SOUTH ASIA

regional program: bangladesh | nepal | india

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South Asia
program summary

The main thrust of the South Asia Region has been to develop and test full-season IPM packages for each crop. These packages are supported by problem specification activities such as grower and pest surveys; component, discipline-based research; and evaluation activities that measure economic and social impacts. While each country develops a work plan based on local needs, every effort is made to coordinate activities among the countries. This is accomplished by holding annual regional planning meetings in one of the collaborating countries on a rotational basis and ensuring that representatives from each country are present at the annual meeting.

In addition, scientists from each country have the opportunity to travel to other countries for special training, workshops, and other functions. As a result several technologies developed in one or the other of these countries have been transferred and adapted to another country. These technologies include grafting, fruit fly pheromone mass trapping, and *Trichoderma* and *Pseudomonas* soil amendments. Opportunities for expansion of IPM CRSP activities in the region are possible since Bangladesh and Nepal have been named Feed the Future countries. It is most likely that mission-based Associate Awards will allow us to expand our programs in Nepal and Bangladesh in the coming year.

In Bangladesh the Bangladesh Agricultural Research Institute (BARI) is the main implementing research partner. Outreach partners include several major non-governmental organizations that support thousands of village-level trainers. It is likely that a new Associate Award in the coming year will expand the technology transfer activities beyond our historical research/demonstration sites to other vegetable growing regions in the country.

In Nepal, the primary sites include Nepal include Lalitpur District in the Kathmandu Valley in the Central Region and the Kaski District in the Western Region, encompassing the city of Pokhara and environs. The Nepal IPM CRSP project developed IPM packages for cucurbit and tomato, and cauliflower and tea, which are in the final stage of development.

In India, the IPM CRSP project involves three partner institutions. Our main partner is Tamil Nadu Agricultural University (TNAU) in southern India's Coimbatore; most of the research and IPM package development is done there, but we also partner with an NGO, The Energy Resource Institute (TERI), based in Delhi. TERI manages research and demonstration projects in three northern India sites: Uttar Pradesh, Andra Pradesh and Karnataka. A third partner is the company, BioControl Research Laboratories (BCRL) based in Bangalore. BCRL manufactures biopesticides, pheromones, soil amendments, parasitoids, and other inputs required by IPM packages. BCRL also provides education and technical assistance to farmers to ensure that the BCRL products are used properly.

BANGLADESH

Coutry bean

Demonstration of management packages for pests of country bean

S. N. Alam, N. K. Dutta, M. F. Khatun, M. A. Hossain, M, I, Islam, M. Y. Mian, E. Rajotte

Earlier in the project, the pod borer, *Maruca vitrata,* was considered as the major pest of country bean in Bangladesh. But recently *Helocovarpa armigera* infesting pods and aphids on shoots, flowers, and fruits have become equally important pests.

In Jessore and Narsingdi farmers' fields, the plot size of 0.2 ha per treatment with three replications in RCB design with two treatments was laid out: 1) IPM plot, comprising hand picking of infested flowers and fruits at alternate days, weekly release of egg parasitoid, *Tricogramma evanescens* (@ 1 gm parasitized eggs/ha/week) and larval parasitoid *Bracon hebetor* (800-1000 adult /ha/week), and spraying soap water (5 gm/liter of water) during initial aphid infestation along with two spraying of biopesticide Spinosad (Tracer 45 SC @ 0.4 ml/liter of water) and 2) Non-IPM treatment of farmers' practice, spraying Voliam Flexi 300 SC or Proclaim 5 SG at 3 days interval. A distance of 200 m was maintained between the IPM and non-IPM plots.

The number of healthy and infested flowers were counted and recorded from randomly selected 50 rachis/inflorescences to determine the insect infestation.

At both the locations, infestations of pod borer in country bean were significantly less than that of farmers' practice. At Jessore 65.7% less pod infestation in the IPM plots resulted in 34.6% higher yield (tab. 1). While at Narsingdi, 82.8% less pod infestation in the IPM plots resulted in 43.8% higher yield (tab. 2). Moreover, in the non-IPM plots, plant growth was stunted and the plants died around one and half month before IPM plots due to phytotoxicity caused by overuse of pesticides.

Table 1. Effect of different treatments on the management of pod borer complex at Satmail, Sadar, Jessore

Treatments	% flower infestation	% pod infestation	% reduction of pod infestation over non IPM plots	Yield (t/ha)	% yield increase over non IPM plots
IPM plot	0.5±0.1 a	3.5±0.6 a	65.68	24.5±0.7 b	34.6
Non IPM (farmers' practice) plot	3.0±0.4 b	10.2±0.9 b	-	18.2±0.4 a	-

Means of 10 observations and 3 replications; Means followed by the same letter in a column did not differ significantly by paired t-test (p<0.01)

Table 2. Effect of different treatments on the management of pod borer complex at Balabo, Narsingdi during 2011-12 cropping season

Treatments	% flower infestation	% pod infestation	% reduction of pod infestation over non IPM plots	Yield (t/ha)	% yield increase over non IPM plots
IPM plot	1.8±0.3 a	2.6±0.4 a	82.8	27.9±0.5 b	43.8
Non IPM (farmers' practice) plot	4.2±0.7 b	14.2±1.3 b	-	19.4±0.3 a	-

Means of 11 observations and 3 replications; means followed by the same letter in a column did not differ significantly by paired t-test (p<0.01)

Bitter gourd

Demonstration of IPM packages for bitter gourd

S. N. Alam, N. K. Dutta, S. Nahar, M. Z. H. Prodhan, M. I. Islam, M. Y. Mian, Edwin G. Rajotte

Bitter gourd is infested by fruit fly, two species of cutworms (*Spodoptera litura* and *S. execua*), and pumpkin caterpillar (*Diaphania indica*). In addition, soilborne fungal diseses also cause serious damage to plants.

A demonstration trial was undertaken in farmers' fields in the Jessore region (Chowgacha upazilla) and in the Bogra region (Sherpur and Sadar upazilla) during November 2011 to March 2012. At all the locations, the plot size was around 0.25 ha per treatment. There

Table 3. Effect of different treatments on the management of fruit fly and borer pest of bitter gourd and their corresponding yield at Jessore, Narsingdi, and Chittagong region

Treatments	Fruit infestation%	% reduction of fruit infestation	Yield (t/ha)	% Yield increase
Chowgacha, Jessore				
IPM field	3.2±0.6 a	63.2	37.4±0.5 b	28.1
Non-IPM field	8.7±0.9 b	-	27.3±0.4 a	-
Sherpur Upazilla, Bogra				
IPM field	1.7±0.2 a	85.2	23.2±0.7 b	26.4
Non-IPM field	11.9±0.8 b		17.3±0.5 a	
Sadar Upazilla, Bogra				
IPM field	1.7±0.4 a	75.1	26.2±0.6 b	29.9
Non-IPM field	6.7±0.9 a		18.5±0.3 a	

Means of 15-20 observations and 3 replications; means followed by the same letter in a column did not differ significantly by paired t-test (p<0.01

Table 4. Effect of Tricho-compost on fungal, viral, and nematode disease infestation of tomato

Treatment	Pathogens infected fruits weight* (t/ha)	Infected fruit weight (%)	Alternaria leaf spot (0-5 scale)	Leaf curl virus infected plants (no.)	Spotted wilt virus infection (0-5 scale)	Gall index (0-10 scale)	% infection reduced
T1	5.233 a	8.07	2.833 b	5.000	2.00 b	3.5 b	20
T2	3.783 b	5.27	2.000 c	3.667	2.33 b	2.3 c	32
T3	3.533 b	4.87	2.167 c	4.000	1.83 b	2.0 c	35
T4	6.300 a	11.15	3.667 a	5.333	3.17 a	5.5 a	
P value	0.0079		0.0011	NS	0.0249	-	
LSD	1.367		0.5508	-	0.799	-	
CV (%)	14.51		10.36	39.89	17.13	-	

T1=1/2 dose of Chemical Fertilizer + Tricho-compost 100g/plant, T2=1/2 dose of Chemical Fertilizer + Tricho-compost 150g/plant, T3=1/2 dose of Chemical Fertilizer + Tricho-compost 200g/plant and T4=Full dose of Chemical Fertilizer; *_Alternaria_, _Colletotrichum_, _Fusarium_ and others

were three dispersed replications set in an RCB design with two treatments: 1) IPM treatment comprised of sanitation, mass trapping of fruit flies with sex pheromone, and weekly release of egg parasitoid, *Tricogramma evanescens* (@ 1 g parasitised eggs/ha/week) and larval parasitoid *Bracon hebetor* (800-1000 adults/ha/week) and 2) Non IPM treatment, comprised of farmers' practice of spraying Voliam Flexi 300 SC or Proclaim 5 SG at 3 day intervals. A distance of 200m was maintained between the IPM and non-IPM plots. Five samples were taken at random in 2 m x 2 m area from each treatment. Numbers and weight of healthy and infested fruit were recorded during each harvest. The fruit infestations by fruit fly and borers were calculated from the recorded data.

At all the locations, fruit infestation by fruit fly and borer in IPM plots were significantly less than that of farmers' practice. At Jessore 63.2% less fruit infestation in the IPM treatment resulted in 28.1% higher yield; at Sherpur, Bogra, 85.2% less fruit infestation in the IPM treatment resulted in 26.4% higher yield; and at Sadar Upazilla, Bogra, 75.1% less fruit infestation in the IPM treatment resulted in 29.9% higher yield (tab. 3).

Tomato

Effect of Tricho-compost on tomato yield

Nahar, M. S., M A Rahman, M Afroz, M.Y Mian and S A Miller

Tricho-compost was found to be effective to control soilborne diseases and increase vegetable crop yields.

An experiment was conducted at BARI-Gazipur on tomato (variety BARI Tomato 14) in the 2011 winter season with four treatments: (i) half-recommended dose of chemical fertilizer + Tricho-compost at 100 g /plant; (ii) half dose of chemical fertilizer + Tricho-compost 150 g /plant; (iii) half dose of chemical fertilizer + Tricho-compost 200 g /plant; and (iv) a full dose of chemical fertilizer. Treatments were laid out in a completely randomized block design with three replications in a field at the research station.

The weight of diseased fruits was significantly lower in T3 and T2 treatment compared to T1 and the control T4 (tab. 4). Percent fruit infection due to pathogens was minimum in T3 (4.87%) followed by T2 (5.27%), T1 (8.07%), and control (11.15%) treatments. *Alternaria* leaf spot was significantly less in T2 and T3 treatments compared to T1 and control plots. The maximum incidence of *Alternaria* leaf spot was recorded in the control treatment. All Tricho-compost-incorporated treatments reduced root-knot nematode infestation (gall indexed) compared to control. The minimum nematode infection was recorded in T3 followed by T2. Nematode infection reduced by 35%, 32%, and 20% in T3, T2 and T1, respectively.

Fruit yield of tomato was increased by Tricho-compost (tab. 5). Total and marketable yield was maximum in T3 followed by T2 and T1 treatments (p=0.001). Yield obtained from T3 and T2 were higher statistically compared to T1 treatment.

Table 5. Effect of Tricho-compost on fruit yield of tomato

Treatment	Total yield (t/ha)	Marketable yield (t/ha)	Yield increased over control (%)
T1	70.07 b	64.83 b	14.74
T2	75.62 a	71.83 a	27.13
T3	76.13 a	72.60 a	28.50
T4	62.13 c	56.50 c	-
P value	0.001	0.001	-
LSD	4.429	3.640	-
CV (%)	3.12	2.74	-

T1=1/2 dose of Chemical Fertilizer + Tricho-compost 100g/plant, T2=1/2 dose of Chemical Fertilizer + Tricho-compost 150g/plant, T3=1/2 dose of Chemical Fertilizer + Tricho-compost 200g/plant and T4=Full dose of Chemical Fertilizer; Tricho-compost at 2.5 t/ha and 3.5 t/ha reduced disease incidence and increased yield of tomato

IPM package for summer tomato

M.A. Goffar, S. Ahmad, N. K. Dutta, M.A. Rahman, Sally Miller and Ed Rajotte

BARI has developed three heat-tolerant hybrid tomato varieties so far. But their production is constrained by bacterial wilt (*Ralstonia solanacearum*), viruses, and nematode infections. The present demonstration trial was undertaken to observe the effect of an IPM package on summer tomato production in a farmer's field.

This study was conducted at farmers' fields in villages of Mathpara and

Kanto Nagar, in Dhunat upazila of Bogra district during the summer season of 2012. Three farmers were selected for this study. The experiment was laid out in an RCB design with three replications. Each farmer was considered as one replication having three decimals of land (three tunnels). There were three treatments: i) T_1-IPM package with grafted tomato seedlings; ii) T_2-IPM package with non-grafted tomato seedlings; and iii) T_3- Farmer's practice. One decimal (one tunnel) of land was allotted for each treatment.

T_1 consisted of BARI hybrid tomato-4 (grafted on *Solanum sisymbriifolium*), using Tricho-compost, spraying of neem seed extract (*Azadirachta indica*), and using yellow sticky traps and pheromone trap. T_2 consists of non-grafted BARI hybrid tomato-4 and all of the above. T_3 (farmer's practice) consisted of non-grafted BARI hybrid tomato-4 and spraying of Maladan, Admire, Diathan-M 45, and Bavistin. In treatments 1 and 2, tricho-compost was used at the rate of 3 kg/tunnel along with cow dung and other recommended fertilizers. Seedlings (30 days old) were transplanted on June 8, 2012 in raised beds, maintaining a 60 cm x 40 cm distance between plants and between and within rows. Two hundred plants were accommodated in each tunnel. Yellow sticky and pheromone traps were placed in every tunnel to control white fly (*Bemisia tabaci*) and cutworm (*S. litura*). Neem oil solution was sprayed four times at 10 day intervals. The crop was protected from rain by a transparent poly-tunnel (10 mm polyethylene sheet).

Under farmer's practice (T_3), cow dung and other recommended fertilizers were used. Thirty day-old seedlings of BARI hybrid tomato-4 were transplanted in the raised bed at 60 x 40 cm distance between plants and between and within rows. Maladan, Admire, Diathan-M 45 and Bavistin were sprayed by the farmers four times at 10 day intervals. The crop was protected from rain by a transparent poly-tunnel. Ten plants were randomly selected from each treatment for data collection. Data were recorded on: number of days to 50% flowering; days to harvest; number of fruits per plant; individual fruit weight; fruit yield per plant; and fruit yield per tunnel/ decimal of land. Incidence of virus, wilting, and nematodes were recorded at 45, 60, 75, and 90 days after sowing (DAS).

Significant differences were observed among the treatments, and the IPM package had a remarkable influence on summer tomato production. The maximum number of fruit per plant (33.11) was recorded from the treatment T_1: plant grown under IPM production system with grafted tomato seedlings. The corresponding fruit yield per plant was also the highest in T_1 (1.25 kg) than T_2 (1.06 kg) and T3 (1.11kg). A wide variation in yield per unit area was recorded between the IPM and non-IPM production systems. From treatment T_1, 197.39 kg of tomato were harvested from one tunnel or one decimal of land when plants were grown under the IPM production system, while the lowest yield of tomato was obtained from treatment T2 (112.65kg) (tab. 6). This variation was mostly attributed due to the difference in survivability of plants among the treatments. The maximum number of tomato plants survived in treatment T_1 (182). This difference was attributed to the effect of grafting tomato seedlings with wild species. In T_1, the highest percent of virus infestation (12% at 90 DAS) and the lowest percent of wilt infestation (6%) were recorded, and no nematode infestation were observed (tab. 7). The lowest virus infestation (8% at 90 DAS) was recorded in T_3. The magnitude of the highest wilt infestation (20% at 90 DAS) was observed in T_2. This result indicated that the IPM system, including the grafting technology, tricho-compost, and neem oil spraying, is essential for tomato production during summer in the wilt prone areas of Bangladesh.

Table 6: Influence of production system (IPM and non-IPM system) on summer tomato production

Treatments	Days to 50% flowering	Days to first harvest	Number of fruits/plant	Individual fruit weight (g)	Fruit yield/ plant (kg)	Yield (kg/ tunnel)	Plant survived/ tunnel
T1 (IPM-graft.)	45.00b	88.00b	33.11a	43.46b	1.25a	197.39a	182.00a
T2 (IPM-non graft.)	53.67a	94.00a	24.48c	48.29a	1.06b	112.65c	149.33c
T3 (Farmer's practice)	53.66a	93.66a	26.41b	47.68a	1.11b	120.64b	158.00b
LSD (0.05)	1.19	3.66	1.7	3.15	0.10	6.55	4.77
CV (%)	1.04	1.76	2.53	2.94	3.71	2.02	1.29

Table 7: Incidence of virus, wilting, and nematode disease on summer tomato grown under IPM and non-IPM production system

Treatments	*Virus infestation (%)				*Bacterial wilt infestation (%)				*Nematode Infestation (%)			
	45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS	75 DAS	90 DAS
T1 (IPM-graft.)	2.0	3.0	4.0	12.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0
T2 (IPM-non graft.)	1.0	2.0	4.0	9.0	0.0	0.0	11.0	20.0	0.0	0.0	0.0	5.0
T3 (Farmer's Practice)	2.0	3.0	2.0	8.0	0.0	0.0	9.15	19.0	0.0	0.0	0.0	4.0

* Cited mean value

Eggplant

Effect of Tricho-compost on eggplant yield

Nahar, M. S., M A Rahman, M Afroz, M. Rahman, M. G. Kibria, M.Y Mian, and S. A Miller

Eggplant is the second most important and popular vegetable in Bangladesh. In Bangladesh, eggplant farmers often fail to obtain the expected yield due to heavy damage caused by various insect-pests and diseases. Tricho-compost is highly effective to control soilborne disease of vegetable crops. This experiment was conducted at BARI, Gazipur on eggplant (variety BARI brinjal 8) in the summer season of 2011, using four treatments that are characterized by the type of fertilizer applied: (i) half dose of recommended chemical fertilizer + Tricho-compost 1.5 t /ha; (ii) half dose of chemical fertilizer + Tricho-compost 2.5 t/ha; (iii) half dose of chemical fertilizer + Tricho-compost 3.5 t/ha; and (iv) full dose of chemical fertilizer ($N_{120}P_{40}K_{60}S_{20}Zn_2B_1$). Treatments were laid out in a completely randomized block design with three replications at the research station. Tricho-compost was applied in the seed bed. In the main field, Tricho-compost was applied in the pits before planting as well as top dressing at vegetative stage. Two thirds of Tricho-compost was applied before transplanting and one third after establishment.

Application of Tricho-compost increased yield and reduced fruit borer, disease, and nematode infestation of eggplant. Pathogens *Phomopsis*, *Alternaria, Colletotrichum,* and *Fusarium* were identified from infected fruits. Percentage of pathogen and borer infected fruits were less in T_3 followed by T_2 and T_1 (p=0.0001). Eggplant shoot and fruit borer infestation significantly reduced due to application of Tricho-compost (p=0.001). Borer infestation was less in T_3 and T_2 treatment than T_1 and control treatment. The minimum nematode gall index was recorded in T_3 and T_2 treatments. Both T_2 and T_3 treatment reduced 33% nematode infestation over control. Yield increase over control was the high in T_3 (55.19%) treatment followed by T_2 (49.92%) and T_1 (37.30%).

IPM package for eggplant

M. Nazmi Uddin and M Khaled Sultan

The production of eggplant is hindered by eggplant shoot and bruit borer (ESFB), mites, Jassid, thrips, and wilt. Through the IPM CRSP program, an IPM package was developed to produce good quality and pollution-free eggplant. For the last couple of years, this package was tested in farmers' fields and was found to be suitable and profitable to produce eggplant. Therefore, an attempt was made to disseminate and popularize the developed package in the Mymensing region.

This study was conducted in farmers' fields in Jordhighi, Tangail and Fulbaria Mymensingh, February to July 2012, to disseminate IPM packages among the farmers. The four treatments with five replications (each farmer was treated as one replication) were: T1 local eggplant variety and farmer's practice; T2 soil amended with Tricho-compost and use of local cultivar; T3 use of Tricho-compost, wilt resistant variety (BARI Begun 8), pheromone, braconoids; and T4 use of Tricho-compost, grafted seedlings (*S. sissymbriflium* as stock and farmers variety as scion), pheromone, and bracanoid release. Seedlings were produced at BARI, Gazipur and planted on April 8–12, 2012. For each treatment, 350 grafted resistant variety and local variety seedlings were planted. Tricho-compost was used @ 12kg/dec. in each plot. The recommended amount of fertilizer, cow dung at the rate of 10 t/ha, Urea 150 kg/ha, and TSP 175kg/ha, and MP 150 kg was applied. Half of the cow dung, all of the TSP, and half of the MP were applied during land preparation. The remaining half of the cow dung was applied during pit preparation. The rest of MP and the entire urea were applied in three equal installments at 15, 30, and 45 days after transplanting. Plants were spaced at 1 x 1 m. Mites were controlled by applying Vertimec two times at 7 day intervals. Irrigation, weeding, and other cultural operations were done as needed. Data were recorded on infection and infestation of BW and ESFB and yield per ha and analyzed statistically.

Yield and infestations were presented in table 8. It was revealed that the grafted plots were more susceptible to wilt as compared to non-grafted plots. An extensive study was made in the pathology laboratory of HRC, BARI, and it was found that the root stock became susceptible to BW. It was concluded that *sissymbriflium* should be checked rigorously in the lab, and a new root stock has to be used instead of *sissymbriflium*. However, infestation of ESFB has been successfully minimized by using pheromones. The fruit yield was significantly higher compared to the farmer's practice. The yield differences were not much higher with the farmer's practice due to adjacent setting of pheromone traps.

Table 8. Infestation and quality yield of eggplant fruit at Tangail and Fulbaria Mymensingh, 2012

Treatment	% Wilt	Amount infested fruit /harvest (kg/plot)	Quality fruit /plot (kg)	Quality fruit /plot (t/ha)
T1	22.3b	8.7a	146.5b	15.3a
T2	16.1c	6.8a	186.2a	18.6a
T3	7.1d	2.3b	189.6a	18.8a
T4	73.3a	1.7b	78.8c	6.1b
Level of significant	*	*	*	*
CV%	5.2	3.3	12.6	9.5

T1 Local eggplant variety & farmer's practice
T2 Soil amended with Tricho-compost and use of local cultivar
T3 Use of Tricho-compost, wilt resistant variety (BARI Begun 8), pheromone, and braconoids
T4 Use of Tricho-compost, grafted seedlings (S. sissymbriflium as stock and farmers variety as scion), pheromone, and braconoid release

Pointed gourd

Effect of Tricho-compost on root-knot disease of pointed gourd

Nahar, M. S., M A Rahman, M.Y. Mian, and S A Miller

Pointed gourd (*Trichosanthes dioica*) is one of the popular vegetables in Bangladesh. Root-knot nematode, *Meloidogyne* sp., causes root damage and facilitates entry of *Fusarium* spp. A trial was conducted to evaluate the effect of tricho-compost on the incidence of root-knot nematode and the fungal disease. Seedlings of pointed gourd raised in polyethylene bags were transplanted in the field. Four treatments consisting of T1= Tricho-compost @1. 5 t/ha; T2= Tricho-compost @ 2. 5 t/ha; T3=Tricho-compost @ 3. 0 t/

Table 9. Effect of Tricho-compost on yield of pointed gourd

Treatment	Average fruit number/ plot	Fruit number increased over control (%)	Average fruit weight (kg)/plot	Fruit weight increased (%)
T1=Tricho-compost 1. 5 t/ha	199	11.17	11.30	15.12
T2=Tricho-compost 2.5 t/ha	217	21.23	13.45	25.12
T3=Tricho-compost 3.0 t/	203	13.41	12.70	18.14
T4=Without Tricho-compost	179		10.75	

ha; and T4= control were laid out in a randomized complete block design.

Both the fruit number and weight increased in Tricho-compost treated plots (tab. 9). An increase in fruit weight (25.12%) over control was recorded in T2. The reduction in number of root-knot nematodes in the rhizosphere was recorded in T3 (63.6%) followed by T2 (54.6%) and T1 (36.4%) treatments.

Okra

Management of okra yellow vein mosaic virus and nematodes of okra

Rahman, M. A., M. Afroz, A. Muqit, M Saifullah, A. Sarker, M. M. Rahman

Infection by *Okra yellow vein mosaic virus* (OYVMV) is considered one of the main causes of yield reduction in okra in addition to anthracnose disease and root knot nematodes. Jassids and white flies are common insect pests and white fly is a vector of OYVMV. The objective of this trial was to identify technologies for management of OYVMV, nematode, and insect pests of okra.

The experiment was laid out in a randomized complete block design with 4 replications during April 2012 with BARI dherose-1 and completed in August 2012. Tricho-compost @ 3 t/ha was used in all treatments as a basal dose except in the control treatment. There were six treatments: (i) Application of salicylic acid (0.5%); (ii) marigold as barrier crop; (iii) spraying of marigold extract (0.1%) + spraying of neem seed kernel extract (10%); (iv) spraying of neem kernel extract (10%); (v) yellow trap; and (vi) untreated control. The sprays in the treatments were given four times at 15 day intervals, starting from 35 days after germination. Data on OYVMV development at 30, 45, 60, and 75 days after germination was recorded. The nematode infestation index and yield were recorded at the end of the experiment.

Results showed that the incidence of OYVMV started from 30 days of plant growth in most of the treatments, with 1%–3% disease incidence. The infection of OYVMV increased with increasing plant age, and at 75 days of plant age about 86.5% to 96.5% plants in the field were infected by OYVMV. The five treatments applied in this experiment were not able to prevent the infection of OYVMV. All the treatments significantly reduced nematode infestation over the control. The nematode infestation was significantly reduced in salicylic acid treated plots. The highest yield was obtained from marigold extract + neem seed kernel extract treated plot.

None of the treatments used in this experiment were effective in controlling OYVMV. Breeding for resistance to OYVMV may the best option available.

Cabbage

IPM package for cabbage production

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Soilborne pathogens *Pythium*, *Sclerotium*, *Phytophthora, Meloidogyne* spp. cause foot and root rot disease to the seedlings of cabbage in the seed bed as well as in the main fields. On the other hand, larvae of diamondback moth *(Plutulla xylostella)* and *Spodopthera litura* cause serious damage in the field. Application of Tricho-compost to reduce the incidence of diseases in hand picking of insect larvae twice a week and use of pheromone traps to monitor *Spodoptera* are also useful techniques in IPM package development. The present study was carried out to identify an effective package for raising a healthy cabbage crop using tricho-compost with a reduced dosage of chemical fertilizers.

Seedlings of cabbage variety "Summer Warrior" were grown on Tricho-compost treated plots in farmers' fields at Darail, Gabtoli, Bogra, in August 2011, which continued into 2012. Three treatments were applied: T_1=Tricho-compost @1.0 t/ha; T_2= 1.5 t/ha; T_3 = 2.0 t/ha; and T_4= farmer's practice, using cowdung @ 5 t/ha + TSP @ 100kg/ha in the selected site. The experiment was set up in the second week of August 2011 for rising seedling. Data on growth characteristics of seedlings were taken from 50 seedlings at 30 days of plant growth. Seedling mortality, plant height, root length, and fresh and dry weight were recorded.

In the main field, two farmers, each having about one bigha (1/3 of an acre) plot, were selected. In these plots, four treatments were applied. The treatments were: T_1= Tricho-compost @ 3.0 t/ha + ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$; T_2= Tricho-compost @ 2.5 t/ha +¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$; T3= Tricho-compost @ 2.0 t/ha + ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$; and T_4= Farmers practice, using the full recommended dose of $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$. In the field, pheromone traps for management of *Spodoptera* were set up after 15 days of transplanting. The head damage by insect infestation, mortality for fusarium wilt, total bio-mass, and marketable yield were recorded.

Mortality of seedlings occurred due to the incidence of damping off disease caused mainly by *Pythium* sp. Mortality of the seedings was reduced in Tricho-compost-treated plots by 9.7-13.9% depending on dose of application (tab. 10). The highest reduction was recorded in T_3 (13.9%). Application of Tricho-compost increased the height of shoot and the dry and fresh weight of cabbage seedlings compared to farmers' practice. The shoot height increased 20.4%–31.8% and dry weight 24.5%–38.5% over farmer's practice.

In the main field, plant mortality due to *Fusarium* wilt was the lowest (2.4%) in Tricho-compost treated plot T_1, where 3.0 t/h compost with ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$ was applied followed by T_2, T_3, and T_4. Similarly, head damage by *Spodoptera* was lower in T_1, T_2 and T_3 compared to farmer's practice (T_4).

Marketable yield and total yield of cabbage were found to be higher in Tricho-compost + fertilizer treated

Table 10. Seedling mortality of cabbage under different treatments at farmers' field in Bogra

Treatment	Total no. of seedlings (m^2)	Dead seedlings (m^2)	Mortality (%)	Reduction of mortality over T4 (%)
T1=Tricho-compost @1.0 t/ha	386.2	72.5	18.8	9.70
T2=Tricho-compost @1.5 t/ha	394.5	62.2	15.8	12.7
T3=Tricho-compost @ 2.0 t/ha	401.3	58.6	14.6	13.9
T4= Farmers' practice (cowdung @ 5 t/ha + TSP @ 100 kg/ha)	345.2	98.6	28.5	-

plots compared to farmer's practice. The highest yield was found in T_1 (75.8 t/h). The increased yield over farmers' practice were 19.8, 11.8, and 7.3 tons/ha in T_1, T_2, and T_3 respectively. The benefit cost ratio (BCR) was highest in treatment T_1 (tab. 8). Application of Tricho-compost sucssfully reduced seedling and plant mortality in the nursery bed and field and increased yield of cabbage. Hence, use of Tricho-compost with ¾ $N_{180}P_{70}K_{120}S_{20}Zn_4B_2Mo_1$ along with *Spodoptera* pheromone trap could be used for healthy cabbage production.

NGO cooperation

Dissemination of IPM technology by NGO

The Mennonite Central Committee (MCC), a partner with the IPM CRSP, is working with a group of 230 farmers in a village called Kamarpara in Chupinagar union, Bogra district. Among the farmers, 33 are producing Tricho-compost, 10 are producing vermicompost, and 35 are using sex pheromone traps in eggplant, cucurbits, cabbage, and cauliflower crops. The plant pathology division of HRC, BARI supplied the *Trichoderma* solution for preparing the Tricho-compost. In total, farmers produced about 18 tons of Tricho-compost from July 2011 to September 2012, and most of them also used it in their vegetable fields. They were very happy to see the effect of Tricho-compost in their fields for preventing wilt disease and higher yield production.

GKSS Agro Enterprise produced 510.5 tons, of which they sold about 434.2 tons, of Tricho-compost over July 2011 to August 2012. They are also marketing Tricho-liquid under the brand name "Tricho power." Last year, they produced 10,485 L of "Tricho power," of which 9536 L were sold. In addition, they trained 4000 farmers and 320 dealers/retailers on Tricho-compost use.

Economic Analysis

A survey of 300 vegetable growers was conducted to assess the impacts of pheromone traps on IPM adoption in gourds and to assess the factors affecting IPM adoption. These analyses are being completed as part of a Ph.D. dissertation at Virginia Tech.

NEPAL

Bitter melon

Evaluation of IPM for bitter melon

To evaluate an IPM package for bitter melon, an experiment was laid out in a randomized block design with four replications and five treatments, with each treatment containing 10 plants.

Treatment 1: Biofertilizers only

Compost (FYM): 5.0kg, Nitro fix: 16.0g, P-sol-B: 28.0g, K-sol-B: 42.0g, Agri-VAM: 22.0g

Treatment 2: Biopesticide only

Compost (FYM): 5.0kg, *Trichoderma viride:* 23.3g, *Trichoderma harzianum: 23.3*g, *Pseudomonas fluorescens: 47.0*g, *Metarhizium anisopliae: 47.0*g, *Paecilomyces* spp.: 47.0g, *Bacillus subtilis:* 9.3g

Treatment 3: Biofertilizers + Biopesticides

Compost (FYM): 5.0kg, Nitro fix: 16.0g, P-sol-B: 28g, K-sol-B: 42.0g, Agri-VAM: 22.0g, *Trichoderma viride:* 23.3g, *Trichoderma harzianum:* 23.3g, *Pseudomonas fluorescens: 47.0*g, *Metarhizium anisopliae: 47.0*g, *Paecilomyces* spp.: 47.0g, *Bacillus subtilis: 9.3*g

Treatment 4: Farmers' practice

Urea: 86g, DAP: 195g, Potash: 150g, Compost (FYM): 5.5kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45 and 60 days after transplantation).

Treatment 5: Control

The combined effect of biofertilizers and biopesticides on bitter gourd (var. Pali) increased yield by 58.2 kg when compared with farmer's practice. The economic return was $17.3 more per treatment when compared with farmers' practice.

The combined effect of biofertilizers and biopesticides in increasing the yield of bitter gourd (var. Chaman) was significant when compared with biopesticides and control treatments.

Table 11: Performance of Biofertilizers and biopesticide in bitter gourd var. Pali in Rupandehi District

Treatments	Mean Yield in (Kg)
Biofertilizers	124.2 b
Biopesticides	116.8 b
Biofertilizers + biopesticides	167.1a
Farmer's practice	108.9 c
Control	38.9 d

Average yield in kg from 10 plants, 4 replications and 19 harvests

Table 12: Performance of biofertilizers and biopesticides on bitter gourd var. Chaman in Rupandehi District

Treatments	Mean Yield in (Kg)
Biofertilizers	103.8 ab
Biopesticides	95.2 b
Biofertilizers + biopesticides	125.0 a
Farmer's practice	102.6 ab
Control	21.4 c

Average yield in kg from 10 plants, 4 replications and 19 harvests

Bitter gourd

Evaluation of IPM package on bitter gourd in Rupandehi district

Field experiments were laid out in a RBD with six replications and two treatments, each treatment containing 15 plants.

Treatment 1 : Biofertilizers and Biopesticides

- Compost (FYM): 7.5kg, Kohinoor 750g and Oxyrich 75g as a basal dose for 15 plants of bitter gourd (var. Chaman).
- Biodan granules 10-15 days after seedling transplant: 30g.
- Second and third dose of Biofertilizers Kohinoor and Oxyrich (750g and 75g) at flowering and fruit setting stage or 45 and 60 days after basal dose application.
- Spraying Bio-hume 6%SL @ 2.5ml per liter of water after transplant.
- Spraying Boom or Agro-Boom @ 2ml per liter of water before flowering stage.
- Spraying bio-fit @ 1g per lit of water to the point of drenching after scouting report justified for diseases.
- Spraying borer gourd @ 0.5-2ml/lit of water to the point of drenching, for red pumpkin beetles and if economic threshold level (ETL) recorded for fruit fly =1 by using pheromones and traps along with food lures.

Treatment 2 : Farmers' practice

- Application of Urea: 130g, DAP: 193g, Potash: 225g, Compost (FYM): 7.5kg for 15 cucurbit plants. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45 and 60 days after transplantation).

Yield of bitter gourd (var. Chaman) increased by 38.6 kg due to the IPM package as compared to farmer's practice. The economic return from the IPM package was $11.50 more per treatment than the farmers' practice.

Table 13: IPM package on bitter gourd var. Chaman in Rupandehi District

Treatments	Mean Yield in kg
IPM package	191.8 a
Farmer's practice	153.2 b

Cucumber

Evaluation of cucumber IPM package

Treatments were same as in bitter gourd.

The yield of cucumber var. Bhaktapur Local increased by 119.1 kg due to the IPM package when compared with the farmer's practice. The economic return from the IPM package was $56.70 per farmer more from cucumber var. Bhaktapur Local than from the farmer's practice (tab. 14).

The yield of cucumber var. Bhaktapur Local increased by 58.2 kg due to the IPM package as compared to Farmers' practice. The economic return from the IPM package was $31.2 more farmers' practice (tab. 15).

Table 14: IPM package on cucumber var. Bhaktapur Local in Kaski District

Treatments	Mean yield in kg
IPM package	332.8 a
Farmer's practice	213.7 b

Average yield in kg from 15 plants, 6 replications, and 29 harvests; significant at 1% level (T-test)

Table 15: IPM package on Cucumber var. Bhaktapur Local in Lalitpur District

Treatments	Mean Yield in kg
IPM package	254.1 a
Farmer's practice	195.9 b

Average yield in kg from 40 plants, 10 farmers' participation as replications, and 12 harvests; significant at 1% level (T-test)

Tomato

Tomato IPM package development

Tomato trials were conducted in two geographical regions:

1. Open fields in Terai (Rupandehi District)
2. Plastic tunnels in Mid-Hills (Pokhara and Lalitpur Districts)

Seedlings were prepared on raised seedbeds amended with compost and *Trichoderma*. Three week-old seedlings were planted on raised beds laid with drip irrigation lines. Before planting, the field was amended with biofertilizers and biopesticides along with compost. Plots were irrigated once a day and pruned as needed. Plants were staked a month after transplantation. Foliar spray of biopesticides was carried out after the first appearance of pest damage symptoms. Fruits were harvested at half ripe stage on alternate days. The weight of harvested fruits was taken from each plot.

Evaluation of new components of tomato IPM Package

Different components, such as biofertilizers, biopesticides, and farmer's practices were evaluated in farmers' fields in three districts of Nepal. Insect traps with pheromones were installed at the time of seedling transplant.

An experiment was conducted in the Kaski District in a RBD with four replications and five treatments, each treatment containing four var. Srijana tomato plants.

Treatment 1: Biofertilizers only

Compost (FYM): 2.7kg, Nitro fix: 4.4g, P-sol-B: 4.0g, K-sol-B: 10.8g, Agri-VAM: 4.0 g

Treatment 2: Biopesticide only

Compost (FYM): 2.7kg, *Trichoderma viride:2.*0g, *Trichoderma harzianum: 2.*0g, *Pseudomonas fluorescens: 4.*0g, *Metarhizium anisopliae:* 4.0g, *Paecilomyces* spp.: 4.0g, *Bacillus subtilis:* 5.2g

Treatment 3: Biofertilizers + Biopesticides

Compost (FYM): 2.7kg, Nitro fix: 4.4g, P-sol-B: 4.0g, K-sol-B: 10.8g, Agri-VAM: 4.0g, *Trichoderma viride: 2.*0g, *Trichoderma harzianum:* 2.0g, *Pseudomonas fluorescens:* 4.0g, *Metarhizium anisopliae:* 4.0g, *Paecilomyces* spp.:4.0g, *Bacillus subtilis: 5.2*g.

Treatment 4: Farmers' practice:

Urea: 34.4g, DAP: 78g, Potash: 60g, Compost (FYM): 2.68g. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. The remaining half dose of urea was applied as three split doses (30, 45 and 60 days after transplantation).

Table 16: Performance of Biofertilizers and biopesticides on Tomato var. Srijana in Kaski District

Treatments	Mean Yield in (Kg)
Biofertilizers	13.98 c
Biopesticides	15.3 b
Biofertilizers + biopesticides	20.38a
Farmer's practice	13.23 cd
Control	7.87 e

Yield in kg averaged over 4 plants, 4 replications, and 22 harvests; significant at 5% level.

Treatment 5: Control

In spite of hail stone damage, the yield of tomato significantly increased due to the combined effect of biofertilizer and biopesticides as compared to all other treatments.

Tomato non-chemical IPM package in Mid-hills

Seeds from tomato variety Srijana are washed with Somguard @ 20mL/L of water to remove pathogens from the seed coat. Before planting, 1 kg of seeds is treated with 5mL of molasses slurry, 5 mL Biohume, and 1 g of microbial consortium. Seedlings are raised in poly bags containing solarized soil, neem seed powder, and biofertilizer- and biopesticide-amended compost.

A spacing of 75 cm between rows and 45–60 cm within rows was adopted. Plants were stacked, mulched, and pruned. (Note: 1 ropani = around 500 m^2.)

Fertilizers applied

Basal dose

Well decomposed farm yard manure (FYM)
1000kg/ropani

Nitrofix – AZ, *Azospirillum*
500g/ropani

P Sol – B, *Bacillus megaterium*
500g/ropani

K Sol – B, *Frateuria aurantia*
500g/ropani

Zn Sol – B, *Thiobacillus thio-oxidans*
500g/ropani

S Sol – B, *Thiobacillus ferro-oxidans*
500g/ropani

Mn Sol –B, *Corynebacterium*
500g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
500g/ropani

Meterhizium anisopliae for soilborne insects pests
500g/ropani

Trichoderma viride for soilborne diseases
500g/ropani

Paecilomyces lilacinus or *Bacillus firmus* for root knot nematode
625g/ropani

All biofertilizers, bioinsecticides, and biofungicides were amended in 50kg FYM and applied at the root zone of each plant.

During initial stage of crop, Biohume 6%SL, mix 5mL/L of water, was applied.

Five pheromone traps/ropani were installed using *Helicoverpa armigera* lure in a funnel trap. Based on the trap catch monitoring, Nuclear polyhedrosis virus (NPV) of *Helicoverpa armigera* @ 0.5-1 mL/L or *Bacillus thuringiensis* var. *kurstaki* (*Btk*) @ 1-2 g/L or Borer guard @ 0.5-1 mL/L of water is applied (Borer guard consists of *Bacillus thuringiensis* var. *kurstaki, Verticillum lecanii, Beauvaria bassiana* and *Metarhizium anisopliae* and a microbes like Silrich constituting *Aspergillus awomori, Trichoderma viride, Cellulomonas uda*, and *Cellulomonas gelida.)*

1st top dressing (One month after field transplant or at flowering stage):

Well decomposed farm yard manure (FYM)
500kg/ropani

Nitrofix – AZ, *Azospirillum*
250g/ropani

P Sol – B, *Bacillus megaterium*
250g/ropani

K Sol – B, *Frateuria aurantia*
250g/ropani

Zn Sol – B, *Thiobacillus thio-oxidans*
250g/ropani

S Sol – B, *Thiobacillus ferro-oxidans*
250g/ropani

Mn Sol –B, *Corynebacterium*
500g/ropani

VAM – *Vesicular arbuscular mycorryza*
250g/ropani

Meterhizium anisopliae for soilborne insects pests
250g/ropani

Trichoderma viride for soilborne diseases
250g/ropani

Paecilomyces lilacinus, or *Bacillus firmus* for root knot nematode
315g/ropani

All biofertilizers and biopesticides are amended in 25kg FYM and applied at root zone of each plant.

2nd top dressing (At fruit development stage):

Farm yard manure (FYM)
500kg/ropani (500m^2)

Amend all biofertilizers and biopesticides in 25kg FYM and apply at root zone of each plant:

Nitrofix – AZ, *Azospirillum*
250g/ropani

P Sol – B, *Bacillus megaterium*
250g/ropani

Zn Sol – B, *Thiobacillus thio-oxidans*
250g/ropani

S Sol – B, *Thiobacillus ferro-oxidans*
250g/ropani

K Sol – B, *Frateuria aurantia*
250g/ropani

Mn Sol –B, *Corynebacterium*
500g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
250g/ropani

Meterhizium anisoplae for soil borne insects pests
250g/ropani

Trichoderma viride for soil borne dis-

Table 17: IPM on tomato var. Srijana in Lalitpur District

Treatments	Mean Yield in (Kg)
Biofertilizers	141 b
Biopesticides	126 bc
Biofertilizers + biopesticides	180a
Farmer's practice	116 bc
Control	98 c

Average yield in kg from 25 plants, 4 replications, and 29 harvests; significant at 5% level

eases
250g/ropani

Paecilomyces lilacinus or *Bacillus firmus* for root knot nematode
315g/ropani

Biohume – Bioactive, Humic & Fulvic Substances

The combined effect of biofertilizers and biopesticides on Tomato var. Srijana increased yield by 64 kg as compared to farmers' practice. The economic return from the IPM package was $34.30 more than farmers' practice.

Cauliflower

Evaluation of biofertilizers and biopesticides on cauliflower

An experiment was conducted in Kaski District in RBD with four replications and five treatments, each treatment containing 20 plants.

Treatments:

Treatment 1: Biofertilizers only

Compost (FYM): 27.0kg, Nitro fix: 36.0g, P-sol-B: 88.0g, K-sol-B: 88.0g, Agri-VAM: 88.0g

Treatment 2: Biopesticides only

Compost (FYM): 27.0kg, *Trichoderma viride: 13.4g*, *Trichoderma harzianum: 13.4g*, *Pseudomonas fluorescens: 26.6g*, *Metarhizium anisopliae: 26.6g*, *Paecilomyces* spp.: 26.6g, *Bacillus subtilis: 54.0g*

Treatment 3: Biofertilizers and biopesticides

Compost (FYM): 27.0kg, Nitro fix: 36.0g, P-sol-B: 88.0g, K-sol-B: 88.0g, Agri-VAM: 88.0g

Trichoderma viride:13.4g, *Trichoderma harzianum: 13.4g*, *Pseudomonas fluorescens: 26.6g*, *Metarhizium anisopliae: 26.6g*, *Paecilomyces* spp.: 26.6g, *Bacillus subtilis:* 54.0g,

Treatment 4: Farmer's practice

Urea: 172g, DAP: 390g, Potash: 300g, Compost (FYM): 20kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45, and 60 days after transplantation).

Treatment 5: Control

Combined effect of biofertilizers and biopesticides on cauliflower var. Snow Mystic increased in yield by 6.5 kg as compared to biofertilizers alone. The economic return from IPM package was recorded $1.90 more compared to farmer's practice.

Cauliflower non-chemical IPM package (Lalitpur District)

Seeds are washed with Somguard @ 20mL/L of water to remove pathogens from the seed coat. Seedlings are raised in nursery beds containing solarized soil, neem seed powder, and biofertilizer- and biopesticides-amended compost.

A spacing of 60 cm in between rows and 45 cm within rows was adopted.

Fertilizers (bio)

Basal dose

Well decomposed farm yard manure (FYM)
1000kg/ropani

Nitrofix – AZ, *Azospirillum*
2000g/ropani

P Sol – B, *Bacillus megaterium*
5000g/ropani

K Sol – B, *Frateuria aurantia*
6000g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
3000g/ropani

Meterhizium anisopliae against soil-borne insects pests
50g/ropani

Trichoderma viride against soilborne diseases
50g/ropani

Trichoderma harzianum
50g/ropani

Pseudomonas flurorescens
50g/ropani

Bacillus subtilis
100g/ropani

Paecilomyces lilacinus or *Bacillus firmus* against root knot nematode
50g/ropani

Crop establishment: During initial stage of crop or period of stress, apply Biohume 6%SL; mix 5 mL/L of water for root dip or nursery drenching applied by drip or spray. If needed, mix 5 g of Oxyrich - N / liter of water and drench nursery bed for planting 800 m^2 of seedling.

Top dressing (One month after field transplant or at head formation stage)

Well decomposed farm yard manure (FYM)
500kg/ropani

Amend all biofertilizers, biopesticides, and biofungicides in 25-50 kg of FYM and apply at root zone of each plant.

Nitrofix – AZ, *Azospirillum*
1000g/ropani

P Sol – B, *Bacillus megaterium*
2000g/ropani

K Sol – B, *Frateuria aurantia*
20000g/ropani

VAM – *Vesicular Arbuscular Mycorryza*
1000g/ropani

*Meterhizium anisopliae*against soil borne insects pests
25g/ropani

Trichoderma viride against soil borne diseases
25g/ropani

Trichoderma harzianum
25g/ropani

Table 18: Performance of biofertilizers and biopesticides on cauliflower var. Snow Mystic in Kaski District

Treatments	Mean Yield in (Kg)
Biofertilizers	14.8 b
Biopesticides	18.3ab
Biofertilizers + biopesticides	21.7a
Farmer's practice	15.2 b
Control	8.9 c

Average yield in kg from 20 plants, 4 replications, and 3 harvests; significant at 1% level

Table 19: Performance of biofertilizers and biopesticides cauliflower var. Snow Mystic in Lalitpur District

Treatments	Mean Yield in (Kg)
Biofertilizers	15.75 c
Biopesticides	13.5 bc
Biofertilizers + biopesticides	25.0a
Farmer's practice	16.75 b
Control	11.5 bc

Pseudomonas fluorescens
25g/ropani

Bacillus subtilis
50g/ropani

Paecilomyces lilacinus or *Bacillus firmus* against root knot nematode
25g/ropani

Evaluation of IPM components on cauliflower in Rupandehi and Kaski districts

Combined effect of biofertilizers and biopesticides on cauliflower var. Snow Mystic increased yield by 8.25 kg compared to biofertilizers alone. Economic return from IPM package was $4.5 more compared to farmer's practice.

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 11kg, Kohinoor 1000g and Oxyrich 100g as a basal dose for 20 cauliflower plants.
- Biodan granules 10-15 days after seedling transplant: 40g.
- Second and third dose of biofertilizers Kohinoor and Oxyrich (1000g and 100g) at flowering and fruit setting stage or 45 and 60 days after basal dose application.
- Spray Bio-hume 6%SL @ 2.5ml per liter of water after transplant during stress period.
- Spray Boom or Agro-Boom @ 2ml per liter of water before flowering stage.
- Spray bio-fit @ 1g per lit of water to the point of drenching after scouting report justifies against diseases.
- Spray borer gourd @ 0.5-2mL/L of water to the point of drenching, for *Spodo* and DBM moths, if economic threshold level (ETL) recorded for DBM =1 and for *Spodoptera litura* moths = 4-5 by using pheromones and traps.

Treatment 2 : Farmer's practice

- Apply urea: 172.0g, DAP: 390.0g, potash: 300.0g, compost (FYM): 11 kg for 20 cauliflower plants. Full dose of potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Average yield in kg from 20 plants, 6 replications, and 3 harvests. Significant at 1% level (T-test)

Cauliflower var. Snow Mystic yielded 5.29 kg more by adopting IPM package compared to farmer's practice. Economic return from IPM package was $ 1.60 more compared to farmer's practice.

Table 20: IPM package on cauliflower var. Snow Mystic in Kaski District

Treatments	Mean Yield in (Kg)
IPM package	17.30 a
Farmer's practice	12.01 b

Average yield in kg from 10 plants, 4 replications. and 7 harvests; significant at 5% level

Eggplant

Evaluation of IPM components on eggplant in Rupandehi District

Field experiment was in RBD with four replications and five treatments each treatment with 20 plants.

Treatment 1: Biofertilizers only

Compost (FYM): 10.0kg, Nitro fix: 10g, P-sol-B: 15g, K-sol-B: 15g, Agri-VAM: 15g

Treatment 2: Biopesticide only

Compost (FYM): 10.0kg, *Trichoderma viride:* 5g, *Trichoderma harzianum:* 5g, *Pseudomonas fluorescens: 10.0*g, *Metarhizium anisopliae: 10.0*g, *Paecilomyces* spp.: 10.0g, *Bacillus subtilis:* 20g

Treatment 3: Biofertilizers + biopesticides

Compost (FYM): 10.0kg, Nitro fix: 10.0g, P-sol-B: 15g, K-sol-B: 15g, Agri-VAM: 15g, *Trichoderma viride:* 5.0g, *Trichoderma harzianum:* 5.0g, *Pseudomonas fluorescens: 10.0*g, *Metarhizium anisopliae: 10.0*g, *Paecilomyces* spp.: 10.0g, *Bacillus subtilis:* 20g

Treatment 4: Farmers' practice

Urea: 172g, DAP: 390g, Potash: 300g, Compost (FYM): 11kg. Full dose of potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45, and 60 days after transplantation).

Treatment 5: Control

Eggplant var. VNR-218 with biofertilizers and biopesticides yielded 4.5 kg more when compared with farmer's practice. Economic return from IPM package was $ 1.34 more when compared with farmer's practice.

Table 21: Performance of biofertilizers and biopesticides on eggplant var. VNR-218 in Rupandehi District

Treatments	Mean Yield in (Kg)
Biofertilizers	16.9 a
Biopesticides	17.9 a
Biofertilizers + biopesticides	18.6 a
Farmer's practice	14.1 ab
Control	8.4 c

Average yield in kg from 18 plants, 4 replications, and 5 harvests; significant at 5% level

Evaluation of IPM package on eggplant in Rupandehi District

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 11 kg, Kohinoor 1000 g, and Oxyrich 100 g as a basal dose for 20 eggplants.
- Biodan granules 10-15 days after seedling transplant: 40g.
- Second and third dose of biofertilizers Kohinoor and Oxyrich (1000g and 100g) at flowering and fruit setting stage or 45 and 60 days after basal dose application.
- Spray Bio-hume 6%SL @ 2.5ml per liter of water after transplant during stress period.
- Spray Boom or Agro-Boom @ 2ml per liter of water before flowering stage.
- Spray bio-fit @ 1g per lit of water to the point of drenching after scouting report justifies against diseases.
- Spray borer gourd @ 0.5-2 mL/L of water to the point of drenching, for eggplant shoot and fruit borer ESFB moths, if economic threshold level (ETL) recorded for ESFB =1 and for *Leucinode orbanalis* moths = 1 by using pheromones and traps.

Treatment 2 : Farmer's practice

- Apply urea: 172.0g, DAP: 390.0g, potash: 300.0g, compost (FYM): 11 kg for 20 eggplants. Full dose of potash and phosphorous along with half dose of urea were applied during transplan-

Table 22: IPM package on eggplant var. VNR-218 in Rupandehi District

Treatments	Mean Yield in (Kg)
IPM package	40.7 a
Farmer's practice	33 b

Average yield in kg from 34 plants, 6 replications, and 5 harvests; significant at 1% level (T-test)

tation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Eggplant var. VNR-218 yielded 7.7 kg more in IPM package than farmer's practice. Economic return from IPM package was $2.30 more when compared with farmer's practice.

Tea

IPM package on tea in Illam

The experiment was laid out in randomized block design with six replications and two treatments. Each treatment had 20 plants.

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 11kg, Kohinoor 1000g and Oxyrich 100g as a basal dose for 20 tea plants.
- Biodan granules 10-15 days after basal dose: 40g.
- Apply second and third dose of Biofertilizers Kohinoor and Oxyrich (1000g and 100g) at 45 and 60 days after basal dose application.
- Spray bio-fit @ 1 g/L of water to the point of drenching after scouting report justifies against *Fusarium* wilt, blister blight, and black spot fungal diseases.
- Spray borer gourd @ 0.5-2mL/L of water to the point of drenching for control of thrips, *Helopeltis,* and red spider mites.

Treatment 2: Farmer's practice

- Urea: 172.0g, DAP: 390.0 g, potash: 300.0 g, compost (FYM): 11 kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Yield of Tea Clone Takdha-78 increased by 0.955 kg in IPM package over farmer's practice. Economic return from IPM package was $ 0.46 more compared to farmer's practice.

Coffee

Coffee IPM package development: Biofertilizer and biopesticide evaluation in the Palpa District

An experiment was conducted to evaluate biofertilizers and biopesticides on coffee in the Palpa District. The experiment was in Completely Randomized Block Design with four blocks and five treatments, and each treatment had 20 plants.

Treatment 1 (T1): Biofertilizers only

Compost (FYM): 54kg, Nitro fix: 200g, P-sol-B: 375g, K-sol-B: 500g, Agri-VAM: 500g,

Treatment 2 (T2): Biopesticides only

Compost (FYM): 54kg, *Trichoderma viride:* 269g, *Trichoderma harzianum:* 269g, *Pseudomonas fluorescens: 269*g, *Metarhizium anisopliae: 538*g, *Paecilomyces* spp.: 538g, *Bacillus subtilis: 108*g

Treatment 3: Biofertilizers + Biopesticides

Compost (FYM): 54kg, Nitro fix: 200g, P-sol-B: 375g, K-sol-B: 500g, Agri-VAM: 500g, *Trichoderma viride:* 269g, *Trichoderma harzianum:* 269g, *Pseudomonas fluorescens: 269*g, *Metarhizium anisopliae: 538*g, *Paecilomyces* spp.: 538g, *Bacillus subtilis: 108*g

Treatment 4: Farmers' practice

Urea: 172.0g, DAP: 390.0g, potash: 300g, compost (FYM): 54kg. Full dose of potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea was applies as three split doses (30, 45, and 60 days after transplantation).

Treatment 5: Control

The combined effect of biofertilizers and biopesticides on *Coffea arabica* increased the yield by 7.95 kg when compared with farmer's practice. The economic return was $3.31 more per plot when compared with farmer's practice.

Table 23: Evaluation of IPM package on Tea in Fikkal, Illam District

Treatments	Mean Yield in (Kg)
IPM package	6599.2 a
Farmer's practice	5644.2 b

Average yield in g from 10 plants, 6 replications and 18 pickings; significant at 5% level (T-test)

Table 24: Performance of biofertilizers and biopesticides on *Coffea arabica* in Palpa District

Treatments	Mean Yield in (Kg)
Biofertilizers	17.37 bcd
Biopesticides	21.85abc
Biofertilizers + biopesticides	26.28a
Farmer's practice	18.33 bcd
Control	12.31 cd

Average yield in kg from 20 plants, 4 replications, and 4 harvests; significant at 5% level

Table 25: Evaluation of IPM package on coffee in Balbhadra Sharma District

Treatments	Mean Yield in (g)
IPM package	10.45 a
Farmer's practice	5.77 b

Average yield in g from 3 plants, 6 replications, and 4 harvests; significant at 5% level (T-test)

Evaluation of Coffee IPM Package in the Sharma District

Field experiments, in randomized block design, were conducted, with six replications and two treatments. Each treatment had 3 plants.

Treatment 1: Biofertilizers and biopesticides

- Compost (FYM): 54kg, Kohinoor 1000g and Oxyrich 100g as a basal dose for 20 Coffee plants.
- Biodan granules 10-15 days after basal dose: 40g.
- Apply second and third dose of biofertilizers Kohinoor and Oxyrich (1000g and 100g) at 45, and 60 days after basal dose application.
- Spray bio-fit @ 1g per lit of water to the point of drenching after scouting report justifies against fungal diseases.
- Spray borer gourd @ 4-6 mL/L of water to the point of drenching

around the main trunk, for control of Coffee White Stem Borer (CWSB).

Treatment 2 : Farmer's practice

- Urea: 172.0g, DAP: 390.0g, Potash: 300.0g, Compost (FYM): 11kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation. Remaining half dose of urea applied in three split doses (30, 45, and 60 days after transplantation).

Yield of *Coffea arabica* in the IPM package increased by 4.68 kg when compared with farmer's practice. Economic return was recorded $ 1.95 higher when compared with farmer's practice.

INDIA

Okra

Okra IPM package trials (TNAU)

One IPM farmer participatory research trial was conducted with the following IPM components:

T1: IPM Module

- Seed treatment with *Trichoderma viride* (4g/kg) and *Pseudomonas fluorescens* (10g/kg).
- Soil application of *Pseudomonas fluorescens* (2.5kg/ha).
- Soil application with neem cake @ 250 kg/ha
- Maize as border crop against movement of whiteflies/*Liriomyza*
- Use of yellow sticky traps
- *Helicoverpa* and *Earias* adult monitoring with pheromone traps
- *Trichogramma* release after each brood emergence of *Helicoverpa* and *Earias*
- Application of neem oil formulations/Neem seed kernel extract
- Need-based application of insecticides/fungicide/acaricide

T2: Farmer's practice

Table 26. Pest incidence, yield and economics in IPM and FP fields of okra trial in Annur, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Aphid (% Plant damage)	4.1	6.0	31.66
Whitefly population (number per leaf)	9.6	18.5	48.10
Leafhopper population (number per leaf)	4.8	9.5	49.47
Serpentine leafminer damage (% leaf damage)	7.6	10.5	27.04
Fruit borer damage (%)	8.1	13.8	41.30
Yellow vein Mosaic (% infected plants)	2.8	7.1	60.56
Powdery mildew (PDI)	6.0	9.4	36.17
Root rot (% infected plants)	6.0	9.2	34.78
M. incognita population (population/250 mL soil)	62.0	102.0	39.21
Nematode gall index	1.1	2.3	52.17
Natural enemies coccinellid beetles/ plant spiders / plant syrphids / plant leafminer parasitism %	 4.3 2.8 1.9 14.8	 2.8 1.2 0.8 7.0	 +34.88 +57.14 +57.89 +52.70
Number of chemical sprays	1	5	
Ecofriendly biopesticides sprays	3	1	
Mean yield (t/ha)	17.00	13.12	+29.57
C:B ratio	1: 2.53	1: 1.23	

Observations were made in 50 plants @ 10 plants each in 5 places in both IPM and FP plots for most of the insect pests and diseases. The fruit damage is recorded during harvest.

The results revealed that the mean population of sucking pests in the IPM plot was low when compared with the farmer's practice. Incidence of leaf miner was observed lesser in IPM plot (7.6 %) as compared to farmer's practice (10.5%). With respect to diseases, powdery mildew, root rot, and YVMV incidence was lesser in IPM plot as compared to farmers' practice. The leaf miner parasitism was high in IPM plots. Nematode severity was found to be lower in IPM plots as compared to FP. The adoption of IPM technology in okra resulted in reduction of the number of chemical sprays to 1 from 5 in non-IPM fields. The crop yield in the IPM plot was 17.00 t/ha coupled with higher C:B (1:2.53) as compared to 13.12 t/ ha with a C:B ratio of 1:1.23 in farmer's practice.

Okra IPM Demonstrations (TERI)

IPM package for okra

- Use of high yielding/tolerant variety - Arka Anamika
- Seed treatment with *Trichoderma viride* and *Pseudomonas fluorescens* @ 10 g /kg
- Soil treatment with *Paecilomyces* for nematode management
- Soil treatment with Neem cake @ 200 kg/ha
- Pheromone traps for monitoring and mass trapping of *Earias vitella* @ 10/ha
- Yellow sticky traps for monitoring and mass trapping of whiteflies, aphids, jassids @ 20 /ha
- Biopesticides such as Neem formulation, Bollcure formulation, *Beauveria bassiana* formulation, and NPV of *H. armigera*
- Need-based use of green label safe pesticides

Farmers practice of okra cultivation:

- Farmers are not aware about resistance/ tolerant varieties
- Seed treatment with biocontrol agents is not a regular practice, some innovative farmers do the same with chemical seed protecting
- No soil treatment, if situation demanded they give only chemical treatment phorate , carbofuran or chlorpyriphos
- No knowledge about nematode infestation
- Most of the farmers are not aware about pheromone trap and yellow sticky traps
- Generally farmers use chemical pesticides, few of them use neem leaf decoction.

Figure 1. *Earias* boring okra fruit (TERI)

Okra IPM trials were conducted at three locations in Western Uttar Pradesh, North India, and three locations in Kolar and Chittoor, South India. IPM growers both in the South and North received better yield and income compared with conventional farm practices. In the North, IPM farmers (Fields 3, 2, and 1) received 105%, 101%, and 45% higher yields than conventional farmer practice (tab. 1), respectively. In the south, IPM farms (Fields 1, 2, and 3) obtained 38.5%, 19.6%, and 22.7% higher yields compared with conventional farm practice, respectively.

In okra fields in both the South and North, the green jassid population was not manageable by any method. In IPM fields, the average jassid population was 1.5 to 18 per leaf, while in conventional farmer practice it was at 40 adults/leaf. *Earias, Helicoverpa,* and *Spodoptera* were the major yield reducers present during the trials.

In the North, the highest fruit damage was observed in farmer practice (30.8%), while in IPM 15.5% fruits were recorded damaged in field 3, followed by field 2 (10.3%) and field 1 (8.4%). In the south, 24% fruit damage was recorded from farmer practice (field 4), while in IPM the highest fruit damage was recorded at field 3 (17.6%) followed by field 1 (14%) and field 2 (12%).

In the North, IPM demonstration trials' average okra yield was 6557 kg/ hectare, while in the South, the average IPM okra yield was 5104 kg/ hectare. About a 22% higher yield was obtained by farmers in the North, the probable reason being the poor soil on which the Southern farmers had laid down their trials. In the North, the average IPM okra farmer income was Rs. 109,775/ hectare, while in the South it was 21,818/ hectare. Income differences were attributed to the low prices obtained in the South versus in the North. Northern farmers sell their produce in a big vegetable market near District Ghaziabad and receive a better price, while all Southern farmers sell their produce in local markets.

In the North, the highest yield was obtained in IPM field 3 (7323 kg), followed by field 2 (7187 kg) and Field 1 (5162 kg), and the lowest yield was recorded in conventional farm Field 4 (3559 kg). Highest net profits were earned by the IPM Field 3 (Rs. 126,236), followed by Field 2 (Rs. 113,812) and Field 1 (Rs. 89,278), whereas in farmer practice (Field 4), the average net profit was Rs. 38,655.

In the South India okra IPM trials, the highest yield was obtained by Mr. Sarvana (5557 kg), but due to price fluctuations, he could not fetch highest net income. Mr. Kumar obtained 4816

Table 27. Yield, fruit damage and income from okra IPM and farmer practice during kharif 2012, North India

Farmer Name	Field no.	DOS	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Ramkishan	Field1	26.3.12	21.0	8.4	5162	110223	89278
Toshif	Field2	20.3.12	19.2	10.3	7187	138616	113812
Khalid	Field3	25.3.12	20.0	15.5	7323	146841	126236
Conventional farm	Field 4	7.3.12	19.8	30.8	3559	70716	38655
CD at 5%				9.1	388.2	-	-
CV				26.0	35.2	-	-

Table 28. Yield, fruit damage, and income from okra IPM during Rabi 2011, South India

Farmer Name	Field no.	DOS	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr.Sarvana	Field 1	20.8.11	6.1	14.0	5557	33962	21612
Mr. Kumar	Field 2	10.8.11	9.2	12.0	4816	44460	22847
Mr.Vishwanath	Field 3	30.7.11	8.0	17.6	4940	39520	20995
Farmer practice	Field 4	1.8.11	9.0	24.0	4025	37050	14820
CD at 5%	-			NS	1378.0	-	-
CV	-				37.0	-	-

Table 29. Pest incidence, yield and economics in IPM and FP fields of Brinjal trial in Karadimadai, Tamil Nadu, 2011–12

Parameter	IPM	FP	% reduction over farmers practice
Aphid (% Plant damage)	11.2	28.0	60.00
Whitefly population (no./leaf)	3.6	8.7	58.62
Leaf miner damage (% leaf damage)	6.2	15.8	60.76
Leaf hopper population (no./leaf)	2.3	5.6	58.93
Fruit borer damage (%)	12.6	31.8	60.37
Epilachna beetle (% leaf damage)	2.4	5.9	59.32
Ash weevil Leaf damage %	8.2	12.7	35.43
Root rot (% infected plants)	6.2	9.7	36.08
M. incognita population(Population/250 ml soil)	132	225	59.38
Nematode gall index	2.0	5.0	60.00
Natural enemies coccinellid beetles/ plant spiders / plant syrphids / plant leafminer parasitism %	 3.0 2.0 1.0 18.0	 1.0 Stray Stray 4.0	 +66.67 - - +77.78
Number of chemical sprays	3	11	
Ecofriendly biopesticides sprays	4	1	
Mean yield (t/ha)	18.50	14.25	+29.80
C:B ratio	1: 2.42	1: 1.12	

Table 30. Distribution of pheromone traps and lures to farmers for eggplant fruit and shoot borer

No. of farmers benefited	Area covered	No. of traps Distributed	No. of lures Distributed
Leucinodes lure: 72 brinjal farmers all over state of Tamil Nadu	52.5 ha	755	2265
Spodoptera and *Helicoverpa* lures:15 tomato farmers of Coimbatore district	10 ha	125	500
Plutella and *Spodoptera* lures: 40 cabbage and cauliflower farmers of Nilgris district and Dindigul district	12ha	100	300
Earias and *Helicoverpa* lures: 42 farmers of Okra in Coimbatore and Trichy district	10 ha	50	200

Table 31. Screening of selected eggplant entries against BFSB, *Leucinodes orbonalis*

Entries	Plant population	No. of fruits	Yield (kg)	Fruit and shoot borer infestation (%)
HD 1	138	4899	85.25	18.8
HD 2	166	4357	79.40	23.5
HD 3	103	3876	63.45	25.0
CO 2	11	147	2.75	46.3

kg of okra fruits and received the highest income of Rs. 22,847 among all farmers in the trials.

Eggplant (Brinjal)

Brinjal IPM trials (TNAU)

One IPM farmer participatory research trial was conducted with the following IPM components

T1: IPM Module

- Seed, nursery, and seedling dip treatment with *Pseudomonas* @ 10 g/ kg of seed/L of water
- Soil application with Neemcake @250 kg/ha
- Maize as border crop against movement of whiteflies/ *Liriomyza*
- Use of yellow sticky traps against White flies and *Liriomyza*
- Clipping of shoot borer infested terminals
- *Leucinodes* adult monitoring with pheromone traps
- *Trichogramma* release after each brood emergence of *Lucinodes*
- Application of Neem products (Azadirachtin based formulations/ NSKE)
- Need based application of insecticides

T2: Farmer's practice

Observations were made in 50 plants @ 10 plants each in 5 places in both IPM and FP plots for most of the insect pests and diseases. The fruit damage was recorded during harvest

The results revealed that the mean population of sucking pests in the IPM plot was low compared with farmers' practice. A lower incidence of leaf miner was observed in the IPM plot (6.2 %) compared with the FP (15.8 %). With respect to diseases, root rot incidence was lower in the IPM plot (6.2%) compared with the FP (9.7%). The leaf miner parasitism was high in IPM plots (18%). Nematode severity was found to be lower in IPM plots compared with FP. The adoption of IPM technology in brinjal resulted in a reduction of the number of chemical sprays to 3 from 11 in non-IPM fields. The crop yield in the IPM plot was 18.50t/ha with higher C:B (1:2.42) compared with the farmer's practice yield of 14.25 t/ha with a C:B of 1:1.12.

Pheromone technology in eggplant shoot and fruit borer (TNAU)

Eggplant shoot and fruit borer is one of the major constraints to the production of quality fruit in Tamil Nadu. Use of pheromone technology is one of the IPM components of eggplant pest management. Considering the importance of this pest, eggplant shoot and fruit borer pheromone lures were supplied to the farmers of Tamil Nadu for popularization and to minimize the use of insecticides. In the current year, pheromone lures were supplied to the farmers of Coimbatore, Tiruppur, Trichy, Madurai, Dindugal, Karur, Erode, Ramanathapuram, Theni,

Table 32. Yield, fruit damage, and income from brinjal IPM and farmer practice during kharif 2012 in North

Farmer Name	Field no.	DOS	DOT	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr. Niranjan	Field 1	29.2.12	20.3.12	4.5	9.1	34638	158771	138458
Mr. Omkar	Field 2	29.2.12	25.3.12	6.4	8.2	22995	147446	132226
Mr. Vinod	Field 3	29.2.12	24.3.12	6.5	12.5	23514	153782	136655
Farmer practice	Field 4	25.2.12	22.3.12	6.1	16.1	21439	131749	106002
CD at 5%					NS	NS	-	-
CV					-	-	-	-

Pudukkotai, Tuticurin, and Virudhunagar districts of Tamil Nadu. Through our field trials, farmers were educated to use the eco-friendly insecticides based on the pheromone trap catches on the need basis. Farmers are also advised to release the *Trichogramma egg* parasitoids based the trap catches.

At the end of the trials, it was observed that many farmers have reduced about three to five sprays in the pheromone traps deployed fields, and it was observed that about 20% of the cost of insecticides has been saved.

Germplasm collection and screening against biotic stress agents for brinjal fruit and shoot borer (TNAU)

The selected entries (HD 1, HD 2, and HD 3) were rigorously screened against fruit and shoot borer using CO 2 as check. To obtain the homogeneity, individual plant selection was made, and the promising entries were used for the breeding programme. See table 31.

The same entries were also used as scions in grafting programme with NBSt-2 as rootstock. The evaluation of the grafted eggplant against FSB is in progress.

Eggplant (brinjal) IPM demonstrations (TERI)

Brinjal IPM trials were conducted at three locations in North and one location in South.

Brinjal IPM practice:

- Use of high-yielding and tolerant / resistant varieties (improved Navkiran)
- Seed treatment with *T. viride* + *P. fluorescens*
- Soil incorporation of Neem cake @ 200 kg/hectare
- Seedling treatment with *T. viride* + *P. fluorescens*
- Monitoring and mass trapping of *Leucinodes* with the help of pheromone traps @ 10-20 traps/hectare
- Yellow sticky traps for monitoring and mass trapping of sucking pests
- Neem, Bollcure formulation, and *Beauveria* formulation for pest management
- Affected shoot clipping
- Need-based spray of eco-friendly insecticides/fungicides

Figure 2. TNAU researchers with farmers and yellow sticky traps

Farmers practice of brinjal cultivation:

- Farmers are not aware about resistance/tolerant varieties
- No seed treatment
- No soil treatment
- Mostly farmers are not aware about pest monitoring and mass trapping by using pheromone and yellow sticky traps
- Farmers use chemical pesticides for plant protection, some of them used neem leaf extract also

Green jassids, *Leucinodes*, and red mite were the major yield limiting factors in brinjal. At IPM managed fields, jassids ranged from 2-5 per plant, fruit borer attacked 20%-60% of the plants/fruits, and red mite ranged from 17.4 to 21.4 per plant. The average jassid population in farmer's practice was 6-8/plant, fruit borer was found in up to 80% plants/fruit infected, and mite population was found to be 50-55/ leaf.

Fruit damage was highest in farmer's practice, whereas in IPM, the highest fruit damage was recorded at field 3 (12.5%), followed by field 1 (9.1%) and field 2 (8.2%).

IPM farmers' yields increased 12.9% and 6.7% over farmer's practice.

Highest net profit was earned by the IPM field 1 (Rs. 138,458), followed by field 3 (Rs. 136,655) and field 2 (Rs. 132226), whereas the lowest net profit was earned in farmer practice (field 4) (Rs. 106,000).

Table 33. Pest incidence, yield, and economics in IPM and FP fields of onion trial in Narasingapuram, Trichy Dist, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Thrips Population (no./plant)	6.92	14.35	51.76
Leaf miner damage (%)	9.83	16.29	39.65
Cut worm damage (%)	2.37	6.15	61.46
Basal rot (%)	3.12	6.46	51.70
Purple blotch (PDI)	22.35	56.14	60.18
Pink root (%)	3.26	11.15	70.76
Number of chemical sprays	2	7	
Ecofriendly biopesticides sprays	4	1	
Mean bulb yield (t/ha)	13.64	9.28	+46.98
C:B ratio	1:1.98	1:1.39	

In the south, brinjal demonstration was in one farmer's field with a yield of 12350 kg fruits per hectare and Rs. 18525 net profit. The farmer's practice field in the same area had a yield of 11400 kg of fruits per hectare and Rs. 12,600 net profit.

Onion

Onion IPM research (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1: IPM Module

- Selection of healthy onion seed bulbs
- Bulb treatment - *Pseudomonas fluorescens* (5 g/kg) + *Trichoderma viride* (5 g/kg)
- Soil application of *P. fluorescens* (1.25 kg/ha) + *T. viride* (1.25 kg/ha) + VAM (12.5 kg/ha) + Azophos (4 kg/ha) + Neem cake (250 kg/ha)
- Growing maize as border crop
- Installation of yellow sticky traps 12/ha
- Installation of pheromone traps (*Spodoptera litura*) 12/ha
- Spraying of *P. fluorescens* (5 g/lit)+ *Beauveria bassiana* (10 g/lit) on 30 DAP
- Spraying of Azadirachtin 1 % (2 ml/lt) on 40 DAP
- Need-based application of Profenophos (2 ml/lit) or Dimethoate (2ml/lit) or Triazophos (2ml/lit) for thrips/leaf miner/cutworm management.
- NBA of Tebuconazole (1.5 ml/lit)/ Mancozeb (2 g/lit)/ Zineb (2 g/lit)

Treatment 2: Farmer's practice

The results revealed that the mean onion thrips population in the IPM plot was 6.92/plant compared to 14.35/plant in the farmer's practice plot. A lower incidence of leaf miner was observed in the IPM plot (9.837%) compared with the farmer's practice (16.29%). Cutworm incidence was found to be minimum: 2.37% in the IPM plot and 6.15% in the farmer's practice. With respect to diseases, basal rot incidence was lower in the IPM plot (3.12 %) compared with the farmer's practice (6.46%). The severity of purple blotch in the IPM plot was lower (22.35 PDI) than the farmer's practice (56.14 PDI). Occurrence of pink root was found in 3.26% of the IPM plot and 11.15% of the farmer's practice. The adoption of IPM technology in onion reduced the number of chemical sprays from 7 in FP to 2 in the IPM plots. The bulb yield in the IPM plot was 13.64 t/ha coupled with a higher C:B (1:1.98) compared with 9.28 t/ ha with a C:B of 1:1.39 in the farmers' practice.

Impact of onion IPM popularization

In the Narasingapuram and Ranganathapuram villages of Trichy district, popularisation of onion IPM technology was taken up through demonstrations and distribution of biopesticides, yellow sticky traps, and pheromone traps. Since then, the onion IPM growers have realized higher bulb yields (12%–20%) coupled with higher economic returns compared with farmers who have adopted a chemical control method only. The number of chemical pesticide sprays in onion IPM fields was reduced to 3 to 4 during the cropping period compared with 6 to 7 in farmers' practice where the reliance was totally on chemical pesticides.

Economic Analysis of the Onion IPM program (TNAU)

Economic analyses of the onion IPM package were partially completed. A survey of 211 onion growers was completed in 2011-12, and analysis of the data was begun in a PhD thesis at TNAU. That thesis will be completed during the coming year.

The objectives of the analyses are to:

1. Assess the extent of adoption of IPM technologies,
2. Identify the determinants of adoption of IPM technologies,
3. Assess the economic benefits of adopting IPM technologies for producers and consumers, and
4. Identify differences in pesticide use for IPM adopters and non-adopters

Table 34. Pest incidence, yield, and economics in IPM and Farmer's Practice chili field trials in T. Kallupatti, Trichy district, Tamil Nadu, 2011–12

Parameter	IPM	FP	% reduction over farmers practice
Mean thrips population (no./leaf)	2.92	4.24	31.13
Fruit borer damage (%)	2.68	3.35	20.00
Yellow mites (no./leaf)	4.60	6.23	26.16
Damping off (%)	1.3	9.7	86.59
Cercospora leaf spot (PDI)	26.4	34.0	22.35
Fruit rot (%)	4.4	7.9	44.30
Green chili fruit yield (t/ha)	35.73	31.38	+12.17
Number of chemical sprays	2	9	
Ecofriendly biopesticides sprays	4	1	
C:B ratio	1:2.38	1:2.02	

Table 35. Pest incidence, yield, and economics in IPM and FP fields of cabbage trial in Vadakadu, Dindigul district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Cut worm damage %	4.0	11.0	63.63
DBM larval population / pl	8.0	18.0	55.55
DBM damage	4.0	16.0	75.00
Spodoptera leaf damage %	7.0	22.0	68.18
M. incognita population (Population/250 ml soil)	190	320	40.63
Nematode gall index	1	5	80.00
NE Cotesia Parasitism %	17.0	7.6	+55.29
Number of chemical sprays	2	7	
Ecofriendly biopesticides sprays	2	0	
Mean yield (t/ha)	20.50	16.25	+26.2
C:B ratio	1:2.03	1:1.40	

Trace incidence of *Alternaria* leaf blight was observed

Table 36. Pest incidence, yield and economics in IPM and FP fields of Cauliflower trial 1 in Vadakadu, Dindigul district, Tamil Nadu

Parameter	IPM	FP	% reduction over farmers practice
Cut worm damage %	3.6	8.2	56.09
DBM larval pop./ pl	2.4	5.6	57.14
DBM damage %	5.2	8.7	40.22
Spodoptera damage %	3.2	11.7	72.64
M. incognita population (Population/250 ml soil)	163	329	50.45
Nematode gall index	1	5	80.00
NE Cotesia Parasitism %	24.6	8.9	+63.84
Number of chemical sprays	1	5	
Ecofriendly biopesticides sprays	3	1	
Mean yield (t/ha)	16.35	12.68	+28.90
C:B ratio	1:3.12	1: 2.03	

Trace incidence of *Alternaria* leaf blight was observed

The graduate student at TNAU who is working on the analysis spent six months at Virginia Tech refining her methods of analysis.

A separate study was begun to assess the economic impacts of papaya mealybug biocontrol program. That study too will be completed in the coming year.

Chili

Chili IPM trials (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Seed treatment with *Trichoderma viride* @ 5g/kg and *Pseudomonas fluorescens* @ 5g/kg of seeds and application of *T. viride* ($5g/m^2$) and *P. fluorescens* ($5g/m^2$) in the nursery bed
- Growing castor as border(trap) crop
- Application of neem cake @ 250 kg/ha along with of *P. fluorescens* @ 1.25 kg/ha + *T. viride* @ 1.25 kg/ha
- Selection of good and virus disease-free seedlings for planting
- Rouging out of virus infected plants up to 45 days of transplanting
- Growing marigold as a trap crop along irrigation channels
- Installation of *Helicoverpa/ Spodoptera* pheromone traps @12 /ha
- Installation of yellow sticky traps @12/ha
- Spraying neem formulations
- Need based application of eco-friendly insecticides/fungicides/ nematicides

Treatment 2 – Farmer's practice

Observations on the incidence of insect pests (thrips, fruit borer, and yellow mites) and disease (damping off, leaf spot, and fruit rot) have been made. The treatments have been made as per the protocol in the IPM module, and in farmers' practice, only chemical control of pests and disease was carried out.

The results (tab. 34) revealed that the mean thrips population in the IPM plot was 2.92/leaf compared with 4.24/ leaf in farmers' practice. The incidence of fruit borer was lower in the IPM plot (2.68%) than the farmer's practice (3.35%). The mean yellow mite incidence was found to be 4.60/leaf in the IPM plot compared with 6.23/leaf in the farmer's practice plot.

Regarding diseases, incidence of damping off was lower in the IPM plot (1.3%) than the farmer's practice (9.7%). The severity of leaf spot in the IPM plot was found to be lower (26.4 PDI) than in the farmer's practice plot (34.0 PDI). Occurrence of fruit rot was observed at 4.4% in the IPM plot compared with 7.9% in the farmer's practice plot. The green chili fruit yield in the IPM plot was 35.73 t/ha coupled with a higher C:B (1:2.38) compared with the farmer's practice plot's 31.38 t/ ha with a lower C:B (1:2.02).

Cabbage and cauliflower

IPM component development for cabbage (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM components

- Seed / nursery treatment with *Pseudomonas fluorescens* @ 10 g/ kg of seed
- Seedling root dip with *Pseudomonas fluorescens* @ 10 g/ lit of water
- Soil application of neem cake @ 250kg /ha
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg /ha in main field
- Mustard intercrop to attract

Table 37. Pest incidence, yield, and economics in IPM and FP fields of cauliflower trial 2 in Oddanchathiram, Dindigul district, Tamil Nadu

Parameter	**IPM**	**FP**	**% reduction over farmers practice**
Cut worm damage (%)	1.6	3.4	52.94
DBM larval pop./plant	5.4	12.2	55.73
DBM damage %	7.2	17.0	57.64
Spodoptera damage %	5.6	11.8	52.54
M. incognita population (population/250 ml soil)	162	348	53.45
Nematode gall index	1	5	80.00
NE *Cotesia* Parasitism %	16.2	7.6	+53.08
Number of chemical sprays	2	5	
Ecofriendly biopesticides sprays	2	4	
Mean yield (t/ha)	15.36	12.92	+18.90
C:B ratio	1:3.25	1: 1.83	

Table 38. Pest incidence, yield, and economics in IPM and FP fields of watermelon trial in Kaliannanpudhur, Coimbatore district, Tamil Nadu, 2011-12

Parameter	**IPM**	**FP**	**% reduction over farmers practice**
Thrips (no./ Plant)	1.5	3.3	54.54
WBNV (% Infection)	5.9	17.3	65.89
Cucumber beetle	1.8	5.4	66.46
Leafminer damage (% leaf damage)	3.7	12.8	71.09
Fusarium wilt (%)	4.3	13.7	68.61
M. incognita population (Population/250 ml soil)	48	132	63.63
Nematode gall index	1	4	75.00
Number of chemical sprays	1	5	
Ecofriendly biopesticides sprays	3	1	
Yield (t/ha)	28.90	22.30	+22.83
C:B ratio	1:2.03	1: 1.50	

Plutella

- Use of yellow sticky traps against aphids
- *Plutella* adult monitoring with pheromone traps @12/ha
- Application of neem products (azadirachtin-based formulations/ NSKE)
- Need-based application of insecticides/fungicides

Treatment 2- Farmer's practice

The results (tab. 35) revealed that the mean population of diamond back moth in the IPM plot was as low as the farmers' practice. Incidence of cut worm was observed to be lower in the IPM plot (4.0%) compared with the farmer's practice (11.0%). The parasitisation by *Cotesia* was high in IPM plots (17.0%). Nematode severity was found to be lower in IPM than farmer's practice plots. The adoption of IPM technology in cabbage resulted in a reduction of the number of chemical sprays to 2 compared with 7 in the farmer's practice plots. The crop yield in the IPM plot was 20.50t/ha coupled with a higher C:B (1:2.03) compared with the farmer's practice field's 16.25 t/ ha and lower C:B (1:1.40).

IPM research trials on cauliflower (TNAU)

Two IPM farmer participatory research trials were conducted.

Treatment 1: IPM Module

- Seed / nursery treatment with *Pseudomonas fluorescens* @ 10 g/ kg of seed / lit of water
- Seedling root dip with *Pseudomonasfluorescens* @ 10 g/ lit of water
- Soil application of Neemcake @ 250 kg /ha
- Soil application of *Pseudomonas fluorescens* @ 2.5 kg /ha in main field
- Mustard inter crop to attract *Plutella*
- Use of yellow sticky traps against aphids
- *Plutella* adult monitoring with pheromone traps @12/ha
- Application of Neem products (Azadirachtin based formulations/ NSKE)
- Need based Application of insecticides/fungicide

Treatment 2- Farmers' practice (FP)

Cauliflower IPM plots registered significantly lower damage by cutworm, diamond back moth, and *Spodoptera*, than the farmer's practice plot in both trials tested during the period under report.

The results revealed that the mean larval population of diamond back moth in IPM plot (2.4) was low compared with FP (5.6). A lower incidence of cut worm was observed in the IPM plot (3.6%) than the FP (8.2%). The parasitisation by *Cotesia* was high in IPM plots (24.6%) compared with FP (8.9%). Nematode severity was found to be lower in IPM plots than FP. The adoption of IPM technology in cauliflower resulted in a reduction of the number of chemical sprays to 1 compared with 5 sprays in FP. The crop yield in the IPM plot was 16.35 t/ha coupled with a C:B of 1:3.12 compared with the FP yield of 12.68 t/ ha and a C:B ratio of 1:2.03.

The results (tabs. 36 and 37) revealed that the mean larval population of the diamond back moth in the IPM plot (5.4) was lower than the FP (12.2). A lower incidence of cut worm was observed in the IPM plot (1.6%) than the FP (3.4%). The parasitisation by *Cotesia* was higher in IPM plots (16.2%) than in FP (7.6%). Nematode severity was found to be lower in IPM plots than FP. The adoption of IPM technology in cauliflower resulted in a reduction of the number of chemical sprays to 2 from 5 in FP. The crop yield in the IPM plot was 15.36t/ha coupled with a C:B of (1:3.25) compared with the FP yield of 12.92 t/ha with a C:B of 1:1.83.

Table 39. Pest incidence, yield, and economics in IPM and FP fields of ash gourd trial in Kaliannanpudhur, Coimbatore district, Tamil Nadu

Parameter	IPM	FP	% reduction over farmers practice
Fruitfly (% affected fruits)	2.3	6.4	64.06
Cucumber beetle (% plant damage)	1.3	12.7	89.76
Whitefly (no./plant)	stray	stray	-
Powdery mildew (PDI)	1.9	4.7	59.57
Downy mildew (%)	Trace	Trace	
M. incognita population	48	132	63.63
(Population/250 ml soil)	148	320	55.31
Nematode gall index	1	5	80.00
CMV (% Infection)	6.8	13.3	48.87
Number of chemical sprays	-	3	-
Ecofriendly biopesticide sprays	2	-	-
Yield(t/ha)	17.70	14.62	+21.07
C:B ratio	1:1.89	1: 1.35	

Table 40. Pest incidence, yield, and economics in IPM and FP pumpkin trial fields in Kaliannanpudhur, Coimbatore district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Fruitfly	-	-	
Cucumber beetle (% plant damage)	3.5	16.8	79.16
Whitefly (number/ plant)	2.2	5.1	56.86
Powdery mildew (PDI)	2.7	4.2	35.71
M. incognita population (Population/250 ml soil)	174	320	45.62
Nematode gall index	2	4	50.00
CMV (% Infection)	4.6	9.4	51.06
Number of chemical sprays	1	4	
Ecofriendly biopesticides sprays	2	-	
Yield(t/ha)	19.30	15.10	+27.81
C:B ratio	1:2.06	1: 1.48	

Table 41. Pest incidence, yield, and economics in IPM and FP fields of bitter gourd trial in Nambialaganpalayam, Coimbatore district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Leaf miner (% damage)	0.2	0.3	33.23
Leafhopper (no./plant)	3.6	12.3	70.73
Whitefly (no./plant)	stray	stray	-
Fruitfly (% affected fruits)	6.4	20.5	58.78
Epilachna damage(% leaf damage)	6.5	23.4	72.02
Powdery mildew (PDI)	3.7	4.8	22.91
M. incognita population (Population/250 ml soil)	152	390	61.02
Nematode gall index	2	5	60.00
CMV (% Infection)	13.5	29.1	53.60
Number of chemical sprays	1	7	
Ecofriendly biopesticides sprays	2	0	
Yield	39.60	33.00	+20.00
C:B ratio	1:2.42	1: 1.68	

Watermelon

Watermelon IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted

Treatment 1 - IPM Module

- Soil application of Neem cake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of yellow sticky traps
- Set up pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need-based application of Insecticide / Acaricide / Fungicide

Treatment 2 – Farmer's practice (FP)

The results (table 38) revealed that the mean thrips population in the IPM plot (1.5) was lower than the FP (3.3). Incidence of cucumber beetle was observed to be lower in the IPM plot (1.8%) than the FP (5.4%). Nematode severity was found to be lower in IPM plots than FP. WBNV incidence was 5.9 % in IPM plots compared with 17.3% in FP. The adoption of IPM technology in watermelon reduced the number of chemical sprays to 1 from 5 in the FP fields. The crop yield in the IPM plot was 28.90t/ha coupled with a C:B (1:2.03) compared with the FP's yield of 22.30 t/ ha with a C:B of 1:1.50.

Cucurbits

Ash gourd IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neem cake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of Yellow sticky traps
- Setup Pheromone traps @12/ha

Table 42. Pest incidence, yield, and economics in IPM and FP fields of snake gourd trial in Thaliyur, Coimbatore district, Tamil Nadu, 2011-12

Parameter	IPM	FP	% reduction over farmers practice
Leaf miner (% damage)	6.3	16.9	62.72
Whitefly(no./plant)	2.2	3.2	31.25
Semilopper (% leaf damage)	8.2	25.3	67.58
Fruitfly (% affected fruits)	10.6	36.8	71.19
M. incognita population (Population/250 ml soil)	142	389	63.49
Nematode gall index	1	5	80.00
CMV infection (%)	8.8	13.4	34.32
Number of chemical sprays	2	8	
Ecofriendly biopesticides sprays	2	0	
Yield	15.23	12.65	+20.40
C:B ratio	1:1.95	1: 1.26	

- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need based application of Insecticide / Acaricide / Fungicide

Treatment 2 - Farmers' practice (FP)

The results (tab. 39) revealed that the mean fruit fly population in IPM plot (2.3) was lower than the FP (6.4). The incidence of cucumber beetle was lower in the IPM plot (1.3%) than the farmer's practice (12.7%). Nematode severity was found to be lower in IPM plots than in FP plots. CMV incidence was 6.8 % in IPM plots as compared with 13.3% in FP. The adoption of IPM technology in ash gourd reduced the number of chemical spray to zero compared with three sprays in FP fields. The crop yield in the IPM plot was 17.70t/ha with a C:B of 1:1.89 compared with the FP plot's 14.62 t/ha and a C:B of 1:1.35.

Pumpkin IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neemcake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of Yellow sticky traps
- Setup Pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need based application of Insecticide / Acaricide / Fungicide

Treatment 2 – Farmer's practice (FP)

The results (tab. 40) revealed that the mean cucumber beetle damage was lower in IPM plots (3.5%) than the farmer's practice (16.8%). CMV incidence was 4.8% in IPM plots compared with 9.4% in FP. The adoption of IPM technology in pumpkin reduced the number of chemical sprays from 4 in the FP fields to 1 in the IPM fields. Nematode severity was found to be lower in IPM plots than FP plots. The IPM crop yield was 19.30t/ha with a C:B of 1:2.06 compared with the FP crop yield of 15.10 t/ ha with a C:B of 1:1.48.

Bitter gourd IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neemcake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of Yellow sticky traps
- Setup Pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma, chrysoperlla*)
- Need based application of Insecticide / Acaricide / Fungicide

Treatment 2 - Farmers' practice (FP)

The results (tab. 41) revealed that the mean leaf hopper population was less in the IPM plot (3.6%) than in farmers' practice plot (12.3%). CMV incidence was 13.5 % in the IPM plots as compared to 29.1 % in FP. Nematode severity was found to be lower in IPM plots as compared to FP.The adoption of IPM technology in bitter gourd resulted in a reduction of the number of chemical sprays to 1 from 7 in FP fields. The crop yield in IPM plot was 39.60t/ha coupled with higher C: B (1:2.42) as compared to 33.00 t/ha with a cost benefit ratio of 1:1.68 in farmers' practice.

Snake gourd IPM research trial (TNAU)

One IPM farmer participatory research trial was conducted.

Treatment 1 - IPM Module

- Soil application of Neemcake @ 250kg/ha
- Soil application of *Pseudomonas fluorescence* @ 2.5kg/ha
- Soil application of *Trichodema viride* @ 2.5kg/ha
- Installation of yellow sticky traps
- Setup pheromone traps @12/ha
- Application of botanical pesticide (NSKE 5% Neem oil)
- Release of biocontrol agents (*Trichogramma chrysoperlla*)
- Need-based application of Insecticide / Acaricide / Fungicide

T2 - Farmers' practice

The results (tab. 42) revealed that the mean semilooper damage was lower in the IPM plot (8.2%) than the FP (25.3%). CMV incidence was 8.8% in IPM plots compared with 13.4 % in FP. The adoption of IPM technology in snake gourd resulted in a reduction of the number of chemical sprays from 8 in the FP to 2 in the IPM plot. Nematode severity was found to be lower in IPM plots than FP. The crop yield in the IPM plot was 15.23 t/ha and a C:B of (1:1.95) compared with the FP's yield of 12.65 t/ ha and C:B radio of 1:1.26.

Figure 3. Harvested sponge gourd (TERI)

Figure 4. *Helicoverpa armigera* damaging bottle gourd flower (TERI)

The root knot nematode encountered in gourds is identified as *Meloidogyne incognita* race 3 through the conventional method of posterior cuticular pattern, and it is also confirmed through enzyme phenotypic method.

Species diversity of fruitflies in various gourds (TNAU)

Trap catches of different *Bactrocera* species in various gourds

The earlier report of fruitfly complex of gourds revealed the presence of *B. cucurbitae*. However, cuelure trap catches from different gourds showed the incidence of *B. caudata* and *B. tau* (trace).

Trap catches of fruit flies revealed the dominance of *B. cucurbitae*. Higher trap catches, ranging from 10.5 in 4th (Jan 2012) and 14.5 in 49th SMWs (Dec 2011) and 5.5 to 15.5 during 4th (Jan 2012) and 49th SMWs (Dec 2011), were recorded in pumpkin and ash gourd, respectively.

B. caudata was collected mostly from traps kept in watermelon and bitter gourd. The maximum trap catches were recorded from watermelon fields. *B. cucurbitae* population ranged from 3.6 to 6.0 during 48 and 52 SMWs in both watermelon and bitter gourd fields.

Snake gourd field-collected *B. cucurbitae* showed an equal emergence of both males and females, ranging from 1.0 : 0.6 to 1.0 : 1.2 during 33 and 26 SMWs. However, observations from 33 to 35 SMWs revealed the sex ratio was towards females, whereas, the sex ration in *B. caudata* was 1:1.

Cucurbit IPM technology (TERI)

Trials on cucurbits (sponge gourd, bottle gourd, and pumpkin) were conducted using the following IPM and farmer's practice methods:

IPM methods:

- Use of high yielding and disease resistant / tolerant varieties (Pratima, Chakor)
- Seed treatment with *Trichoderma* and *Pseudomonas*
- Soil treatment with Neem cake
- Pheromone traps for monitoring and mass trapping of fruit fly-*Bactocera cucurbitae*
- Yellow sticky traps for monitoring and mass trapping of sucking pests (whiteflies, aphids, and jassids) and winged form adults of leaf miners
- Biopesticides such as Neem formulation, Bollcure formulation, Bt formulation, Beauveria formulation
- Need based use of safe chemicals

Farmer's practice:

- No seed treatment
- No soil treatment
- Farmer use only chemicals for insect pest and diseases some farmer use Ashes for control of leaf feeder insects
- Not using any insect monitoring devices nor they are available in the market
- Only some farmer use neem leaf extract

Sponge gourd

Sponge gourd IPM trials were conducted at Village Bhoorgarhi in two different locations.

IPM farmers received 65% and 60% increases in yield compared with farm-

Figure 5. A TERI tomato plot in the north

Table 43. Pest incidence, yield, and economics in IPM and FP fields of tomato trial in polyhouse at Vanniampalayam, Coimbatoredistrict, Tamil Nadu, 2011-12

Parameter	**IPM**	**FP**	**% reduction over farmers practice**
Aphid (% leaf damage)	6.5	12.6	48.41
Whitefly population(number per leaf)	5.9	8.3	28.91
Leafhopper population (number per leaf)	2.3	5.2	55.76
Serpentine leafminer damage(% leaf damage)	12.3	39.6	68.93
Fruit borer damage (%)	6.3	16.7	62.27
Leaf curl disease (% infected plants)	2.3	6.5	64.61
M. incognita population (population/250 ml soil)	135	395	65.82
Nematode gall index	1	5	80.00
Natural enemies coccinellid beetles/ plant spiders / plant syrphids / plant leafminer parasitism %	 6.3 1.8 0.9 12.6	 4.8 0.8 0.4 8.2	 +31.25 +12.50 +12.50 +56.09
Number of chemical sprays	3	12	
Ecofriendly biopesticides sprays	4	2	
Mean yield (t/ha)	52.30	42.57	+22.86
C:B ratio	1:2.04	1:1.86	

er's practice. The highest fruit damage was recorded in farmer's practice field 3 (14.6%), while the lowest was found in IPM fields 1 and 2 (3.1% and 6.8%, respectively). The highest yield was obtained by IPM field 1 (3659 kg) followed by field 2 (3161).

Bottle gourd

Bottle gourd IPM trials were carried out in Upeda village at three different locations. In all bottle gourd fields, *Helicoverpa armigera* was the major yield-limiting factor, destroying up to 80% of flowers and unmanageable by the conventional chemical options.

In our IPM fields, the average flower and fruit damage was in the range of 20% to 60%. IPM farmers received 20.0%, 26.4%, and 4.2% higher yields than the farmer's practice in fields 2, 1, and 3, respectively. The highest net profit was earned by IPM field 2 (Rs. 92501), followed by fields 1 (Rs. 87125) and 3 (Rs. 66368), whereas the lowest net profit was earned in farmer's practice field 4 (Rs. 61527).

Better harvest plan of bottle gourd: Based on the three-year price of Delhi Azadpur market we recommend for farmers in the North to sow bottle gourd in November and mid-May to fetch the best price.

Pumpkin

Pumpkin IPM trials were conducted in Upeda village at three different locations. Green jassids and red pumpkin beetle (RPB) were the major constraints in achieving good yields. The average jassid population ranged from 2 to 10 per leaf, and RPB ranged from 0.4 to 0.6 adults per leaf.

The highest net profit was earned by IPM field 1 (Rs. 121647), followed by fields 3 (Rs. 111792) and 2 (Rs.102134), whereas in farmer's practice (field 4), the net profit was Rs. 76014. Pumpkin farming needed less input, resulting in a handsome net profit for farmers.

Better harvest plan of pumpkin: For better harvesting of pumpkin crops, we recommend that farmers in the North sow pumpkin in May and September to fetch better prices.

Tomato

Tomato IPM trials under polyhouse conditions (TNAU)

One IPM farmer participatory research trial was conducted.

T1 - IPM Module

- Seed treatment with *Pseudomonas fluorescens* @ 10g/kg of seeds
- Nursery application with *Trichoderma viride* and *Pseudomonas fluorescens*
- Application of Neem cake @ 250kg/ha
- Soil application of *Pseudomonas fluorescens* @ 2.5kg/ha
- Selection of good and virus disease free seedlings for planting
- Roguing out of virus infected plants up to 45 days of transplanting
- Set up *Helicoverpa*/*Spodoptera* pheromone traps @ 12 / ha
- Release *Trichogramma chilonis* @

Table 44. Yield , fruit damage, and income from tomato IPM and farmer practice during kharif 2012 in the North

Farmer Name	Field no.	DOS	DOT	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr. Santpal	Field 1	18.3.12		7.80	13.6	18031	141913	116897
Mr. Sanjeev	Field 2	30.3.12		8.30	30.8	14017	116905	79864
Mr. Anil	field 3	27.3.12		8.40	28.3	8180.0	68666	38038
Co farm	Field 5	15.3.12		8.20	44.8	4816	39643	-9657
CD at 5%				-	5.1	1111.5	-	-
CV				-	6.3	163.0	-	-

Table 45. Yield and income from tomato IPM during Rabi 2011 in the South

Farmer Name	Field no.	DOS	DOT	Price Rs/kg	Fruit damage (%)	Yield (Kg)/ha	Monitory return (Rs/ha)	Net profit (Rs./ha)
Mr.Sarvana	field 1	2.8.11	20.9.11	6.25	16.0	9880	61750	24700
Mr. Muniraju	field 2	29.7.11	15.8.11	10.0	20.0	9262	92625	55575
Mr. Kumar	field 3	29.8.11	15.9.11	2.99	25.0	12350	37000	-24700
Mr. Shrinivasreddy	field 4	29.8.11	15.9.11	2.72	15.0	6792	18525	-24700
Mr. Venketeshreddy	field 5	29.7.11	15.8.11	4.0	15.0	12350	49400	24700
Mr. Kaleem	field 6	20.7.11	3.8.11	5.33	10.0	18525	98800	6175
Farmer Practice	Field 7	30.7.11	-	3.33	27.3	7410	24700	-37050
CD at 5%					5.8	NS	-	-
C.V					18.3	-	-	-

50000/ha

- Install yellow sticky traps
- Spraying Neem formulations / Neem seed kernel extract
- Need based application of nematicide / insecticides/fungicide

Treatment 2 – Farmer's practice

The results (tab. 43) revealed that the mean population of sucking pests in the IPM plot was lower than the FP. Incidence of leaf miner was observed to be lower in the IPM plot (12.3%) than in the FP (39.6%). Nematode severity was found to be lower in IPM plots than FP. Leaf curl virus incidence was lower in the IPM plot (2.3%) than the FP (6.5%). The adoption of IPM technology in polyhouse tomato resulted in a reduction in the number of chemical sprays from 12 in FP fields to 3 in the IPM plot. The crop yield in the IPM plot was 52.30t/ha with a C:B of 1:2.04 compared with the FP yield of 42.57 t/ha and C:B of 1:1.86.

Tomato IPM demonstration (TERI)

Four trials in the North and six trials in the South for IPM tomato demonstration were conducted during Rabi and Kharif season of 2011-12. The following methods for the IPM plots and farmer's practice plots were used.

IPM package for tomato:

- Use of high yielding resistant / tolerant varieties - US 1080 and 4545
- Seed treatment with *T. viride* and *P.fluorescens* @ 10 g / kg of seeds
- Soil treatment with Neem cake @ 200 kg per hectare
- Seedlings treatment with *T. viride* + *P. fluorescens* @ 5 g / liter of water
- Pheromone traps for monitoring and mass trapping of *Helicoverpa armigera* @ 10-20 traps/ hectare
- Yellow sticky traps for monitoring and mass trapping of White-flies, Aphids , jassids @ 30 traps/ hectare
- Biopesticides such as Neem formulation, Bollcure formulation, *Beauveria bassiana* formulation and NPV of *H. armigera*
- Need based use of green label safe pesticides

Farmer's practice (FP) of tomato:

- Farmers are not aware about resistance/tolerant varieties
- Seed and seedling treatment with biocontrol agents is not a regular practice, some innovative farmers do the same with chemical
- No soil treatment; if situation demanded they give only chemical treatment phorate, carbofuran or chlorpyriphos
- Most of the farmers are not aware about pheromone trap and yellow sticky traps
- Generally farmers use chemical pesticides, few of them use neem leaf decoction.

This year, a complex of viruses infected almost all the tomato varieties and yield was reduced drastically; an average of 80% to 100% of tomato fields were infected by tospo virus, while leaf curl infected 50%–60% of the crop. In IPM field 2 (North), there was a heavy attack of a complex of viruses; tospo virus infected 60% of plants, while leaf curl covered the whole field. Field 1 was planted earlier than other IPM farmers, and while 50% of the field was infected with tospo virus, it still received a better harvest than the farmer's practice (FP).

Helicoverpa armigera infestation ranged from 0.2 to 0.6 larvae per plant in IPM-managed fields, and leaf miners attacked tomato, with infestation ranging from 0.2 to 0.4 mines per leaf.

Figures 6 and 7. Farmers' meetings on IPM practice for vegetable crops organized by TERI

Jassids, leaf miner, and red mite were also the hurdles in obtaining good yields in IPM plots in the North because jassids may have developed resistance against commonly available pesticides; hence, they could not be controlled effectively by any methods. Severe incidence of fruit borer, *Helicoverpa,* and cut worm, *Spodoptera litura* caused low yield. Fruit damage was highest in a FP field in the North (Field 5, table 3) at 44.8%, and highest in a FP field (Field 7, table 4) in the South at 27.3%. Among IPM growers, the highest fruit damage was recorded in field 2 (30.8%), but the same grower also received the second highest yield and income due to good fruiting and price. In the South the highest yield was achieved in field 6, but the field could not get good returns due to low price.

Even after heavy virus infections, IPM farms still received a better yield than FP: Field 1 received a 73% higher yield, field 2, 65%, and field 3, 41%, than FP (field 5).

In the North, the highest net profit was earned by the IPM farmer field 1 (Rs.116897), followed by field 2 (Rs. 79864) and field 3 (Rs. 38000); the lowest net profit was earned in FP field 5 (Rs. -9657) (tab. 2). In field 1, the farmer received good prices due to sowing slightly earlier than others, and, because of this, his crop was not severely affected by the Tospo virus.

In tomato IPM trials in the North, the highest fruit damage was recorded in field 2 (30.8%), followed by fields 3 (28.3%) and 1 (13.6%); the highest fruit damage (44.8%) was recorded in the FP field (field 5) (tab. 44).

In tomato IPM trials in the South, the highest fruit damage among IPM farmers was recorded from field 3 (25.0%), on a par with FP field 7 (tab. 45).

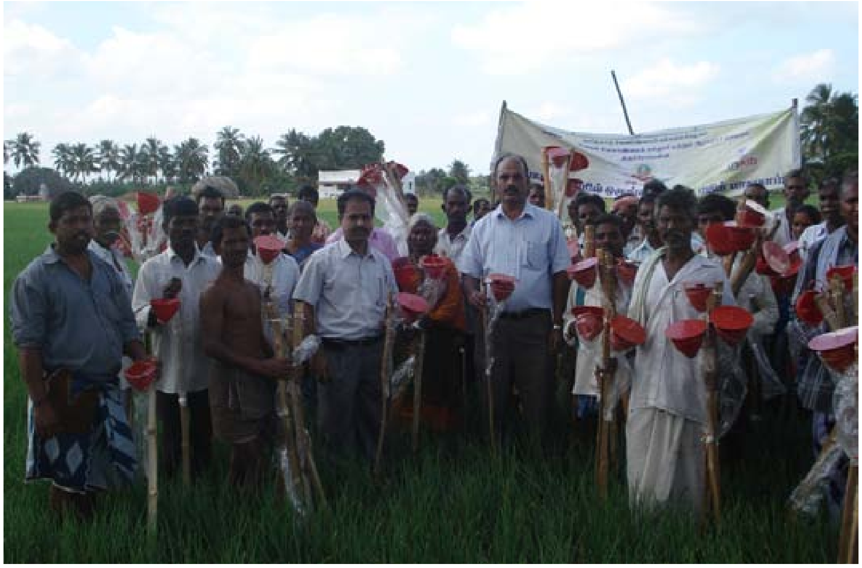
This year, tospo and leaf curl viruses severely equally attacked tomato IPM demonstrations in the South and North. In the South, up to 100% of tomato plants were infected with tospo virus in IPM trials, while in the North, tospo and leaf curl virus both reduced tomato yield. In the North, an average of 12%–55% of plants were infected with *Tomato leaf curl virus* in IPM fields; in FP, which solely depends upon chemical inputs, 100% of the plants were infected.

In the North, the IPM demonstration trials' average yield was 13400 kg/ hectare, and in the South, the average IPM tomato yield was 10291 kg/ hectare; there was a big gap in per hectare yield due to severe infestation of tospo viruses. In the North, the average IPM tomato farmer's income was Rs. 78266/ hectare, while in South, it was Rs.10291/ hectare. The main reason of low yield and income of tomato IPM farmers in the South was the favorable environment for the spread of the viruses and low price of tomato.

In Southern India, the tomato price fluctuated. The farmers who planted early (the last week of July to the first week of August) received good returns, while those who planted late (last week of August) received losses (field 3: Rs.-24700; field 4: Rs. -24700). Huge amounts (up to Rs. 30-40 thousand) were spent for plant protection in FP fields, and they merely received net returns of Rs. 5000.0

Better harvest plan for tomato: Based on the three year price data from National Horticulture Board, tomato can be grown in both seasons in Western Uttar Predesh, and in the South, tomato can be grown year-round. According to NHB's price data of the last three years, we can recommend the following for the North: in Kharif season, an April-May nursery preparation, and in Rabi season, a November-December nursery preparation. These would be beneficial for farmers because, from July to

Figure 8. TNAU researchers with farmers after distributing pheromone traps



November, there was no tomato supply from Western Uttar Pradesh farmers; in this time, all tomatoes came from other places. In the South, tomatoes sown in nurseries in November and March fetch higher prices.

Other

Work with BioControl Research Laboratories, a division of PCI, Bangalore

BCRL develops and sells inputs that are useful in IPM systems. These inputs include antagonistic fungi and bacteria, entomopathogenic fungi and viruses, botanical pesticides, and pheromones. In addition, BCRL maintains a client education program that ensures that its products are used properly. IPM CRSP, in an effort to involve the private sector in the development and dissemination of IPM packages, hopes that private sector firms such as BCRL will carry IPM dissemination beyond the limited scope of the IPM CRSP. Through this collaboration we hope to construct a business model that attracts private firms to IPM service.

Supply of inputs for the IPM CRSP Programme

Along with BCRL Lures for S*podoptera litura* and based on positive feedback from TNAU, pheromone lures for *Spodoptera exigua* were sent to the International Rice Research Institute, Philippines, for further trials. The pheromone lures were sent to West Africa in 2012 for testing against the coffee berry borer, *Hypothenemus hampei*. For brinjal fruit and shoot borer, *Leucinodes orbonalis*, BCRL pheromone lures were tested in Ecuador.