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Evaluation of some chemical insecticides on fall armyworm attacking sweet corn

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ABSTRACT

The fall armyworm (*Spodoptera frugiperda*) presents a significant threat to corn production in Bangladesh, resulting in considerable yield losses. This study aimed to evaluate the effectiveness of commonly used synthetic insecticides-Winmax 40 WG (Emamectin benzoate), Ripcord 10 EC (Cypermethrin), Marshal 20 EC (Carbosulfan), and Shobicron 425 EC (Profenofos and Cypermethrin)-in managing fall armyworm infestations in sweet corn (variety BU Sweet Corn 1) at the experimental field of Bangabandhu Sheikh Mujibur Rahman Agricultural University in Gazipur, Bangladesh, during the Rabi and Kharif seasons of 2022 and 2023. In the Rabi season, leaf infestations ranged from 0.2 to 5.4%, while cob infestations varied from 5.0 to 20.0%. Conversely, in the Kharif season, leaf infestations spiked between 42.8% and 78.8%, and cob infestations ranged from 40.0 to 90.0%. The application of all insecticides significantly reduced leaf and cob infestations, along with fall armyworm larval populations, compared to the control treatment in both seasons. Specifically, Shobicron 425 EC and Marshal 20 EC demonstrated notable effectiveness in reducing infestation levels. Notably, Shobicron 425 EC treatment resulted in the highest cob length (16.4 cm in Rabi and 11.9 cm in Kharif), cob diameter (4.0 cm and 2.1 cm, respectively), cob weight (196.6 g and 80.3 g), grains per cob (537.2 and 98.0), and overall yield (12.7 t/ha and 6.2 t/ha). Collectively, the study findings indicated that the combination of Profenofos and Cypermethrin demonstrates the highest efficacy in controlling fall armyworm infestations in sweet corn under the tested field conditions.

Introduction

Sweet corn (*Zea mays*) is a highly nutritious crop, rich in sugars and an excellent source of protein, carbohydrates, vitamins, and minerals. Among the varieties cultivated in Bangladesh, BU Sweet Corn 1, developed by Bangabandhu Sheikh Mujibur Rahman Agricultural University, is particularly notable for its versatility, as it can be consumed raw or boiled and serves as fodder. While both Rabi (October to March) and Kharif (March to June) seasons are conducive to sweet corn cultivation, the

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highest yields are typically achieved during the Rabi season (Amin *et al.*, 2023).

Despite the favorable soil and climate conditions for maize production in Bangladesh, the crop faces significant challenges from a range of biotic and abiotic factors that impede its growth. Among the biotic factors, insect pests pose a major threat, resulting in substantial annual yield losses. According to Prodhan *et al.* (2020), twelve insect pest species have been identified as particularly damaging to maize, with the invasive fall armyworm (FAW), *Spodoptera frugiperda* (Lepidoptera: Noctuidae), being of significant concern. First reported in Bangladesh in November 2018, FAW has rapidly established itself as a serious pest, affecting nearly 30-35% of maize fields and causing a 5% cob infestation rate in 2019 (CIMMYT, 2020). The caterpillar of FAW is a serious threat to global food security including Bangladesh (Wild 2017; Stokstad 2017).

The larvae of FAW are capable of damaging maize crops at various growth stages, from early vegetative development to physiological maturity (Ullah *et al.*, 2023). Their feeding behavior results in tattered and ripped leaves, as well as damage to developing silks and tassels due to whorl feeding. Additionally, the larvae can consume growing kernels, leading to reduced yields and increased susceptibility to secondary infections, ultimately compromising both the quantity and quality of the grain (Sarker and Dutta, 2022).

In response to the FAW threat, farmers in Bangladesh have increasingly resorted to various synthetic chemical insecticides, including lambda-cyhalothrin, chlorpyrifos, emamectin benzoate, chlorantraniliprole, and trimethoxam. However, many farmers report unsatisfactory results with these products (Sarker and Dutta, 2022). Notably, there has been no research on the infestation status and the efficacy of these commonly used insecticides specifically against FAW in the BU Sweet Corn 1 variety. This study aimed to investigate the field efficacy of various commercially available synthetic chemical insecticides in controlling fall armyworm infestations in the sweet corn variety BU Sweet Corn 1 during two distinct growing seasons of Bangladesh. The findings of this study provide valuable insights for pest management strategies and contribute to improved sweet corn production in Bangladesh.

Materials and Methods

Study site

The experiment was carried out in the field and laboratory at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during the Rabi and Kharif seasons of the year 2022 and 2023. The study site is located nearly in the center of Bangladesh, where the majority of the soils are silty clay loam, the annual mean maximum and minimum temperatures, relative humidity, and rainfall are 36.0 °C and 12.7 °C, 65.8% and 237.6 cm, respectively, and the pH ranges from highly acidic to moderately acidic (5.8 - 6.5) (Amin *et al.*, 2015).

Experimental materials and design

BU Sweet Corn 1, a sweet corn variety was cultivated in 8 rows in 4 m × 4 m sized plots with 25 cm and 60 cm plant to plant and row to row distance, respectively for two different seasons (Kharif and Rabi) in the experimental plot. Randomized complete block design was followed for the experiment and five treatments were replicated four times.

Spraying of insecticides

Four insecticides namely Winmax 40 WG, Ripcord 10 EC, Marshal 20 EC and Shobicron 425 EC @ 0.25g/L water, 1.0 ml/L water, 2.0 ml/L water and 2.0 ml/L water, respectively were applied in the four plots to manage the fall armyworm attacking BU Sweet Corn 1. The insecticides were sprayed twice at 20 days intervals in Kharif and only once in Rabi season. Data were gathered seven days following each spraying. No insecticide was applied in the control plots. Detailed information about insecticides used in this study is presented in Table 1.

Table 1. Details of the four tested insecticides

Trade name	Active ingredient	Mode of action	Class
Winmax 40 WG	Emamectin Benzoate + Thiamethoxam	Systemic	Avermectin+ Neonicotinoid
Ripcord 10 EC	Cypermethrin	Contact and stomach action	Pyrethroid
Marshal 20 EC	Carbosulfan	Contact and stomach action	Organocarbamate
Shobicron 425 EC	Profenofos Q + Cypermethrin	Contact and stomach action	Organophosphate+ Pyrethroid

Observation of leaf and cob infestation (%) by fall armyworm larva

The total number of healthy and infested leaves and cobs of a single plant from four randomly selected plants of BU Sweet Corn 1 was counted under each insecticide treatment, after seven days of every spray of the insecticides in two seasons. Then it was converted into percent infestation using following formula:

$$\text{Leaf or cob infestation (\%)} = \frac{\text{Number of infested leaves or cob}}{\text{Total number of leaves or cob}} \times 100$$

Observation of incidence of fall armyworm larva per plant

Incidence of FAW larva on BU Sweet Corn 1 plant was counted visually before 24 hours of the first application of insecticides and after three and seven days of spraying. At first, five plants from each treatment were chosen randomly and the number of FAW larva/plant was recorded.

Observation of plant characteristics

The yield contributing characteristics like cob length, weight and width, grain number and thousand grain weight were observed under four different insecticide treatment along with control plot. Five randomly selected plants of each treatment were observed for measuring the characteristics.

Yield assessment

A digital weight machine was used to weigh the dried grains of each plot of four different treatments and control plot. The yield was then converted into t/ha following the formula:

$$\text{Yield (t/ha)} = \frac{\text{Weight of grains in kg/plot} \times 10000}{\text{Plot area in square m} \times 1000}$$

Statistical analysis

Data analysis was done using IBM SPSS 20.0, a statistical software program. To ascertain the variation in the rate of leaf and cob infestation, yield contributing characters and yield of BU Sweet Corn 1 with different insecticides one-way analysis of variance (ANOVA) was used, followed by a Tukey HSD posthoc test (at 5% level of significance).

Results and Discussion

The tested insecticides effect on leaf and cob infestation rate by fall armyworm in sweet corn variety BU Sweet Corn 1 field in two seasons (Table 2). The significant variation was observed in leaf and cob infestation rates ($F_{4,15}$=115.3, $p<0.001$, $F_{4,15}$=2.5, $p=0.085$) at seven days after spray of different insecticides during Rabi season, ranging from 0.2 to 5.4% and 5.0 to 20.0%, respectively and the plot treated with Shobicron 425 EC showed the lowest rate. In Kharif season significant variation was observed in leaf infestation rate at seven days after first and second spray of insecticides ($F_{4,15}$=20.9, $p<0.001$ and $F_{4,15}$=26.5, $p<0.001$) ranging from 42.8 to 78.8% and 23.1 to 68.6% respectively and the plot treated with Shobicron 425 EC showed the lowest rate. The significant difference was also observed in the cob

infestation rate at seven days after the spray ($F_{4,15}$=8.9, p<0.01) ranging from 40.0 to 90.0% and the plots treated with Shobicron 425 EC showed the lowest rate.

Abundance of FAW larvae per plant under different treatments is presented in table 3. In Rabi season significant variation was observed in abundance of FAW larvae per plant at three days and seven days after the spray of the insecticides ($F_{4,15}$=36.51, p<0.001, $F_{4,15}$=73.2, p<0.001) ranging from 0.1 to 0.8 and 0.0 to 0.5, respectively and the plots treated with Shobicron 425 EC showed the lowest incidence. In Kharif season, significant variation was observed in abundance of FAW larvae per plant at three days and seven days after the first spray of the insecticides ($F_{4,15}$=32.58, p<0.001, $F_{4,15}$=106.01, p<0.001) ranging from 0.6 to 1.0 and 0.5 to 1.0, respectively and the plots treated with in Shobicron 425 EC had the lowest incidence. The significant variation was also observed in the incidence of FAW larva per plant at three days and seven days after second spray of the insecticides ($F_{4,15}$=116.71, p<0.001, $F_{4,15}$=124.10, p<0.001) ranging from 0.5 to 1.0 and 0.4 to 1.0, respectively. The plots treated with in Shobicron 425 EC showed the lowest incidence.

The significant variation was observed in the yield contributing characteristics such as cob length ($F_{4,15}$=63.1, <0.001, $F_{4,15}$=223.1, <0.001), cob diameter ($F_{4,15}$=31.9, <0.001, $F_{4,15}$=164.8, <0.001), cob weight ($F_{4,15}$=11.2, <0.001, $F_{4,15}$=416.1, <0.001), number of

Table 2. Infestation rate (%) of fall armyworm larvae in sweet corn (BU Sweet Corn 1) field treated with different insecticides in Rabi and Kharif seasons of Bangladesh

Treatment	Infestation rate (%) in Rabi season at 7 days after 1st spray		Infestation rate (%) in Kharif season at 7 days after 1st and 2nd sprays		
	Leaf	Cob	Leaf (after 1st spray)	Leaf (after 2nd spray)	Cob
Winmax 40 WG	0.9±0.2 b	10.0±0.0 b	56.8±3.5 b	45.4±2.2 b	65.0±5.0 b
Ripcord 10 EC	0.8±0.2 b	10.0±4.0 b	55.6±2.6 b	30.9±2.9 c	60.0±4.0 b
Marshal 20 EC	0.4±0.1 c	7.5±2.5 c	48.6±1.6 c	28.8±2.0 cd	45.0±1.9 c
Shobicron 425 EC	0.2±0.2 d	5.0±2.0 d	42.8±3.5 c	23.1±3.2 d	40.0±4.1 c
Control	5.4±0.8 a	20.0±5.8 a	78.8±3.3 a	68.6±6.2 a	90.0±4.1 a

Data expressed as mean± S.E. Means within a column followed by no common letter(s) are significantly different by Tukey posthoc statistic at P ≤ 0.001

Table 3. Abundance of fall armyworm larvae in sweet corn (BU Sweet Corn 1) field treated with different insecticides in Rabi and Kharif seasons of Bangladesh

Treatment	Number of larvae per plant in Rabi season			Number of larvae per plant in Kharif season				
	Pre spray	Three days after 1st spray	Seven days after 1st spray	Pre spray	Three days after 1st spray	Seven days after 1st spray	Three days after 2nd spray	Seven days after 2nd spray
Winmax 40 WG	0.7±0.0 a	0.5±0.0 b	0.2±0.0 b	1.9±0.1 a	1.0±0.0 a	1.0±0.1 a	0.9±0.1 b	0.9±0.0 ab
Ripcord 10 EC	0.6±0.0 a	0.4±0.1 bc	0.05±0.0 c	1.8±0.3 a	0.7±0.1 b	1.0±0.1 a	0.8±0.0 b	0.8±0.0 b
Marshal 20 EC	0.6±0.0 a	0.3±0.0 cd	0.0±0.0 c	1.6±0.2 a	0.6±0.0 bc	0.9±0.1 b	0.8±0.0c	0.6±0.0 c
Shobicron 425 EC	0.6±0.0 a	0.1±0.1 d	0.0±0.0 c	1.6±0.2 a	0.6±0.1 bc	0.5±0.1 c	0.5±0.1 d	0.4±0.1 d
Control	0.7±0.0 a	0.8±0.0 a	0.5±0.0 a	1.8±0.3 a	1.0±0.1 a	1.0±0.1 a	1.0±0.0 a	1.0±0.1 a

Data expressed as mean± S.E. Means within a column followed by no common letter(s) are significantly different by Tukey posthoc statistic at P ≤ 0.001

grains per cob ($F_{4,15}$=30.0, <0.001, $F_{4,15}$=159.5, <0.001) in Rabi and Kharif seasons, respectively (Table 4). In both Rabi and Kharif seasons the plots treated with Shobicron 425 EC had the highest cob length (16.4 cm and 11.9 cm), cob diameter (4.0 cm and 2.1 cm), cob weight (196.6 g and 80.3 g) and grains per cob (537.2 and 98.0) and the control plots had the lowest cob length (7.1 cm and 5.2 cm,), cob diameter (2.7 cm and 0.5 cm), cob weight (88.7 g and 29.5 g) and number of grains per cob (188.5 and 25.3).

There were significant variations in the yield of BU Sweet Corn 1 under different insecticide treatments in both the Rabi and Kharif seasons ($F_{4,15}$=112.8, p<0.001, $F_{4,15}$=239.7, p<0.001) (Figure 1). In Rabi and Kharif season, plot treated with Shobicron 425 EC had

Table 4. Traits of sweet corn (BU Sweet Corn 1) cob when treated the plants with different insecticides during Rabi and Kharif seasons of Bangladesh

Treatment	Rabi season				Kharif season			
	Length (cm)	Diameter (cm)	Weight (g)	Grains cob^{-1}	Length (cm)	Diameter (cm)	Weight (g)	Grains cob^{-1}
Winmax 40 WG	10.1±0.7 c	3.0±0.1 cd	113.0±8.6 bc	302.5±14.4 b	8.6±0.2 c	0.9±0.6 c	57.3±1.1 d	39.3±2.1 c
Ripcord 10 EC	13.8±0.5 b	3.3±0.2 bc	122.3±11.6 bc	332.5±17.9 b	9.6±0.2 b	1.3±0.1 b	62.0±1.1 c	46.5 ±1.3 c
Marshal 20 EC	15.9±0.4 ab	3.6±0.1 ab	156.3±8.5 ab	354.8±21.7 a	10.3±0.2 b	1.9±0.1 a	71.5±1.0 b	85.5±2.1 b
Shobicron 425 EC	16.4±0.5 a	4.0±0.1 a	196.6±22.0 a	537.2±32.1 a	11.9±0.5 a	2.1±0.1 a	80.3±1.0 a	98.0±4.0 a
Control	7.1±0.9 d	2.7±0.1 d	88.7±4.3 c	188.5±34.7 c	5.2±0.2 d	0.5±0.1 d	29.5±0.6 e	25.3±2.1 d

Data expressed as mean± S.E. Means within a column followed by no common letter(s) are significantly different by Tukey posthoc statistic at P ≤ 0.001

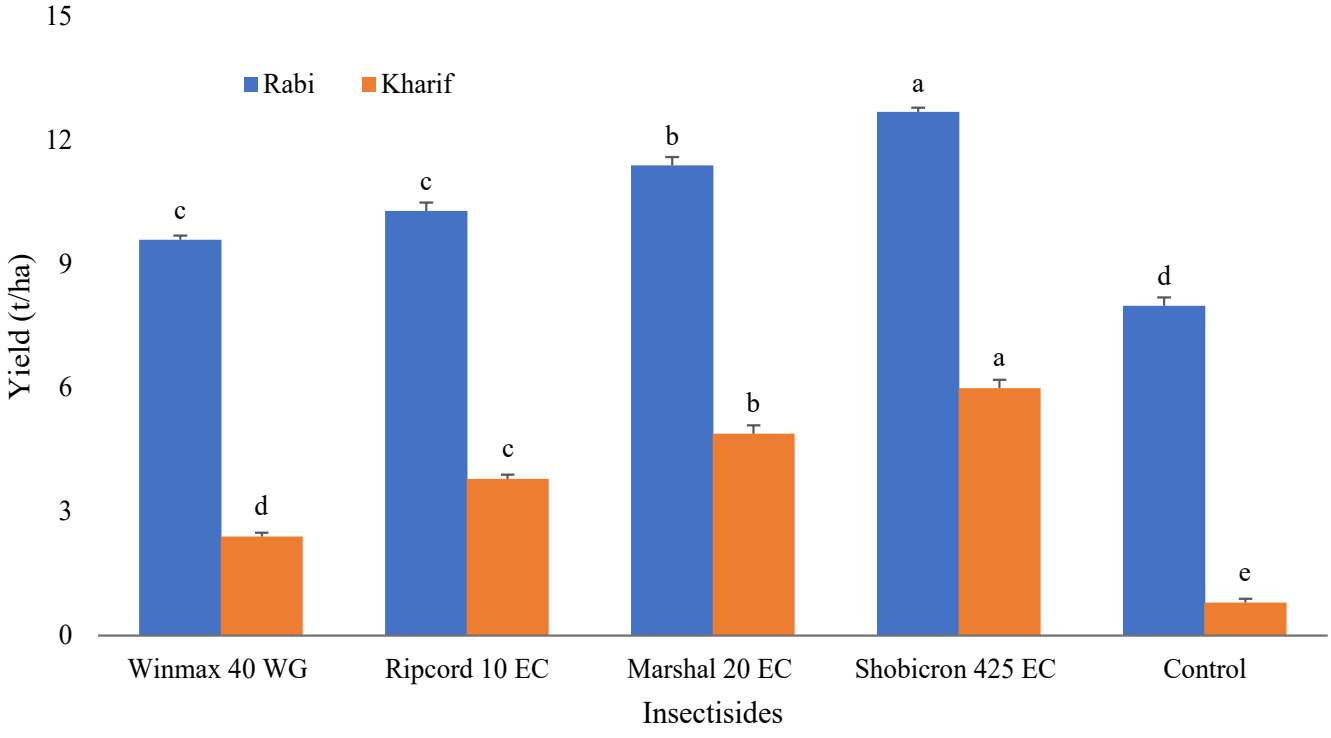

Fig. 1. Yield of sweet corn (BU Sweet Corn 1) attained from the fields treated with different insecticides for fall armyworm management.

the highest yield (12.7 t/ha and 6.2 t/ha) followed by Marshal 20 EC (11.4 t/ha and 4.92 t/ha). The control plot had the lowest yield (7.0 t/ha and 0.81 t/ha).

The present study showed that the abundance of fall armyworm larvae in each plant, leaf and cob infestation was lowest in Shobicron 425 EC treated plants with maximum yield contributing characteristics and the highest yield. Due to the combined effect of two different active ingredients (Profenofos + Cypermethrin) present in the insecticide, the Shobicron 425 EC had the best result in controlling the insect attack. Invasion, distribution, monitoring and farmers perception of fall armyworm (*S. frugiperda*) and farm-level management practices in Bangladesh has recently been reviewed (Ullah *et al.*, 2023). Sisay *et al* (2019) showed that the mean number of larvae was 0.0 after applying Karate and Radiant insecticide treated cobs had highest fresh weight. Deshmukh *et al* (2020) showed Clorantraniriplrole treated plants had the lowest mean number (0.2) of FAW larva and higher yield was obtained in Clorantraniriprole 18.5 SC, Emamectin Benzoate 5 SG and Spinetoram 11.7 SC treated plots compared to control. Sileshi *et al* (2022) reported Deltamethrin (3.7%) and Alpha Cypermethrin (5%) caused significant suppression of FAW larva compared to control plots. The current study revealed that a combination of Profenofos and Cypermethrin present in Shobicron 425 EC is the most effective in controlling fall armyworm in sweet corn in Bangladesh. The findings of the study has practical implication in effective management of fall armyworm in Bangladesh. However, efforts of the utilization of IPM strategy along with the Shobicron 425 EC are needed for sustainable management of this destructive insect pest (Kumar *et al.* 2022; Ullah *et al.* 2023).

Conclusion

In conclusion, our research demonstrates that the combination of Perfenofos and Cypermethrin, as represented by the insecticide Shobicron 425 EC, significantly enhances the management of fall armyworm infestations in sweet corn, specifically the BU Sweet Corn 1 variety. This formulation not only reduces leaf and cob infestations but also minimizes the number of larvae per plant, ultimately leading to improved yield-contributing characteristics and a higher marketable yield. While Shobicron 425 EC proved to be the most effective option among those tested, it is crucial to adopt integrated pest management practices. To protect and conserve beneficial natural enemies within the ecosystem, the judicious use of synthetic chemical insecticides is essential. Furthermore, increasing the application of biorational insecticides could provide an environmentally friendly alternative, fostering sustainable agriculture while effectively controlling fall armyworm populations. The findings of this study provide valuable insights for pest management strategies and contribute to improved sweet corn production in Bangladesh.

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Conflict of Interest

The authors have no conflict of interests.

Author Contributions

Data collection and writing of the manuscript (TTM), conceptualization, data analysis and editing (MRA), review (MRUM, MTI).

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