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Research Article

Evaluation of chemical pesticides for the management of Top Borer (*Scirpophaga excerptalis* Walker) in sugarcane

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ABSTRACT

An experiment was conducted at research field of National Sugarcane Research Program, Jeetpur, Nepal in 2014 and 2016, to evaluate the efficacy of chemical insecticides against sugarcane top borer (*Scirpophaga excerptalis* Walker). Nine different treatments viz. Chlorantraniliprole 0.4 G, Cartap hydrochloride 4 G, Fipronil 0.3 G, Carbofuran 3 G (standard check) as soil application and foliar spray of Chlorantraniliprole 18.5 SC, Thiodicarp 75 WP, Spinosad 45 SC, Chlorpyrifos 20 EC (standard check) and one untreated check (control) were used in randomized complete block design with three replications. The top borer susceptible genotype, Co 0238 was planted on February and single application of these insecticides was done on July at brood stage against top borers. The lowest 10.65 and 12.43, 13.68, 14.61, 14.15 percentage of top borer damage was found in foliar application of Chlorantraniliprole @ 35g a.i. /ha followed by Spinosad @ 125g a.i. /ha and soil application of Cartap hydrochloride @ 1500g a.i /ha and foliar application of Thiodicarp @ 1500g a.i. /ha and Fipronil @ 100g a.i. /ha. The infestation percentage reduction over control was found highest in Chlorantraniliprole (69.40%) followed by Spinosad (64.29%) treated plots. Furthermore, the cane yield was highest in Chlorantraniliprole (92.30 mt/ha) and Spinosad (90.06 mt/ha) treated plots than that of other insecticide treated plots. The number of millable canes and cane diameter in the plots among the treatment was found non-significant. Based on the infestation reduction rate, foliar application of the chemical insecticide (Chlorantraniliprole 18.5 SC and Spinosad 45 SC) could be better option for chemical management of sugarcane top borer.

Keywords: Foliar, Infestation, Management, Pesticides, Soil application

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INTRODUCTION

Sugarcane *Saccharum officinarum* L. is one of the most contributing commercial crop of Nepalese economy. It has been grown in Nepal since long time. Nepal ranks 36th among the sugarcane producing countries in the world (FAOSTAT, 2018). In Nepal, sugarcane is grown in an area of 71.5 thousand hectares producing 3.5 million tonnes of cane with national average yield of 45.67 t/ha (MoALD, 2020). The productivity of Nepal is low as compared to other neighboring countries. The major reason behind the low productivity is lack of improved varieties and

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improved practices including severity of insect pests. Insect pests alone causes 20-60% damage in sugarcane crop (Alam, 1967). In sugarcane, insect pests inflicts loss of around 20% in cane yield and 15% in sugar recovery (Avasty, 1983). Globally, more than 1500 species of insects were found to feed on sugarcane plant (Box, 1953). About a dozen of important insect pests have been mentioned from India and Pakistan (Srikanth, 2012; Chaudhry & Ansari, 1988). The early shoot borer, top shoot borer, internode borer, white grub, sugarcane pyrilla, woolly aphid, scale insect and termites are major pest of sugarcane in Nepal (Ansari *et al.*, 2016; Paudel *et al*., 2019). Top borer is worst pest which is responsible for severe damage in sugarcane causing yield loss and sugar recovery and is major constraint in sugarcane production (Srikanth *et al*., 2012). This borer is also reported from many sugar industries in South-east Asia and is considered as a serious pest of sugarcane (Sallam & Allsopp, 2005). Top borer causes up to 0.11% reduction in brix % juice and similar reductions in pol % juice for every 10% increase in damage. Similarly, for every 10 cm increase in borer tunnel length, it causes decline of 1.2 units of pol % juice (Kuniata *et al*., 2012). So, the management of top borer is of utmost need to make sugarcane a profitable commodity for both farmers and sugar industry. Among the different management strategies, the use of chemical pesticides is one of the important components of Integrated Pest Management. Several chemical pesticides have been evaluated against top borer in sugarcane till date. In spite of that, the problem of top borer still persists. Therefore, the efforts are made to explore appropriate insecticides among the novel products for proper management of top borer in sugarcane.

MATERIALS AND METHODS

A field experiment was conducted for two years in 2014 and 2016 in research field of National Sugarcane Research Program, Jeetpur, Nepal to evaluate the chemical insecticide against of sugarcane top borer. The Experiment was conducted on Randomized Complete Block Design with three replication with plot size of 4m x 5.4 m planted at 90 cm spacing. Nine different treatments were used viz., soil application of Chlorantraniliprole 0.4 G @ 125 g a.i. /ha., Cartap hydrochloride 4 G @ 1500 a.i /ha., Fipronil 0.3 G @ 100 g a.i /ha., Carbofuran 3 G @ 0.5 kg a.i. /ha (standard check) and foliar spray of Chlorantraniliprole 18.5 SC @ 35 g a.i. /ha, Thiodicarp 75 WP @ 1500 g a.i./ha, Spinosad 45 SC @ 200 g a.i. /ha, Chlorpyrifos 20 EC @ 150 g a.i /ha (standard check), Control-untreated check. Treatments were applied once in July against top borer at grand growth stage of sugarcane (approximately after 120 DAP of sugarcane). Total number of millable canes and number of damaged canes (top borer damaged) were recorded at the time of harvesting and percentage borer incidence was worked out. The stalk length, single cane weight and cane diameter were recorded from randomly selected ten canes harvested after removing infested tops and branches.

The formula used to calculate the percent infestation of canes was:

$$\text{Percent infestation} = \frac{\textbf{\textit{Number of infested canes}}}{\textbf{\textit{Total no of canes}}} \text{x} 100$$

The mean original data of percentage infestation was used to calculate percentage reduction over control with the following formula (Abbott's 1925)

$$\text{Percent Reduction} = \frac{Percentage\ infestation\ in\ Control - Percentage\ infestation\ in\ Treatments}{Percentage\ infestation\ in\ Contol} \text{ x } 100$$

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The percentage data of infestation was transformed using arcsine transformation using Excel 2013. The data were analyzed using R package (Version 1.3.1056).

RESULTS AND DISCUSSION

The results on the percentage incidence of top borer infestation at harvesting is presented in table 1.

Table 1. Effect of various chemical pesticides on percentage of top borer infestation

Treatments	Infestation% at harvest			Reduction
	2014	2016	Pooled mean	Over Control
Chlorantraniliprole	9.17 (9.15)	12.15 (16.07)	10.65	69.40
Spinosad	10.69 (10.67)	14.16 (14.11)	12.43	64.29
Cartap hydrochloride	11.23 (11.21)	16.15 (16.07)	13.68	60.70
Thiodicarp	12.01 (12.07)	17.12 (17.04)	14.61	58.03
Fipronil	14.02 (13.97)	14.26 (14.21)	14.15	59.35
Coragen G	14.24 (14.20)	22.67 (22.46)	18.44	47.03
Furadan	17.39 (17.30)	20.9 (20.72)	19.14	45.02
Chlorpyrifos	20.99 (20.80)	28.76 (28.36)	24.85	28.61
Control	29.93 (29.45)	39.83 (38.72)	34.81	-
Mean	15.53	20.67	18.08	-
CV (%)	26.94	19.99	17.15	-
CD at 5%	7.21	7.12	5.35	-
F-test	***	***	***	-

Note: Values in parenthesis indicate real values

Table 2. Effect of various chemical pesticides on number of millable canes per hectare

Treatments	Number of millable canes ('000) per hectare		
	2014	2016	Pooled mean
Chlorantraniliprole	91.69	86.80	89.25
Spinosad	92.14	83.33	87.73
Cartap hydrochloride	91.48	91.45	91.46
Thiodicarp	86.19	84.76	85.43
Fipronil	92.44	84.09	88.27
Coragen G	81.50	83.86	82.68
Furadan	83.57	89.43	86.96
Chlorpyrifos	89.19	81.77	85.48
Control	85.90	88.01	86.95
Mean	88.22	85.95	87.08
CV (%)	9.73	9.46	6.56
CD at 5%	-	-	-
F-test	ns	ns	ns

The lowest percentage of the infestation was found on plots treated with Chlorantraniliprole and Spinosad viz., 10.65% and 12.43% respectively followed by Cartap hydrochloride, Thiodicarp and Fipronil with infestation percentage of 13.68, 14.61 and 14.15 respectively. The highest reduction (69.40%) of infestation was found on Chlorantaraniliprole treated plots over control. (Table 1). The number of millable canes were found to be non-significant in both years. (Table 2). In a 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). This result was similar to the present findings also.

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Table 3. Effect of various chemical pesticides on length of sugarcane stalk

Treatments	Stalk length (m)		
	2014	2016	Pooled mean
Chlorantraniliprole	2.54	2.49	2.52
Spinosad	2.36	2.54	2.45
Cartap hydrochloride	2.36	2.32	2.34
Thiodicarp	2.33	2.32	2.33
Fipronil	2.40	2.42	2.41
Coragen G	2.11	2.07	2.09
Furadan	2.27	1.99	2.13
Chlorpyrifos	2.12	1.80	1.96
Control	1.87	1.83	1.85
Mean	2.26	2.20	2.23
CV (%)	9.13	6.05	6.40
CD at 5%	0.356	0.229	0.25
F-test	*	***	***

All the plots treated were found to have highest stalk length as compared to plots treated with Coragen G, Chlorpyrifos and Control plot in first year. The plots treated with Chlorantraniliprole, Spinosad, Cartap hydrochloride Thiodicarp and Fipronil were found to have significantly different cane length. In Pooled analysis Chlorantraniliprole, Spinosad, Fipronil, Cartap hydrochloride and Thiodicarp treated plots were found to have significantly higher cane length of 2.52, 2.45, 2.41, 2.34 and 2.33m respectively (Table 3). The cane diameter was found insignificant in all the plots. The effect of the treatments were found not to cause any effect on the diameter of the canes (Table 4). Singh and Tomar, (2003) reported that cane yield, net millable canes and cane girth was unaffected by the use of insecticides against *C. infuscatellus* Snellen which was somehow comparable against top borer.

Table 4. Effect of various chemical pesticides on diameter of canes

Treatments	Cane diameter (cm)		
	2014	2016	Pooled mean
Chlorantraniliprole	2.36	2.26	2.31
Spinosad	2.24	2.20	2.22
Cartap hydrochloride	2.35	2.24	2.30
Thiodicarp	2.25	2.19	2.22
Fipronil	2.32	2.26	2.29
Coragen G	2.34	2.20	2.27
Furadan	2.25	2.13	2.20
Chlorpyrifos	2.19	2.12	2.15
Control	2.24	2.12	2.17
Mean	2.28	2.19	2.24
CV (%)	4.07	3.95	3.74
CD at 5%	-	-	-
F-test	ns	ns	ns

Plots treated with Spinosad and Chlorantraniliprole had highest single cane weight which was followed by Fipronil treated plots. In pooled analysis, Spinosad, Chlorantraniliprole and Fipronil were found effective and caused to have highest single cane weight of 1047g, 1036g, 1002.66g respectively (Table 5). In pooled mean, plots treated with Chlorantraniliprole and Spinosad were found to have significantly higher cane yield (92.30, 90.06 t/ha respectively) which was followed by Cartap hydrochloride and Fipronil with 82.04, 78.94 t/ha respectively (Table 6).

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Table 5. Effect of various chemical pesticides on per unit cane weight

Treatments	Single cane weight (g)		
	2014	2016	Pooled mean
Chlorantraniliprole	1054	1018	1036
Spinosad	1065	1028.66	1047
Cartap hydrochloride	1013	864.33	938.66
Thiodicarp	918.67	945	931.83
Fipronil	1011.70	993.67	1002.66
Coragen G	914	859	886.50
Furadan	888.33	941	914.66
Chlorpyrifos	821.67	852	836.83
Control	770.66	820	795.33
Mean	939.67	924.63	932.17
CV (%)	7.54	8.15	4.85
CD at 5%	122.08	129.86	77.90
F-test	***	*	***

Singh & Tomar, 2003 reported that cane lengths, cane weight and green top were found significantly higher in fipronil treated plots than the control. In a study conducted by Bhawar *et al*., (2016), Cartap hydrochloride was found effective in early shoot borer management in sugarcane while Thiodicarp was found ineffective.

Table 6. Effect of various chemical pesticides on per hectare cane yield

Treatments	Cane yield (mt/ha)		
	2014	2016	Pooled mean
Chlorantraniliprole	95.05	89.56	92.30
Spinosad	90.35	89.78	90.06
Cartap hydrochloride	85.47	78.60	82.04
Thiodicarp	74.75	68.95	71.85
Fipronil	82.16	75.71	78.94
Coragen G	76.04	65.18	72.28
Furadan	82.91	72.33	77.62
Chlorpyrifos	67.87	56.57	62.22
Control	64.46	55.17	59.81
Mean	79.90	72.80	76.35
CV (%)	9.26	15.51	11.57
CD at 5%	12.74	19.46	15.21
F-test	**	*	***

These findings are in line with the results of Pandey (2014) and Padmasri *et al*., (2014) who reported that Chlorantraniliprole 18.5 SC is the most effective insecticide against early shoot borer. In the same study, higher cane yield was found in Chlorantraniliprole 18.5 SC treated plots and high B: C ratio with Flubendiamide 39.35 SC and Spinosad 45SC treatments. Other than this, Chlorantraniliprole 18.5 SC has the highest cost than all other test insecticides and gave the maximum percent reduction of early shoot borer. Sheeba *et al*., (2012) and Singh *et al*., (2009) also postulated that rynaxpyr is the most effective treatment as it has recorded the lowest incidence of sugarcane early shoot borer (15.43%). Acute toxicity tests with Chlorantraniliprole and the formulations, Coragen and Altacor, demonstrated low intrinsic toxicity to honey bees (Dinter *et al*., 2009). So, Chlorantraniliprole is the best alternative to manage the borers as well as less harmful to honey bees. Samanta *et al*., (2017) reported that Fipronil 5% SC @ 150 g a.i. / ha is useful in the control of early shoot borer and root borer in sugarcane.

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Other than sugarcane, Chlorantraniliprole was found to be effective in management of borers in different other crops which was similar to our result. Rajavel *et al*., (2011) showed Chlorantraniliprole was effective against brinjal fruit and shoot borer. Likewise, Larrain *et al*. (2014) proved its effectiveness for *Tuta absoluta* (Meyrick) in tomato. Coslor *et al*., (2018) found that injection of Chlorantraniliprole in the apple trunk causes moderate to high mortality of *Choristoneura rosaceana* (Harris). Similar result was found on rice stem borer, *Chilo suppressalis* (Walker) (Huang *et al*., 2016). Hannig *et al*., (2009) stated that Chlorantraniliprole is a novel anthranilic diamide insecticide, effective for control of lepidopteran insect pests which supports its effectiveness against top borer of sugarcane. Lai & Su, (2011) and Han *et al*., (2012) reported that Chlorantraniliprole's sublethal concentration effects on development of *Spodoptera exigua* Hübner and *Plutella xylostella* (Linnaeus). Chlorantraniliprole was found effective for management of lepidopteran pest as it is fastest acting and causing feeding cessation (Hannig *et al*., 2009; Tohnishi *et al*., 2005). New generation insecticides like Chlorantraniliprole could be an alternative in integrated pest pest management as they are selective, less hazardous and with low mammalian toxicity (Qi & Casida, 2013)

Similarly, the Bhavani *et al*., (2016) also postulated that Fipronil 0.3 G @ 25 kg /ha at 0 and 60 DAP is next better insecticidal treatment in controlling the shoot borer and increasing the cane yield in sugarcane, while Mann *et al*., (2009) found the Fipronil was detrimental to *Chilo infuscatellus* Snellen as it reduced the dead hearts by 65%. Sardana, (2001) also found Fipronil 0.3 G as most effective insecticide in reducing the borer pest in sugarcane and increasing the yield. This results supports our findings as it is found to be the next better alternative.

CONCLUSION

Pesticides treatments significantly reduced top borer infestation and produced higher economic yield as compared to untreated check. The Spinosad and Chlorantraniliprole incurred the lowest top borer infestation and produced highest cane yield. The foliar application of pesticides were found more effective in the reduction of damage due to top borer. Therefore, the foliar application of Chlorantraniliprole and Spinosad can be recommended as most viable among the different foliar and soil applying chemical pesticides tested for management of top borer.

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Authors' contributions

Mr. Kapil Paudel was the lead investigator and responsible for the conceptualization, methodology development, data curation and drafting the manuscript of this study. Dr. Naresh Dangi was responsible for review, editing and formal analysis of the manuscript. Dr. Sunil Aryal and Mrs. Rashmi Regmi were responsible for the literature search, data generation and drafting of this manuscript.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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