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Bioefficacy of chlorantraniliprole (AC 01) 0.4%GR against Early Shoot Borer and Termites in Sugarcane

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ABSTRACT

A field study was conducted using a randomized block design with six treatments, each replicated three times, at the Regional Agricultural Research Station, Anakapalle, Andhra Pradesh to evaluate the efficacy of AC 01 (chlorantraniliprole) 0.4% GR, a formulation developed by NATCO Pharma Limited, Hyderabad against commercially available formulations of chlorantraniliprole 0.4G and fipronil 0.3G for the control of early shoot borer and termites in sugarcane. Treatments were applied at the time of planting and again at 40 days after planting (DAP). Observations on termite damage to setts were recorded at 30 DAP, while early shoot borer infestation was assessed at 30, 60, 90, and 120 DAP on a whole-plot basis. Yield-contributing parameters, juice sucrose content, and cane yield were recorded at harvest. The results demonstrated that soil application of AC 01 (0.4% GR) at 75 g a.i./ha at planting and again at 40 DAP significantly reduced termite damage (4.00%) and early shoot borer incidence (20.58% deadhearts), resulting in a higher cane yield (92.17 t/ha) compared to the untreated control (52.52% deadhearts; 19.91% termite incidence; 69.33 t/ha). The performance of AC 01(0.4%GR) was comparable to that of the market sample of chlorantraniliprole 0.4 GR (COVER) at 75g a.i./ha and fipronil 0.3 GR at 100g a.i./ha No phytotoxic effects were observed, even at four times the recommended dosage.

Keywords : Chlorantraniliprole, Early Shoot Borer, Fipronil, Sugarcane, Termites.

INTRODUCTION

In Andhra Pradesh, the early shoot borer (*Chilo infuscatellus* Snellen) is a major pest that affects the sugarcane crop during its initial growth stages. Initially acting as a shoot borer and later transitions into an internode borer once internode formation begins. The larvae penetrate the shoots and feed on the growing points resulting in the formation of a characteristic symptom known as a dead heart. This pest poses a major threat, particularly under stress conditions, where it can cause the complete death of seedlings. Infestation rates have been observed to range from 15.5% to 60.5% of emerging shoots, with up to 90% of clumps affected in the North Coastal Zone, leading to yield losses of approximately 22–23% (Bhavani *et al*, 2016; Anonymous, 2024). In subtropical regions of India, damage caused by the early shoot borer during the early crop stages (May–June) has been reported to range from 30% to 75% (Balasubramaniyan *et al*, 2020). If left unmanaged, this pest can result in substantial reductions in sugarcane tonnage.

Chlorantraniliprole, an anthranilic diamide insecticide, effectively controls lepidopteran pests as well as coleopteran, dipteran and hemipteran pests (Sharma *et al,* 2013) through ryanodine receptor activation, leading to muscle paralysis and insect death (Cordova *et al,* 2006). It has low toxicity to mammals, strong ovicidal and larvicidal properties, long lasting residual effect, and minimal impact on beneficial organisms (Dinter *et al*, 2008) making it suitable for Integrated Pest Management (IPM). With this background, a study has been carried out to evaluate the efficacy of AC 01 (0.4%GR) against early shoot borer and termites in sugarcane.

MATERIALS AND METHODS

A field experiment was conducted during the year 2019-2020 at Regional Agricultural Research Station, Anakapalle, Andhra Pradesh in a Randomised Block design (RBD) with three replications using a sugarcane variety, Co A 99082. The plot size was 28.8 m^2 (6 M X 0.8 M X 6 R). The insecticide granules *viz.*, AC01-0.4% GR (chlorantraniliprole), a product of M/s NATCO Pharma Limited, Hyderabad, chlorantraniliprole 0.4GR (COVER) and fipronil 0.3GR at two dosages were applied in the soil at the time of planting and at 40 days after planting in

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Table 1. Detail of the treatments

Sr. No	Treatment	Dose/hectare		Remarks
		g a.i./ha	Formulation (in kg/ha)	
1	Untreated control	-	-	Bioefficacy + Phytotoxicity studies
2	AC01(0.4GR)	60	15.00	Bioefficacy + Phytotoxicity studies
3	AC 01 (0.4GR)	75	18.75	Bioefficacy + Phytotoxicity studies
4	Chlorantraniliprole 0.4GR	75	18.75	Bioefficacy + Phytotoxicity studies
5	Fipronil 0.3GR	75	25.00	Bioefficacy + Phytotoxicity studies
6	Fipronil 0.3GR	100	33.33	Bioefficacy + Phytotoxicity studies
7	AC 01 (0.4GR)	150	37.50	Phytotoxicity studies
8	AC 01 (0.4GR)	300	75.00	Phytotoxicity studies

Grade	Phytotoxicity symptom%
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

furrows. The required dose was mixed in sand (1:2) and applied in the furrows to spread the insecticide thoroughly around the planting zone. The treatment details were furnished in Table 1.

Observations on the number of shoots germinated in each treatment were recorded 30 days after planting, excluding two border rows. The number of shoots were counted on a whole-plot basis for each treatment, and the percentage germination was calculated accordingly. Data on termite damage to setts and early shoot borer infestation in shoots were collected on a whole-plot basis for each treatment. The total number of shoots and the number of damaged shoots (dead hearts) were recorded at 30, 60, 90, and 120 days after planting. These counts were then used to calculate the percentage incidence of dead hearts (% DH). Observations on juice sucrose (%), cane height(m), cane weight (kg), cane girth (cm) were recorded from 10 randomly selected plants per plot. The number of millable canes and cane yield per plot were recorded at harvest and expressed as the number of millable canes per hectare (NMC/ha) and cane yield in tonnes per hectare (t/ha), respectively. All collected data were subjected to statistical analysis using analysis of variance (ANOVA) to determine the significance of treatment effects.

To assess the phytotoxicity of AC 01 (chlorantraniliprole 0.4%GR) at 60g a.i. ha^{-1}, 75g a.i. ha^{-1} (recommended dose, X), 150g a.i. ha^{-1} (2X), and 300g a.i. ha^{-1} (4X), treatments were applied at the time of planting and at 40 days after planting in sugarcane. Phytotoxicity symptoms *viz*., chlorosis, epinasty, hyponasty, and necrosis were recorded at 30, 60, 90, and 120 days after planting. Observations were made using a 0–100% scale, where 0 indicated no phytotoxicity and 100 indicated complete plant death, in accordance with the Central Insecticide Board and Registration Committee (CIBRC) protocol.

RESULTS AND DISCUSSION

Germination

The data at 35 days after planting (Table 3) revealed that, per cent germination ranged between 67.22 and 74.13. However, among six treatments, the highest per cent germination recorded in AC01(0.4GR) @ 75 g a.i. ha^{-1} (74.13 %) was

Table 2. Bioefficacy of AC01 0.4%GR (chlorantraniliprole) against termites, early shoot borer in sugarcane

Sr. No	Treatment	Dose/ha		Germination (%)	Incidence of termite at 30 DAP (%)	Reduction over control (%)	Incidence of early shoot borer (%DH)					Reduction over control (%)
		g a.i. ha^{-1}	Formulation (Kg/Ha)		Sett damage (%)		30 DAP	60 DAP	90 DAP	120 DAP	Cumu-lative up to 120 DAP	
1	Untreated control	-	-	55.08^b (67.22)	26.48^d (19.91)	-	30.79^c (26.26)	41.06^d (30.04)	33.22^e (43.17)	19.05^d (10.72)	52.23^d (62.52)	--
2	AC01(0.4GR)	60	15.00	56.12^b (68.96)	17.57^c (9.17)	53.94	15.86^b (7.51)	24.99^b (15.17)	22.91^b (17.87)	15.55^c (7.20)	38.03^b (38.01)	39.21
3	AC 01 (0.4GR)	75	18.75	59.41^a (74.13)	11.45^a (4.00)	80.0	12.98^a (5.08)	11.54^a (10.97)	19.31^a (4.04)	3.78^a (0.50)	26.93^a (20.58)	67.08
4	Chlorantraniliprole 0.4GR (Market sample; Cover)	75	18.75	58.96^a (73.43)	11.94^a (4.30)	78.40	13.20^a (5.22)	11.82^a (11.05)	19.38^a (4.22)	6.60^b (1.33)	28.51^a (22.80)	63.53
5	Firponil 0.3GR	75	25.00	58.57^a (72.84)	13.27^b (5.29)	73.43	15.45^b (7.14)	32.22^c (18.72)	25.61^d (28.49)	15.98^c (7.61)	44.81^c (49.70)	20.50
6	Fipronil 0.3GR	100	33.33	59.98^a (75.00)	11.66^a (4.13)	79.26	12.82^a (4.96)	26.92^b (15.08)	22.83^b (20.54)	8.56^b (2.23)	28.75^a (23.20)	64.60
	'F' test	**-**	**-**	Sig.	Sig.		Sig.	Sig.	Sig.	Sig.	Sig.	
	CD (p=0.05)	-	-	2.50	2.43		2.46	2.43	2.10	2.38	2.61	
	CV %	-	-	2.34	8.57		7.91	5.32	5.63	11.16	3.88	

DAP - Days after planting; Figures in parenthesis are original values

Table 3. Impact of AC01 (0.4GR) on juice sucrose, yield attributing characters and marketable cane yield (t/ha)

Sr. No	Treatment	Dose/ha		Juice Sucrose (%)	Yield attributing characters			Cane yield (t/ha)	Increase in cane yield over control (%)
		g a.i. /ha	Formulation (kg/ha)		Cane height (m)	Cane girth (cm)	NMC (000'/ha)		
1	Untreated control	-	-	19.25	1.67	1.47	60.78	69.33	-
2	AC01(0.4GR)	60	15.00	19.49	2.04	1.49	62.22	80.08	17.91
3	AC 01 (0.4GR)	75	18.75	20.07	2.27	1.50	73.11	92.17	32.94
4	Chlorantraniliprole 0.4GR (Market sample; Cover)	75	18.75	20.03	2.28	1.51	72.97	91.33	32.88
5	Fipronil 0.3GR	75	25.00	19.29	2.12	1.50	71.24	80.50	16.11
6	Fipronil 0.3GR	100	33.33	19.69	2.24	1.51	72.78	90.50	30.53
	'F'test			NS	Sig.	NS	Sig.	Sig.	
	CD (p-0.05)			-	0.16	-	10.72	8.31	
	CV%			4.08	4.26	1.20	9.04	4.86	

DAP - Days after planting; Figures in parenthesis are original values

statistically at par with chlorantraniliprole 0.4GR (market sample) @ 75 g a.i./ha (73.83%), fipronil 0.3GR @ 75 g a.i./ha (72.84%) and fipronil 0.3GR @ 100 g a.i./ha (75.00%) but differed from untreated control.

Termites

Based on the data recorded 30 days after planting (Table 2), the percentage of sett damage caused by termites ranged from 4.00% to 19.91%. Among the six treatments, AC 01 (0.4GR) 75 g a.i./ha (4.00%) was found effective against termites as compared to untreated control (19.91%) and it was at par with fipronil 0.3GR 100 g a.i./ha (4.13%) and chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i./ha (4.30%). However, all the insecticidal treatments except AC 01(0.4%GR) 60 g a.i./ha (9.17%) were found effective in reducing the sett damage by termites and recorded good per cent germination over untreated control. The findings regarding fipronil agree with those of Alam *et al* (2001), who reported that soil application of fipronil 0.3G at 100 g a.i./ha was effective in managing white grubs and termites in sugarcane. Similarly, studies by Gold (2014) and Jones *et al* (2017) demonstrated the high efficacy of chlorantraniliprole when applied to soil, noting its ability to provide structural protection and induce rapid termite mortality upon contact. Chlorantraniliprole is particularly valued for its prolonged residual activity and its capacity to quickly suppress termite activity following application

Table 4. Evaluation of AC01 (0.4GR) for phytotoxicity on sugarcane

S. No.	Treatment	Dose/ha		Phytotoxicity scoring							
		g a.i. ha^{-1}	Formulation (kg/ha)	Epinasty	Hypo nasty	Yellowing	Necrosis	Leaf injury	Vein clearing	Wilting	Stunting
1	Untreated control	-	-	0	0	0	0	0	0	0	0
2	AC01(0.4GR)	60	15.00	0	0	0	0	0	0	0	0
3	AC 01 (0.4GR)	75	18.75	0	0	0	0	0	0	0	0
4	Chlorantraniliprole 0.4GR (Market sample)	75	18.75	0	0	0	0	0	0	0	0
5	Fipronil 0.3GR	75	25.00	0	0	0	0	0	0	0	0
6	Fipronil 0.3GR	100	33.33	0	0	0	0	0	0	0	0
7	AC 01 (0.4GR)	150	37.50	0	0	0	0	0	0	0	0
8	AC 01(0.4GR)	300	75.00	0	0	0	0	0	0	0	0

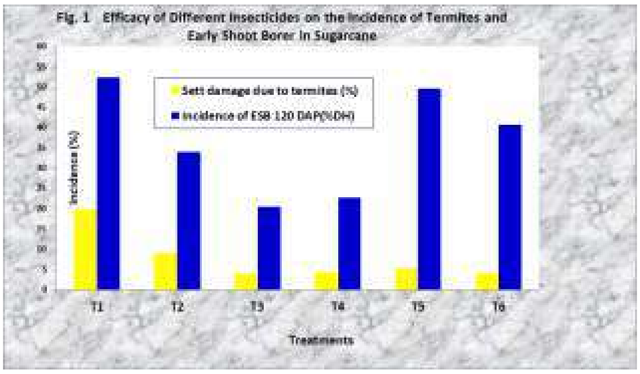

Fig. 1 Efficacy of Different Insecticides on the Incidence of Termites and Early Shoot Borer in Sugarcane

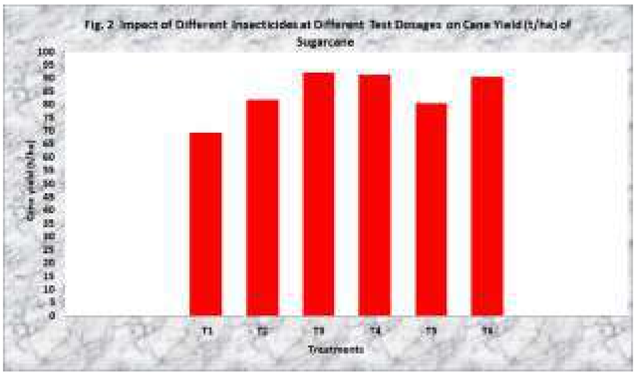

Fig. 2 Impact of Different Insecticides at Different Test Dosages on Cane Yield (t/ha) of Sugarcane

Early shoot borer

The data on the incidence of early shoot borer recorded at 30 days after planting (Table 2) revealed that among six treatments, least incidence of early shoot borer was recorded in crop treated with fipronil 0.3GR @ 100 g a.i./ha (4.96%DH) followed by AC01 (0.4 GR) @ 75 g a.i./ha (5.08 % DH) and chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i./ha (5.22 % DH). These treatments were statistically at par but superior over control (26.26 % DH). The incidence of early shoot borer recorded at 60 days after planting revealed that among six treatments, less incidence of early shoot borer was recorded in AC 01 (0.4GR) @ 75 g a.i./ha (4.04 % DH) and chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i./ha (4.22 %DH) as compared to untreated control (43.17% DH) and these treatments were statistically at par with each other. The incidence of early shoot borer recorded at 90 days after planting revealed that among six treatments, less incidence of early shoot borer was recorded in crop treated with AC01 (0.4GR) @ 75 g a.i./ha (10.97 % DH) and chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i./ha (11.05 %DH) compared to untreated control (30.04% DH) and these two treatments were statistically at par with each other. Data on incidence of early shoot borer was also recorded at 120 DAP (Table 2). Among six treatments, lowest incidence of early shoot borer was recorded in crop treated with AC 01 (0.4%GR) @ 75 g a.i./ha (0.50 %DH) and in chlorantraniliprole 0.4GR @ 75 g a.i./ha (1.33% DH) which were statistically at par with each other and were significantly superior over untreated control (10.72%DH). The data on cumulative incidence of early shoot borer (% DH) revealed that among six treatments, AC 01 (0.4GR) @ 75 g a.i./ha (20.58%DH) and chlorantraniliprole 0.4GR @ 75 g a.i.ha^{-1} (22.80 %DH) were found significantly most effective against early soot borer as compared to other treatments and untreated control (52.52%DH) and were statistically at par with each other (Table 2 & Fig.1).

The results of the study revealed that soil application of AC01 (0.4 GR) at 75 g a.i./ha, applied at planting and 40 days after planting, effectively reduced the incidence of termites and early shoot borer up to 120 DAP. Its performance was comparable to that of chlorantraniliprole 0.4 GR (Market sample; COVER) and fipronil 0.3 GR, with no observed phytotoxic effects even at 4X the recommended dosage. These findings align with Bhavani *et al* (2016) and Choudhary *et al* (2018) reported its effectiveness when applied at planting and again at 60 days after planting (DAP). Similarly, studies by Pandey (2014) and Shobharani *et al* (2018) found chlorantraniliprole 0.4 GR to be effective and comparable to the 20 SC formulation in managing early shoot borer infestations. Umashankar *et al* (2018) also reported that both chlorantraniliprole 0.4 GR and fipronil 0.3 GR effectively reduced the cumulative incidence of *Chilo infuscatellus*, resulting in significantly higher cane yields compared to untreated control. Likewise, Bhawar *et al* (2015) found that treatment with Ferterra 0.4 GR at 75 g a.i.ha^{-1}, along with cartap hydrochloride 4G, effectively reduced dead heart incidence. In the studies conducted by Penn *et al* (2023), Chlorantraniliprole recorded least damage of 0.9 per cent compared to other chemicals and untreated check. Similarly, earlier research supports the effectiveness of fipronil in managing shoot borer and termite infestations**.** Halimie *et al* (1989), Patil *et al* (1993), Nagalakshmi *et al* (1999), and Dheer Singh and Tomar (2003) reported that the application of fipronil 0.3G significantly reduced the incidence of shoot borer.

Juice sucrose

The data on the percentage juice sucrose ranged between 19.25 in untreated control and 20.07 in AC 01 (0.4GR) @ 75 g a.i.ha^{-1}. However, there was no significant difference between the treatments (Table 3).

Cane height

The data on cane height (Table3) revealed that among six treatments, maximum cane height was recorded in plots treated with chlorantraniliprole 0.4GR @ 75 g a.i.ha^{-1} (2.28 m) followed by AC01 (0.4 GR) @ 75 g a.i.ha^{-1} (2.27 m), fipronil 0.3GR @ 75g a.i.ha^{-1} (2.12 m) and @ 100g a.i.ha^{-1} (2.24 m). All these treatments resulted in significantly greater cane height compared to the untreated control (1.67 m).

Cane girth

The data recorded on cane girth at harvest showed that all the treatments recorded significantly more cane girth (1.49 to 1.51 cm) as compared to untreated control (1.47 cm). However, statistically there was no significant difference among the treatments (Table 3).

Number of millable canes (NMC/Ha)

The data presented in Table 3 indicated that the number of millable canes (000'NMC/ha) recorded at harvest ranged between 60.78 to 73.11. Among the six treatments, more number of millable canes per hectare were recorded in plots treated with AC 01 (0.4GR) @ 75 g a.i.ha^{-1} (73.11 NMC/ha) followed by chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i.ha^{-1} (72.97 NMC/ha), fipronil 0.3GR at 100 g a.i.ha^{-1} (71.78 NMC/ha) and at 75 g a.i.ha^{-1} (70.44 NMC/ha) and were significantly superior over control (60.78 NMC/ha), though these four chemical treatments were statistically at par with each other.

Marketable cane yield

Data on marketable cane yields at harvest revealed that among six treatment, highest cane yield was recorded in AC01 0.4GR) @ 75 g a.i.ha^{-1} (92.17 t/ha) with 32.94 percent increase in cane yield followed by chlorantraniliprole 0.4GR (Market sample) @ 75 g a.i.ha^{-1} (91.33 t/ha) with 32.88 per cent increase in cane yield and fipronil 0.3GR @ 100g a.i.ha^{-1} (90.50 t/ha) with 30.53 per cent increase in yield (Table 3, Fig.2). These treatments were statistically superior over untreated control (69.33 t/ha).

Phytotoxicity

The results of the field experiment to assess the phytotoxicity of the AC01 (chlorantraniliprole) 0.4%GR at 60g.a.i.ha^{-1}, 75g a.i. ha^{-1} (X dose), 150g a.i. ha^{-1} (2X dose) and 300g a.i. ha^{-1} (4X dose) applied at the time of planting and 40 days after planting 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 4).

CONCLUSION

The study confirms that soil application of chlorantraniliprole (AC 01) 0.4% GR at 75g a.i./ha or fipronil 0.3G at 100g a.i./ha, administered at the time of planting and again 40 days after planting, is an effective strategy for managing early shoot borer and termite infestations in sugarcane.

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