IPM CRSP South Asia Regional Program

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Summary

In Bangladesh, IPM packages developed for tomato, eggplant, okra, bitter melon, cucumber, cabbage and country bean were field tested and validated. Several vegetable varieties were screened for resistance to insect, fungal, bacterial, viral and nematode pests. Enhanced efforts were made to popularize the use of *Trichoderma,* and insect parasitoids and pheromone traps for control of fungal and insect pests, respectively. A baseline survey was carried out in three vegetable growing districts, Jessore, Narsingdi and Bogra, with a total of 300 farmers. In India at the Tamil Nadu Agricultural University, IPM packages of tomato, okra, eggplant and onion were field tested. The onion IPM package was demonstrated in different districts of the Tamil Nadu state. Information on IPM was disseminated by organizing field days, exhibitions, demonstrations, and training sessions. For mass media communications, government radio and TV channels, and newspapers were utilized to reach the public. The Energy and Resources Institute conducted tomato, eggplant, okra, and cucurbit IPM field demonstrations in Uttar Pradesh, Andhra Pradesh and Karnataka states. Out of a total of 51 field trials, 29 were conducted in Uttar Pradesh and 22 in Andhra Pradesh and Karnataka. Mass media covered most of the field days conducted to demonstrate the IPM packages especially in Uttar Pradesh. In Nepal, experiments were conducted with several biopesticides and biofertilizers for the development of IPM packages for tomato, cucurbits, coffee and tea.

Bangladesh

Evaluation of eggplant germplasm for resistance to fruit and shoot borer, red spider mites and jassids

S. Ahmad, M. A. Rahman, M. S. Nahar, A. K. M. Khorsheduzzaman, J. Chowdhury, L. Yasmin, M. Afroz, A.N.M.R. Karim

Selected eggplant lines were evaluated against fruit and shoot borer (FSB) under conditions of natural infestations without any pest control measures. Twelve promising eggplant lines that were selected last year were planted in three replications in unit plots of 10 x 1 meter using a 12 x 12 Latin Square design. Data were recorded on fruit yields and on infestations of jassids, red spider mites and FSB at appropriate stages of plant growth. Among the twelve test lines, SM-020, BARI Begun-7, and SM-183 suffered no damage of FSB, but fruit yield of SM-183 was extremely poor. Moderate jassid infestations were observed on all the entries, except on SM-011 and SM-191 lines that suffered no leaf burn, but the fruit yield of SM-011 was very poor. All the test lines were free from red spider mite infestation except SM-011 that suffered 44.4% infestation. Based on overall results, the lines SM-182, SM-191 and SM-020 were selected for further tests as source materials for developing improved eggplant varieties.

Evaluation of eggplant and tomato lines against Bacterial Wilt (BW)

Twenty eggplant lines were evaluated during the winter season in BW sickbeds using a completely randomized design with three replications. Each replication contained 10 seedlings of the test lines planted in one-meter rows with 30 cm spacing between plants and 50 cm spacing between rows. Records of wilted plants due to BW infection were recorded every week. Among 20 test entries, EGN-0027 showed resistant reaction (17% wilting) and SM-0011, SM-0012, SM-0058 and SM-0187 moderate resistant reactions (23% to 40% wilting). These materials were selected as sources of resistance for developing BW-resistant eggplants.

Sixteen tomato lines were tested in three replications in BW sickbeds during the winter season. Ten one-month old tomato seedlings were planted in a one-meter row with 30 cm spacing between plants and 50 cm distance between rows. Each row served as a replication. Data on wilted plants due to BW infection was recorded every week. Among the test lines, none exhibited resistance except the line F1-4 which was moderately resistant, showing 30% wilted plants.

Evaluation of eggplant lines against RKN

Nineteen eggplant lines were evaluated against RKN in sickbeds during the winter season. One-month old eggplant seedlings were planted in RKN sickbeds in two replications with 20 cm spacing between plants and 30 cm between rows. After 45 days of planting, the plants were uprooted and washed in running water to examine and grade the galls in the root system on a 0 to 10 scale, with 0 representing no gall (highly resistant) and 10 signifying severe galling (highly susceptible). Among 19 test entries, two (SM-0011 & SM-0179) showed resistant reaction (galling index of 1.0) and seven entries (EGN-0017, SM-0018, SM-0020, SM-00183, SM-00185, SM-00187 & SM-0021) were moderately resistant having galling index of 1.25 to 1.5. These materials were selected for using them as sources of RKN resistance in developing improved eggplant varieties.

Development of cucumber varieties resistant to virus diseases

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Attacks by a complex of viruses, such as *Water melon mosaic virus* (WMV), *Cucumber green mottle mosaic virus* (CGMV), and *Papaya ring spot virus* (PRSV), are the major causes of huge yield losses to cucumber (*Cucumis sativas*). Six cucumber lines that were selected last year having various degrees of virus resistance were retested along with two commercial varieties under natural field conditions at Gazipur during 2010 summer season. Twenty-day old seedlings were transplanted in unit plots of 7.5m x 1m at 1.5m spacing between plants using RCB design with three replications. Standard cultural practices were applied without taking any measure for pest control. Data were recorded on pest and disease incidence, fruit characteristics, fruit weight, fruits per plant, and yield. All the test lines were superior to the commercial varieties (Baromashi and Shila) with respect to virus infestation and insects, fruit characteristics, and fruit yield. Among the lines, CS-0079 and CS-0080 suffered lower virus infection and produced higher number of fruits per plant and higher yield, and they were selected for testing them in “advanced yield trials” in order to propose them as varieties.

The selected two lines of CS-0079 and CS-0080 along with two commercial varieties of 'Baromashi' and 'Shila' were planted at HRC-BARI farm, Gazipur in an RCB design with 3 replications. Standard cultural operations were carried out without taking any pest control measures. Data were taken on infestations of

Table 1. Performance of CS-0079 and CS-0080 cucumber lines against virus disease and yields

Variety/line	Virus incidence (%)	Infestation of leaf feeders (%)	White fly infestation (%)	Fruits per plant (No.)	Fruit yield (t/ha)
CS-0079	26	7.1	6.2	12.7	22.3
CS-0080	20	5.3	4.3	14.1	25.4
Baromashi	33	8.9	5.3	10.7	12.6
Shila	40	7.2	8.5	5.8	11.0

pest insects and virus disease, fruits per plant, and fruit yield. Results of the experiment confirmed that the test lines (CS-0079 and CS-0080) were better than the commercial varieties having lower virus infection (20% to 26% as compared to 33% to 40% of the commercial varieties), and produced twice the yield that commercial varieties did (Table 1). Among these two lines, however, CS-0080 was selected for release because of its better agronomic traits and resistance to virus and other pests.

Evaluation of okra germplasm for resistance to Bhendi yellow vein mosaic virus

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Bhendi yellow vein mosaic virus is the most damaging disease of okra in Bangladesh. An on-station replicated trial was conducted at BARI farm, Gazipur, during 2010 summer season with five okra lines selected from last year's trial. Pest control measures were avoided in order to induce natural infestation of the YVMV white fly vector (*Bemicia tabaci*). Weekly records of virus infection were taken until final harvest. Agronomic data on fruit size, fruit weight, fruits per plant and yields were recorded. Selfing of the virus-resistant plants was done to prevent out-crossing as well as to maintain the genotypic feature of the plant.

All the test lines were superior to BARI Dherosh-1, a recommended okra variety used as a control with respect to yield and virus infection. As compared to 10% virus infection on BARI Dherosh-1, no virus infection was observed on the five test entries (OK-0137, OK-0146, OK-0147, OK-0212, OK-018) when they were 45 days old. After 65 days of planting, BARI Dherosh-1 suffered 30% virus infection as compared to 5% to 22 % on the test entries. But, at 95 days after planting, virus infection was as high as 95% on BARI Dherosh-1 as compared to 58% to 80% on the test entries; the lowest (58%) was observed on OK-018, followed by 62% on OK-0212. Fruit yields of the test lines were also 59% to 85% (15.8 to 18.4 t/ha) higher than that of BARI Dherosh-1 (9.9 t/ha); OK-018 and OK-0212 lines significantly out-yielded all other test lines. Based on the results of lower virus infection and fruit yields, OK-018 and OK-0212 were selected for purification and confirmation of the results.

Development of country bean varieties resistant to pod borer and virus diseases

M. A. Hoque, G. M. A. Halim, A. Muquit, M. S. Hossain, and A. N. M. R. Karim

Production of country bean, *Dolichos lablab*, is seriously constrained due to the attacks of pod borer (*Maruca vitrata*) and *Yellow vein mosaic virus* symptoms. Several moderately resistant country bean lines have been identified through evaluations of available germplasm over the last few years. During 2009-2010 winter season, five country bean lines that were selected last year as promising ones were tested under natural infestation condition in the field of BARI farm, Gazipur, along with a recommended variety 'BARI Sheem-1' as a check. The test lines were planted one meter apart in unit plots of 6m x 1m in three replications using a RCB design. Standard cultural practices were adopted without taking any pest control measure. Data were recorded on pest and virus incidence, agronomic characteristics and yield.

Incidence of pest insects and virus disease was moderate. Among the five test lines, CB-0029 suffered moderate infestations of pod borer and aphid and virus infection. On the other hand, CB- 0223 and CB-0230 had lower virus infection, but were moderately susceptible to pod borer and aphid. In terms of yield and other agronomic characteristics, however, CB-0009, CB-0203, CB-0230 performed better than others. All these lines need to be retested next year to confirm their performance for yields and reactions to pests and virus disease.

Development of IPM packages for country bean, cabbage and tomato

S. N. Alam, N. K. Dutta, Akhtaruzzaman Sarker, and A.N.M.R. Karim

Pest damage is a serious constraint for satisfactory production of country bean, cabbage and tomato. The most damaging pests are pod borers (*M. vitrata* and *Helicoverpa armigera*) and aphids in country bean; diamond back moth (*Plutella xylostella*) and armyworm (*Spodoptera litura*) in cabbage; and fruit borer (*H. armigera*) and white fly transmitted *Tomato leaf curl virus* ((TLCV) in tomato. Trials were continued at BARI farm, Gazipur, to develop suitable IPM packages for the above crops.

Country bean: The country bean plants were raised in plots of 20m x 20m in three replications using an RCB design. There were three treatments consisting of two IPM practices and farmer practice as follows: T_1= IPM package consisting of (a) manual destruction pest-infested flowers and pods at alternate days, (b) weekly release of egg parasitoid, *Trichogramma evanescens*, at the rate of 1g parasitised eggs/ha/week and larval parasitoid, *Bracon hebetor*, at the rate of 800-1000 adults/ha/week and (c) spraying soap water (5g/liter of water) during initial aphid infestation; T_2= weekly release of bio-control agents as described in treatment-1; and T_3= farmers' practice of application of pyrethroid insecticide (Cymbus 10EC) at the rate of 1ml/liter of water every three days. The IPM and non-IPM (farmers' practice of pesticide use) were separated by about 200m. Data were taken on healthy and infested flowers and pods by borers and aphids, pest management cost and yield.

The IPM package (treatment-1) performed significantly better in controlling the pests as well as producing higher yields as compared to that of releasing bio-control agents only (treatment-2) and farmers' practice of pesticide applications (treatment-3). As compared to farmers' practice, the use of IPM package reduced flower infestation by 85% and pod borer infestations by 94% and aphid infestation by 87%, thereby increasing the yield 2.3 times higher and reducing the pest management cost by 43%. Release of bio-control agents only (treatment-2) was effective in controlling the pests and producing higher yields than the farmers' practice, but it was not comparable to the IPM package (Table 2). Similar results were obtained in the past three years, confirming that country bean can be successfully grown by adopting an IPM package practices without pesticides.

Table 2. Performance of IPM and non-IPM practices in controlling pests on country beans at BARI Farm, Gazipur; winter season 2009-2010

Treatment	Flower infestation by borer (%)	Pod infestation by borer (%)	Flower infestation by aphid (%)	Cost of pest management (Tk/ha)	Yield (t/ha)
IPM package	3.2±0.9a	1.4±0.4a	2.5±0.2a	12,500	18.6±1.9b
Release of bio-control agent only	6.4±1.3b	7.8±0.9b	8.9±1.7b	6,500	14.3±1.5b
Farmers' practice	21.3±2.1c	25.4±2.6c	19.4±2.7c	22,000	7.9±0.7a

(b) Trial for cabbage: In order to ensure optimum pest infestations, three experiments were carried out by planting cabbage at the following three different times during the winter season of 2009-2010: (a) First planting on November 8, 2009 (early winter) and harvesting on January 20, 2010; (b) second planting on December 12, 2009 (mid-winter) and harvesting on March 15, 2010; and (c) Third planting on January 7, 2010 (late winter) and harvesting on April 19, 2010. The cabbage seedlings were planted in plots of 10m x 10m, keeping a distance of 200m between IPM and non-IPM (farmers' practice) plots. The following three treatments were laid out in RCB design with three replications: T_1= weekly release of egg parasitoid, *T. chilonis*, at the rate of 1g parasitized eggs/ha/week and larval parasitoid, *B. hebetor*, at the rate of 880-1000 adults/ha/week and spraying of Bt suspension at the rate 4g/liter of water; T_2= weekly release of egg parasitoid, *T. chilonis*, at the rate of 1g parasitized eggs/ha/week and larval parasitoid, *B. hebetor*, at the rate of 880-1000 adults/ha/week and spraying of Spinosad (Tracer 45SC) suspension at the rate of 4g/10 liter of water; and Farmers' practice of spraying pyrethroid insecticide (Cymbush 10EC) at the rate of 1ml/liter of water every three days. Records were taken on pest infestations, number of caterpillars of diamond back moth (DBM) and armyworm (*S. litura*) infesting cabbage heads and yields.

Wide differences in the incidence of DBM and armyworm were observed on the cabbage plants planted at three different times. Irrespective of treatments, cabbage plants grown during the early winter season (planted on November 8, 2009) were completely free from infestation of DBM and armyworm, resulting in no variation in yields among the treatments. Moderate pest infestations were observed in cabbage plants grown during mid-winter period (planted on December 12, 2009). Highest infestation of 17.1% was recorded in the treatment of farmers' practice (applications of pyrethroid insecticide), followed by 2.4% in treatment-2 (release of parasitoids + application of Spinosad insecticide). No cabbage head was infested in treatment-1 (release of parasitoids + application of Bt). Plots receiving IPM treatments, therefore, produced 15% to 20% higher yields than that of farmers' practice. The cabbage crop grown during the late winter period (planted on January 7, 2010) suffered severe pest infestations. All the cabbage plants in the treatment of farmers' practice (pesticide applications) were totally damaged by the

Table 3. Performance of IPM practices in controlling pests of cabbage grown during early winter (November 2009 to January 2010) BARI farm, Gazipur

Treatments	Cabbage infested (%)	DBM larvae per cabbage head (No.)	Armyworm per cabbage head (No.)	Marketable yield (t/ha)
	Early winter	Early winter	Early winter	Early winter
T_1=Release of parasitoids + application of Bt suspension	0.0a	0.0	0.0a	44.8a
T_2= Release of parasitoids + application of Spinosad suspension	2.4±0.9b	0.0	0.1±0.5b	43.2a
T_3= Farmers' practice of pesticide application	17.1±0.6c	1.3±0.3	1.2±0.7c	37.4b

pests, resulting in no harvest of marketable cabbage heads. On the other hand, plots receiving IPM treatments suffered only 4.1% to 5.5% pest infestation, resulting in satisfactory yields of 24.3 to 22.6t/ha (Table 3).

Tomato: Two treatments, one consisting of an IPM package and the other of farmers' practice, were laid out in three replications in plots of 15m x 15m using a RCB design. IPM treated plots were separated from the non-IPM plots (farmers' practice) by about 200m. The IPM package treatments consisted of (a) planting of TLCV-resistant tomato line TLB-182; (b) manual destruction of pest-infested fruits; (c) weekly release of egg parasitoid, *T. evanescens*, at the rate of 1g parasitized eggs/ha/ week and weekly release larval parasitoid, *B. hebetor*, at the rate of 800-1000 adults/ha/week; and (d) use of *Helicoverpa* pheromone bait trap at 10m apart. The treatment of farmers' practice consisted of planting of TLCV-susceptible tomato ((variety BARI Tomato-2) and spraying of synthetic pyrethroid insecticide (Cymbush 10EC) at the 1ml per liter of water every three day days. Data were recorded on white fly numbers, virus incidence, fruit borer infestations, yields and pest management costs.

Compared to farmers' practice that consisted of pesticide applications only, the use of IPM package was highly effective in reducing the

Table 4. Performance of IPM package in controlling pests in tomato production; BARI farm, Gazipur, Winter Season 2009-2010

Treatment	Borer infestation (%)	White fly per leaf (No.)	Virus infected plants (%)	Pest management cost (Tk/ha)	Yield (t/ha)
IPM package	2.0±0.6b	0.5±0.3b	8.8±1.1b	10,000	48.6±0.7b
Farmers' practice-use of pesticides	11.8±1.2a	3.4±0.7a	74.3±4.7a	21,000	33.9±0.9a

infestations of fruit borer by 83%, white fly by 84% and virus infection by 88%. As a result, plots receiving IPM treatments produced 43% higher yield and the pest management cost was half as that of farmers' practice (Table 4). The results including those of the past years confirm that pesticide-free tomato crops can be profitably produced by deploying IPM practices that will improve tomato production as well as farmers' economic gains.

Performance of an IPM package for bitter gourd controlling fruit fly and borer pests

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Cucurbit fruit fly (*Bactrocera cucurbitae*) is the most damaging pest of bitter gourd. In recent years, however, caterpillars of *S.litura* and *S. exigua* and one of *Palpita* (*Diaphania*) *indica* (pumpkin caterpillar) have become major pests causing considerable yield losses. A trial was conducted in farmer's field in Bagharpara upazila of Jessore district to compare and confirm the performance of an IPM package with that of farmer practice that consisted solely of pesticide use every 2-3 days. The treatments of the IPM package consisted of (a) manual destruction of pest-infested fruits every week; (b) use of cuelure pheromone bait trap; and (c) weekly release of egg parasitoid *T. evanescens* at the rate of 1g of parasitized eggs/week/ha and weekly release of larval parasitoid *B. hebetor* at the rate of 1000-1200 adults/week/ha. The treatments were laid out in RCB design with four replications. Records were taken on infestations of fruit fly and borers, pest management costs and fruit yields.

The results of the use of IPM package confirmed those of previous years producing excellent performance in reducing the infestations of fruit fly by 89% and that of borers by 85%. As a result, plots receiving IPM package treatments produced 1.5 times higher yield than that of farmer's practice which was 2.8 times more costly for controlling the pests (Table 5). The results again showed that healthy bitter gourd crops can be profitably grown by adopting IPM practices without relying on pesticide use.

Efficacy tests of Tricho-compost and Tricho-leachate for controlling soil-borne diseases and production of some vegetable crops

M. A. Rahman, M. S. Nahar, L. Yasmin, Mafruha Afroz, and A.N.M.R. Karim

A series of trials were conducted to evaluate the performance of Tricho-compost and Tricho-leachate in controlling soil-borne diseases in lady's finger, stem amaranth and cabbage crops, and to determine the optimum dose of application of Tricho-compost in eggplant, tomato and cabbage crops. Production of Tricho-compost was prepared mixing *Trichoderma harzianum* spore suspension (3 x 10^7 cfu/ml) with definite proportions of decomposed cow dung, decomposed poultry refuse, water hyacinth, vegetable waste, sawdust, ash, maize bran, and molasses at different layers inside a brick-built open top house. The finished product of Tricho-compost

Table 5. Performance of IPM package in controlling fruit fly and borers and its effects on production of cucurbit crop

Treatment	Fruit fly infestation (%)	Borer infestation (%)	Pest management cost (Tk/ha)	Yield (t/ha)
IPM package	2.8±0.4a	4.8±0.8a	12,000	33.7±0.7a
Farmer's practice- use of pesticide	25.4±2.4b	31.7±1.9b	34,000	22.4±0.9b

was available after 6-7 weeks of decomposition. The excess amount of liquid produced during decomposition of Tricho-compost, termed as Tricho-leachate, is also rich in various nutrients and *Trichoderma* spore population. Both Tricho-compost and leachate are effective to control soil-borne disease pathogens and add nutrients to the soil. The following trials were conducted with the Tricho products.

(a). Performance of Tricho-compost in controlling soil-borne diseases and production of okra and stem amaranth: Separate experiments on okra (variety BARI Dherosh-1) and stem amaranth (variety BARI Danta-1) were carried out at HRC-BARI farm with two treatments: (a) use of Tricho-compost at the rate of 3t/ha plus half the amount of recommended dose of chemical fertilizers, and ((b) a control using recommended amount of decomposed cow dung. Using unit plots of 12 sq. meters (4m x 3m), the treatments were laid out in four replications using a paired plot design. The average initial population of root-knot nematode (RKN- *Meloidogyne* spp.) in the experimental plots was two larvae per one gm of soil. Data on RKN infestation in the roots were graded on a scale of 0 to 10, where 0 denotes no visible root galling and 10 represents severe galling. Application of Tricho-compost significantly reduced RKN infestation by 52.2% in okra and 18.7% in stem amaranth. Seedling mortalities also decreased significantly in both the crops. Similarly, Tricho-compost application increased the yields of both crops with 44% yield increase in okra and 52.2% in stem amaranth.

(b). Performance of Tricho-compost and Tricho-leachate in controlling soil-borne diseases in cabbage seedling production: Separate experiments were conducted in tin trays, measuring 75cm x 50cm x 30cm, and in seedbed nursery to determine the effects of Tricho-compost and Tricho-leachate in controlling soil-borne diseases for cabbage seedling production. In tin trays, the effects of Tricho-compost applied at the rate of 50gm/Kg of soil and Tricho-leachate applied at the rate of 50ml/Kg of soil were compared with a control treatment of cow dung applied at the rate of 200gm/Kg of soil. Each treatment was replicated four times. Before adding the treatments, the soils of the tin trays were inoculated with *Sclerotium rolfsii* fungus grown in rice husk at the rate of 20gm/Kg of soil, and the treatments of Tricho-products were applied to the soil 15 days before sowing the cabbage seeds. Data were taken on disease incidence, seedling mortality and seedling weight (fresh).

In the seedbed nursery, Tricho-compost was tested at two rates of application, 5t/ha and 7t/ha, to compare their effects for cabbage seedling production with a control treatment of cow dung applied at 5t/ha. The five treatments were laid out in randomized complete block design with three replications, each measuring 3 square meters (3m x 1 m). The soils of the seedbed nurseries were inoculated artificially with *Sclerotium rolfsii* fungus before adding the treatments. Cabbage seeds were sown 15 days after applying the treatments. Data were taken on seedling germination, plant mortality and seedling growth as observed from seedling weight (fresh weight).

The results of both the experiments carried out in tin trays and in seedbed nurseries showed that applications of Tricho-compost and Tricho-leachate are highly effective in controlling soil-borne pathogens, such as *S. rolfsii,* as reflected from much lower plant mortalities. In tin trays, Tricho-compost and Tricho-leachate reduced plant mortalities by 86% and 91%, respectively. These treatments did not however affect plant growth probably due to lower rates of application. On the other hand, Tricho-compost application in the seedbed nursery was highly effective in producing higher germination of seedlings (71% to 74% higher germination), reduced plant mortalities (86% to 91% lower) and better seedling growth as measured by seedling weight (57% to 62% heavier seedling weight). These results suggest that Tricho-compost and Tricho-leachate can be used profitably to produce cabbage seedlings without the use of chemical fertilizers and pesticides.

(c) Standardization of application rates of Tricho-compost for controlling soil-borne disease pathogens and production of eggplant, tomato and cabbage: Replicated trials were carried out separately on eggplant, tomato and cabbage crops to determine the optimum rates of application of Tricho-compost in field plantings. The experiments were conducted at HRC-BARI farm during the winter season with the following treatments: (a) Tricho-compost at the rate of 100gm/plant plus half the recommended dose of chemical fertilizer; (b) Tricho-compost at the rate of 150gm/plant plus half the recommended dose of chemical fertilizer; (c) Tricho-compost at the rate of 200gm/plant plus half the recommended dose of chemical fertilizer; and (d) a control treatment with only full dose of recommended fertilizers. The initial population of RKN was two larvae per 1gm of soil. The treatments were laid out in RCB design with three replications. Data were recorded on RKN infestation, plant mortalities and yields.

Results of the tomato trial showed that applications at all the rates of Tricho-compost reduced RKN infestation significantly by 46% to 63%, and increased the yields by 16.4% to 25.3%. Similar results were obtained for eggplant and cabbage crops, reducing RKN infestations by 29% to 50% in eggplant and by 50% to 65% in cabbage. The yield increase ranged from 22.5% to 35.6% in eggplant and 45% to 56% in cabbage. In all the experiments of the three crops, however, Tricho-compost applied at 200gm/plant produced the best results.

Study of nematode trophic groups in IPM and non-IPM systems

M. A. Rahman, M. S. Nahar, and A.N.M.R. Karim

Nematodes are broadly classified in to (a) Plant parasitic nematodes that feed on plants are harmful for agricultural crops; (b) Microbivorous and bacteria-feeding nematode, which feed on fungi, bacteria and various decayed products, are beneficial for plants; and (c) Carnivorous or predatory nematodes which are also considered beneficial as they feed on other nematodes and small animals. Earlier studies showed that fields or plots cultivated with IPM approach of organic soil amendments had increased numbers of beneficial nematodes and decreased the number of plant feeding nematodes.

In order to confirm the results of earlier trials, soils amended with various doses of Tricho-compost for growing cabbage, tomato and eggplant crops were examined for the presence of nematodes. Tricho-compost is an organic fertilizer fortified with a fungal bio-control strain of *T. harzianum*. The control plots received recommended doses of chemical fertilizers. Ten soil samples were collected from each treatment of each crop, and extraction, identification and counting of nematodes were performed by using standard procedures.

In tomato crop, Tricho-compost applications at different doses reduced the populations of harmful nematodes by 34% to 67% and increased the populations of beneficial nematodes 2 to 2.7 times more than that of the control plot (treated with chemical fertilizers). Similar results were obtained from eggplant and cabbage crops reducing the harmful nematodes by 31% to 71% and increasing the beneficial nematodes by 35% to 126%. Averaging for the three crops, Tricho-compost application reduced the harmful nematodes by 39% (range 32% - 52%) when applied at 100g per plant (about 2.5t/ha); by 63% (range60% - 66%) when applied at 150g per plant (about

Table 6. Applications of Tricho-compost in Tomato, eggplant and cabbage crops on the population of nematodes

Treatment	Plant-feeding nematode (No.) per 10g of soil			Bacteria-feeding nematode (No.) per 10g of soil		
	Tomato	Eggplant	Cabbage	Tomato	Eggplant	Cabbage
Tricho-compost at 100g/plant	19.7b	26.3b	15.0b	229.0b	179.3b	231.3c
Tricho-compost at 150g/plant	11.3c	15.7c	10.7b	262.7ab	268.3a	291.3b
Tricho-compost at 200g/plant	10.0c	10.3d	9.0b	295.0a	273.3a	327.0a
Control- use of chemical fertilizers	29.7a	39.0a	31.0a	109.3c	132.3c	144.7c

3.75t/ha); and by 71% (range 67% - 74%) when applied at 200g per plant (about 5t/ha). On the other hand, populations of beneficial nematodes increased by 68% (range 35% - 109%) when Tricho-compost was applied at 100g per plant; by 114% (range 101% - 140%) at application rate of 150g per plant; and by 134% (range 106% - 170%) at application rate of 200g per plant (Table 6). The increase in the numbers of fungal feeder, omnivore and predatory nematodes in the Tricho-compost treated plots was, however, marginal indicating that these nematodes probably required richer substrates for their nutrition and growth. The results conform to those of the earlier studies confirming that IPM practices with organic soil amendments will enrich the soils with higher abundance of beneficial nematodes, which will eventually protect the crop plants from the attack of harmful nematodes and animals, and help produce better crops with higher yields.

Mass production of egg and larval parasitoids and predators

S. N. Alam, M. A. Sarker, M. Nabi, and A.N.M.R. Karim

Earlier studies showed that the populations of different parasitoids which are available in vegetable fields could increase three-fold, if pesticide applications were withheld or avoided for a year. Biological controls being a fundamental tool of IPM system studies were carried out to develop techniques for mass rearing of egg and larval parasitoids (*Trichogramma* spp. and *B. hebetor*) and lady bird beetle for their use in controlling various vegetable pests.

(a) Mass rearing of egg parasitoid, *T. chilonis*, on *Sitotroga cerealella* eggs: Five Kg of wheat grains, soaked for 2-3 minutes in boiling water, were spread in equal quantities (2.5kg) over two tin trays (60cm x 50cm x 10cm) and 1g of *S. cerealella* eggs was scattered on the grains and kept undisturbed for 5-6 days. In order to conserve moisture for hatching and development of larvae, an adequate amount of water was mixed with the grains by gentle stirring. After 22-25 days, the tin trays containing the infested wheat grains with *S. cerealella* larvae were transferred to a mass-rearing chamber for adult emergence. Thousands of the emerged adults were collected from the mass-rearing chamber and released in a big cylindrical glass jar, the mouth being covered with a fine 32-mesh net. After mating, the eggs that were laid by the adults on the walls of the cylindrical jar were collected after sieving and cleaning.

Five grams of fresh eggs of *S. cerealella*, taken in a long glass cylinder which was moistened by keeping it for few minutes in a freezer, were rolled so as to make the eggs cling to the inside wall of the cylinder. Then a vial containing 1g of eggs parasitized by *T. chilonis* was put in the glass cylinder and kept under a fluorescent light at 25±2^{0}C. After 9-11 days, all the eggs of *S. cerealella* were parasitized. By following this procedure, thousands of *S. cerealella* eggs parasitized by *T. chilonis* were produced at regular intervals. The parasitized eggs were preserved at 3-4^{0}C and 75-80% RH for 1-1.5 months for using them in different experiments.

(b) Mass rearing of larval parasitoid, *Bracon hebetor*: Larvae of wax moth (*Galleria melonella*) were used as the host of *B. hebetor*. A parent stock of wax moth was first developed in honeycomb placed inside a glass jar. First to second instar larvae of wax moth were reared on an artificial diet prepared by mixing measured amounts of wheat flour, maize flour, milk, animal fat, sugar and yeast. The artificial diet was sterilized in an autoclave putting it at 125^{0}C and 1.5PSI for 70 minutes. Two hundred full grown larvae of the wax moth (takes 18-20 days to develop fully) were then transferred in to a plastic jar containing a corrugated paper sheet, and the larvae slowly settled in the furrows of the corrugated sheet for pupation. Forty adults (30 female and 10 male) of *B.hebetor* were then released within the plastic jar for 8-10 days for egg laying, pupation and adult emergence through parasitizing the wax moth larvae. The mouth of the jar was closed with a piece of black cloth after providing a honey cube inside the jar as food for the adults of *B. hebetor*. The adults of *B. hebetor* parasitized all the larvae of the wax moth in 8-9 days (Avg. 8.8 days). The number of adults of *B. hebetor* emerging from 200 larvae of wax moth averaged 960 (range 888-1025) and the adults lived for about 24 days. This procedure of mass-rearing was followed to produce hundreds of adults of *B. hebetor* at different batches, and thereafter, they were used for controlling the pests in different experiments.

(c) Development of a protocol for mass rearing of lady bird beetle, *Monochilus sexmaculatus*: The work of mass rearing of lady bird beetle (LBB) was carried out simultaneously both at the entomology greenhouse of BARI and the Ispahani Biotech laboratory (IBT) in Konabari of Gazipur from December 2009 to June 2010. A separate set of mass rearing was maintained under natural conditions. Mass rearing of LBB was done by releasing a pair of newly hatched larvae of LBB on an adequate number of 3-day old eggs of *S. cerealella* taken in a petri dish and the LBB larvae were allowed to feed on the eggs to complete its life cycle. This procedure was followed in several batches from egg to adult stages to record various growth periods of LBB.

The growth periods and life cycle parameters were similar for the LBB when reared at BARI and IBT laboratories, but differed when they were reared under natural condition. The maximum number of eggs laid by a female LBB at BARI and IBT ranged from 250-300 compared to 1000 under natural condition. Similarly, the larval period ranged from 10-15 days under laboratory conditions as against 15-30 days under natural conditions. The LBB also lived for a much longer period (60-90 days) under natural conditions as compared to 45-55 days under laboratory conditions. Although the overall growth of LBB was observed to be satisfactory under laboratory conditions, as much as 26.7% loss in body weights of adult LLB was observed when reared for successive generations. This indicated that LBB should be reared with diversified mixed food items and the populations need to be replenished periodically to avoid inbred depression.

Demonstration trial of IPM package for production of cabbage in farmer's field

M. A. Rahman, M. S. Nahar, M. A. Sarker, Mafruha Afroz, and A.N.M.R. Karim

In Bangladesh, cabbage production is seriously constrained due to the damage of the leaf-eating caterpillars of *S. litura* and diamond back moth. In addition, attacks of soil-borne fungal pathogens of *Pythium*, *Sclerotium* and *Phytopthera* species and root-knot nematode also cause considerable yield losses. In an effort to protect the cabbage crops from pest damage, the farmers rely solely on frequent applications of various kinds of pesticides without achieving any satisfactory control of the pests. IPM package consisting of several IPM practices have been found to effectively control these pests and produce better and healthy crops. A demonstration trial was therefore established in farmer's field in Gokulmerpara village in Bogra to determine the performance of the IPM package.

Seedlings of 'summer warrior' cabbage variety were raised using the following three soil amendment treatments: T_1= Incorporation of Tricho-compost at the rate of 1.5t/ha; T_2= Incorporation of Tricho-compost at the rate of 1.0t/ha; and T_3= Farmers' practice of incorporation cow dung at the rate of 5t/ha + use TSP fertilizer at the rate of 100Kg/ha. After 30 days of seedling growth, data were recorded on different aspects of seedling growth, such as (a) Number of seedlings per square meter; (b) Seedling mortality; (c) Shoot height; and (d) shoot weight. One-month old seedlings were then transplanted in 3 replications using a RCB design having the following four treatments: T_1= Incorporation of Tricho-compost at the rate of 1.5t/ha + ¾th of the recommended dose of $NPKSZ_nBM_o$ + use of pheromone baiting for *S. litura* + release of egg and larval parasitoids + destruction of leaf-eating caterpillars by hand-picking; T_2= Incorporation of Tricho-compost at the rate of 2.5t/ha + ¾th of the recommended dose of $NPKSZ_nBM_o$ + use of pheromone baiting for *S. litura* + release of egg and larval parasitoids + destruction of leaf-eating caterpillars by hand-picking; T_3= Incorporation of Tricho-compost at the rate of 3.5t/ha + ¾th of the recommended dose of $NPKSZ_nBM_o$ + use of pheromone baiting for *S. litura* + release of egg and larval parasitoids + destruction of leaf-eating caterpillars by hand-picking; and T_4= Incorporation of recommended full dose of $NPKSZ_nBM_o$ (control).

Results of the effects of soil amendments on seedling growth showed that incorporation of Tricho-compost at both rates of 1.0t/ha and 1.5t/ha were highly effective in reducing seedling mortalities caused by various soil-borne disease pathogens and produced healthier and stronger cabbage seedlings. Presently, the demonstration trial is on-going and is expected to be terminated after final harvest in the first week of November.

Development of an IPM package for production of cucumber

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Attacks by a complex of viruses, such as *Water melon mosaic virus* (WMV), *Cucumber green mottle mosaic virus* (CGMV), and *Papaya ring spot virus* (PRSV) are the main constraint to satisfactory production of cucumber. In addition, plants are also attacked by angular leaf spot disease caused by a bacteria *Pseudomonas syringae* pv. *lachrymans*, *Epilachna* beetle, leaf-eating caterpillars and leaf miners.

A few cucumber lines have been identified through symptomatic and visual examinations as moderately resistant to the virus diseases and pest insects after evaluating about 100 local and exotic cucumber germplasms during the past few years. Among the selected cucumber lines, CS-0079 and CS-0080 were more promising than others in respect of agronomic characters and reactions to virus disease and pests. In order to develop an IPM package for producing healthy and profitable cucumber crops, these two lines (CS-0079 and CS-0080) along with a commercial variety known as 'Baromashi' were included for testing three IPM packages and compared with a control treatment. The IPM package consisted of the following three soil amendment practices along with applications of recommended rates of cow dung (CD) and chemical fertilizers: (a) Tricho-compost at the rate of 3t/ha; (b) Poultry refuse at the rate of 3t/ha; and (c) Mustard oil-cake at the rate of 300 Kg/ha. The following 12 treatments were laid out in three replications using a factorial randomized complete block design: T_1= CS-0079 + Tricho-compost + ½ CD + ½ chemical fertilizer; T_2= CS-0079 + poultry refuse + ½ CD + ½ chemical fertilizer;T_3= CS-0079 + mustard oil-cake + ½ CD + ½ chemical fertilizer; T_4= CS-0079 + CD + ½ chemical fertilizer; T_5= CS-0080 + Tricho-compost + ½ CD + ½ chemical fertilizer; T_6= CS-0080 + poultry refuse + ½ CD + ½ chemical fertilizer; T_7= CS-0080 + mustard oil-cake + ½ CD + ½ chemical fertilizer; T_8= CS-0079 + CD + ½ chemical fertilizer; T_9= Baromashi + Tricho-compost + ½ CD + ½ chemical fertilizer; T_{10}=

Table 7. Performance of various IPM package treatments for production of cucumber; BARI farm, Gazipur, Summer Season, 2010

Treatments	Days to first harvest	Virus infection after 75 days (%)	Fruits/plant (No.)	Yield (t/ha)
T_1 (CS-0079 + Tricho-compost + ½ CD + ½ chemical fertilizer)	62	73	12.5	20.3
T_2 (CS-0079 + poultry refuse + ½ CD + ½ chemical fertilizer)	62	100	13.0	12.9
T_3 (CS-0079 + mustard oil-cake + ½ CD + ½ chemical fertilizer)	61	93	18.6	27.1
T_4 (CS-0079 + CD + ½ chemical fertilizer)	62	92	13.9	21.1
T_5(CS-0080 + Tricho-compost + ½ CD + ½ chemical fertilizer)	52	100	18.7	30.3
T_6(CS-0080 + poultry refuse + ½ CD + ½ chemical fertilizer)	52	92	16.6	30.1
T_7 (CS-0080 + mustard oil-cake + ½ CD + ½ chemical fertilizer)	57	80	14.0	19.2
T_8 (CS-0079 + CD + ½ chemical fertilizer)	52	93	17.1	26.9
T_9 (Baromashi + Tricho-compost + ½ CD + ½ chemical fertilizer)	52	92	16.6	25.6
T_{10} (Baromashi + poultry refuse + ½ CD + ½ chemical fertilizer)	50	93	3.3	21.7
T_{11} (Baromashi + mustard oil-cake + ½ CD + ½ chemical fertilizer)	50	100	20.0	29.1
T_{12} (Baromashi + CD + ½ Chemical fertilizer)	59	100	16.1	24.4

Baromashi + poultry refuse + ½ CD + ½ chemical fertilizer; T_{11}= Baromashi + mustard oil-cake + ½ CD + ½ chemical fertilizer; and T_{12}= Baromashi + CD + ½ Chemical fertilizer. Five 20-day old cucumber seedlings, grown in polybags, were planted in unit plots of 7.5m x 1m at 1.5m spacing. There was 1.5m spacing between plots. Records were taken on virus infection and pest infestation, time of first flowering, fruit characteristics, fruits per plant and yield.

Although all the plants were virus free up to 45 days after planting, 73%-100% plants exhibited mild to moderate virus infection. Infestation of leaf-eating insects was negligible. White fly infestation was moderate with insignificant differences among the treatments. Variation in yields in different treatments was minimal because of mild severity of virus infection. Based on yields and other characteristics, the treatments of T_5 (CS-0080 + Tricho-compost + ½ CD + ½ chemical fertilizer); and T_6 (CS-0080 + poultry refuse + ½ CD + ½ chemical fertilizer) appeared to be more promising (Table7). The results indicate that there is need to include additional treatments in order to protect the plants from virus infection.

Development of IPM package for production of okra

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The attack of Bhendi yellow vein mosaic virus vectored by white fly is the main constraint to satisfactory production of okra. Growth and production of okra are also considerably affected due to the attacks of anthracnose disease and root-knot nematode. As the use of pesticides as practiced commonly by the farmers is ineffective, a trial was conducted to develop an IPM package for the management of the pests. The trial was conducted at BARI farm, Gazipur, and the IPM practices included to develop the package consisted of tactics that are applicable to control soil-borne disease pathogens, RKN and Bhendi yellow vein mosaic virus. The okra variety, 'BARI Dherosh-1, was used for the trial. The following five treatments were laid out in three replications using a RCB design in unit plots of 5m x 3.2m: T_1= Soil incorporation of Tricho-compost at the rate 3t/ha + spray of salicylic acid; T_2= Soil incorporation of Tricho-compost at the rate 3t/ha + spray of milk at 0.5%; T_3= Soil incorporation of Tricho-compost at the rate 3t/ha + spray of 10% neem seed kernel extract (NSKE); T_4= Soil incorporation of Tricho-compost at the rate 3t/ha + spray of soap water at 0.5%; and T_5= Untreated control. Data were recorded at 15 days interval on YVMV infection, RKN infestation and yields.

Starting from 30 days of plant growth, YVMV infection increased gradually with plant growth and maximum infection ranging from 77.4% to 96.4% was observed at 75 days of plant growth. IPM treatments reduced RKN infestation by about 50% to 60% as compared to the control. No significant differences in yields, however, were observed between the treatments and the control, indicating clearly the impact of the damaging effects of YVMV on the plants. It is obvious from the results that development of suitable IPM practice(s) for Bhendi yellow vein mosaic virus management is the most crucial need for developing an effective IPM package for okra production.

Tricho-compost and Tricho-leachate production and their field efficacy test

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On-station trials were conducted to determine the rates of application of Tricho-compost and Tricho-leachate for production of healthy cabbage seedlings in nursery beds. In order to enable the farmers to produce Tricho-compost by themselves on their farmyard, a separate trial was conducted to use Tricho-leachate as an alternative to *Trichoderma* spore suspension for production of Tricho-compost.

(a) Determination of application rates of Tricho-compost and Tricho-leachate for production of cabbage seedlings in nursery seedbed: Two on-station trials were conducted, one at BARI farm in Gazipur and the other at BARI-OFRD farm in Bogra. The trial conducted at BARI, Gazipur consisted of the following four treatments, laid out in a completely randomized block design with three replications: T_1= Tricho-compost @150g + Tricho-leachate @100 ml per sq. meter; T_2= Tricho-compost @100g and Tricho-leachate @ 150 ml per sq. meter; T_3= Only Tricho-leachate @ 500ml per sq. meter; and T_4= Control (Cow dung 3 kg + TSP 50 g per sq. meter). The trial conducted at BARI-OFRD farm in Bogra consisted of the following three treatments laid out in a completely randomized design in four replications:T_1= Tricho-compost @150g + Tricho-leachate 100 ml per sq. meter; T_2= Tricho-compost @100g + Tricho-leachate @ 150 ml per sq. meter; and T_3= Control (cow dung 3 kg + TSP 50 g per sq. meter). Each seedbed measured 3.5 sq. meters.

Tricho-compost and Tricho-leachate were used 12 days before seed sowing. After application of Tricho-compost and Tricho-leachate, the seedbed was covered with polyethylene sheet. In the control treatment, cow dung and TSP were used one day before seed sowing. Two grams of cabbage seed (about 1620-1650 seed) were sown in each seedbed. Germination percentage was 96. Fifty seedlings of one month old were sampled for fresh and dry weight measurement. Data were recorded on disease incidence and seedling growth.

In both the trials conducted at Gazipur and Bogra, the cabbage seedlings grown in seedbed nurseries treated with Tricho-compost and Tricho-leachate were better and healthier in respect of seedling emergence, shoot height and weight, and seedling survival. Seedling emergence in the nurseries treated with Tricho-compost and Tricho-leachate was 5%-18% higher, and the seedlings were 29%-37% taller, and 24%-52% heavier than those of the control treatment; survival of the seedlings in Tricho-compost and leachate treatments were also as high as 92.5% to 98% against 87.3% in the control treatment. Tricho-compost and Tricho-leachate treatments effectively controlled the infections caused by *Rhizoctonia* and *Fusarium* species, but failed to control the attack of *Pythium* spp. as evident from seedling mortalities. Further investigation is needed to confirm the results.

The results of the trial conducted at Bogra were also similar to that obtained at Gazipur. Seedling emergence in the nurseries treated with Tricho-compost and Tricho-leachate was 16% higher, and the seedlings were 21%-29% taller, and 58%-106% heavier than those of the control treatment; survival of the seedlings in Tricho-compost and leachate treatments were also as high ranging from 78% to 81% against only 49% in the control treatment (Table 16). In this trial also, Tricho-compost and Tricho-leachate treatments failed to control the infection of *Pythium* spp., but very effectively controlled the infections caused by *Rhizoctonia*, *Sclerotium* and *Fusarium* species as evident from seedling mortalities.

(b) Use of Tricho-leachate for production of Tricho-compost at Farmer's Level

The scientists BARI-HRC have developed an organic compost fertilizer known as "Tricho-compost" which is enriched with a strain of *T. harzianum*. Tricho-leachate, a liquid byproduct of Tricho-compost, contains *Trichoderma* spores, and it is equally effective for controlling soil-borne pathogens. Presently, spore suspension of *T. harzianum* is being used for Tricho-compost production. Production of T*richoderma* spore suspension needs technical knowledge and a laboratory for its production. In order to spread the technology of Tricho-compost production at the farm level, Tricho-leachate was used as an alternative to spore suspension of *T. harzianum* for producing Tricho-compost. Before using Tricho-leachate for producing Tricho-compost, however, the following tests were conducted to examine (i) size and number of spores of *T. harzianum* present in Tricho-leachate; (ii) pure culture of *T. harzianum* spores of Tricho-leachate and inhibition test for the efficacy of the spores; and (iii) effectiveness of Tricho-leachate to decompose the organic materials for production of Tricho-compost.

(i) Spore number and their size present in Tricho-leachate: Two sets of spore suspension of *T.harzianum* present in Tricho-leachate was diluted 25 fold. Spores of each set were examined under an inverted compound microscope at 100X resolution and were counted by using Hemacytometer and calculated by using the following formula of Hansen (2000): Number of spores in original sample = cells present in 5 small squares of hemacytometer x 50,000 x dilution factors.

Counts of spores taken from two sets after dilution in one ml solution showed that there were 8.5 x 10^7 spores in the first set and 7.9 x 10^7 spores in the second set. On the other hand, only a density of 3 x 10^7 spores per ml of solution is required for complete decomposition of organic materials. Therefore, the density of *T. harzianum* spores present in Tricho-leachate was found to be adequate for using it as a decomposer to produce Tricho-compost.

(ii) Pure culture of *T. harzianum* spores derived from Tricho-leachate and inhibition (effectiveness) test of the spores in the laboratory: In order to obtain a pure culture, two drops of Tricho-leachate was mixed in sterilized Richards solution and the mixture was shaken at a minimum rpm of 40 per minute for 10 days. It was replicated three times. As a control treatment, a small amount of 2 mg of Tricho-compost was mixed similarly with sterilized Richards solution and allowed for shaking for 10 days. After 10 days, the mycelium grown in Richards solution was carefully separated, and a small amount was put on a PDA plate and replicated four times. To maintain its original strength, the process was repeated taking the samples from the pure culture. Similarly, the pathogens of *Sclerotium* and *Fusarium* species were isolated from vegetable crops and were maintained in PDA media.

Effectiveness of *T. harzianum* spores derived and cultured from Tricho-leachate by examining the inhibition zone through utilizing "Dual Culture Technique". *T. harzianum* spores isolated from Tricho-compost and Tricho-leachate were tested for their mycoparasitic ability *via* a colonized plate method. Two assessments were made following the dual culture techniques. The first was to obtain the percentage inhibition of radial growth (PIRG) of *S. roflsii*, and the second one was the number of days taken for the *T. harzianum* isolates to totally overgrow onto the *Sclerotium* colony. Sterilized PDA was poured into petri dishes at 20 ml per plate. Each plate was then seeded with 5mm diameter agar disc cut from the edge of an actively growing pure culture of *S. roflsii*, placed at the circumference of an 8.5cm diameter PDA culture plate. Similarly, a 5mm disc was taken from the edge of a 4- day old pure culture of each *T. harzianum* isolates and placed at the periphery (0cm) on the opposite side of the same petri dish. For the control plate, only *S. rolfsii* was placed in a similar manner without *T. harzianum* on a fresh petri dish. Plates were repeated at least three times under room temperature of 28±2ºC. Results revealed as mean colony growth of the causal pathogen in the presence of the antagonistic pathogen and its growth on the control plate. The outcome of two readings was incorporated into the formula (Skidmore and Dickinson 1976) for calculating the inhibition percentage of radial growth (PIRG) as below:

$$PIRG = \frac{R_1 - R_2}{R_1} X 100$$

Where PIRG = percentage inhibition of radial growth, R_1 = radial growth of *S. rolfsii* in absence of the antagonist (control); R_2 = radial growth of *S. rolfsii* in presence of the antagonist. PIRG and colony overgrowth assessments showed that both the isolates of *T. harzianum* inhibited 60% growth of *S. rolfsii* pathogen within 5 days; complete inhibition of the pathogen occurred after 10 days. The results thus confirmed that *T. harzianum* spores present in Tricho-leachate were highly viable and effective for controlling soil-borne pathogen like *S. rolfsii* and, therefore, Tricho-leachate can be used as an alternative to *T. harzianum* spore suspension for production of Tricho-compost.

(iii) Effectiveness of Tricho-leachate to decompose organic materials for production of Tricho-compost: Organic materials such as cow dung, sawdust, water hyacinth, poultry refuse, maize bran, molasses, and ash were processed and mixed in a defined proportion. Spore suspension of Tricho-leachate containing *T. harzianum* having a density of 8.5 x 10^7 was sprayed in layers and mixed with the organic materials to allow decomposition. The following three treatments were tested to determine and prepare Tricho-compost: T_1= Water spray at the rate of one liter per Tricho-compost house (control); T_2= Tricho-leachate spray at the rate of one liter per Tricho-compost house; and T_3= Tricho-leachate spray at the rate of two liters per Tricho-compost house. There were three replications involving three farmers for each replication per treatment, totaling 9 farmers. Each Tricho-compost house was constructed by placing three concrete circular rings (each measuring 70cm dia x 30cm high) one above the other vertically. Each Tricho-compost house was loaded with about 420Kg organic materials mixed with Tricho-leachate. The liquid byproduct (Tricho-leachate) coming out of the Tricho-compost house was collected from a small pit (30cm x 30cm x 30cm) dug out along the side of each Tricho-compost house, and the leachate started to accumulate in the pits from the second week of decomposition. The rate of decomposition of organic materials, temperature of the decomposing materials, odor and color of the decomposed materials were recorded.

Results showed that *T. harzianum* spores present in Tricho-leachate were highly effective to decompose the organic materials used for producing Tricho-compost. Both the rates of Tricho-leachate, 1liter or 2liters per Tricho-compost house, were equally effective to decompose the organic materials in 40 days as against 72 days of the control treatment to produce a quality amount of odorless Tricho-compost. The results strongly suggest that, with minimum hands-on training, the farmers will be able to produce Tricho-compost at their farmyard at a minimum cost for its use to protect their vegetable crops from the attacks of various disease pathogens and nematodes. Moreover, the use of Tricho-compost will help increase soil fertility.

Study on the prevalence of natural enemies of *Epilachna* beetle and their parasitism efficacy in vegetable crops

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The recent emergence of *Epilachna* beetle (mainly *Epilachna octo-punctata* and *Epilachna 28-punctata*) as a damaging pest on some vegetable crops. This study was conducted to exploit the possibility to control the pest by utilizing natural control system approach, such as the use of parasitoids. Grubs of *Epilachna* beetles, collected weekly from insecticide-free fields of eggplant, sweet gourd and bottle gourd crops, were reared in the laboratory and examined for parasitism. The emerged parasitoids were preserved in 80% alcohol for identification.

The parasitoids that emerged from the mummies of *Epilachna* beetle were locally identified as *Pediobius foveolatus* (Hymenoptera: Elophidae). The parasitism rates observed from the field collected

Table 8. Distribution of sampled respondents

District	IPM farmers			Non-IPM farmers			Grand Total
	Male	Female	Total	Male	Female	Total	
Jessore	38	4	42	58	-	58	100
Bogra	20	7	27	70	3	73	100
Narsingdi	20	10	30	65	5	70	100
Total	78	21	99	193	8	201	300
Gender (%)	26	7	-	64	3	-	-

Epilachna grubs starting from first week of July to second week of September 2010 averaged 14.7% ranging from 2.2% to 52.6%, the highest (52.6%) being in the fourth week of August and lowest (2.2%) in the first week of September. The number of parasitoids emerging from each mummy of the *Epilachna* beetle averaged 19.4 ranging from 5.7 to 32.0. The study clearly showed that natural control of *Epilachna* beetle by parasitoid exists in vegetable fields, and its population can be augmented and conserved.

Global Theme Programs in Bangladesh

Impact Assessment: Baseline Survey on Adoption and Impact of IPM Practices

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IPM technologies developed for vegetable crops by BARI scientists through IPM CRSP project have been adopted by the farmers in different areas of Bangladesh because of their effectiveness against pests and diseases, higher crop yields and high cost-effectiveness. As a result, farmers have switched over from conventional use of pesticides to IPM practices in several areas, enabling them to minimize cultivation costs and fetch higher profits. The recent approval of the government for commercialization of IPM inputs (pheromones and bio-pesticides) has opened up the opportunity for the farmers to collect the IPM inputs from the local markets at suitable times of their need. In order to record the status of the above developments, baseline surveys were carried out in three intensive vegetable growing districts of Jessore, Narsingdi and Bogra.

From each district, two upazilas (sub-district) and from each upazila two agricultural blocks (comprising a minimum of 1,000 acres) were selected for the study. 300 farmers, 100 farmers from each district, comprised of male and female as well as IPM and non-IPM farmers were randomly selected (Table 8) and interviewed by using a pre-tested questionnaire containing a total of 27 questions on (a) demographic & socio-economic characteristics; (b) farming systems; (c) insect pests & diseases; (d) provision of support services; (e) farmers' intentions towards IPM practices; and (f) women's participation.

The demographic and socio-economic characteristics of the responding farmers in three districts were comparable in most cases. The majority (89%) of both the IPM and Non-IPM farmers were 21 to 60 years of age, 48% between 21-40 years and 47% between 41-60 years. IPM farmers had slightly more education and literacy the non-IPM farmers; 79% of the IPM farmers received primary and secondary level education as compared to 70% of the non-IPM farmers. No significant differences were observed with respect to average family size (5.8 to 6.1 per family), average farm size ((0.87 to 1.2 ha), and average working members (2 to 3 per family). Similarly, little variation was observed between IPM and non-IPM farmers in annual income, 75% of which came from farm activities. As much as 58-61% of the income was used for purchasing food for the family. 85% (range 73-91%) of the IPM farmers were associated with IPM school/clubs, cooperative society, and NGOs as compared to only 46% of non-IPM farmers. Farmers of Jessore area were higher in this respect (91%).

The benefits achieved by IPM adopters and non-IPM adopters differed considerably with respect to the cost of vegetable production, crop yields, and profitability. The IPM and non-IPM farmers grew as many as 13 vegetable crops. A higher proportion of IPM farmers, however, grew some vegetable crops more than others probably due to the availability of the IPM inputs, such as sex pheromone baits for growing bitter gourd, teasel gourd, and bottle gourd. Except for the production of country bean, okra, cauliflower and ridge gourd, the costs of production of the rest of the nine vegetable crops were 6% to 158% lower when IPM practices were adopted by the farmers. Production costs of country bean and okra are higher as effective IPM technologies for growing these crops are yet to be developed. On the other hand, the reason of higher production costs for cauliflower and ridge gourd is not known as suitable IPM practices for them are available. IPM practices produced increased yields for five crops, but lower yields for 8 crops. Similarly, by adopting IPM practices, the IPM farmers received 12% to 60% higher economic returns for 7 crops, but lost 14% to 59% in 6 crops. Both IPM and non-IPM farmers sold about 98% of their vegetable production; the rest was used for family consumption.

Of the 12 kinds of insects reported by the farmers to attack their vegetable crops in the three districts of Jessore, Bogra and Narsingdi, the eggplant fruit and shoot borer (FSB) was the most damaging and widespread, followed by fruit fly and red pumpkin beetle in cucurbit crops, pod borer in country bean and yard-long bean, fruit borer in tomato, and cutworm in cauliflower. Among the diseases, the most damaging ones were bacterial wilt, little leaf and phomopsis in eggplant; damping-off and virus disease in tomato; anthracnose and virus disease in country bean and yard-long bean; virus disease in okra; and powdery mildew and virus disease in cucumber and teasel gourd. The non-IPM farmers rely solely on pesticide use for controlling pests and diseases in their crops and applied as many as 11 kinds of insecticides and four types of fungicides. Insecticides of pyrethroid group (mainly cypermethrin) were the most common ones, followed by organophosphates, such as cartap, carbosulfan, diazinon, malathion and quinalphos.

Among the fungicides, the commonly used were mancozeb (ridomil gold) and carbendazim (bavistin). On average, the non-IPM farmers applied pesticides as many as 28 times on bean crops, 25 times on eggplant, 20 times on tomato and 18 times on cucurbit crops. The IPM farmers, on the other hand, adopted various available IPM technologies, such as use of pheromone bait traps, use of soil amendment practices, and destruction of caterpillars by hand-picking and destruction of infested fruits and twigs. All the IPM farmers used pheromone bait traps in their eggplant and cucurbit crops (e.g., cucumber, bitter gourd and bottle gourd). As many as 67% of the IPM farmers adopted soil amendment practices in sweet gourd crop in Jessore, 62% in pointed gourd in Bogra and 75% in bottle gourd in Narsingdi. In absence of suitable IPM technologies, the IPM farmers growing cauliflower, country bean and yard-long beans practiced soil amendment and sanitation by destroying the pest caterpillars mechanically by hand-picking and by clipping off the infested fruits and twigs.

The IPM farmers received IPM training more than once (2-3 times) from the department of agricultural extension or/and BARI. As many as 75% of the respondents showed willingness to adopt IPM practices mainly (a) to reduce pesticide cost (72% respondents), and (b) to avoid health hazards (82% respondents) and environmental pollution (76% respondents). The non-IPM farmers, on the other hand, did not support IPM because of its slow action (72%), lack of knowledge (77%), ineffectiveness against all kinds of pests (71%), and non-availability of pheromone traps (55%).

In Bangladesh, women play an important role in vegetable production, particularly in the homestead gardens. Although the male members (husband) carried out major part of farming, the women took part in vegetable planting (11%), use of IPM practice (39%) and harvesting (76%). In livestock rearing, however, both wife and husband were equally involved.

The overall results of the survey indicate that the adoption rate of IPM practices among the farming community across a vegetable growing area is still in the early stage. Interestingly, none of the IPM adopters mentioned the use of bio-control agents, which are available at the field level. The use of bio-control tool could have a large impact. Expansion of IPM practices appeared to be constrained mainly because of (a) farmers' lack or inadequate knowledge of IPM, (b) lack of farmers' training and field demonstrations, (c) non-availability of IPM inputs, and (d) absence of appropriate IPM package for other major crops.

Global Theme Program on International Plant Diagnostic Network (IPDN)

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In IPM system, the ability to diagnose and detect pests and diseases is indispensable for implementation of proper management practices. In most cases, particularly in Bangladesh, crop losses and misuse of pesticides at the farm level are related with incorrect or wrong diagnosis of pests and diseases. Moreover, there is dearth of facilities in the fields of infrastructure, equipment, and trained personnel. Bangladesh with its tropical agro-climate is highly prone to the proliferation of numerous pests and diseases and was therefore included in IPDN starting from year 1 (2009-2010) of the IPM CRSP phase IV program to address the field problems as well as to fulfill, as much as possible, the needs of capacity building. A team of fungal pathologists, bacteriologists, nematologists and entomologists was involved to carry out the diagnostic activities.

For diseases, surveys were conducted in two districts of Narsingdi and Bogra on six kinds of vegetable crops (cucumber, bitter gourd, sponge gourd, bottle gourd, snake gourd, and pointed gourd). After collecting the diseased samples, they were brought back to the laboratory for identification by growing them in growth medium. Except for a few, incidence of several diseases was fairly high ranging from 28% to 60% on bottle gourd, sponge gourd, cucumber, and snake gourd crops. Disease incidence was lower in bitter gourd and pointed gourd (Table 9). Sponge gourd was mainly infected by virus disease.

A fairly intensive survey was conducted in four regions of Bangladesh: Gazipur, Pabna and Narsingdi (central region), Jessore (south western region), Sylhet (North eastern region) and Rangpur (Northern region) to collect information on the incidence of papaya mealy bug (*Paracoccus marginatus*) which is a highly virulent invasive pest insect. The mealy bug was recorded for the first time in 2008. It feeds on the sap of the vegetative parts as well as fruits causing chlorosis, stunting of plants, leaf deformation, and early leaf and fruit defoliation. Heavy deposition of honeydew induces thick growth of sooty mold fungus.

Table 9. Incidence of diseases in several cucurbit crops in Narsingdi and Bogra districts, Summer Season 2010

Location	Crops	Disease and organism	Disease incidence (%)
Narsingdi	Cucumber	Angular leaf spot (*Pseudomonas lachymans*)	45
	Bitter gourd	Cercospora leaf spot (*Cercospora* sp.)	12
	Snake gourd	Cercospora leaf spot (*Cercospora* sp.)	60
	Sponge gourd	Mosaic virus	46
	Pointed gourd	Fusarium wilt (*Fusarium* sp.)	5
	Bottle gourd	Leaf blight (*Mycospherella* sp.)	37
Bogra	Snake gourd	Cercospora leaf spot (*Cercospora* sp.)	52
	Sponge gourd	Mosaic virus	28
		Cercospora leaf spot (*Cercospora* sp.)	13
	Bottle gourd	Leaf blight (*Mycospherella* sp.)	28
		Leaf spot (*Collectotrichum* sp.)	34

Plants often die in case of high infestations. Papaya mealy bug is polypagous, and therefore, the survey was carried out also on guava, jujube, custard apple, eggplant and okra crops.

Incidence of the papaya mealy bug was observed only in Gazipur and Narsingdi districts on papaya, guava, jujube, custard apple, eggplant and okra crops, with papaya being the most susceptible and damaged crop. In Pabna, a very low population was observed only on custard apple.

Global Theme Program on International Plant Virus Disease Network (IPVDN)

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Surveys were conducted from June to August 2010 in five districts of Gazipur, Narsingdi, Chittagong, Jessore and Bogra to record incidence of virus diseases on 11 vegetable crops of cucumber, sponge gourd, ridge gourd, teasel gourd, pointed gourd, bottle gourd, bitter gourd, okra, yard-long bean, country bean and summer tomato. Most of the crops were in mid vegetative to late fruiting stages at the time of collecting the samples. Severity of viral infection was assessed by visual observation. Samples of diseased plant parts (mainly leaves) taken in an ice box were brought back to the laboratory and preserved at 0^0 C in a refrigerator for ELISA test.

Among the crops, cucumber, ridge gourd, sponge gourd, bottle gourd, okra, and yard-long bean were the most affected ones by viral infection; cucumber topped in disease incidence and severity. Bitter gourd was found to be virus-free, except in Jessore area. Teasel gourd and pointed gourd crops were apparently virus-free.

Global Gender Program: Role of women in vegetable cultivation and IPM technology adoption

Shahnaz Huq-Hussain, Tahera Sultana, Umme Habiba, A.N.M.R. Karim and Maria E. Christie

Gender plays an important role in agriculture and pest management. Farm activities are usually gendered based on their nature of task, which is also related to access to various resources that include land, labor, education and credit. Additionally, farm tasks are also gender based on knowledge, aptitude and practice which influence the adoption of a particular agricultural practice or IPM. Bangladesh is a multi-religious country having varied cultures. Muslim women as well as those of the higher caste Hindu religion do not work in open fields, but they take active part in homestead vegetable gardens and rearing of animals (cattle and poultry). In recent years, many women have become actively involved in vegetable production in several districts of Bangladesh, and they play important roles in decision making and IPM practices.

In order to assess the role of women in vegetable cultivation and adoption and use of IPM practices, two pilot surveys were conducted by two graduate research students (Ms. Tahera Sultana and Ms. Umme Habiba) of the Dhaka University in Jessore and Narsingdi districts.

Women's role in using IPM inputs with emphasis on poultry refuse: A case study in Jessore district

A pilot survey was conducted by Ms. Tahera Sultana, graduate research student of the Dhaka University, for a week in two villages of Gaidghat and Khajura in Jessore district by using a questionnaire that included questions to gather information mainly on (a) demography and socio-economy, (b) vegetable cultivation, (c) production and marketing of vegetables, (d) poultry farming, and (e) pest management practices. Information was collected from 12 women respondents only, 6 from each of the two villages.

The women associated with vegetable production in both villages were relatively young (25-34 age group); 70% of them received primary education, 10% secondary education, and the rest 20% received no formal education. All the women owned the land of their homestead gardens and their experience in vegetable production averaged 10 years. Although 70% of the women earned their income mainly from vegetable cultivation, about 40% of them also earned from poultry farming.

The women grew as many as nine kinds of vegetables, such as cabbage, cauliflower, radish, tomato, country bean, eggplant, okra, cucumber and Indian spinach. About 30% of vegetables were sold and the rest was used for family consumption. Of the sampled women, 25% of them were engaged for four years with poultry farming which served as the main source of income as well as provided nutrition to the family members, particularly the children. Only 10% of the women poultry farmers were knowledgeable about using poultry refuse as bio-fertilizer.

The women could name only few insect-pests that often damaged their crops. These are leaf-eating caterpillars, aphids, cucurbit fruit fly and eggplant fruit and shoot borer. They were not however knowledgeable about the correct names of the diseases. Only 20% of the women heard about IPM and 80% of them used IPM tactics. On the other hand, 80% of the women claimed pesticide use as the main method of pest control, but only 40% of them used pesticides in homestead gardens. In 82% cases, the decisions for pest management actions were taken by the women. The women seemed to be aware of the role of natural enemies that suppress or control various pest insects, but they lacked knowledge about their use and availability. As high as 90% of the women who grew cucurbit crops (gourd crops) adopted pheromone bait traps for fruit fly control. Only 8% of the women heard about poultry refuse as an IPM input and 35% of them used it.

The overall results strongly indicate that the women, although playing an important role in homestead vegetable production that partially meets up their family demand and fetches additional income, have remained largely unexposed to the recent developments in IPM practices. IPM practices will invariably expand among the women farmers if appropriate opportunities are carefully planned and implemented at the village level.

Food security and homestead gardening: women's role in Bangladesh

This pilot survey was carried out by Ms. Umme Habiba, graduate research student of the Dhaka University, in three upazilas (sub-districts) of Shibpur, Belabo and Raipur of Narsingdi district. Women of only 12 homesteads, four from each upazila, were sampled and interviewed through a pre-tested questionnaire that included the following major items: (a) Demographic characteristics, (b) Income and resource, (c) Vegetable cultivation, (d) IPM practices, ((e) Indigenous knowledge on homestead gardening, and (f) Food security.

The age of the respondents ranged from 15 to 65 years; 37.5% of them were in 36-45 age group and the rest were young and old aged. About 75.5% of the women respondents were literate having primary education and 12.5% received degree level education from universities. The area of the homestead vegetable gardens ranged from as small as 1.2 decimal to 15 decimals of land. About 62.5% women were associated with vegetable production and the rest 37.5% grew fruit trees. Sweet gourd, bitter gourd, bottle gourd, eggplant, tomato, country bean and leafy vegetables (e.g., red-leaf amaranth and Indian spinach) were the major vegetable crops cultivated by the women. Vegetable production was the main source of income for 57.5% women; other sources of income included fruit production and poultry rearing. All the women used the vegetables produced in their gardens for family consumption, particularly for the children. The leafy vegetables served as one of the main sources of nutrition and food security of the family.

The women possessing larger homestead gardens were able to produce vegetables commercially. All the women associated with vegetable cultivation received orientation in IPM through a private agency and adopted IPM methods for controlling the pests. They used Tricho-compost and bio-control agents in tomato and country bean crops. The women growing cucurbit crops, such as sweet gourd and bottle, adopted pheromone bait trapping for fruit fly control. For leafy vegetables, they used poultry refuse and mustard oil-cake.

The overall results showed that the women associated with vegetable production in Narsingdi area are exposed to using improved vegetable production methods including the IPM practices, and they are playing important roles in addressing food security problems of their family vis-à-vis the society.

Dissemination of IPM Technologies by NGOs

MCC (Mennonite Central Committee), an international NGO, and GKSS, a local NGO, are actively involved in dissemination of different IPM practices in their target areas. In association with 13 local NGOs, MCC carried out as many as 119 demonstrations involving as many farmers in five districts on seven IPM technologies in seven crops (cabbage, cauliflower, eggplant, tomato, cucumber, bitter and potato) during 2009-2010. Results of the demonstrations showed that the participating farmers harvested 10% to 45% higher crop yields and earned 29% to 58% additional income by adopting the IPM technologies on different crops. Moreover, the farmers were able to reduce the cost of cultivation by 25% 45%. MCC also arranged 45 field days for these demonstrations to reach the IPM technologies to as many as 1,575 participating farmers. In collaboration with the local NGOs, MCC organized ToT (training of trainers) for 41 NGO field staff that involved 11 women participants. MCC also imparted training to as many as 10,500 farmers on different IPM practices.

GKSS (Rural Farmer Assistance Committee), a local NGO produced as much 62 tons of Tricho-compost, an organic fertilizer developed by IPM CRSP-BARI scientists for controlling various soil-borne diseases and improving soil fertility. The organic fertilizer was distributed to establish 40 demonstrations on 11 crops involving several hundred farmers. The participating farmers obtained 25%-30% higher crop yields by using Tricho-compost. In order to popularize the adoption of Tricho-compost, GKSS organized 44 training programs for a total of 1,673 farmers, and held four field days that were participated by 250 farmers.

Role of Private Agricultural Enterprises in Expanding IPM Practices

Presently, some six private agricultural enterprises are engaged in producing different bio-control agents (e.g. parasitoids and predators) and supplying of sex pheromones that are regarded as the most important effective inputs of IPM technologies in Bangladesh. Among the private enterprises, Safe Agriculture Bangladesh Limited (SABL) and Ispahani Bio-tech Limited (IBL) are the leading firms that are contributing significantly to expand IPM technologies at the farm level through providing necessary IPM inputs.

During 2009-2010, SABL supplied as many as 75,000 lures of 'cuelure' pheromone for controlling fruit fly in cucurbit crops of at least 750 ha that involved an estimated 6,000 farmers. SABL also supplied egg and larval parasitoids (e.g., *Trichogramma* spp. and *B. hebetor*) to about 6,000 farmers that covered about 750ha of crop land for controlling various kinds of pest insects. IBL has also been actively contributing to disseminate IPM technologies through producing and supplying various IPM inputs. IBL distributed a record number of 130, 708 'cuelure' pheromone lures that covered about 1,860ha of cucurbit crops belonging to about 15,000 farmers. Supply of bio-control agents (e.g., *Trichogramma* spp. and *B. hebetor*) was made to an estimated 4,600 farmers to cover about 575 ha of crop land for controlling various pest insects.

Based on a special governmental permission, the private agricultural firms have so far been supplying the IPM inputs to the farmers who have been participating in the demonstrations of IPM technologies in different areas. This was done to familiarize and popularize the technologies to the farmers within and around the demonstration areas. In absence of official approval for marketing of the inputs, the farmers therefore were not able to purchase the inputs according to their needs. As a result, adoption of IPM technologies was confined to a limited section of the farming community. Only recently on May 13, 2010, the government approved commercialization of all bio-rationals (e.g., pheromones, bio-pesticides, botanical pesticides) through a gazette notification enabling the private firms to manufacture, formulate, import and market various IPM products. This governmental provision has now opened opportunities for the farmers to adopt IPM technologies by using necessary IPM inputs.

INDIA – TNAU and TERI

Summary

TNAU - Integrated Pest Management modules on vegetable crops with special emphasis on biocontrol were field tested. The module on Onion IPM was demonstrated to onion growers under IPM - CRSP program in large areas in Perambalur and Dindigul districts. IPM plots recorded lesser incidence of thrips, basal rot, purple blotch, leafminer and cutworm compared to farmer’s practice coupled with higher bulb yield and cost: benefit ratio. Field Days were organized to popularize vegetable IPM in different districts of Tamil Nadu. Exhibitions, demonstrations, special lectures, scientists-farmers interactions were organized

and distribution of bio-pesticides and IPM pamphlets to vegetable growers were done during that occasions. In addition, popularization of vegetable IPM technology was made through seminars organized by Department of Agriculture/Horticulture, private agencies, All-India Radio (talks, messages, farmer interaction), publications through local journals, newspapers, etc.

TERI carried out IPM demonstrations in Uttar Pradesh, Andhra Pradesh and Karnataka. A total 51 trials were conducted this year, 29 trials in Uttar Pradesh in the villages Tatarpur, Upeda, Bhoorgarhi, Bagadpur, Patana and Hapur and 22 trials were carried out in Andhra Pradesh and Karnataka in the villages Battegoudanour, Gudipalli, Hanumanthnagar, Dodrahalli, Banahally, Gesthampalli, Balamande and Boyiluru covering total area of 41.5 acres.

Tomato

TNAU:

Two IPM farmer participatory research trials are underway with IPM components dealing with preplant seed and soil treatments (*Trichoderma viride, Pseudomonas fluorescens*), neem cake applied in planting period, use of virus-free seedlings, rouging virus-infected plants within 45 days of transplanting, marigolds as border crops, pheromone-based monitoring of *Helicoverpa* and *Spodoptera*, release of egg parasitoids (*T. chilonis*), yellow sticky traps, neem formulations applied in production period, and need-based application of nematicides/insecticides/fungicides.

These research trials are still in progress. Preliminary data reflect significant improvements in IPM approaches. The following means reflect IPM plots versus non-IPM plots, respectively: % infection by PBNV: 6.9% vs. 7.8-15.0%; infection by tomato leaf curl virus: 1.4% vs. 2.7%; thrips per flower: 2.4-3.8 vs. 5.2-5.6; % fruit injury: 7.3-8.3 vs. 15.6-22.7; nematodes/250 ml soil: 8.0-9.2 vs. 396-410.

TERI:

The IPM package for tomato included use of resistant/tolerant varieties, seed/soil/ seedling treatments with *T.viride,* or *Pseudomona fluorescens*, neem cake applied in planting period, pheromone-based monitoring of *H.armigera*, yellow sticky traps for monitoring and mass-trapping of whiteflies, jassids, and aphids, biopesticides (neem, *Beauveria bassiana*, *Helicoverpa* NPV, applied in production period, and need-based application of spinosad, imidacloprid, thiamethoxam, acetamiprid, propargite, and Sulfex. Plots were maintained in northern India (Uttar Pradesh) as well as southern India (Karnataka, Andhra Pradesh).

We conducted seven trials in three villages. Most of the tomato crop was lost this year due to excessive heat, with the exception of a heat tolerant variety (US 1080), which gave satisfactory results. The major yield-limiting factor in this area was a tospovirus, which attacked tomato and drastically reduced the crop yield. In a cooperating, non-IPM farm, average infection by tospovirus approached 90% of the crop while in IPM plots, virus was present but IPM inputs limited virus impact so the crop was not affected severely. Pest incidence status was low in IPM demonstrations in comparison to the non-IPM farm practices. Jassids were 1.2 to 3.6 per leaf while in the non-IPM farm, populations averaged 5.2 per leaf. Leafminers averaged 2.6 per leaf in IPM plots and 6.3 per leaf in non-IPM farm practice was observed. Leaf curl, fruit rot and tospovirus were higher in non-IPM farm practice but were manageable in IPM demonstrations. Only one IPM demo site suffered with damaged equal to the non-IPM farm practice, attributable to lack of irrigation water.

Brinjal

TNAU

Research on IPM packages took place in two IPM farmer participatory research trials, employing the following IPM components: seed/soil/seedling dip treatment with *Pseudomonas* or neem cake, maize as border crop against movement of whiteflies and *Liriomyza* leafminers, yellow sticky traps against whiteflies and *Liriomyza*, clipping to remove shoot borer-infested terminals, *Leucinodes orbonalis* adult monitoring with pheromone traps, *Trichogramma* release after each brood emergence of *Leucinodes*, application of neem products (azadirachtin based formulations/NSKE), and need based application of insecticides.

These trials are still in progress. Preliminary results reflect consistent improvements using IPM approaches. The following means reflect IPM plots compared with non-IPM plots: percent shoots damaged by eggplant fruit and shoot borer, *L. orbonalis*: 2.3-2.8 vs. 5.1-6.4%' percent fruits damaged by *Leucinodes*: 3.8-4.6% vs. 10.6-12.5%; leafhoppers per leaf: 2.7 vs. 6.8-7.8; whiteflies per leaf: 5.6-12.6 vs. 12.8-22.8; nematodes/250 ml soil: 120-140 vs. 360-420. *Leucinodes* pheromone lures produced locally at TNAU were effective as those produced by IICI.

TERI

Research and demonstration on brinjal IPM packages in both northern and southern India included work on high yielding and tolerant/resistant varieties, seed/soil/seedling treatment with *T.viride* and *P. fluorescens* or neem cake, monitoring and mass trapping of *Leucinodes* with pheromone traps, yellow sticky traps for monitoring and mass trapping of sucking pests, biopesticides (neem, *Beauveria* and *Bt* formulations for pest management in production period, clipping of infested shoots, and need based spray of eco-friendly insecticides/fungicides. Brinjal demonstrations were carried out in two different villages on seven farmers' fields. The major yield limiting factors observed were *Leucinodes*, jassids, and aphids. The options viz., yellow sticky trap, neem spray and *B.bassiana* managed the sucking pest complex. The lepidopteran insect (*Leucinodes*) was managed by using shoot clipping, pheromone traps, *Bt* and spinosad.

Okra

TNAU

Farmer participatory research on okra IPM package in Tamil Nadu included the following IPM components: seed/soil treatment with *T.viride* or *Pseudomonas* or neem cake, maize as a border crop against movement of whiteflies and *Liriomyza* leafminers yellow sticky traps against whiteflies and *Liriomyza*, *Helicoverpa* and *Earias* adult monitoring with pheromone traps, *Trichogramma* release after each brood emergence of *Helicoverpa* and *Earias,* application of neem products, and need-based application of insecticides/fungicide/ acaricide.

These trials are still in progress. Preliminary results reflect consistent improvements using IPM approaches. The following means reflect IPM plots compared with non-IPM plots: 5 infected with yellow vein mosaic virus 2.2 vs. 7.5%; powdery mildew % disease index: 11.2 vs. 20.2; 5 leafminer infestation: 1.8 vs. 5.2%; % fruit damage: 2.3 vs. 12.9%; leafhoppers per leaf: 7.5 vs 18.9; whiteflies per leaf: 2.6 vs. 9.7; nematodes/250 ml soil: 68 vs. 389.

TERI

Development of an okra IPM package in southern India included: resistant/tolerant varieties, seed and soil treatment with *T. viride* and *P. fluorescens*, neem cake and *Paecilomyces* (the latter for nematode management), pheromone traps for monitoring and mass trapping of *Earias vitella*, yellow sticky traps for monitoring and mass trapping of whiteflies, aphids and jassids, biopesticides such as formulations neem, Bt, *B. bassiana* and *Helicoverpa armigera* NPV, and need-based use of green label safe pesticides, e.g. spinosad, imidacloprid, thiomethoxam, acetamiprid, and propargite.

Nematode infestation was the major yield-limiting factor in the village Bhoorgarhi where 40 and 45 % yield losses were recorded. Most of the non-IPM farmers used carbofuran granules for nematode control but they could not control the damage.

Major insect-pests causing considerable damage to okra crop were whitefly (*Bemisia tabaci*), jassids (*Amrasca devastans*), aphids (*Aphis gossypii*), as sucking pests. The chewing insect complex included the insect's viz., *E. vitella*, and *H. armigera*. Major diseases causing loss to okra was BYVMV disease.

Okra IPM demonstrations were conducted on eight different locations of Kolar and Chittoor district of Karnataka and Andhra Pradesh, respectively. Bhendi yellow vein mosaic virus was the major yield-limiting factor in this particular belt. Most of the farmers in this area are growing tomatoes round the year as mono cropping, which increased the particular insect pest of the tomatoes. Due to this problem, we are conducting okra IPM demonstrations and suggesting the farmers to rotate the crops every year. Jassids, whiteflies, *Earias* and *Helicoverpa* were the major insects which reducing okra yield. In non-IPM control farms, BYVMV infestation was up to 50% of the total plant population while in our IPM trials it ranged from 4 to 30% due to the effective use of IPM module. Most of the varieties, which are showing resistance/tolerant against BYVMV in north, were susceptible in south.

Cauliflower

TNAU

Our IPM farmer participatory research trial included the following IPM components: seed/soil/seedling/ nursery treatment with *Pseudomonas*, neem cake, mustard inter crop to attract *Plutella*, yellow sticky traps against aphids, *Plutella* adult monitoring with pheromone traps, application of neem products (azadirachtin based formulations/ NSKE), and need-based application of insecticides and fungicides.

In the IPM plots, there were 5.6% injured by diamondback moth, compared with 13.3% injured in non-IPM plots. Nematodes were reduced by 70% in IPM plots.

Onion

TNAU

Farmer participatory research trials on onion IPM included the following IPM components:

Bulb treatment and soil application using Plant Growth Promoting Rhizobacteria (PGPR) consortia + *T. viride,* + Azophos (trichlorfon) (4 kg/ha) + neem cake (250 kg/ha), PGPR + *Beauveria bassiana* azadairachtin, need-based application of profenophos or dimethoate 2ml/lit/Hostathion (triaziophos) for thrips/leafminer/cutworm management, need-based application of mancozeb (2 g/lit)/ tebuconazole (1.5 ml/lit)/ zineb, yellow sticky traps, pheromone traps for *S. litura*.

The results indicated that the mean onion thrips incidence in IPM plot was 10.81/plant as compared to 14.85/plant in non-IPM plots. Leafminer incidence averaged 13.20 per cent in IPM plots compared to 23.61 per cent in Farmers' practice. Cutworm incidence was 5.48 per cent in IPM plot compared to 9.13 per cent in farmers' practice.

With respect to diseases, basal rot and purple blotch were the two diseases which appeared in the experimental plots. Incidence of basal rot was found to be lower in IPM plot (1.8 %) as compared to 5.6 % in Farmers' practice. Occurrence of purple blotch was noticed in both the plots and the severity was lesser (20.0 %) in IPM plot when compared to farmers' practice which recorded a disease severity of 45.6 %.

The bulb yield in IPM plot was higher i.e., 15.62 t/ha compared to 12.13 t/ha in Farmers' Practice.

Chilies and cucurbits

TNAU

A survey of the current status of IPM in chillies and cucurbits was conducted.

The observations collected from farmers' fields are listed below:

Chilies

- Serpentine leafminer, damping off were seen in nursery.
- Heavy incidence of thrips and mites were recorded on hot pepper
- Heavy incidence of root knot nematode with gall index ranging from 3-5 in chillies and bell pepper.
- Viral disease complex was severe in hybrid chillies. CMV occurrence was observed. Stray incidence of Capsicum chlorosis and flower gall midge was recorded.
- Fruit borer and anthracnose were recorded in some intensive vegetable growing regions.
- Both *Bemisia tabaci* and spiraling whitefly were noticed in hybrid chillies in summer season.
- Pesticide application was more in hybrid chillies as compared to inbreds.
- IPM package adoption is very low in chillies, except the use of castor as border crop; however the benefit of this is unknown by farmers.
- No biocontrol agents were used by farmers in chillies.
- Monitoring pests with traps is practiced by less than 1% of farmers.

Cucurbits

- Heavy incidence of root knot nematode with gall index of 5 in cucumber.
- Root Knot nematode was noticed in many gourds.
- Mosaic Viral disease was higher in bitter gourd, ash gourd and pumpkin.
- Serpentine leaf miner, red pumpkin beetles and fruit flies were predominantly present in all gourds.
- Sporadic incidents of semiloppers were noticed in bottle gourd and snake gourd.
- No biocontrol agent was used by farmers in cucurbits. IPM component adoption is nil in cucurbits.

TERI

Development of the IPM package for cucurbits in northern India included the following elements: high yielding and disease resistant/tolerant varieties, seed treatment

Reduction in pesticide sprays with IPM practices in South India

Crop	Average no of sprays		% Reduction
	IPM	Non-IPM	
Okra	7	14	50
Egglant	7	15	66
Tomato	7	20	54
Cucurbits	5	8	20
Okra	9	14	36
Tomato	9	18	50

with *Trichoderma* and *Pseudomonas*, soil treatment with neem cake, crop staking using wire and bamboo stakes, pheromone traps for monitoring and mass trapping of fruit fly, *Bactrocera cucurbitae*, yellow sticky traps for monitoring and mass trapping of whiteflies, aphids and jassids and leafminer adults, biopesticides such as neem, *Bt*, and *Beauveria* formulations, and need-based use of safe chemicals.

Demonstrations were carried out in three villages on five different farmers' fields. IPM interventions were seed treated with *T. viride* and *P. fluorescens*. Yellow sticky traps were installed to monitor and mass trapping of whiteflies, jassids and winged form of leafminer just after germination. The pheromone traps for *B. cucurbitae* monitoring and mass trapping were installed one month after sowing.

Fruit fly (*B. cucurbitae*), red pumpkin beetle (*Aulocophora fovicolis*), leafminers, whiteflies, and mosaic were observed infesting cucurbits crop in field. The major yield limiting factors observed were fruit fly, red pumpkin beetle and leafminers but at middle age of the crop mosaic virus also had adverse impact and reduced yield of the crop. The fruit fly in control (non-IPM farm practice), caused 16.3 percent fruit damage, whereas it ranged from 4.6 to 7.3 percent fruit damage in IPM practices. Red pumpkin beetle and leafminer were highest in control 4.8 per plant and 9.4 per leaf, respectively and ranged from 1-3 per plant and 3-6.3 per leaf in IPM trials, respectively. Yellow mosaic virus symptom was also severe in control plots (up to 50%) whereas it was in ranged from 15-35 percent in IPM plots. In some of the non-IPM farmer's field 100 % of mosaic virus infestation was also seen.

Farmer meetings and Field Days: 22 farmer's meetings on IPM for vegetable crops were organized by TERI in Upeda, Bagadpur and Tatarpur, Hapur and Battegoudanour with 101 male and 38 female participants. Farmer field days organized with 202 males and 89 females. Demonstration of IPM practices on vegetable crops in farmer fields in six villages in UP, three villages in AP, and four villages in Karnataka. Targeted farmers population in these villages is nearly 80,000 including woman farmers.

Impact Assessment

The IPM demonstrations were carried out in three villages in Andhra Pradesh and three

Increase in yield per hectare because of IPM

Crop	Average yield obtained per hectare	Yield percent increase with respect to average farmers practice
North India		
Okra	10922 kg	40
Brinjal	18817 kg	34
Tomato	19697 kg	60
Cucurbits	11115 kg	98
South India-		
Okra	9373 kg	61
Tomato	12172 kg	27
Brinjal	25000 kg	-

villages in Karnataka in southern India. A total of 19 demonstrations were carried out to promote IPM activities among the farmers during 2009-10 (eight okra and 11 tomato crops). The same IPM packages being implemented in northern India were also effective in southern India with slight modifications in spray schedule.

IPM practice proved better than current farmers practice with respect to yield, quality, environmental impact and price of the commodity and led to a 20-66% reduction in pesticide usage. The IPM crop fetched 1.5-2 times more price in the market than the non-IPM produce. Enhanced income is being utilized by farmers on children's education and construction of a house. Farmers reported better taste of food with IPM crops.

Nepal

IPM Package Development for Tomato

Tomato trials were conducted at Lalitpur and Kaski Districts in plastic tunnels. Seedlings were prepared on raised seedbed amended with compost, *Metarhizium* and *Trichoderma*. Three weeks old seedlings were planted on raised beds laid with drip pipes. The fields were amended with Bio-Fertilizers and Bio-Pesticides along with Compost. Plants were irrigated once a day and staked a month after transplanting. Foliar sprays of bio-pesticides were applied after the first appearance of pest and disease symptoms. Fruits were harvested once in every two days and weighed.

Evaluation of Bio-Fertilizers and Bio-Pesticides

Experiment was laid out in Completely Randomized Block Design with four blocks (four farmers) and five treatments each treatment containing 20 plants.

Treatment 1: Bio-fertilizers and Compost (FYM):11 kg, Nitro fix: 21.76g, P-sol-B: 20.4g, K-sol-B: 54.4g, Agri-VAM: 22.0 g

Treatment 2: Bio-pesticide and Compost (FYM): 11kg, *Trichoderma viride:* 27.5g, *Trichoderma harzianum:*27.5g, *Pseudomonas fluorescens:*27.5g, *Metarhizium anisoplae:*55.0g, *Paecilomyces* spp.:55.0g, *Bacillus subtilis:*11.0g

Effect of bio-fertilizers and bio-pesticides on tomato in Lalitpur District

Treatments	**Mean Yield in (Kg)**
Bio-fertilizers	63
Bio-pesticides	57
Bio-fertilizers + bio-pesticides	73
Farmer's practice	63
Control	28

(Average yield in kg from 20 plants, 1 replication and 7 harvests)

Effect of bio-fertilizers and bio-pesticides on tomato in Kaski District,

Treatments	Mean Yield in (Kg), p = 5%
Bio-fertilizers	42 b
Bio-pesticides	39 c
Bio-fertilizers + bio-pesticides	48 a
Farmer's practice	38 c
Control	31 d

(Average yield of 20 plants, 4 replications and 7 harvests)

Treatment 3: Bio-fertilizers + Bio-pesticides and Compost (FYM):11 kg, Nitro fix: 21.76g, P-sol-B: 20.4g, K-sol-B: 54.4g, Agri-VAM: 22.0 g, *T. viride:* 27.5g, *T.harzianum:*27.5g, *P. fluorescens:*27.5g, *M. anisoplae:* 55.0g, *Paecilomyces* spp.:55.0g, *B. subtilis:*11.0g

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

Treatment 5: Control

Yield of tomato increased due to the combined effect of bio-fertilizer + bio-pesticides on tomato crops as compared to other treatments.

Among the treatments, use of bio-fertilizers and bio-pesticides produced significantly more yield.

Comparison of Grafted and Non-Grafted tomato plant

Grafted plants were evaluated against non-grafted plants in a farmer's field at Lalitpur district. Plants were grown in plastic tunnel adopting farmer's practice. Each treatment had 20 plants

The variety, 'Srijana' grafted on *Solanusm sisymbriifolium* yielded 54 kg where as the

non-Grafted plants of the same variety 'Srijana' 49.5 kg/ plant.

Evaluation of Mulching

Black Plastic mulch of 500 gauge was used to test its efficacy in crop production. Each treatment had 20 plants and 3 replications.

Yield of tomato crops increased significantly due to mulching as compared to hand weeding and control.

Effect of mulching on tomato in Kaski District

Treatments	**Mean Yield in (Kg), p = 5%**
Mulching	72 a
Hand weeding	59 b
Control	34 c

(Yield is an average of 20 plants in 10 harvests)

IPM Package Development for Cucumber

Cucumber trials were conducted in three different project districts namely Lalitpur, Kaski and Rupandehi. Seedlings were raised in poly-bags containing a mixture of soil, sand, compost and *Trichoderma*. Four week old seedlings were used for transplantation. Before transplanting, the field was amended with bio-fertilizers, bio- pesticides and compost. Plants were irrigated once a day. Plants were staked a month after transplantation. Soap water traps with mashed sweet gourd were set at the flowering stage to control fruit flies. Foliar spray of bio-pesticides was done after the first appearance of pest/disease symptoms. Fruit were picked from 50 to 90 days after planting.

Effect of Bio-fertilizers and Bio-pesticides on cucumber

Treatment 1: Bio-fertilizers and Compost (FYM):18.6 kg, Nitro fix: 21.76g, P-sol-B: 56g, K-sol-B: 84g, Agri-VAM: 37.2g

Treatment 2: Bio-pesticide and Compost (FYM): 18.6 kg, *T. viride*: 46.5g, *T. harzianum:* 46.5g, *P.fluorescens:*46.5g, *M. anisoplae:* 93.0g, *Paecilomyces* spp.:93.0g, *B. subtilis:* 18.6g

Treatment 3: Bio-fertilizers + Bio-pesticides and Compost (FYM):18.6 kg, Nitro fix: 21.76g, P-sol-B: 56g, K-sol-B: 84g, Agri-VAM: 37.2g, *T. viride:* 46.5g, *T. harzianum*: 46.5g, *P.fluorescence*:46.5g, *M. anisoplae:* 93.0g, *Paecilomyces* spp.:93.0g, *B. subtilis:* 18.6g 4.

Treatment 4: Farmers' practice: Urea: 156g, DAP: 112g, Potash: 168g, Compost (FYM): 18.6kg. Full dose of Potash and phosphorous along with half dose of urea were applied during transplantation.

Treatment 5: Control

There was a significant difference in yield of the treatment with bio-fertilizers and bio-pesticides over other treatments.

Yield of cucumber significantly increased due to the combined effect of bio-fertilizer + bio-pesticides as compared to bio-pesticides only, farmer's practice and control but remained at same level of significance with bio-fertilizers only.

Effect of bio-fertilizers and bio-pesticides on Cucurbit in Lalitpur District

Treatments	**Mean Yield in (Kg), P = 5%**
Bio-fertilizers	83.4 ab
Bio-pesticides	76.8 b
Bio-fertilizers + bio-pesticides	93.3 a
Farmer's practice	77.9 b
Control	58.7 c

(Average yield from 8 plants, 4 replications and 15 harvests)

Effect of bio-fertilizers and bio-pesticides on Cucumber in Kaski District

Treatments	Mean Yield in (Kg), p = 5%
Bio-fertilizers	15.25 ab
Bio-pesticides	14.25 bc
Bio-fertilizers + bio-pesticides	17.25 a
Farmer's practice	11.75 c
Control	11.75 c

(Average yield of 20 plants, 4 replications and 3 harvests)

Evaluation of effect of Mulching for cucumber plants

Black Plastic mulch of 500 gauge was used to test its efficacy in crop production. Experiment was Completely Randomized Block Design with four blocks and two treatments each treatment containing 20 plants.

Plots with black plastic mulch produced an average yield of 112.25 kg whereas the non-mulch plot yielded 78.47 kg in 10 harvests.

IPM Package Development for Coffee

Trials on coffee IPM package development are being conducted at Palpa district. Palpa represents the typical mid-hills of the country where coffee is regarded as one of the important commercial crops. Our trials were mainly focused on the improvement of production through use of bio-fertilizers and management of coffee white stem borer (CWSB) using a pheromone lure and the enotomo-pathogenic nematode, *Steinernema indic*a. CWSB has become the most important pest and it destroyed several hectares of coffee plantations in the recent few years. The trails were mainly concentrated on 3-4 year old coffee plants.

IPM Package Development for Tea

One experiment on tea IPM package development was conducted at Illam district. Illam is one of leading producer for tea in Nepal. Tea mosquito, red spider mites and thrips were the major pest problems.

Evaluation of performance of Bio-Fertilizers and Bio-Pesticides

An experiment was conducted with four replications and five treatments. Each

Effect of bio-fertilizers and bio-pesticides on Tea in Illam District

Treatments	Mean Yield in gm, p = 5%
Control	4440.0 ns
Farmer's practice	4836.3
Bio-fertilizers	5191.3
Bio-pesticides	4743.3
Bio-fertilizers + bio-pesticides	5140.5

ns – not significant

(Average yield in (g.) from 20 plants, 4 replications and 19 pickings) treatment had 20 plants.

Treatment 1: Bio-fertilizers and Compost (FYM):10kg, Nitro fix: 15.36g, P-sol-B: 19.2g, K-sol-B: 38.4g, Agri-VAM: 17.4g

Treatment 2: Bio-pesticide and Compost (FYM): 10 kg, *T. viride: 12.8g*, *T. harzianum*: 12.8g, *P.fluorescens:* 21.8g, *M.anisoplae: 43.6g*, *Paecilomyces* spp.:43.6g, *B. subtilis:* 8.7g

Treatment 3: Bio-fertilizers + Bio-pesticides and Compost (FYM): 10 kg, *T.viride: 12.8g*, *T. harzianum:*12.8g, *P.fluorescence:* 21.8g, *M. anisoplae: 43.6g*, *Paecilomyces* spp.:43.6g, *B. subtilis:* 8.7g , compost (FYM):10kg, Nitro fix: 15.36g, P-sol-B: 19.2g, K-sol-B: 38.4g, Agri-VAM: 17.4g

Treatment 4: Farmers' practice: Urea: 76.8Kg, DAP: 40g, Potash: 76.8g, Compost (FYM):10kg were applied before the emergence of new leaves.

Treatment 5: Control

Yield of tea was not significantly different among the treatments.

Gender

Patriarchal Value and Practice (PVP) has governed Nepalese society and created the gender discriminative status between man and woman. To break down the gender discrimination, Nepal government has taken initiation of gender equality laws, polices and rules. The gender survey in IPM CRSP was designed to analyze the participation, access to assets, beliefs/perception and laws and policies on gender perspective in three districts of Nepal, two districts are located at Hill and one is Terai.

Majority respondents (15% male & 46% female) are belonging to Bahun, Chetri, Janajati, Dalit and Madhesi communities, and altogether 74% female and 26% male respondents were participated in the study. Majority women had primary level education and majority men have higher secondary school level. This information indicates that women had opportunity of education, but at lower level. Majority households (97% women and 90% men) are involving in vegetable production. 75% women and 90% men decide their product price as per market. They sold vegetables two times in a week except one household. 73% women out of 59 female respondents and 62% men out of 21 male respondents were members of Market Planning Committee and Community Forest User Group.

The patriarchal beliefs and practices still dominate unequal status of women and men in all communities and classes in Nepal. Although, government has taken initiation gender equality policy, rules and budget to minimize the gender issues giving emphasis to increase women's participation in all types of programs. Similarly, program implementing organizations are also alerted on gender equality and they have focused to increase the number of women.