7. Crop Management

PRODUCTION

Rice: *Transplanting methods.* Mean grain yield from System of Rice Intensification (SRI) with adapted cultivars was higher (5.94 tonnes/ha) by 15% at 21 out of 27 locations over standard method of transplanting (5.17 tonnes/ha); integrated crop management method followed with an 8% increase.

Penoxsulam applied up to 5 days after transplanting (DAT) at 0.025% was effective as pre-emergence herbicide at three locations, and as post-emergence at two locations. It did not exhibit any toxicity to rice-crop.

Agro-technology for aerobic rice. Annada, Naveen and IR 64 varieties and Rajalaxmi and KRH 2 hybrids have been found most suitable for direct-seeded aerobic conditions during wet season in coastal Orissa, under irrigated ecosystem. They responded significantly to N up to 120 kg/ha without any major incidence of pests and diseases. Butachlor at 1.25 kg a.i./ha at 3–5 days after sowing (DAS) with one hand weeding at 30–35 DAS effectively controlled weeds.

Wheat and barley: *Improving soil organic carbon through residue management*. The increase in soil organic carbon was 0.1% after two years with full residue incorporation of rice and/or wheat. The content increased from 0.31 to 0.37% with surface residue retention of rice alone and to 0.38% when residues of both rice and wheat were retained.

Seed treatment with *Azotobacter* and phosphate solublizing bacteria showed that about 50% of recommended N and P can be compensated with their application.

Small millets: In fingermillet-growing areas of Orissa, fingermillet growing early in the season, followed by blackgram/cowpea, was found profitable. Alternatively, cowpea as early season crop, followed by fingermillet in the sequence gave higher returns.

Vermi-compost and chullu (wild apricot) cake as N source along with *Azotobacter* seed treatment has been recommended for organic fingermillet production in Uttarakhand.

Forage crops: In guinea-grass + berseem intercropping system, nutrient supplement through farmyard manure (50 tonnes in guinea-grass + 30 tonnes/ha in berseem) recorded 12% higher green forage yield (171.55 tonnes/ha) over inorganic fertilizers (200 kg N +50 kg P_2O_5 + 50 kg K_2O/ha in guinea-grass and 20 kg N+80 kg P_2O_5/ha in berseem). This also improved soil microbial biomass (310.9 mg C/kg soil).

Production technology has included:

- In Eastern zone, significantly higher net monetary returns (Rs 42,981/ha/year) were realized with NB hybrid (perennial) + berseem, which were 48% higher than rice–wheat–greengram system.
- In Central zone, sorghum (fodder)–berseem–maize (fodder) + cowpea (fodder) recorded 94% higher net monetary returns than rice–wheat–greengram.
- In Gangetic plains of West Bengal, rice– oat–sesame was superior and gave net monetary returns of Rs 87,561/ha/year with 63.3% increase over rice–mustard–groundnut system.
- In acidic soil, cowpea and ricebean were at par. Single superphosphate (SSP) at 20 kg P/ha along with farmyard manure at 5 tonnes/ha recorded significantly higher green fodder yield by 42 and 16.8% over control and only 20 kg P as SSP/ha respectively.

Underutilized crops: In Gujarat, grain-amarnath Annapurna, in closer spacing of 22.5 cm × 10 cm resulted in higher yield than wider spacing (45 cm × 10 cm).

In *Jatropha*, height and number of branches per plant increased with spacing, fertilizer dose and age of planting.

Groundnut: Maximum yield of groundnut and wheat was obtained in groundnut-wheat-greengram cropping system, followed by groundnut-wheat system. Soil health in terms of total soil nitrogen and organic carbon also improved in the former system.

Sunflower: In alluvial soils, *Azospirillum* and *Azotobacter* inoculation along with 50% of the recommended N was found profitable in *kharif* sunflower.

Castor: It is found advantageous to sow castor after seed priming with 1% NaCl for 3 hr to get better returns.

Rapeseed-mustard: *Toria* sowing at dough stage of rice has been remunerative in rice-*toria* sequence, and has been recommended for central Brahmaputra valley zone of Asom. In north Gujarat, basal application of 20 kg S/ha in *kharif guar*–mustard and 40 kg S/ha in *kharif* mungbean/pearl millet–mustard sequence have been recommended.

Experimental mustard hybrid evaluation block at the NRCRM

Sesame: Recommended dose of fertilizers (100%) + oilcake (250 kg/ha) + bioinoculants *Azospirillum* at 5 kg/ha + phosphate solubilizing bacteria at 5 kg/ha + *Trichoderma viride* at 5 kg/ha + *Pseudomonas fluorescens* at 5 kg/ha resulted in the highest mean seed yield.

Niger: *In-situ* moisture conservation, one hand weeding at 15 DAS + vegetative mulching at 4 tonnes/ha enhanced seed yield from 366 to 844 kg/ha with increase in benefit : cost ratio from 1.30 to 1.80.

Linseed: Under irrigated conditions of Kanpur, $ZnSO_4$ at 25 kg/ha either in *kharif* or in *rabi* and 5 tonnes/ha FYM during *kharif* in blackgram-linseed sequence proved remunerative and gave higher oil content.

Chickpea: In rainfed areas, urea application at flower initiation and 10 days thereafter showed about 20% higher grain yield of chickpea over control. Seed priming helped in improving emergence and grain yield.

Pigeonpea: Varieties suitable for delayed planting in different zones have been identified: Azad (North Eastern Plains Zone), JKM 189 (Central Zone) and LRG 30, LRG 38 (Southern zone). For intercropping, promising varieties identified are: Pusa 992 (North Eastern Plains Zone), Asha, JKM 7, JKM 189 (Central Zone) and TTB 7 and KM 186, LRG 41 and Co 6 (Southern Zone).

Mungbean: Resistant donors for *Cercospora* leaf-spot disease (BM 4, ML 515, TM 98-50 and AAU 30), mungbean yellow mosaic virus (Pusa 0572, MH 98-7 ML 1265, KM 2241 and MH 98-1) and root-knot nematodes (COGG 912 and ML 1265) have been identified.

Lentil: *Rhizobium* strain DL 1 found efficient in increasing grain yield of lentil, by 8.9% over uninoculated check. L 4685, LH 84-8 and NDL 6-1-5 lentil genotypes have shown tolerance to root-knot nematodes *Meloidogyne javanica* and *M. incognita*.

Rajmash: Urea (2%) sprays at pre-flowering, 25% pod initiation and pod development stages increased *rajmash* pod yield.

Cotton: Recommended doses of fertilizers in soil 50% + 50% through fertigation along with 10 kg $ZnSO_4$/ha in soil significantly increased seed-cotton yield. Four sprays of KNO_3 during crop growth enhanced cotton productivity in Central and South Zones. Relatively drought-tolerant lines, CAT 3640, CAT 3874, CAT 1058, AC 7602, AC 7185 have been identified.

Sugarcane: Physio-biochemical causes for poor sprouting of buds at low temperatures have been established. These include low acid invertase activity and decreased level of reducing sugars, low activity of ATPase, IAA oxidase, accumulation of nitrite and relatively lesser absorption of water. Potassium with last irrigation (one month before harvest), pre-harvest application of Ethrel and post-harvest application of $ZnSO_4$ improved stubble bud sprouting.

Sugarcane planted in paired-row system (30:120 cm) significantly reduced gaps (9.5%), produced highest number of millable canes (120.5 thousand/ha) and cane yield (92.9 tonnes/ha) over conventional 90-cm spacing planting. Increasing 25% seed rate or gap-filling at first irrigation in plant-crop has been identified as a suitable technology for enhancing ratoon productivity.

Sulphitation pressmud cake (10 tonnes/ha) + *Acetobacter* every year registered highest millable canes (102.7 thousand/ha) and cane yield (70 tonnes/ha) in the third ratoon. This also recorded highest soil microbial biomass carbon. This meets nutritional requirement of the crop and also maintains rhizospheric soil quality parameters, physico-chemical characteristics and microbial

activities under multi-ratooning.

Jute: High weed-control efficiency in jute (75.3% at 28 DAS and 79% at 45 DAS) with maximum fibre yield (2.49 tonnes/ha) has been obtained with pre-emergence application of S-Metolachlor at 0.50 kg a.i./ha.

In jute, *Corchorus olitorius*-toria cropping sequence, substitution of recommended fertilizer doses (100% NPK) to the tune of 25% through organic components (FYM, green manures or composts) recorded significantly higher jute fibre yield.

Tobacco: Maize-tobacco and soybean-chickpea systems are profitable alternatives to flue-cured Virginia tobacco in northern black soils of Andhra Pradesh. At Dinhata, jute-*Aman* rice-*Motihari* tobacco gave the highest net returns, followed by *Boro* rice-*Aman* rice-tobacco, maize-*Aman* rice-tobacco, jute-*dhaincha* (green manure)-tobacco and jute-fallow-tobacco.

Mango: Mango Alphonso planted at a 5 m × 5 m spacing on Vellaikolumban rootstock without Paclobutrazol application yielded 8.49 tonnes/ha during seventh year. No residue of Paclobutrazol was observed in pulp or peel following its soil application during October in the third consecutive year. Fruit yield was found to be significantly related with leaf K content. Predominant micronutrient disorders in mango belts of Chitoor, Salem and Erode districts were found associated with zinc and boron deficiencies. Arka Anmol planted at 10 m × 10 m distance recorded significantly higher fruit yield with daily drip irrigation at 75% evaporation replenishment. Drip irrigation followed by fertigation with NPK at fruit setting resulted in higher fruit yield (10,120 kg/ha) than conventional irrigation and fertilizer application in basin (5,430 kg/ha).

Latra rootstock imparted maximum dwarfness to Bombai scion against maximum vigour on random seedling. Double hedgerow system of planting gave significantly higher yield at most of the centres. In high-density planting, maximum number of fruits and yield were recorded in trees pruned on alternate limbs with the application of Paclobutrazol after harvesting. The maximum yield was recorded with heading back of branchlets at 50 cm level in Alphonso and with the application of Paclobutrazol during the rest period in Kesar. In pruning for rejuvenation of overcrowded orchards, maximum cumulative yield was recorded in heading back up to crowded branchlets and centre opening with use of Paclobutrazol during the rest period in mango Banganpalli, Chausa and Langra.

Guava: Guava L 49 showed highest yield at a spacing of 2.5 m × 1.25 m one year after planting. Drip irrigation increased yield up to 40% and by saving water up to 52–60%. The rejuvenation technology involving heading back of old trees to 1.0–1.5 m height above the ground level during May-June or December-February produced new shoots from below the cut-point and allowed the development of fresh canopy with healthy shoots. The newly emerging shoots were allowed to grow up to the length of 40–50 cm, 4–5 months after rejuvenation. These shoots were further pruned to 50% of the total length for the emergence of multiple shoots from below the pruning point. The multiple shoots developed as a result of second pruning led to flowering and fruiting in the following season. Yield enhancement was 70–90% over un-pruned trees in the second year after rejuvenation. A planting density of 555 plants/ha was found economical for getting higher yield in guava Allahabad Safeda. Topping and hedging proved a valuable technique for controlling tree size and improving the yield potential. The yield recorded was 40– 45 tonnes/ha under high-density planting coupled with canopy management without any adverse effect on fruit size, quality and canopy recovery.

A meadow orchard system was developed with 5,000 plants/ha (1.0 m × 2.0 m) and managed judiciously with regular topping and hedging. An average yield of 12.5 tonnes/ha was obtained after the first year and 50 tonnes/ha after the third year. To maintain dwarf tree stature, plants are topped 2 months after planting (October) for the emergence of new shoots from below the cut-end. After appearance of new shoots, they are pruned to 50% of their length again in December – January for further induction of new shoots. This allows to initiate growth, differentiate flowering and attaining well-spread plant canopy by May. Heading back of entire shoots is repeated every year in September and May for making tree canopy dwarf and allowing more fruiting.

Papaya: In papaya, an application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal under Coimbatore conditions.

Passion fruit: Irrigation scheduled at 75% of evaporation replenishment showed significantly higher yield (27 kg/plant). Similarly, 75% of recommended dose of fertilizer showed yield at par with 100% recommended dose. Passion fruit Kaveri could be grown under Bangalore conditions with high yield (20 kg/plant) under kniffin system of training.

Strawberry: In Kashmir valley, growing strawberry inside greenhouse with mulching and drip irrigation advanced fruit harvesting by 45 days with a yield potential of 14.24 tonnes/ha, about 2.37 times as compared to open field. The advancement in fruit harvesting resulted in 3–4 times more price in the market.

Banana: Robusta banana under paired row planting (1.5 m × 1.5 m × 2.0 m spacing) recorded the maximum yield (65.91 tonnes/ha), which was 39.5% higher (47.24 tonnes/ha) than the conventional planting system. Weekly fertigation with 75% recommended fertilizers recorded the maximum yield (57.68 tonnes/ha) in Robusta with a benefit: cost ratio of 2.13. A micronutrient mixture named Banana Shakthi has been developed. The mixture contains all micronutrients in proper proportion required for banana crop. This mixture can be applied to banana either as soil application (10 g/plant) or foliar spray (2% solution) based on soil pH. A computer simulated fertilizer tailoring equation model for Ney Poovan and Rasthali banana has been developed for balanced nutrition and targeted yield.

Two kg farmyard manure enriched with *Pseudomonas fluorescens* (109 cfu/g) and *Pseudomonas lilacinus* (106 cfu/g) per plant at the time of planting and 4 months later significantly reduced *Radopholus similis* (64%) and *Meloidogyne incognita* (76%). Pre-harvest application of Carbendazim (0.1%) followed by post-harvest treatment of neem leaf or garlic or turmeric extract (5%) resulted in complete control of anthracnose rot. Plant spacing of 2 m × 3 m with planting of 3 suckers per pit in Nendran, Grand Naine and Basrai at 1.8 m × 3.6 m spacing with 3 suckers per pit in Robusta have recorded higher yield. Inclusion of VAM, PSB, *Azospirillum* and *Trichoderma harzianum* at 250, 50, 50 and 50 g/plant, respectively, in Rajapuri, Basari and Karpurachakkarakeli to 75% of recommended dose of fertilizer (RDF) improved plant growth and productivity. Application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal at most of the locations. However at Kovvur, 50% RDF with biofertilizers was sufficient for Karpura Chakkarakeli banana (AAB, Mysore). The best intercrops in banana are onion, cowpea and cabbage.

Grape: Thompson Seedless grafted on 110R sprouted earlier as compared to other rootstocks. Water-use efficiency at single leaf stage was maximum on 'Dogridge' rootstock followed by 110R, 1103P and 99R. Of the rootstocks, 110R was found to be the best. Twelve *Aspergillus* isolates from rhizosphere and non-rhizosphere soils of grapevine showed significant effect on P solublization in the laboratory.

Citrus: Site-specific nutrient management (800 g N, 400 g P, 600 g K, 250 g each of $FeSO_4$, $MnSO_4$ and $ZnSO_4$/tree) in 'Mosambi' sweet orange (*Citrus sinensis*) helped improve fruit yield (14.7 tonnes/ha) over conventional farmers' practices (10.6 tonnes/ha) and application of recommended doses of fertilizers (11.6 tonnes/ha).

Sweet orange yields better in site-specific treatment

In fruit, vegetable-based intercropping models, fresh grain yield of 10.73 tonnes/ha of cowpea, 3.18 tonnes/ha of okra, 18.87 tonnes/ha of potato and 115,867 numbers of spikes/ha of *gladiolus* were obtained. However, net income of Rs 187,838 was obtained from okra-gladiolus rotation, followed by Rs 50,350 from cowpea-potato rotation.The highest yield was obtained in double hedgerow system of planting. Maximum yield of fruits was recorded in modified leader system, which was at par with open vase, while minimum yield was recorded in the control. In pruning trial, shoots pruned up to 50 cm at the time of harvesting followed by removal of new flush in November-December gave the maximum yield of quality fruits.

Sapota: A spacing of 5.0 m × 5.0 m for 10-year-old Kalipatti and 8 m × 4 m for 18-year-old PKM 1 at Periyakulam recorded the highest yield. Application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal in sapota. Application of 5 kg vermicompost with 150 g N, 40 g P_2O_5 and 150 g K_2O/plant/year for Kalipatti and PKM 1 sapota recorded significantly higher growth and yield.

Jackfruit: Soft wood grafting of jackfruit using 4-month-old rootstocks under shade during October registered the highest graft take. At Kannara, grafting jack on jack seedlings and jack on Ainipala seedlings recorded higher success.

Apple: The productivity of apple Oregon Spur and Red Chief registered double the average global productivity from 8-year-old orchard raised on semi-dwarfing rootstocks MM 106 at a distance of 2.5 m × 2.5 m, accommodating 1,600 plants/ha. The plants came into bearing after 3 years with pollination, drip irrigation, organic mulching and integrated nutrient and pest management against 7–8 years on seedling rootstocks.

Almond: Under medium high-density plantation, accommodating 625 plants/ha at a spacing of 4

m × 4 m against 278 plants/ha conventionally, 7-year-old almond Waris, Shalimar, Non-Pareil, Pranyaj and Merced recorded a yield of 2.4 tonnes/ha. The plants came into bearing after 3 years (against 6–7 years on seedling raised plants). The plantation was raised with proper pollination, drip irrigation, organic mulching and integrated nutrient and pest management.

Apricot: Medium-density plantation using 5 m × 5 m spacing, accommodating 400 plants/ha against 204 plants/ha in conventional method has been made in apricot. With proper training/pruning, pollination, integrated nutrient and pest management, drip irrigation and organic mulching, Harcot, Apricot AS 1, AS 2 and KS 1 came into bearing 3 years after planting, producing quality fruits. Apricot Selection AS 2 was found promising with fruit weight of 29.00 g, acidity 0.03% and TSS of 17.5°Brix.

Arid zone fruits: Evaluation of aonla-based diversified cropping models in arid ecosystem indicated that ground-storey crops performed well in different cropping models without affecting growth and development of main component crops. Among understorey crops, Seb ber in model 1 recorded an average yield of 70 kg/tree and was significantly superior to the control. In model 2, *Prosopis cineraria* grown in combination with aonla-*suaed*-moth bean-mustard (M_3) as an understorey component recorded an average yield of 0.5 kg/plant (75 kg/ha). Among groundstorey crops, gram excelled other crops recording an average yield of 1 tonne/ha.

In aonla, yield per plot (68 kg) and per ha (7.55 tonnes) were significantly high in double hedgerow system followed by cluster and hedgerow systems of planting. In high-density planting, 10 m × 10 m spacing yielded 130.6 kg/plant (1.31 tonnes/ha). The irrigation through drip and low volume microsprinkler could save 30–45% irrigation water with increased fruit yield (35–40%) over conventional flood irrigation system. Early fruit maturity was also noticed in micro-sprinkler used plots.

The best results were obtained when 50% of the nutrients were applied through chemical fertilizers and rest through biofertilizers and FYM in ber Kaithali budded on *Z. rotundifolia* rootstock. Frost injury in ber could be minimized by spraying of Sulphuric acid (0.5%) in third week of October and first week of November. Application of Atrazine (pre-emergence) with Glyphosate (post-emergence) has been recommended for weed control in aonla. Initial sucker mortality of date palm has been controlled through treating suckers with Carbendazim (0.1%) + Chlorpyriphos (0.1%) + IBA (1,000 ppm).

Vegetable crops: Onion and garlic could be grown on drip as well as sprinkler irrigation technology with a water saving of 40–50% and 15–20% increase in yield coupled with 30% saving of fertilizers. This technology is moving at a faster rate among onion growers in Maharashtra.

The technology has been developed for enhancing productivity in *kharif* onion: (1) raising of nursery in summer on broad bed furrow (BBF) with drip or sprinkler under shade nets and keeping seedlings ready for transplanting in first week of June, so that there would be early harvesting in October, (2) transplanting of seedlings on BBF with drip or sprinkler irrigation, the raised bed in BBF method facilitates quick and efficient drainage of rainwater, which minimizes the incidence of soil-borne and foliar diseases, (3) application of FYM or vermicompost pre-mixed with *Trichoderma viride* before preparation of beds for reducing the incidence of soil-borne diseases, (4) fertigation through drip avoids leaching losses of nutrients, which is common in high rainfall conditions, and (5) application of pre-emergence weedicides. This technology ensures 25 tonnes of yield/ha without hampering the quality of bulbs.

In broccoli, maximum head yield (366.0 q/ha) was recorded by application of poultry manure @ 5 tonnes/ha + half NPK (60:30:30 kg/ha). In organic farming trials of okra, maximum yield was recorded by application of FYM @ 10 tonnes/ha + poultry manure @ 2.5 tonnes/ha. The highest water-use efficiency and water saving were obtained under 75% PE with drip irrigation scheduling at alternate day in cucumber. In water stress study of tomato, the flowering stage is the most critical stage for moisture stress followed by active vegetative stage.

Sprinkler irrigation in onion increases yield (15–20%) and saves water (40–50%)

Potato: Rice-potato-okra followed by rice-potato-jute and potato-French bean followed by potato-sorghum were found most remunerative potato-based crop sequences. Potato + French bean (2:1 ratio) followed by potato + *methi* (2:1 ratio) were most profitable intercropping systems. In

potato-based crop sequences at different centres, NPK requirement of crop next to potato was reduced by 25% of the recommended dose when potato received 100% recommended NPK along with FYM @ 20 tonnes/ha. These crop sequences were rice-potato-wheat, potato-pearl millet, potato-bottle gourd and potato-greengram.

With the use of phosphobacteria, the dose of P could be reduced to 75%. Among potato cultivars Kufri Pukhraj, Kufri Sutlej, Kufri Swarna and Kufri Badshah were found more nitrogen-efficient cultivars than other varieties tested.

Potato Kufri Pukhraj was identified to be a highly input-efficient cultivar having higher N influx. It has capacity to use higher soil N compared to Kufri Jyoti. Similarly, Kufri Swarna was the most nutrient-efficient variety in southern hills. Vermicompost proved to be superior to FYM, as it had direct effect on P availability at a latter stage of crop growth. The stolon formation and tuber initiation stages were identified to be most critical for water supply. Single drip layout application system for raised bed/triple row potato planting with 1.5 lakh plants/ha resulted in nearly 30% higher yield of potato, saving 50% of water compared to traditional method of furrow irrigation.

Coconut: The net primary production estimations of coconut monocrop in different agroclimatic zones indicated annual carbon sequestration potential of coconut above the ground biomass ranged from 8 to 32 CERs. The standing carbon stocks ranged from 18 to 51 CERs.

Cashew: Yield in high-density planting (416 and 500 trees/ha) was significantly higher (726 and 1,138 kg/ha, respectively) than normal density (457 kg/tree). The cashew graft production has been enhanced, producing 2.5 lakh grafts of improved and high-yielding varieties and made them available to farmers and developmental agencies.

Analysis of volatiles collected from virgin females of tea mosquito bug by GCMS revealed the presence of methyl butyrate. Lambda Cyhalothrin has been found to be most effective against foliage pests of cashew. Significant varietal variation has been observed for protein (4.26 – 12.29%), starch (6.75 – 78.66%), sugar (11.44 – 42.07%) and *in-vitro* digestibility of carbohydrate in cashew apple powder.

Mini palm oil mill

A portable snowball tender nut machine was developed. A mini palm oil mill with a capacity to process 1 tonne of fresh fruit bunches (FFB) of oil palm per hour was developed. The mill is devised in such a way that it is easily maintainable and can be repaired locally.

Gerbera: Organic modules have been developed as a component of IPM for an effective management of whitefly in gerbera grown under protected cultivation.

Lilium: Lilium bulb production technology has been standardized with using sawdust of *Cryptomeria japonica* and application of N:P:K (10:25:25) @ 100 g/m^2.

Medicinal and aromatic plants: Propagation of patchouli (*Pogostemom cablin*) from mother plants was standardized using single leaf. Single leaf from the top 2–5 nodes produced fully developed plantlets in 60 days. An Anthroquinone compounds isolated from *Aloe* were characterized through HPTLC and LC-MS/MS. Two major anthroquinone compounds were isolated and found to have mass of 441.0 AMU (which corresponds to sodium adduct of Aloin A) and 577.3 AMU. Application of 7.5 tonnes FYM/ha and harvesting 135 days after planting significantly influenced fresh and dry foliage yield, andrographolide and iron contents, and their total herbage yield in Kalmegh.

Betelvine: The integrated crop management package has been developed for betelvine cultivation in major betelvine-producing areas. Inorganic nitrogen @ 200 kg in splits form + 100 kg P_2O_5 + 100 kg K_2O + irrigation 100% replenishment of cumulative pan evaporation (CPE) + 4 applications of *Trichoderma* + sanitation resulted in better growth and yield attributes. Application of Bordeaux mixture was found superior compared to biocontrol agent for Phytophthora foot rot of betelvine and increased betelvine yield. The application of oil cake + Carbofuran + 3–4 inoculations of *P. lilacinus* inoculated oil cake effectively controlled root-knot nematode and increased leaf yield.

Mushroom: Of the 53 hybrid strains of *Pleurotus sajor-caju* evaluated on wheat straw, 10 gave more than 68–85% BE. In paddy straw, mushroom 42 single spore isolates were compared for their growth rate, type of mycelial thread,

Shiitake mushrooms grown on wheat bran

density of mycelial growth, presence of aerial mycelia and chlamydospores. Cultivation technology of *Flammulina velutipes* standardizing polypropylene bags proved the best cultivation containers. Supplementation of 20% wheat bran proved better for increasing yield of shiitake mushroom. Medicinal mushroom (*Schizophylum commune*) has also been successfully cultivated on sawdust. The Thai culture gave highest yield followed by Korean OE 53. Cultivation practices of button, oyster and paddy straw mushrooms were developed in low-cost bamboo huts with good economic yields.

Tuber crops: Use of vermicompost (15 kg N) along with 45:40:60 kg NPK/ha was recommended for sweet potato. Biofertilizers with half recommended dose of phosphorus was standardized for *Colocasia* for Andhra Pradesh, which gave a cormel yield of 17.23 tonnes/ha. In elephant-foot yam, straw mulching was recommended for its weed management and enhanced yield in West Bengal (61.40 tonnes/ha), Andhra Pradesh (47.44 tonnes/ha) and Kerala, while sesame leaf mulching or black polythene mulching was recommended for Bihar, with a corm yield of 41.6 tonnes/ha.

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 126,000/ha. In Chhattisgarh, elephant-foot yam as intercrop in mango orchard gave the highest corm yield of 9.52 tonnes/ha. Sweet potato was the best intercrop in pre-bearing cashew orchard with a highest cost:benefit ratio (1: 1.36).

PROTECTION

Rice: Many promising entries showing resistance/tolerance have been identified in screening nursery for different insect-pests and diseases.

Biological suppression of crop pests. In a large-scale demonstration of biocontrol-based IPM, the use of *Trichogramma chilonis* and *T. japonicum* as well as antagonistic organisms (*Pseudomonas fluorescens* and *Trichoderma* spp.), covering 1,200 ha of deep-water lands (*cole*) effectively controlled rice pests and diseases and enhanced yield.

Nematode. Nematode distribution atlas of economically important plant-parasitic nematodes of major crops has been compiled and digitized. Hot spots areas in paddy against *Aphelenchoides besseyi* in West Bengal and Himachal Pradesh and *Meloidogyne graminicola* infesting paddy in Tamil Nadu, Karnataka and Himachal Pradesh have been identified. Management of *Meloidogyne graminicola* infecting paddy was achieved through soil solarization of nursery area + Carbofuran 3 G at 1 kg a.i./ha 45 days after transplanting or neem cake at 100 g/m^2 i + Carbofuran in the main field.

Mites. Fenazaquin at 125 g ai/ha or Diafenthiuron at 300–600 g ai/ha or Dicofol at 2.5 ml/litre was found effective in reducing rice sheath mite *Steneotarsonemus spinki*, which was noticed to be severe during the third week of October (47 mites/leaf sheath) on Jaya and Gurjary varieties in Navsari (Gujarat). At Coimbatore, initial field screening of rice genotypes revealed few fairly resistant varieties (harbouring less than 10 to 15 mites/3 cm leaf length) against spidermite,

Promising rice entries identified against insect-pests

Trial	Pest	Promising entries identified
PHS	Plant hoppers	KAU Ptb 9412-13, KAUM MO8 20 KR, CR AC 34997, KAUM 95-1, KAU PTB 9401-2, CORH 3, KAUM 103-104-1
GMS	Gall midge	RP 4642-669, RP 4643-713, RP 4643-723, RP 4643-829, RP 4643-985, RP 4643-1020, RP 4645-688, RP 4644-745, RP 4647-1191, JGL 8644, JGL 11541, JGL 11551, JGL 13391
GMSS	Gall midge	INRC 5073, INRC 17494, INRC 8867, INRC 3021, INRC 7055, INRC 8843, INRC 2489
GEMP	Multiple pest resistance	IC Nos 331779, IC 340054, IC 115503, IC 321504, IC 337578
MRST	Multiple pest resistance	Salkathi (CR AC 35181), RP 4621-1842, RP 4621-1845, RP 4518-2-6, RP 4642-669, RP 4516-3-8, RP 4639-110, JGL 13595
NSN	Multiple pest resistance	IET 17885, IET 18909, IET 19308, IET 19379, IET 19571, IET 19794, IET 19632

PHS, Planthopper screening; GMS, gall midge screening; GMSS, gall midge special screening; GEMP, germplasm evaluation against major pests; MRST, multiple resistance screening trial; NSN, national screening nursery.

Promising entries identified against various diseases

Disease	Promising entries identified
Sheath blight	NSN: IET 18353, 19334, 19929, 20052, 20071, 20075, 20095 DSN: ARC 10573, CB 02-012
Brown spot	NSN: IET 18208, 18725, 18727, 18754, 8647, 19344, 19697, 19656, 19657, 19189, 19212, 19786, 19630, 19631, 19635, 19638, 19640, 19767,19725, 19726, 19731, 19739, 19746, 19530 DSN: ARC 10555, CB03-334, CB02-012, IR 78224-22-2-98, HPR-2505, ARC 10535 and ARC 10573
Sheath rot	NSN: IET 19144, 18647, 18755, 18646, 19389, 19424, 19513, 18808, 19370, 19664, 19162, 19163, 19963, 20064, 20067, 20085, 20006, 19743, 19739, 19744, 19754, 19758, 19759 DSN: CB 01-001,CB 03-008, CB 02-0212, ARC 10560.
False smut	NSN: IET 18732, 18736, 18353, 18781, 18782, 18796, 18990, 19491, 19492, 19117, 19744, 19745
Glume discolouration	DSN: IR 78224-22-2-980, VL 7504, VL 30019, 35VL 30246, HPR 2143, HPR 1156, Bhrigodan
Bacterial blight	NSN: IET 19046, 19590, 19045, 19026, 19144, 18990, 19148, 19120, 20080, 18697, 19542 DSN: CB 01-001, VOPH 3102
Rice tungro disease	NSN: IET 18720, 19706, 19708, 19711, 19712, 19722, 19646, 19662, 19161, 19799, 19742; TNRH-142 DSN: IR 78221-19-6-82, HPR-2413 and ARC 10560
Multiple diseases	IET 20066 (blast, bacterial blight and tungro) IET 19542 (blast, bacterial blight and tungro) IET 19739 (brown spot, sheath rot and tungro) CB 03-008 (blast, sheath blight and sheath rot) CB 02-012 (sheath blight, brown spot and sheath rot)

NSN, National screening nursery; DSN, District screening nursery

Oligonychus oryzae. Abamectin at 0.5 ml/litre and Fenazaquin at 1 ml/litre were effective in checking mite population that peaked between 35 and 70 days after planting.

Wheat and barley: Wheat and barley genotypes showing resistance to various diseases and insect pests have been identified.

IPM in barley. Seed treatment with Carboxim 200 WS at 3 g/kg of seed and Imidacloprid at 0.6 g a.i./kg + foliar sprays of Propiconazole (Tilt 25 EC) at 0.1% and Imidacloprid at 20 g a.i./ha reduced incidence of stripe and stem rusts, covered smut, foliar blight, aphids and termites. It also increased number of plants/plot by reducing seedling death, and increased test weight and grain yield significantly over check.

Maize: Four lines of maize have been registered as the sources of disease resistance.

Registered lines of maize at NBPGR

Line	INGR number	Novel/unique feature
BPPT 1 35	06043	PFSR resistance
BPPT 1 37	06044	PFSR resistance
BPPT 1 38	06045	PFSR resistance
BPPT 1 44	06046	PFSR resistance

Sorghum: *IPM in sorghum.* Wheat straw bundles of 90 cm length and 22 cm diameter were packed in plastic nets and placed in sorghum fields for 15 days for bundles with spiders. These bundles were then placed in rice fields at 20 bundles/ha. This practice along with growing of maize, sunnhemp or *Sesbania* as a border crop significantly increased population of natural enemies concurrent with reduction of yellow stem borer. Many of the volatiles from 30 isolates of 6 species of *Trichoderma* have been found inhibitory to *Sclerotium rolfsii*, *Fusarium oxysporum* f. sp. *vasinfectum* and *F. ciceri*.

Pearl millet: Pearl millet MH 1248, MH 1291, MH 1294, MH 1299, MH 1328, MH 1397, MH 1363, GHB 538, GHB 558, PB 106, Pusa 266, Raj 171, ICMV 221 and JBV 2 have exhibited resistance against downy mildew, smut and rust.

Groundnut: *In-vitro Trichoderma* isolates NRCG T 06 and NRCG T 17 have been found effective against collar rot (*Aspergillus niger*) and stem rot (*Selerotium rolfsii*) and NRCG T12, NRCG T16, NRCG T 32 and NRCG T 34 showed antagonism against *Aspergillus flavus*.

Gypsum at 500 kg/ha at pegging significantly reduced aflatoxin contamination. Garlic and onion rotation in long-term significantly reduced soil population of *A. flavus* and aflatoxin contamination in subsequent crop of groundnut.

Sunflower: Seed treatment with mixture of Iprodione + Carbendazim 0.2%, followed by two sprays of Quintal 0.2% along with two sprays of Propiconazole 0.1%, and seed treatment + two sprays with Hexaconazole 0.1% were effective in reducing *Alternaria* leaf-spot incidence.

Imidacloprid 5 g/kg seed along with its spraying

Wheat and barley genotypes with resistance to diseases and insect-pests

Disease/Insect-pest	Resistant genotypes
Wheat	
Stem, leaf and stripe rusts + leaf blight + powdery mildew + Karnal bunt + flag smut	TL 2934
Stem, leaf and stripe rusts + leaf blight* + Karnal bunt	HS 485
Stem, leaf and stripe rusts + powdery mildew + flag smut	TL 2942
Leaf blight* + flag smut	HS 459
Stem, leaf and stripe rusts + Karnal bunt + flag smut	HS 461
Leaf and stripe rusts + leaf blight*	HPW 251, HW 5037
Leaf and stripe rusts + flag smut	AKDW 2997-16
Leaf and stem rusts + flag smut	GW 373
Leaf and stem rusts + Karnal bunt + flag smut	MACS 2956
Leaf and stem rusts + leaf blight*	HI 1531
Leaf and stem rusts + leaf blight* + flag smut	HPW 254
Leaf and stem rusts + leaf blight* + flag smut + Karnal bunt	VL 890, UP 2632, NW (S) 02-4
Karnal bunt + flag smut	HPW 236, VL 875, JKW 20, VL 870, NIDW 325
Stem, leaf and stripe rusts + foliar aphids	PBW 559, HI 1531
Stem and leaf rusts + foliar aphids	VL 882, DDK 1025
Stripe and leaf rusts + foliar aphids	NW (S) 02-4, VL 891
Stem, leaf and stripe rusts + root aphids	HPW 236, HPW 245, HS 473 and HW 5028
Stripe and leaf rusts + root aphids	VL 870
Stem, leaf and stripe rusts + foliar aphids + root aphids	MACS 6198
Barley	
Stripe rust**	BHS 369, HBL 410, HBL 501, PL 815, RD 2624, RD 2683, RD 2707, RD 2729, RD 2730, RD 2732, RD 2734, RD 2738
Leaf blight	BHS 366, BHS 377, BHS 380, BH 888, DWRUB 52, HUB 194, HUB 195, K 850, K 860, K 866, K 867, K 868, NDB 1173, NDB 1276, NDB 1414, PL 751, PL 808, PL 810, PL 811, PL 812, PL 815, RD 2035, RD 2723, RD 2724, VLB 103, VLB 104, VLB 105, VLB 107, VLB 108
Stripe rust + leaf rust + leaf blight + stem rust	HUB 195, RD 2724, VLB 103

*Moderately resistant; ** Highly resistant

at 0.05% at 30 and 45 days, and seed treatment with Thiomethoxam 4 g/kg of seed, followed by two sprays of Thiomethoxam (0.05%) at 30 and 45 DAS reduced necrosis incidence and increased seed yield. Indoxacarb 0.015% and Profenophos 0.05% have been effective against defoliators and stem borer.

Safflower: Carbendazim at 0.1% was most effective for *Alternaria* leaf spot.

Castor: *Botrytis* grey mold disease could be effectively managed with two sprays of Carbendazim (0.1%) + *Trichoderma viride* (0.3%).

Rapeseed-Mustard: Mustard sowing in first fortnight of October, followed by prophylactic spray of *Allium sativum* bulb aqueous extract (2%) and 5% aqueous leaf extract of *Eucalyptus globosus* managed foliar diseases of mustard can substitute Mancozeb.

Trivir, a biopesticide, for wilt and root-rot diseases

A formulation with trade name Trivir 1% W.P. (DOR B-16 strain of *Trichoderma viride*) has been developed and registered under Section 9 (3B) of the Insecticide Act, 1968 for commercial production. This antagonist strain effectively controls wilt and root-rot diseases of castor, pigeonpea, sesame, chillies, cowpea and pulses. It effectively managed castor wilt as seed treatment (10 g/kg seed) along with soil application (2.5 kg mixed with 125–200 kg of FYM/ha). The improved strain of *T. viride* is tolerant to Carbendazim, and it can be used along with seed-treatment fungicides. This biopesticide also showed suppression of reniform nematodes that predispose castor to wilt disease.

Soybean: Field screening for rust at hot spot helped in identification of resistant lines KDS 327 and 2355.

Sesame: Sesame in 3:3 ratio with greengram, blackgram and clusterbean reduced incidence of leaf roller/capsule borer and bud fly and gave maximum sesame-seed equivalent yield. Seed treatment with *Trichoderma viride* (0.4%) + *Pseudomonas fluorescens* (0.4%) + soil application of *Trichoderma viride* at 2.5 kg/ha + *Pseudomonas fluorescens* at 2.5 kg/ha minimized incidence of *Macrophomina* stem and root rot, *Alternaria* leaf spot and *Phytophthora* blight, and gave highest seed yield.

Linseed: Companion 75WP (63% Mancozeb + 12% Carbendazim) has been most effective in reducing *Alternaria* blight infection and enhancing grain yield. Seed treatment with Thiophanate methyl 75 WP (2.0 g/kg seed) + two sprays of Indofil M-45 (0.25%), followed by seed treatment with Thiophanate methyl 75 WP and 2 sprays of aqueous neem leaf extract (5.0%) effectively reduced *Alternaria* blight and enhanced grain yield.

Chickpea: GNG 1581, IPC 2004-52, JG 2000-14, JG 2004-3 and Phule G 0425-9 have been found resistant to *Fusarium* wilt.

Soil treatment with Carbofuran at 1.5 kg/ha and Carbosulfan 25 ST at 3% ww/kg seed effectively reduced root-knot nematodes population.

IPM in chickpea. In chickpea for suppressing pest incidence seed treatment with *Trichoderma* and *Rhizobium* culture and Chlorpyriphos for termite control, pheromone traps at 5/0.4 ha for monitoring *Helicoverpa* population, spray of 5% neem seed kernel extract (NSKE) and *Ha-NPV* (250 LE/ha), spray of Endosulfan or Indoxacarb and Basalin (herbicide) were found best IPM strategies.

Pigeonpea: E2Y45 20% SC 40 g a.i./ha, followed by Spinosad (Spinosyn A + D, 50:50%) at 73 g a.i./ha controlled pod borer effectively.

Plant-parasitic nematodes. Warked village of Buldhana district (Maharashtra) has been identified as hot spot for *Heterodera cajani* infecting pigeonpea. The Malai village of Jalgaon district in Maharashtra has been observed hot spot for infestation by *Radopholus similis* in banana. Majority of polyhouses in Himachal Pradesh, particularly in districts of Bilaspur, Hamirpur and Kangra having combination of carnation and capsicum were heavily infested with root-knot nematodes.

Biological control of cyst nematode: Pigeonpea is widely attacked by pigeonpea cyst nematode (*Heterodera cajani*) in Tamil Nadu. Seed treatment with *Pseudomonas flourescens* + *Trichoderma viride* at 5 + 5 g/kg seed decreased *Heterodera cajani* population in soil by 32.5% and 37.1%. Its benefit : cost ratio was 2.29. This recommendation has been included in crop-production guide, and is widely accepted by farmers of the state.

Mungbean: The combined application of neem cake at 100 g/m^2 + *Trichoderma viride* at 2.5 kg/ha as soil application at sowing has been found most effective for management of root-knot nematodes infecting mungbean.

Urdbean: Cyhalafop butyl at 100 g/ha as post-emergence herbicide between 21 and 28 DAS effectively managed weeds in *rabi* urdbean.

Cotton: Thiomethoxam 500 FS at 5 ml and 7.5 ml/kg seeds was effective up to 35 days in reducing jassids and aphids. For controlling pink bollworms, Triazophos (0.05%) was effective. Imidacloprid and new insecticides E 2Y45 and Spinosad have been found to have moderate effect in reducing mirid bug population. Two *G. hirsutum* germplasm lines (CT I 425-45R, EL 395A) resistant to most virulent race 18 of *Xanthomonas axonopodis* under pot culture and two *G. hirsutum* lines (A02 N 99 and A 03 N 119) under field conditions, have been identified.

IPM in cottton. Pink bollworm is emerging as a major threat in cotton. Mating-disruption technique using PB Rope L has been demonstrated in large-scale validation trials in Dharwad and Sriganganagar.

Biological suppression of pests in Bt cotton. *Trichoderma* seed treatment + cotton interspersed with *Cassia occidentalis* (6:1) + 10% planting of maize and zinnia + one release of *Chrysoperla carnea* at 14,000/ha effectively reduced sucking pests and increased seed-cotton yield with increased net returns.

Sugarcane: Tolerant strains of *Trichogramma chilonis* at 28°C have been identified.

An artificial diet has been developed for white moth; closely resembling to top-borer. Eggs of this moth have been used for rearing *Telenomus beneficiens*, a potential egg parasitoid of top-borer.

Sett treatment with *Trichoderma* spore suspension, TMC in powder form in farmyard manure at 20 kg/ha at planting, metabolites of *Trichoderma* (2.5%) applied at tiller stage performed better in checking red rot and promoting growth of sugarcane. *T. harzianum* strains T 37 and T 38 induced systemic resistance and provided protection (45–55%) in challenge inoculation with *C. falcatum*. The *T. harzianum* also enhanced germination (10–12%), tillers, number of millable canes and yield (10–15 tonnes/ha) over the check.

Biological suppression of pests. Trichogramma chilonis at 50,000/ha had good impact in reducing incidence of Plassey borer *Chilo tumidicostalis* and in increasing egg parasitism percentage as well as sugarcane yield in Asom. Inoculative release

of predator *Dipha aphidivora* at 1,000 larvae/ha at 10 spots effectively controlled sugarcane woolly aphid population within 60 days at Coimbatore, Puthur, Vellalore and Elayamuthur.

Jute: Stem rot, seedling blight, damping off, collar rot and root rot are prevalent in all jute-growing areas, irrespective of species, variety or place. The intensity ranged from 6.35% at Barrackpore to 41.2% at Bahraich. Anthracnose (*Colletotrichum corchorum*) was recorded only in white jute at Bahraich. Its intensity ranged from 15.50 to 30.60%. Leaf mosaic was of very high incidence (75 to 100%) at Bahraich while other diseases were negligible.

Semilooper, stem weevil, yellow mite, *Myllocerus* sp. and Bihar hairy caterpillar were found in all jute-growing areas but not in very severe form, excepting stem weevil at Bahraich (16.67– 24.51%), Bihar hairy caterpillar at Katihar (38.49%) and jute beetle at Nagaon (60.33%).

Tobacco: *Lantana camara*, *Thevetia nereifolia* and *Nyctanthes* sp. extracts controlled aphid up to 90% at 10 µl concentration. At Hunsur, FCH 221 and FCH 222 have been identified as promising *Fusarium* wilt-resistant advanced breeding lines. In *Motihari* tobacco, bacterial wilt has been significantly reduced by bacterial drench inoculation at 108 cfu/ml and liming at 560 kg/ha and fallowing for 30 days and *in-situ* green manuring with *dhaincha*.

Mango: Disease forecasting models were developed for mango blossom blight. The management practices were standardized for minimizing the incidence of anthracnose and blossom blight. Application of Prochloraz(0.1%) and foliar extract of *Vitex negundo* (5%) followed by post-harvest treatment of neem leaf extract (5%) and *Trichoderma harzianum* reduced fruit rot due to anthracnose. Similarly, post-harvest usage of neem leaf extract (5%) preceded by pre-harvest application of foliar extract of *Vitex negundo* (5%) was found most effective for controlling stem-end rot.

Single application of Methionine, a precursor of ethylene in soil, @ 200 ppm increased flowering (85%) and fruit setting (51.30 fruits/panicle) in mango Dashehari significantly. Soil microbial populations in terms of fungal and bacterial growth were also increased to the tune of 5.3 log fungal cfu/g soil and 8.40 log bacterial cells/g soil with its application.

Three spraying of Imidacloprid and Endosulfan starting first spray of Imidacloprid (0.005%) at panicle emergence followed by two sprays of endosulfan (0.07%) at 15 and 21 days intervals proved highly effective in reducing hopper population with highest yield. In IPM, module-II consisting of Imidacloropid (0.005%), NSKE (5%) and Endosulfan (0.07%) were highly effective by recording lowest survival of hopper population (8.64%) and maximum fruit yield (259.0 kg/tree) in mango Langra. Module-II (Thiomethoxim-Azadirachtin-Ethofenprox) proved superior followed by Module-I (Imidacloprid-NSKE-Endosulphan).

Mancozeb and Chlorothalonil (@ 2 g/litre) controlled anhracnose (60.6%) effectively. Three sprays with Carbendazim (0.1%) or mixture of Carbendazim + Mancozeb (0.2%) or Thiophanate methyl (0.1%) at 15 days interval on appearance of disease were found most effective in controlling this disease.

Guava: Spatial distribution of *Steinernema carpocapsae*, an entomopathogenic nematode in rhizosphere of guava, revealed the prevalence of relatively higher population on western direction of tree site. Furthermore, population level was found to be relatively higher during July compared to January. The highest population density (29,700) was at surface level and 1 m from tree trunk followed by 23,200 at 30 cm depth and 50 cm distance from tree trunk. The prevalence of nemic population is governed by temporal and edaphic factors, particularly moisture content in soil.

Papaya: Combined application of neem cake (250 g) + Carbofuran (1 g ai) + *Pseudomonas fluorescens* (4 g) gave the highest fruit yield and maximum reduction of nematode population in papaya CO 2.

Banana: Application of 200–300 g N and K_2O/plant/crop with foliar spray of urea (2%) followed by bunch spray of 2, 4-D (25 ppm) for Nendran or two post-shooting sprays of CPPU (4 ppm) recorded higher bunch weight. Carbofuran 3 G (40 g/sucker) with Carbendazim (0.2%) drenching (4, 6 and 8 months after planting) was found to be effective for the management of *Fusarium*-nematode complex in banana Rasthali. A new species of *Helicotylenchus* was observed in one of the root populations of a banana hybrid (H 03-10). Steps are taken to identify the species. Effective control of Sigatoka leaf spot of banana was achieved by three sprays of Propiconazole (0.1%) at 30 days interval with *Bacillus subtilis* or *Pseudomonas fluorescens* (0.5%).

Grape: Symptoms of grapevine leaf roll associated with virus (GVLRaV) were observed in 1–5-year-old vineyards at Narayangaon, Dindori (Nasik) and presence of GVLRaV 1+3 strain was confirmed with ELISA tests.

Releases of *Cryptolaemus montrouzieri* at 5,000 larvae/ha against pink mealybug *Maconellicoccus hirsutus* on grapes at Tuljapur near Solapur (Maharashtra) reduced mealybug infestation by 99.0%.

One antagonist yeast and an actinomyetes were isolated from vineyard. Spraying of *Trichoderma*

SUCCESS STORY

Checking root knot nematode in banana

Farmers of Jagannathpur village of Pipli block in Orissa are traditional banana-growers. Gajabantal variety grown there is used as vegetable in the region. Severe infestation of root-knot nematode was observed in all banana fields. Hot-water treatment was given to suckers at 55°C for 20 minutes and Furadan was added at 16.6 g per pit. After treatment, suckers were planted and general package of practices were followed. Growth and natural lustre of banana plants was better in treated plants. Average bunch weight was 30% higher where treated suckers were planted and Furadan + neem cake were incorporated in the pit-soil. Multiplication of the nematodes decreased.

during the last 30 days before harvesting reduced the PHI of Flusilazole from 48 to 18 days. Seasonal incidence of insect-pests in vineyards and its correlation with weather parameters were continued. Thrips and jassids populations were observed during November-December, coinciding with flowering period and berry setting. Two major species of thrips were found economically important. However, mealybug incidence was highest during the harvesting period in February-April.

Eight species of ants were found associated with mealybugs in vineyards. Several new generations insecticides like Spinosad, Buprofezin, Methomyl, Imidacloprid, Ihiamethoxam, Clothianidin, Fipronil, Chlorpyriphos and Cichlorvos were found safe for *Cryptolaemus montrouzieri*.

Screening and incorporation of disease resistance through hybridization resulted in identification of 42 hybrid seedlings free from downy mildew, 32 free from powdery mildew, 31 free from anthracnose,41 resistant/tolerant to rust and 22 free from all four diseases. Disease forecasting models for downy mildew, powdery mildew, anthracnose, rust and greenaria leaf spot were developed. Spraying of oils and *Trichoderma harzianum* and spraing of *Pseudomonas fluorescens* were found suitable to control anthracnose and greenaria leaf spot respectively. White variety Chenin Blanc and red varieties Cabernet Sauvignon and Pinot Noir were found suitable for the production of standard quality dry table-wines. Grapes of Pusa Navarang were found to be very rich in anthocyanins and phenols.

Citrus: Citrus psylla (*Diaphorina citri*) Kuwayama (Hemiptera: Psyllidae) is one of the serious insect-pests of citrus throughout India. Among bioagents, *Tamarixia radiata* (Hymenoptera: Eulophidae), a host-specific parasitoid, has been identified to be the key factor in keeping psylla population under check in Nagpur mandarin. Parasitism by *T. radiata* was more in spring (March, 78.4%) than in summer (July, 23.8%) and autumn (October, 7.2%) flushing seasons. Spring season was favourable for its growth and development. A temperature of 30°C favoured the development of *T. radiata* adults.

Psylla population preferred *Murraya* seedlings as compared to Nagpur mandarin. The multiplication of psylla on *Murraya* was faster than on Nagpur mandarin at 27 ± 2°C temperature and 65–70% RH. Parasitoid population was high during February-March as compared to other months under cage-house conditions. However, with increase in temperature outside during April, the nymphal population after its peak during mid-March faced gradual decline with appearance of psylla adults. Field release of *T. radiata* @ 40 adults/tree resulted in 50–62% reduction of psylla population. Of the indigenously available botanicals [Badakulanjan (*Alpinia galanga*), sweet flag (*Acorus calamus*), *safed kanher* (*Nerium odorum*), nirgundi (*Vitex negundo*) and neem (*Azadirachta indica*)] evaluated against *T.radiata*, rhizome extracts of *A. galanga* was safer as compared to other with regard to adult emergence of *T. radiata*.

Inclusion of VAM, PSB, *Azospirillum* and *Trichoderma harzianum* at 500, 100, 100 and 100 g/plant, respectively, to 75% of RDF for Kinnow and Khasi mandarin (7 years old trees) improved the plant growth parameters and productivity. Application of 75% recommended doses of nitrogen and potash through drip irrigation was found ideal. Leaf miner in citrus was effectively controlled by spraying Imidacloprid (0.005%) followed by NSKE (5%) or *Bacillus thuringiensis* (Bt) at 0.1% or Fenvalerate (0.005%) followed by fenvalerate (0.005%). Two releases of *Mallada boninensis* (4–6 eggs/shoot) have been found effective in IPM of citrus black fly (*Aleurocanthus woglumi*). Application of *Pseudomonas fluroscens* or *B. subtilis* (5 g/pot for each) along with FYM (0.5 kg/pot) and neem cake (50 g/pot) was found better in reduction of dry root rot.

Litchi: The combination of Trichocards @ 50,000 eggs/ha, applied at flowering and again 25 days later and two sprays of Azadiractin 5,000 @ 0.05% at 7 days interval at lentil-sized fruit growth stage followed by a repeated spray of Azadiractin at colour break stage performed better in controlling fruit-borer in litchi. The leaf roller incidence reached its peak in October at Mohanpur, while it was low in March which gradually increased and reached the maximum level in July at Pantnagar. Fruit-borer, *Dichocrosis punctiferalis*, *Platypelpa* sp. and *Conopomorpha cramerell* were also recorded.

Sapota: Three sprayings of lambdacyhalothrin (0.005%) or polytrin C at 15 days interval were found to be effective in management of bud-borer in sapota at Periyakulam.

Pomegranate: Bacterial blight in Maharashtra and Andhra Pradesh was major diseases affecting pomegranate. Bacterial blight (*Xanthomonas axonopodis* pv. *punicae*) was managed under field conditions by spraying of streptocycline (500 ppm).

Fruit-borers (*Deudorix isocrates*), bark-eating caterpillars (*Inderbela* sp.), thrips, aphids and white flies were major insect-pests causing damage to pomegranate.

Vegetable crops: Luring/repellent index of molasses and neem was determined in a laboratory study by recording the relative movement of fruit fly to bitter gourd shoots in a Y-type choice chamber sprayed with bait, repellent and water. The index was calculated taking into account the number of flies present in lure, repellent and middle chamber. The luring index of molasses and neem was more (0.95 and -0.95) in presence of a respective repellent and attractant in the adjacent chamber. While in the presence of water the luring index of molasses was 0.60 and the repellent index of neem was -0.45. In presence of neem the luring index of molasses improved by 58.30%.

In brinjal, damage by shoot-and fruit-borer (*Leucinodes orbonalis*) was significantly reduced with clipping of damaged shoot and release of egg parasitoid *Trichogramma chilonis* @ 50,000/ 0.4 ha at the time of initiation of shoot damage at weekly interval followed by two applications of Bt formulations (Dipel @ 1,000 ml/ha) at peak flowering stage.

IPM in cucumber. The IPM in protected cultivation of cucumber using soil solarization with polyethylene mulch and formaldehyde treatment with soil applications of neem seed powder and *Trichoderma harzianum* gave highest yield of 111 kg/plant over harvest period of 19 weeks.

Nematodes management in cucurbits. In cucurbits (bottle gourd), seed treatment of Carbosulfan (25 DS) at 3% w/w reduced root-knot nematode disease by 3%, resulting in 24% increase in yield over untreated control with a benefit : cost ratio 9.7.

Mites in vegetables. At Navsari, Propargite at 570 g ai/ha on brinjal and Diafenthiuron at 300–600 g ai/ha on field-rose effectively controlled spidermites up to two weeks, while in Ludhiana, Spiromesifen 240 SC at 300–500 ml/ha and Propargite at 750 ml/ha on brinjal resulted in 75% reduction in spidermite population. Propargite (200 ml/0.4 ha) and Kelthane 20 EC (300 ml/0.4 ha) were found promising against spidermites on bell pepper under net house conditions. In West Bengal, Propargite 2–3 mil/litre accounted for 70–78% mortality of spidermite on okra in a week. Two-spotted spidermites *Tetranychus urticae* were found to prefer middle canopy leaves of tomato plant compared to top and bottom canopy leaves. The host-plant resistance to this mite in tomato genotypes LA 1740, LA 1777, LA 280 and LA 2963 is attributed to glandular trichomes and biochemicals like methyl ketones (2 tridecanones and 2 undecanone), phenols and acylsugars. Fenpyroximate at 15–30 g ai/ha or Milbemectin at 3–4 g ai/ha controlled spidermites on tomato for 7–10 days, causing 70% reduction in population. In Coimbatore, Diafenthiuron (300–600 g ai/ha) has been found promising against this mite infesting tomato.

Mites in chilli. All life stages of yellow mite *Polyphagotarsonemus latus* were effectively controlled by Fenpyroximate 30 g ai/ha up to two weeks, resulting in more than 80% reduction in mite population on the popular chilli variety Byadgi Kaddi, which was severely infested (55–60 mites/6 leaves). Indam variety of chilli was fairly tolerant to yellow mite, which caused up to 39% losses in yield of susceptible varieties in West Bengal.

Potato: Two to three sprays of Mancozeb or 1 spray each of Mancozeb and Cymoxanil effectively controlled late blight and increased tuber yield significantly compared to the control in susceptible varieties Kufri Ashoka and Kufri Chandramukhi. Boric acid (3%) treatment of seed tubers before cold storage reduced incidence of bacterial wilt from 10.19 to 4.4% and increased tuber yield from 10.59 to 17.25 tonnes/ha. At Hassan, soil solarization after one irrigation reduced wilt incidence from 3.14 to 0.7% and germplasm accessions, CP 3786 and CP 1571, were found free from wilt.

Model developed for predicting the occurrence of late blight was successful in forecasting the appearance and build-up of disease in Uttar Pradesh. The late blight severity was very high throughout the country both in *rabi* and *kharif* seasons with expected losses up to 22% in Punjab, 70% (Atlantic) in Maharashtra and 20% (Kufri Jyoti) in West Bengal. Cymoxamil- and dimethomorph-based formulation was effective in controlling late blight.

Coconut: Application of vermicomposting in trenches and biofertilizers (*Azospirillum* and phosphobacteria) and raising vanilla and black pepper resulted in higher copra and nut yield. Native *Trichoderma viride*, *T. harzianum* and *T. hamatum* were effective in inhibiting the radial growth of stem bleeding disease pathogen *Thielaviopsis paradoxa* to an extent of 69.35% by *T. viride* followed by *T. hamatum* (66.70%)

and *T. harzianum* (63.33%). *T. harzianum* was applied as a paste on the bleeding patch coupled with basal application of the same bioagent (50 g) in combination with 5 kg neem cake (10.6 cm decrease).

Mites in coconut. Spray of Flufenzin at 80–100 g ai/ha and Clofentezine at 200–300 g ai/ha was found promising against coconut eriophyid mite in Karnataka, Tamil Nadu and Gujarat.

Spices: Endophytic bacteria found effective against *Phytophthora capsici* in black pepper were identified as *Pseudomonas aeruginosa* (BP-35) *Bacillus megaterium* (BP-17) and *P. putida* (BP-25) by analyzing the nucleotide sequence of 16s rDNA. *Bacillus megaterium* (BP-17) and another endophyte *Curtobacterium luteum* (TC-10) was found effective against *Radopholus*. An integrated pest management schedule involving planting of root mealybug-free rooted cuttings in field, removal of weeds in interspaces of black pepper vines during summer, especially when intercropped with coffee, drenching with Imidacloprid (0.075%) and adoption of control measures against *Phytophthora* and nematode infections was developed for the management of root mealybug. Neem gold (0.5%) and neem oil (0.5%) were found to be superior to fish oil insecticidal soap (2.5%) in reducing the population of scale insects in black pepper.

Trichoderma and *Pseudomonas* were found to be effective in controlling diseases of elephant-foot yam. 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. 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 the weevil damage.

Integrated pest management

Plant health clinics are established at four centres to cater to the requirements of the knowledge support and demonstration of IPM strategies to farmers.

On the pest forewarning front, a multiple regression model has been developed using maximum and minimum temperatures, relative humidity and population of one-week lag period for forecasting *Helicoverpa armigera* population at Sriganganagar (Rajasthan). The prediction rules for *Helicoverpa armigera* during *kharif* and *rabi* have been developed using threshold values of rainfall and degree-day accumulation.

Biological control

Introduction of natural enemies. The stem gall-fly *Cecidochares connexa* released in July 2005 for control of Siam weed *Chromolaena odorata* was established in field at Karnataka (2 locations) Tataguni village and GKVK, and has been successful for two winter and summer critical periods.

Pest management information system (PMIS)

PMIS has been developed on cotton, brinjal and okra. Decision-making software (pesticide Advisor) has also been developed with all information on available pesticides. For popularization of IPM, six different songs (in Telugu) along with video (explaining plant protection activities from sowing to harvest in cotton) were developed and broadcast through All India Radio in Andhra Pradesh.

Biosystematic studies on coccinellids. *Halyzia dejavu*, new sibling species of *Halyzia straminea* has been described from India and Nepal. Taxonomic revisions of *Synona*, *Scymnodes*, *Apolinus*, *Rhynchortalia* and *Cryptolaemus* (in part) have been carried out. A new species of *Horniolus* has been recorded from Karnataka.

Halyzia dejavu is a new sibling species

Endophytic bacteria. Antagonistic endophytic bacterium *Bacillus megaterium* induced high level of production of chitinase (2.794ì/g) and *Bacillus* sp. induced a high level of ß-1, 3-glucanase activity; indicating their high biocontrol potential. *Bacillus* sp. could inhibit *Fusarium solani* 50% and *Verticillium dahliae* by 48%, while *Ervinia herbicola* inhibited *F. solani* to 37.5%.

Biological suppression of plant-parasitic nematodes

At the TNAU, and AAU, Anand, talc formulation of *P. lilacinus* and *Pochonia chlamydosporia* at 20 kg/0.4 ha in pigeonpea resulted in 59% reduction in population of pigeonpea cyst nematodes and

Biological suppression of polyhouse pests

Applications of fungal formulations, viz. *Verticillium lecanii*, *Hirsutella thompsonii*, *Metarrhizium anisopliae* and *Beuveria bassiana* effectively reduced population of thrips (*Frankliniella* sp.) on gerbera plants in polyhouses in Kerala.

At Solan, *Paecilomyces fumosoroseus* at 10^{11} conidia/litre was effective in managing whitefly infesting cucumber in polyhouse, killing 67.1 and 39.3% whitefly nymphs within 15 days of treatment.

21% increase in pigeonpea yield. Talc formulations of *P. lilacinus* and *Pochonia chlamydosporia* when stored in aluminium sachet recorded 92–96% and 88–92% spore viability at 12 months of storage at 8–10°C and 4–8% moisture respectively.

Checklist of eriyophyid mites

Checklist of eriyophyid mites on tree species of Karnataka comprising 24 new genera has been prepared. Survey for plant-associated mites fauna revealed occurrence of *Eutetranychus orientalis* and *Brevipalpus phoenicis* on medicinal plants like *Bauhinia variegata, Piper longum, Rauvolfia, Withania somnifera, Ocimum, Dalbergia*, particularly in Varanasi.

Greater activity of predatory mites (Phytoseidae, Stigmaeidae, Tydeidae and Anystidae) and insects like coccinellids were observed on spidermite infested vegetable crops in Ludhiana (Punjab), Kalyani (West Bengal) and Varanasi (Uttar Pradesh).

Rodent management

In Andhra Pradesh, damage to *kharif* rice was recorded from 12.4 to 72.9% and up to 40% to *rabi* rice, and tiller damage was 11.09% and 13.6% in *sali* and *boro* rices. Pineapple suffered maximum with 13.2% fruit damage in lower Brahmaputra region. And cumin, an important seed-spice crop in Rajasthan suffered damage at vegetative growth stage, due to gerbils, *Tatera indica* and *Mus hurrianae*.

Botanicals. Anti-rodent properties of some plant products were evaluated in the laboratory. *Rattus rattus* recorded least preference for *Vitex nigundi* and *Polygonum* treated food in Asom. *Jatropha* seeds and seed coat powder registering negligible consumption by *Tatera indica* in no choice and choice trials in the laboratory indicate their deterrent/repellent properties. Sprinkling of neem leaf powder (0.5%) on gunny bags with alternate food under simulated storage provided total protection to treated bags up to 9 days. Feeding on 2, 4 and 6% root powder of *Calotrophis procera* in bait caused dose-dependent decrease in weight of reproductive organs and sperms function characteristics in *Rattus rattus.* Males of *Bandicota bengalensis* after administration of 0.01 and 0.02% gossypol for 16 days showed sterility effects in terms of decreased sperm motility, vitality and sperm concentration *vis-à-vis* reduced weight of reproductive organs and accessory glands.

Burrow fumigator. The modified burrow fumigator developed at Ludhiana showed more than 90% rodent control success, compared to zinc phosphide (2%) baiting (67% success).

Rodents damaged nursery

A farm woman using burrow fumigator

Rodents damage cumin crop

Traps and trap barrier system. Local made Butta recorded higher-rodent trap index than Tanjore kitty trap; indicating its superiority in trapping field rodents.

Rodenticides. Cholecalciferol, a vitamin D_3-based rodenticide revealed LD_{50} value of 30 and 50 mg/kg body weight for males and females. A new tablet formulation (12 g tab) of aluminium phosphide containing 6% a.i. evaluated in fields at Jodhpur, Bangalore, Jorhat and Marateru at one tablet per burrow dry and wet plugging yielded 65–71 and 55–62% control success at Jodhpur. In other centres control success was between 68 and 75%.

Trichoderma formulations with longer shelf-life developed

Trichoderma harzianum and *Pseudomonas fluorescens* formulations with enhanced shelf-life have been developed through appropriate formulation techniques. *T. harzianum* and *P. fluorescens* population were above 10^8 cfu/ml even after 10 months of storage.

Addition of glycerol in production medium at 3% concentration increased shelf-life of *Trichoderma* up to 8 months with 10^{11} cfu/g compared to control in which the cfu fell down to 10^6/g by the 6th month.

Heat shock (HS) at 30°C for 30 min induced desiccation tolerance in *T. harzianum* and helped in extending shelf-life by an additional one month.

Rodent control in Karnataka. Baits were prepared as prebait. This mixture was packed in plastic covers and each live burrow was prebaited with one such packet by farmers themselves. On the third day, 2% zinc phosphide was mixed with cereal-groundnut oil-groundnut seed mixture. This poison bait was packed again in plastic covers and all burrows were poison-baited. On the fourth day remaining live burrows were poisoned with bromadiolone cake at one cake/burrow. Along with field rodent control, baiting household rodent pests with bromadiolone cakes was also undertaken. At Kodihalli, campaign resulted in 65.5% population reduction in ragi and *jowar* mixed crop. At Konaghatta, it resulted 67.5% and 50.0% reduction in population density in ragi and potato, respectively. Similarly, at Linganahalli, rodent control success was 52.5% in ragi and *jowar* mixed crops.

Agricultural Ornithology

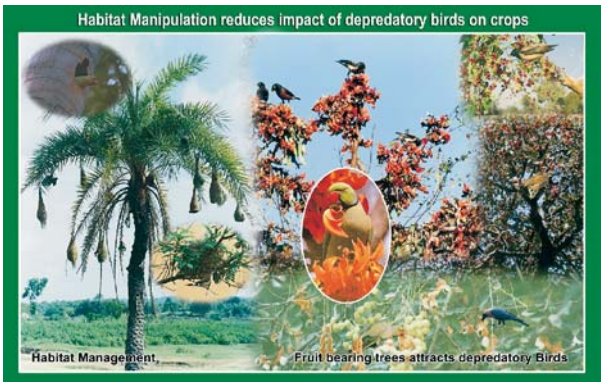
Status of birds and their extent of damage to different crops: In Punjab, monitoring of bird community in selected wheat and paddy fields at 3 locations has revealed occurrence of 23 and 25 species with maximum species richness of 15 and 12 at sowing/sprouting and tiller formation/earhead formation stages, which can be exploited for suppression of insects in these crops. Monitoring 2.02 ha wheat field under bed plantation at village Buani (Ludhiana) revealed 77.69% damage to sproutings and seedlings by house-crow, which resulted in wheat yield of only 500 kg/0.4 ha. While in Gujarat, bird community of wheat-crop agro-ecosystem was found dominated by cattle egret having relative abundance of 31.72%, followed by glossy ibis, Indian ring dove, little brown dove, large grey babbler, and red-wattled lapwing. Damage to germinating wheat seed was non-significant. In Kerala, damage to banana was by small green barbet (21%), to rice by baya-weaver bird, parakeets and teals (9.1, 19.7 and 5.0%), to pulses by parakeets (15.6%) and to pepper by koel, bulbul and barbets (15.9%), to tomato by house-crow (up to 13.5%) and to okra seed by parakeets (up to 11%). GPS and GIS technology in bird-roosting sites have provided information that birds are in close proximity to availability of preferred food, and the feeding activity of the birds showed significant correlation to cropping pattern. The feeding activity ranges between 2.5 and 16.5 km^2 with an average of 8.75 km^2. The extent of damage on different crops varied from 5 to 12%, from roost to roost in relation to number of birds. The incident i.e. of damage was very high within 7.5 km^2 from roost.

Eco-friendly bird management practices: Seed treatment with copper oxychloride at 3 g/kg seed in maize in *kharif* and *rabi* reduced birds abundance drastically from 44 to 67% in *kharif* and 23–74% in *rabi*.

In Punjab, in winter maize, installation of reflective ribbon + camouflaging of cobs in outer row on borders of field and installation of reflective ribbon + beating of drums regulated through rope by standing on a platform erected in the centre of the field resulted in 93.69 and 99.54% bird management success with corresponding damage reduction of 0.06 and 0.17% compared to 12.97% damage recorded in unmanaged (control) field.

Role of beneficial birds: In Andhra Pradesh, in pigeonpea least incidence of pest and extent of damage was observed where NPV + bird perches were employed. A total of 24 species of insectivorous birds were found in varying percentage (5.2–21.21) in different months. Among these birds, 15 species utilized (15.78–94.73) artificial bird perches and helped in controlling pests. In Punjab, in cotton artificial 'T' perches, followed by sorghum/millet perchings outperformed in their utilization than other perching facilities with mean number of visits performed by birds to be 4.00 to 9.27 ± 5.10 and 1.00 to 2.80 ± 1.17 per 20 minutes, respectively, for picking up insects. Relatively less number of bird species utilized 'T' perches and perching facilities in sprayed fields. Maximum utility of perches was by eight species in August-September which corresponded with increased foliage density and corresponding increase in insect infestation intensity. Similarly, in muskmelon, watermelon and bitter-gourd, artificial perches could attract 6, 8, 8 species out of total 8, 11, 13 species visiting crops.

Wooden nest boxes were readily accepted and adopted for breeding by common myna and spotted owlet, which resulted in 68.32% breeding success in common myna. While earthen pots with lids were adopted by house-sparrow and Indian robin,



and their egg laying was recorded in 22.06 and 1.47% pots. Egg laying by common myna was accomplished in three successive layings after successfully rearing of previous brood in 62.74, 27.45 and 17.65% wooden nest boxes.

Analysis of food samples of spotted owlet found high occurrence of rodents (60%) in winter, followed by insects (24%), while in summer and monsoon, insect-diet was predominantly high (58, 35%).

Presence of fruit-bearing trees like *Butea monosperna, Pithecolobium dulce, Morus alba* and *Salvadora persica* around farm lands attracted 18 species of insectivorous birds and helped in controlling crop pests to the extent of 40–63%.

Whitegrubs and other soil arthropods

Whitegrubs: Soil application of Chlorpyriphos 20 EC at 400 g a.i./ha and Bifenthrin 10 EC at 250 g a.i./ha in standing crop of potato against whitegrub *Brahamina coriacia* was found superior in terms of controlling tuber damage. Imidacloprid 0.75 G at 90 g a.i./ha as post-sown soil application in standing crop against whitegrub *Adoretus* sp. in greengram recorded lowest plant mortality at Jorhat centre.

Dissemination of pheromone technique of whitegrub through beetle management was demonstrated in village Sirsi near Jaipur covering 50 ha, involving 10 farmers' families. Out of the total 525 host-trees, only 160 trees were sprayed on the eve of good monsoon rain. One host tree in the radius of 15 m was selected in advance and up to 4 days from the day of monsoon rain, pieces of sponge dipped in pheromone (4/trees/day) were hung on the insecticide-sprayed trees regularly. The beetles attracted to these host trees in the evening after emergences fed on insecticide-treated leaves and died. This reduced egg laying in the field and thereby reduced grub damage in the groundnut field drastically and increased pod yield. This year due to beetle control operations, productivity increased to 1,500 kg/ha as against 400–500 kg/ha.

Termites: At Jorhat, Chlorpyriphos 20 EC at 400 g a.i./ha recorded lowest number of preserved setts of sugarcane infested by termite, and were at a par with Thiamethoxam 25 WG at 150 g a.i./ha and Imidacloprid 70 WS at 700 g a.i./ha. In groundnut, Imidacloprid 200 SL was found at a par with standard check Endosulfan 35 EC applied as seed treatment or as standing crop treatment at Durgapura.

Cutworms: Imidacloprid recorded minimum plant mortality (0.83%) and was significantly superior to Quinalphos (1.46%) and lambda Cyhalothrin (1.58%) against cutworms *Agrotis* species in brinjal. At Ranichauri, *Bacillus thuringensis* (0.02% foliar spray) was found effective against cutworm *Agrotis ipsilon* in potato, recording 7.83% tuber damage.

Pesticide residues

Trials of Imidacloprid on cotton carried out at Hyderabad at 35 and 70 g a.i./ha, showed that none of the samples (soil, lint and seed) exhibited presence of residues at harvest. Mixed formulation of Acephate (50%) and Imidacloprid (1.8% SP) on cotton was evaluated at PAU, Ludhiana. Their residues dissipated below detectable limit (0.02 mg/kg) 15 and 7 days after application.

Multilocation supervised trials of bifenthrin (60.0 and 120.0 g a.i./ha), Fenazaquin (40 and 80 g a.i./ha), Diniconazole (500 and 1,000 g a.i./ha) and Fenpropathrin (450 and 900 g a.i./ha) on apple were carried out at Solan, Mashobra, Matiana and Thanedhar (Himachal Pradesh). The residues were found below detectable limit within 30 days in all locations.

Tebuconazole (2% DS) on groundnut was evaluated at Jaipur, at 0.025 and 0.05 g a.i./kg seed. None of the samples of groundnut or soil showed presence of residues in any of the treatments.

Persistence of Bifenthrin and Fipronil, as termiticide in building soil, was studied jointly by AINP on Pesticide Residues, IARI and Central Building Research Institute (CBRI), Roorkee for five years. Their residues were detected up to

60 cm layer at higher rate of application. Surface residues persisted up to 37 months at lower dosages and up to 53 months at higher dosages (0.075 and 0.1%).

Simple and effective multi-residue methods of analysis of pesticide residues in various food commodities and environmental samples have been developed and validated by all co-ordinating centres. Validated methods for pesticide residues analysis have been documented in "Manual on Pesticide Residue Analysis" and has been published by the Directorate of Information and Publications of Agriculture, ICAR. The website of the All-India Network Project on Pesticide Residues has been launched (www.ainppr.com).

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Mites in flowers

Abamectin and Fenazaquin at 0.25–0.5 ml/ litre to suppression spidermites on marigold for 7 days with more than 90% reduction in mites population. At Coimbatore, Diafenthiuron (300–600 g ai/ha) has been found promising against this mite infesting polyhouse rose.