



The Control of the Sugarcane Pest Top Borer (*Scirpophaga nivella* FAB*) through Many Approaches as Integrated Pest Management

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The sugarcane (*Saccharum officinarum*) is a very important cultivated crop in many states of India. This crop is grown throughout the year; hence it is infested by a large number of pest (fungus, insects etc.). According to a study, sugarcane production is declined by 20-30% or more. Out of several insect pest, *Scirpophaga nivella* (Fabricius) is one of the notorious pest of this crop sugarcane. This pest infests sugarcane crop of three months old crop to till harvesting stages and some similar plants too. In integrated pest management (IPM) several suitable techniques or methods are used harmoniously with the least disruption of the ecosystem. Thus, IPM is being applied to control the top shoot borer (*S. nivella*). Seven different modules were tested to control the infestation of top borer. The percentage of incidence of *S. nivella* in module-4 (*T. chilonis*+ *T. howardi* + carbofaran) were 2.8, 2.2, 1.1 and 0.6 in II, III, IV and V broods respectively which were very less, with highest cane yield of 89.43 t/ha as compared to the other modules tested. From the

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present work, we would recommend for the use of carbofuran(pesticide), *Trichogramma chilonis* (Ishii), and *Tetrastichus howardi* (Olliff) for the higher sugarcane production of Variety Co 0238.

Keywords: Sugarcane; IPM; *Scirpophaga nivella*; *Tetrastichus howardi*; *Trichogramma chilonis*; carbofuran.

1. INTRODUCTION

The crop sugarcane is cultivated app. in 4 million hectares with an average sugarcane yield of 70-75 tones/hectare. This crop is cultivated for the production of white and brown sugar, khansari and jaggery. This crop is native of warm temperate to tropical regions of the Old World. There are many other species of *Saccharum* as *S. aundinaceum*, *S. edule*, *S. robustum* and *S. bengalense* etc. The main product of this crop is sugar, which contains sucrose, lactose and fructose. It is used in a number of product manufacturing.

Sugarcane is a long-duration crop of about 10-18 months and thus likely to be attacked by a number of pests. Khanzada [1] around 11 insects and mite pests on the crop of sugarcane. Some pests of sugarcane crop are bug, early shoot borer, gurdaspur borer, pyrilla, scale insect, stem borers, top shoot borer, termites etc. These pests damage sugarcane crop and reduce sugar production [2-4].

The top borer *Scirpophaga nivella* belong to phylum- Arthropoda, class- Insecta, order- Lepidoptera, family- Pyralidae is a serious pest among the moth borers, which leads to a heavy loss in sugarcane production. In subtropical regions of India states as Andhra Pradesh, Bihar, Maharashtra, Madras, Mysore, Orissa and Uttar Pradesh, it is found as a major pest while in tropical regions as minor occurrence. Several crops like Jawar, Kans, Sarkanda, Dab and some others are also likely to be infested by *S. nivella* [2-4].

An insect *Tetrastichus howardi* of order- Hymenoptera, family- Eulophidae, is a serious gregarious and endopupal polyphagous parasitoid of many lepidopterans' pests with a high degree of potential as biological control of sugarcane top borer too (Baitha and Sinha, [5] La Salle and Polaszek [6], Sunil Kumar Ruhela and Anil Tyagi, [7]. *T. howardi* parasitizes the pupa of sugarcane top borer [8-10].

An other insect *Trichogramma chilonis* of order- Hymenoptera, family- Trichogrammatidae, is a very important polyphagous egg parasitoid of many lepidopterous pests of several crops. It is used as a very effective biological control agent against sugarcane top borer from last decades in Punjab and Sindh, Pakistan [10]. The practice of *T. chilonis* gave very successful results to control the infestation of Gurdaspur borer [11], *Chilo infusctellus* Shahid et al; [12] and sugarcane borer [13-18].

For a long time a number of chemical insecticides have been used to control insect pests including sugarcane top borer. Over the many decades, group of carbamates insecticides are effectively applied to control many species of insect pests including top borers too. Carbamates are very potent inhibitors of acetylcholinesterase of neural system with a lesser half-life in the ecosystem. Carbamates have a broad-spectrum activity [19,20]. These insecticides are also used to control soil-dwelling and foliar-feeding insect pests.

The most important carbamate is carbofuran (2,3-dihydro- 2,2-dimethyl-7-benzofuranyl-N-methylcarbamate) is broadly used for insect control [21,22]. It is mainly used as an insecticide, acaricide and nematocide in agriculture practice for control of pests.

Integrated Pest Management of sugarcane, therefore depends upon monitoring the pest population dynamics and need-based application of pesticides considering the economic threshold level of the pest. The infestation and intensity of insect pests on sugar cane are influenced by number of factors such as season, climate, edaphic, cane variety and cultivation practices etc. (Venugopal, 2003). In IPM, all or most of the suitable techniques or tactics are used with the least disruption of the ecosystem [23-28].

In the present work of IPM on top shoot borer, we studied the contribution of biological agents viz., *Trichogramma chilonis*[Ishii], *Tetrastichus howardi*(Olliff) and chemical insecticide carbofuran against sugarcane top shoot borer *Scirpophaga nivella* (Fabricius) in the field of

sugarcane (var. Co-0238) which is most commonly cultivated variety in western Uttar Pradesh due to its very high cane yield.

2. MATERIALS AND METHODS

Eggs of *Corcyra cephalonica* (Stainton) were collected from the Indian Institute of sugarcane research, Shahjahanpur, Uttar Pradesh. Similarly, *Tetrastichus howardi*, *Trichogramma chilonis* pupa were collected from DSCL, Sugar mill, Rupapur, Hardoi District, Uttar-Pradesh.

For the culture of *Tetrastichus howardi*, 3-4 pupa of silkworm moth were kept in a plastic box along with 20 adults of *Tetrastichus howardi*, then covered with black cloth in the evening and kept overnight. Next day morning adults were removed and parasitized pupa were transferred to another box and maintained at a temperature of 25 ± 2 °C with $50 \pm 5\%$ humidity. After 15 to 20 days the emergence started and adults were transferred to another box having honey cotton swab (diluted with 50% water). Then adults of *Tetrastichus* were transferred to poly-bag (packet), each packet having about 150-200 adults and carried to sugarcane field for field release. Adults at the rate of 3 packets per acre or 8 packets per hectare were released at a gap/interval of one month (30-days) in sugarcane field/experimental area starting from 30 days after planting and thus totally three releases were made as per the treatments.

Trichogramma chilonis is very effective egg parasitoid on several insects. *Corcyra* is a very good and easily available alternative host of *T. chilonis*. It has a very high capacity to breed a large progeny/population in a very short time period in the laboratory. *Corcyra* is cultured in semi crushed maize and their eggs are collected and pasted on paper cards. Eggs of *Corcyrae* are acted as host of *T. chilonis*. Then cards are placed in glass jar and the eggs of *Corcyra* are parasitized by the *T. chilonis* and then parasitized cards (Trichocards) were stored in refrigerator and removed from refrigerator 12-24 hours before tagging in the sugarcane field. To control sugarcane top shoot borer, Trichocards were tagged in the field at the rate of 50000 eggs per hectare at interval of 15 days starting from 30 days or one month after planting, and thus totally five releases were made as per the treatments.

The effect of carbofuran was tested by performing an experiment at a small scale under control circumstances. We used carbofuran 3%

CG (Encapsulated), with packet named "Furadan"-crystal for the treatment of sugarcane top shoot borer at different periods from cane planting. We used carbofuran 3 CG @ 25 kg/ha or 10 kg/acre as guideline of agropedia. To control sugarcane top shoot borer, carbofuran 3 G was applied four times i.e. at the time of planting and at 30, 60, and 90 days after planting as per the treatments.

Group 1=Module -A (Treatment with *T. howardi*)

Group 2=Module -B (Treatment with *T. chilonis*)

Group 3=Module -C (Treatment with Carbofuran)

Group 4=Module -1 (Treatment with *T. howardi*+ *T. chilonis*)

Group 5=Module -2 (Treatment with *T. chilonis*+ Carbofuran)

Group 6=Module -3(Treatment with *T. howardi*+ Carbofuran)

Group 7=Module -4(Treatment with *T. howardi* +*T. chilonis*+ Carbofuran)

Group 8=Control/untreated

To record data of top shoot borer infestation, the numbers of infested tillers were counted from the total number on the basis of dead hearts. The following formula was used to find out the percentage (%) of top shoot borer infestation.

$$\% \text{ Borer infestation} = \frac{\text{Number of infested tillers}}{\text{Total number of tillers}} \times 100$$

To record data of top shoot borer infestation, the number of infested/damaged internodes was counted from the total number. The following formula was used to find out the percentage (%).

$$\% \text{ Borer infestation} = \frac{\text{Number of infested internodes}}{\text{Total number of internodes}} \times 100$$

3. RESULTS AND DISCUSSION

The percentage of incidence of *S. nivella* in module-A (*T. howardi*) were 6.8 ± 0.05 , 5.5 ± 0.12 , 4.7 ± 0.10 and 3.5 ± 0.11 in II, III, IV, and V broods, respectively with cane yield of 85.34 t/ha. The percentage of incidence of *S. nivella* in module-B (*T. chilonis*) were 4.5 ± 0.04 , 3.2 ± 0.07 , 1.5 ± 0.12

and 0.8±0.08 in II, III, IV and V broods respectively with cane yield of 85.84 t/ha. The percentage of incidence of *S. nivella* in module-C (carbofuran) were 3.8±0.13, 3.9±0.13, 3.2±0.08 and 1.8±0.06 in II, III, IV and V broods, respectively with cane yield of 84.54 t/ha.

The percentage of incidence of *S. nivella* in module-1(*T. howardi* +*T. chilonis*) were 4.5±0.01, 3.2±0.04, 1.5±0.08, 2.7±0.14 in II, III, IV and V broods, respectively with cane yield of 83.45 t/ha. The percentage of incidence of *S. nivella* in module-2 (*T. chinolis* + carbofuran) were 3.2±0.04, 2.5±0.01, 1.2±0.04 and 1.2±0.05 in II, III, IV and V broods, respectively with cane yield of 85.84 t/ha. The percentage of incidence of *S. nivella* in module-3 (*T. howardi*+carbofuran) were 3.6±0.07, 2.6±0.04, 1.8±0.07 and 1.4±0.04 in II, III, IV and V broods, respectively with cane yield of 86.65 t/ha.

The percentage of incidence of *S. nivella* in module-4 (*T. chilonis*+ *T. howardi*+ carbofuran) were 2.8±0.09, 2.2±0.04, 1.1±0.03 and 0.6±0.03 in II, III, IV and V broods, respectively which were very less, with maximum cane yield of 89.43 t/ha. The percentage of incidence of *S. nivella* in control (untreated) sugarcane were 9.2±0.11, 10.9±0.11, 13.3±0.03, and 14.7±0.12 in II, III, IV and V broods, respectively which were very high, with least cane yield of 72.81 t/ha (Table 1).

Fig. 3 shows sugar yields influenced by different treatment modules. The sugar yields in modules- A, B, C, 1, 2, 3, and 4 were 85.34, 89.34, 84.54, 83.45, 85.84, 86.65 and 89.43 t/ha respectively.

Fig. 4 shows the comparison of sugar yields in treatment modules with reference to control. The sugar yield in control (untreated) was 72.81 t/ha.

In module-A (*T. howardi*), an average percentage of incidence of *S. nivella* was 5.12 and the percentage of reduction over control was 57.40 % with cane yield 85.34 t/ha. The additional cane yield over control was 12.53 t/ha. The cost as treatment and net return were Rs.780 and Rs.33590 respectively with Cost: benefit Ratio (C: B Ratio)-1:44.07.

In module-B (*T. chilonis*), an average percentage of incidence of *S. nivella* was 2.50 and the percentage of reduction over control was 79.03 % with cane yield 89.50 t/ha. The additional cane yield over control was 16.69 t/ha. The cost as treatment and net return were Rs.450 and Rs.45447 respectively with C: B Ratio-1:101.99.

In module-C (Carbofuran), an average percentage of incidence of *S. nivella* was 2.87 and the percentage of reduction over control was 76.12 % with cane yield 84.54 t/ha. The additional cane yield over control was 11.73 t/ha. The cost as treatment and net return were Rs.8250 and Rs.24007 respectively with C: B Ratio-1:3.91.

In module-1 (*T. howardi* + *T. chilonis*), an average percentage of incidence of *S. nivella* was 2.97 and the percentage of reduction over control was 75.29 % with cane yield 83.45 t/ha. The additional cane yield over control was 10.64 t/ha. The cost as treatment and net return were Rs.1230 and Rs.28030 respectively with C: B Ratio-1:23.78.

Table 1. Means (±SE) percentage incidence in sugarcane by *Scirpophaga nivella* and sugarcane yield in different modules

Module	Percentage Incidence of <i>Scirpophaga nivella</i>				Cane Yield (t/ha)
	II brood	III brood	IV brood	V brood	
MA: <i>T. howardi</i>	6.8±0.05	5.5±0.12	4.7±0.10	3.5±0.11	85.34
MB: <i>T. chilonis</i>	4.5±0.04	3.2±0.07	1.5±0.12	0.8±0.08	89.50
MC: Carbofuran	3.8±0.13	3.9±0.13	3.2±0.08	1.8±0.06	84.54
M1: <i>T. chilonis</i> + <i>T. howardi</i>	4.5±0.10	3.2±0.04	1.5±0.08	2.7±0.14	83.45
M2: <i>T. chilonis</i> + Carbofuran	3.2±0.04	2.5±0.10	1.2±0.04	1.2±0.05	85.84
M3: <i>T. howardi</i> + Carbofuran	3.6±0.07	2.6±0.04	1.8±0.07	1.4±0.04	86.65
M4: <i>T. chilonis</i> + <i>T. howardi</i> + Carbofuran	2.8±0.09	2.2±0.04	1.1±0.03	0.6±0.03	89.43
Control	9.2±0.11	10.9±0.11	13.3±0.03	14.7±0.12	72.81

(Each value is the mean of five values with SE=Standard error of mean)

Tukey's multiple-range-test (p<0.05) p<0.001, Calculated F value=24.809, Critical F value=2.422

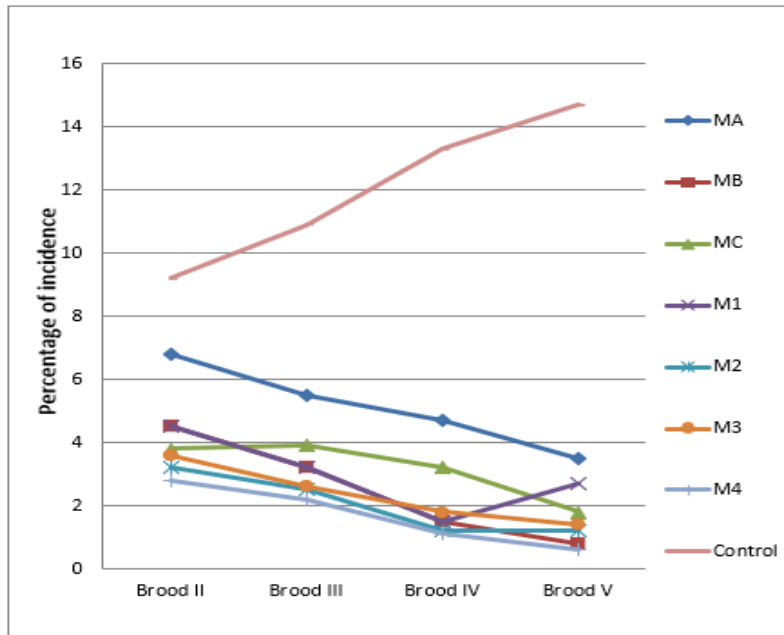


Fig. 1. Comparison of percentage of incidence of *S. nivella* in different modules

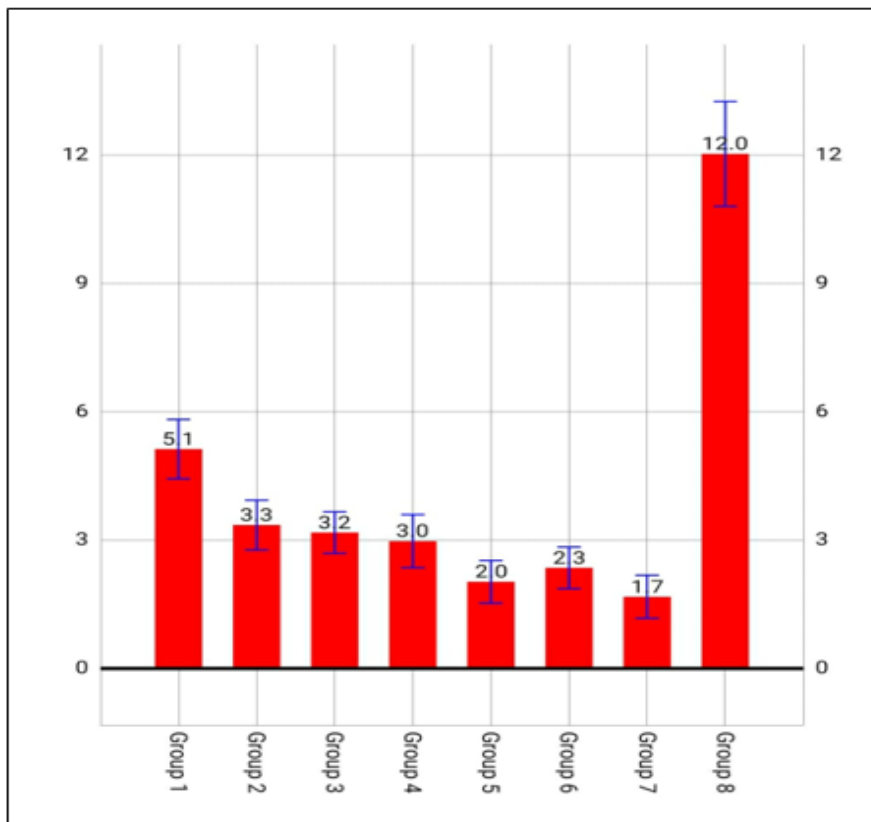


Fig. 2. Percentage of incidence of *S. nivella* in different modules

The mean±SE percentage of incidence of the sugarcane top borer (*S. nivella*) in different treatment modules (A, B, C, 1, 2, 3, & 4) and control were shown in fig. The mean±SE percentage of *S. nivella* in modules A, B, C, 1, 2, 3, and 4 were 5.12±0.69, 2.5±0.83, 2.87±0.36, 2.9±0.62, 2.02±0.49, 2.20±0.47, and 1.6±0.50 respectively. While in control (untreated) the mean±SE percentage of incidence was 12.02±1.42, which was higher as comparison to all treatment modules. IPM module-4 shows very less percentage of incidences among all treatment modules

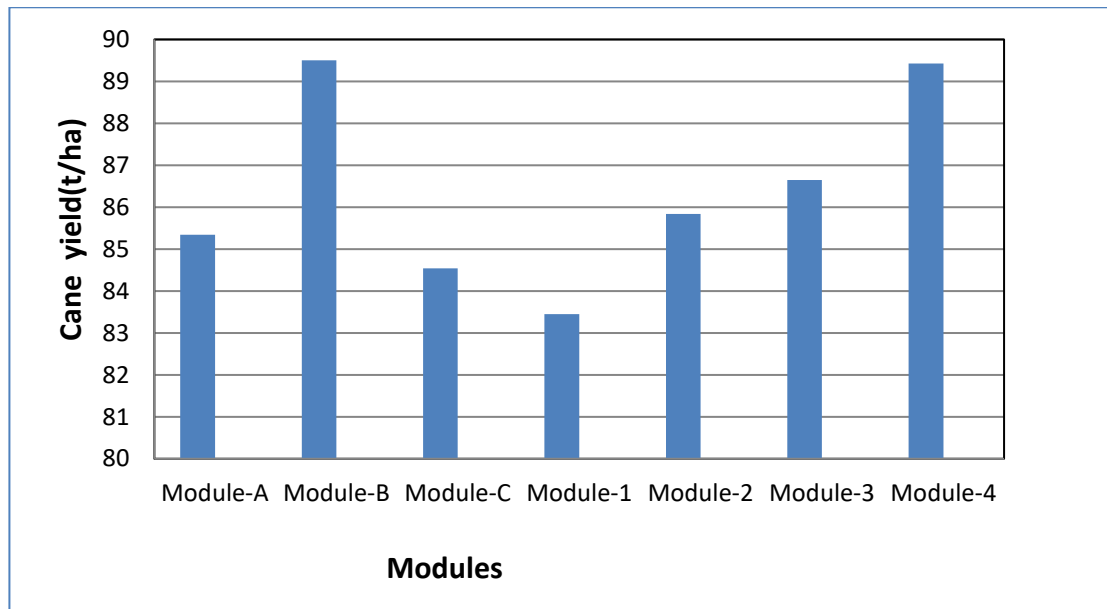


Fig. 3. Sugarcane yields influenced by seven different modules

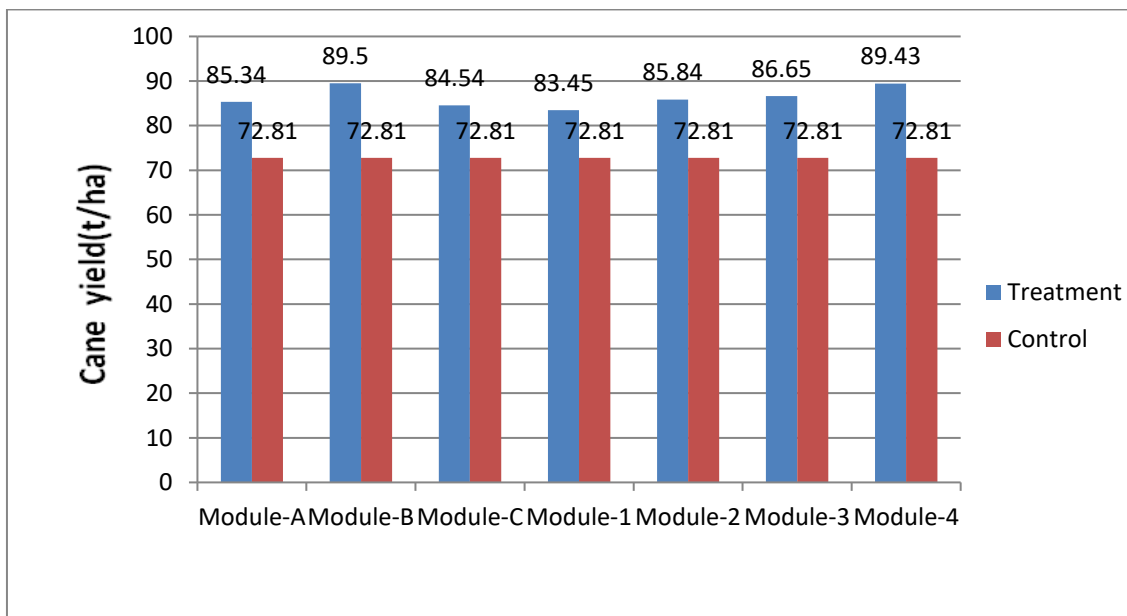


Fig. 4. Comparison of sugar yields of different modules (treatments) with control (untreated)

In module-2 (*T. chilonis*+ Carbofuran), an average percentage of incidence of *S. nivella* was 2.02 and the percentage of reduction over control was 83.19 % with cane yield 85.84 t/ha. The additional cane yield over control was 13.03 t/ha. The cost as treatment and net return were Rs.9030 and Rs.26802 respectively with C: B Ratio-1:3.96.

In module-3 (*T. howardi* + Carbofuran), an average percentage of incidence of *S. nivella*

was 2.20 and the percentage of reduction over control was 81.69 % with cane yield 86.65 t/ha. The additional cane yield over control was 13.84 t/ha. The cost as treatment and net return were Rs.8700 and Rs.29360 respectively with C: B Ratio-1:5.54.

In module-4 (*T. chilonis* + *T. howardi* + *T. chilonis*), an average percentage of incidence of *S. nivella* was 1.67 and the percentage of reduction over control was 86.25 % with cane

yield 89.43 t/ha. The additional cane yield over control was 16.62 t/ha. The cost as treatment and net return were Rs. 9840 and Rs.36225 respectively with C: B Ratio-1:5.54.

The maximum reduction over control i.e., 86.25% was seen in module-4 (IPM: *T. chilonis*+*T. howardi*+Carbofuran) and minimum in module-A among the all-treatment modules. The maximum C: B ratio was in Module-B (*T. chilonis*) and minimum in module-C (Carbofuran) but the maximum net return was in module-4 (IPM) and minimum in module-C (Carbofuran).

With respect to efficiency of *T. howardi*, the result of this study and experiment are in accordance with Baitha, Sinha [5], La salle, Polaszek [6], Pastori [29] and Vargas et al. [9]. Similarly, with respect to efficiency of *T. chilonis*, the results of the present experiment and study are in the same line with the work of Hasmi, Raham (1985); Cock [14], Cheng [15], Asraf et al (1993); Hamid et al [11], Khan, Alam [13], Goebell et al [17], Mustafa et al [18] and Shahid et al [12] in controlling various lepidopteran borers in sugarcane.

With respect to efficiency and effectiveness of carbofuran, the results of present study are in accordance with Malik and Chaudhary [30], Patel et al [31], Khan and Jan [13], Pandey and Singh [24], Mishra et al [32], Sardana [33] Khaliq [34], Balikai et al. [35], Tippannavar et al. [36] and Bhavani [37] in controlling various lepidopteran borers in sugarcane [38,39].

4. CONCLUSION

Integrated Pest Management of sugarcane, therefore depends upon monitoring the pest population dynamics and need-based application of pesticides considering the economic threshold level of the pest. The infestation and intensity of insect pests on sugar cane are influenced by number of factors such as season, climate, edaphic, cane variety and cultivation practices etc.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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 writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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