EVALUATION OF GENETICAL PURITY, GROWTH AND YIELD PERFORMANCE OF MAIZE (*Zea mays*)

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CERTIFICATE

*This is to certify that thesis entitled, "**EVALUATION OF GENETICAL PURITY, GROWTH AND YIELD PERFORMANCE OF MAIZE (Zea mays)**" submitted to the Faculty of Agriculture, Sher-e-BanglaAgricultural University, Dhaka, in partial fulfillment of the requirements for the degreeof **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **SK. MD. SAMIUZZAMAN**, Registration no. **18-09115** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of duringthe course of this investigation has duly been acknowledged.

Date:
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DEDICATED TO MY BELOVED PARENTS

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ABSTRACT

An experiment was conducted during the period from November 2019 to April 2020 in the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to evaluate the genetic purity, growth and yield performance of maize (*Zea mays*). The experiment comprised of single factor with 10 maize genotypes. Among the maize genotypes, there were five (5) maize varieties and five (5) maize lines. The varieties were namely SAU hybrid 1, SAU hybrid 2, ARIZE, ARIZE SUPER and Kaveri 50. The advance lines were namely SAU Test Cross 1, SAU Test Cross 2, SAU Test Cross 3, SAU Test Cross 4 and SAU Test Cross 5. The experiment was laid out in Randomized Complete Block design (RCBD) with three replications. Different hybrids maize varieties and maize lines showed significant effect on growth, yield and yield contributing characters except cob circumference. SAU hybrid 1 took the maximum days (6.00 days) for 80% germination whereas, the minimum days (3.00 days) was taken by SAU Test Cross 2. SAU Test Cross 5 took the highest days (102.67 days) for 80% flowering and the minimum days (92.00 days) was taken by SAU Test Cross 2. SAU Test Cross 5 took the maximum days (104.67 days) for 80% cob formation whereas, the minimum days (95.00 days) was taken by SAU Test Cross 2. SAU Test Cross 1 showed the tallest plant (249.90, 255.50 and 255.70 cm at 110, 125 and 140 DAS, respectively). SAU hybrid 1 showed the highest cob height from surface (133.03 cm). SAU hybrid 1 showed the highest genetic purity (100.00%); whereas SAU Test Cross 2 showed the lowest genetic purity (97.22%). SAU Test Cross 1 showed the maximum cob weight (208.83 g), husk weight (26.39 g), full cob weight (235.22 g), cob length (23.97 cm) and rachis weight (30.11 g), stover yield (13.00 t ha^{-1}) and biological yield (25.92 t ha^{-1}). The highest shelling (78.53%) was recorded from Kaveri 50 variety. SAU hybrid 2 maize variety showed the maximum no. of rows cob^{-1} (18.00), 100 grains weight (28.44 g) and grain yield (13.18 t ha^{-1}) whereas, SAU Test Cross 2 maize line showed the maximum harvest index (51.40%).From the study it was found thatSAU hybrid 1 and SAU hybrid 2 was genetically the most pure variety.In case of yieldmaize variety SAU hybrid 2 performed better than most of the other varieties, which was followed by maize line SAU Test Cross 1.

LIST OF CONTENTS

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

LIST OF ABBREVIATIONS

AEZ	Agro-Ecological Zone
BBS	Bangladesh Bureau of Statistics
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAS	Days After Sowing
eds.	Editors
et al.	et alia (and others)
etc.	et cetera (and other similar things)
FAO	Food and Agricultural Organization
L.	Linnaeus
LSD	Least Significant Difference
i.e.	id est (that is)
MoP	Muriate of Potash
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TDM	Total Dry Matter
TSP	Triple Super Phosphate
UNDP	United Nations Development Programme
var.	Variety
viz.	Namely

CHAPTER I
INTRODUCTION

Maize (*Zea mays* L.) has been originated from teosinte (*Zea mays* L. spp Mexicana) in the Western Hemisphere about 7,000 to 10,000 years ago. It constitutes as one of the most important cereal crop in the world after wheat and rice. Maize is the member of *Poaceae* family. The term *"Zea"* (zela) was derived from an old Greek name for a food grass. It is mostly photo-insensitive, cross-pollinated cereal crops. The Mesoamerican region is known as the center of origin for *Zea mays* (Matsuoka *et al.*, 2002). Maize is a versatile crop grown from 58° N to 40° S from below sea level to altitudes higher than 3000 m and in areas with (250–5000) mm of rainfall per year (Shaw, 1988; Dowswell *et al.*, 1996).

Wheat, rice and maize are the most important cereal crops in the world but maize is the most popular due to its high yielding, easy of processing, readily digested and costs less than other cereals (Jaliya *et al*., 2008). Maize as a major source of carbohydrate is used as human food in different forms, in the textile industry and in the pharmaceutical industry. It is composed of approximately 76–88% of carbohydrate, 6–16% of protein, 4–5.7% fat and 1.3% of minerals. It is more balanced nutritionally, agriculturally small quantity grains are currently used for livestock as well as poultry feed, and this is expected to increase with the development of the livestock and poultry production enterprise in the country.

In Bangladesh, the cultivation of maize was started in the late 19th century but the cultivation has started to gain the momentum as requirement of maize grain is being increased as poultry industry flourishes in Bangladesh. Maize has the highest potential for carbohydrate production per unit area per day. Stem and foliage of maize plant can be used as livestock feed. Stalk, dry leave coveringof cobs (husks) and shelled cobs can be used as fuel (Ahmad *et al.,* 2011). It can be grown all the year round in Bangladesh, and fitted in the gap between the

main cropping seasons without affecting the major crops. It can also be grown in flood prone areas under no tillage, and with no inputs (Efferson, 1982). Maize is being cultivated all over the world but the yield of maize is low in Bangladesh as compared to the other maize growing countries. Today, the variability of the agricultural crops has been massively lost because of the commercial varieties use. For example, only about 5% of maize germplasm is used for commercial purposes (Hoisington *et al.,* 1999). Preservation of the genetic resources in the country is associated with rigorous characterization and evaluation of the genetic diversity (Salillari *et al.,* 2007). However, due to the continuous regeneration and the limited number of the individuals for accessions as well as genetic erosion, the collection is damaged (Fetahu *et al.,* 2005). The plant genetic resources are considered as the main source for the conservation of the biological diversity and long-term sustainability of human life. Identification of the genetic variability by means of the morphological indicators also helps for the determination of the duplicate accessions.

In Bangladesh Maize production have an increasing tendency with the introduction of hybrid since 1993. Area, production, and yield of maize have increased by 17%, 33% and 16%, respectively, which reflects the effect of adopting improved technology. Comparing to the production level in Bangladesh maize ranks 3rd in acreage. It accounts for 4.8% of the total cropped land area and 3.5% of the value of agricultural output (Ahmad *et al.,* 2011). In Bangladesh maize cultivated in about 152 thousand hectares of land and total annual production is 887 thousand Metric tons with an average yield of 5.83 tha^{-1} (BBS, 2014). Introduction of quality protein maize (QPM) in Bangladesh is a long aspiration to feed the million malnourished populations. Thus, maize should get priority considering the protein malnutrition of the people because it contains more digestible protein than the other cereals (Ahamed, 2010).

Maize is suitable for rice-maize cropping system and has been expanded rapidly in the northern districts of Bangladesh (Timsina *et al*., 2010) mainly in

response to increasing demand for poultry food (Ali *et al*., 2010). Currently maize is planted to about 307,000 ha producing 2.12 million tons of grains annually (BBS, 2016). In the Chittagong Hill Tracts (CHT), maize is grown since long as a secondary staple crop for the ethnic communities contributing to 2.1% of national production. With the advancement in breeding and biotechnology high yielding modern varieties and hybrids of maize are developed. In addition, improvement in agronomic management practices also contributes greatly to increasing grain yields (Lee and Tollenaar, 2007). The yield performance differs remarkably across hybrids depending on environmental conditions, agronomic management and choice of varieties. The growth and yield attributes of maize differs among and between local and hybrid maize varieties (Macharia *et al*., 2010 & Ullah *et al*., 2017).

Now a day, there are many government (BARI, BADC, DAE etc.) and non-government organizations (BRAC, Syngenta, private seed producing farms, importers etc.) arc working for increasing maize production in Bangladesh. The demand of hybrid maize varieties is increasing among the farmers due to their high yielding potentialities. Besides, Bangladesh Agricultural Research Institute (BARI) has released sixteen promising hybrid maize varieties. Varieties differ in their pattern of nutrient uptake, dry matter accumulation and yield potential (Kenny, 2005). Hybrid maize cultivation area has increased at the rate of about 20–25% per year since nineties. In Bangladesh, higher yield up to 8–10 t ha^{-1} can he obtained using hybrid seeds, balanced fertilizers and better management practices (Quayyum and Haque, 1995 and Iqbal, 2001). The average yield of maize in the country is rather low compared with leading maize growing countries of the world. In Bangladesh area, production and yield of maize decreased by 2.9%. 3.59% and 0.69% respectively from the year of 1967–68 due to utilization of traditional variety (Mohiuddin, 2003). Introduction of hybrid varieties and appropriate management practices increased area, production and yield by 19.83%, 34.40% and 14.56% respectively from the year 1987–88 to 2003–04 (Moniruzzaman *et al.*, 2007).

Maize currently grown in Bangladesh is of yellow type and is used in the feed industry. Worldwide, the maize grown for human consumption is called white maize, which differs lacking anthocyanin compared to yellow maize. The flour of white maize is tastier than yellow maize. It is also superior to yellow maize in some nutrition especially protein content. It covers only 12% of the total acreage of the world, which is mostly used as human food (FAO-CIMMYT, 1997). During 1970s, the productivity of grown white maize was lower compared to those of yellow ones. With the advanced breeding approaches, worldwide, recent reports demonstrate that the yield productivity of white maize is almost at par with those of the yellow ones (Akbar *et al.*, 2016). Since its inception, the maize species grown in Bangladesh were yellow type except one variety named 'Suvra'. At present the yellow exotic hybrid maize is grown as a fodder crop which although mainly concentrate in the northern districts of Bangladesh (Ullah *et al.*, 2016). In comparison to the landraces, the modern improved varieties are higher yielders showing even 60% more seed yield (Kossou *et al*., 1993). The hybrid varieties show an average yield of 6.90 t ha^{-1} (BBS, 2016).

Therefore, it is important to know the impact of different high yielding and hybrid maize varieties and to determine their adaptability in prevailing environments of Bangladesh. We, therefore, having the above scheme and discussion in mind, the study was conducted to evaluate the genetical purity among different maize genotypes in Bangladesh to fulfil the following objectives:

1. To compare the genetical purity, growth, yield and yield attributes of different maize genotypes under study, and
2. To select suitable variety to meet the demand of maize in Bangladesh.

CHAPTER II

REVIEW OF LITERATURE

The growth and development of maize are influenced due to varietal performance of different maize cultivars and management practices. It may also be influenced by inbred and hybrid varieties. Experimental results are available from home and abroad to reveal that maize cultivars with high yield potential may influence growth and yield to a great extent. Relevant reviews on the above aspects have been presented and discussed in this chapter.

2.1 Review on morphological attributes of maize variety

2.1.1 Plant height

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after 40 DAS. PSC-121 showed the superior performance in terms of plant height over YANGNUO-3000.

Mannan (2018) conducted an experiment at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to examine the varietal performances of white maize as influenced by different level of herbicides. The experiment comprised of two white maize varieties (PSC-121 and Yangnuo-3000) and six levels of weed control treatments, *viz.*, T_0 = No weeding, T_1 = Carfentrazone + Isoproturon 500g @ 1.5 g/ha (Affinity 50.75% WP), T_2 = Carfentrazone + Isoproturon 500g @ 2.0 g/ha (Affinity 50.75% WP), T_3 = Pendimethalin @ 2.0 l/ha (Panida 50EC), T_4 =

Pendimethalin @ 3.0 l/ha (Panida 50EC) and T_5 = One Hand Weeding at 45 DAS. In the experiment, PSC-121 showed the superior performance in terms of plant height over YANGNUO-3000.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised of 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and 5 plants spacing *viz.*, 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The highest plant height was observed from BARI hybrid maize-7. On the other hand, the shortest plant was recorded from Khoi bhutta.

Ullah *et al.* (2017) while conducting an experiment to compare modern varieties of white maize with landraces in Bangladesh observed that the plant height of the modern white maize varieties varied significantly giving a wide range of 167 to 222 cm. Among the varieties, the Suvra showed the highest value while the Plough-201given the lowest plant height value. The Plough-202 gave identical result to that of the Plough-201 but a higher value as compared to that of the Plough-201 (172 cm) which was significantly lower than that of the white maize variety Suvra.

Akbar *et al.* (2016) explored that the plant height ranged between 243 and 279 cm across treatments with an average of 263 cm. Generally, plant height increased with increasing rate of fertilizer application and plants of hybrid PSC-121 were taller than KS-510.

Khan *et al.* (2016) carried out an experiment considering three hybrid maize varieties, e.g., P-3025, P-32T78 and P-3203. From the experiment, he noted that among three hybrid maize varieties, plant height (247.188 cm) was maximum in maize hybrid P-3025, while the minimum plant height (202.00) was recorded in P-32T78.

Ullah *et al.* (2016) reported that YANGNUO-7 showed the highest plant height (35.83 cm) at 30 DAS over the other three varieties (Changnuo-1: 26.52 cm, Changnuo-6: 34.27 cm and Q-Xiannuo-1: 22.17 cm) when conducted an experiment to evaluate the performance seedling transplantation of four white maize hybrids.

Ishaq *et al.* (2015) conducted an experiment to find out genetic potential, variability and heritability of various morphological and yield traits among maize synthetics and showed highly significant differences ($P \leq 0.01$) for all the agronomic and genetic traits. Among the tested populations, Jalal-2003 proved to be superior for most of the traits studied. The highest values for plant height (169.10 cm) was recorded from Jalal-2003.

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (5 levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (2 levels); V_1: KS-510 and V_2: PSC-121. Among the varieties, KS-510 (V_1) showed the tallest plant (175.93 cm) and PSC-121 (V_2) showed the shortest plant (172.56 cm).

Asaduzzaman *et al.* (2014) carried out an experiment with four baby corn varieties *viz*. Hybrid baby corn-271, Shuvra, Khoibhutta and BARI sweet corn-1 at five N fertilizer rates viz. 0 kg N ha^{-1} (N_0), 80 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2), 160 kg N ha^{-1} (N_3) and 200 kg N ha^{-1} (N_4) in the experiment to find out the suitable variety and N fertilizer rate for baby corn production. They reported that, Shuvra produced the tallest plant (179.10 cm) and BARI sweet corn-1 produced the shortest plant (149.30 cm).

Malik *et al.* (2011) evaluated ten maize hybrids at Agriculture Research Institute, Tarnab Farm, Peshawar with the aim to estimate variation among maize hybrids during spring season 2010. The analysis of variance showed highly significant differences among the maize hybrids for plant height.

Mukhtar *et al.* (2011) studied response of maize crop to various NP levels at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during kharif 2009. Six NP rates (0 - 0, 200-100, 250-125, 300-150, 350-175 and 400-200 kg ha^{-1}) were tried on two maize hybrids (YH-1898 and YH-1921) for growth and yield. They reported that, both hybrid varieties, YH-1921 and YH-1898 showed non-significant result (220.56 cm and 213.00 cm, respectively) for plant height.

Ahmed *et al.* (2010) narrated that among three varieties (DK-919, DK-5219 and Pioneer-30Y87); late maturing maize hybrid Pioneer-30Y87 exhibited maximum plant height among the three varieties.

Asghar *et al.* (2010) conducted a study to investigate the effect of different NPK rates on growth and yield of maize cultivars: Golden and Sultan. The varieties V_1 (Golden) (175.30 cm) and V_2 (Sultan) (174.93 cm) did not differ significantly for plant height of maize.

Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at the National Agricultural Research Centre, Islamabad during kharif 2007. Significant differences were observed for plant height. The variety Soan-3 (149 cm) was the shortest and hybrid 30-K-95 (202.3 cm) was the tallest amongst all the varieties and hybrids.

Nizarmuddin *et al.* (2010) conducted the experiment about yield and yield components of five synthetic maize cultivars (EV-3001, Jalal, Kisan, Azam and Pahari) at Chilas Agriculture Farm, district Diamer, Northern Areas, Pakistan during 2005. Cultivars differed significantly for all parameters. Cultivars Jalal, EV-3001 and Kisan produced the tallest plants (278.6. 270.5 and 265.7 cm,

respectively) whereas, check variety Pahari produced the shortest plants (168.8 cm).

Msarmo and Mhango (2005) conducted an experiment at Bunda College during the 2003/04 crop season to assess the effect of fertilizer application practices on performance of maize with emphasis on improving the efficiency of using urea as a top dressing fertilizer. There were three maize varieties and three fertilizer application practices. The maize varieties included local maize, Masika (composite) and DK8031 (hybrid). The result of the study revealed that, local maize had the highest plant height of (245.3 cm) as compared to Masika and DK8031 which had (165.4 cm) and (175.1 cm), respectively.

Ali *et al.* (1999) carried out an experiment taking BARI released five varieties (Amper pop, Sadaf, Suvra, Savar-2 and Barnali) and reported that Suvra showed the medium plant height between the highest (163.1 cm by Savar-2) and the lowest (153.5 cm by Sadaf) plant height at 90 days.

2.1.2 Germination, flowering and cob formation

Malik *et al.* (2011) evaluated ten maize hybrids at Agriculture Research Institute, Tarnab Farm, Peshawar with the aim to estimate variation among maize hybrids during spring season 2010. The analysis of variance showed highly significant differences among the maize hybrids for days to 50% pollen shedding and days to 50% silking.

Arellano Vazquez (2010) evaluated 42 Cacahuacintle maize landraces and the hybrids 'H-33', 'H-44' and 'H-137', in experiments established under rainfed conditions in Calimaya and Metepec, both in Toluca Valley, State of Mexico. Among landraces there were differences (P<=0.01) for days to silking and lodging percent. Days to silking ranged from 99 to 106 d after sowing, and lodging from 12 to 24%. These landraces were classified as late season varieties, with moderate to high lodging.

Li Rong Dan *et al.* (2010) set up an experiment in order to screen new corn varieties with good quality, high yield, strong resistance to diseases and suitable harvesting time and to find out their suitability for planting in Changming Town of Daxin County. Ten new corn varieties were tested in a field experiment in 2009. The 118–123 days growth duration of varieties Taipingyang 98, Zhengda 629, Hongdan 4, Guidan 30 and Hongdan 3 indicated their suitability for planting in Changming town.

Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at the National Agricultural Research Centre, Islamabad during kharif 2007. Significant differences were observed for days to 50% tasselling and silking. Days to 50% tasselling ranged from 47.33 (EV-1098) to 64 (NT-6632) while for silking varied from 47.67 (EV-1098) to 63.33 (30-K-95).

Islam and Mian (2004) showed the results of comparative performance of ten maize hybrids (CTS-991058, CTS-991060, CTS-991062. CTS-993044, CTS-993046, CTS-9930501, Pacific-1, 1434, 3435 and 6734) during Rabi season of 2000–2001. The analysis of variance for days to 6-leaf stage, days to 12-leaf stage, days to bud initiation and days to tassel emergence revealed significant variation among the hybrids. CTS-991062 required minimum days to complete vegetative growth.

2.1.3 Dry matter weight plant^{-1}

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (five levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (two levels); V_1: KS-510

and V_2: PSC-121. At harvest, KS-510 showed the highest dry matter weight plant^{-1} (289.8 g) and PSC-121 showed the lowest dry matter weight plant^{-1} (288.2 g). Variety did not differ in dry matter production.

Asaduzzaman *et al.* (2014) carried out an experiment where four baby corn varieties *viz*. Hybrid baby corn-271, Shuvra, Khoibhutta and BARI sweet corn-1 were planted at five N fertilizer rates *viz.* 0 kg N ha^{-1} (N_0), 80 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2), 160 kg N ha^{-1} (N_3) and 200 kg N ha^{-1} (N_4) to find out the suitable variety and N fertilizer rate for baby corn production. They reported that, Hybrid baby corn-271 produced the highest dry matter plant^{-1} (172.15 g) whereas the Khoibhutta had the lowest dry matter accumulation plant^{-1} (112.56 g).

Athar *et al.* (2012) conducted a pot experiment in a wire netting green house at Bahauddin Zakariya University, Multan, Pakistan in order to assess the beneficial effect of urea on corn cultivars (C-20 and C-79) differing in yield production. Two weeks old plants were subjected to different levels of urea (46% N). Five levels of urea (0, 50, 100, 175 and 225 kg ha^{-1}) with constant (150 kg ha^{-1}), TSP (46% P_2O_5**)** and SOP (50% K_2O) were applied in two steps: half dose at the seedling stage and the remaining half was supplied at vegetative stage (6 weeks) at constant (100 kg ha^{-1}) sulfate of potash (SOP) and triple super phosphate (TSP). They reported that, maximum dry matter accumulation plant^{-1} (100.41 g) was recorded from C-79 and the lowest dry matter accumulation plant^{-1} (60.28 g) was observed from C-20 variety.

Aliu *et al.* (2010) carried out an experiment to investigate some physiological traits and yield of different maize hybrids in growth conditions of Kosovo. The field experiment was conducted in 2006 and 2007 in Kosovo, near Prishtina. Seven commercial maize hybrids belonging to different FAO groups (FAO 300, 400 and 600), originating from two breeding institutions: MaizeDept. of Bc Institute Rugvica - Croatia (Jumbo 48 [H-I], BC418 [H-2], BC408 [H-3], BC288 [H-4], BC394 [H-5]) and from Pioneer Hi-Bred Int. (Austria) (Pregia

[H-6] and Colombo [H-7]) were included. For traits biological dry matter (BDM), higher values were obtained in the 2nd year in comparison to the 1st year. The highest values for all traits, was expressed by the H-6and these values were significantly higher than those of all other hybrids, but not for biological dry matter (BDM).

Santos *et al.* (2010) conducted an experiment to evaluate the dry and fresh matter yield, height of cob insertion, number of cobs per plant, plant height and the cob stem^{-1} leaf^{-1} ratio of six maize varieties recommended for the Brazilian semi-arid region (BR 5033 - Asa Branca, BR 5028 - Sao Francisco, BRS 4103, BRS Caatingueiro, BRS Assum Preto and Gurutuba) aiming at silage production. The varieties Gurutuba, BRS 4103 and BR 5028 - Sao Francisco showed the highest dry matter yield (16.0, 16.5 and 15.8 t ha^{-1}, respectively).

2.2Review on yield contributing attributes of maize variety

2.2.1 Grain rows per cob

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after 40 DAS. PSC-121 showed the superior performance in terms of number of grain row cob^{-1} (13.56) over YANGNUO-3000.

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (5 levels); F_1 = Recommended dose (100%); F_2 = Below 25% of

recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (2 levels); V_1: KS-510 and V_2: PSC-121. Both the varieties, KS-510 (V_1) and PSC-121 (V_2) showed the similar no. of grain rows cob^{-1} (14.11).

Ishaq *et al.* (2015) conducted an experiment to find out genetic potential, variability and heritability of various morphological and yield traits among maize synthetics and showed highly significant differences ($P \leq 0.01$) for all the agronomic and genetic traits. Among the tested populations, Jalal-2003 proved to be superior for most of the traits studied. The highest values for grain rows per cob (13.67) was recorded for Jalal-2003.

Bhuiyan (2012) carried out a research work at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 from December 2010 to May 2011 to determine optimum water requirement for the cultivation of hybrid maize varieties. There were two factors in this experiment, a) four hybrid maize varieties: V_1 (BARI Hybrid Maize-5). V_2 (Pacific 60), V_3 (NK 40) and V_4 (Ajanta) and b) three levels of irrigation: I_1 = Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25. 50 and 75 DAS and I_3 = Four irrigations at 25, 50, 75and 100 DAS, respectively. Grain row per cob varied significantly among the varieties. BARI Hybrid Maize-5 performed better among the four varieties tested in this experiment.

Asghar *et al.* (2010) conducted a study to investigate the effect of different NPK rates on growth and yield of maize cultivars, Golden and Sultan. The varieties V_1 (Golden) (14.70) and V_2 (Sultan) (14.38) did not differ significantly for number of grain rows cob^{-1}.

Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at the National Agricultural Research Centre, Islamabad during kharif 2007. Significant differences were observed for number of grain rows per cob.

Number of grain rows per cob varied from 12 (NT-6622, 30-K95, 2512 and 2514) to 18 (R-2207).

Islam and Mian (2004) showed the results of comparative performance of ten maize hybrids (CTS-99 1058, CTS-991060, CTS-991062. CTS-993044, CTS-993046, CTS-9930501, Pacific-11, 1434, 3435 and 6734) during Rabi season of 2000–2001. The analysis of variance for grain rows per cob revealed significant variation among the hybrids. Hybrid 6734 produced the highest number of grain rows per cob.

Evans (1975) reported that number of grain-rows per cob is variable within and among the varieties of maize.

2.2.2 Grains cob^{-1}

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after 40 DAS. PSC-121 showed the superior performance in terms of number of grains cob^{-1} (468.75) over YANGNUO-3000.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised of 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and 5 plants spacing *viz.*, 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The highest number of grain cob^{-1} was observed in BARI hybrid maize 7. On the other hand, the lowest number of grains cob^{-1} was observed in Khoi bhutta.

Mannan (2018) conducted an experiment at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to examine the varietal performances of white maize as influenced by different level of herbicides. The experiment comprised of two white maize varieties (PSC-121 and Yangnuo-3000). In the experiment, PSC-121 showed the superior performance in terms of grains cob^{-1} (412.0) over YANGNUO-3000.

Ullah *et al*. (2016) carried out an experiment for evaluating yield and yield performance of transplanted white maize varieties under varying planting geometry. Out of four varieties, Changnuo-6 gave the highest number of grains per cob (419), while the lowest number of grains was obtained from Yangnuo-7 (276).

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (5 levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (2 levels); V_1: KS-510 and V_2: PSC-121. Among the varieties, KS-510 (V_1) showed the minimum no. of grain cob^{-1} (450.13), whereas PSC-121 (V_2) showed the maximum no. of grain cob^{-1} (462.0).

Enujeke (2013 b) carried out a study in the teaching and research farm of Delta state University, Asaba Campus from March 2008 to June 2010 to evaluate the effects of variety, organic manure and inorganic fertilizer on number of grain cob^{-1} of maize. Four different rates of poultry manure, cattle dung and NPK 20:10:10 fertilizer were applied to three different maize varieties sown at 75cm × 15 cm and evaluated for number of grains cob^{-1}. The result of the study indicated that, with respect to varietal performance, hybrid

variety 9022-13 had the highest number of grains cob^{-1} (517.8), followed by open-pollinated variety BR9922-DMRSRF_2 (474.0). Agbor local variety had the lowest number of grains cob^{-1} (386.6).

Enujeke (2013 c) carried out a study to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. Four open-pollinated varieties (Suwan-1-SR, ACR97, BR9922-DMRSF_2 and AMATZBRC_2WB) were evaluated under three different plant spacing (75 cm × 15 cm, 75 cm × 25 cm and 75 cm × 35 cm) for yield indices. The results obtained indicated that variety BR9922-DMRSF_2 was outstanding with its number of grains $cob^{-1}$was 467.7 in 2008 and 463.9 in 2009.

Athar *et al.* (2012) conducted a pot experiment in a wire netting green house at Bahauddin Zakariya University, Multan, Pakistan in order to assess the beneficial effect of urea on corn cultivars (C-20 and C-79) differing in yield production. The result of the study revealed that, maximum number of grains cob^{-1} (532.0) was recorded from C-79 variety and the minimum number of grains cob^{-1} (282.0) was found from C-20.

Bhuiyan (2012) carried out a research work at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 from December 2010 to May 2011 to determine optimum water requirement for the cultivation of hybrid maize varieties. There were two factors in this experiment, a) four hybrid maize varieties: V_1 (BARI Hybrid Maize-5). V_2 (Pacific 60), V_3 (NK 40) and V_4 (Ajanta) and b) three levels of irrigation: I_1 = Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25. 50 and 75 DAS and I_3 = Four irrigations at 25, 50, 75and 100 DAS, respectively. The findings revealed that, selected varieties individually had significant effect on yields and yield contributing characters of maize. Grain per cob varied significantly among the varieties. BARI Hybrid Maize-5 performed better among the four varieties tested in this experiment.

Mukhtar *et al.* (2011) studied response of maize crop to various NP levels at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during kharif 2009. Six NP rates (0 - 0, 200-100, 250-125, 300-150, 350-175 and 400-200 kg ha^{-1}) were tried on two maize hybrids (YH-1898 and YH-1921) for growth and yield. They reported that, both hybrid varieties YH-1921 and YH-1898 showed non-significant result (578.17 and 495.83, respectively) for number of grains cob^{-1}.

Ahmed *et al.* (2010) conducted an experiment for two consecutive years taking three varieties (DK-919, DK-5219 and Pioneer-30Y87) and found that during both the years of experimentation, number of grains per cob significantly differed within the hybrids.

Asghar *et al.* (2010) conducted a study to investigate the effect of different NPK rates on growth and yield of maize cultivars: Golden and Sultan. The varieties V_1 (Golden) (415.29) and V2 (Sultan) (410.69) did not differ significantly for number of grains cob^{-1}.

Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at the National Agricultural Research Centre, Islamabad during kharif 2007. Significant differences was observed for number of grain per row. The hybrid P-30-25 produced the maximum number of grains (51) while Grast-8288 produced the lowest (29).

Islam and Mian (2004) showed the results of comparative performance of ten maize hybrids (CTS-99 1058, CTS-991060, CTS-991062. CTS-993044, CTS-993046, CTS-9930501, Pacific-11, 1434, 3435 and 6734) during Rabi season of 2000–2001. The analysis of variance for grains per cob revealed significant variation among the hybrids. Hybrid 6734 produced the highest number of grains per cob.

2.2.3 Grain weight per cob

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after 40 DAS. PSC-121 showed the superior performance in terms of weight of grains cob^{-1} (99.78 g) over YANGNUO-3000.

2.2.4Cob height

Ishaq *et al.* (2015) conducted an experiment to find out genetic potential, variability and heritability of various morphological and yield traits among maize synthetics and showed highly significant differences ($P \leq 0.01$) for all the agronomic and genetic traits. Among the tested populations, Jalal-2003 proved to be superior for most of the traits studied. The highest values for cob height (75.13 cm) was recorded for Jalal-2003.

Bhuiyan (2012) carried out a research work at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 from December 2010 to May 2011 to determine optimum water requirement for the cultivation of hybrid maize varieties. There were two factors in this experiment, a) four hybrid maize varieties: V_1 (BARI Hybrid Maize-5). V_2 (Pacific 60), V_3 (NK 40) and V_4 (Ajanta) and b) three levels of irrigation: I_1 = Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25. 50 and 75 DAS and I_3 = Four irrigations at 25, 50, 75and 100 DAS, respectively. The findings revealed that, selected varieties individually had significant effect on yields and yield contributing characters of maize. Cob height varied significantly among the

varieties. BARI Hybrid Maize-5 performed best among the four varieties tested in this experiment.

Malik *et al.,* (2011) evaluated ten maize hybrids at Agriculture Research Institute, Tarnab Farm, Peshawar with the aim to estimate variation among maize hybrids during spring season 2010. The analysis of variance showed highly significant differences among the maize hybrids for cob height.

Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at the National Agricultural Research Centre, Islamabad during kharif 2007. Significant differences were observed for cob height. Cob height ranged from 70.33 (Soan-3) to 107 cm (NT-6651).

Islam and Mian (2004) showed the results on comparative performance of ten maize hybrids (CTS-99 1058, CTS-991060, CTS-991062. CTS-993044, CTS-993046, CTS-9930501, Pacific-1, 1434, 3435 and 6734) during Rabi season of 2000–2001. Data were recorded on yield and yield contributing characters such as days to 6-leaf stage, days to 12-leaf stage, days to bud initiation, days to tassel emergence, plant height, cob height, cob per plant, cob length, cob circumference, grain rows per cob, kernels per cob and grain yield (t ha^{-1}). The analysis of variance for cob height revealed significant variation among the hybrids.

2.2.5 Cob circumference

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised of 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and 5 plants spacing *viz.*, 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The maximum circumference of cob was observed in BARI hybrid maize 7. On the other hand, the minimum circumference of cob was observed in Khoi bhutta.

Bhuiyan (2012) carried out a research work at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 from December 2010 to May 2011 to determine optimum water requirement for the cultivation of hybrid maize varieties. There were two factors in this experiment, a) four hybrid maize varieties: V_1 (BARI Hybrid Maize-5). V_2 (Pacific 60), V_3 (NK 40) and V_4 (Ajanta) and b) three levels of irrigation: I_1 = Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25. 50 and 75 DAS and I_3 = Four irrigations at 25, 50, 75and 100 DAS, respectively. Cob circumference varied significantly among the varieties. BARI Hybrid Maize-5 performed best among the four varieties tested in this experiment.

Tuncay *et al.*(2005) carried out a research work to determine cob and technological properties of eight sweetcorn cultivars as main and second crops in 2003 in Turkey. There are statistically significant differences among cultivars for cob circumference in both growing periods.

Esiyok *et al.* (2004) evaluated yield, quality and some plant characteristic during 2003 in 10 sweetcorn cultivars (ACX 232, ACX 942, GH 2547, Merit F1, Multi 500, Multi 610, ACX 945 Y, Martha Fl, ACX 935 Y and ACX 1072) grown in Izmir (Bornova-Menemen) and Aydn (Cine), Turkey. Significant differences were observed among the cultivars and locations for all characteristics except cob circumference.

Islam and Mian (2004) showed the results of comparative performance of ten maize hybrids (CTS-99 1058, CTS-991060, CTS-991062. CTS-993044, CTS-993046, CTS-9930501, Pacific-11, 1434, 3435 and 6734) during Rabi season of 2000–2001. The analysis of variance for cob circumference revealed significant variation among the hybrids.

2.2.6Cob length

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to

investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after 40 DAS. PSC-121 showed the superior performance in terms of cob length (18.35 cm) over YANGNUO-3000.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised of 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and 5 plants spacing *viz.*, 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The longest cob was observed in BARI hybrid maize 7. On the other hand, the shortest cob was observed in Khoi bhutta.

Enujeke (2013 c) carried out a study to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. Four open-pollinated varieties (Suwan-1-SR, ACR97, BR9922-DMRSF$_2$ and AMATZBRC$_2$WB) were evaluated under three different plant spacing (75 cm × 15 cm, 75 cm × 25 cm and 75 cm × 35 cm) for yield indices as number of cobs/plant, cob length, grain weight and number of grains/cob of maize. The results obtained indicated that variety BR9922-DMRSF$_2$ was outstanding with cob length of 27.7 cm and 26.7 cm in 2008 and 2009, respectively.

Bhuiyan (2012) carried out a research work at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 from December 2010 to May 2011 to determine optimum water requirement for the cultivation of hybrid maize varieties. There were two factors in this experiment, a) four hybrid maize varieties: V_1 (BARI Hybrid Maize-5). V_2 (Pacific 60), V_3 (NK 40) and V_4 (Ajanta) and b) three levels of irrigation: I_1 = Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25. 50 and 75 DAS and I_3 = Four

irrigations at 25, 50, 75and 100 DAS, respectively. Cob length varied significantly among the varieties. BARI Hybrid Maize-5 performed better among the four varieties tested in this experiment.

Ahmed *et al.* (2010) conducted an experiment for two consecutive years taking three varieties (DK-919, DK-5219 and Pioneer-30Y87) and found that during both the years of experimentation, yield-contributing characters like cob length significantly differed within the hybrids.

Fan *et al.* (2010) conducted an experiment with a view to screen some new corn varieties with high yield and resistance suitable for planting in Xincheng county of Guangxi. Variety Lucheng 133 was characterized by short cob length.

2.2.7Weight of husked and unhusked cob

Tuncay *et al.*(2005) carried out a research work to determine cob and technological properties of eight sweetcorn cultivars as main and second crops in 2003 in Turkey. There were statistically significant differences among cultivars in both growing periods. The heaviest unhusked cob was obtained from Multi 610 in main crop and from GH 2447 in second crop. ACX 232 was the second cultivar regarding the unhusked cob weight in both seasons.

2.2.8Cob weight

Esiyok *et al.* (2004) evaluated yield, quality and some plant characteristic during 2003 in 10 sweetcorn cultivars (ACX 232, ACX 942, GH 2547, Merit F1, Multi 500, Multi 610, ACX 945 Y, Martha Fl, ACX 935 Y and ACX 1072) grown in Izmir (Bornova-Menemen) and Aydn (Cine), Turkey. Significant differences were observed among the cultivars and locations for cob weight. The greatest cob weights (21 370 kg/ha and 20 180 kg/ha) were recorded for GH 2547 and ACX 232 under Menemen conditions. The greatest cob productivity (75.55%) was observed in ACX 1072.

2.2.9 Weight of 100-grain

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after 40 DAS. PSC-121 showed the superior performance in terms of 100 seed weight (35.0837 g) over YANGNUO-3000.

Mannan (2018) conducted an experiment at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to examine the varietal performances of white maize as influenced by different level of herbicides. The experiment comprised of two white maize varieties (PSC-121 and Yangnuo-3000) and six levels of weed control treatments, *viz.*, T_0 = No weeding, T_1 = Carfentrazone + Isoproturon 500g @ 1.5 g/ha (Affinity 50.75% WP), T_2 = Carfentrazone + Isoproturon 500g @ 2.0 g/ha (Affinity 50.75% WP), T_3 = Pendimethalin @ 2.0 l/ha (Panida 50EC), T_4 = Pendimethalin @ 3.0 l/ha (Panida 50EC) and T_5 = One Hand Weeding at 45 DAS. In the experiment, PSC-121 showed the superior performance in terms of 100-seed weight (33.898 g) over YANGNUO-3000.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised of 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and 5 plants spacing *viz.*, 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The highest 100-grain weight was observed in BARI hybrid maize 7. On the other hand, the lowest 100-grain weight was observed from Khoi bhutta.

Ullah *et al*. (2016) carried out an experiment with four white maize varieties (Chamgnuo-1, Changnuo-6, Q-xiannuo-1 and Yangnuo-7) for evaluating yield and yield performance of transplanted white maize varieties under varying planting geometry. The lowest 100-seed weight was recorded from Yangnuo-7 (24.33 g, other varieties showed 31.83–34.67 g).

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (five levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (two levels); V_1: KS-510 and V_2: PSC-121. Among the varieties, KS-510 (V_1) showed the minimum 100-grain weight (35.04 g), whereas PSC-121 (V_2) showed the maximum 100-grain weight (36.78 g).

Bhuiyan (2012) carried out a research work at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 from December 2010 to May 2011 to determine optimum water requirement for the cultivation of hybrid maize varieties. There were two factors in this experiment, a) four hybrid maize varieties: V_1 (BARI Hybrid Maize-5). V_2 (Pacific 60), V_3 (NK 40) and V_4 (Ajanta) and b) three levels of irrigation: I_1 = Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25. 50 and 75 DAS and I_3 = Four irrigations at 25, 50, 75and 100 DAS, respectively. The findings revealed that, selected varieties individually had significant effect on yields and yield contributing characters. 1000-grain weight varied significantly among the varieties. BARI Hybrid Maize-5 performed best among the four varieties tested in this experiment.

Mukhtar *et al.* (2011) studied response of maize crop to various NP levels at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during kharif 2009. Six NP rates (0 - 0, 200-100, 250-125, 300-150, 350-175 and 400-200 kg ha^{-1}) were tried on two maize hybrids (YH-1898 and YH-1921) for growth and yield. They reported that, both hybrid varieties YH-1921 and YH-1898 showed non-significant result (324.17 g and 378.44 g, respectively) for 1000-grain weight.

Ahmed *et al.* (2010) conducted an experiment for two consecutive years taking three varieties (DK-919, DK-5219 and Pioneer-30Y87) and found that during both the years of experimentation, 100-grain weight significantly differed within the hybrids.

Arellano Vazquez (2010) evaluated 42 Cacahuacintle maize landraces and the hybrids 'H-33', 'H-44' and 'H-137', in experiments established under rainfed conditions in Calimaya and Metepec, both in Toluca Valley, State of Mexico. Varieties 7, 11 and 32 stood out for their high values of weight of 100-grains.

Asghar *et al.* (2010) conducted a study to investigate the effect of different NPK rates on growth and yield of maize cultivars: Golden and Sultan. The varieties V_1 (Golden) (248.83 g) and V_2 (Sultan) (246.74 g) did not show any difference in producing 1000-grain weight.

Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at the National Agricultural Research Centre, Islamabad during kharif 2007. Significant differences were observed for 100-grain weight. 100-grain weight ranged from 23 g (EV-6098) to 39 g (2512).

Msarmo and Mhango (2005) conducted a study at Bunda College during the 2003–04 crop season to assess the effect of fertilizer application practices on performance of maize with emphasis on improving the efficiency of using urea as a top dressing fertilizer. There were three maize varieties and three fertilizer application practices. The maize varieties included local maize, Masika

(composite) and DK8031 (hybrid). The result of the study revealed that, DK8031 had the highest 100-seed weight (41.45 g) as compared to local maize and Masika which had (35.17 g) and (34.60 g), respectively.

2.3Review on yield attributes of maize variety

2.3.1 Grain yield

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2, respectively. PSC-121 showed the superior performance in terms of grain yield (8.28 t ha^{-1}) over YANGNUO-3000.

Mannan (2018) conducted an experiment at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to examine the varietal performances of white maize as influenced by different level of herbicides. The experiment comprised of two white maize varieties (PSC-121 and Yangnuo-3000). In the experiment, PSC-121 showed the superior performance in terms of grain yield (7.758 t ha^{-1}) over Yangnuo-3000. Whereas, a grain yield of 6.44 t ha^{-1} was obtained from Yangnuo-3000.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised of 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396. The maximum grain yield was observed from BARI hybrid maize-7. On the other hand, the lowest grain yield was observed in Khoi bhutta.

Akbar *et al.* (2016) explored that grain yield was found between 7.10 t ha^{-1} and 10.12 t ha^{-1} across hybrids and planting scheme. 19% more yield was obtained from PSC-121 than KS-510.

Khan *et al.* (2016) carried out an experiment considering three hybrid maize varieties, e.g., P-3025, P-32T78 and P-3203. From the experiment, he noted that among three hybrid maize varieties, grain yield (2.253 t ha^{-1}) was maximum in maize hybrid P-3025.

Ullah *et al*. (2016) carried out an experiment for evaluating yield and yield performance of transplanted white maize varieties under varying planting geometry. Out of four white maize varieties (Chamgnuo-1, Changnuo-6, Q-xiannuo-1 and Yangnuo-7), the highest significant grain yield per hectare was resulted from Changnuo-6 (8.198 tons) which is preceded by Changnuo-1 (7.457 tons) and Q-Xinagnuo-1 (6.718 tons). The lowest grain yield per hectare was obtained from Yangnuo-7 (4.393 tons) than others.

Ishaq *et al.* (2015) conducted an experiment to find out genetic potential, variability and heritability of various morphological and yield traits among maize synthetics and found highly significant differences ($P \leq 0.01$) for all the agronomic and genetic traits. Among the tested populations, Jalal-2003 proved to be superior for most of the traits studied. The highest values for grain yield (5927 kg/ha) was recorded for Jalal-2003.

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (5 levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (2 levels); V_1: KS-510 and

V_2: PSC-121. Among the varieties, KS-510 (V_1) showed the lowest grain yield (6.56 t ha^{-1}), whereas PSC-121 (V_2) showed the highest grain yield (6.85 t ha^{-1}).

Rahaman (2015) carried out an experiment during January to May 2015 to study the genetic diversity, correlation and path co-efficient analysis for yield and yield contributing characters of maize. For the accomplishment of the experiment, 37 maize genotypes were used as experimental materials. The maximum grain yield/plant (163.84 g) was recorded in the genotype of DEKALB-9120, whereas the minimum grain yield/plant (60.00 g) was from the genotype of BHM-7.

Asaduzzaman *et al.* (2014) planted four baby corn varieties *viz*. Hybrid baby corn-271, Shuvra, Khoibhutta and BARI sweet corn-1 at five N fertilizer rates viz. 0 kg N ha^{-1} (N_0), 80 kg N ha^{-1} (N_1), 120 kg N ha^{-1} (N_2), 160 kg N ha^{-1} (N_3) and 200 kg N ha^{-1} (N_4) in the experiment to find out the suitable variety and N fertilizer rate for baby corn production. They observed that, the maximum cob yield with husk (12.8 t ha^{-1}) was recorded in Hybrid Baby Corn-271 and the minimum (9.70 t ha^{-1}) was recorded in Shuvra.

Enujeke (2013 c) carried out a study to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. Four open-pollinated varieties (Suwan-1-SR, ACR97, BR9922-DMRSF$_2$ and AMATZBRC$_2$WB) were evaluated under three different plant spacing (75 cm × 15 cm, 75 cm × 25 cm and 75 cm × 35 cm) for yield indices. The results obtained indicated that variety BR9922-DMRSF$_2$ was outstanding with its grain weight which was 4.70 t/ha in 2008 and 4.90 t/ha in 2009.

Bhuiyan (2012) carried out a research work at the field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 from December 2010 to May 2011 to determine optimum water requirement for the cultivation of hybrid maize varieties. There were two factors in this experiment, a) four

hybrid maize varieties: V_1 (BARI Hybrid Maize-5). V_2 (Pacific 60), V_3 (NK 40) and V_4 (Ajanta) and b) three levels of irrigation: I_1 = Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25. 50 and 75 DAS and I_3 = Four irrigations at 25, 50, 75and 100 DAS, respectively. The findings revealed that, selected varieties individually had significant effect on yield of maize. Grain yield varied significantly among the varieties. BARI Hybrid Maize-5 performed best among the four varieties tested in this experiment.

Aziz *et al.* (2011) conducted a field trail at the Hill Agricultural Research Station, Khagrachari, Ramgorh and Boropara (Farmers field), Khagrachari during the Rabi season of 2008–2009 to find out the suitable hybrid maize variety for hilly areas. Five varieties of hybrid maize viz., BARI Hybrid Maize-2, BARI Hybrid Maize-3, BARI Hybrid Maize-5, Pacific-11 and Pacific-984 were tested in this study. Among the varieties BARI Hybrid Maize-5 produced maximum grain yield at all the locations (Khagrachari: 10.07 t ha^{-1}, Boropara: 9.71 t ha^{-1} and Ramgorh: 6.71 t ha^{-1}). The lowest grain yield was obtained from Pacific-984 (7.53 t ha^{-1}) at Khagrachari, BARI Hybrid Maize-2 (6.42 t ha^{-1}) at Boropara and BARI Hybrid Maize-3 (4.51 t ha^{-1}) at Ramgorh.

Malik *et al.* (2011) evaluated ten maize hybrids were at Agriculture Research Institute, Tarnab Farm, Peshawar with the aim to estimate variation among maize hybrids during spring season 2010. The analysis of variance showed highly significant differences among the maize hybrids for grain yield.

Mukhtar *et al.* (2011) studied response of maize crop to various NP levels at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during kharif 2009. Six NP rates (0 - 0, 200-100, 250-125, 300-150, 350-175 and 400-200 kg ha^{-1}) were tried on two maize hybrids (YH-1898 and YH1921) for growth and yield. They reported that, both hybrid varieties YH-1921 and YH-1898 showed non-significant result (7.62 t ha^{-1} and 6.73 t ha^{-1}, respectively) for grain yield.

Ahmed *et al.* (2010) conducted an experiment for two consecutive years taking three varieties (DK-919, DK-5219 and Pioneer-30Y87) and found that during both the years of experimentation, higher grain yield was obtained from the early maturing variety early DK-919 compared to that of mid and late maturity maize hybrids.

Arellano Vazquez (2010) evaluated 42 Cacahuacintle maize landraces and the hybrids 'H-33', 'H-44' and 'H-137', in experiments established under rainfed conditions in Calimaya and Metepec, both in Toluca Valley, State of Mexico. Among landraces there were differences (P<=0.01) for grain yield. Grain yield in the best performing landraces ranged from 7.5to 8.9 t ha^{-1}, while varieties 7, 11 and 32 stood out for their high values of grain yield.

Asghar *et al.* (2010) conducted a study to investigate the effect of different NPK rates on growth and yield of maize cultivars: Golden and Sultan. The varieties V_1 (Golden) (4.97 t ha^{-1}) and V_2 (Sultan) (4.88 t ha^{-1}) did not show any difference in producing grain yield.

Fan *et al.* (2010) conducted the present experiment to screen some new corn varieties with high yield and resistance suitable for planting in Xincheng county of Guangxi. A comparative test of corn varieties was undertaken in Panshui village, Chengguan town, Xincheng County in 2009. The varieties Zhengda 999, Ruiheng 269, Dika 008, Taipingvang 98 and Nanxiao 201 showed strong growth vigour and higher yield. These varieties were found suitable for planting widely in Xincheng County. Varieties Ruiheng 666 and Yumeitou 168 performed normally in the field, the increase in yield was not significant as compared to control variety Dika 007. Variety Dongdan 80 showed low yield and variety Lucheng 133 was characterized by short cob length and low yield, both of these varieties were not suitable for planting in Xincheng County.

Frigeri *et al*. (2010) conducted an experiment aiming at evaluating the

agronomic performance of recent releases of simple and triple hybrids of corn developed for high and medium technologies in 2007/08 in Jaboticabal; State of Sao Paulo, Brazil. The high genetic variability of *Zea mays* allows the annual release of new cultivars with superior agronomic characteristics. An experimental design of randomized blocks with 45 corn cultivars with three replications was used. The experimental plot consisted of four rows of five meters, spaced 80 cm between rows, and an initial population of 90,000 seedlings per hectare. One concluded that the simple hybrids RB 9108, 30F35, DKB AS 390 and 1567 presented with the highest yields.

Li Rong Dan *et al.* (2010) set up an experiment in order to screen new corn varieties with good quality, high yield, strong resistance to diseases and suitable harvesting time and to find out their suitability for planting in Changming Town of Daxin County. Ten new corn varieties were tested in a field experiment in 2009. The yield of varieties Taipingyang 98, Zhengda 629, Hongdan 4, Guidan 30 and Hongdan 3 (1.32–18.95% higher as compared to control variety Zhengda 619) indicated their suitability for planting in Changming town. Further, famers prefer Taipingyang 98 and Hongdan 3 rather than other corn varieties due to strong resistance to diseases and fine cob appearance, while Zhengda 305, Zhengda 518, Zhengda 16. Suyu 10 and Sanyuandeng 391 were unsuitable for extension in Changming town Daxin County because of their low yield and weak resistance.

Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at the National Agricultural Research Centre, Islamabad during kharif 2007. Significant differences were observed for grain yield. The hybrids NT-6622 and NT-6651 ranked top and second in grain yield by producing 7842 and 7759 kg ha^{-1}, respectively. Generally, the hybrids produced more grain yield than the open pollinated varieties.

Nizarmuddin *et al.* (2010) conducted the experiment about yield and yield components of five synthetic maize cultivars (EV-3001, Jalal, Kisan, Azam and

Pahari) at Chilas Agriculture Farm, district Diamer, Northern Areas, Pakistan during 2005. Cultivars differed significantly for all parameters. The highest yield (1.803 t/ha) was harvested in maize cultivar EV-3001 which was at par with cultivars Jalal and Azam. Check variety produced the lowest yield (1.15 t/ha).

Ahmmed (2009) conducted a field experiment at the central research farm of Bangladesh Agricultural Research Institute, Gazipur during the period from November 2008 to April 2009 to investigate the effect of different levels of phosphorus application on growth, yield attributes and yield of hybrid maize varieties. The experiment comprised of four hybrid maize varieties *viz.,* BARI hybrid maize-2, BARI hybrid maize-3, BARI hybrid maize-5 and BARI hybrid maize-7 and four levels of phosphorus *viz.* 0, 30, 60 and 90 kg ha^{-1} along with a blanket dose of $N_{250}K_{100}S_{40}Mg_{10}Zn_5B_2$ kg ha^{-1} and Cowdung 5t ha^{-1}. BARI hybrid maize-7 showed the highest grain yield (6.81 t ha^{-1}).

Msarmo and Mhango (2005) conducted a study at Bunda College during the 2003/04 crop season to assess the effect of fertiliudyzer application practices on performance of maize with emphasis on improving the efficiency of using urea as a top dressing fertilizer. There were three maize varieties and three fertilizer application practices. The maize varieties included local maize, Masika (composite) and DK8031 (hybrid). The result of the study revealed that, variety DK8031 was the highest grain yielder (6313 kg ha^{-l}) followed by Masika (5467 kg ha^{-1}) and then local maize (4823 kg ha^{-1}).

Tuncay *et al.*(2005) carried out a research work to determine cob and technological properties of eight sweetcorn cultivars as main and second crops in 2003 in Turkey. There are statistically significant differences between cultivars in both growing periods. The highest yield was obtained from Multi 610 in main crop and from GH 2447 in second crop.

Bozokalfa *et al.* (2004) conducted an experiment where ten sweetcorn cultivars

(ACX 232, ACX 942, OH 2547, Merit Fl, Multi 500, Multi 610, ACX 945 Y, Martha Fl. ACX 935 Y and ACX 1072) were grown in Ege Region, Turkey, during the spring and autumn of 2002 and 2003. The highest yields in spring (16,100 and 15,940 kg/ha) were recorded for ACX 232 and Multi 610. In autumn, the highest yield (11,020 kg/ha) was obtained from Multi 610.

Islam and Mian (2004) showed the results of comparative performance of ten maize hybrids (CTS-99 1058, CTS-991060, CTS-991062. CTS-993044, CTS-993046, CTS-9930501, Pacific-11, 1434, 3435 and 6734) during Rabi season of 2000–2001. The analysis of variance for grain yield revealed significant variation among the hybrids. Hybrid 6734 produced the highest yield of grain (t ha^{-1}).

Begum and Roy (1987) reported that yield variation among the varieties were due to varietal characteristics.

BARI (1987) reported that Guaria 8045 gave significantly higher grain yield (5.15 t ha^{-1}), whereas Pirsabak 8146, LaMaquina and Khoi bhutta produced grain yields of 4.50, 5.07 and 4.00 t ha^{-1} respectively.

2.3.2 Stover yield

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after 40 DAS. PSC-121 showed the superior performance in terms of stover yield (6.56 t ha^{-1}) over YANGNUO-3000.

Mannan (2018) conducted an experiment at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to examine the varietal performances of white maize as influenced by different level of herbicides. The experiment comprised of two white maize varieties (PSC-121 and Yangnuo-3000) and six levels of weed control treatments, *viz.*, T_0 = No weeding, T_1 = Carfentrazone + Isoproturon 500g @ 1.5 g/ha (Affinity 50.75% WP), T_2 = Carfentrazone + Isoproturon 500g @ 2.0 g/ha (Affinity 50.75% WP), T_3 = Pendimethalin @ 2.0 l/ha (Panida 50EC), T_4 = Pendimethalin @ 3.0 l/ha (Panida 50EC) and T_5 = One Hand Weeding at 45 DAS. PSC-121 showed the superior performance in terms of stover yield (6.121 t ha^{-1}) over YANGNUO-3000.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised of 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and 5 plants spacing *viz.*, 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The maximum stover yield was observed from BARI hybrid maize 7. On the other hand, the lowest stover yield was observed in Khoi bhutta.

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (5 levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (2 levels); V_1: KS-510 and V_2: PSC-121. Among the varieties, KS-510 (V_1) showed the lowest stover yield (11.64 t ha^{-1}) whereas PSC-121 (V_2) showed the highest stover yield (12.06 t ha^{-1}).

Nizarmuddin *et al.* (2010) conducted the experiment to find out the data on yield and yield components of five synthetic maize cultivars (EV-3001, Jalal, Kisan, Azam and Pahari) at Chilas Agriculture Farm, district Diamer, Northern Areas, Pakistan during 2005. Cultivars differed significantly for all parameters. The effect of cultivars on stalk yield significantly differed and check variety produced the lowest stalk yield (1.320 t/ha). Other cultivars were at par for stalk yield.

Msarmo and Mhango (2005) conducted a study at Bunda College during the 2003/04 crop season to assess the effect of fertilizer application practices on performance of maize with emphasis on improving the efficiency of using urea as a top dressing fertilizer. There were three maize varieties and three fertilizer application practices. The maize varieties included local maize, Masika (composite) and DK8031 (hybrid) and the fertilizer application practices were 100 kg ha^{-1} urea as basal and 100 kg ha^{-1} urea as top dressing (P_1), 100 kg ha^{-1} urea as basal and 75 kg ha^{-1} urea as top dressing (P_2) and 100 kg ha^{-1} as basal and 150 kgha^{-1} urea as top dressing (P_3). The result of the study revealed that, variety DK8031 showed the highest biomass yield (16131 kg ha^{-1}) followed by local maize (15114 kg ha^{-1}) and then Masika (12408 kg ha^{-1}).

2.3.3 Biological yield

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (5 levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (2 levels); V_1: KS-510 and V_2: PSC-121. Among the varieties, KS-510 (V_1) showed the lowest biological

yield (18.20 t ha^{-1}) whereas PSC-121 (V_2) showed the highest biological yield (18.92 t ha^{-1}).

Mannan (2018) conducted an experiment at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to examine the varietal performances of white maize as influenced by different level of herbicides. The experiment comprised of two white maize varieties (PSC-121 and Yangnuo-3000) and six levels of weed control treatments, *viz.*, T_0 = No weeding, T_1 = Carfentrazone + Isoproturon 500g @ 1.5 g/ha (Affinity 50.75% WP), T_2 = Carfentrazone + Isoproturon 500g @ 2.0 g/ha (Affinity 50.75% WP), T_3 = Pendimethalin @ 2.0 l/ha (Panida 50EC), T_4 = Pendimethalin @ 3.0 l/ha (Panida 50EC) and T_5 = One Hand Weeding at 45 DAS. In the experiment, PSC-121 showed the superior performance in terms of biological yield (13.878 t ha^{-1}) over YANGNUO-3000.

Asghar *et al.* (2010) conducted a study by to investigate the effect of different NPK rates on growth and yield of maize cultivars, Golden and Sultan. The varieties V_1 (Golden) (14.46 t ha^{-1}) and V_2 (Sultan) (14.43 t ha^{-1}) did not show any significant differences in producing biological yield.

2.3.4 Harvest index

Akter (2018) conducted an experiment at agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to investigate the influence of weeding regimes on the performance of white maize varieties. The experiment comprised of two varieties *viz.* YANGNUO-3000 and PSC-121, designated as V_1 and V_2 respectively combined with four weed control treatments *viz.* T_0 = No weeding, T_1= One hand weeding at 60 DAS, T_2= two hand weeding at 40 DAS and 60 DAS and T_3= Weed free after

40 DAS. PSC-121 showed the superior performance in terms of harvest index (55.58%) over YANGNUO-3000.

Mannan (2018) conducted an experiment at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2017 to April 2018 to examine the varietal performances of white maize as influenced by different level of herbicides. The experiment was laid out in Split Plot Design with three replications. The experiment comprised of two white maize varieties (PSC-121 and Yangnuo-3000) and six levels of weed control treatments, *viz.*, T_0 = No weeding, T_1 = Carfentrazone + Isoproturon 500g @ 1.5 g/ha (Affinity 50.75% WP), T_2 = Carfentrazone + Isoproturon 500g @ 2.0 g/ha (Affinity 50.75% WP), T_3 = Pendimethalin @ 2.0 l/ha (Panida 50EC), T_4 = Pendimethalin @ 3.0 l/ha (Panida 50EC) and T_5 = One Hand Weeding at 45 DAS. In the experiment, PSC-121 showed the superior performance in terms of harvest index (55.651%) over YANGNUO-3000.

Islam (2015) conducted an experiment at the experimental field of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to April 2016 to study the growth and yield of white maize varieties under fertilizer doses. The experiment consisted of two factors. Factor A: Fertilizer doses (5 levels); F_1 = Recommended dose (100%); F_2 = Below 25% of recommended dose (75%); F_3 = Below 50% of recommended dose (50%); F_4 = above 25% of recommended dose (125%) and F_5 = above 50% of recommended dose (150%) and factor B: Varieties (2 levels); V_1: KS-510 and V_2: PSC-121. Among the varieties, KS-510 (V_1) showed the lowest harvest index (36.26%) whereas PSC-121 (V_2) showed the highest harvest index (36.41%).

Aliu *et al.* (2010) carried out an experiment where aim of this study was to investigate some physiological traits and yield of different maize hybrids in growth conditions of Kosovo. The field experiment was conducted in 2006 and 2007 in Kosovo, near Prishtina. For calculating and statistical analysis 10

plants per each plot were randomly chosen in the study, seven commercial maize hybrids belonging to different FAO groups (FAO 300, 400 and 600), originating from two breeding institutions: MaizeDept. of Bc Institute Rugvica - Croatia (Jumbo 48 [H-I], BC418 [H-2], BC408 [H-3], BC288 [H-4], BC394 [H-5]) and from Pioneer Hi-Bred Int. (Austria) (Pregia [H-6] and Colombo [H-7]) were included. The harvest index (HI) of the 1st year was of a higher value than the 2nd year. For HI, statistically significant differences were not obtained among the studied maize hybrids.

Asghar *et al.* (2010) conducted a study to investigate the effect of different NPK rates on growth and yield of maize cultivars, Golden and Sultan. The varieties V_1 (Golden) (34.19 %) and V_2 (Sultan) (33.75 %) did not show any differences for harvest index.

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design, crop growing procedure, intercultural operations, data collection and statistical analyses.

3.1 Experimental period

The experiment was conducted during the period from November 2019 to April 2020 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level.

3.2.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.3 Climate

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot

season from March to April and the monsoon period from May to October (Idris *et al.*, 1979). Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix- III.

3.4 Soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.6. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0–15 cm depths were collected from the experimental field. The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix II.

3.5 Planting materials

Five (5) maize varieties and five (5) maize lines was used in this study.

Table 1: Name and origin of the maize (*Zea mays*) genotypes used in the present study

Sl. No.	Genotypes	Source of collection
01	SAU Test Cross 1	SAU
02	SAU Test Cross 2	SAU
03	SAU Test Cross 3	SAU
04	ARIZE	Nilsagor seed
05	Kaveri 50	ACI seed
06	SAU hybrid 1	SAU
07	SAU Test Cross 4	SAU
08	SAU Test Cross 5	SAU
09	ARIZE SUPER	Nilsagor seed
10	SAU hybrid 2	SAU

3.6 Experimental details

Sowing Date: 20 November, 2019

Harvesting Date: 12 April, 2020

3.7 Experimental design

The experiment was laid out in Randomized Complete Block design (RCBD) single factor with three replications. Total 30 unit plots was designed for the experiment with 10 treatments. Each plot will be of required size. The size of each unit plot was 2.50 m × 1.80 m. The distance maintained between the unit plots and blocks were 0.50 m and 1.0 m respectively. Layout of the experimental field is presented in Figure 1.

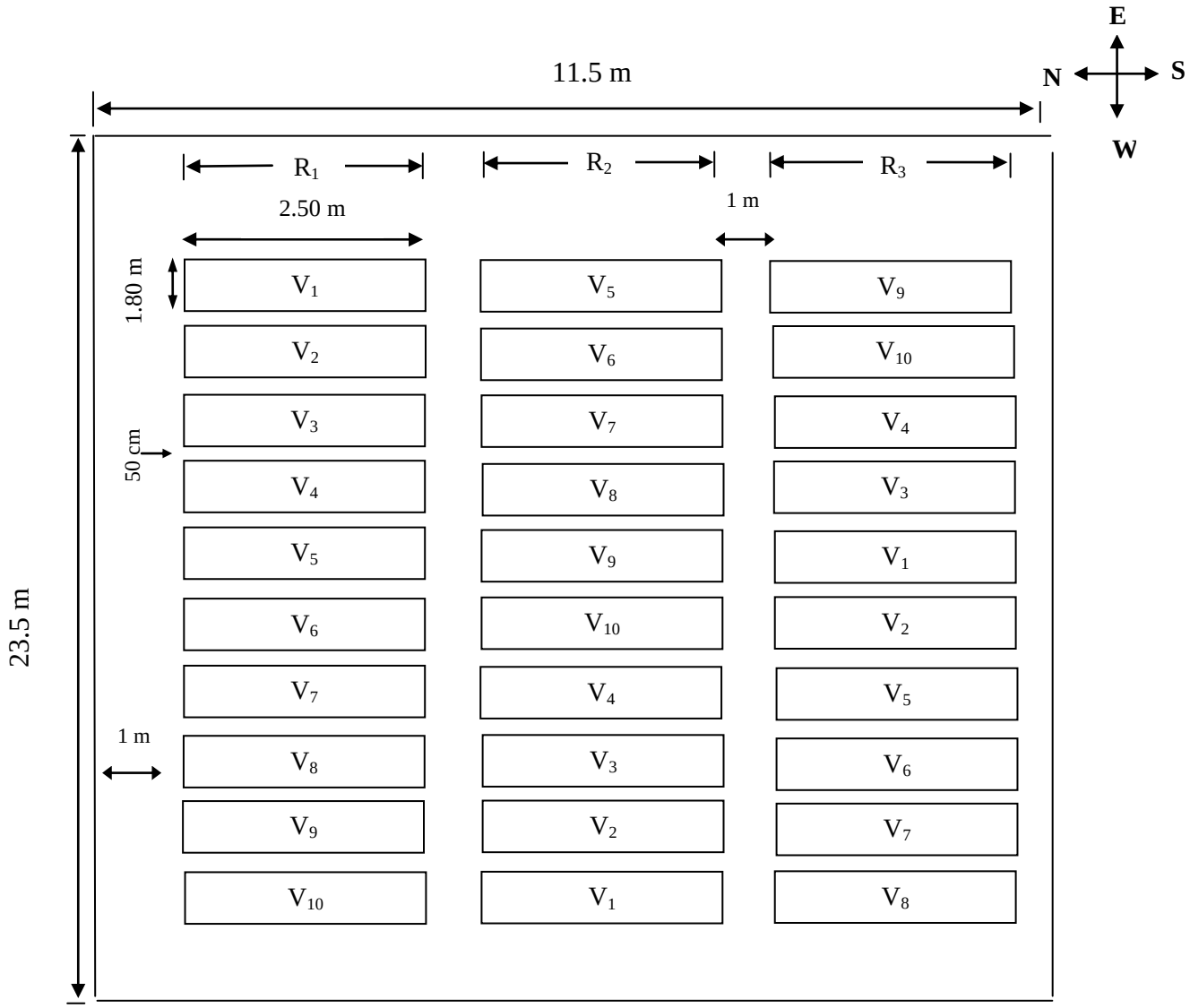
3.8 Detail of experimental preparation

3.8.1 Preparation of experimental land

A pre-sowing irrigation was given on 10 November 2019. The land was opened with the help of a tractor drawn disc harrow on 14 November, 2019 and then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on 19 November 2019 according to experimental specification. Individual plots were cleaned and finally the plots were prepared.

3.8.2 Fertilizer application

Doses of vermicompost was used @ 2 t ha^{-1} before final land preparation. The field was fertilized with nitrogen, phosphate,potash, sulphur, zinc and boron at the rate of 500-250-200-250-15-5 kg ha^{-1} ofurea, triple super phosphate, muriate of potash, gypsum, zinc sulphate andboric acid, respectively (BARI, 2014). The whole amounts of fertilizers were applied as basal doses except Urea. Only one-third Urea was applied as basal doses and the rest amount was applied at 15 DAS interval for three instalments.



Unit plot size = 2.50 m × 1.80 m

Plot spacing = 0.50 m = 50 cm

Between replication = 1 m

Maize lines:

V_1 = SAU Test Cross 1

V_2 = SAU Test Cross 2

V_3 = SAU Test Cross 3

V_7 = SAU Test Cross 4

V_8 = SAU Test Cross 5

Maize varieties:

V_4 = ARIZE

V_5 = Kaveri 50

V_6 = SAU hybrid 1

V_9 = ARIZE SUPER

V_{10} = SAU hybrid 2

Figure 1: Field layout of the experiment in Randomized Complete Block Design (RCBD)

3.9 Intercultural operations

After raising seedlings, various intercultural operations such as irrigation, weeding, gap filling and thinning, drainage, pest and disease control etc. were accomplished for better growth and development of the maize seedlings.

3.9.1 Gap filling and thinning

Gap filling was done on 30 November 2019, which was 10 days after sowing (DAS). During plant growth period, one thinning operation was done on 5 December 2019, which was 15 days after sowing.

3.9.2 Weeding

The hand weeding was done as when necessary to keep the plot free from weeds. During plant growth period two weeding were done. The weeding was done on 15 December 2019 and 4 January 2020, which was 25 and 45 days after sowing, respectively.

3.9.3 Earthing up

Earthing up was done on 20 December 2019 which was 30 days after sowing. It was done to protect the plant from lodging and for better nutrition uptake.

3.9.4 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done as pre-sowing andother four were given at 20, 40, 65 and 85 days after sowing (DAS). First irrigation was given on 10 December 2019, which was 20 days after sowing. Second irrigation was given on 30 December 2019, which was 40 days after sowing. Third irrigation was given on 24 January 2020, which was 65 days after sowing, and fourth irrigation was given on 13 February 2020, which was 85 days after sowing.

3.9.5 Drainage

There were heavy rainfalls during the experimental period. Drainage channels were properly prepared to easy and quick drained out of excess water.

3.9.6 Pest and disease control

Insecticides Diazinon 60 EC @ 2 ml litre^{-1} water was sprayed to control Stem borer on 8 December 2019, 23 December 2019 and 7 January 2020. Ripcord 10 EC @ 2 ml litre^{-1} water were sprayed to control earworm toprotect the crop on 20 January and 4 February 2020. On the other hand, picking of infested leaves with caterpillar larvae was also done as a control measure. Diseased or off type plants were uprooted as and when required.

3.9.7 General observations of the experimental site

Regular observations were made to see the growth stages of the crop. In general, the plot looked nice with normal green plants, which were vigorous and luxuriant.

3.10 Harvesting, threshing and cleaning

The mature cobs were harvested when the husk cover was completely dried and black coloration was found in the grain base. Harvesting Date was12 April, 2020.The cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data.

3.11 Drying

The harvested products were taken on the threshing floor and it was dried for about 3–4 days.

3.12 Crop sampling

Five plants were randomly selected and fixed in each plot from the inner row of the plot for recording data. Plant height and leaf area were recorded from selected plants at harvesting stage. Dry weight of plants were collected by

harvesting five plants at different specific dates from the inner rows leaving border plants and harvest area for cob of white maize.

3.13 Collection of data

Data were collected on the following parameters-

1. 80% germination
2. Plant height (cm)
3. 80% flowering
4. 80% cob formation
5. Cob height from surface (cm)
6. Genetic purity (%)
7. Dry matter plant^{-1} (g)
8. Cob weight (g)
9. Husk weight (g)
10. Full cob weight (g)
11. Cob length with husk (cm)
12. Cob length without husk (cm)
13. Unfilled area of cob (cm)
14. Rachis weight (g)
15. Cob circumference(cm)
16. Number of rows cob^{-1}
17. Number of grains row^{-1}
18. Shelling (%)
19. 100-grains weight (g)

20. Grain yield (t ha^{-1})

21. Stover yield (t ha^{-1})

22. Biological yield (t ha^{-1})

23. Harvest index (%)

3.14 Procedure of recording data

A brief outline on data recording procedure followed during the study is givenbelow:

3.14.1 80% germination

After sowing, the maize seed was observed for germination twice in a day (morning and afternoon) until 80% germination.

3.14.2 Plant height (cm)

The height of plant was recorded in centimetre (cm) at harvest. Data were recorded as the average of five plants selected from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.14.3 80% flowering

Days to 80% flowering was considered when 80% of the plants within a plot were showed up with flowers (silks and tassels). The number of days to 80% flowering was recorded from the date of sowing.

3.14.4 80% cob formation

Days to 80% cob formation was considered when cobs in 80% of plants within a plot were showed up. The number of days to 80% cob was recorded from the date of sowing.

3.14.5 Cob height from surface (cm)

The height of the cob-setting node was measured from the base of a maize plant or from the ground surface to the node at which length the cob was set.

3.14.6 Genetic purity (%)

Maize plants and cobs with homogenous appearance were counted within a single plot to measure genetic purity percentage. For measuring homogeneity of plant height in maize plants, dwarf plants and extra tall plants were counted. For measuring homogeneity in case of cob appearance, deformed / half-formed cob and cob with off-colour grain was counted and genetic purity percentage was measured accordingly. 94% purity percentage was considered as standard for maintaining genetic purity.

3.14.7 Dry weight plant^{-1} (g)

Dry weight plant^{-1} was measured at harvest. From each plot, five plants were uprooted randomly. Then the stem, leaves, cob and roots were separated. The all sample was sliced into very thin pieces and put into envelop and placed in oven maintaining 70°C for 72 hours. Then the entire sample was transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken with the help of following formula:

Total dry weight plant^{-1}(g) = Cob dry weight + Stover dry weight + Root dry weight

3.14.8 Cob weight (g)

Five randomly selected cobs from the five selected plants in each plot was taken and the husk was removed. Then the average weight was recorded in gram.

3.14.9 Husk weight (g)

Husk of five randomly selected cobs from the five selected plants in each plot was separated and the average weight of those husks was recorded in gram.

3.14.10 Full cob weight (g)

Weight of complete cob with husk of five randomly selected cobs from the five selected plants from each plot was taken and the average weight was recorded in gram.

3.14.11 Cob length with husk (cm)

Cob length with husk was measured in centimetre from the base to the tip of the unhusked cob of five corn from the five selected plants from each plot with the help of a centimetre scale then average data were recorded.

3.14.12 Cob length without husk (cm)

Two randomly selected cobs from each plot were taken and husk was removed to measure the length from the base to the tip of the cob. The average result was recorded in cm.

3.14.13 Unfilled area of cob (cm)

Five randomly selected cobs from the five selected plants from each plot was taken. The unfilled area of a complete cob, which was the above portion of the cob occupied by no grain of maize, was measured with the help of a measuring scale. The average data were recorded in centimetre.

3.14.14 Rachis weight (g)

Five randomly selected cobs from the five selected plants from each plot was taken. All the grains of the selected cobs were separated. Weight of the barren cobs without the grains, which are known as rachis, were measured with a measuring scale. The average data were recorded in gram.

3.14.15 Cob circumference

Two cobs were randomly selected from each plot and the circumference of each cob was taken from each commeasured with a measuring tape. Then average result was recorded in cm.

3.14.16 Number of rows cob^{-1}

Row number of five randomly selected cobs from the five selected plants from each plot were counted and mean result was recorded.

3.14.17 Number of grains row^{-1}

Five cobs from each plot were selected randomly and the number of grains per row was counted and then the average result was recorded.

3.14.18 Shelling (%)

Shelling percentage was calculated according to the following formula:

$$\text{Grain weight}\text{Cob weight} \times 100$$

3.14.19 100-grains weight (g)

One hundred clean and dried seeds were randomly taken from each plot and the weight was measured in an electrical balance. The average result was recorded.

3.14.20 Grain yield (t ha^{-1})

The collected grain from each plot was adjusted at 14% moisture level. The grain yield was measured according to the following formula:

$$\text{Grain yield per plot (kg)} \times 10000\text{Area of plot in square meter} \times 1000$$

3.14.21 Stover yield (t ha^{-1})

The stover yield was measured according to the following formula:

$$\text{Stover yield per plot (kg)} \times 10000\text{Area of plot in square meter} \times 1000$$

3.14.22 Biological yield (t ha^{-1})

Grain yield and stover yield together was regarded as biological yield and calculated with the following formula:

$$\text{Biological yield (t ha}^{-1}\text{)} = \text{Grain yield (t ha}^{-1}\text{)} + \text{Stover yield (t ha}^{-1}\text{)}$$

3.14.23 Harvest index (%)

Harvest Index denotes the ratio of economic yield to biological yield. It was calculated with the following formula:

$$\text{Grain yield}\text{Biological yield} \times 100$$

3.15 Statistical analysis

The collected data were analysed following the analysis of variance (ANOVA) techniques by Randomized Complete Block Design (RCBD) to find out the statistical significance of experimental results. The collected data were analysed by computer package program MSTAT-C software (Russell, 1986). The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises presentation and discussion of the results obtained from the study to investigate the evaluation of genetic purity, growth and yield performance of maize (*Zea mays*). The results of genetic purity and crop characters of the production of the crop as influenced by different maize varieties have been presented and discussed in this chapter. Data on different crop characters have been presented in Table 2–5 and Figure 2–7. The analyses of variance (ANOVA) on different parameters were calculated and presented in Appendices IV to IX.

4.1 80% germination

80% germination was significantly influenced by the different maize varieties (Appendix IV and Table 2). SAU hybrid 1 took the maximum days (6.00days) for 80% germination, which was statistically identical (6.00 days) with SAU Test Cross 5 whereas, the minimum days (3.00 days) was taken by SAU Test Cross 2.

4.2 80% flowering

80% flowering was significantly influenced by the different maize varieties (Appendix IV and Table 2). SAU Test Cross 5 took the highest days (102.67 days) for 80% flowering of maize. SAU Test Cross 3 took the second highest days (102.00 days) for 80% flowering of maize which was statistically similar ARIZE SUPER (101.00 days), SAU Test Cross 1 (101.00 days) and SAU hybrid 1 (100.67 days) whereas, the minimum days (92.00 days) was taken by SAU Test Cross 2.

4.3 80% cob formation

80% cob formation was significantly influenced by the different maize varieties (Appendix IV and Table 2). SAU Test Cross 5 took the maximum days (104.67days) for 80% cob formation which was statistically identical (104.00 days) with SAU Test Cross 3 whereas, the minimum days (95.00 days) was taken by SAU Test Cross 2.

Table 2: 80% germination, 80% flowering and 80% cob formation of selected hybrid lines and check varieties of maize

Variety	80% germination (DAS)	80% flowering (DAS)	80% Cob formation (DAS)
SAU Test Cross 1	4.67 c	101.00 bc	103.00 b
SAU Test Cross 2	3.00 e	92.00 h	95.00 f
SAU Test Cross 3	4.00 d	102.00 b	104.00 a
ARIZE	4.67 c	101.00 bc	103.00 b
Kaveri 50	5.00 b	94.00 fg	96.00 e
SAU hybrid 1	6.00 a	100.67 cd	102.67 b
SAU Test Cross 4	4.00 d	95.00 f	97.00 d
SAU Test Cross 5	6.00 a	102.67 a	104.67 a
ARIZE SUPER	5.00 b	97.33 e	99.33 c
SAU hybrid 2	5.00 b	95.00 f	97.00 d
$LSD_{(0.05)}$	**0.23**	**1.02**	**0.93**
CV (%)	**5.60**	**3.71**	**3.63**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.4 Plant height

Significant difference was observed on the plant height at different growth stages of maize due to variety (Appendix V). Figure 2 shows the effect of variety on plant height. At 20 DAS, Kaveri 50 showed the tallest plant (45.08 cm) and SAU Test Cross 5 showed the shortest plant (26.32 cm) which was statistically similar SAU Test Cross 1 (27.28 cm). Among the varieties, SAU hybrid 2 showed the tallest plant (83.74, 120.30, 155.60 and 205.50 cm at 35, 50, 65 and 80 DAS, respectively) which was statistically similar ARIZE SUPER (152.56 cm at 65 DAS, respectively) and SAU Test Cross 1 showed the shortest plant (40.98, 77.64, 112.50 and 164.00 cm at 35, 50, 65 and 80 DAS, respectively) which was statistically similar Kaveri 50 and ARIZE SUPER (165.70 and 168.60 cm at 80 DAS, respectively). At 95 DAS, SAU hybrid 2 showed the tallest plant (228.50 cm) and SAU Test Cross 5 showed the shortest plant (188.30 cm). Among the varieties, SAU Test Cross 1 showed the tallest plant (249.90, 255.50 and 255.70 cm at 110, 125 and 140 DAS, respectively) and SAU Test Cross 5 showed the shortest plant (190.50, 191.50 and 191.50 cm at 110, 125 and 140 DAS, respectively). This finding can be thrust to that of Ullah *et al.* (2017) who reported very closer plant height in white maize variety Suvra. Akter (2018) and Mannan (2018) was reported that PSC-121 showed the superior performance in terms of plant height over YANGNUO-3000. Hasan *et al.* (2018) was reported that the highest plant height was observed from BARI hybrid maize-7.

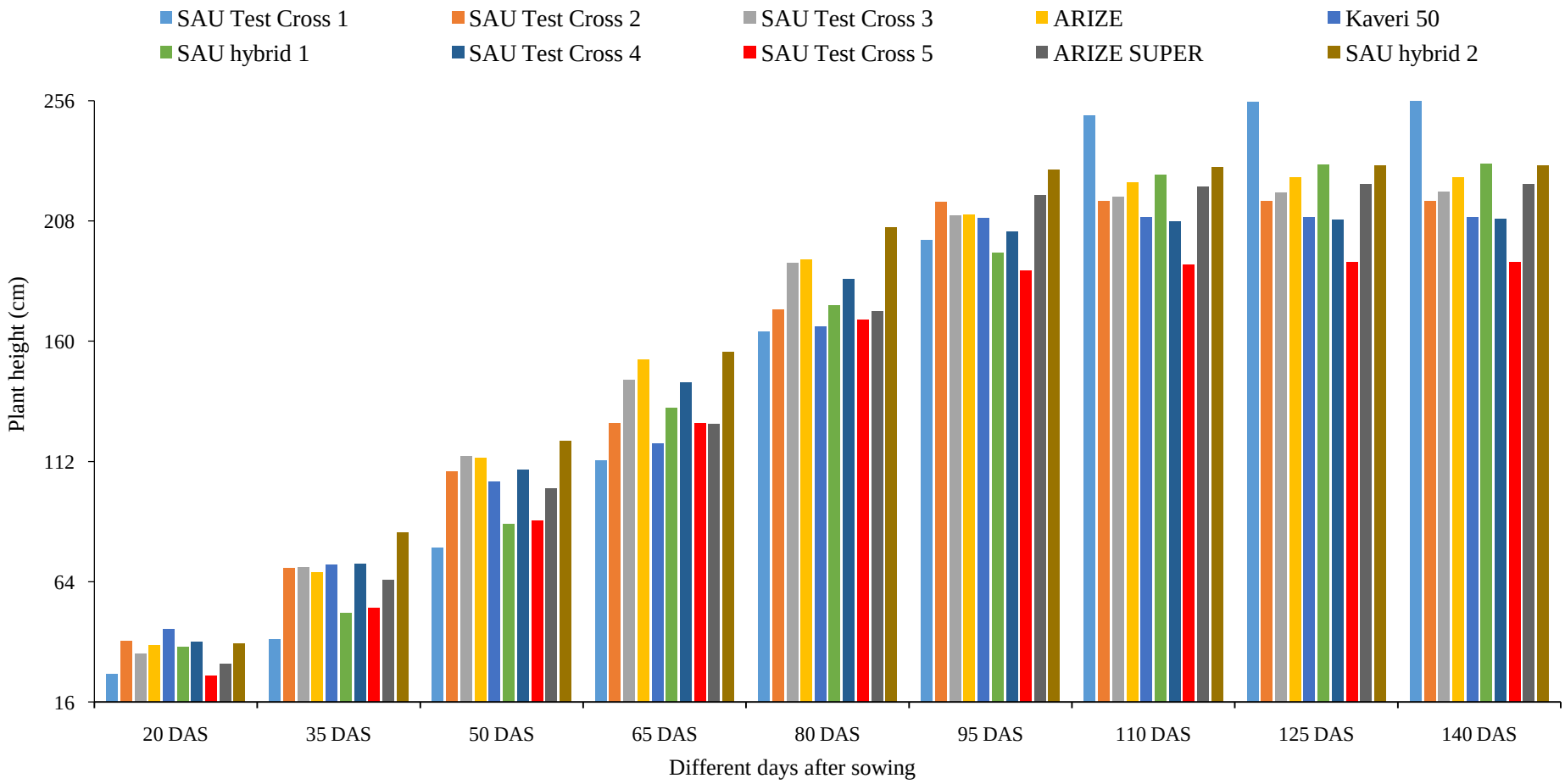


Figure 2: Plant height of selected hybrid lines and check varieties of maize (LSD value = 2.34, 5.23, 8.58, 3.02, 3.82, 9.92, 11.21, 13.27 and 13.31 at 20, 35, 50, 65, 80, 95, 110, 125 and 140 DAS)

4.5 Cob height from surface

From the experiment, it was found that the varieties have a significant effect on cob height from surface (Appendix VI and Table 3). SAU hybrid 1 showed the highest cob height from surface (133.03 cm) which was statistically similar to ARIZE (129.67 cm) over SAU Test Cross 2 which showed cob height from surface of 75.67 cm. Ishaq *et al.* (2015) who reported that the highest values for cob height (75.13 cm) was recorded for Jalal-2003. Bhuiyan (2012) reported that the cob height from surface varied significantly among the varieties. BARI Hybrid Maize-5 performed best among the four varieties tested in this experiment. Malik *et al.* (2010) evaluated 18 hybrids and 13 open pollinated varieties of maize at kharif 2007 and the cob height ranged from 70.33 (Soan-3) to 107 cm (NT-6651).

4.6 Genetic purity

Maize varieties showed a significant variation on genetic purity (Appendix VI and Table 3). SAU hybrid 1 showed the highest genetic purity (100.00%) while the second highest was with SAU hybrid 2 (99.07%); whereas SAU Test Cross 2 showed the lowest genetic purity (97.22%), which was statistically similar with SAU Test Cross 3 (97.22%), ARIZE (97.22%), Kaveri 50 (97.22%), SAU Test Cross 4 (97.22%) and SAU Test Cross 5 (97.22%).

4.7 Dry weight plant^{-1}

Maize variety exhibited significant difference on dry weight plant^{-1} (Appendix VI and Table 3). Among the varieties, SAU Test Cross 1 showed the highest dry weight plant^{-1} (115.55 g) which was statistically similar with SAU hybrid 2 (114.30 g) and SAU Test Cross 2 showed the lowest dry weight plant^{-1} (89.78 g). This is similar to the findings of Asaduzzaman *et al*. (2014) who reported that hybrid maize varieties produced the higher dry matter than others did.Islam (2015) who reported that KS-510 showed the highest dry weight plant^{-1} and PSC-121 showed the lowest dry weight plant^{-1}. Asaduzzaman *et al.* (2014)

reported that Hybrid baby corn-271 produced the highest dry matter plant^{-1} whereas the Khoibhutta had the lowest dry matter accumulation plant^{-1}.

Table 3: Cob height from surface, genetic purity % and dry weight plant^{-1} of selected hybrid lines and check varieties of maize

Variety	Cob height (cm) from surface	Genetic purity (%)	Dry weight plant^{-1} (g)
SAU Test Cross 1	86.73 de	98.15 c	115.55 a
SAU Test Cross 2	75.67 f	97.22 d	80.78 g
SAU Test Cross 3	119.00 b	97.22 d	84.89 f
ARIZE	129.67 a	97.22 d	92.34 d
Kaveri 50	81.27 e	97.22 d	94.67 d
SAU hybrid 1	133.03 a	100.00 a	90.11 de
SAU Test Cross 4	84.73 e	97.22 d	93.66 d
SAU Test Cross 5	92.67 d	97.22 d	99.67 c
ARIZE SUPER	96.67 d	98.15 c	102.22 b
SAU hybrid 2	105.00 c	99.07 b	114.30 a
LSD $_{(0.05)}$	**6.78**	**0.14**	**3.27**
CV (%)	**8.29**	**2.47**	**6.48**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.8 Cob weight

Maize variety exhibited a significant difference in respect of cob weight (Appendix VII and Figure 3). Among the varieties, SAU Test Cross 1 showed the maximum cob weight (208.83 g) and SAU Test Cross 3 showed the minimum cob weight (109.73 g). Akter (2018) who reported that PSC-121 showed the superior performance in terms of weight of grains cob^{-1} over YANGNUO-3000.

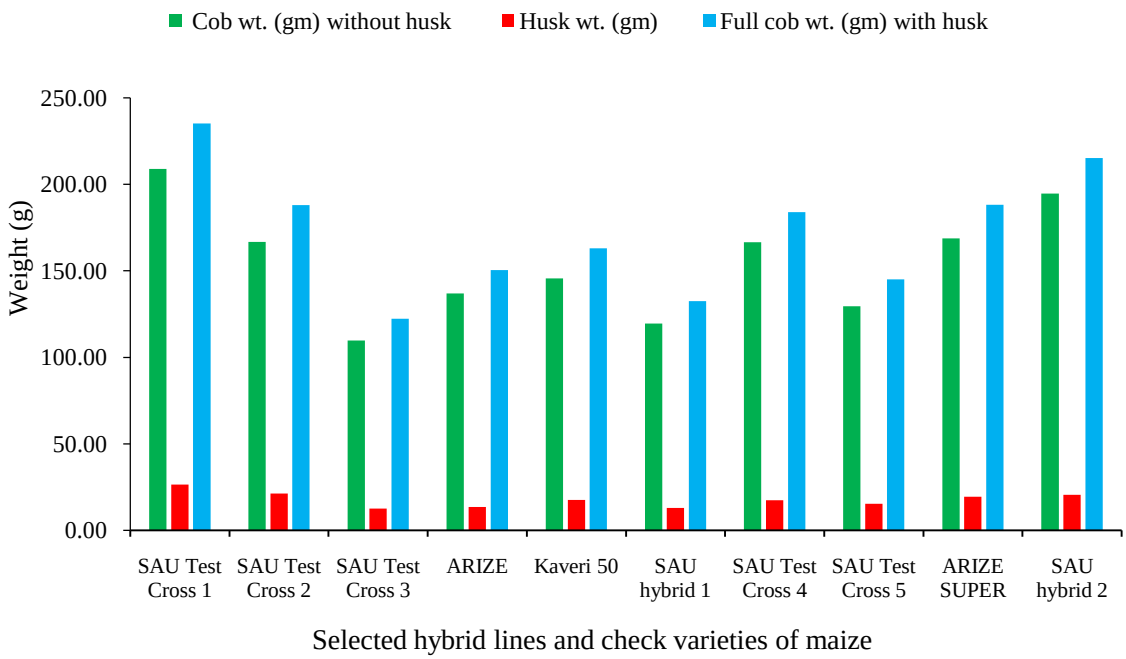


Figure 3: Cob weight, husk weight and full cob weight of selected hybrid lines and check varieties of maize (LSD value = 8.03, 0.62 and 7.39 respectively)

4.9 Husk weight

Maize variety exhibited a significant difference in respect of husk weight (Appendix VII and Figure 3). Among the varieties, SAU Test Cross 1 showed the maximum husk weight (26.39 g) and SAU Test Cross 3 showed the minimum husk weight (12.60 g) which was statistically similar with SAU hybrid 1 (12.95 g).

4.10 Full cob weight

Significant variation was recorded in case of full cob weight for different maize varieties (Figure 3 and Appendix VII). The full cob weight range from 122.33 g to 235.22 g due to different maize varieties. The highest full cob weight (235.22 g) was recorded from SAU Test Cross 1 line. On the other hand, the lowest full cob weight (122.33 g) was recorded fromSAU Test Cross 3 line. Esiyok *et al.* (2004) reported that the greatest cob weights were recorded for GH 2547 and ACX 232 under Menemen conditions.

4.11 Cob length with husk

Effect of variety on cob length with husk is shown in the Figure 4. A statistically significant difference among varieties was revealed regarding cob length with husk (Appendix VII). The maximum cob length with husk (23.97 cm) was reported from SAU Test Cross 1 over SAU Test Cross 5, which showed the cob length of about 19.18 cm. Almost similar figure of cob length with husk was reported by Kebede and Anbasa (2017). Akter (2018) who reported that PSC-121 showed the superior performance in terms of cob length over YANGNUO-3000. Hasan *et al.* (2018) reported that the longest cob was observed in BARI hybrid maize 7. Enujeke (2013 c) carried out a study to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize and the results obtained indicated that variety BR9922-DMRSF$_2$ was outstanding with cob length of 27.7 cm and 26.7 cm in 2008 and 2009, respectively. Bhuiyan (2012) carried out that BARI Hybrid Maize-5 performed best among the four varieties tested in the experiment.

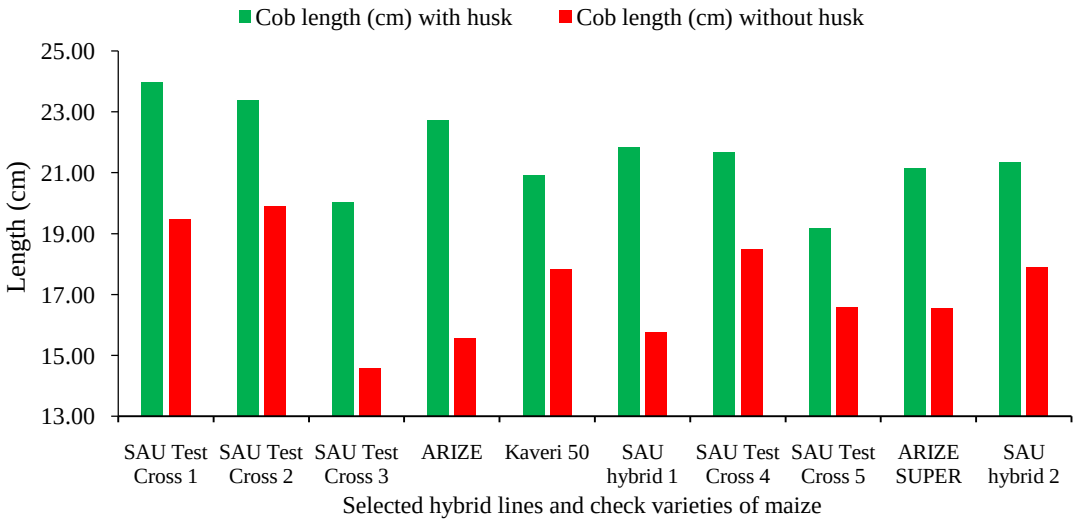


Figure 4: Cob length with husk and cob length without husk of selected hybrid lines and check varieties of maize (LSD value = 0.47 and 0.19 respectively)

4.12 Cob length without husk

Figure 4 shows the effect of varieties on cob length without husk (Appendix VII). From the experiment, it was revealed that SAU Test Cross 2 is the best treatment giving 19.90 cm long cob without husk. The lowest length of cob without husk (13.67 cm) was recorded from SAU Test Cross 3. The result was similar with that of Olabode and Sangodele (2015). Tuncay *et al.*(2005) reported that the heaviest unhusked cob was obtained from Multi 610 in main crop and from GH 2447 in second crop.

4.13 Unfilled area of cob

Maize variety exhibited a significant difference in respect of unfilled area of cob (Appendix VIII and Figure 5). Among the varieties, SAU hybrid 1 showed the maximum unfilled area of cob (2.29 cm) and ARIZE SUPER showed the minimum area (0.69 cm). SAU Test Cross 4 showed the second maximum unfilled area of cob (1.83 cm) and SAU hybrid 2 showed the second minimum area (0.86 cm).

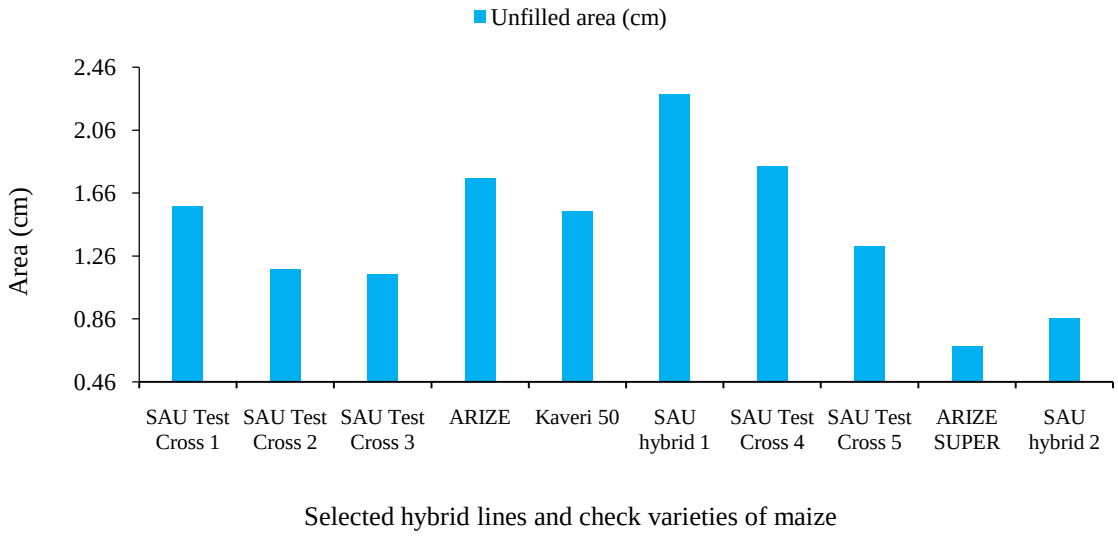


Figure 5: Unfilled area of cob of selected hybrid lines and check varieties of maize (LSD value = 0.14)

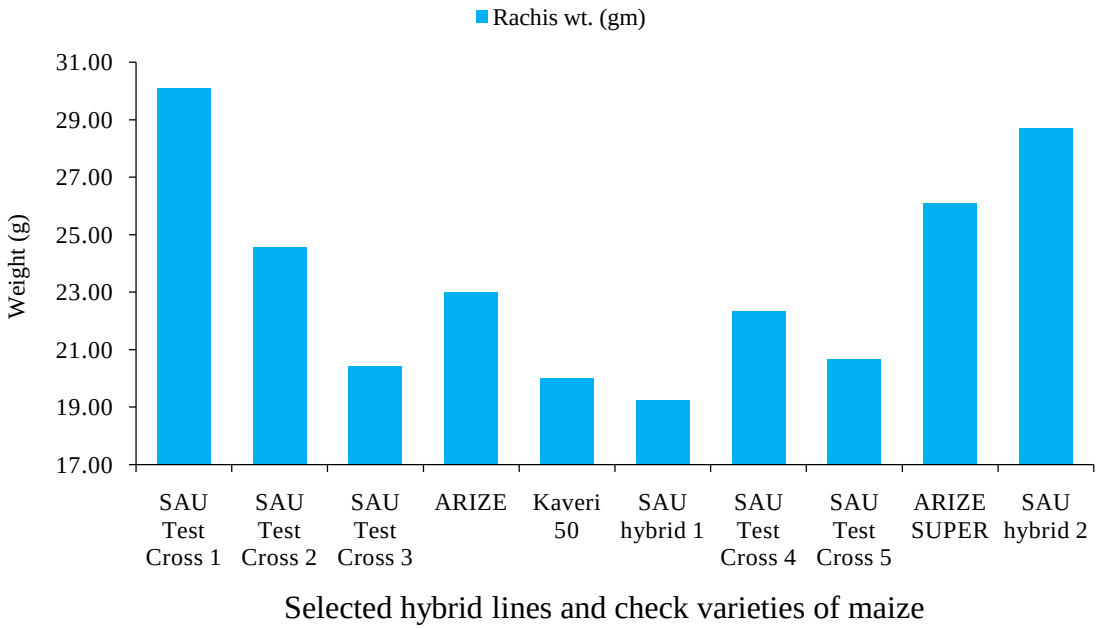


Figure 6: Rachis weight of selected hybrid lines and check varieties of maize (LSD value = 0.71)

4.14 Rachis weight

Significant variation was recorded in case of rachis weight for different maize varieties (Figure 6 and Appendix VIII). The rachis weight range from 19.23 g to 30.11 g due to different maize varieties. The highest rachis weight (30.11 g) was recorded from SAU Test Cross 1 line. On the other hand, the lowest rachis weight (19.23 g) was recorded from SAU hybrid 1.

4.15 Cob circumference

Cob circumference showed positive non-significant difference at different maize varieties (Table 4 and Appendix VIII). Due to different maize variety, the range of cob circumference was found 13.47 cm to 15.71 cm. The numerical highest cob circumference (15.71 cm) was recorded in SAU hybrid 2 while numerical lowest cob circumference (13.71 cm) was recorded in Kaveri 50. Hasan *et al.* (2018) and Bhuiyan (2012) who reported that the maximum circumference of cob was observed in BARI hybrid maize 7.

Table 4: Cob circumference, no. of rows cob^{-1}, no. of grains row^{-1} and shelling % of selected hybrid lines and check varieties of maize

Variety	Cob circumference(cm)	No. of rows cob^{-1}	No. of grains row^{-1}	Shelling %
SAU Test Cross 1	15.51	14.00 d	44.67 a	75.41 de
SAU Test Cross 2	14.63	13.33 f	39.00 b	74.48 f
SAU Test Cross 3	13.88	13.67 e	29.67 d	72.97 g
ARIZE	14.97	14.33 c	29.33 d	76.12 cd
Kaveri 50	13.47	13.00 g	35.33 c	78.53 a
SAU hybrid 1	14.03	13.33 f	30.67 d	76.48 c
SAU Test Cross 4	14.09	14.00 d	36.00 c	77.43 b
SAU Test Cross 5	14.29	13.33 f	34.33 c	75.17 e
ARIZE SUPER	15.45	15.33 b	34.67 c	76.87 bc
SAU hybrid 2	15.71	18.00 a	35.00 c	77.41 b
LSD$_{(0.05)}$	**NS**	**0.31**	**2.26**	**0.91**
CV (%)	**5.02**	**3.49**	**7.30**	**4.92**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.16 Number of rows cob^{-1}

Maize variety exhibited significant difference in respect of the no. of rows cob^{-1} (Table 4 and Appendix VIII). Among the varieties, SAU hybrid 2 maize variety showed the maximum no. of rows cob^{-1} (18.00) and Kaveri 50 maize variety showed the minimum no. of rows cob^{-1} (13.00). This is similar to the findings of Asghar *et al*. (2010) who found that the varieties did not differ significantly for number of rows cob^{-1}. Akter (2018) who reported that PSC−1

21 showed the superior performance in terms of number of grain row cob^{-1} over YANGNUO-3000. Islam (2015) conducted that KS-510 and PSC−1 21 both showed the similar no. of grain rows cob^{-1}.

4.17 Number of grains row $^{-1}$

Maize variety exhibited significant difference in respect of the no. of grains row^{-1} (Table 4 and Appendix VIII). Among the varieties, SAU Test Cross 1 showed the minimum no. of grains row^{-1} (44.67) and ARIZE showed the maximum no. of grains row^{-1} (29.33) which was statistically identical with SAU Test Cross 3 (29.67) and SAU hybrid 1 (30.67). This finding was similar to the findings of Mukhtar *et al*. (2011) and Asghar *et al*. (2010). However, Enujeke (2013) and Athar *et al.* (2012) found the different findings who found that the maize variety exhibited non-significant difference in respect of the no. of grains row^{-1}.

4.18 Shelling (%)

Due to different maize varieties, shelling percentage showed positively significant result (Table 4 and Appendix VIII). The shelling percentage range from 72.97 % to 78.53 % among the varieties. The highest shelling (78.53%) was recorded in Kaveri 50 variety and lowest (72.97%) was recorded in SAU Test Cross 3 line.

4.19 100-grains weight

100 grains weight in maize has a direct impact on the crop yield (Appendix IX). Figure 7 shows the effect of variety on 100 grains weight. A statistically significant difference among the varieties was found regarding the weight of grains per cob. Among the varieties, the maximum 100 grains weight (28.44 g) was found from SAU hybrid 2 variety. SAU Test Cross 3 line showed the

minimum 100 grains weight (22.14 g). The result was in line with that of Akbar *et al.* (2016). Mukhtar *et al*. (2011) and Asghar *et al*. (2010) found the different findings as they found that the varieties did not show any difference in producing 100-grain weight. Akter (2018) who reported that PSC-121 showed the superior performance in terms of 100 seed weight over YANGNUO-3000. Hasan *et al.* (2018) conducted that the highest 100-grain weight was observed in BARI hybrid maize 7. Ullah *et al*. (2016) was reported that the lowest 100-seed weight was recorded from Yangnuo-7 (24.33 g, other varieties showed 31.83–34.67 g).

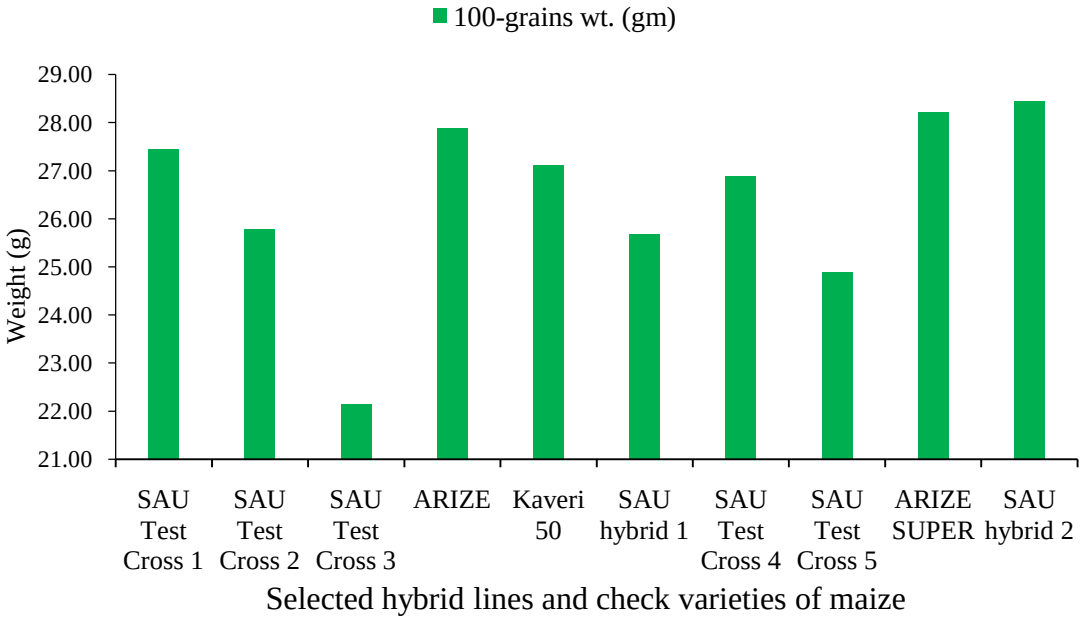


Figure 7: 100-grains weight of selected hybrid lines and check varieties of maize (LSD value = 0.21)

4.20 Grain yield

Maize variety exhibited significant difference in respect of grain yield (Table 5 and Appendix IX). Among the 5 maize lines and 5 varieties, SAU hybrid 2 showed the highest grain yield (13.18 t ha^{-1}). On the other hand, SAU Test Cross 3 showed the lowest grain yield (7.13 t ha^{-1}). This finding was at par with that of Akbar *et al* (2016) and Nazreen *et al.* (2018). Other varieties and lines showed intermediate result. Akter (2018) who reported that PSC-121 showed the superior performance in terms of grain yield over YANGNUO-

3000. Hasan *et al.* (2018) conducted that The maximum grain yield was observed from BARI hybrid maize-7. Khan *et al.* (2016) reported that among three hybrid maize varieties, grain yield was maximum in maize hybrid P-3025. Ishaq *et al.* (2015) conducted that the highest values for grain yield was recorded for Jalal-2003. Rahaman (2015) reported that the maximum grain yield was recorded in the genotype of DEKALB-9120, whereas the minimum grain yield was from the genotype of BHM-7.

Table 5: Yield parameters of selected hybrid lines and check varieties of maize

Variety	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index %
SAU Test Cross 1	12.92 b	13.00 a	25.92 a	49.85 f
SAU Test Cross 2	10.11 f	9.56 e	19.67 e	51.40 a
SAU Test Cross 3	7.13 j	9.26 f	16.39 h	43.50 i
ARIZE	9.27 g	10.28 c	19.55 e	46.41 g
Kaveri 50	10.40 e	9.98 d	20.38 d	50.03 e
SAU hybrid 1	8.37 i	9.88 d	18.25 g	45.86 h
SAU Test Cross 4	10.66 d	10.26 c	20.92 c	50.96 c
SAU Test Cross 5	8.79 h	10.40 c	19.19 f	45.81 h
ARIZE SUPER	11.30 c	11.16 b	22.46 b	50.31 d
SAU hybrid 2	13.18 a	12.58 a	25.76 a	51.16 b
LSD$_{(0.05)}$	**0.18**	**0.21**	**0.25**	**0.11**
CV (%)	**11.00**	**9.05**	**10.20**	**3.09**

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.21 Stover yield

Table 5 represents the effect of variety on stover yield. In case of stover yield, a significant difference between varieties was found (Appendix IX).SAU Test Cross 1 maize line showed the highest stover yield (13.00 t ha^{-1}) which was statistically similar with SAU hybrid 2 (12.58 t ha^{-1}) and SAU Test Cross 3 showed the lowest stover yield (9.26 t ha^{-1}). Nizarmuddin *et al.* (2010) who

reported that the effect of cultivars on stalk yield significantly differed and check variety produced the lowest stalk yield. Msarmo and Mhango (2005) conducted that variety DK8031 showed the highest biomass yield followed by local maize and then Masika.

4.22 Biological yield

Maize variety exhibited significant difference in respect of biological yield (Table 5 and Appendix IX). Among the varieties and lines, SAU Test Cross 1 showed the highest biological yield (25.92 t ha^{-1}) which was statistically similar with SAU hybrid 2 (25.76 t ha^{-1}) and SAU Test Cross 3 maize line showed the lowest biological yield (16.39 t ha^{-1}). Asghar *et al*. (2010) found the different findings as the varieties did not show any difference in producing biological yield. Mannan (2018) who reported that PSC-121 showed the superior performance in terms of biological yield over YANGNUO-3000.

4.23 Harvest index

Effect of variety on harvest index is shown in the Table 5. The experiment revealed that there was significant statistical difference between varieties regarding harvest index (Appendix IX). SAU Test Cross 2 maize line showed the maximum harvest index (51.40%). On the other hand, SAU Test Cross 3 maize line showed the minimum harvest index (43.50%). This is similar to the findings of Asghar *et al*. (2010) who found that the varieties did not show any difference in producing harvest index. This finding was at par with that of Mannan (2018) who also reported the maximum harvest index from PSC-121 (V2). Islam (2015) who reported that KS-510 showed the lowest harvest index whereas PSC-121 showed the highest harvest index. Asghar *et al.* (2010) conducted that the varieties Golden (34.19 %) and Sultan (33.75 %) did not show any differences for harvest index.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November 2019 to April 2020 in Rabi season for evaluation of genetic purity, growth and yield performance of maize (*Zea mays*). The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series.

The planting materials were five (5) maize varieties and five (5) maize lines.The SAU hybrid 1 and SAU hybrid 2 maize were collected from the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Five (5) maize lines *vis.*SAU Test Cross 1, SAU Test Cross 2, SAU Test Cross 3, SAU Test Cross 4 and SAU Test Cross 5 were collected from Sher-e-Bangla Agricultural University, Dhaka-1207. ARIZE maize variety were collected from the Nilsagor seed Co. (Pvt.) Ltd.Kaveri 50 maize variety were collected from the ACI Seed Co. Ltd. ARIZE SUPER maize variety were collected from the Nilsagor seed Co. (Pvt.) Ltd.

20 November 2019 was sowing date and 12 April, 2020 was harvesting date. The experiment was laid out in Randomized Complete Block Design (RCBD) single factor with three replications. Total 30 unit pots made for the experiment with 10 treatments. The size of each unit plot was 4.50 m^2(2.50 m × 1.80 m). Vermicompost was used @ 2 t ha^{-1} before final land preparation. The field was fertilized with nitrogen, phosphate,potash, sulphur, zinc and boron at the rate of 500-250-200-250-15-5 kg ha^{-1} ofurea, triple super phosphate, muriate of potash, gypsum, zinc sulphate andboric acid.

Data were collected on the following parameters-80% germination (DAS), 80% flowering (DAS), 80% cob formation (DAS), plant height (cm), cob height

from surface (cm), genetic purity (%), dry weight plant^{-1} (g), cob weight (g), husk weight (g), full cob weight (g), cob length with husk (cm), cob length without husk (cm), unfilled area of cob (cm), rachis weight (g), cob circumference (cm), rows cob^{-1} (no.), grains row^{-1} (no.), Shelling (%), 100 grains weight (g), grain yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%). The collected data were analysed by computer package program MSTAT-C software. The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability.

Different hybrids maize varieties and maize lines showed significant results on 80% germination, 80% flowering, 80% cob formation, plant height, cob height from surface, genetic purity, dry weight plant^{-1}, cob weight, husk weight, full cob weight, cob length with husk, cob length without husk, unfilled area of cob, rachis weight, number of rows cob^{-1}, number of grains row^{-1}, Shelling, 100 grains weight, grain yield, stover yield, biological yield and harvest index at harvesting stage except cob circumference.

SAU hybrid 1 took the maximum days (6.00days) for 80% germination whereas, the minimum days (3.00 days) was taken by SAU Test Cross 2. SAU Test Cross 5 took the highest days (102.67 days) for 80% flowering and the minimum days (92.00 days) was taken by SAU Test Cross 2. SAU Test Cross 5 took the maximum days (104.67days) for 80% cob formation whereas, the minimum days (95.00 days) was taken by SAU Test Cross 2. SAU Test Cross 1 showed the tallest plant (249.90, 255.50 and 255.70 cm at 110, 125 and 140 DAS, respectively) and SAU Test Cross 5 showed the shortest plant (190.50, 191.50 and 191.50 cm at 110, 125 and 140 DAS, respectively). SAU hybrid 1 showed the highest cob height from surface (133.03 cm) over SAU Test Cross 2, which showed cob height from surface of 75.67 cm. SAU hybrid 1 showed the highest genetic purity (100.00%); whereas SAU Test Cross 2 showed the lowest genetic purity (97.22%). SAU Test Cross 1 showed the highest dry weight plant^{-1} (115.55 g) and SAU Test Cross 2 showed the lowest dry weight

plant^{-1} (89.78 g). SAU Test Cross 1 showed the maximum cob weight (208.83 g) and SAU Test Cross 3 showed the minimum cob weight (109.73 g). SAU Test Cross 1 showed the maximum husk weight (26.39 g) and SAU Test Cross 3 showed the minimum husk weight (12.60 g). The highest full cob weight (235.22 g) was recorded from SAU Test Cross 1 line and the lowest (122.33 g) was recorded fromSAU Test Cross 3 line. The maximum cob length with husk (23.97 cm) was reported from SAU Test Cross 1 over SAU Test Cross 5, which showed the cob length of about 19.18 cm. The maximum cob length without husk (19.90 cm) was recorded from SAU Test Cross 2. The lowest length of cob without husk (13.67 cm) was recorded from SAU Test Cross 3.SAU hybrid 1 showed the maximum unfilled area of cob (2.29 cm) and ARIZE SUPER showed the minimum area (0.69 cm). The highest rachis weight (30.11 g) was recorded from SAU Test Cross 1 line and the lowest (19.23 g) was recorded from SAU hybrid 1. SAU hybrid 2 maize variety showed the maximum no. of rows cob^{-1} (18.00) and Kaveri 50 maize variety showed the minimum no. of rows cob^{-1} (13.00). SAU Test Cross 1 showed the maximum no. of grains row^{-1} (44.67) and ARIZE showed the minimum no. of grains row^{-1} (29.33). The highest shelling (78.53%) was recorded in kaveri 50 variety and lowest (72.97%) was recorded in SAU Test Cross 3 line. The maximum 100 grains weight (28.44 g) was found from SAU hybrid 2 variety and SAU Test Cross 3 line showed the minimum (22.14 g). SAU hybrid 2 showed the highest grain yield (13.18 t ha^{-1}) and SAU Test Cross 3 showed the lowest grain yield (7.13 t ha^{-1}). SAU Test Cross 1 maize line showed the highest stover yield (13.00 t ha^{-1}) and SAU Test Cross 3 showed the lowest stover yield (9.26 t ha^{-1}). SAU Test Cross 1 showed the highest biological yield (25.92 t ha^{-1}) and SAU Test Cross 3 maize line showed the lowest biological yield (16.39 t ha^{-1}). SAU Test Cross 2 maize line showed the maximum harvest index (51.40%) and SAU Test Cross 3 maize line showed the minimum harvest index (43.50%). The results obtained from all other treatments showed intermediate results compared to the highest and the lowest value of all growth and yield parameters.

Conclusion:

Based on the experimental results, it may be concluded that

1. Maize variety SAU hybrid 1was genetically the most pure variety which was closely followed by SAU hybrid 2 among the tested genotypes from the present study.
2. In case of yield, maize variety SAU hybrid 2 performed better than all of the other varieties, which was followed by maize line SAU Test Cross 1 and can be treated as the better genotype among the ten varieties from the present study.

Recommendations

The present experiment was conducted only one season and in a single location. Therefore, it is difficult to recommend these findings without further study. By considering the results of the present experiment, further studies in the following areas are suggested below:

1. Studies of similar nature could be carried out in different Agro Ecological Zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.
2. Studies of similar experiment could be out in different seasons of Bangladesh for the evaluation of seasonal adaptability.

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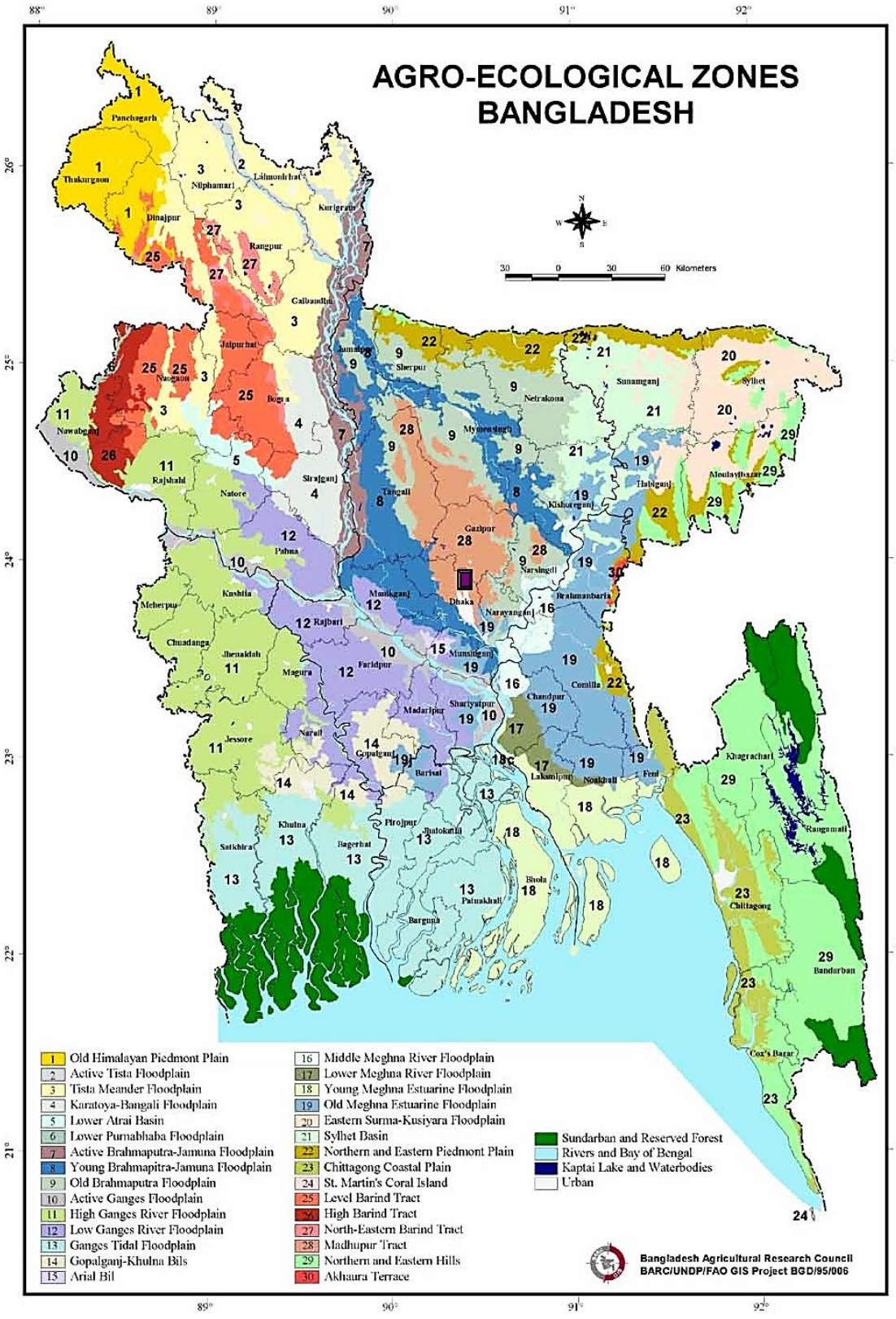
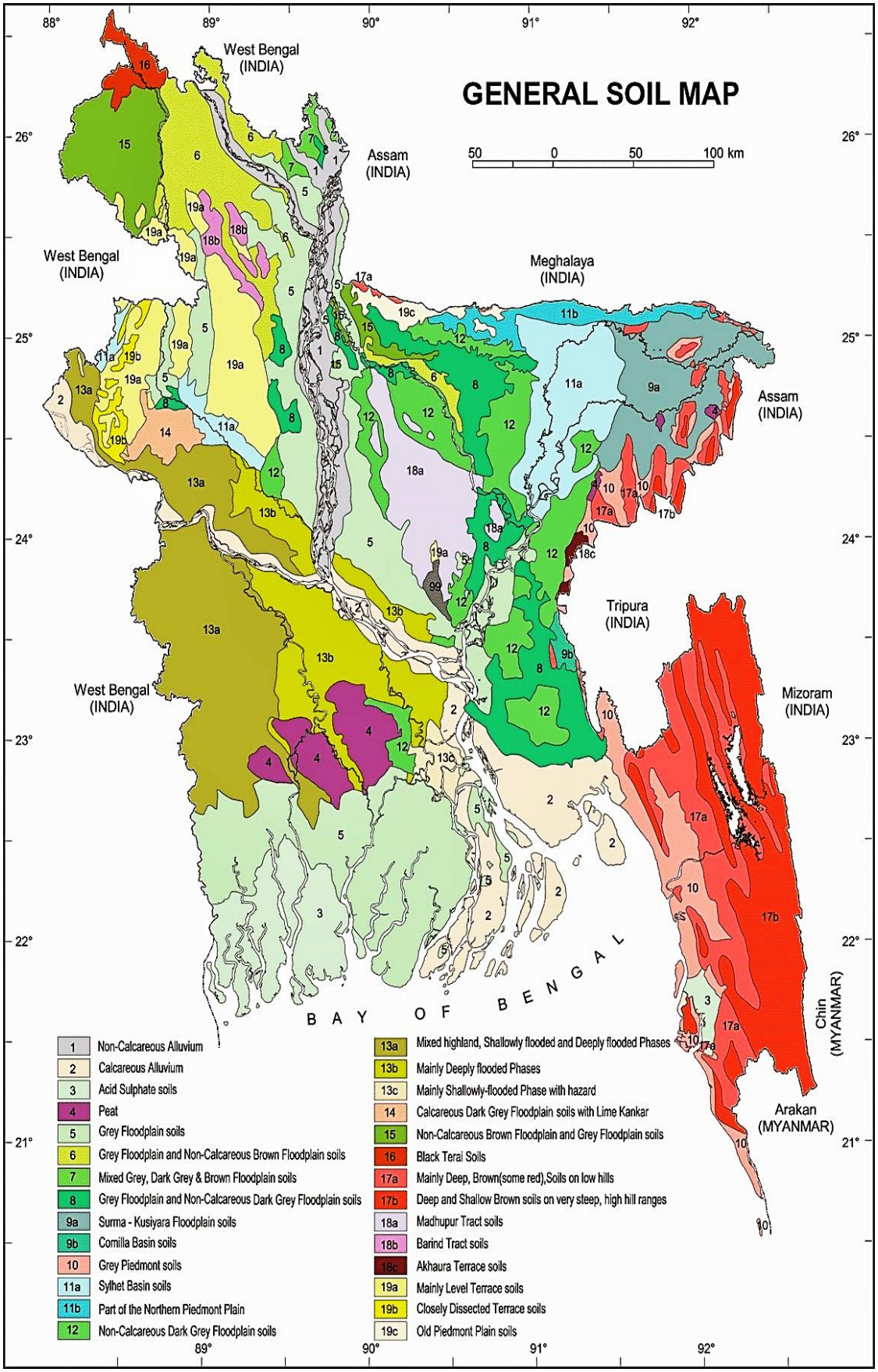
APPENDICES

Appendix I: (A) Map showing the experimental sites under study



The experimental site under study

Appendix I (B): Map showing the general soil sites under study



Appendix II: Characteristics of Agronomy Farm soil is analysed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly levelled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Potato-Aman rice-Maize

B. Physical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30

C. Chemical properties of the initial soil

Characteristics	Value
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (meq 100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI), 2018.

Appendix III: Monthly average temperature, relative humidity and total rainfall of the experimental site during the period from November 2019 to April 2020

Month	Air temperature (^{0}C)		R. H. (%)	Total rainfall (mm)
	Maximum	Minimum		
November, 2019	34.20	18.25	77	35
December, 2019	28.42	15.50	69	8
January, 2020	23.60	11.42	65	5
February, 2020	22.26	9.30	68	9
March, 2020	24.39	16.39	81	56
April, 2020	31.29	24.39	87	125

Source: Bangladesh Metrological Department (Climate and weather division) Agargaon, Dhaka.

Appendix IV: Analysis of variance (ANOVA) of data on 80% germination, 80% flowering and 80% cob formation as influenced by hybrid maize varieties and maize lines

Source of variation	Df	80% germination	80% flowering	80% cob formation
Replication	2	6.181	33.348	31.589
Variety	9	9.373*	62.132*	68.365*
Error	18	1.396	4.802	6.594

*Significant at 5% level of probability

** Significant at 1% level of probability; df = Degrees of freedom

Appendix V: Analysis of variance (ANOVA) of data on plant height at different days after sowing (DAS) and at harvest as influenced by hybrid maize varieties and maize lines

Source of variation	df	Plant height								
		20 DAS	35 DAS	50 DAS	65 DAS	80 DAS	95 DAS	110 DAS	125 DAS	140 DAS
Replication	2	0.522	7.809	15.098	6.057	8.034	12.835	9.273	5.382	8.353
Variety	9	23.581*	22.255*	81.412*	104.095*	153.733*	197.382*	243.380*	265.922*	273.619*
Error	18	0.099	0.843	2.125	0.302	0.475	3.293	0.402	0.825	1.263

*Significant at 5% level of probability

** Significant at 1% level of probability; df = Degrees of freedom

Appendix VI: Analysis of variance (ANOVA) of data on cob height from surface, genetic purity and dry weight plant^{-1} as influenced by hybrid maize varieties and maize lines

Source of variation	df	Cob height from surface	Genetic purity	Dry weight plant^{-1}
Replication	2	0.055	0.002	0.314
Variety	9	23.264*	28.620*	24.680*
Error	18	0.022	0.001	0.051

*Significant at 5% level of probability

** Significant at 1% level of probability; df = Degrees of freedom

Appendix VII: Analysis of variance (ANOVA) of data on cob weight, husk weight, full cob weight, cob length with husk and cob length without husk as influenced by hybrid maize varieties and maize lines

Source of variation	df	Cob weight	Husk weight	Full cob weight	Cob length with husk	Cob length without husk
Replication	2	0.095	0.003	0.005	0.172	0.007
Variety	9	5.955*	2.668**	10.067*	6.282*	6.180*
Error	18	0.022	0.001	0.001	0.065	0.003

*Significant at 5% level of probability

** Significant at 1% level of probability; df = Degrees of freedom

Appendix VIII: Analysis of variance (ANOVA) of data on unfilled area of cob, rachis weight, cob circumference, number of grain rows $^{-1}$, number of grains row^{-1} and shelling % as influenced by hybrid maize varieties and maize lines

Source of variation	Df	Unfilled area of cob	Rachis weight	Cob circumference	No. of rows cob^{-1}	No. of grains rows^{-1}	Shelling %
Replication	2	0.002	0.037	0.509	0.030	0.214	0.282
Variety	9	122.636*	52.104*	0.959**	16.818*	110.026*	32.292*
Error	18	0.036	0.020	0.001	0.107	1.717	0.926

*Significant at 5% level of probability

** Significant at 1% level of probability; df = Degrees of freedom

Appendix IX: Analysis of variance (ANOVA) of data on 100 grains yield, grain yield, stover yield, biological yield and harvest index as influenced by hybrid maize varieties and maize lines

Source of variation	df	100 grains weight	Grain yield	Stover yield	Biological yield	Harvest index
Replication	2	0.001	0.001	0.004	0.031	3.023
Fertilizer dose (A)	3	0.362**	0.166**	0.092**	113.866*	37.951*
Error	22	0.001	0.001	0.001	0.357	1.351

*Significant at 5% level of probability

** Significant at 1% level of probability; df = Degrees of freedom

Some Plates of my research work

Plate 1: Field view of Experimental plot at SAU farm

Plate 2: Net given to prevent bird damage of experimental plots

Plate 3: Maize plants at reproductive stage

Plate 4: Measuring of cob height from soil surface

Plate 5: Cross-section of cob showing rachis, grain color & formation of ARIZE SUPER

Plate 6: Cross-section of cob showing rachis, grain color & formation of SAU Hybrid 1