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Efficacy of Insecticides and Bio Pesticides against Sucking Insect Pests on Bt Cotton

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A B S T R A C T

A field experiment was conducted to evaluate the efficacy of insecticides and bio pesticides against sucking insect pests on Bt cotton at College of Agriculture, Vijayapur during *kharif*-2016-17. The results revealed that the treatment flonicamid 50 WG was observed as significantly superior insecticide in minimizing the thrips population followed by fipronil 5 SC, acetamiprid 20 SP, dinotefuron 20 SG, diafenthiuron 50 WP and thiamethoxam 25 WG. However, significantly least population of aphids were observed from the plots which received flonicamid 50 WG, acetamiprid 20 SP, dinotefuran 20 SG and fipronil 5 SC, thiamethoxam 25 WG and diafenthiuron 50 WP. With respect to jassids and whiteflies, the least population were recorded from the plot treated with flonicamid 50 WG, dinotefuran 20 SG, diafenthiuron 50 WP, acetamiprid 20 SP, thiamethoxam 25 WG and fipronil 5 SC compared to untreated control.

Introduction

Cotton (*Gossypium* spp.) is one of the most commercially important fiber crops in the world. It is an important raw material for the Indian textile industry and plays a key role in the national economy in terms of both employment generation and foreign exchange. Due to its economic importance it is commonly called as "white gold". Which is being cultivated in an area of about 11.8 million ha with 27.8 million bales of production and 513 kg/ha of average productivity in India. Cotton is known to attack by a wide range of insect pests at various stages of growth (Uthamasamy, 1994). Now a days sucking pests are causing severe threat in cotton ecosystem. However, the major sucking pests *viz*., jassids, thrips, aphids, whitefly and mirid bugs etc are continuously damaging and causing considerable yield loss in Bt cotton. Thus, keeping these points in view, the present study was undertaken to determine the field efficacy of different insecticides and bio pesticides against sucking insect pests

Materials and Methods

An investigation was conducted at College of Agriculture, Vijayapur, to study the efficacy of insecticides and bio pesticides against sucking insect pests on Bt cotton under rainfed situation during *kharif* season 2016-17 in a

randomized block design (RBD) with 10 treatments and were replicated thrice. The popular Bt cotton hybrid of Vijayapur district, ACH-155 BG II was selected for the investigation with spacing of 90 x 60 cm in the plot size of 4.2 x 6.3m^2. The crop was raised as per the package of practices (Anon., 2014) except for plant protection measures.

Treatment details

T1: Diafenthiuron 50 WP (0.6g/l)

T2: Dinotefuran 20 SG (0.3g/l)

T3: Fipronil 5 SC (1 ml/l)

T4: Flonicamid 50 WG (0.3g/l)

T5: Quinalphos 25 EC (2ml/l)

T6: Thiamethoxam 25 WG (0.2g/l)

T7: Nimbecidine 1500 ppm (2 ml /l)

T8: *Lecanicillium lecanii* 2×10^{-8} cfu/g (5g/l)

T9: Acetamiprid 20 SP (Standard check) (0.2g/l)

T10: Untreated control

The observations on sucking pests like thrips, aphids, jassids and whiteflies were recorded as number of nymphs and adults per top, middle and bottom 3 leaves on randomly selected 5 plants from each treatment, later the population was averaged as number per 3 leaves. All the insecticidal treatments were imposed four times according to the crop growth stages at 40, 55, 70 and 90 days after sowing. Observation was recorded at one day before, 3, 5 and 10 days after each spray. Care was taken to avoid the drifting of spray droplets between the treatments by placing polythene sheet as physical barrier.

Statistical analysis

The data obtained were subjected to square root transformation ($\sqrt{x+0.5}$) and were analyzed by following analysis of variance and treatment means were compared by following Duncan's Multiple Range Test (DMRT) as suggested by Gomez and Gomez (1984).

Results and Discussion

Thrips

The data regarding mean population of thrips/ 3 leaves at first, second, third and fourth spray were presented in Table 1 and 2. The result revealed that at three days after first spray, significantly lowest thrips population of 35.36 thrips / 3 leaves was recorded from flonicamid 50 WG treated plot followed by fipronil 5 SC (37.25 thrips / 3 leaves), acetamiprid 20 SP (41.29 thrips / 3 leaves) and dinotefuron 20 SG (41.74 thrips / 3 leaves). These treatments were significantly superior and on par with each other. The treatments diafenthiuron 50 WP (45.50 thrips / 3 leaves) and thiamethoxam 25 WG (45.94 thrips / 3 leaves) were emerged as next best than the rest of the treatments. During five, ten days after first spray, second, third and fourth spray also similar trend was noticed with regard to reduction in thrips population. Present investigation clearly indicates that insecticidal treatments were highly efficient in managing the sucking insect pests than bio pesticides. Present study results are in close agreement with findings of Bhavani Sankara Rao *et al.,* (1991) and Ghelani *et al.,* (2006) they also reported that bio pesticides (botanicals and microbials) were less effective over the chemical pesticides against sucking pests of okra. Gaurkhede *et al.,* (2015) reported that fipronil 5 SC, flonicamid 50 WG, dinotefuran 20 SG and acetamiprid 20 SP effectively minimized the thrips density. Ghelani *et al.,*

(2014) and Ravikumar *et al.,* (2016) observed maximum mortality of thrips with flonicamid 50 WG. Similar findings were also documented by Sathyan *et al.,* (2016) and Patil *et al.,* (2009). The present findings are contradictory with the findings of Bharpoda *et al.,* (2014) as they reported that fipronil 5 EC and thiamethoxam 25 WG were less effective and recorded higher thrips population.

Aphids

The aphid incidence was not noticed during 1st and 2nd sprays. The population was started to appear in the month of September, hence only 3rd and 4th sprays observation was taken. In the present investigation the treatments flonicamid 50 WG, acetamiprid 20 SP, dinotefuran 20 SG and fipronil 5 SC were significantly superior and equally effective against aphids over rest of the treatments (7.33, 7.83, 7.91 & 8.87 aphids / three leaves, respectively) at 3 days after 3rd spray and were on par with each other. The next best treatments were thiamethoxam 25 WG (9.07 aphids / 3 leaves), diafenthiuron 50 WP (9.26 aphids / 3 leaves) and quinalphos 25 EC (11.17 aphids / 3 leaves) these were significantly superior to flonicamid 50 WG (7.33 aphids / 3 leaves) (Table 3). Similarly, during five, ten days after third spray and fourth spray same trend of superiority was observed.

The present investigations are in line with the outcome of Ghelani *et al.,* (2014) they also reported that the treatments with flonicamid, acetamiprid, thiamethoxam caused significantly maximum mortality of aphids. Gaurkhede *et al.,* (2015) observed minimum aphid population in the plots treated with flonicamid 50 WG @ 0.02 per cent (2.96 aphids/ leaf) and was at par with dinotefuran 20 SG @ 0.008 (3.50 aphids / leaf). Sathyan *et al.,* (2016) reported that quinalphos 25 EC and flubendiamide 20 WG were found to be less effective against aphid population.

Jassids

Minimum population of jassids was observed in flonicamid 50 WG (0.18 jassids / 3 leaves) and dinotefuran 20 SG (0.21 jassids / 3 leaves), which were equally superior and on par with one another.

The next superior treatments with minimum incidence of jassids were diafenthiuron 50 WP, acetamiprid 20 SP, thiamethoxam 25 WG and fipronil 5 SC with the mean population of 0.26, 0.29, 0.33 and 0.34 jassids / 3 leaves, respectively these were statistically at par with each other (Table 4 and 5). Similar trend was noticed in all the spray with regard to reduction in jassid population. Similar results were obtained by Kadam *et al.,* (2014) they also revealed that maximum mortality of jassid was found in flonicamid treated plot.

Razaq *et al.,* (2005) they also found minimum population of jassids (0.43 jassid / leaf) in plots treated with acetamiprid followed by thiamethoxam (0.95 jassid / leaf), diafenthiuron (1.06 jassid / leaf) at seven days after application. Gaurkhede *et al.,* (2015) reported dinotefuran 20 SG @ 0.008 per cent (0.91 jassids/ leaf), dinotefuran 20 SG @ 0.006 per cent (1.01 jassids / 3 leaves) fipronil 5 SC @ 0.015 per cent (1.12 jassids / 3 leaves), acetamiprid 20 SP @ 0.004 per cent (1.16 jassids / 3 leaves), imidacloprid 30.5 SC @0.005 per cent (1.21 jassids / 3 leaves) and flonicamid 50 WG @ 0.02 per cent (1.28 jassids / 3 leaves) did not differ significantly in minimizing the jassids population.

Whitefly

The treatments flonicamid 50 WG, dinotefuran 20 SG and diafenthiuron 50 WP were significantly superior over other insecticides with regard to whitefly suppression and the whitefly incidence was nil in all these three treatments at 3 DAS.

Table.1 Efficacy of insecticides and bio pesticides against thrips, *Thrips tabaci* (Lindeman) on Bt cotton (1st and 2nd spray)

S. No	Treatments	Mean population of thrips / 3 leaves							
		First spray				Second spray			
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS
1.	Diafenthiuron 50 WP @ 0.6g/ litre	74.49 (8.66)	45.50 (6.78)^{ab}	41.18 (6.46)^{ab}	39.45 (6.32)^{abcd}	47.19 (6.91)^{bc}	28.47 (5.38)^{bc}	22.57 (4.80)^{bc}	6.13 (2.56)
2.	Dinotefuran 20 SG @ 0.3g/litre	72.71 (8.56)	41.74 (6.49)^{a}	37.52 (6.16)^{ab}	36.09 (6.05)^{abc}	43.64 (6.64)^{abc}	21.79 (4.72)^{ab}	16.69 (4.14)^{ab}	5.45 (2.43)
3.	Fipronil 5 SC @1 ml/litre	75.48 (8.71)	37.25 (6.14)^{a}	31.88 (5.69)^{a}	29.83 (5.50)^{ab}	36.15 (6.05)^{ab}	14.64 (3.89)^{a}	11.28 (3.43)^{a}	4.84 (2.29)
4.	Flonicamid 50 WG @ 0.3g/litre	75.85 (8.73)	35.36 (5.98)^{a}	28.56 (5.39)^{a}	25.52 (5.09)^{a}	31.80 (5.68)^{a}	12.41 (3.59)^{a}	9.84 (3.22)^{a}	5.80 (2.50)
5.	Quinalphos 25 EC @ 2 ml/litre	72.45 (8.54)	55.49 (7.48)^{abc}	49.64 (7.07)^{bc}	47.40 (6.92)^{bcd}	59.72 (7.76)^{cd}	39.42 (6.32)^{cd}	32.30 (5.73)^{cd}	4.59 (2.25)
6.	Thiamethoxam 25 WG @ 0.2 g/litre	74.01 (8.63)	45.94 (6.81)^{ab}	42.05 (6.52)^{ab}	40.97 (6.44)^{abcd}	47.45 (6.91)^{bc}	29.27 (5.46)^{bc}	24.00 (4.95)^{bc}	4.60 (2.21)
7.	Nimbicidin 1500 ppm @ 2 ml/litre	73.25 (8.59)	66.26 (8.17)^{bc}	63.78 (8.01)^{c}	63.14 (7.98)^{de}	73.39 (8.59)^{d}	61.45 (7.87)^{e}	57.45 (7.61)^{e}	6.65 (2.67)
8.	*Lecanicillium lecanii* (2x10^{-8}cfu) @ 5g/litre	73.72 (8.61)	65.75 (8.13)^{bc}	60.52 (7.80)^{c}	59.17 (7.72)^{cde}	71.57 (8.49)^{d}	50.80 (7.16)^{de}	45.05 (6.74)^{de}	4.60 (2.23)
9.	Acetamiprid 20 SP @ 0.2g/litre (Std check)	70.03 (8.39)	41.29 (6.46)^{a}	37.47 (6.16)^{ab}	35.69 (6.01)^{ab}	42.40 (6.54)^{abc}	20.56 (4.59)^{ab}	16.12 (4.07)^{ab}	5.20 (2.38)
10.	Untreated control	74.49 (8.40)	84.29 (8.96)^{c}	87.84 (9.27)^{d}	86.65 (9.00)^{e}	104.39 (10.11)^{e}	104.85 (10.05)^{f}	94.49 (9.63)^{f}	6.53 (2.65)
	C. D @ 5%	NS	1.50	1.21	1.67	1.22	1.39	1.01	NS
	S.Em±		0.51	0.41	0.56	0.41	0.47	0.34	
	C.V (%)		12.24	10.33	14.50	9.67	13.69	10.84	

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are √(x+0.5) transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table.2 Efficacy of insecticides and bio pesticides against thrips, *Thrips tabaci* (Lindeman) on Bt cotton (3rd and 4th spray)

S. No	Treatments	Mean population of thrips / 3 leaves							
		Third spray				Fourth spray			
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS
1.	Diafenthiuron 50 WP @ 0.6g/ litre	23.42 (4.89)	9.77 (3.20)^{cd}	5.28 (2.40)^{c}	4.82 (2.31)^{c}	15.96 (4.06)^{cd}	6.70 (2.67)^{bc}	1.41 (1.37)^{bc}	1.06 (1.25)^{b}
2.	Dinotefuran 20 SG @ 0.3g/litre	22.70 (4.79)	6.96 (2.73)^{bc}	3.96 (2.11)^{bc}	3.15 (1.91)^{bc}	11.90 (3.52)^{bc}	4.39 (2.20)^{abc}	0.76 (1.12)^{abc}	0.40 (0.95)^{ab}
3.	Fipronil 5 SC @1 ml/litre	22.69 (4.81)	3.96 (2.11)^{ab}	2.07 (1.60)^{ab}	1.28 (1.33)^{ab}	7.86 (2.89)^{ab}	1.96 (1.54)^{a}	0.24 (0.86)^{a}	0.15 (0.80)^{a}
4.	Flonicamid 50 WG @ 0.3g/litre	23.06 (4.85)	3.33 (1.95)^{a}	1.26 (1.32)^{a}	1.02 (1.23)^{a}	7.02 (2.73)^{a}	1.88 (1.54)^{a}	0.19 (0.83)^{a}	0.11 (0.78)^{a}
5.	Quinalphos 25 EC @ 2 ml/litre	20.22 (4.50)	13.07 (3.61)^{d}	9.70 (3.19)^{d}	8.42 (2.98)^{d}	25.65 (5.11)^{e}	13.38 (3.71)^{d}	8.27 (2.96)^{d}	6.22 (2.59)^{c}
6.	Thiamethoxam 25 WG @ 0.2 g/litre	22.43 (4.79)	9.96 (3.23)^{cd}	5.51 (2.45)^{c}	4.91 (2.32)^{c}	17.40 (4.23)^{d}	7.76 (2.86)^{c}	1.86 (1.53)^{c}	1.11 (1.27)^{b}
7.	Nimbicidin 1500 ppm @ 2 ml/litre	25.66 (5.10)	22.09 (4.75)^{e}	18.46 (4.30)^{e}	18.35 (4.34)^{f}	43.47 (6.63)^{g}	33.83 (5.85)^{f}	27.70 (5.31)^{f}	25.33 (5.08)^{e}
8.	*Lecanicillium lecanii* ($2x10^{-8}$cfu) @ 5g/litre	26.04 (5.14)	21.65 (4.68)^{e}	15.22 (3.96)^{e}	12.90 (3.62)^{e}	34.55 (5.92)^{f}	24.54 (4.97)^{e}	18.22 (4.32)^{e}	14.84 (3.91)^{d}
9.	Acetamiprid 20 SP @ 0.2g/litre (Std check)	22.48 (4.79)	6.52 (2.64)^{abc}	3.80 (2.07)^{bc}	2.92 (1.85)^{abc}	11.52 (3.47)^{bc}	3.85 (2.06)^{ab}	0.69 (1.09)^{ab}	0.34 (0.91)^{ab}
10.	Untreated control	28.33 (5.36)	39.43 (6.31)^{f}	42.48 (6.55)^{f}	63.24 (7.98)^{g}	71.62 (8.44)^{h}	85.70 (9.28)^{g}	91.47 (9.58)^{g}	95.60 (9.79)^{f}
	C. D @ 5%	NS	0.74	0.54	0.63	0.69	0.67	0.43	0.42
	S.Em±		0.25	0.18	0.21	0.23	0.23	0.14	0.14
	C.V (%)		12.17	10.44	12.38	8.53	10.62	8.55	9.05

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are √(x+0.5) transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table.3 Efficacy of insecticides and bio pesticides against aphids *Aphis gossypii* (Glover) on Bt cotton (3rd and 4th spray)

S. No	Treatments	Mean population of aphids / 3 leaves							
		Third spray				Fourth spray			
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS
1.	Diafenthiuron 50 WP @ 0.6g/ litre	15.80 (4.03)	9.26 (3.12)^{ab}	5.96 (2.54)^{ab}	4.60 (2.26)^{ab}	16.00 (4.06)^{ab}	7.15 (2.77)^{b}	3.07 (1.89)^{b}	0.60 (1.05)^{a}
2.	Dinotefuran 20 SG @ 0.3g/litre	14.60 (3.85)	7.91 (2.90)^{a}	4.67 (2.27)^{a}	3.67 (2.04)^{a}	12.53 (3.61)^{a}	3.03 (1.88)^{ab}	0.56 (1.02)^{a}	0.00 (0.71)^{a}
3.	Fipronil 5 SC @1 ml/litre	15.80 (4.02)	8.87 (3.06)^{a}	5.47 (2.44)^{a}	4.32 (2.19)^{a}	15.20 (3.96)^{a}	6.53 (2.65)^{ab}	2.47 (1.72)^{b}	0.00 (0.71)^{a}
4.	Flonicamid 50 WG @ 0.3g/litre	15.33 (3.97)	7.33 (2.80)^{a}	4.13 (2.15)^{a}	3.20 (1.92)^{a}	10.80 (3.36)^{a}	2.60 (1.76)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
5.	Quinalphos 25 EC @ 2 ml/litre	15.23 (3.92)	11.17 (3.41)^{abc}	8.84 (3.05)^{bc}	7.13 (2.76)^{bc}	22.67 (4.81)^{bc}	15.79 (4.04)^{c}	9.47 (3.15)^{c}	5.33 (2.41)^{b}
6.	Thiamethoxam 25 WG @ 0.2 g/litre	15.53 (3.99)	9.07 (3.09)^{ab}	5.53 (2.46)^{a}	4.45 (2.22)^{a}	15.66 (4.02)^{ab}	6.76 (2.69)^{b}	2.60 (1.75)^{b}	0.47 (0.98)^{a}
7.	Nimbicidin 1500 ppm @ 2 ml/litre	15.07 (3.92)	13.93 (3.80)^{cd}	11.95 (3.53)^{c}	11.13 (3.41)^{d}	35.33 (5.99)^{de}	29.20 (5.45)^{d}	21.73 (4.71)^{e}	19.30 (4.45)^{d}
8.	*Lecanicillium lecanii* (2x10^{-8}cfu) @ 5g/litre	15.33 (3.97)	13.07 (3.68)^{bc}	10.93 (3.38)^{c}	9.07 (3.09)^{cd}	29.53 (5.48)^{cd}	22.71 (4.81)^{cd}	15.87 (4.04)^{d}	9.06 (3.09)^{c}
9.	Acetamiprid 20 SP @ 0.2g/litre (Std check)	15.57 (4.01)	7.83 (2.88)^{a}	4.40 (2.21)^{a}	3.53 (2.01)^{a}	12.20 (3.56)^{a}	2.93 (1.85)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
10.	Untreated control	15.87 (4.03)	19.67 (4.40)^{d}	30.13 (5.48)^{d}	52.47 (7.24)^{e}	39.40 (6.23)^{e}	45.62 (6.65)^{e}	51.73 (7.18)^{f}	59.67 (7.73)^{e}
	C. D @ 5%	NS	0.61	0.55	0.50	0.73	0.92	0.62	0.48
	S.Em±		0.21	0.19	0.17	0.25	0.31	0.21	0.16
	C.V (%)		10.74	10.89	9.95	9.50	15.54	13.48	12.47

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are √(x+0.5) transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table.4 Efficacy of insecticides and bio pesticides against jassids, *Amrasca biguttula biguttula* (Ishida) on Bt cotton (1st and 2nd spray)

S. No	Treatments	Mean population of jassids / 3 leaves							
		First spray				Second spray			
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS
1.	Diafenthiuron 50 WP @ 0.6g/ litre	0.67 (1.08)	0.26 (0.87)^{ab}	0.13 (0.79)^{ab}	0.07 (0.76)^{ab}	0.40 (0.95)^{a}	0.16 (0.81)^{a}	0.09 (0.77)^{ab}	0.00 (0.71)
2.	Dinotefuran 20 SG @ 0.3g/litre	0.69 (1.09)	0.21 (0.84)^{a}	0.08 (0.76)^{a}	0.00 (0.71)^{a}	0.36 (0.93)^{a}	0.13 (0.79)^{a}	0.00 (0.71)^{a}	0.00 (0.71)
3.	Fipronil 5 SC @1 ml/litre	0.68 (1.08)	0.34 (0.91)^{ab}	0.19 (0.83)^{ab}	0.13 (0.79)^{ab}	0.61 (1.05)^{ab}	0.30 (0.89)^{ab}	0.21 (0.84)^{ab}	0.00 (0.71)
4.	Flonicamid 50 WG @ 0.3g/litre	0.71 (1.10)	0.18 (0.82)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.33 (0.91)^{a}	0.11 (0.78)^{a}	0.00 (0.71)^{a}	0.00 (0.71)
5.	Quinalphos 25 EC @ 2 ml/litre	0.70 (1.09)	0.55 (1.02)^{bc}	0.39 (0.94)^{bcd}	0.31 (0.90)^{bc}	1.13 (1.28)^{bc}	0.53 (1.01)^{b}	0.37 (0.93)^{b}	0.00 (0.71)
6.	Thiamethoxam 25 WG @ 0.2 g/litre	0.66 (1.08)	0.33 (0.91)^{ab}	0.21 (0.84)^{abc}	0.17 (0.82)^{ab}	0.57 (1.03)^{a}	0.26 (0.87)^{ab}	0.18 (0.82)^{ab}	0.00 (0.71)
7.	Nimbicidin 1500 ppm @ 2 ml/litre	0.74 (1.11)	0.69 (1.09)^{c}	0.62 (1.06)^{de}	0.58 (1.04)^{c}	1.50 (1.41)^{cd}	1.33 (1.35)^{c}	1.21 (1.30)^{c}	0.00 (0.71)
8.	*Lecanicillium lecanii* (2 x10^{-8}cfu) @ 5g/litre	0.74 (1.11)	0.65 (1.07)^{c}	0.53 (1.01)^{cde}	0.47 (0.99)^{c}	1.42 (1.38)^{cd}	1.18 (1.30)^{c}	1.02 (1.23)^{c}	0.00 (0.71)
9.	Acetamiprid 20 SP @ 0.2g/litre (Std check)	0.68 (1.09)	0.29 (0.89)^{ab}	0.13 (0.79)^{ab}	0.09 (0.77)^{ab}	0.40 (0.95)^{a}	0.18 (0.82)^{a}	0.11 (0.78)^{ab}	0.00 (0.71)
10.	Untreated control	0.71 (1.07)	0.80 (1.12)^{c}	0.87 (1.15)^{e}	1.31 (1.33)^{d}	2.01 (1.55)^{d}	2.09 (1.59)^{d}	2.47 (1.70)^{d}	0.07 (0.75)
	C. D @ 5%	NS	0.15	0.17	0.16	0.23	0.18	0.21	NS
	S.Em±		0.05	0.06	0.06	0.08	0.06	0.07	
	C.V (%)		9.21	10.43	10.82	11.91	10.27	12.56	

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are √(x+0.5) transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table.5 Efficacy of insecticides and bio pesticides against jassids, *Amrasca biguttula biguttula* (Ishida) on Bt cotton (3rd and 4th spray)

S. No	Treatments	Mean population of jassids / 3 leaves							
		Third spray				Fourth spray			
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS
1.	Diafenthiuron 50 WP @ 0.6g/ litre	0.43 (0.96)	0.23 (0.85)^{ab}	0.13 (0.79)^{ab}	0.07 (0.75)^{a}	0.61 (1.05)^{ab}	0.30 (0.89)^{a}	0.18 (0.82)^{a}	0.09 (0.77)^{a}
2.	Dinotefuran 20 SG @ 0.3g/litre	0.38 (0.93)	0.19 (0.83)^{ab}	0.07 (0.76)^{a}	0.00 (0.71)^{a}	0.48 (0.99)^{a}	0.24 (0.86)^{a}	0.13 (0.79)^{a}	0.00 (0.71)^{a}
3.	Fipronil 5 SC @1 ml/litre	0.55 (1.02)	0.30 (0.89)^{ab}	0.21 (0.84)^{ab}	0.14 (0.80)^{ab}	0.83 (1.15)^{ab}	0.41 (0.95)^{ab}	0.27 (0.88)^{ab}	0.21 (0.84)^{a}
4.	Flonicamid 50 WG @ 0.3g/litre	0.34 (0.91)	0.15 (0.81)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.43 (0.96)^{a}	0.18 (0.82)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}
5.	Quinalphos 25 EC @ 2 ml/litre	0.63 (1.06)	0.48 (0.99)^{bc}	0.39 (0.94)^{bc}	0.32 (0.90)^{abc}	1.27 (1.32^{bc}	0.88 (1.17)^{b}	0.57 (1.04)^{b}	0.36 (0.93)^{ab}
6.	Thiamethoxam 25 WG @ 0.2 g/litre	0.53 (1.02)	0.27 (0.87)^{ab}	0.18 (0.82)^{ab}	0.12 (0.79)^{ab}	0.81 (1.14)^{ab}	0.39 (0.94)^{ab}	0.24 (0.86)^{ab}	0.17 (0.82)^{a}
7.	Nimbicidin 1500 ppm @ 2 ml/litre	0.73 (1.11)	0.65 (1.07)^{c}	0.59 (1.04)^{c}	0.54 (1.02)^{c}	2.52 (1.74)^{d}	2.09 (1.61)^{c}	1.75 (1.50)^{d}	1.40 (1.37)^{c}
8.	*Lecanicillium lecanii* (2 x10^{-8}cfu) @ 5g/litre	0.67 (1.08)	0.62 (1.06)^{c}	0.52 (1.01)^{c}	0.44 (0.97)^{bc}	2.10 (1.61)^{cd}	1.73 (1.49)^{c}	1.20 (1.30)^{c}	1.01 (1.23)^{bc}
9.	Acetamiprid 20 SP @ 0.2g/litre (Std check)	0.51 (1.00)	0.24 (0.86)^{ab}	0.15 (0.81)^{ab}	0.06 (0.75)^{a}	0.67 (1.08)^{ab}	0.33 (0.91)^{a}	0.20 (0.84)^{a}	0.13 (0.79)^{a}
10.	Untreated control	0.86 (1.16)	1.45 (1.37)^{d}	1.92 (1.54)^{d}	1.73 (1.47)^{d}	4.03 (2.09)^{e}	4.55 (2.24)^{d}	4.20 (2.15)^{e}	4.08 (2.09)^{d}
	C. D @ 5%	NS	0.16	0.15	0.19	0.31	0.23	0.19	0.30
	S.Em±		0.05	0.05	0.06	0.10	0.08	0.06	0.10
	C.V (%)		9.82	9.41	12.21	13.56	11.24	10.19	17.21

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are √(x+0.5) transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table.6 Efficacy of insecticides and bio pesticides against whitefly, *Bemisia tabaci* (Gennadius) on Bt cotton (1st and 2nd spray)

S. No	Treatments	Mean population of whiteflies / 3 leaves							
		First spray				Second spray			
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS
1.	Diafenthiuron 50 WP @ 0.6g/ litre	0.32 (0.90)	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.16 (0.81)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)
2.	Dinotefuran 20 SG @ 0.3g/litre	0.32 (0.90)	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.13 (0.79)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)
3.	Fipronil 5 SC @1 ml/litre	0.37 (0.93)	0.11 (0.78)^{ab}	0.00 (0.71)^{a}	0.07 (0.76)^{a}	0.20 (0.84)^{ab}	0.09 (0.77)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)
4.	Flonicamid 50 WG @ 0.3g/litre	0.38 (0.94)	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.08 (0.78)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)
5.	Quinalphos 25 EC @ 2 ml/litre	0.43 (0.97)	0.34 (0.91)^{bc}	0.26 (0.87)^{b}	0.15 (0.80)^{ab}	0.43 (0.96)^{bc}	0.24 (0.86)^{bc}	0.17 (0.82)^{ab}	0.00 (0.71)
6.	Thiamethoxam 25 WG @ 0.2 g/litre	0.47 (0.98)	0.11 (0.78)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.21 (0.84)^{ab}	0.09 (0.77)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)
7.	Nimbicidin 1500 ppm @ 2 ml/litre	0.43 (0.96)	0.41 (0.96)^{c}	0.34 (0.92)^{bc}	0.30 (0.89)^{bc}	0.51 (1.00)^{cd}	0.35 (0.92)^{c}	0.30 (0.89)^{bc}	0.09 (0.77)
8.	*Lecanicillium lecanii* (2 x10^{-8}cfu) @ 5g/litre	0.46 (0.98)	0.40 (0.95)^{c}	0.32 (0.91)^{bc}	0.27 (0.87)^{bc}	0.49 (0.99)^{cd}	0.31 (0.90)^{bc}	0.27 (0.87)^{bc}	0.07 (0.75)
9.	Acetamiprid 20 SP @ 0.2g/litre (Std check)	0.39 (0.95)	0.07 (0.75)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.16 (0.81)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)
10.	Untreated control	0.38 (0.92)	0.49 (0.98)^{c}	0.56 (1.01)^{c}	0.42 (0.94)^{c}	0.60 (1.04)^{d}	0.41 (0.94)^{c}	0.45 (0.96)^{c}	0.12 (0.79)
	C. D @ 5%	NS	0.13	0.13	0.13	0.14	0.13	0.12	NS
	S.Em±		0.05	0.04	0.04	0.05	0.04	0.04	
	C.V (%)		9.37	9.70	9.80	9.47	9.44	9.75	

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are √(x+0.5) transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT.

Table.7 Bio efficacy of insecticides and bio pesticides against whitefly, *Bemisia tabaci* (Gennadius) on Bt cotton (3rd and 4th spray)

S. No	Treatments	Mean population of whiteflies / 3 leaves							
		Third spray				Fourth spray			
		1 DBS	3 DAS	5 DAS	10 DAS	1 DBS	3 DAS	5 DAS	10 DAS
1.	Diafenthiuron 50 WP @ 0.6g/ litre	0.38 (0.94)	0.08 (0.76)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	1.27 (1.33)^{ab}	0.38 (0.94)^{a}	0.18 (0.82)^{a}	0.04 (0.73)^{a}
2.	Dinotefuran 20 SG @ 0.3g/litre	0.33 (0.91)	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.93 (1.18)^{a}	0.29 (0.89)^{a}	0.13 (0.79)^{a}	0.00 (0.71)^{a}
3.	Fipronil 5 SC @1 ml/litre	0.43 (0.97)	0.14 (0.80)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	1.39 (1.37)^{ab}	0.53 (1.02)^{a}	0.28 (0.88)^{a}	0.18 (0.82)^{a}
4.	Flonicamid 50 WG @ 0.3g/litre	0.33 (0.91)	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	0.80 (1.13)^{a}	0.24 (0.85)^{a}	0.07 (0.75)^{a}	0.00 (0.71)^{a}
5.	Quinalphos 25 EC @ 2 ml/litre	0.43 (0.96)	0.30 (0.90)^{bc}	0.19 (0.83)^{ab}	0.12 (0.79)^{ab}	1.84 (1.53)^{bc}	1.29 (1.34)^{bc}	0.82 (1.15)^{bc}	0.47 (0.98)^{ab}
6.	Thiamethoxam 25 WG @ 0.2 g/litre	0.41 (0.95)	0.16 (0.81)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	1.43 (1.39)^{ab}	0.59 (1.05)^{ab}	0.33 (0.91)^{ab}	0.24 (0.86)^{a}
7.	Nimbicidin 1500 ppm @ 2 ml/litre	0.46 (0.98)	0.41 (0.95)^{cd}	0.37 (0.93)^{b}	0.34 (0.92)^{b}	2.69 (1.78)^{cd}	2.27 (1.65)^{de}	1.60 (1.44)^{d}	1.27 (1.33)^{c}
8.	*Lecanicillium lecanii* (2 x10^{-8}cfu) @ 5g/litre	0.46 (0.98)	0.39 (0.95)^{cd}	0.34 (0.92)^{b}	0.27 (0.88)^{b}	2.57 (1.75)^{cd}	1.90 (1.55)^{cd}	1.32 (1.34)^{cd}	1.00 (1.22)^{bc}
9.	Acetamiprid 20 SP @ 0.2g/litre (Std check)	0.40 (0.95)	0.11 (0.78)^{ab}	0.00 (0.71)^{a}	0.00 (0.71)^{a}	1.33 (1.35)^{ab}	0.43 (0.96)^{a}	0.22 (0.85)^{a}	0.09 (0.77)^{a}
10.	Untreated control	0.48 (0.99)	0.64 (1.05)^{d}	1.31 (1.32)^{c}	2.78 (1.79)^{c}	3.11 (1.87)^{d}	3.32 (1.92)^{e}	3.06 (1.87)^{e}	2.23 (1.61)^{d}
	C. D @ 5%	NS	0.13	0.16	0.16	0.31	0.29	0.24	0.27
	S.Em±		0.05	0.05	0.06	0.10	0.10	0.08	0.09
	C.V (%)		9.26	10.94	10.98	12.32	13.73	12.69	16.10

Note: DBS - Day before spray. DAS - Days after spray.
Figures in the parentheses are √(x+0.5) transformed values.
Means followed by similar alphabets in the column do not differ significantly at 0.05% by DMRT

The next best treatments were acetamiprid 20 SP, thiamethoxam 25 WG and fipronil 5 SC were found superior and on par with each other with the white fly population of (0.07, 0.11, 0.11 whiteflies / 3 leaves). In all the spray the trend of supremacy of the treatments over whiteflies were not changed (Table 6 and 7). The results of the present investigation concludes that the flonicamid 50 WG, dinotefuran 20 SG and diafenthiuron 50 WP found highly effective against whiteflies, followed by acetamiprid 20 SP, thiamethoxam 25 WG and fipronil 5 SC.

Present findings are in close agreement with the results of Ghelani *et al.,* (2014) they also observed that the flonicamid caused significantly maximum mortality of whiteflies (71.47 %) and it was statistically at par with acetamiprid (69.83 %) and imidacloprid (66.17 %) followed by dinotefuron (63.06 %) thiamethoxam (62.76 %). Razaq *et al.,* (2005) also observed minimum number of whiteflies (5.39 whiteflies / leaf) in plots treated with diafenthiuron, acetamiprid (5.85 whiteflies / leaf) and imidacloprid (6.03 whiteflies / leaf) at 24 hours after application of insecticides.

In the present study at ten days after 2nd spray and one day before 3rd spray the pest population was statistically uniform in all the treatments because of rainfall in the respective week, all the pests were washed away and efficacy of the previous spray was not present to affect the pest population.

Overall investigation accomplished that the treatment flonicamid emerged as most superior and promising insecticide over rest of the treatments against all the sucking pests *viz.,* thrips, aphids, jassids and whiteflies followed by fipronil 5 SC, acetamiprid 20 SP, dinotefuron 20 SG, diafenthiuron 50 WP and thiamethoxam 25 WG. Whereas, bio pesticides were less effective against all the sucking pests compared to insecticides.

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