Development of Farmer-led Integrated Management of Major Pests of Cauliflower Cultivated in Rainy Season in India

D.B. Ahuja (Correponding author)
National Centre for Integrated Pest Management, Lal Bahadur Shastri Bhawan
Pusa Complex, New Delhi 110012, India
Tel: 91-112-583-1396 E-mail: deshbandhu4@rediffmail.com

Usha Rani Ahuja
National Centre for Agricultural Economics and Policy Research, Library Avenue
DPS Marg, Pusa Complex, New Delhi, India

P. Srinivas
Central Horticultural Experimental Station, Aiginia, Bhubaneswar, India

R.V.Singh & Meenakshi Malik
National Centre for Integrated Pest Management, Lal Bahadur Shastri Bhawan
Pusa Complex, New Delhi 110012, India

Pratibha Sharma
Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi 110012, India

O. M. Bamawale
National Centre for Integrated Pest Management, Lal Bahadur Shastri Bhawan
Pusa Complex, New Delhi 110012, India

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Abstract

Implementation of Integrated Pest and Disease Management programme in irrigated cauliflower crop led to reduction in number of conventional pesticide sprays by 50-60 %. The safer biorational pesticides, insect growth regulators and cultural methods of pest management as introduced in the IPM programme were well received by the farmers in farmers' participatory trainings (FPT). Lower insect and disease incidence with higher curd production was observed in the IPM fields as compared to conventional non IPM fields. Furthermore the module was able to drag the cost of crop protection down by 45 percent resulting in higher benefit-cost ratio. The IPM module led to reinforcement of natural enemies resulting in sustainable and stable pest control regime warranting less pesticide application. *Cotesia glomeratus* L. was found parasitizing the larvae of *Spodoptera litura* F. in IPM fields whereas there was no parasitization in non IPM fields. Post implementation evaluation of the IPM programme revealed that the farmers were educated about the right choice of pesticides, proper time and dose of application, pest monitoring and application of pesticides based on action threshold. Increase in participation of women in the IPM programme was ensured by educating them about the mechanical management of *S. litura.*

Keywords: Cauliflower, Integrated pest management, *Spodoptera litura*, Alternaria leaf spot damping off, Cabbage head borer

1. Introduction

Cauliflower continues to be important vegetable crop for growers of India. Its total acreage in India is 0.35 million hectare with a production of 6.5 million tons, which makes it fifth important vegetable crop after potato, onion, tomato, egg plant and okra. During past several years, the tobacco caterpillar (*Spodoptera litura F.)* has been the most difficult insect pest to control (Loganathan, 2002; Rao *et al*., 2003; Monobrullah *et al*., 2007) with cabbage head borer *(Hellula undalis*), Alternaria leaf spot (Kohl *et al*., 2010) and damping off (Bhagat & Pan, 2008) also complicating Integrated Pest Management (IPM) decision-making in cauliflower. Most growers continue to apply 10-12 pesticide applications for rainy season crop which last for a period of 4 months from June to mid October (Weinberger & Srinivasan, 2009). High frequency of application results in pesticide residues above maximum limit value (Cesnik *et al*., 2009; Shah *et al*., 2000; Kole *et al*., 2002; Islam *et al*., 2009). The concern is not only that the pest control approach currently being followed by farmers is focused on application of highly toxic insecticides but also the resistance *S. litura* has developed against them (Ashwinder Kaur *et al*., 2006; Niranjan Kumar and Ragupathy, 2000, 2001; Sudhakar and Dhingra, 2002; Kranthi *et al*., 2002) leading to higher frequency of application of pesticides. There are many tracking technologies that have shown promising results for management of individual pest problems as stated above but these have neither featured prominently by practicing together to evolve comprehensive management strategy such as IPM nor provide proportionate economic returns. Attempts to integrate the promising technologies into operational IPM programme have been made in the present study for management of cauliflower pests in farmer's participatory mode. The major focus of this approach was on replacement of such insecticides to which the pest had developed resistance with newly introduced effective insecticides, as suggested by Gupta *et al*. (2004) integrating them with other proven methods of pest control against the target pests. The study was also aimed at participatory farm validation of IPM technology to investigate its appropriateness and acceptance among growers after suitable refinement.

2. Materials and methods

2.1 Selection of the village and baseline information

Palari khurad village of district Sonipat of state of Haryana (India), situated at a distance of 50 km away from National Centre for Integrated Pest Management, New Delhi was selected for the present study on development and validation of IPM module for cauliflower. Generally locations in India where vegetables are grown extensively and intensively are near to the major towns which facilitate the grower to sell their produce at a competitive price as well as outlets of buyers having big brand names are available who purchase the harvested produce with convenience from farmers that provides them with regular cash inflow and *Palari* is one of the such village. Before commencement of implementation of IPM programme, farmers in the village were chosen at random and interviewed using prepared questionnaire. Farmers were asked questions related to their socio-personal profiles like educational level, operational size of land holding, experience in vegetable growing, cropping system, cauliflower cultivation practices, extension contacts, source of seeds, farmer knowledge of the pests, assessment of losses due to the pest, natural enemies and their role in pest regulation, type of pest equipment used, pest control advise and mass media exposure. At the end of 4 years, another questionnaire was prepared to assess their knowledge pertinent to IPM technologies implemented and to investigate farmers' understanding of the various components of IPM programme. Per cent farmer's willing to adopt IPM technology was calculated on the basis of response received from 50 selected famers.

2.2 Field studies

Field experiments were initiated during rainy season at farmer's field in the village from the year 2006 to 2009. Cauliflower was transplanted in first week of July and harvesting was started in first week of September and continued till mid of October. The experiment used paired treatment comparisons to compare the IPM system with the conventional system (designated Non-IPM). Initially there were a few farmers willing to quickly adopt new IPM approach due to risk involved in it (3 and 5 acres area covering 3 and 5 farmers families in year 2006 and 2007, respectively), but as the confidence started building up in the village, number of farmers families as well as area under IPM programme increased and adopted on large scale. (25 acres of area under IPM programme covering 25 farmer families in year 2008 and 2009). The treatments tested in each plot were: (a) IPM module synthesized on the basis of available information from literature (b) Conventional system *vis a vis* farmers' practice (FP), using application of agronomic factors and pest control commonly practiced by the local farmers in the non IPM plots (Table 1). IPM components were applied in three stages *i.e.* in the nursery, at the time of transplanting as well as after transplanting of seedlings. IPM trials were conducted on a cauliflower variety belonging to September maturity group. All the growers in the locality were persuaded to raise nursery and to undertake transplanting simultaneously to minimize the error that may occur due to difference in timing of the sowing of the crop and ultimately may be reflected while estimating the curd yield between IPM trials and conventional practice. Farmers selected under IPM practice and the conventional practices were the ones who had transplanted their crop in the first week of July. Crop was raised under similar agronomic schedule in both IPM and non IPM fields. Fields were prepared by 3-4 ploughing. Nursery was prepared on raised bed of 15 cm height. An average of 0.75-1kg/ha seed was used for sowing and the seedlings were ready for transplanting after 4-5 weeks. Farmers were advised to apply fertilizer at 120 kg N, 60 kg P, 80 kg K (per hectare basis), undertake three hoeing 20 days post sowing at an interval of 15-20 days. Crop geometry maintained was 30 cm and 45 cm between plant to plant and row to row, respectively.

2.3 IPM approach

Various components of IPM technology implemented and farmers' response to their adoption are presented in table 1. Testing of various components of IPM approach was based on the previous results that confirmed the effectiveness of application of bio pesticides early in the season to achieve additional bio control and prevent flare up of pest incidence. The use of reduced risk pesticides was limited to late stage of the crop growth based on timely monitoring and scouting and action threshold based on the percentage of plants infected with *H. undalis*, *S. litura*, Alternaria leaf spot or damping off.

2.3.1 IPM intervention applied in nursery

For sowing of seeds raised beds of 15 cm height were prepared in a well drained area so that excess water could be drained in case of heavy rains. Depending upon the requirement for one acre area (4000m^2), nursery beds of size 10 m^2 area was prepared. These beds were solarized by covering with transparent polythene sheet of 250 gauge thickness for 15-20 days for protection against soil borne pathogens. 2.5 kg talc based formulation of *Trichoderma harzianum* adapted for local conditions (Sharma *et al.,* 2003) was amended with one hundred kg of farm yard manure. It was moistened with water and kept for 15-20 days for enrichment with *T. harzianum*. Neem cake and the enriched FYM were broadcasted on raised beds at 50 g/m^2 and mixed in the soil at the time of sowing. Seeds of cauliflower variety early *kuary* marketed by Doctor seeds (Pvt) Ltd, Ludhiana were treated with paste prepared by mixing 5g talc formulation of *T. harzianum* (10^8 conidia/g) in 10-15 ml of water. Seeds were sown in the first fortnight of June for preparation of seedlings.

2.3.2 IPM intervention at the time of transplanting

Raised beds of heights 15 cm were prepared with the help of tractor driven harrow discs in fields selected for transplanting the seedlings of cauliflower. Such beds were placed at a distance of 45 cm. Seedlings were planted on such beds at a distance of 30 cm. Space between the beds were used as irrigating channel for watering the crop. Raised bed method of transplanting the seedlings also helped in avoiding the accumulation of the excess moisture that prevents the proliferation of pathogens. Before transplanting roots of the seedlings were dipped for 10-15 minutes in the water suspension prepared by dissolving 10 g of talc based formulation of *T. harzianum* per liter of water. Funnel shaped pheromone traps were erected at the rate of three pheromone traps/acre at an equal distance of 50 m apart in a diagonal fashion from each other in the field to monitor the population of *S. litura* so as to time the application of insecticides. These traps consisted of a smooth plastic funnel (21 cm diameter, 20 cm length) and a polythene bag (50 x 30 cm) with a pheromone septum (lure) impregnated with 200 mg (Z) – 11- Hexadecenal (97 %) and (Z) -9-Hexadecenal (3 %) purchased from Pest Control India Ltd, Bangalore. The lures were changed at an interval of 30 days. The height of the trap was kept 30 cm above the plant canopy.

2.3.3 IPM interventions after transplanting

Major pest that affected the cultivation of cauliflower after transplanting was *S. litura*. Farmers were advised to initiate spraying of Sl.NPV at the time of appearance of egg masses as well as number of 8-10 male moth catches/trap/night were observed during weeks time, followed by application of azadirachtin at the rate of 30ppm/liter of water to conserve the natural enemies of the pest. Need based application of reduced risk insecticides, against which the development of resistance has not been reported such as indoxacarb, spinosad and novaluron. Mancozeb (2g/lit) was applied for management for Alternaria leaf spot at its appearance. Plucking of leaves infested with neonate larvae, hand picking of egg masses and older larvae of *S. litura* was advised at curd formation stages when the canopy of the crop became dense and application of pesticides was not feasible.

2.3.4 Counts on pest density

Counts of major pests i.e. *H. undalis*, *S. litura*, Alternaria leaf spot and damping off were taken from 100 cauliflower plants from each of the IPM plots and farmers practice plots at 10 day's interval after transplanting from first fortnight of July till harvesting. Number of plants infested with the larvae of *S. litura* or *H. undalis* or having symptoms of damping off disease or Alternaria leaf spot and plants that had no pest infestation due to the corresponding pest were counted and per cent pest incidence was worked out. Observations on number of insecticide sprays, the amount of insecticide and various IPM inputs used during the growing season were recorded for each plot belonging to IPM as well as farmers practice. The marketable yield of cauliflower per plot was recorded at harvest time.

2.3.5 Observations on parasitiziation of caterpillars of *Spodoptera litura* by *Cotesia glomeratus* L.

Caterpillars of *S. litura* in gregarious stage (before dispersal) infesting cauliflower were collected randomly by observing 100 plants per grower's field measuring 4000m^2 belonging to both category of farmers *i.e.* adopting IPM components as well as others adopting conventional practices. These larvae along with the infested leaves were brought to the laboratory. These were sorted out and 50 larvae belonging to one grower field were placed individually in plastic vials which were kept in BOD incubator maintained at temperature of 30±1ºC. This was treated as one location and caterpillars from such 8 locations half belonging to IPM growers and another half belonging to non IPM farmers' category were observed. Caterpillars were fed leaves of cauliflower and food was changed daily. Larvae were kept for observation till the pupae formation. Observations were recorded on number of adults of *C. glomeratus* L. and *Telenomus* sp. emerged from one lot of 50 larvae and per cent parasitization was worked out. Observations on predator's population in both IPM and non IPM fields were also recorded. Population of predators was also recorded.

2.3.6 Cost of production

Cost of production was calculated by taking into consideration the expenditure incurred on cost for field preparation, nursery sowing, transplanting, fertilizer application, hoeing and weeding, pesticide application, material cost like seed, pesticides, bio control agents, IPM inputs, fertilizers, and irrigation.

2.3.7 Statistical analysis

The data on curd yield (kg/ha), cost of production (Rs/ha) including all inputs and cost of plant protection (Rs/ha) were subjected to paired 't' test using SAS software to see whether the treatments are significant. Pooled analysis for yield, cost of production and cost of plant protection was also carried out using SAS.

3. Results and discussion

3.1 Impact of IPM technology on pest incidence, natural enemies and curd yield

IPM technology implementation was initiated through organizing farmers field schools based on the principle that learning by doing add to farmers' knowledge and experience, and improves their capacity as skilled grower in a way that passive experience, like listening to extension messages, cannot. Therefore, the most important component in the first year of the project was training of the farmers for development of technical skills which led to the transfer of IPM technologies to them for development of technical skills such as reinforcement of FYM with *T. harzianum*, seed treatment and seedling dip with *T. harzianum*. The participatory learning sessions resulted in the increased awareness of participants on action threshold concept, importance of soil-borne diseases, recognition of symptoms, scouting for the damage due to *H. undalis, S. litura* and Alternaria leaf spot (ALS), installation of sex pheromone trap for monitoring of population of *S. litura.* Farmer's participatory training (FPT) also enabled the farmers to recognize the life stages of insect pests such as egg stages of *S. litura*, and scout for the presence of cocoons of natural enemies such as *C. glomeratus* in the field. Finally, the impact of using a broad-spectrum chemical insecticide compared to a specific Sl NPV biopesticide and reduced risk insecticides was discussed. This type of farmers' participatory trainings has had greater success in achieving IPM implementation (Way & van Emden, 2000**)**. In India also training through farmers field school tend to change the attitude of farmers which indicated that farmers trained through FPT tend to adopt IPM technology and have favourable attitude towards IPM in comparison untrained farmers (Krishnamurthy & Veerabhadraiah, 1999).

3.2 Pest incidence

Fields for raising nursery for early cauliflower were prepared in last week of May as per recommended IPM module. Nursery plants were transplanted between 1st and 10th of July by all the adopted IPM famers and the conventional farmers. Several insects were found visiting and feeding the foliage of cauliflower (Table 2). Major pest problems were incidence of *H. undalis* and damping off caused by *Pythium* sp. during nursery stage. After transplanting of the nursery plants in the main field incidences of *S. litura* and leaf spot caused by *Alternaria brassicae* and *A. brassicola* were observed. During the period under study from year 2006-2009, per cent plants infested with *H. undalis* varied from 1.36 per cent to 5.03 per cent in IPM and 1.70 per cent to 14.77 per cent, in non-IPM fields, respectively (Fig.1). Per cent plants infested by the neonate larvae of *S. litura* was also lower in IPM fields (1.5% to 5.04%) than the non-IPM fields (5.47% to 13.5%) (Fig. 2). Maximum male moth catches of *S. litura* and its damage was recorded in the month of August and early September, thereafter both damage and population declined. Incidence of damping off in the nursery with IPM practices varied between 3 to 6 per cent and that of Alternaria leaf spot varied from 2 to 5 percent in IPM main fields. In nursery with farmers conventional practices 5 to 11 per cent damping off incidence was observed whereas 4 to 10 per cent incidence of Alternaria leaf spot diseases was recorded in main plots with farmers practice (Fig. 3 & 4). Other workers have also reported these pests to cause serious damage to curd yield (Singh *et al*., 2002; Loganathan, 2002; Kohl *et al*., 2010). Farmers exclusively use pesticides for management of the above pests (Weinberger & Srinivasan, 2009). However at research farms efficacy of bio control agents such as of soil and seedling treatment with *T. harzianum* has been well documented against damping off pathogens like *Pythium* sp. (Sivan *et al*., 1984; Bhagat & Sitansu, 2008) and against different pathogens in various crops (Harman *et al*., 2002; Fourie *et al*. 2001; Fajola & Alasoadura, 1975; Tran, 1998; Tran, 2010; Aerts *et al*., 2002). Efficacy of *T. harzianum* for biocontrol of Pythium damping-off of cauliflower has also been well established (Mukherjee *et al*., 1989; Mukherjee & Mukhopadhyay 1995). The classic studies of Dennis and Webster (1971a,b,c) revealed antibiotic production and hyphal interaction as the mode of action of biocontrol by some isolates of *T. harzianum.* Moreover, Singh *et al.* (2002) reported that these pest can also be managed through integration of the seed treatment with carbendazim @ 2 g/kg seed, raising seedling in solarized beds, crop raising in green manure field+neem cake 25 kg/ha with soil treatment by *T. viride* @ 2 kg/ha before sowing. Dabbas *et al.* (2009) has also established the effectiveness of soil solarization, soil amendment with *T. viride* and neem cake application in reducing the root diseases caused by *Rhizoctonia solani.* Setting up of funnel traps baited with pheromones at 12nos./ha, collection and destruction of egg masses and gregariously feeding early instar larvae of *S. litura* and 2-3 need-based applications of Sl NPV and chlorpyrifos 20 EC 0.03% produced commendable results. Hussain *et.al*. 2003 reported Sl NPV very effective against *S.litura*. Mandal *et al*. (2009) recommended three application of spinosad (Success 2.5 SC) at 15 and 30g a.i. for management of *S. litura*. Muthukumar *et al*. (2007) reported that spinosad at 75g ai/h, Spinosad, Biolep, emamectin benzoate and neem oil proved safer to natural enemies in the cauliflower ecosystem. Mohapatra *et al*. (1995) reported effectiveness of neem based formulation while Pramanik & Chatterjee (2004) reported the efficacy of novaluron against *S. litura.* Spinosad is also known to reduce the population of *Pieris brassicae* and its application will reduce the chances of it appearance if likely to appear (Atwa *et al*., 2009).

3.3 Natural enemies

In the present study major natural enemies recorded were egg/larval parasitoid (*Telenomus* sp.) and larval parasitoid (*Cotesia glomeratus*) of *S. litura*, *Chrysoperla carnea* (Stephans) predating neonate larvae of *S. litura*. During rainy season, extent of parasitization by *C. glomeratus* in both IPM and farmers field was recorded that was higher in the former as compared to later (Fig.5). Though no parasitization was recorded in the first year of the project, build up of population of natural enemies was observed second year onwards may be due to use of bio pesticides and reduced risk of insecticides which have also been reported safer to them (Muthukumar *et.al*., 2007).

3.4 Curd yield and its economic analysis

Curd yield of cauliflower was recorded in IPM and farmers practiced fields. On an average, the IPM program increased marketable yield by 15.71% and decreased the number of insecticide applications by 50-60%. In cauliflower, cost of production including plant protection (Rs/ha) was less in IPM fields than in farmers practice. Economic analysis of the data also showed higher economic returns and benefit-cost ratios in IPM practice (Rs 179738/ha, 1:4.79) as compared to farmers practice (Rs 152574 /ha, 1: 3.26). Higher benefits were primarily due to decrease in cost of input for plant protection in IPM fields as compared to farmers practice. Mean cost of plant protection in IPM field was Rs.6247/ha as compared to Rs.11488/ha, indicating 45 per cent reduction in cost of plant protection. The reduction in cost of plant protection has taken place due to replacement of cyclidiene, organophosphates, and carbamate and synthetic pyrethroid to which insect has developed resistance (Murugesan & Dhingra, 1995, Niranjan Kumar & Ragupathy, 2000, 2001; Sudhakar & Dhingra, 2002; Kranthi *et al*., 2002), with newly introduced insecticides such as spinosad, indoxacarb, Sl NPV, rimon or corzen with proven efficacy against *S. litura* (Gupta *et. al*., 2004; Mohapatra *et al*., 1995; Pramanik & Chatterjee, 2004; Muthukumar *et al*., 2007) and low residual effect with shorter waiting period for harvest of the produce (Mandal *et. al*., 2009; Atwa *et al*., 2009; Sharma *et al*., 2008). Earlier studies carried out by Patil (2008) in red gram production also indicated negative influence of pesticide excessive usage on the cost of cultivation in non-IPM farmer's fields thereby resulting in negative returns on net profit whereas in IPM farmers, the effect of plant protection chemicals on production was positive. Thus, there is need to educate farmers on the benefits of IPM technology through various extension activities so that its adoption can be extended (Balappa *et al*., 1998). Pouchepparadjou *et al*, (2005) also observed that the economic efficiency was 32 percent among non-adopters and 9 percent among IPM adopter thus have greater potential than that of non-adopter farmers, they show that the adopter farmers can boost output through the use of best practice technologies of IPM in irrigated rice. The results in the present study established that IPM had the economic potential to substitute chemical pesticides without demanding any enhancement in cost of cultivation and over and above it also ensured higher economic returns as well as higher curd yield with added advantage of no adverse effect on environment, natural enemies and human health.

3.5 Farmers' understanding of the IPM technology implemented at their fields

Farmers' response recorded after termination of the project to various components of the IPM technology that were implemented at their fields is presented in table 1. Per cent farmers who consented to continue to adopt application of *T. harzianum* in soil through FYM amendment and as seedling dip was 96 per cent rated as high degree of response as compared to its application as seed dresser which had mean value of 48 percent. Response to adoption of this component of IPM technology was overwhelmed as envisaged through availability of this product with the local vendors in the village which was not available at time of the initiation of the project. Farmers felt that seed treatment is not essential as the seed purchased by the growers is already treated with carbendazim. Only 8 per cent of the farmers agreed to make use of neem cake as soil amendment but farmers didn't provide any explanation not to make use of it, probably non availability in local market may be one of the reasons for non-preference. Farmers were convinced with the preparation of the raised bed for preparation of nursery to avoid water logging conditions during rains and 98 per cent of the farmers were willing to continue to do so. All the farmers were willing to scout for pest damage to time the application of pesticides. Farmers learnt to time the application of insecticides with the recording of egg masses on the lower surface of leaves or on ETL basis and also with the trapping of male moths in sex pheromone trap, but when asked whether they were willing to install these traps, only 40 per cent of farmers showed their willingness to do so, because stray and domestic dogs damaged these traps and made them non functional when male moth catches starts. Response to the choice of insecticide such as spinosad, novaluron, indoxcarb etc. was also 90 per cent as these provided high levels of pest mortality and remained effective for longer period, and helped to avoid repeated spray. Only 10 per cent farmers were convinced about the efficacy of the neem but response towards use of Sl NPV was 40 per cent. Eighty per cent of the farmers were educated to differentiate between the symptoms of the diseases or insect damage and adopt pesticide application accordingly.

4. Conclusions

Implementation of IPM programme resulted reduction in number of sprays by 50-60 % as well as replacement of highly toxic pesticides with bio pesticides like *Trichoderma*, *Neem (Azadirachta indica)* based formulations and Sl NPV more safer insecticides like spinosad, corzen, indoxacarb and Insect growth regulator such as novaluron causing less hazards to environment and safer to natural enemies. As a result there was reinforcement of natural enemies resulting sustainable and stable pest control warranting less pesticide application. *Cotesia glomeratus* was found parasitizing the larvae of *S. litura* in IPM fields whereas there was no parasitization in non IPM fields. Farmers were educated about the proper time of application, proper doses and about the right choice of pesticides. Farmers came to know about the bio pesticides and differentiate between less harmful and more harm full pesticides. Farmers could know about the pest monitoring and application of pesticides based on action threshold. Women laborer who were engaged for hoeing and weeding were educating about the management of *S. litura* through mechanical method *i.e.* women were imparted training to identify the egg masses, bunches of neonate larvae and later instars of caterpillar of *S. litura.* This resulted value addition to their work and helped generating employment opportunities. Farmers were able to identify the various stages of the pest and damage cause by them and could differentiate between the symptom of damage due to insects and diseases, thereby helping to make right choice of the pesticides. The empowerment with knowledge of the producer and consumer would further propel the adoption of the IPM modules as increase in public awareness would also like to fetch a premium price for the farmers following integrated pest management strategies (Govindasamy & Italia, 1997).

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Table 1. Main interventions in IPM and Farmers Practice and farmers' assessment of IPM technology

Crop stage	Management Practice (IPM) Recommended	Per cent farmers willing to adopt IPM technology	Farmers Practice	Remarks (Farmers feedback)
Nursery	Preparation of nursery on raised bed (15 cm height) to avoid water logging condition and prevent the flare up of the diereses Application of neem cake @ 50g/m2, as soil amendment Application of *T. harzianum* @ 250g/q of FYM for mixing in the nursery bed, *T. harzianum* as seed treatment @ 4 gm/Kg seed	96 08 96 48	No raised bed sowing, No *neem* cake application, No application of *T. harzianum* by any method, but applied phorate granule as soil application and Carbendazim as seed treatment	Application of *T. harzianum* as soil treatment, raised bed method of raising nursery adopted and convinced and shall continue to adopt Farmers preferred seeds pretreated with Bavistin Farmers also prefer to use reduced risk pesticides for preventing damage due to *H. undalis* and Damping off disease and was not convinced with the application of neem based formulation alone
At time of transplanting of the seedlings	Transplanting of seedlings on raised beds Seedling dip with *T. harzianum* at10 g/liter of water Installation of pheromone traps for monitoring of *S. litura*	100 80 40	Transplanting of seedlings on raised beds No seedling dip adopted No pheromone traps	Farmers fully convinced with both the components. Farmers are convinced with its utility in terms of both mass trapping as well as timings of application of insecticides, but stray dogs eats away the polythene bags filled with male moth catches.
After transplanting	Scouting and monitoring of pest population	100	No scouting	Convinced to adopt this technology
	Plucking of leaves infested with neonate larvae in gregarious phase, hand picking of egg masses and older larvae of *S. litura*	60	No mechanical control such as hand picking of older larvae/egg masses/ plucking of infested leaves with *S. litura* in gregarious phase	Farmers particularly female labours were trained to do this job when engaged for hoeing. Farmers are convinced about the usefulness of this practice, but due to labour shortage unable to adopt fully
	Need based application of pesticides depending upon ETL 3-5 per cent plant infested due to *H. undalis*, or 5-6 per cent plants infested due to *S. litura* 5-6 per cent due to alternaria leaf spot disease	90	Scheduled 10-12 sprays of highly poisonous and ineffective pesticides	Need based application preferred
	Choice of bio pesticides such as Neem based formulations, Sl NPV Application of reduced risk pesticides such as novaluron, or indoxacarb, or spinosad	10 40 90	Scheduled application of endosulfan, cypermethrin, fenvelaerate chlorpyriphos profenophos, methyl parathion, mancozeb, carbendazim	Neem based formulation not liked but willing to make use of Sl NPV Ready for replacement of conventional insecticides by reduced risk insecticides
	Ability to Identify various stages of the pest and differentiate between symptoms of damage due to insects and pathogens (diseases) Ability to identify natural enemies	80 10	Followed scheduled application of pesticides at regular intervals as advised by pesticide vendor. Have no ability to differentiate between the diseases symptoms and insect damage.	IPM farmers were trained through FPT on different aspects such as pest scouting, could differentiate between disease and insect damage, proper choice of pesticides, timely application etc. A few farmers also could develop ability to notice the presence of natural enemies such as spiders, *Chrysoperla* and cocoons of *C. plutellae*

Table 2. Pest complex associated with cauliflower at farmers fields in Palari village of Sonipat district

Common name	Scientific name	Plant stage damaged	Remark
Cabbage head borer	*Hellula undalis* Fab.	Seedling	Continue to damage even after transplanting but up to four leaf stage
Diamond back moth	*Plutella xylostella* (Curtis)	Seedling	Continue to damage till curd formation
Tobacco caterpillar	*Spodoptera litura* (F.)	Foliage stage	Continue to damage even after formation of curd
Cabbage butterfly	*Pieris brassicae* L.	Foliage stage after transplanting	Continue to damage the foliage up to initiation of the curd formation
Painted Bug	*Bagrada hilaris* (Kirk)	Seedling stage	Continue to damage even up to four leaf stage
Cutworm	*Agrotis ipsilon* Hufn.	After transplanting	Continue to damage up to four leaf stage
Damping off	*Pythium debaryanum* (R. hesse),	Seedling	Continue to damage even after transplanting but up to four leaf stage
Alternaria leaf spot	*Alternaria brassicicola* (Schw.) A. *brassicae*	Foliage stage after transplanting	Continue to damage even after formation of curd
Downy mildew	*Peronospora parasitica (Pers.)*	Foliage stage after transplanting	Continue to damage even after formation of curd
Black rot	*Xanthomonas campestris pv. campestris*	Foliage stage after transplanting	Continue to damage even after formation of curd

Table 3. Mean curd yield and economics of cauliflower cultivation grown in rainy season at Palari village of Sonipat, Haryana (2006-2009)

Parameter	Year 2006[1]		Year 2007[2]		Year 2008[3]			Year 2009[4]			Pooled Mean (Years 2008 & 2009)		
	IPM	FP	IPM	FP	IPM	FP	't' value	IPM	FP	t' value	IPM	FP	't' value
Total cost of production Rs/ha (all inputs)	42250	47500	24850	38900	36718	47605	15.01	38321	45840	8.23	37520	46723	15.29
Mean Yield (q/ha)	61	56	58	53	66	57	4.53	74	62	5.62	70	59	6.69
Cost of plant protection Rs/ha	-	-	-	-	5985	10870	21.26	6510	12105	4.53	6247	11488	26.11
Total Returns (Rs/ha)	181500	168000	138048	125466	159676	137748	-	199800	167400	-	179738	152574	-
Net Returns (Rs/ha)	139250	120500	103198	86566	122958	90143	-	161479	121560	-	142219	105852	-
Cost Benefit Ratio	1:4.29	1:3.53	1:3.96	1:2.22	1:4.34	1:2.89	-	1:5.21	1:3.65	-	1: 4.79	1;3.26	-

Rates of cauliflower: Rs3000 /q[1], Rs.2374 /q[2], Rs.2423 /q[3], Rs.2700/q[4]

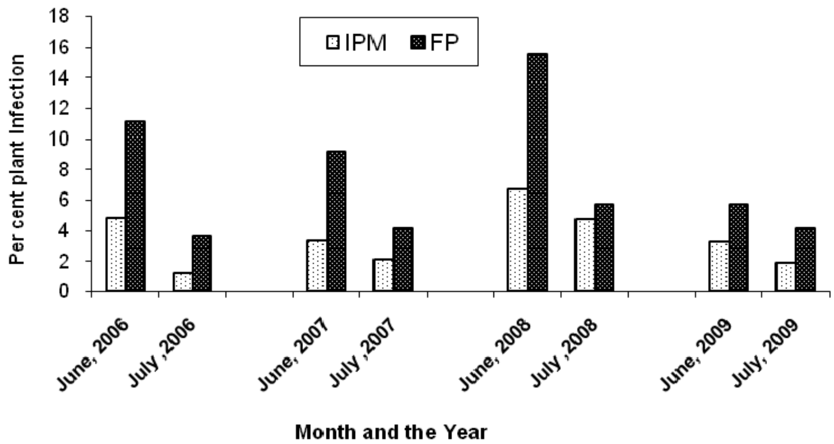

Figure 1. Per cent plant infected with damping off during nursery stage during 2006 to 2009

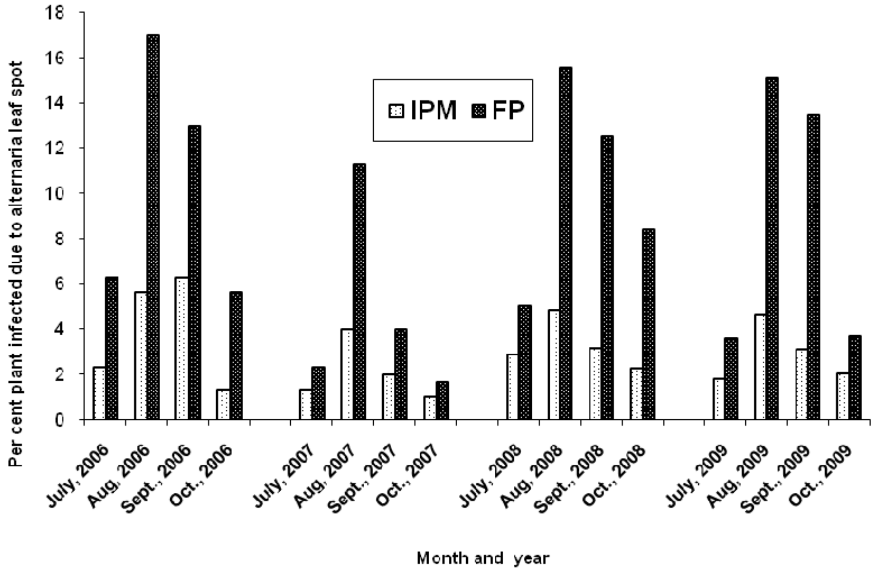

Figure 2. Per cent plant infected with Alternaría leaf spot during crop growth period during 2006 to 2009

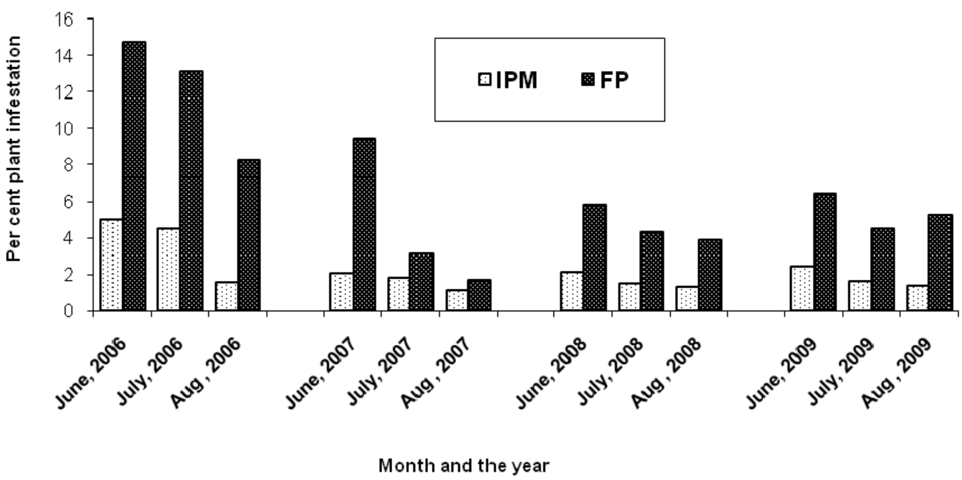

Figure 3. Percent plant infestation due to *Hellula undalis* during crop growth period during 2006 to 2009

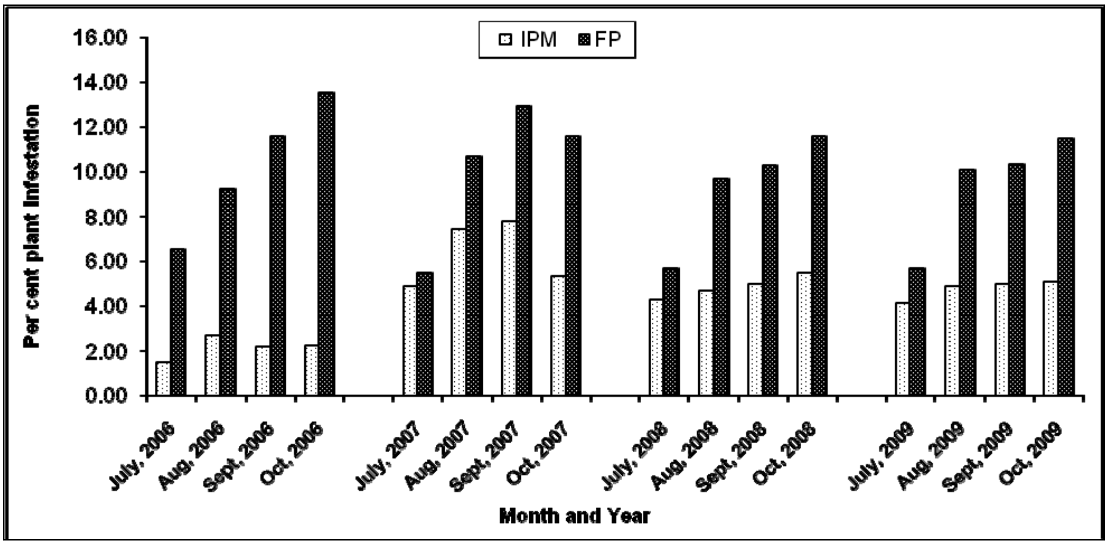

Figure 4. Per cent plant infestation due to *Spodoptera litura* during crop growth period during 2006 to 2009

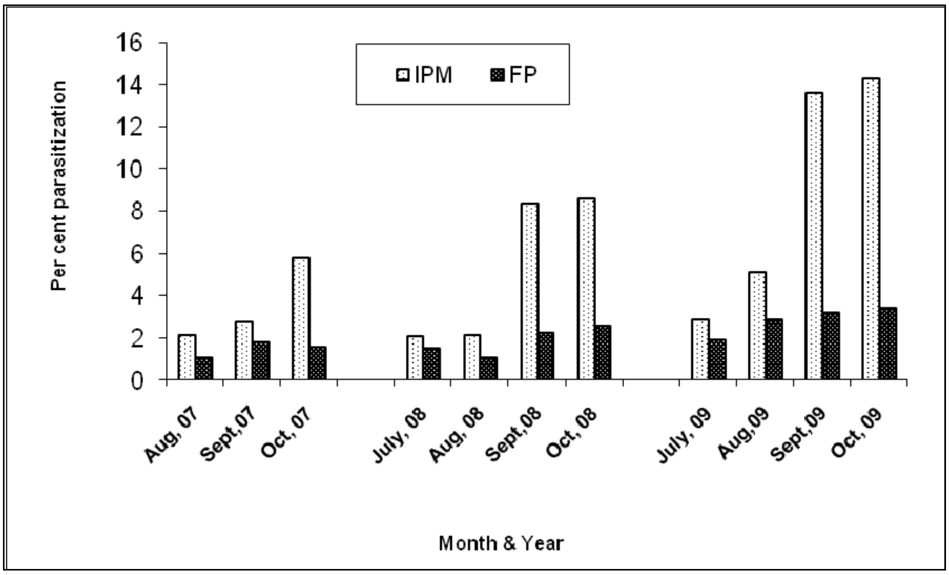

Figure 5. Per cent parasitization on the caterpillar of *Spodoptera litura* by *Cotesia glomeratus* during crop growth period during 2006 to 2009