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FALL ARMYWORM INFESTATION ON THE PERFORMANCE OF SWEET CORN VARIETIES

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ABSTRACT

The study was conducted from November 2021 to April 2022 in the field and laboratory of Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh to compare the morphological, developmental, yield contributing characteristics and leaf infestation status by fall armyworm of four different maize varieties viz. BU Misti Vutta 1, BARI Hybrid Vutta 1, Mohona and Dola. Among the varieties, Dola was the tallest plant having height of 156.9±6.1 cm with the highest internode length (16.0±0.2 cm), and the highest number of internodes (12.8±0.2), number of leaves per plant (11.9±0.3), leaf length (82.0±2.7 cm), and leaf width (10.5±0.2 cm). The maximum base diameter (1.9±0.1 cm) was observed in BU Misti Vutta 1. The lowest duration for seedling emergence was observed in BARI Hybrid Vutta 1 (17.6±0.3 DAS) while the lowest durations for tassel initiation (75.2±0.4 DAS), silk emergence (87.1±0.4 DAS) and earliest harvesting maturity (111.9±0.3 DAS) was observed in BU Misti Vutta 1. There was no leaf infestation (0.0±0.0%) in BU Misti Vutta 1 at 100 DAS. The highest cob length (16.4±0.5 cm), cob diameter (4.0±0.1 cm), cob weight (196.6±22.1 g), number of kernel/ cob (537.2±32.1) and yield (12.6±0.1 t/ha) were also recorded in BU Misti Vutta 1.

Keyword: BU Misti Vutta 1, morphological characters, fall armyworm, infestation, yield

Introduction

Maize (*Zea mays*) is a cereal crop belonging to the family Poaceae and the order Cyperales. It is a good source of carbohydrate, protein, starch, vitamins and minerals which is consumed as popcorn or can be eaten with soup or noodles and also in raw form or by boiling. The kernel can be consumed raw, in salads, or as a vegetable. Additionally, the corn husk and young green leaves are also popular as fodder in our country. The main types of maize are sweet corn, flint corn, popcorn, dent corn and pod corn. The sugar-rich varieties are called sweet corn. Maize is one of the most adaptable field crops to a wide range of agro-climatic conditions. It is grown in both Rabi and Kharif seasons in Bangladesh. The cultivation area and total production of Rabi and Kharif maize, in the fiscal year 2020-2021, was 979210.77 acre, 3563.7 thousand MT and 206440.73 acre, 552.7 thousand MT respectively (BBS 2021).

Sweet corn (*Zea mays* convar. *saccharata* var. *rugosa*) is a subspecies of the variety *Zea mays*. It is also called sugar corn or pole corn. It arises from a naturally occurring recessive mutation in the genes that regulate the conversion of sugar to starch within the corn kernel's endosperm (Erwin 1951). Field corn is harvested when the kernels are dry and mature (the dent stage) but the sweet corn is chosen when it is still immature (the milk stage). Hundred grams of raw yellow sweet corn contain 3.43 grams of glucose, 1.94 grams of fructose, and 0.89 grams of sucrose, according to the USDA (Wikipedia). Besides moderate levels of protein, vitamin and potassium, sweet corn contains 5-6% sugar, 10-11% starch, 3% water soluble polysaccharides and 70% water (Oktem and Oktem 2005). Sugar corn kernels are moderately high in calories in comparison to other vegetables. Sweet corn plays an important role in the human diet because of its health- promoting nutritional characteristics (Swapna *et al*. 2020).

BU Misti Vutta 1 is a sweet corn variety which was registered on 15 May, 2023 by National Seed Board and released by BSMRAU. BU Misti Vutta 1 was first introduced from South Korea. Only 14 inbreed seed was introduced in the country followed by in the field of the

department of Entomology, BSMRAU where it was grown and a fruitful outcome were noted. BU Misti Vutta 1 can be cultivated round the year but higher yield is obtained in Rabi season compared to Kharif season due to higher insect infestation especially of fall armyworm in Kharif season. Sandy-loam and silty-clay loam soil is suitable for cultivating this variety (Amin *et al*. 2023).

Although the soil and climatic conditions are suitable for maize cultivation in Bangladesh, the yield potentiality is low due to several abiotic and biotic constraints. The biotic factors include the attack of different insect pests, which cause serious damage to maize crops every year resulting huge yield loss (Sarker and Dutta 2022). The invasive insect fall armyworm (FAW) was recognized as being harmful to maize crops (Prodhan *et al*. 2020). Among several insect pests of maize, the cutworm (*Agrotis ipsilon*), fall armyworm (*Spodoptera frugiperda*), shoot fly (*Atherigona* sp.), stem borer (*Sesamia inferens* and *Chilo partellus*), aphid (*Rhopalosiphum maidis*), and the pod borer or earworm (*Helicoverpa armigera*) are important (Banglapedia 2023). Fall armyworm is a new invasive pest in our country that severely damages the maize plants and thus reduces yield severely. Without adequate management measures, the fall armyworm (FAW), which has already spread to 44 countries in Africa, has the potential to reduce annual maize production by 8 to 20 million tons in 12 African maize growing countries (Kumbhar *et al.* 2022). In Bangladesh, nearly 30-35% maize field is infected by fall armyworm which caused 5% cob infestation in the year 2019 (CIMMYT 2020).

Fall armyworm larvae damage the crop at different stages of growth, from early vegetative to physiological maturity. It cuts down young plants and also causes damage to the leaves, giving them a ragged, torn appearance. The caterpillar, which feeds inside whorls, is capable of destroying developing tassels and silks. It can also eat growing kernels, which can lower yields by causing direct losses, exposing cobs to secondary infections, and reducing the quantity and quality of grain (Sarker and Dutta 2022).

The infestation of the insect pests depends on the morphological and developmental characteristics of any plant. The insect attack also depends on temperature, humidity and other environmental condition and it needs optimum environment to thrive. So the infestation status of FAW is different in different varieties. The yield also varies greatly among different varieties. Varietal studies are necessary to compare is the insect attack. Therefore, the present study was undertaken to study the morphological, developmental, yield contributing characteristics and FAW infestation status in four different sweet corn varieties.

Materials and Methods

The study was conducted from November 2021 to April 2022 in the field and laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh. The study conducting site is located at 25°25′ North latitude and 89°5′ East longitude, which is almost in the middle of Bangladesh. The research area's yearly mean maximum and minimum temperatures, relative humidity, and rainfall amounts are 36.0°C and 12.7°C, 65.8% and 237.6 cm, respectively (Amin *et al*. 2015).

Experimental design and cultivation of sweet corn varieties: Four sweet corn varieties namely BARI Hybrid Vutta 1, Mohona, Dola, and BU Misti Vutta 1 were cultivated in the experimental plots from November 2021 to April 2022. Seeds of the BARI Hybrid Vutta 1 and BU Misti Vutta 1 were collected from Bangladesh Agricultural Research Institute, Gazipur, and BSMRAU, Gazipur Respectively. Seeds of Mohona and Dola varieties were purchased from Siddique Bazar, Dhaka. The experiment was conducted following randomized complete block design with four replications. The studied varieties were cultivated in 8 rows in 4 m × 4 m plot size in Rabi season. Seeds were sown on 22 November, 2021. Each of the varieties was planted in 4 plots of same size. Both of plot to plot and block to block distance was 1 m. The plant to plant and row to row distance was 25 cm and 60 cm respectively. Fertilizers were applied according to Fertilizer Recommendation Guide (FRG 2018). Intercultural operations such as irrigation, weeding, thinning etc. were done whenever necessary in the experimental field.

Observation of plant characteristics: The various morphological, yield contributing and developmental characteristics of the four maize varieties were studied

every week. The vegetative stages (V1-V12) were considered from the development of branch to emergence of tassel. The reproductive stages (R1-R3) were considered on the development of reproductive structures such as tassel initiation, cob formation and grain maturation. The emergence of the plants, tassel, cob, silk and grain maturation period of the 4 varieties was observed. The plant height, base diameter of plants, length of internode, number of nodes per plants, number of leaves per plant, leaf length and width, cob length, weight and width, grain number and thousand grain weight were also observed of these 4 varieties. Four randomly selected plants of each treatment were observed for measuring the characteristics.

Observation of leaf infestation (%) by fall armyworm larvae: The total number of healthy and infested leaves of a single plant from 4 randomly selected plants was counted for each of the four varieties at 50, 80 and 100 days after sowing (DAS). For assessment of insect infestation, data collections were started from the first sign of infestation, and were continued until final harvest. Number of infested leaves was counted and converted into percent leaf infestation using following formula-

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

Yield Assessment: The dried grains of each plot of four different treatments and control plot was separately weighed using a weighing machine and the yield of each variety was converted into t/ha by using the following formula:

$$\text{Yield (t/ha)} = \frac{\text{Weight of grains in kg/plot}\times 10000}{\text{Plot area in m2}\times 1000}$$

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 morphological, yield contributing characters, yield and leaf infestation rate of the four different maize varieties.

Results and Discussion

Morphological characteristics of the maize varieties: Different varieties of maize varied in their morphological characteristics (Table 1). The study revealed that there was significant variation in the morphological characteristics such as plant height ($F_{3,12}$ = 18.0, <0.001), base diameter ($F_{3,12}$ = 3.8, <0.001), length of internode ($F_{3,12}$ = 84.0, <0.001), number of nodes per plant ($F_{3,12}$ = 34.7, <0.001), number of leaves per plant ($F_{3,12}$ =144.6, < 0.001), leaf length ($F_{3,12}$ = 33.9, <0.001), and leaf width ($F_{3,12}$ = 37.1, <0.001).

Dola was the tallest plant having height of 156.9±6.1 cm followed by BARI Hybrid Vutta 1 (134.4±4.8 cm) which was statistically similar with BU Misti Vutta 1 (121.4±3.8 cm). Mohona had the shortest plants having a height of 112.5±2.8 cm. Maximum stem diameter was observed in BU Misti Vutta 1 (1.9± 0.1 cm) followed by Mohona (1.8 ±0.1 cm) and Dola (1.7±0.0 cm). The lowest stem diameter was observed in BARI Hybrid Vutta 1 (1.6±0.0 cm).

Table 1. Morphological characteristics of the maize varieties

Varities	Morphological Characteristics						
	Plant height (cm)	Base diameter (cm)	Length of internode (cm)	Number of nodes/plant	Leaves/ plant	Leaf length (cm)	Leaf width (cm)
BU Misti Vutta 1	121.4±3.8bc	1.9± 0.1a	10.2±0.3c	10.4±0.2bc	9.4±0.2b	58.8±1.6c	7.9±0.1b
BARI Hybrid Vutta 1	134.4±4.8b	1.6±0.0b	12.9±0.1b	9.6±0.2c	7.3±0.1c	69.1±2.2b	10.5±0.4a
Mohona	112.5±2.8c	1.8±0.1b	13.5±0.4b	10.7±0.3b	5.7±0.3d	85.1±1.7a	6.8±0.4b
Dola	156.9±6.1a	1.7±0.0ab	16.0±0.2a	12.8±0.2a	11.9±0.3a	82.0±2.7a	10.5±0.2a

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

Maximum length of internode was observed in Dola (16.0±0.2 cm) followed by Mohona (13.5±0.4 cm) which was statistically similar with BARI Hybrid Vutta 1 (12.9±0.1 cm). The least length of internode was observed in BU MistiVutta 1 (10.2±0.3 cm). Maximum number of nodes was observed in Dola (12.8±0.2) followed by Mohona (10.7±0.3) which is statistically similar with BU Misti Vutta 1 (10.4±0.2). The lowest number of nodes was observed in BARI Hybrid Vutta 1 (9.6±0.2). Maximum number of leaves per plant was observed in Dola (11.9±0.3) followed by BU Misti Vutta 1 (9.4±0.2) and BARI Hybrid Vutta 1 (7.3±0.1). The lowest number of leaves per plant was observed in Mohona (5.7±0.3). The highest leaf length was observed in Mohana (85.1±1.7cm) which was statistically similar with Dola (82.0±2.7cm). The lowest leaf length was observed in BU Misti Vutta 1 (58.8±1.6 cm). Maximum leaf width was observed in Dola (10.5±0.2 cm) which was statistically similar with BARI Hybrid Vutta 1 (10.5±0.4 cm). The lowest leaf width was observed in Mohona (6.8±0.4 cm) which was statistically similar with BU Misti Vutta 1 (7.9±0.1 cm). The morphological characteristics of the four maize varieties varied greatly may be due to their differences in various biochemical properties.

Developmental characteristics of the maize varieties: Different varieties of maize varied in their developmental stages (Table 2). The study revealed that there was significant variation in the developmental stages such as seedling emergence ($F_{3,12}$ = 23.46, P < 0.001), tassel initiation ($F_{3,12}$ = 38.80, P < 0.001), silk emergence ($F_{3,12}$ = 59.77, P<0.001), harvesting maturity ($F_{3,12}$ = 185.27, P<0.001). The fastest seedling emergence was observed in BARI Hybrid Vutta 1 (17.6±0.3 DAS) followed by BU Misti Vutta 1 (18.4±0.4 DAS), Dola (18.4±.4 DAS) and the slowest in Mohona (21.0±0.2 DAS). The lowest duration for tassel initiation was observed in BU Misti Vutta 1 (75.2±0.4 DAS) which is statistically similar to Dola (75.6±0.2 DAS). Mohana variety revealed the highest duration for tassel initiation (80.4±0.5 DAS). The lowest duration for silk emergence was observed in BU Misti Vutta 1 (87.1±0.4 DAS) followed by BARI Hybrid Vutta 1 (190.6±0.5 DAS). The highest duration for silk emergence was observed in Dola (93.3±0.1 DAS) which was statistically similar with Mohona (92.7±0.3 DAS). BU Misti Vutta 1 (111.9±.3 DAS) had the lowest duration for harvesting maturity followed by BARI Hybrid Vutta 1 (117.5±.4 DAS) and Mohona (119.5±.2 DAS). The highest duration for harvesting maturity was observed in Dola (123.5±0.5 DAS).

Leaf infestation (%) of different maize varieties: The leaf infestation (%) of different varieties of maize in different times of the growing period showed significant differences such as at 50 DAS ($F_{3,36}$ = 3.4, p<0.001), at 80 DAS ($F_{3,36}$ = 57.8, p<0.001) and at 100 DAS ($F_{3,36}$ = 4.0, p<0.001). Infestation rate at 50 DAS ranged from 9.2±4.0 to 38.2±12.0%. The highest infestation rate (38.2±12.0%) was observed in plots having Dola variety which was statistically similar with BARI Hybrid Vutta 1 (35.6±4.7%) and Mohana (30.0±4.3%). The lowest leaf infestation rate (9.2±4.0%) was observed in plots having BU Misti Vutta 1 (Table 3). Infestation rate at 80 DAS ranged from 0.0±0.0 to 43.9±3.4%. The highest infestation rate (43.9±3.4%) was observed in plots having Mohana variety which was statistically similar with BARI Hybrid Vutta 1 (36.4±3.2%). Infestation rate of Dola was 23.4±2.0%. No leaf infestation (0.0±0.0%) was observed in plots having BU Misti Vutta 1 at 80 DAS (Table 3).

Infestation rate at 100 DAS ranged from 0.0±0.0 to 16.6±4.8%. The highest infestation rate (16.6±4.8%) was

Table 2. Developmental stages of the maize varieties

Varieties	Developmental changes (DAS)			
	Seedling emergence	Tassel initiation	Silk emergence	Harvesting maturity of kernel
BU Misti Vutta 1	18.4±.4 b	75.2±.4 c	87.1±.4 c	111.9±.3 d
BARI Hybrid Vutta 1	17.6±.3 b	77.6±.4 b	90.6±.5 b	117.5±.4 c
Mohona	21.0±.2 a	80.4±.5 a	92.7±.3 a	119.5±.2 b
Dola	18.4±.4 b	75.6±.2 c	93.3±.1 a	123.5±.5 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 (DAS = Days after sowing)

Table 3. Leaf infestation (%) of different maize varieties by fall armyworm in Rabi season at different days after sowing.

Varieties	Days after sowing (DAS)		
	50	80	100
BU Misti Vutta 1	9.2±4.0 b	0.0±0.0 c	0.0±0.0b
BARI Hybrid Vutta 1	35.6±4.7 ab	36.4±3.2a	16.6±4.8a
Mohana	30.0±4.3 ab	43.9±3.4a	12.3±4.7ab
Dola	38.2±12.0 a	23.4±2.0b	9.7±1.6ab

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

observed in plots having BARI Hybrid Vutta 1. There was no leaf infestation rate (0.0±0.0%) was observed in plots having BU Misti Vutta 1. The leaf infestation was the higher in the mid vegetative stages and was the lower in the later stages. In BU Misti Vutta 1, the infestation was the least among all. It may be in the later stages the plants get strong enough to resist the pest attack. The plant epidermis got hard and thick so insect cannot attack the plants. The infestation was different may be due to the variations among the morphological characteristics i.e. variation of leaf size, width, leaf hair and various phytochemical and biochemical properties of the four different varieties. BU Misti Vutta 1 having the lowest leaf width and length and fast developmental characteristics may be the reason for least infestation by FAW.

Yield contributing characters of the maize varieties: There were significant variations in the yield contributing characteristics such as cob length ($F_{3,12}$ = 11.6, <0.001), cob diameter ($F_{3,12}$ = 340.3, <0.001), cob weight ($F_{3,12}$ = 35.3, <0.001), number of grains per cob ($F_{3,12}$ = 113.6, <0.001) and number of cobs per plant ($F_{3,12}$ = 14.3, <0.001) (Table 4). The highest cob length was observed in Mohona (18.9±0.6 cm). The lowest cob length was observed in BARI Hybrid Vutta 1 (16.3±0.2 cm) which was statistically similar with BU Misti Vutta 1 (16.4±0.5 cm) and Dola (16.8±0.6 cm). Maximum cob diameter was observed in BU Misti Vutta 1 (4.0±0.1 cm) followed by BARI Hybrid Vutta 1 (3.5±0.0cm) and Mohona (3.0±0.0 cm). The lowest cob diameter was observed in Dola (1.8±0.1 cm).

Maximum cob weight was observed in BU Misti Vutta 1 (196.6±22.1 g). The lowest cob weight was observed in Dola (49.3±1.9 g) which was statistically similar with BARI Hybrid Vutta 1 (73.3±1.4 g), and Mohona (75.1±2.7 g).

Maximum number of grains was observed in BU Misti Vutta 1 (537.2±32.1) followed by Mohona (278.5±8.3) which was statistically similar with BARI Hybrid Vutta 1 (289.1±15.3). The lowest number of grains was observed in Dola (58.5±4.1). Maximum number of cobs per plant was observed in Mohona (2.7±0.3), Dola (2.7±0.2) and BARI Hybrid Vutta 1 (2.3±0.2) which were statistically similar. The lowest number of cobs was observed in BU Misti Vutta 1 (1.50±0.0). The study revealed that BU Misti Vutta 1 showed the best performance in yield contributing characteristics among the four varieties. Due to the lowest leaf infestation level and the lowest leaf width, length, plant height, the BU Misti Vutta 1 had the highest yield contributing characteristics among others.

Table 4. Yield contributing characters of the maize varieties

Varieties	Yield contributing characteristics				
	Cob length (cm)	Cob diameter (cm)	Cob weight (g)	Number of grains/cob	Cobs/ plant
BU Misti Vutta 1	16.4±0.5 b	4.0±0.1 a	196.6±22.1 a	537.2±32.1 a	1.5±0.0 b
BARI Hybrid Vutta 1	16.3±0.2 b	3.5±0.0 b	73.3±1.4 b	289.1±15.3 b	2.3±0.2 a
Mohona	18.9±0.6 a	3.0±0.0 c	75.1±2.7 b	278.5±8.3 b	2.7±0.3 a
Dola	16.8±0.6 b	1.8±0.1 d	49.3±1.9 b	58.5±4.1 c	2.7±0.2 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 $P \leq 0.001$

Seasonal leaf infestation of maize varieties: There was significant variation in the leaf infestation of the four maize varieties during Rabi season such as BU Misti Vutta 1 ($F_{6,21}$ = 531.2, <0.001), BARI Hybrid Vutta 1 ($F_{6,21}$ = 1095.2, <0.001), Mohona ($F_{6,21}$ = 511.3, <0.001), Dola ($F_{6,21}$ = 207.7, <0.001) (Figure 1). In BU Misti Vutta 1 the leaf infestation rate showed a slight increasing trend from 10 to 20 January and reached the peak (10.5±0.2%) on 20 January. Leaf infestation was found declined gradually from end of January. There was no infestation (0.0±0.0%) was found in beginning of January and end of February, during early vegetative stages and reproductive stages respectively.

In BARI Hybrid Vutta 1, the leaf infestation rate showed a slight increasing trend from midJanuary and reached at the peak (35.4±0.4%) on 10 January during growth stages and remained almost similar until 30 January. Leaf infestation rate started to decline from end of January. Lowest abundance (4.0±0.4%) was found in beginning of January followed by at the end of February during early vegetative stages and reproductive stages respectively. For Mohona, the leaf infestation rate showed a rapid increasing trend from January to 10 February and reached the peak (43.5±0.3%) on 10 February. Leaf infestation declined gradually from mid-February to the end of February. The lowest infestation (6.0±0.4%) was found in beginning of January followed by end of February during early vegetative stages and reproductive stages, respectively.

In Dola, the leaf infestation rate showed a rapid increasing trend from 10 January to 20 January and reached the peak (40.4±0.2%) on 20 January. Leaf infestation rate started to decline gradually from end of January. The lowest Infestation (6.4±0.5%) was found in beginning of January followed by end of February during early vegetative stages and reproductive stages, respectively. In all the varieties the lowest leaf infestation was observed at the beginning of January and end of February. When the temperature was too low, the infestation rate was also reduced. Fall armyworm thrives well in warm temperature.

Yield of the maize varieties: Different varieties of maize varied in their yield (Figure 2). The study revealed that there was significant variation in the yield ($F_{3,12}$ = 171.6, <0.001). The highest (12.6±0.1 t/ha) yield was observed in BU Misti Vutta 1 (10.9±0.1 t/ha) followed by BARI Hybrid Vutta 1 (9.9±0.1 t/ha), Mohona and the lowest in Dola (8.4 ±.0.1 t/ha). The study showed that BU Misti Vutta

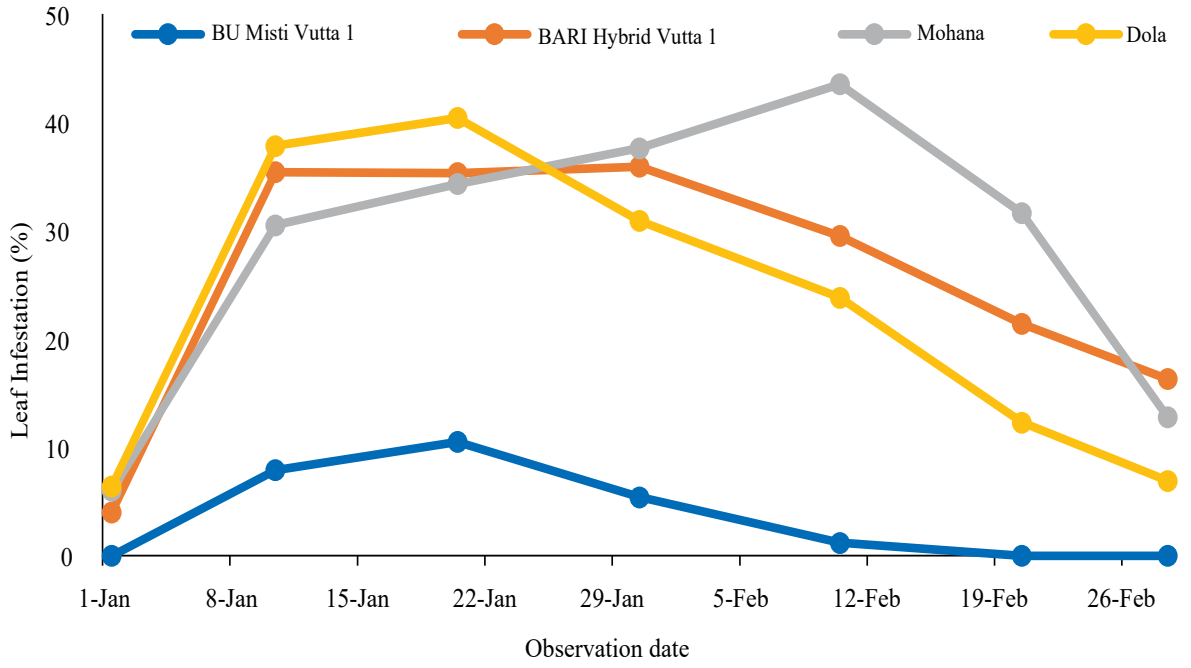


Figure 1. Seasonal leaf infestation (%) of fall armyworm in different varieties of maize during Rabi season.

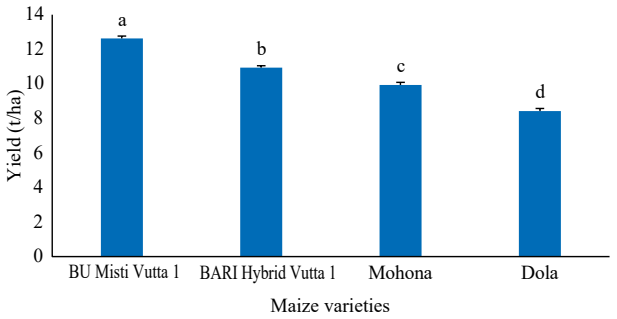


Figure 2. Yield of different maize varieties during Rabi season.

1 had the highest yield due to the lowest leaf infestation by fall armyworm. This variety was less susceptible to fall armyworm infestation compared to others. Islam and Hoshain (2022) reported that the yield of BARI Hybrid Vutta 1 in Rabi season was 7.5-8.5, in Kharif season it was 6.5-7.0 t/ha. In our study the yield of BARI Hybrid Vutta 1 was 12.75 t/ha in Rabi and 12.07 t/ha in kharif season. In the present study, the yield of BU Misti Vutta 1 was 12.6 t/ha which was at per BARI Hybrid Vutta 1.

In conclusion, among the four maize varieties BU Misti Vutta 1 showed the best performance. It had the highest yield with minimum leaf infestation rate by fall armyworm. From the present findings BU Misti Vutta 1 suggested to cultivate is for maximum production in Bangladesh during Rabi season.

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