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Evaluation of pest management practices against sucking pests of *Bt* cotton

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ABSTRACT

The impact of non-pesticide farmer's practice (Jind district, Haryana) adopted by a group of farmers on pest population, natural enemies and yield parameters was studied and compared with Integrated Pest Management strategy and pesticide based farmers' practice within same villages where this group has implemented their pest management strategy in *Bt* cotton. Comparison of population per three leaves of sucking pests (average of 3 years) indicated lowest population of whitefly (adult), jassid and thrips (nymph and adult) in IPM module (7.18, 3.37 and 7.17) followed by NIFP, non-insecticidal farmer's practice (7.70, 3.48 and 7.62) and FP, farmer's practice (9.64, 4.14 and 9.69) respectively. While studying the interaction among sucking pest and natural enemies it was interesting to note that the population, in both the cases, increased gradually and after attaining the peak activity there was a declining trend. Socio-economic studies also supported the above results. In present study, the mean seed cotton yield during 2015, 2016, 2017 in IPM fields was 13.75, 22.45 and 17.42 q/ha, in NIFP it was 14.20, 18.10 and 13.70 as against 8.85, 16.75 and 9.30 q/ha in pesticide based farmers' practice, respectively. The incremental benefit cost ratio in IPM fields was 2.87, 3.56, 3.81 and it was 4.09, 3.53, 3.66 in NIFP fields as against 1.60, 1.99, 1.82 in FP during 2015, 2016 and 2017, respectively. It is evident that by adopting IPM strategy, sucking pests in Bt cotton can be successfully managed along with conservation of natural enemies with minimum application of insecticides.

Key words : Bt cotton, IPM, Natural enemies, Sucking pests

Cotton (*Gossypium* spp) is an important cash crop playing a pivotal role in sustaining economy of India and livelihood of the Indian farming community. Cotton crop is ravaged by an array of insect pests accounting for profound crop loss. With the changes in agronomical practices after the introduction of Bt genotypes for commercial cultivation, reduced number of sprays and use of target specific insecticides, the sucking pests, viz. leaf hoppers, whiteflies, thrips, aphids and mealy bugs assuming major status in Bt cotton ecosystem. Cotton ecosystems throughout the world harbor a wide variety of insects. The number of species found in the crop may range from a few hundred to more than a thousand. The vast majority of these species are parasitoids and predators of phytophagous species. Estimates of the number of pests species range from 20 to 60 but significant damage is caused by 5-10 key pests in most production systems (Luttrell *et al.* 1994). In India, 162 species of phytophagous insects have been recorded on the crop, of which 24 species have attained pest status and nine are key pests in one or more cotton growing zones of the country (Sundramurthy and Chitra 1992, Dhawan 2000). In Punjab and Haryana, there has been a change in pest scenario in the last decades. The main thrust of Indian cotton growers has so far been towards the repeated application of synthetic pesticides to combat pest problem and save the crop. Besides increasing cost of production and environmental problems, the excessive and indiscriminate use of insecticides for the control of these insect pests has resulted in development of insecticidal resistance, decline in natural enemies population and resurgence of the insect pests like whitefly, *Bemisia tabaci* (Gennadius) and jassid, *Amrasca biguttula biguttula* (Ishida). Besides, other sucking pests like thrips, *Thrips tabaci* Lindeman hitherto occurring during May–June and aphids, *Aphis gossypii* Glover at fag end of the crop season are also gaining importance.

During 2014, ICAR-NCIPM identified a group of farmers under *'Keet Saksharta Samuh'* in a few villages of Jind district who managed the cotton pests by conservation of natural enemies and have never used any chemical pesticide against insect-pests. ICAR-NCIPM in collaboration with the farmers of *'Keet Saksharta Samuh'* studied the impact of non-insecticidal farmer's practice (NIFP) on pest population, natural enemies and yield parameters and compared it with Integrated Pest Management (IPM) strategy and pesticide based farmers' practice (FP) within same villages in *Bt* cotton.

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MATERIALS AND METHODS

Baseline information on the pest management strategy adopted by *'Keet Saksharta Samuh',* i.e. NIFP and pesticide based pest management was collected from four villages, i.e. Nidani, N $29^0$25'51.7'' E $076^0$35'48.0'', Alewa, N $29^0$47'52'' E $076^0$44'76'', Mohangarh Chapra, N $29^0$25'05.3'' E 76^0 17'58.1'' and Rajpura Bhend, N $29^0$32'11.2'' E $76^0$30'58.7'' of Jind district of Haryana and IPM trials in *Bt* cotton were conducted in the same four villages during *kharif* 2015, 2016 and 2017 with Bioseed 6588 BG II *Bt* cotton to compare the IPM, NIFP and FP. The details of pest management practices in farmer - participatory mode are given below :

Management practice	Details
Integrated Pest Management (IPM)	Removal of weeds, timely sowing, border crop bajra/maize for natural enemy conservation, yellow sticky traps for monitoring or mass trapping and pheromone traps for monitoring, spray of biopesticides along with need based sprays of insecticides. In 2015, bio pesticides, azadirachtin 1500 ppm @ 3 l/ha, *Verticillium lecanii*, 1 × 109 CFU's/ml @ 3 l/ha and diafenthiuron 50 WP @ 300g ai/ha and spiromesfen 22.9% SC @ 144g ai/ha were sprayed in IPM, whereas in 2016 only two sprays of azadirachtin 1500 ppm @ 500 ml/ha were done and no chemical pesticide was required. In 2017, one spray of azadirachtin 1500ppm @ 3lit/ha and flonicamid 50WG @ 80g ai/ha were required.
Non Insecticidal Farmer's Practice (NIFP)	Removal of weeds, timely sowing and 6-8 sprays of di-ammonium phosphate, urea, zinc (2.5 kg+2.5 kg+0.5 kg/100 l of water) at 15-20 days interval starting from flower initiation along with need based sprays of MOP 1 kg/100 l , $MgSO_4$ 1 kg/100 l, sulphur (80%) 1 kg and boron 250 g in 100 l of water.
Farmer's Practice (FP)	Farmers used 6-11 sprays of insecticides such as dinotefuran 20% SG @ 40g ai/ha, carbaryl 85% WP @ 1200g ai/ha, flonicamid 50@WG @ 75g ai/ha, diafenthiuron 50 WP@300g ai/ha, thiamethoxam 25WG @ 25g ai/ha, imidacloprid 17.8 SL @25g ai/ha, profenofos 50%EC @500g ai/ha, spiromesfen 22.9% SC @ 144g ai/ha, triazophos 40%EC @ 600g ai/ha, acephate 50% + imidacloprid 1.8% SP etc. The farmers usually tend to give higher than the recommended dose.

Weekly observations were recorded on population of sucking pests mainly whiteflies (adult), jassids and thrips (nymph and adult) on three leaves (top, middle and lower) each of 20 randomly selected plants collected from five spots in one-acre field. Among beneficials, population of ladybird beetle (Coccinellids) and green lacewing (Chrysopids) (adults) and spiders (adults and spiderlings) were also recorded on randomly selected 20 plants/plot. Seed cotton yield of each plot was recorded over the three pickings. For economic analysis, number of chemical sprays, biopesticide sprays, cost of cultivation including plant protection, yield, and benefit cost ratios were computed. Farmer's Field School (FFS) were organized at 15-30 days interval in adopted villages during each crop season for dissemination of integrated pest management strategies. FFS included the training on identification of insect pests, diseases and beneficial, Economic Threshold Level (ETL) concept, use of biopesticides and bioagents and management tactics including safer pesticides. Weekly data on insect pests and natural enemies collected from IPM, NIFP and FP fields were subjected to ANOVA using statistical software.

RESULTS AND DISCUSSION

Baseline information

Baseline information collected from 32 farmers indicated that farmers associated with *Keet Saksharta Samuh* (non-insecticidal farmer's practice NIFP) have not used any chemical insecticide for pest management on *Bt* cotton

Table 1 Insect-pest and beneficials at farmer's field of Jind region during three consecutive years (three years *kharif* season, 2015, 2016 and 2017).

Pest/ Beneficials	2015	2016	2017	Average (2015-17)
Jassid (*average nymph or adult/ 3 leaves*)				
IPM	3.80±2.13	2.97±2.00	3.34±2.62	3.37
NIFP	3.93±2.55	2.68±1.80	3.84±2.54	3.48
FP	4.20±3.34	3.84±2.42	4.39±3.92	4.14
Whitefly (*average adult/3 leaves*)				
IPM	12.55±5.56	4.11±3.43	4.90±5.05	7.18
NIFP	13.45±7.41	4.30±3.59	5.36±5.67	7.70
FP	16.64±11.26	6.23±4.05	6.06±5.96	9.64
Thrips (*average adult/ 3 leaves*)				
IPM	7.63±4.85	5.26±6.18	8.62±0.27	7.17
NIFP	7.98±5.28	5.60±6.67	9.29±0.44	7.62
FP	10.09±4.04	8.37±6.71	10.61±0.19	9.69
Spider (*average adult and spiderlings/plant*)				
IPM	0.63±0.27	0.68±0.50	0.61±0.28	0.64
NIFP	0.67±0.18	0.69±0.41	0.66±0.33	0.67
FP	0.43±0.13	0.50±0.32	0.44±0.27	0.45
Lady bird beetle (Coccinellids) (average adult/plant)				
IPM	0.42±0.26	0.39±0.27	0.45±0.25	0.43
NIFP	0.47±0.22	0.50±0.44	0.50±0.19	0.49
FP	0.10±0.12	0.11±0.19	0.13±0.12	0.11
Green lacewing (Chrysopids) (average adult/plant)				
IPM	0.39±0.15	0.34±0.35	0.41±0.22	0.38
NIFP	0.35±0.14	0.40±0.40	0.44±0.23	0.40
FP	0.17±0.09	0.22±0.28	0.18±0.22	0.19

IPM : Integrated Pest Management, NIFP : Non-insecticidal farmer's practice, FP : farmers' practice, ± Standard deviation

and generally used six to eight sprays of di-ammonium phosphate, urea, zinc (2.5 kg+2.5 kg+0.5 kg/100 l of water) at 15-20 days interval along with need based sprays of micronutrients. Other farmers of these villages were not aware of IPM technologies and were dependent on 5-20 sprays of chemical insecticides (dinotefuran, flonicamid, diafenthiuron, acetamiprid, thiamethoxam, imidacloprid, acephate, imidacloprid+acetamiprid, chlorantraniliprole etc.) for *Bt* cotton pest management (farmers' practice) based on advice of pesticide dealers.

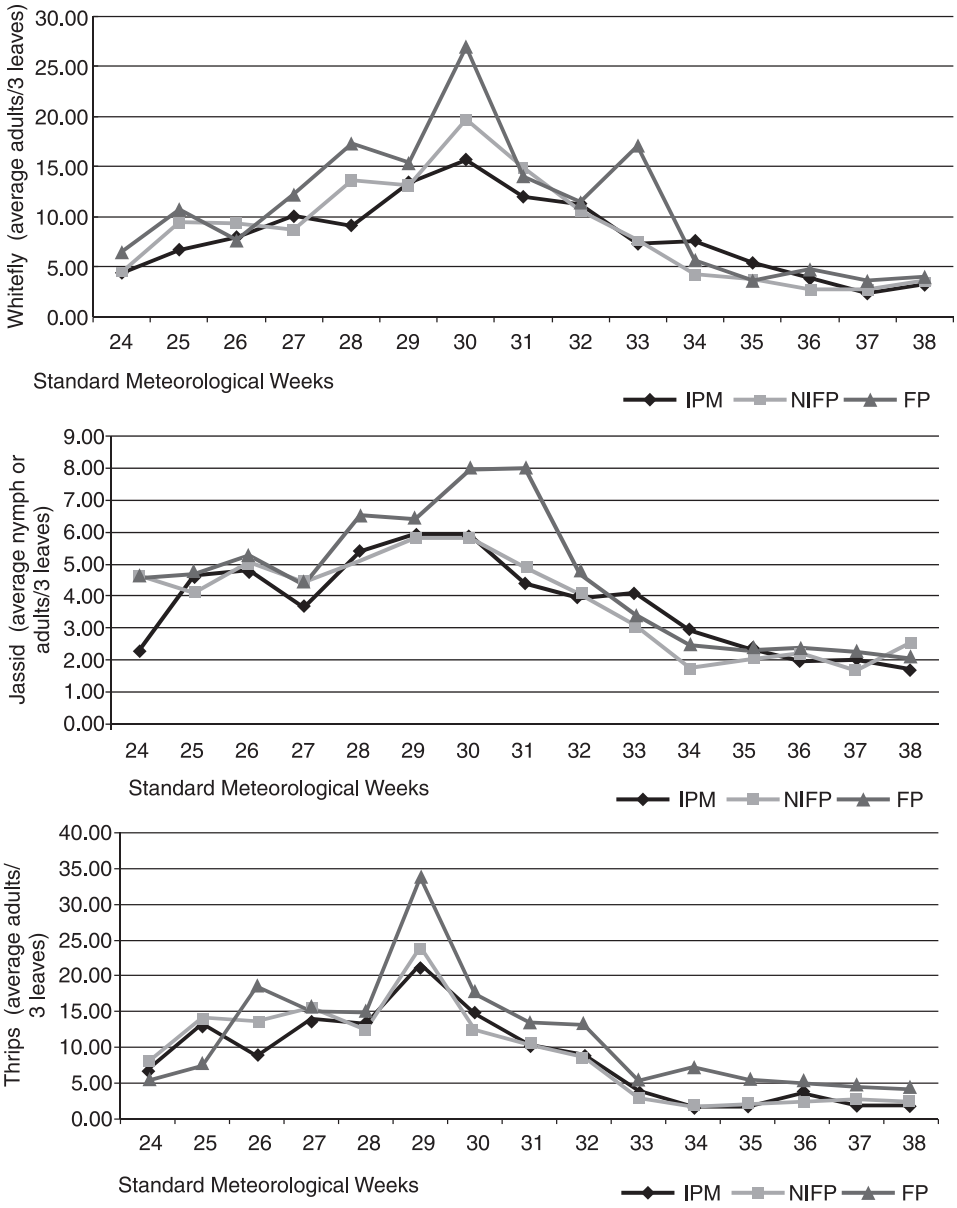
Sucking pests

Comparison of population per three leaves of sucking pests (average of 3 years) indicated lowest population of whitefly (adult), jassid and thrips (nymph and adult) in IPM module (7.18, 3.37 and 7.17) followed by NIFP (7.70, 3.48 and 7.62) and FP (9.64, 4.14 and 9.69) respectively (Table 1). While analyzing the trend of sucking pests individually on weekly basis, it was observed that the population buildup of whitefly was initially 4.46, 4.60 and 6.55 adults/3 leaves in 24 SMW and reached at its peak in 30 SMW with 15.75, 19.75 and 27.04 adults/3 leaves in IPM, NIFP and FP, respectively (Fig 1). After achieving the peak activity there was a gradual decline in population in IPM and NIFP however FP has shown again an increasing trend up to 33 SMW.

In case of jassid initial infestation of 2.29, 4.65 and 4.57 nymphs or adults/3 leaves was recorded in 24 SMW in IPM, NIFP and FP, respectively and reached its peak, i.e. 5.95 and 5.84 nymphs or adults/ 3 leaves in 29 SMW in IPM and NIFP, however, in case of FP highest activity, i.e. 8.02 nymphs or adults/3 leaves was recorded in 31 SMW. In the subsequent weeks there was a declining trend of pest population. In case of thrips, peak population was recorded in 29 SMW, i.e. 21.66, 24.41 and 23.4 nymphs or adults/3 leaves in IPM, NIFP and FP, respectively. Similar to jassid, there was a declining trend in subsequent weeks (Fig. 1).

Beneficials

Among beneficials population of spiders, lady bird beetle and green lacewing remained highest in NIFP (0.67, 0.49 and 0.40 adult/plant) followed by IPM (0.64, 0.43 and 0.38 adult/plant) and FP (0.45, 0.11 and 0.19 adult/plant), respectively (Table 1). While studying the population of beneficials, the peak population, i.e. (0.77, 0.87 and 0.22 adult/plant) of coccinellids and 0.69, 0.69 and 0.54 adult/plant of chrysoperla were observed in 27 SMW except in FP where it was recorded in 28 SMW. While studying the interaction among sucking pest and natural enemies



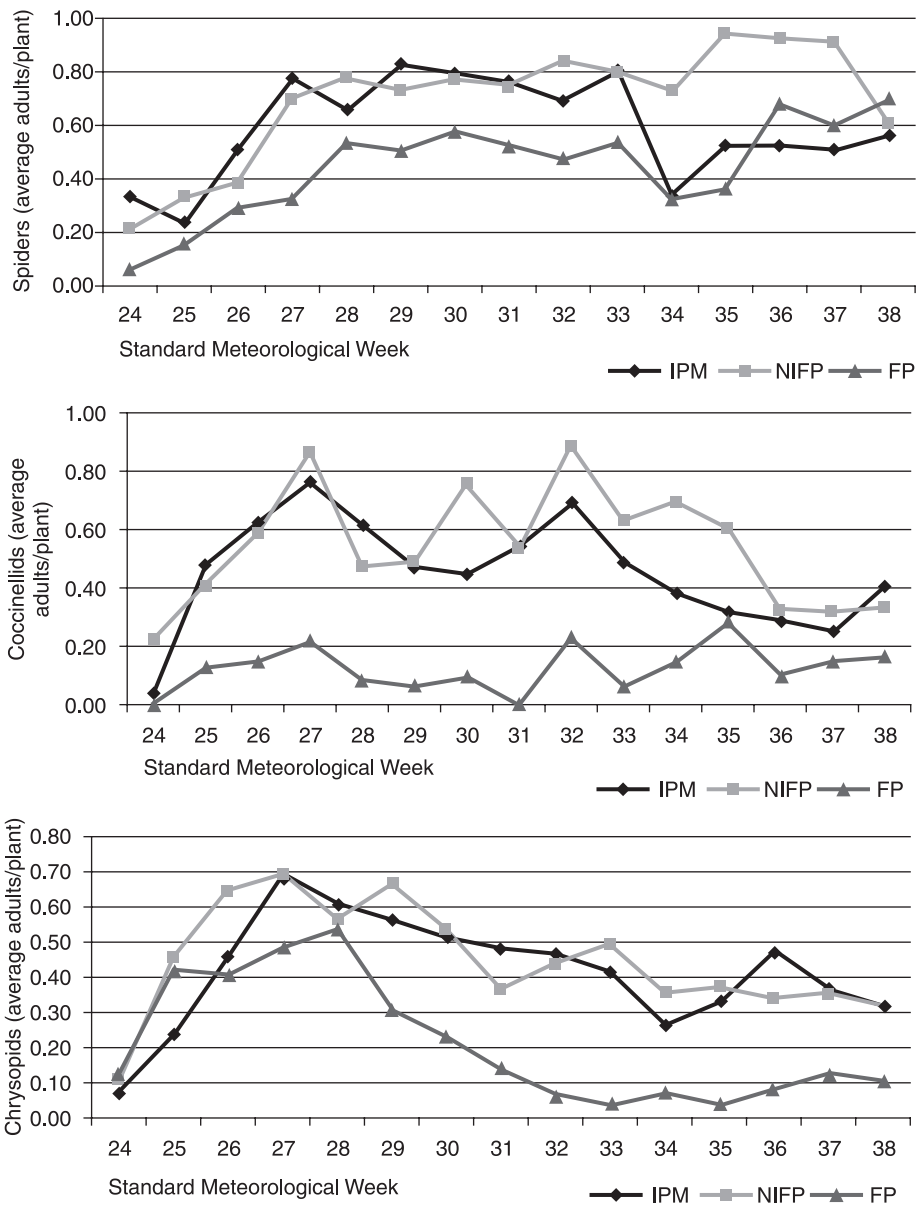
IPM : Integrated Pest Management, NIFP : Non-insecticidal farmer's practice, FP : Pesticide based farmers' practice, data is significant at $P \leqslant 0.05$ except 27 SMW for thrips.

Fig 1 Trend of sucking pest population in pest management treatments fields (pooled data of three years *kharif* season, 2015, 2016 and 2017).

it was interesting to note that population, in both the cases, increased gradually and after attaining the peak activity there was a declining trend. However, the population of natural enemy reaches at its peak little earlier. It is evident from the above results that in spite of highest population of natural enemies in NIFP, the pest population of all the sucking pests still remained higher as compared to IPM but under both the situations the peak population was lower than FP. Differences in the population of pests as well as natural enemies remained statistically significant among three practices in different SMW (Fig 2).

Coccinelids, spiders and chrysopids have shown increasing trend vis-à-vis pest up to 27/28 SMW after that there was decreasing trend confirming the density dependent pattern. Population of sucking pests showed increasing trend up to 29 SMW after that there was a declining trend. Though the natural enemies in present study have definitely played important role as mortality factor but could not keep pace with sucking pests, may be due to high multiplication rate of sucking pests. At this stage there is a need to apply ecofriendly pesticide which can be well fitted in IPM strategy. In IPM module implemented at Jind, all the pesticides applied were from IGR group, therefore, they could manage the pest without much affecting the natural enemies but in case of FP, pesticide applied were of general type which adversely affected natural enemies. In the present case, NIFP is an extreme situation where no insecticide was applied, as a result of which population of natural enemies was significantly increased which to some extent helped in managing the sucking pests (Tanwar *et al*. 2007). Whereas in FP situation, due to indiscriminate use of pesticides, population of natural enemies was significantly reducing and pest population was least managed. IPM tactics, through application of need based safer pesticides, not only ensured the natural enemies but also significantly reduced the pest population. Socio-economic studies also supported the above results. Number of insecticide applications (mentioned in methodology) remained 1, 0, 7.3 and active ingredients remained 73.5g ai/ha, 0 and 1431.6g ai/ha (average of 3 years) in IPM, NIFP and FP respectively. In Jind, in general, overall seed cotton yield as compared to Haryana state is low. In present study, the mean seed cotton yield during 2015, 2016, 2017 in IPM fields was 13.75, 22.45 and 17.42 q/ha, in NIFP it was 14.20, 18.10 and 13.70 as against 8.85, 16.75 and 9.30 q/ha in pesticide based farmers' practice, respectively. The incremental benefit cost ratio in IPM fields was 2.87, 3.56, 3.81 and it was 4.09, 3.53, 3.66 in NIFP fields as against 1.60, 1.99, 1.82 in FP during 2015, 2016 and 2017, respectively (Table 2).

Organizing farmer field school at regular interval adopted in the present validation trial, helped in developing



IPM : Integrated Pest Management, NIFP : Non-insecticidal farmer's practice, FP : Pesticide based farmers' practice, data is significant at 5% level ($P \leq 0.05$) except 24 SMW for chrysopids

Fig 2 Trend of beneficial population in pest management treatments fields (pooled data of three years kharif season, 2015, 2016 and 2017).

Table 2 Economic analysis of pest management technologies in *Bt* cotton fields during 2015-18

Variables	2015-16			2016-17			2017-18		
	IPM	NIFP	FP	IPM	NIFP	FP	IPM	NIFP	FP
No. of insecticide sprays	2 (2)	0 (8)	8.5 (0)	0 (2)	0 (6)	6.6 (0)	1 (1)	0 (7)	6.8 (0)
Amount of insecticides (g ai/ha)	183.0	0.00	1673.9	0.00	0.00	1259.7	37.5	0.00	1361.1
Input cost* (₹/ha.)	21510	15605	24880	28360	23056	37850	20550	16845	23000
Mean yield (q/ha)	13.75	14.20	8.85	22.45	18.10	16.75	17.42	13.70	9.30
Total income (₹/ha.)	61875	63900	39825	101025	81450	75375	78390	61650	41850
Net income (₹/ha.)	40365	48295	14945	72665	68384	37525	57840	44805	18850
Incremental Benefit Cost ratio	2.87	4.09	1.60	3.56	3.53	1.99	3.81	3.66	1.82

IPM : Integrated Pest Management, NIFP : Non-insecticidal farmer's practice, FP : Farmers' practice, ai/ha ; active ingredient/ha. Figures in parentheses indicate the number of biopesticides in IPM and FP and fertilizers in NIFP used, *Input cost included material cost like insecticide/biopesticide, fertilizer for spraying and labour cost for insecticide/biopesticide application, fertilizer application, picking etc. Average rate of seed cotton ₹ 4500/q.

strong linkages among farmers, scientists and extension workers and enabled farmers to understand the role of monitoring, concept of ETL and need based application of pesticides. Previous study by many workers (Bambawale *et al*. 2004, Ameta *et al*. 2006, Kumar *et al* 2011, Dahiya *et al*. 2014, Patil *et al*. 2014, Chandi *et al* 2015) revealed that the application of IPM components, clean cultivation, balance use of fertilizers, judicious use of insecticides and planting of maize/cowpea as border crop provided optimum conditions for multiplication and augmentation of natural enemies. This is in accordance with results of Kranthi *et al*. (2000), who reported that with the adoption of IPM strategies, number of sprays for sucking pests was reduced in north India. Similarly, Dhawan *et al*. (2011) reported 38.39 % reduction in the number of sprays in IPM villages over non-IPM villages. Surulivelu *et al*. (2004) also reported 63 % reduction in number of sprays at Coimbatore and Theni districts of Tamil Nadu with mean of 2.7 sprays in IPM villages as compared to 7.3 sprays in the FP villages. Kumar *et al* (2011) mentioned that insecticide usage can be reduced by adopting IPM module. It has been reported that neem seed kernel extract is safe to parasitoids and predators (Tanwar *et al*. 2006). These results are in accordance with our study as in the present study sowing of bajra as border crop for conservation of natural enemies along with sprays of azadirachtin were successful in managing the sucking pest population. Saravanan *et al*. (2014) also reported that IPM technologies like border cropping, setting up of yellow sticky traps, use of 5% NSKE, use of recommended insecticides on economic threshold basis etc. were successful in managing the *Bt* cotton pests. Farmers field Schools were organized at regular interval and field days were also organized to create awareness and to develop the skill of the farmers about identification of pest and natural enemies, nature of damage and application of IPM components. It is evident that by adopting IPM strategy, sucking pests in *Bt* cotton can be successfully managed along with conservation of natural enemies with minimum application of insecticides. IPM strategy not only increased the seed cotton yield but also enhanced benefit cost ratio and it is also sustainable.

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