RESPONSE OF LOCAL MAIZE VARIETIES TO DIFFERENT DOSES OF FERTILIZER APPLICATION

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CERTIFICATE

*This is to certify that the thesis entitled "**RESPONSE OF LOCAL MAIZE VARIETIES TO DIFFERENT DOSES OF FERTILIZER APPLICATION**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) IN AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MANNAN MIAH**, **Registration No.14-06214** 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 during the course of this investigation has duly been acknowledged.

Dated:

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Dedicated To

My Beloved Parents

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The Author

RESPONSE OF LOCAL MAIZE VARIETIES TO DIFFERENT DOSES OF FERTILIZER APPLICATION

ABSTRACT

An experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Dhaka during November 2019 to April 2020 to examine the response of local maize varieties to different doses of fertilizer application. The experiment comprised of two doses of fertilizer (*viz*. 100% and 50% of the recommended for the composite varieties designed as F_{100} and F_{50}) and eight local maize varieties named according to the grain colour (White, Yellowish, Yellow, Reddish, Red, Blackish-red, Black-bold, and Black-small). The experiment was laid out in Split Plot Design with three replications. The main plot was used for fertilizer doses and sub plot was used for varieties. Data was taken on plant height, no of leaves plant^{-1}, leaf area, base circumference, cob distance, dry weight, cob number plant^{-1}, cob length, number of grains cob^{-1}, grain weight cob^{-1}, 100-grain weight, grain yield, stover yield, biological yield and harvest index. The fertilizers and varieties showed significant differences in almost all the plant parameters. The fertilizer treatments did not show significant difference in terms of grain yields. The variety yellowish, yellow and blackish-red showed statistically similar grain yields (5.2-5.46 t ha^{-1}). Likewise, the interaction of fertilizer and variety had significant differences. The interaction of F_{50} with the varieties White, Yellowish, Yellow, Reddish and Red showed seed yields which were at par but significantly higher over others showing the range between (5.300-5.500 t ha^{-1}). The lowest grain yield was obtained with F_{100}Black-small (3.40 t ha^{-1}).

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ABBREVIATIONS AND ACRONYMS

Abbreviations		Full Meanings
%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
Cm^2	=	Centimeter Square
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DF	=	Degrees of Freedom
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
Fig.	=	Figure
g	=	Gram (s)
HI	=	Harvest Index
i.e.	=	That is
Kg	=	Kilogram (s)
L	=	Liter
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	Milligram
mL	=	Milliliter
No.	=	Number
^oC	=	Degree Celsius
$	=	Dollar
SAU	=	Sher-e-Bangla Agricultural University

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CHAPTER I

INTRODUCTION

Maize ranks third worldwide among the cereals, next to rice and wheat (Cassman *et al*., 2010). But in Bangladesh, maize holds the second position after rice and is followed by wheat in terms of both land coverage and production (Sarwar and Biswas, 2021). Although maize was first incepted almost 60 years ago for research purposes, in 1960 (Karim, 1992), it is still a new crop in Bangladesh (Ullah *et al*., 2017). It is a short duration, quick growing and widely grown crop with high potential, there are no cereal crops with such an immense potentiality, so it is called as "queen of cereals" (Begam *et al*., 2018). It is a multipurpose traditional crop generally grown for food, feed and fodder (KC *et al.*, 2015).

Though the maize revolution came hand in hand with the rise of the poultry and fish feed industry, the government is now trying to promote maize not just as a feed crop, but also as a food crop. Maize has two distinct uses in Bangladesh. It is a major ingredient in feed for livestock and fish, and for humans it is used for popcorn and corn flour. A recent report of the Food and Agriculture Organization (FAO) of the United Nations stated that a few companies in Bangladesh has started producing corn starch for industrial purposes. While farmers hardly make any profit by cultivating investment-intensive winter rice, Boro, their profit from maize is quite significant. Over 3,000 liters of water are required for every kilogram of Boro output, but maize requires only 700 liters. In a 2016 report, the United States Department of Agriculture (USDA) had mentioned that farmers in Bangladesh earned over $2,275 by investing $1,421 for every hectare of maize while Boro fetched them $1,081 against an investment of $1,319. According to FAO, the gross margin from maize sales, per hectare, is 2.4 times greater than that of wheat or rice. Maize also has fewer pest and disease problems. It also notes, by shifting from rice to maize during the dry season, farmers save groundwater from over-exploitation (Dhaka Tribune, 2020). Maize is considered as nutritious food/feed as it contains about 72% starch, 10% protein, 9.5% fiber, 4% fat and supplies energy density of 365 Kcal/100 g (Nuss & Tanumihardjo, 2010).

In 2004-05 the total amount of land under maize cultivation was 165 thousand acres. After the period, the figure increased dramatically. In 2019-20, the total acreage of land under maize cultivation peaked at 1166 thousand acres (Bangladesh Bureau of Statistics, 2021). The world's total maize production was estimated at 1.06 million thousand tonnes in 2020 (Knoema, 2021a). In 2020, maize production for Bangladesh was 4,700 thousand tonnes. Over the last 10 years, maize production of Bangladesh grew substantially from 1,954 to 4,700 thousand tonnes rising at an increasing annual rate that reached a maximum of 17.14% in 2019 and then decreased to 14.63% in 2020 (Knoema, 2021a).

Maize being a high nutrient mining crop it needs a higher amount of NPK for its economic production (Adhikary *et al*., 2020).

Most of the maize varieties being growth currently are hybrids and re used in poultry or livestock industry. There is another group (land races) of maize which is still being used as human food in the hilly areas of Bangladesh. These local land races has a number of genotypes having varying seed colors, seed size, and productivity which are not yet assessed or evaluated. These varieties may be suited to plain land as well as more productive land races needs to be selected to raise the profit of the hilly peoples.

Varieties also play an important role in crop yield. Cultivars suited to particular agro-ecological regions, season, purpose, and maturity should be selected to get optimum yield (Zaidi *et al*., 2017). Hybrid and improved maize varieties are more nitrogen-responsive than local varieties of maize (Shrestha *et al*., 2018). According to fertilizer recommendation guide-2018, the amount of fertilizer to be applied is determined most importantly whether the varieties are local or hybrid. The amount of recommended dose of nitrogen fertilizer for local variety is much lower than that of hybrid variety (Fertilizer recommendation guide, 2018).

In the recent times in Bangladesh, most of the fertilizer-variety interaction researches are conducted on understanding the response hybrid maize varieties on different doses of different fertilizers. Very few researches are carried out to explore the response of local maize varieties to different doses of nitrogen fertilizer. The huge yield gap of local maize varieties with the modern and hybrid varieties, less understanding of the effect of N fertilization on soil properties and crop physiology, and unexplored potentiality of the different local maize varieties used in the experiment have formulated the demand of conducting the research. Therefore, the current research was performed keeping the following objectives into consideration:

1) Exploring the best local maize variety (s) in terms of producing grain yield
2) Find out the appropriate dose of fertilizers to be applied in the local maize to obtain higher yields
3) Determining the best interaction of fertilizer dose and local maize variety in terms of yield productivity

CHAPTER II

REVIEW OF LITERATURE

In industrialized countries maize is mainly used as livestock feed and as a raw material for industrial products, while in many developing countries, it is mainly used for human consumption. Maize is eaten mainly as second cycle produce in the form of meat, eggs and dairy products. The crop has great potentiality for supporting food stuff of the huge population of Bangladesh in the near future when other crop's contribution will fall due to climate change. However, a huge number of research reports so far published on this crop have been reviewed and some of the reviews related to the topic have been elaborated below:

2.1 Biology of maize

Maize or corn (*Zea mays* L.) is a plant that belongs to the family *Poaceae*. It is an emblematic tropical plant having a tall, leafy structure with a fibrous root system, supporting a single culm with as many as 30 leaves. It is susceptible to invasion by weeds *(*Paliwal, 2000*)*.

Maize is a plant of the tribe Maydeae of the grass family *Poaceae*. "*Zea*" (zeal) evolved from an ancient Greek name for a food grass. The genus *Zea* is composed of four species of which *Zea mays* L. is commercially important. The other species are referred to as teosintes, are largely wild grasses endemic to Mexico and Central America. The number of chromosomes in *Z. mays* is 2n = 20 (Tripathi *et al.*, 2011).

Maize plants have staminate spikelets in long spike-like racemes that form terminal panicles (tassels) and pistillate inflorescence. Spikelets occur in 8 to 16 rows in the inflorescence, approximately 30 cm long. The complete structure (ear) is covered by numerous broad foliaceous bracts and a mass of long styles (silks) evolving from the tip as a mass of silky threads (Biology Documents, 2014).

Maize develops inflorescences with unisexual flowers which are always borne in different parts of the plant. The female inflorescence is known as ear that arises from the axillary bud apices and the male inflorescence is known as tassel that develops from the apical growing point at the top of the plant (Mienwipia, 2013). Paliwal (2000), however, revealed that maize resembling other plants tends to maintain homeostasis symmetry between the roots mass and shoot mass. If a soil-acquired resource, such as water or nutrients is insufficient or deficit, more assimilate goes to the root system, and root growth is preferred over shoot growth. Likewise, if radiation is insufficient for growth as a result of shading or cloudy conditions more assimilate become allotted for shoot growth and the root to shoot ratio declines.

2.2 Ecology of maize

Maize can be grown in a wide range of climates. In world aspects, it is sown at the beginning of the rain, but due to its wide variation an adaptation capability, the crop flowers at different times depending on the cultivar selected. Some of the cultivars mature as early as 60 days after emergence while others need over 40 weeks. Maize will perform well on most textural soils, particularly a nutrient rich soil with adequate drainage to allow for the maintaining sufficient oxygen for good root growth and activity, and necessary water-holding capacity to provide adequate moisture throughout the growing period with a pH ($CaCl_2$) in the range of 5.5 and 7.0 (Farrell and O’Keeffe, 2007).

Maize is mainly grown in a warm weather condition and it can withstand a wide range of climatic conditions. Maize can be cultivated in areas having a well distributed annual precipitation of 60 cm throughout its growing stages. More than 50% of total water requirements of maize is needed in about 30 to 35 days following tasseling. A poor yield and shriveled grain in maize may be found if soil moisture is inadequate at grain filling stage. It cannot tolerate frost irrespective of its growth stages. A cloudy period for long time may damage the crop but a alternate fashion of sunlight and clouds of rain may favor the crop growth. In the subcontinent, maize is normally grown in Kharif season due to the availability of high temperature and rain required for optimum growth and of maize. However, due to the introduction of new verities and advanced crop production technology, maize now most popularly is grown in winter (Rabi) season (Tripathi *et al.*, 2011).

2.3 Performance of fertilizer

Hammad *et al.* (2012) conducted an experiment on optimization of water and nitrogen use for maize production under semiarid conditions. In the experiment, they used five doses of nitrogen (0, 75, 150, 225, and 300 Kg ha^{-1}). The results revealed that the N treatments significantly affected growth and development of the crop plants. Photosynthesis and transpiration rates were influenced by the applied nutrients. The N application at 225 Kg ha^{-1} resulted in maximum values for photosynthesis (26.90 and 27.63 μmol m^{-2} s^{-1} during 2009 and 2010, respectively) and transpiration (5.23 and 5.43 m mol $m^{-2}s^{-1}$ during 2009 and 2010, respectively). The highest values for leaf area index (4.93) and grain yield (8.40 t ha^{-1}) were also recorded at this N treatment during both growing seasons. On the other hand, the mean crop growth rate (19.23 g m^{-2} day^{-1}) and biological yield (16.22 t ha^{-1}) were achieved with the 300 kg N ha^{-1} treatments in 2009 and 2010. Nitrogen use efficiency (NUE) was optimum at 75 kg N ha^{-1} during both seasons. The highest water use efficiency (WUE) (16.48 and 18.64 kg ha^{-1} mm^{-1} during 2009 and 2010, respectively) was achieved by application of 225 kg N ha^{-1} with an irrigation water depth of 525 mm during both growing seasons. So, from the experiment it can be inferred that mere increment in nitrogen doses does not result in an increment in yield and yield attributing characters as of 300 Kg N ha^{-1}; it needs an optimum dose like 75 Kg ha^{-1} for optimum nitrogen use efficiency and 225 Kg ha^{-1} for optimum yield.

Maize response to high nitrogenous fertilization levels is a means among other means to reduce the gap between its production and consumption, from this perspective, a field nitrogen management trial using four N levels (214, 286, 357 and 429 75 kg N ha^{-1}) was conducted during 2011 and 2012 seasons. Results of this study indicated that all the N fertilization levels showed such significant effects on maize growth, crop yield and its components. The maximum plant height, leaf area index (LAI), chlorophyll SPAD unit, number of rows cob^{-1} , number of kernels row^{-1}, number of kernels cob^{-1}, 1000 grain weight, stover, grain, biological yields, harvest index and protein content were produced by the application either 429 or 357, 75 kg N ha^{-1} (Kandil., 2013).

The rate, time and method of nitrogen (N) fertilizer application are strongly related to growth, development, and yield of the crop. The study principally focuses on the role of the nitrogen in growth, development, and production of the maize, emphasizing time and methods of fertilizer application and their suitable rates. The review shows that crop yield increases up to certain limit and declines if applied in an excess amount of nitrogen. Nitrogen affects various physiological and biochemical processes in plant cells that ultimately affect the growth and development of the plant. Nitrogen response by maize differs due to growth stages, environment and genotype of maize. Hybrid and improved maize varieties are more nitrogen-responsive than local varieties of maize. Proper nitrogen applications as basal doses at planting stage, split doses at critical growth stages namely knee high, and flowering stages are necessary for higher grain yield. This review serves as a useful tool to maize researchers and growers for making the right decision on nitrogen application on maize (Shrestha *et al.,* 2018).

Poor yield of maize has been attributed to low soil N since maize requires high Nitrogen for optimum productivity. Field experiments were conducted in the late season of 2014 at IITA, Research Farms, in Ibadan and Mokwa. The research was to evaluate the effects of split N fertilizer on nitrogen use efficiency of extra early maize varieties. Arrangement was 5 x 8 factorial fitted into Randomized Complete Block Design, with four replications. Extra early maturing maize varieties (2013 TZEE-W DT STR, TZEE-Y Pop STR C4, TZEE-W Pop STR C5, 2013 TZEE-Y DT STR, and 99 TZEE-Y STR QPM) with Nitrogen fertility rates (0 kg N ha^{-1} (Control), 30 kg N ha^{-1} single, 60 kg N ha^{-1} single, 60 kg N ha^{-1} split (30:30) applied at 2 and 4 weeks after sowing (WAS), 90 kg N ha^{-1} split 60:30 applied at 2 and 4 WAS, 90 kg N ha^{-1} split (30:30:30) applied at 2, 4 and 6 WAS, 120 kg N ha^{-1} split (60:60) applied at 2 and 4 WAS and 120 kg N ha^{-1} split (30:60:30) applied 2, 4 and 6 WAS). Data collected were subjected to Analysis of Variance procedure and significant means were separated using Duncan's Multiple Range Test at $p<0.05$. Results showed that maize variety 2013 TZEE-W DT STR produce highest number of leaves, plant height, leaf area, cob yield (3.33, 3.15 t ha^{-1}), grain yield (2.57, 2.38 t ha^{-1}) and Nitrogen use efficiency (33.03, 28.95%) at Mokwa and Ibadan respectively. Split application of 90 kg N ha^{-1} as (60:30) at 2 and 4 WAS produce significantly ($p<0.05$) higher 1000 grain weight, cob yield (3.90, 3.73 t ha^{-1}) and grain yield (2.99, 2.80 t ha^{-1}) at Mokwa and Ibadan respectively. The control produced significantly reduced dried cob and grain yield by (85, 81%) and (84.4, 80.4%) in Mokwa and Ibadan respectively, compared to the best rate of 60:30 split N application. The N application of 30 kg N ha^{-1} as single dose had the highest Nitrogen use efficiency (51.3, 43.0 %) in both Mokwa and Ibadan, which was significantly different ($p<0.05$) from the rest treatments. Across the varieties used in both locations, Mokwa agro-ecology zone proved to be a favorable location for higher yield of extra early maize varieties. The study concluded that application of 30kgN ha^{-1} at two weeks after sowing efficiently improved extra early maize varieties and is thus recommended as low input package for resource poor farmers (Olaiya *et al.,* 2020).

Caires *et al.* (2012) carried out an experiment to study the effects of organic and mineral fertilizers at sowing (without fertilizers, organic poultry litter fertilizer on the surface and mineral NK + reactive natural phosphate from Arad and NK +triple superphosphate in the furrow) and topdressing (without fertilizers, organic poultry litter fertilization and urea) on chemical attributes of a no-till Oxisol and nutrition and yield of maize landrace (*Zea mays* L.), Carioca variety in a field experiment. Results revealed that P content (Mehlich 1 and resin) was increased in the soil surface layer with organic poultry litter fertilizer on the surface at sowing. Mineral fertilizer in the sowing furrow could be replaced by organic fertilizer with poultry litter on the surface, but topdressing fertilization with urea resulted better N nutrition for the plants and higher grains yield than the organic poultry litter fertilization.

Reduction of soil fertility from year to year due to natural and human made factors is a serious constraint for crop production in Ethiopia. Therefore, the application of actual balanced recommended fertilizer rates based on soil and crop type is one of the best agronomic practices to maximize production. A field experiment was conducted for two consecutive years to evaluate the response of growth, yield components, and yield of hybrid maize varieties to newly introduced blended NPS and N fertilizer rates. The experiment was comprised of three blended NPS and N levels tested on two hybrid maize varieties. Results showed that individual application of 150 kg NPS and 130.5 kg N gave maximum above-ground biomass yield. The highest grain yield was obtained from variety BHQPY545 where plots fertilized with the higher N application rate (87 kg) in 2019 cropping season. Besides, combined fertilizer application of 150 kg NPS by 87 kg N was produced the highest grain yield (10.7 t ha^{-1}) and closely (10.4 t ha^{-1}) followed by combined fertilizer application of 150 kg NPS by 130.5 kg N in 2019 season. According to partial budget analysis, the highest net benefit (85458.0 ETB) with a higher marginal rate of return (1658.6%) was obtained from the combined application of 150 kg NPS with 87 kg N in 2019. Based on this result, it can be concluded that using of combined application of 150 kg NPS with 87 kg N in the study area and other similar agro-ecologies is agronomically optimum and economically feasible levels to maximize maize production (Belay and Adare., 2020).

Studies pertaining to the effect of different nitrogen rates on the yield and yield components of maize cultivars (Azam and Jalal), was conducted at the new developmental form of The University of Agriculture Peshawar, during summer 2011 using Randomized Complete Block Design (RCBD) with split plot arrangement. The treatments comprised 0, 30, 60, 90, 120, 150, 180 and 210 kg N ha^{-1} assigned to main plot and maize cultivars (Azam and Jalal) to sub plots. Results revealed that maximum grain ear (383.2), grain yield (3747.41 kg ha^{-1}) and harvest index (27.66%) were recorded in Azam cultivar. However, maximum ear length (16.33 cm), biological yield (14250 kg ha^{-1}) and thousand grain weight (258.65 g) were observed in Jalal cultivar. Maximum biological yield (16277.78 kg ha^{-1}) was recorded with the application of 180-210 kg N ha^{-1}. However maximum ear length (17.18 cm), grain ear (411.32), grain yield (4888.9 kg ha^{-1}) and thousand grain weight (264.96 g) were observed with the application of 180 kg N ha^{-1} (Ahmad *et al.*, 2018).

A field experiment was conducted at Malakandher Research Farm, NWFP Agricultural University, Peshawar, Pakistan to study the response of maize to planting methods and fertilizer N levels during spring 2004. Two planting methods (ridge and flat) and five levels of nitrogen (0, 80, 120, 160, and 200 kg N ha^{-1}) were applied. The experiment was laid out in well prepared field using RCBD design with split arrangement having four replications. Sowing methods were allotted to main plots while nitrogen levels were allotted to split-plots. Days to 50% tasseling and silking were significantly affected by planting methods and nitrogen levels. Maximum days to 50 % tasseling and 50 % silking were recorded in the treatment of 200kg N ha^{-1} when compared with other treatments. Maximum number of leaves $plant^{-1}$, number of cobs $plant^{-1}$, number of grains $cobs^{-1}$, taller plants, grain and biological yield was recorded in ridge planting and application of 200kg N ha^{-1} when compared with other treatments. It can be concluded from these results that ridge planting method and fertilizer N at the rate of 200kg ha^{-1} produced economical crop of maize under climatic conditions of Peshawar valley (Bakht and Ahmad, 2006).

Most maize (*Zea mays* L.) in the tropics is grown under low-nitrogen (N) conditions, raising the need to assess efficient breeding strategies for such conditions. This study assesses the value of low-N vs. high-N selection environments for improving lowland tropical maize for low-N target environments. Fourteen replicated trials grown under low (no N applied) and high (200 kg N ha^{-1} applied) N at CIMMYT, Mexico, between 1986 and 1995 were analyzed for broad-sense heritability of grain yield, genetic correlation between grain yields under low and high N, and predicted response of grain yield under low N to selection under either low or high N, Broad-sense heritability's for grain yield under low N were on average 29% smaller than under high N because of lower genotypic variances under low N, Error variances were similar at low and high N, Genetic correlations between grain yields under low and high N were generally positive, They decreased with increasing relative yield reduction under low N, indicating that specific adaptation to either low or high N became more important the more low-N and high-N experiments differed in grain yield. Selection under high N for performance under low N was predicted significantly less efficient than selection under low N when relative yield reduction due to N stress exceeded 43%, Maize breeding programs targeting low-N environments in the tropics should include low-N selection environments to maximize selection gains (Bänziger, *et al*., 1997).

Field trials were conducted for three years on the response of maize to nitrogen (N), phosphorus (P), and potassium (K) fertilizers on Oyo Soil Series (Arenic Haplustalf) and Iregun series (Aquic Haplustalf) in the derived savanna and southern guinea savanna zones of Nigeria, respectively. Nitrogen fertilizer as granulated urea at rates 0–300 kg N ha^{-1}, P fertilizer as single superphosphate at rates 0–120 kg P ha^{-1}, and K fertilizer as muriate of potash at rates 0–180 kg K ha^{-1} were used for the different nutrient combinations. The base rates for N, P, and K were 100 kg N ha^{-1}, 40 kg P ha^{-1}, and 60 kg K ha^{-1}, respectively. The results of the trials showed that annual application of the blanket recommended N, P, and K rates to maize grown under intensive land use system could not produce optimum yield. Fertilizer efficiency varied along with soil test values from year to year. The highest response by maize in these zones was to N, the optimum rate ranged from 50–100 kg N ha^{-1}. Application of high rates of P and K fertilizers on soils with fairly sufficient nutrient level showed no significant effect on maize yield. But when P and K were applied at low rates (20 kg P ha^{-1} and 30 kg K ha^{-1}), their contents in the leaf and maize yield, in most cases, increased significantly. The results, however, showed that N, P, and K recommendations for optimum maize yield in both zones are 50–100 kg N ha^{-1}, 20 kg P ha^{-1}, and 0–30 kg K ha^{-1}, respectively (Adediran and Banjoko, 1995).

Hnamte *et al.* (2016) conducted an experiment on effect of NPK fertilizer on growth and yield of maize under different jhum cycles in Mizoram. Intensive jhum cultivation is the biggest ecological threat due to its associated problems such as biodiversity loss, deforestation, soil erosion and the gradual reduction of land productivity in Mizoram. The intrinsic practice of jhum cultivation still dominated the farming system in Mizoram to a large margin. Four levels of nitrogen, phosphorus and potassium soil fertilizer application in local maize variety was conducted in 2 years, 3 years and 5 years jhum cycles. Strong significant ($P<0.05$) response to fertilizer application occurred in the growth and yield performance of maize. Different period of jhum cycles also had significant ($P<0.05$) effect in growth and yield with highest productivity in longest jhum cycle. Taking account of the poor soil nutrient content and the acidic soil in Mizoram, application of urea at lower rate under longer jhum cycle may be adopted.

Abebe *et al.* (2017) conducted an experiment on effects of nitrogen rates and time of application on yield of Maize: rainfall variability influenced time of N application. Nitrogen rate and time of application are among the major abiotic factors limiting the productivity of the crop. Because of such gaps, the experiment was conducted at bako agricultural research center in 2013 and 2014 cropping seasons to determine optimum N rate and time of application. Four levels of N rates (46, 69, 92, and 115 N kg ha^{-1}) and four levels (T_1, T_2 , T_3 and T_4) of different time of N application were arranged in factorial combinations. Moreover, previously recommended N and the control were arranged in a randomized complete block design with three replications. In 2013, the highest significant biomass yield(21.2 t ha^{-1}) was obtained at 115 N kg ha^{-1} and T_4 followed by 69 N kg ha^{-1} at T_1 and T_2 and 92 N kg ha^{-1} at T_2. In contrast, the highest grain yield in 2013 was obtained at 92 N kg ha^{-1} at T_2 followed by 115 N kg ha^{-1} at either T_2 or T_4 and 69 N kg ha^{-1} at either T_1 or T_3 application time. Interestingly, a significant yield increase by 37% was obtained when 92 N kg ha^{-1} at the time of T_2 was applied compared to previous recommended 110 N kg ha^{-1} rate and time of application. In 2014, however, the highest yield was recorded when 92 N kg ha^{-1} at T_1 was used. Application of 46 N kg ha^{-1} at T_2 showed statistically similar yield performance when compared with previous n recommendation. The lowest yield was recorded from the control plot in both years. In 2013, the maximum net profit and acceptable marginal rate of return (mmr) were obtained when 92N kg ha^{-1} at T_2 was used for maize production during erratic and heavy rainfall distribution, particularly at a time of N application. However, the maximum net benefit (30743 etb ha^{-1}) and acceptable mrr could be obtained when 92N kg ha^{-1} at T_1 was used if the rainfall amount and distribution are relatively uniform. In conclusion, application of 92 N kg ha^{-1} at T_1 (10–15 dap and 35–40 dap) is the best N rate and time of application in good rainy seasons and hence recommended for the end users. However, in the case of erratic and heavy rainy seasons, application of 92N kg ha^{-1} at three times application regimes (1/3 N at 10–15 days after planting (dap), 1/3 N at 35–40 dap and 55–60 dap) should be used to get maximum profit and acceptable mrr.

Numoto *et al.* (2019); conducted an experiment was agronomic performance and sweet corn quality as a function of inoculant doses (*azospirillum Brasilense*) and nitrogen fertilization management in summer harvest. The inoculation of sweet corn seeds with *azospirillum brasilense* in association to nitrogen fertilizer may be an agronomic alternative for increasing the crop yield and net income of plant growers. Therefore, the aim of this study was to investigate the effect of the different doses of inoculant (*azospirillum brasilense*) associated to the nitrogen fertilization management on the phenotypic traits of one sweet corn hybrid in summer growing periods, under Supplemental irrigation, in the northwestern paraná state, brazil. The experiment followed the complete randomized Block design with four replications. The treatments were: i) five inoculant doses (0.0, 50, 100, 150 and 200 ml·ha^{-1}) Containing *azospirillum brasilense*; ii) two n doses (0.0 and 30.0 kg·ha^{-1}) applied at sowing time; and iii) two topdressing doses of N (0.0 and 110.0 kg·ha^{-1}) applied at the V_4 stage. The sweet corn hybrid RB 6324 was evaluated in 2012/2013, 2013/2014 and 2014/2015. The traits plant height (ranged from 2.11 to 2.26 m), leaf area Index (3.33 to 4.32), crop yield (7.21 to 10.43 mg.ha^{-1}), and the sugar kernel contents (38.46 to 43.31%) and Protein (12 to 12.81%) were positively influenced by the seed inoculation with *a. Brasilense*, and the nitrogen fertilizer increased all the traits except the kernel total sugars. The dose of inoculant that provided the best agronomic result was 100 ml ha^{-1} in conjunction with the application of N either at sowing or topdressing.

Olusegun, O. S. (2014). Conducted an experiment on Nitrogen (N) and Phosphorus (P) fertilizer application on maize (*Zea mays* L.) growth and yield at Ado-Ekiti, South-West, Nigeria. Nutrient depletion as a result of continuous cultivation without supplementary addition of external inputs is a major challenge to agricultural productivity in South-west Nigeria. An experiment was setup to evaluate the effects of nitrogen (N) and phosphorus (P) fertilizer application rates on the performance of maize (*Zea mays L.*) in field trials at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, south-west Nigeria. The treatments consisted of 2 factors (i) N at 0, 30, 60,90 kg N.ha^{-1} (ii) P at 0, 15, 30, 45 kg P·ha^{-1} in all possible combinations and laid out in a randomized complete block design arranged with three replicates. Data of plant height, leaf area, stem girth and cob length, cob diameter, 100 grain weight and grain yield were collected. The result showed that plant height, stem girth and leaf area· $plant^{-1}$ increased with N and P fertilizer rates. Cob length, cob diameter, 100 grain weight and grain yield, significantly (P=.05) increased with N and P application such that 90 kg $N·ha^{-1}$ and 30kg $N·ha^{-1}$ gave the highest values. It may be concluded that application of the combination of N at 90 $kg·ha^{-1}$ and P at 30 kg ha^{-1} which produced the highest grain yield of maize could be regarded as the optimum for N and P in the study area. Therefore, further work should be carried out to ascertain the validity of this rate for maximum productivity.

A field experiment was conducted at Malakandher Research Farm, The University Agriculture, Peshawar-Pakistan during kharif season 2011, to study the effect of varying levels of phosphorus and sulfur on the yield and nutrient uptake of maize. The experiment was laid out in RCB design with three replications. Phosphorus was applied at the rate 60, 90 and 120 kg ha^{-1} in combination with varying sulfur level viz. 45, 60 and 75 kg ha^{-1} as ammonium sulfate along with control. The results revealed that all treatments significantly increased yield and yield parameters over control and the maximum biomass (both fresh and dry matter yield) was achieved when P and S were applied at the rate of 90 and 60 kg ha^{-1} respectively whereas higher values of 1000 grain weight (248 g) and grain yield (2414 kg ha^{-1}) was obtained in plots treated with 120 kg + 45 kg ha^{-1} P and S, respectively. The minimum yield and 1000 grain weight was recorded in control or plots receiving only basal dose of N and K fertilizers. The P and S content in soil samples collected at silking stage and post-harvest stage were significantly affected and the higher values were recorded in plot receiving the maximum level of the respective fertilizer but the trend of increase was not consistent with respect to soil depth. The P and S content in leaves indicated that higher level of S (75 kg ha^{-1}) resulted low uptake of P and vice versa, indicating their antagonistic effect with each other. This antagonistic effect was displayed in the yield whereby maximum grain yield was obtained where higher dose of P along with lower level of S was beneficial (Ali, 2015).

Maize is the rival of the cereals crops which positions in the third followed by wheat and rice in the whole world. Its creation potential is high so it with fertilization. Demand of cereals crops are increasing due to increasing population of developing countries. Sulphur is a macro nutrient just under the importance of nitrogen (N), phosphorous (P) and potassium (K). When Sulphur deficiency accrues the efficiency of other applied nutrients are affected. The experiment was conducted in Auyob agriculture research institute in Faisalabad. There stood 5 treatments along with 3 replications. There were five levels of sulphur was applied @ 0, 10, 20, 30, and 40 kg ha^{-1} with the recommended dose of NPK. Elemental S (Dusting Sulphur) in powdered form was used as fungicides against powdery mildews, apple scab and black spot. The result was statistically analyzed by using the standard RCBD design. The result was showed that after applying Sulphur fertilizer pH of soil decreased. This in turn facilitates the solubility of heavy metals and grain number ear. Fresh weight, dry weight, grains yield, was increased with the increasing level of sulphur. The application of S at rate of 40 kg ha^{-1} then 0.99 t ha^{-1} average particle profit of maize was increased. It was concluded that the concentration of S increased with the increase of S fertilizer application (Rebi *et al.,* 2020).

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during the period from November 2000 to May 2001 to find the effect of sulphur and nitrogen on the yield and seed quality of maize (cv. Barnali). The study included three levels of Sulphur - 0, 10 and 20 kg ha^{-1} and four levels of Nitrogen, viz., 0, 60, 100 and 120 kg ha^{-1}. Gypsum and urea were used as the sources of Sulphur and Nitrogen, respectively. The highest grain yield and 1000-grain weight were obtained with 20 kg S ha-1. The maximum no of grains cob^{-1}, the highest shelling percentage, the highest 1000-gain weight, Maximum grain yield and maximum stover yield were produced by the application of 120 N ha^{-1}. Grain yield increased with the increasing rates of both Sulphur and Nitrogen but their interaction effects were not significant for all the quantitative characters under study. Seed quality attributes like germination percentage, vigor index, seedling shoot and root length and shoot and root dry weights were not influenced by Sulphur application. Nitrogen application had significant effect on vigor index, seedling shoot and root dry weights. The interaction between Sulphur and Nitrogen levels showed significant effect on seedling shoot and root dry weights. Maximum vigour index and root dry weights/ seedling of maize were found with 120 kg but the highest shoot dry weight/seedling was obtained with 100 kg N ha^{-1}. Maximum shoot and root dry weights $seedling^{-1}$ was obtained by applying 120 kg N ha^{-1} in combination with 20 kg S ha^{-1} (Alam *et al.,* 2003).

A field experiment was conducted during Zaid season of 2021 at SHUATS Department of Agronomy, SHUATS, Prayagraj (U.P). The soil was sandy loam in texture, neutral in reaction (pH 7.0), low in available N (168.75 kg ha^{-1}), medium in available phosphorus (17.40 kg ha^{-1}), medium in available potassium (231.7 kg ha^{-1}), The experiment was laid out in Randomized block design and having ten treatment. The result showed that growth parameters viz, plant height (187.06 cm), no. of leaves $plant^{-1}$ (9.4), leaf area index (7.45), plant dry matter accumulation (3008 g m^{-2}), CGR (29.8), RGR (0.0787) yield attributes like effective Cob $Plant^{-1}$ (1.53), Cob length (16.75 cm), Row cob^{-1} (14.89) Grain row^{-1} (26.94) Grains cob^{-1} (396.5 g), Grain yield (4.5 t ha^{-1}), stover yield (9.5 t ha^{-1}), Seed index weight (28.2 g), Harvest index (32.5) were found to be significantly highest with T9 i.e.,70 Kg ha^{-1} (P) + 60 Kg ha^{-1} (K). Similarly highest gross return (INR 103455 ha^{-1}), net return (INR 74095 ha^{-1}) and benefit: cost ratio (2.52) were recorded superior with application T9 i.e., 70 Kg ha^{-1} (P) + 60 Kg ha^{-1} (K) (Sankadiya and Sanodiya, 2021).

2.4 Performance of variety

Anjum *et al.* (2016) conducted an experiment to Evaluate hybrid and local maize varieties and their respective fertilizer requirements. In the experiment they reported that the fodder scarcity is the major constraint to achieve potential livestock production; and it is high time to introduce high yielding fodder and cereal varieties to ensure good animal health. Two maize Hybrids (Hycorn-11+, Hycron-984) were compared for their performance with local maize (Afgoy) and optimized their NPK requirement evaluating NPK levels of 75-50-50, 100-65-60, 125-80- 70 kg ha^{-1}). The hybrids out-yielded local variety of maize regardless the fertility levels. Hycorn-984, Hycorn-11+, Afgoy produced cob girth of 5.8±0.09, 5.9±0.03, 5.6±0.04 cm; cob weight 82.9±0.61, 79.0±0.42, 73.4±0.85 g; grains Cob^{-1} 176.4±3.73, 167.4±4.81, 157.2±2.29; grain weight $plant^{-1}$ 171.0±2.55, 171.2±2.42, 145.0±2.14g and grain yields of 3152.7±33.11, 3140.0±28.10, 2483.3±30.00 kg ha^{-1}, respectively. The hybrids were not only out yielded conventional maize but also found to be more responsive to higher fertilizer dose and NPK @125-80-70 kg ha^{-1} resulted in highest yield (3237kg ha^{-1}); while lower NPK levels attributed to reduced growth and yield.

In Nepal, the productivity of maize is very low in comparison with developed countries. The use of hybrid varieties with proper nutrient management helps to unlock the high yielding potential of maize. So, the experiment was conducted at Fulbari, Dang, Nepal from June 30, 2019 to October 16, 2019 to find the yield performance of two maize varieties (Local and Hybrid) under different nutrient management. The study was conducted in factorial randomized complete block design with three replications and eight treatments. Treatments consist of different combinations of two maize varieties (Local and hybrid) and four different nutrient management practices. Significant effects of Nutrient management were observed on plant height, leaf area index (LAI), kernels per row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize. Similarly, significant effects of varieties was observed on plant height, leaf number, LAI, cob length, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize. Interaction effect of Nutrient management and varieties was found significant on LAI, kernel rows per cob, kernels per kernel row, kernels per cob maize, test weight, biological yield, economic yield and harvest index of maize. The overall performance of hybrid maize under Leaf color chart (LCC) based nutrient management was found better than other treatments. Therefore, production of Hybrid maize under LCC based nutrient management is suggested (Bashyal *et al.*, 2020).

Hybrid maize varieties have not been widely adopted in the mid-altitude zones of western Kenya. Farmers consider their local varieties to be superior to hybrids under the production system practiced. Performance of hybrids and local maize varieties were compared on-farm, with and without added fertilizer during the long and short rains seasons in 1994 and, on a nutrient depleted soil at the Kakamega Regional Research Center, during the long rains season 1995. The design was a split-plot with three replicates with fertilizer levels (60 kg N plus 60 kg P205 ha^{-1} and no fertilizer) as the main plots and varieties as the sub-plots. Grain yield was consistently higher with the addition of fertilizer. There were no significant genotypes by fertility level interactions. Without fertilizer, the unimproved varieties performed at par with the hybrids, while with fertilizer, the best hybrid had 2.9 t ha^{-1} higher grain yield than the best unimproved variety. Total above-ground dry matter accumulation was highest for H614 and lowest for Nyamula. These results suggest that without fertilizer, the unimproved local varieties are probably as productive as the hybrids. However, when fertilizer is used, hybrids are the most productive. Given the rapidly increasing prices of hybrid seed, Farmers seem to be justified in selecting their own local seed for production under low input production conditions. Future maize improvement research should consider the development of open pollinated varieties for low input conditions (Ojiem *et al.,* 1997).

A research trial at farmer's field was conducted to study the production competition of hybrid (CS-200, cv) and local variety (Azam cv.) under the same application of fertilizer treatment and dozes during summer 2015. The field experiment was laid out in randomized complete block design with split plot arrangements having two maize varieties in main pot and six levels of fertilizer treatments in sub pots repeated four times. Fertilizers treatments were made from the application of Nitrogen (N), Phosphorus (P_2O_5) and farmyard manure (FYM) which was collected from cattle barn yard. A total of six fertilizer treatments were used *viz.* T_1 = control (no application of inputs), T_2= 130 kg N ha^{-1}, T_3 = 130 kg N ha^{-1} + 90 kg P_2O_5 ha^{-1} T_4 = FYM @ 20000 kg ha^{-1}, T_5 = 130 kg N ha^{-1} + 90 kg $P_2O_5ha^{-1}$ + FYM @ 20000 kg ha^{-1} and T6 = 65 kg N ha^{-1} + 45 kg $P_2O_5ha^{-1}$ + FYM @ 20000 kg ha^{-1}. The results indicated that both maize varieties (hybrid and local) showed different responses to different fertilizer treatments application but combined used of farm yard manure, N and P_2O_5 in (T_5) and (T_6) significantly increased yield and yield traits of Hybrid CS-200 and Azam variety than rest of the fertilizers treatments. The significantly maximum plant height of Azam cv. (260 cm) and hybrid (247cm) were recorded in treatment T_5 (N- P_2O_5@ 130-90 kg ha^{-1} + 20 ton per hectare FYM) followed by T_6 (50-45) kg N, $P_2O_5ha^{-1}$ + FYM @ 20000 kg ha^{-1}. The Azam plants were taller than hybrid. The treatment (T_5) significantly yielded more grain (6806 kg ha^{-1}) and (5106 Kg ha^{-1}) from hybrid (CS-200) and a local maize Azam cultivar, respectively. Similarly, stover yield of hybrid (10378 Kg ha^{-1}) and Azam (7708 Kg ha^{-1}) were more in T_5 than the other treatments. So, it is concluded that the combined application of farmyard manure and balanced inorganic fertilizer (Nitrogen + Phosphorus) gave significant yield production in terms of grain and biological yield in clay soil (Ali, *et al.*, 2018).

An European maize (*Zea mays* L.) landrace core collection (EMLCC) was formed with samples from several countries. Evaluation of the EMLCC may contribute to broad the genetic base of maize breeding programs. The objective of this study was to assess the variability of EMLCC under low nitrogen (N) in relation to high N input. Eighty-five landraces of the EMLCC, grouped in four maturity groups, and three check hybrids were evaluated for response to low (0 kg ha^{-1}) and high (150 kg ha^{-1}) N in Spain and Greece. Five plant size traits(plant height, ear height, leaf length, leaf width and leaf area index), two grain traits (1000-kernel weight and grain yield), and two agronomic traits [growing degree units (GDU) and lodging] were studied. Overall means of plant size and grain traits increased when genotypes were grown at 150-N relative to 0-N input. The relative increase for grain traits was smaller in landraces than in hybrids. This suggests that landraces had lower grain yield response to N supply compared to hybrids. Linear regressions of plant size traits on GDU indicated that vegetative development was primarily associated with flowering lateness. The maturity group was the main source of variation for all traits. Landrace variability within maturity groups was significant for all traits across environments, despite significant landrace × environment interactions. Estimates of genetic and genotype × environment variances, and heritabilities at both high and low N inputs were not significantly different from each other. However estimates were generally larger at high N. Genetic and phenotypic correlation coefficients between the two N levels were very high for all traits (Ferro *et al.*, 2007).

Enhancement of the genetic variability of forage quality is needed for developing maize hybrids for silage. The objectives of the study were to assess the variation for stover digestibility and other traits in the maize landraces of restricted national collections from six European countries and to know their potential for being used as breeding material in the development of silage maize varieties. Three hundred ninety five maize landraces from six European countries were evaluated for the content of the stover in digestible organic matter (DOM) (g kg^{-1}) using NIRS, as well as for other agronomic traits in Northwest Spain in 1998 and 1999. The range of least square means (LSM) for stover DOM varied from 697 to 479 g kg^{-1}, which was 7.8 times the least significant difference between two LSM. Several landraces from Germany, Spain, Portugal, France and Italy showed significantly higher stover DOM than the 5-hybrid check mean, which was 607 g kg^{-1}. Large variation and high performance for stover DOM was exhibited among the European maize landraces. Estimate of genotypic variance of landraces was 709.5 (± 91.2) g^2 kg^{-2} for stover DOM. Favorable genetic correlation coefficients were found between stover DOM and other agronomic traits in 1999, such as early vigor (r = 0.36), lodged plants (r = -0.42), ear dry matter content (DMC) (r = -0.45), stover DMC (r = -0.64), ear dry matter yield (DMY) (r = 0.23), and stover DMY (r = 0.29) These results reveal the potential of the European landraces for forage maize breeding purposes (Brichette *et al.*, 2001).

A study was conducted to investigate the effect of different NPK rates on growth and yield of maize cultivars; Golden and Sultan. Application of increasing rate of NPK delayed number of days taken to tasseling, silking and maturity of the crop. The plant height was significantly affected by different rates of NPK. Treatment F_3 (250-110-

85) of NPK produced tallest plants than two other treatments in both the varieties. Too low or high NPK levels reduced the yield and yield parameters of maize crop. Treatment F_2 (175-80-60) seems to be the most appropriate level to obtain maximum grain yield under the prevailing conditions. Application of NPK beyond treatment F_2 (175-85-60) seems to be an un-economical and wasteful practice. Varieties (Golden & Sultan) seem to have similar production potential under uniform and similar growing condition (Asghar *et al.,* 2010).

2.5 Performance of variety and fertilizer interaction

Yield of maize hybrids could be low when grown below optimum management practices. Use of improved varieties and optimum nitrogen fertilizer application practices are unlocking the high yielding potential of hybrids maize. With these in view, a field experiment was executed on farmers' field to determine the effect of varieties and nitrogen fertilizer rate on yield and yield components of maize in two cropping seasons. It is laid out with randomized complete block design in factorial arrangement with three replications. Five maize varieties (BH-540, BH-543, BH-661, BH-660, and BH-140) as main factor and two levels of nitrogen (55 and 110KgNha^{-1}) as sub factors were used with one maize variety (BH-543) without fertilizer as control. Leaf area and leaf area index of maize varieties were significantly affected by application of nitrogen fertilizer rates. Interaction of maize varieties with nitrogen fertilizer rates significantly affected all yield and yield components of maize. Application of half and full recommended nitrogen fertilizer produced mean grain yield advantages of 31 and 41% over control. Therefore, application of half and full recommended nitrogen fertilizer for improved maize varieties has significantly improved grain yield and recommended for maize production in mid altitude area of western Ethiopia (Abera *et al.,* 2017).

A study was conducted in three different sites (Sher-e-Bangla Agricultural University, SAU of Dhaka; Dhamrai of Dhaka district and Fakirpara of Rangpur district) of Bangladesh to evaluate two white maize hybrids (PSC-121 and KS-510) under five different fertilizer doses (50, 75, 100, 125 and 150% of the recommended dose approved for hybrids) at SAU, while three doses (50, 100 and 125%) at Dhamrai and Rangpur. At SAU the variety KS-510 performed better showing significantly higher seed yield (7.762 t ha^{-1}), but at Rangpur the variety PSC-121 had higher seed yield (5.223 t ha^{-1}). At Dhamrai both the varieties showed identical seed yields (6.951 t ha^{-1}

with PSC-121 and 7.051 t ha^{-1} with KS-510). Out of three sites the SAU had higher seed yield (the highest 7.762 t ha^{-1}) compared to other two sites. Dhamrai had higher seed yield (highest 7.057 t ha^{-1}) than that of Rangpur (the highest 5.223 t ha^{-1}). The seed yield was mainly attributed to the number of grains per cob and 100 grain weight. At SAU and Rangpur sites the recommended fertilizer dose (100%) showed the highest seed yields of 8.284 t $ha^{-1}$and 4.992 t ha^{-1} respectively). While at Dhamrai the highest fertilizer dose (125%) showed the highest seed yield (7.901 t ha^{-1}). The interaction treatment of the variety KS-510 and fertilizer dose 75% at SAU showed had the highest seed yield of 8.738 t ha^{-1}), while the variety PSC-121 gave the highest seed yields with 125% at Dhamrai (7.831 t ha^{-1}) and with the recommended dose at Rangpur was 6.000 t ha^{-1} (Ullah *et al.*, 2018).

An experiment was conducted at Malakabad (Gadera) Dargai Malak and KPK to study the effect of different levels of nitrogen and phosphorus on the yield of maize varieties in randomized complete block design with split plot arrangement. Different fertilization treatments (0:0, 100:0, 100:50, 100:100, 150:0, 150:50, 150:100, 150:150 N:P kg ha^{-1}) were assigned to main plot while, maize varieties (Azam, Jalal and local) were kept in sub-plots. Data regarding emergence m^{-2}, days to emergence, days to tasseling, days to silking, number of cobs $plant^{-1}$, plant height, grains cob^{-1} , 1000-grain weight and grain yield were recorded. Emergence m^{-2}, days to emergence, days to tasseling, days to silking, plant m^{-2} at harvest were not significantly affected by different levels of nitrogen and phosphorus while number of cob $plant^{-1}$, thousand grains weight, plant height, grains cob^{-1} and grain yield were significantly affected. Maximum grain yield (5356 kg ha^{-1}) was recorded in Jalal variety, when it was fertilized with 150:100 N:P kg ha^{-1}. Of the factors included in this study, maize cultivars and NP fertilization treatments were dominant in determining grain yield as well as its related components, suggesting that cultivar selection and optimum fertilization are effective strategies to improve grain yield. However, multiplication and multi-year studies are required to test these results using different cultivars under varying edaphic and climatic conditions (Khan *et al.*, 2014).

An experiment was conducted to study the effects of nitrogen levels on yield and yield components in maize cultivars, a split plot experiment based on randomized complete block design with three replications was conducted in 2008 at the Research Farm of Islamic Azad University, Branch of Ardabil. Treatments were arranged in a split plot design with three replicates. N levels (N 0, 80, 160 and 240 kg ha^{-1}) as urea were in the main plots (control =N 0 kg ha^{-1}), and maize cultivars (SC-301, DC-370 and SC-404) were allocated at random in the sub-plots. Results indicated that nitrogen levels had significant effects on yield and yield components in maize hybrids. Maize cultivars had different response to this characteristic. The highest grain yield was obtained from the highest levels of nitrogen fertilizer. The highest number of kernel per ear, the number of grains per ear row, ear diameter, cob length, grain per plant, plant height, the number of grains per ear row and number of kernels per ear were recorded at the highest levels of nitrogen fertilizer. The number of grain row and number of cobs per plant were not affected in maize cultivars by levels of nitrogen fertilizer. Effect of cultivar × nitrogen levels was significant on grain yield. Maximum grain yield (7.76 ton ha^{-1}) was obtained in the plots with N 240 kg ha^{-1} and SC-404 cultivar and minimum of it (5.12 ton ha^{-1}) was obtained in the plots with 0 kg nitrogen ha^{-1} and SC-301 cultivar. It can be suggested that SC-404 hybrid should be applied with N 240 kg ha^{-1} in conditions of Ardabil Plain (Sharifi and Taghizadeh, 2009).

Macro-nutrient deficiency, especially nitrogen, is a common problem in the calcareous soils of Pakistan. From this perspective, a field nitrogen management trial was conducted using four N levels (75 kg ha^{-1}, 150 kg ha^{-1}, 225 kg ha^{-1}, 300 kg ha^{-1}) and three potentially higher yielding maize cultivars (FH-810, DTC, C-20) . Results of this study showed that all the N levels, maize varieties and their interactions showed significant effects on plant growth and crop yield. The maximum plant height, number of grain rows cob^{-1}, cob diameter, number of grains cob^{-1}, 1000-grain weight, harvest index, biological yield and grain yield were produced by the application of 300 kg N ha^{-1}. While, seed protein content was also achieved maximum by the application of 300 kg N ha^{-1}. Among the different varieties, cv. FH-810 showed maximum plant height, number of grains rows cob^{-1}, cob diameter, number of grains cob^{-1}, 1000-grain weight, grain yield, biological yield, harvest index and seed protein contents over cv. DTC and cv.C-20. The interaction between cv.FH-810 and 300 kg N ha^{-1} produced the highest number of grain rows cob^{-1}, cob diameter, number of grains cob^{-1}, 1000-grain weight, grain yield and seed protein contents. Results suggested that the selected cultivar (FH-810) and 300 kg N ha^{-1} could be utilized for attaining the maximal improvement in farmer income by increasing the maize yield under the local conditions of Faisalabad, Pakistan (Khan *et al.*, 2011).

Majid *et al.* (2017) conducted an experiment was carried out at natore sugar mills area, natore, Bangladesh during 2014-15 to evaluate the growth and yield responses of hybrid maize varieties under different levels of nitrogen fertilization. Two hybrid maize varieties *viz.* BARI hybrid maize-7 and BARI hybrid maize-9 were tested under four nitrogen levels (N_0= without external nitrogen supply, N_1= 115 kg N ha^{-1}, N_2= 230 kg N ha^{-1}, and N_3= 345 kg N ha^{-1}). All recommendations agronomic practices were used for both the variety. Yield and yield traits (plant height, plant girth, total leaves plant^{-1}, effective leaves plant^{-1}, non-effective leaves plant^{-1}, total root plant^{-1},straw weight plant^{-1},cob length, grain free cob, cob girth, grain line cob**,** total grain cob^{-1}, grain number line^{-1},1000-grains weight, grain weight cob^{-1},grain yield, straw yield and biological yield) were measured during and on the completion of the study. BARI hybrid maize-9 achieved maximum yield (10.99 t ha^{-1}) and it was followed by the BARI hybrid maize-7 (10.37 t ha^{-1}). Results of study revealed that yield traits and final yield significantly increased with increasing nitrogen fertilizer from 0 to 345 kg ha^{-1}. Among various tested n-fertilizer doses, highest grain yield was obtained from the plot treated with N_3 treatment (345 kg ha^{-1}) but it was not statistically differing from the N_2 treatment (230 kg ha^{-1}). Therefore, N_2 treatment (230 kg ha^{-1}) could be recommended for variety Bari hybrid maize-9 as the best economical nitrogen level for maximum economical yield of maize.

Asaduzzaman *et al*. (2014) conducted an experiment on variety and N-fertilizer rate influence the growth, yield and yield parameters of baby corn (*Zea mays*). 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, 80, 120, 160 and 200 kg N ha^{-1} in the experiment to find out the suitable variety and N fertilizer rate for baby corn production. The experiment was carried out at the regional station under Bangladesh Agricultural Research Institute at Jamalpur, Bangladesh during *Rabi* season of 2008-09. Hybrid baby Corn-271 and Shuvra took about 85 days and Khoibhutta and BARI sweet corn-1 took about 71 days to first Silking. The results revealed that the highest values was recorded in variety Shuvra with 200 kg N ha^{-1} in most of The growth parameters which was statistically similar to 160 kg N ha^{-1}. Number of ear plant^{-1}, length of ear, baby corn yield without husk and with husk varied significantly due to interaction of variety and N-rates. Baby corn yield without husk increased significantly with 160 kg N ha^{-1} and beyond this rate yield increment was not significant in hybrid baby corn-271 and Shuvra while N-rate increased baby corn yield without husk significantly not beyond 120 kg ha^{-1} in Khoibhutta and BARI sweet corn-1. Number of cob plant^{-1} and length of cob were found the main yield parameters attributed to increased baby corn yield without husk.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during November, 2019 to April, 2020 to examine the response of local maize varieties to different doses of fertilizer application. In this chapter the details of different materials used and methodology followed during the experimental period are presented under the following heads:

3.1 Experimental site

The present experiment was conducted at Agronomy farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The location of the experimental site is $23^0 74'$ N latitude and $90^0 35'$ E longitude and at an elevation of 8.2 m from sea level.

3.2 Climate

The experimental area was under the sub-tropical climate characterized by high temperature, high humidity, and heavy rainfall with occasional gusty winds during April - September (kharif season) and less rainfall associated with moderately low temperature during October-March (Rabi season). The weather data of the experimental site during the study period have been presented in Appendix I.

3.3 Characteristics of the soil of experimental site

The soil of the experimental area is medium high land having red brown terrace soil, which belongs to the Modhupur Tract under AEZ no. 28 and the Tejgaon soil series. The soil characteristics of the experimental plot are presented in Appendix II.

3.4 Methods

3.4.1 Treatments

Two factors were used in the present experiment to get 16 treatment combinations which were as follows:

Factor A: Fertilizer dose (02)

1. F_{100}= 100% of the recommended dose of nitrogen fertilizer
2. F_{50}= 50% of the recommended dose of nitrogen fertilizer

Recommended doses of fertilizer for the hybrids: Urea-550 kg ha^{-1}, TSP-250 kg ha^{-1} (P≡53 kg ha^{-1}), MoP-200 kg ha^{-1}(K≡100 kg ha^{-1}), Gypsum-250 kg ha^{-1} ($CaSO_{4≡}$37 kg ha^{-1}), $ZnSO_4$-12 kg ha^{-1} (2.85 kg Zn ha^{-1}) and Boric acid- 8 Kg ha^{-1} (8kg≡1.44 kg B ha^{-1}) and half of Urea (total dose 550 kg urea≡253 kg N ha^{-1}), (BARI, 2019)

Factor B: Variety (08), Based on seed colour and size

1. White
2. Yellowish
3. Yellow
4. Reddish
5. Red
6. Blackish-red
7. Black-bold and
8. Black-small

Treatment combinations: Sixteen treatment combinations are as follows-

F_{50}White, F_{50}Yellowish, F_{50}Yellow, F_{50}Reddish, F_{50}Red, F_{50}Blackish-Red, F_{50}Black-bold, F_{50}Black-small, And F_{100}White, F_{100}Yellowish, F_{100}Yellow, F_{100}Reddish, F_{100}Red, F_{100}Blackish-Red, F_{100}Black-bold, F_{100}Black-small

3.4.2 Experimental design and layout

The experiment was laid out in Split Plot Design with three replications. Each block, representing a replication, was divided into 16 units, where main plot used for fertilizer and sub plot for varieties. The total number of unit plots was 48. The size of each unit plot was 1.875 m × 1.916 m (plot size 3.611m^2). The distance maintained between the unit plots and blocks were 0.70 m and 1.0 m respectively. Layout of the experimental field is presented in Appendix III.

3.5 Collection of seeds

Healthy seeds of different maize land races were collected from Thansi Upazilla of Bandarban district.

3.6 Germination test

Germination test was performed before sowing the seeds in the field. For laboratory test, petridishes were used. Filter paper was placed on petridishes and the papers were Soaked with water. Seeds were distributed at random in petridishes. Data on emergence were calculated expressed as percentage by using the following formula:

$$\text{Germination (\%)} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds set for germination}} \times 100$$

3.7 Land preparation

The experimental field was first opened on November, 2019 with the help of a power tiller and prepared by three successive plowing and cross- plowing. Each plowing was followed by laddering to have a desirable fine tilt. The visible larger clods were hammered to break into small pieces. All kinds of weeds and residues of previous crop were removed from the field. Individual plots were cleaned and finally leveled with the help of wooden plank.

3.8 Fertilizer application

Manures and fertilizers that were applied to the experimental plot presented in Table 1. Total amount of TSP, MoP, Gypsum, Zinc sulphate, Boric acid and half of Urea were applied as basal dose at the time of land preparation. The rest amount of Urea was applied at 30 days after seed sowing (19 Dec 2019), and before flowering.

Table 1. Doses and methods of application of fertilizers applied in the local maize field

Name of manure and fertilizer	**Doses**	**Methods of application**
Cow dung	2.5 t ha^{-1}	Total as basal
Urea	275 kg ha^{-1}	1/3rd as basal and 2/3rd as top dressing at 30 days after seed sowing and before flowering
TSP	125 kg ha^{-1}	Total as basal
MoP	100 kg ha^{-1}	Total as basal
Gypsum	125 kg ha^{-1}	Total as basal
$ZnSO_4$	6.0 kg ha^{-1}	Total as basal
Boric acid	4.0 kg ha^{-1}	Total as basal

Source: BARI, 2019

3.9 Sowing of seeds

Seeds were sown on the 19th November, 2019 in line sowing method maintaining the spacing of 60 cm × 20 cm placing two seeds per hill. Thinning was done 25 days after emergence keeping the better seedling $hill^{-1}$.

3.10 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the experimental crop:

3.10.1 Irrigation

No irrigation was provided during seed germination as there was enough moisture in the field for the seedlings. The first flood irrigation was provided in each plot using a pipe connected to the water source at 45 DAS. Other two irrigations were provided at flowering and at dough stage.

3.10.2 Weeding

Weeding was done as per necessity.

3.11 Harvesting and post-harvest processing

The crop was harvested at 21st April, 2020 (although the varieties matured at varying DAS, data was not taken) when the leaves, stems become yellowish and the base of the grain turns into black color (black band) when husk color turned in to pale brown which was approximately from 25 to 30 days after tasseling. Ten sample plants from each of the plots were harvested for recording the yield data. The harvested plants were tied into bundles and carried to lab to recording data.

3.12 Sampling

The sampling was done consecutively at 35 DAS, 60 DAS, 90 DAS, 120 DAS and finally at harvest. At each sampling, five plants were selected randomly from each plot. The selected plants for the first sample were uprooted carefully by hand as the root system was not so strong. But the samples collected later on were cut from the ground using a sickle. After collecting the necessary data stover and grains (at final harvest) were oven dried at $60^{o}C$ for 72 hours to record constant dry weights.

3.13 Recording of data

The data on the following parameters were recorded at each harvest.

3.13.1 Growth parameters

1. Plant height (cm)
2. Number of leaves plant^{-1}
3. Leaf area (cm^2)
4. Base circumference (cm)
5. Cob setting node position from ground (cm)
6. Whole plant dry weight (g)

3.13.2 Yield parameters

1. Number of cobs plant^{-1}
2. Cob length (cm)
3. Number of grains cob^{-1}
4. Weight of grains cob^{-1} (g)
5. 100-grain weight (g)
6. Grain yield (t ha^{-1})
7. Stover yield (t ha^{-1})
8. Biological yield (t ha^{-1})
9. Harvest index (%)

3.14 Procedure of recording data

Randomly selected five plants at harvest were used to collect data or the parameter chosen. The procedure of recording data at harvest is given below:

3.14.1 Plant height (cm)

The plant height was measured from the ground level to the tip of the individual plant. Mean value of five selected plants was calculated for each unit plot and expressed in centimeter (cm).

3.14.2 Number of leaves plant^{-1}

Number of leaves per plant was counted and the data were recorded from 5 selected plants and then calculated and mean value was recorded.

3.14.3 Leaf area plant^{-1} (cm^2)

The length and width of all green leaves of record plants were measured using a meter rule. The product of the length and width of each leaf was multiplied by 0.75 to give the area for each leaf (Mannan *et al.,* 2019). Then the total number of leaves per plant was established after the flag leaf. The total leaf area per plant was obtained by summing up the leaf area of the recorded plants and then the mean leaf area of a plant was determined for each treatment.

3.14.4 Base circumference (cm)

Base diameter of each sampled plant was taken by measuring the diameter of the first inter node nearest to ground using a measuring tape.

3.14.5 Cob setting node position from ground

The position of cob setting node was determined by counting the nodes from ground to the node where the first cob was set.

3.14.6 Whole plant dry weight (g)

After separating cobs from the selected plants each of the plants were dried and weight was taken using electric balance. The whole plant dry weight was composed of stover dry weight, cobs dry weight and root dry weight.

3.14.7 Number of cobs plant^{-1}

Total cobs in a plant were counted manually at both 120 DAS and at harvest.

3.14.8 Cob length (cm)

Cob length was measured by setting a measuring tape from base to the tip of the cob

3.14.9 Number of grains cob^{-1}

Each cob was composed of a number of rows of grains. Those rows of grains were counted manually. After that the number of grains per row was counted and multiplied with the total number of rows to get the total number grains per cob.

3.14.10 Weight of grains cob^{-1} (g) and 100 grain weight (g)

Firstly, the threshed grains of each cob was taken in paper bags and kept in an oven at 60^0C for 24 hours. After drying, the grains from each paper bag were measured using digital electric balance. After that, one hundred cleaned and dried seeds were counted randomly from each of the harvested samples and weighed by using a digital electric balance and the mean weight was expressed in gram.

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

The yield per hectare was computed by converting the yield per plant to yield per hectare by using the following relation:

Yield per hectare = {(mean grain yield per plant x 83000) ÷ 1000 ÷1000} [83000 plants stand when planting spacing is maintained to 60cm × 20cm (Adeboyee *et al.*, 2006)

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

All the dry plant parts except grains are gathered to calculate stover yield. The stover yield was measured according to the following formula:

Stover Yield (t ha^{-1}) = {(mean dry weight of shoot excluding cob × 83000) ÷1000÷1000} [As 83000 plants stand when planting spacing is maintained to 60 cm × 20 cm (Adeboyee *et al.*, 2006)]

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

Final grain yield was adjusted at 14% moisture. Grain yield together with stover yieldwas regarded as biological yield and calculated with the following formula:

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

3.14.14 Harvest Index (%)

It denotes the ratio of grain yield to biological yield and is expressed in percentage. The following formula was used to calculate harvest index:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.15 Statistical analysis

The data recorded on different parameters were tabulated as per block laid out in the experimental field. The analyses of variance were done following Split Plot Design with the help of a computer package program Statistix-10. The mean values were compared using LSD at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

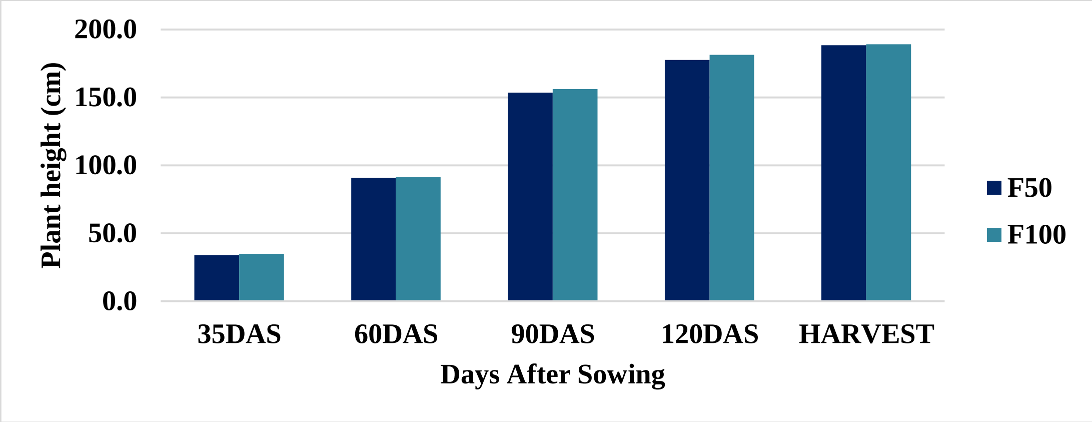
The results obtained from the study have been presented, discussed and compared in this chapter through different tables, figures and appendices. The possible interpretation has also been given under the following headings:

4.1 Growth parameters

4.1.1 Plant height (cm)

Effect of fertilizer doses on plant height

Figure 1 gives information about the effect of fertilizer doses on plant height. There was a sharp increase in plant height in the first 90 DAS by the application of both F_{50} and F_{100}. After that the rate of increment was slowed down. Beginning with a plant height of 34.0 cm at 35 DAS, the final plant height at harvest reached up to 189.1 cm. Data from different days after sowing, 100% of the recommended dose (F_{100}) was found to provide the taller plants of (34.9 cm, 91.3 cm, 156.0 cm, 181.4 cm, and 189.1 cm at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively) as compared to 50% of the recommended dose (F_{50}). Overall, there was no statistically significant effect of fertilizer doses on plant height throughout the growth stages. However, without the exceptions at 35 DAS and harvest, F_{100} was statistically significant over F_{50} at 60 DAS, 90 DAS, and 120 DAS. This finding was similar with the findings of Sahoo and Panda (2009) who reported that plant height increased gradually with an increase in fertilizer dose.

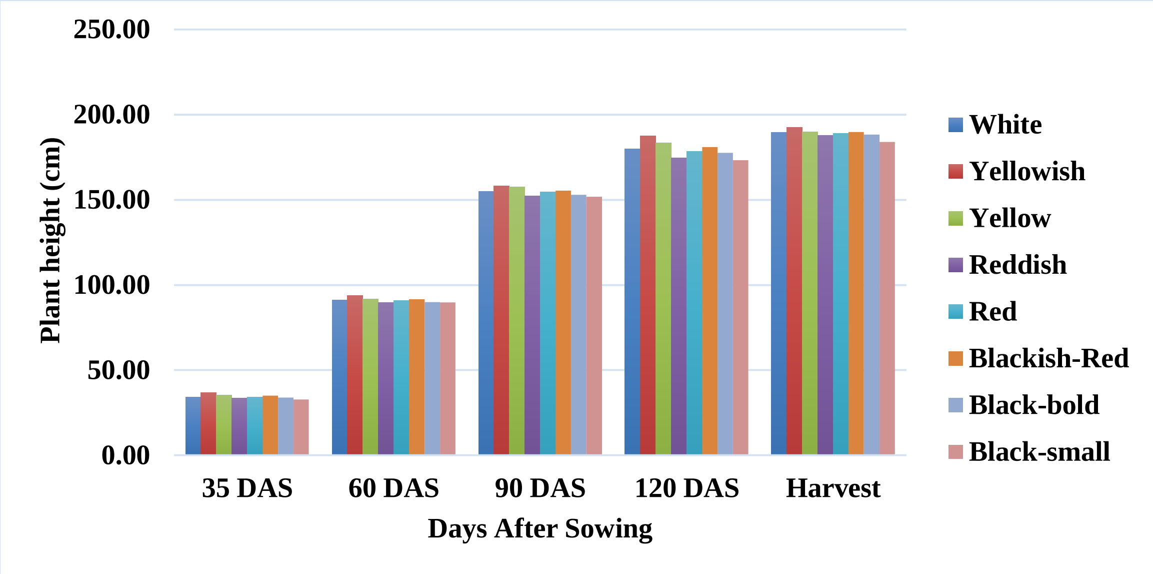


F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 2.15, 0.20, 2.04, 0.40, and 2.30 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and Harvest, respectively)

Figure 1. Average plant heights of local maize at different days after sowing (DAS) under varying doses of fertilizers.

Effect of varieties on plant height

Figure 2 illustrates the effect of eight different varieties on plant height at five individual days after sowing of time. In general, there was a dramatic rise in plant height till 90 DAS. From 90 DAS to harvest, still there was a gradual increase. The maximum plant height of 36.83 cm, 93.83 cm, 158.17 cm, 187.50 cm and 192.5 cm were obtained from the variety Yellowish at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively. On the other hand, the minimum plant height of 32.75 cm, 89.83 cm, 151.83 cm, 173.17 cm, and 183.92 cm were found in the variety Black-small at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively. Although the effect of variety was not found absolutely statistically significant at any of the growth stages, same of the varieties at every growth stages showed significant difference over the others. For instance, the variety Yellowish was statistically significant over other varieties at all of data at different days ater sowing except 35 DAS. Plant height is influenced by variety. Clark *et al*. (2013) has reported that plant height a genetic trait and it varies genotypes to genotypes. As the result suggest, it can be inferred that the variety Yellowish has the best genotypic make up; that’s why it showed the highest plants.



($LSD_{0.05}$ = 2.72, 0.44, 0.60, 0.88, and 1.04 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and Harvest, respectively)

Figure 2. Plant height in different varieties of local maize at different days after sowing (DAS).

Effect of fertilizer doses and varieties interaction on plant height

Table 2 shows the effect of fertilizer dose and variety combinations on plant height at different days after sowing. Overall, there was a rapid increase in plant height from 35 DAS to 90 DAS. After that the rate of increase was slight from 90 DAS to harvest. However, Between 120 DAS and harvest the increase in plant height was about to plateau. The tallest plants of 37.67 cm (35 DAS), 95.0 cm (60 DAS), 165.0 cm (90 DAS), 178.0 cm (120 DAS), and 197.17 cm (harvest) were obtained from the combinations- F_{50}Yellowish, F_{100}Yellowish, F_{50}Yellow, F_{100}Yellow, and F_{100}White, respectively. On the other hand, the shortest plants having height of 32.0 cm (at 35 DAS), 87.33 cm (60 DAS), 147.0 cm (90 DAS), 167.33 cm (120 DAS), and 182.0 cm (harvest) were recorded from F_{100}Black-bold, F_{100}Black-small, F_{50}Black-bold, F_{50}Black-small, and F_{50}White, respectively. On the whole, the effect was not absolutely significant at any of the growth stages. But some individual combinations showed superiority over other combinations. To illustrate, at 90 DAS, 120 DAS, and harvest, the best combination was statistically significant over the other combinations. Mondal *et al.* (2015) showed that when two best treatment included to two different factors are coupled the resulting interaction also shows the best performance. In the same way, in this study it was found that the combination of the best variety and fertilizer dose provided the best plant height.

Table 2. Plant height in local maize as influenced by the interaction effect of fertilizer application and varieties at different days after sowing (DAS) and harvest

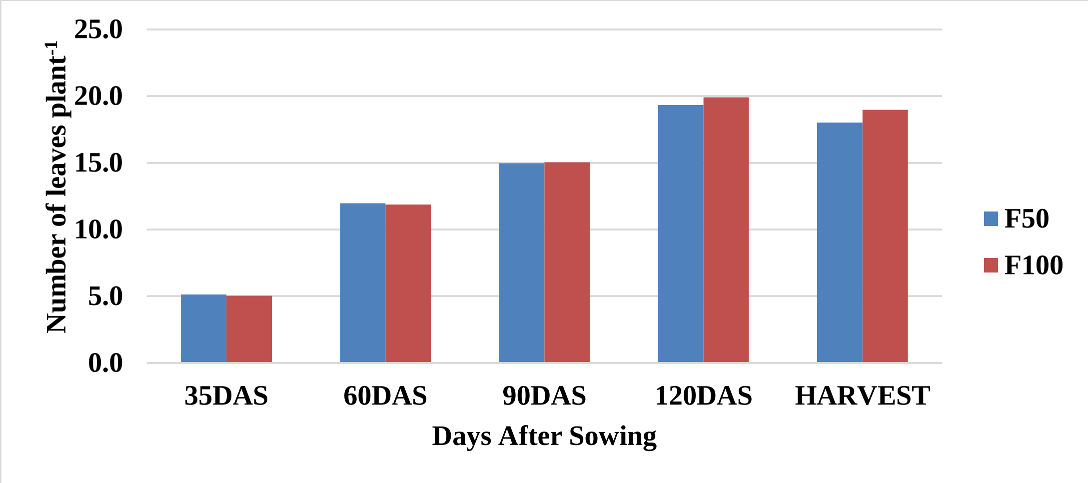
Treatment Combinations	Plant Height (cm)				
	35 DAS	60 DAS	90 DAS	120 DAS	Harvest
F_{50}White	34.00	94.00	156.67	181.67	182.00
F_{50}Yellowish	37.67	92.67	159.00	182.00	193.83
F_{50}Yellow	36.33	95.00	150.33	178.67	188.33
F_{50}Reddish	34.33	91.67	148.67	174.00	190.50
F_{50}Red	33.67	91.73	151.67	179.00	189.17
F_{50}Blackish-Red	34.67	88.33	151.33	173.53	192.67
F_{50}Black-bold	35.67	85.00	159.00	172.00	188.00
F_{50}Black-small	32.50	92.33	150.67	179.00	183.33
F_{100}White	34.33	88.33	153.00	178.00	197.17
F_{100}Yellowish	36.00	95.00	157.33	193.00	191.17
F_{100}Yellow	34.33	88.67	165.00	188.33	191.33
F_{100}Reddish	32.67	88.00	156.00	175.00	185.00
F_{100}Red	34.67	90.00	157.67	178.00	188.67
F_{100}Blackish-Red	35.33	95.00	159.33	188.33	186.83
F_{100}Black-bold	32.00	95.00	147.00	183.00	188.50
F_{100}Black-small	33.00	87.33	153.00	167.33	184.50
$LSD_{0.05}$	3.8527	0.6261	0.8559	1.2516	1.4740
CV	6.69	0.41	0.33	0.42	0.47

F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids (BARI 2019)

4.1.2 Number of leaves plant^{-1}

Effect of fertilizer doses on number of leaves plant^{-1}

Figure 3 shows the effect of fertilizer doses on number of leaves plant^{-1} at different days after sowing. In the experiment it was seen that the number of leaves plant^{-1} increased consistently from 35 DAS to 120 DAS. In this period of 85 days, leaf number increased by almost 15. After that there was a slight decrease towards harvest. Therefore, it can be inferred that the number of countable leaves in a maize plant does not increase continuously throughout its life cycle. At a certain point it may drop. Turning to more specific influence of fertilizer doses, the highest number of leaves plant^{-1} varied in accordance with growth stages and nutrient doses. At 35 DAS and 60 DAS, the higher number of leaves (5.1 and 12.0, respectively) was recorded from 50% of the recommended dose (F_{50}), while at 90 DAS the number of leaves was same (15.0) in both F_{50} and F_{100}. On the contrary, more leaves plant^{-1} (19.9 and 19.0 at 120 DAS and harvest, respectively) were recorded with the application of 100% of the recommended dose (F_{100}) as compared to F_{50}. So, in the final consideration, F_{100} may be regarded as the better treatment between F_{50} and F_{100} as it imparted higher leaves in the cob setting period. However, irrespective of numerical differences between the treatments, there were no statistically significant relationships at any of the growth stages recorded. The result was almost similar wit that of Ullah *et al.* (2018).

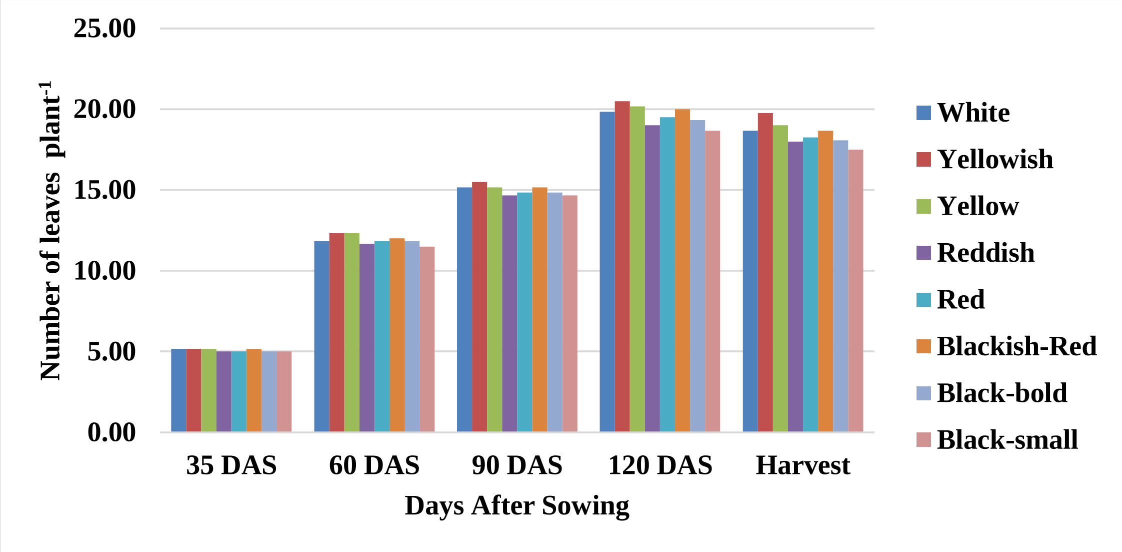


F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.35, 0.64, 4.65, 1.40, and 3.89 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and Harvest, respectively)

Figure 3. Number of leaves plant^{-1} of local maize at different days after sowing (DAS) under varying doses of fertilizers.

Effect of varieties on number of leaves plant^{-1}

Effect of fertilizer doses on number of leaves plant^{-1} is illustrated in the figure 4 at different growth stages. The general trend found in the figure is that the number of leaves rose constantly from 0 to around 20 in the first 120 days and then fell slightly at the end. By focusing on the specific results it was observed that the variety Yellowish produced the highest number of leaves: 5.17, 12.33, 15.50, 20.50, and 19.75 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively. On the other hand, the variety Black-small produced the lowest number of leaves (5.0, 11.5, 14.67, 18.67, and 17.5 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively). In term significance, the effect of variety on number of leaves plant^{-1} was not statistically significant at any of the stages. In most of the cases, the highest and the lowest lea number producing varieties stayed in the same range of least significance difference (LSD). This finding was in line with Clark *et al.* (2013).



($LSD_{0.05}$ = 0.30, 0.76, 1.92, 1.40, and 2.33 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and Harvest, respectively)

Figure 4. Number of leaves plant^{-1} in different varieties of local maize at different days after sowing (DAS) and harvest.

Effect of fertilizer doses and varieties interaction on number of leaves plant^{-1}

Table 3 represents the data that depicts the combined effect of fertilizer doses and varieties on number of leaves plant^{-1}. In general, the number of leaves plant^{-1} increased up to a certain period and then fell. Leaves count plant^{-1} reached to the maximum of about 21. The highest number of leaves plant^{-1} of 5.33 was shown by a number of different combinations (F_{50}White, F_{50}Yellow, F_{50}Blackish-Red, and F_{100}Yellowish) at 35 DAS. Similarly, at 60 DAS, the maximum leaves number- 12.67 was recorded from three individual combinations (F_{50}Yellow, F_{100}White, and F_{100}Yellowish). In these two stages (35 DAS, and 60 DAS) the lowest leaves number recorded were 5.0 and 11.0. However, at 90 DAS, 120 DAS, and harvest, the zenithal count of leaves were 16.0 (F_{50}Yellowish, and F_{50}Blackish-Red), 21.33 (F_{50}Yellowish, and F_{100}Yellow), 20.5 (F_{100}Yellowish), respectively. However, in all of the three stages the lowest number of leaves plant^{-1} was recorded from F_{50}Black-small (14.0, 17.33, and 17.17, respectively). Mondal *et al.* (2015) also showed the similar pattern of result.

Table 3. Number of leaves plant^{-1} in local maize as influenced by the interaction effect of fertilizer application and varieties at different days after sowing (DAS) and harvest

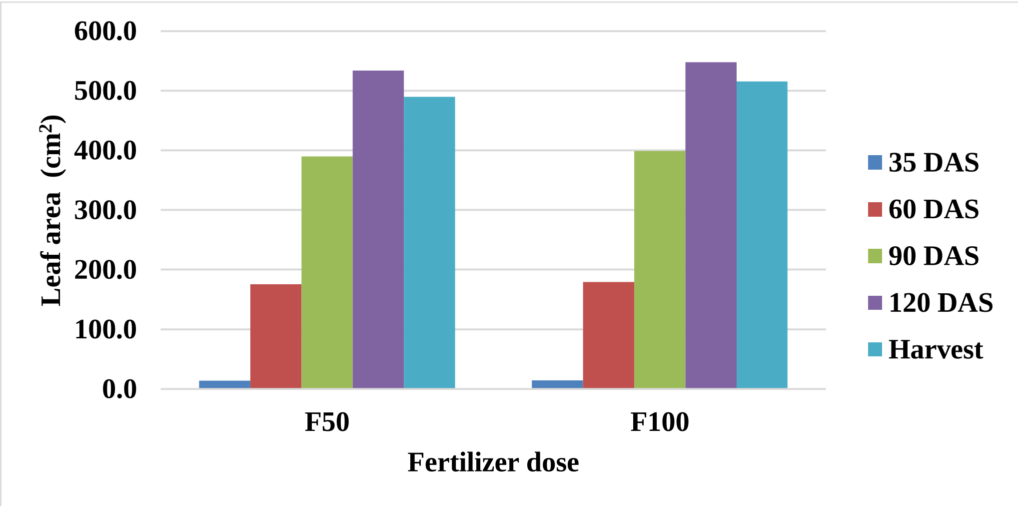
Treatment Combinations	Number of leaves plant^{-1}				
	35 DAS	60 DAS	90 DAS	120 DAS	Harvest
F_{50}White	5.33	11.00	14.67	20.00	17.50
F_{50}Yellowish	5.00	12.00	16.00	21.33	19.00
F_{50}Yellow	5.33	12.67	15.00	19.00	17.83
F_{50}Reddish	5.00	12.33	15.00	18.67	18.00
F_{50}Red	5.00	12.00	14.33	20.00	18.50
F_{50}Blackish-Red	5.33	12.33	16.00	20.33	18.83
F_{50}Black-bold	5.00	12.00	14.67	18.00	17.17
F_{50}Black-small	5.00	11.33	14.00	17.33	17.17
F_{100}White	5.00	12.67	15.67	19.67	19.83
F_{100}Yellowish	5.33	12.67	15.00	19.67	20.50
F_{100}Yellow	5.00	12.00	15.33	21.33	20.17
F_{100}Reddish	5.00	11.00	14.33	19.33	18.00
F_{100}Red	5.00	11.67	15.33	19.00	18.00
F_{100}Blackish-Red	5.00	11.67	14.33	19.67	18.50
F_{100}Black-bold	5.00	11.67	15.00	20.67	19.00
F_{100}Black-small	5.00	11.67	15.33	20.00	17.83
$LSD_{0.05}$	NS	1.0873	NS	3.6142	NS
CV	5.03	5.46	10.83	10.83	10.66

F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids (BARI 2019)

4.1.3 Leaf Area (cm^2)

Effect of fertilizer doses on leaf area (cm^2)

Figure 5 exhibition the effect of fertilizer doses on leaf area (cm^2) at different growth stages recorded in this experiment. In general, there was a dramatic increase in leaf area (cm^2) till 120 days from sowing. After that, at harvesting stage a slight decrease was recorded. Between 35 DAS and 60 DAS, there was almost 12 folds increment in leaf area indicating that this is the most vigorous growth stage. Between the fertilizer doses, F_{100} was recorded to provide the higher leaf area (14.3 cm^2, 179.4 cm^2, 399.0 cm^2, 547.7 cm^2, 515.7 cm^2) over the F_{50} (14.0 cm^2, 175.3 cm^2, 389.9 cm^2, 533.7 cm^2, 489.8 cm^2) at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively. Overall, the effect of nitrogen fertilizer doses was not significant. However, except 35 DAS, the effect of F_{100} was significant over F_{50} at all other four growth stages (60 DAS, 90 DAS, 120 DAS, and harvest). Akter *et al.* (2021) reported leaf area in the range of 65 cm^2 to 706 cm^2 which is nearly similar to the findings of this current study.



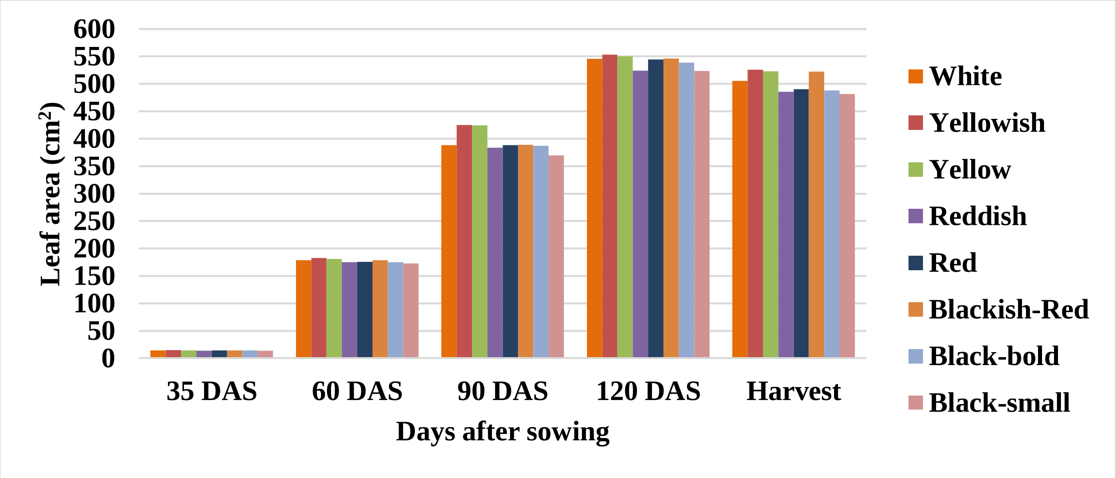
F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.50, 1.64, 1.91, 0.46, and 0.37 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and Harvest, respectively)

Figure 5. Leaf area plant^{-1} of local maize at different days after sowing (DAS) under varying levels of fertilizers.

Effect of varieties on leaf area (cm^2)

Figure 6 illustrates the effect of varieties on leaf area (cm^2) at five different days after sowing. The general trend in the experiment found regarding leaf area was the significant rise of leaf area up to 120 DAS and then a slight fall towards harvesting in all varieties used. The approximate difference between the leaf area of 35 DAS and 120 DAS was 530 cm^2 (nearly 38 folds accretion). The highest leaf area (cm^2) of

14.55 cm^2, 182.85 cm^2, 424.83 cm^2, 553.2 cm^2, and 525.75 cm^2 was obtained from the variety Yellowish at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively. The Yellowish was followed by the Yellow and Blackish-red. On the other hand, the lowest leaf area (13.69 cm^2, 172.52 cm^2, 369.7 cm^2, 523.4 cm^2, and 481.65 cm^2 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively) was recorded from the Black-small. The effect of variety on leaf area (cm^2) was not statistically significant throughout the growth periods. The maximum leaf area holder- the Yellowish was significant over the other varieties at different days after sowing except 35 DAS. However, at 90 DAS it was statistically similar with the variety Yellow. The finding was in line with that of Akter *et al.* (2021).



($LSD_{0.05}$ = 0.66, 0.69, 0.78, 0.37, and 0.46 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and Harvest, respectively)

Figure 6. Leaf area plant^{-1} in different varieties of local maize at different days after sowing (DAS) and harvest.

Effect of fertilizer doses and varieties interaction on leaf area (cm^2)

Table 4 exhibited the combined effect of fertilizer doses and varieties on leaf area (cm^2) at five different days after sowing (DAS). In general, leaf area increased up to 120 DAS and after that there was a gradual fall. Among the combinations, F_{100}White (14.89 cm^2), F_{50}Yellowish (185.77 cm^2), F_{50}White (436.77 cm^2), F_{50}White (592.50 cm^2), and F_{100}Blackish-Red (551.70 cm^2) were recorded to provide the highest leaf area at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively. On the other hand, at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest the lowest leaf area of

13.53 cm^2 (F_{50}White), 167.30 cm^2 (F_{100}Black-small), 355.10 cm^2 (F_{100}Black-small), 498.30 cm^2 (F_{100}White), and 473.80 cm^2 (F_{50}Black-bold) were recorded, respectively. In terms of statistical significance, the highest leaf area providers at different days after sowing were significant over the other combinations. Similar pattern of leaf area was also found by Akter *et al.* (2021).

Table 4. Leaf area plant^{-1} in local maize as influenced by the interaction effect of fertilizer application and varieties at different days after sowing (DAS) and harvest

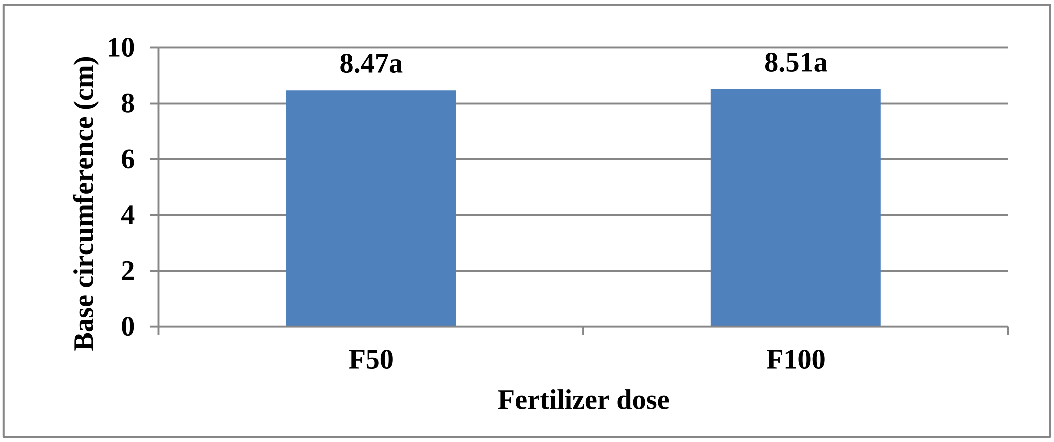
Treatment Combinations	**Leaf Area (cm^2)**				
	35 DAS	**60 DAS**	**90 DAS**	**120 DAS**	**Harvest**
F_{50}White	13.53	179.57	436.77	592.50	508.70
F_{50}Yellowish	14.60	185.77	430.90	557.80	532.20
F_{50}Yellow	14.47	177.73	418.77	516.60	502.50
F_{50}Reddish	13.68	168.20	411.80	543.50	440.10
F_{50}Red	13.93	180.33	408.67	584.30	491.20
F_{50}Blackish-Red	14.07	184.70	407.43	534.00	493.00
F_{50}Black-bold	14.37	180.87	399.63	513.80	473.80
F_{50}Black-small	13.67	177.73	396.70	538.90	477.00
F_{100}White	14.89	177.07	394.00	498.30	502.30
F_{100}Yellowish	14.50	179.93	384.30	548.60	519.30
F_{100}Yellow	14.52	183.90	380.13	584.00	543.20
F_{100}Reddish	13.84	181.60	377.50	504.60	530.90
F_{100}Red	14.40	170.53	373.60	504.50	489.40
F_{100}Blackish-Red	14.63	172.86	369.80	558.10	551.70
F_{100}Black-bold	13.87	169.40	365.97	563.70	502.41
F_{100}Black-small	13.71	167.30	355.10	507.90	486.30
$LSD_{0.05}$	0.9465	0.9882	1.1706	0.5345	0.6550
CV	3.99	0.33	0.16	0.06	0.08

F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids

4.1.4 Base Circumference (cm)

Effect of fertilizer doses on base circumference

Figure 7 depicts the effect of fertilizer doses on base circumference of the fertilizer doses used in this experiment. The effect was recorded to be insignificant. Between the two doses, F_{100} showed the higher base circumference (8.51 cm) as compared to F_{50} (8.47 cm).



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.63)

Figure 7. Base circumference of local maize under varying levels of fertilizers.

Effect of varieties on base circumference

How base circumference of the varieties used in the current research varied is illustrated in the Figure 8. Even though there were numerical differences among the treatments, no difference was recorded to be statistically significant. While the variety- Yellowish possessed the maximum base circumference (8.83 cm), Black-small had the lowest (8.08 cm). Both the highest and the lowest base circumference providers stayed in the same level of statistical significance.

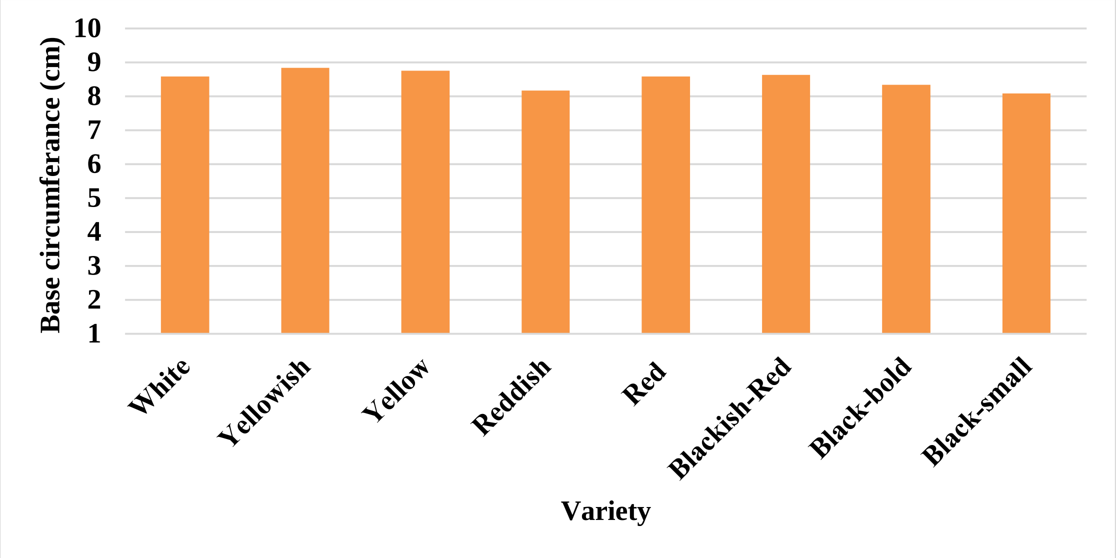


Figure 8. Base circumference in different varieties of local maize ($LSD_{0.05}$ = 0.72).

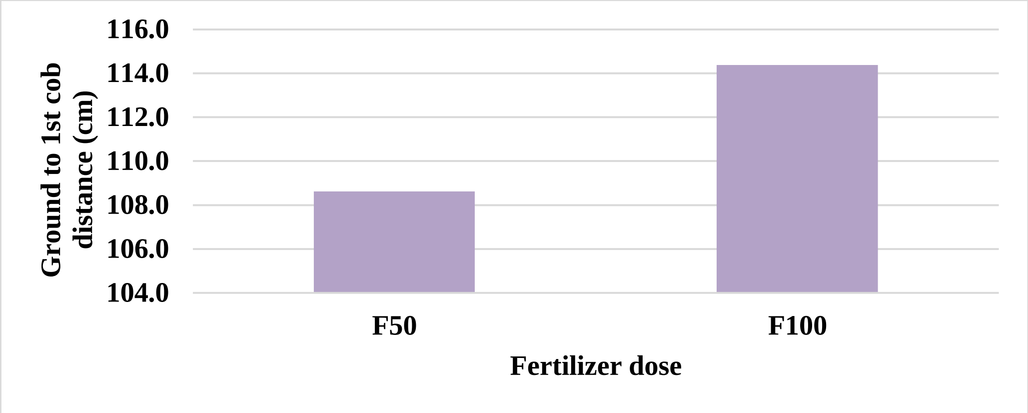
Effect of fertilizer doses and varieties interaction on base circumference

Table 5 provides the combined effect of fertilizer doses and varieties on base circumference. The effect was found to be insignificant. However, there were numerical differenced among the combination. Plants having maximum base circumference were found in the plots treated with F_{100}Blackish-Red (9.27 cm) followed by F_{50}Yellow (9.17 cm). On the other hand, the minimum base circumference (7.83 cm) was recorded from F_{100}Black-small combinations.

4.1.5 Ground to first cob distance (cm)

Effect of fertilizer doses on ground to first cob distance (cm)

Figure 9 illustrates the effect of nitrogen fertilizer doses on distance of the first cob setting from the ground. The effect was statistically significant. In the plots treated with fifty percent of the recommended dose nitrogen (F_{50}) set cobs to 108.63 cm high from the ground. On the other hand, the cob setting distance was 114.38 cm in the plots applied with 100% of the recommended dose nitrogen (F_{100}). Ullah *et al.* (2018) reported an average cob setting position distance of about 102 cm which is slightly low than the findings of the current study.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 1.34)

Figure 9. Cob heights of local maize at different levels of fertilizer application.

Effect of varieties on ground to first cob distance (cm)

Figure 10 shows the effect of varieties on ground to first cob setting distance. In general the effect was not statistically significant. Among the varieties, the highest cob setting distance was recorded from the variety Yellowish (117.8c cm) and it was followed by Yellow (114.67 cm), Blackish-red (114.33), and White (112.83 cm). The Yellowish was significant over the other varieties. However, the lowest cob setting distance of 106.17 cm was recorded from Black-small and it was preceded by Reddish (107.50 cm). The findings of the study were nearly similar with the findings of Ullah *et al.* (2018).

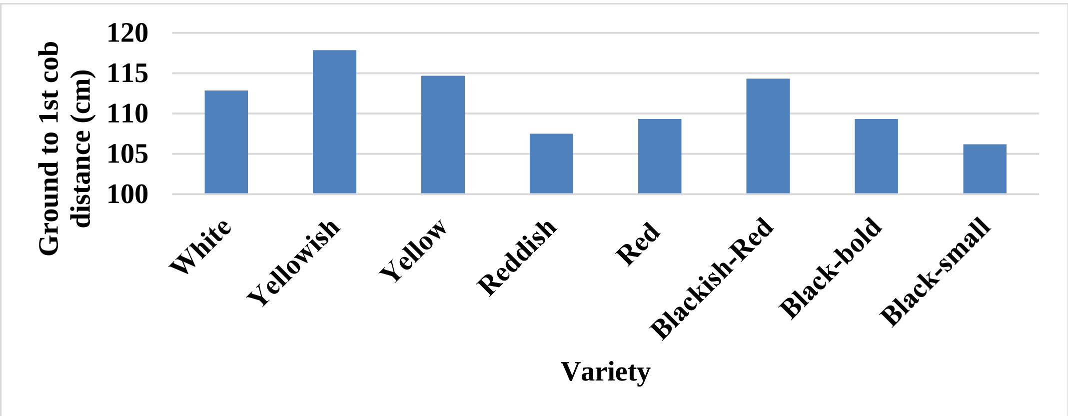


Figure 10. Cob distance in different varieties of local maize ($LSD_{0.05}$ = 1.85).

Effect of fertilizer dose and varieties interaction on ground to first cob distance (cm)

Table 5 shows the effect of fertilizer doses and varieties combinations on ground to first cob setting distance (cm). Overall, the effect was statistically significant. The cob that was set to the highest point (119.33 cm) from ground was recorded from the combinations F_{100}Yellowish and it was statistically significant over the other combinations. This combination was followed by F_{100}Blackish-Red (116.67 cm). On the other hand, the lowest cob setting point was F_{50}Black-small (100.0 cm). The findings of the study can be thrust to the findings of Ullah *et al.* (2018).

Table 5. Base circumference and cob distance in local maize as influenced by the interaction effect of fertilizer application and varieties

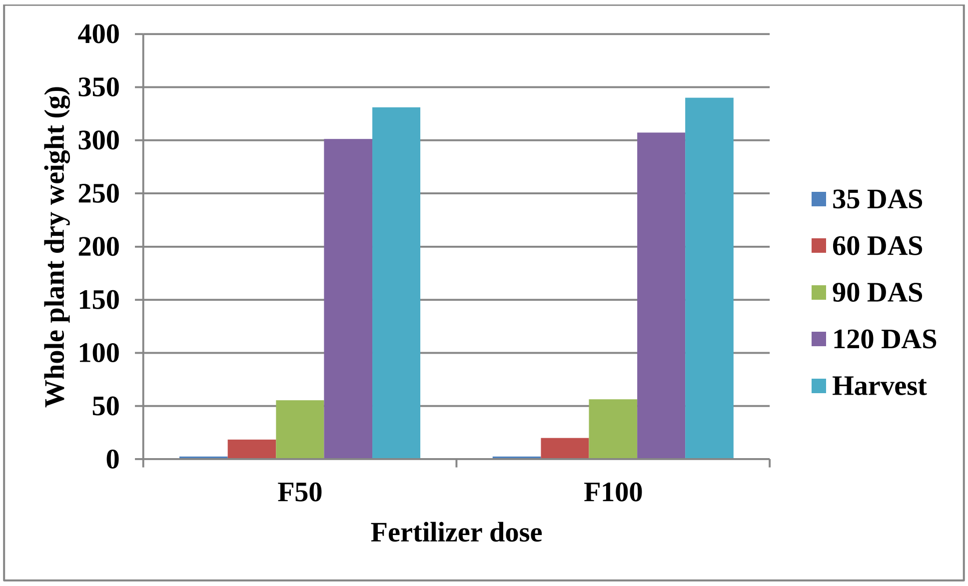
Treatment Combinations	**Base circumference (cm)**	**Ground to 1st cob distance (cm)**
F_{50}White	8.83	110.00
F_{50}Yellowish	8.67	116.33
F_{50}Yellow	9.17	116.33
F_{50}Reddish	8.00	102.33
F_{50}Red	8.67	103.00
F_{50}Blackish-Red	8.00	112.00
F_{50}Black-bold	8.17	109.00
F_{50}Black-small	8.33	100.00
F_{100}White	8.33	115.67
F_{100}Yellowish	9.00	119.33
F_{100}Yellow	8.33	113.00
F_{100}Reddish	8.33	112.67
F_{100}Red	8.50	115.67
F_{100}Blackish-Red	9.27	116.67
F_{100}Black-bold	8.50	109.67
F_{100}Black-small	7.83	112.33
$LSD_{0.05}$	1.0253	2.6186
CV	7.22	1.40

F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids

4.1.6 Whole Plant Dry Weight (g)

Effect of fertilizer doses on whole plant dry weight (g)

Figure 11 illustrates the effect of fertilizer doses on whole plant dry weight. The effect was significant in all of the days after sowing except 35 DAS. Between the two nitrogen fertilizer doses, F_{100} showed higher whole plant dry weight (2.5 g, 19.9 g, 56.3 g, 307.4 g and 340 g at 35 DAS, 60 DAS, 90 DAS, 120 DAS and at harvest, respectively, as compared to F_{50} which revealed whole plant dry weight of 2.4 g, 18.5 g, 55.4 g, 301.1 g and 331 g at 35 DAS, 60 DAS, 90 DAS, 120 DAS and harvest, correspondingly. The whole plant dry weight of 194 to 296 was recorded in an experiment conducted by Ullah *et al.* (2018) that is almost similar with the whole plant dry weight found in this study.

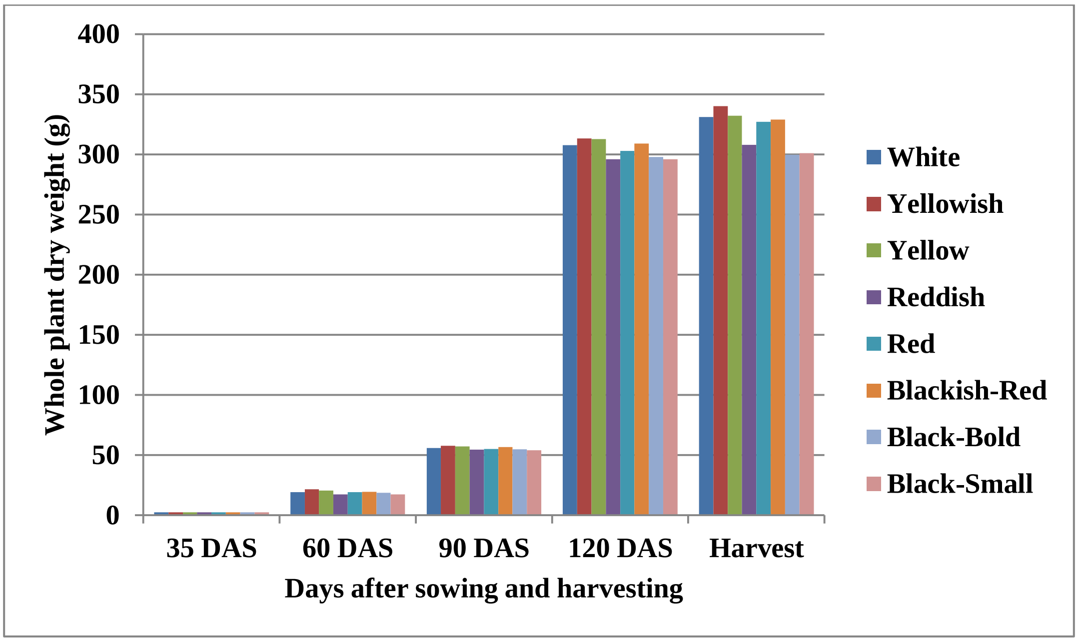


F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.14, 0.52, 0.62, 1.72 and 1.85 at 35 DAS, 60 DAS, 90 DAS, 120 DAS and harvest, respectively)

Figure 11. Dry weight plant^{-1} of local maize at different days after sowing (DAS) under varying doses of fertilizers.

Effect of varieties on whole plant dry weight (g)

Figure 12 illustrates the effect of different eight varieties on whole plant dry weight (g). In general, the effect was significant. In all consecutive days after sowing the variety yellowish showed the highest whole plant dry weight of 2.6 g, 21.7 g, 57.8 g, 313.2 g, and 340 g respectively. The effect of the variety was significant over other varieties at all of the growth stages except at 35 DAS where it had no superiority over any of the rest treatments. However, the lowest whole plant dry weight of 2.4 g, 17.5 g, 54.0 g, 296 g, and 301 g were recorded from the variety Black-small at 35 DAS, 60 DAS, 90 DAS, and 120 DAS and at harvest, respectively. The Black-small was statistically similar with its precedent variety, Reddish in at all of the five stages. This result was in line with that of Ullah *et al.* (2018).



($LSD_{0.05}$ = 0.24, 0.62, 0.73, 0.83, and 0.88 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and Harvest , respectively)

Figure 12. Dry weight plant^{-1} in different varieties of local maize at varying days after sowing (DAS) and harvest

Effect of fertilizer dose and varieties interaction on whole plant dry weight (g)

Table 6 shows the effect of variety and fertilizer combinations on whole plant dry weight. At the 35 days after sowing, the highest (2.73 g) and the lowest values were 2.4g obtained from the combinations F_{50}Yellow and F_{100}Black-small, respectively and all of the combinations were statistically similar. However, at 60 DAS, 90 DAS and 120 DAS, the maximum dry weight (23.67 g, 59.33 g, and 331.33 g, respectively) were obtained from the combinations F_{50}Yellowish. Whereas the lowest whole plant dry weight in these sequential three stages as 60,90,120 DAS were found from F_{100}Black-small- 16.0 g , 52.33 g, and F_{50}Reddish- 290.33 g. On the other hand, the highest whole plant dry weight at harvest was recorded from F_{100}Yellowish (136.33 g) and the lowest one was obtained from F_{100}Black-bold (121.17 g). The findings regarding whole plant dry weight of the study were confirmed by Ullah *et al.* (2018).

Table 6. Dry weight plant^{-1} in local maize as influenced by the interaction effect of fertilizer application and varieties at different days after sowing (DAS) and harvest

Treatment Combinations	Plant Dry Weight (g plant^{-1})				
	35 DAS	60 DAS	90 DAS	120 DAS	Harvest
F_{50}White	2.43	20.67	56.67	308.33	330
F_{50}Yellowish	2.50	23.67	59.33	331.33	338
F_{50}Yellow	2.73	21.67	55.333	308.00	327
F_{50}Reddish	2.37	16.67	55.33	290.33	300
F_{50}Red	2.43	18.67	56.33	292.33	320
F_{50}Blackish-Red	2.60	19.00	57.333	299.00	320
F_{50}Black-bold	2.33	20.00	54.67	289.00	286
F_{50}Black-small	2.37	19.00	55.67	293.33	298
F_{100}White	2.40	18.00	55.33	307.03	332
F_{100}Yellowish	2.63	19.67	56.33	295.00	342
F_{100}Yellow	2.37	19.33	59.33	317.67	337
F_{100}Reddish	2.40	18.33	54.00	301.67	316
F_{100}Red	2.37	19.67	54.00	313.33	334
F_{100}Blackish-Red	2.40	20.00	56.33	319.00	338
F_{100}Black-bold	2.43	17.33	55.33	306.67	313
F_{100}Black-small	2.3333	16.00	52.33	298.67	304
$LSD_{0.05}$	0.3461	0.8868	1.0460	1.1787	1.314
CV	8.47	2.76	1.12	0.23	0.18

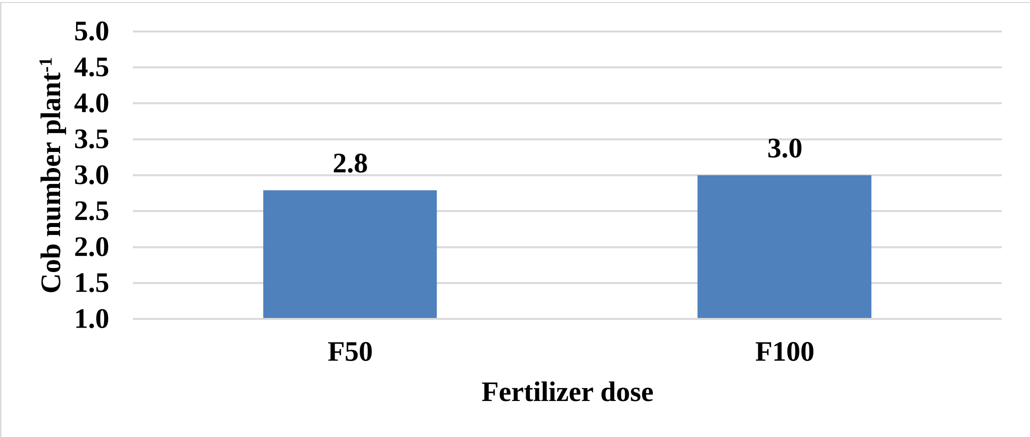
F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids

4.2. Yield Parameters

4.2.1 Cob number plant^{-1}

Effect of fertilizer doses on number of cob plant^{-1}

Figure 13 shows the effect of fertilizer doses on number of cobs plant^{-1}. Application of the two different doses of fertilizer did not make any statistical difference in cob number plant^{-1} inferring that the effect was insignificant. Between the treatments the higher number of cobs plant^{-1} (3.0) was obtained by the application of F_{100} as compared to F_{50} where the cob number plant^{-1} was 2.79. One corn plant, given adequate growing conditions, will produce between two and four ears of corn (Christen, 2018). Therefore, the finding of the current study is in line previous findings.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids

($LSD_{0.05}$ = 1.79)

Figure 13. Number of cobs plant^{-1} of local maize under varying levels of fertilizer application.

Effect of varieties on number of cob plant^{-1}

Figure 14 illustrates the effect of varieties on number of cobs plant^{-1}. The number of cobs plant^{-1} varied among the treatments but the differences were not statistically significant. The highest and the same number of cobs plant^{-1} (3.17) was recorded from three varieties (Yellowish the Yellow, and the Blackish-red). On the other hand, the lowest number of cobs plant^{-1} of 2.33 was obtained from the variety Black-small. This was preceded by the Reddish (2.66) and the Black-bold (2.83) and these two were statistically similar with Black-small. The finding of the study is similar with that of Christensen (2018).

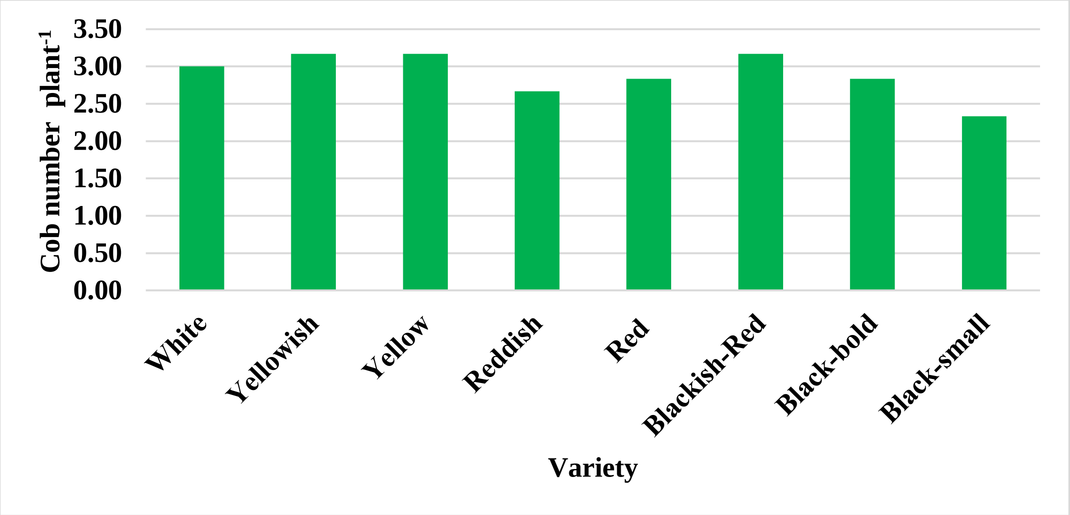


Figure 14. Number of cobs plant^{-1} in different varieties of local maize.

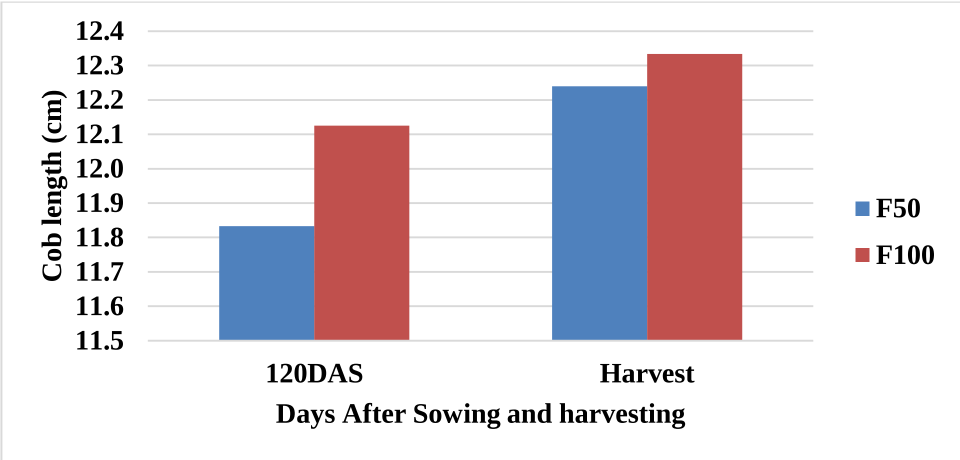
Effect of fertilizer dose and varieties interaction on number of cob plant^{-1}

Table 7 provides information about the combined effect of fertilizer doses and varieties on the number of cobs plant^{-1}. Although there were numerical differences among the combinations, the differences were not statistically significant. In the experiment, the highest number of cobs plant^{-1} (3.67) was obtained from the combination F_{100}White and it was followed by F_{100}Yellowish (3.33), F_{100}Yellow (3.33), and F_{50}Blackish-Red (3.33). On the other hand, the lowest number of cobs plant^{-1} of 2.33 was given by a number of different combinations (F_{100}Black-small, F_{100}Reddish, F_{50}Black-small, and F_{50}White). The result of this study is in line with the findings of Christensen, (2018).

4.2.2 Cob Length (cm)

Effect of fertilizer doses on cob length (cm)

Figure 15 shows the effect of fertilizer doses on the change of cob length at two different growth stages. Overall, the influence of fertilizer doses on cob length was not significant at neither of the stages. The longer cob lengths of 12.12 cm and 12.33 cm were recorded at 120 DAS and harvest respectively when the 100% fertilizer of the recommended dose (F_{100}) was applied as compared to the application of 50% of the recommended dose (F_{50}). In the F_{50} treated plots, the cob lengths were 11.83 cm and 12.24 cm at 120 DAS and harvest, respectively. Cob length is a very important determiner of grain yield. Ullah *et al.* (2018) found cobs in the length from 15 cm to 17.78 cm which conflicts with the findings of this study. The current study reported much lower cob lengths.

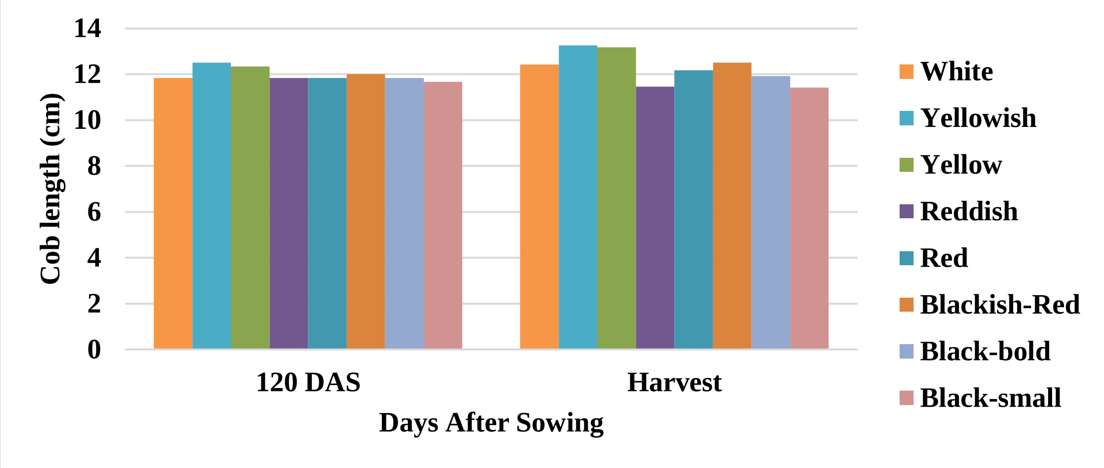


F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.80, and 0.54 at 120 DAS and Harvest, respectively)

Figure 15. Cob length of local maize at 120 days after sowing (DAS) and harvest under varying levels of nitrogen fertilizers.

Effect of varieties on cob length (cm)

Figure 16 provides information about the effect of different varieties on cob length. It was revealed that at both 120 DAS and harvest stages, the variety Yellowish gave the longest cobs of 12.5 cm and 13.25 cm, respectively. This was followed by the variety Yellow and had a statistically insignificant relation with the first one (Yellowish) at 120Das and harvest. However, the shortest cobs of 11.42 cm and 11.67 cm were recorded, respectively, at 120 DAS and harvest from the plots where the variety Black-small was planted. The findings of the study were dissimilar with the findings of Ullah *et al.* (2018).



($LSD_{0.05}$ = 0.84, and 0.98 at 120 DAS and Harvest, respectively)

Figure 16. Cob length in different varieties of local maize at 120 days after sowing and harvest.

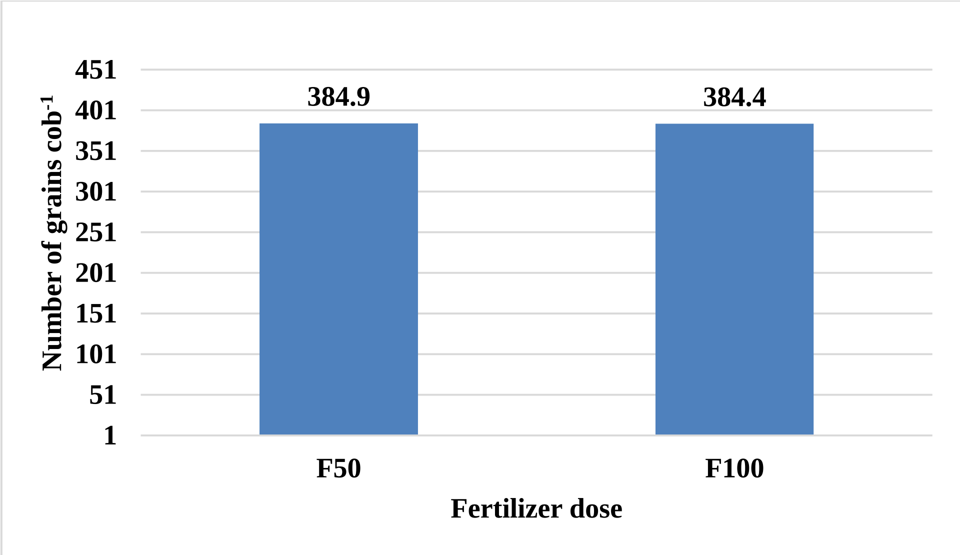
Effect of fertilizer dose and varieties interaction on cob length (cm)

Table 7 shows the combined effect of fertilizer doses and varieties on cob length at 120 DAS and harvest. Overall, the effect was insignificant. At 120 DAS, the highest cob length (12.67 cm) was obtained from the combination F_{100}Yellowish and it was statistically similar with all other treatments. On the contrary, at harvesting stage, F_{50}White was found to give the highest cob length of 13.83 cm keeping a statistically similar relation with a number of other combinations. However, the lowest cob length (10.83 cm) was obtained from the treatment F_{100}Black-small. The findings of the study can be thrust to the findings of Ullah *et al.* (2018).

4.2.3 Number of grains cob^{-1}

Effect of fertilizer dose on number of grains cob^{-1}

Figure 17 shows the effect of fertilizer doses on number of grains cob^{-1}. Between the fertilizer doses, the plots applied with 50% of the recommended doses showed the higher number of grains. About 385 and 384 grains were recorded from F_{50} and F_{100} treated plots. Irrespective of the numerical difference of about 1 grain between the treatments, there was no statistically significant difference. This refers that, fertilizer doses have no significant effect on number of grains cob^{-1}. The finding was similar wit the finding of Mannan *et al.* (2019).



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 5.85)

Figure 17. Number of grains cob^{-1} of local maize as influenced by varying doses of fertilizers.

Effect of varieties on number of grains cob^{-1}

Effect of different varieties used in the experiment is shown in the Figure 18. There were remarkable fluctuations among the varieties regarding number of grains cob^{-1}. The highest number of grains cob^{-1} (432.22) was recorded from the variety Yellowish and it was followed by the varieties Yellow (412.82) and Blackish-red (405.63), consecutively. The difference of Yellowish was statistically significant over the other varieties. On the other hand, the lowest number of grains cob^{-1} (323.72) was obtained from the variety Black-small. Therefore, the difference between the highest and the lowest number of grains cob^{-1} was 108.5. The finding was similar with the finding of Mannan *et al.* (2019).

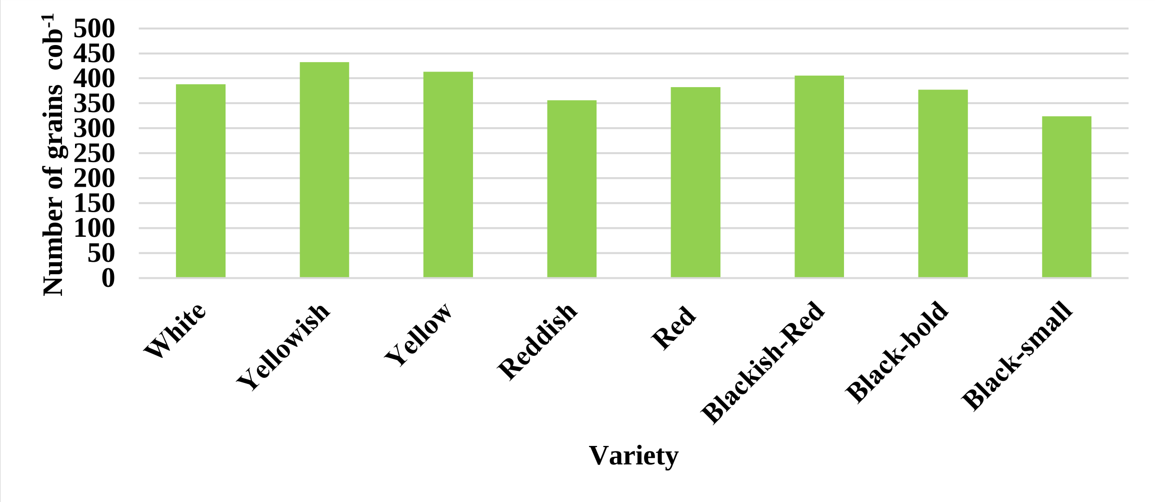


Figure 18. Number of grains cob^{-1} in different varieties of local maize.

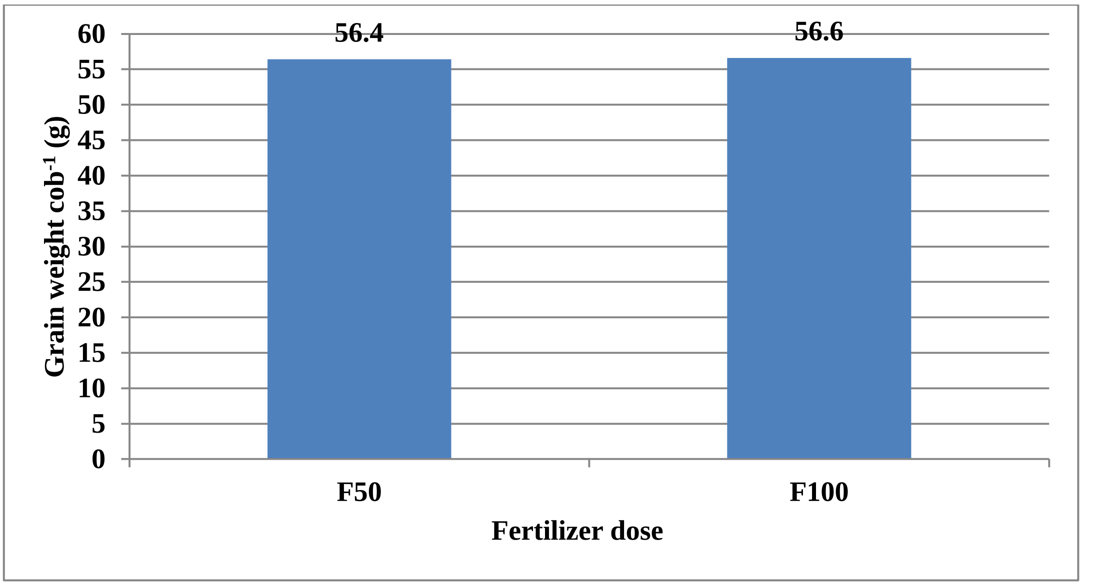
Effect of fertilizer dose and varieties interaction on number of grains cob^{-1}

Table 7 gives information about the combined effect of fertilizer doses and varieties on number of grains cob^{-1}. In the experiment, the combination F_{50}Yellowish was found to provide the highest number of grains cob^{-1} (461.27). This combination was followed by F_{50}Blackish-Red (440.17). The F_{50}Yellowish was statistically superior over all other combinations including the F_{50}Blackish-Red. On the other hand, F_{100}Black-small showed the lowest number of grains cob^{-1} (321.93) and it was preceded byF_{50}Black-small (325.50). Both F_{50}Black-small and F_{50}Black-small were statistically similar. The finding was similar wit the finding of Mannan *et al.* (2019).

4.2.4 Grain weight cob^{-1} (g)

Effect of fertilizer dose on grain weight cob^{-1}

Figure 19 shows the effect of fertilizer doses on grain weight cob^{-1}. The effect was insignificant statistically. Grain weight cob^{-1} in both cases was nearly similar. Between the fertilizer doses 100% of the recommended dose (F_{100}) showed higher grain weight cob^{-1} (56.6 g) as compared to 50% of the recommended dose (F_{50}) having grain weight cob^{-1} of 56.4 g. Mannan *et al.* (2019) found grain weight cob^{-1} in the range of 66-112 while conducting an experiment with hybrid maize varieties. Local maize varieties provide lower grain weight cob^{-1}, consequently, grain weight cob^{-1} was found in the current study.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 2.68)

Figure 19. Grain weight of local maize under varying doses of fertilizers.

Effect of varieties on grain weight cob^{-1}

Figure 20 provides information about the effect varieties on grain weight cob^{-1}. Overall, the effect was not significant because some of the varieties were statistically similar to others. In the experiment, the variety Yellowish was recorded to have the highest grain weight cob^{-1} (79.05 g) and it was followed by Yellow (78.33 g) and Blackish-red (63.58 g). The Yellowish and the Yellow were statistically similar, while these two were statistically significant over the Blackish-red. On the other hand, the minimum grain weight cob^{-1} (42.25 g) was recorded from Black-small and it was preceded by Reddish (43.08 g). These both were statistically similar. This finding can be thrust to the finds of Mannan *et al.* (2019).

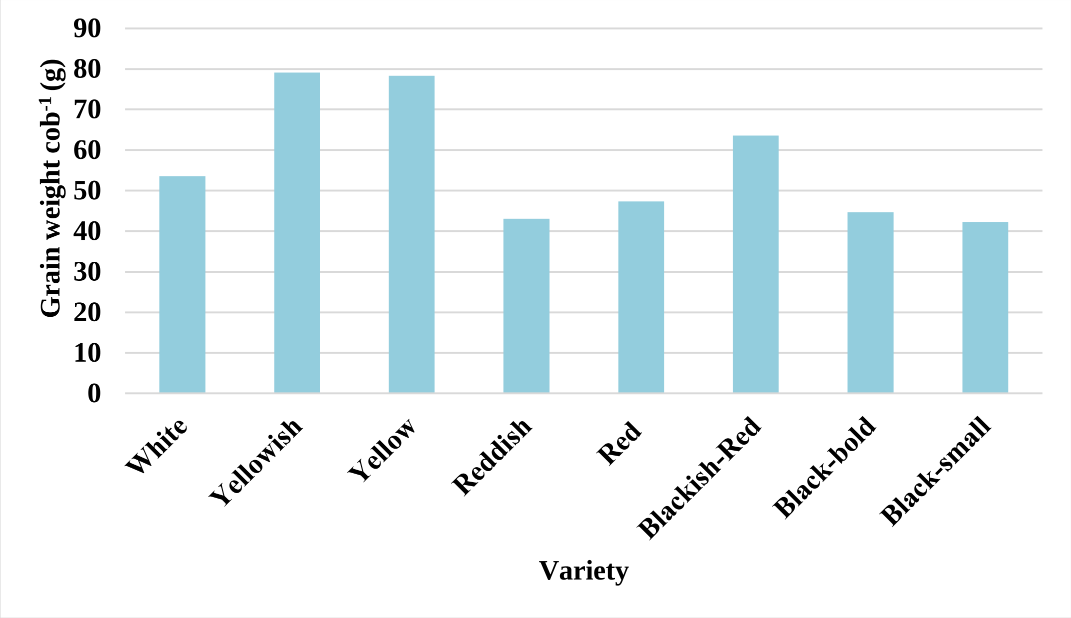


Figure 20. Grain weight cob^{-1} in different varieties of local maize ($LSD_{0.05}$ = 1.68).

Effect of fertilizer dose and varieties interaction on grain weight cob^{-1}

Table 7 gives information about the combined effect of nitrogen fertilizer doses and varieties on grain weight cob^{-1} (g). The weight varied remarkably among the combinations but the effect was not significant. The combination F_{50}Yellowish showed the highest grain weight cob^{-1} of 89.0 g and it was followed by F_{100}Yellow (83.33 g) and F_{50}Yellow (73.33 g), respectively. These three combinations were statistically significant over one another. However, the lowest grain weight cob^{-1} of 42.0 g was obtained from F_{100}Reddish and it was statistically similar with few others preceded combinations. This result can be thrust to infer the findings of Mannan *et al.* (2019).

Table 7. Number of cob plant^{-1}, cob length, number of grains cob^{-1}, and grain weight cob^{-1} in local maize as influenced by the interaction effect of fertilizer application and varieties

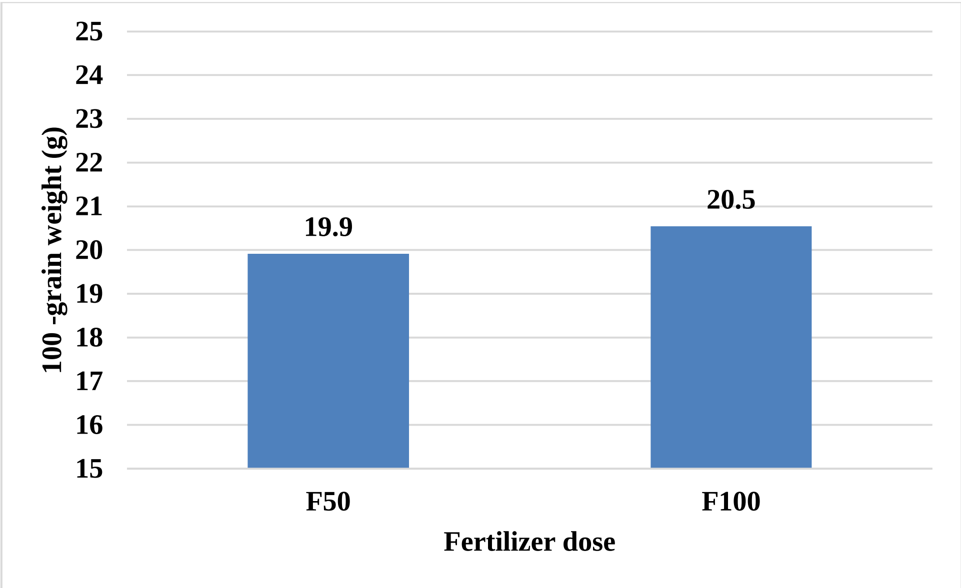
Treatment Combinations	Number of cob plant^{-1}	Cob length (cm)		Number of grains cob^{-1}	Grain weight Cob^{-1} (g)
		120 DAS	Harvest		
F_{50}White	2.33	11.33	13.83	383.77	50.17
F_{50}Yellowish	3.00	12.33	13.67	461.27	89.00
F_{50}Yellow	3.00	12.33	13.50	396.87	73.33
F_{50}Reddish	3.00	11.67	13.17	329.25	44.17
F_{50}Red	2.67	11.33	12.83	386.00	47.17
F_{50}Blackish-Red	3.33	12.00	12.67	440.17	61.33
F_{50}Black-bold	2.67	12.00	12.67	356.70	45.50
F_{50}Black-small	2.33	11.67	12.50	325.50	42.33
F_{100}White	3.67	12.33	12.33	392.10	57.00
F_{100}Yellowish	3.33	12.67	11.92	403.17	69.17
F_{100}Yellow	3.33	12.33	11.83	428.77	83.33
F_{100}Reddish	2.33	12.00	11.67	382.43	42.00
F_{100}Red	3.00	12.33	11.17	378.30	47.50
F_{100}Blackish-Red	3.00	12.00	11.00	371.10	65.83
F_{100}Black-bold	3.00	11.67	11.00	397.33	43.83
F_{100}Black-small	2.33	11.67	10.83	321.93	42.17
$LSD_{0.05}$	1.02	1.20	1.39	8.35	2.39
CV	20.98	5.99	6.76	1.30	2.53

F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids

4.2.5 100-grain Weight (g)

Effect of fertilizer doses on 100-grain weight (g)

The effect of fertilizer doses on 100 grain weight is shown in the Figure 21. In the experiment it was found that F_{100} provided the highest 100 grain weight (20.5 g) while F_{50} gave the lowest 100 grain weight (19.9 g). Instead of having a difference in value among the doses, no statistically significant difference was recorded referring that the fertilizer doses had no remarkable influence on 100 grain weight. In the study of Akbar *et al.*, (2016), 100 grain weight was found to be around 30 while conducting an experiment using maize hybrids. Therefore, it is expected that the 100-grain weight cob^{-1} from local maize varieties will be lower and that is reflected in the current study.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.51)

Figure 21. 100-grain weight (g) of local maize under varying doses of fertilizers.

Effect of varieties on 100-grain weight (g)

Figure 22 illustrates the effect of varieties on 100 grain weight (g). Although there was no statistically significant difference among the varieties overall, some of the varieties were significant to others. The highest 100 grain weight (25.5 g) was given by the variety Yellowish. The highest yield was followed by the variety Yellow (21.5 g). The Yellowish was statistically significant over the Yellow. On the contrary, the lowest yield (15.3 g) was recorded from the variety Black-small. The difference in 100 grain weight among different varieties occurred probably due to the variation of competitive ability (Francis *et al.*, 1978).

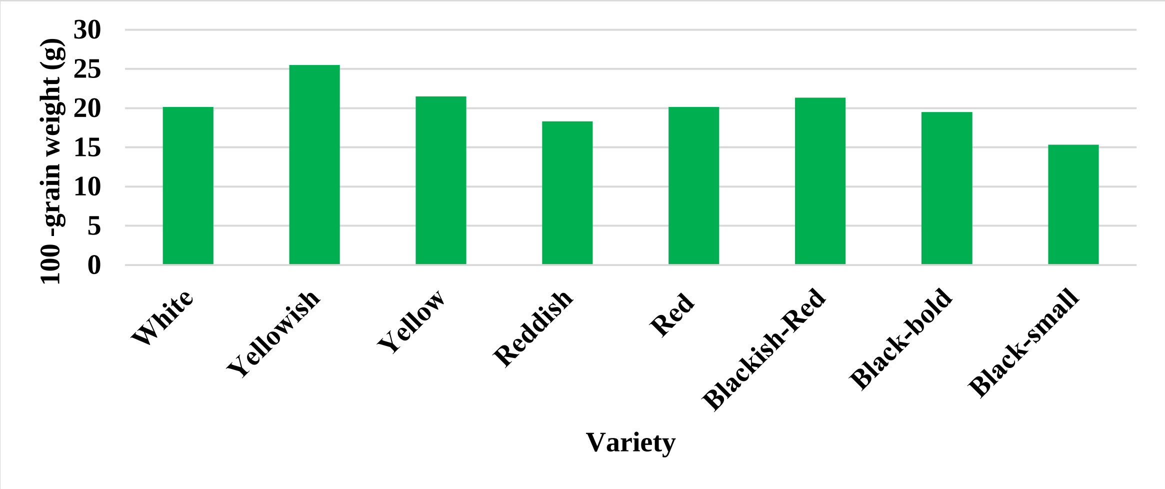


Figure 22. 100-grain weight in different varieties of local maize.

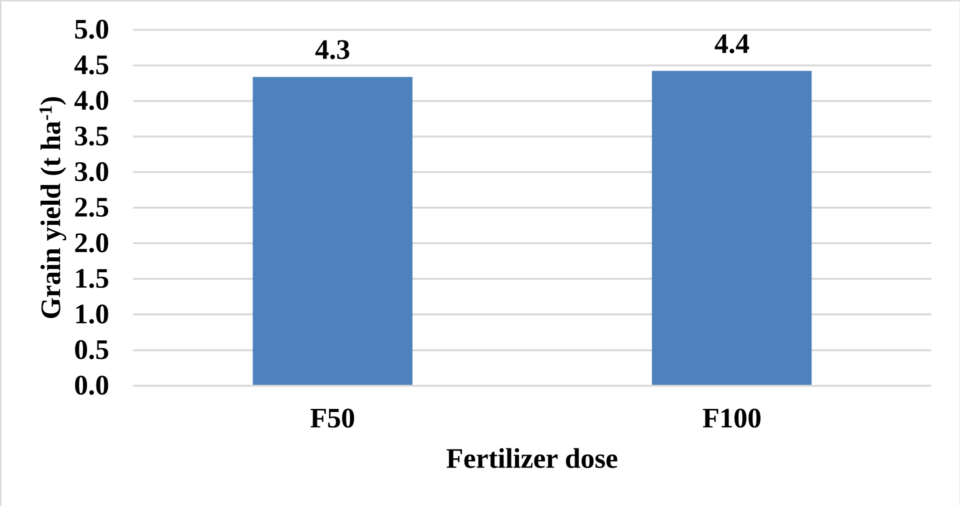
Effect of fertilizer dose and varieties interaction on 100-grain weight (g)

Table 8 shows the combined effect of fertilizer doses and varieties on 100 grain weight (g). From the experiment, the F_{100}Yellowish combination was recorded to provide the highest 100 grain weight (25.67 g) and it was followed by F_{50}Yellowish (25.33 g). However, the combinations were statistically insignificant. The subsequent of F_{50}Yellowish were F_{50}Blackish-Red and F_{100}Yellow giving the same level of 100 grain weight (23.0 g). In contrast, the lowest 100 grain weight of 14.33 g was obtained from the interaction of F_{100} Black-small.

4.2.6 Grain Yield (t ha^{-1})

Effect of fertilizer doses on grain yield

Graph 23 illustrates the effect of nitrogen fertilizer doses on grain yield (t ha^{-1}). The highest yield (4.4 t ha^{-1}) was given by the plants treated with the 100% of the recommended dose (F_{100}). A yield of 4.3 t h^{-1} was recorded from the plants applied with 50% of the recommended dose (F_{50}). Although there was a numerical difference between the nitrogen fertilizer dose treatments, the difference was not statistically significant. While conducting an experiment on the effect of nutrient management, Bashyal *et al.* (2020) reported an average grain yield of about 4.5 to 5 ton per hectare that is almost similar with the finding of the current study.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.23)

Figure 23. Grain yield t ha^{-1} of local maize under different doses of fertilizers.

Effect of varieties on grain yield

Graph 24 shows the influence of varieties on the grain yield. It represents that among the 8 varieties, the Yellowish gave the best yield (5.46 t ha^{-1}) which was succeeded by the Yellow (5.43 t ha^{-1}) and the Balckish-red (5.2 t ha^{-1}). These three varieties were statistically similar. On the other hand, the lowest yield was obtained from the Balck-small (3.4 t ha^{-1}) and it was preceded by the Reddish (3.5 t ha^{-1}). Both of the varieties were statistically similar. Bashyal *et al.* (2020) found the similar range of grain yield.

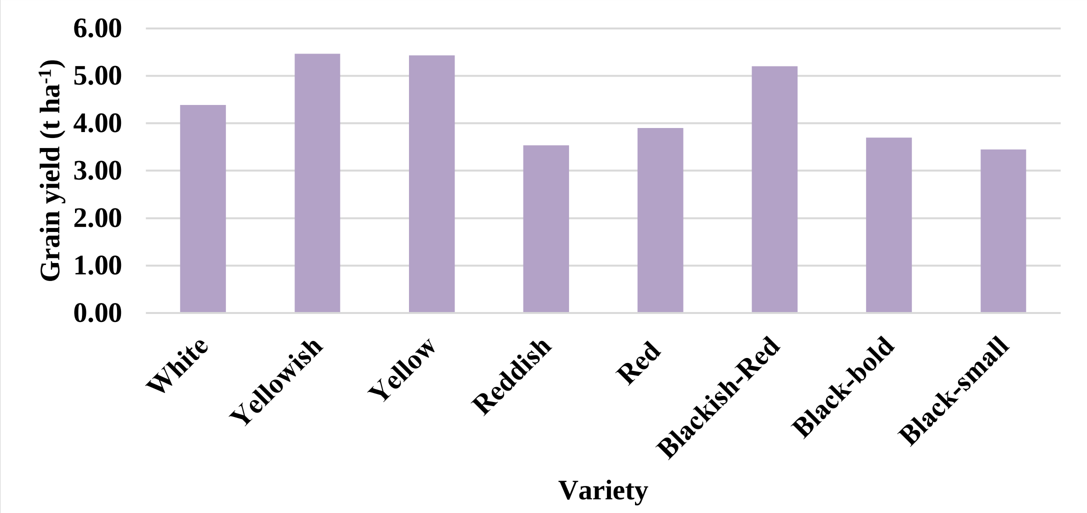


Figure 24. Grain yield t ha^{-1} in different varieties of local maize.

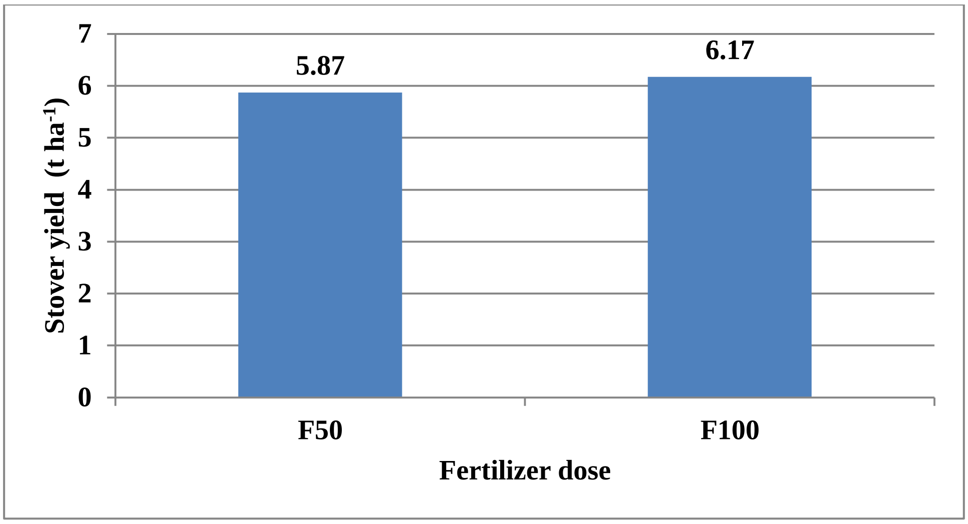
Effect of fertilizer dose and varieties interaction on grain yield

Table 8 shows the combined effect of fertilizer doses and varieties on grain yield. In the experiment it was found that the combination F_{50}Yellowish and F_{100}Yellowish was the maximum grain yield (5.47 t ha^{-1}) giver. The grain yield of F_{50}Yellowish was followed by others combinations- F_{50}Yellow (5.36 t ha^{-1}), F_{100}Yellowish (5.43 t ha^{-1}), F_{100}Blackish-red (5.30 t ha^{-1}). Contrarily, the lowest grain yield was found from the combinations F_{100}Black-small (3.40 t ha^{-1}) and it was statistically similar with all other combinations of F_{100} except F_{100}White. The result was in line with that of Bashyal *et al.* (2020).

4.2.7 Stover Yield (t ha^{-1})

Effect of fertilizer doses on stover yield

Graph 25 illustrates the effect of fertilizer doses on stover yield (t ha^{-1}). The highest stover yield (6.17 t ha^{-1}) was given by the plants treated with the 100% of the recommended dose (F_{100}). A stover yield of 5.87 t h^{-1} was recorded from the plants applied with 50% of the recommended dose (F_{50}). Although there was a numerical difference between the fertilizer dose treatments, the difference was not statistically significant. While conducting an experiment on the effect of herbicides on white maize, Mannan *et al.* (2019) reported an average stover yield of about 5.14 to 7.35 ton per hectare that is almost similar with the finding of the current study.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.15)

Figure 25. Stover yield t ha^{-1} of local maize under different doses of fertilizers.

Effect of varieties doses on stover yield

Graph 26 shows the influence of varieties on the stover yield. It represents that among the 8 varieties, the Yellowish gave the best yield (6.32 t ha^{-1}) which was succeeded by the Yellow (6.25 t ha^{-1}) and the Blackish-red (6.25 t ha^{-1}). These three varieties were statistically similar. On the other hand, the lowest yield was obtained from the Black-small (5.65 t ha^{-1}) and it was preceded by the Black-bold (5.82 t ha^{-1}). Both of the varieties were statistically similar. While conducting an experiment on the effect of herbicides on white maize, Mannan *et al.* (2019) reported an average stover yield of about 7.35 to 5.14 ton per hectare that is almost similar with the finding of the current study.

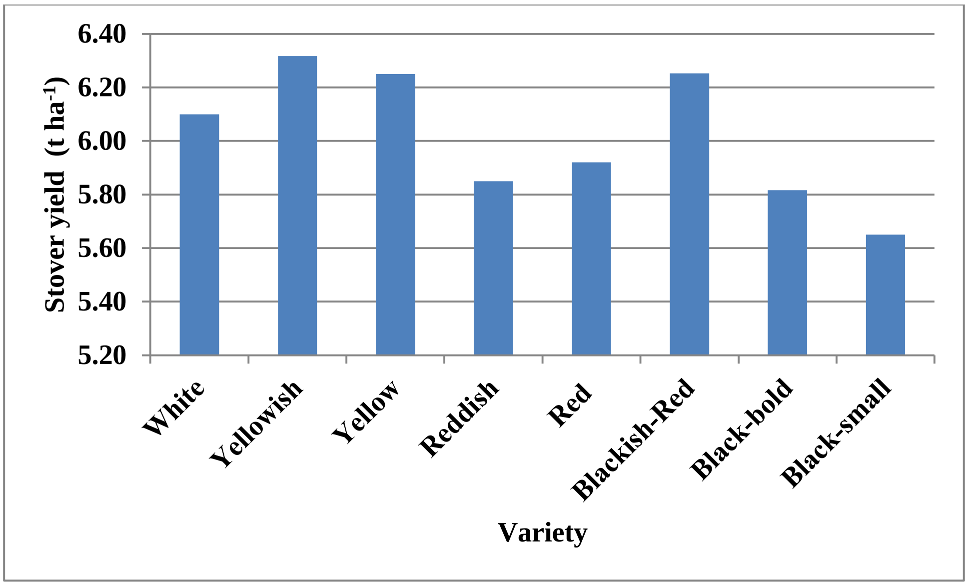


Figure 26. Stover yield t ha^{-1} in different varieties of local maize ($LSD_{0.05}$ = 0.46).

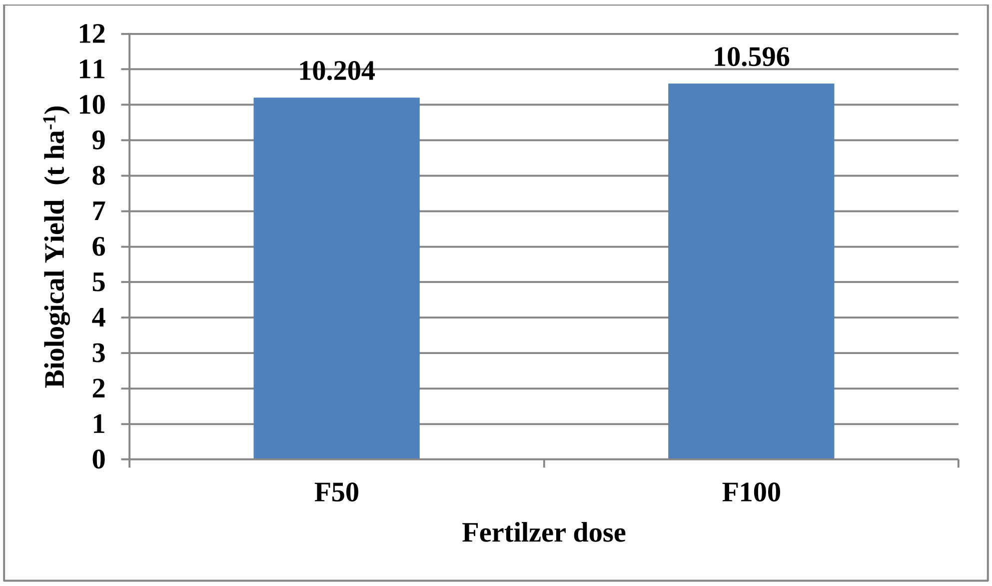
Effect of fertilizer dose and varieties interaction on stover yield

Table 8 shows the combined effect of fertilizer doses and varieties on stover yield. In the experiment it was found that the combination F_{100}Yellow was the maximum stover yield (6.75 t ha^{-1}) given. The stover yield of F_{100}Yellow was followed by four others combinations F_{50}Yellowish (6.67 t ha^{-1}), F_{100}Blackish-Red (6.30 t ha^{-1}), F_{50}Blackish-Red (6.19 t ha^{-1}) and F_{100}Black-bold (6.19 t ha^{-1}). Contrarily, the lowest stover yield was found from the variety – F_{50}Black-bold (5.44 t ha^{-1}). The result was in line with that of Mannan *et al.* (2019).

4.2.8 Biological Yield (t ha^{-1})

Effect of fertilizer doses on biological yield

Graph 27 illustrates the effect of fertilizer doses on biological yield (t ha^{-1}). The highest biological yield 10.596 t ha^{-1} was given by the plants treated with the 100% of the recommended dose (F_{100}). A biological yield 10.204 t h^{-1} was recorded from the plants applied with 50% of the recommended dose (F_{50}). Although there was a numerical difference between the fertilizer dose treatments, the difference was not statistically significant. While conducting an experiment on the effect of herbicides on white maize, Mannan *et al.* (2019) reported an average biological yield of about 10.79 to 16.17 ton per hectare that is almost similar with the finding of the current study.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.41)

Figure 27. Biological yield t ha^{-1} of local maize under different doses of fertilizers.

Effect of varieties doses on biological yield

Graph 28 shows the influence of varieties on the biological yield. It represents that among the 8 varieties, the Yellowish gave the best biological yield (11.77 t ha^{-1}) which was succeeded by the Yellow (11.71 t ha^{-1}) and the Blackish-red (11.45 t ha^{-1}). These three varieties were statistically similar. On the other hand, the lowest biological yield was obtained from the Black-small (9.1 t ha^{-1}) and it was preceded by the Reddish (9.38 t ha^{-1}). Both of the varieties were statistically similar but numerical difference present. The result was in line with that of Mannan *et al.* (2019).

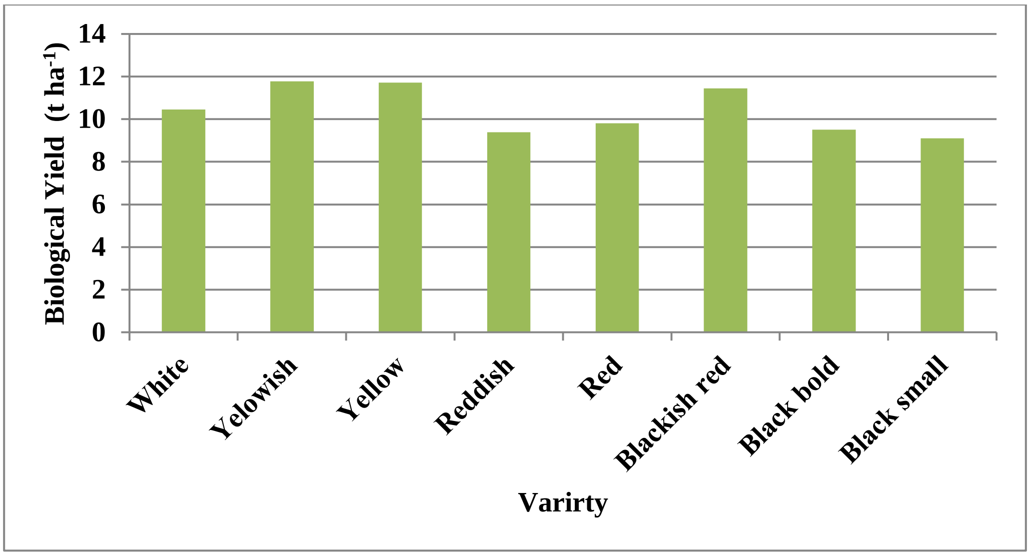


Figure 28. Biological yield t ha^{-1} in different varieties of local maize ($LSD_{0.05}$ = 0.57).

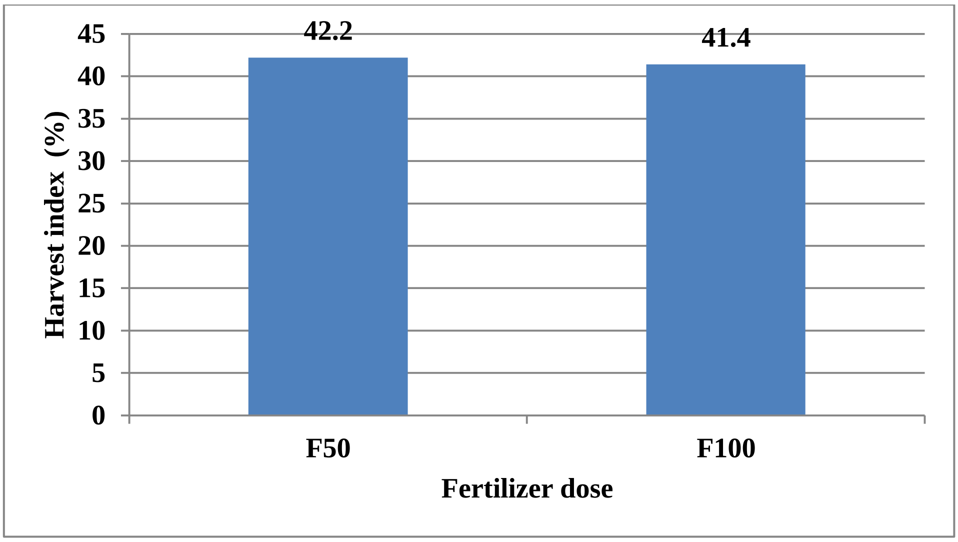
Effect of fertilizer dose and varieties interaction on biological yield

Table 8 shows the combined effect of fertilizer doses and varieties on biological yield. In the experiment it was found that the combination F_{100}Yellow was the maximum biological yield (12.25 t ha^{-1}) given. The biological yield of F_{100}Yellow was followed by two others combinations F_{100}Yellowish (12.10 t ha^{-1}), F_{50}Yellowish (11.47 t ha^{-1}). Contrarily, the lowest biological yield was found from the combination F_{100}Black-small (9.00 t ha^{-1}) and it was statistically similar with F_{50}Reddish (9.21 t ha^{-1}) F_{100}Reddish (9.56 t ha^{-1}). The result was in line with that of Mannan *et al.* (2019).

4.2.9 Harvest Index (%)

Effect of fertilizer doses on harvest index

Figure 29 shows the effect of fertilizer doses on harvest index (%). The effect of both fertilizer doses was statistically similar indicating that fertilizer doses had no significant effect on harvest index. Harvest index was 42.2% when 50% of the recommended dose (F_{50}) was applied. On the other hand, a harvest index of 41.4% was recorded with the application of 100% of the recommended dose (F_{100}) which was lowered by 0.8% as compared to F_{50}. The result was in line with that of Bashyal *et al.* (2020). Probably, the extra assimilates mostly contributed to the vegetative growth that attributed to the decrease in harvest index.



F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids ($LSD_{0.05}$ = 0.92)

Figure 29. Average harvest index of local maize under varying doses of fertilizers.

Effect of varieties on harvest index

Figure 30 illustrates the effect of varieties on harvest index. In this case harvest index of the varieties varied from the lowest 37.65% to the highest 46.51%. The highest harvest index was recorded from the variety Yellow, whereas the lowest one was obtained from Reddish. The Yellowish was followed by Yellow (46.51%) and Blackish-red (45.43%). In terms of statistical significance, the effect of variety on harvest index was not significant. The varieties Yellow, Yellowish, and Blackish-red were statistically similar.

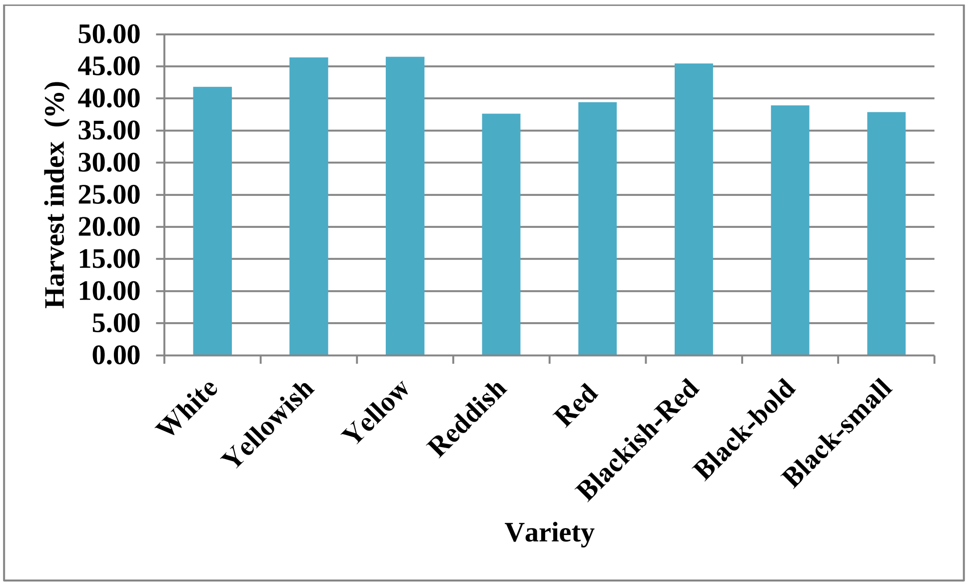


Figure 30. Harvest index in different varieties of local maize ($LSD_{0.05}$ = 2.21)

Effect of fertilizer doses and varieties interaction on harvest index

Table 8 provides information about the combined effect of fertilizer doses and varieties on harvest index. Overall, the effect was not significant. Among the twelve combinations, F_{50}Yellow and F_{50}Yellowish showed the highest (48.11%) and (47.95) harvest index. These two combinations were statistically similar. On the other hand, the lowest harvest index of 35.88 % was recorded in the combination F_{100}Reddish. The result was in line with that of Bashyal *et al.* (2020).

Table 8. 100-grain weight (g), grain yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index in local maize as influenced by the interaction effect of fertilizer and varieties

Treatment Combinations	100 Grain Weight (g)	Grain Yield (t ha^{-1})	Stover Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)
F_{50}White	19.67	4.10	6.32	10.42	39.34
F_{50}Yellowish	25.33	5.50	5.97	11.47	47.95
F_{50}Yellow	20.00	5.36	5.78	11.14	48.11
F_{50}Reddish	18.67	3.63	5.58	9.21	39.41
F_{50}Red	18.33	3.76	5.95	9.71	38.72
F_{50}Blackish-Red	23.00	5.10	6.19	11.29	45.17
F_{50}Black-bold	18.00	3.73	5.44	9.17	40.68
F_{50}Black-small	16.33	3.50	5.71	9.21	38.00
F_{100}White	20.67	4.66	5.87	10.53	44.25
F_{100}Yellowish	25.67	5.43	6.67	12.10	44.88
F_{100}Yellow	23.00	5.50	6.75	12.25	44.90
F_{100}Reddish	18.00	3.43	6.13	9.56	35.88
F_{100}Red	22.00	4.03	5.87	9.90	40.71
F_{100}Blackish-Red	19.67	5.30	6.30	11.60	45.68
F_{100}Black-bold	21.00	3.66	6.19	9.85	37.15
F_{100}Black-small	14.33	3.40	5.60	9.00	37.78
$LSD_{0.05}$	1.38	0.38	0.66	0.80	3.13
CV	4.08	5.22	6.51	4.62	4.48

F_{50}= 50% and F_{100} = 100% of all fertilizer doses as recommended for the hybrids

CHAPTER V

SUMMARY AND CONCLUSION

The present study was conducted at the agronomy farm of Sher-e-Bangla Agricultural University, Dhaka during November 2019 to April 2020 to examine the response of local maize verities to different doses of fertilizer application. The experiment was set up by taking two treatment factors. The treatment factors are: (1) Fertilizer dose; having two levels, viz. F_{100} = 100% of the recommended dose of the nitrogen fertilizer & F_{50} = 50% of the recommended dose of the nitrogen fertilizer; (2) Varieties: 8, viz. White, Yellowish, Yellow, Reddish, Red, Blackish-red, Black-bold, and Black-small. The experiment was conducted in Split Plot Design with three replications. Data on different parameters were recorded and analyzed statistically.

Overall, Nitrogen dose, variety and their interaction had no statistically significant effect on the growth and yield of maize varieties used in the experiment. But there were numerical significant relationships among and between the treatments which helped to determine the superior fertilizer dose, variety, and interaction of variety and fertilizer regarding different plant parameters studied in the research.

The higher plant height (34.9 cm, 91.3 cm, 156.0 cm, 181.4 cm, and 189.1 cm at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively), number of leaves plant^{-1} (19.9 and 19.0 at 120 DAS and harvest, respectively), leaf area (14.3 cm^2, 179.4 cm^2, 399.0 cm^2, 547.7 cm^2, 515.7 cm^2 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively), base circumference (8.51 cm), ground to first cob distance (114.38 cm), whole plant dry weight (2.5 g, 19.9 g, 56.3 g, 307.4 and 340 g at 35 DAS, 60 DAS, 90 DAS, 120 DAS and harvest, respectively), cob number plant^{-1} (3.0), cob length (12.12 cm and 12.33 cm at 120 DAS and harvest, respectively), 100-grain weight (20.5 g) and grain yield (4.4 t ha^{-1}) were recorded from F_{100} as compared to F_{50}. On the other hand, the higher number of grains cob^{-1} (385), grain weight cob^{-1} (56.62 g), stover yield (6.75 t ha^{-1}), biological yield (12.25 t ha$^{-1)}$ and average harvest index (42.2%) were obtained from F_{50} as compared to F_{100}.

In terms of varietal performance, the highest plant height (36.83 cm, 93.83 cm, 158.17 cm, 187.50 cm and 192.5 cm at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively), number of leaves plant^{-1} (5.17, 12.33, 15.50, 20.50, and 19.75 at 35

DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively), leaf area (14.55 cm^2, 182.85 cm^2, 424.83 cm^2, 553.2 cm^2, and 525.75 cm^2 at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively), base circumference (8.83 cm), ground to first cob distance (117.8c cm), whole plant dry weight (2.6 g, 21.7 g, 57.8 g, 313.3 g, and 131.9 g at 35 DAS, 60 DAS, 90 DAS, 120 DAS and harvest, respectively), cob number plant^{-1} (3.17), cob length (12.5 cm and 13.25 cm at 120 DAS and harvest, respectively), number of grains cob^{-1} (432.22), grain weight cob^{-1} (79.05 g), 100-grain weight (25.5 g), grain yield (5.46 t ha^{-1}) and harvest index (46.51%) were revealed from the variety Yellowish. On the contrary, the lowest were obtained from the variety Black-small (3.4 t ha^{-1}).

In case of the interaction effect of fertilizer dose and variety, the superiority of the combinations varied from parameter to parameter. But the best combination in the most crucial growth stage (among 35 DAS, 60 DAS, 90 DAS, 120 DAS and harvesting) for a specific parameter will be considered as the best performer in the final consideration. The tallest plants of 37.67 cm (35 DAS), 95.0 cm (60 DAS), 165.0 cm (90 DAS), 178.0 cm (120 DAS), and 197.17 cm (harvest) were obtained from the combinations- F_{50}Yellowish, F_{100}Yellowish, F_{100}Yellow, F_{100}Yellowish, and F_{100}White, respectively. On the other hand, the shortest plants having height of 32.0 cm (at 35 DAS), 87.33 cm (60 DAS), 147.0 cm (90 DAS), 167.33 cm (120 DAS), and 182.0 cm (harvest) were recorded from F_{100}Black-bold, F_{100}Black-small, F_{100}Black-bold, F_{100}Black-small, and F_{50}White, respectively.

The highest number of leaves plant^{-1} of 5.33 was shown by a number of different combinations (F_{50}White, F_{50}Yellow, F_{50}Blackish-Red, and F_{100}Yellowish) at 35 DAS. Similarly, at 60 DAS, the maximum leaves number- 12.67 was recorded from three individual combinations (F_{50}Yellow, F_{100}White, and F_{100}Yellowish). In these two stages (35 DAS, and 60 DAS) the lowest leaves number recorded were 5.0 and 11.0. However, at 90 DAS, 120 DAS, and harvest, the zenithal count of leaves were 16.0 (F_{50}Yellowish, and F_{50}Blackish-Red), 21.33 (F_{50}Yellowish, and F_{100}Yellow), 20.5 (F_{100}Yellowish), respectively. However, in all of the three stages the lowest number of leaves plant^{-1} was recorded from F_{50}Black-small (14.0, 17.33, and 17.17, respectively).

For leaf area, F_{100}White (14.89 cm^2), F_{50}Yellowish (185.77 cm^2), F_{50}White (436.77 cm^2), F_{50}White (592.50 cm^2), and F_{100}Blackish-Red (551.70 cm^2) were recorded to provide the highest leaf area at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest, respectively. On the other hand, at 35 DAS, 60 DAS, 90 DAS, 120 DAS, and harvest the lowest leaf area of 13.53 cm^2 (F_{50}White), 167.30 cm^2 (F_{100}Black-small), 355.10 cm^2 (F_{100}Black-small), 498.30 cm^2 (F_{100}White), and 473.80 cm^2 (F_{50}Black-bold) were recorded, respectively.

In case of whole plant dry weight, at 35 DAS the highest (2.73 g) and the lowest values were obtained from the combinations F_{50}Yellow and F_{100}Black-small, respectively. However, at 60 DAS, 90 DAS and 120 DAS, the maximum dry weight (23.67 g, 59.33 g, and 331.33 g, respectively) were obtained from the combination-F_{50}Yellowish. Whereas the lowest whole plant dry weight in these sequential three stages were found from F_{100}Black-small- 16.0 g (60 DAS), 52.33 g (90DAS), and F_{50}Reddish- 290.33 g (120 DAS). On the other hand, the highest whole plant dry weight at harvest was recorded from F_{100}Yellowish (340 g) and the lowest one was obtained from F_{100}Black-bold (299.8 g). Plants having maximum base circumference were found in the plots treated with F_{100}Blackish-Red (9.27 cm) followed by F_{50}Yellow (9.17 cm). On the other hand, the minimum base circumference (7.83 cm) was recorded from F_{100}Black-small combinations. For cob setting position, the cob that was set to the highest point (119.33 cm) from ground was recorded from the combination F_{100}Yellowish. On the other hand, the lowest cob setting point was F_{50}Black-small (100.0 cm).

The most critical stage of development for maize plants is the blister stage which is around 120 DAS. This is because the corn plants are utilizing considerable amounts of water each day for “cooling” itself and for sugar production, to support the large plants and the grain-filling processes. Also during this period of growth and development, the number of kernels per row on the ears is finally determined (Coffman, 1998). Hence, for the growth parameters - plant height, number of leaves $plant^{-1}$, leaf area, whole plant dry weight, base circumference, and position of cob setting node the best combinations are F_{100}Yellowish, F_{50}Yellowish, F_{50}White, F_{50}Yellowish, F_{100}Blackish-Red and F_{100}Yellowish, respectively.

For yield contributing parameters – cob number $plant^{-1}$, cob length, number of grains cob^{-1}, grain weight cob^{-1}, 100-grain weight, grain yield, stover yield, biological yield and harvest index, the best performances were shown by F_{100}White (3.67), F_{50}White (13.83 cm), F_{50}Yellowish (461.27), F_{50}Yellowish (89.0 g), F_{100}Yellowish (25.67 g),

F_{50}Yellowish and F_{100}Yellow (5.50 t ha^{-1}), F_{100}Yellow(6.75 t $ha^{-1)}$, F_{100}Yellow(12.25 t $ha^{-1)}$ and F_{50}Yellow (48.11%), respectively.

On the other hand, the lowest cob number $plant^{-1}$ (2.33) were shown by F_{50}White F_{50}Black-small F_{100}Reddish F_{100}Black small and cob length (10.83 cm), number of grains cob^{-1} (321.93), grain weight cob^{-1} (42.0 g), 100-grain weight (14.33 g), grain yield (3.40 t ha^{-1}), Stover yield (5.44 t ha^{-1}), biological yield (9.00 t ha^{-1}) and harvest index (35.88%) were shown, F_{100}Black-small, F_{100}Black-small, F_{100}Reddish, F_{100} Black-small, F_{100}Black-small, F_{50}Black-bold, F_{100}Black-small and F_{100}Reddish, respectively.

Overall, from the above discussion it can be concluded that,

1. Between the fertilizer doses, 100% of the recommended dose (F_{100}) is better performer regarding almost all growth and yield attributes.
2. Among the varieties, the Yellow and Yellowish was the best.
3. Among the combinations, F_{50}Yellowish, F_{50}Yellow, F_{100}Yellowish and F_{100}Blackish-Red were the best combinations for obtaining the maximum growth and yield.
4. F_{50}Yellowish, F_{50}Yellow and F_{50}Blackish-Red may be preferred for farmer because of half dose of fertilizer fill up the statistically higher yield.

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APPENDICES

Appendix I: Monthly records of air temperature, relative humidity and Rainfall during the period from November, 2019 to April 2020

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	Min.	Mean	
November	65.00	32.00	19.00	26.00	35.00
December	74.00	29.00	15.00	22.00	15.00
January	68.00	26.00	10.00	18.00	7.00
February	57.00	15.00	24.00	25.42	25.00
March	57.00	34.00	16.00	28.00	65.00
April	66.00	35.00	20.00	28.00	155.00

(Source: timeanddate.com)

Appendix II: Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (AEZ 28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

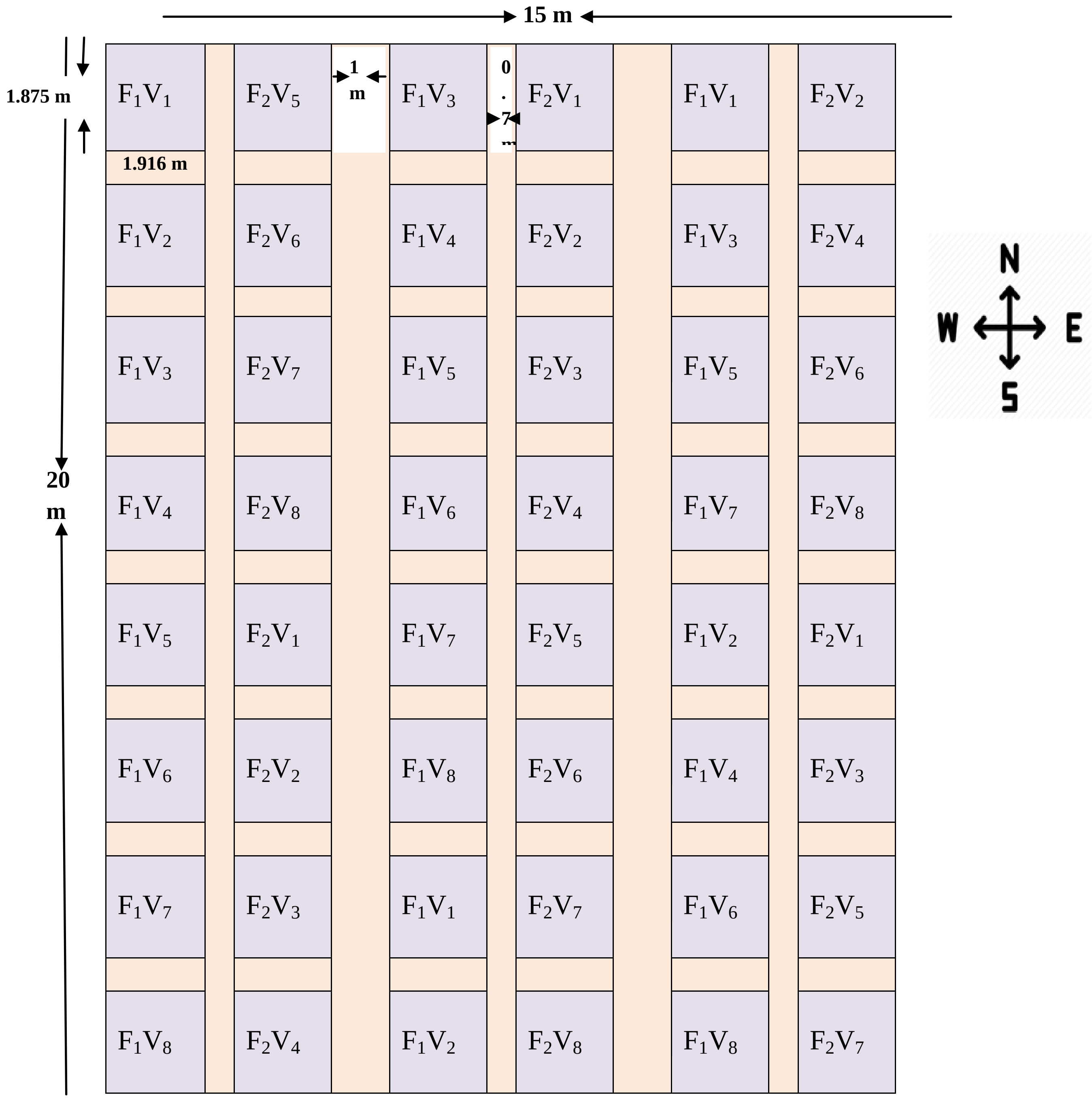
Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Particle size analysis % Sand	27.00
%Silt	43.00
% Clay	30.00
Textural class	Silty Clay Loam
pH	5.60
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45.00

Source: Soil Resource Development Institute (SRDI)

Appendix III: Layout of experimental field.



Factor A: Fertilizer doses (2)

$F_1 = F_{100}$ = 100% of the recommended dose of nitrogen (N)

$F_2 = F_{50}$ = 50% of the recommended dose of nitrogen (N)

Factor B: Variety (8)

V_1 = White, V_2 = Yellowish, V_3 = Yellow, V_4 = Reddish, V_5 = Red, V_6 = Blackish-Red, V_7 = Black-Bold, V_8= Black-Small

Appendix IV: Analysis of variance of the data on plant height (cm)

Source	DF	Mean Square Values				
		35 DAS	60 DAS	90 DAS	120 DAS	Harvest
Rep	2	18.1140	3.2377	0.253	0.954	0.2519
Fertilizer	1	7.9219	2.1675	82.688	181.741	5.3333
Error Rep*Fertilizer	2	3.0056	0.0269	2.710	0.106	3.4577
Variety	7	9.5112	10.9723	32.521	130.488	35.6042
Fertilizer*Variety	7	4.1838	56.1675	102.735	125.331	66.1548
Error Rep*Fertilizer*Variety	28	5.3062	0.1401	0.262	0.560	0.7767

Appendix V: Analysis of variance of the data on number of leaves plant^{-1}

Source	DF	Mean Square Values				
		35 DAS	60 DAS	90 DAS	120 DAS	Harvest
Rep	2	0.33333	0.14583	0.0625	32.6875	17.5990
Fertilizer	1	0.08333	0.08333	0.0833	4.0833	11.5052
Error Rep*Fertilizer	2	0.08333	0.27083	14.0208	1.2708	9.8490
Variety	7	0.04762	0.52381	0.5238	2.2738	2.8743
Fertilizer*Variety	7	0.08333	1.32143	1.7500	4.6548	2.0647
Error Rep*Fertilizer*Variety	28	0.06548	0.42262	2.6369	4.6696	3.8847

Appendix VI: Analysis of variance of the data on leaf area (cm^2)

Source	DF	Mean Square Values				
		35 DAS	60 DAS	90 DAS	120 DAS	Harvest
Rep	2	0.43432	0.505	1.48	5.68	4.62
Fertilizer	1	0.79262	195.743	940.10	2339.42	8035.00
Error Rep*Fertilizer	2	0.16254	1.745	2.29	0.14	0.09
Variety	7	0.58749	71.308	2190.22	765.54	2088.84
Fertilizer*Variety	7	0.46459	129.434	1084.43	5111.68	1951.25
Error Rep*Fertilizer*Variety	28	0.32029	0.349	0.38	0.10	0.15

Appendix VII: Analysis of variance of the data on base circumference and ground to first cob distance (cm).

Source	DF	Mean Square Values	
		Base circumference	Ground to 1st cob distance
Rep	2	0.79021	0.748
Fertilizer	1	0.01333	396.750
Error Rep*Fertilizer	2	0.26521	1.167
Variety	7	0.44369	97.524
Fertilizer*Variety	7	0.67524	49.131
Error rep*Fertilizer*Variety	28	0.37580	2.451

Appendix VIII: Analysis of variance of the data on whole plant dry weight (g)

Source	DF	Mean Square Values				
		35 DAS	60 DAS	90 DAS	120 DAS	Harvest
Rep	2	0.07313	0.0452	0.1290	0.1290	0.1233
Fertilizer	1	0.03521	22.6875	11.0208	11.0208	18.7500
Error Rep*Fertilizer	2	0.01396	0.2519	0.1815	0.1815	0.1900
Variety	7	0.04140	11.9494	11.2589	11.2589	35.4732
Fertilizer*Variety	7	0.03997	7.3542	8.4018	8.4018	67.2024
Error Rep*Fertilizer*Variety	28	0.04283	0.2812	0.3912	0.3912	0.4090

Appendix IX: Analysis of variance of the data on cob number plant^{-1}, cob length, number of grains cob^{-1} and grain weight cob^{-1}

Source	DF	Mean Square Values			
		Cob number plant^{-1}	Cob length	Number of grains cob^{-1}	Grain weight cob^{-1}
Rep	2	0.08333	0.48771	12.05	2.21
Fertilizer	1	0.52083	1.02083	3.60	0.88
Error Rep*Fertilizer	2	2.08333	0.42271	22.25	4.68
Variety	7	0.52083	0.49702	6955.15	1416.43
Fertilizer*Variety	7	0.52083	0.35417	2953.29	121.57
Error Rep*Fertilizer*Variety	28	0.36905	0.51497	24.95	2.04

Appendix X: Analysis of variance of the data on 100-grain weight, grain yield and harvest index

Source	DF	Mean Square Values				
		100-grain weight	**Grain yield**	**Stover yield**	**Biological yield**	**Harvest index**
Rep	2	0.3102	0.42021	0.20813	0.92772	12.2890
Fertilizer	1	4.6875	0.10083	1.11021	1.81624	8.5852
Error Rep*Fertilizer	2	0.1694	0.03646	0.01521	0.11212	0.5527
Variety	7	50.3304	4.48905	0.35830	7.31683	87.6345
Fertilizer*Variety	7	9.6399	0.09464	0.39449	0.25481	14.2533
Error Rep*Fertilizer *Variety	28	0.6807	0.05238	0.15595	0.22943	3.4970

PLATES

Plate I: Tagging plots

Plate II: Seedling germination and irrigation

Plate III: Intercultural operation (weeding)

Plate IV: Fully grown maize plants

Plate V: Data collection

Plate VI: Data acquisition

Plate VII: Displaying harvested cobs

Plate VIII: Displaying harvested cobs of all combination

Plate IX: Displaying harvested cobs' grains sample