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Sustainable management of corn borer, *Helicoverpa zea* of maize through using some chemicals and bio-rational insecticides

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ABSTRACT

Maize (Zea mays) has emerged as the most important cereal crop after rice in Bangladesh. The country has a great potentiality to improve and expand the maize production. The yield of maize is being hampered due to infestation of insects especially corn borer. Experiments were conducted at the Entomology Field laboratory under Department of Entomology in Bangladesh Agricultural University (BAU), Mymensingh during Rabi season (07 November, 2018 to 15 March, 2019) in order to evaluate the effectiveness of twelve insecticides for controlling corn borer, Helicoverpa zea of maize. The experiment was laid out in randomized complete block design (RCBD) with three replications. Maize var. BHM-09 variety was used as experimental crop. Twelve insecticides viz. Chloropyriphos 50% + Cypermethrin 5% (Acmix 55 EC) @ 1.5ml/L, Azadirecta indica (Nimbicide) @ 2ml/L, Thiamethoxam 20% + Chlorantraniliprole 20% (Virtako 40 WG) @ 0.4g/L, Bacillus thuringiensis @ 1g/L, Spinosad (Libsen 45 SC) @ 0.4ml/L, Emamectin benzoate 5 SG (Suspend 5 SG) @ 1g/L, Acephate (Fortuate 75 SP) @ 1.5g/L, Thiomethoexam 14.1% + Lambdacyhalothrin 10.6% (Lamix 24.7 SC) @ 1ml/L, Carbosulfan 20 SC (Advantage 20 SC) @ 3ml/L, Spirotetreamat (Movento 150 OD) @ 1ml/L, SNPV @ 2ml/L, Fipronil 5% SC (Nema 50SC) @ 1ml/L were used as treatments. From the result, it clearly revealed that, Thiamethoxam 20% + Chlorantraniliprole 20% (Virtako 40 WG) @ 0.4g/L was the better performance on corn borer of maize than others tested insecticides i.e. it can act as an effective chemical control agent for controlling corn borer of maize while yield and all yield attributes were also higher. Besides, based on the maize grains and percentage of cobs infestation, the present study showed that positive co-relation (significant correlation) existed between percent of infestation of test grains and yield loss of the grains. Therefore, from the results, it could be recommended that further trail of this work in different doses and the effect of toxicity on human, soil and environment is needed for researcher and farmers.

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I. Introduction

Maize (*Zea mays* L.) is the most important cereal crop after rice (Alam et al., 2018) and is grown under a wide spectrum of soil and climatic conditions. Maize is used as food and oil for human intake and also as feed for livestock (Hossain et al., 2014). Every year huge amount of maize is utilized in Bangladesh of which only 42% is produced by the country and remaining imported from other countries (BBS, 2010). In Bangladesh, the production of maize grain is about 3.2 million tons per year and another 1.0 million tons for the growing animal feed industry (BBS, 2016). About 90% of total consumed maize is used as poultry feed and the remaining part is used as fish feed and human food products in Bangladesh (Alam et al., 2019; BBS, 2008). The ministry of agriculture (MoA) has been considering converting all lands under tobacco cultivation into maize fields to raise the production of the cereal up to 6.0 million tonnes by 2021. Maize can be grown throughout the world (Alam et al., 2019)**.** The major maize growing areas of Bangladesh are Panchagoar, Thakurgaon, Dinajpur, Rangpur, Bogura, Joypurhat, Rajshahi, Kushtia, Maherpur, Magura, Jhenidah, Jessor and Comilla (Krishi Dairy, 2017). The traditional cereal crop including rice, mustard and wheat seems quite unable to meet up the nutritional requirements to the increasing population (Alam et al., 2015c). So, it is high demand to introduce a new crop like maize to the existing cropping patterns of the country (Alam et al., 2019). Maize could be a good source of protein, carbohydrate and lipids for the malnourished population (Iita, 2007). There are approximately 11.1 g protein, 3.6g fat, 2.7g fibre, 348 mg phosphorus, 15.9 mg of total sodium, 114 mg of total sulphur, 1.78 mg of total amino acid, 1.5 g of total minerals, 66.2 g of total carbohydrates, 10 mg of total calcium, 2.3 mg of total iron, 286 mg of total potassium, 90 ug of carotene and 0.12 mg of total vitamin C contain in 100 g of dry maize grain (Gopalan et al., 2012).

Maize can be a potential grain crop for nutritional support to the country population. Maize can be grown all year round in Bangladesh and can therefore be fitted in the gap between the main cropping seasons without affecting the major crops. For continuous cultivation of maize, the infestation of insects is becoming high little by little. Among the major insect pests corn borer is the most serious one (Alam et al., 2014). Mathur (1987) observed over 250 species of insects which were associated with maize in the field and storage conditions. Of these, 74 species have appeared recently and about a dozen were of potential economic importance (Mathur, 1992). Among them corn borer is the most important constraint to corn production. The larva, *Helicoverpa zea* (Boddie) (formerly in the genus Heliothis) is a major agricultural pest and polyphagous in nature attacking more than 182 plant species. Older larvae became aggressive and cannibalistic, resulting in 1 or 2 larvae per feeding site (Boyd, 2008). The larvae feed on the silk down into the kernels. This damage prevents pollination and introduces various fungi into the ear. Annual yield loss ranged from 5-7 percent in field like mustard crop (Alam et al., 2015a) and 10-15 percent corn for human consumption (Bell and McGeoch, 1996). The extent of damage varied from crop to crop and season to season as like mustard crop (Alam, et al., 2015b). Heliothis infested resulting in a yield loss of 0.876% in cotton and others (Williams, 2007). Sekulic et al. (2004) reported 93.7, 90 and 85.3% damage in maize, sunflower and soybean, respectively. However data on the role of plant characters that provide resistance are inconclusive. The biochemical constituents present in quantities and proportion to each other in host plants have been reported to exert profound influence on the growth, survival and reproduction of insects in various ways (Painter, 1951). The secondary plant substances present in maize which affect the plant suitability to other insects are also likely to affect the growth and development of the pest. Significant progresses in developing resistant varieties in maize has been made in Bangladesh but until now no commercial resistant variety against corn borer have been released in Bangladesh and no proper research thrust has been given for the improvement of maize. Better knowledge on genetic diversity or genetic similarity could help to get long term selection gain in plants (Chowdhury et al., 2002).

For all these reasons, now it is essential to search the sustainable control measures and develop a bio-rational based integrated pest management (IPM) package for the corn borer in corn production. The concept of chemicals and bio-rational based integrated pest management with the emphasis on host

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plant resistance has gained momentum. Considering the above scenario, the present study was, therefore, planned and designed.

II. Materials and Methods

Experimental Site and Soil

Maize (*Zea mays*) is the most important cereal crop after rice in Bangladesh. The country has a great potentiality to improve and expand the maize production. The yield of maize is being hampered due to infestation of insects especially corn borer. Experiments were conducted at the Entomology Field Laboratory under Department of Entomology in Bangladesh Agricultural University (BAU), Mymensingh during Rabi season (07 November, 2018 to 15 March, 2019) in order to evaluate the effectiveness of some chemical and bio-rational insecticides for controlling corn borer, *Helicoverpa zea* of maize cv. BHM-09. The experimental field was located at 24.75° N latitude and 0.50° E longitudes at an average altitude of 18m above the mean sea level. The experimental site belongs to the Sonatola series of the dark grey floodplain soil type under Old Brahmaputra Floodplain Agro-Ecological Zone (AEZ-9). Weather information regarding temperature, relative humidity, rainfall and sunshine hours prevailed at the experimental site during the study period is presented in Table 01. The field was a medium high land with well drained silty-loam texture having pH value 6.5 and moderate fertility level with 1.67% organic matter content and others nutrient components well (Table 02).

Table 01. Meteorological data recorded at the experimental site during the study period (Rabi season, 2018-19)

Months	During Experimental Period (2018-19)					
	Average Temperature (^{0}C)			Average Relative Humidity (%)	Average Rainfall (mm)	Total sunshine (hrs.)
	Maxi.	Min.	Mean			
January	25.9	12.8	19.4	76.7	0.0	5.4
February	28.3	15.8	22.1	75.1	0.20	5.6
March	28.0	18.6	23.3	78.5	163.70	5.0
April	30.4	22.2	33.7	82.5	329.50	4.1
May	32.8	25.4	29.1	82.2	594.30	4.0
June	-	-	-	-	-	-
July	-	-	-	-	-	-
August	33.2	26.8	30.0	81	97.6	179.6
September	32.0	26.1	29.1	87	408.6	125.6
October	32.4	24.2	28.3	84	31.7	200.9
November	29.5	18.1	23.4	81	1.0	204.8
December	27.5	14.2	21.1	81.4	0.0	180.30

Source: Weather Yard, Department of Irrigation and Water Management, BAU, Mymensingh.

Table 02. Details status of Soil at the research conducted area, Entomology field laboratory Bangladesh Agricultural University, Mymensingh, Bangladesh during the Rabi season (07 November, 2018 to 15 March, 2019)

Sites	pH	OM (%)	Total N (%)	(meq/100g soil)	(ug/g soil)			
				K	P	S	Zn	B
BAU Campus	6.23	1.04	0.08	0.041	8.96	26.72	1.32	0.32

Source: Alam et al., 2014

Experimental Treatments and Design

To validate the evaluation of some chemical and bio-rational insecticides against corn borer at field condition, the following research methodology was followed. Herein twelve insecticides were used as treatments. The detail information of treatments has been presented in Table 03. Randomized complete block design (RCBD) with three replications followed for setting the experiments in the field. Total number of plots was 39. The unit plot size was 4m×3m where spacing of 75cm between two plots. The distance of plant to plant and row to row was 25cm & 50cm, respectively. Maize *var.* BHM-09 was used as experimental crop.

Table 03. Details of selected insecticides and the specification of treatments

Treatments	Trade Name	Name of Chemicals and Botanicals	Dose
T_1	Acmix 55 EC	Chloropyriphos 50% + Cypermethrin 5%	1.5 ml /L
T_2	Nimbicide (Azadirachtin 300 ppm)	*Azadirecta indica*	*2 ml/L*
T_3	Virtako 40WG	Thiamethoxam 20% + Chlorantraniliprole 20%	0.4g/L
T_4	Bacillus thuringiensis	*Bacillus thuringiensis*	1g/L
T_5	Libsen 45 SC	Spinosad	0.4ml/L
T_6	Suspend 5 SG	Emamectin benzoate 5 SG	1g/L
T_7	Fortuate 75 SP	Acephate	1.5g/L
T_8	Lamix 24.7 SC	Thiomethoexam 14.1% + Lambdacyhalothrin 10.6%	1ml/L
T_9	Advantage 20 SC	Carbosulfan 20 SC	3ml/L
T_{10}	Movento 150 OD	Spirotetreamat	1ml/L
T_{11}	SNPV	SNPV	2ml/L
T_{12}	Nema 50SC	Fipronil 5% SC	1ml/L
T_{13}	Control		

Crop Husbandry

The climatic condition was moderately hot and high humid with frequent rain during vegetative stage. Land was prepared well through six (06) ploughing. The fertilizers were used in properly. All fertilizers were applied during land preparation except urea and MoP. One-fourth of urea and MoP were applied at the time of final land preparation. The nitrogen, phosphorus, potassium, sulphur and zinc fertilizers were applied in form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate at the rate of 220, 100, 60, 60 and 10 kg ha-1, respectively. Seed of maize variety BHM-09 was sown on 07 November, 2018 in line. Remaining urea and MoP were applied three equal installments at pre-vegetative stage, full vegetative stage and early corn formation period. Weeding, irrigation, crop protection measure and other intercultural operation were done as and when necessary. During field experiment, all solutions of treatments were prepared in treatment wise with fresh water, and standard doses were used in this experiment. All treatments were applied at the time of corn formation when plants were affected by corn borer. The maize crop was harvested on 15 March, 2019. After sun drying of cob, the harvested cobs were threshed by power thresher. The yield of maize was recorded in treated plot wise, and converted into yield per hectare according to treatment. At maturity, different data were collected in different parameter wise.

Data collection

On the basis of infested plants and corns, the number of healthy and infested plants and corn was counted and recorded from randomly selected 10 plants per plot before application of treatments and on 1st, 3rd, & 7th days after spraying at cob formation stage and the percentage of infestation was calculated. The whole plot was harvested when 95% of the cobs became matured in grains. The harvested cobs were then threshed, cleaned and dried to moisture content of 12-14%. Before and after harvesting cob, yield and yield attributes parameter related data were collected from randomly selected 10 plants from each replication per treatment. Data on yield contributing and other characters such as % infested plants, Plant height, cob length and diameter without husk, number of row per cob, number of grains per row, number of grains per cob, 100 grain weight and grain yield per hectare were recorded at before and after harvest. Weight of grains were recorded and converted into t ha^{-1}. The percentage of infestation was calculated by using the following formula (Alam et al., 2018):

$$\text{Infested plant (\%)} = \frac{\text{Total number of plants per plot} - \text{number of healthy plant per plot}}{\text{Total number of plants per plot}} \times 100$$

The percentage of reduction of infestation over control was estimated through the following formula (Alam et al., 2018):

$$\text{Reduction (\%) of infestation over control} = \frac{\text{Cumulative mean infestation in control condition} - \text{Cumulative mean infestation in treated condition}}{\text{Cumulative mean infestation in control condition}} \times 100$$

Data analysis

The data obtained for yield contributing character and yield were statistically analyzed to find out the significance of differences among the treatments. The mean values of all the characters were evaluated and analysis of variance was performed by using R statistics software version 3.5.3 and the mean differences were adjudged by Duncans Multiple Range (DMRT) Test (Gomez and Gomez, 1984). Relation of variables with the yield and cob infestation was studied using Pearson's Correlation Coefficient and Multiple Regression analysis.

III. Results

Field evaluation of some selected chemical and bio-rational insecticides for management of corn borer of maize

Twelve insecticides *viz.* Acmix 55 EC @ 1.5ml/L, Nimbicide @ 2ml/L, Virtako 40WG@ 0.4g/L, Bacillus thuringiensis @ 1g/L, Libsen 45 SC @ 0.4ml/L, Suspend 5 SG@ 1g/L, Fortuate 75 SP @ 1.5g/L, Lamix 24.7 SC@ 1ml/L, Advantage 20 SC@3ml/L, Movento 150 OD@ 1ml/L, SNPV@ 2ml/L, and Nema 50 SC@1ml/L were evaluated for their performance against corn borer of maize under farmer's field condition during Kharif-1 season (22 February, 2019 to 30 August, 2019) at the Entomology Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh-2202. Observations were made on the mean percent infestation of cob caused by different insecticides for management of corn borer of maize and yield & yield attributes of maize as influenced by corn borer, and their results are presented in Table 04 & 05 below.

Effect of different insecticides on the percent reduction of corn borer

The mean percent infestations of cob caused by the tested different insecticides at different time interval are depicted in Table 04. The effect of different insecticides was observed up to 7 days after application. The mean percent of cob infestation differed significantly (P≤0.05) among the treatments. The mean percentage of cob infestation was recorded in the range of 31.4 to 88.95. The results clearly revealed that different insecticides had significant effect (P≤0.05) on the cob infestation and the effect was clearly dose and time dependent. Significant level of cob infestation was found at 1 DAT which was further increased at 3 DAT and reached to the peak level by 7 DAT.

At 1 DAT, among the different insecticides, the highest percentage of cob infestation (67.8 %) was found in T_{13} (control) which was followed by 62.4%, 60.0 %, 57.5%, 55.01%, 52.4%, 50.1%, 48.2%, 45.7%, 42.1%, 39.4% and 35.21% in T_7,T_{12}, T_9, T_6, T_8,T_{10}, T_2,T_5,T_1, T_4 and T_{11}, respectively, whereas the lowest (31.4%) cob infestation was recorded in T_3. At 3 DAT, among the different insecticides, the highest percentage of cob infestation (74.57%) was found in T_{13} (control) which was followed by T_7(52.0%), T_{12}(49.6%), T_9(47.1%), T_6(44.7%), T_8(42.0%), T_{10} (39.7%), T_2(37.8%), T_5(35.3%), T_1(31.7%), T_4 (29.0%) and T_{11}(24.81%), respectively whereas the lowest (21.0%) cob infestation was recorded in T_3. On the other hands, similar type of trend of result was found at 7 DAT and they showed similar type of significant (P≤0.05). Among the different insecticides, control treatment (T_{13}) showed the highest (88.95%) percentage of cob infestation which was followed by 36.3%, 33.9%, 31.4%, 29.01%, 26.3%, 24.0%, 22.1%, 19.6%, 16.0%, 13.3% and 9.11% in T_7, T_{12},T_9, T_6, T_8, T_{10}, T_2, T_5, T_1, T_4 and T_{11}, respectively whereas the lowest (5.3%) cob infestation was recorded in T_3.

From the result of cumulative mean of infestation, the highest (77.1%) infestation was observed in control treatment (T_{13}) whereas the lowest (19.23%) infestation was recorded in Virtako 40 WG @ 0.4g/L (T_3). With a view of overall insecticidal effect on corn borer of maize, based upon the percent reduction of corn borer over control, the highest percent reduction of cob infestation (75.06%) was recorded in Virtako 40 WG @ 0.4g/L (T_3) followed by T_{11}(70.13%), T_4(64.68), T_1(61.18%), T_5(56.51%), T_2(53.27%), T_{10}(50.80%), T_8(47.82%), T_6(44.32%), T_9(41.21%) and T_{12}(37.96%), respectively whereas the lowest (34.85%) reduction of cob infestation was recorded in T_7. The present findings are in agreement with the findings with Saraswati et al. (2016) who reported that Thiamethoxam 20% + Chlorantraniliprole 20% @ 0.4g/L (Virtako 40 WS) is highly potential against corn borer of maize. The present result is in agreement with the findings of Nalini and Kumar (2016) and Khan et al. (2010).

Table 04. Field evaluation of some selected chemical and bio-rational insecticides on the management of corn borer, *Helicoverpa zea* at cob formation stage at different time intervals during the Rabi season (07 November, 2018 to 15 March, 2019)

Treatments	Mean percentage of infested cobs at				Cumulative mean	Reduction (%) of infested corn over control
	Before Spray	1 DAT	3 DAT	7 DAT		
T_1	65.1 a	42.1 j	31.7 j	16.0 j	29.93 j	61.18
T_2	64.7 a	48.2 h	37.8 h	22.1 h	36.03 h	53.27
T_3	65.0 a	31.4 m	21.0 m	5.3 m	19.23 m	75.06
T_4	65.0 a	39.4 k	29.0 k	13.3 k	27.23 k	64.68
T_5	64.8 a	45.7 i	35.3 i	19.6 i	33.53 i	56.51
T_6	64.2 a	55.01 e	44.7 e	29.0 e	42.93 e	44.32
T_7	65.57 a	62.4 b	52.0 b	36.3 b	50.23 b	34.85
T_8	65.2 a	52.4 f	42.0 f	26.3 f	40.23 f	47.82
T_9	65.2 a	57.5 d	47.1 d	31.4 d	45.33 d	41.21
T_{10}	65.1 a	50.1 g	39.7 g	24.0 g	37.93 g	50.80
T_{11}	64.9 a	35.2 l	24.8 l	9.1 l	23.03 l	70.13
T_{12}	66.2 a	60.0 c	49.6 c	33.9 k	47.83 k	37.96
T_{13}	64.5 a	67.8 a	74.57 a	88.95 a	77.11 a	
Level of significance	NS	*	*	*	*	
CV (%)	10.21	8.54	7.68	8.27	7.45	
LSD	0.3	1.72	1.97	1.68	1.69	
SE (±)	1.56	1.14	0.97	1.02	1.11	

In column, means followed by different letters are significantly different, In column, means followed by same letters are not significantly different, *means at 5% level of probability, NS means non-significance. DAT=means Day after treatment. T_1= Acmix 55 EC @ 1.5ml/L, T_2= Nimbicide @ 2ml/L, T_3= Virtako 40WG@ 0.4g/L, T_4= Bacillus thuringiensis @ 1g/L, T_5=Libsen 45 SC @ 0.4ml/L, T_6= Suspend 5 SG@ 1g/L, T_7= Fortuate 75 SP @ 1.5g/L, T_8= Lamix 24.7 SC@ 1ml/L, T_9= Advantage 20 SC@3ml/L, T_{10}= Movento 150 OD@ 1ml/L, T_{11}= SNPV@ 2m/L, T_{12}= Nema 50 SC@1ml/L, T_{13}= Control

Effect of different insecticides on yield and yield attributes

Plant height (cm): The results of performance of different insecticides on plant height of maize are presented in Figure 01. The effects of different treatments on plant height were statistically significant at 5% level of probability and their ranged 180.0 to 154.1cm. Among the different insecticides, the highest plant height (180.0cm) was observed in T_3 (Virtato 40 WG @ 0.4g/L) followed by T_{11}(178.3cm), T_4(177.0cm), T_1(176.0cm), T_5(174.1cm), T_2(172.5cm), T_{10}(171.0cm), T_8(170.0cm), T_6(168.4cm), T_9(166.3cm), T_{12}(165.5cm) and T_7(163.6cm), respectively. The lowest (154.1cm) plant height was recorded in T_{13} (Control). This is directly in agreements with the findings of Saraswati et al. (2016) who stated that plant height was increased due to decrease of cobs infestation of maize.

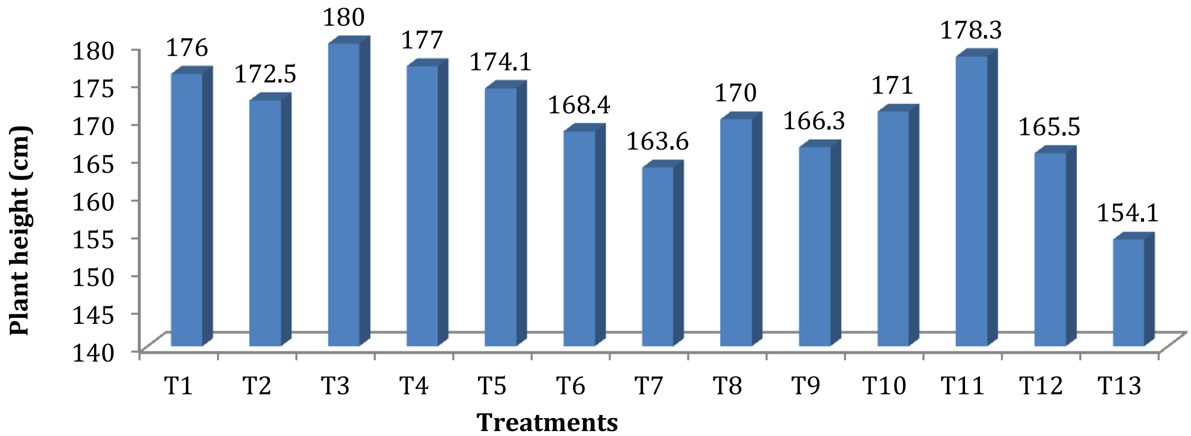

Figure 01. Effect of different insecticides on plant height (cm)

Cob length (cm): Cob length was significantly affected by different insecticides (Table 05). However, the effect of application of different insecticides on cob length of maize was statistically significant at

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5% level of probability. The length of cob without husk ranged 11.0 to 16.2 cm. Among the different insecticides, the highest (16.2cm) length of cob without husk was observed in T_3 (Virtako 40 WG @ 0.4g/L) which was followed by T_{11}(15.5cm), T_4(15.0cm), T_1(14.5cm), T_5(14.0cm), T_2(13.5cm), T_{10}(13.0cm), T_8(12.5cm), T_6(12.42cm), T_9(12.0cm), T_{12}(11.5cm) and T_7(11.45cm), respectively whereas the lowest (154.1cm) cob length was found in T_{13} (Control). The results of present study are similar with the study of Alam, et al., 2018; Khan et al. (2010) and Sharma & Gautam, 2010. They reported that cob length was directly decreased with the increase of corn borer infestation during corn formation stage of maize.

Cob diameter (cm): Considering the cob diameter, similar type of trend of result was found from cob diameter and they showed similar type of significant ($P \leq 0.05$). Among the different insecticides, Virtako 40 WG treated treatment (T_3) showed the highest (13.12cm) cob diameter which was followed by 12.62cm, 12.12cm, 12.12cm, 11.62cm, 11.60cm, 11.43cm, 10.92cm, 10.40cm, 9.89cm, 9.62cm and 9.12cm in T_{11}, T_4, T_1, T_5, T_2, T_{10}, T_8, T_6, T_9, T_{12} and T_7, respectively, whereas the lowest cob diameter was found in T_{13} (Control) (Table 05). Mollah et al., 2016 was found similar type of result regarding corn borer of maize under field laboratory condition. The results of present study are similar with the study of Alam, et al., 2018; Khan et al. (2010) and Sharma & Gautam, 2010. They reported that cob diameter was directly decreased with the increase of corn borer infestation during corn formation stage of maize.

Number of row per cob: The effects of different treatments on number of row per cob were statistically significant at 5% level of probability and their ranged 8.0 to 13.0 (Table 05). Number of row per cob was fully affected by different insecticide during the period of controlling the corn borer under farmer's field condition. They showed similar type of significant ($P \leq 0.05$). Among the different insecticides, the maximum (13.0) number of row per cob was found in Virtako 40 WG treated treatment (T_3) followed by 12.5, 12.0, 12.0, 11.5, 11.48, 11.31, 10.80, 10.28, 9.77, 9.50, and 9.0 in T_{11}, T_4, T_1, T_5, T_2, T_{10}, T_8, T_6, T_9, T_{12} and T_7, respectively, whereas the minimum (8.0) number of row per cob was recorded in T_{13} (Control). Mollah et al., 2016 and Mollah, et al., 2015 was found similar type of result in different crops regarding corn borer infestation of maize under field laboratory condition. On the other hand, the results of present study are also similar with the study of Alam, et al., 2018; Khan et al. (2010) and Sharma & Gautam, 2010. They reported that number of row per cob was directly decreased with the increase of corn borer infestation during corn formation stage of maize.

Grain number row^{-1}: The number of grain row^{-1} differed significantly ($P \leq 0.05$) among the treatments. The effect of different insecticides on number of grain row^{-1} has shown in the Table 05. The number of grain row^{-1} was recorded in the range of 27.85 to 34.1. Among the different insecticides, the highest (34.1) grain number row^{-1} was observed in T_3 (Virtato 40 WG @ 0.4g/L) followed by T_{11}(33.60), T_4(33.1), T_1(32.61), T_5(32.1), T_2(31.6), T_{10}(31.1), T_8(30.62), T_6(30.1), T_9(29.60), T_{12}(29.1) and T_7(28.50), respectively. The lowest (27.85) number of grain row^{-1} was found T_{13} (Control). Mollah et al., 2016 and Mollah, et al., 2015 was found similar type of result in different crops regarding corn borer infestation of maize under field laboratory condition. On the other hand, the results of present study are also similar with the study of Alam, et al., 2018; Khan et al. (2010) and Sharma & Gautam, 2010. They reported that grain number per row was directly decreased with the increase of corn borer infestation during corn formation stage of maize.

Grain number cob^{-1}: The number of grain cob^{-1} differed significantly at 1% level of probability among the treatments. The effect of different insecticides on number of grain cob^{-1} has depicted in the Table 05. The number of grain cob^{-1} was recorded in the range of 222.8 to 443.3. Among the different insecticides, the maximum (443.3) grain number cob^{-1} was recorded in T_3 (Virtato 40 WG @ 0.4g/L) followed by T_{11}(420.0), T_4(397.2), T_1(391.32), T_5(369.15), T_2(362.77), T_{10}(351.74), T_8(330.69), T_6(309.43), T_9(289.19), T_{12}(276.45) and T_7(256.5), respectively. The minimum (222.8) number of grain cob^{-1} was found T_{13} (Control). The results of present study are similar with the finding of the study of Alam, et al., 2018; Khan et al. (2010) and Sharma & Gautam, 2010. They reported that grain number per cob was directly decreased with the increase of corn borer infestation during corn formation stage of maize.

Table 05. Effect of some chemical and bio-rational on yield and yield attributes of maize as affected by corn borer during the Rabi season (07 November, 2018 to 15 March, 2019)

Treatments	Cob length (cm)	Cob diameter (cm)	No. of row/cob	Grain No./row	No. of grain/cob	100 grain wt. (g)	GY (t ha^{-1})	YI (%) over control
T_1	14.5d	12.12 c	12.0 c	32.61 d	391.32 d	21.0 d	5.78 d	47.92
T_2	13.5 f	11.60 d	11.48 d	31.6 f	362.77 f	20.2 f	5.3 f	43.20
T_3	16.2 a	13.12a	13.0 a	34.1 a	443.3 a	22.2 a	6.5 a	53.69
T_4	15.0 c	12.12c	12.0 c	33.1 c	397.2 c	21.4 c	6.02 c	50.0
T_5	14.0 e	11.62 d	11.5 d	32.1 e	369.15 e	20.6 e	5.54 e	45.66
T_6	12.42gh	10.40 f	10.28 f	30.1 i	309.43 i	19.0 i	4.58 i	34.27
T_7	11.45ij	9.12 h	9.0 h	28.50 l	256.5 l	17.8 l	3.86 l	22.02
T_8	12.5k	10.92 e	10.80 e	30.62 h	330.69 h	19.4 h	4.82 h	37.55
T_9	12.0 h	9.89 g	9.77 g	29.60 j	289.19 j	18.6 j	4.34 j	30.64
T_{10}	13.0 g	11.43 de	11.31 de	31.1 g	351.74 g	19.8 g	5.06 g	40.51
T_{11}	15.5 b	12.62 b	12.5 b	33.60 b	420.0 b	21.8 b	6.26 b	51.91
T_{12}	11.5 i	9.62 gh	9.50 gh	29.1 k	276.45 k	18.2 k	4.1 k	26.58
T_{13}	11.0 j	8.02 i	8.0 i	27.85 m	222.8 m	15.8 m	3.01 m	
Level of significance	*		*	*	**	*	*	
CV (%)	8.42	8.22	7.60	7.12	8.51	9.71	6.78	
LSD	0.46	0.48	0.47	0.44	4.01	0.37	0.22	
SE (±)	1.23	1.03	0.98	1.14	1.26	0.78	0.86	

In column, means followed by different letters are significantly different, *means at 5% level of probability, **means at 1% level of probability. PH=Plant Height, GY= Grain Yield, YI (%) = Percent Yield Increase over control. T_1= Acmix 55 EC @ 1.5ml/L, T_2= Nimbicide @ 2ml/L, T_3= Virtako 40WG@ 0.4g/L, T_4= Bacillus thuringiensis @ 1g/L, T_5=Libsen 45 SC @ 0.4ml/L, T_6= Suspend 5 SG@ 1g/L, T_7= Fortuate 75 SP @ 1.5g/L, T_8= Lamix 24.7 SC@ 1ml/L, T_9= Advantage 20 SC@3ml/L, T_{10}= Movento 150 OD@ 1ml/L, T_{11}= SNPV@ 2ml/L, T_{12}= Nema 50 SC@1ml/L, T_{13}= Control

Weight of 100 grain: The effects of different treatments on the weight of 100 grain were statistically significant at 5% level of probability and their ranged 15.8 to 22.2g (Table 05). Among the different insecticides, the maximum (22.2g) weight of 100 grain was recorded in Virtako 40 WG treated treatment (T_3) followed by 21.8g, 21.4g, 21.0g, 20.6g, 20.2g, 19.8g, 19.4g, 19.0g, 18.6g, 18.2g and 17.81g in T_{11}, T_4, T_1, T_5, T_2, T_{10}, T_8, T_6, T_9, T_{12} and T_7, respectively, whereas the minimum (15.8g) weight of 100 grain was observed in T_{13} (Control). The results of present study are similar with the finding of the study of Alam, et al., 2018; Khan et al. (2010) and Sharma & Gautam, 2010.

Grain yield (t ha^{-1}): The grain yield differed significantly at 5% level of probability among the treatments. The effect of different insecticides on grain yield has depicted in the Table 05. The yield of grain was recorded in the range of 3.01 to 6.5 t ha^{-1}. Among the different insecticides, the maximum (6.5 t ha^{-1}) grain yield was recorded in T_3 (Virtato 40 WG @ 0.4g/L) followed by T_{11}(6.26 t ha^{-1}), T_4(6.02 t ha^{-1}), T_1(5.78 t ha^{-1}), T_5(5.54 t ha^{-1}), T_2(5.3 t ha^{-1}), T_{10}(5.06 t ha^{-1}), T_8(4.82 t ha^{-1}), T_6(4.58 t ha^{-1}), T_9(4.34 t ha^{-1}), T_{12}(4.1 t ha^{-1}) and T_7(3.86 t ha^{-1}), respectively. The minimum (3.01 t ha^{-1}) grain yield was found T_{13} (Control). Mollah et al., 2016 and Mollah, et al., 2015 was found similar type of result in different crops regarding corn borer infestation of maize under field laboratory condition. On the other hand, the results of present study are also similar with the study of Alam, et al., 2018; Khan et al. (2010) and Sharma & Gautam, 2010. They reported that grain yield per hectare was directly decreased with the increase of corn borer infestation during corn formation stage of maize.

Percent increase of grain yield over control: The results of percent increase of grain yield over control are summarized in Table 05. It was evident from the table that grain yield was affected by different insecticides for management of corn borer when used as treatments. With a view of overall insecticidal effect on corn borer of maize, based upon the percent increase of grain yield over control, the maximum percentage increase of grain yield (53.69%) over control was found in T_3 (Virtago 40 WG@ 0.4g/L). The second highest increase of grain yield over control was observed in T_{11}(51.91%) followed by T_4(50.0), T_1(47.92), T_5(45.66), T_2(43.20), T_{10}(40.51), T_8(37.55), T_6(34.27), T_9(30.64) and T_{12}(26.58), respectively. The minimum (22.02%) percentage increase of yield was found T_7.

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Correlation between Cumulative mean percentage of infested cobs and yield loss of maize grain by corn borer, *Helicoverpa zea*

Correlation study was done to establish the relationship between cumulative mean percentage of infested cobs and yield loss of maize grain. From the Figure 02, it was revealed that positive correlation was observed between the parameters. It was evident that the equation yield=7.64+(-0.066) ×infestation gave a good fit to the data and the co-efficient of determination (R^2 = 0.93) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that cumulative mean percentage of infestation of cobs was strongly as well as positively correlated with yield loss of maize grain. Yield loss of maize grain was increased due to increase of percentage of cobs infestation of maize.

IV. Discussion

Virtako 40WG is an insecticide; its formulations containing chlorantraniliprole and thiamethoxam have been introduced in maize act as controlling agent against corn borer seed in Bangladesh. The mode of action of Virtako 40WG insecticides is may be by a neural mechanism (Tomizawa and Casida, 2012), and its active ingredient is Thiamethoxam 20% + Chlorantraniliprole 20%. It is also systemic insecticides and act on the nervous system of insect. That's why, among the all tested insecticides, Virtako 40WG provided the best control of corn borer with the highest yield from virtako 40WG treated plot. The present findings can also be compared with those of Lanka et al. (2012), who reported that Virtako 40WG was the most effective insecticide in suppressing the corn borer, *Helicoverpa Zea* by 75.06%. The finding of this study is also in close agreement with the findings of Sharma and Gautam (2010) who reported that in control plots, maize yield was less by 27.9 % due to infestation of maize stem borer as compared to pesticide applied plots. On the others hand, Virtako 40WG containing Neonicotinoids, it exhibit a variety of lethal and sublethal effects on aspects such as insect feeding, oviposition, and fecundity in Lepidoptera, Coleoptera, and Hemiptera (Hugo, 2011).

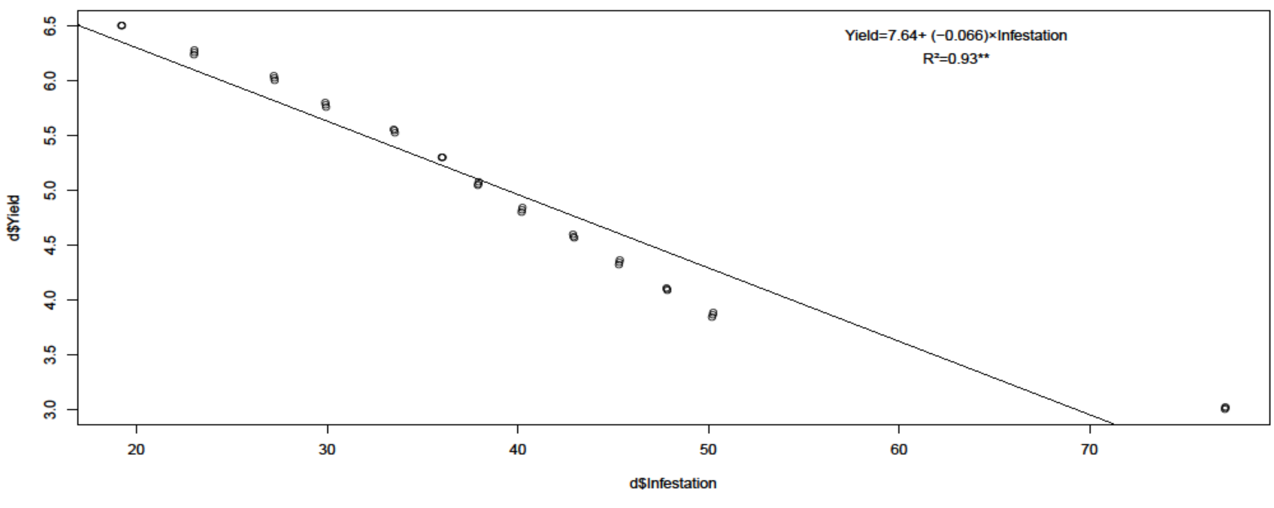

Figure 02. Relationship between cumulative mean percentage of infested cobs and yield loss of maize grain by corn borer, *Helicoverpa zea*

V. Conclusion

Considering the above result of the evaluation of the efficacy of twelve insecticides for controlling the corn borer, *Helicoverpa zea*, it was observed that Thiamethoxam 20% + Chlorantraniliprole 20% (Virtako 40 WG) @ 0.4g/L was better performance on corn borer than others tested insecticides. It is concluded from the present study that Thiamethoxam 20% + Chlorantraniliprole 20% (Virtako 40 WG) @ 0.4g/L can act as an effective chemical control agent for controlling corn borer of maize while yield and all yield attributes were also higher. On the other hand, based on the maize grains and percentage of cobs infestation, the present study showed that positive co-relation (significant correlation) existed between percent of infestation of test grains and yield loss of the grains. Therefore, from the results, it could be recommended that further trail of this work in different doses and the effect of toxicity on human, soil and environment is needed for researcher and farmers.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

VI. References

[1]. Alam, M. J., Ahmed, K. S., Hossen, B., Mozammel, H. and Hoque, A. B. M. Z. (2019). Storage pests of maize and their status in Bangladesh. Journal of Bioscience and Agriculture Research, 20(02), 1724-1730. https://doi.org/10.18801/jbar.200219.210

[2]. Alam, M. J., Ahmed, K. S., Mollah, M. R. A., Tareq, M . Z. and Alam, M. J. (2015a). Effect of planting dates on the yield of mustard seed. International Journal of Applied Sciences and Biotechnology, 3 (4), 651-654. https://doi.org/10.3126/ijasbt.v3i4.13974

[3]. Alam, M. J., Ahmed, K. S., Mollah, M. R. A., Tareq, M. Z. and Chowdhury, M. M. I. (2015b). Effect of spacing on mustard yield at Shibganj and Sadar upazila of Bogra district. Bangladesh Journal of Environmental Science, 28, 133-136.

[4]. Alam, M. J., Ahmed, K. S., Mollah, M. R. A., Tareq, M. Z. and Mottalib, M. A. (2015c). Effect of seed rate and sowing method on the yield of mustard. Bangladesh Journal of Environment Science, 29, 37-40.

[5]. Alam, M. J., Ahmed, K. S., Sultana, A., Firoj, S. M. and Hasan, I. M. (2018). Ensure food security of Bangladesh: Analysis of post-harvest losses of maize and its pest management in stored condition. Journal of Agricultural Engineering and food technology, 5(1), 26-32.

[6]. Alam, M.J., Ahmed, K. S. and Mollah, M. R. A. (2014). Survey of insect pests of maize crop and their identification in Shibganj upazilla under Bogra district. Bangladesh Journal of Seed Science and Technology, 18 (1&2), 73-77.

[7]. BBS, 2008, 2010 & 2016: Statistical Year Book of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning, Bangladesh.

[8]. Bell, J. C. and Mcgeoch, M. A. (1996). An evaluation of the pest status and research conducted on phytophagous Lepidoptera on cultivated plants in South Africa. African Entomology, 4(2), 161-170.

[9]. Boyd, B. M. (2008). Predaceous Behavior by *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae: Heliothinae). Journal of Insect Behavior, 21, 143-46. https://doi.org/10.1007/s10905-007-9113-0

[10]. Chowdhury, J. P., Ramzan, M. D. and Atwal, A. S. (2002). Preliminary studies on the biology of wheat aphids. Indian Journal of Agricultural Science, 39, 671-675.

[11]. Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agricultural research (2nd Edition). An International Rice Research Institute Book. *John Wiley and sons*, New York, USA. P-680.

[12]. Gopalan, C., Rama, Sastri, B. V. and Balasubramanian, S. C. (2012). Nutritive value of Indian foods, National Institute of Nutrition, Indian Council of Medical Research (ICMR), Hyderabad, India. pp. 47.

[13]. Hossain, M. M. (2014). An Economic Analysis of Maize Cultivation in Saturia Upazila of Manikgonj District, MS Thesis, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh, Bangladesh.

[14]. Hugo, D. G. (2011). Maize Yield Losses from Stem borers in Kenya. International Journal of Tropical Insect Science, 22(2), 89-96. https://doi.org/10.1017/S1742758400015162

[15]. IITA (2007). Research Guide 30, IITA Training Program PMB 5320, Ibadan, Nigeria 43.

[16]. Khan, N. A., Ahmad, D., Khan, M. A. and Anwar, M. (2010). Management of maize stem borer. Journal of Agriculture, 15, 467-471.

[17]. Krishi Dairy (2017). Krishi Dairy of Ministry of Agriculture, Bangladesh.

[18]. Lanka, S. K., Ottea, J. A., Davis, J. A., Hernandez, A. B. and Stout, M. J. (2012). Systemic effects of thiamethoxam and chlorantraniliprole seed treatments on adult *Lissorhoptrus oryzophilus*. Pest Management Science, 2, 45-52. https://doi.org/10.1002/ps.3382

[19]. Mathur, L. M. L. (1987). Bibliography of maize pests in India. AICMIP, Indian Agricultural Research Institute, New Delhi (Monograph).
[20]. Mathur, L. M. L. (1992). Insect pest management and its future in Indian maize programme. XIX International Congress of Entomology, June 27- July 4, 1992, Beijing, China.
[21]. Mollah, M. R. A., Ali, M. A., Ahmad, M., Hassan, M. K. and Alam, M. J. (2015). Effect of planting dates on the yield and quality of true seeds of onion. International Journal of Applied Sciences and Biotechnology, 3(1), 67-72. https://doi.org/10.3126/ijasbt.v3i1.11847
[22]. Mollah, M. R. A., Ali, M. A., Prodhan, M. Z. H., Rahman, M. M. and Alam, M. J. (2016). Effect of containers on storability of true seeds of onion. European Journal of Biomedical and Pharmaceuttical Sciences, 3 (1), 01-04.
[23]. Nalini, C. and Kumar, A. (2016). Population dynamics and comparative efficacy of certain chemicals and bio-pesticides against shoot and fruit borer. The bioscan, 11(3), 1589-1592.
[24]. Painter, R. H. (1951). Insect resistance in corn plants. The University Press of Kansas, Lawrence and London. Pp. 207-212.
[25]. Saraswati, N., Ghanashyam, B., Sheela, D. S., Surendra, Y. and Subash, S. (2016). Management of corn borer in maize using conventional pesticides in Chitwan, Nepal. Journal of Maize Research and Development, 2(1), 13-19. https://doi.org/10.3126/jmrd.v2i1.16211
[26]. Sekulic, R., Tatjana, K., Masirevic, S., Vajgand, D., Gordana, F. and Radojcic, S. (2004). Incidence and damage of cotton bollworm (*Helicoverpa armigera*) in Vojvodina Province in 2003. Biljni Lekar Plant Doctor, 32(2), 113-124.
[27]. Sharma, P. N., and Gautam, P. (2010). Assessment of yield loss in maize due to attack by the maize borer, *Chilo partellus* in Nepal. Journal of Science and Technology, 11, 25-30. https://doi.org/10.3126/njst.v11i0.4085
[28]. Tomizawa, M., and Casida, J. E. (2012). Neonicotinoid insecticide toxicology: mechanisms of selective action. Annual Review of Pharmacology and Toxicology, 45, 247-268. https://doi.org/10.1146/annurev.pharmtox.45.120403.095930
[29]. Williams, M. R. (2007). Cotton insect losses 2006.pp. 974-1026. *In* Proc. 2007 Beltwide Cotton Conference. National Cotton Council. Memphis, TN.

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Vancouver
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