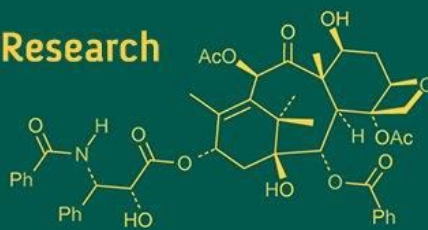


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693

ISSN Online: 2617-4707

IJABR 2024; 8(9): 170-175

www.biochemjournal.com

Received: 03-07-2024

Accepted: 10-08-2024

Rank VH

Student, Department of
Agricultural Entomology, B.A.
College of Agriculture, Anand
Agricultural University,
Anand, Gujarat, India

Dulera JG

Assistant Research Scientist,
Regional Research Station,
Anand Agricultural
University, Anand, Gujarat,
India

Bagul GD

Ph. D. scholar, N. M. College of
Agriculture, Navsari
Agricultural University,
Navsari, Gujarat, India

Corresponding Author:**Rank VH**

Student, Department of
Agricultural Entomology, B.A.
College of Agriculture, Anand
Agricultural University,
Anand, Gujarat, India

Efficacy of different insecticides against major sucking insect-pests infesting *Bt* cotton

Rank VH, Dulera JG and Bagul GD

DOI: <https://doi.org/10.33545/26174693.2024.v8.i9c.2120>

Abstract

A field experiment was conducted during *kharif*, 2023-2024 to evaluate the bio-efficacy of major sucking insect-pests infesting *Bt* cotton at regional research station, Anand agricultural university, Anand, Gujarat. Among evaluated different insecticides dinotefuran 20% SG, clothianidin 50% WDG and tolfenpyrad 15% EC were most effective in reducing leafhopper and aphid population while, acetamiprid 20% SP, spiromesifen 240 SC and afidopyropen 50 gL⁻¹ DC were most effective for whiteflies, whereas clothianidin 50% WDG, fipronil 5% SC and tolfenpyrad 15% EC significantly reduced thrips population. The highest cotton yield was recorded from the treatment dinotefuran followed by clothianidin and tolfenpyrad. Looking to the ICBR dinotefuran provided the highest return (1:11.34), followed by acetamiprid (1:10.29) and acephate (1:8.23).

Keywords: *Bt* cotton, leafhopper, whitefly, thrips, aphid, insecticides

Introduction

Cotton derived from the Arabic 'quon', belongs to the *Gossypium* genus and the Malvaceae family (Lee and Fang, 2015) [6]. Cotton valued for its economic importance and commonly referred to as "white gold" and the "king of appraisal fibre," plays a vital role in the global textile market. Cotton seeds contain 14.5-25.6% oil is used for culinary purposes and produce a protein-rich oil cake for livestock feed. All parts of the cotton plant are useful in different ways, showing its wide range of benefits. India is the world's second-largest cotton producer with Gujarat being the second-largest producer within India. In 2022-23, India produced 337.23 lakh bales of cotton from 130.49 lakh hectares, with a productivity of 439 kg lint/ha, as the Directorate of Economics and Statistics reported. Gujarat's cotton production in 2022-2023 was 91.83 lakh bales (Anonymous, 2023) [1]. Transgenic *Bt* cotton (Cry 1AC & Cry 1AB) effectively targets lepidopteran pests like bollworms but not sucking pests leading to increased populations of the latter due to reduced insecticide use (Krishna and Qaim, 2012) [5]. Sucking pests harm vegetative growth significantly reducing boll production and cotton yield, while late-season infestations decrease fiber quality by depositing honeydew on lint, making them a major concern for farmers.

Materials and Methods

The experiment was conducted during *kharif* 2023-2024 at regional research station, Anand Agricultural University, Anand, Gujarat. All recommended agronomical practices, except plant protection measures were followed to raised cotton crop. The experiment was laid out in randomized block design (RBD) with three replications. Different ten insecticides evaluated against major sucking insect-pests in *Bt* cotton. The first spray was given at the appearance of insect-pests population and the second spray was applied 20 days after the first spray. All the insecticides were applied as a foliar spray using a knapsack sprayer fitted with a hollow cone nozzle. To evaluate the field efficacy of insecticides five plants from each net plot were selected randomly and tagged. The observations on the number of major sucking pests per three leaves per five plants were recorded before spray and 3, 7, 10 and 14 days after each insecticide spray.

Mean data on each pest during each observation was calculated. The periodical data on pest population was subjected to statistical analysis after square root transformation ($\sqrt{X + 0.5}$).

The treatment means were compared using Duncan's New Multiple Range Test (Steel & Torrie, 1980) ^[12].

Result and discussion (Table 1 to 5)

Leafhopper

The population of leafhoppers a day before the first treatment recorded ranged from 4.92 to 5.59/leaf and there was no significant difference among different treatments. Lowest population of leaf hoppers after 3, 7, 10 and 14 days was noticed in treatment dinotefuran 20 SG (1.25 leafhoppers / leaf) and found superior followed by tolfenpyrad (1.38 leafhoppers / leaf) and clothianidin (1.33 leafhoppers/leaf) after first spray. After the second spray, leafhopper population was reduced significantly in all treatments and the minimum population of leafhoppers (0.98 leafhoppers/leaf) was noticed in dinotefuran followed by clothianidin (1.06 leafhoppers/leaf) and tolfenpyrad (1.13 leafhoppers/leaf) (Table 1).

The data on pooled over periods and sprays of leafhopper population revealed that dinotefuran (1.11 leafhopper/leaf) was found significantly most effective among all treatments except clothianidin and tolfenpyrad with 1.19 and 1.25 leafhopper per leaf, respectively. Thus, the present results conform with Kamal *et al.* (2024) ^[4] who reported that dinotefuran recorded the lowest population of jassids among all treatments. The application of dinotefuran was most effective in reducing the jassids population (Surwase *et al.*, 2017) ^[13]. Treatment dinotefuran 20 SG @ 0.008 per cent was found most superior against jassids. (Ram *et al.*, 2020) ^[10].

Whitefly

The data on whitefly population recorded 3,7,10 and 14 after the first spray (Table 2) indicated that there were significant differences among the treatments, significantly lowest population of whiteflies (0.91 whiteflies/leaf) was recorded in the treatment of acetamiprid which remained at par with spiromesifen (1.02 whiteflies/leaf) and afidopyropen (1.16 whiteflies/leaf). Pooled over periods data of second spray asserted that acetamiprid (0.89 whiteflies/leaf) was found significantly superior to all the treatments 3,7 10 and 14 days after second spray. Treatments spiromesifen (0.98 whiteflies/leaf) and afidopyropen (1.07 whiteflies/leaf) were next best treatments which was at par with acetamiprid.

After pooling over periods and sprays, the mean whitefly population revealed that acetamiprid (0.90 whiteflies/leaf) was found significantly the most effective among all. Other insecticides except spiromesifen and afidopyropen. With 1.00 and 1.11 whiteflies/leaf, respectively. Thus, these results are more or less associated with present findings. Boda and Ilyas (2017) ^[2] revealed a maximum reduction in the whitefly population with the treatment of spiromesifen 240 SC followed by acetamiprid 20 SP. Ghosal *et al.* (2018)

^[3] recorded the lowest population of whiteflies in the treatment spiromesifen which was at par with acetamiprid in the current study.

Thrips

Among the insecticides clothianidin treatment recorded the lowest thrips population (1.43 thrips/leaf) after 3,7,10 and 14 days after 1st spray (Table 3). Fipronil (1.55 thrips/leaf) and tolfenpyrad (1.64 thrips/leaf) were statistically equally effective in controlling thrips populations and both were at par with the most effective treatment clothianidin. Data compiled pooled periods following the second spray after 3,7,10 and 14 days indicated that clothianidin (0.81 thrips/leaf) was significantly more effective compared to all treatments except fipronil (0.91 thrips/leaf) and tolfenpyrad (0.98 thrips/leaf).

Results revealed that clothianidin (1.10 thrips/ leaf) was found most effective among all. Other insecticides except fipronil and tolfenpyrad with 1.22 and 1.30 thrips per leaf, respectively showed two spray data on pooled over periods and sprays of thrips population. The above results are in agreement with the findings of Priyanka *et al.* (2022) ^[9], who stated that clothianidin was highly effective against thrips in cotton. Additionally, fipronil recorded the significantly lowest thrips population among all insecticides (Rao *et al.*, 2022) ^[11], which is completely parallel to the findings of the present research. Similarly, Ram *et al.* (2020) ^[10] reported that fipronil recorded a lower thrips population.

Aphids

The data pooled over periods *i.e.*, before, 3,7,10 and 14 days after first and second spray presented in Table 4 showed a significant difference among various insecticides. The treatment dinotefuran recorded the lowest population of aphids (1.96 aphids/leaf) and it was statistically at par with clothianidin (2.06 aphids/leaf) and tolfenpyrad (2.15 aphids/leaf) after first spray. After second spray pooled over periods data of periods 3,7,10 and 14 days after 2nd spray. The result showed that the treatment of dinotefuran was found most effective and recorded the lowest number of aphids (1.52 aphids/leaf) and it was at par with clothianidin (1.60 aphids/leaf) and tolfenpyrad (1.72 aphids/leaf).

The data pooled over periods and sprays presented in Table 4 indicated that the maximum reduction in aphid population was observed in the treatment of dinotefuran (1.74 aphids/leaf), which was at par with clothianidin (1.83 aphids/leaf) and tolfenpyrad (1.93 aphids/leaf). Surwase *et al.* (2017) ^[13] reported that dinotefuran was the most effective in reducing the aphid population. Treatment of clothianidin was found most effective in reducing the aphid population (Mahale *et al.*, 2017) ^[7]. Naveena (2019) ^[8] found that dinotefuran was the most effective in the reduction of aphid population.

Table 1: Bio-efficacy of insecticides against leafhoppers infesting *Bt* cotton

Tr. No.	Treatments	Conc. (%)	Before spray	No. of leafhoppers/leaf at indicated days after spray										Pooled over periods and sprays
				1 st spray					2 nd spray					
				3	7	10	14	Pooled over periods	3	7	10	14	Pooled over periods	
T ₁	Spiromesifen 240 SC	0.0288	2.47 (5.59)	2.14 ^{ef} (4.06)	2.12 ^c (3.98)	2.09 ^c (3.86)	2.25 ^{ef} (4.57)	2.15 ^c (4.11)	2.11 ^c (3.97)	2.08 ^c (3.82)	2.05 ^c (3.70)	2.02 ^c (3.60)	2.07 ^c (3.80)	2.11 ^c (3.96)
T ₂	Acetamiprid 20% SP	0.004	2.43 (5.42)	1.70 ^{bc} (2.38)	1.66 ^b (2.27)	1.61 ^{bc} (2.09)	1.87 ^{bc} (2.99)	1.71 ^b (2.42)	1.67 ^{bc} (2.28)	1.61 ^b (2.11)	1.57 ^b (1.96)	1.56 ^b (1.93)	1.61 ^b (2.10)	1.66 ^b (2.26)

T ₃	Dinotefuran 20% SG	0.006	2.33 (4.92)	1.30 ^a (1.20)	1.25 ^a (1.07)	1.24 ^a (1.03)	1.50 ^a (1.76)	1.32 ^a (1.25)	1.26 ^a (1.10)	1.22 ^a (0.99)	1.18 ^a (0.89)	1.15 ^a (0.83)	1.21 ^a (0.98)	1.27 ^a (1.11)
T ₄	Fipronil 5% SC	0.015	2.36 (5.08)	2.09 ^{de} (3.87)	2.08 ^c (3.84)	2.05 ^{bc} (3.72)	2.24 ^{def} (4.51)	2.12 ^c (3.98)	2.08 ^{de} (3.83)	2.05 ^c (3.69)	2.02 ^c (3.58)	2.01 ^c (3.55)	2.05 ^c (3.69)	2.08 ^c (3.83)
T ₅	Acephate 75% SP	0.0584	2.45 (5.49)	1.74 ^{cd} (2.53)	1.70 ^b (2.41)	1.65 ^d (2.22)	1.88 ^{bcd} (3.03)	1.74 ^b (2.54)	1.69 ^c (2.36)	1.64 ^b (2.19)	1.62 ^b (2.12)	1.60 ^b (2.05)	1.64 ^b (2.19)	1.69 ^b (2.36)
T ₆	Tolfenpyrad 15% EC	0.03	2.35 (5.02)	1.37 ^{ab} (1.37)	1.32 ^b (1.24)	1.27 ^{ef} (1.11)	1.53 ^{ab} (1.83)	1.37 ^a (1.38)	1.32 ^{ab} (1.25)	1.28 ^a (1.14)	1.25 ^a (1.06)	1.22 ^a (0.99)	1.27 ^a (1.13)	1.32 ^a (1.25)
T ₇	Clothianidin 50% WDG	0.004	2.33 (4.93)	1.34 ^a (1.29)	1.29 ^a (1.17)	1.26 ^{ef} (1.09)	1.51 ^a (1.79)	1.35 ^a (1.33)	1.29 ^a (1.17)	1.25 ^a (1.07)	1.20 ^a (0.94)	1.19 ^a (0.92)	1.24 ^a (1.06)	1.30 ^a (1.19)
T ₈	Fenprothrin 30% EC	0.015	2.46 (5.53)	2.15 ^{ef} (4.14)	2.14 ^c (4.10)	2.11 ^b (3.95)	2.26 ^{ef} (4.60)	2.17 ^c (4.20)	2.16 ^c (4.16)	2.13 ^c (4.05)	2.09 ^c (3.87)	2.08 ^c (3.83)	2.12 ^c (4.02)	2.15 ^c (4.11)
T ₉	Afidopyropen 50 g/L DC	0.01	2.39 (5.22)	1.76 ^{cd} (2.59)	1.75 ^b (2.55)	1.70 ^{cd} (2.37)	1.90 ^{cde} (3.09)	1.77 ^b (2.65)	1.72 ^{cd} (2.46)	1.67 ^b (2.28)	1.66 ^b (2.26)	1.64 ^b (2.18)	1.67 ^b (2.30)	1.72 ^b (2.47)
T ₁₀	Control	-	2.46 (5.57)	2.48 ^f (5.66)	2.49 ^d (5.69)	2.50 ^f (5.73)	2.60 ^f (6.25)	2.52 ^d (5.83)	2.54 ^f (5.98)	2.58 ^d (6.17)	2.56 ^d (6.05)	2.50 ^d (5.76)	2.55 ^d (6.02)	2.53 ^d (5.92)
S. Em. ± Treatment (T)			0.14	0.11	0.10	0.11	0.11	0.05	0.11	0.10	0.08	0.08	0.05	0.04
Period (P)			-	-	-	-	-	0.03	-	-	-	-	0.03	0.02
Spray (S)			-	-	-	-	-	-	-	-	-	-	-	0.02
T x P			-	-	-	-	-	0.10	-	-	-	-	0.10	0.07
T x S			-	-	-	-	-	-	-	-	-	-	-	0.05
PxS			-	-	-	-	-	-	-	-	-	-	-	0.03
TxPxS			-	-	-	-	-	-	-	-	-	-	-	0.10
F test (T)			NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. (%)			9.74	10.18	10.02	10.92	9.79	9.87	10.91	9.74	11.45	9.43	9.81	9.80

Note: 1. Figures outside the parentheses are $\sqrt{X} + 0.5$ transformed values and those inside the parentheses are retransformed values

2. Significant parameters and its interactions: S, P, T and P x S

3. Treatment mean(s) with the letter(s) in common are not differing significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance

4. NS: Non-significant and Sig.: Significant

Table 2: Bio-efficacy of insecticides against whiteflies infesting *Bt* cotton

Tr. No.	Treatments	Conc. (%)	No. of whiteflies/leaf at indicated days after spray											Pooled over periods and sprays
			Before Spray	1 st spray					2 nd spray					
				3	7	10	14	Pooled over periods	3	7	10	14	Pooled over periods	
T ₁	Spiromesifen 240 SC	0.029	2.50 (5.75)	1.25 ^a (1.06)	1.20 ^a (0.95)	1.12 ^a (0.76)	1.36 ^a (1.36)	1.23 ^a (1.02)	1.28 ^a (1.13)	1.22 ^a (0.99)	1.19 ^a (0.91)	1.17 ^{ab} (0.88)	1.22 ^a (0.98)	1.22 ^a (1.00)
T ₂	Acetamiprid 20% SP	0.004	2.40 (5.26)	1.22 ^a (0.99)	1.14 ^a (0.81)	1.08 ^a (0.66)	1.31 ^a (1.21)	1.19 ^a (0.91)	1.23 ^a (1.02)	1.21 ^a (0.96)	1.16 ^a (0.84)	1.11 ^a (0.73)	1.18 ^a (0.89)	1.18 ^a (0.90)
T ₃	Dinotefuran 20% SG	0.006	2.45 (5.51)	1.69 ^{ab} (2.35)	1.65 ^b (2.21)	1.60 ^b (2.06)	1.76 ^b (2.59)	1.67 ^b (2.30)	1.68 ^b (2.32)	1.66 ^b (2.25)	1.60 ^b (2.06)	1.51 ^{bcd} (1.77)	1.61 ^b (2.09)	1.64 ^b (2.18)
T ₄	Fipronil 5% SC	0.015	2.40 (5.25)	2.10 ^d (3.90)	2.06 ^d (3.76)	2.03 ^c (3.61)	2.15 ^{de} (4.14)	2.09 ^c (3.85)	2.10 ^d (3.91)	2.07 ^{cde} (3.81)	2.05 ^c (3.72)	1.90 ^{ef} (3.10)	2.03 ^c (3.63)	2.06 ^c (3.73)
T ₅	Acephate 75% SP	0.058	2.43 (5.42)	2.08 ^d (3.82)	2.05 ^{cd} (3.68)	2.01 ^c (3.52)	2.13 ^{cde} (4.03)	2.06 ^c (3.76)	2.08 ^{cd} (3.83)	2.05 ^{bcd} (3.68)	2.03 ^c (3.61)	1.87 ^{def} (2.98)	2.00 ^c (3.52)	2.03 ^c (3.63)
T ₆	Tolfenpyrad 15% EC	0.03	2.48 (5.67)	1.71 ^c (2.43)	1.68 ^{bc} (2.33)	1.62 ^b (2.14)	1.78 ^{bc} (2.68)	1.70 ^b (2.39)	1.71 ^b (2.42)	1.69 ^{bc} (2.34)	1.63 ^b (2.15)	1.53 ^{bcd} (1.84)	1.64 ^b (2.18)	1.67 ^b (2.27)
T ₇	Clothianidin 50% WDG	0.004	2.37 (5.13)	1.73 ^c (2.48)	1.72 ^{bcd} (2.45)	1.66 ^b (2.26)	1.81 ^{bcd} (2.79)	1.73 ^b (2.49)	1.72 ^{bc} (2.46)	1.72 ^{bcd} (2.44)	1.67 ^b (2.28)	1.56 ^{cdef} (1.94)	1.67 ^b (2.28)	1.69 ^b (2.37)
T ₈	Fenpropathrin 30% EC	0.015	2.54 (5.94)	2.11 ^d (3.93)	2.09 ^d (3.86)	2.05 ^c (3.70)	2.17 ^{de} (4.21)	2.10 ^c (3.93)	2.13 ^d (4.02)	2.10 ^{de} (3.92)	2.08 ^c (3.85)	1.92 ^f (3.19)	2.06 ^c (3.74)	2.08 ^c (3.82)
T ₉	Afidopyropen 50 g/L DC	0.01	2.47 (5.6)	1.29 ^{ab} (1.18)	1.28 ^a (1.14)	1.17 ^a (0.88)	1.40 ^a (1.46)	1.29 ^a (1.16)	1.32 ^a (1.24)	1.26 ^a (1.10)	1.23 ^a (1.01)	1.20 ^{abc} (0.95)	1.25 ^a (1.07)	1.27 ^a (1.11)
T ₁₀	Control	-	2.43 (5.39)	2.46 ^c (5.54)	2.47 ^c (5.58)	2.47 ^d (5.62)	2.48 ^c (5.66)	2.47 ^d (5.60)	2.50 ^c (5.77)	2.47 ^c (5.58)	2.44 ^d (5.44)	2.40 ^g (5.25)	2.45 ^d (5.51)	2.46 ^d (5.55)
S. Em. ± Treatment (T)			0.11	0.11	0.10	0.11	0.10	0.05	0.12	0.08	0.08	0.08	0.05	0.04
Period (P)			-	-	-	-	-	0.03	-	-	-	-	0.03	0.02
Spray (S)			-	-	-	-	-	-	-	-	-	-	-	0.01
T × P			-	-	-	-	-	0.10	-	-	-	-	0.10	0.07
T × S			-	-	-	-	-	-	-	-	-	-	-	0.05
PxS			-	-	-	-	-	-	-	-	-	-	-	0.03
TxPxS			-	-	-	-	-	-	-	-	-	-	-	0.10
F test (T)			NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. (%)			9.11	11.07	9.90	11.49	9.24	10.10	11.23	9.59	11.45	9.43	10.10	10.04

Note: 1. Figures outside the parentheses are $\sqrt{X} + 0.5$ transformed values and those inside the parentheses are retransformed values

2. Significant parameters and its interactions: T and P x S

3. Treatment mean(s) with the letter(s) in common are not differing significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance

4. NS: Non-significant and Sig.: Significant

Table 3: Bio-efficacy of insecticides against thrips infesting *Bt* cotton

Tr. No.	Treatments	Conc. (%)	No. of thrips/leaf at indicated days after spray											Pooled over periods and sprays
			Before spray	1 st spray					2 nd spray					
				3	7	10	14	Pooled over periods	3	7	10	14	Pooled over periods	
T ₁	Spiromesifen 240 SC	0.0288	2.91 (7.94)	1.83 ^{bc} (2.83)	1.74 ^b (2.54)	1.72 ^{bc} (2.46)	1.91 ^{bc} (3.13)	1.80 ^b (2.75)	1.65 ^b (2.23)	1.53 ^b (1.83)	1.45 ^b (1.60)	1.37 ^b (1.38)	1.50 ^b (1.75)	1.65 ^b (2.23)
T ₂	Acetamiprid 20% SP	0.004	2.94 (8.16)	2.30 ^d (4.79)	2.23 ^c (4.47)	2.20 ^d (4.36)	2.26 ^{de} (4.62)	2.25 ^c (4.56)	2.03 ^c (3.62)	1.83 ^{cd} (2.84)	1.80 ^d (2.73)	1.72 ^c (2.47)	1.84 ^c (2.90)	2.05 ^c (3.69)
T ₃	Dinotefuran 20% SG	0.006	2.98 (8.39)	1.86 ^{bc} (2.95)	1.79 ^b (2.69)	1.76 ^c (2.61)	1.94 ^{cd} (3.25)	1.84 ^b (2.87)	1.68 ^b (2.32)	1.54 ^b (1.87)	1.49 ^b (1.73)	1.39 ^b (1.43)	1.53 ^b (1.83)	1.68 ^b (2.32)
T ₄	Fipronil 5% SC	0.015	3.05 (8.79)	1.41 ^a (1.49)	1.39 ^a (1.42)	1.36 ^a (1.36)	1.57 ^a (1.97)	1.43 ^a (1.55)	1.33 ^a (1.28)	1.24 ^a (1.03)	1.12 ^a (0.76)	1.06 ^a (0.62)	1.19 ^a (0.91)	1.31 ^a (1.22)
T ₅	Acephate 75% SP	0.0584	3.00 (8.50)	2.26 ^d (4.60)	2.19 ^c (4.29)	2.17 ^d (4.21)	2.25 ^{de} (4.55)	2.22 ^c (4.41)	2.00 ^c (3.51)	1.82 ^{cd} (2.80)	1.78 ^{dc} (2.66)	1.70 ^c (2.40)	1.82 ^c (2.83)	2.02 ^c (3.58)
T ₆	Tolfenpyrad 15% EC	0.03	3.02 (8.62)	1.46 ^{ab} (1.63)	1.41 ^a (1.49)	1.39 ^{ab} (1.43)	1.60 ^{ab} (2.05)	1.46 ^a (1.64)	1.35 ^a (1.32)	1.27 ^a (1.10)	1.18 ^a (0.89)	1.08 ^a (0.67)	1.22 ^a (0.98)	1.34 ^a (1.30)
T ₇	Clothianidin 50% WDG	0.004	2.96 (8.24)	1.38 ^a (1.42)	1.33 ^a (1.26)	1.31 ^a (1.20)	1.55 ^a (1.89)	1.39 ^a (1.43)	1.28 ^a (1.13)	1.21 ^a (0.96)	1.08 ^a (0.67)	1.01 ^a (0.51)	1.14 ^a (0.81)	1.27 ^a (1.10)
T ₈	Fenpropathrin 30% EC	0.015	2.92 (8.06)	1.90 ^c (3.10)	1.81 ^b (2.77)	1.79 ^c (2.72)	1.95 ^{cde} (3.32)	1.86 ^b (2.97)	1.70 ^b (2.38)	1.56 ^{bc} (1.94)	1.52 ^{cb} (1.80)	1.42 ^b (1.51)	1.55 ^b (1.90)	1.71 ^b (2.41)
T ₉	Afidopyropen 50 g/L DC	0.01	3.06 (8.87)	2.33 ^d (4.94)	2.25 ^c (4.55)	2.22 ^d (4.44)	2.28 ^c (4.69)	2.27 ^c (4.65)	2.06 ^a (3.73)	1.89 ^d (3.07)	1.82 ^d (2.81)	1.75 ^c (2.55)	1.88 ^c (3.02)	2.07 ^c (3.80)
T ₁₀	Control	-	2.99 (8.43)	2.95 ^c (8.17)	2.86 ^d (7.65)	2.75 ^c (7.05)	2.70 ^f (6.77)	2.81 ^d (7.40)	2.59 ^d (6.21)	2.50 ^c (5.73)	2.39 ^c (5.21)	2.27 ^d (4.65)	2.44 ^d (5.44)	2.62 ^d (6.38)
S. Em. ± Treatment (T)			0.17	0.11	0.11	0.11	0.10	0.05	0.09	0.08	0.08	0.08	0.04	0.03
Period (P)			-	-	-	-	-	0.03	-	-	-	-	-	0.03
Spray (S)			-	-	-	-	-	-	-	-	-	-	-	0.01
T x P			-	-	-	-	-	0.10	-	-	-	-	0.08	0.06
T × S			-	-	-	-	-	-	-	-	-	-	-	0.05
P×S			-	-	-	-	-	-	-	-	-	-	-	0.03
TxPxS			-	-	-	-	-	-	-	-	-	-	-	0.09
F test (T)			NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. (%)			9.80	9.60	9.26	9.93	8.56	9.00	9.14	8.46	8.75	9.79	8.70	8.88

Note: 1. Figures outside the parentheses are $\sqrt{X} + 0.5$ transformed values and those inside the parentheses are retransformed values

2. Significant parameters and its interactions: S, P, T and P × S

3. Treatment mean(s) with the letter(s) in common are not differing significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance

4. NS: Non-significant and Sig.: Significant

Table 4: Bio-efficacy of insecticides against aphids infesting *Bt* cotton

Tr. No.	Treatments	Conc. (%)	No. of aphids/leaf at indicated days after spray											Pooled over periods and sprays
			Before spray	1 st spray					2 nd spray					
				3	7	10	14	Pooled over periods	3	7	10	14	Pooled over periods	
T ₁	Spiromesifen 240 SC	0.0288	2.92 (8.04)	2.48 ^d (5.65)	2.41 ^{de} (5.30)	2.36 ^d (5.06)	2.65 ^{de} (6.54)	2.48 ^c (5.63)	2.43 ^{cd} (5.38)	2.39 ^d (5.20)	2.31 ^d (4.83)	2.26 ^{cd} (4.61)	2.35 ^c (5.00)	2.41 ^c (5.31)
T ₂	Acetamiprid 20% SP	0.004	2.93 (8.08)	2.02 ^b (3.59)	1.95 ^b (3.30)	1.90 ^b (3.12)	2.24 ^{bc} (4.50)	2.03 ^b (3.61)	1.97 ^b (3.39)	1.91 ^b (3.15)	1.86 ^b (2.94)	1.79 ^b (2.72)	1.88 ^b (3.05)	1.95 ^b (3.32)
T ₃	Dinotefuran 20% SG	0.006	2.89 (7.83)	1.60 ^a (2.04)	1.48 ^a (1.68)	1.40 ^a (1.46)	1.80 ^a (2.75)	1.57 ^a (1.96)	1.52 ^a (1.80)	1.46 ^a (1.63)	1.40 ^a (1.46)	1.31 ^a (1.23)	1.42 ^a (1.52)	1.50 ^a (1.74)
T ₄	Fipronil 5% SC	0.015	2.95 (8.20)	2.46 ^{cd} (5.53)	2.39 ^{cde} (5.20)	2.33 ^{cd} (4.95)	2.62 ^{cde} (6.38)	2.45 ^c (5.50)	2.41 ^{cd} (5.29)	2.36 ^{cd} (5.06)	2.28 ^{dc} (4.70)	2.23 ^{cd} (4.48)	2.32 ^c (4.88)	2.38 ^c (5.19)
T ₅	Acephate 75% SP	0.0584	2.91 (7.95)	2.09 ^{bc} (3.87)	1.99 ^{bc} (3.46)	1.93 ^b (3.23)	2.27 ^{cd} (4.63)	2.07 ^b (3.78)	2.00 ^b (3.51)	1.94 ^b (3.27)	1.88 ^b (3.05)	1.83 ^b (2.83)	1.91 ^b (3.16)	1.99 ^b (3.47)
T ₆	Tolfenpyrad 15% EC	0.03	2.99 (8.42)	1.65 ^a (2.24)	1.55 ^a (1.90)	1.46 ^a (1.63)	1.85 ^{ab} (2.92)	1.63 ^a (2.15)	1.58 ^a (2.01)	1.52 ^a (1.82)	1.46 ^a (1.64)	1.38 ^a (1.42)	1.49 ^a (1.72)	1.56 ^a (1.93)
T ₇	Clothianidin 50% WDG	0.004	2.90 (7.89)	1.63 ^a (2.17)	1.52 ^a (1.80)	1.43 ^a (1.54)	1.83 ^a (2.83)	1.60 ^a (2.06)	1.55 ^a (1.89)	1.49 ^a (1.71)	1.43 ^a (1.53)	1.34 ^a (1.30)	1.45 ^a (1.60)	1.53 ^a (1.83)
T ₈	Fenpropathrin 30% EC	0.015	2.91 (7.98)	2.50 ^d (5.76)	2.45 ^c (5.51)	2.38 ^d (5.17)	2.69 ^c (6.73)	2.51 ^c (5.78)	2.45 ^d (5.50)	2.40 ^d (5.28)	2.34 ^d (4.98)	2.29 ^d (4.76)	2.37 ^c (5.13)	2.44 ^c (5.45)
T ₉	Afidopyropen 50 g/L DC	0.01	2.93 (8.06)	2.11 ^{bc} (3.94)	2.01 ^{bcd} (3.54)	1.95 ^{bc} (3.29)	2.30 ^{cde} (4.77)	2.09 ^b (3.87)	2.03 ^{bc} (3.60)	1.96 ^{cb} (3.36)	1.92 ^{bc} (3.18)	1.86 ^{bc} (2.95)	1.94 ^b (3.27)	2.02 ^b (3.56)
T ₁₀	Control	-	2.97 (8.31)	3.02 ^e (8.65)	3.08 ^c (8.98)	3.17 ^e (9.55)	3.25 ^f (10.08)	3.13 ^d (9.31)	3.34 ^e (10.66)	3.39 ^e (10.99)	3.52 ^e (11.87)	3.59 ^e (12.39)	3.46 ^d (11.47)	3.30 ^d (10.36)
S. Em. ± Treatment (T)			0.14	0.11	0.12	0.12	0.12	0.06	0.12	0.12	0.11	0.12	0.06	0.04
Period (P)			-	-	-	-	-	0.04	-	-	-	-	0.04	0.03
Spray (S)			-	-	-	-	-	-	-	-	-	-	-	0.02
T x P			-	-	-	-	-	0.11	-	-	-	-	0.11	0.08
T x S			-	-	-	-	-	-	-	-	-	-	-	0.06
PxS			-	-	-	-	-	-	-	-	-	-	-	0.04
TxPxS			-	-	-	-	-	-	-	-	-	-	-	0.11
F test (T)			NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
C. V. (%)			8.27	9.07	9.84	10.06	9.02	9.14	9.67	10.07	9.40	10.06	9.45	9.30

Note: 1. Figures outside the parentheses are $\sqrt{X} + 0.5$ transformed values and those inside the parentheses are retransformed values

2. Significant parameters and its interactions: S, P, T, T × S and P × S

3. Treatment mean(s) with the letter(s) in common are not differing significantly by Duncan's New Multiple Range Test (DNMRT) at 5% level of significance

4. NS: Non-significant and Sig.: Significant

Table 5: Economics of insecticides evaluated against major sucking insect-pests infesting *Bt* cotton

Tr. No.	Insecticides	Quantity of insecticides required for 2 sprays (Kg or L/ha)	Price of insecticides (₹/Litter or kg)	Cost of insecticides (₹/ha)	Labour charge (₹/ha)	Total cost of plant protection (₹/ha)	Seed yield (q/ha)	Net gain over control (kg/ha)	Net realization (₹/ha)	ICBR
1	Spiromesifen 240 SC	1.2	8100	9720	3504	12323	18.25	3.76	26395	1:2.00
2	Acetamiprid 20% SP	0.2	2980	596	3504	3756	20.50	6.01	42190	1:10.29
3	Dinotefuran 20% SG	0.3	7660	2298	3504	4044	23.86	9.37	65777	1:11.34
4	Fipronil 5% SC	3.0	1720	5160	3504	8664	18.56	4.07	28571	1:3.30
5	Acephate 75% SP	0.8	1536	1198	3504	4440	20.00	5.51	38680	1:8.23
6	Tolfenpyrad 15% EC	2.0	4372	8744	3504	11104	22.87	8.38	58828	1:4.80
7	Clothianidin 50% WDG	0.5	18750	9375	3504	12879	23.11	8.62	60512	1:4.70
8	Fenprothrin 30% EC	0.5	1935	967.5	3504	4472	18.07	3.58	25132	1:5.62
9	Afidopyropen 50 g/L DC	1.0	3400	3400	3504	6904	19.79	5.30	37206	1:5.39
10	Control	-	-	-	-	-	14.49	-	-	-

Note: 1. Labour charges @

Semi-skilled labour: ₹ 487.00 per day x 2 labour = 974.00 ₹/ ha

Farm labour: ₹ 389.00 per day x 2 labour = 778.00 ₹/ ha

Labour charge for one spray: ₹ 974.00 + ₹ 778.00 = 1752.00 ₹/ ha

Total labour charge for two sprays: ₹ 1752.00 x 2 sprays = 3504.00 ₹/ ha

2. Market price of cotton = ₹ 7020/ 1 q

Economics

The data on the economics of various insecticides that were evaluated for their bio efficacy against sucking insect-pests in cotton are presented in Table 5. Maximum realization over control (₹ 76928/ha) was obtained with the treatment of dinotefuran followed by clothianidin (₹ 707770/ha), tolfenpyrad (₹ 68800/ha), acetamiprid (₹ 49342/ha), acephate (₹ 45237/ha) and afidopyropen (₹ 43513/ha). The minimum realization over control (₹ 29392/ha) was exhibited by the treatment of fenprothrin.

The highest ICBR (1:11.34) was observed for the treatment of dinotefuran followed by acetamiprid (1:10.29) and acephate (1:8.23). The ICBR values for the treatments comprising fenprothrin, afidopyropen, tolfenpyrad, clothianidin and fipronil were 1:5.62, 1:5.39, 1:4.80, 1:5.50 and 1:30 respectively. The treatment of spiromesifen showed the lowest ICBR (1: 2.00).

Conclusion

From the present study it is concluded that among all ten insecticides, dinotefuran, clothianidin and tolfenpyrad were found to be most effective for the reducing population of leafhoppers. Whereas, the lowest whitefly population was found in treatments acetamiprid, spiromesifen and afidopyropen. However, Among the evaluated insecticides, clothianidin, fipronil and tolfenpyrad were found significantly the most effective for reducing the thrips population. However, the lowest numbers of aphids were recorded in the treatments dinotefuran, clothianidin and tolfenpyrad. In the context of the ICBR of the evaluated insecticides, the highest return was observed from the treatment dinotefuran (1:11.34). Treatments acetamiprid (1:10.29) and acephate (1:8.23) stood next. However, the lowest return was observed from treatment spiromesifen (1:2.00).

Acknowledgments

The authors thank the Director of Research and the Dean of Post Graduate Studies at Anand Agricultural University, Anand for their support, resources and encouragement throughout this investigation.

References

1. Anonymous. Area and production data of cotton in India [Internet]. 2023 [cited 2023 Sep 6]. Available

from:

https://aiccip.cicr.org.in/CD_22_23/AICRP_AR_2022_23.pdf

2. Boda V, Ilyas M. Evaluation of new insecticides against sucking pests of *Bt* cotton. *Int J Plant Anim Environ Sci.* 2017;7(2):66-72.
3. Ghosal A, Chatterjee ML, Bhattacharyya A. Field bio-efficacy of some new insecticides and tank mixtures against whitefly on cotton in new alluvial zone of West Bengal. *Pestic Res J.* 2018;30(1):31-6.
4. Kamal AP, Navi S, Vijaykumar L, Kumar C, Somu G, Rajendra B, *et al.* Field evaluation of newer insecticides for the management of sucking pests in cotton (*Gossypium hirsutum* L.). *Mysore J Agric Sci.* 2024;58(1):48-57.
5. Krishna VV, Qaim M. *Bt* cotton and sustainability of pesticide reductions in India. *Agric Syst.* 2012;107:47-55.
6. Lee JA, Fang DD. Cotton as a world crop: origin, history, and current status. In: Fang D, Percy R, editors. *Cotton.* 2nd ed. Madison: American Society of Agronomy; 2015. p. 1-24. doi: 10.2134/agronmonogr57.2013.0019.
7. Mahale AS, Suryawanshi DS, Khandare S, Ukey NS. Efficacy of systemic insecticides as stem application against sucking pests of cotton. *J Entomol Zool Stud.* 2017;5(4):1355-60.
8. Naveena JB. Effect of different insecticides against aphids, *Aphis gossypii* and whiteflies, *Bemisia tabaci*. *J Pharmacogn Phytochem.* 2019;8(5):1572-3.
9. Priyanka N, Shaila O, Anuradha M, Rani VD, Rajashekhar M. Efficacy of newer insecticides against the major sucking pests of groundnut (*Arachis hypogaea* L.). *Int J Environ Climate Change.* 2022;12(11):557-64.
10. Ram AA, Baraiya KP, Kotak JN. Efficacy of newer insecticides against sucking pest complex in summer sesame. *J Entomol Zool Stud.* 2020;8(3):1599-604.
11. Rao N, Gaur RK, Kumar R, Singh S, Kamboj R. Bioefficacy of insecticides against *Thrips palmi* in cotton (*Gossypium hirsutum*). *Indian J Agric Sci.* 2022;92(9):1119-23.
12. Steel RGD, Torrie JH. Principles and procedures of statistics. New York: McGraw Hill Book Company; 1980.

13. Surwase SR, Zanwar PR, Masal MS. Bioefficacy of newer insecticides against sucking pest complex of transgenic cotton. Bull Environ Pharmacol Life Sci. 2017;6(2):226-32.