***Original Research Article***

**Bio-efficacy of Chlorantraniliprole 600 g/l SCagainst Sugarcane Early Shoot Borer, *Chilo infuscatellus* (Snellen)**

**ABSTRACT**

Sugarcane (*Saccharum* spp.) is one of the most important commercial crops grown mainly for sugar, jaggery and bio energy. The early shoot borer, *Chilo infuscatellus* Snellen is considered to be most destructive insect inflicting severe damage in early growth stage. To evaluate the bio-efficacy of chlorantraniliprole 600 g/l SC against sugarcane early shoot borer, experiment was conducted during 2020-21 and 2022-23 at RARS, Anakapalle. The results indicated that, chlorantraniliprole 600 g/l SC @ 100 g a.i ha-1 recorded lowest dead heart damage (2.23-2.31%) with highest per cent pest reduction over untreated control (88.49-88.69 %), however it was statistically on par with chlorantraniliprole 600 g/l SC @ 75 g a.i ha-1. Untreated control treatment recorded at highest per cent dead heart damage (19.37-20.43 %). The yields recorded were 90.69-93.67 tha-1 in the treatment chlorantraniliprole 600 g/l SC @ 100 g a.i ha-1, whereas untreated control recorded lowest yields of 56.32-58.34 tha-1. During both the years, there was no ill effect after treatment imposition was observed on the population of coccinellids and spiders.

**Keywords**:Sugarcane, early shoot borer, Chlorantraniliprole

**INTRODUCTION**

Sugarcane (*Saccharum* spp.) is one of the most important commercial crops grown mainly for sugar and jaggery in many countries and also for bio energy production from its by-products bagasse and molasses. Sugarcane is also one of the important cash crops in India and plays pivotal role in both agricultural and industrial economy. India ranks first in the world with an area of 4.73 million hectares having 2.46per cent share of total area with a production of 376.9 million tonnes (FAOSTAT, 2020).Sugarcane being a long duration crop, its production and productivity is affected by many factors viz, soil type, selections of variety, fertilizer management, irrigation management and damage caused by pests (Bhawar et al., 2015). During entire cropping period it suffers the attack of a wide range of insect pests from planting to till harvesting, out of these the borers i.e., root, shoot, top, internode and Plassey borer are caused heavy losses to the quality as well as quantity of the crop (Kumar et al., 2017). Among them, the early shoot borer, *Chilo infuscatellus* Snellen is considered to be noxious and destructive insect conflicting severe damage in early growth stage and yield loss (Douressamy et al., 2018).

Chlorantraniliprole,3-bromo-N-[4-chloro-2-methyl-6-[(methylamino)carbonyl]phenyl]-1-(3-chloro-2-pyridinyl)-1H-pyrazole-5-carboxamide is an anthranilic diamide insecticide with a novel mode of action called ‘Ryanodine muscle contraction’ is found effective against several lepidopteran as well as coleopteran, dipteran, and hemipteran pests. 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. Chlorantriniliprole has excellent profile of safety to beneficial arthropods, pollinators, honeybees and non-target organisms such as earthworms and soil microorganisms (Dinter et al., 2008).The remarkably favourable toxicity profile of chlorantriniliprole, combined with low use rates, provides large margins of safety for consumers and agricultural workers(Sharma etal.,2013). With this background, a study has been carried out to assess the bio-efficacy of Chlorantraniliprole 600 gl-1 SC in comparison to other chemicals against early shoot borer on sugarcane.

**MATERIALS AND METHODS**

The research work was carried out at the Regional Agricultural Research Station, Anakapalle, Visakhapatnam, Andhra Pradesh during 2021-22 and 2022-23 to assess the bio-efficacy of different doses of chlorantraniliprole 600 gl-1 SC in comparison to other chemicals against early shoot borer on sugarcane.

**Cultivation of Sugarcane**

The sugarcane crop was raised in an area of 0.2 ha adopting a spacing of 90 cm between rows with the variety 93A145 in randomized block design replicated thrice with eight treatments as detailed in table 1. All the agronomic practices were adopted as per the standard recommendations to raise the crop except for plant protection measures.

**Data on early shoot borer**

Dead heart damage caused by early shoot borer was recorded at 30, 45, 60 and 90 days after application. Total number of dead heart damaged shoots and total number of shoots were recorded leaving two border rows in each plot to calculate per cent dead heart damage. The cumulative per cent dead heart damage reduction over untreated control was recorded at 90 days after application as per the formula (Sithanantham,1973)

$$Dead heart damage\left(per cent\right)=\frac{Number of dead heart shoots}{Total number of shoots}×100$$

**Data on natural enemies**

Effect of treatments on spiders and coccinellids were recorded at 30, 45, 60 and 90 days after application by recording population of natural enemies on 10 randomly selected clumps per plot.

**Yield**

Plot wise yield was recorded at the time of harvest. Yield per hectare was calculated and expressed as tons per hectare.

**Statistical Analysis**

The experiments have been replicated thrice during two subsequent years. The data from field experiments was screened by ANOVA (analysis of variance) after getting transformed as per Gomez (1984). Pooled RBD ANOVA was done using Microsoft excel. Critical difference was calculated at 5per cent probability level and treatments mean values were compared using Duncan’s Multiple Range Test (DMRT) as per Gomez and Gomez, 1984.

**RESULTS AND DISCUSSION**

 The data on various parameters on bio-efficacy of different doses of chlorantraniliprole 600 gl-1 SC in comparison to other chemicals against early shoot borer on sugarcane are presented in table 2 and table 3.

During 2021-22, among all the treatments, from 30 to 90 days after application, chlorantraniliprole 600 gl-1 SC @ 100 g a.iha-1 recorded lowest dead heart damage ranging from (0.00- 2.75 per cent) with highest per cent reduction over untreated control (87.53per cent) which was found on par with the chlorantraniliprole 600 gl-1 SC @ 75 g a.i.ha-1which recorded 0.00-2.85 per cent dead hearts and 86.84 per cent reduction over control. Chlorantraniliprole 18.5per cent SC @ 75 g a.i.ha-1was also statistically on par with these treatments recording 0.37-3.04 per cent dead hearts and 85.96 per cent reduction over control. These were followed by chlorantraniliprole 600 gl-1 SC @ 50 g a.i.ha-1 which recorded 1.26-6.67 per cent dead hearts and 69.21 per cent reduction over control which was on par with chemical check chlorpyriphos 20.0% EC @300mll-1 recording 3.97-6.36 per cent dead hearts and 70.54 per cent reduction over control.Untreated control treatment recorded at highest per cent dead heart damage (20.43 per cent). With regard to natural enemies,the cumulative data revealed that there was no ill effect after treatment imposition as the population of coccinellids *(Cryptolaemus montrouzieri, Chilocorus nigrita and Scymnus nubilus*) and spiders did not show any significant treatmental differences. The population of coccinellids varied between 5.67 to 8.00 per ten clumps and spiders ranged between 6.67 and 8.33 per ten clumps. Among all the treatments chlorantraniliprole 600 gl-1 SC @ 100 g a.i.ha-1 recorded highest yield (92.83 tha-1) which was found on par with the chlorantraniliprole 600 gl-1 SC @ 75 g a.i.-1ha (92.13 tha-1) and chlorantraniliprole 18.5per cent SC @ 75 g a.i.ha-1 (91.53 tha-1). The untreated control treatment recorded lowest yield of 56.32 tha-1.

Similar results were obtained in the year 2022-23. Data recorded from 30 to 90 days after application,chlorantraniliprole 600 gl-1 SC @ 100 g a.i.ha-1 recorded lowest dead heart damage (0.00-2.23per cent) with highest per cent disease reduction over untreated control (88.49per cent). This was found on par with the chlorantraniliprole 600 gl-1 SC @ 75 g a.i.ha-1which recorded 0.00-2.37 per cent dead heart damage and resulted in 87.76 per cent reduction compared to untreated plots. chlorantraniliprole 18.5per cent SC @ 75 g a.i.ha-1was also statistically on par with these treatments recording to 0.14-2.48 per cent dead hearts resulting in 87.20 per cent reduction of damage. It was followed by chlorantraniliprole 600 gl-1 SC @ 50 g a.i.ha-1 which recorded 3.19-5.48 per cent dead hearts and 70.93 per cent reduction over control which was on par with chemical check chlorpyriphos 20.0% EC @300mll-1 recording 0.89-5.63 per cent dead hearts and 71.71 per cent reduction over control.Untreated control treatment recorded at highest per cent dead heart damage (3.42-19.37per cent).The cumulative population of coccinellids(6.00-8.00 per 10 clumps) and spiders(6.67-8.00 per 10 clumps) were statistically on par in all the treatments including untreated check, suggesting no ill effect of chlorantraniliprole 600 gl-1 SC on them. With regard to yield, chlorantraniliprole 600 gl-1 SC @ 100 g a.i.ha-1 recorded highest yield (93.67 tha-1) which was found on par with the chlorantraniliprole 600 gl-1 SC @ 75 g a.i.-1ha (93.28 tha-1 per ha) and chlorantraniliprole 18.5per cent SC @ 75 g a.i.ha-1 (92.12 tha-1), which were high compared to chlorantraniliprole 600 gl-1 SC @ 50 g a.i.ha-1 which recorded 82.81 tha-1and chlorpyriphos 20.0% EC @300mll-1recording 82.23 tha-1. The untreated control treatment registered the least yield of 58.34 tha-1.

 Many researchers have reinstated the bio-efficacy of various Chlorantraniliprole formulations in tackling borers in sugarcane. Sunilkumar et.al.,(2018)stated that sett drenching with chlorantraniliprole was most effective in reducing the early shoot borer damage and gave higher yields compared to other chemicals tested. In the studies conducted by Paudel et al.(2021), the lowest percentage of the infestation was found on plots treated with chlorantraniliprole and spinosad *viz*., 10.65 per cent and 12.43 per cent respectively followed by cartap hydrochloride, thiodicarb and fipronil with infestation percentage of 13.68, 14.61 and 14.15 respectively. The highest reduction (69.40 per cent) of infestation was found on chlorantaraniliprole treated plots over control. In another study, it is found that chlorantraniliprole 35%WG @ 75 g a.i. /ha were found effective in reducing Internode borer damage (Sunilkumar et al., 2018). High efficacy of chlorantriniliprole in reducing borer damage in sugarcane has been reported by Rajinder Kumar et al.,(2020).Similarly, Pandey (2014) and Padmasri et al., (2014) also reported that chlorantraniliprole is the most effective insecticide against early shoot borer. Studies conducted by Douressamy et al (2018), revealed that chlorantraniliprole registered lower damage of early shoot borer and internode borer and also recorded highest cane yield. According to Wilson et al.(2022), results across trials demonstrated superior control was achieved with chlorantraniliprole over [novaluron](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/novaluron) and [tebufenozide](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/tebufenozide) for management of borers in sugarcane. Novaluron and chlorantraniliprole have proven effective in reducing *D. saccharalis* injury, achieving reductions ranging from 39.1 to 99.4per cent (Reay Jones et al. 2005). Chlorantraniliprole and flubendiamide have demonstrated high effectiveness in the management of *E. loftini* (Wilson et al. 2017).Sheeba et al., (2012) and Singh et al., (2009) have also postulated that Chlorantraniliprole was most effective treatment registering lowest incidence(15.43 per cent) of early shoot borer in sugarcane. In the studies conducted by Penn et al.(2023), Chlorantriniliprole recorded least damage of 0.9 per cent compared to other chemicals and untreated check. The spray of chlorantraniliprole reduced the damage of the sugarcane borer by about 52% in the field studies as per Assis et al.(2019).

In the present study, chlorantraniliprole was found to be safe to natural enemies, which is in consensus with the reports by Dinter et al.(2008)who revealed that in Acute toxicity tests with chlorantraniliprole and the formulations, coragen and altacor, demonstrated low intrinsic toxicity to beneficial insects. Douressamy et a.l (2018).Venkateswarluet al.(2011), mentioned that emamectin benzoate and chlorantraniliprole proved safe to natural enemies in their studies. Qi and Casida (2013) have revealed that new generation insecticides like chlorantraniliprole could be an alternative in integrated pest management as they are selective, less hazardous and with low mammalian toxicity. Studies conducted by Rajinder Kumar et al.,(2020) revealed that the populations of natural enemies were comparable in all the treatments suggesting the safety of chlorantriniliprole to natural enemies. Falin He et al.(2019), found that chlorantriniliprole could be classified as harmless or slightly harmful to coccinnellid beetles. According to Patel et al.(2016), the population of spiders was statistically on par in different doses of chlorantriniliprole and untreated check, reinstating the bio-safety of the chemical.

**CONCLUSION**

The results of the experiment revealed that, among all the treatments, chlorantraniliprole 600 gl-1 SC @ 100 and 75 g a.i.ha-1 treatments effectively controlled early shoot borer and recorded higher yield with no adverse effect on natural enemies.

**COMPETING INTERESTS**

There is no conflict of interest on the manuscript. Competing interest in disclosure of the research work has been considered by the authors. The authors undertake full responsibility of the data/ statements / opinions contained in the manuscript.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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| **Table 1: Treatment details** |
| **Tr. No.** | **Treatments** | **Dosage** | **Time and method of application** |
| **g a.i.ha**-1 | **Formulation (g or mlha**-1**)** |
| T1 | Chlorantraniliprole 600 gl-1 SC | 50 | 83.33 | Drenching over the cane setts at planting |
| T2 | Chlorantraniliprole 600 gl-1 SC | 75 | 125 |
| T3 | Chlorantraniliprole 600 gl-1 SC | 100 | 166.6 |
| T4 | Chlorantraniliprole 18.5% SC | 75 | 375 |
| T5 | Fipronil 05.00 % SC | 100.0 | 2000 | Foliar spray at 35 days after planting |
| T6 | Thiamethoxam 75.00% w/w SG | 120.0 | 160 | Drenching over the cane setts at planting |
| T7 | Chlorpyriphos 20% EC | 300 | 1500 | Foliar spray at 30 days after planting  |
| T8 | Untreated control | - | - | - |

**Table 2. Bio-efficacy Chlorantraniliprole 600 gl-1 SCagainst Early shoot borer in sugarcane (2021-22)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Tr. No.** | **Treatments** | **Dead heart damage (%)** | **% Reduction Over untreated Control at 90 DAA** | **Coccinellids/ 10 clumps** | **Spiders/ 10 clumps** | **Yield (**tha-1**)** |
| **30 DAA** | **45 DAA** | **60 DAA** | **90 DAA** |
| T1 | Chlorantraniliprole 600 gl-1 SC @ 50 g a.i.ha-1 | 1.26(6.41) | 5.06(13.00) | 8.41(16.86) | 6.67(14.96) | 69.21 | 6.00 | 7.67 | 79.86 |
| T2 | Chlorantraniliprole 600 gl-1 SC @ 75 g a.i.ha-1 | 0.00(0.00) | 2.54(9.17) | 3.69(11.07) | 2.85(9.71) | 86.84 | 5.67 | 8.33 | 92.13 |
| T3 | Chlorantraniliprole 600 gl-1@ 100 g a.i.ha-1 | 0.00(0.00) | 2.45(8.99) | 3.57(10.89) | 2.70(9.44) | 87.53 | 6.00 | 6.67 | 92.83 |
| T4 | Chlorantraniliprole 18.5% SC @ 75 ga.i.ha-1 | 0.37(2.02) | 2.65(9.37) | 3.83(11.26) | 3.04(10.03) | 85.96 | 7.33 | 7.33 | 91.54 |
| T5 | Fipronil 5.0% SC @ 100ml a.i.ha-1 | 3.87(11.33) | 7.86(16.28) | 10.20(18.62) | 8.95(17.4) | 58.68 | 6.00 | 7.00 | 74.57 |
| T6 | Thiomethoxam 75.0% w/w SG @ 120 g a.i.ha-1 | 2.03(8.18) | 8.23(16.67) | 9.89(18.33) | 8.79(17.25) | 59.42 | 8.00 | 8.00 | 75.85 |
| T7 | Chlorpyriphos 20.0 % EC @ 300 ml a.i.ha-1 | 3.97(11.47) | 4.89(12.78) | 7.76(16.17) | 6.36(14.6) | 70.64 | 6.67 | 6.67 | 80.45 |
| T8 | Untreated control | 4.02(11.55) | 20.68(27.05) | 23.56(29.03) | 21.66(27.74) | - | 7.00 | 8.00 | 56.32 |
|   | **S. Em (±)** | **0.80** | **0.17** | **0.31** | **0.20** | **-** | **-** | **-** | **0.85** |
|   | **CD (P=0.05)** | **2.42** | **0.52** | **0.93** | **0.60** | **-** | **NS** | **NS** | **2.58** |

\*Figures in parenthesis are arcsine transformed values;; NS= Non-Significant, DAA= Days after application

**Table 3. Bio-efficacy Chlorantraniliprole 600 gl-1 SCagainst Early shoot borer in sugarcane (2022-23)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Tr. No.** | **Treatments** | **Dead heart damage (%)** | **% Reduction Over untreated Control at 90 DAA** | **Coccinellids/ 10 clumps** | **Spiders/ 10 clumps** | **Yield (**tha-1**)** |
| **30 DAA** | **45 DAA** | **60 DAA** | **90 DAA** |
| T1 | Chlorantraniliprole 600 gl-1 SC @ 50 g a.i.ha-1 | 0.89(5.39) | 4.48(12.21) | 7.23(15.59) | 5.63(13.73) | 70.93 | 6.33 | 8.00(2.94) | 82.23 |
| T2 | Chlorantraniliprole 600 gl-1 SC @ 75 g a.i.ha-1 | 0.00(0.00) | 1.64(7.33) | 2.93(9.85) | 2.37(8.86) | 87.76 | 5.67 | 7.00 | 93.28 |
| T3 | Chlorantraniliprole 600 gl-1@ 100 g a.i.ha-1 | 0.00(0.00) | 1.58(7.23) | 2.81(9.64) | 2.23(8.58) | 88.49 | 7.00 | 6.67 | 93.67 |
| T4 | Chlorantraniliprole 18.5% SC @ 75 ga.i.ha-1 | 0.14(1.25) | 1.76(7.61) | 3.13(10.20) | 2.48(9.05) | 87.20 | 6.00 | 8.00 | 92.12 |
| T5 | Fipronil 5.0% SC @ 100ml a.i.ha-1 | 3.26(10.38) | 6.03(14.21) | 8.76(17.21) | 7.83(16.25) | 59.58 | 6.67 | 7.33 | 76.78 |
| T6 | Thiomethoxam 75.0% w/w SG @ 120 g a.i.ha-1 | 1.17(6.12) | 6.36(14.60) | 8.61(17.06) | 7.66(16.06) | 60.45 | 6.00 | 8.00 | 77.11 |
| T7 | Chlorpyriphos 20.0 % EC @ 300 ml a.i.ha-1 | 3.19(10.29) | 4.23(11.86) | 6.98(15.30) | 5.48(13.53) | 71.71 | 7.33 | 7.00 | 82.87 |
| T8 | Untreated control | 3.42(10.65) | 18.41(25.41) | 21.62(27.7) | 19.37(26.11) | - | 8.00 | 6.67 | 58.34 |
|   | **S. Em (±)** | **0.53** | **0.28** | **0.26** | **0.26** | **-** | **-** | **-** | **0.67** |
|   | **CD (P=0.05)** | **1.61** | **0.83** | **0.77** | **0.80** | **-** | **NS** | **NS** | **2.04** |

\*Figures in parenthesis are arcsine transformed values;; NS= Non-Significant, DAA= Days after application