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Bio-efficacy of Sulfoxaflor and Other Insecticides Against Sucking Pests of Cotton

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ABSTRACT

The field trials were conducted for two consecutive years during *kharif,* 2015 and 2016 seasons at the Regional Agricultural Research Station, Warangal, Telangana, India to study the bio efficacy of sulfoxaflor and other broad-spectrum insecticides on sucking pests and natural enemies of cotton under rain fed black soils. Among the treatments, a significant (47.6%) reduction of aphids was recorded with sulfoxaflor at 100 g a.i. ha^{-1} followed by flonicamid at 75 g a.i. ha^{-1} (42.8%) and sulfoxaflor at 90 (42.8%) as compared to other treatments. The highest reduction (61.0 %) of jassid was observed in flonicamid at 75 g a.i. ha^{-1} followed sulfoxaflor at 90 (50.8%) as compared to other treatments. The highest reduction (30.2%) of thrips was observed in sulfoxaflor at 100 g a.i. ha^{-1} followed by flonicamid at 75 g a.i. ha^{-1} (19.8%) and sulfoxaflor at 90 (19.8%) respectively, as compared to other treatments. The highest reduction (41.9%) of whitefly was observed in buprofezin at 250 g a.i. ha^{-1} followed by dinotefuran at 150 g a.i. ha^{-1} (35.5%) as compared to other treatments. None of the insecticidal treatments has affected the abundance of the natural enemy population during both the years of study. Overall, the study further revealed that, Sulfoxaflor at 100 g a.i ha^{-1} and flonicamid at 75 g a.i. ha^{-1} have shown good efficacy against sucking pests as well as recorded the highest seed cotton yield compared to other treatments and can be used as an alternative to other insecticides in the control of Cotton sucking pests.

KEYWORDS: Bio efficacy, cotton, insecticides, natural enemies, sucking pests, sulfoxaflor

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1. INTRODUCTION

Cotton is an important commercial crop of India which is grown in more than 13.3 mha, with a production of 360 lakh bales and with a productivity of 459 kg ha^{-1} (Anonymous, 2021). All the 4 cultivated species of cotton, viz. *Gossypium arboreum* L., *Gossypium hirsutum* L., *Gossypium herbaceaum* L. and *Gossypium barbadense* L. along with intra-specific and inter-specific hybrids are grown in India under diverse agro climatic conditions, varying from 8°–32° N latitude and 70°–80° E longitude. Major Cotton producing states are Maharashtra, Gujarat, Telangana, Andhra Pradesh, Tamil Nadu, Karnataka, Rajasthan, Punjab and Haryana. In India area under cotton cultivation is more than the world, but productivity is still low. Among the various causes, major cause of low productivity in cotton is attack of insect pests. Cotton crop harboured 1326 insect species from sowing to maturity in different cotton growing areas of the world (Hargreaves, 1948) and 162 species have been reported on the cotton crop in India alone, of which 24 species have attained pest status (Sundramurthy and Chitra, 1992). Insect pests and crop diseases are major yield-limiting factors in almost all cotton growing countries (Luttrell et al., 1994). The introduction of *Bacillus thuringiensis* (*Bt*) cotton reduced the problem of bollworms, increased yields, reduced production costs and environmental contamination (Edge et al., 2001; Shelton et al., 2002; Sharma and Pampapathy et al., 2006) but unfortunately, the population of piercing-sucking insect pests gradually increased. Right from the seedling stage, sucking pests have become the main constraints for yield loss, which may reduce up to 21.20% (Dhawan et al., 1988). *Bt*-Cotton cultivation occupied a major share (>90%) in India, which is susceptible to sucking pests (Hofs et al., 2004). The highest share of damage to the cotton is done by the cotton bollworm complex and sucking pest complex. Sucking pest complex of cotton includes aphid, jassid, whitefly, thrips, red cotton bug, mealy bug and dusky cotton bug. Amongst these, the first four pests are economically most important in many parts of the cotton growing regions. According to an estimate, bollworms and sucking pest complex cause about 20%–40% yield losses in Pakistan (Ahmad, 1999). Pink bollworm *Pectinophora gossypiella* developed resistance to *Bt* cotton, in Central and South India, where it has been causing yield losses since 2013 (Naik et al., 2018). Due to the sucking pest problem, there was a 22.85% of seed cotton yield reduction in Cotton (Satpute et al., 1990, Kulkarni et al., 2003). Moreover, extensive insecticide applications cause side effects on non-target natural enemies (Soares et al., 2019) as well as create pesticide pollution (Hladik et al., 2014; Ippolito et al., 2015) and rapid development of resistance to sucking insects (Kranthi et al., 2002; Kady et al., 2003; Nazir et al., 2017). According to Biradar and Venilla (2008), *Bt*-cotton succumb to yield loss due to sucking pests such as leafhoppers, aphids, thrips and whitefly, etc. Chavan et al. (2010) reported 28.13% avoidable yield loss due to major sucking pests in cotton. The adoption of transgenic *Bt*-cotton expressing genes from the soil-inhabiting spore-forming bacterium, *Bacillus thuringiensis* Berliner in countries, such as India, has changed the entire pest scenario in the cotton ecosystem. The pest status of bollworms and leaf-feeding insects has declined, but sap feeders are emerging as serious pests (Kumar et al., 2015). Therefore, such a crop can resist or tolerate bollworms but lack tolerance/resistance to sucking insects (Ranjith et al., 2010, Carrière et al., 2015). Based on the severe impacts induced by sap-sucking insects on cotton, this study was initiated to evaluate the efficacy of some non-conventional insecticides (recently developed and/or not regularly used) on the abundance of cotton sucking pests to assess the efficacy of these on seed cotton yield.

2. MATERIALS AND METHODS

The study was carried out for two consecutive seasons during *kharif* seasons (June–December, 2015 and July–December, 2016) in the research farm (18° 55" and 79° 36°10" East) of Regional Agricultural Research Station, Warangal, Professor Jayashankar Telangana State Agricultural University, Telangana state, India. The cotton seeds of RCH-2 (*Bt*-cotton carrying the Cry 1 Ac+Cry 2 Ab gene delta-endotoxins) were obtained from Rasi Seeds Pvt. Ltd. and sown on 30th June 2015 and 4th July 2016 respectively, at a spacing of 90×60 cm^2. All recommended agronomic practices were followed during the experimentation for proper crop management. The distance between 2 replications was 1.5 m and it was 1.0 m between the treatments. In the present study, 6 insecticidal treatments i.e., sulfoxaflor 50% WG @ 75 g, 90 g and 100g a.i. ha^{-1} , flonicamid 50% WG @ 75 g, buprofezin 25% SC @ 250 g, dinotefuran 20% SG @ 30 g a.i. ha^{-1} and untreated control were evaluated against sucking pests. Regarding observations for sucking pests, the observations were recorded on five randomly selected plants in each plot. The observations were recorded before and after each spray at 1 day after spray (DAS), 5 DAS and 10 DAS. The observations on the actual count of sucking pests viz., aphids, jassids, thrips and whiteflies were recorded from top, middle and bottom three leaves from the selected plants. Regarding observations on natural enemies, the observations were recorded on five randomly selected plants in each plot. The observations were recorded before and after each spray at 1 day after spray (DAS), 5 DAS and 10 DAS. The observations on the actual count of spiders and coccinellids were recorded randomly from five selected plants. Cotton yield was recorded from each treatment and the data were presented as seed cotton yield in kg ha^{-1}. The observations on the number of sucking pests and natural enemies were subjected to square root transformation before statistical analysis. Data of both the years were pooled for statistical analysis as per the method given by Panse and Sukhatme (1967).

3. RESULTS AND DISCUSSION

3.1. Efficacy of Sulfoxaflor and other insecticides against aphids

Results of both the seasons (*kharif*, 2015 and 2016) revealed that before spray treatment the mean aphid population ranged from 2.0–6.1 (6 leaves)$^{-1}$ in different insecticidal treatments and control and the population did not differ significantly. One day after spray treatment, sulfoxaflor 50% WG at 100 g a.i. ha^{-1} and flonicamid 50% WG at 75 g a.i. ha^{-1} recorded significantly less aphid population in comparison to remaining insecticidal treatments and control. Sulfoxaflor 50% WG at 75 g a.i. ha^{-1} was the next effective treatment, recording significantly less aphid population in comparison to remaining insecticidal treatments and control (Table 1). 5 days after spray treatment, all insecticidal treatments recorded significantly less aphid population in comparison to control. Amongst the insecticidal treatments, sulfoxaflor 50% WG at 100 g a.i. ha^{-1} recorded significantly less aphid population, in comparison to remaining insecticidal treatments, except flonicamid 50% WG at 75 g a.i. ha^{-1} and sulfoxaflor 50% WG at 90 and at 75 g a.i. ha^{-1} (Table 1). 10 days after spray treatments, all insecticidal treatments recorded significantly less aphid population in comparison to control. Amongst the treatments, sulfoxaflor 50% WG at 100 g a.i. ha^{-1} recorded minimum and significantly less aphid population followed by flonicamid 50% WGat 75 g a.i. ha^{-1} and sulfoxaflor 50% WG at 90 g a.i. ha^{-1} as compared to other treatments. Overall, among the treatments, the highest reduction (47.6%) of the aphid population was observed in sulfoxaflor 50% WG at 100 g a.i. ha^{-1} followed by flonicamid 50% WG at 75 g a.i. ha^{-1} (42.8%) and sulfoxaflor 50% WG at 90 g a.i. ha^{-1} (42.8%) as compared to other treatments. These findings are supported by Gore et al. (2013) who reported that sulfoxaflor is likely going to be used as an alternative to other insecticides in the control of the cotton aphids, i.e., it is going to be widely present in agricultural lands in the coming years. Sulfoxaflor is extremely effective against many sap-feeding insects, including scales, aphids, leafhoppers and whiteflies according to Bedford et al. (1994). According to Morita et al. (2007), flonicamid was found very active against a wide range of aphid species and also effective against some other species of sucking insects. Flonicamid became available for use worldwide in 2005 and 2006 to control multiple aphid species on various crops (Morita et al., 2007). Flonicamid is a pyridine carboxamide that has a novel mode of action, acting via the nervous system, and eventual death is a result of starvation from a cessation of feeding that occurs immediately after exposure (Morita et al., 2007). Field research in cotton demonstrated good control of cotton aphid with flonicamid (Hancock, 2003).

Table 1: Bio-efficacy of Sulfoxaflor and other insecticides on the incidence of cotton aphids

Sl. No.	Treatments	Dose ha^{-1}		Number of aphids (6 leaves)$^{-1}$				% Reduction over control
		g a.i.	Formulation (g ml^{-1})	Pre treatment	1 Day after Spray	5 Days after Spray	10 Days after Spray	
1.	Sulfoxaflor 50% WG	75	150	2.0 (1.7)	2.8 (1.9)	2.5 (1.9)	3.0 (2.0)	28.6
2.	Sulfoxaflor 50% WG	90	180	2.3 (1.8)	3.2 (2.1)	2.3 (1.8)	2.4 (1.9)	42.8
3.	Sulfoxaflor 50% WG	100	200	2.0 (1.7)	2.1 (1.7)	1.7 (1.6)	2.2 (1.8)	47.6
4.	Flonicamid 50% WG	75	150	2.1 (1.8)	2.4 (1.8)	2.2 (1.8)	2.4 (1.8)	42.8
5.	Buprofezin 25% SC	250	1000	6.1 (2.6)	4.6 (2.4)	4.6 (2.4)	3.7 (2.2)	11.9
6.	Dinotefuran 20% SG	30	150	4.0 (2.2)	4.1 (2.3)	3.3 (2.1)	3.6 (2.1)	14.3
7	Untreated control	-	-	3.7 (2.1)	4.0 (2.2)	4.8 (2.4)	4.2 (2.3)	
	SEm±			0.2	0.1	0.1	0.0	
	CD (p=0.05)			NS	0.3	0.4	0.1	

Figures in parentheses are converted to $\sqrt{x+1}$

3.2. Efficacy of Sulfoxaflor and other insecticides against jassids

Regarding jassids, before spray treatments, the jassid population ranged from 4.0–5.9 (6 leaves)$^{-1}$ in insecticidal treatments. 1 day and 5 days after spray treatment, all insecticidal treatments recorded significantly less jassid population in comparison to control. Among these, flonicamid 50% WG at 75 g a.i. ha^{-1} recorded significantly less jassid population followed by sulfoxaflor 50% WG at 100 g a.i. ha^{-1} in comparison to remaining insecticidal treatments. 10 days after spray treatment, an increase in the jassid population was recorded in all treatments, but the jassid population was significantly less in insecticidal treatments in comparison to control. Flonicamid 50% WG at 75 g a.i. ha^{-1} recorded least jassid population followed by sulfoxaflor 50% WG at 100 g a.i. ha^{-1} as compared to other insecticidal treatments (Table 2). The highest reduction (61.0%) of jassid was observed in flonicamid 50% WG at 75 g a.i. ha^{-1} followed sulfoxaflor 50% WG at 90 g a.i. ha^{-1} (50.8%) as compared to other treatments. Similarly, in recent years, sulfoxaflor, flonicamid, chlorfenapyr, spirotetramat, fipronil, and nitenpyram insecticides are being used for the control of various sucking insect pests including *A. devastans* (Saeed et al., 2017).

3.3. Efficacy of Sulfoxaflor and other insecticides against thrips

Table 4 shows non-significant differences in thrips population in between treatments during the pre-spray counts and the mean thirps population ranged from 9.2–11.4 (6 leaves)$^{-1}$ in different insecticidal treatments and control. 1, 5 and 10 days after spray treatments all insecticidal treatments recorded significantly less thrips population in comparison to control. Amongst the treatments, sulfoxaflor 50% WG at 100 g a.i. ha^{-1} recorded minimum and significantly fewer thrips population in comparison to remaining treatments after 1, 5 and 10 days after treatments (Table 3). The highest reduction (30.2%) of thrips was observed in sulfoxaflor 50% WG at 100 g a.i. ha^{-1} followed by flonicamid 50% WG at 75 g a.i. ha^{-1} (19.8%) and sulfoxaflor 50% WG at 90 (19.8%) respectively, as compared to other treatments. Similarly, 3 rounds of foliar application of spinetoram 10% w/w WG+sulfoxaflor 30% w/w WG at 350 ml ha^{-1} and spinetoram 10% WG+sulfoxaflor 30% WG at 300 ml ha^{-1} were superior and effective in reducing the thrips damage on leaves and berries, which also recorded higher fruit yield and Cost-Benefit Ratio reported by Chinniah et al. (2019).

Table 2: Bio-efficacy of Sulfoxaflor and other insecticides on the incidence of cotton jassids

Sl. No.	Treatments	Dose ha^{-1}		No. of Jassids (6 leaves)$^{-1}$				% Reduction over control
		g a.i.	Formulation (g ml^{-1})	Pre treatment	1 Day after Spray	5 Days after Spray	10 Days after Spray	
1.	Sulfoxaflor 50% WG	75	150	5.1 (2.5)	3.6 (2.1)	2.8 (1.9)	3.8 (2.2)	35.6
2.	Sulfoxaflor 50% WG	90	180	4.3 (2.3)	3.5 (2.1)	2.6 (1.9)	3.4 (2.1)	42.4
3.	Sulfoxaflor 50% WG	100	200	4.5 (2.4)	2.6 (1.9)	1.9 (1.7)	2.9 (2.0)	50.8
4.	Flonicamid 50% WG	75	150	4.0 (2.2)	2.2 (1.8)	1.6 (1.6)	2.3 (1.8)	61.0
5.	Buprofezin 25% SC	250	1000	4.9 (2.4)	4.7 (2.4)	2.4 (1.8)	3.5 (2.1)	41.0
6.	Dinotefuran 20% SG	30	150	4.7 (2.4)	3.3 (2.1)	2.8 (2.0)	3.4 (2.1)	42.4
7	Untreated control	-	-	5.9 (2.6)	5.8 (2.6)	4.4 (2.3)	5.9 (2.6)	
	SEm±			0.1	0.1	0.1	0.0	
	CD (p=0.05)			0.2	0.2	0.2	0.1	

Figures in parentheses are converted to $\sqrt{x+1}$

3.4. Efficacy of Sulfoxaflor and other insecticides against whiteflies

Before spray treatments, the whitefly population ranged from 1.2–1.4 (6 leaves)$^{-1}$ in different insecticidal treatments and the control and the population did not differ significantly. Though the whitefly population was low during the experimentation, however the lowest population (1.5 (6 leaves)$^{-1}$) was recorded in sulfoxaflor 50% WG at 100 g a.i. ha^{-1} and flonicamid 50% WG at 75 g a.i. ha^{-1}, respectively followed by dinotefuran 20% SGat 150 g a.i. ha^{-1} (1.6 (6 leaves)$^{-1}$). 5 days after treatment, except dinotefuran, all insecticidal treatments recorded significantly less whitefly population in comparison to control. Amongst the treatments, sulfoxaflor 50% WG at 100 g a.i. ha^{-1} recorded lowest (1.5 (6 leaves)$^{-1}$) population followed by flonicamid 50% WG at 75 g a.i. ha^{-1} (1.6 (6 leaves)$^{-1}$) and buprofezin 25% SC at 250 g a.i. ha^{-1} (1.6 (6 leaves)$^{-1}$), respectively. 10 days after spray treatment, all insecticidal treatments recorded significantly less. whitefly population in comparison to control, but the lowest (1.8 (6 leaves)$^{-1}$) population was recorded in buprofezin 25% SC at 250 g a.i. ha^{-1} followed by dinotefuran 20% SG at 150 g a.i. ha^{-1} (2.0 per 6 leaves). The highest reduction (41.9%) of whitefly was observed in buprofezin 25% SC at 250 g a.i. ha^{-1} followed by dinotefuran 20% SG at 150 g a.i. ha^{-1} (35.5%) as compared to other treatments (Table 4). Similar findings were confirmed by Abhijit et al., 2018 reported that Buprofezin (thiadiazinone derivative) and sulfoxaflor were

Table 3: Bio-efficacy of Sulfoxaflor and other insecticides on the incidence of cotton thrips

Sl. No.	Treatments	Dose ha^{-1}		No. of thrips (6 leaves)$^{-1}$				% Reduction over control
		g a.i.	Formulation (g ml^{-1})	Pre treatment	1 Day after Spray	5 Days after Spray	10 Days after Spray	
1.	Sulfoxaflor 50% WG	75	150	9.4 (3.2)	4.3 (2.3)	11.1 (3.5)	7.9 (3.0)	17.7
2.	Sulfoxaflor 50% WG	90	180	11.4 (3.5)	3.7 (2.2)	5.0 (2.4)	7.7 (2.9)	19.8
3.	Sulfoxaflor 50% WG	100	200	11.2 (3.5)	3.1 (2.0)	3.2 (2.0)	6.7 (2.8)	30.2
4.	Flonicamid 50% WG	75	150	10.8 (3.4)	6.5 (2.7)	5.2 (2.5)	7.7 (2.9)	19.8
5.	Buprofezin 25% SC	250	1000	9.2 (3.2)	7.5 (2.9)	5.1 (2.5)	7.2 (2.9)	25.0
6.	Dinotefuran 20% SG	30	150	12.0 (3.6)	6.1 (2.7)	5.3 (2.5)	7.9 (3.0)	17.7
7	Untreated control	-	-	9.5 (3.2)	8.6 (3.1)	8.2 (3.0)	9.6 (3.3)	
	SEm±			0.1	0.1	0.1	0.1	
	CD (p=0.05)			NS	0.4	0.3	0.3	

Figures in parentheses are converted to $\sqrt{x+1}$

effective insecticides against whitefly at the recommended doses. Similarly, Sushila et al., 2015 reported that buprofezin 70% DF @ 300 g a.i. ha^{-1} proved to be the most effective chemical by registering lowest population of whitefly of 0.41 per leaf, followed by its next lower dosage of 250 g a.i. ha^{-1}. Similarly Gogi et al., 2021 pyriproxyfen and buprofezin were more effective than Methoxyfenozide and tebufenozide in reducing the whitefly population.

3.5. Impact of Sulfoxaflor and other insecticides against natural enemies

Table 5 shows non-significant differences in the natural enemy population in between treatments during pre-spray and post-spray. None of the insecticidal treatments has affected the abundance of the natural enemy population during both the years of study. Our results were comparable to the experiment described by Garzon et al. (2015) where sulfoxaflor was harmless to the third-instar larvae of *Chrysoperla carnea*.

Table 4: Bio-efficacy of Sulfoxaflor and other insecticides on the incidence of cotton whitefly

Sl. No.	Treatments	Dose ha^{-1}		No. of whitefly (6 leaves)$^{-1}$				% Reduction over control
		g a.i.	Formulation (g ml^{-1})	Pre treatment	1 Day after Spray	5 Days after Spray	10 Days after Spray	
1.	Sulfoxaflor 50% WG	75	150	1.4 (1.5)	2.2 (1.8)	1.9(1.7)	2.7 (1.9)	12.9
2.	Sulfoxaflor 50% WG	90	180	1.2 (1.5)	2.1 (1.8)	2.2 (1.8)	2.6 (1.9)	16.1
3.	Sulfoxaflor 50% WG	100	200	1.3 (1.5)	1.5 (1.6)	1.5 (1.6)	2.3 (1.8)	25.8
4.	Flonicamid 50% WG	75	150	1.2 (1.5)	1.5 (1.6)	1.6 (1.6)	2.1 (1.8)	32.2
5.	Buprofezin 25% SC	250	1000	1.3 (1.5)	1.7 (1.6)	1.6 (1.6)	1.8 (1.7)	41.9
6.	Dinotefuran 20% SG	30	150	1.2 (1.5)	1.6 (1.6)	2.0 (1.7)	2.0 (1.7)	35.5
7.	Untreated control	-	-	1.3 (1.5)	1.7 (1.6)	2.0 (1.7)	3.1 (2.0)	
	SEm±			0.0	0.0	0.0	0.1	
	CD (p=0.05)			NS	0.1	0.1	0.2	

Figures in parentheses are converted to $\sqrt{x+1}$

3.6. Efficacy of Sulfoxaflor and other insecticides on yield

In all the insecticidal treatments, the yield was found to be significantly more in comparison to control. Amongst the insecticidal treatments, sulfoxaflor 50% WG at 100 g a.i ha^{-1} recorded the highest (2240 kg ha^{-1}) seed cotton yield followed by flonicamid 50% WG at 75 g a.i. ha^{-1} (2207 kg ha^{-1}) and sulfoxaflor 50% WG at 90 g a.i ha^{-1} (2001 kg ha^{-1}) as compared to other treatments (Table 6). Similarly, the highest seed cotton yield (1414 kg ha^{-1}) as well as benefit cost ratio (1.02) was recorded in chlorpyriphos, flonicamid, emamectin benzoate, clothianidin, indoxacarb

Table 5: Impact of Sulfoxaflor and other insecticides on the abundance of natural enemies

Sl. No.	Treatments	Dose ha^{-1}		No. of natural enemies (5 plants)$^{-1}$							
		g a.i.	Formulation (g ml^{-1})	Pre treatment		1 Day after Spray		5 Days after Spray		10 Days after Spray	
				Spider	Coccinellid	Spider	Coccinellid	Spider	Coccinellid	Spider	Coccinellid
1.	Sulfoxaflor 50% WG	75	150	0.4 (1.2)	0.2 (1.1)	0.5 (1.2)	0.1 (1.1)	0.4 (1.2)	0.1 (1.0)	0.5 (1.2)	0.2 (1.1)
2.	Sulfoxaflor 50% WG	90	180	0.3 (1.1)	0.1 (1.1)	0.6 (1.2)	0.2 (1.1)	0.4 (1.2)	0.1 (1.0)	0.6 (1.3)	0.2 (1.1)
3.	Sulfoxaflor 50% WG	100	200	0.5 (1.2)	0.3 (1.1)	0.4 (1.2)	0.1 (1.0)	0.4 (1.2)	0.1 (1.0)	0.5 (1.2)	0.1 (1.0)
4.	Flonicamid 50% WG	75	150	0.4 (1.2)	0.2 (1.1)	0.3 (1.1)	0.1 (1.0)	0.4 (1.2)	0.1 (1.0)	0.5 (1.2)	0.1 (1.1)
5.	Buprofezin 25% SC	250	1000	0.5 (1.2)	0.2 (1.1)	0.4 (1.2)	0.1 (1.1)	0.4 (1.2)	0.1 (1.0)	0.6 (1.3)	0.2 (1.1)
6.	Dinotefuran 20% SG	30	150	0.5 (1.2)	0.2 (1.1)	0.4 (1.2)	0.1 (1.1)	0.5 (1.2)	0.1 (1.0)	0.5 (1.3)	0.1 (1.0)
7	Untreated control	-	-	0.4 (1.2)	0.2 (1.1)	0.3 (1.2)	0.1 (1.1)	0.4 (1.2)	0.2 (1.1)	0.6 (1.3)	0.1 (1.1)
SEm±				0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
CD (p=0.05)				NS	NS	NS	NS	NS	NS	NS	NS

Figures in parentheses are converted to √x+1

Table 6: Effect of Sulfoxaflor and other insecticides on cotton kapas yield

Sl. No.	Treatments	Dose ha^{-1}		Yield (kg ha^{-1})
		g a.i.	Formulation (g ml^{-1})	
1.	Sulfoxaflor 50% WG	75	150	1870
2.	Sulfoxaflor 50% WG	90	180	2001
3.	Sulfoxaflor 50% WG	100	200	2240
4.	Flonicamid 50% WG	75	150	2207
5.	Buprofezin 25% SC	250	1000	1681
6.	Dinotefuran 20% SG	30	150	1739
7	Untreated control	-	-	1432
	SEm±			108.5
	CD (p=0.05)			338

Figures in parentheses are converted to √x+1

+acetamiprid sequential spray reported by Prasad and Ashwini, 2021. Similarly, Lakshmanna et al. (2021) reported that Monocrotophos (36% SL) at 1.6 ml l^{-1} recorded highest yield (1376 kg ha^{-1}) which was on par with flonicamid (50% WDG) at 0.3 g l^{-1} and sulfoxaflor (75% WG) at 1.5 ml l^{-1} which recorded 1248 and 1235 kg ha^{-1}, respectively.

4. CONCLUSION

Sulfoxaflor at 100 g a.i ha^{-1} and flonicamid at 75 g a.i. ha^{-1} had shown good efficacy against sucking pests as compared to other treatments. These two insecticides going to be used as an alternative to other insecticides in the control of Cotton sucking pests as they are found to be safe to the natural enemy populations.

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