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Carbofuran 3G: A promising granular insecticide for the management of Top borer (*Scirpophaga nivella*), Early shoot borer (*Chilo infuscatellus*) and Root borer (*Emmalocera depressella*) in Sugarcane.

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Abstract: Sugarcane (*Saccharum officinarum*) is an industrial cash crop of Pakistan. A monocot crop assailed by the numbers of insect pests, which adversely affected its yield. Borers are key insects pests attacking at all the growth stages of the sugarcan from germination to harvesting. Insecticides are used for the management of borers to avoid the incurred losses. Five treatments of Carbofuran 3G were applied at different growth stages of the crop. 80% reduction in dead hearts was found in treatment when 3.56 a.i kg/ha Carbofuran 3G were applied at four different times on the sugarcane crop. Maximum dead hearts percentage was recorded in untreated plants. The maximum internode damage was caused by *Chilo infuscatellus* in untreated plots. *Scirpophaga nivella* showed similar results like *C. infuscatellus* on different doses of Carbofuran. *Emmalocera depressella* showed significant internode infestation in the control. In case of root borer, Carbofuran 3G treated blocks have lesser internode damage percentage (1.09-1.91%) but no significance was observed between the treatments. Sugarcane yield was significantly affected by the infestation of the borers. Cane yield was significantly increased in comparison with the control. An increase of 41.95 tons/ ha in cane yield was recorded. It is concluded that among all the treatments, 3.56 a.i kg/ha Carbofuran at four different times) was best treatment for the management of borers of sugarcane.
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Key words: Carbofuran, *Chilo infuscatellus, Scirpophaga nivella, Emmalocera depressella,* Internode damage, Dead hearts.

Introduction

Sugarcane (*Saccharum officinarum*) is major crop in Pakistan as it contributes 2.9% in total value addition of agriculture (Khurshid *et al*. 2020) but it is likely to be attacked by numeral insect pests due to its long duration survival (8-10 months). Approximately 2660 insects belong to 10 orders and 44 species have been disclosed in sugarcane field. (Xavier and Merlindayana, 2012). Among various insect pests, borers, whiteflies, termites, bugs and pyrilla etc. attack the crop and resulted in heavy losses in production and quality. Out of all these pests, borers are the major critical factors that caused massive losses in sugar contents by internode damage and milliable canes. (Sharma et al., 2011). Sugarcane is exposed to assail by insect pests at all possible growth stages, equally in tropical and sub-tropical regions. This trouble is further stern more in the subtropical regions as compare to tropical region. Over substantial time of year sugarcane provide shelter and food to the host organisms and due to asset of its development, allows homogenous agro-ecosystem (Chaudhary, 2008). Borers are the chief pests strike sugarcane at all the growth stages of the crop, from germination to harvesting. Root borer, *Emmalocera depressella*; Early Shoot borer, *Chilo infuscatellus* and top borer, *Scirpophaga nivella* are major pests in sub-tropical region.

C. infuscatellus being an emerging threat, infests the crop during early developmental phase from February to March. *C. infuscatellus* destroys 26-65 % of mother shoots and causes 22-33% loss in yield, 27% loss in jaggery and 12% loss in sugar recovery. The threshold level for *C. infuscatellus* was found to be 13 to 15 % bored internodes (Bhavani2016). More than 25% reduction in weight is caused by the 3rd and 4th broods of sugarcane borers (Ahmad *et al.,* 2012, Gupta and Singh 1997). *S. nivella* larvae pierce the plant body within few hours of eclosion and causes massive yield losses of 31–52% (Madan and Singh 2001). *E. depressella* also a serious problem after early shoot borer and top borer, damage caused by root borers not only reduces percentage of sugar recovery but also affects cane yield in the susceptible sugarcane cultivars (Goebel and Way, 2007).

Considering the significance of pest and competence to incurred losses and substantial increase in food production demands the high use of insecticides. Since a long time many insecticides are used for the control of borers in sugarcane. Over the last three decades, carbamates are being intensively used in crop protection, because of their high efficiency, comparatively lower environmental half life and broad spectrum activity (Tsiplakou et al., 2010 and Castagnoli et al., 2012). Carbamates are strong inhibitors of acetylcholinesterase of nervous tissues are used to manage soil dwelling and foliar feeding insect pests. At present, carbamates are most commonly used among all classes of pesticides. Amid the alternatives, organophosphate are enormously toxic, organochlorines pose a delayed neurotoxicity trouble and have a long lasting residue diligence problem (Hallberg, 1987; Kross et al., 1992).

Most active and persistent carbamate, carbofuran (2,3-dihydro-2,2-dimethylbenzofuranyl-7 N- is broadly used in soil applications for insect management (Petty and Kuhlman, 1972).

Among all carbamates, carbofuran is mostly widely used as a broad spectrum insecticide in forestry. Throughout the world it is commonly used as nematicide, acaricide and insecticide in agriculture for the control of insect pest (Bushway et al., 1992; Waite et al., 1992). Although its effectiveness against insect pest is well known, slight information is also present on the side effects of this insecticide. Considering the significance of pest, an experiment was executed to check the effectiveness of carbofuran 3 G (Furadan® 3G) against sugarcane borers in field. In this study we evaluate the effectiveness of this compound at different doses and growth stages of the crop for the management of sugarcane borers.

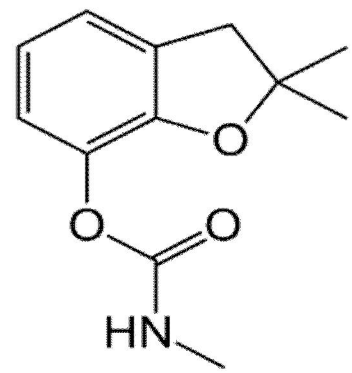

Figure 1: Chemical presentation of Carbofuran

Material and Methods

Experiments were conducted at research area of Sugarcane Research Institute, Faisalabad, Punjab, Pakistan. Sugarcane variety CPP-248 was planted. The experiment was laid out in RCBD (Randomized Complete Block Design) with six treatments including check; replicated thrice in 5X.5 m sq plot size having 5 rows (1.20m apart) made by Ridge plough. All other agronomic practices were uniformly applied except insecticide application. Carbofuran 3 G (Furadon® 3G, FMC, Pakistan) at different doses were applied and compared with an untreated control plot.

Table 1: List of treatments and dose rate used in the present experiment

Treatments	Insecticide	Active Ingredient (kg ha^{-1})	Time of Application (Dose kg/ha)			
			Planting	30 DAP*	60 DAP	90 DAP
T_1	Carbofuran 3 G	2.37	0.59	0.59	0.59	0.59
T_2	Carbofuran 3 G	2.96	0.59	0.59	0.59	1.19
T_3	Carbofuran 3 G	3.56	0.59	0.59	1.19	1.19
T_4	Carbofuran 3 G	3.56	1.19	-	1.19	1.19
T_5	Bifenthrin + Carbofuran 3G	250ml +2.37	-	0.59	1.19	-
T_6	Control	-	-	-	-	-

*DAP: Days after planting

For recording data on borer infestation on dead heart basis, central two rows were selected from each plot, healthy and infested tillers were counted separately. Borer infestation %age on dead hearts basis caused by early shoot, top and root borers was calculated by following formula.

Borer infestation %age (Dead heart basis) = $\frac{\text{Number of Dead hearts}}{\text{Total number of Tillers}} \times 100$

For recording borer infestation on internode damage basis, a sample of 10 canes was randomly collected from each plot at harvesting time and canes were split longitudinally and closely examined. Total number of internodes along with infested internodes was counted separately from each cane for each borer and borer infestation %age on internode damage basis was calculated by following formula.

Borer infestation %age (Internode damage basis) = $\frac{\text{Number of Infested Internodes}}{\text{Total number of Internodes}} \times 100$

Thereafter, the reduction percentage over control was calculated by using the following formula.

% Reduction = $\frac{\text{Control} - \text{Treatment}}{\text{Control}} \times 100$

Statistical Analysis

Analysis of variance (ANOVA) and mean comparison was calculated using Statistix 8.1 software. For comparison of means, the Tukey's HSD (honestly significant difference) Test at <0.05 was implemented.

Results & Discussions

An insect develops resistance to those chemicals which were practiced immensely and regularly (Aftab *et al*. 2020). Carbofuran 3G is such an insecticide which was use for the management of sugarcane borers for many years. In our study, we compare the bio-efficacy of Carbofuran 3G doses at different times of the crop life.

The efficacy of five different doses of Carbofuran 3G applied at different times were tested against sugarcane borers (*Scirpophaga nivella* Fab., *Chilo infuscatellus, Emmalocera depressella* Swin.) in the sugarcane field.

Impact of Carbofuran 3G doses on Dead Hearts percentage

A comparison of the dead heart percentage in all the treatments showed that dead hearts percentage was similar and significantly reduced as compared to T6 (Control). The average percentages of dead hearts in all treatments were statistically at par but significantly different from the control. The lowest dead hearts incidence was found in T3 (2.39 ± 0.43%) (Figure 2); the carbofuran 3G @ 3.56 a.i kg/ha was applied at four different times in a crop life (df=5; F value=24.13; *P*=0.00). Bhavani (2016) results also indicate that carbofuran decreased the dead hearts percentage up to 80.61% at the dose of 33kg/ha.

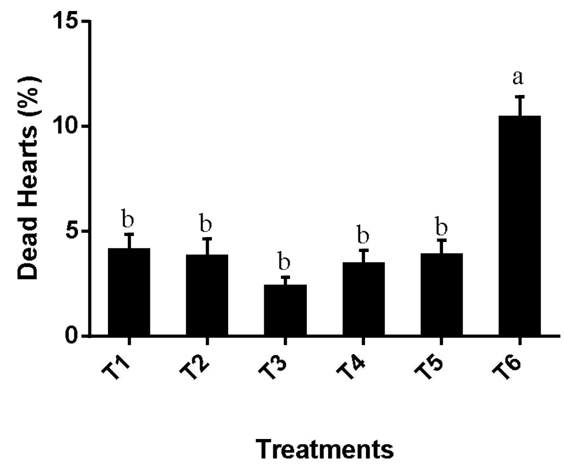

Figure 2: Percent Dead Hearts infestation of sugarcane borers on different doses of Carbofuran 3G.

The highest dead heart percentage was observed in non-treated blocks (10.43 ± 0.98%) (Figure 2), was significantly different from the other treatments. Our conclusions were also supported with those of Marwat and Khalid (1985), Rana et al. (1992), Halimie et al. (1994) and Mishra et al. (1998).

Impact of Carbofuran 3G doses on Internode Damage of Sugarcane

Among the insect pests of *S. officinarum* L, borers are the major insect pests. Internode damage by *S. nivella* Fab., *C. infuscatellus, E. depressella* Swin in all six treatments are shown in Table 2.

Table 2: Means (±SE) Percentage Internode Damage in Sugarcane by *Scirpophaga nivella* Fab., *Chilo infuscatellus, Emmalocera depressella* on Different Treatments.

Percent Internodes Infestation by Borers (Mean + Standard error)			
Carbofuran 3G Doses	***Scirpophaga nivella* Fab.**	***Chilo infuscatellus***	***Emmalocera depressella* Swin.**
T1 (2.37 a.i kg/ha)	3.35 ± 0.23 b	3.65 ± 0.56 b	1.91 ± 0.63 b
T2 (2.96 a.i kg/ha)	2.67 ± 0.35 bc	2.92 ± 0.49 bc	1.89 ± 0.36 b
T3 (3.56 a.i kg/ha)	2.05 ± 0.07 c	1.85 ± 0.43 c	1.09 ± 0.37 b
T4 (3.56 a.i kg/ha)	2.76 ± 0.25 bc	2.40 ± 0.20 bc	1.55 ± 0.60 b
T5 (*Spray+ 2.37 a.i kg/ha)	3.34 ± 0.35 b	3.31 ± 0.60 bc	1.89 ± 0.50 b
Control	6.04 ± 0.30 a	6.25 ± 0.40 a	5.48 ± 0.36 a

Means within the columns followed by letters are significantly different (Tukey's multiple range test: p<0.05).
*Spray of Bifenthrin@250ml/acre on sets.

S. nivella Fab. is a major destructive borer of sugarcane and massively decreases the produce. (Rafiq et al., 1986; Manager Singh et. al., 2004). Minimum infestation was recorded in T3 by *S. nivella* Fab. (2.05 ± 0.25%) which was significantly different with all other treatments. Control had significantly highest inter-node damage (6.25 ±0.40%) (df=5; F=37.70; *P*=0.00). In other treatments, internode infestation was significantly less than the control (Table 2). *S. excerptalis* has capacity to reduce the yield of the sugarcane around 36-56 % in the natural field conditions (Pandey et. al., 1997). Khaliq (2005) use various control measures for the control of *S. nivella* Fab. and found carbofuran was the 2nd effective control method.

About 60-70% damage of mother shoot and 35-43% tillers reduction was caused by *C. infuscatellus* (Jhansi, 2009; Prasad Rao et al., 1991). *C. infuscatellus* show similar results like *S. nivella* Fab. Untreated blocks showed the maximum internode damage (6.25± 0.40%) among all the borers, made it the most destructive borer. Minimum damage was found in T3 (1.85±0.43%) (Table 2) (df=5; F=17.35; *P*=0.00).

E. Depressella showed no significance internode damage in all the treatments but significantly different in comparison with the control (5.48± 0.36%) (df=5; F=39.91; *P*=0.00). Among the insecticides, Ram (2015) recorded that after Chlorantraniliprole 0.4 G, Carbofuran 3G was the best granular insecticide against *E. depressella* swin. Minimum internode damage was depicted in T3 by all borers in which Carbofuran G @3.56 a.i kg/ha applied at sowing, after 30, 60 and 90 days (Table 2).

The maximum cumulative internode damage (8.54 %) was recorded in T5 where spray + 2.37 a.i kg /ha were applied; followed by T1 (8.40%), T2 (7.40%) and T (6.21%) as compared to 16.84% in control plots (df=5; F=66.44; *P*=0.00). The minimum cumulative internode damage was depicted by T3 (4.99%) where 3.56 a.i kg/ ha Carbofuran 3G were applied at four different times i.e; at the time of planting, at 30, 60 and 90 DAP. (Figure 3).

Ahmad et al., 2012, compared the effectiveness of granular insecticides against *C. infuscatellus* and was found lowest percent damage (10.22%) in Carbofuran 3G treated blocks. Bhavani (2016) also examined the lowest aggregate damage of C. *infuscatellus* where doses of Carbofuran 3G and Fipronil 0.3G applied at four different times. Same results were reported by Dheersingh and Tomar (2003). Talpur et al 2002 noted that Furadan (carofuran 3G) being systemic in nature was effective in all the applications. The efficiency of carbofuran against Pyrallids infestation was also reported by Patel et al, 1993 and Sardana 2001.

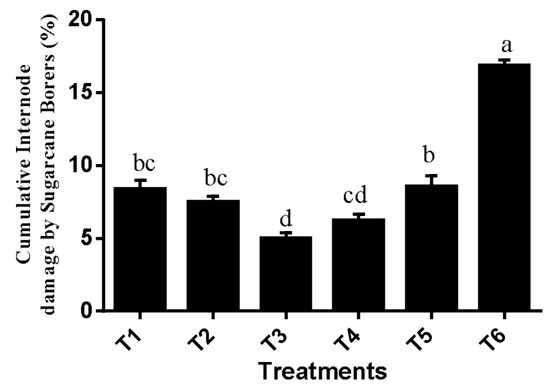

Figure 3: Percent Cumulative Internodes damage by the Sugarcane borers in different doses of Carbofuran 3G.

Impact of Carbofuran 3G doses on the yield of the Sugarcane

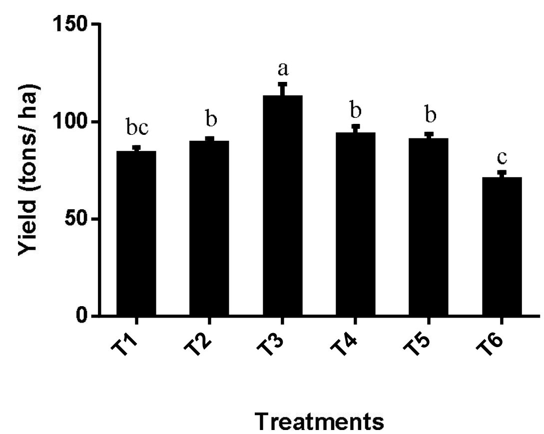

Figure 4: Yield of Sugarcane in different treatments

The results obtained on sugarcane yield were shown in Figure 4. It was observed that cane yield was significantly affected by the infestation of the borers. It is recorded that sugarcane yield was significantly increased in comparison with the control (Fig. 3) (df= 5F=15.73; p=0.00). Bhavani (2016) also record highest percent increase in cane yield over control (88.4 tons/ha) in Carbofuran 3G treated plots. In treatment T3, an increase of 41.95 tons/ ha in cane yield was recorded. Highest yield was achieved by checking the infestation of borers and strong growth of the crop after carbofuran 3G applications (Malik and Chaudhry, 1990). Reduction of stem borer populations by the practical use of granular insecticides like Furadan and Basudin were documented by (Khan and

Jan, 1994; Mishra et al. 1998), which ultimately increase cane yield.

It is concluded that Carbofuran 3G is the efficient granular insecticide against sugarcane borers. Application of Carbofuran 3G @ 3.56 kg/ ha i.e 0.59 kg @time of planting, 0.59 kg after 30 DAP, 1.19 kg after 60 DAP and 90 DAP respectively was found effective dose for the management of *S. nivella* Fab, *C. infuscatellus* and E. *depressella* Swin.

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