Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(5): 2288-2292

Received: 27-07-2020
Accepted: 30-08-2020

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Comparative efficacy of novel insecticide molecules against sucking pests in cotton

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DOI: https://doi.org/10.22271/j.ento.2020.v8.i5ae.7819

Abstract
A field trial was conducted to evaluate the efficacy of novel chemistry insecticides in managing the sucking pests of cotton during the year 2018 at Regional Agricultural Research station, Nandyal. Results revealed that new molecule Flonicmide @ 0.3 g/lit of water had registered lowest mean leafhopper population of 2.56 and 2.59/3 leaves after first and second sprays respectively followed by Difenthiuran@ 1.25 g, Sulfoxaflor@ 0.7 ml and Spinetoram@0.6 ml which registered 2.93, 3.12, and 3.90 leafhopper population per three leaves respectively after first spray. Same trend was noticed after second spray also. Highest yield of 2348 kg/ha was recorded in treatment Flonicmide @ 0.3 g/lit.

Keywords: Sucking pests, Novel insecticides, Resistance, Mode of action

Introduction
Cotton *Gossypium hirsutum* L. (Family: Malvaceae) is the most important commercial crop of India, which is subjected to the ravages of a number of insect pests. Sucking pests have become quite serious from seedling stage their heavy infestation at times reduces the crop yield to a great extent. The estimated loss due to sucking pests is up to 21.20% [1]. In India More than 90 per cent area is under Bt cotton which is susceptible to sucking pests [2, 3, 4]. Introduction of Bt cotton technology solved the bollworm problem but continuous cultivation of Bt cotton has at some places led to increased incidence of sucking and other pests in the recent years [5] Among the sap feeders aphids *Aphis gossypii* (Glover), leafhoppers *Amrasca biguttula biguttula* (Ishida), *Thrips Thrips*tabaci (Linn) and whitefly *Bemisia tabaci* are deadly pests. Cotton growers in India depend heavily on synthetic pesticides to combat sucking pests. At least 2-3 sprays are directed against sucking pests. Due to continuous and indiscriminate use of synthetic insecticides, there is resistance and hence the efficacy has become less reliable. To overcome this problem discovery of novel substances with different biochemical targets are needed. Novel molecules are effective at low doses and have less exposure in the environment. Old generation neonicotinoid insecticides like Imidaclopride, Acetamipride and Thiomethoxam managed sucking pests effectively when they were first introduced but after certain period of time sucking pests particularly leafhoppers developed manifold resistance to wards old generation neonicotinoids due to selection pressure of these insecticides. Bt cotton is highly vulnerable to sucking pests which spread throughout the growing season, as the biotic potential of these sucking pests are high they are potential threat to Bt cotton. Farmers generally use old generation molecules which are hazardous to mammals and ecosystem [6-12]. Although resistance to neonicotinoids was slow to develop, several insect pests including *Aphis gossypii* have been shown to possess a potential for resistance development. Neonicotinoids like Imidacloprid, Acetamiprid, and Thiomethoxam are not effective against cotton leafhopper at their recommended dosages and the pest had developed several fold resistance to these chemicals [13]. Hence the present study was taken up to evaluate the novel insecticide molecules against sucking pests in cotton.

Materials and Methods
A Field trial was conducted to evaluate the comparative efficacy of some of the novel molecules against sucking pests of cotton. The experiment was laid out in Randomized block design with ten treatments replicated thrice at Regional Research station, Nandyal during the kharif season of 2018. Jadoo B.G II cotton was sown during last week of July, spacing of 90x45cm was adopted between rows and plants respectively. Treatment size was 5x4 meters all the standard agronomic practices were adopted as prescribed by Agricultural University

except plant protection practices for sucking pests. A total of ten treatments were used in the experiment with a combination of old and new molecules, treatmental imposition of all the treatments were done i.e. first spray after sucking pests particularly leafhoppers crossing economic threshold level, pretreatment observations of all sucking pests were recorded a day before the imposition of treatments. Post treatmental data on sucking pests were recorded at 1, 3, 5,7 and10 days after first spray. Data was recorded on five tagged plants in each treatment, sucking pests count was recorded on upper, middle and lower leaves of the plant. Second spray was done at an interval of fifteen days of first spray, similarly pre treatment and post treatment data was recorded after second spray also. Seed cotton yield was recorded at the time of last picking, all the data was subjected to statistical analysis for comparison of treatments.

Results

The leafhoppers population ranged from 2.60 to 8.60 leafhoppers/ 3 leaves at a day after spray. The lowest leafhoppers population of 2.60 leafhoppers/ 3 leaves was recorded in Flonicamid @ 0.3 g/ l which was on par with Diafenthiuron @ 1.25 g / l which recorded 3.87 leafhoppers/ 3 leaves. The next best treatments were Acephate @ 1.5 g, Sulfoxaflor @ 0.7 g, Thiamethoxam @ 0.2 g, Spinetoram @ 0.6 ml and Fipronil @ 2 ml/l which recorded 4.40, 4.53, 4.67, 4.80 and 5.60 leafhoppers/ 3 leaves, respectively. However, the highest leafhopper population of 8.60 leafhoppers/ 3 leaves was recorded in water spray. (Table:1)

The lowest leafhopper population of 1.67 was recorded in Flonicamid @ 0.3 g/l which was on par with Fipronil @ 2 ml, Sulfoxaflor @ 0.7 g and Diafenthiuron @ 1.25 g/ l which recorded 1.73, 2.33 and 2.60 leafhoppers/ 3 leaves, respectively. These treatments were followed by Thiamethoxam @ 0.2 g, Acephate @ 1.5 g and Spinetoram @ 0.6 ml/l which recorded 3.47, 3.47 and 3.93 leafhoppers / 3 leaves, respectively and were on par with each other at 3 DAS. The highest leafhopper population was recorded in water spray (8.40 leafhoppers / 3 leaves) at 3 DAS. (Table:1)

At 5 DAS, the treatment Flonicamid @ 0.3g/ l has recorded the lowest leafhoppers population (1.60 leafhoppers/ 3 leaves) which was on par with Sulfoxaflor @ 0.7 g, Diafenthiuron @ 1.25 g, Fipronil @ 2 ml and Spinetoram @ 0.6 ml/l which registered 2.27, 2.47, 2.53 and 2.73 leafhoppers / 3 leaves. Thiamethoxam @ 0.2 g, Acephate @ 1.5 g, Pyriproxyfen @ 1.5 ml and Fenpropathrin @ 1.5 ml/l followed the best treatment by recording 3.27, 3.40, 3.60 and 4.80 leafhoppers / 3 leaves and were on par with each other. The highest leafhoppers population was recorded in water spray i.e. 6.53 leafhoppers/ 3 leaves. (Table:1)

The lowest leafhopper population of 0.60 was recorded in Diafenthiuron @ 1.25 g/l at 7 DAS which was on par with Flonicamid @ 0.3 g, Sulfoxaflor @ 0.7 g and Spinetoram @ 0.6 ml/l which recorded 0.87, 1.60 and 2.87 leafhoppers/ 3 leaves, respectively. However, the highest leafhoppers population was recorded in water spray i.e. 7.80 leafhoppers/ 3 leaves. (Table:1)

At 9 DAS, the lowest leafhopper population of 1.53 leafhoppers / 3 leaves was recorded in Flonicamid @ 0.3 g / l which was on par with Sulfoxaflor @ 0.7 g, Diafenthiuron @ 1.25 g and Fenpropathrin @ 1.5 ml/l which recorded 1.73, 1.67 and 2.67 leafhoppers/ 3 leaves, respectively. Spinetoram @ 0.6 ml/l was the next best treatment which recorded 3.07 leafhoppers / 3leaves which was on par with Fipronil @ 2.0 ml, Acephate @ 1.5 g and Thiamethoxam @ 0.2 g/l which recorded 4.07, 4.67 and 4.87 leafhoppers/ 3 leaves, respectively and were on par with each other at 9 DAS. However, the highest leafhoppers population was recorded in water spray (8.20 leafhoppers/ 3 leaves). (Table:1)

Flonicamid @ 0.3 g/l emerged as the best treatment at 10 DAS by recording 2.27 leafhoppers / 3 leaves which was on par with Sulfoxaflor @ 0.7 g, Diafenthiuron @ 1.25 g and Spinetoram @ 0.6 ml/l which recorded 2.60, 3.00 and 3.47 leafhoppers/ 3 leaves, respectively. The next best treatments were Fenpropathrin @ 1.5 ml, Fipronil @ 2.0 ml, and Acephate @ 1.5 g, Pyriproxyfen @ 1.5 ml and Thiamethoxam @ 0.2 g/l which recorded 4.60, 4.73, 5.20, 5.33 and 5.60 leafhoppers / 3 leaves, respectively and were on par with each other. (Table:1)

The mean leafhopper population after 1st spray revealed that the lowest leafhoppers population was recorded in Flonicamid (2.56 leafhoppers/ 3 leaves) followed by Diafenthiuron and Sulfoxaflor which recorded 2.93 and 3.12 leafhoppers / 3 leaves, respectively. (Table:3)

2nd Spray

The leafhoppers population ranged from 2.13 to 7.13 leafhoppers/ 3 leaves at a day after spray. The lowest leafhoppers population of 2.13 leafhoppers/ 3 leaves was recorded in Diafenthiuron @ 1.25 g/l which was on par with Flonicamid @ 0.3 g and Sulfoxaflor @ 0.7 g /l which recorded 2.27 and leafhoppers/ 3 leaves, respectively. The next best treatments were acephate @ 1.5 g, Spinetoram @ 0.6 ml, Thiamethoxam @ 0.2 g, Fipronil @ 2 ml and Pyriproxyfen @ 1.5 ml/l which recorded 3.80, 4.00, 4.07, 5.27 and 5.53 leafhoppers/ 3 leaves, respectively. However, the highest leafhopper population of 7.13 leafhoppers/ 3 leaves was recorded in water spray. (Table:2)

The lowest leafhopper population of 1.87 was recorded in Diafenthiuron @ 1.25 g/l which was on par with Flonicamid @ 0.3 g/l and Acephate @ 1.5 g/l which recorded 2.00, and 2.73 leafhoppers/ 3 leaves, respectively. These treatments were followed by Sulfoxaflor @ 0.7 g, Thiamethoxam @ 0.2 g, Spinetoram @ 0.6 ml and Fipronil @ 2 ml/l which recorded 3.13, 3.47, 3.73 and 4.13 leafhoppers/ 3 leaves, respectively and were on par with each other.. The highest leafhopper population was recorded in water spray (6.87 leafhoppers / 3 leaves) at 3 DAS. (Table:2)

At 5 DAS, the treatment Flonicamid @ 0.3g/ l has recorded the lowest leafhoppers population of 1.67 leafhoppers/ 3 leaves which was on par with Diafenthiuron @ 1.25 g, Thiamethoxam @ 0.2 g, Acephate @ 1.5 g, Sulfoxaflor @ 0.7 g and Spinetoram @ 0.6 ml/l which registered 1.93, 2.40, 2.47, 2.53 and 2.73 leafhoppers / 3 leaves, respectively. Fipronil @ 2ml and Pyriproxyfen @ 1.5 ml/l followed the best treatment by recording 3.40 and 4.13 leafhoppers / 3 leaves, respectively and were on par with each other. (Table:2)

The lowest leafhopper population of 1.53 was recorded in sulfoxaflor @ 0.7 g/l which was on par with almost all the treatments except fenpropathrin and water spray at 7DAS. At 9 DAS, the same trend has been observed as that observed at 7 DAS. (Table:2)

The mean leafhopper population after 2nd spray revealed that the lowest leafhoppers population was recorded in Diafenthiuron i.e. 2.81 leafhoppers/ 3 leaves followed by Flonicamid, Sulfoxaflor and Acephate which recorded 2.89, 3.35 and 3.53 leafhoppers / 3 leaves, respectively. (Table:3)

Yield

The highest yield of 2348 kg/ha was recorded in the treatment Flonicmid@ 0.3g/lit of water which was on par with Fipronil and Sulfoxaflor which recorded 2160 and 2130 kg/ha of seed cotton yield, respectively. (Table:3)

Table 1: Comparative Efficacy of different novel insecticides against leafhoppers in cotton after First spray

Chemical	Dose (g or ml / l)	1DBS	1DAS	3DAS	5DAS	7DAS	9DAS	10DAS	MEAN
Sulfoxaflor	0.7	6.80	4.53	2.33	2.27	1.60	1.73	2.60	3.12
		(2.69)	(2.24)	(1.68)	(1.65)	(1.40)	(1.45)	(1.76)	
Spinetoram	0.6	6.40	4.80	3.93	2.73	2.87	3.07	3.47	3.90
		(2.62)	(2.30)	(2.08)	(1.78)	(1.72)	(1.87)	(1.97)	
Pyriproxyfen	1.5	7.40	7.53	5.60	3.60	4.80	5.07	5.33	5.62
		(2.79)	(2.83)	(2.46)	(2.02)	(2.30)	(2.35)	(2.41)	
Fenpropathrin	1.5	6.60	7.13	5.80	4.80	7.13	2.67	4.60	5.53
		(2.66)	(2.76)	(2.51)	(2.29)	(2.75)	(1.76)	(2.24)	
Flonicamid	0.3	7.40	2.60	1.67	1.60	0.87	1.53	2.27	2.56
		(2.80)	(1.76)	(1.47)	(1.45)	(1.14)	(1.41)	(1.65)	
Thiamethoxam	0.2	7.80	4.67	3.47	3.27	4.00	4.87	5.60	4.81
		(2.86)	(2.27)	(1.95)	(1.94)	(2.12)	(2.31)	(2.47)	
Diafenthiuron	1.25	6.33	3.87	2.60	2.47	0.60	1.67	3.00	2.93
		(2.60)	(2.06)	(1.76)	(1.72)	(1.04)	(1.47)	(1.87)	
Acephate	1.5	6.60	4.40	3.47	3.40	4.20	4.67	5.20	4.56
		(2.66)	(2.21)	(1.97)	(1.97)	(2.11)	(2.27)	(2.38)	
Fipronil	2.0	8.07	5.60	1.73	2.53	3.53	4.07	4.73	4.32
		(2.91)	(2.46)	(1.49)	(1.73)	(1.95)	(2.13)	(2.28)	
Water spray	-	9.40	8.60	8.40	6.53	7.80	8.20	8.27	8.17
		(3.13)	(3.01)	(2.98)	(2.64)	(2.88)	(2.94)	(2.96)	
F-test		NS	S	S	S	**S**	**S**	**S**	
SEm±		0.19	0.14	0.16	0.12	0.24	0.15	0.13	
CD(P=0.05)		0.57	0.41	0.47	0.37	0.71	0.44	0.39	
CV (%)		11.91	10.00	13.42	11.24	21.20	12.71	10.33	

DBS: Day before spray
DAS: Days after spraying
* Figures in parentheses are square root (x+0.5) transformed values

Table 2: Comparative Efficacy of novel insecticides against leafhoppers in cotton (Second spray)

Chemical	Dose (g or ml / l)	1DBS	1DAS	3DAS	5DAS	7DAS	9DAS	10DAS	MEAN
Sulfoxaflor	0.7	7.47	3.33	3.13	2.53	1.53	2.20	3.27	3.35
		(2.80)	(1.96)	(1.90)	(1.74)	(1.42)	(1.61)	(1.92)	
Spinetoram	0.6	6.87	4.00	3.73	2.73	2.20	2.87	3.47	3.70
		(2.71)	(2.12)	(2.05)	(1.76)	(1.64)	(1.83)	(1.97)	
Pyriproxyfen	1.5	7.73	5.53	5.80	4.13	2.53	2.40	3.33	4.50
		(2.85)	(2.45)	(2.49)	(2.15)	(1.71)	(1.70)	(1.93)	
Fenpropathrin	1.5	6.93	6.27	6.47	6.73	6.73	6.67	4.60	6.34
		(2.72)	(2.59)	(2.64)	(2.69)	(2.68)	(2.67)	(2.24)	
Flonicamid	0.3	7.73	2.27	2.00	1.67	2.20	2.73	1.60	2.89
		(2.86)	(1.66)	(1.58)	(1.47)	(1.63)	(1.79)	(1.41)	
Thiamethoxam	0.2	8.13	4.07	3.47	2.40	2.27	2.53	2.93	3.69
		(2.92)	(2.13)	(1.98)	(1.70)	(1.66)	(1.74)	(1.85)	
Diafenthiuron	1.25	6.67	2.13	1.87	1.93	1.80	2.27	3.00	2.81
		(2.67)	(1.62)	(1.53)	(1.56)	(1.52)	(1.65)	(1.87)	
Acephate	1.5	7.27	3.80	2.73	2.47	2.33	2.93	3.20	3.53
		(2.78)	(2.07)	(1.79)	(1.70)	(1.68)	(1.85)	(1.91)	
Fipronil	2.0	8.73	5.27	4.13	3.40	2.33	2.80	2.07	4.10
		(3.03)	(2.40)	(2.14)	(1.97)	(1.66)	(1.81)	(1.57)	
Water spray	-	10.07	7.13	6.87	6.47	7.00	6.13	2.27	6.56
		(3.24)	(2.76)	(2.71)	(2.64)	(2.74)	(2.56)	(1.66)	
F-test		NS	S	S	S	S	S	NS	
SEm±		0.18	0.15	0.12	0.12	0.13	0.13	0.17	
CD(P=0.05)		NS	0.44	0.32	0.37	0.38	0.38	NS	
CV (%)		10.74	11.76	10.23	11.10	12.01	11.50	15.92	

DBS: Day before spray
DAS: Days after spraying
* Figures in parentheses are square root (x+0.5) transformed value

Table 3: Comparative Efficacy of different novel insecticides on yield of cotton

Chemical	Dose(g or ml/ l)	Mean leafhoppers population / 3 leaves		Seed cotton Yield (Kg/ha)
		1st spray	2nd spray	
Sulfoxaflor	0.7	3.12	3.35	2130
Spinetoram	0.6	3.90	3.70	1672
Pyriproxyfen	1.5	5.62	4.50	1663
Fenpropathrin	1.5	5.53	6.34	1738
Flonicamid	0.3	2.56	2.89	2348
Thiamethoxam	0.2	4.81	3.69	1390
Diafenthiuron	1.25	2.93	2.81	1652
Acephate	1.5	4.56	3.53	1931
Fipronil	2.0	4.32	4.10	2160
Water spray	-	8.17	6.56	1313
F-test				S
SEm±				154.54
CD(P=0.05)				459
CV (%)				14.87

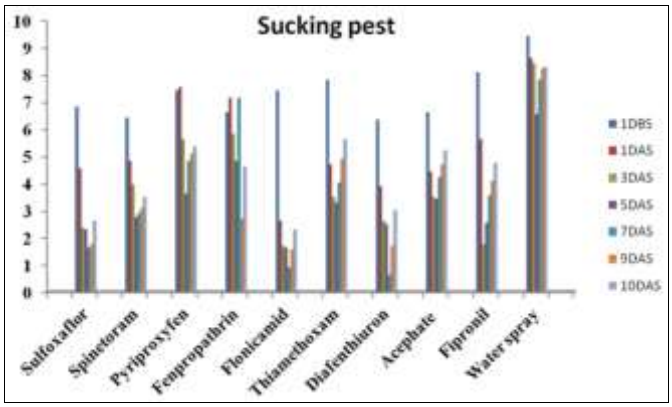

Fig 1: Comparative efficacy of novel insecticides against sucking pests after 1st spray.

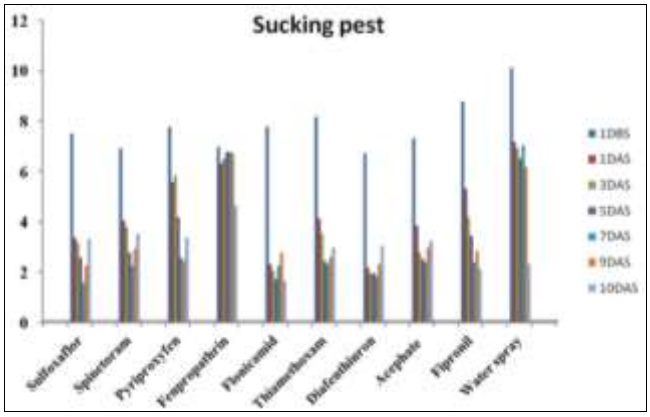

Fig 2: Comparative efficacy of novel insecticides against sucking pests after 2nd spray.

Discussion

The above results were in corroboration with the results of Kadam *et al*. in 2014 who studied the bioefficacy of newer neonicotinoids against sucking pests of Bt cotton. The results revealed that significantly lowest population of sucking pests was recorded in Nitepyram 10 WSG @ 100 g a.i. ha-1, Dinotefuron 20 % SG @ 50 g a.i ha and Clothianidin 50 % WDG @ 20 g a.i. ha-1 as compare to Acetameprid 20 SP @ 20 g a.i. ha-1, Imidacloprid 17.8 SL @ 25 g a.i. ha-1 and Thiamethoxam 25 % WS @ 25 g a.i. ha-1 [14]. Ghelani *et al*. in 2014 evaluated ten insecticides against major sucking pests infesting the Bt cotton, They observed that among the insecticides, tested Flonicamid 0.02 per cent was found more effective against all major sucking pests [15]. Sulfoxaflor exhibits a high degree of efficacy against a wide range of sap-feeding insects, including those resistant to neonicotinoids and other insecticides. Sulfoxaflor is an agonist at insect nicotinic acetylcholine receptors (nAChRs) and functions in a manner distinct from other insecticides acting at nAChRs. The sulfoximines also exhibit structure activity relationships (SAR) that are different from other nAChR agonists such as the neonicotinoids. Sulfoxaflor is extremely effective against many sap-feeding insects, including scales, aphids, leafhoppers and whiteflies according to Bedford *et al.*, 1994 [16]. According to Morita, M. etal flonicamid found very active against wide range of aphid species and also effective against some other species of sucking insects [17].

Conclusion

Novel insecticide molecules like Flonicmide, Sulfoxaflor, and Spinetoram are very effective against sucking pests of cotton and also they are relatively safer to environment. These insecticides can be conveniently used for sucking pests which are resistance to neonicotinoid insecticides.

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