YIELD PERFORMANCE OF WHITE MAIZE (SAUWMT-9-3-4) UNDER VARYING FERTILIZER DOSES AND SPACING IN KHARIF-1 SEASON

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CERTIFICATE

This is to certify that the thesis entitled ***"YIELD PERFORMANCE OF WHITE MAIZE (SAUWMT-9-3-4) UNDER VARYING FERTILIZER DOSES AND SPACING IN KHARIF-1 SEASON*** *submitted to the Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTERS OF SCIENCE (MS)*** *in* ***AGRONOMY****, embodies the results of a piece of authentic research work successfully carried out by* ***NUR HOSSAIN*** *Registration No.* ***18-09189*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, as has been availed of during the course of this investigation has duly been acknowledged

December, 2020

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Dedicated to

My

Beloved Parents

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The Author

YIELD PERFORMANCE OF WHITE MAIZE (SAUWMT- 9-3-4) UNDER VARYING FERTILIZER DOSES AND SPACING IN KHARIF-1 SEASON

ABSTRACT

The experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during Kharif-1 season from 22th March 2019 to 24th June 2019 to study the yield performance of white maize (SAUWMT-9-3-4) under varying fertilizer doses and spacing in Kharif-1 season. The experiment comprised two factors, Factor A: Different fertilizer doses i.e. F_1= Recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = 25% more than recommended doses of fertilizer and, Factor B: Three level of spacing i.e. S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm, S_3 = 40 cm× 20 cm, The experiment was conducted following split plot design with three replications. Both the fertilizer dose and spacing level along with their Combined had significant effect on almost all vegetative and reproductive parameters. The highest values in plant heights (202.20 cm and 209.75 cm), highest leaf areas at lower (731.63 cm^2 and 733.26 cm^2), at cob (762.27 cm^2 and 749.61 cm^2) and upper units (809.56 cm^2 and 573.34 cm^2) plant^{-1} respectively found from $F_3S_{1.}$ The highest values in number of rows cob^{-1} (14.33), number of grain row^{-1} (30.78), and number of grain cob^{-1} (414.74) and 100 grain weight (34.70 g) were recorded from the treatment F_3S_2. The highest grain yield, stover yield and biological yield (10.22, 11.27 and 21.49 t ha^{-1}, respectively) were found from F_3S_2.

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Acronyms
SAU =	Sher-e-Bangla Agricultural University
SPD =	Split Plot Design
AEZ =	Agro-Ecological Zone
BARI =	Bangladesh Agricultural Research Institute
BAU =	Bangladesh Agricultural University
BBS =	Bangladesh Bureau of Statistics
CV% =	Percentage of coefficient of variance
LSD =	Least Significant Difference
DAE =	Department of Agriculture Extension
DAS =	Days after sowing
^{0}C =	Degree Celsius
et al =	And others
FAO =	Food and Agriculture Organization
g =	gram(s)
Ha^{-1} =	Per hectare
SRDI =	Soil Resource and Development Institute
LAI =	Leaf Area Index
HI =	Harvest Index
kg =	Kilogram
mg =	Milligram
No. =	Number
NS =	Non-significant
% =	Percent
N =	Nitrogen
TSP =	Triple Super Phosphate
MoP =	Muriate of Potash
NPK =	Nitrogen, Phosphorous and Potassium

LIST OF ABBREVIATIONS AND ACRONYMS (Cont'd)

Abbreviation	Acronyms
WP =	Wettable powder
Wt. =	Weight
Agri. =	Agriculture
KGF =	Krishi Gobeshona Foundation
viz. =	Videlicet (namely)
cv. =	Cultivar
No.	Number
RCBD =	Randomized Complete Block Design
WUE =	Water Use Efficiency
Mm =	Millimeter
Max =	Maximum
Min =	Minimum
Contd. =	Continued

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world agricultural economy both as food for human as well as feed for animal consumption. This cereal crop falls under the family of Poaceae. It has very high yield potential, there is no cereal on the earth which has more yield potentiality like this and that is why it is called "Queen of cereals" (FAO, 2002). The main staple crops of Bangladesh is rice and wheat from where food grains for 16 million people is supplied. Being C_3, rice and wheat may not be able to supplying food requirements at or after fifties as the population of Bangladesh is still in increasing trend. On the other hand, the maize being a C_4 is more than two folds productive as compared to rice and wheat.

It is also forecasted that due to increasing global temperature due to climate change, the yield potential of wheat will be decreasing day by day as if its grain filling could not be synchronized with period of low temperature. In Bangladesh, about 989582 lac acres of land is under the coverage of maize producing 3288102 metric tons annually (BBS, 2018).

Introduction of maize in Bangladesh as human food can be a viable alternative for sustaining food security as the productivity of maize much higher than rice and wheat (Ray *et al.*, 2013). It serves many of the vitamins B as well as essential minerals along with fiber, but absence of some other nutrients, such as vitamin B_{12} and vitamin C. People in many developed and developing countries produce and consume maize as staple food. Maize has been a recent introduction in Bangladesh. Rice, maize cropping system has been expanded (Timsina *et al.*,2010) rapidly in the northern districts of Bangladesh mainly in response to increasing demand for poultry feed (BBS, 2016) and as a result, its area has been increasing in Bangladesh at an average annual rate of 28.35 % (FAO, 2019).

There are two kinds of maize in respect of grain color; yellow and white. Worldwide, the yellow maize is mainly used as fodder, while the white ones are consumed as human food (FAO, 2002). The currently grown maize in this country is yellow type which is mainly adapted importing genetic materials from CIMMYT. Again although there are some indigenous local maize in the south east hills those have also not improved for having higher yields (Ullah *et al.*, 2016).

However, there is no high yielding white maize varieties in Bangladesh and so Bangladesh has to generate technologies for the cultivation of white maize which either are imported or developed (Ullah *et al.,* 2017a). In general the yield productivity of any crop in this country is low which is generally attributed to the poor agronomic managements. Among the agronomic managements, setting optimum population density using the correct planting configuration and application of balanced fertilizers are two of the important agronomic operations. Maize's yield is dependent on many management factors of which the population density is one of those.

Iken and Anusa (2004) recommended an optimum plant population of 53,333 plants/ha for maximum yield of maize. Plant spacing is one factor that determines the population density and thereby affects efficiency of use of land, light, water and nutrients. Leaf area can be increased by increasing population density or sowing seeds by using narrow spacing (Major and Daynard, 1972; Zeidan *et al.*, 2006; Liu, *et al.*2004).Potential higher yields of modern hybrids obtainable with higher population encouraged planting maize at narrower spacing (Khan *et al.*, 2005). (Ullah *et al.,* 2017 b). showed that in Bangladesh, a population density of 83,000 planted in rows at 60 cm × 20 cm configuration gave the highest grain yield. Optimum plant density, however, depends largely on genotype, season, available growth resources and agronomic management conditions significantly (Khan *et al.*, 2005).

Highly fertilized soils are required for intensive cropping system and integrated plant nutrient management system helps to sustain those soils (Bationo and Koala, 1998). Chemical fertilizers became popular for their suitable, easy to use and satisfactory yield although the chemical fertilizers are responsible for soil quality degradation, water source pollution, soil nutrient leaching, decline the soil physical structure, degradation of soil biological properties (like microorganisms which make the nutrient available for plant, friendly insects which protect the crop from disease and pathogen), disruption of soil chemical structure such as soil acidification or alkalization. Choudhary and Bailey (1994), integrating organic manure with the chemical fertilizer has a lot of beneficial effects such as improvement in soil physical properties, soil fertility, aeration, water holding capacity and activate micro-organisms in the soil that make the nutrient available to the plant. Such benefits of using chemical fertilizers along with organic manure has also been reported many other workers (Reganold, 1995; Abedi *et al.,* 2010; Kazemeini *et al.*, 2010; Mugwe *et al.,* 2009).

Researchers conducted many researches on spacing of maize but white maize is a new introduction in our country. Very few research findings are available in our country on white maize. So, there is a wide scope to conduct research on fertilizer doses and spacing of white maize. This study will helps us to evaluate the effect of different plant spacing and fertilizer doses on growth and yield potential of white maize production. Based on the above points, the current study was conducted with the following objectives:

3. Objectives of the Research work:

1. To evaluate the response of white maize genotype SAUWMT-9-3-4 to varying doses of fertilizers.
2. To examine the performance of white maize genotype SAUWMT-9-3-4 to varying levels of spacing
3. To assess the Combined effect of different fertilizer doses and spacings on the overall performance of white maize genotype SAUWMT-9-3-4

CHAPTER II

REVIEW OF LITERATURE

2.1 Effect of fertilizer

Abebe and Feyisa (2017) reported that, despite the fact that maize productivity is relatively better than other major cereal crops, its current productivity is still far below its potential productivity. N rate and time of application are among the major abiotic factors limiting the productivity of the crop. Because of such gaps, an experiment was conducted by them at Bako Agricultural Research Center in 2013 and 2014 cropping seasons to determine optimum N rate and time of application. Four doses of N rates (46, 69, 92, and 115 N kg ha^{-1}) and four doses (T_1, T_2, T_3 and T_4) of different time of N application were arranged in factorial combinations. Results showed that 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 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 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. Woldesenbet and Haileyesus (2016) reported that, maize response to high fertilization doses is a means among other means to know maximum productivity, from this perspective, a field fertilizer management trial using five N doses (0, 23, 46, 69 and 92 kg N/ha) with three replications.

The study was conducted in 2015 in Decha District, Modyo Gombera Kebele, Kaffa Zone of SNNPR State. The experiment was laid out in RCBD. The result of this study indicated that effects of different rates of N fertilizer had influenced the growth and yield components of maize. The tallest plant (360.66 cm) was recorded from the application of 92 kg N ha^{-1} and the shortest (347.33 cm) from no N application. The number of kernels per ear showed that the lowest kernels per ear (497.86) were obtained from no N application and the highest kernels per ear (588) were obtained from the application of 92 kg N ha^{-1} although there was no significant difference between the application of 69 and 92 kg N ha^{-1}. Regarding to ear length the data showed that the longest ear (23.63 cm) was obtained from the application of 92 kg N ha^{-1}. The effect of N on grain yield indicated that there is no significant difference between the application of 69 and 92 kg N ha^{-1} even if there is a slight difference on yield. Generally, maximum N fertilization level (92 Kg N/ha) in this study area showed increase in growth and yield components (number of kernels per ear and ear length). However, the application of 69 kg N ha^{-1} seems adequate to get the optimum yield.

Maqbool *et al.* (2016) conducted a field experiment for two consecutive years to study the effect of fertilizer application methods and inter and intra-row weed-crop competition durations on density and biomass of different weeds and growth, grain yield and yield components of maize. The experimental treatments comprised of two fertilizer application methods (side placement and below seed placement) and inter and intra-row weed-crop competition durations each for 15, 30, 45, and 60 days after emergence, as well as through the crop growing period. Fertilizer application method didn't affect weed density, biomass, and grain yield of maize. Below seed fertilizer placement generally resulted in less mean weed dry weight and more crop leaf area index, growth rate, grain weight per cob and 1000 grain weight. Minimum number of weeds and dry weight were recorded in inter-row or intra-row weed-crop competition for 15 DAE. Number of cobs per plant, grain weight per cob, 1000 grain weight and grain yield decreased with an increase in both inter-row and intra-row weed-crop competition durations. Maximum mean grain yield of 6.35 and 6.33 tha-1were recorded in inter-row and intra-row weed competition for 15 DAE, respectively.

Eltelib *et al.* (2006) studied the effect of fertilizer and phosphorus application on growth, forage yield and quality of fodder maize growing in Sudan. The variety used was Giza 2. Fertilizer was applied at the rates of (0, 40 and 80 kg ha^{-1}), while phosphorus doses were (0, 50 and 100 kg P_2O_5 ha^{-1}). Parameters studied were plant height, number of leaves per plant, stem circumference and leaf area index (LAl), days to 50% tasseling, dry matter yield, crude protein and crude fibre contents were studied.

Results showed that addition of fertilizer significantly increased plant height, stem circumference and LAI, forage dry matter yield and protein content. Phosphorus fertilizer application had no significant effect on growth, days to 50% tasseling, dry matter yield and crude protein content. Neither fertilizer nor phosphorus had a significant effect on the crude fibre content. Field experiments were conducted on Nitisols (acidic soils) for two consecutive cropping seasons at Wujiraba watershed, northwestern highlands of Ethiopia. The experiments were laid down in RCBD as factorial combinations of three doses of N (0, 60 and 120 kg N ha^{-1}), compost (0, 5 and 10 ton compost ha^{-1}) and S (0, 15 and 30 kg S ha^{-1}) fertilizers which were replicated three times. In this experiment, significant ($p \leq 0.05$) differences were observed on maize grain yield, total above ground dry biomass, plant height, grain number per cob, cob weight, thousand seed weight, N and S concentration of leaves and grains by such fertilizers combinations. The highest mean grain yield, dry biomass, plant height, grain number per cob, cob weight, thousand seed weight, N concentration in leaf and grain (7.9, 22.4 t ha^{-1}, 2.52 m, 486, 0.44 g, 492 g, 3.25 and 1.4%) were observed in plots treated with fertilizer combinations of 120 kg N ha^{-1}, 10 t compost ha-1and 15 kg S ha^{-1}, respectively. From this study it is possible to infer that integrated application of organic and inorganic fertilizers increased crop yields. Hence, incorporation of compost with inorganic N and S fertilizers for maize enhanced grain yield by adding nutrients.

Ademba *et al.* (2015) stated that, phosphorus, fertilizer and Striga hermonthica are the major constraints to maize production in the Nyanza Province of Kenya. Field trials were conducted on-farm in Nyanza Province to investigate the effects of phosphate fertilizers and manure on maize yields. The experimental design was a Randomized Complete Block Design (RCBD) with maize as the test crop. The maize was top dressed with calcium ammonium nitrate (CAN) fertilizer at a uniform rate of 30 kg N/ha diammonium phosphate (DAP), Minjingu rock phosphate (MRP) and triple super phosphate (TSP) fertilizers were applied at 60 kg/ha P2O5, farmyard manure (FYM) at 10 t/ha and a non-phosphorus (P) treatment (control) plus lime only. Responses ($P \leq 0.01$) from grain yield, total dry matter yield and harvest index to phosphate fertilizers and manure treatments were found. Nutrient uptake and removal by the crop increased ($P \leq 0.01$) due to fertilizers and manure application. Phosphate fertilizers and manure application increased ($P \leq 0.01$)) available soil P, agronomic phosphorus use efficiency (APUE) and Physiological P use efficiency (PPUE). The results indicate that phosphate fertilizers and manure applications are essential to improve maize yield and nutrient P use efficiency.

Crista *et al.* (2014) stated that, fertilizers make their best contribution to the enhancement only if it falls within a hierarchical system of good technological measures and the doses used are related to crop plants, soil, climate, and culture technology. The fertilization system influenced the maize harvest, leading to the production of 9034 kg of maize / ha. In recent years, the amount of fertilizer used has remained relatively constant while average yields have steadily increased. Because of the complex nature of soil and weather variability, farmers face significant challenges in optimizing the amount of fertilizer to apply to each field, year and area within a field. This results in under-application of fertilizer in some years and fields, with resulting yield losses, and over application of fertilizer in other years and field areas resulting in inefficient use of fertilizer resources.

Ahmad *et al.* (2018) conducted an experiment to study the effect of different fertilizer rates on the yield and yield components of maize cultivars (Azam and Jalal), 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-1 (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 grains 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^{-1} (411.32), grain yield (4888.9 kg ha^{-1}) and thousand grains weight (264.96 g) were observed with the application of 180 kg N ha^{-1}.

Amin (2011) conducted a field experiment for two consecutive seasons in 2004/2005 and 2005/2006 at the demonstration farm of the Faculty of Agriculture, Omdurman Islamic University, Sudan, to investigate the effect of different fertilizer sources on growth, yield and quality of fodder maize (*Zea mays* L.). The fertilizer sources are urea, nitrophoska (NPK), ammonium sulphate nitrate (ASN) and ammonium sulphate (AS). The design used was completely randomized block design with four replicates. The growth attributes measured, were plant height, stem diameter, number of leaves, leaf area, leaf area index. Number of days to 50% tasseling, forage yield, crude protein and crude fiber were also investigated in this study. The results revealed that fertilizer sources significantly affected growth parameters at all sampling occasions during the two seasons. Remarkable results noticed at fertilizer sources ASN flowed by NPK and the AS, as compared with urea. The results showed that, the number of the days for 50% tasseling, fresh forage yield and dry forage yield were significantly affected by fertilizer sources during two seasons. Moreover, dry and fresh forage yield, increased progressively by ASN and NPK as compared with other fertilizer sources. The present data revealed that, the crude protein and crude fiber were significantly affected by fertilizer sources in both seasons. The urea gave the lowest crude protein compared with the other fertilizer sources. On the other hand, the lowest crude fiber content was recorded when plant was treated with (ASN) fertilizer, while the highest crude fiber content was recorded only under the control.

Xu *et al*. (2006) stated that, analyses of fertilization suggest the following key messages. Households that obtained fertilizer on time and used animal draft power or mechanical power in land preparation are more likely to find fertilizer use profitable than other groups of households located in the same district. Subsidized fertilizer under government programs in Zambia has often been distributed late.

Adeniyan and Ojeniyi (2005) reported that, the comparative effects of 300 kg/ha NPK 15-15-15 fertilizer, 7t/ha poultry manure (Pm), six combinations of reduced doses of NPK 15-15-15 fertilizer and poultry manure, and control (no fertilizer) on maize growth, nutrients uptake and soil chemical properties were investigated for two years at Akure, South West Nigeria. Application of poultry manure, and combination of poultry manure and or NPK fertilizer significantly increased soil chemical composition, maize plant dry matter yield, grain yield, plant height, leaf area and nutrients uptake. The highest grain yields were obtained with combined use of NPK fertilizer and poultry manure in 1996 and 1997. The highest values were recorded with combined use of 3t/ha poultry manure and 200kg/ha NPK fertilizer with respect to dry matter yield, grain yield and nutrients uptake in both years.

Rasheed *et al.* (2004) laid out the experiment in randomized complete block design (RCBD) having three replications with net plot of 4.2 × 7.5 m to evaluate the effect of fertilizer and sulfur on growth, yield and quality of double cross hybrid (DCH) maize (Cargil-707). Application of fertilizers at the rate of 150 + 30 and 150 + 20 kg of fertilizer and sulfur per hectare respectively greatly increased dry weight per plant (DWP), plant grains number per ear (GNE) and grain weight per ear (GWE) over other treatments. Similarly, the highest grain yield of 8.59 tons per hectare was recorded from the plot fertilized at the rate of 150 kg N and 30 kg S per hectare, while maximum grain oil content (GOC) and grain protein contents (GPC) were recorded from plot fertilized at the rate of 150 + 30 and 150 + 20 kg N and S per hectare respectively.

2.2 Effect of spacing

Sabo *et al*. (2016) conducted a field experiment at the Abubakar Tafawa Balewa University teaching and research farm Bauchi state of Nigeria, during the 2013 rainy season, to investigate the effect of variety and intra-row spacing on growth and yield of maize (*Zea mays* L.) in Bauchi state. The Treatments consist of three varieties of corn (DMR, TZEE and QPM) and three intra-rows spacing (20, 25 and 30 cm). The experiment was laid-out in a randomized complete block design, replicated three times. Data was collected on plant height, number of leaves, leaf area, leaf area index, number of cobs per plot, cob length, 100 seeds weight and grain yield. The results obtained showed that varieties differed significantly, in which, DMR significantly produced the highest yield, and followed by QPM and TZEE which are similar in yield performance. Intra-row spacing of 25 cm was observed to be significantly ($p=0.05$) higher than 20 cm and 30 cm spacing in all the characters studied. Based on the results of the study, it may be concluded that DMR variety and 25 cm intra-row spacing proved more promising in the study area.

Hasan *et al.* (2018) conducted an experiment at the Agronomy Field Laboratory, Agricultural University, Mymensingh in Bangladesh during December 2015 to April 2016 to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised five varieties viz., Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C- 1921, P-3396 and five plants spacing viz., 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The experiment was laid out in a randomized complete block design with three replications. Results revealed that variety and plant spacing had significant effect on the studied crop characters and yield. The highest plant height, highest number of leaves plant-1, longest cob, maximum circumference of cob, highest number of kernel cob-1, the highest 1000-grain weight, maximum grain yield and stover yield were observed in BARI hybrid maize 7. On the other hand, the shortest plant, lowest number of cob, circumference of cob, lowest number of grains cob^{-1} , 1000-grain weight, and grain yield and stover yield were observed in Khoi bhutta. The longest plant, highest cob, maximum circumference of cob, highest number of kernel cob^{-1} the highest 1000-grain weight, maximum grain yield and stover yield was observed in the spacing of 75 cm × 25 cm. In contrast, the spacing of 75 cm × 30 cm produced the lowest values of the above mentioned plant parameters and also showed the lowest grain yield. In regard to Combined effect of variety and spacing, the highest plant height (232.67 cm), maximum number of cob plant^{-1} (1.73), maximum circumference of cob (4.60 cm), highest number of kernel cob^{-1} (34), maximum stover yield (12.38 t ha^{-1}) were observed at the spacing of 75 cm × 25 cm with BARI hybrid maize 7 and resulting in the highest grain yield (9.04 t ha^{-1}). The lowest values of the above parameters were recorded in the narrowest plant spacing of 75 cm × 35 cm with Khoi bhutta. Based on the experimental results, it may be concluded that maize (cv. BARI hybrid maize 7) can be cultivated with a spacing of 75 cm × 25 cm for appreciable grain yield.

Jiang *et al.* (2013) reported that the maize cultivar Denghai 661 was planted in rectangular tanks (0.54 m × 0.27 m × 1.00 m) under 27 cm (normal) and 6 cm (narrow) abnormal plant spacing, narrow plant spacing generated less root biomass in the 0– 20 cm zone under both N rates, slight reductions of dry root weight in the 20–40 cm and 40–70 cm zones at the mid-grain filling stage, and slight variation of dry root weights in the 70–100 cm zone during the whole growth period. Narrow plant spacing decreased root reductive activity in all root zones, especially at the grain-filling stage. Grain yield and above-ground biomass were 5.0% and 8.4% lower in the narrow plant spacing than with normal plant spacing, although narrow plant spacing significantly increased N harvest index and N use efficiency in both grain yield and biomass, and higher N translocation rates from vegetative organs. These results indicate that the reductive activity of maize roots in all soil layers and dry weights of shallow roots were significantly decreased under narrow plant spacing conditions, resulting in lower root biomass and yield reduction at maturity. Therefore, a moderately dense sowing is a basis for high yield in summer maize.

Sener *et al.* (2004) reported that, maize hybrids reacted differently to various plant density and intra-row spacing. A two-year study was conducted at Mustafa Kemal University, Agricultural Faculty, Research Farm to determine the optimum intra-row spacing for maize hybrids commercially grown in Eastern Mediterranean Region during 2000 and 2001 growing seasons. The experimental design was a Randomized Complete Block in a split-plot arrangement with three replications. Main plots were maize hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb711 and Dekalb 626. Split-plots were intra-row spacing of 10.0, 12.5, 15.0, 17.5 and 20.0 cm. Split-plot size was 2.8 by 5.0 m with four rows per plot. The effects of intra-row spacing on the grain yield and some agronomic characteristics were statistically significant. Hybrid x intra-row spacing Combined effects were significant only at ear length and grain yield. The highest grain yields were obtained from Pioneer 3223 and Dracma at 15.0 cm intra-row spacing (11718 and 11180 kg ha^{-1}, respectively).

Sangoi *et al.* (2001) conducted a trial to evaluate the effect of row spacing reduction on grain yield of different maize cultivars planted at different dates. The trial was conducted in Lages, in the State of Santa Catarina, Brazil, during 1996/97 and 1997/98 growing seasons, in a split-split plot design. Early (October 1st) and normal (November 15) planting dates were tested in the main plot; two morphologically contrasting cultivars (an early single-cross and a late double-cross hybrids) were evaluated in the split plots and three row widths (100, 75 and 50 cm) were studied in the split-split plots. The reduction of row spacing from 100 to 50 cm increased linearly maize grain yield. The yield edge provided by narrow rows was higher when maize was sown earlier in the season. Differences in hybrid cycle and plant architecture did not alter maize response to the reduction of row spacing.

2.3 Combined effect of fertilizer and spacing

Amaral and Filho, (2009) carried out a study in Jaboticabal, Sao Paulo, Brazil, in2000/01. The treatments comprised 2 row spacing (0.60 and 0.80 m), 3 population densities (40 000, 60 000 and 80 000 plants ha^{-1}) and 4 N rates (0, 50, 100, and 150 kg N ha^{-1}). Increased N rates in top-dressing led to an increase in the leaf N and estimated chlorophyll concentration, number of grains ear^{-1}, mass of thousand grains, grain yield and protein content of grains. Higher grain yield was achieved with increasing top-dressed N rates in combination with 0.80 m row spacing and a plant density of 80 000 plants ha^{-1}.

Badr and Othman (2006) conducted two field experiments in Gharbia Governorate, Egypt, in 2003 and 2004 to investigate the effects of 3 planting densities (16 000, 20 000 and 24 000 plants $feddan^{-1}$), 3 organic manure (OM) and biofertilizer Microbian (B) treatments (0, OM and B) and 4 N doses (0, 60, 80 and 100 kg $feddan^{-1}$) on the growth, yield and yield components of maize, as well as soil fertility status at harvest. Plant and ear heights were increased significantly by increasing plant density in both seasons, whereas area of topmost ear leaf was decreased significantly by increasing plant density in both seasons. Number of grains per row and 100-grain weight decreased significantly due to increasing plant density in the 2 seasons. Grain yield was increased significantly in the first season, while the differences were not significant in the second season as the plant density increased. All the growth characters were increased significantly by adding OM or treating the seeds with the B. Grain yield and its components followed the same trend. The increasing N level significantly increased the growth, yield and yield components. The increases in grain yield were 80.41, 122.62 and 156.08% with N doses of 60, 80 and 100 kg feddan^{-1} compared with the control in the first season and 32.43, 49.19 and 56.77% in the second season, respectively. Grain yield was affected significantly due to the Combined of plant densities and N doses in 2003. In 2003 and 2004, OM and B interacted with N to alter the grain yield.

The treatments of 24 000 plants feddan^{-1} +B+60 kg N feddan^{-1} resulted in the highest value of N use efficiency (NUE). The highest value of grain N uptake was due to the combination of 16 000 plants +B+100 kg N feddan^{-1} (1 feddan = 0.0048 km^2). The combination of 16 000 plants feddan-1 +B+100 kg N feddan^{-1} proved the best in terms of soil fertility. NUE increased as plant density increased. Addition of organic fertilizer or treating the seeds with B seemed to increase NUE. Increasing N level resulted in reduced NUE values. Increasing the plant density slightly decreased the grain N uptake, while addition of organic fertilizer or treating the seeds with B enhanced this character. The grain N uptake gradually increased due to increasing N up to 100 kg feddan^{-1}.

Chandankar *et al.* (2005) conducted a field experiment during the monsoon season of 2003 in Maharashtra, India to evaluate the effects of farmyard manure (FYM at 0 and 5 t ha^{-1}), N:P:K rates (90:45:22.5, 120:60:30 and 150:75:37.5 kg ha^{-1}), and plant density (83 333 and 111 111 plants ha^{-1}) on maize yield and economics. FYM increased plant height. The highest NPK rate showed 34.1% higher grain yield over the lowest rate. Low plant density produced taller plants, with broader and heavier ears.

From the above discussed review of literature, it may be concluded that fertilizer and plant spacing need to be optimized for higher maize yield.

CHAPTER III
MATERIALS AND METHODS

The field experiment was conducted during the period from 22 March 2019 to 24 June 2019 to study the effect of different level of fertilizer doses and spacing on the yield of white maize. The materials and methods of this experiment are presented in this chapter under the following headings.

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. Bangladesh, which is situated at 23°74/ North latitude and 90°35/ East longitude (Anonymous, 1989). It belongs to Madhupur tract (AEZ 28). The land was 8.6 m above the sea level. For better understanding about experimental site it is shown in the Map of AEZ of Bangladesh in (Appendix- I.)

3.2 Climate

The experimental area is characterized by high temperature, high humidity and high rainfall with occasional puffy winds in Kharif-1 season (April-September) and less rainfall associated with moderately low temperature during rabi season (October-March). Weather condition of the experimental field has been presented in (Appendix II).

3.3 Soil

The field belongs to the general soil type which was characterized by shallow red brown terrace soil. The land of the selected experimental plot was medium high under the Tejgaon series. There was available sunshine during the experimental period. Soil sample was collected from 15 cm depth of the experimental site and was sent to SRDI, Dhaka for analysis. The result of analysis was given in (Appendix- III).

3.4 Planting materials

For this research work, the seeds of white maize were collected from white maize project named ‘'Collection, Evaluation and Introduction of White Maize for Human Consumption in Bangladesh’.

3.5 Factors and treatments of the experiment

Factor A: Fertilizer doses-3

a) F_1 = Recommended doses of fertilizer

b) F_2 = 25% Less than recommended doses of fertilizer

c) F_3 = 25% more than recommended doses of fertilizer

Recommended dose: Doses of cow dung 5.0 t ha^{-1} and for chemical fertilizer Urea, TSP, MP, Gypsum, $ZnSO_4$, Boric acid -500-250-200-250-10-7 kg ha^{-1} respectively.

Factor B: Spacing-3

a) S_1 = 60 cm × 20 cm

b) S_2 = 50 cm × 20 cm

c) S_3 = 40 cm × 20 cm

3.6 Design and layout of the experiment

The experiment was conducted in Split Plot Design with three replications and 9 treatments (Appendix-IV) where fertilizer doses and spacing were ascribed in the sub-plots. There were 27 sub plots where area of each sub plots was 2.5 m × 1.75 m (4.37 m^2). The doses of fertilizer and spacing of the experiment were distributed randomly in each replication.

3.7 Detail of experimental preparation

3.7.1 Preparation of the main field

The plot selected for the experiment was exposed at first week of March in 2019 with a power tiller, and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross-ploughed at several times followed by laddering to make a good tilth. Weeds and stubbles were removed, and finally made a desirable tilth of soil for planting of maize seeds. The experimental plot was partitioned into the sub plots in accordance with the experimental design. Recommended doses of fertilizers were mixed with the soil of each sub plot. Chemical fertilizers were applied in each plot as per treatment.

3.7.2 Application of fertilizers

The recommended chemical fertilizer used for white maize variety was 10.5 kg, 5.25kg, 4.2 kg, 5.25 kg, 0.21 kg and 0.14 kg of Urea, TSP, MP, Gypsum, $ZnSO_4$, Boric acid respectively. Fertilization (basal dose) was completed on 22st Mach, 2019. One third of urea along with full amount of other fertilizers as per treatment applied during final land preparation as a basal doses and rest of urea as per treatment was applied in two equal installments as side dressing The first installment of fertilizer was given on 15th April, 2019 and the second installment of fertilizer was given on 15th May, 2019.

3.7.3 Sowing of seed

The maize seeds were sown with the mixed of Sevin 85 WP in lines each having a line to line distance of 60, 50, and 40 cm, respectively and plant to plant distance of 20 cm having three seeds in each hole under direct sowing in the well-prepared plot on 22th March 2019.

3.8 Intercultural operation

3.8.1 After care

When the seedlings started to emerge in the research field it was always kept under careful observation. After emergence of seedlings, various intercultural operations were done for better growth and development of the maize seedlings.

3.8.2 Irrigation

At the season was Kharif-1, rainfall occurred frequently and accordingly the irrigation was provided depending on the happening of the rain. First irrigation was given first week of April, 2019 which was 15 days after sowing. Second irrigation was given last week of April, 2019 which was 32 days after sowing.

3.8.3 Thinning

Keeping one seedling in each hill, the excess plants were thinned out from all of the plots at 20 days after sowing (DAS) for maintaining optimum population as per experimental treatments.

3.8.4 Weeding and mulching

Weeding and mulching were done to keep the plots free from weeds, easy aeration of soil and to conserve soil moisture, which ultimately ensured better growth and development. The weeds were uprooted carefully after complete 30 emergences of maize seedlings as and whenever necessary. Breaking the crust of the soil, when needed was done through mulching.

3.8.5 Earthingup

Earthingup was done on 22th April, 2019 which was 30 days after sowing. It was done to protect the plant from lodging and for better nutrition uptake

3.8.6 Plant protection measures

After 28 days of planting, first spray of Darsban was applied against the pest such as cut worm on 21 April, 2019. The larvae are killed after collecting from the infested cobs. Cypermethrin (Ripcord 10 EC/Cymbush 10 EC) @ 2 ml litre^{-1} water sprayed to control this pest

3.8.7 Harvesting

The mature cobs were harvested when the husk cover was completely dried and black coloration (black layer) was found in the grain base. The cobs of three randomly selected plants of each plot were harvested separately for recording yield attributes and other data. The inner two lines were harvested for recording grain yield. Harvesting was done on 24th June, 2019.

3.8.8 Drying

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

3.9 Data collection

The following yield and yield contributing attributes data were recorded

3.9.1 Growth parameters

1. Plant height (cm)
2. Tassel length plant^{-1} (cm)
3. Leaf area plant^{-1} (cm^2)
4. Dry weight plant^{-1} (g)

3.9.2 Yield contributing parameters

1. Cob length (cm)
2. Cob circumference (cm)
3. Number of rows cob^{-1}
4. Number of grains row^{-1}
5. Number of grains cob^{-1}
6. 100 grain weight (g)

3.9.3 Yield parameters

1. Chaff weight cob-1 (g)
2. Shell weight cob-1 (g)
3. Grain weight cob-1 (g)
4. Cob weight (g)
5. Grain yield ha-1
6. Stover yield ha-1
7. Biological yield ha-1
8. Harvest Index (%)

Data recording procedure

3.9.1 Growth parameters

3.9.1.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at the time of flowering stage (45 DAS) and harvesting time. Data were recorded as the average of three plants selected randomly from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.9.1.2 Tassel length plant^{-1} at harvesting stage (cm)

The length of the tassel was recorded plant^{-1} in centimeter (cm) at harvesting time. Data were recorded as the average of three plants selected at randomly from the inner rows of each plot. The length was measured from the neck to the tip of the tassel.

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

Leaf area was measured plant^{-1} at 45 DAS and at harvest and this data was taken from three part of the plant (lower leaves, cob leaves and upper leaves) separately. It was measured with the help of meter scale by taking leaf length and breadth in cm^2 .

3.9.1.4 Dry matter content plant^{-1} (g)

Dry matter content plant^{-1} was measured at 45 DAS and at harvest and this data was taken from three part of the plant (lower part of the cob, cob part along with node and upper part of the cob) separately. Sample plants from each plot were collected. The plant parts were packed in paper packets and then kept in the oven at 80° C for 72 hrs to reach a constant weight. Then the dry weights were taken with an electric balance. The mean values were determined.

3.9.2 Yield contributing parameters

3.9.2.1 Cob length (cm)

Cob length was measured in centimeter from the base to the tip of the ear for three cobs and averages them to get length cob^{-1}.

3.9.2.2 Cob circumference (cm)

Three cobs were randomly selected plot^{-1} and the circumference was taken from each cob. Then average result was recorded in cm.

3.9.2.3 Number of rows cob^{-1}

The number of row of three cobs was counted at each of the three randomly selected plants in each plot and averaged.

3.9.8 Number of grains row^{-1}

Number of grain per rows was recorded for each row of three cobs and then average value was taken.

3.9.9 Number of grains cob^{-1}

Grain number of three randomly selected cobs plot^{-1} were counted for total grain from the base to tip of the ear and finally averaged.

3.9.10 Weight of 100-grains (g)

From the seeds sample from three randomly selected plants in each plot, 100-grains were taken to weigh them in gram.

3.9.3 Yield parameters

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

Cleaned and well dried grains collected from each plot were weighed and converted into ton ha^{-1}.

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

Stover yield was determined from the 4.37 m2 of all 2 inner rows. After threshing, the sub sample was oven dried to a constant weight and finally converted to t ha^{-1}.

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

It was the total yield including both the economic and stover yield.

i.e Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Stover yield (t ha^{-1})

3.9.15 Harvest index (%)

Harvest index is the ratio of economic (grain) yield and biological yield. It was calculated by dividing the economic yield grain from the harvested area by the biological yield of the same area (Donald, 1963) and multiplying by 100.

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

Here, Biological yield (t ha^{-1}) = Grain yield (t ha^{-1}) + Stover yield (t ha^{-1})

3.10 Statistical analysis

The obtained data for different characters were statistically analyzed with the computer based software Statistix10 to find out performance of white maize variety under different spacing and integrated fertilizer management and the mean values of all characters were evaluated and analysis of variances were performed by the F-test. The significance of the difference among treatment means were estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of different level of fertilizer combination and spacing on the yield of white maize (SAUWMT-9-3-4). Data on different growth and other parameters, yield and yield attributes were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix. The results have been presented with the help of graphs and table, and possible interpretations given under the following headings

4.1 Growth parameters

4.1.1 Plant height (cm)

4.1.1.1 Effect of fertilizer

Plant height showed statistically significant variation at 45 DAS and at harvest (90 DAS) for different doses of fertilizer doses and their combinations under the present trial (Figure 1 and Appendix V). The plant height ranged from (186.89 cm to 194.49 cm) was recorded at 45 DAS and (194.89 cm to 202.14 cm) at harvesting time (90 DAS) respectively. The tallest plant (194.49 cm and 202.14 cm) was recorded in F_3 treatment (F_3 = 25% more than recommended doses of fertilizer) and shortest plant (186.89 cm and 194.89 cm) was recorded in F_2 treatment (F_2 = 25% Less than recommended doses of fertilizer) at 45 DAS and at harvest (90 DAS) respectively. The finding is also observed with the findings of Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Maqbool *et al*. (2016), Jolokhava *et al*. (2016).

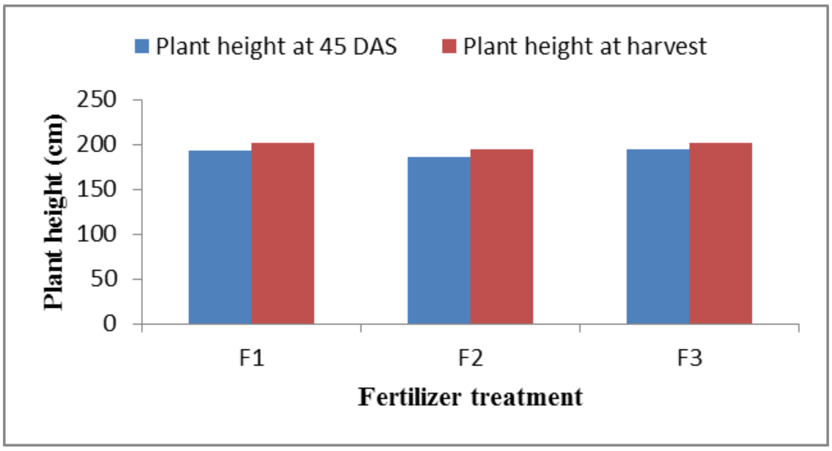

Figure 1. Effect of different fertilizer doses on plant height at different days after sowing of white maize variety (LSD $_{(0.05)}$ =4.36 and 7.84 at 45 DAS and harvest (90 DAS), respectively).

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.1.1.2 Effect of spacing

Significant variation was observed by different plant spacing on plant height of white maize (Fig. 2 and Appendix V) at different days after sowing. The ranges of plant height (184.24 cm to 198.8 cm) at 45 DAS and (192.17 cm to 206.44 cm) at harvest (90 DAS) was found. Results indicated that the highest plant height (198.8 cm) was found in S_1 (60 cm × 20 cm) at 45DAS and followed by (206.44 cm) was found in S_1 (60 cm × 20 cm) at harvest. The lowest plant height (184.24 cm and 192.17 cm) was attained from the plant spacing S_3 (40 cm × 20 cm) at 45DAS and at harvest also. The present finding agreed with the finding of Sabo *et al.* (2016), Jiang *et al.* (2013), Sener *et al.* (2004). and Sangoi *et al.* (2001)

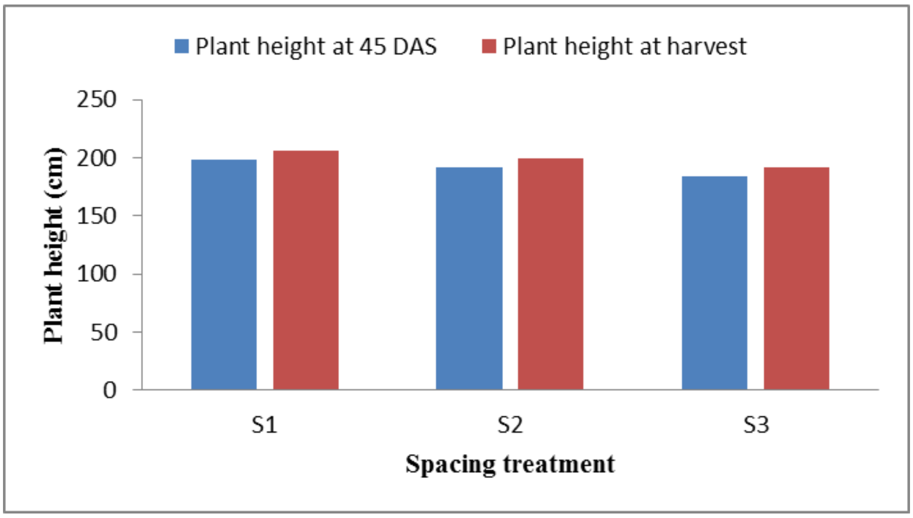

Figure 2. Effect of spacing on plant height at different days after sowing of white maize variety (LSD $_{(0.05)}$ = 8.48 and 4.18 at 45 DAS and harvest (90 DAS), respectively).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm, S_3 = 40 cm× 20 cm.

4.1.1.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer doses and spacing showed statistically significant variation on plant height (Table 1 and Appendix V). For combined effect on plant height ranges from (179.16 cm to 202.20 cm) at 45 DAS and (187.44 cm to 209.75 cm) at harvest was recorded. The highest plant height (202.20 cm and 209.75 cm) was found in F_3S_1 which was statistically similar with F_1S_1, F_1S_2, F_2S_1 and F_3S_2 at 45 DAS and F3S1 which was also statistically similar with F_1S_1, F_2S_1 and F_3S_2 at harvest respectively. Shortest plant was found in F_2S_3 which was similar with F_1S_3, F_2S_2 and F_3S_3 combination at 45 DAS and at harvest, shortest plant was found in F_2S_3 which was also similar with F_3S_3 combination compared to the other combinations.

4.1.2. Tassel length (cm)

4.1.2.1 Effect of fertilizer

Tassel length showed significant difference among them at different doses of fertilizer application in maize (Figure 3 and Appendix V). Due to application of different doses of fertilizer, the range of tassel length was found (30.55 cm to 35.25 cm). The highest tassel length (35.25 cm) was recorded in F_3 (F_3 = 25% more than recommended doses of fertilizer). While the lowest tassel length (30.55 cm) was recorded in F_2 (F_2 = 25%

Less than recommended doses of fertilizer) From the recorded data, finding showed that F_1 and F_3 gave the statistically similar.

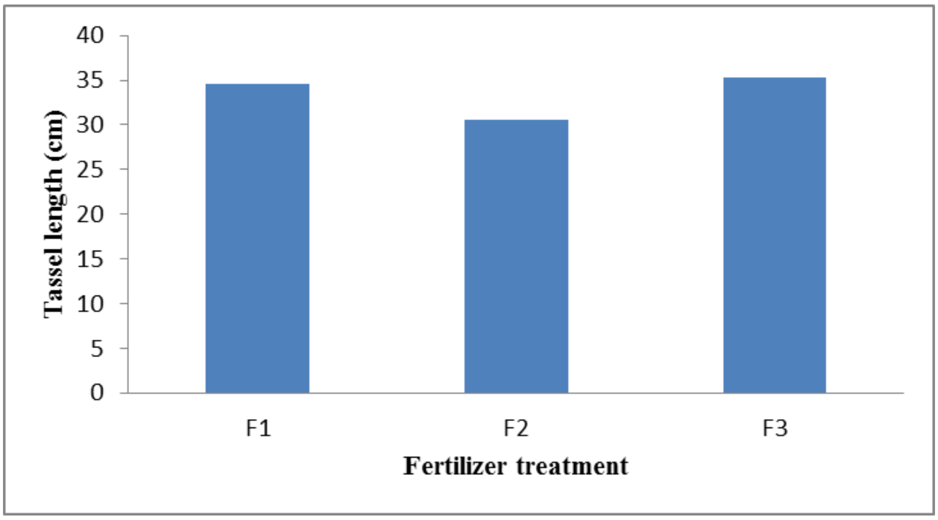

Figure 3. Effect of fertilizer doses on tassel length of white maize variety(LSD $_{(0.05)}$ = 1.61).

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.1.2.2 Effect of spacing

Tassel length showed statistically significant due to different spacing of maize cultivation (Figure 4 and Appendix V). The tassel length ranges from 31.63 cm to 34.91 cm. Due to influence of spacing the highest tassel length was recorded 35.68 cm in S_1 while lowest tassel length was 31.63 cm in S_3. The present finding S_1 and S_2 is statistically similar with another.

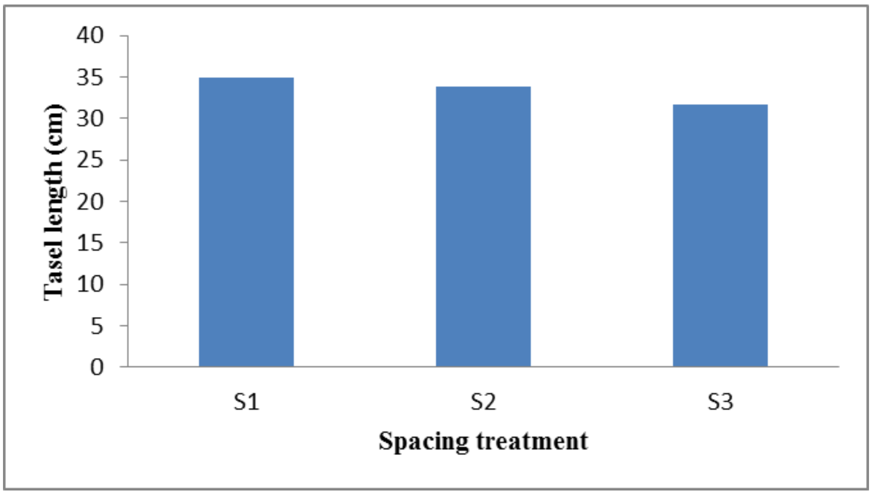

Figure 4. Effect of spacing on tassel length of white maize variety (LSD $_{(0.05)}$ = 2.73).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm, S_3 = 40 cm× 20 cm.

4.1.2.3 Combined effect of fertilizer doses and spacing

Significant variation was observed of combined effect of fertilizer and spacing on tassel length in white maize (Table 1 and Appendix V). For combined effect on tassel length ranges from 29.22 cm to 38.45 cm. The highest tassel length (38.45 cm) was found in F_3S_2 which was statistically similar with F_1S_1 and F_3S_1 and lowest tassel length (29.22 cm) was found in F_2S_2 which was statistically similar with F_1S_3, F_2S_1 and F_3S_3 Combined.

Table 1. Combined effect of fertilizer and spacing on plant height at different days after sowing and tassel length of white maize variety

Combined (fertilizer × spacing)	Plant height (cm) at 45DAS	Plant height (cm) at harvest	Tassel length(cm) at harvest
F_1S_1	199.67 ab	207.30 a	37.31ab
F_1S_2	192.10 abc	199.47 bc	34.00 bcd
F_1S_3	189.44 bcd	197.25 bc	32.55 cde
F_2S_1	194.54 abc	202.27 ab	31.92 cde
F_2S_2	186.36 cd	194.96 c	29.22 e
F_2S_3	179.16 d	187.44 d	30.50 de
F_3S_1	202.20 a	209.75 a	35.50 abc
F_3S_2	197.16 abc	204.85 ab	38.45 a
F_3S_3	184.12 cd	191.81 cd	31.84 cde
$LSD_{(0.05)}$	**12.73**	**9.75**	**4.17**
CV%	**4.31**	**2.04**	**7.93**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.1.3 Leaf area plant^{-1} (cm^2) at 45 DAS

4.1.3.1 Effect of fertilizer

Leaf area plant^{-1} showed significant difference among the mean due to application of fertilizer at 45 DAS (Figure 5 Appendix VI). Leaf area at 45 DAS was recorded at three different parts of the plant viz. at lower leaves, cob leaves and upper leaves (Table 4). At lower leaves, the highest leaf area at 45 days after sowing (718.72 cm^2) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer) followed by F_3 (F_3 = 25% more than recommended doses of fertilizer). F_1 and F_2, which are statistically similar also, the lowest leaf area at 45 DAS (683.92 cm^2) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer). At cob leaves, the highest leaf area at 45 DAS (747.48 cm^2) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer) whereas the lowest leaf area at 45 DAS (725.50 cm^2) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer) which was statistically identical with F_1 and F_3. At upper leaves, the highest leaf area at 45 DAS (798.89 cm^2) was recorded from the treatment F_1 (F_1 =

Recommended doses of fertilizer) followed by F_3 (F_3 = 25% more than recommended doses of fertilizer). F_1 and F_3, which are statistically similar, the lowest leaf area at 45 DAS (756.08 cm^2) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer).

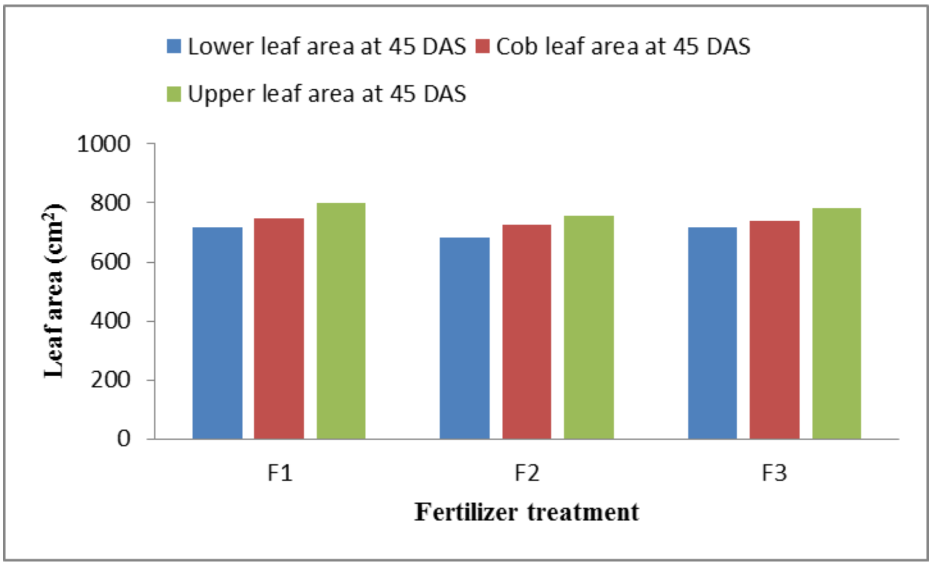

Figure 5. Effect of fertilizer doses on leaf area plant^{-1} at 45 DAS of white maize variety ($LSD_{(0.05)}$ = 17.05 at lower leaf area, 44.55 at cob leaf area and 21.01 at upper leaf area).

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.1.3.2 Effect of spacing

Significant variation was observed on leaf area of maize at 45 DAS as affected by different planting configurations (Figure 6 and Appendix VI). Leaf area at 45 DAS was recorded at three different parts of the plant *viz*., at lower leaves, cob leaves and upper leaves. At lower leaves, the highest leaf area at 45 DAS (726.49 cm^2) was recorded from the treatment S_1 (60 cm × 20 cm) whereas the lowest leaf area at 45 DAS (678.49 cm^2) was found from the treatment S_3 (40 cm × 15 cm). whereas S_1 and S_2 was statistically similar. At cob leaves, the highest leaf area (756.74 cm^2) was recorded from the treatment S_1 (60 cm × 20 cm), which was significantly different from other treatments whereas the lowest leaf area (712.16 cm^2) was found from the treatment S_3 (40 cm × 20 cm). At upper leaves, the highest leaf area (805.29 cm^2) was recorded from the treatment S_1 (60 cm × 20 cm) followed by S_2 (50 cm × 20 cm) whereas the lowest leaf area (734.09 cm^2) was found from the treatment S_3 (40 cm × 20 cm), which was significantly different from other treatments.

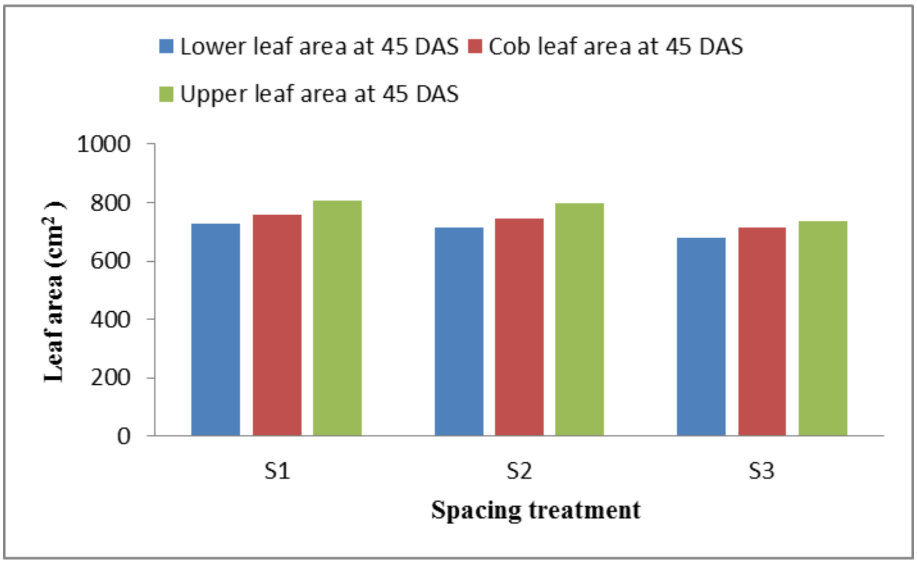

Figure 6. Effect of spacing on leaf area plant^{-1} at 45 DAS of white maize ($LSD_{(0.05)}$ = 20.25 at lower leaf area, 31.42 at cob leaf area and 19.94 at upper leaf area).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm, S_3 = 40 cm× 20 cm.

4.1.3.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer and spacing on leaf area plant^{-1} was presented by (Table 2 and Appendix VI). The significant variation was observed on leaf area plant^{-1} with combined effect of fertilizer and spacing. At lower leaves, the highest leaf area (731.63 cm^2) was recorded from the combination F_3S_1 which was statistically similar with F_1S_1, F_1S_2, F_1S_3, F_2S_1, F_2S_2 and F_3S_2 and followed by F_3S_3 whereas the lowest leaf area (627.15 cm^2) was found from the Combined F_2S_3. At cob leaves, the highest leaf area (762.27 cm^2) was observed from the treatment F3S_1, which was statistically similar with the same trend of lower leaf area whereas the lowest leaf area (695.34 cm^2) was found from the treatment F_2S_3. At upper leaves, the highest leaf area (809.56 cm^2) was found from F_3S_1, which was statistically similar with F_1S_1, F_1S_2, F_1S_3, F_2S_1, F_2S_2 and F_3S_2 and followed by F_3S_3 whereas the lowest leaf area (677.91 cm^2) was found from the treatment F_2S_3 , which was significantly different from other treatments.

Table 2. Combined effect of fertilizer doses and spacing on leaf area plant^{-1} at different days after sowing of white maize variety

Combined (fertilizer × spacing)	Leaf area at 45 DAS (cm^2)		
	Lower leaf area of cob	Cob leaf area	Upper leaf area of cob
F_1S_1	727.79 ab	758.22 ab	806.36 a
F_1S_2	716.15 ab	744.60 abc	796.76 a
F_1S_3	712.22 ab	739.63 abc	793.56 a
F_2S_1	720.07 ab	749.74 abc	799.96 a
F_2S_2	704.55 ab	731.42 abc	790.36 a
F_2S_3	627.15 c	695.34 c	677.91 c
F_3S_1	731.63 a	762.27 a	809.56 a
F_3S_2	723.93 ab	754.07 abc	803.16 a
F_3S_3	696.10 b	701.52 bc	730.80 b
$LSD_{(0.05)}$	**33.16**	**62.47**	**34.95**
CV%	**2.79**	**4.15**	**2.49**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.1.4. Leaf area (cm^2) at harvest

4.1.4.1 Effect of fertilizer doses

Leaf area plant^{-1} showed significant difference among the mean due to application of fertilizer at harvest (Figure 7 Appendix VII). Leaf area at harvest was recorded at three different parts of the plant viz. at lower three leaves, cob leaf and upper three leaves (Table 4). At lower three leaves, the highest leaf area at harvest (718.89 cm^2) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer) followed by F_3 (F_3 = 25% more than recommended doses of fertilizer). whereas the lowest leaf area (670.61 cm^2) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer). From the result F_1, F_2 and F_3 which were statistically significant. At cob leaves, the highest leaf area at (731.15 cm^2) was found from the treatment F_1 (F_1 = Recommended doses of fertilizer) whereas the lowest leaf area (700.13 cm^2) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer). From the result F_2 and F_3 which was statistically similar with F_1. At upper leaves, the highest leaf area (556.18 cm^2) was found from the treatment F_3 (F_3 = 25% more than recommended doses of fertilizer) followed by F_1 and F_3 which are statistically similar. whereas the lowest leaf area (526.56 cm^2) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer).

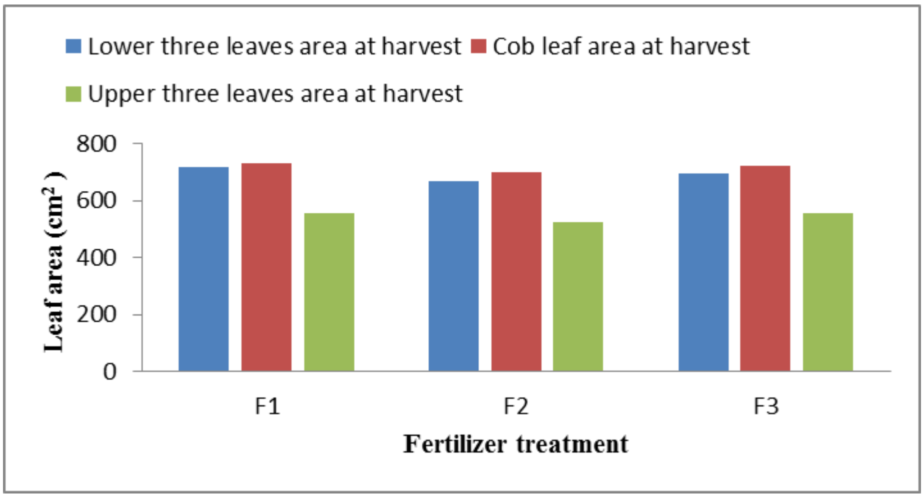

Figure 7. Effect of fertilizer doses on leaf area plant^{-1} at harvest of white maize variety ($LSD_{(0.05)}$ = 5.61 at lower three leaves, 44.64 at cob leaf area and 14.40 at upper three leaves area at harvest).

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.1.4.2 Effect of spacing

Significant variation was observed on leaf area of white maize at harvest as affected by different planting configurations (Figure 8 and Appendix VII). Leaf area at harvest was measured at three different parts of the plant *viz*. at lower three leaves, cob leaf and upper three leaves. At lower leaves, the highest leaf area (727.51 cm^2) was found from the treatment S_1 (60 cm × 20 cm) and followed by (706.33 cm^2) from the treatment S_2 (50 cm × 20 cm) whereas the lowest leaf area (649.65 cm^2) was found from the treatment S_3 (40 cm × 15 cm). At cob leaves, the highest leaf area (744.24 cm^2) was recorded from the treatment S_1 (60 cm × 20 cm), which was statistically similar with S_2 (50 cm × 20 cm) treatments whereas the lowest leaf area (679.89 cm^2) was found from the treatment S_3 (40 cm × 20 cm). At upper leaves, the highest leaf area (567.90 cm^2) was recorded from the treatment S_1 (60 cm × 20 cm) followed by

(551.15 cm^2) from the treatment S_2 (50 cm × 20 cm) whereas the lowest leaf area (734.09 cm^2) was found from the treatment S_3 (40 cm × 20 cm), which was significantly different from other treatments.

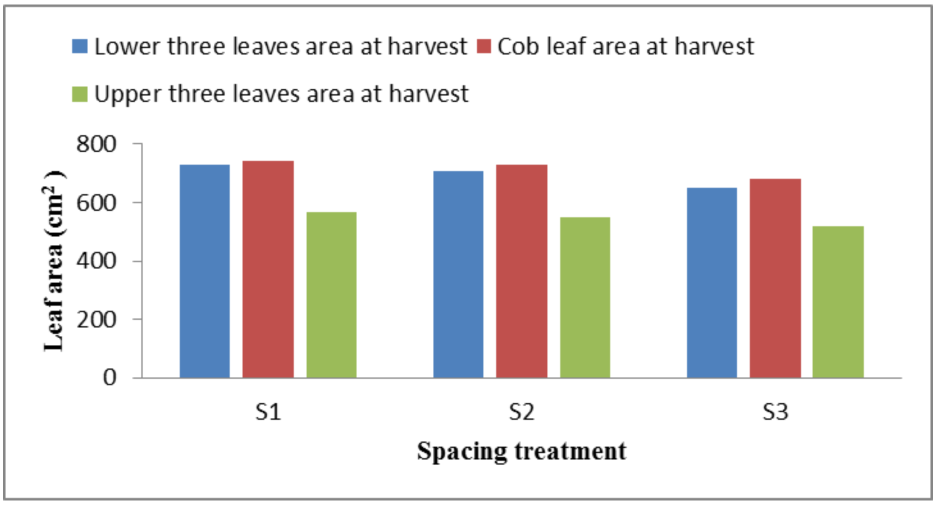

Figure 8. Effect of spacing on leaf area plant^{-1} at harvest of white maize variety (LSD$_{(0.05)}$ = 5.80 at lower three leaves, 37.07 at cob leaf and 8.51 at upper leaves area).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.1.4.3 Combined effect of fertilizer doses and spacing

Effect of fertilizer and spacing on leaf area plant^{-1} was presented by (Table 3 and Appendix VII). The significant variation was observed on leaf area plant^{-1} at harvest with combined effect of fertilizer and spacing. At lower three leaves, the highest leaf area (733.26 cm^2) was recorded from the combination F_3S_1 which was statistically similar with F_1S_1 and F_3S_2 and followed by F_1S_3 whereas the lowest leaf area (613.18 cm^2) was found from the Combined F_2S_3. At cob leaves, the highest leaf area (749.61 cm^2) was observed from the Combined F3S1 which was statistically similar with F_1S_1 and F_3S_2. Whereas the lowest leaf area (652.93 cm^2) was found from the Combined F_2S_3. At upper leaves, the highest leaf area (573.34 cm^2) was found from F_3S_1 which was statistically similar with F_1S_1. Again F_3S_1 was statistically identical with F_2S_1 and F_3S_2 followed by F_3S_3 whereas the lowest leaf area (482.08 cm^2) was found from the treatment F_2S_3 which was significantly different from other treatments.

Table 3. Combined effect of fertilizer and spacing on leaf area at harvest of white maize variety

Combined (fertilizer × spacing)	Leaf area at harvest (cm^2)		
	Lower three leaves area	**Cob leaf area**	**Upper three leaves area**
F_1S_1	728.95 ab	745.58 a	569.51 a
F_1S_2	716.02 cd	733.49 ab	551.20 bcd
F_1S_3	711.71 d	714.37 abc	545.76 cde
F_2S_1	720.33 bcd	737.52 ab	560.85 abc
F_2S_2	678.33 e	709.95 abc	536.75 de
F_2S_3	613.18 g	652.93 c	482.08 f
F_3S_1	733.26 a	749.61 a	573.34 a
F_3S_2	724.64 abc	741.55 a	565.49 ab
F_3S_3	624.07 f	672.39 bc	529.71 e
$LSD_{(0.05)}$	**9.88**	**68.39**	**18.63**
CV%	**0.81**	**3.69**	**1.52**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.2 Dry matter content (g) at 45 DAS

4.2.1 Effect of fertilizer doses

Significant variation was observed on dry matter content of white maize at 45 DAS at different portion of plant as affected by different fertilizer doses (Figure 9 and Appendix VIII). Dry matter content at 45 DAS was recorded at three different parts and total dry matter plant^{-1} of the white maize plant *viz*. at lower part, cob part and upper part (Table 6). At lower part, the highest dry matter content at 45 DAS (15.13 g) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer), which was statistically similar with F_3 whereas the lowest dry matter content (13.06 g) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer) which was significantly different from other treatments.

At cob part, the highest dry matter content at 45 DAS (14.01 g) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer) which was statistically similar with F_2. On the other hand, the lowest dry matter content (11.90 g) was found from F_3

(F_3 = 25% more than recommended doses of fertilizer), which was significantly different from other treatments. At upper part, the highest dry matter content (18.68 g) was found from the treatment F_1 (F_1 = Recommended doses of fertilizer). On the other hand, the lowest dry matter content (14.81 g) was found from the treatment F_2 which was statistically identical with F_3 (F_3 = 25% more than recommended doses of fertilizer).

At total dry matter plant^{-1} showed significant variation, the highest total dry matter content at 45 DAS (47.82 g) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer). On the other hand, the lowest total dry matter content (40.68 g) was found from F_3 (F_3 = 25% more than recommended doses of fertilizer) which was statistically identical with F_2 (F_2 = 25% less than recommended doses of fertilizer).

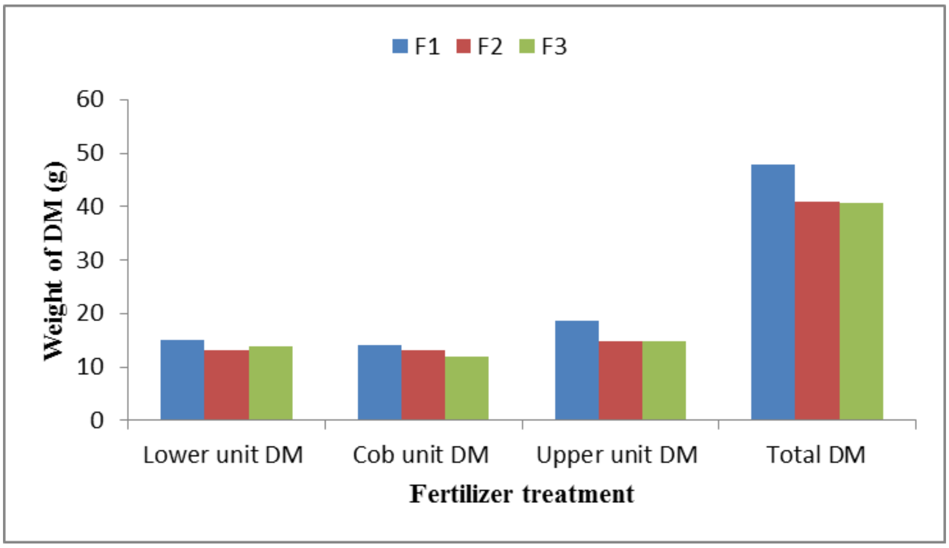

Figure 9. Effect of fertilizer doses on dry matter content at 45 DAS of white maize variety ($LSD_{(0.05)}$ =1.39 at lower part, 1.451 at cob part , 2.55 at upper part and 3.06 at 45 DAS total dry matter plant^{-1}).

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.2.2 Effect of spacing

Dry matter content at 45 DAS showed non- significant difference at different portion of plant as affected by different plant spacing (Figure 10 and Appendix VIII). Dry matter content at 45 DAS was recorded at three different parts of the white maize plant *viz*. at lower part, cob part and upper part. At lower part, the highest dry matter content at 45 DAS (15.32 g) was recorded from the treatment S_1 (S_1 = 60 cm × 20 cm) whereas the lowest dry matter content (13.11 g) was found from the treatment S_3 (S_3 = 40 cm× 20 cm) which was statistically identically with S_1 (S_1 = 60 cm × 20 cm).

At cob part, the highest dry matter content at 45 DAS (13.28 g) was recorded from the treatment S_1 (S_1 = 60 cm × 20 cm), which was statistically similar with S_2 (S_2 = 50cm× 20 cm). On the other hand, the lowest dry matter content (12.55 g) was found from S_3 (S_3 = 40 cm× 20 cm). At upper part, the highest dry matter content (16.39 g) was found from the treatment S_2 (S_2 = 50 cm× 20 cm). On the other hand, the lowest dry matter content (15.70 g) was found from the treatment S_1 (S_1 = 60 cm × 20 cm) which was statistically identical with one another.

At total dry matter content plant^{-1} showed the highest dry matter content at 45 DAS (44.84 g) was recorded from the treatment S_2 (S_2 = 50 cm × 20 cm) whereas the lowest dry matter content (41.96 g) was found from the treatment S_3 (S_3 = 40 cm× 20 cm), which was statistically identically with S_1 (S_1 = 60 cm × 20 cm) and S_2 (S_2 = 50 cm × 20 cm).

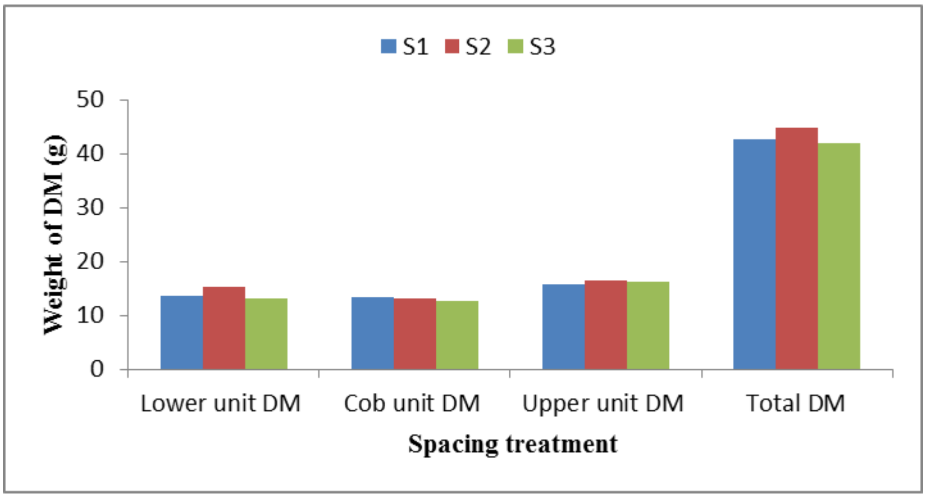

Figure 10. Effect of spacing on dry matter content at 45 DAS of white maize variety ($LSD_{(0.05)}$ =1.44 at lower part, 0.70 at cob part ,2.54 at upper part and 3.22 at harvest total dry matter plant^{-1}).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.2.3 Combined effect of fertilizer doses and spacing

Effect of fertilizer and spacing on dry matter content at 45 DAS was presented by (Table 4 and Appendix VIII). The significant variation was observed on dry matter content at 45 DAS with combined effect of fertilizer and spacing. At lower portion, the highest dry matter content (16.90 g) was recorded from the combination F_1S_1 which was statistically similar with F_1S_2, F_3S_2 and F_3S_3. Whereas the lowest dry matter content (11.18 g) was found from the Combined F_3S_1 which was statistically similar with F_1S_3, F_2S_1 and F_2S_3, At cob portion, which was statistically non-significant.

Table 4. Combined effect of fertilizer and spacing on dry matter content at 45 DAS of white maize variety

Combined (fertilizer × spacing)	Dry matter content at 45 DAS (g)			
	Lower unit	Cob unit	Upper unit	Total dm
F_1S_1	16.90 a	15.26	19.43 a	51.59 a
F_1S_2	16.22 ab	14.70	18.68 a	49.60 a
F_1S_3	12.27 de	12.07	17.92 ab	36.23 c
F_2S_1	12.81cde	14.14	13.08 d	40.04 bc
F_2S_2	14.20 bcd	13.01	14.20 cd	41.41 bc
F_2S_3	12.19 de	11.99	17.16 abc	41.34 bc
F_3S_1	11.18 e	10.45	14.60 bcd	42.26 b
F_3S_2	15.55 ab	11.67	16.29 a-d	43.51 b
F_3S_3	14.88 abc	13.58	13.820 cd	42.28 b
$LSD_{(0.05)}$	**2.45**	**(NS)**	**3.66**	**5.45**
CV%	**9.99**	**5.24**	**11.38**	**7.26**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

At upper portion, the highest dry matter content (19.43 g) was found from F_1S_1 which was statistically identical with F_1S_2 and again F_1S_3, F_2S_3 and F_3S_2 was statistically similar with F_1S_1 also. Whereas the lowest dry matter content (13.08 g) was found from the treatment F_2S_1 which was significantly different from other treatments and followed by F_2S_2 and F_3S_3. At total dry matter content plant^{-1} showed, the highest dry matter content (51.59 g) was recorded from the combination F_1S_1, which was statistically identical with F_1S_2. Whereas the lowest total dry matter content (36.23 g) was found from the Combined F_1S_3 which was statistically similar with F_2S_1, F_2S_2 and F_2S_3.

4.3 Dry matter content at harvest

4.3.1 Effect of fertilizer doses

Significant variation was observed on dry matter content of white maize at harvest at different portion of plant as affected by different fertilizer doses (Figure 11 and Appendix IX). Dry matter content at harvest was recorded at three different parts of the white maize plant *viz*. at lower part, cob part and upper part.

At lower part, the highest dry matter content at harvest (20.99 g) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer), which was followed by F_3 whereas the lowest dry matter content (16.80 g) was found from the treatment F_2 (F_2 = 25% Less than recommended doses of fertilizer), which was significantly different from other treatments.

At cob p art, the highest dry matter content at harvest (139.83 g) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer). On the other hand, the lowest dry matter content (121.50 g) was found from F_2 (F_2 = 25% Less than recommended doses of fertilizer), which was statistically similar with F3 treatments.

At upper part, the highest dry matter content (22.71 g) was found from the treatment F_1 (F_1 = Recommended doses of fertilizer). On the other hand, the lowest dry matter content (19.78 g) was found from the treatment F_2 which was significantly different from other treatments.

At total dry matter plant^{-1} showed significant variation, the highest total dry matter content at harvest (183.53 g) was recorded from the treatment F_1 (F_1 = Recommended doses of fertilizer). On the other hand, the lowest total dry matter content (158.08 g) was found from F_2 (F_2 = 25% less than recommended doses of fertilizer) which was statistically significant with one another.

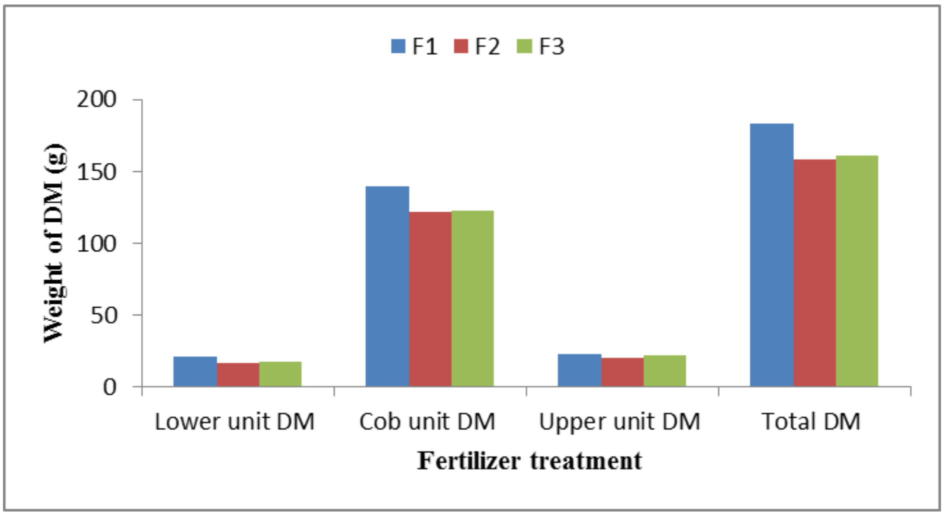

Figure 11. Effect of fertilizer doses on dry matter content at harvest of white maize variety ($LSD_{(0.05)}$ = 0.34 at lower part, 1.57 at cob part 0.31 at upper part and 1.86 at total dry matter plant^{-1} at harvest).

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.3.2 Effect of spacing

Dry matter content at harvest showed significant variation at different portion of plant as affected by different plant spacing (Figure 12 and Appendix IX). Dry matter content at harvest was recorded at three different parts of the white maize plant *viz*. at lower part, cob part and upper part.

At lower part, the highest dry matter content at harvest (18.74 g) was recorded from the treatment S_1 (S_1 = 60 cm × 20 cm) and followed by S_2 (S_2 = 50 cm× 20 cm).On the other hand, the lowest dry matter content (17.95 g) was found from the treatment S_3 (S_3 = 40 cm× 20 cm) which was significantly different from other treatments.

At cob part, the highest dry matter content at harvest (128.34 g) was recorded from the treatment S_2 (S_2 = 50 cm × 20 cm). On the other hand, the lowest dry matter content (127.56 g) was found from S_3 (S_3 = 40 cm× 20 cm) which was statistically non-significant with one another.

At upper part, the highest dry matter content (21.51 g) was found from the treatment S_1 (S_1 = 60 cm× 20 cm). On the other hand, the lowest dry matter content (21.402 g) was found from the treatment S_2 (S_2 = 50 cm × 20 cm), which was statistically non-significant with one another.

At total dry matter content plant^{-1} showed the highest dry matter content at harvest (168.02 g) was recorded from the treatment S_1 (S_1 = 60 cm × 20 cm) whereas the lowest dry matter content (167.01 g) was found from the treatment S_3 (S_3 = 40 cm× 20 cm) which was statistically identically with S_1 (S_1 = 60 cm × 20 cm) and S_2.

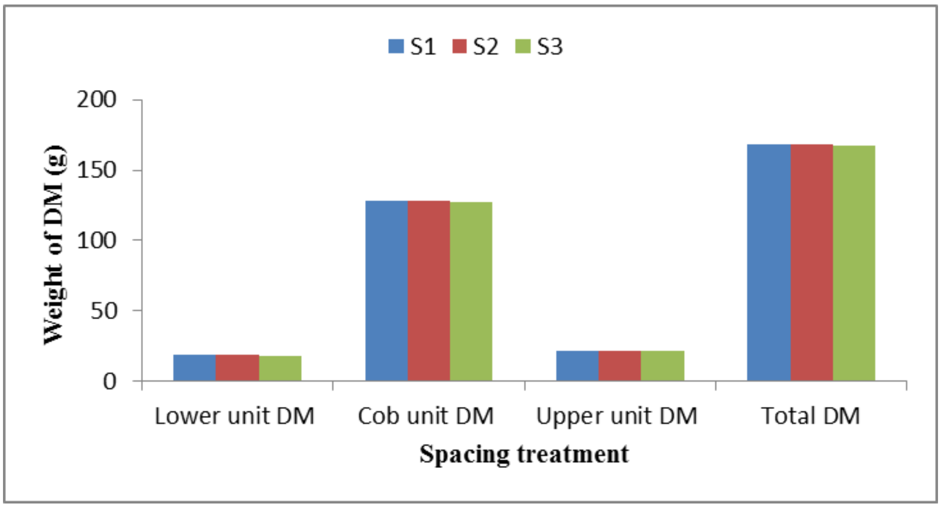

Figure 12. Effect of spacing on dry matter content at harvest of white maize variety ($LSD_{(0.05)}$ = 0.29 at lower part, 1.380 at cob part, 0.31 at upper part and 1.35 at total dry matter plant^{-1}).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.3.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer and spacing on dry matter content at harvest was presented by (Table 5 and Appendix IX). The significant variation was observed on dry matter content at harvest with combined effect of fertilizer and spacing. At lower portion, the highest dry matter content (22.98 g) was recorded from the combination F_1S_1. Whereas the lowest dry matter content (16.27 g) was found from the Combined F_3S_1which was statistically similar with F_2S_3 and F_3S_2. At cob portion, the highest dry matter content (144.02 g) was recorded from the combination F_1S_1. Whereas the lowest dry matter content (112.65 g) was found from the Combined F_3S_1 which was statistically identical with F_2S_3. At upper portion, the highest dry matter content (24.20 g) was found from F_1S_1. Whereas the lowest dry matter content (19.10 g) was found from the treatment F_2S_2, which was significantly different from other treatments.

At total dry matter content plant^{-1} showed, the highest dry matter content (191.20 g) was recorded from the combination F_1S_1. Whereas the lowest total dry matter content (150.15 g) was found from the Combined F_3S_1, which was statistically identical with F_2S_3.

Table 5: Combined effect of fertilizer and spacing on dry matter content at harvest of white maize variety

Combined (fertilizer × spacing)	**Dry matter content at harvest (g)**			
	Lower unit	Cob unit	Upper unit	Total dm
F_1S_1	22.98 a	144.02 a	24.20 a	191.20 a
F_1S_2	21.00 b	139.83 b	22.56 b	183.39 b
F_1S_3	19.00 c	135.63 c	21.37 cd	176.00 c
F_2S_1	16.96 d	126.66 e	19.10 g	162.72 d
F_2S_2	17.11 d	122.99 f	19.78 f	159.88 e
F_2S_3	16.33 e	114.85 g	20.46 e	151.64 f
F_3S_1	16.27 e	112.65 g	21.23 d	150.15 f
F_3S_2	16.73 de	122.19 f	21.87 c	160.78 de
F_3S_3	18.52 c	132.22 d	22.66 b	173.39 c
$LSD_{(0.05)}$	**0.53**	**2.49**	**0.54**	**2.65**
CV%	**1.56**	**1.05**	**1.42**	**0.78**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm.

4.4 Yield contributing parameters

4.4.1 Cob length (cm)

4.4.1.1 Effect of fertilizer

Cob length showed non-significant effect by different fertilizer doses on cob length (Figure 13 and Appendix X). Due to application of fertilizer the cob length showed statistically similar trend with fertilizer doses. Numerically, cob length ranges from 13.97 cm to 14.45 cm. The highest cob length (14.45 cm) was recorded in F_1 treatment and lowest cob length (13.97 cm) was recorded in F_2 treatment. This might be due to the proper supply of nutrient from F_1 treatment facilitated proper reproductive growth of plant. The present finding close conformity with the findings of Liverpool-Tasie *et al*. (2017), Ademba *et al*. (2015), Hill (2014), Nasim *et al*. (2012).

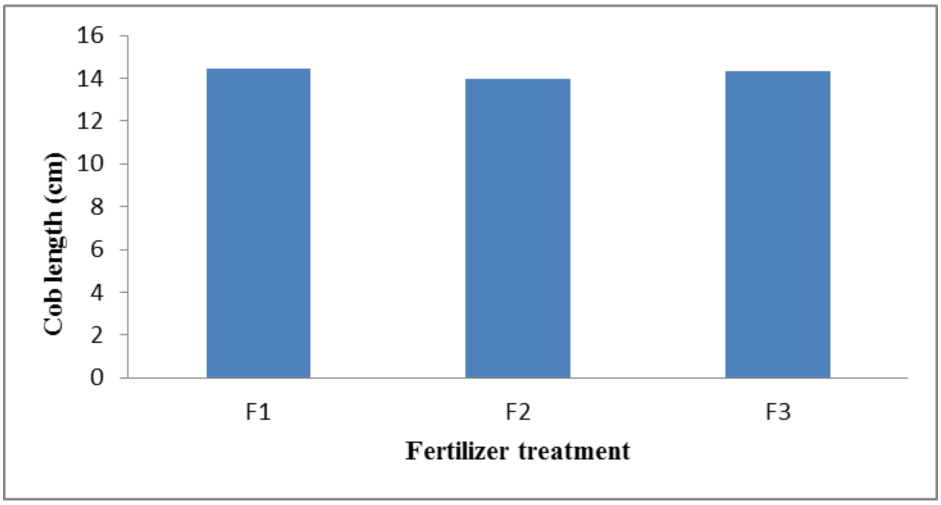

Figure 13. Effect of fertilizer doses on cob length (cm) of white maize variety ($LSD_{(0.05)}$= ns)

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.4.1.2 Effect of spacing

Significant variation was observed on cob length due to different spacing of maize cultivation (Figure 14 and Appendix X). The cob length ranges from 13.00 cm to 15.39 cm. Due to influence of spacing the highest cob length was recorded 15.39 cm from S_1 while lowest cob length was 13.00 cm from S_3. The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

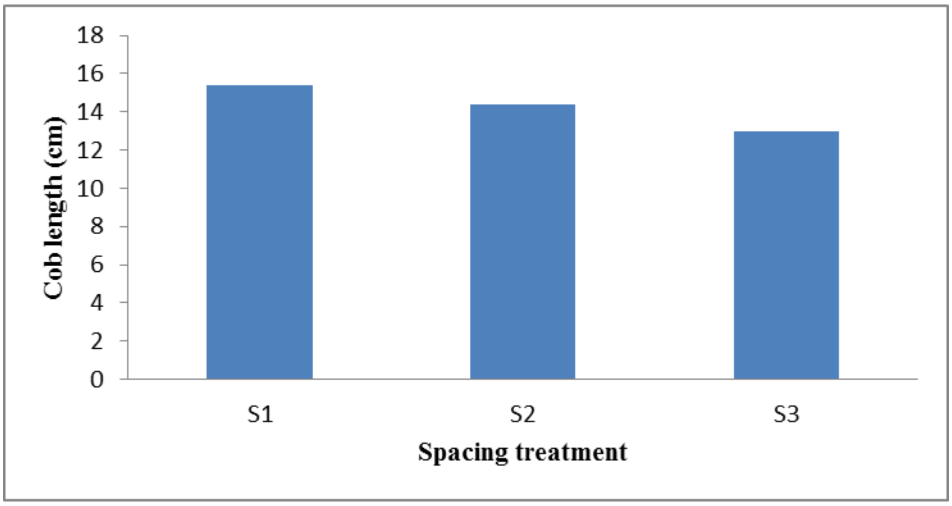

Figure 14. Effect of spacing on cob length (cm) of white maize variety (LSD $_{(0.05)}$ = 0.31).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.4.1.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer and spacing produced statistically significant on cob length (Table 6 and Appendix X). For combined effect cob length ranges from 12.463 cm to 16.09 cm. The highest cob length 16.09 cm was found in F_1S_1 treatment and lowest cob length 12.463 cm was found in F_1S_3 combination which was statistically similar with F_3S_3.

4.4.2 Cob Circumference (cm)

4.4.2.1 Effect of fertilizer

Cob circumference showed non- significant difference among them at different doses of fertilizer application in maize (Figure 15 and Appendix X). Due to application of different doses of fertilizer, the range of cob circumference was found 13.65 cm to 13.92 cm. The highest cob circumference 13.92 cm was recorded in F_1. On the other hand, the lowest cob circumference was recorded in F_3 (13.65 cm). From the recorded data, finding showed that F_2 and F_3 gave the statistically similar finding. The highest cob circumference in F_1 might be due to adequate nutrient. The finding is close conformity with the findings of Abebe and Feyisa (2017), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Ademba *et al*. (2015).

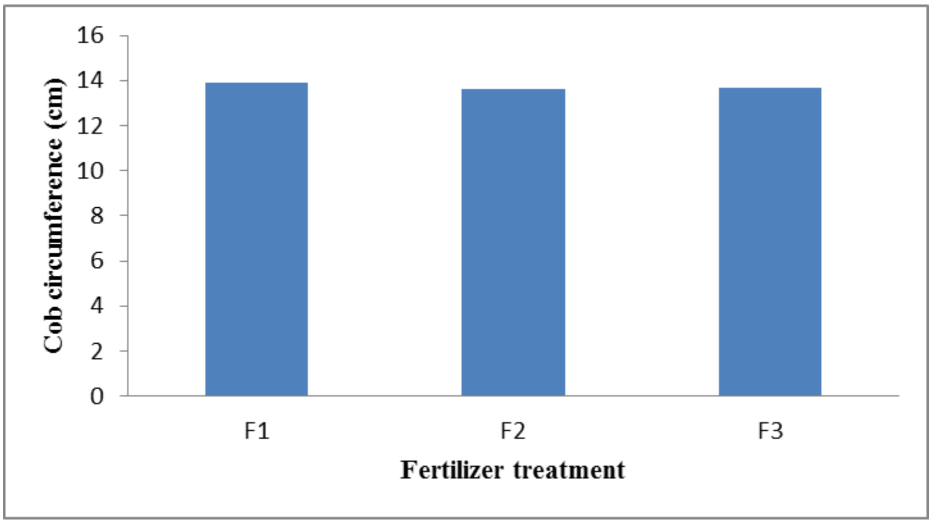

Figure 15. Effect of fertilizer doses on cob circumference of white maize variety ($LSD_{(0.05)}$ = 0.25).

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer

4.4.2.2 Effect of spacing

Significant variation was observed on cob circumference due to different plant spacing (Figure 16 and Appendix X). The cobs circumference ranges from 13.33 cm to 14.14 cm. The highest cob circumference (14.14 cm) was found in S_1 while the lowest cob circumference (13.33 cm) was recorded in S_2 which was significantly different from one another . The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

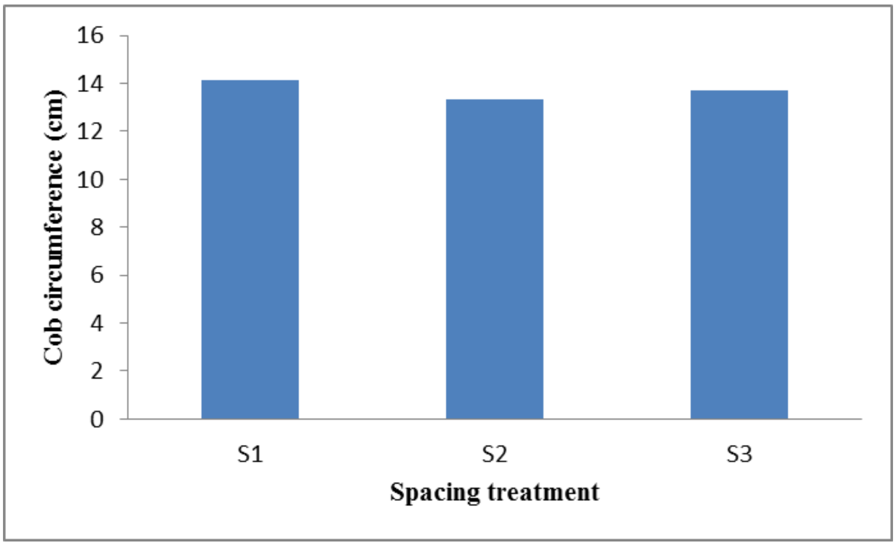

Figure 16. Effect of spacing on cob circumference of white maize variety ($LSD_{(0.05)}$= 0.15).

S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

Table 6. Combined effect of fertilizer and spacing on cob length (cm) and cob circumference of white maize variety

Combined (fertilizer × spacing)	Cob length (cm)	Cob circumference(cm)
F_1S_1	16.09 a	14.24 a
F_1S_2	14.81 b	13.71 bc
F_1S_3	12.46 d	13.81 b
F_2S_1	15.213 b	14.51 a
F_2S_2	13.33 c	12.47 d
F_2S_3	13.38 c	13.89 b
F_3S_1	14.86 b	13.67 bc
F_3S_2	15.06 b	13.82 b
F_3S_3	13.18 cd	13.46 c
$LSD_{(0.05)}$	**0.77**	**0.32**
CV%	**2.12**	**1.05**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.4.2.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer doses and spacing had significant effect on cob circumference of maize (Table 6 and Appendix X). The cob circumference ranges from 12.47 cm to 14.51 cm while F_2S_1 combination produced the height cob circumference (14.51 cm) which was statistically identical with F_1S_1. On the other hand, the lowest cob circumference (12.47 cm) was found from F_2S_2 combination.

4.4.3 Number of rows cob^{-1}

4.4.3.1 Effect of fertilizer

Significant variation was observed due to effect of different doses of fertilizer on number of rows cob^{-1} of maize (Table 7 and Appendix X). The number of rows cob^{-1} range from 12.65 to 13.75. The highest number of rows cob-1 (13.75) was found in F_3 (F_3 = 25% more than recommended doses of fertilizer). On the other hand, the lowest number of rows cob^{-1} (12.65) was found in F_2 (F_2 = 25% Less than recommended doses of fertilizer). This might be due to the proper supply of nutrient from F_3 treatment facilitated proper reproductive growth of plant. The present result is agreed with the findings of Maqbool *et al*. (2016), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015).

4.4.3.2 Effect of spacing

The number of rows cob^{-1} showed statistically non-significant impact due to different spacing of maize cultivation (Table 7 and Appendix X). The number of rows cob^{-1} ranges from 12.68 to 13.75 Although having non-significant influence of spacing the highest number of rows cob^{-1} (13.75) was found from S_3 (S_3 = 40 cm× 20 cm). While the lowest number of rows cob-1 (12.68) was found from S_1 (S_1 = 60 cm × 20 cm). The present finding is disagreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

4.4.3.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer and spacing showed statistically significant effect on number of rows cob^{-1} in maize (Table 7 and Appendix X). The highest number of rows cob^{-1} (14.33) was found in F_3S_2 which was statistically similar with F_1S_1, F_1S_2,

F_1S_3, F_2S_3, F_3S_1 and F_3S_3 treatment. On the other hand, the lowest number of rows cob^{-1} (12.13) was found in F_2S_1.

4.4.4 Number of grains row^{-1}

4.4.4.1 Effect of fertilizer

Number of grains row-1 showed statistically significant variation at different doses of fertilizer (Table 7 and Appendix X). Due to application of different doses of fertilizer, the range of number of grains row^{-1} was found (24.56 to 29.13). The highest number of grain row^{-1} (29.13) was recorded in F_3 (F_3 = 25% more than recommended doses of fertilizer) while the lowest number of grains row^{-1} (24.56) was recorded in F_2 (F_2 = 25% Less than recommended doses of fertilizer). This might be due to adequate nutrient was in F_1 treatment. The present result supported by the Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Rudnick and Irmak (2014), Crista *et al*. (2014), Nasim *et al*. (2012), Xu *et. al* (2006), and Rasheed *et al*. (2004).

4.4.4.2 Effect of spacing

Significant variation was found on number of grains row^{-1} as affected by different planting configurations (Table 7 and Appendix X). The highest number of grain row^{-1} (29.06) was found from S_3 (S_3 = 40 cm× 20 cm). However, the lowest number of grains row^{-1} (25.42) was found S_1 (60 cm × 20 cm). The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

4.4.4.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer doses and spacing showed significant variation on number of grains row^{-1} of maize (Table 7 and Appendix X). The highest number of grains row^{-1} (30.78) was found in F_3S_2 which was statistically similar with F_1S_3 and F_3S_3 combination. On the other hand, the lowest number of grains row^{-1} (22.46) was found in F_2S_1 which was statistically identical with F_2S_2 combination.

4.4.5 Number of grains cob^{-1}

4.4.5.1 Effect of fertilizer

Significant variation was observed on number of grain cob^{-1} in maize (Table 7 and Appendix X). Number of grain cob^{-1} increased steadily with the increment of fertilizer doses from the lowest to highest doses, but rate of increase was slower in the lower two doses after that the rate of increase was steady. The highest number of grain cob^{-1} (395.05) was recorded in F_3 (F_3 = 25% more than recommended doses of fertilizer). On the other hand, the lowest number of grain cob^{-1} (330.70) was recorded in F_2 (F_2 =25% less than recommended doses of fertilizer) treatment. This might be due to the more supply of nutrient from F_3 treatment facilitated proper growth of plant. The present finding is close conformity with the findings of Liverpool-Tasie *et al*. (2017), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Soro *et al*. (2015), Hill (2014), Nasim *et al*. (2012), Amin (2011), Orosz *et al*. (2009), Mugwira *et al*. (2007).

4.4.5.2 Effect of spacing

Significant variation was observed on number of grain cob^{-1} as affected by different planting configurations (Table 7 and Appendix X). The significant influence of spacing facilitated highest number of grain cob^{-1} (392.59) was found from S_3 (40 cm× 20 cm) while the lowest number of grain cob^{-1} (347.81) was found from S_1 (60 cm × 20 cm) which was significantly different from other treatments. The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

4.4.5.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer doses and spacing produced statistically significant variation on number of grain cob^{-1} in maize (Table 7 and Appendix X). The highest number of grain cob-1 (414.74) was found in F_3S_2 combination. On the other hand, the lowest number of grain cob^{-1} (288.44) was found in F_2S_1 combination which was significantly different from other combination.

4.4.6 100 grains weight (g)

4.4.6.1 Effect of fertilizer

Significant variation was found on 100 grains weight (g) as affected by different fertilizer doses (Table 7 and Appendix X). The highest 100 grain weight (33.24 g) was found in F_3 (F_3 =25% more than recommended doses of fertilizer) and the lowest 100 grain weight (29.80 g) was found in F_2 (F_2 = 25% Less than recommended doses of fertilizer) which was statistically identical with F_1. Our finding is closed with the findings of Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Soro *et al*. (2015), Rudnick and Irmak (2014), Hill (2014), Crista *et al*. (2014) and Rasheed *et al*. (2004).

4.4.6.2 Effect of spacing

Significant variation was observed on 100 grains weight (g) as affected by different planting configurations of white maize (Table 7 and Appendix X). Results represented in Figure 17 indicated that the highest 100 grains weight (32.30 g) was found in S_2 (S_2 =50 cm × 20 cm) whereas the lowest (29.76 g) was found in S_3 (S_3 =40 cm × 20 cm). The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

4.4.6.3 Combined effect of fertilizer doses and spacing

Significant variation was found on 100 grain weight (g) of combined effect of fertilizer and spacing on maize (Table 7 and Appendix X). The highest 100 grains weight (34.70 g) was found in F_3S_2 (25% more than recommended doses of fertilizer and spacing 50 cm× 20 cm). On the other hand the lowest 100 grains weight (27.58 g) was found in F_2S_3 (F_2 = 25% Less than recommended doses of fertilizer and spacing 40 cm × 20 cm) combination compared to the others combination.

Table 7. Effect of fertilizer, effect of spacing and combined effect on number of rows cob^{-1}, number of grains row^{-1}, number of grains cob^{-1} and 100 grain weight of white maize variety

Treatments	Number of rows cob^{-1}	Number of grains row^{-1}	Number of grains cob^{-1}	100 grains weight (g)
Effect of fertilizer				
F_1	13.50 b	28.35 b	388.78 a	30.13 b
F_2	12.65 c	24.56 c	330.70 b	29.80 b
F_3	13.75 a	29.13 a	395.05 a	33.24 a
LSD(0.05)	**2.78**	**4.72**	**10.69**	**1.01**
Effect of spacing				
S_1	12.68	25.42 c	347.81 c	31.09 b
S_2	13.46	27.55 b	374.12 b	32.30 a
S_3	13.75	29.06 a	392.59 a	29.77 c
LSD(0.05)	**1.18**	**1.19**	**8.27**	**0.87**
Combined (fertilizer × spacing)				
F_1S_1	13.08 abc	27.23 cd	382.26 bc	29.32 e
F_1S_2	13.58 abc	28.53 bc	390.16 b	31.50 bc
F_1S_3	13.83 ab	29.28 abc	393.91 b	29.54 de
F_2S_1	12.13 c	22.46 e	288.44 e	31.11 cd
F_2S_2	12.48 bc	23.33 e	317.45 d	30.70 cde
F_2S_3	13.33 abc	27.88 cd	386.21 bc	27.58 f
F_3S_1	12.83 abc	26.58 d	372.74 c	32.84 b
F_3S_2	14.33 a	30.78 a	414.74 a	34.70 a
F_3S_3	14.08 ab	30.03 ab	397.66 b	32.18 bc
$LSD_{(0.05)}$	**1.67**	**1.68**	**15.74**	**1.58**
CV%	**8.68**	**4.22**	**2.17**	**2.73**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

4.5 Yield parameters

4.5.1 Chaff weight cob^{-1} (g), Shell weight cob^{-1} (g), Grain weight cob^{-1}(g) and Cob weight (g)

4.5.1.1 Effect of fertilizer

Significant variation was observed on chaff weight cob^{-1} (g) at different doses of fertilizer application (Table 8 and Appendix XI).). The highest chaff weight cob^{-1} (10.90 g) was found in F_3 (25% more recommended doses of fertilizer). On the other hand, the lowest chaff weight cob^{-1} (8.402 g) was recorded in F_2 (25% less than recommended doses of fertilizer). Which was significantly different from other treatment.

Significant variation was observed on shell weight cob^{-1} (g) at different doses of fertilizer application (Table 8 and Appendix XI).). The highest shell weight cob^{-1} (13.80 g) was found in F_3 (25% more recommended doses of fertilizer) which was statistically identical with F_1 (Recommended doses of fertilizer). On the other hand, the lowest shell weight cob^{-1} (10.38 g) was recorded in F_2 (25% less than recommended doses of fertilizer).Which was significantly different from other treatments.

Significant variation was recorded on grain weight cob^{-1}(g) of maize for different fertilizers doses, and their combinations (Table 8 and Appendix XI). The highest grain weight cob^{-1} (91.636 g) was found in F_1 (Recommended doses of fertilizer) which was statistically identical with F_3 (25% more recommended doses of fertilizer). On the other hand, the lowest grain weight cob^{-1} (73.29 g) from F_2 (25% less than recommended doses of fertilizer) which was significantly different from other treatments.

Significant variation was observed on cob weight (g) at different doses of fertilizer application (Table 8 and Appendix XI).). The highest cob weight (115.41 g) was found in F_3 (25% more recommended doses of fertilizer) which was statistically identical with F_1 (Recommended doses of fertilizer). On the other hand, the lowest cob weight (92.00 g) was recorded in F_2 (25% less than recommended doses of fertilizer).Which was significantly different from other treatments.

4.5.1.2 Effect of spacing

Significant variation was found on chaff weight cob^{-1} (g) of maize as affected by different planting configuration (Table 8 and Appendix XI). Due to the effect of spacing on chaff weight cob^{-1} (g) of maize, the highest chaff weight cob^{-1} (10.69 g) was found in S_2 (50 cm× 20cm) while the lowest chaff weight cob^{-1} (8.25 g) was recorded in S_3 (40 cm × 20 cm) treatment which was significantly different from other treatments.

Significant variation was found on shell weight cob^{-1} (g) of maize as affected by different planting configuration (Table 8 and Appendix XI). Due to the effect of spacing on shell weight cob^{-1} (g) of maize, the highest shell weight cob^{-1} (13.86 g) was found in S_1 (60 cm× 20 cm) while the lowest shell weight cob^{-1} (10.779 g) was recorded in S_3 (40 cm × 20 cm) treatment which was significantly different from other treatments.

Significant variation was found on grain weight cob^{-1} (g) of maize as affected by different planting configuration (Table 8 and Appendix XI). Due to the effect of spacing on grain weight cob^{-1} (g) of maize, the highest grain weight cob^{-1} (92.32 g) was found in S_2 (50 cm× 20 cm) which was statistically identical with S_1 (60 cm× 20 cm) while the lowest grain weight cob^{-1} (74.19 g) was recorded in S_3 (40 cm × 20 cm) treatment which was significantly different from other treatments.

Significant variation was found on cob weight (g) of maize as affected by different planting configuration (Table 8 and Appendix XI). Due to the effect of spacing on cob weight (g) of maize, the highest cob weight (115.98 g) was found in S_2 (50 cm× 20 cm) which was followed by S_1 (60 cm× 20 cm) while the lowest cob weight (93.23 g) was recorded in S_3 (40 cm × 20 cm) treatment which was significantly different from other treatments.

4.5.1.3 Combined effect of fertilizer and spacing

Combined effect of fertilizer doses and spacing showed significant variation on chaff weight cob^{-1} (g), shell weight cob^{-1} (g), grain weight cob^{-1} (g) and cob weight (g) of white maize variety (Table 8, Appendix XI). The highest chaff weight cob^{-1} (13.66 g) was found in F_3S_2 (25% more than recommended doses of fertilizer and 50 cm× 20 cm spacing). On the other hand, the lowest chaff weight cob^{-1} (7.19 g) was found in

F_1S_3 (Recommended doses of fertilizer and spacing 40 cm × 20 cm combination) which was significantly different from other combination.

Whereas the highest shell weight cob^{-1} (16.27 g) was found from F_1S_1 (Recommended doses of fertilizer and spacing 60 cm × 20 cm combination) with combined effect of fertilizer and spacing which was statistically similar with F_3S_2. On the other hand, the lowest shell weight cob^{-1} (10.11 g) was found from F_2S_3 (25% less than recommended doses of fertilizer and spacing 40 cm × 20 cm combination) which was statistically identical with F_1S_3, F_2S_1, F_2S_2 and F_3S_3.

On grain weight cob^{-1} (g), the highest grain weight cob^{-1} (101.69 g) was found from F_3S_2 (25% more than recommended doses of fertilizer and 40 cm× 20 cm spacing) which was statistically similar with F_1S_1 and F_1S_2 with combined effect of fertilizer and spacing. On the other hand, the lowest grain weight cob^{-1} (65.78 g) was found from F_2S_3 (25% less than recommended doses of fertilizer and spacing 40 cm × 20 cm combination) which was significantly different from other combination.

On cob weight (g), the highest cob weight (130.93 g) was found from F_3S_2 (25% more than recommended doses of fertilizer and 40 cm× 20 cm spacing) which was statistically similar with F_1S_1 with combined effect of fertilizer and spacing. On the other hand, the lowest cob weight (83.71 g) was found from F_2S_3 (25% less than recommended doses of fertilizer and spacing 40 cm × 20 cm combination) which was significantly different from other combination.

Table 8. Effect of fertilizer, effect of spacing and combined effect on Chaff weight cob^{-1} (g), Shell weight cob^{-1} (g), Grain weight cob^{-1}(g) and Cob weight (g) of white maize variety

Treatment	Yield parameters			
	Chaff weight cob^{-1} (g)	Shell weight cob^{-1} (g)	Grain weight cob^{-1}(g)	Cob weight (g)
Effect of fertilizer				
F_1	8.75 b	13.43 a	91.63 a	113.82 a
F_2	8.40 c	10.38 b	73.22 b	92.00 b
F_3	10.90 a	13.80 a	90.71 a	115.41 a
LSD(0.05)	**0.15**	**0.76**	**6.76**	**6.45**
Effect of spacing				
S_1	9.11 b	13.86 a	89.05 a	112.03 b
S_2	10.69 a	12.97 b	92.32 a	115.98 a
S_3	8.26 c	10.78 c	74.19 b	93.23 c
LSD(0.05)	**0.15**	**0.63**	**3.40**	**3.39**
Combined (fertilizer × spacing)				
F_1S_1	8.88 e	16.27 a	98.10 ab	123.26 ab
F_1S_2	10.18 b	12.98 c	99.68 a	122.84 b
F_1S_3	7.19 h	11.03 d	77.13 c	95.35 d
F_2S_1	9.16 d	10.69 d	78.27 c	98.13 d
F_2S_2	8.22 f	10.34 d	75.61 c	94.17 d
F_2S_3	7.82 g	10.11 d	65.78 d	83.71 e
F_3S_1	9.28 d	14.62 b	90.79 b	114.69 c
F_3S_2	13.66 a	15.58 ab	101.69 a	130.93 a
F_3S_3	9.76 c	11.197 d	79.66 c	100.62 d
$LSD_{(0.05)}$	**0.26**	**1.17**	**8.24**	**7.98**
CV%	**1.56**	**4.90**	**3.89**	**3.09**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm

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

4.5.2.1 Effect of fertilizer

Significant variation was observed on grain yield (t ha^{-1}) at different doses of fertilizer application (Table 9 and Appendix XI).). The highest grain yield (9.20 t ha^{-1}) was found in F_3 (25% more recommended doses of fertilizer). On the other hand, the lowest grain yield (7.38 t ha^{-1}) was recorded in F_2 (25% less than recommended doses of fertilizer). Which was significantly different from other treatment. The present finding is agreed with the findings of Abebe and Feyisa (2017), Liverpool-Tasie *et al*. (2017), Maqbool *et al*. (2016), Jolokhava *et al*. (2016), Dong *et al*. (2016), Admas *et al*. (2015), Ademba *et al*. (2015), Soro *et al*. (2015).

4.5.2.2 Effect of spacing

Significant variation was found on grain yield (t ha^{-1}) of maize as affected by different planting configuration (Table 9 and Appendix XI). Due to the effect of spacing on grain yield of maize, the highest grain yield (9.31 t ha^{-1}) was found in S_3 (40 cm× 20 cm) while the lowest grain yield (7.26 t ha^{-1}) was recorded in S_1 (60 cm × 20 cm) treatment which was significantly different from other treatments. The present finding is agreed with the finding of Sabo *et al*. (2016), Jiang *et al*. (2013), Sener *et al*. (2004). and Sangoi *et al*. (2001).

4.5.2.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer doses and spacing showed significant variation on grain yield (t ha^{-1}) of white maize variety (Table 9, Appendix XI). The highest grain yield (10.22 t ha^{-1}) was found in F_3S_2 (25% more than recommended doses of fertilizer and 50 cm× 20 cm spacing). On the other hand, the lowest grain yield (6.65 t ha^{-1}) was found in F_2S_1 (25% less than recommended doses of fertilizer and spacing 60 cm × 20 cm combination) which was significantly different from other combination.

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

4.5.3.1 Effect of fertilizer

Significant variation was observed on stover yield (t ha^{-1}) at different doses of fertilizer application (Table 9 and Appendix XI).). The highest grain yield (9.95 t ha^{-1}) was found in F_3 (25% more recommended doses of fertilizer). On the other hand, the lowest grain yield (7.65 t ha^{-1}) was recorded in F_2 (25% less than recommended doses of fertilizer),which was significantly different from other treatments.

4.5.3.2 Effect of spacing

Significant variation was found on stover yield (t ha^{-1}) of maize as affected by different planting configuration (Table 9 and Appendix XI). Due to the effect of spacing on stover yield of maize, Results that the highest stover yield (9.84 t ha^{-1}) was attained with S_3 (40 cm × 20 cm), whereas the lowest stover yield (7.58 t ha^{-1}) was found with S_1 (60 cm × 20 cm), which was significantly different from other treatments. The result obtained by Hasan *et al.,* (2018) was similar with the present findings.

4.5.3.3 Combined effect of fertilizer doses and spacing

Significant variation was observed on stover yield (t ha^{-1}) at different doses of fertilizer application and different plant spacing of white maize variety (Table 9, Appendix XI). From the data the highest stover yield (11.27 t ha^{-1}) was found from F_3S_2 (25% more than recommended doses of fertilizer and spacing 50 cm × 20 cm combination) with combined effect of fertilizer and spacing. On the other hand, the lowest stover yield (6.76 t ha^{-1}) was found from F_2S_1 (25% less than recommended doses of fertilizer and spacing 60 cm × 20 cm combination), which was significantly different from other combination.

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

4.5.4.1 Effect of fertilizer

Significant variation was recorded in biological yield of maize for different fertilizers doses, and their combinations (Table 9 and Appendix XI). The highest biological yield (19.15 t ha^{-1}) was found in F_3. On the other hand, the lowest (15.03 t ha^{-1}) from F_2 which was significantly different from other treatments. This finding related to Ahmad *et al.* (2018)

4.5.4.2 Effect of spacing

Effect of spacing on biological yield was significantly differently from one another of white maize variety (Table 9 and Appendix XI). From the figure 22 indicated that the highest biological yield (19.14 t ha^{-1}) was obtained with S_3 (40 cm × 20 cm) where the lowest (14.84 t ha^{-1}) was with S_1 (60 cm × 20 cm).

4.5.4.3 Combined effect of fertilizer doses and spacing

Significant variation was observed on biological yield (t ha^{-1}) at different doses of fertilizer application and different plant spacing of white maize variety (Table 9, Appendix XI). The highest biological yield (21.49 t ha^{-1}) was found from F_3S_2 (25% more than recommended doses of fertilizer and 40 cm× 20 cm spacing). With combined effect of fertilizer and spacing. On the other hand, the lowest biological yield (13.41 t ha^{-1}) was found from F_2S_1 (25% less than recommended doses of fertilizer and spacing 60 cm × 20 cm combination), which was significantly different from other combination.

4.5.5 Harvest index (%)

4.5.5.1 Effect of fertilizer

Harvest index for different fertilizers doses, and their combinations treatments showed significantly different from one another (Table 9 and Appendix XI). Numerically, the highest harvest index (49.18 %) was recorded from F_2 (F_2 = 25% Less than recommended doses of fertilizer) which was statistically identical with F_1 (F_1 = Recommended doses of fertilizer). On the other hand, the lowest harvest index (48.05 %) was recorded from F_3 (F_3 = 25% more than recommended doses of fertilizer).

4.5.5.2 Effect of spacing

Harvest index for different spacing, and their combinations treatments showed non-significant influences (Table 9 and Appendix XI). Results represented in Figure 13 indicated that the numerically highest harvest index (48.93 %) was attained in S_1 (60 cm × 20 cm) where the lowest (48.59 %) was found in S_3 (40 cm × 20 cm) which was statistically identical with one another.

4.5.5.3 Combined effect of fertilizer doses and spacing

Combined effect of fertilizer doses and spacing on harvest index of white maize is presented in (Table 9 and Appendix XI). Results showed that, the highest harvest index (49.97 %) was recorded from the combined effect of F_2S_2 which was significantly similar with F1S3 and F_2S_1. whereas the lowest harvest index (47.56 %)

was observed by F_3S_2 combination which was significantly similar with F_2S_3 and F_3S_1 combination.

Table 9. Effect of fertilizer, effect of spacing and combined effect on grain yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%) of white maize variety

Treatment	**Yield parameters**			
	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Effect of fertilizer				
F_1	8.97 b	9.28 b	18.25 b	49.16 a
F_2	7.38 c	7.65 c	15.03 c	49.18 a
F_3	9.20 a	9.95 a	19.15 a	48.05 b
LSD(0.05)	**0.16**	**0.18**	**0.34**	**0.27**
Effect of spacing				
S_1	7.26 c	7.59 c	14.84 c	48.93
S_2	8.98 b	9.46 b	18.44 b	48.88
S_3	9.31 a	9.84 a	19.14 a	48.59
LSD(0.05)	**0.091**	**0.19**	**0.25**	**0.49(ns)**
Combined (fertilizer × spacing)				
F_1S_1	7.67 e	7.95 e	15.62 e	49.09 bc
F_1S_2	9.51 c	9.86 c	19.36 c	49.10 bc
F_1S_3	9.74 b	10.01 c	19.75 c	49.29 ab
F_2S_1	6.65 h	6.76 g	13.41 g	49.60 ab
F_2S_2	7.23 g	7.24 f	14.46 f	49.97 a
F_2S_3	8.26 d	8.96 d	17.22 d	47.98 de
F_3S_1	7.45 f	8.03 e	15.48 e	48.11 de
F_3S_2	10.22 a	11.27 a	21.49 a	47.56 e
F_3S_3	9.92 b	10.54 b	20.47 b	48.49 cd
$LSD_{(0.05)}$	**0.21**	**0.32**	**0.48**	**0.75**
CV%	**1.04**	**2.11**	**1.40**	**1.00**

F_1 = Recommended doses of fertilizer, F_2 = 25% Less than recommended doses of fertilizer, F_3 = 25% more than recommended doses of fertilizer, S_1 = 60 cm × 20 cm, S_2 = 50 cm× 20 cm and S_3 = 40 cm× 20 cm.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh during the period from March 2019 to June 2019 to study the effect of different level of fertilizer combination and spacing on the yield of white maize (SAUWMT 9-3-4). The experiment comprised of two factors, Factor A: Different fertilizer doses i.e. F_1 = Recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer**,** F_3 = 25% More than recommended doses of fertilizer and factor B: three different plant spacing viz. S_1 (60 cm × 20 cm) , S_2 (50 cm × 20 cm) and S_3 (40 cm × 20 cm) The experiment was laid out in split-plot design with three replications. Data on different growth parameters, yield attributes and yield were recorded and analyzed.

Data were collected on plant height (cm), tassel length (cm), leaf area (cm^2), dry matter content (g), cob length (cm), cob circumference (cm), number of rows cob^{-1}, number of grain row^{-1}, number of grains cob^{-1}, 100- grains weight (g), chaff weight cob^{-1} (g), shell weight cob^{-1} (g), grain weight cob^{-1} (g), cob weight cob^{-1} (g), grain yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index(%).

Results under the present study in terms of growth parameters showed that the plant height range from (186.89 cm to 194.49 cm) was recorded at 45 DAS and (194.89 cm to 202.14 cm) at harvesting time (90 DAS) respectively. The tallest plant (194.49 cm and 202.14 cm) was recorded in F_3 treatment. Effect of spacing on plant height the ranges of plant height (184.24 cm to 198.8 cm) at 45 DAS and (192.17 cm to 206.44 cm) at harvest (90 DAS) was found. Results indicated that the highest plant height (198.8 cm) was found in S_1 (60 cm × 20 cm) at 45 DAS and followed by (206.44 cm) was found in S_1 (60 cm × 20 cm) at harvest. The lowest plant height (184.24 cm and 192.17 cm) was attained from the plant spacing S_3 (40 cm × 20 cm) at 45DAS and at harvest also. For combined effect on plant height ranges from (179.16 cm to 202.20 cm) at 45 DAS and (187.44 cm to 209.75 cm) at harvest was recorded. The highest plant height (202.20 cm and 209.75 cm) was found in $F_3S_1$and shortest plant was found in F_2S_3 at 45 DAS and at harvest.

The highest tassel length (35.25 cm) was recorded in F_3 treatment and lowest tassel length (30.55 cm) was recorded in F_2. Due to influence of spacing the highest tassel length was recorded 34.91 cm in S_1 while lowest tassel length was (31.63 cm) in S_3. The highest tassel length (38.45 cm) was found in F_3S_2 treatment and lowest tassel length (29.22 cm) was found in F_2S_2 combination.

At 45 DAS, the highest leaf area plant^{-1} was found (718.72, 747.48 and 798.89 cm^2) from F_1 at lower leaf, cob leaf and upper leaf respectively. Similarly the lowest leaf area was found (683.92, 725.50 and 756.08 cm^2) from F_2 at lower leaf, cob leaf and upper leaf respectively also. For considering effect of spacing on leaf area, the highest leaf area plant^{-1} was found (726.49, 756.74 and 805.29 cm^2) from S_1 at lower leaf, cob leaf and upper leaf respectively. On the other hand the lowest leaf area was found (678.49, 712.16 and 734.09 cm^2) from S_3. And again the combined effect of fertilizer and spacing, the highest leaf area was found (731.63, 762.27 and 809.56 cm^2) from F_3S_1. On the other hand, the lowest leaf area was found (627.15, 695.34 and 677.91 cm^2) from F_2S_3. At harvest, the highest leaf area and lowest leaf area plant^{-1} followed the similar trend of 45 DAS at lower leaf, cob leaf and upper leaf area viz. F_1 and F_2 respectively. For considering the effect of spacing on leaf area, the highest leaf area and lowest leaf area plant^{-1} also followed the similar trend of 45 DAS viz. S_1 and S_3 respectively. And again the combined effect of fertilizer and spacing, the highest leaf area and lowest leaf area followed to the F_3S_1 and F_2S_3.

On the effect of fertilizer and spacing the maximum dry matter content at 45 DAS (16.89,15.26,19.43 and 51.60 g at lower unit, cob unit, upper unit and total dm respectively) and dry matter content at harvest (22.98,144.02, 24.19 and 191.20 g) at lower unit, cob unit, upper unit and total dm respectively) were found from the treatment F_1S_1 whereas the lowest dry matter content at 45 DAS (11.18, 10.44 g were found F_3S_1,13.08g from F_2S_1 and 36.22 g from F_1S_3 at lower unit, cob unit, upper unit and total dm respectively) and dry matter content at harvest (16.26, 112.65, 19.09 and 150.15 g at lower unit, cob unit, upper unit, and total dm respectively) were found from the treatment F_3S_1 except upper unit.

In terms of yield contributing parameters, on the effect of fertilizer the highest cob length and cob circumference (14.45 cm and 13.92 cm) were found from F_1, and number of row cob^{-1}, number of grain row^{-}1 and number of grain cob^{-1} (13.75, 29.13

and 395.05) and100 grain weight (33.24 g) were recorded from the treatment F_3. On the other hand, the lowest cob length and cob circumference (13.97 cm, 13.62 cm) were found from F_2, and number of row cob^{-1}, number of grain row^{-1} , number of grain cob^{-1} and 100 grain weight (12.65, 24.56, 330.7 and 29.8 g) were recorded from the treatment F_2.

And again on the effect of spacing, the highest cob length and cob circumference (15.39 cm, 14.14 cm) were found from S_1, and number of row cob^{-1}, number of grain $row^{-}1$ and number of grain cob^{-1} (13.75, 29.06 and 392.59) were recorded from S_3 and100 grain weight (32.3 g) were recorded from the treatment S_2. On the other hand, the lowest cob length (13 cm) from S_3, cob circumference (13.33 cm) were found from S_2, and number of row cob^{-1}, number of grain $row^{-}1$ and number of grain cob^{-1} (12.68, 25.42 and 347.81) were recorded from S_1 and100 grain weight (29.76 g) were recorded from the treatment S_3.

Whereas the Combined effect, the highest cob length and cob circumference (16.09 cm and 14.51 cm) were found from F_1S_1 and F_2S_1treatment and lowest cob length 12.463 cm was found from F_1S_3 treatment and cob circumference 12.467 cm was found from F_2S_2 treatment. The highest number of row cob^{-1}, number of grain $row^{-}1$ and number of grain cob^{-1} (14.33, 30.78and 414.74) and 100 grain weight (34.70 g) were recorded from the treatment F_3S_2. On the other hand, the lowest number of row cob^{-1}, number of grain $row^{-}1$, number of grain cob^{-1} (12.13, 22.46 and 288.44) were recorded from the treatment F_2S_1 and 100 grain weight (27.542 g) was found from F_2S_3.

On the effect of fertilizer, the highest Chaff weight cob^{-1} (g), Shell weight cob^{-1} (g), Grain weight cob^{-1} (g) and Cob weight (g) of white maize variety (10.90 g, 13.80 g) were found from F_3, (91.63 g) found from F_1 and (115.41 g) was found from F_3. On the other hand, the lowest Chaff weight cob^{-1} (g), Shell weight cob^{-1} (g), Grain weight cob^{-1} (g) and Cob weight (g) of white maize variety (8.40 g, 10.38 g, 73.21 g and 92.00 g) were found from the treatment F_2. On the effect of spacing, the highest chaff weight cob^{-1} (10.68 g) was found in S_2, Shell weight cob^{-1} (13.862 g) was found from S_1, Grain weight cob^{-1} (92.326 g) was found from S_2 and Cob weight (115.98 g) was found from S_2 of white maize variety. On the other hand, the lowest chaff weight cob^{-1}, Shell weight cob^{-1} (g), Grain weight cob^{-1} (g) and Cob weight (g) of white maize variety (8.26 g, 10.78 g, 74.19 g and 93.23 g) were found from S_3 treatment. Whereas the effect of Combined, the highest chaff weight cob^{-1}(13.66 g) was found from F_3S_2, Shell weight cob^{-1} (16.27 g) was found from F_1S_1, Grain weight cob^{-1} (101.69 g) and Cob weight (130.93 g) were found from F_3S_2. On the other hand, the lowest Chaff weight cob^{-1} (g), Shell weight cob^{-1} (g), Grain weight cob^{-1} (g) and Cob weight (g) of white maize variety (7.82 g, 10.11 g, 65.78 g and 83.71 g) were found from F_2S_3.

The highest grain yield, stover yield and biological yield (9.20, 9.95 and 19.15 t ha^{-1}) were recorded in F_3 and harvest index (49.18%) was found from F_2. While the lowest yield (7.38, 7.65 and 15.03 t ha^{-1}) was recorded in F_2 respectively and harvest index (48.05%) was found from F_3. Due to the effect of spacing on maize the highest grain yield, stover yield and biological yield (9.31, 9.84 and 19.14 t ha^{-1}) were found from S3 (40 cm× 20 cm) and harvest index (48.93%) was found from S_1. While the lowest yield (7.26, 7.58 and 14.84 t ha^{-1}) was recorded in S_1 respectively and harvest index (48.59 %) was found from S_3. Whereas the effect of Combined, the highest grain yield, stover yield and biological yield (10.22, 11.27 and 21.49 t ha^{-1}) were found from F_3S_2 and harvest index (49.97 %) was found from F_2S_2.On the other hand the lowest yield (6.65, 6.76 and 13.41 t ha^{-1}) were found from F_2S_1 treatment respectively. In case of harvest index the lowest harvest index (47.56 %) was observed by F_3S_2 combination.

Based on the results of the present study, the following conclusions may be described as follows as-

The best fertilizer dose was F_3 in respect of showing the highest grain yield (9.20 t ha^{-1}) required.

The best plant spacing was S_3 (40 cm× 20cm) where the highest grain yield was (9.31t$ha^{-1)}$.

The treatment combination showing the highest grain yield (10.22 t ha^{-1}) was F_3S_2 treatment.

However, such response of the genotype may vary depending on the changes of the surrounding environment. Therefore, similar studies could be carried out in different agro-ecological zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.

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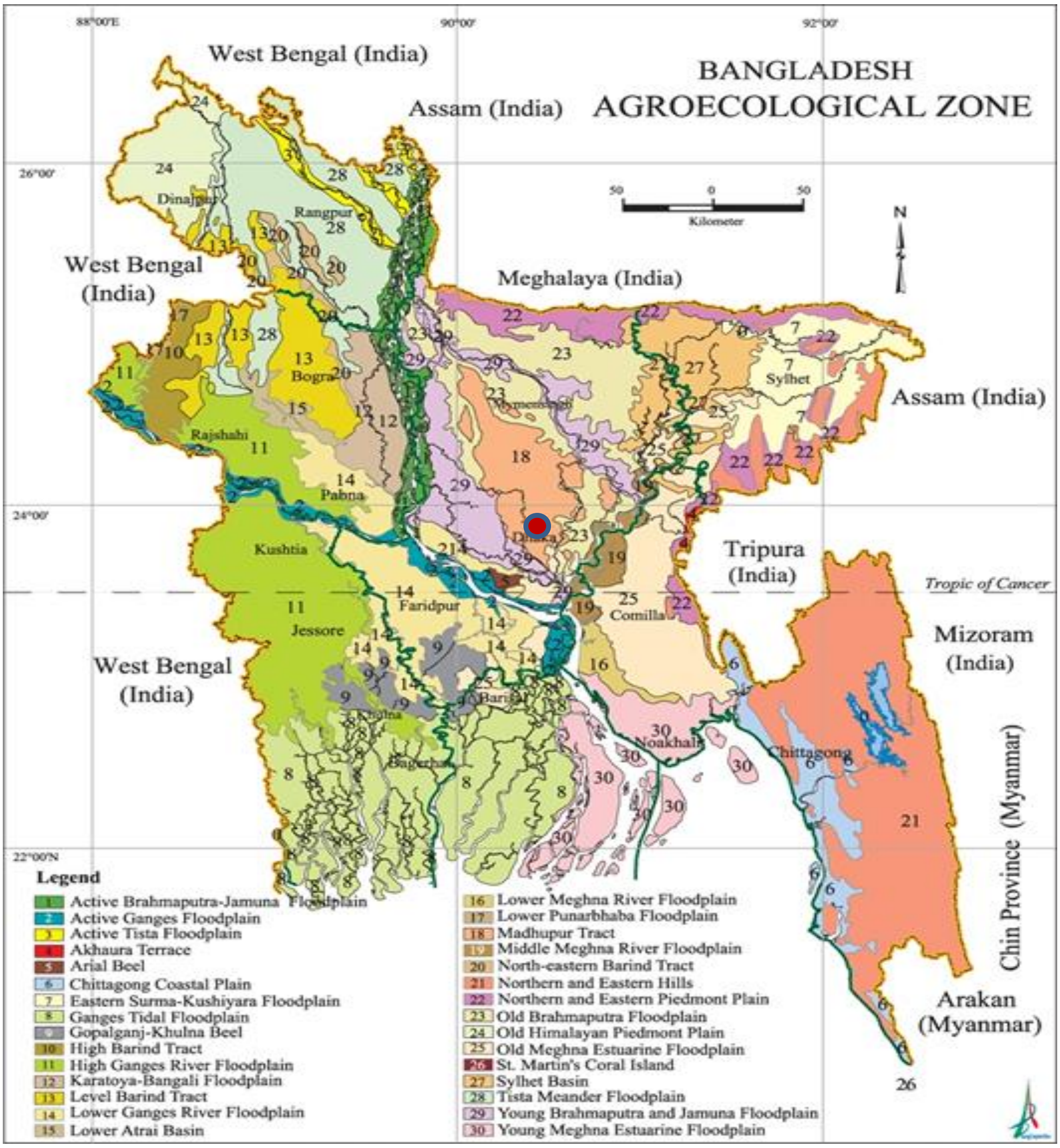
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from March 2019 to June 2019.

Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
March	31.5	21.1	69	72	7.58
April	33.7	23.6	72	173	6.67
May	34.9	26.4	75	195	3.54
June	33.6	26.6	85	260	3.05
July	33.8	26.9	88	368	2.06

Source: Bangladesh Meteorological Department (climate division), Agargaon, Dhaka-1207

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

A. Morphological characteristics of the experimental soil

Morphological features	Characteristics
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (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

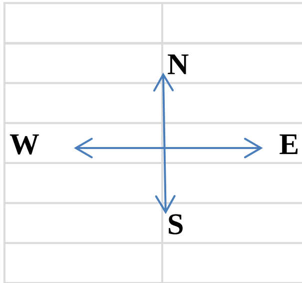
Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

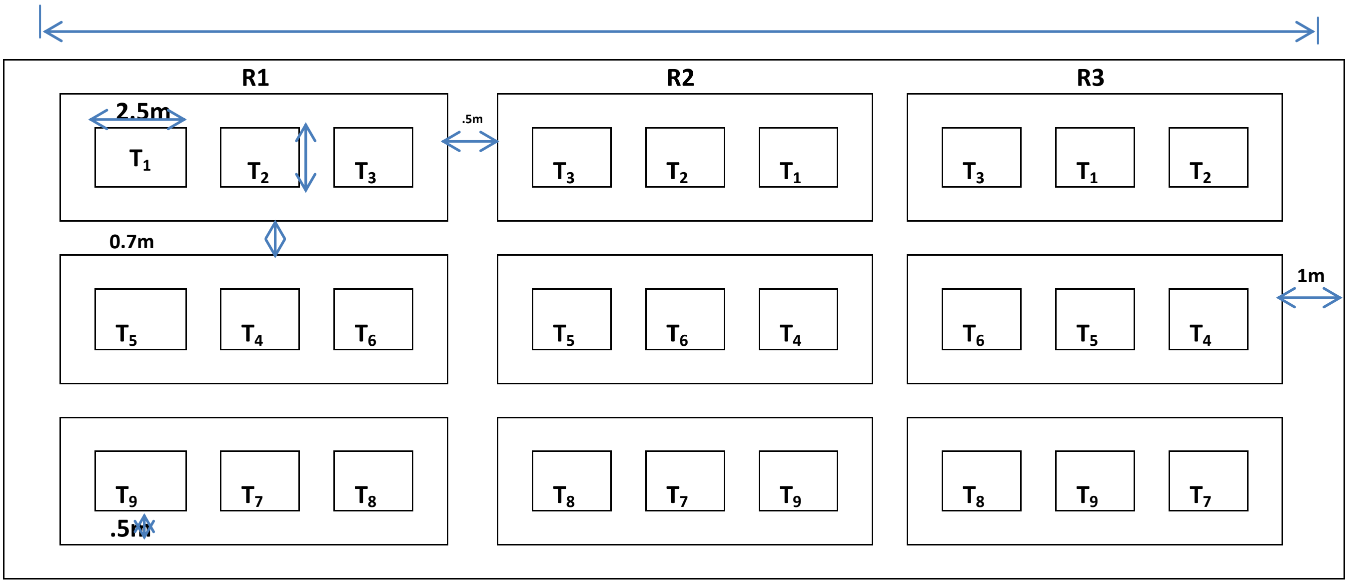
Characteristics	Value
Partical size analysis	
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty-clay
P^H	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix I V. Layout of the experimental Split Plot Design



Length =30.50 m, Breath = 11.05 m, area =337.02 m^2, area of sub-pot = 2.5×1.75=4.37 m^2



Treatments

$T_1 = F_1S_1$	$T_4 = F_1S_1$	$T_7 = F_3S_1$
$T_2 = F_1S_2$	$T_5 = F_2S_2$	$T_8 = F_3S_2$
$T_3 = F_1S_3$	$T_6 = F_2S_3$	$T_9 = F_3S_3$
F_1 = Recommended doses of fertilizer	F_2 = 25% Less than recommended doses of fertilizer	F_3 = 25% more than recommended doses of fertilizer
S_1 = 60 cm × 20 cm	S_2 = 50 cm× 20 cm	S_3 = 40 cm× 20 cm

Appendix V. Analysis of variance of the data on mean square of plant height (cm) and cob length (cm)

Source	DF	Mean square of plant height and tassel length		
		At 45 DAS	At harvest	Tassel length
Replication (A)	2	9.501	43.132	5.5875
Fertilize (B)	2	166.808*	142.081 NS	58.8793**
Error I	4	11.075	35.915	1.5186
Spacing (C)	2	477.427**	459.15**	25.3924 NS
B×C	4	22.877 NS	23.731 NS	15.4474 NS
Error II	12	68.166	16.592	7.0440

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

Appendix VI. Analysis of variance of the data on mean square of leaf area at 45 DAS

Source	DF	Mean square of leaf area at 45 DAS		
		Lower leaf	Cob leaf	Upper leaf
Replication (A)	2	250.55	1883.9	666.2
Fertilize (B)	2	3482.45**	1110.67 NS	4165.7**
Error I	4	169.72	1158.69	257.7
Spacing (C)	2	5644.8**	4709.03*	13605.4**
B×C	4	1516.25*	563.1 NS	3042.2**
Error II	12	388.56	936.11	377.1

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

Appendix VII. Analysis of variance of the data on mean square of leaf area at harvest

Source	DF	Mean square of leaf area at harvest		
		Lower three leaves	**Cob leaf**	**Upper three leaves**
Replication (A)	2	33.7	282.19	117.85
Fertilize (B)	2	5246.1**	2146.76 NS	2572.25**
Error I	4	18.4	918.42	121
Spacing (C)	2	14584.8**	8987.83**	5513.03**
B×C	4	2728.7**	1454.22 NS	730.23**
Error II	12	31.9	708.6	68.74

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

Appendix VIII. Analysis of variance of the data on mean square of dry matter content at 45 DAS

Source	DF	Mean square of dry matter content at 45 DAS			
		Lower unit	Cob unit	Upper unit	Total dm
Replication (A)	2	0.0072	0.7648	3.1808	7.287
Fertilize (B)	2	9.7228*	10.0648*	43.795*	147.872**
Error I	4	1.1329	1.2292	3.784	5.483
Spacing (C)	2	12.0549*	1.3598 NS	1.2525 NS	20.522 NS
B×C	4	13.2467**	9.1588**	9.3003 NS	49.696*
Error II	12	1.9639	0.4634	3.3711	9.81

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

Appendix IX. Analysis of variance of the data on mean square of dry matter content at harvest

Source	DF	Mean square of dry matter content at harvest			
		Lower unit	Cob unit	Upper unit	Total dm
Replication (A)	2	0.4056	16.083	1.6723	32.37
Fertilize (B)	2	48.4967**	962.804**	20.6615**	1720.06**
Error I	4	0.0677	1.449	0.0564	2.02
Spacing (C)	2	1.4119**	1.427 NS	0.0303 NS	3.07 NS
B×C	4	7.6178**	224.061**	4.4634**	337.86**
Error II	12	0.0818	1.805	0.0935	1.73

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

Appendix X. Analysis of variance of the data on mean square of yield contributing parameters

Source	DF	**Mean square of Yield contributing parameters**					
		Cob length	Cob circumference	Number of rows cob^{-1}	Number of grains row^{-1}	Number of grains cob^{-1}	100 grain weight
Replication(A)	2	0.1525	0.01249	1	1	59.4	0.7976
Fertilize (B)	2	0.5898 ^{NS}	0.24163 ^{NS}	2.9925 ^{NS}	53.839 ^{NS}	11329.3**	32.459**
Error I	4	0.244	0.03693	4.52	1.30	66.7	0.5958
Spacing (C)	2	12.8887**	1.4729**	2.7475 ^{NS}	30.0876**	4557.8**	14.4746**
B×C	4	1.9655**	1.07832**	0.385 ^{NS}	6.80513*	2225.6**	3.0792*
Error II	12	0.0913	0.02073	1.33333	1.33333	64.9	0.7184

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

Appendix XI. A. Analysis of variance of the data on mean square of yield parameters

Source	**DF**	Mean square of Yield parameters			
		Chaff weight cob^{-1}	Shell weight cob^{-1}	Grain weight cob^{-1}	Cob weight
Replication(A)	2	0.0507	0.11	0.877	0.87
Fertilize (B)	2	16.4555**	31.6643**	969.175**	1539.83**
Error I	4	0.0141	0.3395	26.695	24.3
Spacing (C)	2	13.6566**	22.6473**	840.787**	1329.99**
B×C	4	5.8754**	7.2924**	64.272**	146.9**
Error II	12	0.0214	0.378	10.963	10.94

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

B. Analysis of variance of the data on mean square of yield parameters

Source	**DF**	Mean square of Yield parameters			
		Grain yield	Stover yield	Biological yield	Harvest index
Replication(A)	2	0.0021	0.0538	0.0588	0.35824
Fertilize (B)	2	8.8242**	12.558**	42.1147**	3.77897**
Error I	4	0.016	0.0198	0.0669	0.04286
Spacing (C)	2	10.9373**	13.1183**	48.0101**	0.30806 ^{NS}
B×C	4	0.9285**	1.746**	5.0898**	1.87106**
Error II	12	0.0079	0.0358	0.0599	0.23579

**** = 1% level of significant, * = 5% level of significant, NS = Non significant**

PLATE

Plate 1. General view of fertilization

Plate 2. General view of seed sowing

Plate 3. General view of intercultural operation

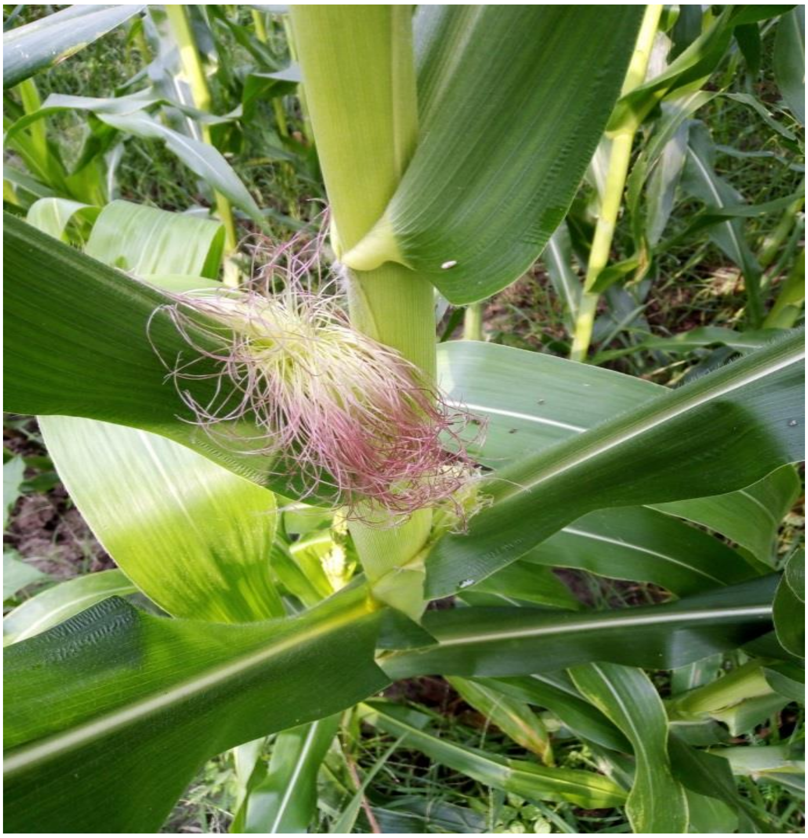


Plate 4. General view of silking

Plate 5. General view of an open cob