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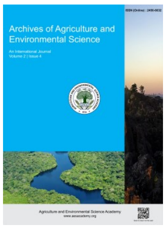

ORIGINAL RESEARCH ARTICLE

Effect of genotype on proximate composition and biological yield of maize (*Zea mays* L.)

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ABSTRACT

An experiment was conducted to study the proximate composition of five released maize varieties (*Zea mays* L.) of Bangladesh Agricultural Research Institute (BARI), which was popularly growing in Bangladesh namely BHM-5, BHM-8, BHM-13, BHM-15, and Barnali. There was none a single variety performed best in all nutrient parameters. Among these maize varieties, the highest grain weight of 100 seeds, and yield was found in BHM-15 (32.84g and 12.6 ton/ha). In the case of proximate analysis, the highest protein, ash, and fat content was recorded from BHM-15 (13.11%, 2.33%, and 5.44%), the highest carbohydrate content was recorded from BHM-13 (82.40%), and the highest amount of fiber was recorded from BHM-5 (2.07%). On the other hand, the lowest amount of carbohydrate and protein was recorded from BHM-15 (77.67%) and BHM-8 (10.96%), respectively. BHM-13 contained the lowest amount of fiber (1.24%) and fat (4.27%). Barnali and BHM-15 showed better performance for most of the minerals. The findings concluded that the different genotypes of maize differ substantially in their chemical and mineral compositions.

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INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice. Maize literally means that which "sustains life". Pieces of evidence from Botany, Genetics and Cytology have pointed towards a common origin for every existing type of maize (2n = 20). Maize belongs to Family Poaceae and Genus *Zea*. Maize is a highly cross-pollinated species. It was also one of the first plant species identified to photosynthesize by C4 pathway with high yield potential. The suitability of maize to diverse environments is unmatched by any other crop as the expansion of maize to new areas and environment still continues, as it has a range of plasticity. By origin, it is a tropical crop and has adapted magnificently to temperate environments with much higher productivity. It is grown from latitude 580 N to 400 S, from sea level to higher than 3000 m altitude and in areas receiving yearly rainfall of 250 to 5000 mm (Dowswell *et al.*, 1996; Premlatha and Kalamani, 2010). The United States of America has the largest cultivated area of corn. Major maize producers are the USA (30%), China (15%), European Union (14%), Brazil (4%) and India (3%). These five countries have around 60% of the world's corn harvested area (Annonymous, 2007; Tao Ye *et al.*, 2015).

Maize is used as a basic food ingredient, either in its original or modified form. Maize grains are a rich source of starch (72%), ash (17%), protein (10.4%), fiber (2.5%), oil (4.8%), vitamins and minerals (Farhad *et al*., 2009; Zhiqiang *et al*., 2018). The oil and protein contents have commercial value and are used in food products manufacturing (Paliwal, 2000). Maize is used primarily as a food for humans in most areas of the world, in contrast to the United States where about 85 percent of the crop is used as cattle feed. Maize is used for livestock feeds in a variety of ways. It may be used for grain, silage, hogging down, grazing and forage. Most of the crop in the United States is used for grain. About 40 percent is fed to hogs, followed by cattle (29%) and poultry (19%). The mixed feed manufacturing industry is the largest industrial user of shelled grain. Byproducts of processing are gluten feed, gluten meal, oil cake meal, germ meal, distiller's and brewer's grains. About three-fourths of the mixed feed industries output is manufactured poultry and dairy feed. American industries are greatly interested in the starch part of the kernel.

In general, it has a great worldwide significance as human food, animal feed and a source of a large number of industrial products. It has the highest potential of per day carbohydrate productivity. Thus, the father of the green revolution, the renowned Noble Laureate, Dr. Norman E. Borlaug, stated that "After the last two decades saw the revolution in rice and wheat, the next few decades will be known as maize era". A number of genotypes e.g. single crosses, double crosses, three-way crosses, vertical hybrids, multiple hybrids composites, synthetics, pools, populations etc. are feasible to maize growing farmers for commercial cultivation by virtue of the crop being highly cross-pollinated (Tao Ye *et al*., 2015; Zhiqiang *et al*., 2018). Though maize is an important crop occupies a huge area in Bangladesh chemical characteristics contributing to yield are not clearly understood. Keeping in view of the above facts the present investigations were undertaken to evaluate the physical and chemical composition of different varieties of maize, to compare the physico-chemical parameters and nutrition quality of different varieties of maize and to identify nutritionally potential maize varieties for the welfare of human being.

MATERIALS AND METHODS

The experiment was conducted at the Laboratory of Department of Biochemistry, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh; and, oilseed research center and soil science division, BARI, Gazipur, Bangladesh. Five released variety of maize namely Barnali (Evolved by the BARI in 2005 and grain is small in size and yellow in color), BHM-5 (Evolved by the BARI in 2005 and grain is big in size and yellow in color), BHM-8 (Evolved by the BARI in 2005 and grain is big in size and yellow in color), BHM-13 (Evolved by the BARI in 2005 and grain is big in size and white in color), BHM-15 (Evolved by the BARI in 2005 and grain is big in size and yellow in color) were selected for the study. The seeds were collected from Bangladesh Agriculture Research Institute (BARI). Seeds were cleaned, sun-dried and stored into a plastic container in a cool place until used for the chemical analysis (Figure 1).

Figure 1. *Photograph showing variations in seed coat color, seed size and shape of maize varieties (Z. mays).*

Determination of 100 grain seed weight

The mass was determined by randomly selecting 25 seed samples and weighing in an electronic balance of 0.001 g sensitivity. The weight was then converted into 100 seed mass.

Determination of moisture

The moisture content of maize sample was determined by the method of (Ezeagu *et al*., 2011). The drying, cooling, and weighing were continued repeatedly until a constant weight was obtained by the difference. The weight of the moisture loss was determined and expressed in percentage. The procedure was repeated for samples. It was calculated as shown below:

$$\text{Moisture (\%)} = \frac{(\text{W2} - \text{W1})}{(\text{W2} - \text{W3})} \times 100$$

Determination of ash

The sample is ignited at 600°C to burn off organic material. The inorganic material which does not volatilize at that temperature is called ash. The procedure was described by Ranganna (1986). It was calculated as shown below:

$$\text{Ash (\%)} = \frac{\text{Weight of the ash}}{\text{Weight of the sample taken}} \times 100$$

Chemical analysis

Estimation of fats

The fat content of the samples was determined by the continuous solvent extraction using a Soxhlet apparatus by the methods of Hughes (1969) which contains usual lipids including waxed pigments, certain gums, and resins. A better name for these constituents would be "ether soluble extract". It was calculated as shown below:

$$\text{Crude fat (on a dry weight) (\%)} = \frac{\text{Wt. of thimble \& sample before extraction} - \text{Wt. of thimble \& sample after extraction}}{\text{Weight of sample before extraction}} \times 100$$

Estimation of total protein content by Micro Kjeldhal method

The protein content of foodstuff is obtained by estimating the nitrogen content of the material and multiplying the nitrogen value by 6.25 (according to the fact that nitrogen constitutes on average 16% of a protein molecule). This is referred to as crude protein content since the non-protein nitrogen (NPN) present in the material is not taken into consideration. The estimation of nitrogen is done by the Kjeldahl method (AOAC, 1984).

$$\mathrm{N}\ (\%) = \frac{(14.007) \times (\text{normality of the acid}, 0.02) \times (\mathrm{TV})}{\text{Weight of sample (mg)}} \times 100$$

Where 14.007 is the equivalent weight of nitrogen

Nitrogen % is converted into protein by multiplying with a factor 6.25 for cereals and pulses.

Estimation of carbohydrate

Total carbohydrate estimated by the methods of Raghuramulu *et al.* (2003). The content of the available carbohydrate was determined by the following equation:

Carbohydrate = 100 − {(Moisture+ Fat protein +Ash+ Oil/Fats) g/100g}

Estimation of minerals

Digestion solution

Concentrated Perchloric acid (100ml) was added to 500 ml concentrated HNO_3 to prepare the nitric-perchloric solution.

Digestion of maize seed sample for determination of Ca, Mg, P, S, Zn, Fe, Cu, Mn, Fe and B

Analytical procedure

Nitric-perchloric solution (1:5) is used for digestion of samples than by using a combination dilute-dispenser, 1 ml aliquot was taken from the filtrate and 19 ml water (dilution 1) was added. The other dilutions were made in the following order. For sulpher (S) determination, 7 ml of the aliquot from dilution 1, 9 ml of acid seed solution and 4 ml of turbidimetric solution were mixed together thoroughly. It was allowed to stand 20 minutes and not longer than 1 hour. The reading was taken in turbid meter or in colorimeter at 535 nm using a cuvette with 2 cm light path. For phosphorous (P), and potassium (K) determination, 1 ml aliquot from dilution 1, 9 ml of water and 10 ml of color reagent were mixed together. It was allowed to stand about 20 minutes and reading was taken of the spectrophotometer at 680 nm. For calcium (Ca) and magnesium (Mg) determination, 1 ml aliquot from dilution 1, 9 ml of water and 10 ml of 1% lanthanum solution were mixed together. It was analyzed by AA procedure. For Iron (Fe) and Zinc (Zn) determination, the original filtrate was used to analyze these elements by the AA procedure.

Statistical analysis

The recorded data for each character from the experiments were analyzed statistically to find out the variation resulting from experimental treatments using R software. The mean for all the treatments was calculated and analysis of variance of characters under the study was performed by F variance test. The mean differences were evaluated by Least Significance test.

RESULTS AND DISCUSSION

Biological yields

The highest weight of 100-grain weight was found in BHM-15 (32.84g) where the lowest weight was found in BHM-13 (26.40g). According to Jha *et al.* (1979), variation ranged from 10.8 to 25.7 g in 100 grain weight which might as much as similar. Duncan and Hesketh (1968) observed the variation in plant height of different genotypes in maize ranging from 120 cm to 300 cm where highest plant height in BHM-5 (153.98 cm) and lowest in BHM-13 (146.47 cm). However, Yield of BHM-15 (12.6 ton/ha) showed the highest value where the lowest value was found in Barnali (4.8 ton /ha) which one as similar as reported by Paramasivan *et al.* (2011) presented in Table 1. Seed deterioration increased when the moisture content is increased. Maize seeds contain above 18% moisture which may accelerate insect infestation and diseases. The maximum moisture was measured in BHM-5 (13.84%) and the minimum was recorded in BHM-13 (10.22%) which is almost similar to Gopalan *et al.* (1985). On the other hand, Ash reported by Cortéz and Wild-Altamirano (1972) and Bressani *et al.* (1958) was more or less similar with BHM-15 (2.33%) which was the highest value and lowest amount of ash content (1.24%) showed by BHM-5 followed by BHM-13, Bornali, and BHM-8 (1.67%,1.68%,1.70%). However, BHM-13 contains significantly the highest amount of dry matter (89.78%) and the lowest amount of dry matter content (86.16%) was recorded in BHM-5.

Table 1. Weight of 100 seeds, plant height, yield, moisture, ash and dry matter of different maize (*Z. mays*).

Name of the varieties (Treatment)	100 seeds weight (g)	Plant height (cm)	Yield (ton/ha)	Moisture (%)	Ash (%)	Dry matter (%)
Bornali	27.36b	147.88c	4.8e	11.65c	1.68b	88.35c
BHM-5	27.30b	153.98a	9.4d	13.84a	1.24c	86.16e
BHM-8	27.32b	149.47b	10.6c	12.06b	1.70b	87.94d
BHM-13	26.40c	146.47d	11.1b	10.22e	1.67b	89.78a
BHM-15	32.84a	146.86d	12.6a	11.55d	2.33a	88.45b
$LSD_{(0.05)}$	0.021	0.138	0.087	0.059	0.055	0.059
CV(%)	13.56	18.32	2.45	0.26	1.66	0.04

Figure in a column followed by common letter do not differ significantly at 5% level by DMRT.

Proximate analysis

Carbohydrate

Generally, starch, reducing sugar and crude fiber are considered the main components of carbohydrate. Tomov and Min (1995) recorded that grain yield and 100-grain weight were negatively correlated with grain starch in maize lines and hybrids where BHM-13 gave significantly the highest amount of carbohydrate (82.40%) and BHM-15 contains significantly the lowest amount of carbohydrate (77.67%) presented in Table 2.

Protein

Protein content is genetically controlled. The amount of protein has been presented in Table 2. The results showed that among the different maize varieties BHM-15 contains significantly the highest amount of protein (13.11%) and BHM-5 contains significantly the lowest amount of protein (9.46%). Proteins reported by Krishnaveni (1983), Verma *et al.* (2003), Xiang-ling *et al.* (2011) were more or less similar with present value.

Fat

Crude fat is one of the most important components of maize grains; improvement in fat content is useful for good human health. In the present study, the highest total means fat content are present in BHM-15 (5.44%) and BHM-13 contains significantly the lowest amount of fat (4.027%) as similar to Xiang-ling (2011).

Crude fiber

The crude fiber content of different maize cultivars is varied from 1.24% to 2.07% presented in Table 2. The concentration of protein decreases and the fiber content increases as the plant matures (Vaswani *et al*., 2016). The significantly highest amount of crude fiber contents were found in BHM-5 (2.07%) which was followed by the varieties of BHM-8, Bornali, and BHM-15 (1.63%, 1.60%, and 1.45%). Significantly lowest amount of crude fiber content was found in BHM-13 (1.24%).

Minerals

The range of Calcium (%) reported in different maize varieties varied from 2.47 to 3.92%. The Phosphorus (%) of ranged from 0.30 to 0.39% which is presented in Table 3. However, Singh (1976) reported Ca and P content (%) of two maize varieties Ganga-5 (0.65, 0.14) and Vijay (0.47, 0.15), the difference observed might be due to different cultivars and environmental conditions. The concentration ranges of the micro-minerals Cu, Fe, Mn, and Zn were 10.71-13.95 ppm, 57.54-74.52 ppm, 34.65-45.89 ppm and 30.51-42.18 ppm respectively. Calcium, copper, zinc and iron were present in appreciable quantities in all the varieties of maize. The main factors affecting the mineral composition of forages are species, variety, stage of maturity, soil and environmental factors, morphological fraction and use of fertilizers etc. On the other hand, minerals content of Mg, K, S and B were ranged from 1.07-1.42%, 0.51-0.60%, 0.02-0.06% and 11 ppm- 30 ppm, respectively.

Azim *et al.* (1989) also observed the variation in Na, K, Ca and, P content of different fractions of the plant. Hussaini *et al.* (2008) showed that nitrogen fertilizer application up to 60kg/ha significantly increased the concentration of N, P, Ca and Mg in maize grain. Zhang *et al.* (2010) evaluated the effects of genotype and environment on mineral compositions of wheat grains grown in different locations, and found a large variation for all mineral elements. Peterson *et al.* (1983) also reported significant variation in mineral concentration by genotypes and concluded that the genotype effect was much larger than environment factors.

Table 2. Proximate analysis of protein, fat, crude fiber and carbohydrate of different released and advanced line of maize varieties (*Z. mays*).

Name of the varieties (Treatment)	Carbohydrate (%)	Protein (%)	Fat (%)	Crude fiber (%)
Bornali	80.05d	11.47b	5.20b	1.60c
BHM-5	82.08b	9.46e	5.14b	2.07a
BHM-8	80.64c	10.96c	5.07c	1.63b
BHM-13	82.40a	10.42d	4.27d	1.24e
BHM-15	77.67e	13.11a	5.44a	1.45d
$LSD_{(0.05)}$	0.087	0.029	0.069	0.021
CV(%)	0.06	0.13	0.72	0.77

Figure in a column followed by common letter do not differ significantly at 5% level by DMRT.

Table 3. Proximate analysis of several minerals of different maize varieties (*Z. mays*).

Name of the varieties (Treatment)	Ca (%)	Mg (%)	P (%)	K (%)	S (%)	B (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)
Bornali	2.47d	1.07d	0.39a	0.56b	0.02d	30.00a	10.71e	57.54e	34.65e	42.18a
BHM-5	3.19c	1.23bc	0.36b	0.51e	0.03c	19.00b	12.51c	67.44d	40.63d	40.40b
BHM-8	3.23c	1.28b	0.34c	0.54d	0.04b	16.00b	12.43d	72.34b	41.96c	32.63d
BHM-13	3.39b	1.21c	0.30e	0.55c	0.06a	11.00c	12.62b	70.33c	42.56b	34.14c
BHM-15	3.92a	1.42a	0.32d	0.60a	0.04b	17.33b	13.95a	74.52a	45.89a	30.51e
$LSD_{(0.05)}$	0.066	0.069	0.006	0.006	0.006	3.27	0.055	0.055	0.029	0.075
CV(%)	1.1	2.97	1.13	0.12	6.19	9.30	0.24	0.04	0.04	0.11

Figure in a column followed by common letter do not differ significantly at 5% level by DMRT.

Conclusion

From the above results, it was observed that none of the variety of maize performed the best by all nutrient parameters. BHM-13 could be considered better for carbohydrate. BHM-15 and BHM-5 performed well results in protein and fiber contents. In case of minerals, most of the varieties contained the higher amount of minerals than the reference rate due to change of fertilizer application rate and as well as soil properties of the different maize growing area. Different varieties *viz.*, Barnali and BHM-15 showed better performance for most of the minerals. Farmers are cultivating maize in their field for the consumption as feed, fodder as well as public consumption. Based on the information mentioned above, it may be concluded that Barnali, BHM-5, BHM-13, and BHM-15 can be grown in large scale as they contained the highest amount of different nutrient contents. These results will be useful to know about the nutritional properties of the local maize varieties and may guide us in designing strategies that maximize the utility of maize germplasm.

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