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Research Article

Bio-efficacy of selected insecticides against pink bollworm in Bt cotton

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Abstract: The field experiment was carried out at the Cotton research Station, Junagadh Agriculture University, Junagadh during Kharif-2015-16, 2016-17 and 2017-18. The results of experiment were revealed that all the nine insecticidal treatments were found significantly superior to untreated control in reducing the larval population in cotton. The significantly lowest larval population was recorded in plots treated with Lambda cyhalothrin 2.5 EC 0.0025% (1.34 larvae) and Deltamethrin 2.8 EC 0.0028% (1.52 larvae). These two insecticidal treatments were significantly superior to rest of the tested insecticides. While in case of green boll damage, the lowest boll damage was found in Lambda cyhalothrin 2.5 EC 0.0025% (4.2%) and Deltamethrin 2.8 EC 0.0028% (4.9%) and there was a significant difference in damage to open bolls and locule at harvest among treatments. The lowest open bolls and locule damage was recorded in Lambda cyhalothrin 2.5 EC (19.07%) and Deltamethrin 2.8 EC (21.28%). The highest seed cotton yield was recorded in Lambda cyhalothrin 2.5 EC 0.0025% (2337 kg/ha) and Deltamethrin 2.8 EC 0.0028% (2296 kg/ha). The present study suggests that the Lambda cyhalothrin 2.5 EC 0.0025% and Deltamethrin 2.8 EC 0.0028% could effectively reduce pink bollworm infestation and lead to improve productivity of Bt cotton.

Keywords: *Bt* Cotton, Pink bollworm, Insecticides

INTRODUCTION

Cotton is an important commercial crop grown for fiber, fuel and edible oil. It plays an important role in Indian economy. In Gujarat, cotton is grown in 23.83 laces ha. In 2014-15, Gujarat occupied second largest area (Approx. 30 laces ha) after Maharashtra state. Today cotton ecosystem is dominated by the *Bt* cotton (>95% area) and claimed to afford protection against bollworms. Further, the farmers of Gujarat are growing *Bt* cotton in irrigated conditions as early as April-May than recommended normal sowing of June-July in other areas without irrigation facility. The recent problems of bollworm occurrence, especially of the pink bollworm on Bt cotton, irrespective of any hybrids may be attributed to the reasons of congenial climate or resistance build up or low expression of genes for PBW control necessitates to relook the dynamics of bollworms on cotton hybrids may be of non Bt, BG I or BG II in light of early sowing practices adopted by the farmers. Now-a-days, pink bollworm, *Pectinophora gossypiella* (Saunders) was found to infest the crop in later stage in *Bt* cotton. Pink bollworm, *Pectinophora gossypiella* (Saunders) is the most serious cotton pests of cotton (Hussein *et al.* 2002). Therefore, the present experiment was carried out to find out effective and economic insecticides for the better control of the pest.

MATERIALS AND METHODS

With a view to find out the efficacy of different insecticides for managing pink bollworm in *Bt* cotton, a field experiment was conducted in randomized block design with three replication at Cotton Research Station, Junagadh Agricultural University, Junagadh during three consecutive year *kharif* 2015-16, 2016-17 and 2017-18. All the recommended agronomical practices were followed to raise good crop. The insecticidal solutions were sprayed through manually operated hydraulic knapsack sprayer till the whole plant was cover thoroughly. The first application of insecticides was made at 75 days after sowing, while the second application was made at 15 days interval after the first spray.

The observation on number of pink bollworm larvae per 10 green bolls was recorded before spray and 5, 10 and 15 days after the spray. Green boll damage was counted based on number of healthy and damaged bolls on five randomly selected plants from each treatment. Similarly, observations of open bolls and locules damage by pink bollworm were recorded at the harvest. Yield of seed cotton was recorded at each picking, total 3 pickings.

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Observation recorded

1. Larval population of pink bollworm (no.)
2. Green boll damage (%)
3. Open and locule boll damage at harvest (%)
4. Seed cotton yield (kg/ha)

RESULTS AND DISCUSSION

The results obtained after insecticidal treatments are presented in Table 1 to 5 revealed significantly impact of all the insecticidal treatments over control in larval population, green boll damage, open boll and locule damage as well as seed cotton yield due to pink bollworm during individual experimental years as well as in pooled results.

Larval population

Larval population of pink bollworm was found non-significant in individual years, but in pooled results it was significant and it varied from 1.59 to 2.37, 2.09 to 3.25, 1.79 to 2.78 and 1.87 to 2.79 larvae in 2015-16, 2016-17, 2017-18 and pooled results, respectively at before spray. Looking to the pooled results, at 5 DAS all the insecticidal treatments were found significantly superior to untreated control in reducing the larval population in cotton. The significantly lowest larval population was recorded in plots treated with Lambda cyhalothrin 2.5 EC 0.0025% (1.34 larvae) and Deltamethrin 2.8 EC 0.0028% (1.52 larvae). These two insecticidal treatments were significantly superior to rest of the tested insecticides. More or less similar trend was observed after 10 & 15 days of first spray as well as 5, 10 and 15 days of second spray (Table 1 - 2).

Table 1: Efficacy of insecticides against pink bollworm on *Bt* cotton (1st Spray)

Treatment	No. of pink bollworm larvae							
	Before spray				5 DAS			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T1: Emamectin benzoate 5 SG 0.0025%	1.37 (1.88)	1.74 (3.03)	1.43 (2.04)	1.51 (2.29)	1.31 (1.72)	1.40 (1.96)	1.36 (1.85)	1.36 (1.84)
T2: Chloropyriphos 20 EC 0.04%	1.28 (1.64)	1.56 (2.43)	1.46 (2.12)	1.43 (2.05)	1.28 (1.63)	1.54 (2.37)	1.43 (2.05)	1.42 (2.01)
T3: Indoxacarb 15.8 EC 0.0079%	1.31 (1.71)	1.45 (2.09)	1.41 (1.99)	1.39 (1.93)	1.34 (1.79)	1.38 (1.91)	1.36 (1.85)	1.36 (1.85)
T4: Trizophos 40 EC 0.08%	1.30 (1.69)	1.42 (2.01)	1.38 (1.91)	1.37 (1.87)	1.23 (1.50)	1.36 (1.84)	1.38 (1.91)	1.32 (1.75)
T5: Spinosad 45 SC 0.014%	1.40 (1.97)	1.48 (2.18)	1.41 (1.98)	1.43 (2.04)	1.34 (1.79)	1.38 (1.90)	1.36 (1.84)	1.36 (1.84)
T6: Profenofos 50 EC 0.1%	1.33 (1.78)	1.56 (2.44)	1.38 (1.91)	1.43 (2.04)	1.28 (1.64)	1.41 (1.98)	1.38 (1.91)	1.36 (1.84)
T7: Thiodicarb 75 WP 0.015%	1.28 (1.64)	1.56 (2.43)	1.36 (1.84)	1.40 (1.96)	1.34 (1.79)	1.43 (2.05)	1.36 (1.85)	1.38 (1.90)
T8: Lambda cyhalothrin 2.5 EC 0.0025%	1.26 (1.59)	1.52 (2.31)	1.34 (1.79)	1.37 (1.88)	1.15 (1.31)	1.15 (1.31)	1.18 (1.39)	1.16 (1.34)
T9: Deltamethrin 2.8 EC 0.0028%	1.27 (1.60)	1.56 (2.44)	1.36 (1.85)	1.40 (1.95)	1.23 (1.52)	1.21 (1.46)	1.26 (1.59)	1.23 (1.52)
T10: Control	1.54 (2.37)	1.80 (3.25)	1.67 (2.78)	1.67 (2.79)	1.59 (2.52)	1.75 (3.05)	1.79 (3.19)	1.71 (2.91)
S.Em.±	**0.11**	**0.12**	**0.08**	**0.06**	**0.07**	**0.10**	**0.06**	**0.04**
C.D. at 5 %	**NS**	**NS**	**NS**	**0.17**	**0.21**	**0.29**	**0.19**	**0.13**
C.V. %	**14.33**	**12.73**	**9.71**	**12.38**	**9.25**	**11.95**	**7.89**	**9.89**
Y	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.03**	--	--	--	**0.02**
C.D. at 5 %	--	--	--	**0.09**	--	--	--	**0.07**
YXT	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.10**	--	--	--	**0.08**
C.D. at 5 %	--	--	--	**NS**	--	--	--	**NS**

Figures in parentheses are original values; those outside are square root transformed values; DAS- Days after spray

Table 1: Conti…

Treatment	No. of pink bollworm larvae							
	10 DAS				15 DAS			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T1: Emamectin benzoate 5 SG 0.0025%	1.23 (1.52)	1.35 (1.83)	1.26 (1.58)	1.28 (1.64)	1.38 (1.91)	1.41 (1.98)	1.28 (1.65)	1.36 (1.84)
T2: Chloropyriphos 20 EC 0.04%	1.20 (1.43)	1.49 (2.23)	1.36 (1.84)	1.35 (1.82)	1.35 (1.83)	1.52 (2.30)	1.33 (1.78)	1.40 (1.96)
T3: Indoxacarb 15.8 EC 0.0079%	1.26 (1.59)	1.31 (1.71)	1.26 (1.58)	1.27 (1.62)	1.41 (1.99)	1.40 (1.97)	1.26 (1.58)	1.36 (1.84)
T4: Trizophos 40 EC 0.08%	1.14 (1.31)	1.30 (1.70)	1.28 (1.65)	1.24 (1.55)	1.31 (1.71)	1.36 (1.84)	1.31 (1.72)	1.32 (1.75)
T5: Spinosad 45 SC 0.014%	1.26 (1.59)	1.31 (1.72)	1.25 (1.56)	1.27 (1.62)	1.41 (1.99)	1.36 (1.85)	1.28 (1.65)	1.35 (1.83)
T6: Profenofos 50 EC 0.1%	1.20 (1.43)	1.36 (1.84)	1.28 (1.65)	1.28 (1.64)	1.35 (1.83)	1.40 (1.97)	1.31 (1.72)	1.36 (1.84)
T7: Thiodicarb 75 WP 0.015%	1.26 (1.59)	1.34 (1.79)	1.23 (1.51)	1.28 (1.63)	1.41 (1.99)	1.38 (1.91)	1.26 (1.58)	1.35 (1.82)
T8: Lambda cyhalothrin 2.5 EC 0.0025%	1.05 (1.10)	1.08 (1.17)	1.03 (1.07)	1.06 (1.11)	1.15 (1.31)	1.17 (1.37)	1.07 (1.14)	1.13 (1.27)
T9: Deltamethrin 2.8 EC 0.0028%	1.18 (1.39)	1.15 (1.31)	1.09 (1.20)	1.14 (1.30)	1.21 (1.46)	1.23 (1.51)	1.12 (1.25)	1.19 (1.41)
T10: Control	1.71 (2.92)	1.84 (3.39)	1.77 (3.13)	1.77 (3.14)	1.82 (3.32)	1.95 (3.79)	1.84 (3.40)	1.87 (3.50)
S.Em.±	**0.07**	**0.10**	**0.08**	**0.05**	**0.06**	**0.10**	**0.07**	**0.05**
C.D. at 5 %	**0.21**	**0.28**	**0.25**	**0.14**	**0.17**	**0.30**	**0.22**	**0.13**
C.V. %	**10.01**	**12.24**	**11.16**	**11.24**	**7.35**	**12.45**	**9.89**	**10.17**
Y	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.03**	--	--	--	**0.03**
C.D. at 5 %	--	--	--	**0.08**	--	--	--	**0.07**
YXT	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.08**	--	--	--	**0.08**
C.D. at 5 %	--	--	--	**NS**	--	--	--	**NS**

Figures in parentheses are original values; those outside are square root transformed values; DAS- Days after spray

Table 2: Efficacy of insecticides against pink bollworm on *Bt* cotton (2nd Spray)

Treatment	No. of pink bollworm larvae											
	5 DAS				10 DAS				15 DAS			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T1	1.38 (1.91)	1.31 (1.72)	1.23 (1.52)	1.31 (1.71)	1.46 (2.1)	1.26 (1.5)	1.18 (1.3)	1.30 (1.69)	1.45 (2.1)	1.36 (1.8)	1.23 (1.5)	1.35 (1.82)
T2	1.30 (1.70)	1.45 (2.11)	1.28 (1.65)	1.35 (1.81)	1.38 (1.9)	1.41 (1.9)	1.26 (1.5)	1.35 (1.82)	1.52 (2.3)	1.50 (2.2)	1.28 (1.6)	1.43 (2.05)
T3	1.45 (2.09)	1.31 (1.71)	1.20 (1.44)	1.32 (1.74)	1.48 (2.1)	1.28 (1.6)	1.20 (1.4)	1.32 (1.74)	1.63 (2.6)	1.42 (2.0)	1.23 (1.5)	1.43 (2.04)
T4	1.48 (2.19)	1.33 (1.78)	1.26 (1.58)	1.36 (1.84)	1.47 (2.1)	1.33 (1.7)	1.22 (1.5)	1.34 (1.80)	1.69 (2.8)	1.45 (2.0)	1.25 (1.5)	1.46 (2.14)
T5	1.45 (2.09)	1.31 (1.72)	1.22 (1.50)	1.33 (1.76)	1.52 (2.3)	1.21 (1.4)	1.21 (1.4)	1.31 (1.72)	1.60 (2.5)	1.30 (1.6)	1.23 (1.5)	1.38 (1.90)
T6	1.38 (1.91)	1.36 (1.85)	1.25 (1.56)	1.33 (1.77)	1.45 (2.1)	1.33 (1.7)	1.26 (1.5)	1.35 (1.82)	1.56 (2.4)	1.46 (2.1)	1.28 (1.6)	1.43 (2.06)
T7	1.48 (2.18)	1.34 (1.79)	1.23 (1.52)	1.35 (1.82)	1.54 (2.3)	1.28 (1.6)	1.21 (1.4)	1.34 (1.80)	1.56 (2.4)	1.31 (1.7)	1.23 (1.5)	1.37 (1.87)
T8	1.08 (1.17)	1.08 (1.16)	1.00 (0.99)	1.05 (1.11)	1.07 (1.1)	1.02 (1.0)	1.00 (0.9)	1.03 (1.06)	1.08 (1.1)	1.09 (1.2)	1.02 (1.0)	1.07 (1.14)
T9	1.15 (1.31)	1.17 (1.37)	1.09 (1.20)	1.14 (1.29)	1.09 (1.2)	1.08 (1.1)	1.06 (1.1)	1.08 (1.16)	1.12 (1.2)	1.15 (1.3)	1.09 (1.2)	1.12 (1.25)
T10	1.69 (2.84)	2.03 (4.12)	1.86 (3.46)	1.86 (3.46)	1.80 (3.2)	2.14 (4.5)	1.88 (3.5)	1.94 (3.77)	1.95 (3.8)	2.19 (4.7)	1.90 (3.6)	2.01 (4.04)
S.Em.±	**0.08**	**0.09**	**0.08**	**0.05**	**0.08**	**0.09**	**0.08**	**0.05**	**0.08**	**0.10**	**0.08**	**0.05**
C.D. at 5 %	**0.25**	**0.27**	**0.25**	**0.14**	**0.25**	**0.27**	**0.24**	**0.14**	**0.24**	**0.31**	**0.23**	**0.14**
C.V. %	**10.56**	**11.60**	**11.63**	**11.26**	**10.26**	**11.99**	**11.26**	**11.17**	**9.13**	**12.79**	**10.39**	**10.86**
Y	--	--	--	--	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.03**	--	--	--	**0.03**	--	--	--	**0.03**
C.D. at 5 %	--	--	--	**0.08**	--	--	--	**0.08**	--	--	--	**0.08**
YXT	--	--	--	--	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.09**	--	--	--	**0.09**	--	--	--	**0.09**
C.D. at 5 %	--	--	--	**NS**	--	--	--	**NS**	--	--	--	**NS**

Figures in parentheses are original values; those outside are square root transformed values; DAS- Days after spray

Green Boll Damage

Damage to green boll by *P. gossypiella* was found non-significant during the experimental year 2016-17 and 2017-18, but during the experimental year 2015-16 and in pooled results it was significant and it varied from 9.37 to 12.63 & 7.97 to 10.32 and 19.09 to 24.54 & 8.44 to 11.46 per cent, respectively at before spray. Looking to the pooled results, at 5 DAS the lowest boll damage was found in Lambda cyhalothrin 2.5 EC 0.0025% (4.27%) and Deltamethrin 2.8 EC 0.0028% (4.92%). The remaining tested insecticides were equally effective in reducing the green boll damage in *Bt* cotton. More or less similar trend was observed after 10 & 15 days of first spray as well as 5, 10 and 15 days of second spray (Table 3 - 4).

Table 3: Efficacy of insecticides against pink bollworm on *Bt* cotton (1st Spray)

Treatment	Green boll damage (%)							
	Before spray				5 DAS			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T1: Emamectin benzoate 5 SG 0.0025%	26.38 (19.74)	18.53 (10.10)	16.97 (8.52)	17.67 (9.21)	14.43 (6.21)	15.98 (7.58)	16.49 (8.06)	15.63 (7.26)
T2: Chloropyriphos 20 EC 0.04%	24.84 (17.64)	17.90 (9.45)	16.54 (8.10)	16.89 (8.44)	13.94 (5.80)	16.05 (7.65)	16.47 (8.03)	15.48 (7.13)
T3: Indoxacarb 15.8 EC 0.0079%	26.13 (19.40)	18.54 (10.11)	16.75 (8.30)	17.53 (9.07)	15.29 (6.96)	16.05 (7.64)	16.48 (8.05)	15.94 (7.54)
T4: Trizophos 40 EC 0.08%	27.29 (21.02)	18.47 (10.03)	16.90 (8.45)	17.94 (9.49)	14.94 (6.64)	16.26 (7.84)	16.60 (8.16)	15.93 (7.53)
T5: Spinosad 45 SC 0.014%	25.67 (18.76)	17.83 (9.37)	16.40 (7.97)	17.11 (8.66)	13.81 (5.70)	16.34 (7.92)	16.45 (8.02)	15.54 (7.17)
T6: Profenofos 50 EC 0.1%	26.88 (20.44)	18.93 (10.52)	17.45 (8.99)	18.05 (9.60)	15.54 (7.18)	16.69 (8.25)	17.03 (8.57)	16.42 (7.99)
T7: Thiodicarb 75 WP 0.015%	27.38 (21.15)	19.29 (10.91)	17.96 (9.50)	18.44 (10.00)	15.80 (7.41)	16.02 (7.61)	17.51 (9.06)	16.44 (8.01)
T8: Lambda cyhalothrin 2.5 EC 0.0025%	25.91 (19.09)	18.34 (9.90)	16.56 (8.12)	17.36 (8.90)	10.08 (3.06)	11.97 (4.30)	13.73 (5.63)	11.92 (4.27)
T9: Deltamethrin 2.8 EC 0.0028%	25.14 (18.05)	18.86 (10.45)	17.15 (8.70)	17.38 (8.92)	11.66 (4.09)	12.97 (5.03)	13.81 (5.69)	12.81 (4.92)
T10: Control	29.70 (24.54)	20.81 (12.63)	18.74 (10.32)	19.79 (11.46)	17.71 (9.26)	20.07 (11.77)	19.35 (10.97)	19.04 (10.64)
S.Em.±	**0.71**	**0.77**	**0.90**	**0.37**	**0.82**	**0.86**	**0.76**	**0.47**
C.D. at 5 %	**2.06**	**NS**	**NS**	**1.03**	**2.44**	**2.54**	**2.27**	**1.33**
C.V. %	**5.34**	**7.08**	**9.10**	**7.10**	**9.93**	**9.36**	**8.06**	**9.08**
Y	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.20**	--	--	--	**0.26**
C.D. at 5 %	--	--	--	**0.56**	--	--	--	**0.73**
YXT	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.63**	--	--	--	**0.81**
C.D. at 5 %	--	--	--	**NS**	--	--	--	**NS**

Figures in parentheses are original values; those outside are Arcsine transformed values; DAS- Days after spray

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Table 3: Conti…

Treatment	Green boll damage (%)							
	10 DAS				15 DAS			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T1: Emamectin benzoate 5 SG 0.0025%	14.24 (6.05)	15.75 (7.37)	15.99 (7.59)	15.33 (6.99)	17.31 (8.85)	19.23 (10.85)	19.23 (10.85)	18.59 (10.16)
T2: Chloropyriphos 20 EC 0.04%	13.65 (5.57)	15.76 (7.38)	16.10 (7.69)	15.17 (6.85)	18.44 (10.01)	20.28 (12.02)	20.28 (12.02)	19.67 (11.33)
T3: Indoxacarb 15.8 EC 0.0079%	14.39 (6.17)	15.84 (7.45)	15.98 (7.58)	15.40 (7.06)	16.54 (8.11)	18.54 (10.11)	18.54 (10.11)	17.88 (9.42)
T4: Trizophos 40 EC 0.08%	14.80 (6.52)	16.12 (7.71)	16.10 (7.69)	15.67 (7.30)	17.91 (9.45)	19.78 (11.46)	19.78 (11.46)	19.16 (10.77)
T5: Spinosad 45 SC 0.014%	14.79 (6.52)	15.98 (7.58)	15.93 (7.53)	15.57 (7.20)	16.62 (8.18)	18.61 (10.19)	18.61 (10.19)	17.95 (9.50)
T6: Profenofos 50 EC 0.1%	15.82 (7.43)	16.52 (8.09)	16.47 (8.04)	16.27 (7.85)	18.36 (9.92)	20.20 (11.92)	20.20 (11.92)	19.59 (11.24)
T7: Thiodicarb 75 WP 0.015%	15.92 (7.52)	15.83 (7.44)	16.89 (8.44)	16.21 (7.80)	17.50 (9.05)	19.42 (11.05)	19.42 (11.05)	18.78 (10.36)
T8: Lambda cyhalothrin 2.5 EC 0.0025%	8.24 (2.05)	11.73 (4.14)	12.72 (4.84)	10.89 (3.57)	10.10 (3.07)	9.96 (2.99)	9.96 (2.99)	10.00 (3.02)
T9: Deltamethrin 2.8 EC 0.0028%	8.65 (2.26)	12.68 (4.82)	13.06 (5.11)	11.46 (3.95)	10.46 (3.30)	10.36 (3.24)	10.03 (3.03)	10.29 (3.19)
T10: Control	20.28 (12.01)	20.41 (12.16)	19.83 (11.51)	20.18 (11.90)	24.79 (17.58)	24.74 (17.52)	24.79 (17.58)	24.78 (17.56)
S.Em.±	**0.64**	**0.83**	**0.81**	**0.44**	**0.77**	**0.75**	**0.75**	**0.44**
C.D. at 5 %	**1.91**	**2.46**	**2.41**	**1.25**	**2.30**	**2.21**	**2.22**	**1.24**
C.V. %	**7.91**	**9.16**	**8.82**	**8.71**	**7.96**	**7.13**	**7.16**	**7.40**
Y	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.24**	--	--	--	**0.24**
C.D. at 5 %	--	--	--	**0.69**	--	--	--	**0.68**
YXT	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.76**	--	--	--	**0.76**
C.D. at 5 %	--	--	--	**NS**	--	--	--	**NS**

Figures in parentheses are original values; those outside are Arcsine transformed values; DAS- Days after spray

Table 4: Efficacy of insecticides against pink bollworm on *Bt* cotton (2nd Spray)

Treatment	Green boll damage (%)											
	5 DAS				10 DAS				15 DAS			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T1	16.79 (8.35)	18.29 (9.85)	17.98 (9.53)	17.69 (9.23)	14.43 (6.21)	15.54 (7.17)	15.98 (7.58)	15.31 (6.97)	16.84 (8.40)	18.36 (9.92)	15.17 (6.85)	16.79 (8.34)
T2	17.95 (9.50)	19.38 (11.0)	18.42 (9.99)	18.59 (10.16)	13.07 (5.11)	14.56 (6.32)	16.51 (8.08)	14.71 (6.45)	16.21 (7.79)	17.71 (9.26)	15.65 (7.28)	16.53 (8.09)
T3	16.01 (7.60)	17.57 (9.11)	17.44 (8.98)	17.01 (8.55)	15.83 (7.44)	16.28 (7.86)	16.28 (7.86)	16.13 (7.72)	18.30 (9.85)	19.66 (11.32)	15.49 (7.13)	17.81 (9.36)
T4	17.41 (8.95)	17.91 (9.45)	18.58 (10.15)	17.97 (9.51)	16.33 (7.91)	16.27 (7.85)	16.31 (7.88)	16.30 (7.88)	17.91 (9.46)	19.54 (11.19)	15.50 (7.14)	17.65 (9.20)
T5	16.09 (7.68)	17.64 (9.19)	17.64 (9.19)	17.13 (8.67)	14.68 (6.43)	14.80 (6.53)	16.24 (7.82)	15.24 (6.91)	16.97 (8.52)	18.23 (9.79)	15.44 (7.09)	16.88 (8.44)
T6	17.87 (9.42)	19.30 (10.92)	18.11 (9.66)	18.43 (9.99)	17.29 (8.83)	17.70 (9.24)	16.70 (8.25)	17.23 (8.77)	19.41 (11.04)	20.88 (12.71)	15.91 (7.51)	18.73 (10.31)
T7	17.00 (8.55)	18.48 (10.05)	18.42 (9.99)	17.97 (9.51)	16.20 (7.78)	16.69 (8.25)	17.17 (8.72)	16.69 (8.24)	18.98 (10.58)	20.24 (11.97)	16.40 (7.97)	18.54 (10.11)
T8	9.21 (2.56)	8.60 (2.24)	9.34 (2.63)	9.05 (2.47)	8.77 (2.33)	8.19 (2.03)	8.12 (2.00)	8.36 (2.11)	7.95 (1.91)	8.08 (1.98)	7.22 (1.58)	7.75 (1.82)
T9	9.62 (2.79)	9.01 (2.45)	9.63 (2.80)	9.42 (2.68)	9.01 (2.45)	8.12 (2.00)	8.77 (2.33)	8.64 (2.26)	8.19 (2.03)	7.90 (1.89)	7.55 (1.72)	7.88 (1.88)
T10	24.79 (17.58)	24.84 (17.65)	25.06 (17.95)	24.90 (17.73)	23.38 (15.74)	24.82 (17.62)	25.09 (17.99)	24.43 (17.10)	24.84 (17.65)	24.92 (17.76)	24.69 (17.45)	24.82 (17.62)
S.Em.±	**0.81**	**0.67**	**0.72**	**0.43**	**0.81**	**0.65**	**0.68**	**0.41**	**0.67**	**0.74**	**0.92**	**0.45**
C.D. at 5 %	**2.40**	**2.00**	**2.15**	**1.21**	**2.40**	**1.93**	**2.03**	**1.17**	**2.00**	**2.21**	**2.74**	**1.29**
C.V. %	**8.60**	**6.83**	**7.34**	**7.59**	**9.40**	**7.35**	**7.53**	**8.12**	**7.05**	**7.33**	**10.73**	**8.34**
Y	--	--	--	--	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.23**	--	--	--	**0.23**	--	--	--	**0.25**

C.D. at 5 %	--	--	--	**0.66**	--	--	--	**0.64**	--	--	--	**0.71**
YXT	--	--	--	--	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.74**	--	--	--	**0.72**	--	--	--	**0.79**
C.D. at 5 %	--	--	--	**NS**	--	--	--	**NS**	--	--	--	**NS**

Figures in parentheses are original values; those outside are Arcsine transformed values; DAS- Days after spray

Open Boll and Locule Damage at Harvest

There was a significant difference in damage to open bolls and locule at harvest among treatments. The lowest open bolls damage was recorded in Lambda cyhalothrin 2.5 EC 0.0025% during individual experimental years as well as in pooled results 25.34, 20.77, 12.08 and 19.07 per cent, respectively and it was remained statistically at par with Deltamethrin 2.8 EC 0.0028% (21.28%) in pooled result. Similarly, the lowest locule damage was recorded in Lambda cyhalothrin 2.5 EC 0.0025% during individual experimental years as well as in pooled results 15.07, 13.28, 6.81 and 11.45 per cent, respectively and it was remained statistically at par with Deltamethrin 2.8 EC 0.0028% (12.69%). These two insecticides were significantly superior to rest of the treatments for open boll as well as locule damage by pink bollworm in pooled result (Table 5).

Table 5: Damage to open boll and locule by pink bollworm at harvest and seed cotton yield in different insecticides

Treatment	Open Boll Damage (%)				Locule Damage (%)				Seed cotton yield (kg/ha)			
	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled	2015-16	2016-17	2017-18	Pooled
T1	33.53 (30.51)	29.98 (24.97)	23.51 (15.91)	29.01 (23.51)	24.80 (17.60)	23.18 (15.49)	17.84 (9.38)	21.94 (13.96)	1979	1951	2017	1982
T2	34.79 (32.55)	29.85 (24.78)	24.93 (17.76)	29.86 (24.78)	25.28 (18.23)	23.23 (15.55)	19.15 (10.76)	22.55 (14.71)	2020	2207	2227	2151
T3	36.27 (35.01)	32.04 (28.15)	25.64 (18.72)	31.32 (27.02)	28.50 (22.77)	25.16 (18.07)	20.21 (11.94)	24.62 (17.36)	1915	2087	2138	2047
T4	34.51 (32.10)	31.60 (27.46)	25.89 (19.07)	30.67 (26.02)	28.54 (22.83)	23.89 (16.39)	19.35 (10.98)	23.92 (16.45)	1866	2022	2160	2016
T5	34.25 (31.67)	31.46 (27.24)	24.70 (17.47)	30.14 (25.21)	26.37 (19.73)	22.76 (14.96)	18.94 (10.54)	22.69 (14.88)	1975	2000	2116	2030
T6	35.88 (34.35)	32.09 (28.23)	26.17 (19.46)	31.38 (27.12)	29.69 (24.53)	26.82 (20.35)	22.15 (14.22)	26.22 (19.52)	1747	1894	1962	1868
T7	36.23 (34.93)	33.04 (29.73)	25.84 (19.00)	31.70 (27.62)	28.35 (22.55)	25.34 (18.32)	20.43 (12.18)	24.71 (17.47)	1726	1973	2072	1924
T8	30.23 (25.34)	27.11 (20.77)	20.33 (12.08)	25.89 (19.07)	22.84 (15.07)	21.37 (13.28)	15.13 (6.81)	19.78 (11.45)	2303	2284	2425	2337
T9	32.19 (28.37)	28.48 (22.74)	21.75 (13.73)	27.47 (21.28)	24.30 (16.94)	22.30 (14.40)	16.00 (7.60)	20.87 (12.69)	2266	2241	2381	2296
T10	41.11 (43.22)	36.25 (34.97)	28.73 (23.11)	35.36 (33.50)	33.63 (30.67)	29.25 (23.87)	24.95 (17.79)	29.27 (23.91)	1464	1538	1653	1552
S.Em.±	**1.45**	**1.33**	**1.23**	**0.77**	**1.32**	**1.11**	**0.90**	**0.65**	**81.38**	**84.72**	**109.59**	**53.56**
C.D. at 5 %	**4.32**	**3.95**	**3.67**	**2.20**	**3.93**	**3.31**	**2.67**	**1.84**	**241.80**	**251.72**	**325.63**	**151.94**
C.V. %	**7.22**	**7.37**	**8.64**	**7.68**	**8.41**	**7.93**	**8.02**	**8.24**	**7.32**	**7.27**	**8.97**	**7.95**
Y	--	--	--	--	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**0.42**	--	--	--	**0.36**	--	--	--	**29.33**
C.D. at 5 %	--	--	--	**1.20**	--	--	--	**1.01**	--	--	--	**83.22**
YXT	--	--	--	--	--	--	--	--	--	--	--	--
S.Em.±	--	--	--	**1.34**	--	--	--	**1.13**	--	--	--	**92.76**
C.D. at 5 %	--	--	--	**NS**	--	--	--	**NS**	--	--	--	**NS**

Figures in parentheses are original values; those outside are Arcsine transformed values

Yield

There was a significant difference in cotton yield among treatments. The treatment of Lambda cyhalothrin 2.5 EC 0.0025% recorded significantly higher seed cotton yield 2303, 2284, 2425 and 2337 kg/ha during individual experimental years and pooled result, respectively and looking to the pooled result, it was remained at par with Deltamethrin 2.8 EC 0.0028% (2296 kg/ha). These two treatments differed significantly in producing the higher seed cotton yield than rest of the tested insecticides.

The results were found convenient with the earlier researcher like Gupta *et al.* (1984), Khurana and Verma (1991), Mourad *et al.* (1991) and Rani *et al.* (2010).

CONCLUSION

It can be concluded that the insecticidal treatment of Lambda cyhalothrin 2.5 EC @ 0.0025% and Deltamethrin 2.8 EC @ 0.0028% at 75 DAS and subsequent spray at 15 days interval found effective against pink bollworm in *Bt* cotton.

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