EFFICACY OF CHLORANTRANILIPROLE 35 WG AGAINST BORERS OF SUGARCANE

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Abstract

Two field experiments were conducted to study the bioefficacy of chlorantraniliprole 35 WG against sugarcane borers at Sugarcane Research Station, Cuddalore during 2015-2017 in randomized block design with seven treatments replicated thrice with a plot size of 50 m^2 per replication. Applications of insecticides were made at the time of planting in furrow for early shoot borer (ESB) management followed by drenching at 90-92 days after planting (DAP) for internode borer and other pests. Germination of sugarcane setts was recorded at 30 DAP in each treatment. ESB infestation was observed at 30, 60 and 90 DAP and internode borer infestation was observed on 120, 150 and 180 DAP. The population of coccinellid beetles was observed at weekly intervals after second application and the phytotoxicity rating was observed at x (75 g a.i. ha^{-1}), 2x and 4x doses. The results revealed that the mean per cent damage of early shoot borer was found significantly lower in chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1} than other treatments in all the periods of observation and on par with chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1} and chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}. The per cent germination observed at 30 DAP revealed that chlorantraniliprole 35 WG did not cause any impact on the germination of sugarcane setts in both trials. At all the test doses there was no significant reduction in the population of coccinellids in the field and at x, 2x and 4x doses did not show any phytotoxicity symptoms in the sugarcane crop. Hence, it is concluded that, chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1} effectively controlled the early shoot borer and internode borer infestation in sugarcane ecosystem.

Key words: Sugarcane, borers, chlorantraniliprole 35 WG, bioefficacy

Introduction

Sugarcane is an important sugar crop, besides being utilized as biofuel around the world (Chandel et al. 2012). The world's three major sugarcane producing countries are Brazil, India, and China (Dawson and Boopathy 2007). In India, sugarcane is grown in an area of 49.27 lakh ha with the production of 348.45 million tons with an average productivity of about 70.7 t/ha of cane yield during 2015-16. 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 have been reported to cause considerable loss in yield. The early shoot borer, top shoot borer, internode borer, white grub, pyrilla, white woolly aphid, scale insect and termites are major pests of sugarcane, amongst, borers are considered to be noxious pests as they cause severe damage in early growth stage and yield loss. To effectively control sugarcane borers and increase the yield, chlorantraniliprole (CAP) has been introduced and used before planting.

Chlorantraniliprole, 3-bromo-N-[4-chloro-2-methyl-6[methylamine]carbonyl] phenyl] -1-(3-chloro-2- pyridinyl)-1H-pyrazole-5-carboxamide is an anthranilic diamide insecticide with a novel mode of action called 'Ryanodine Receptor Activators', which are essential for muscle contraction, is found effective against several lepidopteran as well as coleopteran,

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dipteran, and hemipteran pests (Sharma et al. 2013). This activation in insects stimulates the release and depletion of intracellular calcium stores from the sarcoplasmic reticulum of muscle cells, causing impaired muscle regulation, paralysis and ultimately death of sensitive insects (Cordova et al 2006). It has very low toxicity for mammals (both acute and chronic), high intrinsic activity on target pests, strong ovilarvicidal and larvicidal properties, long lasting crop protection and no cross-resistance to any existing insecticide. Chlorantraniliprole has an excellent profile of safety to beneficial arthropods, pollinators, honeybees and non-target organisms such as earthworms and soil microorganisms (Dinter et al 2008). Whereas, the new mode of action makes chlorantraniliprole a valuable option for Insecticide Resistance Management (IRM) strategies, safety to key beneficial arthropods and honeybees confer a strong fit within Integrated Pest Management (IPM) programs. The remarkably favourable toxicity profile of chlorantraniliprole, combined with low use rates, provides large margins of safety for consumers and agricultural workers (Sharma et al. 2013). With this background, a study has been carried out to assess the efficacy of chlorantraniliprole 35 WG against early shoot borer and internode borer on sugarcane and assessment of residual effect of chlorantraniliprole 35 WG on succeeding crop safety.

Materials and methods

Two field experiments were conducted at Sugarcane Research Station, Tamil Nadu Agricultural University, Cuddalore during 2015 – 2017 in Randomized Block Design (RBD) with three replications on the sugarcane variety COC (SC) 24. Applications of insecticides were made at the time of planting and 90 days after planting (DAP). The required dose was mixed in 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; T_1 - Chlorantraniliprole 35 WG @ 62 g a.i. ha^{-1}, T_2 - Chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1}, T_3 - Chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1}, T_4 - Chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}, T_5 - Chlorpyriphos 20 EC @ 250 g a.i. ha^{-1}, T_6 - Fipronil 5 SC @ 75 g a.i. ha^{-1} and T_7 - Untreated check.

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 row at 30 DAP and converted in to tillers numbers per hectare. Early shoot borer (ESB) infestation in sugarcane was observed at 30, 60 and 90 days after application and internode borer infestation was observed at 120,150 and 180 DAP after second application on randomly selected 10 plants per replication. The per cent infestation was calculated by using the formula,

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

Control of ESB / INB infestation was calculated over untreated control treatment using below formula,

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

Cane yield was recorded in each plot and total yield was converted to tonnes per hectare. The effect of chlorantraniliprole 35 WG on the natural beneficial fauna of sugarcane ecosystem was assessed at 7 and 14 days after second application. The experiment was conducted in a randomized block design with three replications and the plot size of 50 m^2. To assess the phytotoxocity of chlorantraniliprole 35 WG in sugarcane, 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. Follow up crop, cowpea was raised in the residual study plot to study the residual effect on succeeding crop. The plant population, plant height and yield were recorded in the residual plots.

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 the field trial laid out at Sugarcane Research Station, Cuddalore to evaluate the efficacy of chlorantraniliprole 35 WG against early shoot borer and internode borer on sugarcane and assessment of residual effect of chlorantraniliprole 35 WG on succeeding crop safety revealed that germination of the sugarcane setts was not affected by the application of insecticides (Table

Table 1. Percent germination in different treatments.

S. No	Treatments	Mean per cent germination	
		2015 - 2016	2016 - 2017
1.	Chlorantraniliprole 35 WG @ 62 g a.i. ha^{-1}	86.56	83.30
2.	Chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1}	84.82	85.20
3.	Chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1}	85.71	84.00
4.	Chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}	84.28	85.00
5.	Chlorpyriphos 20 EC @ 250 g a.i. ha^{-1}	84.82	85.40
6.	Fipronil 5 SC @ 75 g a.i. ha^{-1}	86.42	84.00
7.	Untreated control	87.37	80.20
	Phytotoxicity study doses		
8.	Chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1}	85.72	85.20
9.	Chlorantraniliprole 35 WG @ 150 g a.i. ha^{-1}	84.52	83.33
10.	Chlorantraniliprole 35 WG @ 300 g a.i. ha^{-1}	86.60	85.40

Table 2. Bioefficacy of insecticides against early shoot borer on COC (SC) 24

Treatments	Mean per cent damage of early shoot borer									
	2015 - 2016					2016 - 2017				
	30 DAP	60 DAP	90 DAP	Pooled mean	PRC	30 DAP	60 DAP	90 DAP	Pooled mean	PRC
Chlorantraniliprole 35 WG @ 62 g a.i. ha^{-1}	13.76 $(21.81)^{c}$	19.07 $(25.91)^{c}$	18.44 $(25.40)^{d}$	17.09 $(24.43)^{c}$	58.90	14.78 $(22.63)^{b}$	20.07 $(26.64)^{c}$	19.78 $(26.42)^{d}$	18.21 $(25.23)^{d}$	58.47
Chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1}	5.91 $(14.08)^{a}$	9.69 $(18.15)^{a}$	10.35 $(18.81)^{ab}$	8.65 $(17.15)^{a}$	79.20	4.65 $(12.52)^{a}$	8.17 $(16.54)^{a}$	9.32 $(17.76)^{ab}$	7.38 $(15.61)^{ab}$	83.16
Chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1}	5.32 $(13.31)^{a}$	9.24 $(17.68)^{a}$	8.33 $(16.74)^{a}$	7.63 $(17.05)^{a}$	81.65	4.12 $(11.68)^{a}$	8.65 $(17.15)^{a}$	7.33 $(15.68)^{a}$	6.70 $(14.84)^{a}$	84.72
Chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}	5.88 $(14.06)^{a}$	10.18 $(18.63)^{a}$	11.45 $(19.82)^{b}$	9.17 $(17.66)^{a}$	77.95	5.86 $(14.06)^{a}$	9.01 $(17.46)^{a}$	10.41 $(18.81)^{b}$	8.43 $(16.78)^{b}$	80.77
Chlorpyriphos 20 EC @ 250 g a.i. ha^{-1}	9.93 $(18.34)^{b}$	13.40 $(21.47)^{b}$	15.43 $(23.11)^{c}$	12.92 $(21.05)^{b}$	68.93	11.77 $(20.09)^{b}$	13.99 $(21.97)^{b}$	16.91 $(24.27)^{c}$	14.22 $(22.11)^{c}$	67.57
Fipronil 5 SC @ 75 g a.i. ha^{-1}	11.25 $(19.64)^{b}$	17.92 $(25.03)^{c}$	20.31 $(26.78)^{d}$	16.49 $(23.97)^{c}$	60.35	13.67 $(21.72)^{b}$	19.41 $(26.13)^{c}$	21.87 $(27.0)^{d}$	18.32 $(25.25)^{d}$	58.22
Untreated control	31.73 $(34.57)^{d}$	46.75 $(43.13)^{d}$	46.29 $(42.88)^{e}$	41.59 $(40.16)^{d}$	-	35.69 $(36.69)^{c}$	48.11 $(43.91)^{d}$	47.78 $(43.74)^{e}$	43.85 $(41.45)^{e}$	-
SE	0.52	0.69	0.85	0.68		0.83	0.86	0.79	0.58	
CD (0.05)	1.61	2.12	2.63	2.09		2.55	2.64	2.44	1.79	

DAP – Days After Planting; PRC – Percent Reduction over Control; Figures in the parentheses are arcsine transformed values. In a column figures followed by a common alphabet are not significantly different at 5% level by DMRT

Table 3. Bioefficacy of insecticides against internode borer on CoC (SC) 24

Treatments	Mean per cent damage level of inter node borer									
	2015 - 2016					2016 - 2017				
	120 DAP	150 DAP	180 DAP	Pooled mean	PRC	120 DAP	150 DAP	180 DAP	Pooled mean	PRC
Chlorantraniliprole 35 WG	19.08	19.63	19.44	19.38	64.36	21.36	21.64	20.88	21.29	62.01
@ 62 g a.i. ha^{-1}	$(25.91)^{c}$	$(26.28)^{b}$	$(26.13)^{b}$	$(26.13)^{b}$		$(27.56)^{b}$	$(27.69)^{b}$	$(27.20)^{b}$	$(27.48)^{b}$	
Chlorantraniliprole 35 WG	9.78	11.40	12.02	11.07	79.64	9.07	10.62	11.17	10.29	81.64
@ 75 g a.i. ha^{-1}	$(18.21)^{ab}$	$(19.73)^{a}$	$(20.27)^{a}$	$(19.46)^{a}$		$(17.50)^{a}$	$(19.00)^{a}$	$(19.55)^{a}$	$(18.70)^{a}$	
Chlorantraniliprole 35 WG	9.42	10.79	11.37	10.53	80.64	8.15	10.54	10.41	9.70	82.69
@ 88 g a.i. ha^{-1}	$(17.85)^{a}$	$(19.19)^{a}$	$(19.73)^{a}$	$(18.91)^{a}$		$(16.64)^{a}$	$(18.91)^{a}$	$(18.81)^{a}$	$(17.99)^{a}$	
Chlorantraniliprole 18.5 SC	12.05	10.85	12.22	11.71	78.47	11.13	10.28	11.31	10.91	80.53
@ 75 g a.i. ha^{-1}	$(20.36)^{b}$	$(19.28)^{a}$	$(20.44)^{a}$	$(20.00)^{a}$		$(19.46)^{a}$	$(18.72)^{a}$	$(19.64)^{a}$	$(19.27)^{a}$	
Chlorpyriphos 20 EC	18.25	23.59	22.76	21.53	60.42	20.25	24.54	23.88	22.89	59.16
@ 250 g a.i. ha^{-1}	$(25.35)^{c}$	$(29.06)^{c}$	$(28.52)^{c}$	$(27.62)^{b}$		$(26.78)^{b}$	$(29.67)^{b}$	$(29.27)^{c}$	$(28.57)^{b}$	
Fipronil 5 SC	18.11	24.21	21.13	21.15	61.11	19.98	23.50	22.49	21.99	60.77
@ 75 g a.i. ha^{-1}	$(25.18)^{c}$	$929.47)^{c}$	$(27.27)^{c}$	$(27.35)^{b}$		$(26.57)^{b}$	$(29.00)^{b}$	$(28.32)^{c}$	$(27.96)^{b}$	
Untreated control	50.71	55.02	57.44	54.39	-	52.48	57.14	58.54	56.05	-
	$(45.40)^{d}$	$(47.87)^{d}$	$(49.26)^{d}$	$(47.52)^{c}$		$(46.43)^{c}$	$(49.08)^{c}$	$(49.89)^{d}$	$(48.47)^{c}$	
SE	0.72	0.65	0.42	0.64		1.22	1.13	0.34	0.48	
CD (0.05)	2.23	2.00	1.31	1.98		3.76	3.47	1.04	1.48	

PRC – Percent Reduction over Control; DAP – Days After Planting; Figures in the parentheses are arcsine transformed values. In a column figures followed by a common alphabet are not significantly different at 5% level by DMRT

1). Per cent germination ranges between 84.52 to 87.37 during first season and 83.30 to 85.40 during second season in various treatments and all the treatments were on par with each other (Table 1).

The mean per cent damage incidence of early shoot borer (ESB) was found significantly lower in chlorantraniliprole 35 % WG @ 88 g a.i. ha^{-1} than other treatments in all the periods of observation. It was on par with chlorantraniliprole 35 % WG @ 75 g a.i. ha^{-1} and chlorantraniliprole 18.5 % SC @75 g a.i. ha^{-1} in both the seasons (Table 2). Based on percent reduction over control, order of relative efficacy of the insecticides against ESB was chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1} > chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1} > chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1} > chlorpyriphos 20 EC @ 250 g a.i. ha^{-1} > fipronil 5 SC @ 75 g a.i. ha^{-1} > chlorantraniliprole 35 WG @ 62 g a.i. ha^{-1} (Table 2).

The observation of internode borer (INB) damage was taken at 30 days after second application of insecticide i.e. 120 days after planting (DAP). Mean per cent damage of the INB varies between 9.42 to 50.71 per cent during first season and 8.15 to 52.48 per cent during second season in various insecticidal treatments at 120 DAP (Table 3). Chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1} registered lower damage of INB throughout the observation period than other treatments followed by chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1} and chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}. Based on percent reduction over control, order of relative efficacy of the insecticides against INB borer is chlorantraniliprole 35 WG @ 88 g

Table 4. Effect of chlorantraniliprole 35 WG on coccinellid beetles in sugarcane

Treatments	Number of beetles per hill					
	2015 - 2016			2016 - 2017		
	PTC	7 DAS	14 DAS	PTC	7 DAS	14 DAS
Chlorantraniliprole 35 WG @ 62 g a.i. ha^{-1}	2.67 (1.63)[a]	2.67 (1.63)[a]	3.33 (1.82)[a]	3.33 (1.82)[a]	3.33 (1.82)[a]	3.66 (1.91)[a]
Chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1}	3.00 (1.73)[a]	2.67 (1.63)[a]	3.33 (1.82)[a]	3.33 (1.82)[a]	3.33 (1.82)[a]	3.44 (1.85)[a]
Chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1}	2.67 (1.63)[a]	3.33 (1.82)[a]	2.67 (1.63)[a]	3.00 (1.73)[a]	3.33 (1.82)[a]	3.11 (1.76)[a]
Chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}	3.33 (1.82)[a]	3.66 (1.91)[a]	3.33 (1.82)[a]	3.67 (1.91)[a]	3.67 (1.91)[a]	3.56 (1.88)[a]
Chlorpyriphos 20 EC @ 250 g a.i. ha^{-1}	2.67 (1.63)[a]	3.33 (1.82)[a]	2.67 (1.63)[a]	3.33 (1.82)[a]	3.00 (1.73)[a]	3.22 (1.79)[a]
Fipronil 5 SC @ 75 g a.i. ha^{-1}	3.33 (1.82)[a]	2.67 (1.63)[a]	3.33 (1.82)[a]	3.33 (1.82)[a]	3.33 (1.82)[a]	3.22 (1.79)[a]
Untreated control	3.66 (1.91)[a]	3.66 (1.91)[a]	3.66 (1.91)[a]	3.67 (1.91)[a]	3.33 (1.82)[a]	3.56 (1.88)[a]
SE	1.86	0.40	0.35	0.45	0.40	0.36
CD (0.05)	5.67	1.24	1.06	1.39	1.22	1.11

PTC – Pre treatment count before second drenching; DAS – Days after second drenching; Figures in the parentheses are square root transformed values. In a column figures followed by a common alphabet are not significantly different at 5% level by DMRT a.i. ha^{-1} > chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1} = chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1} > chlorantraniliprole 35 WG @ 62 g a.i. ha^{-1} > fipronil 5 SC @ 75 g a.i. ha^{-1} > chlorpyriphos 20 EC @ 250 g a.i. ha^{-1} (Table 3).

Effect of chlorantraniliprole 35 WG on coccinellid beetles in sugarcane field was assessed at the time of second application of insecticides. The pre treatment population of coccinellids was 2.67 to 3.66 per hill during first season and 3.00 to 3.67 per hill during second season (Table 4). Population of coccinellids was not influenced by the application of insecticides and all the treatments were on par with each other during the period of observation (Table 4).

The results of the yield obtained in treated plots revealed that the highest cane yield of 120.0 and 120.43 ton ha^{-1} was recorded in chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1} than other treatments during first and second season, respectively (Table 5). It was followed by chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1} and chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1} with cane yield of 119.48 and 120.29 ton ha^{-1} and 119.23 and 119.64 ton ha^{-1} during first and second season, respectively and both are on par with each other (Table 5). The results of the field experiment conducted to assess the pytotoxicity of the chlorantraniliprole 35 WG at 75 g a.i. ha^{-1} (X dose), 150 g a.i. ha^{-1} (2X dose) and 300 g a.i. ha^{-1} (4X 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 all the days of observation (Table 6).The results of the residual effect of chlorantraniliprole 35 WG at 75 g a.i. ha^{-1} (X dose) and 150 g a.i. ha^{-1} (2X dose) on succeeding cowpea crop revealed that the mean plant population level per m^2, mean plant height

Table 5. Yield of sugarcane in different insecticides treated plots

Treatment	Mean yield(T/ha) 2015-2016	Mean yield(T/ha) 2016-2017
Chlorantraniliprole 35 WG @ 62 g a.i. ha^{-1}	103.04 (10.15)^{f}	103.27 (10.16)^{d}
Chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1}	119.48 (10.93)^{a}	120.29 (10.97)^{a}
Chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1}	120.00 (10.95)^{a}	120.43 (10.97)^{a}
Chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}	119.23 (10.91)^{a}	119.64 (10.94)^{ba}
Chlorpyriphos 20 EC @ 250 g a.i. ha^{-1}	113.96 (10.67)^{d}	114.26 (10.69)^{b}
Fipronil 5 SC @ 75 g a.i. ha^{-1}	107.38 (10.36)^{e}	107.47 (10.36)^{c}
Untreated control	86.69 (9.31)^{g}	87.24 (9.34)^{e}
S. Em ±	0.02	0.01
CD (0.05)	0.05	0.04

Figures in the parentheses are square root transformed values; In a column figures followed by a common alphabet are not significantly different at 5% level by DMRT.

Table 6. Evaluation of chlorantraniliprole 35 % WG for phytotoxicity on Sugarcane

Treatments	Epinasty			Hyponasty			Yellowing			Necrosis			Leaf Injury			Vein Clearing			Wilting			Stunting		
	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3	R_1	R_2	R_3
T_1 - Chlorantraniliprole 35 WG @ 75 g a.i/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_2 - Chlorantraniliprole 35 WG @ 150 g a.i/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_3 - Chlorantraniliprole 35 WG @ 300 g a.i/ha	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T_4 - Untreated control	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DAD: Days After Drenching

Table 7. Residual effect of chlorantraniliprole 35 WG in succeeding crop - Cowpea

Treatments	Mean plant population / m^2				Mean plant height (cms)				Mean grain yield (Kg/ha)	
	2015-2016		2016-2017		2015-2016		2016-2017		2015 - 2016	2016 - 2017
	15 DAS	30DAS	15 DAS	30DAS	15 DAS	30DAS	15 DAS	30DAS		
Chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1}	20.00	20.67	21.67	21.00	6.17	19.00	6.67	17.83	952.94	875.01
Chlorantraniliprole 35 WG @ 150 g a.i. ha^{-1}	21.00	20.00	21.00	20.66	7.17	19.50	6.75	17.83	959.61	890.57
Untreated control	21.00	21.00	21.33	21.00	6.83	18.50	7.17	18.33	964.03	888.35

and mean grain yield were not influenced by the treatments (Table 7).

Discussion

The results revealed that, chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1} registered lower damage of ESB and INB throughout the season followed by chlorantraniliprole 35 WG @ 75 g a.i. ha^{-1} and chlorantraniliprole 18.5 SC @ 75 g a.i. ha^{-1}. Chlorantraniliprole 35 WG did not cause any phytotoxicity to the sugarcane crop even at 4X dosage and not cause any impact on the natural enemy population. The yield of chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1} treated plots was higher than other treatments and on par with the recommended dose 75 g a.i. ha^{-1} and did not cause any harm to the succeeding cowpea crop. The results are in confirmation with the findings of Bhavani et al. (2017), Badgujar (2017). Bhawani et al. (2017) found that the soil application of chlorantraniliprole 0.4 G @ 22.5 kg /ha at 0 and 60 DAP was the best in reducing the ESB infestation and increasing the cane yield in sugarcane. Choudhary et al. (2018) reported that the soil application of chlorantraniliprole 0.4 G @ 22.5 kg /ha or fipronil 0.3 G @ 25 kg /ha at planting and 60 DAP may be recommended for the effective management of ESB in sugarcane. To conclude, chlorantraniliprole 35 WG @ 88 g a.i. ha^{-1} and 75 g a.i. ha^{-1} were recorded best in the management of damage by ESB and INB without affecting the natural enemy population besides increasing the cane yield.

References

Badgujar MP, Chaudhari PM, Ajotikar MV, Solanke AV (2017) Evaluation of new chemical molecules against sugarcane early shoot borer (*Chilo infuscatellus* Snellen). In: Proceedings of International Symposium on "Sugarcane Research Since Co 205: 100 Years and Beyond (SucroSym 2017), ICAR-Sugarcane Breeding institute, Coimbatore, India, 374-376.

Bhavani B, Bharatha Laxmi M, Veerabhadra Rao K (2017) Bio-efficacy of selective new insecticides against sugarcane borer complex in Andhra Pradesh, India. Advances in Applied Science 2017: 25-31.

Bhawani B, Visalakshi M Bharatha, Venugopala Rao (2017) Bio-efficacy of chlorantraniliprole against sugarcane early shoot bore in north coastal zone of Andhra Pradesh, India" Abstract in Proceedings of International Symposium on "Sugarcane Research Since Co 205: 100 Years and Beyond (SucroSym 2017), ICAR-Sugarcane Breeding institute, Coimbatore, India, 380-381.

Chandel AK, da Silva SS, Carvalho W, Singh OV (2012) Sugarcane bagasse and leaves: foreseeable biomass of biofuel and bio-products. Journal of Chemical Technology and Biotechnology 87:11-20.

Choudhary AK, Amrate PK, Chatterjee A (2018) Bio-efficacy of some insecticides for the management of early shoot borer, *Chilo infescatellus* (Snellen) in Sugarcane. International Journal of Chemical Studies 6(3): 1371-1373.

Cordova D, Benner EA, Sacher MD, Rauh JJ, Sopa JS, Lahm GP, Selby TP, Stevenson TM, Flexner L, Gutteridge S, Rhoades DF, Wu L, Smith RM, Tao Y (2006) Anthranilic diamides: A new class of insecticides with a novel mode of action and ryanodine receptor activation. Pesticide Biochemistry and Physiology 84, 196-214.

Dawson L, Boopathy R (2007). Use of post-harvest sugarcane residue for ethanol production. Bioresource Technology 98: 1695-1699.

Dinter A, Brugger K, Bassi A, Frost NM, Woodward MD (2008) Chlorantraniliprole (DPX-E2Y45, Rynaxypyr®) (Coragen® 20SC and Altacor® 35WG) - A novel DuPont anthranilic diamide insecticide - demonstrating low toxicity and low risk for beneficial insects and predatory mites. IOBC WPRS Bulletin 35: 128-135.

Leslie G (2004). Pests of Sugarcane. In: Sugarcane: World Agricultural Series. (ed. G. James), 2nd Ed. pp. 78-100. Blackwell Science Ltd, India

Sharma N, Mandal K, Kumar R, Kumar B, Singh B (2013) Persistence of chlorantraniliprole granule formulation in sugarcane field soil. Environmental Monitoring and Assessment, 186, 2289-2295.

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