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MORPHOLOGICAL CHARACTERIZATION OF MAIZE GENOTYPES IN SYLHET

Md Tazul Islam[1], Sabiha Akter Swapna[2], A.F.M. Saiful Islam[3], Saraf Uddin[4], Md Sazzat Hossain Raihan[2]*, Sharmita Rani Mallick[5] and Md. Abdul Baki[6]

[1]Department of Agricultural Extension (DAE), Bangladesh; [2]Department of Agroforestry, and [5]Department of Genetics and Plant Breeding, Faculty of Agriculture, Bangladesh Agricultural University, Mymensingh-2202; [3]Department of Crop Botany and Tea Production Technology, and [4]Department of Agroforestry and Environmental Science, Sylhet Agricultural University; [6]Department of Agronomy and Agricultural Extension, University of Rajshahi.

***Corresponding author:** Md Sazzat Hossain Raihan; E-mail: sazzatraihan@gmail.com

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ABSTRACT

Maize plays an important role both as food and feed throughout the world. For morphological characterization and evaluation of yield attributes of maize genotypes an experiment was carried out at the experimental field of the Department of Crop Botany and Tea Production Technology, Sylhet Agricultural University (SAU). The experimental materials were seven exotic maize genotypes viz.ZM 0001, ZM 0002, ZM 0003, ZM 0004, ZM 0005, ZM 0006ZM 0007 along with BARI Maize 6 as control. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Significant variations were observed among eight maize genotypes for most of the plant characters studied. The tallest plant was found in ZM 0005(246.5 cm). The highest number of leaves was produced in ZM 0001 (14.01). The longest and widest leaf was recorded in ZM 0004 (94.67 cm) and BARI Maize 6 (10.32 cm), respectively. The longest internode was found in ZM 0004 and ZM 0005 (21.61 cm). The genotype ZM 0004 was the earliest in respect of tasseling and silking. Ear height was highest in ZM 0005 (143.8 cm). The genotype ZM 0004 matured the earliest (109.3 days) while BARI Maize 6 matured the last (126 days). No variation was found for ear shape but in terms of kernel color, kernel type, kernel row arrangement and shape of upper surface of the kernel there were great variations among the genotypes. BARI Maize 6 produced the largest kernel with the highest thousand kernel weight. Grain yield plant^{-1} t ha^{-1} was highest in BARI Maize 6 which was closely followed by ZM 0005 and ZM 0004 among the studied genotypes. A correlation study between the yield and yield contributing characters showed that ear length, ear diameter, number of kernels row^{-1}, kernel length, kernel width, kernel thickness, thousand kernel weights, and the weight of kernels ear^{-1}, prolificacy index and weight of kernels plant^{-1} had a significant positive correlation with grain yield.

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INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop throughout the world. It is ranked as the third most important cereal crop followed by rice and wheat in the world (FAO, 2010). It is imagined as a miracle crop and is called as 'Queen of Cereals' due to its high productivity and potentiality compared to other members of the Gramineae family. Besides this, it is better than rice and wheat in terms of nutritional value (Rohman et al., 2011). It is an energy-rich food having highly digestible carbohydrates for human nutrition; contains cholesterol-free oil, moderate levels of protein and a good quantity of trace minerals. In Bangladesh, due to the gradual decrease of cultivable land and increase in food demand, the production of high-yielding crops is necessary. The average production of cereal crops i.e., rice and wheat are 3.71 and 2.77 t ha^{-1}, respectively whereas the average production of maize is 4.52 t ha^{-1} (BBS, 2021). If the traditional rice-based food habit can be diversified with maize it can play a vital role in the food security of Bangladesh. In Bangladesh, maize is mainly used as food (Rooti, Chapra, Firni, Satuetc.), feed (poultry, dairy, and fish), green cob, boiled, roasted and pop, fodder and fuel. Among these items, poultry feed requires 90% of the total maize (Hasan, 2008). There are about 65,902 poultry farms in Bangladesh (BER, 2013) which requires plenty of maize per annum. At present, the annual demand for maize is 1.6 million metric tons (Ahmed, 2013). But only 1.02 million metric ton maize is produced in the country per annum (BBS, 2021). Besides this, Bangladesh has to import 75% maize seed for cultivation (Rohman et a*l.*, 2011). Considering the above facts development of high-yielding maize variety is essential.

To develop a variety, proper characterization and evaluation of existing germplasm is a prerequisite. Different methods could be used for characterization but the morphological characterization is the earliest, most convenient and most effective genetic marker for any germplasm assessment. CIMMYT (International Maize and Wheat Improvement Centre) recommends a 'Descriptor for Mize' to evaluate the morphological characters of maize germplasm to provide a correct and effective use of traits in the breeding programs. Therefore, considering the facts an experiment was carried out to characterize eight maize genotypes to select the most potential genotype(s) for future breeding.

MATERIALS AND METHODS

The experiment was carried out at the experimental field of the Department of Crop Botany and Tea Production Technology, Sylhet Agricultural University (SAU), Bangladesh. The soil of the experimental field belongs to the Khadimnagar soil series under the Agro-Ecological zone of the Eastern-Surma-Kushiyara Floodplain (AEZ 20). The selected plots of land were high land. It was low to medium fertile and well drained. The soil of the land was acidic but it was corrected to soil p^H 6.80 by applying dolomite. The experimental area is located under the sub-tropical climate which is characterized by little rainfall during the Rabi season (October to March) but high temperature and heavy rainfall during the Kharif season (April to September). In the Rabi season, atmospheric temperature is generally low with plenty of sunshine. But the atmospheric temperature tends to increase from the month of February and onwards towards the Kharif season. However, the monthly rainfall varied from 0 to 17.78 mm and temperature fluctuated from 14.8 to 33.1^{0}C during the experimental period. The seeds were sown on 26 December 2014 and harvesting was completed on 2 May 2015. Seven exotic maize genotypes viz. ZM 0001, ZM 0002, ZM 0003, ZM 0004, ZM 0005, ZM 0006, ZM 0007 along with BARI Maize-6 (control) were used as experimental materials. Among them, BARI Maize-6 was collected from Bangladesh Agricultural Research Institute (BARI). The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 2.5 m × 1.5 m, with plant spacing of 50 × 25 cm having a 0.50 m gap between two adjacent plots. Crop husbandry was maintained according to Bangladesh Agricultural Research Institute (BARI) recommendation to ensure optimum plant growth and development.

Data were collected on plant height, internode length, number of leaves $plant^{-1}$, leaf length, leaf breadth, venation index, number of leaves above the uppermost ear, days to 50% tasseling, days to 50 silking, length of tassel, ear height, days to maturity, ear shape, kernel color, kernel type, kernel row arrangement, the shape of the upper surface of kernel, ear peduncle length, ear length, ear diameter, number of kernel rows ear^{-1}, number of kernels row^{-1}, kernel length, kernel width, kernel thickness, 1000 kernel weight, grain yield ear^{-1}, prolificacy index, grain yield $plant^{-1}$, and grain yield (t ha^{-1}). The means for all the parameters were calculated and analysis of variance was performed by F-variance test. The significance of differences between the pairs of treatment means was calculated by Duncan's Multiple Range Test (DMRT).

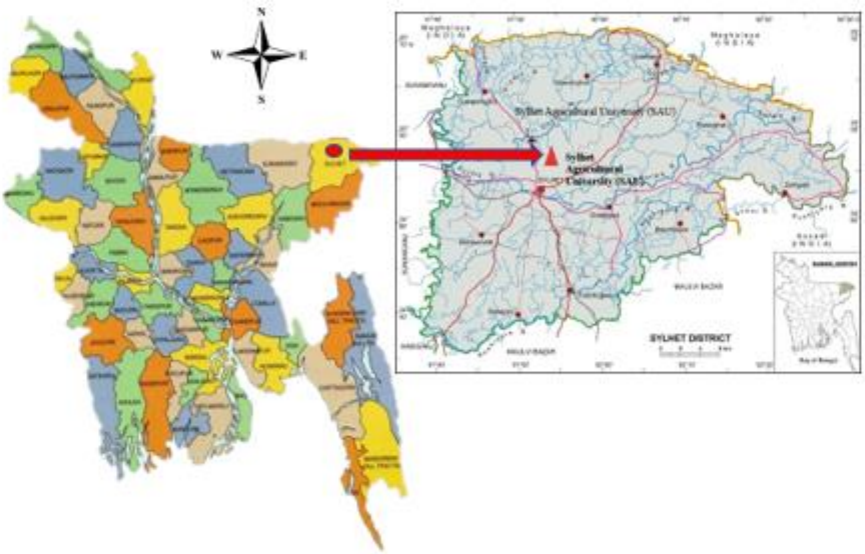

Figure 1. Study Area Sylhet Agricultural University (SAU), Bangladesh

RESULTS AND DISCUSSION

Significant variations were observed for most of the characters amongst the genotypes. The findings of the present study are presented in tables 1 to 5.

Plant Height (cm)

The plant height of the genotypes varied from 175.10 to 246.50 cm. The genotype ZM 0005 showed the highest plant height (246.50 cm) which was statistically similar to ZM 0004 (225.50 cm). The shortest plant was recorded in ZM 0007 (175.10 cm) (Table 1). This result is similar to Oner and Gulumser (2014) and Kumar et al. (2012).

Internode Length (cm)

Internode length varied from 17.83 to 21.61 cm. The longest internode was found in ZM 0004 and ZM 0005 (21.61 cm) which was closely followed by ZM 0001 (19.72 cm), ZM 0003 (19.64 cm) and BARI Maize 6 (19.50 cm). The shortest internode was found in ZM 0007 (17.83 cm) which was statistically similar to ZM 0002 (18.00 cm) and ZM 0006 (18.17 cm) (Table 1). The variation in internode length might be due to genetic makeup of genotypes.

Number of Leaves Per Plant

The number of leaves plant^{-1} varied from 11.35 to 14.05. The maximum number of leaves was produced by ZM 0001 (14.05) while the minimum number was in ZM 0007 (11.35) (Table 1). A similar result was also obtained by Oner and Gulumser (2014) and Jaric et al. (2010). Oner and Gulumser (2014) observed 7.6 to 16.2 leaves plant^{-1}, whileJaric et al. (2010) reported10.80 (PF-ZM 18) to 13.30 (PF-ZM 5) leaves plant^{-1}.

Leaf Length (cm)

The longest leaf was found in ZM 0004 (94.67 cm) while the shortest was in ZM 0001 (81.00 cm) (Table 1). This result was supported by Jaric et al. (2010) who noted the longest leaf (95.9 cm) in PF-ZM 37 and the shortest leaf (67.9 cm) in PF-ZM 26.

Leaf Breadth (cm)

The widest leaf was produced in BARI Maize 6 (10.32 cm) which was statistically identical to ZM 0001 (9.83 cm) and ZM 0003 (9.35 cm). The narrowest leaf was produced in the genotype ZM 0005 (8.633 cm) (Table 1). The present results are in agreement with the findings of Jaric et al. (2010) who reported significant variations among different maize accessions which varied from 8.40 to 11.10 cm.

Venation Index

The highest venation index was found in ZM 0005 (3.63) followed by ZM 0004 (3.12) due to the production of a greater number of veins along the leaf and also due to having the narrowest leaves. The lowest index was found in ZM 0001 (2.303) (Table 1). These results are in partial fulfillment with the findings of Jaric et al. (2010) who reported significant variation among different maize accessions for venation index which varied from 2.2 (PF-ZM 4) to 2.6 (PF-ZM 34) with a mean value of 2.4.

Number of Leaves Above the Uppermost Ear

The highest number of leaves above the uppermost ear was produced in BARI Maize 6 (6.75) which was closely followed by ZM 0005 (6.42), ZM 0004 (6.25), ZM 0001 (6.17), ZM 0007 (6.17) and ZM 0006 (6.08). The least number of leaves was produced in ZM 0003 (5.17) (Table 1). These results are in partial fulfillment with the findings of Jaric et al. (2010) who reported significant variation among different maize accessions for the number of leaves above the uppermost ear. They noted a higher number of leaves above the uppermost ear in PF-ZM 5 (5.8) and the lowest number of leaves in PF-ZM 4 (4.7).

Table 1. Plant related characters of eight maize genotypes in Sylhet

Genotype	Plant height (cm)	Internode length (cm)	Leaf No.	Leaf length (cm)	Leaf breadth (cm)	Venation index	No. of leaves above the uppermost ear
ZM 0001	203.60abc	19.72ab	14.05	81.00	9.83ab	2.30c	6.17ab
ZM 0002	188.10bc	18.00b	12.93	84.13	8.75bc	2.84bc	5.67bc
ZM 0003	204.80abc	19.64ab	12.50	89.87	9.35abc	2.42bc	5.17c
ZM 0004	225.50ab	21.61a	12.39	94.67	9.07bc	3.12ab	6.25ab
ZM 0005	246.50a	21.61a	12.33	86.83	8.63 c	3.63a	6.42ab
ZM 0006	206.10abc	18.17 b	12.83	85.15	8.88bc	2.77bc	6.08ab
ZM 0007	175.10 c	17.83 b	11.35	83.83	8.90bc	2.47bc	6.17ab
BARI Maize 6	191.60bc	19.50ab	12.50	86.17	10.32a	2.53bc	6.75a
Significance	**	**	NS	NS	*	**	**
CV (%)	8.61	8.11	-	7.82	6.36	10.24	5.08

Days to 50% Tasseling

It was observed that 72-84 days were required for 50% tasselling. BARI Maize 6 required a maximum time (84 days) for 50% tasseling which was statistically identical to ZM 0002 (78.33 days) and ZM 0007 (77.33 days). On the other hand, ZM 0004 required minimum times (72 days) for 50% tasseling which was closely followed by ZM 0001 (73.67 days), ZM 0003 (74.33 days), ZM 0005 (74.67 days) and ZM 0006 (75.00 days) (Table 2). This result was in harmony with the findings of Azad et al. (2012) who observed significant variation for 50% tasseling. Otung (2014) observed that the exotic varieties tasseled earlier than the control. The variation in days required for 50 %tasseling might be due to the genetic makeup of genotypes.

Days to 50% Silking

The genotypes took 75.33 to 87.33 days for 50% silking. BARI Maize 6 required the longest time (87.33 days) for 50% silking which was statistically alike to ZM 0002 (81.33 days). In contrast, ZM 0004 required the minimum number of days (75.33 days) for 50% tasseling which was closely followed by ZM 0001 (77 days), ZM 0003 (77.33 days), ZM 0005 (77.67 days), ZM 0006 (78 days) and ZM 0007 (80 days) (Table 2). The variation in days required for 50%silking might be due to the genetic makeup of genotypes.

Length of Tassel (cm)

Tassel length varied from 37.67 to 46.73 cm. The longest tassel was found in ZM 0004 (46.73 cm) whereas the shortest was in ZM 0007 (37.67 cm) (Table 2). This result was partially supported by Lucchin et al. (2003) who recorded the longest tassel in NSt6 (51.6 cm) and the smallest in NSt8 (44.7 cm).

Ear Height (cm)

Maximum ear height was observed in ZM 0005 (143.80 cm) while minimum ear height was in ZM 0003 (123.80 cm) (Table 2). Lucchin et al. (2003) reported similar results i.e. maximum and minimum values for ear height were scored by NSt1 (165 cm) and NSt21 (135.00 cm), respectively. The variation in ear height was due to variations in plant height, internode length and upper ear-bearing node number.

Days to Maturity

The studied genotypes took 109.30 to 126.00 days for maturity. All of the exotic genotypes (ZM 0001, ZM 0002, ZM 0003, ZM 0004, ZM 0005, ZM 0006and ZM 0007) matured earlier compared to the control genotype (BARI Maize 6). However, the earliest harvesting genotype was ZM 0004 (109.3 days) which was closely followed by ZM 0001 (110 days), ZM 0003 (110 days), ZM 0006 (111.7 days), ZM 0005 (112 days), ZM 0007 (112.7 days), and ZM 0002 (115.3 days). The highest number of days was required to mature for BARI Maize 6 (126 days) (Table 2). This variation was due to the variation of days to tasseling and silking as well as varietal impact. This result was in agreement with the findings of Otung (2014) who reported that the exotic variety (CAU 541) could be harvested earlier than the local control variety. The present result was also supported by Devi et al. (2013) who reported variations among forty different maize landraces for days required to maturity and they observed 96 to 130 days required for maturity.

Table 2. Flowering characters of eight maize genotypes in Sylhet

Genotype	Days to 50% tasseling	Days to 50% silking	Length of tassel (cm)	Days to maturity	Ear height (cm)
ZM 0001	73.67b	77.00b	40.57	110.00b	136.00
ZM 0002	78.33ab	81.33ab	41.60	115.30b	129.30
ZM 0003	74.33b	77.33b	40.87	110.00b	123.80
ZM 0004	72.00b	75.33b	46.73	109.30b	140.60
ZM 0005	74.67b	77.67b	41.67	112.00b	143.80
ZM 0006	75.00b	78.00b	41.97	111.70b	134.70
ZM 0007	77.33ab	80.00b	37.67	112.70b	137.50
BARI Maize 6	84.00a	87.33a	40.13	126.00a	128.30
Significance	**	**	NS	**	NS
CV (%)	3.56	3.18	8.60	1.98	6.48

Ear Shape

The ears of all the genotypes were conical-cylindrical shaped and there was no significant variation among the genotypes in this respect (Table 3).

Kernel Color

Four different colors were observed in the kernel. Out of eight maize genotypes 5 produced white (ZM 0002, ZM 0003, ZM 0004, ZM 0005 and ZM 0006), 1 red (ZM 0001), 1 variegated (ZM 0007) and 1 yellow (BARI Maize 6) colored kernel (Table 3). Variations in kernel color might be due to environmental impact and the genetic makeup of genotypes. A similar variation in kernel color was also observed by Devi et al. (2013) who noted 8 different colored kernels in forty accessions. Selvi et al. (2013) also recorded 3 different colors of the kernel in seventeen inbred.

Kernel type

Four types of kernels were found in eight genotypes. Five genotypes were found with the pop typed kernel (ZM 0001, ZM 0002, ZM 0003, ZM 0004 and ZM 0007) while the rest of the genotypes had flint (ZM 0006), flint-like (ZM 0005) and semi-flint (BARI Maize 6) typed kernels (Table 3). Variations in kernel type might be due to environmental impact and the genetic makeup of genotypes.

Kernel Row Arrangement

Three different arrangements were found among eight genotypes. Five genotypes were found with the regular type of arrangement (ZM 0001, ZM 0002, ZM 0004, ZM 0007 and BARI Maize 6). The rest three genotype had straight (ZM 0003 and ZM 0006) and spiral (ZM 0005) types of arrangement (Table 3). Variation in kernel type might be due to the genetic makeup of genotypes. The present result is in agreement with Selvi et al*.* (2013) and Devi et al*.* (2013) who reported variations in a kernel row arrangement. Devi et al*.* (2013) noted regular (23), irregular (7), straight (6) and spiral (4) arrangement of kernels among the studied maize accessions.

The shape of Upper Surface of Kernel

Two differently shaped kernels were found among the genotypes. The genotypes ZM 0001, ZM 0003, ZM 0004 and ZM 0006 had round-shaped upper surfaces while ZM 0002, ZM 0005, ZM 0007 and BARI Maize 6 had indented shaped upper surfaces of kernels (Table 3). This variation in the shape of the upper surface of the kernel might be due to the genetic makeup of genotypes. A similar result was also reported by Selvi et al*.* (2013) and Devi et al*.* (2013) who observed variations in the shape of the upper surface of the kernel.

Table 3. Qualitative ear characters of maize genotypes in Sylhet

Genotype	Ear shape	Kernel color	Kernel type	Kernel row arrangement	Shape of upper surface of kernel
ZM 0001	Conico-cylindrical	Red	Pop	Regular	Round
ZM 0002	Conico-cylindrical	White	Pop	Regular	Indented
ZM 0003	Conico-cylindrical	White	Pop	Straight	Round
ZM 0004	Conico-cylindrical	White	Pop	Regular	Round
ZM 0005	Conico-cylindrical	White	Flint-like	Spiral	Indented
ZM 0006	Conico-cylindrical	White	Flint	Straight	Round
ZM 0007	Conico-cylindrical	Variegated	Pop	Regular	Indented
BARI Maize 6	Conico-cylindrical	Yellow	Semi flint	Regular	Indented

Ear Peduncle Length (cm)

Peduncle length varied from 6.72 to 8.583 cm. The longest peduncle was found in BARI Maize 6 (8.583 cm) which was closely followed by ZM 0006 (8.543 cm), ZM 0003 (8.057 cm), ZM 0004 (8.05 cm) and ZM 0005 (7.56 cm). The shortest peduncle was found in ZM 0001 (6.72 cm) which was statistically similar to ZM 0007 (6.733 cm) (Table 4). The variation in ear peduncle length might be due to the genetic makeup of genotypes.

Ear Length (cm)

The ear length varied between 12.80 and 16.06 cm. The longest ear was recorded in BARI Maize 6 (16.06 cm) and the shortest in ZM 0001 (12.80 cm) which was statistically similar to ZM 0002 (13.01 cm), ZM 0006 (13.34 cm), ZM 0004 (13.75 cm), ZM 0005 (13.84 cm), ZM 0003 (13.89 cm) and ZM 0007 (14.10 cm) (Table 4). The variation in ear length was due to variation in kernel thickness and the number of kernels row^{-1} in an ear. Similar results were observed by Rahman et al*.* (2015), Oner and Gulumser (2014), Selvi et al*.* (2013) and Azad et al*.* (2012). All of them observed significant variation among maize genotypes for ear length. Oner and Gulumser (2014) observed 9.7 to 23 cm and Selvi et al*.* (2013) observed 11 (UMI 190) to 15 cm (UMI 61 and UMI 101) ear length in maize genotypes.

Ear Diameter (cm)

The ear diameter varied between 3.58 to 4.61 cm. The highest diameter was recorded in BARI Maize 6 (4.61 cm) and the lowest ear diameter was observed in ZM 0003 (3.58 cm) which was statistically similar to ZM 0006 (3.79 cm), ZM 0002 (3.81 cm), ZM 0005 (3.86 cm), ZM 0001 (3.86 cm), ZM 0007 (3.93 cm) and ZM 0004 (3.99 cm) (Table 4). The variation in ear diameter was due to variation in kernel length and width and also the number of kernel rows ear^{-1}. Similar variation was also observed by Rahman et al. (2015) and Oner and Gulumser (2014). Oner and Gulumser (2014) reported 3.17 to 4.98 cm ear diameter in maize.

Number of Kernel Rows Ear^{-1}

The number of kernel rows varied from 12 to 14 among all genotypes. On an average, the highest number of kernel rows ear^{-1} was found in ZM 0005 (13.89) while the least number of rows was found in ZM 0002 (12.33) (Table 4). This result is in agreement with Otung (2014) who found no significant variation among different maize varieties for the number of kernel rows and here number of kernel rows ear^{-1} 11.8-13.6. Many other scientists also found similar result; Oner and Gulumser (2014) observed number of kernel rows in the ears vary from 8 to 16. Jaric et al. (2010) reported that the number of kernel rows varies from 11.7 to 15.3. Harada et al. (2009) observed most of the ears had kernel row numbers 12 and 14. Lucchin et al. (2003) noted the maximum number of kernel rows 15.2 (NSt14) and the minimum number of kernel rows 12 (NSt9).

Number of Kernels Row^{-1}

The number of kernels row^{-1}was varied from 25.33 to 30.89. The highest number of kernels row^{-1} was noted in BARI Maize 6 (30.89) while the minimum number of kernels row^{-1} was found in ZM 0001 (25.33) (Table 4). This result agrees with Otung (2014) who found no significant variation among different maize varieties for the number of kernels row^{-1}and he observed it from 22.3 to 28.7. Harada et al. (2009) also observed a similar result when they recorded the mean number of kernels row^{-1} of forty maize accessions as 27.6.

Table 4. Quantitative ear characters of maize genotypes

Genotype	Ear peduncle length(cm)	Ear length (cm)	Ear diameter (cm)	Kernel rows ear^{-1}	Kernels row^{-1}
ZM 0001	6.72b	12.80b	3.86b	13.67	25.33
ZM 0002	8.18a	13.01b	3.81b	12.33	28.56
ZM 0003	8.06ab	13.89b	3.58b	13.00	29.78
ZM 0004	8.05ab	13.75b	3.99b	13.17	26.78
ZM 0005	7.56ab	13.84b	3.86b	13.89	27.28
ZM 0006	8.54a	13.34b	3.79b	13.33	28.33
ZM 0007	6.73b	14.10b	3.93b	13.67	29.44
BARI Maize 6	8.58a	16.06a	4.61a	13.67	30.89
Significance	**	**	**	NS	NS
CV (%)	6.68	5.39	4.81	5.64	8.64

Kernel Length (mm)

Kernel length was varied9.00 to 9.99 mm. The longest kernel was found in ZM 0005 (9.99 mm) which was statistically identical to ZM 0004 (9.86 mm), BARI Maize 6 (9.74 mm) and ZM 0007 (9.40 mm). The shortest kernel was found in ZM 0001 (9.00 mm) which was statistically identical to ZM 0003 (9.07 mm) and ZM 0002 (9.08 mm)(Table 5). The variation in ear kernel length might be due to environmental and varietal impact. A similar variation was also noticed by Jaric et al. (2010) who recorded mean length of the kernel of ten maize accessions was 11.1 mm.

Kernel Width (mm)

Kernel widthvariedfrom7.51 to 8.98mm. The widest kernel was found in BARI Maize 6 (8.98mm) while the narrowest was found in ZM 0001 (7.51 mm) which was closely followed by ZM 0002 (7.63mm), ZM 0006 (7.76mm), ZM 0003 (8.00mm), ZM 0004 (8.01mm), ZM 0005 (8.16 mm) and ZM 0007 (8.20mm) (Table 5). The variation in ear kernel width might be due to environmental and varietal impact. This result agrees with Jaric et al. (2010) who reported kernel width varies from 8 to 9.4 mm.

Kernel Thickness (mm)

Kernel thickness varied from 3.83 mm to 4.36 mm. The thickest kernel was found in ZM 0005 (4.36mm) which was statistically identical to BARI Maize 6 (4.29 mm), ZM 0004 (4.26mm), ZM 0007 (4.14mm), and ZM 0003 (4.05 mm). The thinnest kernel was recorded in ZM 0002 (3.83 mm) followed by ZM 0001 (3.92 mm) (Table 5). The variation in ear kernel width might be due to environmental and varietal impact. This result is in agreement with Jaric et al. (2010) who reported considerable variations among the maize accessions regarding kernel thickness.

Table 5. Yield and yield contributing characters of eight maize genotypes in Sylhet

Genotype	Kernel length (mm)	Kernel width (mm)	Kernel thickness (mm)	1000 kernel weight (g)	Grain yield ear^{-1} (g)	Prolificacy index	Grain yield plant^{-1} (g)	Grain Yield (t ha^{-1})
ZM 0001	8.997c	7.510b	3.917cd	185.0c	38.41e	1.000b	38.41e	3.073e
ZM 0002	9.083c	7.627b	3.833d	187.7c	39.40e	1.213a	47.85de	3.827de
ZM 0003	9.073c	8.003b	4.050abcd	198.6c	45.54cde	1.210a	54.96cd	4.397cd
ZM 0004	9.863a	8.013b	4.263abc	233.4ab	49.95bcd	1.330a	66.07bc	5.283bc
ZM 0005	9.990a	8.160b	4.363a	248.8ab	56.56b	1.247a	70.45b	5.637b
ZM 0006	9.127bc	7.763b	3.970bcd	193.3c	43.03de	1.287a	55.31cd	4.427cd
ZM 0007	9.403abc	8.203b	4.143abcd	228.1b	52.45bc	1.167ab	61.17bc	4.893bc
BARI Maize 6	9.737ab	8.977a	4.293ab	253.4a	65.64a	1.277a	83.72a	6.697a
$LSD_{(0.01)}$	0.6016	0.7002	0.3181	20.35	7.777	0.1719	10.84	0.8662
Significance	*	**	*	**	**	**	**	**
CV (%)	3.64	3.58	4.46	3.88	6.55	5.93	7.46	7.46

1000 Kernel Weight (g)

Thousand kernel weight varied from 185.00 to 253.40 g. A maximum 1000 kernel weight was observed in BARI Maize 6 (253.40 g) which was statistically identical with ZM 0005(248.80 g) and ZM 0004 (233.40 g). Minimum thousand kernel weight was observed in ZM 0001 (185.00 g), ZM 0002 (187.70 g), ZM 0006 (193.30 g) and ZM 0003 (198.60 g) (Table 5). The variation in the thousand kernel weight was due to the variation in kernel size (kernel length, width and thickness). This result is in harmony with Rahman et al. (2015), Selvi et al. (2013), Azad et al. (2012), Harada et al. (2009) and Lucchin et al. (2003). All of them reported significant variations among the maize genotypes for thousand kernel weight. Rahman et al. (2015) reported 1000 kernel weight varies from 122 (Sweet corn) to 291 g (BHM 7). Selvi et al. (2013) found 1000 seed weight vary from 120 (UMI 69) to 260 g (UMI 395). Harada et al. (2009) recorded mean 1000 kernel weight of forty maize landraces was 230 g.

Grain Yield Ear^{-1} (g)

Grain yield ear^{-1} varied from 38.41 to 65.64 g. The maximum kernel weight of an ear was observed in BARI Maize 6 (65.64 g) whereas minimum weight was observed in ZM 0001 (38.41 g) which was statistically similar to ZM 0002 (39.4 g) (Table 5). The variation in the weight of kernels ear^{-1} was due to the variation in the number of kernels ear^{-1} and the difference in kernel size (kernel length, width and thickness). This result is in harmony with Fetahu et al. (2010), Harada et al. (2009) who reported significant variations in grain yield ear^{-1}.

Table 6. Correlation matrix between grain yield and yield contributing characters of different maize genotypes

Characters	Ear diameter	No. of kernel rows ear^{-1}	No. of kernels rows^{-1}	Kernel length	Kernel width	Kernel thickness	1000 kernel weight	Wt. of kernels ear^{-1}	Prolificacy index	Wt. of kernels plant^{-1}	Grain yield
Ear length	0.78**	0.11^{NS}	0.70**	0.46*	0.85**	0.56**	0.68**	0.85**	0.27^{NS}	0.80**	0.80**
Ear diameter		0.23^{NS}	0.48*	0.45*	0.66**	0.33^{NS}	0.60**	0.73**	0.05^{NS}	0.64**	0.64**
No. of kernel rows ear^{-1}			-0.25^{NS}	0.30^{NS}	0.18^{NS}	0.39^{NS}	0.40^{NS}	0.41*	-0.27^{NS}	0.25^{NS}	0.25^{NS}
No. of kernels row^{-1}				0.20^{NS}	0.45*	-0.02^{NS}	0.21^{NS}	0.47*	0.16^{NS}	0.43*	0.43*
Kernel length					0.37^{NS}	0.40^{NS}	0.75**	0.69**	0.23^{NS}	0.66**	0.66**
Kernel width						0.68**	0.79**	0.86**	0.37^{NS}	0.85**	0.85**
Kernel thickness							0.80**	0.67**	0.31^{NS}	0.68**	0.68**
1000 kernel weight								0.93**	0.34^{NS}	0.90**	0.90**
Wt. of kernels ear^{-1}									0.28^{NS}	0.93**	0.93**
Prolificacy index										0.06**	0.06**
Wt. of kernels plant^{-1}											1.00**

** = Significant at 1% level of probability;
* = Significant at 5% level of probability;
NS = Not significant

Prolificacy Index

The highest Prolificacy index was recorded in ZM 0004 (1.33) which was statistically similar to ZM 0006 (1.29), BARI Maize 6 (1.28), ZM 0005 (1.25), ZM 0002 (1.21) and ZM 0003 (1.21). The minimum index was observed in ZM 0001 (1.00) (Table 5). This result is in agreement with Devi et al. (2013), Azad et al. (2012) and Lucchin et al. (2003). They reported significant variations amongst the genotypes. Devi et al. (2013) recorded mean number of ears plant^{-1} of forty maize landraces was 1.23. Azad et al. (2012) observed a prolificacy index from 1 to 1.3.

Grain Yield Plant^{-1} (g)

A significant difference was observed in Grain yield plant^{-1} which varied from 38.41 to 83.72 g. The highest grain weight plant^{-1} was observed in BARI Maize 6 (83.72 g) followed by ZM0005 (70.45 g) whereas minimum weight was observed in ZM 0001 (38.41 g) followed by ZM 0002 (47.85 g) (Table 5). The variation in the grain yield plant^{-1} was due to the variation in the grain yield plant^{-1} and prolificacy index. This result is in harmony with Rahman et al. (2015), Oner and Gulumser (2014), Azad et al. (2012), Harada et al. (2009) who reported significant variations for grain yield plant^{-1}. Rahman et al. (2015) observed grain yield plant^{-1}varied from 37.8 (Duranta) to 98 g (BHM 7). Oner and Gulumser (2014) reported, grain yield plant^{-1}varied from 26.9 to 197.7 g. Azad et al. (2012) recorded 47.93 to 131.21 g grain weight plant^{-1}.

Grain yield (t ha^{-1})

Grain yield varied from 3.07 to 6.70t ha^{-1}. The highest grain yield was observed in BARI Maize 6 (6.70t ha^{-1}) followed by ZM 0005 (5.64t ha^{-1}) whereas it was the lowest in ZM 0001 (3.07t ha^{-1}) followed by ZM 0002 (3.83t ha^{-1}) (Table 5). The variation in the grain yield (t ha^{-1}) was due to the variation in the grain yield plant^{-1} and also due to genotypic impact. This result is in agreement with Anjorin (2013) and Lucchin et al. (2003) who reported significant variations in yield among the maize genotypes. Anjorin (2013) noted a maximum yield (6.03 t ha^{-1}) in Obatanpa variety while the lowest yield (4.52 t ha^{-1}). Lucchin et al. (2003) observed grain yield from 3.38 t ha^{-1} to 4.51t ha^{-1}.

Correlation Between Yield and Yield Contributing Characters

The correlation between grain yield and yield contributing characters were shown in Table 6. It was revealed that grain yield was significantly positively correlated with ear length (0.80), ear diameter (0.64), number of kernels row^{-1} (0.43), kernel length (0.66), kernel width (0.85), kernel thickness (0.68), thousand kernel weight (0.90), the weight of kernels ear^{-1} (0.93), prolificacy index (0.06) and weight of kernels plant^{-1} (1.00) indicating that grain yield would increase with the increase of these characters. The number of kernel rows ear^{-1} had a positive but non-significant correlation with grain yield (0.25).

Ear length had a significant positive correlation with ear diameter (0.78), number of kernels row^{-1} (0.70), kernel length (0.46), kernel width (0.85), kernel thickness (0.56), thousand kernel weight (0.68), the weight of kernels ear^{-1}(0.85) and weight of kernels plant^{-1}(0.80). Ear diameter had a significant positive correlation with number of kernels row^{-1} (0.48), kernel length (0.45), kernel width (0.66), thousand kernel weight (0.60), the weight of kernels ear^{-1} (0.73) and weight of kernels plant^{-1} (0.64). Number of kernels row^{-1} showed a significant positive correlation with the weight of kernels ear^{-1} (0.41) but that negative with the number of kernels row^{-1} (-0.25) and prolificacy index (-0.27). The number of kernels row^{-1} revealed a significant positive correlation with kernel width (0.45), the weight of kernels ear^{-1} (0.47) and weight of kernels plant^{-1} (0.43) but that of negative with kernel thickness (-0.02). Kernel length had a significant positive correlation with thousand kernel weight (0.75), the weight of kernels ear^{-1} (0.69) and the weight of kernels plant^{-1} (0.66). Kernel width had a significant positive correlation with kernel thickness (0.68), thousand kernel weight (0.79), the weight of kernels ear^{-1} (0.86) and weight of kernels plant^{-1} (0.85). Kernel thickness had a significant positive correlation with thousand kernel weight (0.80), the weight of kernels ear^{-1} (0.67) and weight of kernels plant^{-1} (0.68). Thousand kernel weight revealed a significant positive correlation with the weight of kernels ear^{-1} (0.93) and the weight of kernels plant^{-1} (0.90). Weight of kernels ear^{-1} and prolificacy index showed a significant positive correlation with the weight of kernels plant^{-1} (0.93 and 0.06, respectively).

CONCLUSION

From the findings of the present study, it can be concluded that a wide variability exists among the maize genotypes. BARI Maize 6, ZM 0005 and ZM 0004 performed better among the genotypes in respect of yield attributes leading to higher grain yield. The genotype ZM 0004 and ZM 0005 produced almost similar yields to that of the control genotype (BARI Maize 6). The exotic genotypes could be harvested 11 to 17 days earlier than the control genotype (BARI Maize 6) which will help to increase the cropping intensity. As ZM 0005, ZM 0007 and ZM 0004 are white in grain colour, the flour of these white grain maize genotypes can be mixed with wheat flour to make different food items that will supplement better nutrition to the human diet.

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CONFLICT OF RESEARCH INTEREST

The authors declare that they have no competing interests.

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