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Assessment of different modules for management of pink bollworm, *Pectinophora gossypiella* (Saunders) in *Bt* cotton

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Abstract
A field experiment was carried out for the management of pink bollworm in *Bt* Cotton using different modules at Regional Agricultural Research Station, Warangal, Telangana state during *kharif* 2016 and 2017. Among different modules, the lowest number of Pink bollworm (PBW) larvae (32.5/25 green bolls) and locule damage (71/100 fully opened bolls) was noticed in chemical control module followed by biological control module (47 larvae/25 green bolls; 102 damaged locules/100 fully opened bolls) and biological + chemical control module (52.5 larvae/25 green bolls; 105.5 damaged locules/100 fully opened bolls). The highest number of PBW larvae (67 /25green bolls) and locule damage (130.5 damaged locules/100 fully opened bolls) was observed in untreated control module. Over all, the highest benefit cost ratio was recorded in chemical control module as compared to other modules. From this study, it is concluded that for management of PBW insecticidal sprays at ETLs proved better than biological control and other methods.

Keywords: *Bt* cotton, pink bollworm, modules, management

1. Introduction
Cotton, *Gossypium spp*. is one of the commercially important fibre crop in the world for fibre, fuel and edible oil, is playing an important role in Indian economy. In Telangana state, cotton was gown in 18.24 lakh ha with a production of 57 lakh bales and 531 kg/ha productivity during 2017-18. In the recent past, Pink bollworm (*Pectinophora gossypiella* Saunders) has become a major threat to *Bt* Cotton in the last 2 years and is causing considerable loss to Cotton, in terms of yields. The Pink bollworm, once a serious problem for non *Bt* Cotton especially in later stage of the crop has now become a major problem in *Bt* Cotton hybrids appearing from the flowering stage of the crop and inflicting damage if unattended. World over, Pink bollworm, *Pectinophora gossypiella* (Saunders) has become economically the most destructive pest of Cotton and has known to cause 2.8 to 61.9 per cent loss in seed cotton yield, 2.1 to 47.10 per cent loss in oil content and 10.70 to 59.20 per cent loss in normal opening of bolls [1]. Estimated yield losses in the U.S.A. due to pink bollworm range from 9% when chemically controlled to 61% when uncontrolled [2], although 100% crop loss can occur with heavy infestations. The control of this pest depends largely on the application of pesticides, which has precipitated the development of resistance. As a result, in order to achieve effective control, more chemical applications per season are needed [3]. Furthermore, to control this pest alternative control strategies like release of egg parasitoids at ETLs in combination with insecticidal sprays are being studied. The egg parasitoids, *Trichogrammatoidea spp*. have been used in IPM of cotton for the control of *P. gossypiella* and proved as good biological agents in the laboratory [4]. Several studies revealed the role of *Trichogramma spp*. in controlling different insect pests infesting the cotton crop in different parts of the world [5, 6]. The present study was undertaken to evaluate different modules for the management of Pink bollworm in Bt cotton in order to find out an effective and economic module.

2. Materials and methods
Evaluation of different modules for control of Pink bollworm in Bt cotton was studied in Bt cotton hybrid "RCH-836" during *Kharif* seasons of 2016 and 2017 at Regional Agricultural Research Station, Warangal Telangana state. The experiment was carried out with four

modules, viz., Biological control module, Insecticide control module, Biological + Insecticidal control module and an untreated control module, each in 500 sq.m. area separated with 2m buffer distance. The crop was grown under rainfed conditions in heavy black soil at a spacing of 90 x 60 cm following all recommended agronomic practices except plant protection measures. Biological control module includes ecofriendly strategies and chemical control module comprised of chemical insecticidal sprays which are normally effective against Pink bollworm (Table1). Sowing was done on 02-7-2016 during 2016 and on 01-7- 2017 during 2017. In untreated control plot, no insecticidal sprays were taken up during both the seasons. The pest management interventions were carried out only when the pests crossed economic threshold level. In all the treatments, cotton seed treated with imidacloprid 70 WS were sown in order to manage the early sucking pests. Each plot was divided into four equal blocks to minimize the error while recording the data. The first block was treated with Trichogrammatoidea bactrae@ 20,000/ ha at 10 days interval if the moth catches exceed 8 per trap for 3 consecutive days and spraying of Neem oil @ 5ml/l was initiated. The tricho cards of *Trichogrammatoidea bactrae* (NBAII-MP-TRI-02) were procured from NBAIR, Bangalore. The second block was treated with conventional insecticides, received a total of five sprays during the season. The third block received a combination of biological and chemical methods as soon as the moth catches reached an economic threshold level. The fourth block was untreated and served as a control. To record pink bollworm incidence 25 fruiting bodies per plot were plucked at 140, 150,160,170 1nd 180 days after sowing during *kharif* 2016 where the incidence was started at 140 DAS and 120, 130, 140, 150, 160, 170 and 180 days after sowing during *kharif* 2017 where incidence started early at 120 DAS. To record incidence of bollworms in fully opened bolls at harvest time, 100 opened bolls per plot were plucked randomly and were collected in polyethylene bags and estimated locule damage. The data of all the observations was pooled to arrive at seasonal means (Table 4 & 5). Cotton yield was recorded from each treatment and the data were presented as seed cotton yield in q/ha and benefit cost ratio of each treatment was worked out.

Table 1: Treatment details of different modules in *Bt* Cotton

Treatments	
Module 1	1. Installation of Pheromone traps @ 10 per hectare at 45 DAS for monitoring Release of Trichogrammatoidea bactrae @ 20,000/ ha at 10 days interval if the moth catches exceed 8 per trap for 3 consecutive days 2. Spraying of Neem seed kernel extract @ 5% or Neem oil @ 5ml/l 3. Collection and destruction of Rosette flowers
Module 2	1. Spraying of Thiodicarb @ 1.5g/l 2. Spraying of Quinalphos @ 2.0 ml/l 3. Spraying of Spinosad @ 0.3 ml/l 4. Spraying of Indoxacarb @ 1ml/l 5. Spraying of Lambdacyhalothrin @ 1ml/l Insecticidal sprays arrived at using the male catches (ETL) in the pheromone traps
Module 3	1. Installation of Pheromone traps @ 10 per hectare at 45 DAS for monitoring 2. Release of Trichogrammatoidea bactrae @ 20,000/ ha at 10 days interval if the moth catches exceed 8 per trap for 3 consecutive days 3. Spraying of Neem seed kernel extract @ 5% or Neem oil @ 5ml/l 4. Collection and destruction of Rosette flowers 5. Spraying of Thiodicarb @ 1.5g/l 6. Spraying of Quinalphos @ 2.0 ml/l Insecticidal sprays arrived at using the male catches (ETL) in the pheromone traps
Module 4	Control

3. Results and discussion

A study was conducted to evaluate different modules for effective management of Pink bollworm in *Bt* cotton during *kharif* 2016 and 2017. It is seen from the data in Table 4 that all modules were significantly superior over untreated control during kharif 20016 and 2017. In the present investigation, incidence of Pink bollworm remained low when chemical control was adopted as compared to other methods of control during both the years. It was revealed that the lowest number of pink bollworm larvae (18) through destructive sampling was observed in module 2 followed by module 1 (36), module 3 (45) while, the highest was noticed in module 4 (61) during 2016-17. Similarly, the lowest number of pink bollworm larvae (47) through destructive sampling was observed in module 2 followed by module 1 (58), module 3 (60) while, the highest was noticed in module 4 (73) during 2017-18 indicating the influence of insecticidal interventions over biological and other modules. The present findings are in conformity with reports of [7] who reported low incidence of Pink bollworm in chemical control method. Similarly [8] observed low incidence of Pink bollworm in chemical insecticides treated plot.

At the time of harvesting, locule damage was recorded from 100 fully opened bolls. The lowest locule damage (49) was noticed in module 2 followed by module 1 with 66 damaged per 100 fully opened bolls followed by module 3 with 94 damaged per 100 fully opened bolls while, the highest locule damage (119) was noticed in module 4 untreated control during 2016-17. Similarly, the lowest number of damaged locules (93) from 100 fully opened bolls was observed in module 2 followed by module 3 (117), module 1 (138) while, the highest damaged locules (142) per 100 fully opened bolls was observed in module 4 during 2017-18 (Table 4). The present findings are in conformity with reports of [9] who reported that among all treatments, chemical are the best which was followed by botanical, botanical + chemical, intercrop + trichogramma + botanical, biological control for control of bollworms in cotton.

Seed Cotton yield in different modules

Results presented in Table 5 showed that during *kharif* 2016 and 2017 all modules were significantly superior over

untreated control. Highest seed cotton yield (21.99 q/ha) was obtained in module 2 followed by module 1 (17.99 q/ha), module 3 (16.77 q/ha) while, the lowest seed cotton yield (13.67 q/ha) was recorded in untreated control module.

Economics of various modules

Highest gross income was obtained in chemical control method (module 1) during both the years of investigation. Over all, the benefit cost ratio was high in chemical control module (module 1) as compared to other modules (Table 6). The results clearly indicated that initiation of chemical control methods at ETLs proved to be better for the management of Pink bollworm as compared to other methods.

4. Conclusion

From the present study, it is concluded that among all modules, chemical control module is the best followed by biological control module, biological module + chemical module for the management of Pink bollworm in *Bt* Cotton.

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Table 2: Number of PBW larvae per 25 green bolls through destructive sampling at different days of crop growing period during 2016-17

Treatments	Days after sowing					Mean
	140 days	150 days	160 days	170 days	180 days	
Module 1	2	34	35	39	72	36
Module 2	2	14	13	33	27	18
Module 3	4	38	39	67	76	45
Module 4	10	54	64	78	98	61

Table 3: Number of PBW larvae per 25 green bolls through destructive sampling at different days of crop growing period during 2017-18

Treatments	Days after sowing							Mean
	120 days	130 days	140 days	150 days	160 days	170 days	180 days	
Module 1	9	31	64	69	90	75	70	58
Module 2	13	33	55	50	64	53	60	47
Module 3	13	35	44	61	89	67	111	60
Module 4	17	45	64	90	107	78	108	73

Table 4: Effect of different modules on Pink bollworm

	No.of PBW larvae/25 green bolls		Pooled	No. of damaged locules /100 fully opened bolls		Pooled
	2016-17	2017-18		2016-17	2017-18	
Module 1	36	58	47	66	138	102
Module 2	18	47	32.5	49	93	71
Module 3	45	60	52.5	94	117	105.5
Module 4	61	73	67	119	142	130.5

Table 5: Effect of different modules on seed cotton yield

	Seed cotton yield (q/ha)		Pooled
	2016-17	2017-18	
Module 1	18.88	17.11	17.99
Module 2	25.17	18.82	21.99
Module 3	16.90	16.65	16.77
Module 4	13.87	13.47	13.67

Table 6: Economics of different modules

Particular	2016-17				2017-18			
	Module 1	Module 2	Module 3	Module 4	Module 1	Module 2	Module 3	Module 4
Yield (q/ha)	18.88	25.17	16.90	13.87	17.11	18.82	16.65	13.47
Income from crop (Rs./ha)	78,541	1,04,707	70,304	57,699	73,915	81302	71928	58190
Gross income (Rs./ha)	78,541	1,04,707	70,304	57,699	73,915	81,302	71,928	58,190
Total Cost of cultivation (Rs./ha)	64,115	68,945	64,835	58,750	66,060	67,025	64,835	58,250
Benefit: Cost ratio	1.22	1.52	1.08	0.98	1.12	1.21	1.11	0.99

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