango disposals from Lucknow were the second best in the past 6 years. The disposal of mango to the markets outside the state of Uttar Pradesh was higher, *i.e.*, about 72 per cent during 2011 as against only about 60 per cent during the previous year. New Delhi continued to be the favorite destination for Lucknow mangoes as 19.36 thousand MT of mangoes, accounting for 30.7 per cent of total disposal Lucknow. Punjab and Maharashtra were the other major markets, which received 12.6 and 11.7 per cent from Lucknow region, respectively. Madhya Pradesh, Rajasthan and West Bengal were the other important markets. Gujarat, which could be another important market for Lucknow mangoes, received only 0.18 per cent disposals during 2011. The mango disposals from Lucknow region commenced from May 23 and continued up to July 17, 2011. During this period, about 95 per cent were disposed off in different markets across the country. Trading outside Uttar Pradesh was from May 30 to July 10, 2011, while disposals within the State were concentrated between June-6 to July 10, 2011.

The total arrivals in Lucknow market was 70.48 thousand MT during 2011. Although it was about 19 per cent less than the arrivals during the previous year, it was about 101 per cent higher than the arrivals during 2009. The fruits started arriving in Lucknow market from January 2011 onwards, although up to February, it was less than two quintals per month. Thereafter, the arrival of mangoes in the wholesale market started increasing at a faster rate. It was 10.5 MT during March, 2011, which increased to 121.3 MT during April and thereafter, increased to 2,304.5 MT in May. The arrivals during these months were mainly from South India particularly, Andhra Pradesh and Tamil Nadu. Banganapalli was the predominant cultivar, although some quantities of Suvarnarekha were also traded. With the onset of Dashehari season during the second fortnight of May, the arrival from South India mangoes tapered. June 2011 witnessed maximum arrivals in Lucknow, *i.e.*, 53.03 thousand MT, accounting for 75 per cent of the total arrivals in 2011, followed by July, which accounted for 20.39 per cent. Dashehari was the predominant cultivar during June and first fortnight of July. The weighted average price during 2011 was Rs. 1,114 q-1 in Lucknow market.

A total of 188.68 thousand MT of Dashehari were traded in different markets of the country. Delhi alone received 133.77 thousand MT accounting for 70.9 per cent of total Dashehari trading (Fig.35). Lucknow, the main production belt of Dashehari, accounted for 11.5 per cent of the total trading followed by 5.7 per cent

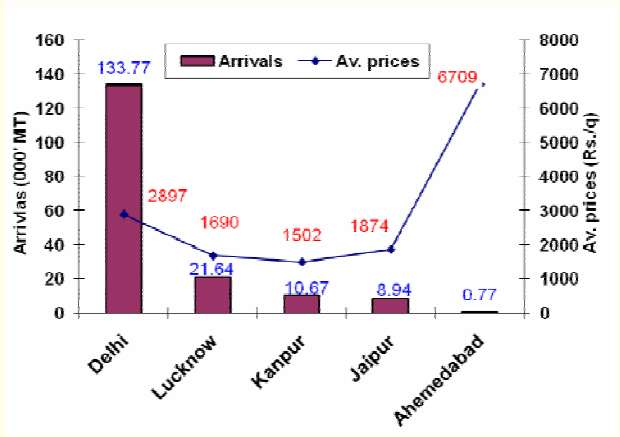


Fig. 35: Arrivals and average wholesale prices of Dashehari in major markets of the country during 2011.

trading in Kanpur. Jaipur was the other important market receiving Dashehari. Delhi received it from May to July which reduced during August. It received Dashehari from Lucknow in the main season and thereafter from Saharanpur belt and Tarai region of Uttarakhand during July and August. The average weighted price in all the markets taken together was Rs. 2,601 q^{-1}. The average price of Rs. 1,690 and Rs. 1502 q^{-1} prevailed in Lucknow and Kanpur markets. The weighted average price was Rs. 2,897 q^{-1} in Delhi wholesale market. The markets of Ahmadabad received Dashehari during April to July, although, the quantity received was 0.77 thousand MT during 2011. However, the average wholesale price of the cultivar was Rs. 6,709 q^{-1}, which was the highest amongst all the markets of the country. Guwahati and Chennai were other markets which offered an average price of Rs. 4,373 and Rs. 3,881 q^{-1} and these markets could be further exploited by enhancing the direct supplies of fruits from Lucknow region.

Total trading of Langra in different markets of the country during 2011 was 25.7 thousand MT, of which Kolkata alone accounted for 44 per cent. The weighted average price of Langra in Kolkata was Rs. 2,796 q^{-1}. Jaipur was another market which accounted for 27.5 per cent of total Langra trading in the country, but the price realization in the market was however low at Rs. 1,827 q^{-1}. Although, the highest price of Langra, *i.e.*, Rs. 3,881 q^{-1}, was in Chennai market, its arrival was very low at 3 quintals only Quwahati market recorded a price of Rs. 3,191 q-1 and received 1.45 thousand MT, mainly from North Bangal districts of Malda and Murahidabad. Lucknow market received 0.49 thousand MT Langra with a price realization of Rs. 1,657 q^{-1}.

The trading in Chausa was 47.16 thousand MT during 2011, which was 57 per cent of the trading in the previous year . The peak arrival of Chausa was during July followed by August, which accounted for about 70 and 23 per cent of total Chausa trading, respectively. Delhi was the most important market accounting for about 75 per cent of total trading in Chausa. Kolkata and Ahemedabad accounted for 8.9 and 7.9 per cent of the total trading of the cultivar. The weighted average price of Chausa was the highest, i.e., Rs. 11,938 q-1, in Ahmadabad. This high price differential between price at Ahmadabad and ruling price of Rs. 1,374 q-1 in Lucknow could absorb the transportation cost as well as transit losses very effectively. The price of the cultivar was significantly higher, i.e., Rs. 3,926 and 3,708 q-1 in Delhi and Kolkata markets.

Banganapalli arrival period extended form early January to May-June and declined after the arrival of North Indian cultivars. Its total trading during 2011 was 183.19 thousand MT. Since the arrival of the cultivar was in the early season, the average weighted all India price was Rs. 4,399 q-1. The arrival of the cultivar was the highest, *i.e.*, 72.14 thousand MT, accounting for about 39.4 per cent of total trading of the variety in the country. It was followed by Nagpur and Delhi, which had a share of 17.2 and 8.9 per cent of the total trading. Chennai and Kolkata were the other important markets for this cultivar. The maximum average price of Banganapalli was highest, *i.e.*, Rs. 7,669 q-1 in Hyderabad market, which incidentally received maximum quantities of the fruit. The prices in Guwahati, Jammu, Srinagar was above Rs. 3000 q-1, but the off-take in these markets was low. The price of Banganapalli was Rs. 2,924 q-1 in Delhi market.

A total of 69.26 thousand MT of Totapuri was traded all through the country, of which Hyderabad alone accounted for 60.0 per cent. This market served as assembly market from where the cultivar dispersed to other markets of the country. It was followed by Chennai and Nagpur by accounting for 18.1 and 7.8 per cent of total trading in Totapuri. The weighted average price of Totapuri Cultivar worked out to Rs. 2,822 q^{-1} across the markets. Its price was the highest, *i.e.*, 3,939 q^{-1} followed by Rs. 1,902 q^{-1}, 1,666 q^{-1} and Rs. 1,522 q^{-1} in Kanpur, Surat and Chandigarh markets.

Exports : India exported Rs. 162.92 worth of mangoes during 2011. It exported the fruits to 43 countries as against 55 countries in the previous year. The current year witnessed a significant drop of 20.5 and 19.1 per cent in both quantity and value of mango exports to

different countries. In fact the exports have been successively declining since 2008-09, when the exports touched an all time high of 83.70 thousand MT (Fig. 36). However, the value of exports touched an all time high during 2009-10 at Rs. 200.54 crores. The country, nevertheless, registered a spectacular growth of 71.0 and 127.7 per cent in the quantity and value of exports over 12 year period of 1999-2000 to 2010-11, respectively. Off late Bangladesh has emerged as leading importer of Indian mangoes. However, UAE again emerged as the leading importer of the fruit from India during the 2010-11. The export of mango to Bangladesh attained an all time high volume of 45.10 thousand MT worth Rs. 40.86 crores during 2008-09 after which it declined gradually to close at 23.05 thousand MT worth Rs. 18.69 during 2010-11 depicting a decline of 48.9 and 54.5 per cent in quantity and value of mango exports, respectively. The UAE has been a very consistent and sustained importer of Indian mangoes, which needs further consolidation. The mango exports to the country were maximum (26. 53 thousand MT worth Rs. 73.04 crores) during 2005-06, after which it declined marginally to 22.05 and 22.47 thousand MT during two successive years. Thereafter, the exports have been increasing consistently so as to reach 25.73 thousand MT worth Rs. 100.67 crores. The exports of mango to other gulf countries have been fluctuating, while it has been increasing consistently to U.K. This emphasizes production of quality mangoes in the country in order to capture export arena.

The export of pulp accounted for 78.6 and 76.3 per cent of total quantity (218.66 thousand MT) and values (Rs. 1066.52 crores) products exports from India during 2010-11. A total of 73 countries imported Indian mango pulp as against 72 countries in the previous year. The export of pulp declined from 186.20 to 171.93 thousand MT during 2009-10 and 2010-11 depicting a decline of 7.7 per cent, while its value increased from Rs. 744.61 to 814.01crore during the same years registering an escalation of 9.3 per cent. The export of jam from India was 41.82 thousand MT worth Rs. 225.74 crores, which accounted for 19.13 per cent in quantity and 22.17 per cent in value. It was exported to 60 countries as against 62 countries in the previous year. The export of mango pulp increased from 72.38 thousand MT during 1999-2000 to 171.93 thousand MT during 2010-11, depicting an increase of 137.5 per cent (Fig. 36). During the corresponding period the value of the pulp export increased from Rs. 196.53 to

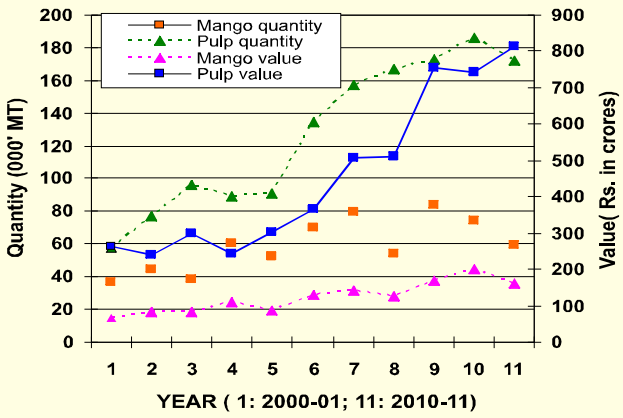


Fig. 36: Exports of fresh fruits and pulp from India.

814.01 crores, an increase of 314.2 per cent. Saudi Arabia emerged as the single largest importer of the pulp from India, by importing 48.69 thousand MT and accounting for 28.3 per cent of the total pulp exports from the country during 2010-11 as against only 19.89 thousand MT during the base year, *i.e.,* 1999-2000, depicting an overall increase of 144.8 per cent. The value of exports to the country increased from Rs. 40.18 to Rs. 210.62 crores during the corresponding period thus depicting an over all increase of 424.2 per cent. The exports of pulp to UAE, Kuwait and USA have also been increasing slowly but steadily. However, the exports of pulp to the Netherlands and U.K. have been increasing at a faster pace, although it was much lower than the exports to Saudi Arabia and UAE. The analysis exemplifies ample scope to enhance the pulp exports to gulf as well as European Union.

Import : India imported 90.57 MT of mangoes worth Rs. 2.13 lakhs from 5 countries. Bangladesh sent maximum of 83 per cent of total mangoes imported into India during 2010-11. The country imported 775.52 MT of mango products worth Rs. 30.21 lakhs during 2010-11. Out of this juice alone accounted for 82.5 per cent. Jam was the other product accounting for 15.5 per cent of total quantity of mango products imported into India. It was interesting to note that there was a drastic reduction of 73.5 per cent in the Imports of all the products into India during 2001-10 and 2010-11. The country imported 640.03 MT of juice worth Rs. 26.68 lakhs form 15 countries during the year. Bangladesh, Sri Lanka, Thailand and UAE were the major exporters to India and accounted for 48, 17, 10 and 8 per cent of the total imports of the product in India, respectively.

Guava (*Psidium guajava* L.)

Storage

Evaluation of guava cultivars for quality parameters : Ten guava cultivars were assessed for quality parameters at edible ripe stage. Ascorbic acid content (mg 100 g^{-1}) was the lowest in Pant Prabhat (136.7 mg 100 g^{-1}) while G-31 had maximum (520.9 mg 100 g^{-1}). Lycopene content of fruits was the highest (0.75 mg100 g^{-1}) in S R Surkha and the lowest (0.05mg100 g-1) in G-31.Anthocyanin content of fruits was maximum (0.37mg 100 g^{-1}) in S R Surkha and the lowest (0.06 mg 100 g^{-1}) in Sangam.

Growth and development: The fruits of cvs Lalit and Shewta were tagged at fruit set stage and fruits were harvested at regular intervals to appraise the biochemical changes. Maximum ascorbic acid in Lalit (214 mg100 g^{-1}) and (244 mg100 g^{-1}) in Shweta were recorded on the 110 days of fruit set, thereafter a decrease was noticed. The firmness in the fruits decreased from more than 12 kg cm^{-2} in both the varieties to around 11.9 kg cm^{-2} in both the cultivars after 110 days of fruit set which further decreased to 4.6 and 9.23 kg cm^{-2} in cvs Lalit and Shewta , respectively.

Bio-agents for enhancing shelf life: Mature fruits of Allhabad Safeda were subjected to post-harvest dip treatment of bio-agents, *viz. Streptosporangium pseudovulgare* @ 108 cells ml^{-1} and Bacillus subtilis strains 1, 2, 3 and 4 @ 10^8 cells ml^{-1} for 30 min. The treated fruits were subsequently packed and stored under ambient conditions (18 ± 2 ^{0}C and 57 ± 5 % RH). The cumulative loss in weight was 6.10 per cent in (Bacillus subtilis strain 1 @ 10^8 cells ml^{-1}) in comparison to other bio-agents treated fruits on the day 6 of storage. Firmness (11.27 kg cm^{-2}), TSS (11.93 ^{0}B), titratable acidity (0.31%) and ascorbic acid content (180.50 mg 100 g^{-1}) was observed in fruits treated with *Bacillus subtilis* strain 1 @ 10^8 cells ml^{-1} on the 6th day of storage. Microbiological analysis revealed that on bio-agent treated fruit surface, *B.subtilis* was the dominant surface micro flora.

Value addition

Evaluation of varieties/hybrids for processing: Among four selections/varieties evaluated for their processing potential, ascorbic acid content varied from 81 to 164 mg 100 g^{-1}, while titratable acidity ranged between 0.29 to 0.51 per cent. Ascorbic acid content was maximum in fresh fruit (164 mg 100 g^{-1}) as well as processed pulp (209 mg 100 g^{-1}) of Allahabad Safeda seedling selection and minimum (81 mg 100 g^{-1} in fresh fruit and 96 mg 100 g^{-1} in processed pulp) in cv. Red Flesh. Sensory evaluation of RTS beverage prepared from processed pulp indicated that Allahabad Safeda seedling selection had the best score (7.5) followed by Sardar seedling selection I (7.2).

Preparation of cider from over-ripe fruits : A method was standardized for the preparation of cider from over ripe guava fruits through partial fermentation of ameliorated pulp using Saccharomyces cerevisiae. The prepared cider had 16.7 0B TSS, 0.58 per cent titratable acidity, 19.6 mg 100 ml-1 ascorbic acid and 1.32 per cent reducing sugars. The beverage containing mild alcohol (4.8%) was found organoleptically acceptable.

Market analysis

Arrival and price: The arrivals in the market during 2011-12 were 1.915 thousand MT which was the highest during last 6 years. In fact it was about 50.8 per cent higher than the previous year. The arrival of the fruit during monsoon season was the highest at 144.1 MT in August, after which it declined sharply to 59.6 MT during September. The winter crop started arriving in Lucknow from October and continued to increase up to December, after which it declined. The highest arrival of 605.0 MT was during December followed by October at 461.8 MT. Highest weighted average price of Rs. 1,400 q^{-1} was observed during February 2012, which declined sharply to Rs. 484 q^{-1} during March due to deterioration in fruit quality owing to higher temperatures. The entire year weighted average wholesale price worked out as Rs. 685 q^{-1}, which was the highest during last six years.

The total trade in guava in different markets of the country during 2011-12 was 69.24 thousand MT of which winter season (November to March) accounted for 77.5 per cent. Maximum amount, *i.e.,* 15.91 thousand MT accounting for 23.0 per cent, was traded during January 2012 followed by February 2012 and December 2011, accounting for 17.5 and 15.8 per cent of the total trading. Hyderabad, which particularly specialized in winter crop, received 24.7 thousand MT accounting for 35.7 per cent of total trading in the country. It was followed by Delhi and Mumbai, which accounted for 24.3 and 12.2 per cent of total guava. Average weighted wholesale price in the country during 2011-12 worked out to Rs. 2,795 q^{-1}. The price of guava was generally high in Hyderabad market and the average price for all the trading months taken

together was Rs. 4,480 q^{-1}. It was followed by Gangtok at Rs. 2,774 q^{-1} but the quantity traded was quite less.

Exports : The export of guava from India declined from 2496 MT worth Rs. 41.72 crores during 2007-08 to 286.31 MT worth Rs. 0.633 crores during 2010-11 showing a decline of 88.4 and 98 per cent in quantity and value, respectively. Saudi Arabia imported only 1.6 per cent of the total guava exports from India. In absolute terms the exports of guava to Saudi Arabia has declined from 565 to 4.72 MT during 2010-11 showing a drastic decline of 99.2 per cent over the four year period. Similarly, Nepal, that received 24.2 per cent of the guava from India in 2007-08, imported only 12.9 per cen during 2010-11. The overall decline to Nepal is from 604 to 37.20 MT depicting a decline of 93.8 per cent during the four year period. UAE and Bahrain have emerged as the leading importers by accounting for 28.4 and 14.8 per cent of the total guava exports during 2010-11.

India exported 6.5 thousand MT of products worth Rs. 158.32 lakhs during 2010-11. Jelly was the main product accounting for 85.2 per cent of total product exports from India. In value terms, its share was 83.4 per cent. The country exported jelly to 26 countries. Indonesia was the leading importer accounting for 23 per cent of the jelly exports, followed by 14, 13 and 10 per cent to Saudi Arabia, Netherlands and U. K., respectively.

AONLA (*Emblica officinalis* Gaertn.)

Value addition

Storage of pigment-rich spray-dried aonla powder: Spray dried powders, prepared from aonla juice as well as from its blends with 10 per cent beet and/or carrot juices, were stored up to six months in laminated aluminium foil pouches at room temperature. During storage, increase in anthocyanins and NEB values were noted, while the contents of total carotenoids and ascorbic acid decreased. The amount of anthocyanins was the highest (23.8 mg100 g^{-1}) in powder prepared from blended juices of aonla and beet, while total carotenoids were maximum (5.48 mg 100g-1) in powder prepared from blends of aonla and carrot juices after 6 months of storage. The value of NEB was the highest (0.146 OD) in powder prepared from blended juices of aonla and beet after 6 months of storage. The antioxidant (FRAP) value in different spray-dried powders did not vary significantly during storage. Maximum retention of ascorbic acid (2053.4 mg100 g^{-1}) was observed in pure aonla powder after 6 months of storage. The content of polyphenols did not change significantly either in pure aonla powder or powder obtained from blended juices during storage. The critical and danger points in terms of equilibrium moisture content (EMC) for spray-dried aonla powder were observed to be 1.96 and 1.86 per cent, respectively. At 50 per cent RH, colour of the powder changed from white to brown and formation of lump started. The liquefaction of powder started and mould growth appeared at 80 per cent RH.

Storage of spray-dried aonla powder: Spray-dried aonla powder was prepared and stored in different food grade pouches up to six months at room temperature. Maximum retention of ascorbic acid (2442 mg 100 g^{-1}) and minimum non-enzymatic browning (0.037 OD) was recorded in aonla powder packed in laminated aluminum foil pouches after six months of storage as compared to powder stored in 100 or 200 gauge LDPE pouches. The antioxidant (FRAP) value of powder in different packaging materials did not change significantly during storage.

BAEL (*Aegle marmelos* Correa)

Value addition

Evaluation of selections for their processing potential: Bael selections CISH B-1 and B-2 were evaluated for the preparation of powder at different stages of fruit growth. An increase in the yield of powder (from 21.8 to 27.5% in B-1 and from 19.4 to 27.3% in B-2) was obtained as the growth period prolonged (up to 280 days) in both the selections because of the increase in average fruit weight over the growth period. TSS and titratable acidity were slightly higher in B-2 than B-1. A decreasing trend in pectin content in both the selections was observed. In B-1, pectin content decreased from 4.84 to 3.37 AIS 100 g^{-1} pulp after 280 days of fruit growth, while in B-2, it decreased from 4.12 to 3.71 AIS 100 g^{-1} after the same period.

Evaluation of selections for nutraceuticals: CISH B-1 and B-2 were collected at different stages of fruit development and analysed for marmelosin, psoralen, polyphenols and tannic acid contents. Both marmelosin and psoralen contents decreased gradually in B-1 as the fruit growth advanced, whereas B-2 presented a variation. Marmelosin content declined from 1660 µg g^{-1} at 150 days of fruit growth to 522 µg g^{-1} after 280 days of fruit development, whereas psoralen content decreased from 213 to 108 µg g^{-1} after

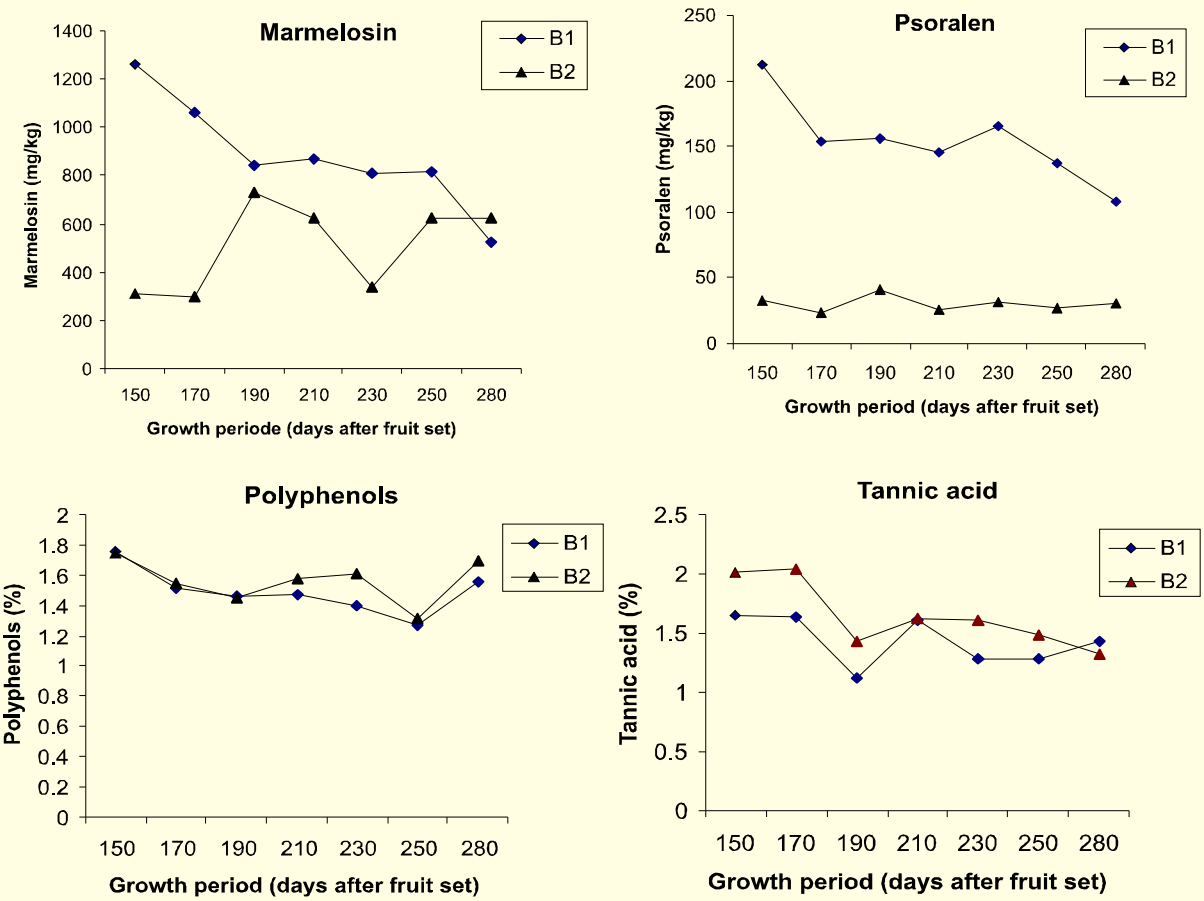


Fig. 37: Marmelosin (a), psoralen (b), polyphenols (c) and tannic acid (d) contents of two bael selections (CISH B-1 and B-2) at different developmental stages.

280 days of fruit growth in CISH B-1. In CISH B-2, the reduction in marmelosin content was from 733 to 621 µg g^{-1} and psoralen from 41 to 30 µg g-1 after 150 and 280 days of fruit development, respectively (Fig.37 a, b). Both polyphenols as well as tannic acid contents showed a decreasing trend with the advance of fruit growth in both the bael selections (Fig. 37 c, d). Polyphenols content in B-1 ranged between 1.27 to 1.76 per cent, whereas in B-2, it ranged between 1.31 to 1.75 per cent. Tannic acid content in B-1 ranged between 1118 to 1651 mg $100g^{-1}$, while in B-2, it varied between 1323 to 2036 mg $100g^{-1}$.

Papaya (Carica papaya L.)

Market analysis

Arrival and price: The total arrival in Lucknow mandi during 2011-12 was 9.54 thousand MT as against 8.35 thousand MT during the previous year. The monthly arrivals ranged between a minimum of about 264 MT during June and July 2011 to maximum of 1.7 thousand MT during March 2012. Incidentally, arrivals in Lucknow witnessed increasing trends during the last five years, depicting an increase of 101 per cent over and above total arrivals during 2007-08 at 4.77 thousand MT. The market received higher quantities of fruit during winter and summer months of December to April. The quality of fruits during these months was distinctly superior in comparison to monsoon arrival. The supply in other months was however low. The weighted average price during the entire 2011-12 was Rs. 598 q^{-1}, which was the highest in the last five years. In fact it increased from Rs. 382q^{-1} during 2007-08 to Rs. 598 q^{-1} during 2011-12 depicting an increase of 56 per cent. The lowest price of papaya was during June-July, when the arrivals were the least, while during winter months the price was in the range of Rs. 550 to 650 q^{-1}.

Litchi (*Litchi chinensis*)

Value addition

Characterization of fission yeast isolated from spoiled juice : The fission yeast (Shizosaccharomyces pombe) isolated from spoiled litchi juice, could tolerate heating at 90 ^{0}C for 6 min. The yeast was found to have alcohol dehydrogenase activity.

MULBERRY (Morus alba)

Value addition

Development of mulberry wine: Out of three varieties screened, wine prepared from MI- 497 had attractive red colour, higher anthocyanins and antioxidant values and least undesirable changes throughout the storage period of 9 months. Phenolic compounds, *viz.* gallic acid, catechin, coumaric acid and kaempferol, were detected by HPLC in all the wines obtained from all the three varieties, while epi-catechin was found in MI-497 and MI-362. Epicatechin has been reported to lower blood pressure and the associated end-organ damages.

4. TECHNOLOGY ASSESSMENT AND TRANSFER

Impact Assessment

Different farmer-friendly technologies of mandated subtropical fruit crops have been developed by the Institute. The impacts of these technologies was assessed by surveying the orchards of the beneficiaries and non-beneficiaries of Bakhtiyar Nagar and Dhedemau of Malihabad block of Lucknow. The survey revealed that average yield of mango in the orchards of the adopted farmers was 108.2 kg tree^{-1} with gross return of Rs.1082.0 against average fruit yield of 66.5 kg tree^{-1} with gross return of Rs. 665.0 in the orchards of non-adopted farmers. Data showed that 79 per cent of the farmers adopted the polythene banding of mango for the control of mealy bugs. They wrapped polythene sheet on the stem of the mango tree one and a half feet above the ground level and tied it with a rope followed by greasing/mud pasting at the lower side a technology of CISH, Lucknow.

Survey was conducted at Saidpur village of Kakori block, Lucknow to assess the impact of technology where rejuvenation was performed on 108 Dashehari mango trees during 2001 in the month of December. After the rejuvenation mango trees were found fertilized with the recommended dose of 100 kg FYM, 2 kg urea, 1 kg DAP and 1.5 kg MOP tree^{-1}. Other recommended practices of crop protection by CISH were also followed. Rejuvenated trees started fruiting from the year 2003. Prior to rejuvenation the average yield was 23.14 kg tree^{-1}. The fruit yield increased steadily from 13.88 kg tree^{-1} in the 3rd year of fruiting to 83.33 kg tree^{-1} during 2010-11. The yield loss as of the first two years of rejuvenation was reportedly compensated by the sale of cutwood and intercropping with potato and cucumber which fetched approximately Rs. 58,000/- and Rs.25,000/-, respectively.

A preliminary survey was conducted using PRA tool 'Key informant rating' for assessment of high yielding varieties of mango in village Kanar, Malihabad, Lucknow Socio economic discussion indicated that among the 350 farm families 15 per cent belonged higher caste, 30 per cent were backwards while the rest were Schedule Castes. About 95 per cent of the households of the village possessed pucca house. The village has one Ayurveda Chikitsalya and one each primary, middle school and a private intermediate college. The village also has Panchayat Bhawan and a pesticide shop. The private tube wells were the major source of irrigation in the village. Majority of the farmers (91%) have of Dashehari orchards followed by almost equal number (2% each) of Langra and Lucknow Safeda and 5 per cent of local seedling varieties of mango.

The main constraints experienced by the farmers in mango cultivation were socio-economical, infrastructural, technological and ecological.

Extension Interventions

Showcasing of the technologies **:** The institute organized showcasing of technologies at village Thawar of Mall block, Lucknow on March 22, 2012. In this event, different innovative technologies of the institute on mango production and post harvest management were displayed and demonstrated to the farmers.

Exhibitions: The Institute participated in different state as well as national level exhibitions and displayed its achievements and technologies on mandate crops as per the following details.

Sl. No.	Name of the event	Organizer	Date	Place
1.	Horticulture Fair, Kisan Gosthi & Agicultural Exhibition	CPRI Regional Station, Modipuram, Meerut ,	March 5-6, 2011	CPRI Regional Station, Modipuram
2.	National Farmers' Fair	IIVR, Varanasi	March 27, 2011	KVK, Sargatia, Kushinagar
3.	All India Mango-Expo 2011.As a part of Global Conference or/and by CISH Lucknow in participation with ISHS, Belgium.	CISH, Lucknow	June 21-24, 2011	Lifestyle Hotel, Lucknow

3.	Mango Festival	DTDC, New Delhi	July 1-3, 2011	Dilli Haat, New Delhi
4.	Mango Show	CISH, Lucknow	July 2, 2011	NASC Complex, New Delhi
5.	IVRI Kisan Mela-2012	IVRI , Izatnagar	October 18-20, 2011	IVRI, Bareilly,
6.	Farmers' fair Agril Exhibition and Kisan Gosthi	V. K. Singh Krishi Vigyan Kendra, Dhaura	Nov 05, 2011	Dhaura, Unnao.
7.	*Bharat Nirman Jansuchna Abhiyan Programme*	PIB, Lucknow, Ministry of Information & broadcasting, Govt of India	Nov 28-30, 2011	Bahraich
8.	Kisan Gosthi and Demonstration on Central Opening in mango	Village Committee Kachnar , Sitapur	Dec. 27, 2011	Kachnar Village,
9.	Science Expo-2012	Regional Science Centre, Lucknow	Feb 01-05, 2012	Regional Science Centre, Lucknow
10.	14th Indian Agricultural Scientists and Farmers' Congress on Diversification in Agriculture & Agripreneurship	Bioved Research Institute of Agriculture & Technology	Feb 18-19, 2012	Allahabad,
11.	State Fruit, Vegetable & Flower Exhibition-2012	Directorate of Horticulture & Food Processing, U.P.	Feb 25-26 , 2012	Raj Bhawan, Lucknow
12.	*Pusa Krishi Vigyan Mela-2012*	IARI, New Delhi	March 01-03, 2012	IARI, New Delhi

Exposure visit: More than 1100 farmers, 62 farm women, 34 officials of department of horticulture from different states and 34 students from the College of Agriculture, Reva, M.P. visited the institute. During their visit they were shown scientific innovatives scientific nursery facilities, experimental farms, processing and packaging lines, laboratories and technology information centre to make them aware about the different research activities and technologies developed by the institute.

Trainings: A total number of 14 training programmes on production, protection and post-harvest technologies of fruit crops, high density planting and canopy management of fruit crops, production, protection and post-harvest management of guava, production, processing and market management of guava, rejuvenation of mango and intercropping, scientific nursery management were organized in which 180 farmers and 41 officials sponsored by SHM Samiti, Sagar, ATMA, Bhagalpur, Department of Agriculture, Pachora, Jalgaon, Department of Horticulture, Ashoknagar, ATMA, Madhubani, Department of Horticulture, Ramanathapuram, ATMA, Buxar, ATMA, Bhojpur, ATMA, Darbhanga, Krishi Vigyan Kendra, Majhgawan, Satana, District Horticulture Mission, Tikamgrah participated. A total of 34 officials sponsored by NHM, Junagarh and 24 officials sponsored by NHM for NE and Himalayan States and Directorate of Horticulture and Food Processing Chaubatia, Ranikhet were trained in the production technologies of mango and guava, fruit nursery management and high density cultivation and canopy management of mango and guava, respectively.

The Precision farming Development Centre (PFDC) organized four training programmes in four districts of Uttar Pradesh, *viz*. Chitrakoot, Banda, Sultanpur and Barabanki on micro-irrigation, polyethylene mulching and protected cultivation of vegetables. Besides two hundred farmers and orchardists, twenty state government officers were also trained. Apart from these trainings, 22 on-farm trainings were also conducted which were sponsored by District Horticulture Mission, technologies mission, state saghan bagvani mission and RKVY (Horticulture Division) and ATMA from states like Uttar Pradesh, Uttarakhand, Maharashtra, Andhra Pradesh, Tamil Nadu, Rajasthan, Odisha, West Bengal, Haryana, etc., wherein 3200 farmers and government officials participated.

Three training programmes were organized for the farmers, officers and extension functionaries of the North Eastern Hill region under Technology Mission for Integrated Development of Horticulture in North Eastern Sates, Sikkim, Jammu & Kashmir, Himachal Pradesh and Uttarakhand. One hundred and ten farmers/officers/extension functionaries participated in off-campus training programmes in Assam(40), Mizoram(40) and Sikkim(30).

Farmers helpline(0522-2841082): A total number of 36 calls from farmers received were related to insect pests and diseases management (22% and 18%), planting material of high yielding varieties of mango, guava, bael and aonla (32%), crop production (18%), PHM and farm machinery (8%) and physiological (2%) like irregular flowering and alternate bearing. Solutions to their problems were provided by the thematic experts through telephonic conversation. The new facility, phone-in-live (0522-2841082), developed by the Institute also responded to the queries of the farmers and entrepreneurs. The farmers were suitably advised by the institute subject matter scientists. Thirty eight queries related to such different aspects as production technology of mango, insects pest and diseases management in mango, use of high yielding varieties of mango, guava, bael and aonla, physiological disorders in mango, meadow orcharding and high density planting in guava, rejuvenation in mango, farm machinery, nursery management, organic farming of fruit crops and storage, processing and export of mangoes by the team experts were responded through Phone-in-live programme on every Friday. Growers' queries related to various aspects of subtropical fruits were also attended through communication in Hindi/English. Extension folders and bulletins related to scientific cultivation of mango, aonla, guava and papaya were provided to the orchardists.

***Farmers' counselling*:** Twelve farmers and extension functionaries from different parts of the country visited the Institute and the problems faced by them during the implementation of production technologies of fruit crops in the field were discussed and solutions provided by the experts.

***Demonstrations*:** Method demonstration of the centre opening technique in mango using power operated chain saw was conducted at farmers' field in village Udhavapur, Ailiya block of Sitapur on December 27, 2011 wherein 50 farmers participated. Improved vegetative propagation techniques for multiplication of mango, guava and aonla were demonstrated to different farmers groups during their visit to the Institute.

Radio/TV talks

Sl. No.	Radio/TV Topic	Resource Person	Date
1	*Kinnow ki vyavsayik kheti* ®	Dr. A.K.Singh	02.05.2011
2	*Aam ke bagon mein samayik prabandhan* (TV)	Dr. R.P Shukla	10.05.2011
3	*Aam ke bagon mein samayik Karya* (TV)	Dr. Dushyant Mishra	28.07.2011
4	*Aam ke bagon mein samayik karya* (TV)	Dr. Dushyant Mishra	14.12.2011
5	*Saamyik Bagwani work*®	Dr. A.K. Singh	23.01.12
6	Integrated management of insect pest and diseases of mango (TV)	Dr. B. K. Pandey	31.01. 2012
7	Cultivation of Tomato and Capsicum under polyhouse conditions (TV)	Dr. V. K. Singh	7.02.2012
8	Guava production under high density plantation (TV)	Dr. V. K. Singh	10.02.2012
9	*Aam ke bagon mein samayik karya* ®	Dr. Dushyant Mishra	21.03.2012
10	Samayik Bagvani Karya (TV)	Dr. R.P Shukla	21.03.2012

5. EDUCATION AND TRAINING

Training

Under human resource development programme the following scientists/officers were deputed for training in the country and abroad.

Abroad

Dr. Sridhar Gutam, Senior Scientist (Plant Physiology) attended a programme under International expert consultation on Building the CIARD framework for data and information sharing held at Beijing, China. (June 20-23, 2011).

Dr. Maneesh Mishra, Senior Scientist (Hort.) attended NAIP sponsored training on Bio-security at Michigan State University, East Lansing, Michigan, USA. (January 15 to April 13, 2012).

India

Shri H.C. Verma, Scientist SS, (Computer Science) attended a training programme on Data mining and GIS for decision support in agriculture held at IIM, Lucknow. (March 28 – April 8, 2011).

Dr. Tarun Adak, Scientist (Soil Physics) attended the national training on Climate change, carbon sequestration and carbon credits held at IISS, Bhopal. (April 5-18, 2011).

Ms. Nimisha Sharma, Scientist (Biotech.) attended NAIP sponsored national training on Molecular markers for genetic diversity assessment and tools for genome resource conservation held at NBFGR, Lucknow. (April 21- May 4, 2011).

Dr. Sridhar Gutam, Senior Scientist (Plant Physiol.) attended training programme on Basic training on LC MS/MS at Labindia Research and Development Laboratory, Gurgaon. (May 25-27, 2011).

Dr. Tarun Adak, Scientist (Soil Physics) attended the training workshop of Agropedia project held at IIT, Kanpur. (July 30, 2011).

Dr. Tarun Adak, Scientist (Soil Physics) attended the national training on Forecasting modeling in crops at IASRI, New Delhi. (August 3-12, 2011).

Dr. Sridhar Gutam, Senior Scientist (Plant Physiol.) attended training programme on AGROVOC management, applications and use of VocBench for AGROVOC managers and editors from South and Southeast Asian Region held at ICRISAT, Hyderabad. (October 12-14, 2011).

Er. Anil Kumar Verma, Scientist SG (Agril. Engg.) and Ms. Pushpa K., Scientist (Food and Nutition) attended the national training on Non-thermal non-chemical processing and membrane technology in food systems held at CIAE, Bhopal. (October 12-21, 2011).

Dr. R. A. Ram, Principal Scientist (Hort.) participated in the management development programme in Agricultural research management held at NAARM, Hyderabad. (October 20-25, 2011).

Dr. P. K. Shukla, Senior Scientist (Plant Path.) participated in the refresher course on Agricultural Research Management for newly recruited senior/principal scientists held at NAARM, Hyderabad. (November 3-23, 2011).

Dr. Sridhar Gutam, Senior Scientist (Plant Physiol.) attended the training programme on Nutritional-hormonal dynamics and photosynthetic efficiency in crop plants under abiotic stress at TNAU, Coimbatore. (November 9-18, 2011).

Dr. S.K. Shukla, Principal Scientist (Hort.) attended training programme on Policy perspectives in value chain management and commodity research in Indian agriculture held at NAARM, Hyderabad (December 12-21, 2011).

Dr. Bharati Killadi, Scientist (Hort.) attend training on Science policy and technology forecasting in agriculture held at NAARM, Hyderabad (January 16-25, 2012).

Shri Muthukumar M. Scientist (Biotech.) attended NAIP sponsored national training on Development of gene chip for microbial identification using DNA probes held at NBAIM, Mau (January 28 – February 10, 2012).

Dr. Kailash Kumar, Principal Scientist (Soil Chem. / Fertility / Microbiol.) attended the management development programme in Agricultural Research Management held at NAARM, Hyderabad (February 2-7, 2012).

Shri H.C. Verma, Scientist SS (Computer Sci.) attended a training programme on Data mining using SAS held at IASRI, New Delhi (February 6-11, 2012).

Dr. Anju Bajpai, Senior Scientist (Genetics and Cytogenetics), Dr. Sridar Gutam, Senior Scientist (Olant Physiol.) and Shri Muthukumar M., Scientist, (Biotech.) participated in the training course on Phenotyping and molecular breeding

for improving drought adaptive traits in crops held at UAS, Bangalore (February 13-22, 2012).

Dr. Ajay Verma, Principal Scientist (Agril. Economics) participated in Capacity Building Programme on International Trade Towards Enhancement of Competitiveness of Indian Agriculture, New Delhi (February 27-March 3, 2012).

Shri Anil Kumar Singh, Technical Officer (T-6) and Shri C. P. Dwivedi, Technical Officer (T-5) participated in the training programme on Skill development in communication of ICAR Scientists/Officers - Creative writing in agriculture held at IIMC, New Delhi. (March 12 - 16, 2012).

Lectures Delivered

The scientists of the Institute delivered lectures at different fora.

Global Conference on Augmenting Production and Utilization of Mango: Biotic and Abiotic Stresses held at Lucknow, June 21-24, 2011.

Dr. Shailendra Rajan on Geospatial analysis for mango germplasm management.

Dr. Ramesh Chandra on Progress and future prospects of developing transgenics in mango (*Mangifera indica* L.).

Dr. H. Ravishankar on Status of planting material production in mango (*Mangifera indica* L.), problems and quality standards.

Dr. Kailash Kumar on Appraisal of some critical abiotic factors in mango (*Mangifera indica* L.) culture.

Dr. H. Ravishankar on Dynamics of potential organic persuasions for sustainable mango (*Mangifera indica* L.) culture.

Dr. R.P. Shukla on Strategies of integrated insect pest management in mango – global scenario.

Dr. R.M. Khan on EPN as a possible tool for insect management in mango.

Dr. A.K. Misra on New diseases of mango of unknown and known etiology in India.

Dr B. K. Pandey on Molecular diagnostics of anthracnose of mango.

Dr. D.K. Tandon on Maturity indices and ethylene assisted and other alternate modules for ripening in mango.

Dr. Ajay Verma on International trade in mango-Is India ready for quantum leap.

Dr. V.K. Singh on Current status of mango malformation.

Dr. Neelima Garg on By-product development and waste management.

Others

Dr. Neelima Garg on Value addition of fruit industry waste in the National Seminar on Horti Business Linking Farmers with Market (Swadesh Prem Jagriti Sangosthi-2011) organized by Lt. Amit Singh Memorial Foundation, New Delhi held at Dehradun, May 28-31, 2011.

Dr. Ajay Verma on ICT for market information system (MIS): A suggested model in the National Seminar on Horti Business Linking Farmers with Market (Swadesh Prem Jagriti Sangosthi-2011) organized by Lt. Amit Singh Memorial Foundation, New Delhi held at Dehradun, May 28-31, 2011.

Dr V. K. Singh on Physiology of flowering of horticultural crops with special reference on mango in the National Seminar on Sustainable Crop Productivity through Physiological Intervention organized jointly by ISPP and IARI, New Delhi held at Ramnarain Ruia College, Mumbai, November 25, 2011.

Dr V. K. Singh on Photosynthetic aptitude of leaves on flowering and non flowering terminals in mango (*Mangifera indica* L.) cv. Dashehari in the International Conference on Issue for Climate Change, Land Use Diversification and Biotechnological Tools for Livelihood Security held at SVPU&T, Meerut, October 8-10, 2011.

Dr. Neelima Garg on Utilization of horticultural waste for livelihood security in the International Conference on Issue for Climate Change, Land Use Diversification and Biotechnological Tools for Livelihood Security held at SVPU&T, Meerut, October 8-10, 2011.

Dr. Neelima Garg on Post harvest technology and processing of processed fruits in the Workshop on Packaging of Processed Products organized by Indian Institute of Packaging, New Delhi held at Lucknow, January 20, 2012.

Lectures Organized

Under lectures series programme following scientists of the Institute and experts from outside delivered lectures on emerging scientific areas:

Dr. A.K. Singh, Principal Scientist (Hort.) on his visit to Sri Lanka under SAARC (August 30, 2011).

Dr. Maneesh Mishra, Senior Scientist (Hort.) on Advances in transformation of horticultural crops (October 1, 2011).

Dr. Kesava Kumar, Scientist (Nematology) on Entomopathogenic nematode: A Journey from soil to insects (November 30, 2011).

Ms. Poonam Jayant Singh, Scientist, N.B.F.G.R., Lucknow on IPR and commercialization of technologies (December 5, 2011).

Mr. M.Muthukumar, Scientist (Biotech.) on Recent developments in marker technologies for crop improvement (December 15, 2011).

PG Education

The Institute imparted guidance to students leading to their obtaining B. Tech. / M.Sc. / Ph.D. degrees and project work in collaboration with different universities.

S. N.	Name of Student	University	Degree	Title of the Thesis / Project work	Period	Name of guide
1	Abhay Pratap	Shobhit University, Meerut	B. Tech. Bioinformatics	Database on IPR issue and primer sequences of mango	15-01-11 to 15-05-11	S. Rajan
2	Anurag Srivastava	Shobhit University, Meerut	B. Tech. Bioinformatics	Database on IPR issue and primer sequences of guava	15-01-11 to 15-05-11	S. Rajan
3	Ashotosh Pandey	Shobhit University, Meerut	B. Tech. Bioinformatics	Database on IPR issue and primer sequences of aonla	15-01-11 to 15-05-11	.S. Rajan
4.	Shweta Saxena	Shobhit University, Meerut	B. Tech. Bioinformatics	Database on IPR issue and primer sequences of bael	15-01-11 to 15-05-11	S. Rajan
5	Navin Kumar Gaur	Integral University, Lucknow	B. Tech. Biotechnology	*In silico* analysis and molecular characterization of regulatory genes controlling flowering in mango	15-01-12 to 31-03-12	Anju Bajpai
6	Rashmika Singh	Integral University, Lucknow	B. Tech. Biotechnology	Genomics tools for characterization of anthocynanin pigmentation genes associated with peel colour in mango (*Mangifera indica* L.)	15-01-12 to 31-03-12	Anju Bajpai
7	Faizia Iram	Integral University, Lucknow	M. Sc. Biochemistry	Genomics' approaches for physical mapping of chloroplast genes in mango (*Mangifera indica* L.)	15-01-12 to 31-03-12	Anju Bajpai
8	Pooja Singh	Integral University, Lucknow	M. Sc. Biochemistry	Molecular characterization of guava mapping populations using micro-satellites and chloroplast genes	15-01-12 to 31-03-12	Anju Bajpai

6. AWARDS AND RECOGNITIONS

Awards

The *Rajbhasha Patrika* "*Udyan Rashmi*" of the Central Institute for Subtropical Horticulture, Lucknow was adjudged 2nd during the six monthly Town Official Language Implementation Committee (TOLIC) meeting held at Hindustan Aeronautics Limited (HAL), Lucknow on August 24, 2011. Shri Chandra Prakash Vishwakarma, Chief General Manager, HAL and President, TOLIC, Lucknow handed over the Puraskar to Dr. H. Ravishankar, Director.

Dr. H. Ravishankar, Director and others with Lucknow TOLIC Award

The Central Institute for Subtropical Horticulture, Lucknow got the 10th award amongst the 174 Central Government Offices of Lucknow during the six monthly Town Official Language Implementation Committee (TOLIC) meeting held at Hindustan Aeronautics Limited (HAL), Lucknow on February 14, 2012.

Venkatesh M.S., B. Majumdar and Kailash Kumar received IMPHOS-FAI Award on Role of phosphorus on yield and quality of crops for the year 2011.

Dr. H. Ravishankar, Director was conferred with ISHS medal and citation for cooperation in furthering horticulture by ISHS, Belgium during the Global Conference in June 21-24, 2011.

Dr. S. Rajan was bestowed with 'Dashehari' award for his significant contributions in the field of crop improvement of mango by the Society for Development of Subtropical Horticulture, CISH, Lucknow during the Global Conference in June 21-24, 2011.

Bajpai, Anju, Muthukumar M. and S. Rajan received the best poster award on paper entitled Use of molecular markers for establishing genuineness of mango mother blocks in the National Conference on Horti Business: Linking Farmers with Market (Swadesh Prem Jagriti Sangosthi-2011) held at Dehradun, May 28-31, 2011.

Mishra, M., Nimisha Sharma, Rajeshpati, Kulbhushan and Ramesh Chandra received the best poster award on paper entitled Nucellar embryogenesis in mango as influenced by osmoticum, size of transplanted embryo and phytohormones in the Global Conference on Augmenting Production and Utilization of Mango : Biotic and Abiotic Stresses, June 21-24, 2011.

Rajan, S., Divya Tiwari, V.K. Singh, Y.T.N. Reddy, K.K. Upreti, M.M. Burondkar, A. Bhagwan, R. Kennedy and Pooja Saxena received the best poster award on paper entitled BBCH scale and its application for phenological studies in mango in the Global Conference on Augmenting Production and Utilization of Mango : Biotic and Abiotic Stresses, June 21-24, 2011.

Pandey, B. K., Madhu Kamle, Ashutosh Pandey, Rupesh Kumar Mishra, Purnima Sareen and M. Muthukumar received the best poster award on paper entitled A single step multiplex PCR based rapid detection of Colletotrichum gloeosporioides Penz. and Sacc. an incitant of mango anthracnose disease in the Global Conference on Augmenting Production and Utilization of Mango : Biotic and Abiotic Stresses, June 21-24, 2011.

Bhagwan, A., K. Kumar, K. Purshotam and A.K. Misra received the best poster award on paper entitled Effect of climatic change on the productivity of mango cv. Banganpalli under Andhra Pradesh condition in the Global Conference on Augmenting Production and Utilization of Mango: Biotic and Abiotic Stresses, June 21-24, 2011.

Misra, A.K. and Om Prakash received the best paper award on article entitled *Aam ki agyat bimariyan tatha phul wale parjivi paudhe evam adhipadap* in *Udyan Rashmi*. **12** (1): 16-23, 2011.

Recognitions

Dr. A.K. Misra was elected Zonal President, Indian Phytopathological Society (IPS), New Delhi.

Dr. R.M. Khan was elected Councillor, Society of Plant Protection Sciences, New Delhi.

Dr. R.P. Shukla acted as a Member, Advisory Committee of National Horticultural Research and Development Foundation (NHRDF), Nashik, Maharashtra.

Dr. A.K. Misra was conferred Fellowship of the Confederation of Horticulture Association of India.

Dr. R. Chandra, A.K. Misra, Neelima Garg, D.K. Tandon and G. Pandey were conferred Fellowship of the Society for Development of Subtropical Horticulture, CISH, Lucknow.

Dr. V.K. Singh was nominated as a member of IMC, Central Institute for Arid Horticulture, Bikaner.

Dr. V.K. Singh acted as Chairman in the technical session-10 - Physiology of plantation, horticultural crops and medicinal plants, natural resources management bio-diversity and pharmacognosy in the National Seminar on Sustainable Crop Productively through Physiological Intervention held at Ramnarain Ruia College, Mumbai, November 24-26, 2011.

Dr. R.P. Shukla acted as Co-Chairman of the technical session V - Insect pest management in the 20th Group Workers Meeting of AICRP (STF) held at HCRI, Periyakulaum, September 29 - October 2, 2011.

Dr V.K. Singh acted as Co-Chairman in the technical session V - International Conference on Issues for Climate Change, Land Use Diversification and Biotechnological Tools for Livelihood Security, SVPU&T, Meerut, October 8-10, 2011.

Dr. D. Pandey acted as Co-Chairman in the technical session I - Advances in disease and insect management in the National Seminar on New Frontiers and Future Challenges in Horticultural Crops, PAU, Ludhiana, March 15-17, 2012.

Dr V.K. Singh acted as Convener of the technical session III - Dynamics of production technologies and quality planting materials in the Global Conference on Augmenting Production and Utilization of Mango: Biotic and Abiotic Stresses, held at CISH, Lucknow, June 21-24, 2011.

Dr. R.P. Shukla acted as a Convener of the technical session IV - Plant health management in the Global Conference on Augmenting Production and Utilization of Mango: Biotic and Abiotic Stresses held at CISH, Lucknow, June 21-24, 2011.

Dr. Neelima Garg acted as Resource Person for the Workshop on Packaging of Processed Fruits organized by Indian Institute of Packaging, New Delhi held at Hotel Gomti, Lucknow, January 20, 2012.

Dr. S. Rajan acted as Resource Person during Technical Advisory Committee meeting held at CIH, Dimapur, Nagaland, February 3, 2012.

Dr. Neelima Garg acted as Resource Person in the Product Development Workshop on Aonla organized by Center for Technology and Entrepreneurship Development, Jagdishpur, CSM Nagar (U.P.) held at Pratapgarh, March 30, 2012.

Dr. V.K. Singh acted as Resource Person during the brainstorming session on Prioritization of Plant Physiology and Biochemistry Research for 12th Five Year Plan Period held at IARI, New Delhi, August 6 - 7, 2011.

Dr V. K. Singh acted as Rapporteur in the technical session VIII - Post-harvest physiology of fruit crops in brainstorming meeting on Prioritization of Plant Physiology and Biochemistry Research for 12th Five Year Plan Period held at IARI, New Delhi, August 6, 2011.

Dr. D. Pandey acted as Rapporteur in session III - Rootstock, propagation, planning density, training and pruning in the 20th Group Workers' Meeting of AICRP (STF) held at HC &RI, Periyakulaum, September 29 - October 2, 2011.

Dr V. K. Singh acted as Rapporteur in session IV - Effect of growth regulators and chemicals on flowering and fruiting in the 20th Group Workers' Meeting of AICRP (STF) held at HC&RI, Periyakulam, September 29 – October 2, 2011.

7. LINKAGE AND COLLABORATION

Institute has linkages with different National and International organizations such as DAC-NCPAH, Ministry of Agriculture, DBT, DST, NMPB, PPV & FRA, UPCST, UPCAR, NAIP, AMAAS, NICRA, the Sultanate of Oman and UNEP/GEF. The Institute has in place MoUs to facilitate capacity building initiatives with Amity University, Lucknow; Lucknow University, Lucknow; Babasaheb Bhimrao Ambedkar Agricultural University, Lucknow; Integral University, Lucknow; Sam Higginbotham Institute of Agriculture, Technology and Science, Allahabad; SVPUA&T, Meerut and Bundelkhand University, Jhansi for pursuing research as part of M.Sc. and Ph.D. degrees of their students. Institute is also recognized by IGNOU, New Delhi as one of the study centers for offering one year Diploma on Value added products from fruits and vegetables and a Certificate course on Organic farming. National Horticulture Mission has identified the institute as nodal centre for imparting training on rejuvenation of old and unproductive mango orchards and meadow orcharding in guava.

The externally and foreign funded projects in operation at the Institute are listed below:

Sl. No.	Project Title	PI	Period
	DAC, NCPAH, Ministry of Agriculture, GOI, New Delhi		
1.	Hi-tech horticulture for efficient utilization of resource through precision farming (PFDC)	Dr. V.K.Singh	May 2002 - Continuing
	AMAAS, Mau, UP		
2.	Utilization of mango processing waste for obtaining value added products through fermentation.	Dr. (Smt.) Neelima Garg	April 2007 – Continuing
	ICAR Networking Project, New Delhi		
3.	Network project on transgenics in crops (Papaya).	Dr. Ramesh Chandra up to February, 2012 Dr. Maneesh Mishra March, 2012	Oct. 2005 - March 2013
4.	Network project on Assessment of gender issues and identification and refinement of selected women specific technologies in horticultural crops.	Dr. S.K.Shukla Co-PI	2009- 2012
5.	Intellectual Property Management and Transfer/ Commercialization of agriculture technology scheme	Dr. (Smt.) Neelima Garg	April 2008– March 2013
	Outreach Programme in Network Mode(ICAR), New Delhi		
6.	Outreach programme on Management of sucking pests on horticultural crops. Sub Project : Mango hopper	Dr. R.P.Shukla	April 2009- March 2013
7.	Outreach programme on Diagnosis and management of leaf spot diseases of field and horticultural crops. Sub Project : *Colletotrichum* (Mango)	Dr. B.K.Pandey	June 2009- March 2013
8.	Outreach programme on *Phytophthora*, *Fusarium* and *Ralstonia* diseases of horticultural and field crops. Sub Project : *Fusarium* (Guava)	Dr. B.K.Pandey	April 2009- March 2013
	UPCST, Ministry of Science & Technology, Govt. of UP, Lucknow		
9.	Genetic transformation of guava (*Psidium guajava* L.) for wilt resistance	Dr. Maneesh Mishra	March 2010 – April 2013
	National Medicinal Plants Board, Ministry of Health & Family Welfare, GOI, New Delhi		
10.	Anti-diabetic activity guided fractionation and associated attributes in potential germplasm of jamun (*Syzgium cumini* Skeels).	Dr. A.K. Singh	April 2008- July, 2012

Technology Mission, GOI, New Delhi			
11.	Technology Mission for integrated development of horticulture in North-Eastern State Subproject – Organic/ biodynamic cultivation of horticultural crops in N.E. region including Sikkim	Dr. R.A.Ram,	April 2003 – Continuing
NAIP, ICAR, New Delhi			
12.	Understanding the mechanism of off season flowering and fruiting in mango under different environmental conditions	Dr. S. Rajan Consortium PI	March 2009-March 2012
13.	A value chain on mango and guava for domestic and export markets	Dr. S.K.Shukla Consortium PI	2009-2012
14.	Mobilizing mass media support for sharing agro-information	Director CCPI	2009-2012
15.	Holistic approach fro improving livelihood security through livestock based farming system in Barabanki and Raebareli district of U.P.	Dr. R.A. Ram CCPI	2009-2012
PPV & FRA, Ministry of Agriculture, GOI, New Delhi			
16.	Developing National Repository and creating facilities for DUS testing in Mango (*Mangifera indica*), Guava (*Psidium guajava*) and Litchi (*Litchi chinesis*)	Dr. S. Rajan	June 2010 - 2013
UPCAR, Ministry of Agriculture, Govt. of UP, Lucknow			
17.	Management studies for irregular bearing in mango.	Dr. V.K. Singh	Oct. 2008 – Oct. 2011
18.	Establishment of model nursery for organic production of quality planting materials of mango, guava, aonla and bael with modern techniques	Dr. R.A. Ram	2007-Dec., 2011
National Initiative on Climate Resilient Agriculture (NICRA), ICAR, New Delhi			
19.	Understanding the change sin host-pest interactions and dynamics in mango under climate change scenario	Dr. R.P.Shukla Co-PI	Nov. 2011 - March, 2017
The Sultanate of Oman			
20.	Mango Tree Encyclopedia Project	Dr. S. Rajan	Nov. , 2008 – Oct., 2012
UNEP/GEF-PDF-B			
21.	Conservation and sustainable use of cultivated and wild tropical fruits diversity: Promoting sustainable Livelihoods, food security and ecosystem services.	Dr. S. Rajan	2009 - 2014

8. AICRP/ PFDC

AICRP (STF)

All India Coordinated Research Project on Subtropical Fruits (AICRP, STF) has its headquarters located at Central Institute for Subtropical Horticulture (CISH), Lucknow with activities of 18 centres working on mango, guava, litchi and grapes being coordinated. Out of these, 5 centres are based at different ICAR institutes, 12 in SAUs and one in a non-government agency. Two ICAR based centres are regular centres, while 3 are co-opted centres. The research on grapes is being carried out at 4 centres under the supervision of NRC on Grapes, Pune. A new centre on grape at JNKVV, Mandsore (MP), was added in XIth Plan. Research activities on mango, guava and litchi are implemented under the guidance and supervision of AICRP (STF) headquarters situated at CISH, Lucknow. A total number of 68 trials divided into 6 sections related to crop improvement, crop production and crop protection aspects of mango, guava and litchi were conducted at different centres during the period of report.

Genetic stocks of mango, guava and litchi were collected, evaluated and maintained in nine regular and three voluntary centres of AICRP (STF) for selection of suitable cultivars/varieties for different regions and for using them for further crop improvement and production programme along with other different traits. The germplasm were evaluated for their qualitative and quantitative traits. Cataloguing of genetic stocks of different subtropical fruits was done using various descriptors.

Crop Improvement and Genetic Resources

Mango (*Mangifera indica* L.)

A total number of 104 seedling mango germplasm were collected and characterized. Out of these, 4 from FRS, Rewa, 7 from AES, Paria, 48 from RFRS, Vengurle, 27 from HC&RI, Periyakulam, and 7 each from FRS, Sangareddy, RCA, Udaipur and AES, Paria were collected. Apart from these, 44 superior clones of leading varieties under different agro-ecological regions were also collected. These were 35 of Neelum, Bangalora, Kalepad, Mulgoa, Banganpalli, Alphonso, Sendura and Salem Sendura from HC&RI, Periyakulam, 3 of Banganpalli, 2 each of Dashehari, Pairi and Alphonso from GBPUA&T, Pantnagar, AES, Paria and RFRS, Vengurle, respectively. A total number of 638 germplasm of mango accessions were evaluated. These were 12 from Sangareddy, 43 from BAC, Sabour, 54 from AES, Para, 250 from IIHR, Bangalore, 60 from FRS, Rewa, 113 from RFRS, Vengurle, 18 from RCA, Udaipur and 08 from GBPUA&T, Pantnagar. During evaluation, CISH-M-2 recorded maximum cumulative yield (232 kg tree^{-1}) based on 9 bearing years as well as during the year 2011-12 (82.4kg plant^{-1}) at FRS, Sangareddy. Cultivars Maldah Surajgarh recorded maximum fruit yield (81kg tree^{-1}) followed by Amrapali (80kg) at BAC, Sabour. Cultivar Sora recorded maximum (1166g) fruit weight followed by Tenneru (945g) at IIHR, Bangalore. Similarly, highest fruit weight was recorded in cvs Vanraj (500g) followed by Dilsad (385g) and Fazli (351g) at FRS, Rewa and Hemlet (1176g) at RFRS, Vengurle. In general, cvs Totapuri and Amrapali recorded consistent economic yield at most of the centres. Dashehari-35 performed consistently better at FRS, Sangareddy.

Under varietal trials, variety Zardalu recorded maximum number of fruits (88.25 fruits tree^{-1}). Highest yield of 37.03kg tree^{-1} and 60.30kg tree^{-1} were recorded in Bangalora at AES, Paria and BCKV, Mohanpur, respectively.

A total number of 1752 flowers were crossed in twelve cross combinations involving 12 male and Amrapali as female parent at IARI, New Delhi, whereas six different cross combinations employing 2403 flowers were attempted and 192 fruits were harvested at AES, Paria. A total of 9192 flowers were crossed involving Alphonso, Vanraj and Amrapali at IIHR, Bangalore. Amongst the various F_1 populations available at IIHR, one promising hybrid R_1 P_2 from Amrapali x Arka Anmol was released based on field and laboratory evaluation. This hybrid possessed optimum fruit size (224g) with TSS (24^{0}Brix) and 68.8 per cent pulp recovery. At RFRS, Vengurle, a total number of 2127 flowers were crossed using five cross combinations resulting into 80 F_1 populations. These 80 F_1 progenies were sown in pots for germination.

A total number of 231 mango germplasm were screened against important insect pests under different agro-ecological regions. Amongst them, 91 were screened from FRS, Sangareddy, 39 from AES, Paria, 58 from RFRS, Vengurle and 43 from BAC, Sabour.

Highest infestation of stone weevil (6-20%) was recorded under unmanaged orchards in Rangareddy, Mahboobnagar and Medak districts of Andhra Pradesh. The popular cultivars, Neelum and Banganpalli were found free from stone weevil infestation in the region. Among the 70 varieties screened at Sangareddy negligible infestation (0 to 3%) was recorded. Commercial varieties such as Baganpalli, Totapuri, Alphonso, Kesar, Neelum, juicy varieties like Cherukurasam, Chinnarasam and Peddarasam and coloured varieties Husnara and Janardhan Pasand and off season varieties Royal Special and Baramasia were free from stone weevil infestation. Thirty nine accessions of mango germplasm were screened for hoppers and thrips at AES, Paria. Maximum hopper population (13.7 panicle^{-1}) was recorded in cv. Vellaikolumban whereas minimum in Zardalu, Himsagar and Bombai (1.1 panicle^{-1}). Cultivars Alphonso, Sabja and Sindhu were found free from stone weevil infestation and none of the cultivars were found free from fruit fly infestation, maximum being recorded in Dilpasand (36%) at RFRS, Vengurle. Maximum hopper population was recorded in Dudhiya Maldah (12.5panicle^{-1}) followed by Nazara Bombay (12.2panicle^{-1}) at BAC, Sabour.

A total number of 266 mango cultivars screened against powdery mildew were classified as disease free (178), highly resistant (53), resistant (31), moderately susceptible (3), susceptible (1) and highly susceptible (0) following 0-5 disease scale at FRS, Sangareddy. Cultivars Kapuria, Calcattia Maldah, Dadmiyan, Dudhia Maldah, Gilas, Surjgarh Maldah and Dholikoti Maldah showed no infestation of powdery mildew at BAC, Sabour. The important resistant varieties at AES, Paria were Ostin, Palmer Lily, Keitt, Arka Neelkiran, Sensation, Zardalu, Kensington, Malviyabhog. The cultivars Totapuri Red Small, Totapuri, Tomy Atkins, Lilly and Kothare were found to be resistant at RFRS, Vengurle.

Guava (*Psidium guajava* L.)

Three new accessions of guava germplasm collected from RFRS, Vengurle were added to gene bank. A total number of 104 accessions of guava germplasm were evaluated at various centres, *viz*. 42 at FRS, Rewa, 25 at FRS, Sangareddy, 26 at RCA, Udaipur and 13 at RFRS, Vengurle.

Under varietal trial with six guava varieties, the Red Fleshed registered maximum number of fruits (254 fruits tree^{-1}) and yield (27.61kg tree^{-1}) at HC&RI, Periyakulam, whereas Sardar (16.0kg tree^{-1}) followed by Lalit (15.60kg tree^{-1}) recorded maximum yield at RFRS, Vengurle.

Guava selection Lalit performed best based on growth and yield compared to other guava hybrids/ selections at RCA, Udaipur although maximum vitamin C (199mg100g^{-1}) was noticed in the selection Shweta. Similarly, maximum TSS and sugars were recorded in hybrid Arka Amulya.

Litchi (*Litchi chinensis* Sonn)

A total number of 82 germplasm accessions of litchi were maintained in field gene bank at various centres, *viz*. NRCL, Muzaffarpur (40), BCKV, Mohanpur (11) and GBPUA&T, Pantnagar (31). Based on evaluation of litchi germplasm at various centres, Rose Scented, Calcuttia, PLS-1 performed better at GBPUAT, Pantnagar, Early Large Red recorded higher yield followed by Green and Large Red at CISH, Lucknow. In varietal trial of litchi, a set of 12 varieties was laid out at 4 locations. Maximum fruit weight (20.60g) and pulp weight (14.11g) were recorded with minimum seed weight (2.39g) and TSS (20.0^{0}B) in cv. Bedana although maximum fruit yield was obtained in cv. Bombai. At GBPUA&T, Pantnagar, maximum fruit yield (50.25kg tree^{-1}), fruit weight (21.26g), TSS (23.0^{0}Brix) along with minimum acidity (0.46%) was recorded in cv. Rose Scented.

Crop Production

Mango (*Mangifera indica* L.)

Maximum fruit weight (431.0g) and yield (47.20kg tree^{-1}) were recorded with scion cv. Banganpalli at FRS, Sangareddy and maximum number of fruits (46.25 fruits tree^{-1}) and yield (20.93kg tree^{-1}) with scion cv. Alphonso at RFRS, Vengurle grafted on Vellaikolumban rootstock although the cumulative (2004-11) yield (453.99kg tree^{-1}) was highest on Nekkare rootstock at FRS, Sangareddy. Cultivar Totapuri recorded highest yield (55.20kg tree^{-1}) on Olour rootstock at IIHR, Bangalore. Maximum fruit yield was recorded in double hedgerow system of planting at HC&RI, Periyakulam, CISH, Lucknow and GBPUA&T, Pantnagar. Under pruning trial for high density planting, maximum number of fruits (174.33 fruits tree^{-1}) were recorded with 10 cm heading back of terminal shoots biennially just after fruit harvest during the month of June-July although maximum fruit weight (295.0g fruit^{-1}) was recorded with 20cm heading back

of terminal shoots biennially during the rest period before the emergence of new growth in mango cv. Alphonso at RFRS, Vengurle. Similarly, maximum number of fruits (58.33 fruit tree^{-1}) and yield (9.0 MT ha^{-1}) were recorded with cv. Dashehari at GBPUA&T, Pantnagar.

Pruning trial with bearing trees, planted at normal distance, the treatment thinning of crowded branchlets and centre opening after fruit harvest along with the application of standard dose of paclobutrazol recorded highest yield (311.17 kg tree^{-1}) and fruit weight (417.77g) at HC&RI, Periyakulam and BCKV, Mohanpur. However, under pruning for rejuvenation of overcrowded orchards the thinning of up to the crowded branches and centre opening along with application of standard dose of paclobutrazol during the pre-emergence of new growth recorded highest yield (29.60kg tree^{-1}) and number of fruits (110.33 fruits tree^{-1}) at AES, Paria. Similar results were also obtained at HC&RI, Periyakulam.

Under evaluation of substrate dynamics for IPNM of mango, application of recommended dose of fertilizers along with foliar spraying of Zn (0.5%)+ B (0.2%)+ Mn (1%)+ Ca (0.6%) twice during August and October followed by 10 cm thick mulching gave maximum number of fruits (136.83 fruits tree^{-1}) and total yield (55.16 kg tree^{-1}) at FRS, Sangareddy, whereas normal application of recommended dose of fertilizers recorded maximum yield at RFRS, Vengurle. Under the nutritional survey of mango orchards, the higher yield and fruit weight were correlated with higher availability of N (470.40 kg ha^{-1}) in top 50 cm layer of soil, whereas higher TSS and vitamin C were correlated with higher available of K under farmers orchard at FRS, Sangareddy. Average mango yield in Ratnagiri districts of Maharashtra was between 2.6 to 3.0MT ha^{-1} however, well managed orchards with recommended cultural practices the yield was 7-8MT ha^{-1}at RFRS, Vengurle. Maximum number of fruit (115 fruits tree^{-1}) and yield (32.13 kg tree^{-1}) along with higher cost benefit ratio were recorded in treatment vermi-compost (50 kg tree^{-1}) + *Azospirillium* culture (250 g tree^{-1}) + PSB (250 g tree^{-1} at FRS, Sangareddy, whereas highest yield was recorded in treatment vermi-compost (50 kg tree^{-1}) + *Azospirillium* culture (250 g tree^{-1}) + PSB (250 g tree^{-1}) + vermiwash at AES, Paria.

In order to understand the effect of different chemicals on regulation of flowering and fruiting in mango, maximum number of fruits and yield were recorded in treatment KH_2PO_4 (1%) + KNO_3 (1%) at FRS, Sangareddy, HC&RI, Periyakulam and CISH, Lucknow. However, highest fruit yield was recorded by spraying KH_2PO_4 (1%) alone at RFRS, Vengurle and K_2HPO_4 (1.0%) + KNO_3 (1%) at AES, Paria.

Pre-harvest spray of $CaCl_2.6H_20$ (6%) along with mulching increased the fruit set (7.17), number of fruits (149.30 fruits tree^{-1}), fruit weight (396.30g fruit^{-1}), TSS (20^{0}Brix) and storage life (13.37 days) of mango at FRS, Sangareddy, whereas mulching + K_2SO_4 (1%) registered highest yield at HC&RI, Periyakulam. Spraying of borax (1%) + mulching registered highest fruit weight and yield at GBPUA&T, Pantnagar although, minimum PLW and higher marketable fruits were recorded with spraying of $CaCl_2$ (6.0%) and mulching.

The sprays of boric acid and sorbitol significantly enhanced the fruit set (13) and fruit weight (386g fruit^{-1}) although maximum number of fruits (168 fruits tree^{-1}) and cumulative fruit yield (236kg tree^{-1}) were recorded with the spraying of boric acid or Sorbitol alone at FRS, Sangareddy. At HC&RI, Periyakulam, spraying of Ca $(NO_3)_2$ (0.6%) showed maximum yield (81.70kg tree^{-1}) although maximum fruit weight and TSS were recorded with Ca $(NO_3)_2$ (0.6%) + Sorbitol (2%). At AES, Paria, single spraying of calcium, boron or sorbitol alone was quite effective in maximizing yields compared to combined sprays. Highest yield was recorded with treatment Ca NO_3 (0.6%) at RFRS Vengurle and BAC, Sabour. The maximum number of fruits and fruit yield were recorded in mango cvs Bombay at BAC, Sabour, Totapuri at AES, Paria, Langra at FRS Rewa and Mallika at FRS, Sangareddy in relation to weather parameters under different agro-climatic conditions.

Guava (*Psidium guajava* L.)

Under evaluation of substrate dynamics for IPNM of guava, the maximum yield was obtained in the treatment of recommended dose of fertilizers followed by spraying of Zn (0.5%) +B (0.2%) + Mn (1%) during the month of August and October at FRS, Sangareddy, whereas non-significant difference were recorded in terms of yield and fruits quality at RCA, Udaipur. At FRS, Rewa full recommended dose of fertilizer followed by foliar spray of Zn (0.5%) +B (0.2%) + Mn (1%) along with use of 10cm thick organic mulch recorded highest yield (55.30kg tree^{-1}). Application of ½ recommenced dose of fertilizer + 50 kg FYM +250 g *Azospirillum* gave maximum yield (65.33kg tree^{-1}) along with average fruit weight (120g fruit^{-1}) and TSS (9.9^{0}Brix) at GBPUA&T, Pantnagar, whereas maximum number of fruits (866.33 fruit tree^{-1}), fruit yield (99.91kg

tree^{-1}) along with fruit weight was recorded with the application of ½ recommended dose of fertilizer + 25kg FYM + 250g *Trichoderma* at BAC, Sabour. Maximum yield (140kg tree^{-1}) was recorded when irrigation was provided with 4 dripper plant^{-1} daily at FRS, Rewa.

Litchi (*Litchi chinensis* Sonn.)

Maximum yield (32.02kg tree^{-1}) was recorded in treatment having half dose of recommended fertilizers+ 50kg FYM + 5kg vermi-compost at GBPUA&T, Pantnagar, whereas ½ of the recommended dose of fertilizers + 250g *Azotobactor* + 5kg vermin-compost and 25kg FYM produced highest yield (17.66kg tree^{-1}) at NRC Litchi, Muzaffarpur.

Application of normal dose of fertilizers followed by pre-harvest spraying of Zn (0.5%) + B (0.2%) + Mn (1%) + Ca (0.6%) resulted into maximum yield in cv. Rose Scented at GBPUA&T, Pantnagar. Soil and leaf nutrient contents varied in different litchi orchards under different centres. Under irrigational trial of litchi, maximum yield (30.51kg tree^{-1}), fruit weight (21.15 g) and TSS (22.3° Brix) were recorded at 1.0 V level of irrigation at GBPUA&T, Pantnagar.

Controling of sun light through shade net was found most effective treatment in delaying harvesting by 7-11 days along with high yield and good quality fruits at GBPUA&T, Pantnagar. Similarly, maximum fruit yield and quality were influenced by girdling (1mm wide and deep) of 25 per cent primary branches in cv. Rose Scented at Pantnagar. Four pre-harvest sprays of 400 ppm ethephon resulted in maximum flowering shoots (82.60%), fruit weight (23.70g) and yield (92.50kg plant^{-1}) at BCKV, Mohanpur, whereas KNO_3 (10g l^{-1}) significantly increased yield and other physico-chemical traits in litchi at GBPUA&T, Pantnagar.

Crop Protection

Mango (*Mangifera indica* L)

Peak activity of hopper population (12.8 hoppers panicle^{-1}) was noticed during 6th standard week (2nd week of February) in cv. Banganapalli and positively correlated with maximum temperature and relative humidity at FRS, Sangareddy. At BAC, Sabour maximum population of hopper was recorded between 11th - 12th and 16th - 17th standard weeks. The peak population of hopper (2.10 hoppers panicle^{-1}) was recorded during 9th standard week at AES, Paria. Hoppers activity was seen throughout the year and positive correlation with maximum sun shine hours was observed, whereas major peak population of thrips was noticed during 14th standard week recording 3.0 thrips twig^{-1} and significant positive correlation with maximum temperature and sun shine hours. Similarly, fruit fly was active throughout the year and highest population was observed during 22nd std week (592 males trap^{-1}) which coincided with fruit maturity. The positive correlation was observed with minimum temperature and relative humidity. Peak population of mango hopper and fruit fly were noticed during first fortnight of March and 25th to 28th standard week (66 and 80 males trap^{-1}) at BCKV, Mohanpur. However, at GBPUA&T, Pantnagar hopper populations (20 to 22 hoppers panicle^{-1}) was high during the month of February, March and April coincide with flowering and fruit growth whereas highest population of fruit flies (1268 flies trap^{-1} week^{-1})were found during June-July. At RFRS, Vengurle, the highest hopper population (17.40 hoppers panicle^{-1}) was recorded during first fortnight of February, whereas maximum fruit fly population was observed (408.75 trap^{-1} week^{-1}) during 24th standard week.

Hanging of wide mouth glass bottle trap containing methyl eugenol (l0.1%) and DDVP (0.1%) @10traps ha^{-1} was most effective followed by Dapoli trap in controlling fruit flies at FRS, Sangareddy. However, hanging of wooden block soaked solution in the ratio of 6:4:1 (alcohal: methyl eugenol: DDVP) in plastic bottle was found more effective at BAC, Sabour, AES, Paria, GBPUA&T, Pantnagar and RFRS, Vengurle.

Under IPM of mango, the Module-III (first spray of thiamethoxam (0.3g l^{-1}) at panicle emergence stage followed by second spray (after 21days) of profenophos (1.5ml l^{-1}) was superior in controlling mango hoppers at FRS, Sangareddy. However, Module –IV proved to be better over other modules in reducing the hopper population (1.5 hopper panicle^{-1}) with highest yield (85.75kg tree^{-1}) at AES, Paria. Similarly Module-III and IV proved better over other modules at GBPUA&T, Pantnagar as they produced highest yield 316.25kg tree^{-1} and 298.75 kg tree^{-1} respectively. No significant differences were recorded in different modules, although Module-III was superior over other treatments (modules) as it recorded highest yield (2.67MT ha^{-1}) at RFRS, Vengurle and MPKV, Rahuri.

Survey and surveillance of pollinators of mango in different agro-ecological regions showed that average population of pollinators was in the middle of the tree (2 to 4 m height) at FRS, Sangareddy, BAC, Sabour and GBPUA&T, Pantnagar.

A total number of 650 accessions of mango germplasm including standard varieties/ hybrids/ seedlings/clones were evaluated against mango malformation at RFRS, Vengurle (195), FRS, Sangareddy (296), BCKV, Mohanpur (76), AES, Paria (40) and BAC, Sabour (43). Approximately 192 accessions were found free from malformation under different agro-ecological regions of India during the year 2010-11. The important accessions which have recorded nil malformation are Meghalantan at BCKV, Mohanpur, Mallika, Baneshan, Bangalora, Suvarnrekha at AES, Paria, Nazara Bombai, Latkampoo, Calcuttia Maldah, Dudhia Maldah, Gilas and Gangasagar at BAC, Sabour.

Appearance of powdery mildew was noticed on 1st week of March (15.20%) at BCKV, Mohanpur, 4th week of January at FRS, Sangareddy, 2nd week of January on third flush (55.20%) at RFRS, Vengurle, last week of January at CISH, Lucknow and FRS, Rewa. However, at AES Paria, the powdery mildew was first noticed in mango cv. Alphonso (7.56%) during 6th standard week and reached to maximum disease intensity (43.11%) at mean maximum temperature (36.76^{0}C), minimum temperature (13.24^{0}C), relative humidity (61.64%) sunshine hours (8.60 h day^{-1}), wind velocity (2.53km h^{-1}) and vapour evaporation (4.20mm day^{-1}) with clean sky conditions.

Pre-harvest spraying of tricyclozole (0.1%) checked the anthracnose spread over other treatments at FRS, Sangareddy, RFRS, Vengurle, AES, Paria and Saaf at BCKV, Mohanpur and FRS Rewa. However, at BAC, Sabour, carbendazim (0.1%) excelled over all other treatments. Mango blossom blight (combined infection of anthracnose and *alternaria*) could be controlled by pre-harvest application of zineb + hexaconazole (0.2%) at FRS, Sangareddy and carbendazim (0.10%) followed by tricyclazole (0.1%) at RFRS, Vengurle, mancozeb (0.2%) at BAC, Sabour, carbendazim + mancozeb (0.2%) at FRS, Rewa and CISH, Lucknow.

Under the cost effective management of post-harvest anthracnose of mango by pre and post-harvest treatments shows that two pre-harvest sprays of carbendazim (0.01 %) at 30 days interval prior to harvest completely checked the spreads of anthracnose during storage at FRS, Sangareddy, whereas one spray of thiophenate methyl 15 days prior to harvest proved to be effective at FRS, Rewa. Two sprays of thiophenate methyl followed by hot water treatment supplemented with half dose of thiophenate methyl completely checked anthracnose incidence during storage at AES, Paria and CISH, Lucknow. However, all the post-harvest fruit dip (including control) either with hot water treatment alone or supplemented with fungicides except one spray of thiophenate methyl followed by hot water treatment were most effective in controlling post harvest rot of mango cv. Alphonso at RFRS, Vengurle.

Guava (*Psidium guajava* L.)

Hanging of wooden blocks soaked in solution containing alcohol, methyl eugenol and DDVP in the ratio of 6:4:1 in plastic bottles was found highly effective in trapping maximum fruit flies (40.6 and 60 flies' trap^{-1} week^{-1}) at BAC, Sabour and MPKV, Rahuri, respectively.

Highest severity of wilting (14%) was recorded in Ajmer by CISH, Lucknow, whereas maximum incidence of anthracnose fruit spot (18.50%), scab/ canker (13.75%), algal rust (5.35%) and *Phytopthora* fruit rot (3.0%) were recorded as major diseases during monsoon season and wilt (10.15%) and dieback (6.40%) during pre-monsoon season in guava orchards at BCKV, Mohanpur. At FRS, Rewa the anthracnose followed by die back, fruit rot and canker were recorded during monsoon and winter season, respectively.

Litchi (*Litchi chinensis* Sonn)

Surveillance of the pest complex and their natural enemies showed that infestation of leaf roller was relatively low in July (20.5%) and increased gradually to a maximum level in October (45.5%) and fruit borer (*Conopemorpha cramerella)* infestation appeared after 61 days, and reached to maximum (>35%) after 67 days after fruit set at BCKV, Mohanpur. Infestation of leaf roller increased with the increase in temperature and highest infestation (39.67%) was recorded in the month of July at GBPUA&T, Pantnagar.

Two sprays of endosulfan (0.07%) were found effective in managing litchi pest complex with minimum infestation (8.1%) along with highest yield (90.5 kg tree^{-1}) at BCKV, Mohanpur and minimum fruit infestation (11.67%) and highest fruit yield (68.33kg tree^{-1}) at GBPUA&T, Pantnagar. IPM module for litchi mite revealed that burning of pruned infested leaves and shoots during June followed by spraying of dicofol (0.05%) at the emergence of new flush reduced the infestation (60.67%) and resulted into good yield (34.33kg tree^{-1}) at GBPUA&T, Pantnagar. Survey and

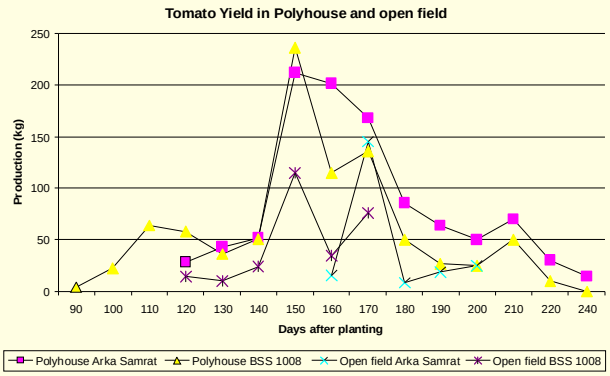
surveillance of pollinators in litchi showed that *Apis* bees and *Dipterans* accounted for 41 and 42 per cent, respectively, at BCKV, Mohanpur, whereas maximum population of pollinators were recorded in the last week of March at medium height of tree which consisted *Syrphid* (72.6 to102.4 flies 50 panicles^{-1}), *Apis* sp (56.4 to 76.2 bees 50 panicles^{-1}) and non *Apis* sp. (18.6 to 30.2 bees 50 panicles^{-1}) at GBPUA&T, Pantnagar.

PFDC

The Precision Farming Development Centre (PFDC) was established through National Committee on Plasticulture Applications in Horticulture (NCPAH) at the Institute during 2001-2002. The main activities of the centre include technology development and refinement in hi-tech horticulture, technology dissemination and validation, micro-irrigation, plastic mulching, greenhouse technology publication of scientific literature and organizing workshop and trainings for state officials and farmers.

Greenhouse production of tomato

The performance of two cultivars *viz*. Arka Samrat and BSS 1008 was evaluated under polyhouse conditions. The picking of full mature fruits at colour break stage started 40 days early in cv. Arka Samrat and earliness of 20 days was observed in cv. BSS 1008 under polyhouse conditions vis-à-vis open field conditions. Increased cumulative production of 124.89 MT ha^{-1} in cv. Arka Samrat under polyhouse conditions as compared to 61.57 MT ha^{-1} in open conditions was obtained. BSS 1008 recorded higher cumulative production of 101.35 MT ha^{-1} under protected conditions as compared to 42.11 MT ha^{-1} under open conditions.



Effect of polyhouse on flowering and fruiting of tomato

9. LIST OF PUBLICATIONS

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10 LIST OF APPROVED ON GOING RESEARCH PROJECTS

Division of Crop Improvement and Biotechnology

Programme

I. Genetic resources management and improvement of subtroPIcal fruits

Programme Leader: H. Ravishankar

Projects

1. **Genetic resources management and improvement of mango and guava**

   PI: S. Rajan

   Co-PIs: Ram Kumar, G. Pandey, Anju Bajpai, Muthukumar M.

   Collaborators: D.K. Tandon, B.K Pandey, R.P.Shukla, Achal Singh, Maneesh Mishra

2. **Development of stable hermaphrodite types in important gynodioecious papaya varieties of commercial value**

   PI: A.K. Singh

   Co-PIs: H. Ravishankar, Umesh Hudedamani

3. **Improvement of aonla and bael for high yield and nutraceutical value**

   PI: D. Pandey

   Co-PI: Umesh Hudedamani

   Collaborator: A.K. Bhatacherjee

4. **Identification of rootstocks in mango for tolerance to abiotic stress**

   PI: H. Ravishankar

   Co-PIs: A.K. Singh, V.K. Singh, Kailash Kumar, Sridhar Gutam, Muthukumar M., Umesh Hudedamani, Tarun Adak

5. **Evaluation of mango germplasm for Rubisco and associated enzyme activities**

   PI: H. Ravishankar

   Co-PIs: V.K. Singh, S. Rajan, Muthukumar M.

Division of Crop Production

Programme

II. System approach to optimize resource use for enhancing productivity and quality of fruits

Programme Leader: Kailash Kumar

Projects

1. **Integrated water and nutrient management system in mango and guava**

   PI: Kailash Kumar

   Co-PIs: S.K. Shukla, Tarun Adak, Atul Singha

   Collaborators: V.K. Singh, Ajay Verma, R.P. Shukla, Achal Singh, P.K. Shukla

2. **Understanding the mechanism of flowering in mango**

   PI: V. K. Singh

   Co-PIs: H. Ravishankar, S. Rajan, Muthukumar M, Anju Bajpai, Sridhar Gutam

   Collaborator: Kailash Kumar

3. **Development of mango based cropPIng system for enhanced factor productivity**

   PI: S.K. Shukla

   Co-PIs: Dushyant Mishra, Tarun Adak, Atul Singha, Kailash Kumar

   Collaborators: Achal Singh, H.C. Verma, Ajay Verma, R. P. Shukla, P. K. Shukla

4. **Canopy architecture management for higher productivity in mango**

   PI: Dushyant Mishra

   Co-PIs: V.K. Singh, Anil Kumar Verma

   Collaborators: R.P. Shukla, B.K. Pandey, Kailash Kumar, Achal Singh, H.C. Verma, Tarun Adak

5. **Development of decision support system for enhancing mango productivity.**

   PI: H.C. Verma

   Co-PIs: Ram Kumar, B.K. Pandey

   Collaborators: R. P. Shukla, Kailash Kumar, V.K. Singh, Ajay Verma, Tarun Adak

6. **Organic farming for sustaining soil health in mango production**

   PI: R.A. Ram

   Co-PIs: Kailash Kumar, Atul Singha

   Collaborators: R.P. Shukla, Ajay Verma, B.K. Pandey, Achal Singh, Bharti Killadi, Tarun Adak

7. **Assessment of mango production technologies through farmers participatory approach**
   PI: Barsati Lal
   Co-PI: Subhash Chandra, Achal Singh, Ajay Verma
   Collaborators: Dushyant Mishra, B.K. Pandey, Neelima Garg
8. **Impact of mango production technologies developed by the Institute on mango and guava**
   PI: Subhash Chandra
   Co-PI: Barsati Lal, Achal Singh
   Collaborators: Dushyant Mishra, Ajay Verma

Division of Crop Protection

Programme

III. **Integrated insect pest, nematode and disease management in mango, guava and papaya**
Programme Leader: R.P. Shukla

Projects

1. **Integrated insect pest management in mango and guava**
   PI: R.P. Shukla
   Collaborator: Ajay Verma
2. **Etiology and management of wilt and shoulder browning of mango**
   PI: P.K. Shukla
   Co-PI: Achal Singh, R.P. Shukla, H. Kesava Kumar
   Collaborator: A.K. Misra
3. **Development of forewarning system for decision support in management of hopper and mealy bug of mango**
   PI: R.P. Shukla
   Co-PIs: H.C. Verma, Achal Singh
   Collaborator: S.K. Shukla
4. **Development of forewarning system for decision support in management of anthracnose, blossom blight and powdery mildew of mango**
   PI: P.K. Shukla
   Co-PIs: H.C. Verma, Achal Singh
   Collaborator: S.K. Shukla
5. **Development of disease diagnostic for anthracnose disease of mango**
   PI: B.K. Pandey
   Co-PI: A.K. Misra
   Collaborator: Muthukumar M.
6. **Integrated management of guava wilt disease**
   PI: R. M. Khan
   Co-PI: B.K. Pandey, S. Rajan, Atul Singha, Tarun Adak, A.K. Bhattachaerjee

Division of Post Harvest Management

Programme

IV. **Product diversification and waste utilization of fruits for livelihood security**
Programme Leader: Neelima Garg

Projects

1. **Development of value added products from fruits**
   PI: D.K. Tandon
   Co-PI: Pushpa K.
   Collaborators: Neelima Garg, A.K. Bhattacherjee
2. **Fermentation of fruits and fruit industry waste for value addition**
   PI: Neelima Garg
   Collaborators: Anil Kumar Verma, Pushpa K.

V. Programme

1. **Integration of pre- and post-harvest systems for quality fruits**
   Programme Leader: Neelima Garg

Projects

1. **Shelf life enhancement of subtropical fruits**
   PI: Bharati Killadi
   Co-PI: Pushpa K., B.K. Pandey
   Collaborators: Anil Kumar Verma, Neelima Garg
2. **Analysis of pesticide residues in soil and mango fruits**
   PI: A.K. Bhattacherjee
   Collaborators: R.P. Shukla, B.K. Pandey, V.K. Singh
3. **Market intelligence and export promotion of subtropical fruits**
   PI: Ajay Verma
4. **Design and development of machinery for fruit crops**
   PI: Anil Kumar Verma
   Collaborators: D.K. Tandon, B.K. Pandey, Bharti Killadi, Ajay Verma, Devendra Pandey, Ram Kumar, A.K. Singh, Neelima Garg

11. CONSULTANCY, PATENTS AND COMMERCIALIZATION OF TECHNOLOGIES

Consultancy/ Advisory

Five cases of consultancy/ testing of products were received during the year 2011-12 for processing to CPC Cell. Only two cases viz., PI Industries Ltd., Gurgaon for testing of PII 405 15% EC against mango hopper, thrips insects, powdery mildew and anthracnose disease and Bharat Petroleum Corporation Ltd., Mumbai for MAK all season HMO against mango hopper were approved by ICAR, New Delhi.

Scientists of the Institute rendered scientific/ technical services on improvement of production, protection and post-harvest management technologies of mandate fruit crops to the farmers. The information on scientific cultivation of underutilized fruit crops was also provided to farmers. The technical know-how of the technologies such as rejuvenation of old and unproductive orchards, high density planting, nutrient management, management of insect pests and diseases and post-harvest management on mandate fruit crops was also provided to growers by the scientists and technical officers at their locations.

Patents Processed

One patent each on A low energy process for extraction of fibre from mango processing waste of finisher stage and A biscuit composition enriched with dietary fibre extracted from mango processing waste of finisher stage and a process for preparation of the same has been submitted on February 24, 2011. The patents have been published under section 11A of The Patents Act, 1970, by Controller General of Patents, Design and Trademarks, Delhi.

12. RESEARCH ADVISORY COMMITTEE, INSTITUTE MANAGEMENT COMMITTEE/INSTITUTE RESEARCH COMMITTEE, ETC.

Research Advisory Committee (RAC)

Sixteenth Research Advisory Committee (RAC) Meeting of Central Institute for Subtropical Horticulture, Lucknow was conducted under the Chairmanship of Dr. D. P. Ray Vice Chancellor, Orissa University of Agriculture and Technology , Bhubaneshwar , Odisha from June 24-25, 2011. It was the first meeting of the newly constituted Research Advisory Committee of the institute during the year 2011. The following members attended the meeting:

Dr. Yog Raj Chanana	Member
Dr. Y.N. Reddy	Member
Dr. S.K. Mitra	Member
Shri S.S. Mehta	Member
Dr. D.S. Khurdiya	Member
Dr. S. Rajan	Member
Shri Rajveer Singh	Member
Shri K.K. Sharma	Member
Dr. H. Ravishankar	Member
Dr. R.P. Shukla	Member Secretary

16th RAC metting in progress.

Significant Decisions

After in depth discussion with scientists on the progress of research during the year, the RAC made the following recommendations:

Crop Improvement and Biotechnology

- Suitable varieties of mandate crops should be developed with respect to climate change, frost and other abiotic stress.
- DNA fingerprinting of litchi varieties should be done.
- Guava descriptor should be developed.
- Institute should share its germplasm through AICRP.
- Work on development of salt tolerant varieties in guava and juvenility reduction in bael needs to be initiated.

Crop Production

- Package of practices for organic production of mango and guava should be developed.
- Anthocyanin content in aonla needs to be estimated.
- Technologies developed by the institute should be demonstrated through AICRP centres, which are located different agro-climatic zones of the country.
- Cost of cultivation should be worked out for mandate crops and should be published in English and other regional languages.

Crop Protection

- Insect pests/ diseases dynamics in relation to weather changes should be thoroughly investigated.
- New emerging insect pests and diseases of mango and guava should be studied in relation to their cause, bioecology and management.
- Forecasting models should be developed for major insect pests and diseases of mango and guava.

Post Harvest Management

- Processed and value added products should be developed on pilot scale.
- Kaolin may be used for coating mango fruits to prevent post-harvest diseases and enhance shelf life.
- Semi auto-decorticator should be developed for mango.

- Machines for bagging and packaging should be developed.
- Cheaper bagging of mango fruits without print using semi polar/ non-polar/ non-absorbent paper should be developed.
- Low cost graders, pre-cool chambers and storage houses should be developed.
- Grading and packaging technologies of fruits should be publicized through frequent trainings, demonstrations, print and electronic media.

General

- Chairman, RAC suggested that chairmen of QRT and RAC of institute should be invited during IRC meetings conducted by Institute for better interaction and suggestions.
- Low cost machinery including tractor mounted tree pruner should be developed.

Institute Research Committee (IRC)

The 30th and 31st Institute Research Committee (IRC) meetings of CISH were held during May 16 and 18 to 20, 2011 and August 11, 12, 16 to 20, 23 to 26, 2011 under the chairmanship of Dr. H. Ravishankar, Director to review the progress made in ongoing research projects during 2010-2011 and approval of the technical programmes for the following year. Dr. S.N. Pandey, Ex. ADG (Hort.), ICAR, New Delhi, Dr. H.S. Shukla, Ex. Prof. & Head, Department of Horticulture, CSAUA&T, Kanpur, Dr. G. Singh, Ex. Prof. & Head, Department of Entomology, GBPUA&T, Pantnagar, Dr. R.V. Singh, Ex. Prof. & Head, Department of Plant Pathology, NDUA&T, Kumarganj, Faizabad and Dr. D.S. Khurdiya, Ex. Head, Division of Post Harvest Technology, IARI, New Delhi also as resource persons for improving the research programmes during the 30th meeting. Dr. Vishal Nath, Director, NRC, Litchi, Muzaffarpur attended the 31st meeting and offered valuable comments especially the work related to canopy management.

IRC meeting in progress.

Significant Decisions (30th IRC)

Crop Improvement and Biotechnolgy

- Synonymous names in mango varieties should be found out.
- Cataloguing of all available germplasm should be done.
- Molecular markers should be developed for red/ pink colour and soft seededness in guava.
- DNA finger printing of aonla varieties should be done.
- Aonla germplasm should be registered with NBPGR, New Delhi.
- Emphasis should be laid on evaluation of aonla accessions for processing traits like high vitamin C, polyphenols and its retention in finished products with respect to improved varieties.
- Dwarf plant type with high yield traits and high marmelosin content in bael should be developed.
- Second generation breeding programme should be initiated for developing hybrids having attributes pertaining to high yield, regular bearing, dwarf, malformation tolerance and good quality of mango fruits with red peel.
- Markers should be developed for dwarfing traits and tolerance to abiotic factors in mango.
- Prioritization should be done to limit the crossing in mango and parents should be selected for more than one trait.
- Guava wilt resistant rootstock should be developed which gives easy rooting and dwarf in nature.
- Micropropagation techniques should be developed for rapid multiplication of guava wilt resistant rootstock.
- Gynodiocious papaya varieties having resistance to frost and viruses should be developed.

Crop Production

- Integrated plant nutrient management should be studied in detail.
- Molecular characterization of mango rootstocks should be done.

- Soil health parameters should be studied in mango.
- Principal component analysis should be undertaken in mango.
- Nutrient interactions should be worked out in mango.
- Organic farming should be addressed in holistic manner.
- PRA should be done.
- Impact assessment of the technologies developed by the institute should be undertaken.

Crop Protection

- Forecasting models for hopper and fruit fly of mango should be developed.
- Trial on hot water treatment of mango should be stopped.
- Causal organism of stalk end rot of bael should be found out.
- Mango wilt and guava wilt are the major problems and are required to be addressed through team approach.
- Post harvest diseases should be managed commencing from pre-harvest stages.

Post Harvest Management

- Experiments should be done under controlled and ambient conditions for increasing shelf life of mango.
- Fruit quality of mango at storage should be studied.
- Stability of processed products should be studied after storage.
- Large scale trials on *Saccharomyces cerevisiae* should be conducted.
- Viability and cost of technologies developed should be worked out.
- Phenolics of aonla tea should be estimated.
- Ply from mango fibre shell may be made.
- Availability of raw material used for making value added products should be considered.
- Guava harvester which can cut guava fruits with one cm stalk should be designed.
- Video film on mango harvester should be prepared and shown to farmers.
- Low cost machines should be developed suiting to small and marginal farmers.

Significant Decisions (31st IRC)

Crop Improvement and Biotechnolgy

- Emphasis should be on genomics of mango and guava germplasm.
- Rumani should be used as a parent in crossing programme for dwarfing character in mango.
- Rubisco in relation to carbon balance and utilization and profiling resilience of gene pool needs to be studied in mango.
- Dynamics of mango and guava germplasm with respect to weather dynamics should be profiled and G x E interactions should be studied.
- Gene silencing issues in relevant cases need to addressed.
- Dwarf gynodioecious varieties of papaya should be evolved with good fruit quality parameters.
- Production issues of bael are also required to be addressed as the demand for planting material is gradually increasing.
- Basic work on the growth and development pattern of bael should be taken up.

Crop Production

- Leaf nutrient guides for mango should be developed and site-specific studies are necessary.
- Nutrient interactions impacting yield in mango should be profiled in different studies for rationalization nutrient application.
- Basic research work needs to be undertaken for jelly seed formation in mango. Sustainability and profitability of mango and guava based integrated cropping systems need to be addressed and resource analysis of the system should be done in consultation with Agricultural Economists.
- Impact assessment of CISH developed technologies should be carried out by third party for which few technologies be identified.
- Profiling of technologies should be done.
- Questionnaire should be developed for data collection.
- ICT should be considered in transfer of technologies in view of the emerging socio-economic dynamics.

Crop Protection

- New emerging pests, *viz.* thrips, fruit borer and shoot gall psylla, in mango and fruit borer in guava should be targeted.
- Some exploratory work on the efficacy of fungicides against shoulder browning may be taken up.
- Scientific rationale of bagging of fruits is required to be elucidated.
- Activities relevant to forewarning system, *viz.* development of computerized data base, determination of key weather parameters and development / validation of forewarning system, are required to be focused.
- A catalogue of all isolates of *Colletotrichum* infecting mango should be brought out. Major emphasis should be laid on *Colletotrichum* and *Fusarium* causing anthracnose of mango and wilt of guava, respectively.
- *Mycorrhizae* are important component of the ecosystem, their role with respect to management of guava wilt may also be explored.

Post Harvest Management

- Intrinsic food value of the different products should be worked out as their potential could be effective in combating the degenerative diseases.
- Role of oligosaccharides and others like lupeol, resveratrol and other phytosterols may be profiled in different mandate crops.
- Work is also required to be initiated on low cost minimally processed products.
- Only commercial juicy varieties of mango should be taken up for development of RTS beverage.
- Nutraceutical value of the blended product should also be studied.
- Work on RTS of jamun need to be taken up.
- Work on uneven ripening of bael should be initiated.
- A number of strains should be screened out instead of depending upon single strain. Registration of strain(s) with designated authority is also required.
- Work on bio-fuel may be taken up only on laboratory scale.
- Nutraceutical value of jamun seeds is required to be profiled.
- Work on cosmetic products should be taken up in collaboration with relevant institute including toxicological data.
- Concern of ICAR and Ministry of Health regarding use of calcium carbide / ethylene should be taken into consideration.
- Work on export-response model and alternate markets should be taken up.
- Fruit size and weight relationships are to be worked out.
- Work on refinement of existing CFB boxes should be taken up.
- Comparison with the traditional method of packaging in respect of adaptability to be undertaken.
- Alternative methods of packaging (like polypropylene) should also be looked into.

13. PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, SEMINAR, SYMPOSIA ETC.

Meetings

Dr. R.P. Shukla attended the brain storming session on Onion and garlic in the changing climatic conditions held at NHRDF Nashik (April 2, 2011).

Dr. S. Rajan attended the second meeting of experts committee for appraisal of proposals under the scheme Establishment of mother plant nurseries for high pedigree planting materials of fruit crops at NHB, Gurgaon (April 29, 2011).

Dr. Neelima Garg and Shri Muthukumar M. attended AMAAS project review meeting and discussions on XII plan proposals at NBAIM, Mau (May 14-15, 2011).

Dr. Neelima Garg attended ICAR – CII Industry Meet 2011 at NASC Complex, New Delhi (May 23, 2011).

Dr. Neelima Garg attended first meeting of the national committee on Post-harvest technology and value addition at NASC Complex, New Delhi (June 10-11, 2011).

Drs R. P. Shukla, Neelima Garg, Kailash Kumar and S. Rajan attended meeting – cum- workshop of HODs of ICAR Institutes at CIAE, Bhopal (June 14-15, 2011).

Dr. A. K. Misra, Project Coordinator (STF) attended an interactive meeting of Project Directors/Project Coordinators held at CIAE, Bhopal (June 16, 2011).

Dr. A. K. Misra attended the meeting of working group of horticulture crops held at ICAR, New Delhi on June 24, 2011.

Dr. A. K. Misra attended the review meeting of all PCs under Horticulture Division held at ICAR, New Delhi (July 25, 2011).

Dr. A. K. Misra attended the meeting of Working sub-group of horticulture crops held at NASC Complex New Delhi (July 26, 2011).

Dr. V. K. Singh and Shri Umesh Hudedamani attended the brain storming meeting on Prioritization of plant physiology and biochemistry research for XII Five Year Plan period held at IARI, New Delhi (August 6-7, 2011).

Dr. R. P. Shukla attended a national meeting on Agricultural entomology for the 21st Century : The way forward held at NBAII, Bangalore (August 25-26, 2011).

Dr. R. P. Shukla attended a meeting on Platforms on different themes areas of Horticulture Division held at NASC Complex, New Delhi (September 7, 2011).

Dr. Tarun Adak attended the national Stakeholder consultation on climate change platform held at CRIDA, Hyderabad (September 19-20, 2011).

Dr. A. K. Misra attended the special meeting of Vice Chancellor of Agriculture Universities and Project Coordinators at NASC Complex, New Delhi (September 26, 2011).

Dr. Neelima Garg attended meeting on Future agriculture research priority held at NASC Complex, New Delhi (September 27-28, 2011).

Dr. Kailash Kumar attended the national consultation meet on Water: Research prioritization held at NBFGR, Lucknow (September 18, 2011).

Dr. S. Rajan participated in PPV & FRA foundation day programme held at New Delhi (November 11, 2011).

Dr. V. K. Singh attended the IMC meeting of CIAH, Bikaner (November 15, 2011).

Dr. A. K. Misra attended a meeting for finalizing the draft proposal for National network project on PGR management under XII Plan under Agro-biodiversity platform held at New Delhi (November 18, 2011).

Dr. Neelima Garg attended the Brain storming meeting on Secondary agriculture held at IASRI, New Delhi (November 18, 2011).

Dr. R.P. Shukla attended the 63rd Advisory committee meeting of NHRDF held at New Delhi (November 25, 2011).

Dr. A. K. Misra attended the National Symposium on Biology of infection, immunity and disease control in pathogen plant interactions held at Osmania University, Hyderabad (December 2-4, 2011).

Dr. Kailash Kumar and V. K. Singh attended the JIT meeting of UP held at Directorate of Horticulture, Lucknow (December 14, 2011).

Dr. R. P. Shukla attended the review meeting of Outreach programme on sucking pests of

horticultural crops held at CTCRI, Trivandrum (December 16-17, 2011).

Dr. Neelima Garg attended the IMC meeting of NRC Litchi, Muzaffarpur (January 23, 2012).

Dr. Neelima Garg attended the IMC meeting of CPRI, Shimla (January 24, 2012).

Drs S. Rajan, V. K. Singh and Tarun Adak attended the National dialogue on Climate resilient horticulture held at IIHR, Bangalore (January 28-29, 2012).

Dr. S. Rajan attended the meeting of NOMA held at Kanyakumari (January 30, 2012).

Drs R. P. Shukla and P.K. Shukla attended the group discussion and training programme under NICRA project held at RFRS, Vengurle (February 2-3, 2012).

Drs H. Ravishankar and A. K. Misra attended the Directors / Vice Chancellors Interface and Directors Conference held at NASC Complex, New Delhi (February 17-18, 2012).

Dr. R. M. Khan attended a programme on RFD at NASC Complex, held at New Delhi (February 21, 2012).

Dr. Ajay Verma attended the Capacity building programme on International trade towards enhancement of competitiveness of Indian agriculture, held at IIFT, New Delhi (February 27 –March 3, 2012).

Dr. B.K. Pandey attended the final review meeting of Outreach programme on Alacocera and Phytofura held at IIHR, Bangalore (March 3-4, 2012).

Er. Anil Kumar Verma attended the Horticulture-Industry meet at IIHR, Bangalore (March 6, 2012).

Dr. R. M. Khan attended a programme on Nano Agriculture Mission held at NASC Complex, New Delhi (March 12, 2012).

Dr. V. K. Singh attended the group workers meeting of AICRP (STF) centres collaborating under NICRA project held at IIHR, Bangalore (March 12, 2012).

Dr. S. Rajan participated in the Mango workers group discussion on Mango flowering phenology held at IIHR, Bangalore (March 13, 2012).

Shri. Muthukumar M. attended the partners' meet of National agricultural bioinformatics grid held at NBPGR, New Delhi (March 16, 2012).

Congress/ Conference

Drs H. Ravishnakar, Ramesh Chandra, Neelima Garg, Ajay Verma, S. Rajan, Ghanshyam Pandey, Devendra Pandey, V. K. Singh, Ram Kumar, A. K. Singh, B. K. Pandey, Anil Kumar Verma, Anju Bajpai, Maneesh Mishra, Achal Singh, Dushyant Mishra and Barsati Lal participated in the National Conference on Horti business - linking farmers with markets held at KDMIP, Dehradun (May 28 – 31, 2011).

All the scientists of the Institute attended Global Conference on Augmenting production and utilization of mango: biotic and abiotic stresses held at The Lifestyle Hotel, Lucknow (June 21-24, 2011).

Drs Neelima Gard, S. Rajan and V. K. Singh attended the International Conference on Issue for climate change, land use diversification and biotechnological tools for livelihood security, held at SVPU&T, Meerut (October 8-10, 2011).

Dr. Neelima Garg participated in 34th All India Conference of Indian Botanical Society held at Lucknow University, Lucknow (October 10–12, 2011).

Dr. V. K. Singh attended the Agriculture Connects - 2011 Conference-cum-Exhibition held at IARI, New Delhi (October 14-16, 2011).

Dr. V. K. Singh attended the National Horticulture Conference for Improvement of horticulture production and productivity held at the Hotel Ashoka, New Delhi (February17, 2012).

Symposia/Seminars

Dr. R. P. Shukla attended the National Seminar on Transfer of technology of strategic pesticides use to enhance agricultural production and food security held at NASC Complex, New Delhi (June 2, 2011).

Drs D. K, Tandon and Ajay Verma attended Agricultural production, marketing, export and processing–AGRICON 2011, held at IISR, Lucknow (November 4-5, 2011).

Dr. V. K. Singh attended the National Seminar on Sustainable crop productivity through physiological intervention" held at Ram Narain Ruia College, Mumbai (November 24-26, 2011).

Dr. A.K. Bhattacherjee attended the International Symposium on Minor fruits and medicinal plants for health and ecological security held at BCKV, Kalyani (December 19-22, 2011).

Dr. Tarun Adak attended the National Seminar on New frontiers and future challenges in horticultural crops held at PAU, Ludhiana (March 15-17, 2012).

Drs Sridhar Gutam and Atul Singha attended the National Seminar on Management of salt affected soils and waters: Challenges of the 21st Century held at CSSRI Regional Station, Lucknow (March 16-17, 2012).

Dr. P. K. Shukla attended the National Seminar on Glimpses of phytopathology for sustainable agriculture held at TM Bhagalpur University, Bhagalpur (March 27-28, 2012).

Workshop

Drs A. K. Misra, R.P. Shukla and P.K. Shukla attended the Workshop on Understanding the changes in host-pest interactions and dynamics in mango under climate change scenario under NICRA project held at ICAR Research Complex for Eastern Region, Ranchi (June 29-30, 2011).

Dr. A.K. Singh attended a Regional Workshop on Exploration, characterization and utilization of under-utilized fruits and vegetable plant species in SAARC Countries held at Kandy, Sri Lanka (July 4-5, 2011).

Drs H. Ravishankar, A. K. Misra, R. P. Shukla, S. Rajan, Ghanshyam Pandey, V. K. Singh, D. Pandey, Ram Kumar, A. K. Singh, R. A. Ram, B. K. Pandey and Dushyant Mishra participated in Group Worker meeting of AICRP (STF) held at HC & RI, Periyakulam (September 27 - October 3, 2011).

Drs H. Ravishankar, R. P. Shukla, B.K. Pandey, and Dushyant Mishra attended the Workshop on Horticultural crops held at Ram Naresh Tripathi Sabhagar, Sultanpur (November 9, 2011).

Dr. S. Rajan participated in NAGS Workshop held at NBPGR, New Delhi (November 18, 2011).

Drs D.K. Tandon and Dushyant Mishra attended the Workshop on Weather index based crop insurance system held at NHB, Gurgaon (December 9, 2011).

All the scientists of the Division of Post Harvest Management participated in Workshop on Packaging of processed fruits, organized by IIP, New Delhi held at Hotel Gomti, Lucknow (January 20, 2012).

Dr. Tarun Adak attended the 26th Biennial Workshop of AICRP on Micro and secondary nutrients and pollutant elements in soils and plants held at BCKV, Kalyani (February 10-13, 2012).

Ms. Pushpa K. attended the National Workshop on Nondestructive methods for quality evaluation of foods, CIPHET, Ludhiana (February 9-10, 2012).

Dr. S. Rajan participated in the Annual Workshop of the NAIP (Component-IV) held at NASC Complex, New Delhi (March 19-20, 2012).

Dr. Sridhar Gutam attended the National Workshop on Frugal innovations for sustainable solutions in fisheries and agricultural sectors held at NBFGR, Lucknow (March 24, 2012).

Dr. Neelima Garg participated in Workshop on Innovative products developed from aonla, organized by the Centre for Technology and Entrepreneurship Development, Jagdishpur, held at Pratapgarh (March 30, 2012).

14. WORKSHOPS, SEMINARS, SYMPOSIA, ETC. ORGANISED

Global Conference

The Central Institute for Subtropical Horticulture, Lucknow in partnership with the Society for Development of Subtropical Horticulture and the International Society for Horticultural Science (ISHS), Belgium organized a four-day Global Conference on "Augmenting Production and Utilization of Mango : Biotic and Abiotic stresses" from June 21-24, 2011 at the Lifestyle Hotel Pvt. Ltd., Lucknow. The theme of the Conference was 'Mango for Health Care and Livelihood'. The Conference was attended by over 350 persons representing scientists, farmers and students from India and abroad. The global conference was represented by different countries like Thailand, Indonesia, Australia, Kenya, USA, South Africa, Oman, Egypt, Spain and Germany. The technical deliberations of the Conference were organized in nine

Dr. H. Ravishankar, Director addressing be gathering

Participants in the Conference

sessions including the inaugural and plenary sessions. In each session, there were lead lectures from experts on recent developments in respective areas.

Dr. H.P. Singh, DDG (Hort.) in his inaugural address highlighted the history of mango in India and its movement from India to other parts of the world. He told that mango is becoming important as a source of livelihood and demand for the fruits is increasing particularly from health conscious population. There is an urgent need for improvement in the transportation and post-harvest management systems, he emphasized. He also outlined the growth of horticulture sector the country by the focused extension and policy support provided by the Government. The exploitation of genetic resources, popularization of new hybrids, utilizing the tools of biotechnology for faster breeding programmes understanding dynamics of nutrients and water to produce more with limited land, water and emerging dynamics of climate change are to be looked into. He said that climate is changing for which adoption and mitigation techniques assume significance. He explained the sudden ripening of fruits last year in Uttar Pradesh resulting into gluts and delayed harvest during this year and said that intensive studies are needed to delineate the impacts of climate change.

Dr. H. Ravishankar, Director, CISH and the Convener of the Global Conference welcomed the delegates and guests. Dr. Sisir Kumar Mitra gave a brief account of International Society of Horticultural Sciences (ISHS)Belgium. Mr. Manoj Kumar Singh, Principal Secretary (Horticulture & Food Processing), Govt. of U.P., Dr. Thomas L. Davenport from USA, Dr. Victor Galan Sauco from Spain, Dr. J. Prasad, Chairman, U.P. Higher Education Services Commission also spoke on the occasion highlighting the importance of mango in rural economies and livelihood and need for diversification of research.

The issues emerged during the core collections, conservation of existing diversity, understanding the resilience of germplasm under different agro climatic situations, identitification of markers for important traits, understanding the structural and functional, differential management of water nutrients and vegetative, reproductive, fruit development and fruit maturity status, development of forecasting models, diagnostic approaches and the decision support system for effective plant health management and integrate pre- and post-harvest management system.

Consortium Advisory Committee Meeting

The fourth Consortium Advisory Committee meeting to review the progress of NAIP subproject on A value chain on mango and guava for domestic and export markets was held on July 25, 2011 under the chairmanship of Dr. D.S. Rathore, ex-VC, CSKHPKV, Palampur. It was attended by the members Dr. H. Ravishankar, Director, CISH, Lucknow, Dr. R. K. Goyal, National Coordinator, NAIP (Component-II), Dr. B. K. Mittal, Ex-Head, Food Science and Technology, Mrs. Laxmi Dwivedi, NGO representative, Shri Shailendra Kumar Raghuvanshi (Progressive farmer) and Dr. S. K. Shukla, Principal Scientist, CPI and member secretary from CISH, Lucknow. The CCPIs from various copartners, *viz*. TNAU, Coimbatore, YSRAPHU, Tedepalligudem (AP), NAU, Navsari and BAIF Development Research Foundation, Pune also participated in the meeting. The presentations were made by the Consortium P.I. and different CCPIs highlighting the technical and financial achievements under the project. While reviewing the work of different partners, the Chairman remarked that there should be objectivity in reporting of the achievements. Requirements to record the gaps/feedback from farmers in adoption of technological interventions was emphasized. Good agricultural practices should be promoted through the project and reduction of losses in response to technological interventions should also be recorded. The administrative and financial matters regarding fund release and enhancement of emoluments were also discussed.

Stakeholders' Consultative Meet

A Stakeholders' Consultative Meet was organized by the Institute under the Chairmanship of Dr. H. Hanumaiah, VC, BBAU on 19th December, 2011 with an aim to engage new batch of stakeholders in order to assess the horticulture potential, appraise the constraints and develop roadmap for the integrated development of horticulture in the region. Prof. B. Hanumaiah focused on the issues of production of healthy seed and planting material of horticultural crops, value addition and processing, nutraceutical values, transport of fruit and use of irradiation for storage. On this occasion, Dr. H. Ravishankar, Director, CISH laid emphasis on integrated development of horticulture through crop diversification and climate resilient agriculture. Dr. A.N. Mukhopadhyay, Ex-Vice Chancellor, Assam Agricultural University, Jorhat, Dr. P.S.Pathak, Ex-Director, Indian Grassland and Fodder Research Institute, Jhansi, Dr. Mathura Rai Ex Director, Indian Institute of Vegetable Research, Varanasi, Dr. S.K. Pandey, Ex Director, Central Potato Research Institute, Shimla, Dr. Vishal Nath, Director, National Research Centre for Litchi, Muzaffarpur and Dr. C.S. Nautiyal, Director, National Botanical Research Institute, Lucknow, the guests of honors also expressed their views and participated in the deliberations.

Dr. H. Ravishankar, Director addressing during the Stakeholders' meet

Mr. Ram Saran Verma a progressive and national award winning farmer shared his experiences with respect to the cultivation of banana, potato and mentha crop cultivation and rotation system. Mr. Rahul Mishra, another progressive farmer, appraised about his experiences about gerbera, tuberose and gladiolus cultivation in and around Lucknow and Barabanki, their marketing and export. Dr. A.N. Mukhopadhyay exhorted the farmers to use of biocontrol agents to minimize use of fungicides. He further emphasized to establish cooperative societies for easy marketing of their produce.

About 100 farmers from different districts of the state apart from entrepreneurs, KVKs, state department of horticulture and financial institutions interacted with experts and subject matter specialist on various issues. Stakeholder's perceptions were recorded for deriving solutions to the key issues in the days ahead.

The specific issues emerged out of the meet included, the non availability of genuine chemicals, timely availability of quality seeds and planting materials and other critical inputs, risk management through crop insurance and market information system and crop disposal system. Gender issues / women empowerment, training for skill development, rootstocks and improved varieties were the other major issues. Availability of skilled manpower followed by processing infrastructure and policy support were also considered the constraints for processors. Institute while framing / reorienting research priorities would consider feasible issues for its research frame work development.

15. DISTINGUISHED VISITORS

Shri Chaman Kumar, Additional Secretary, DARE and Financial Adviser, ICAR, Krishi Bhawan, New Delhi-110 114 (April 1, 2011).

Dr. J.N. Jena, Director, National Bureau of Fish Genetic Resources, Lucknow-226 002 (June 10, 2011).

Dr. H.P. Singh, DDG (Hort.), KAB - II, ICAR, New Delhi-110 012. (June 21-24, 2011).

Dr. D.S. Rathore, former Vice-Chancellor, HPKV, Palampur (June 24-25, 2011).

Dr. D.P. Ray, Vice-Chancellor, Orissa University of Agriculture & Technology, Bhubaneswar–751 003, Odisha. (June 24, 2011).

Dr. Yog Raj Chanana, Member, Institute RAC, former Head, Department of Horticulture, PAU, Ludhiana B-293, Bhai Randhir Singh Nagar,Ludhiana-141 012 (June 24-25, 2011).

Dr. Y.N. Reddy, Member Institute RAC, Former Prof. & Head, Department of Horticulture, ANGRAU, Hyderabad, Flat No. 203, Keerthy Residency, Balajinagar, Kukkatpalli Hyderabad-500 072 (June 24-25, 2011).

Shri S.S. Mehta, Member, Institute RAC, President, Amla Growers Association of India, Secretary, Confederation of Indian Horticulture, 256, Advaita Ashram Road, Fairlands, Salem-636 016 (June 24-25, 2011).

Dr. D.S. Khurdiya, Member Institute RAC, former Head, Division of Post-Harvest Technology, IARI, SFS-149, Pocket – 10 Sector-XI (Extn.), Golden Jubilee Apartment, Rohini, New Delhi-110 085. (June 24, 2011).

Dr. P.L. Saroj, Incharge ADG (Hort.-I), ICAR, Krishi Anusandhan Bhavan-II, Pusa, New Delhi – 110 012 (June 24, 2011).

Shri Rajveer Singh, Member, Institute RAC, House No. A-216, Yamunapuram DPS Road, Near Sai Mandir, Bulandshahar-203 001 (June 24, 2011).

Dr. Vandana Dwivedi, Joint Adviser (Agri.), Planning Commission, New Delhi-110 (July 1, 2011).

Shri Shiv Shankar Singh, Special Secretary (Coordination) & Staff Officer of APC, Govt. of U.P., Lucknow – 226 001(July 12, 2011).

Dr. S.B. Dandin, Vice-Chancellor, University of Horticultural Sciences, Bagalkot-587 102 (July 20, 2011).

Dr. B.M.C. Reddy, former Director, CISH, Lucknow, National Project Coordinator, NPMU-UNEP/ GEFTFT Project, IIHR, Bangalore-560 080(July 20, 2011).

Shri Bijay Kumar, Managing Director, Plot No.85, Sector-18, Institutional Area, Gurgaon-122 015 (August 26, 2011).

Shri N.C. Mistry, Additional Managing Director, NHB, Plot No.85, Sector-18, Institutional Area, Gurgaon-122 015 (August 26, 2011).

Shri Bani Singh, Head, Regional Office, Directorate of Horticulture & Food Processing, 2, Sapru Marg, Lucknow-226 002(August 26, 2011).

Shri D.K. Sharma, Vice-President, All India Mango Growers' Association, Civil Lines II (Opp. Rita Tyagi Nursing Home), Judges Court, Bijnore-246 701 (August 26, 2011).

Dr. S.A.H. Abidi, former Member, ASRB, New Delhi, CM-11, Sector-B, Aliganj, Lucknow- 226 020 (September 14, 2011).

Shri N. Vijayan, Director & Chief Executive Officer (Addl. Director of Agriculture), Vegetable and Fruit Promotion Council, Keralam, Mythri Bhavan, Near Doordarshan Kendra, Kakkanad-682 037 (October 12, 2011).

Dr. M.D. Pathak, former Director General, UPCAR, Lucknow 226 (October 14, 2011).

Shri Omkar Singh, Deputy Commissioner (Machinery), Ministry of Agriculture (Deptt. of Agri. & Coop.), Govt. of India, Krishi Bhavan, New Delhi-110 114 (October 31, 2011).

Prof. David Dilcher, NAS, Department of Biology & Geology, Indiana University, Bloomington, IN 47405, U.S.A. (November 23, 2011).

Dr. Jag Mohan Singh Chauhan, former Vice-Chancellor, Dr. YSPUH&F, Solan Village Kothi, Majhgaon, P.O. Shamli, Solan (November 29, 2011).

Dr. C.P.A. Iyer, former Director, CISH, Lucknow, Gokul, 333-West of Chord Road, II Stage, 12 'B' Cross, 4th Mai, Bangalore-560 086 (January 11, 2012).

Dr. Gorakh Singh, Horticulture Commissioner, Govt. of India, Ministry of Agriculture, DAC, Krishi Bhawan, New Delhi-110 001 (January 23, 2012).

16. PERSONNEL

H. Ravishankar, Ph.D.
Director

SCIENTIFIC

Division of Crop Improvement and Biotechnology

Shailendra Rajan, Ph.D.
Pr. Scientist (Hort.) & Head
(w.e.f. 06.05.2011)

Ramesh Chandra, Ph.D., F.I.S.G.P.B, F.H.S.I.
Pr. Scientist (Eco. Bot.)
(up to 29.02.2012)

Devendra Pandey, Ph.D.
Pr. Scientist (Hort.)

A. K. Singh, Ph.D.
Pr. Scientist (Hort.)

Ram Kumar, Ph.D.
Pr. Scientist (Hort.)

Maneesh Mishra, Ph.D.
Sr. Scientist (Hort.)

Anju Bajpai, Ph.D.
Sr. Scientist (Gen. & Cyto.)

H.C. Verma, Ph.D.
Scientist (SS)
(Computer Appl.)

Muthukumar M., M.Sc.
Scientist (Biotech.)

Nimisha Sharma, M.Sc.
Scientist (Biotech.)

Umesh Hudedamani, M.Sc.(Ag.)
Scientist (Plant Breeding)

Division of Crop Production

Kailash Kumar, Ph.D.
Pr. Scientist (Soil Chem./Fert./Micro.) & Head

V. K. Singh, Ph.D.
Pr. Scientist (Pl. Physiol.)

R. A. Ram, Ph.D.
Pr. Scientist (Hort.)

S. K. Shukla, Ph.D.
Pr. Scientist (Hort.)

Achal Singh, Ph.D.
Sr. Scientist (Ag. Stat.)

Barsati Lal, Ph.D.
Sr. Scientist (Ag. Ext.)

Sridhar Gutam, Ph.D.
Sr. Scientist (Pl. Physiol.)

Subhash Chandra, M.A.
Scientist (SG) (Ag. Ext.)

Dushyant Mishra, Ph.D.
Scientist (SS) (Hort.)

Atul Singha, Ph.D.
Scientist (Ag. Micro.)

Tarun Adak, Ph.D.
Scientist (Soil Phy./Water Conserv.)

Division of Crop Protection

R. P. Shukla, Ph.D.
Pr. Scientist (Ag. Ento.) & Head

R. M. Khan, Ph.D., F.P.S.I.
Pr. Scientist (Nematol.)

B. K. Pandey, Ph.D.
Pr. Scientist (Pl. Path.)

A. K. Singh, Ph.D.
Pr. Scientist (Pl. Path.)
(Up to 09.09.2011)

P.K. Shukla, Ph.D.
Sr. Scientist (Pl.Path.)

H. Kesava Kumar, M.Sc.
Scientist(Nematol.)

Division of Post Harvest Management

Neelima Garg, Ph.D.
Pr. Scientist (Micro.) & Head

D. K. Tandon, Ph.D., F.H.S.I.
Pr. Scientist (Biochem.)

Ajay Verma, Ph.D.
Pr. Scientist (Ag. Eco.)

A. K. Bhattacherjee, Ph.D.
Sr. Scientist (Ag. Chem.)

Anil Kumar Verma, M. Tech.
Scientist (SG) (FM & P)

Bharti Killadi, Ph.D.
Scientist (Hort.)

Pushpa K., M.Sc.
Scientist (Food & Nutrition)

Project Coordinator Cell (Subtropical Fruits)

A. K. Misra, Ph.D., F.P.S.I., F.I.S.M.P.P.
Project Coordinator

Ghanshyam Pandey, Ph.D.
Pr. Scientist (Hort.)

Rakesh Chandra, M.Sc.
Scientist (SG) (Ag. Stat.)

TECHNICAL

S.K.S. Raghav, Ph.D.(Ag.)
T- 7-8 (T.O.) (Farm Management)

R. P. Shankhwar, B.Sc. (Ag.), T.D.C
T-7-8 (T.O.) (Lab.)

Santosh Kumar, M.Sc. (Ag.)
T-7-8 (T.O.) (Farm Management)

Raghubir Singh, Ph.D.
T-7-8 (T.O.) (Farm Management)

Sanjay Kumar, M.Sc.
T-7-8 (T.O.) (Lab.)

Abhay Dikshit, M.Sc.
T-7-8 (T.O.) (Lab.)

S. K. Arun, B.Sc. (Ag.)
T-6 (T.O.) (Lab.)

Om Prakash, B.Ed., Ph.D.
T-6 (T.O.) (Lab.)

Pradeep Kumar Kulshrestha, B.Sc.
T-6 (T.O.) (Lab.)

Vinod Kumar Singh, Ph.D.
T-6 (T.O.) (Lab.)

Ramendra Tiwari, B.Tech.
T-6 (T.O.) (Ag.Engg.)

D.K. Shukla, M. Tech.
T-6 (T.O.) (Lab.)

Prem Kumar, D.M. (Mech.)
T-6 (T.O.) (Photography)
(Up to 30.04.2011)

Rekha Chaurasia, B.Sc.
T-6 (T.O.) (Lab.)

Anil Kumar Singh, M.Sc.
T-6 (T.O.) (Lab.)

Bahadur Singh, Dip. (Refrig. & Aircond.)
T-6 (T.O.) (Lab.)

Ram Sharan, B.Sc. (Ag.)
T-6 (T.O.) (Lab.)

C. P. Dwivedi, M.A.
T-5 (T.O.) (Lab.)

B.P. Shukla, M.Sc., L.L.B., B.J.M.C.
T-5 (T.O.) (Lab.)

Chandra Bhal, B.Sc.
T-5 (T.O.) (Lab.)

H. Rehman, B.F.A. (Commercial Arts)
T-5 (T.O.) (Art)

Braham Pal, Dip. (Ag. Ext.)
T-5 (T.O.) (Field)

Ram Autar, Inter (Ag.)
T-5 (T.O.) (Field)

Anjani Kumar, B.A.
T-5 (T.O.) (Field)

R.P. Misra
T-5 (T.O.) (Driver)(Up to 29.02.2012)

Ayodhya Prasad
T-5(T.O.) (Driver)

Mashooq Ali
T-5(T.O.) (Workshop)

Arvind Kumar, M.Sc.(Ag.)
T-5 (T.O.) (Lab.)

Priti Sharma, M.Sc., M.Phil.
T-5(T.O.) (Lab.)

Shri Ganga Sharan, B.A.
Dip. (Ag. Ext.)
T-5(T.O.) (Lab.)

ADMINISTRATIVE

Shri Firoz Khan, M.Sc., B.Ed.
Senior Administrative Officer

Dhiraj Sharma, M. A., P.G.J.M.C.
Assistant Director (Official Language)

Shri G.D. Amola, B.A.,L.L.B.
Finance & Accounts Officer

Ravi Bhadra, M.Com.
Assitant Finance & Accountants Officer
(Up to 30.06.2011)

Shri A.M. Srivastava, B.A.
Assistant Administrative Officer
on deputation(Up to 28.04.2011)

Ram Naresh
Private Secretary

17. OTHER INFORMATIONS

Field Day

Field day on Harvesting, post-harvest management and marketing of mangoes was organized on June 4, 2011 at Au Mau village in Mall block, Lucknow under NAIP project on 'A value chain on mango and guava for domestic and export markets' to apprise the farmers about the latest techniques and innovations. Dr. H. Ravishankar, Director and scientists of the Institute made the farmers aware of the harvesting and post-harvest protocols for mango for quality of probability. Farmers were impressed upon to establish tie up with Mother Dairy for sale of their mango produce in leading domestic as well as export markets through Mango Pack House. Besides 250 farmers from Au Mau and adjoining villages of Mall block, the programme was also attended by Dr. Vineet Kathuria, Deputy Manager (Products), Mother Dairy, New Delhi, Mr. N.S. Pruthi, Goblin Foods Pvt. Ltd., Mumbai, exporters and officials from state department of horticulture Mango Pack House and Mandi Parishad, U.P.

Mango Diversity Show

A Mango Diversity Show was organized during the Global Conference on Augmenting Production and Utilization of Mango : Biotic and Abiotic Stresses held at Lucknow from June 21 - 24, 2011. In the Show, over 800 varieties/clones and hybrids from across the country were displayed. The farmers' varieties were also exhibited. An exhibition showcasing the inputs use and technological innovations was also organized on the occasion.

Mango Festival

The Institute participated in the annual mango festival organized by DTDC at Delhi Haat during July 1-3, 2011. The festival was inaugurated by Ms. Kiran Walia, Minister for Health, Delhi Government. It was hoped that the visitors to the festival would be enthralled to see the diversity of mango displayed by the Central/State agencies and progressive farmers. His Excellency, Mr. Albert Peter Burleigh, Ambassador of USA visited the CISH stall and enquired about the mango varieties suitable for export to USA. Mrs. Sheila Dikshit, Chief Minister of Delhi also visited the stall and appreciated the display of promising varieties. CISH also demonstrated preparation of some mango based products for the benefit of visitors.

His Excellency, Mr. Albert Peter Burleigh, Ambassador of USA at the CISH Stall

Mango Exhibition-cum-Festival

The Institute organized a mango show for the second consecutive year at the NASC Complex , Pusa, New Delhi in collaboration with Resident Welfare Association and Society for Development of Subtropical Horticulture, Lucknow held on July 2, 2011 under the Chairmanship of Hon'ble Secretary DARE and DG, ICAR, New Delhi. A number of ICAR dignitaries visited the mango show. During the show, various varieties were displayed. A mango eating competition was also held on this occasion.

Dr. S. Ayyappan, DG, ICAR addressing during the mango exhibition

Consortium Implementation Committee Meeting

Consortium Implementation Committee meeting to review the progress of NAIP subproject entitled "A value chain on mango and guava for domestic and export markets" (Component-II) was held on July 25, 2011 under the chairmanship of Dr. H. Ravishankar,

Director, CISH, Lucknow. The meeting was attended by Dr. S.K. Shukla, Consortium P.I. and CCPIs from various co-partners namely, TNAU, Coimbatore, YSRAPHU, Tedepalligudem (A.P.), NAU, Navsari and BAIF Development Research Foundation, Pune apart from the Institute's scientists associated with the project. The programmes implemented during the year and to be conducted were discussed thoroughly. Important suggestions were offered by the Chairman for effective implementation of the programme and maximization of the outputs.

Showcasing of Agricultural Technologies and Media Meet

The Institute organized Showcasing of Agricultural Technologies and Media Meet with a theme of 'Diversified agriculture for augmenting income and livelihood security' on March 22, 2012 at village Thawar, Mall, Lucknow in collaboration with M/S Bayer Crop Science Ltd. Dr. M. S. Aulakh, Hon'ble Vice Chancellor, Manyavar Shri Kanshi Ram University of Agriculture and Technology, Banda was the Chief Guest. Presiding over the function, Dr. Bangali Baboo, National Director, National Agricultural Innovation Project (NAIP), ICAR, New Delhi highlighted the innovations made and popularized through different NAIP projects in the country with a view to augment the farmers profitability. Dr. T.P. Trivedi, Project Director, Directorate of Knowledge Management in Agriculture and Assistant Director General, ARIS, ICAR, New Delhi emphasized the need of strengthening the linkages for effective dissemination of agricultural technologies from ICAR Institutes/State Agricultural Universities to the farmers through print and electronic media. Dr. H. Ravishankar, Director, CISH welcomed the guests and enumerated the importance of

Dr. M. S. Aulakh, Hon'ble VC, MSKRUA & T, Banda inaugurating the exhibition

Distinguished dignitaries at the dais

diversification in agriculture and its impact on risk minimization and sustainability of income and enduring livelihood security. The dignitaries Dr. S. A. H. Abidi, Ex-member Agricultural Scientists Recruitment Board, Dr J. K. Jena, Director, NBFGR, Lucknow, Mr. Insram Ali, President, Mango Growers Association of India, Lucknow, Shri Bhupendra Singh, Ex-Director, NHB expressed their views on the occasion. Around 30 stalls were put up by different ICAR/CSIR institutes, government/non-government organizations and private industries wherein the latest agricultural technologies were showcased for the benefit of farmers/stakeholders. Elite planting materials of mango, guava, bael, aonla, pomegranate and jamun produced at hi-tech nursery of the Institute were also displayed and made available for sale. Around 700 farmers from mango growing belts of Kakori, Malihabad and Mall blocks participated in the programme. In the interactive meeting of the scientists and farmers, the solutions/suggestions were provided to the problems/queries related to horticultural crops production, protection and post-harvest management besides credit and marketing by the experts.

Hindi Chetna Mass and other Rajbhasha Activities

The Institute organized Hindi Chetna Mass from September 14 to October 14, 2011. The function began with *Hindi Diwas Samaroh* wherein talk on Importance of Hindi was delivered by Dr. S.A.H. Abidi, former Member, ASRB, New Delhi. During the period, several Hindi competitions like debate, essay, Shabdawali, Hindi tankan, etc. were held. The Chief Guest of the valedictory function was Dr. M.D. Pathak, former Director General, UPCAR, Lucknow. Apart from the Hindi Chetna Mass, 4 workshops and quarterly meetings were also organised to propagate Hindi amongst the employees of the Institute.

18. METEOROLOGICAL DATA

	Temperature (^{0}C)		Relative humidity (%)	Bright Sunshine hours	Wind velocity	Total Rainfall	Pan Evaporation
Month	Max	Min			km/hr	mm	mm
April	35.8	18.8	71.0	3.5	3.5	3.0	6.8
May	37.9	23.4	74.0	3.6	3.6	101.8	7.1
June	34.9	24.9	82.3	6.2	4.6	267.5	6.0
July	33.2	25.7	89.0	3.8	3.8	351.0	4.3
August	31.9	25.3	88.4	4.3	7.0	481.8	3.5
September	32.9	24.4	88.7	6.8	3.7	247.8	3.8
October	32.6	17.0	84.3	7.9	1.6	0.0	2.9
November	28.2	11.7	90.1	5.6	1.3	0.0	1.7
December	22.0	6.6	88.7	4.4	1.7	0.0	1.2
January	19.9	8.7	92.10	1.8	3.3	2.01	1.5
February	24.5	10.4	83.34	4.0	4.5	1.16	3.4
March	31.1	10.4	47.42	7.9	3.5	4.2	4.1

Monthly average meteorological data during April 2011- March 2012.

Dr. K. L. Chadha, Ex-DDG (Hort.), ICAR and Project Co-ordinator AICRP (Fruits) & Founder Head, CMRS, Rehamankhera, Lucknow Receiving Padma Shri from Hon'ble President of India, Dr. Pratibha Devi Singh Patil on March 23, 2012

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