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EFFICACY OF LABEL CLAIMED INSECTICIDES AGAINST SUCKING PESTS IN *Bt* COTTON

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ABSTRACT

Seven synthetic insecticides were evaluated for three years (2020-21 to 2022-23) against sucking pests leafhopper, whitefly, thrips and aphid on *Bt* cotton hybrid. Flonicamid 50 WG at 0.015% was the most effective, recording the lowest pest's population (4.17 aphid, 1.49 leafhopper, 4.08 thrips and 1.14 whitefly/three leaves) and being safer for natural enemies, *Chrysoperla carnea*, spiders and coccinellids. It was comparable to diafenthiuron 50 WP at 0.06% for mealybug control. The highest seed cotton yield was obtained with flonicamid 50 WG (26.64 q/ha) and dinotefuran 20 SG (26.36 q/ha), with flonicamid providing the best net returns. The highest Insecticidal Cost Benefit Ratio (1: 12.44) was registered in flonicamid 50 WG followed by imidacloprid 17.8 SL (1:12.34), dinotefuran 20 SG (1:10.96), difenthiuron 50 WP (1:6.83), pyriproxyfen 10 EC (1:3.96), spinetoram (1:2.62) and spiromesifen 22.9 SC (1:1.41). Overall, flonicamid 50 WG emerged as the most effective and economically viable option for managing sucking pests in cotton.
***Keywords*:** Aphid, cotton, leafhopper, natural enemies, thrips, whitefly, economics.

Introduction

Cotton (*Gossypium* spp.) is a globally significant cash crop cultivated for its high-quality fiber (Hussain *et al.,* 2023) and holds significant importance in the economic, political and social spheres. Cotton crop as commercial commodity plays an important role in industrial activity of nation, in terms of both employment generation and foreign exchange, hence it is popularly known as "White gold' and "Friendly fiber". Cotton is cultivated in 77 countries across the globe and 105 countries consume cotton of which China leads in cotton production, yielding 56 lakh tones, which equates to 329 lakh bales of 170 kg. Following closely, India stands as the second largest producer with 53.85 lakh tones, equivalent to 316 lakh bales of 170 kg. In Gujarat, cotton occupies an estimated area of 26.83 lakh ha with an annual production of 89.65 lakh bales and a productivity of 568 kg/ha (Anon., 2024). India has largest acreage of cotton in the world but productivity is still low. Like other plants, cotton experiences annual losses ranging from 10 to 30 per cent due to various biotic stress factors, including insects and pests. Besides biotic stress, the cotton plant is susceptible to abiotic stress factors such as drought, salinity, extreme temperatures and exposure to pollutants (such as heavy metals, polyaromatic hydrocarbons, herbicides, and insecticides), all of which can impede growth and affect quality (Abdelraheem *et al.,* 2020). The major biotic constraint in attainment of desired productivity levels in *Bt* cotton production is the sucking pests (Kranthi, 2012). *Bt* cotton succumb to yield loss due to the sap feeders *i.e.* leafhoppers, aphids, thrips, whiteflies and mealybugs spread throughout the growing season. The right from seedling emergence to harvest, as the biotic potential of sucking pests being high, they are a potential threat to *Bt* cotton (Biradar and Venilla, 2008).The estimated loss due to sucking pest's complex was up to 21.20 per cent (Dhawan *et al.,* 1988). Now-a-days, numbers of new molecules are introduced in the market and those are not only effective but also cost effective and less toxic to the

existing natural enemies of the pests. Therefore, the present investigation was conducted to evaluate the efficacy of different insecticides against sucking insect pests infesting *Bt* cotton.

Material and Methods

The experiment was laid out in a Randomized Block Design with three replications having plot size of 6.0 x 5.4 m consecutively for three years (2020-23) at Main Cotton Research Station, Navsari Agricultural University, Surat. *Bt* cotton hybrid Ajeet-155 BG II was raised at 120 x 45 cm. Recommended agronomical practices except plant protection were followed for raising the crop. First spray application of respective insecticides was given on the appearance of the pests and subsequently two sprays were given at 15 days interval using manually operated knapsack sprayer having duromist nozzle with slight runoff stage. The observations on population of sucking insect pests (aphid, leafhopper, thrips and whitefly) were made on three leaves, each selected randomly on five plants from top, middle and bottom canopy. The mealybug observation was recorded on 5 cm twig from each selected five plants. The sucking insect pests and natural enemies *viz. Chrysoperla carnea*, spiders and coccinellids per plant were also recorded before as well as 3, 5, 7, 10 and 14 days after each spray. Seed cotton yield was recorded picking-wise from each plot. The data thus obtained for sucking insect pests and natural enemies were analyzed by adopting square root transformation before statistical analysis following Gomez and Gomez (1984) to test the significance of treatment effects. The economics of each synthetic insecticide was calculated.

Results and Discussion

The three-year data on efficacy of insecticides were subjected to overall pooled analysis and presented as under. The data presented on post-treatment counts of sucking pests (aphid, leafhopper, thrips and whitefly) population at 3, 5, 7, 10 and 14 days after spray (DAS) as well as pooled over periods, sprays and years revealed significant differences amongst treatments.

Aphid: There was homogenous population of aphid prior to treatments applications. At 3 DAS, flonicamid 50 WG at 0.015% (6.74 aphids/3 leaves) and dinotefuran 20 SG at 0.006% (8.14 aphids/3 leaves) recorded significantly lower aphid populations, being statistically comparable and superior to other treatments (Table 1). Diafenthiuron 50 WP at 0.06% (10.86 aphids/3 leaves) was the next effective treatment, followed by the standard check, imidacloprid 17.8 SL at 0.0044% (16.89 aphids/3 leaves). At 5, 7, 10, and 14 DAT, flonicamid 50 WG at 0.015% consistently exhibited the lowest aphid population, followed by dinotefuran 20 SG at 0.006% and diafenthiuron 50 WP at 0.06%, all significantly superior to imidacloprid 17.8 SL. Pooled results confirmed flonicamid 50 WG at 0.015% as the most effective (4.17 aphids/3 leaves), followed by dinotefuran 20 SG at 0.006% (6.21 aphids/3 leaves) and diafenthiuron 50 WP at 0.06% (8.68 aphids/3 leaves), with all treatments significantly superior to imidacloprid 17.8 SL (17.22 aphids/3 leaves). The present results are comparable with the observations of Ghelani *et al.* (2014) who reported that the treatments with flonicamid caused significantly maximum mortality of aphids. Gourkhede *et al.* (2015) observed minimum aphid population in the plots treated with flonicamid 50 WG at 0.02 per cent. Similarly, Samih *et al.* (2013) obtained highest aphid mortality with flonicamid in the laboratory experiment under control condition. According to Morita *et al.* (2014) flonicamid was a very active against wide range of aphid species and also effective against some other species of sucking insects.

Leafhopper: The pre-treatment population was homogeneous across treatments (Table 2). At 3 days after treatment, flonicamid 50 WG at 0.015% recorded the lowest population (2.32 leafhoppers/3 leaves) followed by dinotefuran 20 SG at 0.006% (3.03 leafhoppers/3 leaves) and diafenthiuron 50 WP at 0.06% (3.50 leafhoppers/3 leaves), all significantly superior to the standard check, imidacloprid 17.8 SL at 0.0044% (6.16 leafhoppers/3 leaves). A similar trend was observed at 5, 7, 10, and 14 DAS, with flonicamid 50 WG, dinotefuran 20 SG, and diafenthiuron 50 WP demonstrating superior efficacy over imidacloprid 17.8 SL. Pooled results confirmed that flonicamid 50 WG at 0.015% achieved the lowest overall mean population (1.49 leafhoppers/3 leaves), followed by dinotefuran 20 SG at 0.006% (2.26 leafhoppers/3 leaves) and diafenthiuron 50 WP at 0.06% (3.19 leafhoppers/3 leaves), all significantly superior to imidacloprid 17.8 SL (5.85 leafhoppers/3 leaves). The present findings are in agreement with Chinna Babu Naik *et al.* (2017) who reported that flonicamid 50 WG is very effective in managing cotton leafhopper. Per cent reduction of leafhopper population was found higher with flonicamid at 75 g a.i./ha reported by Chandi *et al.* (2016). Similar results were obtained by Kadam *et al.* (2014) and Kumar and Dhawan (2011) who observed that maximum mortality of leafhopper was found in flonicamid treated plot.

Thrips: Pre-treatment populations were homogeneous (Table 3). Pooled analysis revealed that flonicamid 50

WG at 0.015% recorded the lowest thrips population (8.26 thrips/3 leaves), statistically comparable to spinetoram 11.7 SC at 0.0098% (8.62 thrips/3 leaves), which was at par with dinotefuran 20 SG at 0.006% (10.13 thrips/3 leaves). At 5 DAS, flonicamid 50 WG at 0.015% recorded the lowest thrips population followed by spinetoram 11.7 SC at 0.0098%, dinotefuran 20 SG at 0.006% (5.65 to 6.52 thrips/3 leaves) and diafenthiuron 50 WP at 0.06% (9.74 thrips/3 leaves), all significantly superior to imidacloprid 17.8 SL at 0.0044%. A similar trend was observed at 7, 10, and 14 DAS. Pooled results confirmed that flonicamid 50 WG at 0.015% had the lowest overall mean population (4.08 thrips/3 leaves), followed by spinetoram 11.7 SC at 0.0098% (5.36 thrips/3 leaves), dinotefuran 20 SG at 0.006% (6.58 thrips/3 leaves), and diafenthiuron 50 WP at 0.06% (9.80 thrips/3 leaves), all significantly superior to imidacloprid 17.8 SL (13.86 thrips/3 leaves). These findings align with Gaurkhede *et al.* (2015), who reported effective thrips management using fipronil 5 SC, flonicamid 50 WG, dinotefuran 20 SG and acetamiprid 20 SP. Similar results were documented by Ghelani *et al.* (2014), Ravikumar *et al.* (2016), Meghana *et al.*. (2018), Sathyan *et al.* (2016) and Patil *et al*. (2009), highlighting the efficacy of flonicamid 50 WG in thrips control.

Whitefly: Initial populations were uniform across treatments. At 3 DAS, flonicamid 50 WG at 0.015% recorded the lowest whitefly population (1.52 whiteflies/3 leaves), followed by spiromesifen 22.9 SC at 0.027% (2.32 whiteflies/3 leaves), diafenthiuron 50 WP at 0.06% and dinotefuran 20 SG at 0.006% (3.07–3.50 whiteflies/3 leaves), all significantly superior to the standard check, imidacloprid 17.8 SL at 0.0044% (6.16 whiteflies/3 leaves). A similar trend was observed at 5, 7, 10, and 14 DAS, where flonicamid 50 WG, spiromesifen 22.9 SC, spinetoram 11.7 SC, dinotefuran 20 SG, and diafenthiuron 50 WP were more effective than imidacloprid 17.8 SL. Pooled results showed flonicamid 50 WG at 0.015% recorded the lowest overall mean population (1.14 whiteflies/3 leaves), followed by spiromesifen 22.9 SC at 0.027% (1.60 whiteflies/3 leaves) and diafenthiuron 50 WP at 0.06% (2.29 whiteflies/3 leaves), all significantly superior to imidacloprid 17.8 SL (6.26 whiteflies/3 leaves). These findings align with Ghelani *et al.* (2014), who reported effective whitefly control with flonicamid 0.02% on *Bt* cotton (Table 4).

Mealybug: The scattered population (Table 5) was noticed in different treatments in later stage of the crop and lower mealybug was noticed in flonicamid, diafenthiuron, dinotefuran, pyriproxyfen and spiromesifen (5.95 to 8.50 mealybugs/5 cm twig) compared to 14.40 mealybugs/5 cm twig in control. The pooled results over period and year after last spray revealed that the lowest population of mealybug (3.83 mealybug/5 cm twig) was noticed in flonicamid 50 WG at 0.015% which was statistically at par to diafenthiuron 50 WP at 0.06% (4.65 mealybug/5 cm twig) and the later treatment was also comparable on other side to dinotefuran 20 SG at 0.006% (4.98 mealybug/5 cm twig). All these treatments were significantly superior to untreated control (21.12 mealybug/5 cm twig).

Natural enemies: No significant difference was observed in the initial population of natural enemies (Table 6). At 3, 5, 7, 10, and 14 DAS, the highest population of natural enemies was found in the untreated control, followed by diafenthiuron 50 WP, flonicamid 50 WG, and spiromesifen 22.9 SC, all significantly higher than the standard check, imidacloprid 17.8 SL. Pooled results indicated that the highest population of natural enemies was found in the untreated control (3.38/plant). In terms of safety, diafenthiuron 50 WP at 0.06%, flonicamid 50 WG at 0.015%, and spiromesifen 22.9 SC at 0.027% supported higher to moderate populations (2.32 to 2.49/plant), significantly higher than imidacloprid 17.8 SL (1.57/plant). These findings align with Chandi *et al.* (2016), who reported flonicamid as comparatively safer to the predatory complex and Jansen *et al.* (2011), who noted flonicamid selectivity for aphid antagonists.

Seed cotton yield: The seed cotton yield was found higher in flonicamid 50 WG at 0.015% (26.64 q/ha), dinotefuran 20 SG at 0.006% (26.36 q/ha) and diafenthiuron 50 WP at 0.06% (25.39 q/ha) and found comparable to each other (Table 7). It was 22.10 q/ha in imidacloprid 17.8 SL at 0.0044% as against 15.62 q/ha in control. These findings are in conformity with Chandi *et al.* (2016) who recorded that significantly higher yield was obtain in plot treated with flonicamid at 75 and 100 g a.i. ha^{-1}.

Economics: The net gain in seed cotton yield (Table 8) over control was maximum (11.02 q/ha) in flonicamid 50 WG at 0.015% (26.64 q/ha) followed by dinotefuran 20 SG at 0.006% (10.74 q/ha), diafenthiuron 50 WP at 0.06% (9.77 q/ha), spinetoram 11.7 SC at 0.0098% (8.15 q/ha) whereas of standard conventional insecticide, imidacloprid 17.8 SL at 0.0044% (6.48 q/ha). The highest (81602 Rs./ha) realization was calculated in plots treated with flonicamid 50 WG at 0.015% @ 150 g/ha followed by dinotefuran 20 SG at 0.006% (78735 Rs./ha) and diafenthiuron 50 WP at 0.06% (68176 Rs./ha). The net realization was registered lowest in spiromesifen 240

SC at 0.027% (16287 Rs./ha) followed by pyriproxyfen 10 EC at 0.02% (34492 Rs./ha). The highest ICBR was registered in flonicamid 50 WG at 0.015% (1:12.44) followed by imidacloprid 200 SL at 0.0044% (1:12.34), dinotefuran 20 SG at 0.006% (1:10.96) and diafenthiuron 50 WP at 0.06% (1:6.83).

Conclusion

Considering efficacy against sucking pests, flonicamid 50 WG at 0.015%, dinotefuran 20 SG at 0.006% and diafenthiuron 50 WP at 0.06% against aphid, leafhopper and mealybug; Flonicamid 50 WG at 0.015%, spinetoram 11.7 SC at 0.0098%, dinotefuran 20 SG at 0.006% and diafenthiuron 50 WP at 0.06% against thrips; Flonicamid 50 WG at 0.015%, spiromesifen 22.9 SC at 0.027% and diafenthiuron 50 WP at 0.06% against whitefly were found effective than conventional insecticide, imidacloprid 17.8 SL at 0.0044%. As far as safety to natural enemies is concerned, diafenthiuron 50 WP, flonicamid 50 WG and spiromesifen 22.9 SC were found moderately safer and better than imidacloprid 17.8 SL. The seed cotton yield was higher in flonicamid 50 WG (26.64 q/ha), dinotefuran 20 SG (26.36 q/ha) and diafenthiuron 50 WP (25.39 q/ha) than conventional standard check imidacloprid 17.8 SL (20.74 q/ha). The net realization over control was higher in flonicamid 50 WG at 0.015% followed by dinotefuran 20 SG at 0.006% and diafenthiuron 50 WP at 0.06%. The highest ICBR was registered in flonicamid 50 WG (1:12.44) followed by imidacloprid 200 SL (1:12.34), dinotefuran 20 SG (1:10.96) and diafenthiuron 50 WP (1:6.83).

Table 1: Efficacy of different insecticides against aphids infesting in cotton

Tr. No.	Insecticides	Conc. (%)	No. of aphids/3 leaves													
			Before spray		3 DAS		5 DAS		7 DAS		10 DAS		14 DAS		Pooled	
1	Spinetoram 11.7 SC	0.0098%	4.77 (22.25)		4.49^{d} (19.66)		4.29^{e} (17.90)		4.24^{e} (17.48)		4.64^{e} (21.03)		5.19^{e} (26.44)		4.57^{e} (20.38)	
2	Pyriproxyfen 10 EC	0.02%	4.80 (22.54)		4.72^{de} (21.78)		4.51^{f} (19.84)		4.48^{f} (19.57)		4.98^{f} (24.30)		5.43^{ef} (28.98)		4.82^{f} (22.73)	
3	Dinotefuran 20 SG	0.006%	4.72 (21.78)		2.94^{a} (8.14)		2.60^{b} (6.26)		2.19^{b} (4.30)		2.44^{b} (5.45)		2.78^{b} (7.23)		2.59^{b} (6.21)	
4	Spiromesifen 22.9 SC	0.027%	4.73 (21.87)		4.92^{e} (23.71)		4.76^{g} (22.16)		4.73^{g} (21.87)		5.23^{g} (26.85)		5.59^{f} (30.75)		5.05^{g} (25.00)	
5	Diafenthiuron 50 WP	0.06%	4.60 (20.66)		3.37^{b} (10.86)		3.00^{c} (8.50)		2.43^{c} (5.40)		2.94^{c} (8.14)		3.39^{c} (10.99)		3.03^{c} (8.68)	
6	Flonicamid 50 WG	0.015%	4.97 (24.20)		2.69^{a} (6.74)		2.17^{a} (4.21)		1.89^{a} (3.07)		1.90^{a} (3.11)		2.15^{a} (4.12)		2.16^{a} (4.17)	
7	Imidacloprid 17.8 SL	0.0044%	4.83 (22.83)		4.17c (16.89)		3.97^{d} (15.26)		3.75^{d} (13.56)		4.37^{d} (18.60)		4.79^{d} (22.44)		4.21^{d} (17.22)	
8	Control	-	4.86 (23.12)		5.77^{f} (32.79)		5.85^{h} (33.72)		6.00^{h} (35.50)		6.16^{h} (37.45)		6.42^{g} (40.72)		6.04^{h} (35.98)	
			S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)
Treatment (T)			0.11	NS	0.08	Sig.	0.06	Sig.	0.05	Sig.	0.04	Sig.	0.08	Sig.	0.04	Sig.
Year (Y)			0.07	Sig.	0.04	Sig.	0.04	Sig.	0.04	Sig.	0.04	Sig.	0.04	Sig.	0.02	Sig.
T x Y			0.07	NS	0.07	Sig.	0.06	Sig.	0.06	Sig.	0.06	Sig.	0.08	Sig.	0.04	Sig.
C. V. %			7.62		8.09		7.78		8.20		7.80		8.36		7.04	

Notes : Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values

: Treatment means with the letter(s) in common are non-significant by DNMRT at 5% level of significance

Table 2: Efficacy of different insecticides against leafhoppers infesting in cotton

Tr. No.	Insecticides	Conc. (%)	No. of leafhoppers/3 leaves						
			Before spray	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Pooled
1	Spinetoram 11.7 SC	0.0098%	2.61 (6.31)	2.71^{cd} (6.84)	2.62^{cd} (6.36)	2.56^{d} (6.05)	2.70^{e} (6.79)	2.93^{e} (8.08)	2.70^{e} (6.79)
2	Pyriproxyfen 10 EC	0.02%	2.67 (6.63)	2.81^{d} (7.40)	2.71^{d} (6.84)	2.70^{d} (6.79)	2.82^{ef} (7.45)	3.00^{ef} (8.50)	2.81^{ef} (7.40)
3	Dinotefuran 20 SG	0.006%	2.69 (6.74)	1.88^{b} (3.03)	1.70^{b} (2.39)	1.46^{a} (1.63)	1.54^{b} (1.87)	1.74^{b} (2.53)	1.66^{b} (2.26)
4	Spiromesifen 22.9 SC	0.027%	2.64 (6.47)	2.84^{d} (7.57)	2.78^{d} (7.23)	2.76^{d} (7.12)	2.96^{f} (8.26)	3.12^{f} (9.23)	2.89^{f} (7.85)
5	Diafenthiuron 50 WP	0.06%	2.58 (6.16)	2.00^{b} (3.50)	1.87^{b} (3.00)	1.74^{b} (2.53)	1.89^{c} (3.07)	2.08^{c} (3.83)	1.92^{c} (3.19)
6	Flonicamid 50 WG	0.015%	2.57 (6.10)	1.68^{a} (2.32)	1.43^{a} (1.54)	1.24^{a} (1.04)	1.25^{a} (1.06)	1.44^{a} (1.57)	1.41^{a} (1.49)
7	Imidacloprid 17.8 SL	0.0044%	2.70 (6.79)	2.58^{c} (6.16)	2.46^{c} (5.55)	2.30^{c} (4.79)	2.51^{d} (5.80)	2.75^{d} (7.06)	2.52^{d} (5.85)
8	Control	-	2.64 (6.47)	3.29^{e} (10.32)	3.32^{e} (10.52)	3.35^{e} (10.72)	3.37^{g} (10.86)	3.45^{g} (11.40)	3.36^{g} (10.79)

	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)
Treatment (T)	0.05	NS	0.06	Sig.	0.06	Sig.	0.07	Sig.	0.05	Sig.	0.05	Sig.	0.04	Sig.
Year (Y)	0.05	Sig.	0.03	Sig.	0.02	Sig.	0.02	Sig.	0.03	Sig.	0.03	Sig.	0.01	Sig.
T x Y	0.05	NS	0.05	NS	0.04	Sig.	0.03	Sig.	0.04	NS	0.05	NS	0.03	NS
C. V. %	8.85		9.27		8.25		7.20		9.07		8.79		7.66	

Notes : Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values

: Treatment means with the letter(s) in common are non-significant by DNMRT at 5% level of significance

Table 3: Efficacy of different insecticides against thrips infesting in cotton

Tr. No.	Insecticides	Conc. (%)	No. of thrips/3 leaves						
			Before spray	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Pooled
1	Spinetoram 11.7 SC	0.0098%	5.60 (30.86)	3.02^{ab} (8.62)	2.48^{b} (5.65)	2.08^{ab} (3.83)	2.13^{b} (4.04)	2.38^{b} (5.16)	2.42^{b} (5.36)
2	Pyriproxyfen 10 EC	0.02%	5.69 (31.88)	4.60^{e} (20.66)	4.05^{e} (15.90)	3.51^{de} (11.82)	3.93^{ef} (14.94)	4.52^{f} (19.93)	4.12^{f} (16.47)
3	Dinotefuran 20 SG	0.006%	5.72 (32.22)	3.26^{b} (10.13)	2.65^{b} (6.52)	2.21^{b} (4.38)	2.46^{c} (5.55)	2.73^{c} (6.95)	2.66^{c} (6.58)
4	Spiromesifen 22.9 SC	0.027%	5.76 (32.68)	4.94^{f} (23.90)	4.18^{e} (16.97)	3.74^{e} (13.49)	4.15^{f} (16.72)	4.85^{g} (23.02)	4.37^{g} (18.60)
5	Diafenthiuron 50 WP	0.06%	5.85 (33.72)	3.84^{c} (14.25)	3.20^{c} (9.74)	2.70^{c} (6.79)	3.00^{d} (8.50)	3.30^{d} (10.39)	3.21^{d} (9.80)
6	Flonicamid 50 WG	0.015%	5.75 (32.56)	2.96a (8.26)	2.22^{a} (4.43)	1.79^{a} (2.70)	1.78^{a} (2.67)	1.93^{a} (3.22)	2.14^{a} (4.08)
7	Imidacloprid 17.8 SL	0.0044%	5.92 (34.55)	4.27^{d} (17.73)	3.79^{d} (13.86)	3.20^{d} (9.74)	3.68^{e} (13.04)	4.00^{e} (15.50)	3.79^{e} (13.86)
8	Control	-	5.92 (34.55)	5.98^{g} (35.26)	5.85^{f} (33.72)	5.69^{f} (31.88)	6.00^{g} (35.50)	5.81^{h} (33.26)	5.87^{h} (33.96)

	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)
Treatment (T)	0.14	NS	0.09	Sig.	0.07	Sig.	0.11	Sig.	0.10	Sig.	0.11	Sig.	0.06	Sig.
Year (Y)	0.08	Sig.	0.05	NS	0.04	NS	0.03	NS	0.04	Sig.	0.04	Sig.	0.02	NS
T x Y	0.08	NS	0.07	NS	0.06	Sig.	0.05	Sig.	0.06	Sig.	0.06	Sig.	0.05	Sig.
C. V. %	7.10		8.34		8.26		7.75		9.00		7.48		7.48	

Notes : Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed value

: Treatment means with the letter(s) in common are non-significant by DNMRT at 5% level of significance

Table 4: Efficacy of different insecticides against whitefly infesting in cotton

Tr. No.	Insecticides	Conc. (%)	No. of whitefly/3 leaves						
			Before spray	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Pooled
1	Spinetoram 11.7 SC	0.0098%	2.47 (5.60)	2.48^{e} (5.65)	2.40^{e} (5.26)	2.46^{d} (5.55)	2.48^{f} (5.65)	2.63^{e} (6.42)	2.49^{f} (5.70)
2	Pyriproxyfen 10 EC	0.02%	2.25 (4.56)	2.25^{d} (4.56)	2.06^{d} (3.74)	1.82^{c} (2.81)	2.09^{e} (3.87)	2.27^{d} (4.65)	2.10^{e} (3.91)
3	Dinotefuran 20 SG	0.006%	2.46 (5.55)	2.00^{c} (3.50)	1.78^{c} (2.67)	1.58^{b} (2.00)	1.73^{d} (2.49)	1.97^{c} (3.38)	1.81^{d} (2.78)
4	Spiromesifen 22.9 SC	0.027%	2.46 (5.55)	1.68^{b} (2.32)	1.48^{b} (1.69)	1.22^{a} (0.99)	1.39^{b} (1.43)	1.50^{b} (1.75)	1.45^{b} (1.60)
5	Diafenthiuron 50 WP	0.06%	2.44 (5.45)	1.89^{c} (3.07)	1.64^{bc} (2.19)	1.37^{a} (1.38)	1.58^{c} (2.00)	1.86^{c} (2.96)	1.67^{c} (2.29)
6	Flonicamid 50 WG	0.015%	2.60 (6.26)	1.42^{a} (1.52)	1.30^{a} (1.19)	1.20^{a} (0.94)	1.23^{a} (1.01)	1.24^{a} (1.04)	1.28^{a} (1.14)
7	Imidacloprid 17.8 SL	0.0044%	2.53 (5.90)	2.58^{e} (6.16)	2.54^{e} (5.95)	2.41^{d} (5.31)	2.66^{g} (6.58)	2.77^{e} (7.17)	2.60^{g} (6.26)
8	Control	-	2.53 (5.90)	3.11^{f} (9.17)	3.10^{f} (9.11)	3.19^{e} (9.68)	3.24^{h} (10.00)	3.26^{f} (10.13)	3.18^{h} (9.61)

	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)
Treatment (T)	0.08	NS	0.04	Sig.	0.06	Sig.	0.06	Sig.	0.04	Sig.	0.05	Sig.	0.03	Sig.
Year (Y)	0.05	Sig.	0.02	Sig.	0.02	Sig.	0.02	Sig.	0.02	NS	0.02	Sig.	0.01	Sig.
T x Y	0.05	NS	0.04	Sig.	0.04	Sig.	0.03	Sig.	0.04	Sig.	0.04	Sig.	0.02	Sig.
C. V. %	9.70		8.57		9.03		8.46		9.64		8.25		7.78	

Notes : Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values

: Treatment means with the letter(s) in common are non-significant by DNMRT at 5% level of significance

Table 5: Efficacy of different insecticides against mealybug infesting in cotton

Tr. No.	Insecticides	Conc. (%)	No. of mealybug/5 cm twig						
			Before spray	3 DAS	5 DAS	7 DAS	10 DAS	14 DAS	Pooled
1	Spinetoram 11.7 SC	0.0098%	3.28^{bc} (10.26)	3.26^{b} (10.13)	3.10^{c} (9.11)	2.76^{c} (7.12)	3.26^{d} (10.13)	3.53^{c} (11.96)	3.18^{d} (9.61)
2	Pyriproxyfen 10 EC	0.02%	2.70^{a} (6.79)	2.53^{a} (5.90)	2.49^{b} (5.70)	2.72^{c} (6.90)	2.93^{c} (8.08)	3.17^{b} (9.55)	2.77^{c} (7.17)
3	Dinotefuran 20 SG	0.006%	2.69^{a} (6.74)	2.53^{a} (5.90)	2.15a (4.12)	2.11^{b} (3.95)	2.36^{b} (5.07)	2.55^{a} (6.00)	2.34^{b} (4.98)
4	Spiromesifen 22.9 SC	0.027%	3.00^{ab} (8.50)	3.28^{b} (10.26)	3.25^{c} (10.06)	3.51^{d} (11.82)	3.80^{e} (13.94)	3.79^{c} (13.86)	3.53^{e} (11.96)
5	Diafenthiuron 50 WP	0.06%	2.66^{a} (6.58)	2.59^{a} (6.21)	2.17^{ab} (4.21)	1.96^{ab} (3.34)	2.23^{b} (4.47)	2.40^{a} (5.26)	2.27^{ab} (4.65)
6	Flonicamid 50 WG	0.015%	2.54^{a} (5.95)	2.38^{a} (5.16)	2.06^{a} (3.74)	1.75^{a} (2.56)	1.98^{a} (3.42)	2.22^{a} (4.43)	2.08^{a} (3.83)
7	Imidacloprid 17.8 SL	0.0044%	3.65^{cd} (12.82)	3.55^{a} (12.10)	3.77^{d} (13.71)	3.74^{d} (13.49)	3.96^{e} (15.18)	4.27^{d} (17.73)	3.86^{f} (14.40)
8	Control	-	3.86^{d} (14.40)	4.20^{c} (17.14)	4.50^{e} (19.75)	4.70^{e} (21.59)	4.83^{f} (22.83)	5.03^{e} (24.80)	4.65^{g} (21.12)

	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)
Treatment (T)	0.17	Sig.	0.12	Sig.	0.11	Sig.	0.09	Sig.	0.07	Sig.	0.11	Sig.	0.07	Sig.
Year (Y)	0.05	Sig.	0.06	Sig.	0.04	Sig.	0.05	Sig.	0.05	Sig.	0.05	Sig.	0.02	Sig.
T x Y	0.05	NS	0.06	Sig.	0.04	Sig.	0.05	NS	0.05	NS	0.05	NS	0.06	Sig.
C. V. %	8.40		9.41		7.34		8.82		8.29		6.90		7.15	

Notes : Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values

: Treatment means with the letter(s) in common are non-significant by DNMRT at 5% level of significance

Table 6: Impact of different insecticides against natural enemies in cotton

Tr. No.	Insecticides	Conc. (%)	No. of natural enemies/plant											
			Before spray		3 DAS		5 DAS		7 DAS		10 DAS		14 DAS		Pooled	
1	Spinetoram 11.7 SC	0.0098%	1.70 (2.39)		1.62^{cd} (2.12)		1.52^{d} (1.81)		1.48^{d} (1.69)		1.54^{d} (1.87)		1.63^{def} (2.16)		1.56^{cd} (1.93)	
2	Pyriproxyfen 10 EC	0.02%	1.75 (2.56)		1.58^{d} (2.00)		1.48^{de} (1.69)		1.46^{d} (1.63)		1.50^{d} (1.75)		1.59^{ef} (2.03)		1.52^{d} (1.81)	
3	Dinotefuran 20 SG	0.006%	1.74 (2.53)		1.63^{cd} (2.16)		1.58^{cd} (2.00)		1.49^{d} (1.72)		1.58^{cd} (2.00)		1.67^{cde} (2.29)		1.59^{c} (2.03)	
4	Spiromesifen 22.9 SC	0.027%	1.84 (2.89)		1.73^{bc} (2.49)		1.65^{bc} (2.22)		1.59^{c} (2.03)		1.66^{bc} (2.26)		1.76^{bcd} (2.60)		1.68^{b} (2.32)	
5	Diafenthiuron 50 WP	0.06%	1.83 (2.85)		1.78^{b} (2.67)		1.72^{b} (2.46)		1.65^{b} (2.22)		1.72^{b} (2.46)		1.81^{b} (2.78)		1.73^{b} (2.49)	
6	Flonicamid 50 WG	0.015%	1.79 (2.70)		1.76^{b} (2.60)		1.68^{bc} (2.32)		1.62^{bc} (2.12)		1.69^{b} (2.36)		1.78^{bc} (2.67)		1.70^{b} (2.39)	
7	Imidacloprid 17.8 SL	0.0044%	1.79 (2.70)		1.52^{d} (1.81)		1.40^{e} (1.46)		1.35^{e} (1.32)		1.41^{e} (1.49)		1.50^{f} (1.75)		1.44^{e} (1.57)	
8	Control	-	1.86 (2.96)		1.94^{a} (3.26)		1.96^{a} (3.34)		1.98^{a} (3.42)		1.97^{a} (3.38)		1.98^{a} (3.42)		1.97^{a} (3.38)	
			S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)	S. Em. ±	CD (5%)
Treatment (T)			0.07	NS	0.04	Sig.	0.03	Sig.	0.03	Sig.	0.03	Sig.	0.04	Sig.	0.02	Sig.
Year (Y)			0.02	Sig.	0.01	NS	0.02	NS	0.02	NS	0.02	NS	0.02	NS	0.01	Sig.
T x Y			0.02	NS	0.03	NS	0.03	NS	0.03	NS	0.03	NS	0.03	NS	0.02	NS
C. V. %			5.01		7.50		8.20		8.08		8.34		8.30		7.26	

Notes : Figures in parentheses are retransformed values; those outside are $\sqrt{X+0.5}$ transformed values

: Treatment means with the letter(s) in common are non-significant by DNMRT at 5% level of significance

Table 7: Effect of different insecticides on seed cotton yield (Pooled over years)

Tr. No.	Treatments	Conc. (%)	Seed cotton yield (q/ha)			
			2020-21	2021-22	2022-23	Pooled
1	Spinetoram 11.7 SC	0.0098%	25.51^{a}	23.10^{abc}	22.71^{ab}	23.77^{bc}
2	Pyriproxyfen 10 EC	0.02%	22.63^{ab}	20.68^{cd}	19.75^{c}	21.02^{de}
3	Dinotefuran 20 SG	0.006%	28.19^{a}	26.44^{a}	24.45^{a}	26.36^{a}
4	Spiromesifen 22.9 SC	0.027%	19.75^{bc}	19.03^{de}	18.52^{c}	19.10^{e}
5	Diafenthiuron 50 WP	0.06%	26.95^{a}	25.51^{ab}	23.70^{a}	25.39^{ab}
6	Flonicamid 50 WG	0.015%	28.29^{a}	26.70^{a}	24.94^{a}	26.64^{a}
7	Imidacloprid 17.8 SL	0.0044%	23.45^{ab}	22.12^{bcd}	20.74^{bc}	22.10^{cd}
8	Control	-	15.12^{c}	16.67^{e}	15.06^{d}	15.62^{f}
S. Em.±			1.96	1.26	0.94	0.76
CD at 5%			Sig.	Sig.	Sig.	Sig.
S. Em. ± (YxT)			-	-	-	1.45
CD at 5% (YxT)			-	-	-	NS
CV%			14.31	9.67	7.70	11.17

Treatment means with the letter(s) in common are non-significant by DNMRT at 5% level of significance

Table 8: Economics of different insecticides used for sucking pests management in cotton

Tr. No.	Treatments	Seed cotton yield (q/ha)	Yield increase over control (q/ha)	Total additional income over control (Rs./ha)	Quantity of insecticides used (ml or g/ha)	Total cost of treatment (Rs./ha)	Net Realization (Rs./ha)	ICBR
1	Spinetoram 11.7 SC	23.77	08.15	65200	1260	17988.0	47212	1:02.62
2	Pyriproxyfen 10 EC	21.02	05.40	43200	3000	08708.0	34492	1:03.96
3	Dinotefuran 20 SG	26.36	10.74	85920	0450	07185.0	78735	1:10.96
4	Spiromesifen 22.9 SC	19.10	03.48	27840	1800	11553.0	16287	1:01.41
5	Diafenthiuron 50 WP	25.39	09.77	78160	1800	09984.0	68176	1:06.83
6	Flonicamid 50 WG	26.64	11.02	88160	0450	06558.0	81602	1:12.44
7	Imidacloprid 17.8 SL	22.10	06.48	51840	0375	03885.0	47955	1:12.34
8	Control	15.62	-	-	-	-	-	-

1. Labour charges @ Rs. 268/- per day x 2 labours x 3 spray = Rs. 1608/ha for application of insecticides
2. Price of seed cotton: Rs. 8000/q

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