



Improvement and Management of Horticultural Crops

FRUIT CROPS

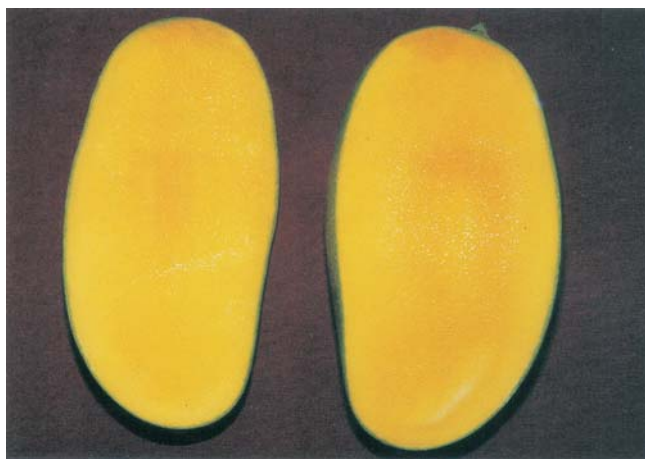
Mango

Mango superior trees of different varieties were identified and scion sticks collected at IIHR, Bangalore. Eighteen accessions in mango were characterized morphologically. *Mangifera odorata* recorded maximum TSS (21.7° Brix). The pulp recovery was found 83 and 81% in mango Keraligoa and Khudadath (variant), respectively. Distinct physiological shift of seed into germination

- Eighteen accessions of mango were characterized
- T 19 and T 20, clones of mango Himsagar, were promising
- Salem and Javori, clones of mango Bangalora were promising
- Hybrid H 311 gave maximum fruit yield
- Rejuvenation of mango orchards was done

mode allows the seed to act as a stronger physiological sink, enabling it to draw water and other nutrients from adjoining mesocarp resulting in spongy tissue. The survey of mango orchards of Krishna district for nutrient status indicated that the age of orchards decides the deficiency of micronutrients and their management for yield and quality. The correction of micronutrient disorders in mango Banganapalli in Krishna districts recorded 12–18% increase in yield. The causes of low yield in mango orchards

Fruit quality of treated tree



in Kolar district in Karanataka indicated zinc (13–17 ppm) and boron (34–45 ppm) deficiencies. Zinc (15–17 ppm), manganese (28–32 ppm) and boron (42 ppm) deficiencies were also found in Krishnagiri. The studies on pest risk analysis of *Bactrocera caryeae* showed that it is restricted to west coast of India and major mango belts of South India are free from it. Extensive surveys carried out for mango fruit fly and stone weevil infestation in South India on Banganapalli showed that Krishna, Mehaboobnagar/Rangareddy districts of Andhra Pradesh, were free from these pests.

At CISH, Lucknow, plastic mulch enhanced flowering in mango. The response of black plastic mulch (100 µ) was evaluated against root growth, nutrient status of soil and plant, flowering and yield of mango Chausa. Mulching was done during flower-bud differentiation (October–November) stage. The mulch stimulated the lateral root growth particularly in nutrient rich upper soil layer. However, there was no difference in dry weight of roots. The data on nutritional status revealed the improvement in levels of Ca (521.05 ppm), Zn (0.93 ppm), Cu (1.61 ppm), Mn (6.66 ppm) and Fe (4.90 ppm) in mulched soil as compared to control (440.95, 0.75, 0.66, 4.52 and 3.6 ppm, respectively). Among different nutrients, phosphorus (0.21%) and potash (0.8%) were found significantly higher in leaves of mulched plants in comparison to control (0.15 and 0.56%). Enhancement in flowering and yield (38–70 and 40–60%) were also recorded in 'off' and 'on' year because of mulch. Increase in these attributes may be associated with increase in root area along with enhanced ability of tree to take more nutrients particularly phosphorus and potassium from soil under mulched condition.

Single application of five bacterial antagonists isolated from mango pathosystem and leaf based organic liquid pesticides were found effective against mango bacterial canker disease. These organisms were identified as species of *Bacillus*, *Pseudomonas* and *Acinetobacter*.

Under All India Coordinated Research Project on Sub-Tropical Fruits, Dudhiya Malda performed very well followed by Dholikothi Maldah at Sabour, Bappakai and Sensation at Sangareddy, Bangalore Goa followed by Zafrani Gola at Pantnagar and Keraligoa, Khudadath and Navneetham at IIHR, Bangalore. Peddapur-16 seedling at Sangareddy and collection Nos. 7/80, and 10/80 were found promising at Sabour. Two clones, T19 and T20, of Himsagar



were found promising for high yield at Mohanpur and clone Rati Banganpalli having cluster bearing habit, early Baneshani having early maturity, Pedda Benishan and Allahabad Benishan bearing bigger sized fruits than Banganpalli performed well at Sangareddy. Similarly, two clones of Bangalora, i.e. Salem and Javori having big fruits (300–500 g) were found promising at Periyakulam. Hybrid H-311 (Alphonso × Neelum) recorded maximum yield and was found free from spongy tissue disorder at Vengurle. Neeleshwari and Neeleshan were found promising at Paria.

In planting system-cum-high-density planting trial, double hedgerow system of planting gave significantly higher yield at most of the centres. In pruning trial for high-density planting, maximum number of fruits and yield were recorded in the trees pruned on alternate limbs after harvesting with application of paclobutrazol at Sangareddy, whereas at Paria and Vengurle, heading back of 20 cm terminal shoot biennially with application of paclobutrazol during rest period gave higher yield. Heading back of branchlet at 50 cm level with the application of paclobutrazol during rest period gave higher yield in trees planted at normal distance at Vengurle. Rejuvenation of overcrowded orchards (heading back up to crowded branchlets and centre opening) along with use of paclobutrazol during the rest period gave maximum cumulative yield of last seven years at Sangareddy and Pantnagar.

Maximum hopper population was recorded on panicles during flowering stage, i.e. second fortnight of March (65.5) followed by that on trunk of tree (57.1) in first fortnight of April and on leaves in first fortnight of July (58.6) at Mohanpur. Higher activity of hopper was observed during flowering stage, while thrips had two peaks (October–November and March–May) coinciding with new flush period at Paria. Three sprayings of Imidacloprid and Endosulphon starting first spray of Imidacloprid (0.005%) at panicle emergence followed by the rest two sprays of Endosulphan (0.07%) at 15 days and 21 days intervals proved highly effective by reducing hopper population by 20.07% with highest yield of 346.6 kg/tree at Sabour. Number of fruits set at marble and harvesting stages were significantly higher in treated plots sprayed with Imidacloprid (0.005%) at panicle emergence than in untreated control at AES, Paria. Module-II (Imidacloprid (0.005%), NSKE (5%) and Endosulphan (0.07%) was highly effective by resulting in lowest survival of hopper population (8.64%) and maximum fruit yield (259 kg/tree) in mango Langra at Sabour.

Banana

Forty-six exotic accessions of banana were introduced from Belgium at NRC for Banana, Trichy. Phylogenetic relationship among 45 AB diploid accessions was analysed using microsatellite markers. Embryogenic cell suspensions of banana Nendran (French Plantain) and Ney Poovan were developed. Kanai Bansi,

- Forty-six exotic accessions of banana were added
- Primers, OPB1, OPB7 and OPB17, showed polymorphism
- Four distinct bacterial clones were isolated
- A total of 1,1000 suckers of banana were supplied at Arabhavi, 50,000 at Jorhat and 680 at Mohanpur

M. balbisiana, Athiakol, Bhimkol and Attiakola were potential resistant donors against burrowing and root lesion nematodes, while Ankur was moderately resistant to root-knot nematode. Nattu Poovan, Thella Chakkarakeli, Teraben, Mannan, *Musa balbisiana*, Ladan, Erode Kai and Pisang Berlin were drought tolerant based on leaf water retention capacity.

In Red Banana, plants grown under paired row planting system with a population of 3,800 plants/ha recorded 29.5% more yield than 2,500 plants/ha. The fruits recorded highest TSS (23.5° Brix), total sugars (20.96%), ascorbic acid (12.53 mg/100 g), peel carotene (3.02 mg/100 g) and low acidity (0.26%) under paired row planting.

In Rasthali, application of 15 kg rice husk ash + 80% recommended NPK + 25 g VAM/plant recorded highest average bunch weight of 12.3 kg with 30% increase over control (9.4 kg). Under high soil pH (>8.5) condition, soil application of iron and boron and foliar application of zinc increased bunch weight in Ney Poovan banana. Fertilizer adjustment equations were developed for optimum production of banana Rasthali.

For integrated pest management in banana, a semi-chemical Eicosane evoked higher response (0.732 eV) to female antenna, whereas cyclohexane responded to male antenna (0.292 eV). Complete mortality of burrowing nematode was observed with application of flower and root extracts of *Tagetes erecta*. Applications of 30 g *Trichoderma viride* at planting, and 3 and 5 months after planting or in combination with *Pseudomonas fluorescens* reduced nematode population significantly with increased plant growth.

Primers, OPB1, OPB7 and OPB17, showed polymorphism and differentiated different foci by cluster analysis. Nit mutants were generated for VCG grouping of different foci isolates. Presence of VCG's 0124, 0125, and 0128 of foci in India has been confirmed. Two of the rDNA-ITS sequences of foci have been deposited in the NCBI genbank. Complete genome of banana streak virus (BSV) was cloned, sequenced and deposited with the NCBI genbank (Accession 859899). The viral genome was 6950 bp in length and had three ORFs. This BSV sequence is more similar to BSV-OL and GD sequences, 900 bp intergenic BSV sequence was cloned for assessing the promoter activity. The BBTV cp gene was cloned into an expression vector for producing recombinant coat protein.

The ACC oxidase gene was isolated and fused with CaMV 35S promoter and terminator in anti-sense orientation to develop



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transgenic banana with delayed ripening. This whole cassette of ACC oxidase in anti-sense orientation with respect to CaMV 35S promoter was shuffled to binary vectors of pGreen and pCambia.

Under AICRP on Tropical Fruits, four accessions of banana have been catalogued for their morphological traits at Coimbatore. At Kannara, 15 regenerated new accessions of banana were planted for field evaluation. At Coimbatore, 20 crosses were made using Manoranjitham and Karpooravalli as female parents and Rose, YKM 5, Pisang Lilin and H-65 as male parents, which yielded 106 seeds. The hybrid progeny from different crosses were established in field under Kannara conditions. At Kovvur, RAPD analysis corroborated the genetic variability discovered by isoenzyme analysis between *Fusarium* wilt resistant Silk banana Martman from other susceptible members of group. The cultivar can directly be deployed in *Fusarium* (race-1) endemic areas. Banana hybrid, 96/7 and H 212, tolerant to nematodes were proposed as pre-release cultures at TNAU, Coimbatore. Application of fertilizers of 200 : 50 : 200 N, P₂O₅ and K₂O respectively/plant/crop along with spraying of 2,4-D at 10 ppm gave higher yield during plant crop of banana under Arabhavi conditions, while at Kannara, 2, 4-D (25 ppm) as bunch spray along with soil application of 200 g N and foliar application of urea (2%) recorded yield increase in banana Nendran. At Coimbatore, combined treatment of 300 g N and 300 g K₂O with two post-shooting spraying of CPPU (4 ppm) gave maximum bunch weight of 37.25 kg. The treatment propiconazole (0.1%) + spraying of *Bacillus subtilis* @ 5 ml/litre controlled Sigatoka leaf spot effectively under Arabhavi and Kannara. A total of 1,100 suckers of banana were supplied at Arabhavi, 50,000 at Jorhat and 680 at Mohanpur.

For molecular characterization of fruit fly species, molecular differences in mitochondrial cytochrome oxidase I (mtCOI) gene of three fruit fly species, viz. *Bactrocera dorsalis*, *B. correcta* and *B. zonata* (Tephritidae: Diptera) were carried out using mtCOI specific primers. Sequence analysis of PCR amplified fragments showed appreciable differences in nucleotide sequences of three fruit fly species.

Four distinct bacterial clones were isolated from bacterial contamination displaying *in vitro* cultures of banana Grand Naine and single colony-purified and identified through 16S rDNA sequence analysis. These organisms included *Pantoea agglomerans*, *Bacillus subtilis*, *Klebsiella variicola* and *Staphylococcus epidermidis*. All these endophytes appeared detrimental to banana cultures overrunning them within 2–4 weeks of *in vitro* culturing.

Citrus

At NRC for Citrus, Nagpur, one early-maturing clone (N₂) of Nagpur mandarin (early-February) and another less-seeded clone

(N₄) of less than 3 seeds/fruit were identified for evaluation at farmers' fields. In germplasm collection, 49 exotic germplasm comprising 30 scions (14 of mandarin, 9 of sweet orange, 7 of grapefruit and pummelo from USA, France, Japan and Niger) and 19 of rootstocks (mostly from USA, a few from Australia) and 532 indigenous collections have been maintained at Nagpur. Besides, 75 superior clones of Nagpur mandarin, 12 of acid lime and 5 of Mosambi were under field evaluation. For micronutrient-use efficiency in Nagpur mandarin, suboptimum Zn and Fe nutrition are considered to be the global concerns for sustainable citrus production. Better efficiency of soil applied Zn over foliar application and vice-versa in case of Fe, was observed with respect to response on flowering intensity, fruit setting, tree canopy volume,

- Seventy-five clones of Nagpur mandarin, 12 of acid lime and 5 of mosambi were evaluated
- On selection each of sweet orange and pummelo were collected

fruit yield and quality indices. Higher movements of Zn through xylem compared to Fe and of Fe through phloem in comparison to Zn, were identified as the major distinguishing factor in understanding the differential response between Zn and Fe fertilization.

Continuous trenching between two rows of trees across the slope (3.8%) conserves 30–35% run-off and 25–30% soil and available nutrients (N, P, and K) in young Nagpur mandarin, producing better plant growth. In bearing acid lime as well, continuous trenching produced the best response conserving 35–38% run-off and 32–35% soil and available N, P, and K in addition to raising fruit yield by 18% with better fruit quality (43.2% juice) over control (35.4% juice). Harvested rainwater from 3.1 ha of catchments through a tank of 35 m × 35 m × 3 m size was successfully recycled through drip irrigation with plastic mulch in 1 ha (288 plants) of 3-year-old Nagpur mandarin orchard.

Of the nine biopesticides tested, choicest biopesticides/new molecules in their order of toxicity to blackfly and leaf miner were found – abamectin > spinosad > novaluron and to psylla and – spinosad > abamectin > novaluron to leaf minor. Oviposition

Use of Bioagents

In field release of bioagents against citrus insect pests, release of *Mallada boninensis* @ 30 larvae/tree and *Tamarixia radiata* @ 40 adults/tree resulted in 28–30, 42–45 and 23–26% reduction in blackfly, psylla and leaf miner, respectively.



preference by leaf miner, blackfly and psylla on Nagpur mandarin revealed that citrus blackfly and leaf miner preferred 15–20 and 5–10 days old leaves, respectively, whereas psylla preferred 5 days old twig for egg laying.

Under AICRP on Tropical Fruits, one selection in sweet orange and another in pummelo were collected and planted at Tirupati. Sweet orange mosambi selections 2 and 4 and acid lime promising selection RHR-L-124 continued to record their superiority for yield and fruit quality at Rahuri. At Tinsukia, Khasi mandarin selection CRS-4 continued to be superior among 12 clonal selections. Addition of VAM (500 g/plant) + PSB (100 g/plant) + *Azospirillum* (100 g/plant) + *T. harzianum* (100 g/plant) to 100% RDF/plant/year produced highest yield of sweet orange at Rahuri. Fifty-seven grafts of sweet orange Mosambi and 315 seedlings of acid lime (Sai Sharbati) were supplied to farmers at Rahuri. Virus-free kinnow was budded on 2,000 plants of Rough lemon at Ludhiana.

Grape

Eight exotic accessions of *Vitis vinifera* were introduced in addition to collection of four wine grape accessions from private winery at NRC for Grapes, Pune. The National Grape germplasm collection now has 415 accessions. A total of 149 accessions were characterised based on berry and bunch characters. Forty-four accessions were characterised using RAPD and microsatellite markers and genetic relationship among these accessions was established.

Several hybrids of indigenous species and varieties with introduced cultivars were found promising for early ripening and quality traits. Germplasm was screened for resistance to thrips and downy mildew and several accessions showing varying levels of tolerance were identified, which can be used in breeding programme to develop resistant commercial varieties. In microsatellite analysis of a large number of downy mildew resistant and susceptible grape accessions identified a marker which is present in only susceptible accessions.

Thompson Seedless grafted on 110R produced significantly more bunches and higher yield as compared to those grafted on other rootstocks as well as own roots. Nutrient uptake pattern was found to be different for different nutrients in grafted and own

Software in Grape Production

The software for grape germplasm information system was made operational. Database for molecular data of grape accessions was designed.

rooted vines. Vines grafted on Dogridge and 110R accumulated lower chlorides in tissues than those grafted on Salt Creek. The shiny spot symptoms was found to be due to potassium deficiency. Similarly, low potassium content was found to be associated with marginal necrosis of leaf blade.

The IBA concentration was standardized for propagation of grape rootstocks using hardwood cuttings. No adverse effect on growth, yield and quality parameters were observed in nine years old Tas-A-Ganesh grafted on Dogridge rootstock with different levels of stock scion growth ratio (inverted bottleneck symptom). In Thompson Seedless, maximum photosynthetic rate and internal CO₂ was recorded during fruit-bud differentiation and full bloom stages on 110R rootstock compared to other rootstocks. Stock scion ratio of 0.9–1.0 was recorded in Tas-A-Ganesh when grafted on 110 R and B2/56 rootstocks, while it was 0.8–0.9 on Dogridge indicating higher vigor inducing nature of Dogridge. However, yield and number of bunches were maximum on 110 R followed by that on Dogridge rootstock.

Increased root : shoot length ratio and water-use efficiency were observed in most of the rootstocks at 50% moisture stress over control. At 50% moisture stress, although Dogridge recorded maximum root : shoot length ratio, 110R showed maximum water-use efficiency. Total phenolic compounds and individual class of phenols like flavonoids, flavonols, flavon – 3 – ols were estimated in Thompson Seedless grafted on different rootstocks at three different berry growth stages. Preliminary investigation revealed positive correlation between phenolic compositions and reduced incidence of powdery mildew.

In Thompson Seedless, higher bud fruitfulness was recorded in upward positioned shoots with maximum bud fruitfulness at 5–7th bud position. In Tas-A-Ganesh horizontal single cordon training modification recorded higher yield than double cordon system. Double stem four cordon system in Tas-A-Ganesh though resulted in higher yield as compared to single stem and other training modifications, however berry and bunch quality characteristics were low in this treatment. In plastic covered Tas-A-Ganesh girdling at 6–7 mm berry size resulted in improved performance of vines with respect to berry weight, diameter and length, total soluble solids and early berry setting. In Sharad Seedless, girdling at 6–8 mm berry size resulted in higher berry diameter, and berry and bunch weight. In Merlot and Sauvignon

- A total of 149 accessions were characterized
- A software for grape germplasm information system was made operational
- A prototype disease forecasting of software for powdery mildew management in grape was developed
- Statistical model was developed to predict powdery mildew incidence in grape



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Blanc maximum bud fruitfulness was recorded when spur pruned at 5th and 4th bud respectively.

At reduced level of irrigation, vines raised on B2/56 performed better than Dogridge and own roots. The cost : benefit ratio was highest for B2/56 at 75% and 50% of recommended irrigation level. Similarly, cost : benefit ratio of subsurface irrigation at 75% of recommended level was on par with recommended level, thus resulting in a saving of 25% irrigation water. In another experiment, irrigation requirement could be reduced by 25% using mulch and antistress, although the cost : benefit ratio of this treatment was less than the recommended levels of irrigation.

A prototype disease forecasting software for powdery mildew management was developed. The software takes daily weather data, field data and generates diagnosis and recommends the choice and dose of fungicides. The software was released and made available to growers.

Several environmentally safe chemicals and new molecules were tested and found promising for controlling powdery mildew. The efficacy of Carbendazim was improved by adding citric acid @30 g/100 litres of spray water. Biocontrol agent, *Trichoderma* was tested for antagonism to *Elsinoe ampelina* and significant mycoparasitism was observed.

Among several antagonistic microorganisms isolated from grape rhizosphere and endophytes, three were found to be promising for the control of post-harvest decay and three were promising against *Botryodiplodia theobromae*.

At Bangalore, three promising Thompson Seedless vines producing loose bunches and bold berries were identified. Total antioxidant capacity was significantly higher in Bangalore Blue grape seed followed by peel due to higher total phenols in seeds and anthocyanins and phenols in peel when compared to whole fruit. Raisins from Thompson Seedless grape had higher total antioxidant capacity (FRAP - 474 mg AEAC/100 g dwt), radical scavenging capacity (DPPH - 4339.4 mh/100 g) and total flavonoids (112 mg of catechin equivalents/100 g) compared to fresh grapes (430, 3922 and 91 mg/100 g dwt of FRAP, DPPH and total flavonoids respectively). Residues of Imidacloprid (Confidor 200 SL) on grapes was evaluated following spray applications (4 times) at recommended dose, revealed that crop was free of any Imidacloprid residue at harvestng, 105 days after treatment. Statistical model was developed to predict powdery mildew incidence in grapes The prediction power of empirical model was worked out to be 68.3%. Further, optimized model developed using maximum temperature, relative humidity and rainfall predicted powdery mildew incidence reasonably well ($R^2 = 0.60$) and possessed minimum average prediction errors. Statistical models were developed to optimize the role of weather factors and simultaneously to predict anthracnose incidence in grapes

cv. Anab-E-Shahi. The optimized model showed that morning and evening relative humidity could predict the incidence to 77.5%.

Papaya

An advanced generation hybrid has been developed at IIHR, Bangalore, which has medium-sized fruits (800 g), with deep pink coloured pulp, high TSS (13–14° Brix) and good keeping quality. For quick detection of virus in plants and seedlings, molecular diagnostic assay based on RT-PCR was developed using coat protein gene specific primers. Under AICRP on Tropical Fruits at Coimbatore, genotypes G 22, G 27, and G 15 were found early and

- An advance generation hybrid of papaya was developed
- Papaya genotypes, G 22, G 27 and G 15, were found early and tolerant to cold

tolerant to cold. Fruits from these genotypes were harvested and seeds collected to raise F_3 generation. Survey at Coimbatore revealed 20–40% incidence of papaya ring spot virus (PRSV).

Sapota

Eleven accessions of sapota were characterized at IIHR, Bangalore, using standard descriptors. The average fruit weight ranged from 26.44 g in Badam to 130.42 g in DHS 2. Thirty-two germplasm collections were studied for their susceptibility to chiku moth (*Nephopteryx eugraphella*), bud-borer (*Anarsia achrasella*), leaf miner (*Acrocercops gemoniella*) and ash weevil (*Myliocerus* sp.). Leaf nutrient guides for sapota have been developed for economic and balanced nutrient management. The nutrient guides for micronutrients have also been developed for sapota farmers. Potash has been identified as the most limiting nutrient in orchards surveyed in Karnataka.

- Eleven accessions of sapota were characterized with standard descriptors.
- Thirty-two germplasm accessions of sapota were studied

Under AICRP on Tropical Fruits, high-yielding clone DHS 1(2/1) identified earlier continued to show its superiority at Arabhavi. Application of 5 kg vermicompost with 200 g N, 40 g P_2O_5 and 150 g K_2O /plant/year in Kalipatti recorded higher yield. The treatment carbendazim (0.1%) effectively controlled leaf spot disease of sapota.

Guava

CISH-G4, a selection from population of Apple Colour guava,



was found promising, at CISH, Lucknow. It was released as Shweta for commercial cultivation. This has globose, medium-sized fruits, creamy white exocarp with red blush, snow white pulp, high TSS (12.5–13.2%) content and vitamin C (300 mg/100 g EP) with good keeping quality.



Guava Shweta

Under AICRP on Sub-Tropical Fruits, six germplasm accessions were added to the germplasm collection. Lucknow-49 followed by Allahabad Safeda and Lucknow-46-2 gave high yield at Sangareddy. Guava Allahabad Safeda excelled under Sabour conditions. The evaluation of germplasm at Bangalore revealed that fruit weight was maximum (246.5 g) in Dhareedar followed by Local Pink (244.2 g). The quality parameter revealed that TSS

- Six accessions of guava were added
- Three accessions of litchi were added
- Twelve fruit species were collected from Kerala
- In Jammu, 12 collections were evaluated
- Seven genotypes of aonla were added
- Three genotypes of date palm were added
- Aonla Selection 1 was identified
- F 6/a, a new mateera, was ready for release
- BS 1, a genotype of ber, was identified
- Storage life of pomegranates of Bhagwa could be extended for 3 weeks

ranged from 9.0° Brix in Aneuploid to 21.09° Brix in Local Pink. The acidity was low (0.524%) in Thailand 2, followed by Thailand 1 (0.613%). The vitamin 'C' was more (298.2 mg/100 g pulp) in Dhareedar. In planting system-cum-high-density planting, maximum yield was recorded in 'double hedgerow system' of planting and minimum in 'square system'.

Litchi

Three accessions were added to the gene bank making a total of

55 cultivars of litchi at NRC for Litchi, Muzaffapur. Litchi Shahi proved to be more robust compared to other cultivars. Allied species of litchi, longan (*Dimocarpus longan*) came to fruiting three years after planting. The keeping quality of longan fruit was very good and taste was sweeter than litchi with small seeds.

Major insect pests of litchi were identified. Trichogramma @ 50,000/ha with Ninbicide (0.5%) or cypermethrin @ (0.005%) with Nimbicide 0.5% sprays proved superior in minimizing the damage by fruit-borer when sprayed at fruit setting (lentil-sized) and at colour development stages.

One thousand four hundred litchi layers were supplied to litchi growers during 2006. Qualitative characteristics of Shahi and China litchi were analysed for wine making purpose.

Under AICRP on Sub-Tropical Fruits, double hedgerow system of planting gave highest yield at Pantnagar, while square system at Mohanpur. Shoots pruning up to 50 cm at the time of harvesting of fruits, followed by removal of new flush in November–December, 2006, provided maximum yield of quality fruits at Pantnagar.

Leaf roller incidence reached its peak in October (42–43%) and caused 51.5% fruit damage 67 days after fruit setting at Mohanpur. Incidence of leaf roller was low in March, 2006 and gradually increased maximum level in July at Pantnagar.

Mango Karpuria, Hathijhool, Audhia Maldah, Police, Maldah (Surajgarha) and Maldah (Dholikoth) showed only one per cent of malformation. Critical temperature (19.45°–35.61°C) and relative humidity (52.98–96%) with 9.01 h/day sunshine have been found to favour the maximum disease development of powdery mildew in Himsagar at Mohanpur. At Sangareddy, powdery mildew was observed during fourth week of January, 2006 on susceptible Ratna and Swarnajehangir with PDI of 61–80 when mean minimum temperature and mean maximum temperature were 10.71°C and 28.8°C.

The incidence of powdery mildew was first noticed on second flush in first week of January at Vengurle. It was found to be positively correlated to minimum temperature and panicle age. At Paria, maximum disease (86%) was observed in Alphonso at mean maximum temperature of 22.99°C, minimum of 14.17°C, RH of 68.64%, sunshine hour of 9.6 hours/day and vapour evaporation at 5.51 litre/day with clean sky position.

Passion fruit

Irrigation and fertilizer schedules for passion fruit revealed that irrigation at 75% of evaporation replenishment recorded higher yield as compared to irrigation at 50% of evaporation replenishment and basin irrigation. Fertigation with 75 and 100% of recommended dose of fertilizer recorded higher yield as compared to soil application of fertilizer. This indicates a saving of 25% of water and fertilizer.



Jackfruit

Jackfruit grafts of selected plants for raising clonal stocks at Kannara and those of Palur 1 from Periyakulam centre are maintained at Vellanikkara under AICRP on Tropical Fruits. At Mohanpur, four new germplasm have been identified. Twelve elite jackfruit clones were collected at Kovvur.

Underutilized fruits

In under-utilized fruits, three species of Pandanus, one each of *Baccaurea ramiflora*, *Spondias cytherea*, *Dillinia indica*, *Averrhoa bilimbi*, *Malpigia glabra*, *Baccaurea sapida*, *Cordia oblique*, *Artocarpus* spp. and *Garcinia* spp. were added from Andaman island. Another 12 fruit species found in Kerala forests were also collected: *Antidesma ghaesmbilla* (Black current), *Salacia chinensis*, *S. beddomei*, *Flacourtia Montana*, *Syzygium zeylanicum*, *Elaeocarpus serratus*, *Chrysophyllum cainito* (Star apple), *Flacourti (lovi-lovi)*, *Averrhoa bilimbi* (Bilimbli), *A. carambola* (sour type), (*Carambola*), *Psidium guineense* (*Guva* sp.), *Aporosa lindleyana* and *Psidium littorale*. In jamun, 12 collections were observed for their variable reaction to leaf miner, *Acrocercops* sp., fruit weevil, *Balaninus c- album*, bark eating cater pillar, *Indarbela* sp. and ash weevil, *Myloceros* sp. Fifteen pummelo germplasm collections were evaluated for resistance to citrus leaf miner and *Phyllocnistis citrella*.

Temperate fruits

At CITH, Srinagar, medium high-density plantation with 625 budded plants of almond/ha at 4 m × 4 m distance was compared with 278 plants/ha planted traditionally at 6 m × 6 m distance. The budded plants commenced into bearing only after 3 years in comparison to 7 years of seedling trees. Consequently, the productivity has been raised from existing 0.86 tonne/ha to more than 3 tonnes/ha from 6 years old plants. This showed the possibility of increasing the productivity manifold with use of varieties like Waris, Shalimar, Makhdoom and Non-Pareil.

Arid zone fruits

Seven genotypes of aonla and three of date palm were added to national repository. Large collections of bael, jamun, karonda, tamarind, mahua, chironji and wood apple were also made at CHES, Vejalpur, Godhra. However, due to sub zero temperatures, which prevailed continuously for 3–4 days during January 2006, all germplasm of ber (except Tikadi and Snaur), aonla, pomegranate and lasora were severely affected with frost injury while date palm and khejri germplasm were not affected.

A selection of aonla (Aonla Selection 1) was identified, which is early-maturing and high-yielding due to more number of female flowers under rainfed conditions of semi-arid region. A new variety of mateera (F6/a), which is free from cracking, good in TSS (9.5–

11.2° Brix), low in seed content, red in pulp is ready to be released.

For tissue culture plant, a three step hardening process involving primary in acclimatization hood made of plastic tray covered with polycarbonate sheet with ventilation devices, subsequent transfer to evaporative cool chamber and thereafter,



Medium high-density plantation in almond



Almond bearing in medium high-density plantation



Non-pareil

Shalimar

acclimatization of plantlets either in shade house or low-cost polyhouse equipped with intermittent fogging device has been found effective in surviving of plants.

The fertigation practices has been standardized in Kinnow mandarin and results revealed that 70 and 40% of recommended



dose of nitrogen and phosphorus during February–June, 20, 50 and 40% of recommended dose of nitrogen, phosphorus and potash during July–September and remaining 10% of N and P and 60% of potash during October–December may be applied through micro-irrigation (drip and micro-sprinkler) for optimum productivity with maximum water and nutrient-use efficiency.



Veneer grafting in khirnee (*Manilkara hexandra*)



Aonla cider

Under microirrigation system, maximum root volumes were estimated in 20–40 cm deep soil layers in pomegranate, kinnow and ber trees. During April–June 28–45% more moisture was conserved under black polythene mulch in aonla. In arid conditions, FYM mulch (140 tonnes/ha) increased the water-use efficiency, moderate the extreme soil temperatures and increased fruit yield in brinjal and kachri crops. The use of vermicompost in sandy soils has better influence on soil moisture retention in root zone for a longer period, which also helps to make the nutrients available for plants.

Pomegranate and aonla fruits infested by post-harvest pathogens were investigated for presence of mycotoxins with special reference to Aflatoxins. Aonla, NA-6, NA-7, Chakaiya and Krishna were observed with infection due to *Aspergillus* spp. and it was maximum (33.2%) in Krishna, followed by NA 6 (17.8%). Four pathogenic isolates of *Aspergillus* spp. were tested for mycotoxins and aflatoxins, viz. B₁, B₂, G₁ and G₂. These were produced in growth media and fruits as well. Detection of aflatoxins in pomegranate arils by agar plugs method showed positive response with different compounds when the samples were loaded on silica gel (TLC). Aflatoxin B₂ was secreted by all isolates in growth media and infected arils. The fungicidal seed dressing with ridomil Mz @ 2.5 g/kg seed was adjudged as best treatment which provide maximum transplant yield with least mortality due to post-emergence damping off disease.

Under AICRP on Arid Zone Fruits, a genotype of ber 'BS-1' has been identified. It is tolerant to fruit fly and resistant to powdery

mildew. The genotype has been registered as a promising line of ber by NBPGR, New Delhi.

In custard-apple (*Annona squamosa*), additional pollination gave best fruit setting, size and shape in both dry and wet years without significantly affecting fruit quality. Under integrated nutrient management programme, 50% of recommended doses of NPK and S along with biofertilizers and recommended dose of FYM proves to be best combination for aonla, ber, date palm and pomegranate at different centers.

Application of neem oil 60 EC (A) @ 3% and neem oil 60 EC @ 30% effectively reduced powdery mildew of ber and *Trichoderma viride* 10 g/kg of soil reduced root rot incidence in different fruit crops.

Post-harvest management

Mango fruit peels were found to possess very high antioxidant activity. The antioxidants can be extracted from peels as valuable byproducts from waste. Hot water treatment of fruits of mango Chausa, Amrapali and Mallika at 48°C ± 1°C for 1 hour controlled all stages of mango fruit fly (*Bactrocera zonata*). Individual shrink-wrapping of mature green fruits of Alphonso and Banganapalli with semi-permeable polymeric films extended their green storage life to 5 weeks at 8°C without any chilling injury symptoms. Alphonso mangoes packed in bulk by inner lining of entire 4 kg CFB box with micro-perforated semi-permeable films could be stored for 1 month at 8°C in unripe hard green condition without any chilling injury symptoms.

The storage life of pomegranate fruits (Bhagwa) could be extended to 3 weeks by bulk MAP and 1 month by individual shrink wrapping at ambient temperature. At 8°C, storage life could be extended to 3 months by these packing methods with a weight loss of less than 1% as compared to 20% weight loss in non-wrapped fruits.

VEGETABLE CROPS

Crop improvement

Chilli Kashi Anmol a determinate variety, suitable for production of green fruits, has been developed. Its fruits are dark green, 5–6 cm long and 2 cm girth, pungent (0.6% capsaicin) with smooth surface, early fruiting, first picking 55 days after transplanting, with an average yield of 250 q/ha (green fruits). Kashi Early is a hybrid with early fruiting suitable for production of green fruits. Its fruits are dark green, 6–7 cm long, 2.3 cm girth with smooth surface; first picking starts 45 days after transplanting. Its average yield is 275 tonnes/ha (green fruits). It is recommended for cultivation in Bihar, Uttar Pradesh, Uttaranchal, Jharkhand, Delhi and Punjab. Kashi Vishwanath is a cms based hybrid suitable for dry fruit production. Its fruits are 10–11 cm long, 2–2.3 cm girth with wrinkled surface, light yellow-green, average yield of 200 q/ha (red ripe fruits). Its is



- A number of new vegetable varieties were released
- More than 85 putative transgenic plants were regenerated
- Brinjal genotypes were used for regeneration and transformation
- F_1 hybrids of chilli were analysed for purity
- A total of 200 primers were used for screening polymorphism
- A technique to estimate antioxidant activity in tomato has been standardized
- Thirty-two isolates of *A. flavus* were studied

recommended for cultivation in Bihar, Delhi, Haryana, Andhra Pradesh, Karnataka and Tamil Nadu.

Okra IIVR 11 is a new variety. Its plants grow 110–130 cm high, flowering starts 30–34 days after sowing. It is suitable for cultivation during rainy as well as summer season. Fruits are of five ridges, green and 13–15 cm long. This is resistant to YVMV with an average yield of 150–170 q/ha. Its is recommended for cultivation in Chhattisgarh, Orissa, Andhra Pradesh, Rajasthan, Gujarat, Haryana and Delhi.

Cauliflower Kashi Kunwari is an early-maturing variety. Its curd is semi-dome type, white compact; fine texture, curd weight 300–450 g with an average yield of 300–350 q/ha. It is suitable for cultivation in Punjab, Uttar Pradesh, Bihar and Jharkhand.

Radish Kashi Hans is suitable for September to February planting and harvesting can be done 40–45 days after sowing. Its roots are straight, tapering, 30–35 cm long, 3.5–4.2 cm diameter; with an yield potential of 430–450 q/ha. It is released for cultivation in Uttar Pradesh, Punjab, Bihar and Jharkhand. Cowpea Kashi Gauri is bushy, dwarf, photo-insensitive and early variety suitable for sowing in both spring-summer and rainy seasons. It flowers in 35–38 days and pods becomes ready for harvesting 45–48 days after sowing. Pods are 25–30 cm long, green, tender, fleshy, less fibrous and free from parchment layer. Resistant to golden mosaic virus and *Pseudocercospora cruenta*. It produces 100–125 q/ha green pods.

Genetic transformation: Transformation was performed using *Agrobacterium tumefaciens* in tomato H 86 using *Cry 1Ac* gene from T-DNA of binary vector plasmid pBinAR. More than 85 putative transgenic plants were regenerated and are being maintained under laboratory conditions. The putative transgenic plants were tested for confirmation of inserted gene through PCR analysis. The inserted gene was detected by *npt II* gene and *Cry 1Ac* gene specific primer which shows 700 bp for *npt II* and 900 bp for *Cry 1Ac* gene. After PCR analysis, positive plants were subjected to southern blot hybridization. The PCR positive plants were also tested for strip test (strip that contain Anti *Cry 1AC* antibody) and

ELISA test. PCR and southern positive plants are being used for insect bioassay and segregation analysis.

Transformation: Brinjal genotypes Punjab, Sadabahar, Pant Rituraj, VR Baigan 1 (IVBR 1), VR Baigan 3 (IVBR 3), VR Baigan 9 (IVBL 9) and VR Baigan 14 (BRSPS 14), were used for regeneration and transformation. Transformation was performed using *Agrobacterium tumefaciens* in VR Baigan 9 (IVBL 9) using *Cry 1Ac* gene from T-DNA of binary vector plasmid pBinAR. More than 80 putative transgenic plants were regenerated. The gene integration was detected by PCR analysis. The amplification of 0.7 kb band for *npt II* and 0.9 kb for *Cry 1Ac* shows the presence of inserted gene. The transformants were further analyzed by southern blot hybridization. Southern analysis revealed 1 kb band with single blot hybridization in most of the transformants. The presence of *Cry 1Ac* toxin protein in plant was confirmed strip



Chilli Kashi Anmol



Chilli Kashi Vishwanath



Cauliflower Kunwari



Radish Kashi Hans



Cowpea Kashi Gauri



Symptomless GKC 29 scion grafted on susceptible Pusa Jwala

coated with anti *cry 1 Ac* antibodies. Insect bioassay was also done using neonate larvae (*Leucinodes orbonalis*) brinjal shoot-and fruit-borer with PCR and southern blot analysis confirmed transformants. Segregation analysis was done with only PCR and Southern positive plants and most of plant showed 3 : 1 ratio.

Resistance sources to Pep-LCV: From field screened 307 genotypes against pepper leaf curl virus (PepLCV) during previous season, selfed progenies of eight symptom-less and highly resistant lines were challenged by viruliferous white fly under glasshouse conditions. Of them, GKC 29, BS 35, EC 497636, showed no symptoms. Using scion and rootstock of susceptible genotype (Pusa Jwala), these three putative symptomless genotypes were further challenged by grafting and alternate grafting. The resistant reactions of GKC 29, BS 35, EC 497636 were confirmed because even after 50 days of successful grafting/alternate grafting, no viral symptom appeared on all grafted plants of Pusa Jawala in all three genotypes. When subjected to PCR amplification with degenerate primers designed to detect begamovirus like PepLCV, three symptom-less genotypes did not show any amplification, suggesting that resistant reaction in three identified resistant sources was because of absence/non-replication of viral genome and these lines are not symptom-less carrier.

Genetic purity testing: Two commercial F_1 hybrids of chilli, CCH 2 ($A_1 \times$ Pusa Jwala) and CCH 3 ($KA 2 \times$ R Line), and their

corresponding parents were analyzed for purity testing. A total of 200 primers (10 mer) were used for screening polymorphism between two pairs of parents. Of these primers, 145 produced clear amplification products. On an average each primer amplified three scorable bands. The primers that generated bands specific to male parent were repeated at least 2–3 times. These primers giving the same pattern in two or more replicates were chosen for further use. The 4 primers were found useful in determining seed purity. For hybrid CCH 2, 2 male specific bands were found with primers OPZ 6 and OPY 20 and among these, OPZ 6 was found most suitable for hybrid purity testing with band size of 700 bp. For hybrid CCH 3, 2 male specific bands with primers (OPS 1 and OPQ 18) were found amongst which OPS 1 was found most suitable for hybrid purity testing with band size of 400 bp.

Crop production

Integrated nutrient management: Ten organic nutrient sources, i.e. FYM @ 20 tonnes/ha, sewage sludge @ 20 tonnes/ha, vermicompost @ 10 tonnes/ha, neem cake @ 5 q/ha, NPK @ 150 : 60 : 80 kg/ha, FYM @ 20 tonnes/ha + Azotobactor, sewage sludge @ 20 tonnes/ha + Azotobactor, vermicompost @ 10 tonnes/ha + Azotobactor, neem cake @ 5 q/ha + Azotobactor, NPK @ 150 : 60 : 80 kg/ha + Azotobactor were given to tomato Sartaj. The observations reveal that application of vermicompost @ 10 tonnes/ha + Azotobactor gave significantly higher yield (962.5 q/ha), plant height (118.6), fruit size (37.8 cm²) compared to other treatments. The minimum values were noted under sewage sludge treated plots.



Staked tomato grown under IPNM

Antioxidant activity (AOA) in tomato: A technique has been standardized for estimation of antioxidant activity in tomato fruits to assess variability. Total antioxidant activity of sample extracts was analyzed using 2, 2-diphenyl-1-picryl-hydrazyl (DPPH) by recording absorbance at 515 nm. The standard curve was prepared for the reaction of TROLOX with DPPH and data was converted to activity in terms of μ moles trolox equivalents/100 g sample. Significant differences ($p > 0.05$) were recorded for antioxidant activity among 15 cultivars which ranged from 2.19 to 5.79 μ moles trolox equivalents/g with an overall mean for all the entries of 3.854 μ moles trolox equivalents/g.

Effect of bioagents: Thirty-two isolates of *A. flavus* were studied for radial growth inhibition against *Trichoderma viride*, *T. harzianum* and *T. koenigii*. Mean radial growth inhibition of 30 plates of *A. flavus* by three biocontrol agents in dual culture showed general inhibition of mycelial diameter above 60% in almost all test combinations. Relative inhibition efficacy varied among test bioagents. Maximum inhibition of *A. flavus* isolates with bioagent *T. viride* which not only restrict the growth of meeting point but also fully overlap growth of test organism.

Use of bait: During peak infestation period, molasses (10%) + carbaryl (0.1%) cover spray recorded significantly lowest (20.36%) fruit infestation being at par with spot spray of molasses (10%) + carbaryl (0.1%) manifesting 27.4% fruit damage while in control plot 55.28% fruits were damaged by fruit fly. Mean cumulative fruit damage over all the pickings indicated the superiority of molasses bait in either of the treatments. Molasses bait spray in spots recorded minimum (18.51%) followed non-significantly by molasses + insecticide cover spray (19.94%). The level of fruit damage in most usually applied insecticide cover spray was 26.67%. The control plot recorded 37.54% fruit damage. Maximum healthy fruit yield was recorded in molasses bait spray applied in spot.

Effect of seed treatment: The mean seedling length (25.26 cm) and vigour index (2,357.82) were maximum in

thiamethoxam treated seeds days after sowing. Seedling vigour index in carbosulfan treatment was adversely affected due to low germination. Thiamethoxam was most ideal treatment with maximum plant dry weight (70.01 g) 50 days after sowing. In jassid population thiamethoxam also was significantly superior to all treatments harbouring least number of jassids (9.46/plant) compared to control (27.59 jassids/plant). The yield in this treatment was also highest (126.82 q/ha) followed by imidacloprid (112.01 q/ha).

Tomato varieties at farmers' fields

Tomato Kashi Amrit, Kashi Anupam and Kashi Vishesh developed by IIVR Varanasi, were demonstrated at farmers' fields of Varanasi, Chandauli, Sonebhadra and Mirzapur districts in Uttar Pradesh. On an average, all varieties gave 520.83 q/ha compared to 365.25 q/ha (control). All these varieties are spreading at



Yield of tomato Kashi Vishesh at farmers' fields



Performance of Kashi Vishesh at farmers' fields



farmers' fields very rapidly due to their better productivity. Tomato Kashi Vishesh has proven a boon for mid-season tomato growers. In rainfed condition, in Sonebhadra district farmers taking only wheat as a major crop now are growing tomato as a major cash crop. The farmers express that flesh and hardness of all the varieties are like hybrids, which help them for distant marketing and improving their socio-economic status.

MUSHROOM

The National Mushroom Repository has been enriched by adding 312 mushroom cultures. Of which, a few are new records for India. Genetic improvement studies of temperate and tropical mushrooms

- Of the 312 mushroom cultures, a few of them are new ones.
- Fifty-three strains of mushrooms were evaluated
- Spent mushroom substrate and coir pith gave highest mushroom yield
- Polypropylene bags were best for containers
- A semi-automatic compost turner has been fabricated

revealed the identity of several single spore selections in *Volvariella volvacea*, *Agaricus bisporus* and hybrids in *Pleurotus sajor-caju*. Fifty three hybrid strains of *Pleurotus sajor-caju* were evaluated on wheat straw. Of them, 10 strains gave more than 68-85% BE. In paddy straw mushroom, 42 single spore isolates were compared for their different growth characters. Molecular characterization of various *Mycogone* cultures collected from different mushroom farms revealed no genetic variability, whereas *Trichoderma* isolates collected from various locations were identified as *Trichoderma asperellum*, *T. harzianum* *T. longibrachiatum* and *T. virens*.

The spent mushroom substrate and coir pith gave highest mushroom yield. Polypropylene bags proved to be best containers for cultivation of *Flammulina velutipes*. Supplementation of 20% wheat bran proved better for increasing productivity of shiitake mushroom. Another medicinal mushroom (*Schizophyllum commune*) has been also successfully cultivated on sawdust. Among different cultures of *Ganoderma lucidum*, Thai culture gave highest yield followed by Korean OE 53. The cultivation of button, oyster and paddy straw mushrooms in low-cost bamboo huts with good yields were demonstrated to framers. The design of semi-automatic compost turner of 5 tonnes/hour capacity is being fabricated.

TUBER CROPS

Potato

Germplasm collection was raised to 2,850 accessions by augmenting cultivated and wild species obtained from 30 countries.

Two parental lines, i.e. JW/96 (a good combiner of yield) and E/79-42 with combined resistance to late blight and potato cyst nematode have been registered as elite germplasm by ICAR/NBPGR germplasm. Potato Kufri Surya, Kufri Arun and Kufri Chipsona 3 were released for commercial cultivation. Hybrid MP/97-644 combining high dry-matter and low sugar contents, acceptable chip colour having resistance to late blight has been identified. Nine transgenic lines expressing *Ama1* gene had significantly higher (20–49%) total soluble protein content. The osmotin gene cloned from wild species, *Solanum chacoense*, was introduced into late blight susceptible cultivars. Transgenic lines of these lines was confirmed by molecular analysis. Reduction in lesion size due to

- Germplasm collection of potato was enriched to 2,850 accessions
- JW/96 and E/79-42 were registered as elite germplasm
- Kufri Surya, Kufri Arun and Kufri Chipsona 3 were released
- Nine transgenic lines of Kufri Badshah had better colour in their chips
- Russet scab has been important disease of potato
- A highly sensitive PCR technique to detect potato leaf curl was developed
- Eight meiotic cultivars showed resistance to late blight
- Potato salties, potato sweet nuggets and potato sewia—new value-added products—were developed
- Sree Athulya and Sree Apoorva, new cassava varieties, were recommended
- Two orange-fleshed clones of sweet potato were identified

late blight pathogen was observed in all these lines. Work on production of transgenic lines carrying resistance to bacterial wilt and potato tuber moth had yielded promising results. Fourteen transgenic lines of potato Kufri Badshah harbouring tobacco invertase inhibitor gene, Nt-Inhh showed substantial improvement

in chip colour compared to non-transgenic control tubers. Putative subunits of potato RNase P (an endonuclease) were identified, cloned and sequenced.

At Patna, rice equivalent yield and economic returns were highest in potato–onion–rice followed by potato–maize–rice crop sequence,



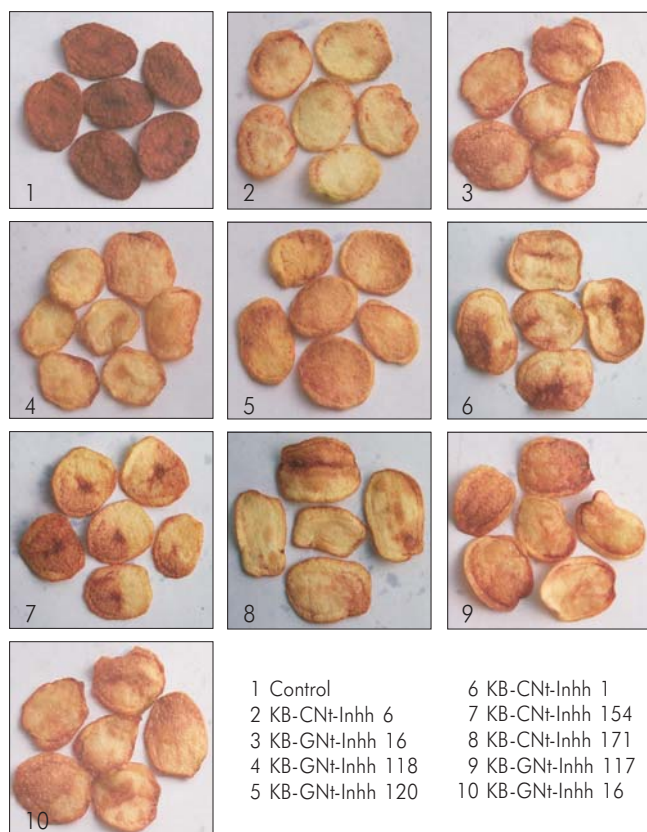
→ Leaf, flower, sprout, DNA fingerprints and tubers of MP/97-644 a promising hybrid for hills



IMPROVEMENT AND MANAGEMENT OF HORTICULTURAL CROPS

while at Ooty in southern hills, potato + French bean intercropping in a 75 : 50 ratio was best. Fertilizer requirements for maize in potato + maize intercrop for Shimla were also worked out. In a 3 : 1 ratio of potato + maize intercropping, maize required only 75% of recommended N (100 kg/ha) on population basis.

Kufri Pukhraj was mostly N and K efficient cultivar. In acidic soil, *Azotobacter* and vermincompost was superior to *Azospirillum* and FYM in terms of increased ammonical and nitrate availability in soil and its utilization by potato crop. Integrated use of 25% vermincompost and 75% of NPK through inorganic fertilizers resulted in higher yield over inorganically raised crop at Modipuram in northwestern plains. At Shimla, radio tracer studies revealed higher ^{32}P activity in potato leaves at critical growth stages with phosphorus-solubilizing bacteria.



Russet scab has emerged as an important disease of potato in recent years, disfiguring appearance of tubers. There was significant reduction in russet scab by cultivation of turmeric, inducing water stress, application of boric acid or sulphur and priming of seed tubers with FYM + *T.viride*.

Strains of *T.viride* efficient against control of *R. solani* identified and mass multiplication of antagonist standardized on cheap plant based solid media. The biogents B4 and B5, controlled black scurf significantly at Gwalior

Potato aphids (*Myzus persicae*) indirectly affects potato as virus vector and thus leads to degeneration of seed stocks. Population of aphids crossed the critical level of 20 aphids/100 leaves in third week of December at Modipuram (northwestern plains), in third week of January at Patna and approached the critical level in third week of July at Kufri/Fagu. At Modipuram, *M. persicae* population showed tolerance to Metasystox 0.03% and Rogor, whereas tolerance to imidacloprid @ 0.03 and 0.005% was below 5%.

In country stored potatoes at Kangra, use of CIPC (grow stop) treatment @ 60 ml/ha reduced tuber damage by potato tuber moth larvae from 37.5 to 6% 60 days after of storage. The residue of CIPC in stored potatoes was much below the tolerance level of 30 mg/kg. Accessions, CP 3030 and CP 3109, were tolerant to potato tuber moths up to 60 days. A highly sensitive PCR technique was developed to detect potato apical leaf curl disease. The PCR amplification of coat protein gene (770 bp) of TLCNDV in 44 samples potato plants of different varieties and germplasm accessions using coat protein gene specific primers to amplify CP gene located on DNA-A of its bipartite genome.

Nine plant cultures designated as BP 1, BP 2, BP 3, BP 4, BP 5, BP 6, BP 7, BP 8 and BP 9 were found promising under both *in vitro* and in detached leaf experiments against *P. infestans*. Eight meiotic tetraploid cultivars, viz. HR 9-5, HR 5-2, HR 6-4, HR 9-3, VMT2-3, VMT 2-10, VMT 5-3 and VMT 14-3, showed resistance to late blight but also yielded significantly higher yield.

Three new value-added products, viz. *Potato Salties*, *Potato Sweet Nuggets* and *Potato Sewia* were developed. Mixing of potato flour up to 50% with wheat flour improved taste and texture of *chapattis*. Of the total starch present in freshly harvested tubers, 39.8% was recovered during extraction, 11.8% remained in pulp and 18.2% was lost during extraction. The mean diameter of starch granules separated from tubers of Kufri Jyoti before storage was 15 μm and after 90 days of storage at 4, 8, 12 and 16°C, diameter 19, 22, 25 and 24 μm , respectively.

Fog application of CIPC @ 50 ml/tonne significantly reduced sprout index, weight and total losses up to 90 days of storage in heaps and tubers were acceptable for table purposes. Under heap storage, CIPC residues were higher in peels with spray application compared to fog treatment. Acceptable French fries were obtained from CIPC treated tubers up to 30 days of storage in tubers of Kufri Chandramukhi, up to 90 days of Kufri Jyoti and up to 150 days of Kufri Surya, Kufri Chipsona 1 and Kufri Chipsona, 2 and Atlantic.

About 798 q of breeders' seed was produced both in hills and plains. A total of 18,588 quintal breeders' seed of 15 varieties from plains and 1,242 q of 3 varieties from hills was produced. About 546 q of quality seed in main crop and 224 q seed in autumn was produced at Ooty. A total of 38,947 microtubers of 10 Indian



Potato–maize intercropping at Shimla



Fallow-potato (control)



Turmeric–potato



Value-added product

varieties produced *in vitro* at Shimla, while 100,830 minitubers and 146,041 tubers were produced in nethouse/nursery-beds.

Tropical tuber crops

Two high starch, high-yielding triploid hybrids of cassava, Sree Athulya and Sree Apoorva were recommended for cultivation in industrial areas of Tamil Nadu. Clone MNga 1 (Sree Padmanabha) having consistently resistance to cassava mosaic has been proposed for release in Tamil Nadu plains. First *Amorphophallus* hybrid variety developed through intervarietal hybridization and selection, Sree Athira, is proposed for release in Kerala. Cassava lines, CMR 1, CMR 15 and CMR 21, with high starch content (25–28%) and high tuber yield (40–60 tonnes/ha) were found to be resistant to cassava mosaic. Two orange-fleshed clones of sweet potato, 362 - 7 and SV 98, with total carotene and β -carotene contents of 6–7 and 4–5 mg/100 g fresh weight, respectively were identified.

- A reproducible protocol in cassava was standardized
- Organic farming of elephant-foot yam was comparatively better than traditionally-growing one
- Cassava transformation protocol was standardized
- Coat protein gene of SPFMV has been cloned
- A technology for making light coloured chips from tubers was standardized
- Geriatric health drinks from cassava and arrowroot starches were made
- Two types of glubators were made for sago-making
- Over 707 germplasm accessions of tuber crops were maintained
- About 276 new accessions were added
- Use of vermicompost along with NPK was recommended

A reproducible protocol for regeneration of plantlets through high efficiency somatic embryogenesis in cassava was standardized. It includes induction of primary embryogenic callus from immature leaf lobes and maturing of somatic embryos in MS medium with sucrose and growth regulators.

Application of Mg and B along with recommended dose of NPK+FYM resulted in highest tuber yield of 26.753 tonnes/ha, which was on a par with application of B and Zn (26.667 tonnes/ha), B alone (25.673 tonnes/ha) and Mg, Zn and B along with the recommended dose of NPK + FYM (24.773 tonnes/ha). The yields obtained from vermicompost (24.283 tonnes/ha), coir pith compost (22.933 tonnes/ha) and green manuring *in situ* with cowpea (22.143 tonnes/ha) were on a par with FYM @ 12.5 tonnes/ha (22.023 tonnes/ha). Application of vermicompost and coir pith compost, and B, Mg and Zn reduced cyanogenic glucoside content in tubers considerably.



Organic farming of elephant-foot yam gave significantly higher corm yield (70.625 tonnes/ha). Organically-grown plants produced significantly higher corm biomass as well as whole plant biomass. Cooking quality of both corms produced organically and traditional practices were equally good. The dry-matter and starch contents were slightly higher in corms grown organically.

Leaves of nine varieties of cassava were distilled and distillates were tested against *S. oryzae*, *Rhizopertha dominica* and *Callosobruchus maculatus*. The extracts of all varieties gave cent per cent mortality on *R. dominica* and *C. maculatus* 1 day after treatment, whereas mortality on *S. oryzae* ranged from 7.67% in Sree Rekha to 100% in H226. Since distillate from H226 was highly toxic, this variety was used for subsequent studies.

Cassava transformation protocol was standardized for the ruling H226 using pCambia2301 vector through Agrobacterium mediated transformation. The incorporation of gene through GUS assay and PCR amplification using *npt II* primer was confirmed. *Amorphophallus* mosaic virus was detected and identified as a potyvirus using potyvirus specific primers under PCR. Coat protein gene of SPFMV has been cloned in pGEM-T vector and sequenced. Amplification was done with different SPLCV specific primers using DNA isolated from SPLCV infected sweet potato plants. Presence of *Dioscorea alata* Badna virus was detected in *Dioscorea alata* (Sree Keerthi) leaves and tubers which showed mosaic and distortion symptoms through PCR. Glucan and protein elicitors were purified from *Phytophthora colocasiae* mycelium and culture filtrate respectively.

Technology for making light coloured chips from taro, tannia and sweet potato was standardized. Pre-fermentation with yeast was found effective in taro and sweet potato. Cassava flour with low energy density was made through termamyl treatment and pre-fermentation with yeast. The resultant flour had low calorific value and was tried in biscuit making. Geriatric health drinks were made using cassava and arrowroot starches. Nutritional, rheological and functional evaluation of health drinks was made to identify best formulation. The formulae with whey protein concentrate as a partial substitute for milk powder had high protein content (13–15%). Cationic starch was prepared from cassava using four solvents. Wide variations in starch, vitamin C, phenolics and oxalates were observed in different cultivars of taro, indicating their potential use.

Two types of globulators, oscillatory and vibrating types, were made for mechanical globulation of cassava starch for sago-making. These were evaluated at different speeds. Texture profile studies on fried sago and wafers indicated that as the temperature and time of frying increased, oil content in fried products increased and moisture content decreased. Expansion ratio of fried products along thickness and diameter increased with increase in frying

temperatures and time. Hardness decreased as frying time and temperature increased.

The farmers' participatory varietal evaluation trials on yams revealed that promising accessions of greater yam, DA 68, Sree Keerthi, Sree Shilpa and USM 2 and white yam clones, Sree Priya, Sree Subhra and DR 164, were preferred most by farmers in Kerala. However, under laterite soil condition, white yam was opined to be unsuitable owing to its longer duration, long tuber shape and difficulty in harvesting and less market demand.

Over 707 germplasm accessions of different tuber crops were maintained at the Regional Centre, Bhubaneswar. Twenty-two *in vitro* sweet potato germplasm accessions received from CIP were maintained and multiplied. Ten germplasm samples of different tuber crops have been collected from Mizoram, Manipur, Tripura and West Bengal.

Studies using RAPD markers in sweet potato and taro revealed homology or uniformity between *in vitro* raised and source plants. *In vitro* cultures of different yam species, *D. alata*, *D. esculenta* and *D. rotundata* have been established through auxiliary shoot proliferation by culturing nodal explants, tuber sprouts in MS media supplemented with 0.25 mg/litre each of NAA, BA, 0.5 mg/litre GA₃ and ascorbic acid (1,000 mg/litre). Rate of multiplication could be enhanced by 20–30% in *D. alata* by using sprouts of aerial tubers as explant source and 2, 4-D as auxin source in medium. Regeneration through callusing and organogenesis was also achieved in *D. alata* by subsequent culture of nodal segments in media supplemented with 0.25 mg/litre 2, 4-D and 0.25 mg/litre each of NAA, BA and 0.5 mg/litre of GA₃. *In vitro* raised plants were hardened and transferred to field. A high frequency (76–84%) field establishment was achieved in *D. alata* and *D. esculenta*.

A total of 4,350 collections in 24 species of root and tuber crops consisting of sweet potato (2,020) with 175 new additions, cassava, 596 accessions, *Colocasia esculenta*, 900 accessions (taro, bunda and swamp taro types), elephant-foot yam, 195 accessions (33 newly added), yam bean, 205 collections are being maintained. During the period, 276 accessions were newly added to germplasm collections. Cassava accessions evaluated for starch content in tubers at Yethapur (Coimbatore) revealed that 67 accessions had more than 25% starch content.

Use of vermicompost (15 kg N) along with 45 : 40 : 60 kg NPK/ha was recommended for sweet potato. Two-thirds recommended dose of N with *Azospirillum* (2 kg as vine dipping and 10 kg/ha as soil application) was recommended for sweet potato which gave tuber yield of 29.3 tonnes/ha and 21.28 tonnes/ha in Bihar and Assam respectively. Similarly, biofertilizers with half the recommended dose of phosphorus was standardized for *Colocasia* in Hyderabad areas of Andhra Pradesh, which gave a cormel yield of 17.23 tonnes/ha and high cost : benefit ratio of 1 : 6.5.



In elephant-foot yam, straw mulching was recommended for weed management and enhanced yield in West Bengal (61.40 tonnes/ha), Andhra Pradesh (47.44 tonnes/ha) and Kerala, while sesamum leaf mulching or black polythene mulching was recommended for Bihar, with a corm yield of 41.6 tonnes/ha.

In Bihar, elephant-foot yam as an intercrop in litchi orchards with full dose of fertilizer (80 : 60 : 80 NPK kg/ha) recorded maximum corm yield of 37.3 tonnes/ha with a net return of Rs 1,26,000/ha. In Chhattisgarh, elephant-foot yam as intercrop in mango orchard gave highest corm yield of 9.52 tonnes/ha. In Konkan region, sweet potato was the best intercrop in pre-bearing cashew orchard with highest cost : benefit ratio of 1 : 1.36.

The sex pheromone septa developed in collaboration with BARC, Mumbai, as one of the components of IPM of sweet potato weevil was found to be effective in suppressing weevil damage. *Trichoderma* and *Pseudomonas* were found to be effective in controlling diseases of elephant-foot yam. Combined application of yam bean seed extract and soap nut seed extract checked the snail population in tuber crops. Cauliflower waste leaves were good in luring snail population in elephant-foot yam crop. Yam bean border crop around elephant-foot yam crop reduced the snail infestation significantly. Yam bean seed extract was toxic to third instar larvae of Bihar hairy caterpillar, *Spilosoma obliqua* at Dholi. Yam bean seed powder was effective against cockroach. Baiting prepared with yam bean seed powder + maize flour (1 : 8) with little sugar and mustard oil (a few drops) was an effective biopesticide against cockroach.

FLORICULTURE

Rose

Rose Pusa Gaurav was found to be best for cut flower production. Neelambari and Arunima were good roses for loose flower production, whereas Banjara and Arunima for garden display. Basal dose of fertilizers, vermicompost and 3% manchurian tea gave better performance in respect of plant height, length of flowering shoot and number of flowering shoots/plant. The stems of rose showed considerable increase in keeping quality when held in a solution of $\text{Al}_2(\text{SO}_4)_3 \cdot 16 \text{H}_2\text{O}$ (300 ppm) during wet refrigerated storage. Holding solution comprising aluminium sulphate (300 ppm) + sucrose (1.5%) significantly increased the vase-life and final flower diameter.

Gladiolus

Gladiolus Urvashi and Neelima have been developed. Early-flowering was recorded in Bindiya, while it was late in Anjali at Hyderabad. Gladiolus White Prosperity when sprayed with 4% *panchagavya* + 4% *manchurian* tea performed better. Sucrose (4%) + calcium hypochlorite (bleaching powder), 50 ppm chlorine

- Pusa Gaurav rose was found best for cut flowers
- Aluminium sulphate along with sucrose increased vase-life of roses
- Gladiolus Urvashi and Neelima have been developed
- Bindinya gladiolus recorded early flowering
- Chrysanthemum Punjab Gold and Punjab Anuradha were suitable for pot culture
- The vase-life of Sonia 17 (*Dendrobium*) was maximum
- Highest flower stalk length was recorded in Ria Bamboo Red anthurium
- Cancan was best anthurium for flower production
- The packaging of cut spike of tuberose in polythene sleeves increased their keeping quality
- Calcutta Orange, Calcutta Pink and Cassava were promising gerberas for flower production

was found to be best in improving vase-life (7.67 days), florets opened (100%) and floret size (6.13 cm) compared to all other treatments used in White Prosperity. Four fungicides, Indofil M-45 (0.2%), Kavach (0.2%), Antracol (0.2%) and Quintal (0.2%) were recommended for reducing *Botrytis* blight in gladiolus Sancerre.

Carnation

Recommended dose of fertilizer (50%) + vermicompost 3% + manchurian tea 3% + *panchagavya* 3% increased number of flowers/plant/year and number of flowers/m².

Chrysanthemum

Chrysanthemum Chandrika and Yellow Gold were found suitable for loose and cut flower purposes, whereas Punjab Gold and Punjab Anuradha for pot culture. Early flowering was observed in Punjab Anuradha, while late-flowering was observed in Yellow Gold. Vase-life duration was significantly high when treated with bud opening solutions, sucrose 2% + biocide + BAP 25 ppm (2.85 days); sucrose (2%) + biocide (2.53) and Biocide + BAP (50 ppm) (1.75 days). The vase solution containing sucrose (2%) + biocide (AgNO_3 , 25 ppm + citric acid, 75 ppm) + BAP, 50 ppm was rated the best for opening of immature buds in chrysanthemum, improving their longevity and preventing yellowing of leaves in the vase.

Orchids

Full dose of recommended fertilizers along with organic manures gave better response in vegetative characters compared to that with half dose, in two varieties (Shavin White and Earsakul) of *Dendrobium*. Recommended dose of fertilizer (50%) + vermicompost (3%) + *panchagavya* (3%) was most effective in influencing all characters. *Aerides multiflorum* produced highest number of flowers followed by *Rynchostylis retusa* at Kalyani. The NPK @ 20 : 10 : 10 at 0.2% spray with VAM is best treatment combination for most of the characters. The vase-life of



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Dendrobium Sonia 17 was found to be maximum in holding solution consisting of HQ 400 ppm + sucrose 5%. Maximum vase-life of 25.67 days was achieved when the stems were kept in a holding solution containing 25 ppm silver nitrate, 400 ppm hydroxy-quinone and 5% sucrose.

Anthurium

Highest flower stalk length (59.2 cm) was recorded in Ria Bamboo Red; maximum spathe length (12.3 cm) and width (11.6 cm) in Honduras and spadix length was maximum in Red Dragon. Cancan is best variety for flower production. However, Kalimpong Pink, was the best performer for flower size. The NPK @ 30 : 10 : 10 at 0.2% spray + GA_3 200 ppm + *Azospirillum* + Phosphobacteria recorded highest stalk length. The NaOCl 50 ppm as well as $Al_2(SO_4)_3$ 16 H₂O along with sucrose 5% gave better vase-life in anthurium Tropical.

Tuberose

The NPK @ 200 : 100 : 100 kg/ha produced highest number of spikes of tuberose/plot during April and June. March planting of tuberose bulbs was proved profitable for production of flower spikes with more number of florets/spike at Kalyani, while at Kahikuchi, May planting was best for yield. The NPK @ 150 : 100 : 200 kg/ha in two split doses significantly increased yield at Kahikuchi, while at Kalyani NPK @ 100 : 150 : 150 kg/ha is recommended to enhance number of florets/spike. Vase solution containing sucrose (5%) + $Al_2(SO_4)_3$ 16H₂O, 300 ppm was most effective for improving vase-life of cut tuberose. The packaging of cut spikes in polyethylene sleeves significantly enhanced the keeping quality.

Gerbera

Gerbera Calcutta Orange, Calcutta Pink and Cassava were promising for flower production. About 25% shade is suitable for increasing plant height, stalk length and flower diameter, while 50% shade is suitable for number of leaves at Kalyani. Maximum vase-life of 7.6 days in gerbera was obtained in $Al_2(SO_4)_3$ at 100 ppm pulsing treatment in Sun Ray gerbera.

PLANTATION CROPS

Coconut

Coconut germplasm was strengthened by adding nine accessions. A total of 86 coconut germplasm types were collected from different regions for further evaluation. Cryopreservation of zygotic embryos of West Coast Tall (WCT) palms of coconut was achieved using the encapsulation-dehydration technique. Hybrid ECT × MYD performed better than all other hybrids in the last few years and has given uniformly around 100 nuts/palm/year.

Vetiver (*Vetiveria zizanoides*) crop established well in coconut

Digital Library

The Bioinformatics Centre and Library has developed digital library using D space software and made accessible through the library website <http://www.bioinfpcpri.org/>. In bioinformatics, two new databases on pest management and cocoa germplasm have been added.

garden, yielding 88 g of dry roots/plant and 780 kg of dry roots/acre. The net return obtained by growing vetiver was about Rs 28,000/acre of coconut garden. Among shrubs, growth of Karinkurinji (*Nilgiranthus ciliatus*) performed well and yielded 27 g of fresh root and 532 g of fresh shoots/plant. The net return obtained by cultivating *Nilgiranthus* in one acre of coconut garden was Rs 30,000 for one-and-a-half year.

Plant growth-promoting rhizobacteria, *Brevibacillus brevis* inoculation increased shoot elongation (up to 21%) and seedling girth (up to 18%), whereas combined inoculation of *B. brevis* and *B. coagulans* increased root elongation (up to 6%), shoot dry weight (up to 16%) and root dry weight (up to 21%) over the control. Root : shoot ratio was maximum in *Bacillus coagulans* treatment. Seedling quality index and PGPR inoculum efficiency were highest in combined inoculation of *Brevibacillus brevis* + *Bacillus coagulans* which was on a par with treatment having *B. coagulans* alone. The application of these inoculants stimulated the beneficial soil microflora in root region of coconut seedlings. Both *B. brevis* and *B. coagulans* were found to produce L-tryptophan-derived auxins *in vitro* and in field soil. The *Bacillus coagulans* either alone or in combination with *Brevibacillus brevis* can be used for inoculation of coconut seedlings for their growth promotion while raising them in nursery.

SUCCESS STORY

An Enterprising Vermicompost Man

Mr Jacob.K. Cheriyan, Kariyadil Puthenparambil, Kattanam, a retired geologist, is cultivating coconut, banana, mango, coffee and vegetables. After attending KVK training programme in vermicomposting, he constructed five vermicompost units with taps for collecting vermiwash, a tonic for plant growth. Now he is getting vermicompost (800–1,000 kg) worth Rs 3,500–4,000/month besides worms, vermiwash etc. Mature worms are used for feeding ducklings and fish fingerlings. He produces 50–60 bottles of vermiwash at bimonthly intervals, which is used for foliar spray. Vegetables produced by organic farming are much tastier than those produced inorganically' says Mr Jacob Cheriyan. Nowadays, he serves as a master farmer for farmer-to-farmer technology transfer.



The CGD × WCT hybrid, planted during 1991, recorded a ten-year cumulative average yield of 71 nuts/palm/year, even though 68% of hybrids recorded incidence of root (wilt) disease. Fifty-three progenies derived from root (wilt) resistant palm (WCT 421) were characterized with microsatellite markers. The recombination fraction based on classical estimate was highest between CNZ 13 F and CNZ 40 (0.722) followed by CNZ 13F and CNII E6 (0.614) and CNZ 43 and CNZ 13 F (0.611). The 'r' value was lowest between the locus CNZ A4 and CNZ 40 (0.294). Among seven primers used, locus CnCir C11, CNZ A4, CNZ 13F, CNZ E6 and CNZ 40 showed 1 : 1 segregation ratio among progenies. The LOD score was maximum between locus CNZ 13F and CNZ 40 (1.6). Here for all the 7 loci tested the LOD scores were less than 3, hence no linkage could be established. The SSR loci map showed the arrangement of SSR locus. The total map size obtained was 624.1 cM. The map distance between CNZ 42 and CNZ 40 were the lowest.

Induction of resistance/tolerance against root (wilt) pathogen using salicylic acid and triazol induced higher glucanase activity and digitonin induced higher peroxides and PPO activity. Higher peroxidase activity was also observed in *Pseudomonas fluorescens* and *Bacillus amyloliquefaciens* treated seedlings. The culture filtrate of *Trichoderma harzianum* showed 54% inhibition, while culture filtrates of *B.amyloliquefaciens* showed 80% inhibition of *Ganoderma*. An acaropathogenic fungus *Hirsutella thompsonii* was isolated from coconuts infested with eriophyid mites which is considered as the most important natural enemy of eriophyid mite throughout the world.

Wax moth (*Galleria mellonella*) could be used as an alternate host for mass rearing of larval parasitoids *Goniozus neophantidis*, *Bracon brevicornis* and pupal parasitoid *Trichospilus pupivorus* of coconut black headed caterpillar, *Opisina arenosella*. Egg parasitoid *Chrysobalsicea indica* and predator *Endochus inornatus* were found to be natural enemies of coreid bug (*Paradasynus rostratus*).

Agro-processing Centre was established with all the proven technologies for plantation crops. A low-cost salinity sensor based on graphite electrode, shell fired copra dryer, coconut punch and cutter were the new gadgets developed. A technology for canning of coconut kernel and paste by boiling water bath method was perfected.

Arecanut

Seven accessions from Gujarat and two from Karnataka were collected. Arecanut Saigon is likely to be released. Shatavari, nilgiri antus, vetiver and brahmi were more remunerative with net returns of Rs 80,000; 42,000, 21,000 and 15,000/ha in arecanut garden, respectively. The lemon grass registered highest return of Rs 50,000/ha in arecanut plantation followed by patchouli (Rs 37,000) and davana (Rs 29,000).

Fertigation at 75% recommended NPK at 10 days intervals produced significantly higher chali yield (4,016 kg/ha) compared to other doses, indicating a saving of 25% fertilizer if supplied through microirrigation.

Arecanut based HDMSCS (arecanut, pepper, banana, clove, nutmeg and citrus) at Kahikuchi (Assam) under graded levels of fertilizers coupled with organic biomass recycling in the form of compost revealed higher yield of arecanut, pepper and citrus at two-thirds of the recommended dose of fertilizer. However, banana yield was higher under full dose of recommended fertilizer. The highest recovery of vermicompost from arecanut wastes was 80.2% in cement tank within 55 days during May–October when temperature and relative humidity were optimum.

Oil palm

Preliminary analysis of RAPD data of first set of germplasm showed that each genotype forms separate cluster. Uniformity among Costa Rican palms was more. Others have considerable divergence within genotypes. Molecular characterization of second set of germplasm showed that biochemical parameters were on a par in Palode and Costa Rican materials compared with African genotypes. Soluble and total carbohydrates were highest level in these two genotypes, indicating their superior performance in irrigation condition of Andhra Pradesh, which is yet to be correlated with yield.

Hybrid combination of 115 D × 291 P recorded highest yield of FFB, i.e. 121.75 kg/palm/year (17.4 tonnes/ha), whereas 109 D × 291 P recorded highest bunch weight (24.38 kg) at Mulde Centre in Maharashtra. Thirteen botanicals (extracted from fresh leaves)

- A total of 86 coconut germplasm types were collected
- Vetiver was good intercrop in coconut gardens
- Arecanut Saigon is likely to be released
- Aromatic crops in arecanut garden were more remunerative
- Lemon grass gave highest return in arecanut garden
- Old palm hybrid, 115 D × 291 P, gave highest yield of FFB
- Thirteen botanicals were evaluated against *Ganoderma* species
- A technology for making window shades from oil palm frond rachis has been standardized
- Oil palm window shades were good for offices, residences, restaurants etc.
- Hand-made paper boards were made from shredded empty fruit bunches
- Oil palm EFB was used for making cooling pads.
- The 173 accessions of palmyrah palm are being maintained
- New cashew Bhaskara has been released



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were evaluated against *Ganoderma* sp. (Makinavarigudem isolate) and it was found that alcoholic and acetone extracts of *Vinca rosea*, *Aloe vera*, *Parthenium hysterophorus*, *Phyllanthus niruri* and *Tridax procumbens* showed 100% inhibition. Alcohol extracts

Palm Oil Mill

A mini palm oil mill with a capacity to process 1 tonne of fresh fruit bunches/hour was developed. The total cost of the mill including infrastructure is estimated about Rs 20 lakh. The mill operation is simple and can be managed by woman labourers also.

of *Cassia auriculata*, *Cassia occidentalis*, *Acyranthus aspera* and *Ocimum sanctum* also showed 100% inhibition. Aqueous extracts of *Acyranthus aspera* plant product exhibited 75% inhibition followed by 70% inhibition with *Parthenium hysterophorus* plant extract.

A technology to make window shades from oil palm frond rachis has been mechanized by employing a wood planer machine with modifications. A technology has also been evolved to make insect and fungal proof shades. Oil palm window shades proved to be suitable for use in offices, residences, restaurants etc. as a replacement of bamboo made window shades.

A mobile oil palm waste shredding unit was designed and developed to shred Empty Fruit Bunches and oil palm fronds. The mobile unit reduces collection and transportation cost of wastes scattered in plantation and factory premises. This is suitable for areas which are non-accessible to electrical power.

Oil palm EFB, which is cheap and available in bulk compared to other sources of natural fibres were used to make cooling pads and it was found that the room temperature was reduced by 3°C and humidity was increased by 20% by using cooling pad.

Palmyrah palm

The 173 accessions are maintained at Killikulam, while 176 accessions have been collected and maintained at Pandirimamidi.

Paper Boards from Oil Palm

Hand-made paper boards were made from shredded empty fruit bunches in a pilot paper plant. The effect of mixing cotton waste and paper waste pulps in different proportions on pulp quality was studied. Testing of paper boards prepared from these pulps indicated that Empty Fruit Bunches are suitable for making paper boards. Paper files, cartons and packaging material can be prepared from these boards. Addition of cotton wastes and paper wastes improved the finishing of boards.

Fourteen palmyrah local germplasm types collected from coastal region of Andhra Pradesh were added to germplasm.

Cashew

Bhaskara, a new cashew variety developed from a tree of seedling origin, was released during March 2006 for coastal region of Karnataka. Having mid-season flowering habit, it has a potential to escape from the attack of tea mosquito bug under low to moderate outbreak situation. This variety has yielded more than 1 tonne/ha from fourth harvest onwards, highest yield being 2,975 kg/ha (10.7 kg/tree) during 11th harvesting. A bold nut (9 g) and high-yielding cashew tree was identified in Andhra Pradesh which appears to be tolerant to flower and panicle drying malady.

So far, a total of 500 accessions have been conserved in National Cashew Field Gene Bank. Thirty-one cashew types having high yield, cluster bearing habit, bold nut type and maximum nut weight were identified, collected and conserved in Regional Cashew Field Gene Banks (RCFGBs) existing in Centres of AICRP on Cashew thereby increasing total germplasm accessions to 1,274.

The DNA extraction from dry leaves was also standardized. Diversity analysis and species relationship in 10 cashew accessions using RAPD and isozyme markers was done and *Anacardium pumilium* was found as most divergent. About 42 cashew varieties were characterized using RAPD and isozyme markers.

Pruned trees gave higher yield over un-pruned trees in third fruiting season after pruning. The limb pruned trees had an average of 9.64 kg/tree yield in four different varieties, while



Cashew Bhaskara



unpruned trees had 5.59 kg/tree. Modified crescent bund and staggered trenches with coconut husk burial between two rows of cashew conserved the maximum soil moisture.

Chlorpyrifos (0.4%) reduced significantly re-infestation of cashew stem-and root- borer followed by chlorpyrifos (0.2%). Phytosanitation also reduced infestation of the pest over years.

MEDICINAL AND AROMATIC PLANTS

Aloe

The flowers of aloe showed protandry. Major floral visitors, birds, honey bees and ants were observed in plant population and sun-bird (*Nectarinia asiatica* var. *asiatica*) played a major role in pollen-transfer. Pollen-grains remained viable even after 76 hours of storage in humidity chamber at both room temperature and refrigerated condition. Pollination experiments showed that selfing, crossing and open-pollination occur in *A. barbadensis*.

All accessions were of diploids with somatic chromosome number $2n = 2x = 14$. Total chromosome length (TCL) of diploid chromosome complement ranged from 84.58 to 197.5 μm , average chromosome length being 14.11–6.04 μm .

Isabgol

Downy disease is a major constraint in cultivation of isabgol. The downy mildew infection on bio-constituents of host leaf



Sunbird (*Nectarinia asiatica* var. *asiatica*) mediated pollen transfer in *Aloe barbadensis*

revealed that moisture content of leaves increased due to infection. Leaves at early stage of infection, showing slight chlorosis contained significantly higher amount of total and OD phenol (14.64 and 7.9 mg/g dry leaf, respectively).

A total of 80 lines of isabgol were evaluated for six characters at Mandsaur. The seed yield ranged from a minimum of 406 kg/ha (GI 2) to 1,364 kg/ha (Udaipur 1). At Mandsaur, maximum grain yield was obtained when sowing was done on 21 November (856 kg/ha) followed by 750 kg/ha from 14 November sowing. A maximum yield of 762 kg/ha was also obtained when three irrigations (at tillering, before ear head emergence and after ear head emergence) were given.

- A total of 500 accessions have been conserved
- A total of 80 lines of isabgol were evaluated for seed yield
- A total of 119 germplasm accessions of aswagandha were evaluated
- A number of genotypes were evaluated for different characters
- Saponin content and its yield were highest 24 months after planting
- Maximum latex yield was recorded in UO 1385.
- About 235 germplasm lines of opium poppy were evaluated
- A protocol for *in vitro* fleshy root formation in safed musli has been standardized
- Twenty-four lines of safed musli were tested
- A software package for identification of medicinal and aromatic plants has been developed

At Udaipur, 68 genotypes along with controls (RI 89, GI 2 and Sel 10) were evaluated for higher seed yield. Six genotypes gave higher seed yield over best control RI 89 (1,390 kg/ha).

Seventeen genotypes along with three controls, RI 89, GI 2 and selection 10, were evaluated for higher seed yield at Udaipur. Genotype RI 129 (1,728 kg/ha) recorded highest seed yield followed by PB 31 (1,312 kg/ha) and Palampur 2 (1,301 kg/ha).

Ashwagandha

A total of 119 germplasm accessions of aswagandha were evaluated for 13 different characters at Mandsaur. Among lines, a wide variability was observed. Mean dry root yield ranged from 100 kg/ha (MWS 325) to 1,166 kg/ha (RAS 34). Mean seed yield was 145 kg/ha (red berries) to 652 kg/ha (MWS 208).

Fifty-two genotypes along with three controls, Jawahar Aswagandha 20, WS 90-127 and Jawahar Aswagandha 134, were evaluated for higher dry root yield/plant and total alkaloid content at Udaipur. The dry root yield/plant was 2.7 g/plant (RAs 11) to 7 g/plant (WS-90-136). Maximum total alkaloid content, i.e. 0.40% was in WS 90-105, WS 90-136 and RAS 35.

Thirteen genotypes along with JA 134, WS 90-127 and JA 20 were evaluated at Udaipur. Eight genotypes, viz. WS 90-140 (1,190 kg/ha), RAs 10 (1,180 kg/ha), WS 90-101 (1,140 kg/ha), RAs 7 (1,119 kg/ha), RAs 15 (1,053 kg/ha), WS 90-124 (948 kg/ha), RAs 21 (910 kg/ha) and WS 90-141 (909 kg/ha) showed higher dry root yield over best control WS 90-127 (825 kg/ha).

At Mandsaur, vermicompost at 5 tonnes/ha + RD 50% recorded maximum dry root yield of 994 kg/ha followed by FYM + RD ($N_{20}P_{60}K_{40}$ kg/ha) 50% (973 kg/ha) and poultry manure + RD 50% (958 kg/ha) among 16 different treatments tried.

At Akola, a seed rate of 10 kg/ha produced significantly more root yield (546 kg/ha) which was on a par with 9 kg/ha (540 kg/



ha). Application of 10 tonnes/ha of FYM recorded maximum dry root yield (567 kg/ha) which was at par with 5 (550 kg/ha) and 7.5 tonnes/ha FYM (562 kg/ha). Superiority of application of FYM was recorded over control (no FYM applied) and 2.5 tonnes/ha FYM. The alkaloid yield showed increasing trend from flower initiation reaching highest at 100% harvesting (3.47 kg/ha) and decreasing thereafter. The root yield was found significantly influenced by harvesting time. Early harvesting at flower initiation produced significantly low root yield (269 kg/ha).

At Hisar, dry root yield was recorded to be 2.37 and 2.95 kg/ha in JA 20 and JA 134, respectively. Seed rate at 12 kg/ha recorded maximum root yield and alkaloid content, resulting in higher alkaloid yield followed by 10, 8 and 6 kg/ha. Root length and root diameter were found to be significant, resulting in higher dry root weight and dry root yield. Quality of alkaloid was influenced by different dates of harvesting. Alkaloid yield was recorded to be maximum (4.16 kg/ha) 180 days after sowing. Among different rates of application of FYM, (7.5 tonnes/ha) recorded maximum dry root yield (3.85 tonnes/ha) and alkaloid yield (4.17 kg/ha).

Satavari

A spacing of 60 cm × 60 cm had significant effect on fresh (4,730 kg/ha) and dry fasciculated root yield (870 kg/ha) over 60 cm × 90 cm and 90 cm × 90 cm. Harvesting of crop (duration) 24 months after planting recorded significantly more fresh (3,610 kg/ha) and dry fasciculated root yield (680 kg/ha) as compared to harvesting 21 and 18 months after planting. Saponin content (5.68%) and saponin yield (49.61 kg/ha) were highest at 60 cm × 60 cm and crop harvested 24 months after planting recorded maximum saponin yield (38.48 kg/ha). Root moisture content was highly influenced by environmental conditions and it was significantly highest (9.76%) during July. The root samples contained 5.83% saponin. It became significantly lowest at the end of storage period (4.62%) which was on a par 10 months after storage, i.e. November sampling (4.85%).

Liquorice

Liquorice (mulhati) planted in at a spacing of 75 cm × 30 cm, 75 cm × 45 cm, 90 cm × 30 cm and 90 cm × 45 cm showed maximum sprouting when planted in January (71.2–79.3%) as compared to February and March planting. There was a drastic reduction in sprouting in March planting (18.1–33.3%). A spacing of 90 cm × 30 cm and 75 cm × 45 cm recorded maximum stolon yield of 7,428 and 6,836 kg/ha respectively as compared to other spacings. Variations were also found significant in stolon length (3'–10') and girth (2.0–5.2 cm).

Opium poppy

Maximum latex yield was recorded in UO 1385 (38.74 kg/ha)

Digital Herbarium

A software package entitled "Digital Herbarium of Medicinal & Aromatic Plants in India" has been developed for authentic identification of medicinal and aromatic plants. The software package consists of three types of search engines, "simple search", "multiple search" and "advanced search".

and minimum in UOP 69 (1.45 kg/ha). Maximum seed yield was recorded in ND03-4 and NC 57950 (790 kg/ha) and minimum in UO 221 and UOP 6 (420 kg/ha). Maximum husk yield was recorded in NC 57950 (982 kg/ha) and minimum in UO 1285, UO 37 and UOP 71 (124 kg/ha).

At Mandsaur, 235 germplasm lines were evaluated for different qualitative and quantitative characters. Latex yield ranged from 33.06 (MOP 1069) to 70.54 kg/ha (UOP 490) and seed yield from 87 (ND 16) to 1,102 kg/ha (ND 25). Similarly, morphine content ranged from 12.4 to 17.3%. Highest husk yield (986 kg/ha) could be obtained from the recommended dose ($N_{150}P_{75}K_{40}$ kg/ha) followed by 10 tonnes/ha vermicompost + RD 50% (928 kg/ha) and 10 tonnes/ha FYM + RD 50% (720 kg/ha). Highest seed yield of 1,160 kg/ha could be obtained from RD ($N_{150}P_{75}K_{40}$ kg/ha) followed by 10 tonnes/ha vermicompost + RD 50% (1,031 kg/ha) and 10 tonnes/ha FYM + RD 50% (948 kg/ha). Latex yield also followed same trend (55, 50 and 48 kg/ha).

A total of 152 genotypes along with control Chetak Aphim and IC 42 were evaluated for higher latex yield, seed yield and morphine content at Udaipur. Latex yield ranged from 11.59 (UOP 52) to 57.75 kg/ha (NC 57915). Seed yield ranged from 656.00 (UO 790) to 2,111 kg/ha (NC 57936). Maximum morphine content was found in ND 21 (12.79%) and minimum in UOP 55 (9.04%).

Ten crosses along with IC 42 and Chetak Aphim were evaluated. Two crosses, viz. UOP 86 × Chetak Aphim (32.63 kg/ha) and UO 1985 × IC 42 (30.88 kg/ha) recorded higher latex yield over the control IC 42 (30.39 kg/ha), while UOP 6 × JA 16 (1,504 kg/ha), UOP 86 × Chetak Aphim (1,474 kg/ha) and UOP 82 × JA 16 (1,395 kg/ha) showed higher seed yield over IC 42 (1,331 kg/ha). Highest morphine content was found in UOP 17 × Chetak Aphim (12.10%), UOP 85 × Chetak Aphim (11.95%) and IC 42 (11.92%).

At Faizabad, latex yield was recorded highest (27.39 kg/ha) in treatment applied as 25% FYM. Seed yield was recorded highest (701 kg/ha) in treatment applied as 25% vermicompost and lowest (312 kg/ha) in 100% vermicompost. Treatment with 25% vermicompost gave highest husk yield (486 kg/ha) and lowest being 263 kg/ha in 100% vermicompost.

At Udaipur, sowing on 25 October gave significantly maximum gum yield (4,393 kg/ha), seed yield (1,383 kg/ha) and husk yield



(1,268 kg/ha) as compared to 5 and 15 November sowing. Plant population (3.5 and 4 lakh plants/ha) on the other hand did not affect significantly. However, plant protection treatment significantly increased plant height, gum yield, seed yield and husk yield.

Plant height (91.64 cm), capsules/plant (1.65/plant), gum yield (57.61 kg/ha), seed yield (1,688 kg/ha) and husk yield (1,510 kg/ha) were highest with 8 irrigations at stem elongation 30 days after sowing, rosette 45 DAS, bud 58 DAS, flower initiation 70 DAS, 50% flowering 85 DAS, late capsule 98 DAS, capsule maturity 108 DAS and at after lancing 120 DAS were given at Udaipur.

Safed musli

The protocol for *in vitro* fleshy root formation of safed musli was standardized. Fibrous rooting of micropropagated shoots was readily achieved upon transferring shoots onto half-strength MS media containing IAA with sucrose within 8–10 days of culture. Twenty-four lines of germplasm were tested at Mandsaur. Fresh weight of fleshy root ranged from 375 kg/ha (MCB 420) to 3,150 kg/ha (MCB 409). Maximum mean yield of fresh fasciculated root yield (2,371 kg/ha) was in MCB 409.

Three genotypes, viz. Anand Safed Musli, Mandsaur Safed Musli 412, Mandsaur Safed Musli 414 and control Jawahar Safed Musli 405 were tested at Anand and Mandsaur. At Anand, ASMV II yielded significantly high fasciculated root, which was 81.37% higher than the control MCB 405.

At Mandsaur, maximum fasciculated root yield of 1,453 kg/ha was recorded by MCB 414 which was significantly superior to control (JSM 405) 1,315 kg/ha. MCB 414 recorded significantly higher fasciculated root yield (2,357 kg/ha) followed by MCB 412 (1,901 kg/ha) than control JSM 405 (1,796 kg/ha).

At Mandsaur, application of FYM at 20 and 10 tonnes/ha and vermicompost at 5 tonnes/ha along with control and spacing at 30

cm × 10 cm, 30 cm × 15 cm and 30 cm × 20 cm recorded a maximum yield of 1,843 kg/ha from 20 tonnes/ha FYM and 1,512 kg/ha from spacing of 30 cm × 10 cm. A lowest yield of 596 kg/ha was obtained from control (no organic manure).

At Akola, highest fresh root yield was recorded at 180 DAP (3,205 kg/ha), while lowest at 90 DAP (2,265 kg/ha). Significantly highest dry fleshy root yield was recorded at 240 DAP (695 kg/ha). The saponin content decreased successively with increase in harvesting time and significantly lowest content was recorded at 240 DAP (6.00%). Fleshy root harvested at 90 and 120 DAP contained highest saponins (7.45 and 7.35%, respectively). At Udaipur, lowest weight loss was recorded from wooden box containing 4² layer of musli + 4² layer of soil (27.73%) followed by wooden box containing 4² layer of musli + 4² layer of sand (28.77%), earthen pot containing 1 kg roots mixed with 1 kg sand and mud plastering (30.27%).

Valerian

At Solan, maximum fresh aerial biomass of 5.38, 9.68, 24.44, 65.42 and 98.64 g/plant was recorded when planted at ridges as compared to furrows, level beds and sloppy terrace at 6, 9, 12, 15 and 18 months respectively. Similarly, transplanting on 16 August recorded maximum fresh aerial biomass of 6.63, 12.86, 31.61, 65.73 and 108.91 g/plant compared to transplanting on 31 August and 15 September.



In vitro fasciculated root formation in safed musli



Inflorescence in valerian



Maximum aerial biomass (75.42 g/plant), fresh underground biomass (47.76 g/plant), fresh root yield (24.83 g/plant), and fresh rhizome yield (22.93 g/plant), could be obtained from a combination of Azotobacter + PSB + VAM followed by a combination of other biofertilizers. Valepotriate content was maximum (2.39) when applied with Azotobacter at 10 kg/ha followed by Azotobacter + PSB (2.35) and PSB at 10 kg/ha (2.34). The organic carbon (0.13%), N (361.96 kg/ha), P (38.2 kg/ha) and K (187.2 kg/ha) were also maximum in combination of Azotobacter + PSB + VAM. Similarly nutrient content and nutrient uptake were also found maximum.

- Over 350 accessions of betervine are being maintained
- The 155 accessions of betervine were catalogued

Different growth media had positive effect and use of vermicompost in site soil (1 : 1) gave maximum plant height (29.29 cm), fresh aerial biomass (198.05 g/plant) and fresh underground biomass (57.52 g/plant) 18 months after transplanting. Valepotriate content was maximum (2.80) when grown in soil + sawdust followed by soil + FYM (2.43) and soil + sand + FYM (2.39).

Betelvine

Over 350 accessions are being maintained at different centres and 255 were catalogued during the year. Hybrid evaluation trial indicated that only GN₁ Hybrid (Godi Bangla × Kapoori Nasik) showed normal vigour. Even for GN Hybrid, leaf yield was much below than local control variety.

Highest leaf yields was recorded with application of 200 kg N in the form of oil + urea or FYM with 100 kg each of phosphorus and K₂O/ha. Optimum plant population, replenishment of 100% pan evaporation soil moisture during dry periods along with recommended doses of manures and application of 4 drenches plus 8 sprays of Bordeaux mixture resulted in better quality yield as well as higher cost : benefit ratio at all centres compared to farmer's practices. Staggered lowering of betelvine influenced growth and yield. Leaf yield was found higher when July–November and February–June lowering of betelvine was carried out at BCKV, Kalyani.

The regression analysis of disease development with weather parameters, rate of evaporation contributed to 72.43% followed by maximum temperature (14.55%), morning relative humidity (5.98%) and bright sunshine hours (5.64%), whereas overall influence of all meteorological parameters contributed to 47% towards disease incidence besides other individual factors.

Maximum temperature, morning relative humidity and rainfall had significant negative correlation for anthracnose disease, while

minimum temperature, evening relative humidity and number of rainy days had positive correlation with incidence and spread of disease at Jorghat. Maximum temperature contributed to 25.89% disease development, whereas evapotranspiration contributing to 66.77%. The overall influence of climatic factors in disease development was recorded to be 70.7%.

At Jabalpur, maximum humidity was positively correlated with bacterial disease development in betelvine, whereas maximum temperature and rainfall are partially significant in development of bacterial infection. At Sirugamani, minimum temperature, relative humidity (evening) and rainfall had positive effect on disease incidence.

Integrated disease management of Phytophthora foot rot includes sanitation + one soil drenching of Bordeaux mixture + Trichoderma application (after one month) + one more soil drenching of Bordeaux mixture which significantly reduced the disease incidence and increased leaf yield.

Application of wettable sulphur 0.15% spray significantly reduced the population of red spider mites. The cost : benefit ratio is 1 : 13.94. The combination of wettable sulphur 0.15% + Azadirachtin 0.03% was found to be best treatment for effective management of mites thereby reducing number of damaged leaves. The cost : benefit ratio was highest (1 : 99.7) for treatment with wettable sulphur followed by wettable sulphur + Azadirachtin (1 : 77.1).

The incidence of major insect pests/mite pest was negligible (1.4–3.1%) in Bangla, Kali Bangla, Awami Pan, Black Leaf, Simarali Babna Local, Nov Bangla, SGM 1, Godi Bangla and Maghai. Bangla Bihar, Bangla Banarasi, Calcutta Bangla, Nava Cuttak, Dese Bangla, Bangla Mohoba, Maghai, Bangla Ghamela, and Bangla Ghaneghatte, remained uninfested, however, Dpb 6, K. Pacchaikodi, K. Valiaikodi, K. Telleku and K. Chittikavti were infested by betelvine bug. At Karpoori, Tellakku, Vellaikodi, Karapakku, Kuljedu, Sirugamani BV 2, Andhiyur, Tellakku Uttukar, Sarkarai Kodi and Halisagar Sanchi showed field tolerance to scale insect.

SPICES

Black pepper

Fifteen qualitative morphological characters of 16 wild species of black pepper in south India were studied and plotted the hierarchical cluster, using SPSS software. Bioclimatic analysis and prediction system (BIOCLIM) comparison of these clusters revealed rich diversity and 'niches' where *Piper* species occur predominantly. The highest richness grid was found to have 15–16 species, while highest diversity was 1.8–3. The *P. bababudani*, *P. schmidtii* and *P. wightii* were also related to *P. nigrum*. Variation in inter-microsatellite regions among cultivars was found to be low. A protocol for isolation of PCR amplifiable genomic DNA (modified



CTAB extraction step followed by purification and PEG precipitation of DNA) was developed.

Black pepper grafted on *P. colubrinum* rootstock (resistant to *P. capsici*), plants remained healthy even 7 years after planting. On an average, a yield of 0.65 kg (dry) pepper/vine was obtained in un-irrigated gardens. Evaluation of various formulations of endophytic bacteria, promising against nematodes indicated that chitin based formulation sustained bacterial population ($\times 10^7$ cfu/g) even after 90 days of storage. The portion of Open Reading Frame I (ORF I) and ORF III of badnavirus infecting black pepper was

- Sixteen wild species of black pepper were studied
- A protocol for isolation of PCR amplifiable genomic DNA of black pepper was developed
- Black peppers stored in vacuum showed good quality even 8 months of storage.
- Sequence analysis has confirmed the identity of virus
- Thirty-one hybrid samples of paprika were evaluated
- Two new accessions of seed spices were identified

amplified, cloned and sequenced. Sequence analysis and comparison with other known badnavirus indicated high levels of identity with Piper yellow mottle virus (PYMV) followed by Banana streak virus (BSV). A method for simultaneous isolation of RNA and DNA from infected black pepper plants and multiplex PCR for simultaneous detection of CMV and Badnavirus in a single reaction was standardized.

The transmission of cucumber mosaic virus by four species of aphids was confirmed by DAS-ELISA. Species-specific primers were developed for identification of *Radopholus similis* based on sequence information from ITS gene, and their use in identifying *R. similis* was proved in laboratory. The primer set generated a single PCR fragment of 398 bp in length that was specific to *R. similis*. The amplified product was cloned and sequenced to get partial sequence of ITS1 and 5.8S genes, which were submitted to EMBL, sequence database (Reference gil110321606lembIAM286692.1 [110321606]). Sequencing of *R. similis* genome is done for the first time in India.

The yield level was markedly higher under organic system (1.7 kg/vine) compared to IPNM (0.96 kg/vine) and chemical (1.36 kg/vine) systems. The rainfall excess than normal from July to December-end was beneficial to crop and would help in enhancing the yield. The rainfall excess than normal beyond December would reduce yield of black pepper. Substituting sand with granite powder, a waste material obtained from stone quarries, in nursery black pepper mixture is more economical.

Black pepper samples stored in vacuum, showed good quality even after 8 months of storage. Essential oil constituents of

organically cultivated Panniyur 1 and Karimunda showed higher Caryophyllene (up to 30%) in Panniyur 1 and 24% in Karimunda.

Ginger and turmeric

Variations in curcuminoids were observed during growth stages in turmeric as determined by HPLC. Variations were observed for curcumin I (1.6–3.39%), curcumin II (0.39–1.08%) and curcumin III (0.48–1.1%) in Alleppey, Prabha, Prathibha, Suguna and Sudarsana.

The *Pythium myriotylum*, causing rhizome rot in ginger in Kerala, Karnataka, Uttar Pradesh and Sikkim, was identified. The

New Germplasm

The germplasm of black pepper (612), cardamom (273), ginger (633), turmeric (1,326), tree spices (230) and seed spices (4,117) was enriched.

pathogenicity trial further confirmed that this was highly aggressive on ginger. PCR based method was found suitable for identification of *P. myriotylum*. Primers specific for *P. myriotylum* were found to amplify 150 bp sequences in the genomic DNA of *P. myriotylum*. Mango ginger (*C. amada*) was found resistant to natural infection by *R. solanacearum*.

Mermithid nematode (*Hexameris* sp.) was recorded as a major natural enemy of shoot-borer larvae in field at Peruvannamuzhi and percentage of population of larvae parasitized by nematode was higher during August–September.

Tree spices

Cassia C1 (IC 370415) has been registered as INGR 05029 at NBPGR, New Delhi, for its high oleoresin content (10.5%). Molecular characterization of 10 elite accessions of nutmeg with 13 random primers was done and 75% polymorphism was observed.

Nutmeg mace blanched for 2 minutes in boiling water showed better colour retention (Lycopene 49.9%) compared to 1 minute blanching (Lycopene 38.7%) and no blanching (Lycopene 9.98%) after storing in 300 g polypropylene covers.

Vanilla

A virus causing mild chlorotic mottle and streaks on leaves of vanilla was identified as a strain of Cymbidium mosaic virus (CymMV) based on coat protein gene sequence comparison and phylogenetic studies. The coat protein gene of virus was cloned and sequenced. Sequence analyses confirmed the identity of virus as a strain of CymMV. An identity of 92.3–97.3% was seen with different CymMV isolates infecting different orchids in India while with available partial CP sequences of CymMV isolates infecting vanilla identity ranged from 98.2 to 99.4%.



Paprika

Thirty-one hybrid samples and 30 germplasm samples were evaluated for colour value, oleoresin and capsaicin content. Accession 0107-7011 showed 308 ASTA units with 15.9% oleoresin and 1.02% capsaicin. MS-2X B-2 showed 308 ASTA units with 15.7% oleoresin and 1% capsaicin.

Seed spices

Two new varieties one each of anise, NRCSS Aani 1 and celery, NRCSS Cel 1 have been identified for release. These are first ever approved varieties in India. A total of 50 fungi were isolated in different stored spices. The fungi included *Aspergillus niger*, *A. flavus*, *Penicillium* spp. and *Mucor* spp. *A. flavus* and *A. parasiticus* have been isolated from a few samples especially nutmeg and ginger. These samples also possess lower content of essential oil and oleoresin.

PhyDisH, a new database on *Phytophthora* cultures conserved in the National Repository of *Phytophthora* at the institute and 'Spice Pat', a searchable database on patents related to spices were developed.

High-yielding varieties of cardamom (ICRI 5 and ICRI 6), coriander (RCr 480, Hisar Surabhi and Sudha), cumin (RZ 341 and Gujarat Cumin 4), fennel (RF 178), fenugreek (RMt 351 and Gujarat Methi 2) are ready for release. Cardamom ICRI 5 is first hybrid, which has high yield potential under intensive management. Cumin Gujarat Cumin 4 is identified as *Fusarium* wilt resistant and fenugreek RMt 351 resistant to powdery mildew and root-knot nematodes. Gujarat Methi 2 is resistant to root rot and downey mildew. Coriander Hisar Surabhi and fenugreek Gujarat Methi 2 are recommended for national/state release while others are recommended for state release.