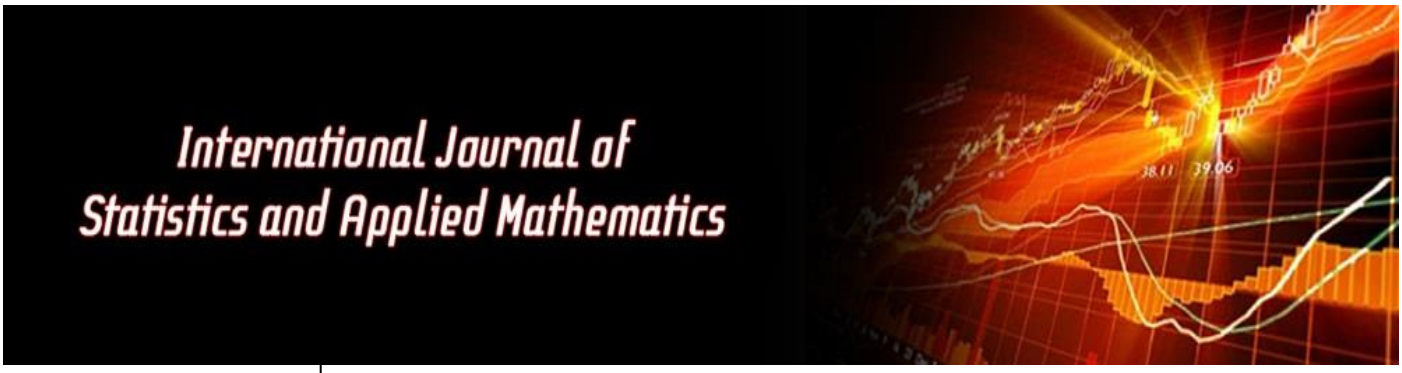

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Bio efficacy of different insecticides against pink bollworm, *Pectinophora gossypiella* (Saunders) on Bt cotton

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Abstract
The present research on "Bio efficacy of different insecticides against pink bollworm, *Pectinophora gossypiella* (Saunders) infesting *Bt* cotton" was carried out at Village: Daliya, Ta. Gondal, Dist. Rajkot during *Kharif*, 2020-21. The results of experiment were revealed that Chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior than the rest of the treatments, but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% and profenophos 40 + cypermethrin 4 EC 0.088% at seven and fourteen days after first and second application against rosette flower and green boll damage due to pink bollworm. Profenophos 40 + cypermethrin 4 EC 0.088% and indoxacarb 14.5 SC 0.012% followed by chlorpyriphos 50 + cypermethrin 5 EC 0.110% and deltamethrin 2.8 EC 0.003% were next in order. Profenophos 50 EC0.125% and chlorpyriphos 20 EC 0.040%were proved to be least effective against this pest. The highest Incremental Cost Benefit Ratio (ICBR) (1:16.55) was obtained with the treatment of profenophos + cypermethrin followed by chlorantraniliprole 9.3 + lambda-cyhalothrin (1:9.79) and chlorpyriphos (1:9.61). Among the different insecticides, chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC 0.007% found most effective insecticidal treatment against pink bollworm.

Keywords: *Bt* cotton, insecticides, pink bollworm

Introduction
Cotton (*Gossypium sp.*) is one of the principal commercial fiber crop grown under diverse agro-climatic conditions around the world which belongs to the family Malvaceae. India, United States, China, Brazil, Pakistan are the leading cotton producing countries in the world (Anon., 2019) [4]. India commands highest share (36%) in terms of area under cotton cultivation in the world. India is the largest producer of cotton in the world accounting for about 25 per cent of the world cotton production. In India, cotton was cultivated under 133.73 lakh hectare area with production of 365 lakh bales (1 bale = 170 kg) and productivity of 464 kg per hectare during 2019-20 (Anon., 2018a) [2].

The cotton crop is attacked by 1326 species of insect pests throughout the world, of which about 130 different species of insects and mites found to devour cotton at different stages of crop growth in India. Spotted bollworm (*Earias vitelli* Fabricius), American bollworm (*Helicoverpa armigera* Hubner), pink bollworm (*Pectinophora gossypiella* Saunders), leaf eating caterpillar (*Spodoptera litura* Fabricius), aphid (*Aphis gossypii* Glover), jassid (*Amrasca biguttula biguttula* Ishida), thrips (*Thrips tabaci* Lindeman), whitefly (*Bemisia tabaci* Gennadius), mite (*Tetranychus telarious* Linnaeus), mealy bug (*Phenacoccus solenopsis* Tinsley) and dusky cotton bug (*Oxycarenus laetus* Kirby) are the major insect pests attacking the cotton crop (Davidson and Lyon, 1978) [6].

Among major insect pests attacking the cotton, pink bollworm, *P. gossypiella* [Lepidoptera: Gelechiidae] is the one of the most destructive and serious pest of cotton cultivation and has known to cause losses in seed cotton yield, oil content, loss in normal opening of bolls, damage of locules, and reduction in seed cotton yield.

The management of pink bollworm on cotton has become a tough task because the larval stages of this pest were spent in the cotton bolls. Therefore, conventional control methods including insecticidal application are difficult to control this pest.

Hence, evaluate the efficacy of insecticides for effective management of pink bollworm.

Materials and Methods

An experiment was conducted to evaluate the field efficacy of different insecticides against pink bollworm in *Bt* cotton at Village: Daliya, Ta. Gondal, Dist. Rajkot during *Kharif*, 2020-21 with Randomized Block Design with ten treatments and three replications. The crop was sown in a gross and net plot size of 4.5 m x 3.6 m and 2.7 m x 2.4 m, respectively at spacing of 90 cm x 60 cm. All agronomical practices were adopted as per the recommendation in vogue. Details of insecticidal treatments are given in Table 1.

Table 1: Details of different insecticides used for their bio-efficacy against *P. Gossypiella*in *Bt* cotton

Tr. No.	Name of insecticides/ treatments	Trade name	Conc. (%)	Dose (ml or g/10 liter of water)	Source
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC	Ampligo	0.007	5 ml	Syngenta Private Limited
T_2	Chlorpyriphos 50 + cypermethrin 5 EC	Double Star	0.110	20 ml	Swal Corporation Limited, Mumbai
T_3	Profenofos 40 + cypermethrin 4 EC	Profex Super	0.088	20 ml	Nagarjuna Fertilizers and *Chemicals, Hyderabad*
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC	Plethora	0.017	17.5 ml	Adama India Private Limited
T_5	Indoxacarb 14.5 SC	Dhawa Gold	0.012	8.33 ml	Dhanuka Agritech Limited, Haryana
T_6	Deltamethrin 2.8 EC	Decis	0.003	10 ml	M/S. Bayer India Ltd.
T_7	Chlorpyriphos 20 EC	Dursban	0.040	20 ml	Dow Agro Sciences
T_8	Profenophos 50 EC	Curacron	0.125	25 ml	Syngenta Private Limited
T_9	Emamectin benzoate 1.9 EC	Proclaim	0.002	12 ml	Syngenta Private Limited
T_{10}	Control	-	-	-	-

Application of treatments: The spraying of all insecticides was carried out with the help of knapsack sprayer with spray solution @ 500 litre/ha. The spray solution required for uniform coverage was estimated by spraying known quantity of water before spray and then insecticides were mixed thoroughly in water. The care was taken to obtained uniform coverage of insecticides on each plant. Total two sprays were applied during season. Among these, first insecticidal spray was applied at initiation of the pest infestation, while looking to the continuous pest infestation the second spray was repeated after 15 days of first spray.

Method of recording observation: Observations on pest population were recorded from five randomly selected and tagged plants from the net area of each plot at 24 hrs before and at 7 and 14 day after each spraying. Observations on number of healthy and damaged (rosette) flower/square, green bolls and number of larvae were recorded per plant. At harvesting time, healthy and damaged open bolls and locules per plant were recorded.

Yield and Economics: The yield is an important criterion for comparing the efficacy of different treatments. *Bt* Cotton was harvested from net plot area separately and was weighed treatments wise. The yield per hectare was calculated for each treatment and data were subjected to statistical analysis. The per cent increase in yield over control was calculated by using following formula (Pradhan, 1969) [9].

$$\text{Yield increased (Per cent)} = 100\times \frac{T-C}{C}$$

Where,
T = Yield of respective treatment (kg/ha).
C = Yield of control (kg/ha).

Economics of all the treatments were worked out by considering the price of *Bt* cotton, cost of insecticide used and labour charges for spraying of insecticides. Cost benefit ratio was worked out to compare the economics of different insecticidal treatments.
Cost Benefit Ratio (CBR) and net return of each insecticide used were worked out for each treatment. For the purpose, gross realization was worked out to compare the economics of the insecticidal treatments.

Statistical analysis of data: Statistical analysis of data was carried out by following the ANOVA techniques as given by Panse and Sukhatme (1985) [8].

Results and Discussion

The data on different periods *i.e.*, before spray, seven and fourteen days after spray (DAS) were pooled and indicated that all the experimental plots showed non-significant variation with respect to the rosette flower and green boll damage per plant before first application of insecticides.

Table 2: Effect of different insecticides against rosette flower caused by pink bollworm, *P. Gossypiella* infesting *Bt* cotton after first spray *Kharif*, 2020-21

Tr. No.	Treatments	Rosette flower (%) per plant			
		Before	7 DAS	14 DAS	Pooled
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC 0.007%	16.43 (8.00)	13.81 (5.70)	11.39 (3.90)	12.59 (4.80)
T_2	Chlorpyriphos 50 + cypermethrin 5 EC 0.110%	17.05 (8.60)	16.06 (7.70)	15.61 (7.20)	15.83 (7.45)
T_3	Profenophos 40 + cypermethrin 4 EC 0.088%	16.74 (8.30)	14.18 (6.00)	13.16 (5.20)	13.65 (5.60)
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC 0.017%	16.53 (8.10)	13.90 (5.80)	11.65 (4.10)	12.79 (4.95)
T_5	Indoxacarb 14.5 SC 0.012%	16.84 (8.40)	15.23 (6.90)	14.02 (5.87)	14.62 (6.38)
T_6	Deltamethrin 2.8 EC 0.003%	16.95 (8.50)	16.32 (7.90)	15.60 (7.20)	15.93 (7.55)
T_7	Chlorpyriphos 20 EC 0.040%	17.05 (8.60)	16.85 (8.40)	16.64 (8.20)	16.74 (8.30)
T_8	Profenophos 50 EC 0.125%	17.26 (8.80)	16.85 (8.40)	16.54 (8.10)	16.68 (8.25)
T_9	Emamectin benzoate 1.9 EC 0.002%	16.74 (8.30)	15.45 (7.10)	14.10 (5.97)	14.77 (6.53)

T_{10}	Control	16.60 (8.60)	19.32 (10.8)	20.89 (12.70)	19.73 (11.74)
S.E.M. ± T		0.96	0.87	0.81	0.76
P		-	-	-	0.55
T x P		-	-	-	0.418
C.D. at 5% T		NS	2.52	2.40	2.27
P		-	-	-	1.63
T x P		-	-	-	NS
C.V. (%)		9.88	9.65	9.19	9.42

Notes: 1. DAS = Days After Spray.
2. NS = non-significant @ 5%.
3. Figures in the parenthesis indicate retransformed values, while outside are arcsine transformed values.

The pooled data (Table 2) over different periods of first spray revealed that chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior [4.80% rosette flower/plant] than the rest of the treatments but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% (4.95%), profenophos 40 + cypermethrin 4 EC 0.088% (5.60%). Profenophos 40 + cypermethrin 4 EC 0.088% (5.20%) was found at par with indoxacarb 14.5 SC 0.012% (6.38%) and emamectin benzoate 1.9 EC 0.002% (6.53%). Whereas, the highest (8.30%) rosette flower was observed in plots treated with chlorpyriphos 20 EC 0.040% which was at par with profenophos 50 EC 0.125% (8.25%), deltamethrin 2.8 EC 0.003% (7.55%) and chlorpyriphos 50 + cypermethrin 5 EC 0.110% (7.45%).

Table 3: Effect of different insecticides against rosette flower caused by pink bollworm, *P. Gossypiella* infesting *Bt* cotton after second spray during *Kharif*, 2020-21

Tr. No.	Treatments	Rosette flower (%) per plant		
		7 DAS	14 DAS	Pooled
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC 0.007%	10.30 (3.20)	9.95 (3.00)	10.10 (3.10)
T_2	Chlorpyriphos 50 + cypermethrin 5 EC 0.110%	15.34 (7.00)	14.76 (6.50)	15.01 (6.75)
T_3	Profenophos 40 + cypermethrin 4 EC 0.088%	11.54 (4.00)	10.47 (3.30)	10.96 (3.65)
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC 0.017%	11.09 (3.70)	10.30 (3.20)	10.69 (3.45)
T_5	Indoxacarb 14.5 SC 0.012%	13.20 (5.20)	12.64 (4.80)	12.91 (5.00)
T_6	Deltamethrin 2.8 EC 0.003%	15.45 (7.10)	15.00 (6.70)	15.22 (6.90)
T_7	Chlorpyriphos 20 EC 0.040%	16.32 (7.90)	15.98 (7.60)	16.15 (7.75)
T_8	Profenophos 50 EC 0.125%	16.22 (7.80)	15.21 (6.90)	15.72 (7.35)
T_9	Emamectin benzoate 1.9 EC 0.002%	13.60 (5.50)	12.79 (4.90)	13.15 (5.20)
T_{10}	Control	22.75 (14.90)	23.70 (16.10)	22.97 (15.48)
S. Em. ± T		0.83	0.80	0.74
P		-	-	0.56
T x P		-	-	0.414
C.D. at 5% T		2.48	2.39	2.19
P		-	-	1.68
T x P		-	-	NS
C.V. (%)		9.71	9.83	9.77

Notes: 1. DAS = Days After Spray.
2. NS = Non-Significant @ 5%.
3. Figures in the parenthesis indicate retransformed values, while outside are arcsine transformed values.

The pooled data (Table: 3) over periods of second spray showed that chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior [3.10% rosette flower/plant] than the rest of the treatments but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% (3.45%), profenophos 40 + cypermethrin 4 EC 0.088% (3.65%). Profenophos 40 + cypermethrin 4 EC 0.088% (3.65%) was found at par with indoxacarb 14.5 SC 0.012% (5.00%) and emamectin benzoate 1.9 EC 0.002% (5.20%). Whereas, the highest (7.75%) rosette flower was observed in plots treated with chlorpyriphos 20 EC 0.040% which was at par with profenophos 50 EC 0.125% (7.35%), deltamethrin 2.8 EC 0.003% (6.90%) and chlorpyriphos 50 + cypermethrin 5 EC 0.110% (6.75%).

In case of green boll damage, the pooled data (Table 4) over periods of first spray showed that chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior [4.10% green boll damage/plant] than the rest of the treatments but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% (4.85%), profenophos 40 + cypermethrin 4 EC 0.088% (5.17%). Profenophos 40 + cypermethrin 4 EC 0.088% (5.17%) was found at par with indoxacarb 14.5 SC 0.012% (6.25%) and emamectin benzoate 1.9 EC 0.002% (6.75%). Whereas, the highest (9.40%) rosette flower was observed in plots treated with chlorpyriphos 20 EC 0.040% which was at par with profenophos 50 EC 0.125% (9.17%), deltamethrin 2.8 EC 0.003% (9.05%) and chlorpyriphos 50 + cypermethrin 5 EC 0.110% (8.45%).

Table 4: Effect of different insecticides against green boll damage due to pink bollworm, *P. gossypiella* infesting *Bt* cotton after first spray during *Kharif*, 2020-21

Tr. No.	Treatments	Green boll damage (%) per plant			
		Before	7 DAS	14 DAS	Pooled
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC 0.007%	18.25 (9.80)	12.47 (4.70)	10.79 (3.50)	11.64 (4.10)
T_2	Chlorpyriphos 50 + cypermethrin 5 EC 0.110%	18.47 (10.00)	17.36 (8.90)	16.43 (8.00)	16.87 (8.45)
T_3	Profenophos 40 + cypermethrin 4 EC 0.088%	18.48 (10.00)	13.87 (5.70)	12.52 (4.70)	13.14 (5.17)
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC 0.017%	18.56 (10.10)	13.48 (5.40)	12.01 (4.30)	12.69 (4.85)
T_5	Indoxacarb 14.5 SC 0.012%	18.24 (9.80)	15.05 (6.70)	13.96 (5.80)	14.45 (6.25)
T_6	Deltamethrin 2.8 EC 0.003%	18.72 (10.30)	17.95 (9.50)	17.06 (8.60)	17.49 (9.05)
T_7	Chlorpyriphos 20 EC 0.040%	18.31 (9.90)	18.15 (9.70)	17.53 (9.07)	17.84 (9.40)
T_8	Profenophos 50 EC 0.125%	18.59 (10.20)	18.00 (9.55)	17.29 (8.80)	17.62 (9.17)
T_9	Emamectin benzoate 1.9 EC 0.002%	17.85 (9.40)	15.40 (7.05)	14.60 (6.40)	15.05 (6.75)
T_{10}	Control	18.34 (9.90)	20.38 (12.13)	21.67 (13.60)	20.72 (12.52)
S. Em. ± T		0.92	0.86	0.85	0.79
P		-	-	-	0.81
T x P		-	-	-	0.63
C.D. at 5% T		NS	2.55	2.52	2.35
P		-	-	-	2.41
T x P		-	-	-	NS
C.V. (%)		9.40	9.36	9.70	9.53

Notes: 1. DAS = Days After Spray.
2. NS = Non-Significant @ 5%.
3. Figures in the parenthesis indicate retransformed values, while outside are arc sine transformed values.

The pooled data (Table 5) over different periods of second insecticidal application revealed that chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior [1.75% green boll damage/plant] than the rest of the treatments but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% (2.60%), profenophos 40 + cypermethrin 4 EC 0.088% (2.90%). Profenophos 40 + cypermethrin 4 EC 0.088% (2.90%) was found at par with indoxacarb 14.5 SC 0.012% (3.95%). Whereas, the highest (8.70%) green boll damage was observed in plots treated with chlorpyriphos 20 EC 0.040% which was at par with profenophos 50 EC 0.125% (8.20%), deltamethrin 2.8 EC 0.003% (7.95%) and chlorpyriphos 50 + cypermethrin 5 EC 0.110% (7.05%).

Table 5: Effect of different insecticides against green boll damage due to pink bollworm, *P. Gossypiella* infesting *Bt* cotton after second spray during *Kharif*, 2020-21

Tr. No.	Treatments	Green boll damage (%) per plant		
		7 DAS	14 DAS	Pooled
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC 0.007%	8.35 (2.10)	6.84 (1.40)	7.50 (1.75)
T_2	Chlorpyriphos 50 + cypermethrin 5 EC 0.110%	15.84 (7.45)	14.90 (6.60)	15.35 (7.05)
T_3	Profenophos 40 + cypermethrin 4 EC 0.088%	10.60 (3.40)	8.96 (2.40)	9.73 (2.90)
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC 0.017%	10.02 (3.00)	8.49 (2.20)	9.20 (2.60)
T_5	Indoxacarb 14.5 SC 0.012%	12.40 (4.60)	10.50 (3.30)	11.41 (3.95)
T_6	Deltamethrin 2.8 EC 0.003%	16.49 (8.10)	16.17 (7.80)	16.37 (7.95)
T_7	Chlorpyriphos 20 EC 0.040%	17.24 (8.80)	17.05 (8.60)	17.14 (8.70)
T_8	Profenophos 50 EC 0.125%	16.80 (8.40)	16.48 (8.00)	16.62 (8.20)
T_9	Emamectin benzoate 1.9 EC 0.002%	12.90 (5.00)	11.00 (3.60)	11.90 (4.30)
T_{10}	Control	22.68 (14.80)	23.21 (15.50)	22.76 (15.14)
S. Em. ± T		0.81	0.72	0.70
P		-	-	0.36
T x P		-	-	0.25
C.D. at 5% T		2.41	2.13	2.08
P		-	-	1.09
T x P		-	-	NS
C.V. (%)		9.92	9.22	9.57

Notes: 1. DAS = Days After Spray.
2. NS = Non-Significant @ 5%.
3. Figures in the parenthesis indicate retransformed values, while outside are arc sine transformed values.

The data (Table 6) on the effectiveness of different insecticides against open boll damage caused by the *P. Gossypiell*a at harvest revealed that chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior [8.50% open boll damage /plant] than the rest of the treatments but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% (9.80%), profenophos 40 + cypermethrin 4 EC 0.088% (10.90%). Profenophos 40 + cypermethrin 4 EC 0.088% (10.90%) was found at par with indoxacarb 14.5 SC 0.012% (12.30%) and emamectin benzoate 1.9 EC 0.002% (13.90%). Whereas, the highest (16.30%) open boll damage was observed in plots treated with chlorpyriphos 20 EC 0.040% which was at par with profenophos 50 EC 0.125% (15.80%), deltamethrin 2.8 EC 0.003% (15.20%) and chlorpyriphos 50 + cypermethrin 5 EC 0.110% (15.15%).

Table 6: Effect of different insecticides against open boll and locule damage due to pink bollworm, *P. Gossypiella* infesting *Bt* cotton at harvest during *Kharif*, 2020-21

Tr. No.	Treatments	Open boll damage per plant (%)	Locule damage per plant (%)
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC 0.007%	16.95 (8.50)	14.18 (6.00)
T_2	Chlorpyriphos 50 + cypermethrin 5 EC 0.110%	22.90 (15.15)	18.72 (10.30)
T_3	Profenophos 40 + cypermethrin 4 EC 0.088%	19.28 (10.90)	15.78 (7.40)
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC 0.017%	18.23 (9.80)	15.10 (6.80)
T_5	Indoxacarb 14.5 SC 0.012%	20.55 (12.30)	17.05 (8.60)
T_6	Deltamethrin 2.8 EC 0.003%	22.90 (15.20)	19.00 (10.60)
T_7	Chlorpyriphos 20 EC 0.040%	23.81 (16.30)	19.90 (11.63)
T_8	Profenophos 50 EC 0.125%	23.42 (15.80)	19.50 (11.17)
T_9	Emamectin benzoate 1.9 EC 0.002%	21.88 (13.90)	18.53 (10.10)
T_{10}	Control	27.67 (22.10)	23.05 (15.60)
S. Em. ±		1.20	0.94
C.D. at 5%		3.56	2.80
C. V. %		9.66	9.03

Note: Figures in the parenthesis indicate retransformed values, while outside are arc sine transformed values.

The data (Table 6) on the effectiveness of different insecticides against locule damage caused by the *P. Gossypiell*a at harvest revealed that chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior [6.00% locule damage/plant] than the rest of the treatments but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% (6.80%), profenophos 40 + cypermethrin 4 EC 0.088% (7.40%). Profenophos 40 + cypermethrin 4 EC 0.088% (7.40%) was at par with indoxacarb 14.5 SC 0.012% (8.60%) and emamectin benzoate 1.9 EC 0.002% (10.10%). Whereas, the highest (11.63%) locule damage was observed in plots treated with chlorpyriphos 20 EC 0.040% which was at par with profenophos 50 EC 0.125% (11.17%), deltamethrin 2.8 EC 0.003% (10.60%) and chlorpyriphos 50 + cypermethrin 5 EC 0.110% (10.30%).

According to Bajya *et al.* (2015) [5], chlorantraniliprole 9.3 per cent + lambda-cyhalothrin 4.6% ZC was recorded the best treatment against larval population of pink bollworm. Desai (2017) [7] recorded highest reduction in rosette flower, green boll damage, larval population, open boll and locule damage due to pink bollworm with indoxacarb 15.8 EC 0.0079% and it was followed by emamectin benzoate 5 SG 0.0025%, profenophos 50 EC 0.1%, deltamethrin 2.8 EC 0.0028% and chloropyriphos 20 EC 0.04%. Anonymous (2018b) [3] recorded less mean damage to flower in the treatments of indoxacarb 15.8 EC, spinosad 45 SC and emamectin benzoate 5 SC, whereas, less pink bollworm larval population, green boll damage, open boll and locule damage was observed in the treatments of indoxacarb 15.8 EC, emamectin benzoate 5 SC and spinosad 45 SC. The similar results were also reported by Anonymous (2017) [1]. Rambhau *et al.* (2018) [10] founded that chlorantraniliprole + lambda cyhalothrin was highly effective in controlling green boll damage as well as locule damage and it was followed by novaluron + indoxacarb and profenophos + cypermethrin.

In the present findings, looking over the general effect of various insecticides against rosette flower, green boll, open boll as well as locule damage due to pink bollworm, chlorantraniliprole 9.3 + lambda-cyhalothrin 4.6 ZC 0.007% was found significantly superior than the rest of the treatments but it was found at par with novaluron 5.25 + indoxacarb 4.5 SC 0.017% and profenophos 40 + cypermethrin 4 EC 0.088%. It was followed by indoxacarb 14.5 SC 0.012%, emamectin benzoate 1.9 EC 0.002%, chlorpyriphos 50 + cypermethrin 5 EC 0.110%, deltamethrin 2.8 EC 0.003% and profenophos 50 EC 0.125%. Chlorpyriphos 20 EC 0.040% was found less effective among the tested insecticides against the pink bollworm.

Table 7: Effect of different insecticides on seed cotton yield during *Kharif*, 2020-21

Tr. No.	Treatments	Seed cotton yield (kg/ha)	Per cent increase in yield over control
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC 0.007%	2201	57.21
T_2	Chlorpyriphos 50 + cypermethrin 5 EC 0.110%	1805	28.92
T_3	Profenophos 40 + cypermethrin 4 EC 0.088%	2092	49.42
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC 0.017%	2140	52.85
T_5	Indoxacarb 14.5 SC 0.012%	1960	40.00
T_6	Deltamethrin 2.8 EC 0.003%	1740	24.28
T_7	Chlorpyriphos 20 EC 0.040%	1690	20.71
T_8	Profenophos 50 EC 0.125%	1720	22.85
T_9	Emamectin benzoate 1.9 EC 0.002%	1850	32.14
T_{10}	Control	1400	-
S. Em. ±		96.60	-
C.D. at 5 %		284.99	-
C.V. %		9.10	-

The data (Table 7) on the seed cotton yield of *Bt* cotton reveled that all the insecticides gave significantly higher seed yield of *Bt* cotton as compared to control. The highest seed cotton yield was recorded in the treatment of chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC 0.007% (2201 kg/ha) and it was at par with novaluron 5.25 + indoxacarb 4.5 SC 0.088% (2140 kg/ha), profenophos 40 + cypermethrin 4 EC 0.088% (2092 kg/ha) and indoxacarb 14.5 SC 0.012% (1960 kg/ha). The lowest seed cotton yield was recorded in plots treated with chlorpyriphos 20EC 0.040%

(1690 kg/ha) and it was at par with profenophos 50 EC 0.125% (1720 kg/ha), deltamethrin 2.8 EC 0.003% (1740 kg/ha), chlorpyriphos 50 + cypermethrin 5 EC 0.110% (1805 kg/ha), emamectin benzoate 1.9 EC 0.002% (1850 kg/ha) and indoxacarb 14.5 SC 0.012% (1960 kg/ha).

Considering the per cent increase in seed cotton yield over control, the maximum per cent increase in seed yield over control was recorded (Table 6) in the treatment of chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC 0.007% (57.21%) followed by novaluron 5.25 + indoxacarb 4.5 SC 0.088% (52.85%), profenophos 40 + cypermethrin 4 EC 0.088% (49.42%), indoxacarb 14.5 SC 0.012% (40.00%), emamectin benzoate 1.9 EC 0.002% (32.14%), chlorpyriphos 50 + cypermethrin 5 EC 0.110% (28.92%), deltamethrin 2.8 EC 0.003% (24.28%) andprofenophos 50 EC 0.125% (22.85%) considered as mediocre in their effectiveness. The lowest percent increase in seed yield was recorded in the treatment of chlorpyriphos 20EC 0.040% (20.71%) and considered as less effective treatment.

According to Desai (2017) [7], the highest seed cotton yield was recorded in the treatment of indoxacarb 15.8 EC 0.0079% and it was found at par with the treatments of emamectin benzoate 5 SG 0.0025% and spinosad 45 SC 0.014%. Rambhau *et al.* (2018) [10] recorded the highest yield from plots treated with chlorantraniliprole + lambda cyhalothrin and it was followed by novaluron + indoxacarb, profenophos + cypermethrin. Thus, the present findings are more or less in agreement with the results repeated by earlier workers.

Table 8: Economics of different insecticides for the management of pink bollworm infesting *Bt* cotton

Tr. No.	Treatments	Quantity of insecticide (kg or lit/ha) for 2 sprays	Yield (kg/ha)	Cost of treatment (Pesticides, labor charge etc.), (₹/ha)	Gross realization (₹/ha)	Net realization (₹/ha)	ICBR
T_1	Chlorantraniliprole 9.3 + Lambda cyhalothrin 4.6 ZC 0.007%	0.50	2201	4500	121055	44055	1:9.79
T_2	Chlorpyriphos 50 + cypermethrin 5 EC 0.110%	2.00	1805	2460	99275	22275	1:9.05
T_3	Profenophos 40 + cypermethrin 4 EC 0.088%	2.00	2092	2300	115060	38060	1:16.55
T_4	Novaluron 5.25 + Indoxacarb 4.5 SC 0.017%	1.75	2140	5550	117700	40700	1:7.33
T_5	Indoxacarb 14.5 SC 0.012%	0.83	1960	3324	107800	30800	1:9.26
T_6	Deltamethrin 2.8 EC 0.003%	1.00	1740	2880	95700	18700	1:6.49
T_7	Chlorpyriphos 20 EC 0.040%	2.00	1690	1660	92950	15950	1:9.61
T_8	Profenophos 50 EC 0.125%	2.50	1720	2550	94600	17600	1:6.90
T_9	Emamectin benzoate 1.9 EC 0.002%	1.20	1850	3160	101750	24750	1:7.83
T_{10}	Control	-	1400	-	77000	-	-

The result (Table 8) among the different treatments indicated that the profenophos 40 + cypermethrin 4 EC 0.088% gave the highest incremental cost benefit ratio of 1:16.55. The next in order being chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC 0.007% (1:9.79), chlorpyriphos 20EC 0.040% (1:9.61), indoxacarb 14.5 SC 0.012% (1:9.26), chlorpyriphos + cypermethrin (1:9.05), emamectin benzoate 1.9 EC 0.002% (1:7.83), novaluron 5.25 + indoxacarb 4.5 SC 0.088% (1:7.33), profenophos (1:6.90) and deltamethrin (1:6.49).

Among the different aspects insecticides, chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC 0.007% found most effective over rest of the insecticidal treatments. The next best treatments were novaluron 5.25 + indoxacarb 4.5 SC 0.017%, profenophos 40 + cypermethrin 4 EC 0.088%, indoxacarb 14.5 SC 0.012%, emamectin benzoate 1.9 EC 0.002%, chlorpyriphos 50 + cypermethrin 5 EC 0.110%, deltamethrin 2.8 EC 0.003%, profenophos 50 EC 0.125% and chlorpyriphos 20 EC 0.040%.

Conclusion

From the overall results of the present investigation, it can be concluded that the among the different aspects of pest management, chlorantraniliprole 9.3 + lambda cyhalothrin 4.6 ZC 0.007% found most effective over rest of the insecticidal treatments.

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