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Integrated pest management module for major insect pests in high density planting system (HDPS) of cotton

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ABSTRACT : The experiment was conducted during *kharif,* 2017-2018 and 2018-2019 in the research field of the Regional Research and Technology Transfer Station, Bhawanipatna in Kalahandi district of Odisha under Odisha University of Agriculture and Technology to find out the most effective integrated pest management module for cotton under high density planting system (HDPS). The experiment was carried out with three modules, *viz.* Module I (Modified IPM package), Module II (Existing IPM package) and Module III (Conventional practice). Among the three modules, Modue I (Seed treatment with cow dung and urine, timely sowing of seeds in east west direction leaving a gap of 90 cm after 10 rows of cotton, use of castor, marigold and maize as trap crop and eco feast crop, spraying of *neem* pesticide at 30 and 50 DAS, installation of yellow sticky trap at 50 DAS and pheromone traps at 60 DAS, release of *Trichogramma chilonis* egg parasitoids four times at weekly interval at 70 75 DAS, spraying of *Bt* pesticide at 110 DAS) recorded minimum population of aphids (10.8 / 3 leaves), jassids (3.0 / 3 leaves), thrips (2.7 / 3 leaves), whitefly (2.7 / 3 leaves), American bollworm (0.14 larvae/5 plants), spotted bollworm (0.17 larvae/5 plants), *Spodoptera* (0.29 larvae/5 plants) and boll damage percentage (10.3 %). This IPM module recorded maximum natural enemies like lady bird beetle, spider and syrphid fly. Module I recorded maximum seed cotton yield (25.4 q/ha) as compared to Module II (Existing IPM package) with 24.5 q/ha) and Module III (Conventional practice) with 23.6 q/ha. Maximum net return (Rs. 82,518) and benefit cost ratio (2.59) was recorded in Module I (Modified IPM package).

Key words : Cotton, high density planting system, insect pests, IPM, natural enemies

Cotton is one of the most important commercial crop of India often referred as the "**White Gold**". By 2050 AD, India is planning to produce 40 million bales of lint to meet the anticipated domestic and export requirements. To fulfil this projected requirement, the cotton production has to be increased by 15 per cent over existing levels and this production increment has to come mainly from increased productivity. The primary reason for the low productivity of cotton in India is the cultivation of this crop mostly under rainfed condition, predominance of pests on the crop, inadequate and unscientific method of cultivation.

The major factor responsible for the low productivity and quality deterioration of cotton is the severe attack of insect pests from sowing to harvesting. Large area under rainfed situation and extensive replacement of conventional varieties with superior hybrids have made the crop easily vulnerable to insect pests. In India, cotton crop is attacked by 162 species of insect pests from sowing to harvesting, which cause loss of yield up to 50-

60 per cent. Among these, the bollworms *viz.*, American bollworm (*Helicoverpa armigera*), spotted bollworm (*Earias vittella* and *Earias insulana*), pink bollworm (*Pectinophora gossypiella*) pose greater threat to cotton production. In addition, bollworms especially, American bollworm, *Helicoverpa armigera* (Hubner) and pink bollworm, *Pectinophora gossypiella* (Saunders), cause considerable damage to the crop in India (Deore *et al.,* 2010). Aphid (*Aphis gossypii*), jassids (*Amrasca biguttula biguttula*), thrips (*Thrips tabaci*) and whitefly (*Bemisia tabaci*) are the major sucking pests of cotton (Kadam *et al.*, 2014). For management of these pests farmers mostly depend on chemical insecticides. But due to misuse, over use or use of insecticides at sub lethal doses, there is development of pest resistance, secondary pest outbreak and environmental pollution. With the increasing resistance of many insect pest species to chemical insecticides, pest control strategies are slowly shifting towards more sustainable, ecologically sound and economically viable options. It is also well known that climatic fluctuations are the major factors affecting insect biology, activity and distribution of natural enemies in agro ecosystems. Therefore, ecofriendly pest management approaches have become a promising option to overcome production constraints. The Integrated Pest Management (IPM) technologies for cotton developed, validated and implemented by cotton growers throughout the country are location specific, economically and ecologically viable (Narula *et al.*, 2001). Despite yield and economic advantages of high density planting system (HDPS) cotton, especially in rainfed and marginal soils, the adoption of closure spacing and high plant density create congenial condition for buildup of pests population. Keeping this in view the present experiment was formulated to develop a pest management package in high density planting system (HDPS) of cotton against sucking pests and bollworm complex by changing the crop micro habitat with respect to orientation and planting geometry and need based application of botanicals or biopsticides, which favour natural enemies to keep pest population below economic threshold limit.

MATERIALS AND METHODS

The experiment was conducted during *kharif,* 2017-2018 and 2018-2019 in the Research held, OUAT Regional Research and Technology Transfer Station, Bhawanipatna OUAT Kalahandi district of Odisha. The experiment was carried out with three modules, *viz.* Module I (Modified IPM package), Module II (Existing IPM package) and Module III (Conventional practice) as presented in Table 1. Each module was laid out on an area of 1000 m^2 in four replications. The soil of the experimental site was clay loam in texture, low in available N (120 kg/ha), high in available P (33.2 kg/ha) and medium in K (274 kg/ha) with pH of 6.2. The cotton variety 'Suraj' was sown with a spacing of 60 x 10 cm in high density planting system (HDPS) on 13th July, 2017 and 9th July 2018. The crop was raised with all recommended package of practices other than the crop protection measures, which were under testing. Intercultural and weeding operations were carried out as needed and the spraying of insecticides was done as per the modules. Observations on the population and incidence of insect pests were recorded on 50 randomly selected plants in each module at weekly interval excluding the boarder rows. Population of sucking pests like aphids, jassids, thrips and white flies were recorded by visual count from three leaves (each from top, middle and bottom of the plant) and natural enemies population like spider, lady bird beetle and *Chrysoperla* / plant were also noted. With respect to bollworms population like American bollworm (*Helicoverpa armigera*), Spotted bollworm (*Earias vittella*) and Pink bollworm (*Pectinophora gossypiella*), larvae were counted per five plants and fruiting bodies damage. The plot seed cotton yield in each module was recorded and expressed in q/ha. The economics of the pest management in all the modules was worked out to compare the

Table 1. Treatment details

Module I: Modified IPM package

- Seed treatment with cow dung and cow urine
- Timely sowing of treated seeds during last week of June and first week of July
- Sowing of seed in east west direction (for easy penetration of light and free wind movement)
- After 10 row of cotton, 90 cm gap (allay way of sowing) for easy spraying of botanicals/bio-pesticides and movement of air, which reduce humidity inside crop ecosystem)
- Sowing of castor as trap crop on the north and south side of the plot at spacing of 2 m. Growing of maize (eco feast crop) in between castor at spacing of 30 cm. Transplanting of marigold at the spacing of 60 cm in a separate row as a trap crop
- Spraying *Neem* pesticide / NSKE at 30 and 50 days after sowing (DAS)
- Installation of yellow sticky trap at 50 DAS
- Installation of pheromone traps both for *Spodoptera* and *H. armigera* at 60 DAS @ 5 s/ha for monitoring
- Release of *Trichogramma chilonis* egg parasitoids@ 1.5 lakh/ ha four times at weekly interval at 70-75 DAS
- spraying of S-NPV/H-NPV/ *Bt* by assessing the larval population at 110 DAS
- Need based application of *neem* pesticide/NSKE (applied on cotton leaving trap crops to diversify the pests to trap crops) or *Beauveria bassiana*

Module II: Existing IPM package

- Seed treatment with imidacloprid 70 WS @ 7g/kg of seeds
- Timely sowing of treated seeds during last week of June and first week of July
- Boarder row of maize (spacing 30 cm) and intercrop with cowpea at every 10 rows of cotton
- Installation of Pheromone traps @ 5/ ha at 45 DAS
- NSKE (5%) *neem* pesticide spraying at 45 and 90 DAS
- Release of *Trichogramma chilonis* @ 1.5 lakh/ ha at 70 and 80 DAS
- Buprofezin 25 SC @1000 ml/ha at 60 DAS
- Profenophos @ 1000 ml/ha at 120 DAS

Module III: Conventional practice

- Seed treatment with Imidacloprid 70 WS@7 g/kg of seeds
- Need based foliar application of chemical insecticides
- Buprofezin (25 SC) @1000 ml/ha at 45 DAS
- Profenophos (50 EC) @ 1000 ml/ha at 60DAS
- Indoxacarb (14.5 SC) /Thiodicarb (75 WP) @ 500 ml/ha at 75 DAS
- Flonicamid (50 WG) @ 150 g/ha at 90 DAS
- Spinosad (45 SC) @200 ml/ha at 105 DAS
- Indoxacarb (14.5 SC) /Thiodicarb (75 WP) @ 500 ml/ha at 120 DAS

efficiency of these modules.

RESULTS AND DISCUSSION

The data presented in Table 2, 3 and 4 and depicted in Fig. 1, 2, 3 and 4 revealed that the population of sucking pests, bollworms, foliage feeder and boll damage per cent were significantly influenced by different package of practices adopted in each module.

Jassid: Among the sucking pests, jassids was the most serious one. The jassid incidence was noticed from 34^{th} standard week (SW) and continued till 50^{th} standard week with a population range of 0.2 – 8.6/ 3 leaves in all the modules. Maximum jassid population was recorded from 40^{th} 42^{nd} SW with peak population of 8.6 jassids/ 3 leaves at 41^{st} SW in Module III with conventional practices. Mean jassid population was minimum in Module I *i.e* modified IPM practices (3 jasids/ 3 leaves) followed by Module II *i.e* existing IPM practice (3.4 jassids/ 3 leaves). The present findings are in agreement with the report of Mallapur *et al.*, (2004) who observed minimum sucking pests population in IPM module plots compared to recommended package. Sohi *et al.*, (2004) and Garg and Patel (2014) reported that the incidence of leaf hoppers and whiteflies/leaf were found low in IPM block as compared to farmers practice and checks.

Thrips: The thrips incidence was recorded at the early stage of crop growth *i.e* 34 37 SW with a highest population of 10.9 thrips/ 3 leaves (36 SW) in Module III. The modified IPM (Module I) recorded minimum thrips (2.7 thrips/ 3 leaves) followed by IPM practice (Module II) and

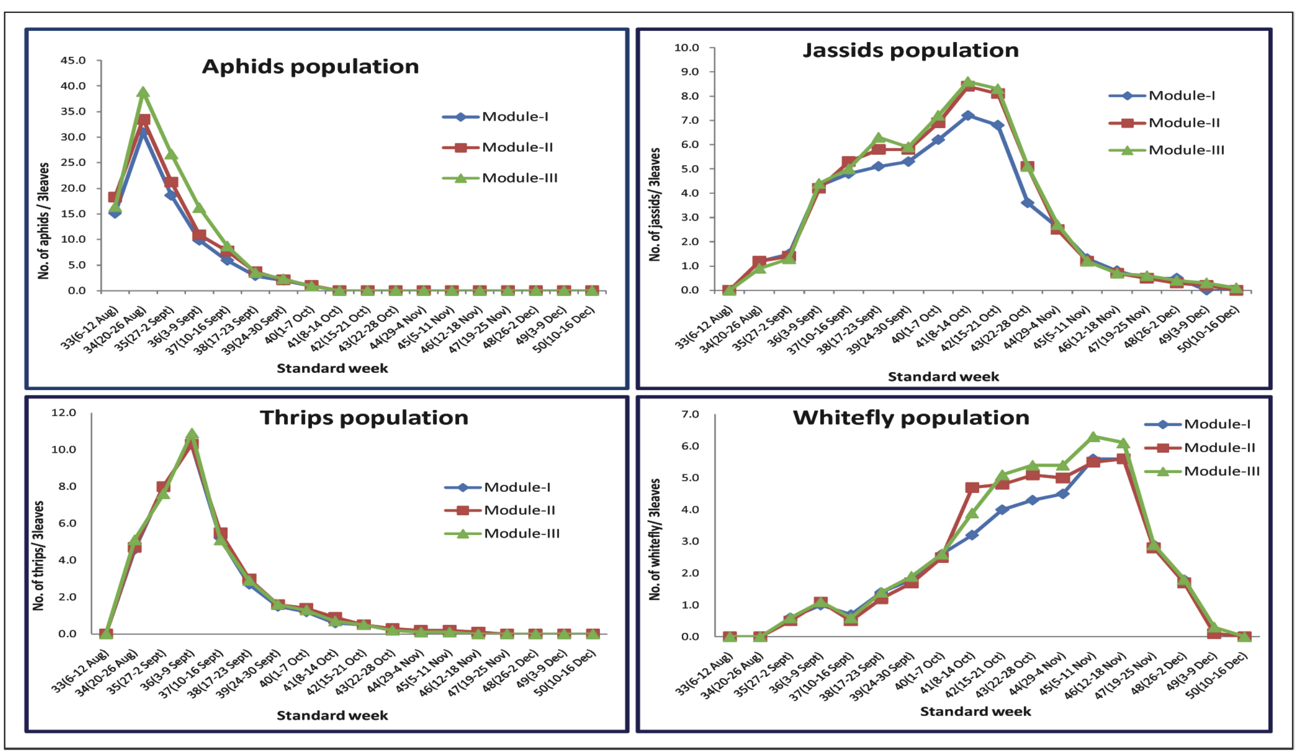

Fig. 1. Period of incidence of different sucking pests as affected by different modules in cotton under HDPS

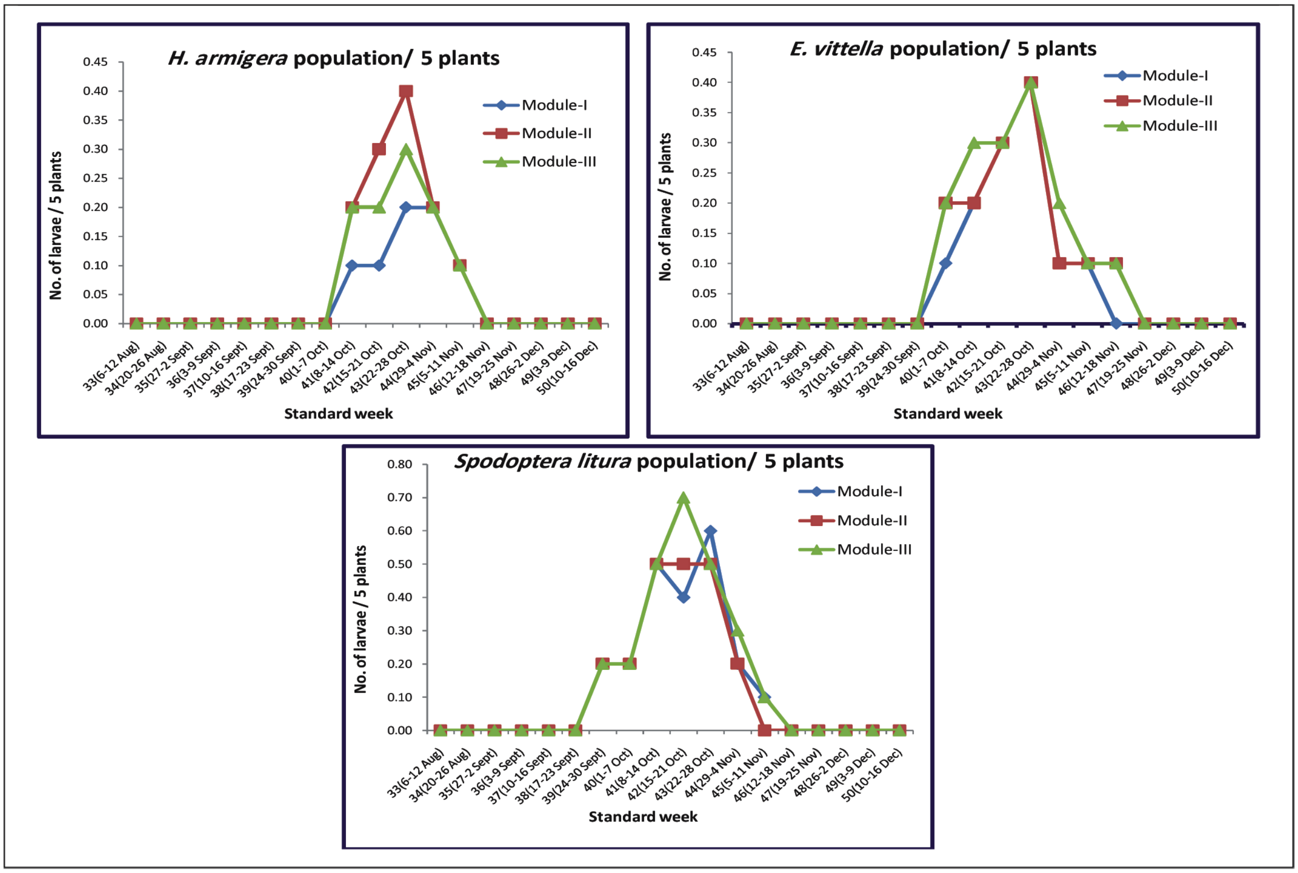

Fig. 2. Period of incidence of different bollworms and spodoptera as affected by different modules in cotton under HDPS

Table 2. Effect of different modules on population of aphids, jassids, thrips and whitefly in cotton under high density planting system during the period of incidence (Mean data of two years).

Treatment	Aphids population / 3 leaves		Jassids population /3 leaves		Thrips population /3 leaves		Whitefly population /3 leaves	
	Mean	Peak	**Mean**	Peak	**Mean**	Peak	**Mean**	Peak
Module I	**10.8**	30.9	**3.0**	7.2	**2.7**	10.3	**2.7**	5.6
Module II	**12.3**	33.5	**3.4**	8.4	**2.8**	10.3	**2.8**	5.5
Module III	**14.2**	38.9	**3.5**	8.6	**2.8**	10.9	**3.0**	6.3

Table 3. Effect of different modules on population of American bollworm, spotted bollworm and spodoptera in cotton under high density planting system during the period of incidence (Mean data of two years).

Treatment	American bollworm larvae / 5 plants		Spotted bollworm larvae / 5 plants		Spodoptera larvae / 5 plants		Boll damage (%)
	Mean	Peak	**Mean**	Peak	**Mean**	Peak	**Mean**
Module I	**0.14**	0.2	**0.17**	0.4	**0.29**	0.4	**10.3**
Module II	0.24	0.4	0.20	0.4	**0.29**	0.5	**11.3**
Module III	**0.20**	0.3	**0.23**	0.4	**0.34**	0.7	**11.6**

non IPM practice (M III) with thrip population of 2.8/ 3 leaves. Similar results were obtained by Patil *et al.*, (2011) and Mallapur *et al.*, (2004) who reported that the incidence of sucking pests like thrips, aphids and jassids population were low in integrated pest management modules as compared to recommended plant protection.

Whitefly: Population trends implied that the whitefly population increased from 41st SW and continued upto 46th SW, after that it declined. Maximum whitefly population (6.3 whitefly / 3 leaves) was recorded at 45th SW in Module III. Modified IPM (Module I) noticed minimum whitefly population (2.7 whitefly/ 3 leaves) followed by IPM practice (Module II) with 2.8 whitefly/ 3 leaves and conventional practice (Module III) with 3 whitefly/3 leaves. These findings are in comfirmity with those obtained by Sohi *et al.*, (2004) who reported that the incidence of whiteflies and leaf hoppers were found low in IPM block as compared to farmers practice and check plots.

Aphids: The aphid incidence was noticed during early growth period of cotton 34th SW and reached to the maximum (38.9 nos/3 leaves) during 34th SW in Module III. The population declined after 38th SW and continued till 40th SW. Mean data revealed that the lowest aphid population was recorded in modified IPM practice (10.8 aphids/3 leaves) followed by existing IPM practice (12.3 aphids/ 3 leaves) and conventional practice (14.2 aphids/ 3 leaves). Present investigation clearly indicates that modified IPM modules were highly efficient in managing the sucking insect pests than conventional practice. Results of present study are in close agreement with findings of Mallapur *et al.*, (2004) and Patil *et al.*, (2011) who reported that IPM practice were more effective over the farmers practice against sucking pests of cotton.

Bollworms : The crop was infested with bollworms like American bollworm (*Helicoverpa armigera*) and spotted bollworm (*Earias vitella*) during both the years. Howevwe, there was no incidence of pink bollworm (*Pectinophora gossypiella*). Two years data on American bollworm population revealed that the incidence of the pests started during 41st SW and continued till 45th SW. The peak incidence (0.4 larvae/ 5

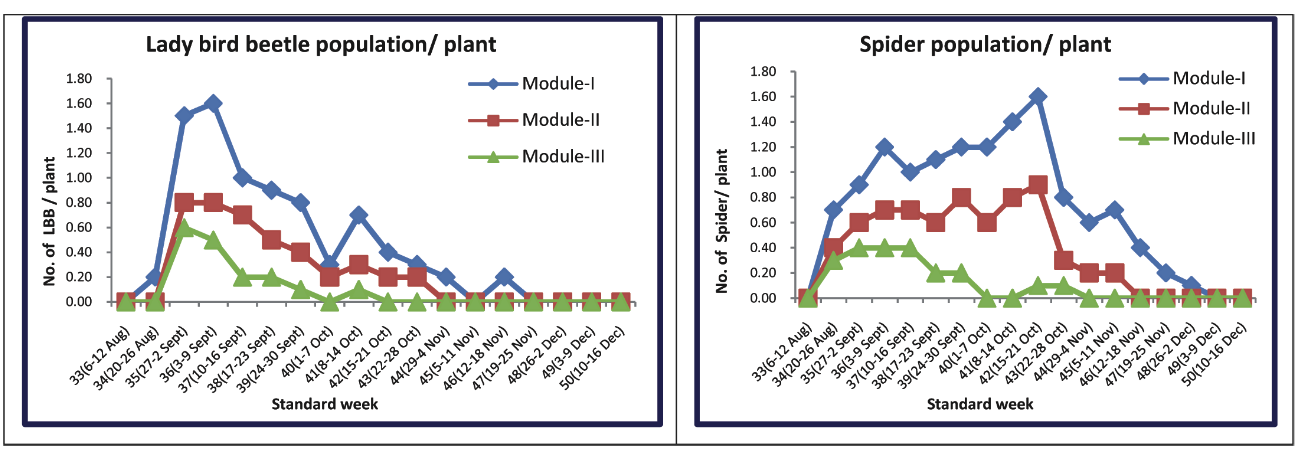

Fig. 3. Period of incidence of natural enemies as influenced by different modules in cotton under HDPS

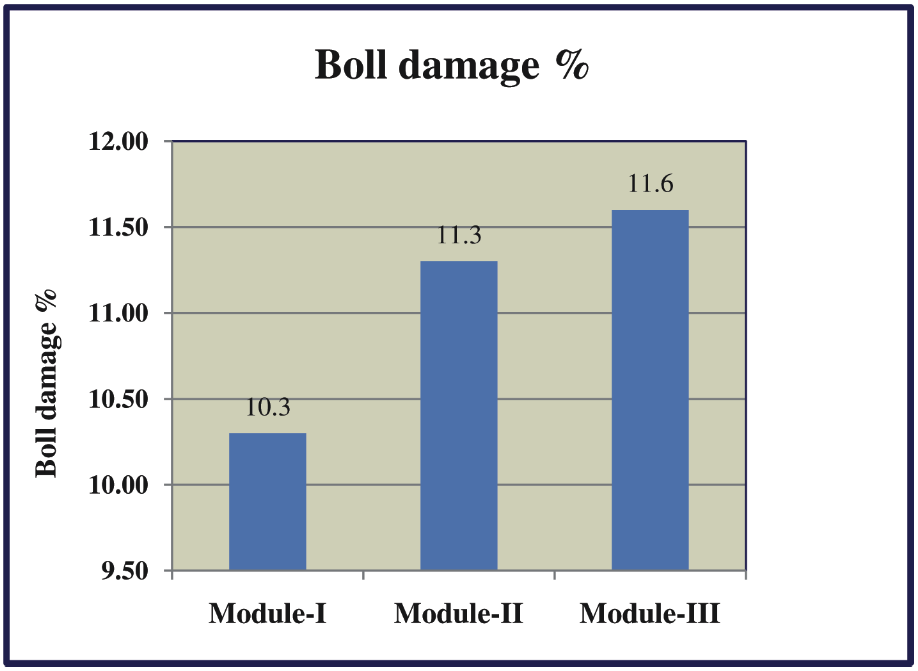

Fig 4. Boll damage per cent as influenced by different modules in cotton under HDPS

plants) was observed during 43rd SW in Module II *i.e* existing IPM. The mean minimum population (0.14 larvae/ 5 plants) was recorded in Module I.

The spotted bollworm population was maximum during 43rd SW in all the modules. However, the minimum population (0.17 larvae/ 5 plants) was recorded in Module I. The boll damage per cent was lowest in Modified IPM *i.e* 10.3 per cent, followed by IPM practice (11.3%) and conventional practice (11.6%).

Garg and Patel (2014) and Sohi *et al.*, (2004) reported that the larval incidence of *H. armigera*, *Earias* sp. and *P. gossypiella* in intact boll damage were low in IPM practice. Significant reduction in boll damage by the bollworm in *Bt* cotton with IPM which was 11.5 per cent as against 29.4 per cent in farmers practices. Similar results were also documented by Mallapur *et al.,*(2004) and Bombawale *et al.*, (2004).

***Spodoptera* :** Among the foliage feeders, *Spodoptera litura* was the most important pest

Table 4. Effect of different modules on population of lady bird beetle, spiders and Syrphid fly in cotton under high density planting system during the period of incidence (Mean data of two years).

Treatment	Lady bird beetle population/ plant		Spiders population/ plant		Syrphid fly population/ plant	
	Mean	Peak	**Mean**	Peak	**Mean**	Peak
Module I	**0.59**	1.6	**0.84**	1.6	**0.24**	0.4
Module II	**0.30**	0.8	**0.44**	0.9	**0.11**	0.2
Module III	**0.12**	0.5	**0.13**	0.1	**0.03**	0.1

infecting the crop from 39th to 45th SW. The maximum population of 0.7 larvae/5 plants was recorded during 42nd SW in Module III. The minimum population of 0.29 larvae/ 5 plants was noticed in Module I and Module II.

Natural enemies : Lady bird beetle, spider and Syrphid fly were the major natural enemies observed during both the years of experimentation. The maximum presence of natural enemies like lady bird beetle, spider and Syrphid fly was recorded in 36th SW (1.6 / plant), 42nd SW (1.6 / plant) and 36th (0.4 / plant) SW, respectively in Module I.

In the present investigation, the natural enemy activities were normal in modified IPM module with boarder crop, eco feast crop, bio control agent, spraying of *neem* pesticides and seed treatment with cow dung and cow urine and other eco friendly IPM components, whereas in existing IPM module and conventional practice their activity was drastically reduced due to the toxic effects of insecticide used. Similar trend was observed by Garg and Patel (2014), Garg *et al.*, (2007) and Dhawan *et al.*, (2011). Basapa (2009) reported that in bio intensive IPM module, the population of predators like *Chrysoperla* sp., *C. sexmaculata*, *C. furcellata*, and spiders was three fold higher than Chemical IPM module and non IPM module.

Present study revealed that in the modified IPM practice (Module I) the insect pests population was comparatively low. Due to pro/ planting geometry and crop orientation there was increase sunlight penetration and wind movement inside crop microhabitat which reduceed the humidity in the crop canopy thereby reducing the pest population build up. This package of practice will be more sustainable because of its compatibility with biological control. Present study and its principle may lay the foundation for its wider application and serve as a model for the management of insect pests of other economic crops

Yield and economics : Data on the seed cotton yield along with economics of different IPM modules has been presented in Table 5. Modified IPM package (Module I) recorded maximum seed cotton yield of 25.4 q/ha as compared to Module

Table 5. Seed cotton yield and economics of different pest management practices in cotton under HDPS (Mean data of two years).

Sl. No.	Particulars	ModuleI	ModuleII	ModuleIII
1.	Seed cotton yield (q/ha)	25.4	24.5	23.6
	Maize as boarder crop (q/ha)	0.40	1.44	-
	Castor as trap crop (q/ha)	0.15	-	-
	Cowpea as intercrop (q/ha)	-	1.00	-
2.	Gross return (Rs./ha)	1,34,330/-	1,33,700/-	1,22,720/-
3.	Cost of crop protection measures (Rs./ha) (Chemicals/bio pesticides, traps, lures etc.)	3,300/-	4,000/-	7,000/-
4.	Cost of other expenditure (Rs./ha)	48,512/-	51,265/-	53,335/-
5.	Total expenditure (3+4)	51,812/-	55,765/-	60,835/-
6.	Net return (Rs./ha)	82,518/-	77,935/-	61,885/-
7.	Benefit : Cost Ratio	2.59	2.39	2.01

II *i.e* existing IPM package (24.5 q/ha) and Module III *i.e.,* conventional practice with 23.6 q/ha. The increase in seed cotton yield in Module I was 3.7 and 7.6 per cent more over Module II and Module III, respectively. Increase in seed cotton yield in Module I may be due to increased sunlight penetration and wind movement inside crop microhabitat reducing the crop canopy humidity and eco friendly management of pests in this modified IPM package due to changed planting geometry and crop orientation which interfered the build up of pest and natural enemies population. These results are in line with the findings of Saharan *et al.,* (2016) and Mallapur *et al.,* (2004), who reported higher seed cotton yield in integrated pests management practices compared to farmers practices.

Maximum cost of cultivation was incurred in Module III (Rs. 60,835/) which was 17.4 and 9.1 per cent higher than Module I and Module II, respectively. Maximum net return (Rs. 82,518) and benefit cost ratio (2.59) was recorded in Module I.

CONCLUSION

It can be concluded from the two years experiment that sucking pests of cotton like aphids, jassids and thrips, bollworms like American bollworm (*H. armigera*), Spotted bollworm (*Earias vittella*) and foliage feeder like Spodoptera can be effectively controlled by the adoption of modifed IPM package *i.e.,* seed treatment with cow dung and cow urine, timely sowing of seeds in east west direction leaving a gap of 90 cm after 10 rows of cotton, using castor, marigold and maize as trap and eco feast crop, spraying *neem* pesticide at 30 and 50 DAS, installation of yellow sticky trap at 50 DAS and pheromone traps at 60 DAS, release of *Trichogramma chilonis* egg parasitoids four times at weekly interval at 70 75 DAS, spraying of *Bt* pesticide at 110 DAS. This module recorded maximum seed cotton yield (25.4 q/ha) as compared to Module II (24.5 q/ha) and Module III (23.6 q/ha). Maximum net return (Rs. 82,518/) and benefit cost ratio (2.59) was recorded in Module I. This package of practice will be more sustainable because of its compatibility with biological control methods. Present study and its principle may lay the foundation for its wider application and serve as a model for the management of insect pests of other economic crops.

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