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RESEARCH ARTICLE

EVALUATION OF F9252 (BIFENTHRIN 8% + CLOTHIANIDIN 10% SC) AGAINST INSECT PESTS OF SUGARCANE

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Abstract

Two field experiments were conducted to study the bioefficacy of F9252 (bifenthrin 8 % + clothianidin 10 % sc) against termite, *Odontotermes obesus* Rambur (Isoptera: Termitidae) and early shoot borer, *Chilo infuscatellus* Snellen (Lepidoptera: Pyralidae) of sugarcane at Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore during 2015 -2017 in randomized block design with eleven treatments replicated thrice with a plot size of 50 m^2 per replication. Applications of insecticides were made at the time of planting. Germination of sugarcane setts was recorded at 30 days after planting (DAP) in each treatment. Termite infestation was observed at 60, 120 DAP and at harvest and the per cent infestation was calculated. Early shoot borer infestation was observed at 30, 45 and 60 DAP. The effect of F9252 at X (Recommended dose) and 2x doses on the natural beneficial fauna were assessed at 30, 60 and 120 DAP. The per cent germination observed at 30 DAP revealed that the F9252 at 100+125 g a.i. ha^{-1} treatment recorded higher germination (91.00 per cent) and it was on par with F9252 at 80+100 g a.i. ha^{-1} (87.06 per cent), untreated control recorded the least germination of 43.50 per cent. The termite damage was minimum in the plots treated with the test chemical F9252 at 100+125 g a.i. ha^{-1} at all the days of observation after the treatment and recorded the mean percent control over untreated check of 87.06, 79.13 and 69.20 per cent at 60 DAP, 120 DAP and at harvest, respectively and it was on par with the F9252 at 80+100 g a.i. ha^{-1}. The above two treatments resulted in significantly superior control of termite damage over all other treatments. At 30, 45 and 60 DAP the highest per cent control of early shoot borer damage in sugarcane was recorded in the treatment, F9252 at 100+125 g a.i. ha^{-1} (77.99, 70.07 and 60.95 percent control over untreated check) followed by F9252 at 80+100 g a.i. ha^{-1} (86.13, 79.58 and 73.20 percent control over untreated check) compared to all other treatments. Hence, it is concluded that, F9252 at 100+125 g a.i. ha^{-1} remained on par with F9252 at 80+100 g a.i. ha^{-1} have effectively controlled the termite and early shoot borer infestation in sugarcane ecosystem.

Key words: Sugarcane, early shoot borer, termite, Bifenthrin 8% + Clothianidin 10% SC, bioefficacy

Introduction

Sugarcane is an important commercial crop that is cultivated in more than seventy countries in the world. India is the second largest producer after Brazil producing nearly 15 and 25 % of global sugar and sugarcane respectively and is the top most consumer of the sugar in the world. In India sugarcane is grown in an area of 49.27 lakh ha with the production of 348.448 million tons with an average productivity of about 70.7 t/ha of cane yield during 2015-16. The importance of sugarcane in the agrarian economics of India needs no emphasis because of its high value as a cash crop, a major source of white sugar and gur (Padmasri *et al.,* 2014). Sugarcane is known to be attacked by many insects belonging to broad spectrum of orders such as Lepidoptera, Homoptera, Coleoptera, Hemiptera, Orthoptera and Isoptera (Leslie, 2004). However, 15 pests are reported to cause considerable loss in yield. The early shoot borer, top shoot borer, internode borer, white grub, sugarcane pyrilla, white woolly aphid, scale insect and termites are major pests of sugarcane, amongst, early shoot borer is

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considered to be noxious pest as it causes severe damage in early growth stage and yield loss. The early shoot borer, *Chilo infuscatellus* (Snellen) (Pyralidae; Lepidoptera) causes economic losses (Avasthy and Tiwari, 1986) from 22 - 23 per cent in yield, 12 per cent in sugar recovery and 27 per cent in jaggery. The young cane is vulnerable up to 8 weeks after planting. The caterpillars enter into the young shoots by making holes just above the ground levels and tunnels downwards causing "dead hearts". (Patil and Hapse, 1981). On the other hand subterranean termites are the major problem attacking sugarcane crop from its germination through shoot emergence and finally it affects the quality of canes. As many as 13 species of termite are reported to cause damage to sugarcane in India. Among them *Microtermes obesi* Holmgren, *Odontotermes obesus* Rambur, *O. assmuthi* Holmgren, *O. wallonensis* (Wasmann) and *Trinervitermes biformis* (Wasmann) are major pests (David and Nandhagopal, 1986). These termites damage setts, shoots, canes as well as stubbles. Termite infestation occurs soon after planting and continues till harvest. Teotia *et al.* (1963) and Roonwal (1981) reported 30-60 per cent destruction of buds due to termite attack, while Avasthy (1967) reported it to be 40, which results in an yield loss of 33 per cent. Organochlorine insecticides such as heptachlor and dieldrin have been used in the past, but due to long residual effect and considering ecological sustainability, these insecticides are banned now. Due to inopportune effects of conventional insecticides like organophosporous and organochlorines, novel groups like neonicotinoids that imparts potential selectivity towards target pest occupies predominance in pest management scenario for the past few years. The use of insecticides as combination product with different modes of action and target may help in reduction enhancement of different categories of pests. Furthermore, number of insecticide application would be reduced which may pave the opportunity for easy fit into the strategies of integrated pest management (Nauen *et al.,* 2003) With this scientific scope, two field experiments were conducted to evaluate bioefficacy of combination product bifenthrin 8% + chlothianidin 10 % SC against termites and early shoot borer and their safety towards non target organism in sugarcane.

Materials and Methods

Two field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore during 2015 – 2017 in Randomized Block Design (RBD) with three replications. Applications of insecticides were made at the time of planting. The target dose rate was mixed in required quantity of water and sprayed (using pneumatic knapsack sprayer by removing nozzle) over the planted setts in the furrows for the insecticide to spread thoroughly around the planting zone. The treatment details are given as follows; T_1 - Untreated check, T_2 - F9252 @ 60 + 75 g ai. ha^{-1}, T_3 - F9252 @ 80 + 100 g ai. ha^{-1}, T_4 - F9252 @ 100 + 125 g ai. ha^{-1}, T_5 - Clothianidin 50 WDG @ 100 g ai. ha^{-1}, T_6 - Clothianidin 50 WDG @ 125 g ai. ha^{-1}, T_7 - Bifenthrin 10 EC @ 80 g ai. ha^{-1}, T_8 - Bifenthrin 10 EC @ 100 g ai. ha^{-1}, T_9 - Chlorantraniliprole 18.5SC @ 125 g ai. ha^{-1}, T_{10} - Fipronil 5 SC @ 100 g ai. ha^{-1}, and T_{11} - Chlorpyriphos 20 EC @ 300 g ai. ha^{-1}.

I. Method of assessment

Germination of sugarcane setts was recorded at 30 days after planting (DAP) in each treatment. Number of tillers were counted per 5 meter linear

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row at 60 and 120 DAP and converted in to tillers numbers per hectare. Termite infestation was observed in sugarcane at 60 days after application (DAA), 120 DAA and at harvest and the per cent infestation was calculated by using the formula,

$$\text{ESB infestation} = \left(\frac{\text{Number of sampling unit with ESB infestation}}{\text{Total sampling point}}\right) \text{X } 100$$

Termite control was calculated using the formula,

$$\text{Termite control} = \left(\frac{\text{Infestation in control} - \text{Infestation in Treatment}}{\text{Infestation in control}}\right) \text{X } 100$$

Early shoot borer (ESB) infestation in sugarcane was observed at 15, 30, 45 and 60 days after application by using below formula,

$$\text{Termite infestation} = \left(\frac{\text{Number of sampling unit with presence of termite}}{\text{Total sampling point}}\right) \text{X } 100$$

Control of early shoot borer infestation was calculated over untreated control treatment using below formula,

$$\text{Control of ESB infestation} = \left(\frac{\text{Infestation in control} - \text{Infestation in treatment}}{\text{Infesatation in control}}\right) \text{X } 100$$

Cane yield was recorded in each plot and total yield was converted to tonnes per hectare. The effect of F9252 at X and 2x doses on the natural beneficial fauna of sugarcane ecosystem were assessed at 30, 60 and 120 days after application. The experiments were conducted in a randomized block design with three replications and the plot size of 40m^2. Symptoms of phytotoxicity *viz.,* leaf injury, wilting, vein clearing, necrosis, yellowing, stunting, epinasty and hyponasty were observed from at 5, 10, 15, 20, 30 and 60 days after application as per Central Insecticide Board Registration Committee (CIBRC) protocol. Phytotoxicity symptoms was assessed on visual rating from 0-10 based on below grading scale,

Table 1. Effect of F9252 on germination of sugarcane

Treatments	**Dose g a.i. ha^{-1}**	**Germination Per cent @ 30 DAP**	
		First season	**Second season**
Untreated check	-	46.00	41.00
F9252	60 + 75	75.00	74.00
F9252	80 + 100	87.00	89.00
F9252	100 + 125	90.00	92.00
Clothianidin 50 WDG	100	70.00	69.00
Clothianidin 50 WDG	125	73.00	73.00
Bifenthrin 10 EC	80	61.00	59.00
Bifenthrin 10 EC	100	65.00	67.00
Chlorantraniliprole 18.5 SC	125	68.00	63.00
Fipronil 5 SC	100	57.00	54.00
Chlorpyriphos 20 EC	300	54.00	50.00
SEM		**4.16**	**4.15**
CD @ 5%		**12.28**	**12.24**

DAP-Days after planting

Grade	Phytotoxicity symptoms %
0	No phytotoxicity
1	1 – 10
2	11 – 20
3	21 – 30
4	31 – 40
5	41 – 50
6	51 – 60
7	61 - 70
8	71 – 80
9	81 – 90
10	91 – 100

Results

The results of two consecutive seasons trials are presented here. The per cent germination observed at 30 DAP revealed that the F9252 at 100+125 g a.i. ha^{-1} treatment recorded higher germination (90.00 and 92.00 per cent, respectively) and it was on par with F9252 at 80+100 g a.i. ha^{-1} (87.00 and 89.00 per cent, respectively). The above two treatments showed significantly higher germination per cent than all other treatments including standard checks. Among treatments, untreated control recorded the least germination of 46.00 and 41.00 per cent, respectively (Table 1). All insecticide treatments were recorded higher tillering compared to untreated control treatment (Table 2). Among all the insecticide treatments, the higher number of tillers was observed in plots treated with F9252 at 100+125 g a.i. ha^{-1} (261.00 and 358.00 thousand tillers ha^{-1} at 60 and 120 DAP respectively) and in F9252 at 80+100 g a.i. ha^{-1} (257.00 and 336.00 thousand tillers ha^{-1} at 60 and 120 DAP respectively) treatment, which remained on par with each other. During the second season, F9252 at 100+125 g a.i. ha^{-1} recorded 270.00 and 367.00 thousand tillers ha^{-1} at 60 and 120 DAP respectively and F9252 at 80+100 g a.i. ha^{-1} recorded 263.00 and 354.00 thousand tillers ha^{-1} at 60 and 120 DAP respectively, which remained on par with each other.

Table 2. Effect of F9252 on sugarcane tillering

Treatments	Dose g a.i. ha^{-1}	Tiller count (000 ha^{-1})			
		First season		Second season	
		60 DAP	120 DAP	60 DAP	120 DAP
Untreated check	-	96.00	101.00	89.00	112.00
F9252	60 + 75	219.00	281.00	221.00	299.00
F9252	80 + 100	257.00	336.00	263.00	354.00
F9252	100 + 125	261.00	358.00	270.00	367.00
Clothianidin 50 WDG	100	198.00	267.00	211.00	270.00
Clothianidin 50 WDG	125	207.00	275.00	214.00	284.00
Bifenthrin 10 EC	80	138.00	214.00	143.00	222.00
Bifenthrin 10 EC	100	142.00	223.00	156.00	235.00
Chlorantraniliprole 18.5 SC	125	159.00	206.00	170.00	210.00
Fipronil 5 SC	100	136.00	164.00	126.00	178.00
Chlorpyriphos 20 EC	300	124.00	153.00	129.00	163.00
SEM		**11.52**	**15.47**	**11.88**	16.12
CD @ 5%		33.99	45.63	35.03	47.56

Table 3. Effect of F9252 on termite damage in sugarcane

Treatments	First season						Second season					
	60 DAA		120 DAA		At harvest		60 DAA		120 DAA		At harvest	
	PD	PRC	PD	PRC	PD	PRC	PD	PRC	PD	PRC	PD	PRC
Untreated check	10.20 (18.59)	-	13.00 (21.09)	-	26.13 (30.69)	-	8.33 (16.74)	-	14.80 (22.58)	-	22.93 (28.56)	-
F9252 @ 60 + 75 g a.i. ha^{-1}	2.40 (8.88)	76.47	3.93 (11.40)	69.77	10.47 (18.82)	59.93	2.00 (8.10)	75.99	4.80 (12.62)	67.57	10.87 (19.19)	52.59
F9252 @ 80 + 100 g a.i. ha^{-1}	1.33 (6.61)	86.96	2.73 (9.50)	79.00	8.27 (16.69)	68.35	1.07 (5.93)	87.15	3.07 (10.08)	79.26	6.87 (15.18)	70.04
F9252 @ 100 + 125 g a.i. ha^{-1}	1.07 (5.94)	89.51	2.40 (8.90)	81.54	7.73 (16.12)	70.42	0.67 (4.69)	91.96	2.20 (8.52)	85.14	5.93 (14.08)	74.14
Clothianidin 50 WDG @ 100 g a.i. ha^{-1}	2.93 (9.82)	71.27	4.33 (12.00)	66.69	11.60 (19.89)	55.61	2.53 (9.14)	69.63	5.13 (13.08)	65.34	10.87 (19.23)	52.59
Clothianidin 50 WDG @ 125 g a.i. ha^{-1}	2.67 (9.37)	73.82	4.07 (11.62)	68.69	11.00 (19.33)	57.90	2.20 (8.51)	73.59	4.53 (12.26)	69.39	10.20 (18.59)	55.52
Bifenthrin 10 EC @ 80 g a.i. ha^{-1}	3.73 (11.11)	63.43	5.53 (13.56)	57.46	15.07 (22.79)	42.33	3.47 (10.71)	58.34	7.53 (15.88)	49.12	13.00 (21.08)	43.31
Bifenthrin 10 EC @ 100 g a.i. ha^{-1}	3.20 (10.29)	68.63	5.40 (13.42)	58.46	14.27 (22.17)	45.39	3.33 (10.50)	60.02	7.20 (15.55)	51.35	12.53 (20.71)	45.36
Chlorantraniliprole 18.5 SC @ 125 g a.i. ha^{-1}	3.33 (10.50)	67.35	5.27 (13.25)	59.46	14.00 (21.94)	46.42	3.13 (10.17)	62.42	6.80 (15.09)	54.05	11.87 (20.12)	48.23
Fipronil 5 SC @ 100 g a.i. ha^{-1}	4.53 (12.27)	55.59	6.47 (14.72)	50.23	17.80 (24.93)	31.88	4.33 (12.00)	48.02	9.00 (17.44)	39.19	15.93 (23.50)	30.53
Chlorpyriphos 20 EC @ 300 g a.i. ha^{-1}	4.80 (12.64)	52.94	6.80 (15.10)	47.69	18.20 (25.23)	30.35	4.20 (11.81)	49.58	8.33 (16.76)	43.72	14.80 (22.60)	35.46
SEM	**0.33**		0.41		0.67		0.31		0.46		0.63	
CD 5%	0.97		1.19		1.98		0.92		1.34		1.85	

Figures in the parentheses are arc sine transformed value; DAA-Days after application;
PD – Percent damage; PRC – Percent reduction over control

Table 4. Effect of F9252 on shoot borer damage in Sugarcane

Treatments	First season						Second season					
	30 DAA		45 DAA		60 DAA		30 DAA		45 DAA		60 DAA	
	PD	PRC	PD	PRC	PD	PRC	PD	PRC	PD	PRC	PD	PRC
Untreated check	21.00 (27.22)	-	24.33 (29.50)	-	29.07 (32.57)	-	19.20 (25.94)	-	24.67 (29.73)	-	32.33 (34.60)	-
F9252 @ 60 + 75 g a.i. ha^{-1}	4.87 (12.71)	76.81	7.73 (16.09)	68.23	12.93 (21.01)	55.52	4.00 (11.50)	79.17	6.93 (15.22)	71.91	10.87 (19.19)	66.38
F9252 @ 80 + 100 g a.i. ha^{-1}	3.20 (10.29)	84.76	5.40 (13.42)	77.81	8.93 (17.37)	69.28	2.40 (8.90)	87.50	4.60 (12.37)	81.35	7.40 (15.77)	77.11
F9252 @ 100 + 125 g a.i. ha^{-1}	2.80 (9.62)	86.67	4.73 (12.55)	80.56	7.87 (16.27)	72.93	1.87 (7.85)	90.26	3.87 (11.33)	84.31	6.73 (15.02)	79.18
Clothianidin 50 WDG @ 100 g a.i. ha^{-1}	5.93 (14.08)	71.76	8.47 (16.90)	65.19	14.00 (21.95)	51.84	4.87 (12.73)	74.64	8.13 (16.55)	67.04	12.93 (21.05)	60.01
Clothianidin 50 WDG @ 125 g a.i. ha^{-1}	5.40 (13.41)	74.29	8.13 (16.53)	66.58	13.60 (21.60)	53.22	4.60 (12.36)	76.04	7.33 (15.68)	70.29	12.00 (20.23)	62.88
Bifenthrin 10 EC @ 80 g a.i. ha^{-1}	7.33 (15.67)	65.10	10.73 (19.07)	55.90	16.40 (23.83)	43.58	6.20 (14.38)	67.71	9.73 (18.13)	60.56	15.27 (22.95)	52.77
Bifenthrin 10 EC @ 100 g a.i. ha^{-1}	8.00 (16.41)	61.90	10.20 (18.61)	58.08	15.93 (23.50)	45.20	5.80 (13.92)	69.79	9.27 (17.71)	62.42	14.33 (22.22)	55.68
Chlorantraniliprole 18.5 SC @ 125 g a.i. ha^{-1}	3.87 (11.33)	81.57	6.00 (14.16)	75.34	9.53 (17.95)	67.22	2.87 (9.74)	85.05	5.07 (12.99)	79.45	8.13 (16.54)	74.85
Fipronil 5 SC @ 100 g a.i. ha^{-1}	9.00 (17.44)	57.14	11.93 (20.18)	50.97	17.20 (24.48)	40.83	7.20 (15.55)	62.50	10.93 (19.28)	55.70	16.80 (24.17)	48.04
Chlorpyriphos 20 EC @ 300 g a.i. ha^{-1}	9.33 (17.77)	55.57	12.80 (20.94)	47.39	18.67 (25.58)	35.78	7.53 (15.91)	60.78	11.67 (19.96)	52.70	17.93 (25.03)	44.54
SEM	**0.49**		**0.57**		**0.70**		**0.45**		**0.55**		**0.69**	
CD 5%	**1.43**		**1.67**		**2.06**		**1.32**		**1.62**		**2.03**	

Figures in the parentheses are arc sine transformed value; DAA-Days after application;

PD – Percent damage; PRC – Percent reduction over control

Table 5. Effect of F9252 on cane yield of sugarcane

Treatments	First season		Second season	
	Yield (t ha^{-1})	CB ratio	Yield (t ha^{-1})	CB ratio
Untreated check	46.00	-	42.20	-
F9252 @ 60 + 75 g a.i. ha^{-1}	63.00	1: 24.00	64.66	1:31.71
F9252 @ 80 + 100 g a.i. ha^{-1}	74.72	1:34.47	77.00	1:41.76
F9252 @ 100 + 125 g a.i. ha^{-1}	75.51	1:30.79	78.21	1:37.58
Clothianidin 50 WDG @ 100 g a.i. ha^{-1}	58.05	1:12.05	60.70	1:18.50
Clothianidin 50 WDG @ 125 g a.i. ha^{-1}	61.00	1:12.86	63.20	1:18.00
Bifenthrin 10 EC @ 80 g a.i. ha^{-1}	56.60	1:18.84	57.30	1:26.84
Bifenthrin 10 EC @ 100 g a.i. ha^{-1}	57.25	1:18.15	58.00	1:25.48
Chlorantraniliprole 18.5 SC @ 125 g a.i. ha^{-1}	62.52	1:6.29	54.45	1:4.67
Fipronil 5 SC@ 100 g a.i. ha^{-1}	54.65	1:7.41	52.60	1:8.91
Chlorpyriphos 20 EC@ 300 g a.i. ha^{-1}	53.30	1:14.80	51.20	1:18.24
SEM	**3.38**	**-**	**3.62**	**-**
CD @ 5%	**9.98**	**-**	**10.69**	**-**

The treatment with F9252 at 100+125 g a.i. ha^{-1} recorded the higher per cent control of termite damage *viz.,* 89.51, 81.54 and 70.42 at 60 DAA, 120 DAA and at harvest, respectively followed by F9252 at 80+100 g a.i. ha^{-1} with 86.96, 79.00 and 68.35 per cent control recorded at 60 DAA, 120 DAA and at harvest respectively. Alike, in second season, F9252 at 100+125 g a.i. ha^{-1} contributed for 91.96, 85.14 and 74.14 per cent control at 60 DAA, 120 DAA and at harvest, respectively followed by F9252 at 80+100 g a.i. ha^{-1} with 87.15, 79.26 and 70.04 per cent control recorded at 60 DAA, 120 DAA and at harvest, respectively (Table 3).

Regarding the control in shoot borer damage, F9252 at 100+125 g a.i. ha^{-1} recorded the highest per cent control of early shoot borer damage *viz.,* 92.93, 86.67, 80.56, and 72.93 at 15, 30, 45 and 60 days after application respectively followed by F9252 at 80+100 g a.i. ha^{-1} (91.49, 84.76, 77.81 and 69.28 per cent control at 15, 30, 45 and 60 days after application, respectively). During second season, F9252 at 100+125 g a.i. ha^{-1} registered 90.26, 84.31 and 79.18 per cent control at 30, 45 and 60 days after application, respectively followed by F9252 at 80+100 g a.i. ha^{-1} (87.50, 81.35 and 77.11 per cent control) at 30, 45 and 60 days after application, respectively (Table 4). F9252 @ 100+125 g a.i. ha^{-1} resulted in higher yield of 75.51 and 78.21 t ha^{-1}, respectively which remained on par with F9252 at 80+100 g a.i. ha^{-1} treatment recording 74.72 and 77.00 t ha^{-1}, respectively during two seasons. The lowest

Table 6. Effect of F9252 on natural enemies in sugarcane

Treatments	Natural enemies population (number/plant)					
	First spray			Second spray		
	30 DAA	**60 DAA**	**120 DAA**	**30 DAA**	**60 DAA**	**120 DAA**
Untreated check	**3.00	2.67	3.07	**2.53	2.13	2.20
	*(1.87)	(1.78)	(1.89)	*(1.74)	(1.62)	(1.64)
F9252	2.67	3.07	3.00	3.07	3.20	1.93
@ 60 + 75 g a.i. ha^{-1}	(1.78)	(1.89)	(1.87)	(1.89)	(1.92)	(1.56)
F9252	3.00	2.87	3.00	2.53	3.13	2.07
@ 80 + 100 g a.i. ha^{-1}	(1.87)	(1.83)	(1.87)	(1.74)	(1.90)	(1.60)
F9252	3.13	2.80	2.73	2.47	2.40	2.60
@ 100 + 125 g a.i. ha^{-1}	(1.90)	(1.82)	(1.80)	(1.72)	(1.70)	(1.76)
Clothianidin 50 WDG	2.67	3.13	2.73	2.27	2.00	1.80
@ 100 g a.i. ha^{-1}	(1.78)	(1.90)	(1.80)	(1.66)	(1.58)	(1.52)
Clothianidin 50 WDG	2.40	2.93	2.60	2.33	2.13	1.87
@ 125 g a.i. ha^{-1}	(1.70)	(1.85)	(1.76)	(1.68)	(1.62)	(1.54)
Bifenthrin 10 EC	2.67	3.07	2.67	2.20	3.07	2.00
@ 80 g a.i. ha^{-1}	(1.78)	(1.89)	(1.78)	(1.64)	(1.89)	(1.58)
Bifenthrin 10 EC	2.87	3.00	2.33	2.93	2.60	1.93
@ 100 g a.i. ha^{-1}	(1.83)	(1.87)	(1.68)	(1.85)	(1.76)	(1.56)
Chlorantraniliprole 18.5 SC	2.80	2.73	3.07	2.13	3.07	1.73
@ 125 g a.i. ha^{-1}	(1.82)	(1.80)	(1.89)	(1.62)	(1.89)	(1.49)
Fipronil 5 SC	2.40	2.67	3.07	2.07	2.93	1.87
@ 100 g a.i. ha^{-1}	(1.70)	(1.78)	(1.89)	(1.60)	(1.85)	(1.54)
Chlorpyriphos 20 EC	3.00	3.13	2.87	1.93	1.80	1.53
@ 300 g a.i. ha^{-1}	(1.87)	(1.90)	(1.83)	(1.56)	(1.51)	(1.42)
CD @ 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

** Data are original values *Figures in the parentheses are transformed value; DAA-Days after application; NS-Non Significant yield was observed in untreated check (46.00 and 42.20 t ha^{-1}, respectively in two seasons). F9252 at 80+100 g a.i. ha^{-1} recorded the higher cost benefit ratio of 1:34.47 and 1:41.76, respectively in two seasons (Table 5). The population of coccinellids and spiders were recorded from treatment and untreated control plots. The results revealed that all the treatments were on par with untreated control indicating no adverse impact on natural enemies (Table 6). The results of the field experiment conducted to assess the pytotoxicity of the F9252 at 80+100 g a.i. ha-1 (X dose) and 160+200 g a.i. ha-1 (2 X dose) applied in sugarcane did not show any phytotoxic effects like leaf injury, wilting, vein clearing, necrosis, yellowing, stunting, epinasty and hyponasty. Phytotoxicity rating of 0 was observed at 5, 10, 15, 20, 30 and 60 days after application.

Discussion

The above investigation results unveiled that the insecticides namely, F 9252 (Bifenthrin 8% + clothianidin 10% SC) as combined product relatively subdued termites and early shoot borer damage. F 9252 @ 100 + 125 g a.i. ha^{-1} was found more effective against *C. infuscatellus* and termites. Nevertheless it did not exhibit any phytotoxicity and adverse effect on natural enemies. Furthermore, it recorded higher cane yield without affecting juice parameters. Clothianidin is a new neonicotinoid insecticide possessing a thiazolyl rings that exhibit excellent insecticidal activity with a high level of safety for vertebrates. It has been shown that neonicotinoids act as agonists on nicotinic acetylcholine receptors (nAChR) (Bai *et al.,* 1991; Yamamoto *et al.,* 1995). The “super agonist” action of clothianidin leads to its characteristic insecticidal properties. Since the mode of action of clothianidin differs from that of organophosphates, carbamates, pyrethroids and IGRs, it can display a high level of activity against pest insects that have developed resistance to these existing compounds. Clothianidin is even effective for Dipteran, Coleopteran and Lepidopteran pests and can be applied by a wide variety of treatment methods. Bifenthrin, a non-alpha cyano pyrethroid insecticide, acts as an excitatory compound at sodium channel (Kostromytska *et al*., 2011). The efficacy of insecticides belonging to synthetic pyrethroids and neonicotinoids group against early shoot borer and termites has been documented earlier, which may be corroborated with our findings. Sett dip of imidacloprid 70 WS at 0.1 and 0.15 per cent and spray over setts of imidacloprid 200 SL at 250 and 375 ml ha^{-1} resulted in increased germination of setts. These treatments protected the crop from termite damage and were equal to chlorpyriphos 20 EC at 5 lit.ha^{-1} in the efficacy (Santharam *et al.,* 2002). Manager-Singh *et al.* (2002) investigated the effect of sett and soil treatments with insecticides on bud damage (caused by termite infestation) and germination of sugarcane c.v. Cos 767. Maximum bud damage was observed in the control (32.21% & 31.66%). Among the treatments, sett dipping in 0.20% solution of imidacloprid recorded the minimum bud damage of 6.84%, which was at par with soil application of phorate 10 G at 2.5 kg a.i. ha^{-1}, chlorpyrifos 20 EC at 1 kg a.i. ha^{-1} and chlorpyrifos 15 G at 2.5 kg a.i. ha^{-1}. These treatments resulted in 56.76% – 59.14% increase in germination.

The results from field experiment conducted at the Regional Agricultural Research Station, Anakapalle, India during 2008 – 2011 revealed that carbofuran 3G @ 33kg ha^{-1} (13.44 deadhearts %) and fipronil 0.3G @ 25kg ha^{-1} (14.20DH%) recorded significantly less incidence of early shoot borer (% deadhearts) compared to untreated control (69.3%) and were statistically equivalent with the highest per cent reduction of early shoot borer incidence (80.61%:79.52%, respectively) over control (Bhavani, 2016). Samanta *et al.* (2016) reported that fipronil 5% SC @ 150 g a.i. ha^{-1} was found most effective against early shoot borer and root borer where minimum dead hearts of 4.29, 3.20 and 2.23% were recorded after first, second and third spraying, respectively. Fipronil 5% SC @ 150 g a.i. ha^{-1} recorded the highest reduction of dead hearts over control (48.75, 65.81 and 78.22%) after three sprays with maximum yield (81.21 t ha^{-1}). Umashankar *et al*., (2018) reported Chlorantraniliprole 0.4G @ 0.09 g a.i ha^{-1} and Cartap hydrochloride 4G @ 0.50 g a.i ha^{-1} were effective in reducing the incidence of *C. infuscatellus* in Co 86032. Chlorantraniliprole 0.4G recorded lowest cumulative incidence (2.79 %) and highest per cent reduction over the control (85.78 %) which was followed by Cartap hydrochloride 4G (5.37% and 72.65%), Chlorantraniliprole 18.5 SC (5.95% and 75.62%). Cartap hydrochloride 4G was found to be the best insecticide in getting a highest cost benefit ratio (1:12.39). Hence to conclude, the present study clearly indicates that combining a sodium channel toxin (bifenthrin) and a synaptic toxin (imidacloprid) may lead to greater than additive neurophysiological and toxic effects which may pave for noteworthy success in pest management.

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