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TOXICITY OF SOME INSECTICIDES AND THEIR SUBLETHAL EFFECTS ON NUTRITIONAL INDICES OF FALL ARMYWORM IN SWEET CORN PLANT

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ABSTRACT

Corn is a vital cereal crop in Bangladesh, significantly contributing to food security and economy. However, the fall armyworm *Spodoptera frugiperda*, poses a severe threat to corn cultivation. This study evaluates the toxicity of four insecticides and their effect on the nutritional indices of fall armyworm. Experiment was conducted from November 2022 to April 2023 with sweet corn variety BU Misty Vutta 1 at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. In this research four insecticides: Winmax 40 WDG, Ripcord 10 EC, Marshal 20 EC, and Shobicron 425 EC, were tested on fall armyworm larvae at multiple concentrations. The mortality of fall armyworm larvae was observed at 24, 48, 72, and 96 hours after treatment. Results indicated significant differences in larval mortality across treatments, with Shobicron 425 EC showing the highest mortality rate (100% at 72 hours after treatment), while Winmax 40 WDG showed the lowest. The median lethal concentration (LC50) and lethal concentration for 95% mortality (LC95) values supported the findings, with Shobicron 425 EC demonstrating superior efficacy. Additionally, Shobicron 425 EC resulted in the lowest food consumption (0.1), consumption index (0.2), Approximate digestibility (19.5%), Efficiency of conversion of ingested food (3.9%) and Efficiency of conversion of digested food (1.1%). The study concludes that Shobicron 425 EC is the most effective insecticide for controlling fall armyworm in sweet corn, suggesting its potential for integrated pest management strategies.

Keywords: Food consumption, digestibility, *Zea mays*, *Spodoptera frugiperda*, mortality

Introduction

Sugar rich variety of corn is called sweet corn. BU Misti Vutta 1 is a sweet corn variety in Bangladesh, which has 75.2% water, 18.5% carbohydrate, 3.3% sugar, 1.9% fiber, 1.1% fat and 3.1% protein. Every 100 g grain contains 6.8 mg vitamin C. Besides, vitamin A, B1 and B3, amino acids, iron, potassium and manganese are also present in this sweet corn (Amin *et al*. 2023).

The fall armyworm (FAW), scientifically known as *Spodoptera frugiperda*, poses a significant threat to sweet corn cultivation in Bangladesh. This invasive pest has gathered widespread attention due to its rapid spread and devastating impact on crops, particularly maize and other cereal crops. In response to the threat posed by the fall armyworm, farmers and agricultural experts have turned to insecticides as a primary means of control. However, the efficacy of insecticides in managing FAW populations can vary widely, and there are growing concerns about the potential toxicity of these chemical agents to humans, non-target organisms, and the environment. As a result, understanding the toxicity and efficacy of different insecticides is crucial for developing sustainable pest management strategies that minimize environmental impact while safeguarding crop yields and human health.

Since the occurrence of FAW in Bangladesh, synthetic chemical insecticides have been widely used as emergency responses to minimize damage in maize fields. Farmers mostly spray Lambda-cyhalothrin, Chlorpyrifos, Emamectin Benzoate, Chlorantraniliprole + Thiamethoxam. But in most cases farmers are not getting satisfactory results by spraying these toxic chemical insecticides (Sarker and Dutta 2022). There is a pressing

need to test the efficacy of insecticides to control the devastating insect, fall armyworm in maize. Besides being BU Misti Vutta 1 being a new variety, no study was made on mortality rate of fall armyworm treated with different insecticides. Therefore, the present study was undertaken to determine the efficacy of different insecticides on toxicity and mortality rate of fall armyworm larva.

This study aims to evaluate the toxicity and efficacy of various insecticides commonly used in sweet corn cultivation against fall armyworm populations in Bangladesh. By systematically assessing the effectiveness of different chemical control measures, we can provide valuable insights into the most suitable insecticide options for managing FAW infestations while mitigating adverse effects on the environment and human health. Additionally, this research contributes to the ongoing efforts to develop integrated pest management practices that integrate multiple control methods, including cultural, biological, and chemical approaches, to achieve sustainable and resilient agricultural systems in Bangladesh.

Materials and Methods

The study was conducted from November 2022 to April 2023 in the laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh. The corn seeds of BU Misti Vutta 1 were sown in the plots and intercultural operations such as irrigation, weeding, thinning etc. were done whenever necessary in the experimental field.

Observation and calculation of the mortality of larvae: Experiment on mortality effects of the insecticides was done following completely randomized design (CRD). Four concentrations of each insecticide were prepared. Fresh corn leaves were collected from the field and were cut into pieces. The leaves were soaked in the solutions at four different doses and dried. After drying, these were placed in the petri dishes. The applied doses for Winmax 40 WG were 300, 250, 200 and 150 ppm, for Ripcord 10 EC 1200, 1000, 800 and 600 ppm whereas for Marshal 20 EC the doses were 3200, 3000, 2800 and 2600 ppm. Doses for Shobicron 425 EC were 2200, 2000, 1800 and 1600 ppm. Digital weighing balance was used for measuring water-dispersible granule (WG) insecticides and micropipette was used for measuring emulsifiable concentrate (EC) insecticides. The leaf pieces were then transferred into Petri dishes that contained fall armyworm larva. FAW larvae were collected from the corn field by hand picking. Each Petri dish had 5 larvae and the leaf pieces were used as their diet. In untreated control, only fresh leaf pieces were provided as larval diet. Number of dead larvae in each Petri dish was recorded at 24, 48, 72 and 96 hours after treatment and percent mortality was calculated. Observation for each dose was repeated four times and the means were used in probit analysis.

In the present study as the mortality of larvae in control was less than 5 so corrected mortality was not needed to be calculated. Detailed information about insecticides used in this study is presented in Table 1. In this study, recommended concentration and some other concentrations are also used for specific purposes.

Observation of nutritional indices of FAW larvae: The small pieces of fresh corn leaves were treated with the insecticides at the recommended doses. The leaf pieces were then transferred into Petri dishes. Individual weight of the larva and leaf weight was measured using digital weighing balance and then the larva was placed into the petri dish individually containing insecticide treated leaf pieces. The untreated control was made with the larva containing fresh leaf. After 24 hours, weight of larva, excreta and leaf was measured for each treatment. In a control Petri dish (without larva), the leaf weight was measured before and after 24 hours and moisture loss of leaf was calculated:

The following nutritional indices were calculated as per Waldbauer (1968) and Scriber and Slansky (1981):

$$\text{Consumption index (CI): } CI = \frac{F}{TA}$$

$$\text{Approximate digestibility (AD): } AD = \frac{100\times(F-E)}{F}$$

$$\text{Efficiency of conversion of ingested food in to body matter (ECI): } ECI = \frac{100\times G}{F}$$

$$\text{Efficiency of conversion of digested food into body matter (ECD): } ECD = \frac{100\times G}{F-E}$$

Table 1. Basic information of the studied insecticides

Trade name	Active ingredient	Mode of action	Recommended dose (ppm)
Winmax 40 WG	Emamectin Benzoate + Thiamethoxam	Systemic	250
Ripcord 10 EC	Cypermethrin	Contact and stomach action	1000
Marshal 20 EC	Carbosulfan	Contact and stomach action	3000
Shobicron 425 EC	Profenofos Q + Cypermethrin	Contact and stomach action	2000

Where, F =Fresh weight of food eaten (g), T = Duration of the feeding period (days), A = Mean fresh weight of larvae during feeding period (g), G = Fresh weight gain of larvae during feeding period (g), E = Weight of excreta (g).

Statistical analysis: The statistical software package IBM SPSS 20.0 was used for data analysis. One way analysis of variance (ANOVA) followed by Tukey HSD posthoc test (at 5% level of significance) was done to determine the variation of the mortality and nutritional indices of larvae. Probit analysis was employed for analyzing the dose-mortality response at 95% fiducial confidence interval. LC50 and LC95 values and their fiducial limits were estimated.

Results and Discussion

The insecticides vary in their active ingredients and modes of action, including systemic and contact/stomach actions (Table 1).

The mortality effect of different insecticides at their recommended dose on the larvae of fall armyworm at 24, 48, 72 and 96 hours after treatment is presented in Table 2, which revealed significant differences ($F_{4,15}$=101.2, p<0.001), ($F_{4,15}$=284.3, p<0.001), ($F_{4,15}$=494.9, p<0.001) and ($F_{4,15}$=770.3, p<0.001). The highest mortality (65.1%), (71.2%), (100.0 %) and (100.0%) was found in larvae treated with Shobicron 425 EC at 24, 48, 72 and 96 HAT respectively. The lowest mortality (39.8%), (49.5%), (68.1) and (85.7%) was found in larvae treated with Winmax 40 WG at 24, 48, 72 and 96 HAT respectively.

This study found that Shobicron 425 EC achieved the highest mortality rate of fall armyworm (FAW) larvae, with 100% mortality at 72 hours after treatment (HAT), while Winmax 40 WG had the lowest effectiveness. The superior performance of Shobicron 425 EC is likely due to the combination of its two active ingredients. This aligns with Sisay *et al*. (2019), who reported 90-100% FAW larval mortality at 72 HAT with Radiant being the most effective insecticide. Additionally, Sileshi *et al*. (2022) observed that Deltamethrin, Alpha cypermethrin and Diazinon caused 100% mortality at 48 HAT, indicating that these insecticides may act more quickly.

Different insecticides showed toxicity effect on larva of fall armyworm. Toxicity data revealed that at 24 hours after treatment LC50 and LC95 values ranged from 275.4 to 2899.5 and 682.5 to 3855.9 ppm, respectively (Table 3). At 48 hours after treatment, LC50 and LC95 values ranged from 255.6 to 2807.9 and 624.1 to 3522.6 ppm, respectively (Table 4). At 72 hours after treatment LC50 and LC95 values ranged from 226.0 (178.6 - 331.8) to 2683.0 and 520.5 to 3259.1 ppm, respectively (Table 5). At 96 hours after treatment LC50 and LC95 values ranged from 196.1 to 2591.3 and 369.6 to 2926.3 ppm, respectively (Table 6).

This study found that Marshal 20 EC had the highest mortality rates, followed by Shobicron 425 EC, with Winmax 40 WG showing the lowest effectiveness. The concentration-response curves had the steepest slopes, indicating that small changes in concentration led to significant changes in mortality rates. The lethal concentration (LC) values, including LC50 and LC95, were highest for Marshal 20 EC due to its higher dose. This finding is consistent with Deshmukh *et al*. (2020), who reported the highest LC50 and LC95 values for Emamectin-benzoate.

Table 2. Effect of different insecticides (optimum doses) on the mortality (%) of fall armyworm larvae

Treatment	Mortality (%)			
	24 HAT	48 HAT	72 HAT	96 HAT
Winmax 40 WG	39.8±2.1 b	49.5±2.5 b	68.1±3.1 d	85.7±1.5 b
Ripcord10 EC	46.8±1.6 b	54.2±1.4 b	76.5±0.8 c	93.9±2.9 a
Marshal 20 EC	57.8±4.2 a	66.4±0.8 a	87.3±1.3 b	100.0±0.0 a
Shobicron 425 EC	65.1±2.6 a	71.2±1.8 a	100.0±0.0 a	100.0±0.0 a
Control	0.0±0.0 c	3.8±0.6 c	4.5±1.4 e	4.5±0.6 c

Data expressed as mean± S.E. Means within a column followed by no common letter(s) are significantly different by Tukey posthoc statistic at $P \leq 0.001$ (HAT = Hours after treatment).

The 5th instar larvae of fall armyworm reared on the leaves treated with 4 different insecticides treatment showed variation in their nutritional indices such as food consumption ($F_{4,15}$= 26.9, $p < 0.001$), consumption index ($F_{4,15}$= 9.5, $p < 0.001$), approximate digestibility ($F_{4,15}$= 55.6, $p < 0.001$), efficiency of conversion of ingested food ($F_{4,15}$= 76.4, $p < 0.001$) and efficiency of conversion of digested food ($F_{4,15}$= 41.9, $p < 0.001$) (Table 7). The amount of food consumption was highest (0.8%) in Winmax 40 WG and the lowest was observed in the larvae treated with Shobicron 425 EC (0.1%). The consumption index (CI) was the highest in Winmax 40 WG (1.7%) and lowest CI (0.2%) was observed in the larvae treated with Shobicron 425 EC. The approximate digestibility (AD) was highest in Winmax 40 WG (40.8%) and the lowest AD was observed in the larvae treated with Shobicron 425 EC (19.5%). The efficiency of conversion of ingested food (ECI) was highest in Winmax 40 WG (8.1 %) and the lowest ECI was observed in the larvae treated with Shobicron 425 EC (1.1%). The efficiency of conversion of digested food (ECD) was highest in Winmax 40 WG (15.3%) and the lowest ECD was observed in the larvae treated with Shobicron 425 EC (3.9%).

These results showed that Shobicron 425 EC had the lower values among all the insecticides showing the most effective one to control the pest. The fall armyworm larvae consumed least amount of leaf and had the lowest efficiency of conversion of ingested and digested food due to treated with Shobicron 425 EC. Due to the combined effect of two different active ingredients present in Shobicron 425 EC, it showed the best result in controlling the FAW. Rajisha *et al.* (2022) reported that the CI, AD, ECI and ECD values of fall armyworm third instar larvae were 2.3, 35.70%, 18.33% and 51.3% respectively feeding with maize leaf. Al-Ayat *et al.* (2022) reported CI, AD, ECI and ECD values of 3rd to sixth instar larvae as a whole were 2.79, 66.38%, 26.05% and 70.59% respectively.

Table 3. Toxicity effect of the studied insecticides on fall armyworm at 24 hours after treatment

Insecticides	Slope (±S.E)	LC50 (95% fl)	LC95 (95% fl)	χ^2 (df)	P
Winmax 40 WG	4.2±0.5	275.4 (254.4-306.0)	682.5 (548.8- 953.7)	2.6(3)	=0.482
Ripcord 10 EC	7.9±0.9	1004.8 (968.2-1054.0)	1620.2 (1449.1-1931.2)	3.8 (3)	=0.289
Marshal 20 EC	13.3±1.4	2899.5 (2840.7-2967.9)	3855.9 (3638.9-4207.2)	3.8 (3)	=0.282
Shobicron 425 EC	9.0±0.9	1811.6 (1757.7-1869.1)	2754.9 (2552.1-3080.5)	3.6 (3)	=0.300

Each datum represents the mean of four replicates, each set up with five larvae, Concentrations are expressed as ppm, fl stands for fiducial limits.

Table 4. Toxicity effect of the studied insecticides on fall armyworm at 48 hours after treatment

Insecticides	Slope (±S.E)	LC50 (95% fl)	LC95 (95% fl)	χ^2 (df)	P
Winmax 40 WG	4.2±0.4	255.6 (237.7-279.6)	624.1 (513.0 -836.0)	4.3(3)	=0.235
Ripcord 10 EC	7.6±0.9	971.4 (936.9-1015.1)	1595.0 (1427.3-1900.6)	2.8(3)	=0.419
Marshal 20 EC	16.7±1.5	2807.9 (2694.9-2931.5)	3522.6 (3269.8 - 4158.1)	6.1(3)	=0.109
Shobicron 425 EC	11.1±1.0	1742.9 (1587.2- 1896.5)	2452.7 (2157.6 - 3533.1)	10.3(3)	=0.016

Each datum represents the mean of four replicates, each set up with five larvae, Concentrations are expressed as ppm., fl stands for fiducial limits.

Table 5. Toxicity effect of the studied insecticides on fall armyworm at 72 hours after treatment

Insecticides	Slope (±S.E)	LC50 (95% fl)	LC95 (95% fl)	χ2 (df)	P
Winmax 40 WG	4.5±0.4	226.0 (178.6- 331.8)	520.5 (346.4- 3044.6)	14.0(3)	<0.01
Ripcord 10 EC	10.4±0.9	874.0 (811.0- 935.6)	1259.4 (1118.9- 1657.8)	6.6(3)	=0.087
Marshal 20 EC	19.5±1.6	2683.0 (2538.2-2804.4)	3259.1 (3051.2-3829.1)	9.4(3)	<0.05
Shobicron 425 EC	16.2±1.3	1626.7 (1243.4 - 1888.4)	2054.4 (1808.9 - 5972.0)	34.4(3)	<0.001

Each datum represents the mean of four replicates, each set up with five larvae, Concentrations are expressed as ppm., fl stands for fiducial limits.

Table 6. Toxicity effect of the studied insecticides on fall armyworm at 96 hours after treatment

Insecticides	Slope (±S.E)	LC50 (95% fl)	LC95 (95% fl)	χ2 (df)	P
Winmax 40 WG	5.9±0.5	196.1 (131.5- 288.3)	369.6 (263.9-3163.1)	29.0(3)	< 0.001
Ripcord 10 EC	14.8±1.1	818.3 (672.7- 918.3)	1056.6 (935.1 - 1901.0)	26.3(3)	< 0.001
Marshal 20 EC	31.2±2.5	2591.3 (2326.9- 2788.3)	2926.3 (2741.2- 4366.2)	27.4(3)	< 0.001
Shobicron 425 EC	19.2±1.6	1567.2 (1188.6- 1801.7)	1908.1 (1707.0- 5672.5)	32.5(3)	< 0.001

Each datum represents the mean of four replicates, each set up with five larvae, Concentrations are expressed as ppm. fl stands for fiducial limits.

Table 7. Nutritional indices of fall armyworm larvae feeding sweet corn leaves treated with sublethal doses of different insecticides

Treatment	Nutritional indices				
	FC	CI	AD (%)	ECI (%)	ECD (%)
Winmax 40 WG	0.8±0.1b	1.7±0.2a	40.8±1.4b	8.1±0.8b	15.3±0.5b
Ripcord 10 EC	0.4±0.1bc	0.9±0.3b	36.4±0.8b	5.9±0.4c	9.2±0.4c
Marshal 20 EC	0.1±0.0c	0.3±0.02b	26.8±0.9c	2.6±0.2d	6.1±0.3cd
Shobicron 425 EC	0.1±0.0c	0.2±0.01b	19.5±1.0c	1.1±0.1d	3.9±0.1d

Data expressed as mean± S.E. Means within a column followed by no common letter(s) are significantly different by Tukeyposthoc statistic at $P \leq 0.001$ (FC=Food consumption, FI= feeding index, AD= Approximate digestibility, CI= Consumption index, ECI= Efficiency of conversion of ingested food, ECD= Efficiency of conversion of digested food).

Conclusions

The present study depicted that the Shobicron 425 EC had the highest comparative sublethal effects on nutritional indices of fall armyworm by showing increasing mortality of larva in laboratory. Therefore, the Shobicron 425 EC may be used as the most effective insecticide for controlling fall armyworm in sweet corn plant.

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