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Efficacy of novel insecticides and their combinations against leafhoppers and pink bollworm in cotton in Scarce rainfall zone of Andhra Pradesh

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Abstract
Field experiment conducted at Regional Agricultural Research Station, Nandyal during Kharif, 2016-17 to evaluate the efficacy of individual and combination of chemicals i.e., Spinetoram, Sulfoxaflor, Pyriproxyfen, fenpropathrin along with standard check and untreated control against leafhoppers and pink bollworm revealed that Spinetoram 10% + Sulfoxaflor 30% WG @ 350 ml/ha, Spinetoram 10% + Sulfoxaflor 30% WG @ 300 ml/ha, Spinetoram @ 300 ml/ha and Sulfoxaflor @ 300 ml/ha were effective in reducing the leafhopper population in cotton whereas Spinetoram 10% + Sulfoxaflor 30% WG @ 350 ml/ha, pyriproxyfen @ 750 ml/ha and Sulfoxaflor @ 300 ml/ha were found effective in reducing the pink bollworm damage in green bolls along with highest yield.

Keywords: Cotton, sucking pests, bollworms, chemicals, spinetoram, sulfoxaflor

Introduction
Cotton (*Gossypium hirsutum* L.), popularly known as "white gold" is an important fibre and cash crop of India having global significance. It provides 65% raw material to textile industry and contributed 1/3rd of foreign exchange earning of India [1] Cotton production in India during 2018-19 was 36.1 million bales of 170 kg each from an area of 12.24 million hectares with a productivity of 501 kg lint /ha. Cotton being a long duration and succulent crop, it is infested by a number of insect pests throughout its growth period. In India, about 162 insect pest species attack cotton crop from sowing to harvesting and causes yield loss up to 50-60 per cent [2]. The insect pests of cotton can be primarily divided into two groups as sucking pests and bollworms. Aphid (*Aphis gossypii* Glover), jassids (*Amrasca biguttula biguttula* Ishida), thrips (*Thrips tabaci* Lind.) and whitefly (*Bemisia tabaci* Genn.) are the major sucking pests of cotton. These sucking pests are noticed at all the stages of crop growth and responsible for direct and indirect yield losses. A reduction of 22.85 per cent in seed cotton yield due to sucking pests has been reported by [3, 4]. According to [5], Bt cotton succumb to yield loss due to sucking pests such as leafhoppers, aphids, thrips and whitefly, etc. Regular and indiscriminate use of insecticides and the misuse of synthetic pesticides on the crop have led to development of insecticide resistance in target pests, pest resurgence and secondary pest outbreaks, loss of bio-diversity, environmental pollution and residual toxicity and occurrence of human health hazards. However, in present day context chemical control has its own popularity over the other methods of pest control due to its immediate action and remarkable pest control. Crop protection with need based use of safer insecticides is considered as an effective and dependable component of IPM and one of the most important aspects of agro-ecosystem management with regards to the ecological and socio-economic values.

In this context, some newer group of insecticides alone or in combination at recommended dose are used for bringing about effective pest management of cotton. Keeping this in view, the present study was carried out to find the most effective new molecules of insecticides against sucking pests in cotton.

Materials and Methods
The experiment was conducted during *Kharif*, 2016-17 on Black vertisols under All India Coordinated Research Project on Cotton at the Regional Agricultural Research Station,

Nandyal, Kurnool District, Andhra Pradesh . The experiment was laid out in Randomized Block Design with eleven treatments in three replications. Eleven treatments at their formulation doses *viz.* Spinetoram 10% + Sulfoxaflor 30% WG @ 300 ml/ha (formulation), Spinetoram 10% + Sulfoxaflor 30% WG @ 350 ml/ha, Spinetoram 10% SC @ 300 ml/ha, Sulfoxaflor 30% SC @ 300 ml/ha, Spinetoram 10% SC @ 350 ml/ha, Sulfoxaflor 30% SC @ 350 ml/ha, Pyriproxyfen 5% EC + Fenpropathrin 15% EC @ 37.5 + 112.5 @750 ml/ha, Pyriproxyfen 5% EC @ 750 ml/ha, Fenpropathrin 15% EC @ 750 ml/ha, Water spray and Control (No spray) were evaluated against insect pests of cotton. The sowing was done by hand dibbling with untreated seeds of cotton variety Suraj by placing two seeds/hill with a spacing of 60 cm x 30 cm on 2nd July, 2016. Chemical fertilizers were applied @ 120:60:60 kg N: P2O5: K2O/ha. Gap filling was done within 5-10 days after emergence of the crop and thinning was carried out at 15 days after emergence of the crop keeping one healthy seedling per mount. Intercultural and weeding operations were carried out as needed. Two sprays of insecticides were done, first spray at economic threshold level (ETL) of pests and subsequent sprays at 10 days interval. During the period of experimentation jassid appeared as the major sucking pest and the remaining sucking pests were recorded below ETLs and among the bollworms, pink bollworm has only appeared in the season. The observations on incidence of sucking pests like jassids and thrips were recorded by visual count from three leaves (each from top, middle and bottom) of five plants in each plot at a day before spraying (DBS), 1, 3, 5, 7 and 10 days after spraying (DAS) . With respect to bollworms, population of pink bollworm was recorded on green boll basis (destructive sampling) on 20 randomly selected green bolls per plot and the damage was converted into percentage basis. The plot yield in each treatment was recorded and expressed in kg/ha. The data recorded was suitably transformed and analyzed using the statistical procedures [6].

Results

During first spray

At a day before the treatment imposition, there was no significant difference between the treatments with respect to leafhopper population. At a day after first spray, the lowest leafhopper population was recorded in spinetoram + sulfoxaflor @ 350 ml/ha which recorded 1.33 leafhoppers/ 3 leaves which was on par with sulfoxaflor 30% @ 435 ml/ha, spinetoram + sulfoxaflor @ 300 ml/ha, sulfoxaflor30%@ 375 ml/ha , and pyriproxyfen+fenpropathrin @ 750 ml/ha which recorded 1.73, 1.80, 2.67 and 2.80 leafhoppers/ 3 leaves, respectively. The highest leafhoppers population of 7.53 leafhoppers/ 3 leaves was recorded in control (water spray) (Table 1).

The treatment spinetoram + sulfoxaflor @ 350 ml/ha has recorded the lowest leafhopper population of 2.80 leafhoppers/ 3 leaves and 2.93 leafhoppers/ 3 leaves at 3rd and 5th day after spraying and was on par with almost all other treatments except control (both water spray and unsprayed). However, the treatment spinetoram 10% @ 350 ml/ha followed the best treatment by recording 5.53leafhoppers/ 3 leaves which was on par with rest of the treatments at 5th Day after spraying.

The treatment spinetoram + sulfoxaflor @ 350 ml/ha has recorded the lowest leafhopper population of 3.47 leafhoppers/ 3 leaves which was on par with sulfoxaflor @ 350 ml/ha , sulfoxaflor @ 300 ml/ha, spinetoram + sulfoxaflor @ 300 ml/ha, spinetoram @ 350 ml/ha and pyriproxyfen 5% EC + fenpropathrin 15% EC @ 750 ml/ha which recorded 3.80, 4.13, 4.53 5.33 and 5.60 leafhoppers/ 3 leaves, respectively at 7days after spray.

At 9 DAS, the lowest leafhopper population of 4.13 leafhoppers/ 3 leaves was recorded in sulfoxaflor @ 350 ml/ha which was on par with almost all the treatments except spinetoram @ 350 ml/ha and control (both untreated and water sprayed) whereas at 10 DAS, lowest leafhopper population of 4.20 leafhoppers/ 3 leaves was recorded in spinetoram + sulfoxaflor @ 350 ml/ha which was on par with almost all the treatments except spinetoram + sulfoxaflor @ 350 ml/ha and control (both untreated and water sprayed) (Table 1).

During second spray

At a day before the treatment imposition, there was no significant difference between the treatments with respect to leafhopper population.

At a day after first spray and at 3 DAS, the lowest leafhopper population was recorded in pyriproxyfen 5% EC + fenpropathrin 15% EC @ 350 ml/ha which recorded 2.13 leafhoppers/ 3 leaves which was on par with majority of the treatments except fenpropathrin 15% EC @ 750 ml/ha and control (both untreated and water spray) (Table 2). At 5 DAS, the treatment spinetoram + sulfoxaflor @ 350 ml/ha has recorded the lowest leafhopper population of 3.47 leafhoppers/ 3 leaves which was on par with majority of the treatments except control (both untreated and water spray).

At 7 and 9 DAS, the same trend has been observed as that at 5 DAS. At 10 DAS, lowest leafhopper population of 2.47 leafhoppers/ 3 leaves was recorded in spinetoram @ 350 ml/ha which was on par with spinetoram + sulfoxaflor @ 350 ml/ha and sulfoxaflor @ 300 ml/ha which recorded 4.40 and 4.80 leafhoppers/ 3 leaves, respectively(Table 2).

Table 1: Efficacy of different insecticidal treatments against cotton leafhoppers during first Spray

Treatment	Formulation /ha	No. of leafhoppers/. 3 leaves (first spray)						
		1DBS	1DAS	3DAS	5DAS	7DAS	9DAS	10 DAS
Spinetoram + Sulfoxaflor	300	7.60	1.80	3.27	3.40	4.53	5.20	5.53
		(2.82)*	(1.52)*	(1.92)*	(1.94)*	(2.23)*	(2.37)*	(2.43)*
Spinetoram + Sulfoxaflor	350	8.87	1.33	2.80	2.93	3.47	4.13	4.20
		(3.04)	(1.35)	(1.80)	(1.84)	(1.97)	(2.14)	(2.15)
Spinetoram	300	8.80	3.47	4.87	5.00	5.33	6.00	6.40
		(3.03)	(1.98)	(2.30)	(2.34)	(2.40)	(2.53)	(2.60)
Sulfoxaflor	300	7.00	2.67	3.07	3.53	4.13	4.47	4.80
		(2.73)	(1.78)	(1.87)	(2.00)	(2.13)	(2.21)	(2.28)
Spinetoram	350	8.40	4.40	4.87	5.53	6.07	6.73	7.07
		(2.98)	(2.20)	(2.31)	(2.44)	(2.55)	(2.68)	(2.74)
Sulfoxaflor	350	5.80	1.73	2.87	3.27	3.80	4.13	4.33

		(2.50)	(1.47)	(1.81)	(1.93)	(2.06)	(2.13)	(2.19)
Pyriproxyfen+fenpropathrin	750	6.27	2.80	3.87	5.53	5.60	6.27	6.47
		(2.60)	(1.75)	(2.06)	(2.44)	(2.46)	(2.60)	(2.62)
Pyriproxyfen	750	7.00	3.60	3.73	5.13	6.00	6.33	6.80
		(2.72)	(2.02)	(2.06)	(2.36)	(2.54)	(2.61)	(2.70)
fenpropathrin	750	6.47	3.47	4.80	5.27	6.07	6.40	6.73
		(2.62)	(1.98)	(2.29)	(2.38)	(2.56)	(2.62)	(2.68)
Control (unsprayed)	-	6.47	6.60	6.53	7.00	6.73	7.07	8.13
		(2.63)	(2.66)	(2.64)	(2.73)	(2.68)	(2.74)	(2.92)
Control (water spray)	-	8.27	7.53	7.33	8.07	8.33	8.67	8.93
		(2.95)	(2.83)	(2.79)	(2.92)	(2.96)	(3.02)	(3.06)
F-Test		NS	S	S	S	S	S	S
SEm (±)		0.20	0.15	0.18	0.19	0.18	0.18	0.18
CD (p=0.05)		0.58	0.45	0.55	0.55	0.53	0.53	0.54
CV(%)		12.15	13.44	14.77	14.15	12.98	12.32	12.18

*Figures in parentheses are √(x+0.5) transformed values

Table 2: Efficacy of different insecticidal treatments against cotton leafhoppers during second Spray

Treatment	Formulation/ha	No. of leafhoppers/. 3 leaves (second spray)						
		1DBS	1DAS	3DAS	5DAS	7DAS	9DAS	10 DAS
Spinetoram + Sulfoxaflor	300	8.33	3.67	3.93	4.27	4.80	4.93	5.73
		(2.95)*	(2.02)*	(2.10)*	(2.18)*	(2.29)*	(2.31)*	(2.49)*
Spinetoram + Sulfoxaflor	350	10.20	2.80	3.27	3.47	3.93	4.07	4.40
		(3.25)	(1.78)	(1.92)	(1.97)	(2.10)	(2.11)	(2.20)
Spinetoram	300	9.80	3.87	4.33	5.07	5.73	5.80	6.27
		(3.20)	(2.08)	(2.17)	(2.35)	(2.49)	(2.51)	(2.59)
Sulfoxaflor	300	7.93	3.33	3.93	4.07	4.27	4.60	4.80
		(2.89)	(1.95)	(2.10)	(2.12)	(2.15)	(2.24)	(2.27)
Spinetoram	350	9.40	3.53	4.00	4.73	5.27	6.27	2.47
		(3.14)	(2.00)	(2.10)	(2.26)	(2.39)	(2.59)	(1.71)
Sulfoxaflor	350	5.80	3.47	3.87	3.93	4.47	5.07	5.73
		(2.49)	(1.97)	(2.07)	(2.06)	(2.20)	(2.35)	(2.47)
Pyriproxyfen+fenpropathrin	750	6.93	2.13	3.00	4.40	5.40	5.73	6.00
		(2.71)	(1.62)	(1.86)	(2.21)	(2.41)	(2.48)	(2.52)
Pyriproxyfen	750	8.00	3.60	4.07	4.53	5.00	5.33	5.73
		(2.90)	(2.00)	(2.12)	(2.23)	(2.33)	(2.39)	(2.49)
fenpropathrin	750	7.13	4.60	5.13	5.33	5.60	6.20	6.87
		(2.75)	(2.24)	(2.36)	(2.41)	(2.46)	(2.57)	(2.71)
Control (unsprayed)	-	6.80	7.20	7.07	7.80	8.40	9.47	9.07
		(2.68)	(2.77)	(2.74)	(2.86)	(2.97)	(3.14)	(3.07)
Control (water spray)	-	9.27	7.60	7.40	8.00	8.73	9.33	9.40
		(3.11)	(2.83)	(2.81)	(2.91)	(3.03)	(3.12)	(3.12)
F-Test		NS	S	S	S	S	S	S
SEm (±)		0.20	0.17	0.16	0.19	0.20	0.21	0.20
CD (p=0.05)		NS	0.50	0.48	0.57	0.58	0.63	0.59
CV(%)		12.06	13.74	12.83	14.41	13.98	14.55	13.69

*Figures in parentheses are √(x+0.5) transformed values

Table 3: Efficacy of different insecticidal treatments against green boll damage by pink bollworm in coton

Treatment	Formulation/ha	Green Boll damage by PBW			Yield (kg/ha)
		90 DAS	110 DAS	130DAS	
Spinetoram + Sulfoxaflor	300	19.00	27.33	42.33	4481
		(25.79)*	(31.42)*	(40.54)*	
Spinetoram + Sulfoxaflor	350	9.00	16.00	26.67	5985
		(17.45)	(23.48)	(31.01)	
Spinetoram	300	25.00	34.67	51.33	3859
		(29.94)	(35.87)	(45.80)	
Sulfoxaflor	300	14.00	17.33	27.33	4585
		(21.77)	(24.48)	(31.48)	
Spinetoram	350	26.67	40.00	53.33	3944
		(30.80)	(39.17)	(46.95)	
Sulfoxaflor	350	24.67	31.33	44.67	4459
		(28.87)	(33.09)	(41.95)	
Pyriproxyfen+fenpropathrin	750	26.00	39.33	56.00	3844
		(30.59)	(38.79)	(48.54)	
Pyriproxyfen	750	13.33	28.00	43.00	4411
		(21.35)	(31.73)	(40.95)	

fenpropathrin	750	28.00 (31.73)	44.67 (41.95)	66.33 (54.85)	3333
Control (unsprayed)	-	42.67 (40.71)	59.33 (50.79)	72.67 (58.62)	3281
Control (water spray)	-	39.67 (38.94)	61.33 (51.6)	78.00 (62.60)	3296
F-Test		S	S	S	S
SEm (±)		3.52	3.60	3.44	440.75
CD (p=0.05)		10.39	10.63	10.14	1300.22
CV(%)		21.12	17.06	13.01	18.46

Figures in parentheses are arc-sin transformed values

Green boll damage

At 90 days after sowing, the treatment spinetoram + sulfoxaflor @ 350 ml/ha has recorded the lowest green boll damage of 9.00% which was on par with Pyriproxyfen @ 750 ml/ha, sulfoxaflor@ 300 ml/ha and spinetoram + sulfoxaflor @ 300 ml/ha which recorded 13.33, 14.00 and 19.00% green boll damage, respectively.

The treatment spinetoram + sulfoxaflor @ 350 ml/ha has recorded the lowest green boll damage of 16.00% which was on par with sulfoxaflor @ 300 ml/ha, spinetoram + sulfoxaflor @ 300 ml/ha and sulfoxaflor @ 350 ml/ha which recorded 17.33, 27.33 and 31.33% green boll damage, respectively at 110 days after sowing.

At 130 days after sowing, spinetoram + sulfoxaflor @ 350 ml/ha has recorded the lowest green boll damage of 26.67% which was on par with sulfoxaflor @ 300 ml/ha, spinetoram + sulfoxaflor @ 300 ml/ha and pyriproxyfen @ 750 ml/ha which recorded 27.33, 42.33 and 43.00% green boll damage, respectively (Table 3).

Yield

The highest yield of 5985 kg/ha was recorded in spinetoram + sulfoxaflor @ 350 ml/ha which was followed by sulfoxaflor @ 300 ml/ha which recorded 4585 kg/ha of yield and was on par with majority of the treatments. However, the lowest yield of 3281 kg/ha was recorded in control (unsprayed) (Table 3).

Discussion

From the results obtained it is evident that spinetoram@ 350 ml/ha, spinetoram + sulfoxaflor @ 350 ml/ha, sulfoxaflor @ 300 ml/ha and spinetoram + sulfoxaflor @ 300 ml/ha were effective in reducing the leafhopper population compared to other insecticides and the present results are in agreement with the findings of [7-10] who have reported the efficacy of spinetoram + sulfoxaflor @ 350 and 300 ml/ha in reducing the sucking pests population with special reference to leafhoppers in cotton. The individual chemical efficacy of spinetoram and sulfoxaflor as obtained in the present investigation against leafhoppers were in accordance with the reports of [11] and the efficacy of spinetoram individually and in combination with sulfoxaflor against bollworms in cotton especially against pink bollworm as reported by [7, 9] were in agreement with the present results obtained against pink bollworm in cotton. However, the efficacy of sulfoximes was also reported in cotton against leafhoppers and against plant hoppers by [12, 13] also supports the results of the present investigation.

Conclusion

Spinetoram 10% w/w + Sulfoxaflor 30% w/w WG @ 140 g ai/ha was effective chemical for the management of sucking pests as well as bollworms in cotton when compared to the other chemicals tested

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