Int J Pharm Bio Sci 2015 April; 6(2): (B) 989 - 998

Research Article **Allied Science**

International Journal of Pharma and Bio Sciences **ISSN 0975-6299**

STUDIES ON MANAGEMENT OF BOLLWORMS USING DIFFERENT INTEGRATED PEST MANAGEMENT STRATEGIES IN COTTON

S. NAGENDRA*

Agriculture Officer, Department of Agriculture, Mysore, Karnataka (India).

ABSTRACT

This investigation was aimed to study the management of bollworms using different integrated pest management strategies in cotton. Highest infestation in bolls at harvest was recorded in module-5 and lowest was recorded in module-2. Net returns were highest in module-5, which also recorded maximum cost-benefit ratio. Low net returns and cost-benefit ratio were recorded in module-3. Eventhough, seed cotton yield was recorded maximum in module-6 where combinations of different biopesticides and conventional chemical insecticides were used, the net returns and cost-benefit ratios were highest in module-5 where *Setaria* sp. was intercropped with cotton and cultural practices were practiced to manage the bollworm infestation along with use of bioagents and biopesticides. Thus, it can be concluded that module-5 comprising of mixed cropping with *Setaria*, 5% neem seed kernel extract spray, mechanical control of large size larvae, two releases of *Trichogramma*, *Helicoverpa armigera* nucleopolyhedrosis virus and *Bacillus thuringinesis* spray at economic threshold level can be adopted as an effective IPM module in cotton.

KEYWORDS: IPM, cotton, Cost-benefit ratio, biopesticides, synthetic pesticides.

*Corresponding author

S. NAGENDRA
Agriculture Officer, Department of Agriculture, Mysore, Karnataka (India).

INTRODUCTION

Cotton is popularly referred as white gold in India as it plays an important role in Indian economy. It is single most cash crop which is cultivated extensively throughout the world [1]. It is an important raw material for textile industry. Among several factors responsible for low yield of cotton in our country, the insect pests play a vital role [2]. Although, as many as 326 species of insect pests infesting cotton are reported, only 130 species of insect and non-insect pests were recorded on this crop in India [3, 4]. In India, insect pests of cotton are responsible for 30-40% of yield loss, in addition to significant deterioration of seed and lint quality [5]. The bollworms usually damage the fruiting bodies like buds, flowers and immature bolls. It is necessary to control the cotton bollworms effectively. The present strategy of controlling bollworms includes use of insecticides alone which are sprayed every year in enormous quantities on cotton crop to control bollworms [6]. Nearly, 40% of the total pesticide consumption in India is on cotton crop alone, yet satisfactory control of bollworms is not attained [7]. Besides these, the insecticides pollute soil, air and water resources in nature. Adoption of mere biological methods is also not economical as the action of these bio-control agents is slow and depends on weather conditions [8]. In the above pretext, it is obligatory for the scientists to develop environmentally sound, pest control techniques for management of cotton bollworms. The interaction of use of bio-agents, bio-pesticides and chemical insecticides at different stages of crop growth may prove their worth in management of bollworms. Considering these, the present investigation was undertaken to study 1) the different integrated pest management (IPM) modules for cotton bollworms, 2) find out the most effective module for cotton bollworms and 3) the effect of different treatments on natural enemies in cotton.

MATERIALS AND METHODS

The field experiment was conducted to evaluate an effective IPM module for bollworm management in cotton var. PHH 316. It was conducted in the kharif season of 2004-2005 at experimental fields of Cotton Research Station, Marathwada Agricultural University, Parbhani.

(i) Climatic condition

Parbhani has subtropical climate and is situated on 408.50 m above mean sea level. It lies between 18° 58' to 20° 2' North latitude and 76° 4' to 77° 42' East longitude. The mean annual rainfall is about 829.38 mm in 61 rainy days mostly during June to September. The rainfall is assured for kharif and rabi crops. The mean maximum temperature vary from 28.7°C during December to 41.2 °C in May. The mean minimum temperature vary from 11.32 °C to 25.77 °C in winter and summer respectively. Summer is hot and dry while winter is cool. The relative humidity ranges from 30 to 90%.

(ii) Soil characteristics

All the experiments were conducted on well drained clay soils. The depth of the soil varied from 2 to 3 metres.

(iii) Cultural practices

The field was deeply ploughed followed by 2 harrowings for crushing the clods and to bring the soil to fine tilth before sowing the cotton seeds. The crop was fertilized with recommended dose of NPK (25:25:25 kg/ha) as basal dose and top dressed with 25 kg N per ha through urea by ring method during the kharif season. Top dressing was done 45 days after sowing. Certified seeds of cotton variety PHH-316 were dibbled on 30th June, 2004. The row to row spacing was 90 cm and plant to plant 60 cm. Seeds were germinated within one week after sowing. Gap filling was not necessary as the germination was above 90%. Two hand weedings were done to keep the plot free from weeds and two hoeings were done to conserve the moisture in the soil. The seeds of cotton variety PHH-136 which were pre treated with imidachloprid were used for dibbling and this took care of the seedlings till 30 days after germination (DAG) from sucking pest damage. One spraying of systemic insecticide dimethoate 30 EC at the rate of 0.03% was done on the crop at 30 DAG.

(***iv) Management of bollworms***

Design	:	Randomised Block Design
Plot size	:	Gross – 9.00 m x 7.2 m, Net – 7.2 m x 6.00 m
No. of replications	:	Three
No. of treatments	:	Eight
Spacing	:	Row to row 90 cm and Plant to plant 60 cm

Treatment details

The details of treatments are as follows

IPM Module-1 a) Neem seed extract (NSE) 5% at 45 DAG, b)Release of *Trichogramma chilonis* @ 1.5 lakh/ha after noticing the eggs of bollworms, c) Endosulfan 0.06% (at ETL), and d) Cypermethrin 0.00725% (at ETL). IPM Module-2 a) NSE 5% at 45 DAG, b)Two need based releases of *T. chilonis* @ 1.5 lakh/ha after noticing eggs of bollworms, c) HaNPV 500 LE/ha (1 LE = 1.97 x 10^9 POBs) after noticing the < 3rd instar stage of *H. armigera*, d) Endosulfan 0.06% (at ETL), and e) Fenvalerate 0.0125% (at ETL). IPM Module-3 a) NSE 5% at 45 DAG, b) Two need based releases of *T. chilonis* @ 1.5 lakh/ha after noticing the eggs of bollworms, c) Spinosad @ 50 g a.i./ha (at ETL), d) Beta cyfluthrin 0.0025% (at ETL). IPM Module-4 a) Intercropping of cotton with cowpea (6:1), b) Release of *T. chilonis* @ 1.5 lakh/ha after noticing the eggs of bollworms, c) Indoxacarb 0.015% (at ETL), d) *B.t.* 0.075 kg a.i./ha (at ETL), e) Decis tablets 0.0025% (at ETL). IPM Module-5 a) Mix cropping of cotton with Bhagar (Setaria), b) NSE 5% at 45 DAG, c) Mechanical control of spotted, pink and large size larvae of *Helicoverpa* along with infested plant parts, d) Two need based releases of *Trichogramma chilonis* @ 1.5 lakh/ha after noticing the eggs of bollworms, e) HaNPV 500 LE/ha after noticing the <3rd instar stage of *Helicoverpa*, f) *B.t.* 0.075 kg a.i./ha (at ETL). IPM Module-6 a) NSE 5% at 45 DAG, b) NSE 5%+ half dose of endosulfan @ 0.03% (at ETL), c) HaNPV 250 LE/ha + half dose of endosulfan @ 0.03% (at ETL) d) Beta cyfluthrin 0.0025% + half dose of spinosad 25 g a.i./ha (at ETL). IPM Module-7 a) Endosulfan 0.06% (at ETL), b) Quinalphos 0.05% (at ETL), c) Carbaryl 0.2% (at ETL) and d) Cypermethrin 0.0075% (at ETL). Module-8 Untreated control.

Application of insecticides

The insecticide solutions were prepared by mixing respective insecticides in a known quantity of water and were used for spraying. The treatment sprays were given in morning hours with knapsack sprayer. *T. chilonis* was also released in the morning hours. However, HaNPV spraying was done in the evening hours. Teepol 1.0 g and a quarter of an egg white were mixed in 10 litre of HaNPV solution before spraying. The treatment sprays were given as and when the level of infestation of bollworms reached ETL i.e. 5% infestation in fruiting bodies or shed material. The bioagent *T. chilonis* were released according to schedule after noticing the eggs of bollworms on the plants. The observations were recorded at 10 days interval and whenever the infestation level reached 5%, subsequent sprays were taken and the releases of bioagent were made at 10 days interval.

(v) Sampling and collection of experimental data

Five plants were randomly selected from each net plot and the observations were recorded on these plants. The observations recorded during the course of investigation are given below.

(vi) Infestation of E. vittella and H. armigera in shed material

The shed squares, flower buds and bolls from each of the observation plant were collected at 10 days interval after each spraying. These collected samples were taken to the laboratory and were examined to find out the infestation by bollworms and per cent infestation of bollworms in shed material was worked out.

(vii) Infestation of bollworms in fruiting bodies

The fruiting bodies (squares, flower buds and bolls) on the plants from each sample plant were observed for infestation of *E. vittella, Helicoverpa* and *Pectinophora* as well.

(viii) Infestation of bollworms in bolls at harvest

Total number of picked bolls from sample plants were observed for infestation of

bollworms at harvest and per cent infestation was worked out.

(ix) Infestation in locules

To detect *Pectinophora gossypiella* infestation in locules at harvest, the infested bolls picked from each sample plant were brought to the laboratory and dissected and per cent locule infestation was worked out.

(x) Effect of different IPM modules on population of lady bird beetles

To study the effect of different IPM modules on the lady bird beetle, observations were made on number of beetles from randomly selected five plants in each plot of various treatments.

(xi) Effect of different IPM modules on population of Chrysoperla carnea

Observations were made on number of C*hrysoperla* adults, grubs and eggs on five randomly selected plants from each plot to study the effect of different modules on *Chrysoperla* population.

(xii) Effect of different IPM moduels on yield of seed cotton:

Three pickings were done in December, 2004 at an interval of 15-20 days. Seed cotton from each treatment was weighed separately and the yield in kg/ha was worked out.

(xiii) Statistical analysis

Observations on population of aphids, jassids, thrips and whiteflies were subjected to $\sqrt{x+0.5}$ transformation and the data on per cent infestation by bollworms were transformed into angular transformation values before statistical analysis. The data were statistically analysed by standard analysis of variance method for Randomised Block Design and treatments were compared by using 'F' test [9].

RESULTS AND DISCUSSION

The use of insecticides has played a major role in increasing cotton productivity from the last two decades [10]. However, the indiscriminate use of insecticides has led to many problems including the resurgence of sucking pests and development of resistance by bollworm, *H. armigera* Hub. against several insecticides [11]. Hence, there is a need to adopt an efficient IPM module which can increase the cost-benefit ratio to the farmers and decrease the dependence on conventional insecticides. Table 1 showing the schedule of different treatments executed in different IPM modules (days after germination-DAG).

Table 1
Schedule of different treatments executed in different IPM modules (days after germination-DAG).

Treatments	IPM modules						
	I	II	III	IV	V	VI	VII
Spraying of NSKE 5%	45	45	45	-	45	45	-
First release of *T. chilonis* @ 1.5 lakh/ha	55	55	55	55	55	-	-
Second release of *T. chilonis* @ 1.5 lakh/ha	-	65	65	-	65	-	-
Spraying of HaNPV @ 500 LE/ha	-	75	-	-	75	-	-
Mechanical collection of larvae	-	-	-	-	65		
Spraying of B.t. @ 0.075 kg a.i./ha	-	-	-	115	115	-	-
Spraying of HaNPV 250 LE/ha + 0.03% endosulfan	-	-	-	-	-	90	-
Spraying of spinosad @ 50 g a.i./ha	-	-	115	-	-	-	-
Spraying of endosulfan @ 0.06%	75	75	-	-	-	-	55
Spraying of indoxacarb @ 0.015%	-	-	-	75	-	-	-
Spraying of quinalphos @ 0.05%	-	-	-	-	-	-	75
Spraying of Beta cyfluthrin @ 0.0025%	-	-	-	-	-	-	-
Spraying of fenvalerate @ 0.0125%	-	115	-	-	-	-	-
Spraying of NSKE 5% + endosulfan 0.03%	-	-	-	-	-	75	-
Spraying of cypermethrin @ 0.00725%	115	-	-	-	-	-	-
Spraying of Beta cyfluthrin @ 0.0025% + spinosad @ 25 g a.i./ha	-	-	-	-	-	115	-
Spraying of carbaryl @ 0.2%	-	-	-	-	-	-	-

(i) Effect of IPM modules on management of bollworms

Per cent infestation of bollworms in fruiting bodies

The data recorded regarding per cent infestation of bollworms in fruiting bodies at 10 days interval starting from 36th meteorological week to know the ETL for executing different treatments are presented in Table 2.

Table 2
Per cent infestation of bollworms in fruiting bodies.

IPM modules	Meteorological weeks						
	36	37	39	40	42	44	45
I	65.30	17.80	4.75	5.34	1.80	0.86	6.10
II	58.89	0.00	4.53	5.32	0.78	0.93	5.23
III	58.46	10.93	5.18	3.18	2.86	0.84	6.30
IV	47.19	10.42	3.94	1.45	3.59	1.69	5.34
V	45.61	0.81	3.54	2.92	1.50	0.00	5.30
VI	47.17	4.50	3.32	2.32	0.34	0.49	5.00
VII	36.39	5.40	2.32	0.63	1.76	0.47	3.78
Untreated control	69.63	10.00	5.88	3.92	1.24	1.18	8.38
SE ±	4.32	5.92	3.50	3.09	2.19	2.30	2.53
CD at 5%	13.10	17.93	NS	9.37	6.64	NS	NS

The highest infestation was noticed in module-8 (56.93%) during 36th MW and was followed by module-1 (53.93%) during 36th MW. The infestation percentage was found to be many folds above ETL in all the modules during 36th MW. During 37th MW no infestation was recorded in module-2 and it was on par with module 7, 8 and 4. Whereas, modules 3, 1, and 6 were significantly damaged compared to other modules. The infestation level was on par in all the modules during 39th MW and it was less than that during previous week. The module-7 (2.63%) showed significantly lower infestation than module-1 (12.93%) during 40th MW. All other modules showed similar infestation levels as that of module-1, and all were above ETL except module-4. Similar trend was observed in 42nd MW also, whereas, only module-8 (5.02%) and 4 (5.66%) showed above ETL values in 44th MW. Module-8 (15.86%) recorded highest infestation percentage during 45th MW and it was on par with all other treatments. Based on the ETL values obtained in different modules, the treatments were executed.

Per cent infestation of bollworms in shed material

Table 3, represent the data recorded regarding per cent infestation of bollworms in shed material during different meteorological weeks to calculate ETL for executing treatments in different IPM packages. This table indicates heavy bollworm infestation in shed material during 37th MW, where module-1 and 6 (84.14%) recorded highest infestation in the entire plant growth period. The trend showed that the infestation decreased towards 39th MW and then it started increasing. It is evident from the Table 3 that the infestation of bollworms in shed material however, was many fold greater than the normal ETL (5%) values and it was found non-significant among different modules throughout the season. Since, we recorded infestation above ETL in shed material, all treatments in different modules were executed as per schedule

.

Table 3
Per cent infestation of bollworms in shed material.

IPM modules	Meteorological weeks						
	36	37	39	40	42	44	45
I	96.29	96.97	49.17	56.19	54.43	46.57	49.03
II	95.33	89.63	58.89	54.12	69.10	50.08	52.54
III	90.65	95.00	62.97	76.77	52.51	36.47	39.13
IV	88.14	96.67	51.67	62.96	37.95	32.87	35.01
V	91.67	89.74	86.67	61.51	85.19	36.20	38.34
VI	88.13	96.97	47.86	68.89	42.10	41.09	43.22
VII	87.50	93.33	44.84	56.67	58.20	44.19	45.86
Untreated control	95.70	96.49	86.31	74.81	61.81	52.61	54.39
SE ±	4.39	7.62	8.07	14.43	6.9	4.02	3.94
CD at 5%	NS	NS	24.45	NS	20.91	NS	NS

The findings of the present investigations revealed that the per cent infestation of bollworms in fruiting bodies and in shed material was above ETL during entire crop growth period except during 44th MW where only module-8 (5.02%) and module-4 (5.66%) recorded above ETL values in fruiting bodies. The maximum% infestation in shed material was recorded in module-1 and 6 (84.14%) where very few (4) IPM practices were executed in each case under different combinations of biological and conventional pesticides. Per cent bollworm infestation in bolls at harvest was maximum in module-5 (45.31%) and minimum in module-2 (37.34%). Module-5 IPM package consisted of Setaria intercropping which was harvested much before the harvest of cotton and no conventional pesticides were used. Module-2 received sprays of endosulfan (0.06%) and fenvalerate (0.0125%) at the later stage of the crop growth and this attributed to the minimum infestation of bollworms in bolls at harvest. The infestation significantly varied in different modules. The control plot (42.96%) recorded next highest per cent infestation in bolls at harvest. The similar trend was observed with regard to per cent bollworm infestation in locules at harvest.

Effect of IPM modules on per cent bollworm infestation in bolls at harvest

Per cent bollworm infestation data recorded in different IPM modules are presented in Table 4 showed that the highest infestation was recorded in module-5 (45.31%) and it differed significantly from all other modules. The lowest infestation was recorded in module-2 (37.34%) which was on par with module-1 (37.80%). In general, module-8 (42.46%), module-7 (41.76%) and other modules-3, 4 and 6 differed significantly with regard to infestation in bolls at harvest.

Table 4

Population of lady bird beetles on cotton in different modules (number of beetles/plant).

IPM modules	Meteorological weeks						
	36	37	39	40	42	44	45
I	0.13	0.46	0.80	0.07	0.13	0.00	0.13
II	0.20	0.20	0.60	0.13	0.00	0.00	0.13
III	0.06	0.13	0.33	0.00	0.13	0.00	0.13
IV	0.66	0.13	0.60	0.13	0.13	0.00	0.13
V	0.20	0.00	0.33	0.00	0.00	0.00	0.13
VI	0.66	0.13	0.60	0.00	0.07	0.00	0.07
VII	0.20	0.13	0.47	0.00	0.00	0.07	0.13
Untreated control	0.13	0.13	0.27	0.00	0.00	0.00	0.20
SE ±	0.05	0.13	0.11	0.03	0.05	0.02	0.06
CD at 5%	0.15	NS	NS	NS	NS	NS	NS

Effect of IPM modules on per cent locule infestation

The data recorded regarding per cent locule infestation in different IPM modules are presented in Table 5. It is evident from the data that the lowest locule infestation was recorded in module-2 (36.50%) and highest infestation was seen in module-5 (44.18%). The bollworm infestation in locules in different modules showed significant differences among each other.

Table 5

Per cent bollworm infestation in locules at harvest.

IPM modules	R-I	R-II	R-III	Mean
I	36.30 (37.05)	36.70 (37.29)	35.45 (35.94)	36.15 (36.95)
II	35.67 (36.65)	35.43 (36.53)	35.08 (36.31)	35.39 (36.50)
III	38.26 (38.20)	38.19 (38.15)	38.13 (38.14)	38.19 (38.17)
IV	39.58 (38.98)	39.45 (38.92)	39.31 (38.84)	39.45 (38.90)
V	48.80 (44.31)	48.56 (44.17)	48.39 (44.07)	48.58 (44.18)
VI	40.13 (39.21)	40.04 (39.25)	39.86 (39.18)	40.01 (39.23)
VII	42.43 (40.65)	42.37 (40.59)	42.26 (40.53)	42.35 (40.60)
Untreated control	44.54 (41.87)	44.38 (41.76)	44.46 (41.81)	44.46 (41.81)
SE ±				0.075
CD at 5%				0.23

(ii) Effect of different IPM modules on natural enemies

Effect of different IPM modules on population of lady bird beetle

Lady bird beetle populations in different IPM modules during different meteorological weeks were recorded and presented in Table 6. The highest lady bird beetle population was recorded in module-1 (1.13/plant) during 39th MW. The population of the predator beetle was more during initial stage of the crop in all the modules and it decreased towards the end of the cropping season. Modules 4 and 6 (1.07 beetles/plant) recorded significantly higher lady bird beetle population during 38th MW and the difference in population was non-significant among different modules throughout the entire crop growth period. The lowest population (0.71 beetle/plant) was recorded in all the modules during 44th MW.

Table 6

Population of lady bird beetles on cotton in different modules (number of beetles/plant).

IPM modules	Meteorological weeks						
	36	37	39	40	42	44	45
I	0.13 (0.79)	0.46 (0.93)	0.80 (1.13)	0.07 (0.75)	0.13 (0.79)	0.00 (0.71)	0.13 (0.79)
II	0.20 (0.83)	0.20 (0.83)	0.60 (1.05)	0.13 (0.79)	0.00 (0.71)	0.00 (0.71)	0.13 (0.79)
III	0.06 (0.75)	0.13 (0.79)	0.33 (0.89)	0.00 (0.71)	0.13 (0.79)	0.00 (0.71)	0.13 (0.79)
IV	0.66 (1.07)	0.13 (1.06)	0.60 (1.01)	0.13 (0.79)	0.13 (0.79)	0.00 (0.71)	0.13 (0.79)
V	0.20 (0.83)	0.00 (0.71)	0.33 (0.91)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.13 (0.79)
VI	0.66 (1.07)	0.13 (0.79)	0.60 (1.02)	0.00 (0.71)	0.07 (0.75)	0.00 (0.71)	0.07 (0.75)
VII	0.20 (0.83)	0.13 (0.79)	0.47 (0.98)	0.00 (0.71)	0.00 (0.71)	0.07 (0.75)	0.13 (0.79)
Untreated control	0.13 (0.79)	0.13 (0.79)	0.27 (0.87)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.20 (0.83)
SE ±	0.05	0.13	0.11	0.03	0.05	0.02	0.06
CD at 5%	0.15	NS	NS	NS	NS	NS	NS

Effect of different IPM modules on population of Chrysoperla carnea

The data regarding population of *Chrysoperla* recorded in different IPM modules during different meteorological weeks are presented in Table 7. The data showed the highest population of *Chrysoperla* in modules-2 and 3 (1.33/plant) during 37th MW and this was on par with module-1 (1.21/plant) and significantly higher than in other modules. The *Chrysoperla* population did not vary much among different modules during rest of the crop growth period. However, more population of the natural enemy was recorded in initial stage in all the modules and it decreased towards the terminal stage of plant growth. The lowest (0.71/plant) population was recorded during 44th and 45th MW in almost all the modules. In the present investigations, the difference in the population of natural enemies (Coccinellid beetle and *Chrysoperla carnea*) varied non-significantly among different IPM modules. But, highest populations of lady bird beetle (1.13/plant) and *Chrysoperla carnea* (1.33/plant) were recorded in module-1, module-2 and 3, respectively.

Table 7
Population of Chrysoperla on cotton in different modules.

IPM modules	Meteorological weeks						
	36	37	39	40	42	44	45
I	0.27	1.00	0.67	0.13	1.53	0.00	0.00
II	0.60	1.27	0.73	0.07	0.80	0.00	0.00
III	0.80	1.27	0.53	0.00	0.87	0.00	0.00
IV	0.40	0.87	0.60	0.00	0.93	0.0	0.00
V	0.27	0.53	0.60	0.20	0.27	0.00	0.00
VI	0.67	0.67	0.40	0.07	0.47	0.00	0.00
VII	0.27	0.87	0.53	0.00	0.40	0.00	0.00
Untreated control	0.13	0.33	0.53	0.00	0.13	0.00	0.00
SE ±	0.11	0.09	0.07	0.05	0.19	0.02	0.02
CD at 5%	NS	0.30	NS	NS	NS	NS	NS

(iii) Influence of different IPM modules on yield and net returns in cotton

Effect of different IPM modules on the yield of seed cotton

The yields of seed cotton obtained in different IPM modules were recorded and presented in the Table 8. The highest yield of seed cotton was recorded in module-6 (1024 kg/ha) and this was significantly superior over all other modules. The lowest yield was recorded in module-8 (781 kg/ha) where no plant protection strategies were undertaken. The seed cotton yield of different modules varied significantly from each other.

Table 8
Effect of different IPM modules on the yield of seed cotton (kg/ha).

IPM modules	R-I	R-II	R-III	Mean
I	903	905	907	905
II	996	998	1002	999
III	991	988	990	990
IV	878	883	881	881
V	785	781	784	783
VI	1020	1018	1033	1024
VII	957	954	966	959
Untreated control	783	778	782	781
SE ±				1.92
CD at 5%				5.81

Cost-benefit ratio in different IPM modules

The Table 9 showing the cost:benefit ratios of different IPM modules revealed that maximum net returns were obtained in module-5 (Rs. 15377/ha) followed by module-4 (Rs. 12971/ha) and module-8 (Rs. 12162/ha). The lowest net returns were recorded from module-3 (Rs. 10039/ha) where cost of plant protection (Table 10) was maximum (Rs. 3636/ha) among all the modules. The C-B ratio was more in module 5 (1:2.444) and it was followed by module 7 (1:2.176) and the lowest C-B ratio was observed in module-3 (1:1.855)

Table 9
Net returns and cost:benefit ratio in different IPM modules.

IPM module	Seed cotton yield (kg/ha)	Inter-crop yield (kg/ha)	Cotton equi-valent yield (kg/ha)	Total yield (kg/ha)	Gross returns (Rs/ha)	Cost of culti-vation + cost of plant protection (Rs/ha)	Net returns (Rs/ha)	C-B ratio
I	905	--	--	905	19910	9498	10412	1:2.096
II	999	--	--	999	21978	10495	11483	1:2.094
III	990	--	--	990	21780	11741	10039	1:1.855
IV	881	191	226	1107	24354	11383	12971	1:2.139
V	783	568	400	1183	26026	10649	15377	1:2.444
VI	1024	--	--	1024	22528	11418	11110	1:1.973
VII	959	--	--	959	21098	9695	11403	1:2.176
Untreated control	781	--	--	781	17182	8105	12162	1:2.120

Note :
Price of cotton : Rs. 2200/q
Price of cowpea : Rs. 2600/q
Price of setaria : Rs. 1550/q
Cost of cultivation for cotton: Rs. 8105.00/ha

Significantly higher yield was recorded in module-7 where only chemical sprays were used and was at par with module-6 [12]. Similar results were also recorded in the present investigation where module-6 recorded highest yield (1024 kg/ha). Hence, the present findings are in corroboration with earlier works. But the cost:benefit ratio was found to be maximum in module-5 (1:2.444), where cotton was intercropped with Setaria and this was followed by module-7 (1:2.176) where only 2 sprays of chemicals (endosulfan 0.06% and quinalphos @ 0.05% were sprayed based on ETL.

Table 10
Cost of plant protection in different IPM modules.

IPM module	Costs (Rs./ha)
I	1393.00
II	2390.00
III	3636.00
IV	3278.00
V	2544.00
VI	3313.00
VII	1590.00
Untreated control	0.00

CONCLUSION

The present investigations clearly confirmed that the seed cotton yield was recorded maximum in module-6 where combinations of different biopesticides and conventional chemical pesticides were used, the net returns and C-B ratios were highest in module-5 where Setaria was intercropped with cotton and cultural practices were practiced to manage the bollworm infestation along with use of bioagents and biopesticides. Hence, it can be concluded that module-5 comprising of mixed cropping with Setaria, NSKE 5 % spray, mechanical control of large size larvae, two releases of *Trichogramma*, HaNPV (500 LE/ha) and *Bacillus thuringinesis* (0.075 kg a.i./ha) spray at ETL can be adopted as an effective IPM module in cotton.

ACKNOWLEDGEMENT

I would like to thank Prof. B.S. Kadam, for his valuable guidance throughout my studies.

CONFLICT OF INTEREST
Conflict of interest declared none.

REFERENCES

1. USDA, ERS (United States Department of Agriculture, Economic Research Service) (2011). <http://www.ers.usda.gov/Briefing/Cotton/> (accessed 18.07.11).
2. Khan MQ and Rao VP, Insect and mite pest on cotton in India. Indian Cent. Cotton Common. Bombay, 207-301, (1960).
3. Sohi GS, Pests of cotton. In entomology in India (ed). Entomology Society of India, 111-148, (1964).
4. Rani, M., Rana, J. S., Dahiya K. K. and beniwal, V. Molecular characterization of *Rhizoctonia solani* AG-7 causing root rot on cotton crop in india. Int J Pharm Bio Sci 2013 Apr; 4(2): (B) 703 – 712.

5. Mustafee TPC, Increasing agricultural production. Pestology, Annual, 1995-96, 12-17, (1996).
6. Chaturvedi C, Status of insecticide resistance in the cotton bollworm, *Helicoverpa armigera* (hubner). J Cent Eur Agr. 8(2):171-182, (2007).
7. Chidawanyika F, Mudavanhu P and Nyamukondiwa S, Biologically Based Methods for Pest Management in Agriculture under Changing Climates: Challenges and Future Directions. Insects 3: 1171-1189; doi:10.3390/insects3041171, (2012).
8. Manjunath TM, *Bt*-cotton in India: The technology wins as the controversy wanes. 63rd Plenary Meeting of International Cotton Advisory Committee (ICAC) Meeting, Mumbai, 1-9, (2004).
9. Panse VG and Sukhatme PV, Statistical Methods for Agricultural, Workers, ICAR, New Delhi, (1967).
10. Vitale J, Ouattarra M and Vognan G. Enhancing Sustainability of Cotton Production Systems in West Africa: A Summary of Empirical Evidence from Burkina Faso. Sustainability 3:1136-1169; doi:10.3390/su3081136, (2011).
11. Patel Y, Utilization of newer insecticides for management of cotton bollworms. Res Crit. 1(1):1-6, (2014).
12. Anonymous. Integrated management of bollworms. Annual Progress Report of Cotton Research, 2003-04, MAU, Parbhani, ENT 83-86, (2004).