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Effect of bio rational management practices on pink bollworm damage in *Bt* cotton

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Abstract

The present investigation entitled was carried out during *kharif* of 2018-19 on, the research farm of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The field experiment was laid out in Randomized Block Design with nine treatments and three replications. The results revealed that minimum green fruiting bodies damaged was recorded in treatment T₆ i.e. 0.68 per cent where weekly destruction of rosette flower along with 5 releases of trichocards @ 3 cards/acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE were carried out whereas, maximum 2.01 per cent was recorded in untreated control. Same trend was observed in case of green boll damaged where minimum green boll damaged recorded due to pink bollworm was 9.58 per cent and maximum 32.92 per cent was observed in control. Overall minimum pink bollworm damage was recorded in treatment T₆ i.e. 10.83 per cent and maximum 52.41 per cent was recorded in untreated control at the time of harvest.

Keywords: *Bt* Cotton, bio rational, *Pectinophora gossypiella*, Azadirachtin, Trichocards, *Beauveria bassiana*

Introduction

Cotton the “King of fibres” or “White gold” is one of the most important crop producing natural fibre which has been under commercial cultivation for domestic consumption and export needs of about 111 countries in the world. It plays prominent role in the National and International economy. It is grown mainly for its fiber, used in the manufacture of cloth for mankind ^[1]. Cotton, the most important commercial crop of India ranks first in acreage in the world. In India cotton is cultivated on 122.29 lakh ha with production of 370 lakh bales per ha. In Maharashtra cotton crop is grown on 42.07 lakh ha with production of 85.00 lakh bales and productivity of 343.00 lint kg/ha ^[2]. Major constraint in attaining high production of seed cotton is the damage inflicted by insect pests. In early growth stages of crop, sucking pests like aphids, leaf hoppers, thrips and whiteflies and in later growth stages of crop, different kinds of bollworms cause reduction in yield and quality of cotton. In Central India During 2018-19, the productivity decreased from 479 to 445 kg lint /ha, mainly attributed to productivity decline in Gujarat from 674 to 577 kg lint /ha ^[3]. Production depends mainly on the timely arrival of monsoon, distribution of rainfall and management interventions. However, pink bollworm in central Maharashtra may cause yield losses albeit to a minor extent. The intensity of pink bollworm was more in the irrigated tracts of central Maharashtra. During 2017, pink bollworm damage was high in Jalgaon and severe in Dhule and Nandurbar. Yield losses in these districts could have been close to 20-25 per cent due to the boll damage in the second-third pickings of cotton, which was estimated at 40,000 bales worth US\$ 12 million in the three districts. The state may contribute 8.0 m bales during 2018 from an area of 3.6 to 3.8 m hectares ^[4]. Since, pink bollworm is now emerging pests of *Bt* cotton growing area and farmers are totally dependent on chemical insecticidal management resulted in elimination of natural enemies of pink bollworm and also affecting the cotton ecosystem badly. Therefore, the present investigation was carried out with an objective to evaluate different biorational management practices against pink bollworm in *Bt* cotton which will be helpful for minimizing chemical insecticidal pressure in cotton ecosystem.

2. Materials and Methods

Field experiment was laid out with Randomized Block Design (RBD) having nine treatments and three replications. The plot size was 6.3 meter × 6 meter with spacing 90 × 60 cm. PKV

Hy. 2 BG II cultivar was used in present investigation and sowing was done on 29th June. All the agronomical practices were carried out as per the recommendations except, plant protection measures.

Table 1: Treatment details are as follows:

Treatment No	Treatment details
T ₁	Weekly destruction of rosette flowers starting at 50 DAE + 3 sprays of Azadirachtin @ 10 ml/10 litres at 10 days interval starting at 50 DAE
T ₂	Weekly destruction of rosette flowers + 3 sprays of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 10 days interval starting at 50 DAE
T ₃	Weekly destruction of rosette flowers + 5 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE
T ₄	Weekly destruction of rosette flowers + 7 releases of trichocards @ 3 cards/acre at 10 days interval starting at 50 DAE
T ₅	Weekly destruction of rosette flowers + 9 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE
T ₆	Weekly destruction of rosette flowers + 5 releases of trichocards @ 3 cards/acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 litres at 10 days interval starting at 50 DAE
T ₇	Weekly destruction of rosette flowers starting at 50 DAE + 4 alternate sprays of Azadirachtin @ 10 ml and <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 10 days interval starting at 50 DAE
T ₈	Weekly destruction of rosette flowers starting at 50 DAE + spray of Azadirachtin @ 10 ml at 60 DAE + releases of trichocards @ 3 cards/acre at 70 DAE + spray of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 80 DAE
T ₉	Control

Periodical observations were undertaken to record fruiting bodies damage by pink bollworm at weekly interval started from square formation and calculated by using following formulae-

$$\text{Fruiting bodies damage (\%)} = \frac{\text{Number of damaged green fruiting bodies}}{\text{Total number of green fruiting bodies}} \times 100$$

The observations of green bolls damaged due to pink bollworm were recorded from 90 days after emergence (DAE) up to 160 DAE at an interval of 10 days. Randomly 20 matured green bolls were plucked from each plot and these bolls were dissected and observed for pink bollworm damage. The data thus, obtained was expressed in terms of per cent green boll damage and per cent loculi damage by using following formulae-

$$\text{Green boll damage (\%)} = \frac{\text{Number of damaged green bolls}}{\text{Total number of green bolls observed}} \times 100$$

$$\text{Loculi damage (\%)} = \frac{\text{Number of damaged loculi}}{\text{Total number of loculi observed}} \times 100$$

For recording open boll damage and loculi damage due to pink bollworm, all open bolls randomly selected from five plants from each net plot were assessed at final picking. From this data the per cent open boll damage and loculi damage at harvest was worked out. Thus, the data so far generated were subjected to proper transformation and then statistically analyzed.

3. Results and Discussion

3.1 Effects of different treatments on per cent green fruiting bodies damage by pink bollworm

The data recorded on green fruiting bodies damaged by pink bollworm is presented in Table 2. The observations of green fruiting bodies damage were started at 45 days after

emergence (DAE). Treatment T₆ found statistically significant over rest of the treatments from 45 DAE to 122 DAE. The per cent mean green fruiting bodies damage by pink bollworm from 45 DAE to 122 DAE were ranged from 0.68 to 2.01 per cent in which minimum mean green fruiting bodies damage was recorded in treatment T₆ (0.68%) which was followed by T₅ (1.01%) whereas, maximum (2.01%) mean total fruiting bodies damage was observed in control treatment (T₉). The next best treatment were T₄ (1.15%), T₃ (1.31%) and T₇ (1.46%)

Significant reduction in per cent infestation of PBW in green bolls was recorded i.e. 12.54 to 66.36 and 43.74 to 90.03 per cent as compared to untreated control in 2013 and 2014, respectively. Moreover, 4-releases of trichocards early at (>50%) flowering stage succeeded to suppress the infestation with PBW by 66.36 and 90.03 per cent in the both 2013 and 2014 seasons, respectively [5]. Spray of three local extracts such as tobacco (*Nicotiana tabacum*), neem (*Azadirachta indica*) and datura (*Datura stramonium*) at different intervals indicated the highest pest population reduction of 17.45-15.09 per cent by tobacco followed by 14.58-15.33 per cent due to neem and 11.72-7.81 per cent by datura in two varieties and similar trend was also noted in the second year of the study [6]. Presents results are in close conformity with the above findings.

3.2 Effects of different treatments on per cent green boll damage by pink bollworm

The data recorded on per cent green boll damaged by pink bollworm is presented in Table 3. The green boll damage was recorded at 90 days after emergence (DAE) to 160 DAE. Efficacy wise per cent green boll damage was ranged from 3.33-20.00, 3.33-26.67, 3.33-30.00, 6.67-33.33, 6.67-36.67, 6.67-40.00, 6.67-46.67, 10.00-50.00 and 10.00-50.00 per cent in T₆, T₅, T₄, T₃, T₇, T₈, T₁, T₂ and T₉ respectively. Treatment T₆ was found consistently significant over rest of the treatments from 90 DAE to 160 DAE. The per cent mean green boll damage by pink bollworm from 90 DAE to 160 DAE was ranged from 9.58 - 32.92. Among the treatments, maximum 32.92 per cent mean green boll damage was

observed in control treatment (T₉). The minimum per cent mean green boll damage was recorded in T₆ (9.58%) and it was statistically at par with T₅ (13.33%), and T₄ (16.25%). The next promising treatments were T₃ (19.58%), T₇ (22.92%), T₈ (25.00%), T₁ (27.08%), and T₂ (30.00%).

Parasitoid releases gave best results in reducing PBW infestation in the fallen cotton flower buds and/or the squares and the green bolls compared with both insecticides and check treatments. The reduction attained 9.4, 39.4 and 7.7 per cent in the fallen cotton flower buds and/or squares and 36.5, 41.7 and 25.4 per cent in green bolls in the seasons 1999, 2000 and 2001 respectively [7]. The results of the present study are similar to the above finding.

3.3 Effects of different treatments on per cent loculi damage by pink bollworm

The data recorded on per cent loculi damaged by pink bollworm is presented in Table 4. Data on per cent loculi damage revealed that treatment T₆ proved its efficacy over rest of the treatments by recording minimum loculi damage starts from 90 DAE to 160 DAE. The per cent mean data on loculi damage by pink bollworm from 90 DAE to 160 DAE were ranged from 2.36-10.59 among the treatments. However, the per cent mean loculi damage in T₆ (2.36%) was statistically at par with T₅ (3.85%). The next best treatment was T₄ (5.30%) and which is statistically on par with T₃ (6.52%), T₇ (7.29%), T₈ (7.71%), T₁ (8.30%), T₂ (9.04%). Whereas maximum (10.59%) loculi damage by pink bollworm was recorded in control (T₉).

The treatments of BIPM practices registered 3.43 and 2.41 per cent damage to green bolls and locule as against 4.43 and 3.08 per cent in farmers practices, respectively. Both these treatments recorded significantly low incidence of PBW compared to untreated check [8].

Two release of *T. chilonis* with two sprays of *Btk* recorded less larval population (0.33/plant), less damage on shed squares (42.78%), intact squares (9.12%) bolls (14.20%) and

loculi (10.68%) and recorded higher yield (782 kg/ha) [9]. The results of the present study are similar to the above finding.

3.4 Effects of different treatments on per cent open boll damage at harvest by pink bollworm.

The data recorded on per cent open boll damage by pink bollworm at harvest was presented in Table 5. Treatment T₆ found consistently significant over rest of the treatments at the time of harvest. The per cent mean open boll damage at harvest by pink bollworm was ranged from 10.83-52.41 per cent. Among the treatments maximum 52.41 per cent mean open boll damage was observed in control treatment (T₉). Significantly lower open boll damage was recorded in T₆ (10.83%) which was at par with T₅ (13.10%). The next promising treatments were T₄ (14.42), T₃ (18.32%), T₇ (20.00%), T₈ (22.74%) and T₁ (25.96%). Treatment T₂ recorded higher open boll damage 30.09 per cent among the treatments which was next to the control.

3.5 Effects of different treatments on per cent loculi damage at harvest by pink bollworm

The data recorded on per cent loculi damage by bollworm complex at harvest was presented in Table 6. At harvest results revealed that treatment T₆ was significantly superior over control. The per cent mean loculi damage due to pink bollworm were found to be in the range of 3.52-17.45 per cent. Treatment T₆ recorded significantly minimum mean loculi damage (3.52%) and was at par with T₅ (4.84%). The next promising treatment were T₄ (4.87%), T₃ (5.31%), T₇ (6.05%), T₈ (7.19%), T₁ (8.19%), T₂ (9.58%). However, maximum per cent loculi damage (33.68%) was recorded in T₉ – control.

The present findings are more or less parallel to two releases of *T. chilonis* with two sprays of *Btk* which recorded less larval population (0.33/plant), less damage in shed squares (42.78%), intact squares (9.12%) bolls (14.20%) and loculi (10.68%) [9].

Table 2: Effects of different treatments on per cent green fruiting bodies damage by pink bollworm

Tr. No.	Treatments	Green fruiting bodies damage (%)												
		45 DAE	52 DAE	59 DAE	66 DAE	73 DAE	80 DAE	87 DAE	94 DAE	101 DAE	108 DAE	115 DAE	122 DAE	C MEAN
T1	Weekly destruction of rosette flower starting at 50 DAE + 3 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE.	1.63 (1.28)*	1.73 (1.31)*	1.49 (1.22)*	1.96 (1.39)*	1.98 (1.40)*	2.42 (1.55)*	2.63 (1.62)*	1.01 (1.01)*	0.60 (0.77)*	0.00 (0.00)*	0.00 (0.00)*	0.00 (0.00)*	1.72 (1.28)*
T2	Weekly destruction of rosette flower + 3 sprays of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 liters of water at 10 days interval starting at 50 DAE	1.68 (1.30)	1.86 (1.36)	1.98 (1.41)	2.11 (1.45)	2.17 (1.47)	2.26 (1.50)	2.48 (1.57)	1.05 (1.02)	0.56 (0.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.79 (1.31)
T3	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	1.40 (1.18)	1.39 (1.17)	1.34 (1.15)	1.61 (1.26)	1.58 (1.25)	1.49 (1.21)	1.63 (1.27)	0.89 (0.94)	0.45 (0.67)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.31 (1.12)
T4	Weekly destruction of rosette flower + 7 releases of trichocards @ 3 cards/acre at 10 days interval starting at 50 DAE	1.34 (1.15)	1.33 (1.15)	1.01 (1.00)	1.39 (1.17)	1.52 (1.23)	1.44 (1.19)	1.22 (1.08)	0.71 (0.84)	0.40 (0.63)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.15 (1.05)
T5	Weekly destruction of rosette flower + 9 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	1.19 (1.09)	1.12 (1.06)	1.00 (0.98)	1.24 (1.09)	1.14 (1.07)	1.27 (1.12)	1.13 (1.05)	0.69 (0.82)	0.33 (0.57)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.01 (0.98)
T6	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE	0.69 (0.68)	1.06 (1.02)	0.75 (0.87)	0.57 (0.76)	0.73 (0.84)	0.57 (0.61)	1.03 (1.01)	0.65 (0.80)	0.07 (0.15)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.68 (0.75)
T7	Weekly destruction of rosette flower starting at 50 DAE + 4 alternate sprays of Azadirachtin @ 10 ml and <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 10 days interval starting at 50 DAE	1.55 (1.24)	1.45 (1.20)	1.42 (1.19)	1.69 (1.29)	1.66 (1.27)	1.84 (1.34)	2.19 (1.48)	0.89 (0.94)	0.48 (0.69)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.46 (1.18)
T8	Weekly destruction of rosette flower starting at 50 DAE + spray of Azadirachtin @ 10 ml at 60 DAE + releases of trichocards @ 3 cards/acre at 70 DAE + spray of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 80 DAE	1.60 (1.26)	1.58 (1.24)	1.47 (1.21)	1.76 (1.32)	1.93 (1.39)	2.19 (1.48)	2.38 (1.54)	0.94 (0.97)	0.51 (0.71)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.60 (1.24)
T9	Control	1.73 (1.32)	2.11 (1.45)	2.20 (1.48)	2.49 (1.58)	2.50 (1.58)	2.59 (1.61)	2.75 (1.66)	1.08 (1.04)	0.66 (0.81)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.01 (1.39)
	F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	-	-	-	Sig
	SE (m) ±	0.107	0.083	0.081	0.093	0.085	0.099	0.087	0.056	0.048	0	0	0	0.062
	CD at5%	0.32	0.25	0.24	0.29	0.25	0.29	0.26	0.17	0.14	0	0	0	0.18
	CV%	15.89	11.80	12.03	12.79	11.46	13.31	11.07	10.36	12.94	0	0	0	9.30

Table 3: Effects of different treatments on per cent green boll damage by pink bollworm

Tr. No.	Treatments	Green boll damage (%)								C MEAN
		90 DAE	100 DAE	110 DAE	120 DAE	130 DAE	140 DAE	150 DAE	160 DAE	
T1	Weekly destruction of rosette flower starting at 50 DAE + 3 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE.	6.67 (2.11)*	10.00 (3.16)*	23.33 (28.78)**	26.67 (31.00)**	30.00 (33.00)**	33.33 (35.22)**	40.00 (39.15)**	46.67 (43.08)**	27.08 (27.99)
T2	Weekly destruction of rosette flower + 3 sprays of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 liters of water at 10 days interval starting at 50 DAE	10.00 (3.16)	10.00 (3.16)	26.67 (31.00)	30.00 (33.00)	33.33 (35.22)	36.67 (37.22)	43.33 (41.15)	50.00 (45.00)	30.00 (29.39)
T3	Weekly destruction of rosette flowers + 5 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	6.67 (2.11)	6.67 (2.11)	16.67 (23.86)	16.67 (23.86)	20.22 (26.07)	23.33 (28.29)	33.33 (35.22)	33.33 (35.22)	19.58 (23.04)
T4	Weekly destruction of rosette flower + 7 releases of trichocards @ 3 cards/acre at 10 days interval starting at 50 DAE	3.33 (1.05)	6.67 (2.11)	13.33 (21.14)	13.33 (21.14)	16.67 (23.86)	20.00 (26.57)	26.67 (30.79)	30.00 (33.21)	16.25 (20.88)
T5	Weekly destruction of rosette flower + 9 releases of trichocards @ 3 cards/acre at an interval of 10	3.33	3.33	10.00	10.00	13.33	16.67	23.33	26.67	13.33

	days starting at 50 DAE	(1.05)	(1.05)	(18.43)	(15.00)	(21.14)	(23.86)	(28.78)	(31.00)	(18.31)
T6	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE	0.00 (0.00)	3.33 (1.05)	3.33 (6.14)	6.67 (12.29)	10.00 (18.43)	13.33 (21.14)	20.00 (26.07)	20.00 (26.07)	9.58 (14.33)
T7	Weekly destruction of rosette flower starting at 50 DAE + 4 alternate sprays of Azadirachtin @ 10 ml and <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 10 days interval starting at 50 DAE	6.67 (2.11)	10.00 (3.16)	20.00 (26.57)	20.00 (26.07)	23.33 (28.78)	26.67 (31.00)	40.00 (39.15)	36.67 (37.14)	22.92 (25.14)
T8	Weekly destruction of rosette flower starting at 50 DAE + spray of Azadirachtin @ 10 ml at 60 DAE + releases of trichocards @ 3 cards/acre at 70 DAE + spray of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 80 DAE	6.67 (2.11)	10.00 (3.16)	23.33 (28.78)	23.33 (28.78)	26.67 (31.00)	30.00 (33.00)	40.00 (39.15)	40.00 (39.23)	25.00 (26.46)
T9	Control	10.00 (3.16)	13.33 (3.60)	30.00 (33.00)	33.33 (35.22)	36.67 (37.22)	40.00 (39.15)	46.67 (43.08)	50.00 (45.00)	32.92 (30.23)
	F test	NS	NS	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE(m) ±	0.878	0.715	2.650	2.839	2.784	2.421	3.528	2.845	2.333
	CD at 5%	2.63	2.14	7.94	8.51	8.34	7.25	9.76	8.52	6.89
	CV%	81.19	49.38	18.97	19.55	17.03	13.70	15.75	13.24	28.60

(Note: Fig. In parentheses, * Square root transformation, ** arc sin transformation, DAE-Day after emergence, C mean-cumulative mean, NS-Non sig)

Table 4: Effects of different treatments on per cent loculi damage by pink bollworm

Tr. No.	Treatments	Loculi damage (%)								
		90 DAE	100 DAE	110 DAE	120 DAE	130 DAE	140 DAE	150 DAE	160 DAE	C MEAN
T1	Weekly destruction of rosette flower starting at 50 DAE + 3 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE	1.61 (1.03)*	2.50 (1.58)*	6.44 (2.53)*	9.09 (3.01)*	9.74 (3.11)*	10.33 (3.21)*	12.01 (3.47)*	14.72 (3.83)*	8.30 (2.72)
T2	Weekly destruction of rosette flower + 3 sprays of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 liters of water at 10 days interval starting at 50 DAE	2.46 (1.57)	2.50 (1.58)	6.49 (2.54)	9.07 (2.96)	10.83 (3.29)	11.67 (3.41)	12.34 (3.50)	16.94 (4.12)	9.04 (2.87)
T3	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	1.59 (1.03)	1.61 (1.04)	5.73 (2.38)	8.56 (2.92)	6.57 (2.55)	7.07 (2.64)	10.83 (3.27)	10.21 (3.17)	6.52 (2.37)
T4	Weekly destruction of rosette flower + 7 releases of trichocards @ 3 cards/acre at 10 days interval starting at 50 DAE	0.83 (0.53)	1.57 (1.02)	3.99 (1.98)	6.44 (2.53)	6.29 (2.50)	6.33 (2.50)	7.15 (2.65)	9.80 (3.12)	5.30 (2.10)
T5	Weekly destruction of rosette flower + 9 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	0.76 (0.50)	0.83 (0.53)	2.42 (1.56)	2.46 (1.26)	5.51 (2.34)	3.97 (1.97)	5.83 (2.40)	9.00 (2.98)	3.85 (1.69)
T6	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE	0.00 (0.00)	0.76 (0.50)	0.78 (0.51)	1.63 (1.04)	3.16 (1.75)	1.63 (1.04)	4.67 (2.11)	6.28 (2.50)	2.36 (1.18)
T7	Weekly destruction of rosette flower starting at 50 DAE + 4 alternate sprays of Azadirachtin @ 10 ml and <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 10 days interval starting at 50 DAE	1.61 (1.04)	2.42 (1.56)	5.83 (2.40)	8.13 (2.84)	8.13 (2.84)	8.78 (2.95)	12.01 (3.47)	11.43 (3.35)	7.29 (2.56)
T8	Weekly destruction of rosette flower starting at 50 DAE + spray of Azadirachtin @ 10 ml at 60 DAE + releases of trichocards @ 3 cards/acre at 70 DAE + spray of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 80 DAE	1.67 (1.05)	2.42 (1.56)	6.41 (2.52)	8.80 (2.96)	8.33 (2.85)	9.63 (3.09)	11.92 (3.45)	12.50 (3.52)	7.71 (2.63)
T9	Control	2.48 (1.57)	4.17 (2.02)	8.94 (2.98)	11.67 (3.41)	13.33 (3.65)	14.17 (3.76)	12.50 (3.52)	17.50 (4.18)	10.59 (3.14)
	F test	NS	NS	Sig	Sig	Sig	Sig	Sig	Sig	Sig
	SE(m) ±	0.432	0.355	0.203	0.284	0.196	0.217	0.213	0.226	0.267
	CD at 5%	1.29	1.06	0.61	0.85	0.59	0.65	0.64	0.68	0.79
	CV%	80.85	48.64	16.28	19.31	12.29	13.74	11.92	11.47	26.81

(Note: Fig. In parentheses * Square root transformation, DAE-Day after emergence, C mean-cumulative mean)

Table 5: Effects of different treatments on per cent open boll damage at harvest by pink bollworm

Tr. No.	Treatments	Average boll damage (%)			
		RI	RII	RIII	Mean
T1	Weekly destruction of rosette flower starting at 50 DAE + 3 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE.	20.48 (26.91)**	34.56 (36.01)**	22.85 (28.56)**	25.96 (30.49)**
T2	Weekly destruction of rosette flower + 3 sprays of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 liters of water at 10 days interval starting at 50 DAE	24.56 (29.71)	32.98 (35.05)	32.74 (34.90)	30.09 (33.22)
T3	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	14.71 (22.55)	21.62 (27.71)	18.62 (25.56)	18.32 (25.27)
T4	Weekly destruction of rosette flower + 7 releases of trichocards @ 3 cards/acre at 10 days interval starting at 50 DAE	15.56 (23.23)	14.38 (22.28)	13.33 (21.42)	14.42 (22.31)
T5	Weekly destruction of rosette flower + 9 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	11.26 (19.61)	10.80 (19.19)	17.24 (24.53)	13.10 (21.11)
T6	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE	13.47 (21.53)	8.33 (16.78)	10.69 (19.08)	10.83 (19.13)
T7	Weekly destruction of rosette flower starting at 50 DAE + 4 alternate sprays of Azadirachtin @ 10 ml and <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 10 days interval starting at 50 DAE	26.26 (30.83)	14.38 (22.28)	19.35 (26.10)	20.00 (26.40)
T8	Weekly destruction of rosette flower starting at 50 DAE + spray of Azadirachtin @ 10 ml at 60 DAE + releases of trichocards @ 3 cards/acre at 70 DAE + spray of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 80 DAE	19.10 (25.91)	18.65 (25.59)	30.47 (33.50)	22.74 (28.33)
T9	Control	50.47 (45.27)	52.63 (46.51)	54.12 (47.36)	52.41 (46.38)
	F test	-	-	-	Sig
	SE(m) ±	-	-	--	1.909
	CD at 5%.	-	-	-	5.72
	CV%	-	-	-	11.78

(Note: Fig. In parentheses, ** arc sin transformation, DAE-Day after emergence, C mean-cumulative mean).

Table 6: Effect of different treatments on per cent loculi damage by pink bollworm

Tr. No.	Treatments	Average loculi damage (%)			
		RI	RII	RIII	Mean
T1	Weekly destruction of rosette flower starting at 50 DAE + 3 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE	6.26 (14.49)**	9.88 (18.32)**	8.44 (16.89)**	8.19 (16.57)**
T2	Weekly destruction of rosette flower + 3 sprays of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 liters of water at 10 days interval starting at 50 DAE	8.64 (17.09)	10.44 (18.85)	9.67 (18.12)	9.58 (18.02)
T3	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	4.24 (11.88)	6.32 (14.56)	5.36 (13.39)	5.31 (13.28)
T4	Weekly destruction of rosette flower + 7 releases of trichocards @ 3 cards/acre at 10 days interval starting at 50 DAE	5.10 (13.05)	4.88 (12.76)	4.64 (12.44)	4.87 (12.75)
T5	Weekly destruction of rosette flower + 9 releases of trichocards @ 3 cards/acre at an interval of 10 days starting at 50 DAE	5.02 (12.95)	3.16 (10.24)	6.35 (14.60)	4.84 (12.59)
T6	Weekly destruction of rosette flower + 5 releases of trichocards @ 3 cards/acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE	4.99 (12.91)	2.45 (9.01)	3.12 (10.17)	3.52 (10.70)
T7	Weekly destruction of rosette flower starting at 50 DAE + 4 alternate sprays of Azadirachtin @ 10 ml and <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 10 days interval starting at 50 DAE	7.12 (15.48)	4.59 (12.37)	6.45 (14.71)	6.05 (14.19)
T8	Weekly destruction of rosette flower starting at 50 DAE + spray of Azadirachtin @ 10 ml at 60 DAE + releases of trichocards @ 3 cards/acre at 70 DAE + spray of <i>Beauveria bassiana</i> 1.15 @ 40 g/10 litres of water at 80 DAE	6.25 (14.48)	5.48 (13.54)	9.84 (18.28)	7.19 (15.43)
T9	Control	16.21 (23.74)	17.36 (24.62)	18.78 (25.68)	17.45 (24.68)
	F test				Sig
	SE(m) ±				0.957
	CD at 5%				2.87
	CV%				10.79

4. Conclusion

Minimum green fruiting bodies damage by pink bollworm was recorded in treatment T₆ i.e. 0.68 per cent whereas, maximum 2.01 per cent was recorded in control. Minimum green boll damage 9.58 per cent and minimum loculi damage 2.36 per cent by pink bollworm was recorded in treatment T₆ and maximum 32.92 per cent green boll damage and maximum loculi damage 10.59 per cent was observed in control. Lowest open boll damage and lowest loculi damage by pink bollworm at harvest was recorded in treatment T₆ i.e. 10.83 per cent and 3.52 per cent respectively, and the highest open boll damage 52.41 per cent and highest loculi damage 17.45 per cent at harvest was observed in control. From the data overall it was concluded that weekly destruction of rosette flowers followed by 5 releases of trichocards @ 3 cards per acre alternated with 4 sprays of Azadirachtin @ 10 ml/10 liters at 10 days interval starting at 50 DAE provided maximum protection from pink bollworm damage in *Bt* cotton.

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