COMPARING PAIRED ROW SYSTEM WITH CONVENTIONAL SYSTEM OF PLANTING IN WHITE MAIZE UNDER VARYING FERTILIZER APPLICATION

MOST. RABEYA KHATUN

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

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BY

MOST. RABEYA KHATUN

Reg. No. 19-10262

E-mail: raabeeyaao1@gmail.com

Mobile: 01826-058273

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Approved by:

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(Prof. Dr. Md. Jafar Ullah)	**(Prof. Dr. H.M.M. Tariq Hossain)**
Supervisor	**Co-supervisor**

____

(Prof. Dr. Md. Abdullahil Baque)

Chairman

Examination Committee

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Phone: 44814043

CERTIFICATE

This is to certify that the thesis entitled ‘‘***COMPARING PAIRED ROW SYSTEM WITH CONVENTIONAL SYSTEM OF PLANTING IN WHITE MAIZE UNDER VARYING FERTILIZER APPLICATION***’’ submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** IN **AGRONOMY**, embodies the result of a piece of *bona fide* research work carried out by, **MOST. RABEYA KHATUN,** Registration number: **19-10262** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

Date: December, 2021
Dhaka, Bangladesh

Prof. Dr. Md. Jafar Ullah
Department of Agronomy
Sher-e-Bangla Agricultural University,
Dhaka-1207

Dedicated to

My Beloved

Parents and Teachers

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COMPARING PAIRED ROW SYSTEM WITH CONVENTIONAL SYSTEM OF PLANTING IN WHITE MAIZE UNDER VARYING FERTILIZER APPLICATION

ABSTRACT

An experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January to May 2021 to comparing paired row system with conventional system of planting in white maize under varying fertilizer application. The experiment consisted of two factors. Factor A: Fertilizer doses namely, F_1 = 100% 0f recommended dose; F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose; and factor B: sowing methods, namely S_1 = sowing in line using planting configuration 50cmx 25cm; S_2= sowing in paired rows with 50 cm between two adjacent paired rows of planting configuration of 30cm x 25cm; S_3= sowing in paired rows with 70 cm between two adjacent paired rows of planting configuration of 30cm x 25cm. From the trial, it was evident that the highest plant height (208.67cm), number of leaves (13.66), dry matter weight at 60 DAS and harvest , cob length (19.02 cm), cob circumference (18.53 cm), number of grains cob^{-1} (423), shell weight (16.83) and 100-grains weight (28.88 g), grain weight plant^{-1} (85.93g) were achieved by the treatment F_4S_1, while in case of sunshine below the canopy , F_4S_2 had the highest sunshine and F_1S_1 had lowest sunshine. The lowest plant height (185.43), no of leaves (10), dry matter weight at 80 DAS and at harvest, cob length (13.7 cm), cob circumference (12.1 cm), 100 grain weight (21.63g) were achieved by F_3S_2, however lowest shell weight (8.66 g), number of per cob (323.67) were obtained from F_2S_2. But in terms of grain yield (7.83 t ha^{-1}), stover yield (12.91 t ha^{-1}) and biological yield (20.74 t ha^{-1}), the highest result was obtained with F_4S_2 where the lowest grain yield (5.67 t ha^{-1}), stover yield (7.37 t ha^{-1}) and biological yield (13.04 t ha^{-1}) were with F_3S_1. In case of harvest index highest result was (42.73%) for F_3S_3 and the lowest result was (35.3%) for F_4S_1. The regression and correlation coefficients were found to be strongly positive among most of the plant parameters with leaf area and sunshine. The grain yield ha^{-1} of F_1S_2 and F_4S_2 was statistically identical (7.68-7.83 t ha^{-1}).

LIST OF CONTENTS

LIST OF CONTENTS (Cont’d)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF FIGURES

LIST OF APPEDICES

LIST OF PLATES

LIST OF ACRONYMS

AEZ = Agro-Ecological Zone

ANOVA=Analysis of Variance

BARI = Bangladesh Agricultural Research Institute

BBS = Bangladesh Bureau of Statistics

CIMMYT=International Maize and Wheat Improvement Center

cv. = Cultivar

DAP= Di Ammonium Phosphate

DAS = Days after sowing

DF=Degrees of Freedom

et al. = And others

FAO = Food and Agricultural Organization

FYM=Farm Yard Manure

ha-1 = per hectare

HI = Harvest Index

hr= hour

kg = Kilogram

LAI = Leaf area index

NS = Non significant

Min = Minimum

ppm= parts per million

mg = Micro gram

MS=Mean Sum of Square

mm = Millimeter

Max = Maximum

Q = Quintal

ppm= parts per million

SAUWMOPMT=Sher-e Bangla Agricultural University White Maize Open Pollinated Medium Tall

SRDI = Soil Resources and Development Institute

SS=Sum of Square

TSP = Triple Super Phosphate

viz. = Videlicet (namely)

% = Percent

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world's agricultural economy which is used both as food and feed. This cereal crop belongs to the family Poaceae. It has very high yield potential, there is no cereal on the earth which has so immense potentiality and that is why it is called "Queen of cereals". In Bangladesh, it covers about 3.5 lac hectares of land producing 23 lac metric tons grains. The current average yield of maize is 7300 kg ha^{-1} which much lower than that of some other developed countries.

The yield of maize is governed by many agronomic factors among which using optimum population density is one of the prime ones which can be adjusted both by manipulating inter row and intra-row spacing. Iken and Anusa (2004) recommended an optimum plant population of 53,333 plants ha^{-1} for maximum yield of maize. However, Ullah et al. (2016) reported it to be above 80,000 plants ha^{-1} in white maize. Fertilizer application affects plant growth and development greatly and as such affects yield through dry matter partitioning of the grain producing crops. The recommended dose of N, TSP, MOP, Gypsum, Zinc, Boric Acid for the production of hybrid maize are 500, 250, 200, 250, 10, 7 kg ha^{-1} respectively (BARI, 2016).

In Bangladesh the maize that is being grown in yellow which is used as fodder. The maize which is consumed by human is white which a new introduction in our country is. So it is necessary to optimize the population density and fertilizer dose for the white maize production. The currently grown maize in this country is yellow type, which is mainly adapted importing genetic materials from CIMMYT, 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).

The yellow maize currently grown in Bangladesh are mostly hybrid whose cultivation has been increasing at the rate of about 20-25% $year^{-1}$ since nineties (Ullah *et al.*, 2017a; Ullah *et al.* 2017b; Fatima *et al.*, 2019; Shompa *et al.*, 2020). The yield of maize ranges between 5.50–7.00 and 12.00 t ha^{-1} (Nasim *et al.*, 2012). Maize responds differently to different practices such as input use, cultivation practices; and prevailing environment etc during the growing season (Ullah *et el.*, 2018a; Ullah *et el.*, 2018b; Ullah *et el.*, 2018c; Bithy and Ahamed, 2018). The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices (such as proper management of planting configuration, irrigation interval, fertilizer managements, weeding, thinning, earthing up etc), and limited use of input, insufficient technology generation, poor seed quality, disease, insect, pest and weeds (Ullah *et al.,* 2017a).

Agronomic management, especially spacing which significantly influence on yield, since it is ultimately correlated with plant population, root development, plant growth and fruiting (Davi *et al.,* 1995; Akbar *et al.* 2016; Ahmmed *et al.,* 2020). The relationship between yield and spacing is intricate.

Salam *et al.* (2006) reported the highest grain yield of BARI hybrid maize 3 when sown at 75 cm × 25 cm spacing. Biswas (2019) tested two hybrid white maize at three different spacing (50 cm × 25 cm, 60 cm × 25 cm and 70 cm × 25 cm) at Dhamrai during rabi 2015-16 and reported the highest grain yields at the closer spacing. Ullah *et al.* (2018c) tested eight different hybrid white maize varieties at two different spacing (60 cm × 25 cm and 75 cm× 25 cm) at the Sher-e-Bangla Agricultural University Farm during rabi season of 2015-16 and reported the highest grain yield (7.551 t ha^{-1}) at 60 × 25 cm spacing which was significantly higher than that (5.832 t ha^{-1}) of the 75 cm × 25 cm treatment. In another trial at Dhamrai of Dhaka in the same season, they tested two different hybrid white maize varieties and observed that the comparable grain yield (8.740 t ha^{-1}) was obtained from the closest spacing (50 cm × 20 cm) as was from the paired rows with 70 cm spacing (8.773 t ha^{-1}) which were significantly higher than that (7.920 t ha^{-1}) from the spacing of 60 cm × 20 cm.

In the 2015-16 rabi season, Ullah *et al.* (2018c) also carried out another separate experiment at Rangpur Sadar with two hybrid white maize varieties planted at three different planting configuration. Results showed that the closer spacing of 50cm x 20cm produced greatest grain yield (6.670 t ha^{-1}) and compared to the yields of 5.198 and 6.626 t/ha obtained, respectively from the wider spacing of 60 cm × 20 cm and inter paired rows spacing of 70 cm spacing. They also set another experiment at Rangpur with a hybrid white maize variety PSC-121 at different planting configurations (row to row 50 cm to 80 cm and plant to plant 20-40 cm) and reported the highest grain yields from the 80 cm × 20 cm spacing. In another separate trial set at Bandarban with two different hybrid white maize varieties plant at different planting configurations (row to row spacing 50-70 cm and paired rows.

From the review of the results from the above trials, it may be concluded that the higher grain yields were mostly obtained from row to row spacing either of 60 cm or below this. The researchers (Ullah *et al*. 2018c; Ullah *et al*. 2018d; Biswas, 2019) opined that the grain yield of an individual maize plant increases with gradual increase in row spacing and plant to plant spacing within a row. But the grain yield in a community level (per hectare) depends on the plant population density and the plant characters such as plant height, leaf area, leaf orientation and leaf erectness. It was also reported that using paired row keeping closer spacing between the paired rows and wider spacing between two adjacent paired rows provides more favourable environment for better use of the available resources as compared to the conventional planting method (using a particular inter row distance).

Again, the fertilizer dose and planting method interact with each other affecting leaf area production; and thereby influence light entrance in to the canopy of plants. In kharif season there is scarcity of light due to the cloud coverage either for the whole day or full day. So, using paired row system leaves wider space between two adjacent paired row which allows more light interception through the canopy and in tern it may increase grain yields.

Objectives of the Research work:

1. To study light interception under varying sowing method and fertilization and the resultant effect on the yield of white maize SAUWMOPMT

2. To optimize the fertilizer doses for the production of white maize SAUWMOPMT

3. To examine the interaction effect of sowing method and fertilizer doses on the yield of white maize SAUWMOPMT

CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available in the country and abroad regarding the effect of different varieties and level of fertilizer management on the growth and yield of white maize to gather knowledge helpful in conducting the present research work and subsequently writing up the result and discussion.

2.1 Effect of different levels of fertilizers

Msarmo and Mhango (2005) conducted that the maize varieties included local, Masika (composite) and DK8031 (hybrid) and the fertilizer application

Practices were 100 kg ha^{-1} urea as basal and 100 kg ha^{-1} urea as top dressing (P_1), 100 kg ha^{-1} urea as basal and 75 kg ha^{-1} urea as top dressing (P_2) and 100 kg ha^{-1} as basal and 150 $kgha^{-1}$ urea as top dressing (P_3). The result of the study revealed that, P_1 gave the highest plant height of 177.7 cm followed by P_2 (175 cm) and then P_3 (172.6 cm).

Kaur et al. (2017) revealed that application of 150 kg N ha^{-1} produced significantly higher seed yield over higher number of cobs (1.2), cob girth (3.6 cm), number of grains cob^{-1} (274.8) which were comparably higher as compared to other treatments.

Ravi et al. (2012) opined that application of 10 t FYM + 100 % RDF ha^{-1}(T_1) recorded significantly higher grain yield (71.79 q ha^{-1}) over rest of the treatments but it was on par with T_{10}, T_8, T_6 and T_4 (70.75, 68.84, 68.00 and 67.25 q ha^{-1} , respectively).

Lingaraju et al. (2010) observed that an application of 100% RDF (100:50:25 kg NPK ha^{-1}) produced significantly higher maize grain yield of 5578 kg ha^{-1} as compared to 75 % RDF (75 :37.5:18.7 kg NPK ha^{-1}) and 50 % RDF (50:25:12.5 kg NPK ha^{-1}), which gave 5281 and 4917 kg ha^{-1} grain yields, respectively.

Sidhu and Thind (2008), while assessing the nitrogen, phosphorus and potassium requirement of winter maize at Ludhiana, on sandy loam soil during 2002-03 observed that an application of 175:60:30 kg NPK ha^{-1} recorded significantly the highest grain yield of maize over 150:60:30 and 200:60:30 kg NPK ha^{-1} .

Athar et al. (2012) conducted a pot experiment in a wire netting green house at ahauddin Zakariya University, Multan, Pakistan in order to assess the beneficial effect of urea on corn cultivars (C-20 and C-79) differing in yield production. Corn plants were grown in loam soil with alkaline in reaction. The pots were arranged in a complete randomized manner with six replicates. Two weeks old plants were subjected to different levels of urea (46% N). Five levels of urea (0, 50, 100, 175 and 225 kg ha^{-1}) with constant (150 kg ha^{-1}) TSP (46% P_2O_5) and SOP (50% K_2O) were applied in two steps half dose at the seedling stage and the remaining half was supplied at vegetative stage (6 weeks) at constant (100 kg ha^{-1}) sulfate of potash (SOP) and triple super phosphate (TSP). They reported that, tallest plant height (182.31 cm) was recorded for 50 kg ha^{-1} urea application and the shortest plant (102.38 cm) was found from control treatment (0 kg ha^{-1}).

Onasanya et al. (2009) observed that maximum plant height was recorded from at 8 week after transplanting. The tallest plant height (192.50 cm) was recorded from T_3 (120 kg N ha^{-1} + 0 kg P ha^{-1}) where as the shortest plant height (167.06 cm) was recorded from untreated control.

Law-ogbomoa and Law-ogbomo (2009) presented that the plant height was increased with successive increment in fertilizer application rate up to 600 kg ha^{-1}. Maize plants were tallest (168.35 cm) that received 600 kg NPK ha^{-1} and the shortest plant (148.20 cm) was recorded that received no fertilizers.

Number of leaves plant^{-1}

A field nitrogen management trial was conducted by Woldesenbet et al. (2016) indicated that, there is an increase in number of leaves with an increase in N level. The data showed that the maximum numbers of leaves per plant (17.2) were obtained from the application of 69 and 92 kg N ha^{-1} and the minimum number of leaves per plant (15.8) were obtained from no N application.

Onasanya et al. (2009) revealed that, T_3 (120 kg N ha^{-1} + 0 kg P ha^{-1}) produced the maximum number of leaves plant^{-1} (12.39) which differ from all other treatments. Control treatment had the least number of leaves plant^{-1} (10.51).

Law-ogbomoa and Law-ogbomo (2009) conducted that, the highest number of leaves plant^{-1} (32.10) was recorded from the maize plants that received 600 kg ha^{-1} and the lowest number of leaf plant^{-1} (8.50) was recorded from the maize plants that received without fertilizer applications.

Leaf area plant^{-1}

Asaduzzaman et al. (2014) observed that, plot treated with 200 kg ha^{-1} gave the highest LAI (5.23) where as the plot treated with 0 kg ha^{-1} had the lowest LAI (2.75).

Athar et al. (2012**)** that, maximum leaf area plant^{-1} (5700 cm^2) was recorded for 100 kg ha^{-1} urea application and the minimum leaf area plant^{-1} (3854 cm^2) was found from control treatment (0 kg ha^{-1}).

Onasanya et al. (2009) presented that, the highest leaf area plant^{-1} (964.71 cm^2) was recorded in T_{10} (120 kg N ha^{-1} + 20 kg P ha^{-1}) at 8 WAP. However, this was not significantly different from T11 (120 kg N ha^{-1} + 40 kg P ha^{-1}) and T_3 (120 kg N ha^{-1} + 0 kg P ha^{-1}). The control plot (T_1) gave the lowest value of leaf area plant^{-1} (501.22 cm^2).

Law-ogbomoa and Law-ogbomo (2009) the highest leaf area plant^{-1} (1600.00 cm^2) was recorded from the maize plants that received 600 kg ha^{-1} and the lowest leaf area plant^{-1} (46.75 cm^2) was recorded from the maize plants that received no fertilizers.

Kumar et al. (2007) reported that, Irrespective of the growth stages, the treatments which received 75% RDN or more (T_1, T_2, T_3, T_3, T_{10}, T_{13}, T_{14} and T_{16}) recorded higher leaf area index than other treatments. The highest leaf area index was recorded in treatment T_{13}, which received 100% RDN + 100% RDP + 125% RDK (0.63, 3.35 and 3.05 at 30, 60 DAS and at harvest, respectively). The lowest leaf area index was recorded in treatment T_{12} which received 50% RDN + 75% RDP + 75% RDK (0.35, 2.67 and 2.50 at 30, 60 DAS and at harvest, respectively).

Dry matter plant^{-1}

Asaduzzaman et al. (2014) observed that, plot treated with 200 kg ha^{-1} produced the highest dry matter plant^{-1} (215.45 g) where as the plot treated with 0 kg ha^{-1} had the lowest dry matter accumulation plant^{-1} (85.67 g).

Athar et al. (2012) conducted a pot experiment in a wire netting green house at BahauddinZakariya University, Multan, Pakistan in order to assess the beneficial effect of urea on corn cultivars (C-20 and C-79) differing in yield production. Corn plants were grown in loam soil with alkaline in reaction. The pots were arranged in a complete randomized manner with six replicates. Two weeks old plants were subjected to different levels of urea (46% N). Five levels of urea (0, 50, 100, 175 and 225 kg ha^{-1}) with constant (150 kg ha^{-1}) TSP (46% P_2O_5) and SOP (50% K_2O) were applied in two steps half dose at the seedling stage and the remaining half was supplied at vegetative stage (6 weeks) at constant (100 kg ha^{-1}) sulfate of potash (SOP) and triple super phosphate (TSP). They reported that, maximum dry matter accumulation $plant^{-1}$ (103.58 g) was recorded for 175 kg ha^{-1} urea application and the lowest dry matter accumulation $plant^{-1}$ (65.29 g) was found from control treatment (0 kg ha^{-1}). Stem diameter Seidel et al. (2016) conducted a study aimed to evaluate production components, yield of maize intercropped with jack bean and soil resistance to penetration using different doses of gypsum. The experimental design was a randomized complete block design in split plots with four replications and was carried out during season 2013/2014. The main plots were maize intercropped with jack beans and maize sown alone, and the subplots were six doses of gypsum (0, 1, 2, 3, 4, 5 t ha^{-1}).They reported that stem diameter did not significantly influenced by different rate of gypsum. The highest stem diameter was (2.89 cm) recorded from 5 t ha^{-1} gypsum and the lowest stem diameter (2.82 cm) was recorded from 0 t ha^{-1} gypsum.

Onasanya et al. (2009) presented an experiment to evaluate the effect of twelve different rates of nitrogen and phosphorus fertilizers on growth and yield of maize (*Zea mays L.)* in southern Nigeria between June and October, 2007. They reported that, the highest stem girth was recorded in T_{10} (120 kg N ha^{-1} + 20 kg P ha^{-1}), while the lowest stem girth was recorded in the control.
The stem girth ranged from 7.33cm in the control (T_1) to 8.44cm in T_{10} (120 kg N ha^{-1} + 20 kg P ha^{-1}), respectively. Law-ogbomo (2009) conducted field trials to estimate the effect of NPK 15:15:15 fertilizer on the growth and yield of maize which were conducted over a two year period. Field trials were carried at Teaching and Research Farms, Benson Idahosa University, Benin City (5004′ N and 5045′ E) between March and June in 2005 and 2006. The trials were laid down in a randomized complete block design. The treatments included four NPK fertilizer rates viz. 0 (0 kg + 0 kg P + 0 kg K), 200 (30 kg + 13.58 kg P + 24.90 kg K), 400 (60 kg + 27.16 kg P + 49.80 kg K) and 600 (90 kg + 40.70 kg P + 74.70 kg K) kg ha^{-1} of compound fertilizer. The results of the trials revealed that, stem girth was increased with successive increment in fertilize application rate up to 600 kg ha^{-1} the maize plants that received 600 kg ha^{-1} had the greatest stem girth (7.67 cm) and the lowest stem girth (6.34 cm) was recorded that received no fertilizers.

Number of rows ear^{-1}

A field nitrogen management trial was conducted by Woldesenbet et al. (2016) to know the maximum productivity of Maize response to high nitrogenous fertilization levels, from this perspective, using five N levels (0, 23, 46, 69 and 92 kg N ha^{-1}) with three replications. The study was conducted in 2015 in Decha District, Modyo Gombera Kebele of Kaffa Zone, SNNPR State. The experiment was laid out in RCBD. The result of this study revealed that, the application of different levels of nitrogen (46 kg ha^{-1}, 69 kg ha^{-1} and 92 kg ha^{-1}) is non-significant on number of rows per plant. This result is similar to Aria et al. (2010) who found non-significant result by applying 80 kg N ha^{-1}, 120 kg N ha^{-1}and 160 kg N ha^{-1}**.** Moraditochaee et al. (2012) also showed that the application of N fertilizer was non-significant on number of rows per ear.

A study was conducted by Asghar et al. (2010**)** to investigate the effect of different NPK rates on growth and yield of maize cultivars; Golden and Sultan.

The experiment was laid out in a randomized complete block design (factorial) with three blocks. The maximum number of grain rows per cob (15.30) was produced by NPK application at the rate of 250-110-85 kg ha^{-1}, however, did not differ statistically when compared with treatment 175-80-60 kg ha^{-1} which gave 15.03 number of grain rows per cob. The treatment F_1 (100-50-35 NPK g ha^{-1}) results 14.30 and seemed to be better than the control 13.53.

Number of grains ear^{-1}

A field nitrogen management trial was conducted by Woldesenbet et al. (2016) to know the maximum productivity of Maize response to high nitrogenous fertilization levels, from this perspective, using five N levels (0, 23, 46, 69 and 92 kg N ha^{-1}) with three replications. The study was conducted in 2015 in Decha District, Modyo Gombera Kebele of Kaffa Zone, SNNPR State. The experiment was laid out in RCBD. The result of this study revealed that maximum number of kernels (588.00) was produced when 92 kg N ha^{-1} was applied and the minimum number of grains (497.86) was recorded from no N application.

Enujeke (2013a) carried out a study in the Teaching and Research Farm of Delta state University, Asaba Campus from March 2008 to June, 2010 to evaluate the effects of variety, organic manure and inorganic fertilizer on number of grain cob^{-1} of maize. The experiment was carried out in a Randomized Complete Block Design (RCBD) replicated three times in a factorial layout. Four different rates of poultry manure, cattle dung and NPK 20:10:10 fertilizer were applied to three different maize varieties sown at 75cm 15 cm and evaluated for number of grains cob^{-1}. The result of the study indicated that, plants that received inorganic fertilizer NPK 20:10:10 had the highest number of grains cob^{-1} (506.0) followed by plants that received poultry manure (468.0). Plants that received cattle dung had the lowest number of grains cob^{-1} (458.0). Athar et al. (2012) conducted a pot experiment in a wire netting green house at Bahauddin Zakariya University, Multan, Pakistan in order to assess the beneficial effect of urea on corn cultivars (C-20 and C-79) differing in yield production. Corn plants were grown in loam soil with alkaline in reaction. The pots were arranged in a complete randomized manner with six replicates. Two weeks old plants were subjected to different levels of urea (46% N). Five levels of urea (0, 50, 100, 175 and 225 kg ha^{-1}) with constant (150 kg ha^{-1}) TSP (46% P2O5) and SOP (50% K2O) were applied in two steps half dose at the seedling stage and the remaining half was supplied at vegetative stage (6 weeks) at constant (100 kg ha^{-1}) sulfate of potash (SOP) and triple super phosphate (TSP). The result of the study revealed that, maximum number of grains ear^{-1} (552.0 g) was recorded for 175 kg ha^{-1} urea application and the minimum number of grains ear^{-1} (297.0 g) was found from control treatment (0 kg ha^{-1}).

A study was conducted by Asghar et al. (2010) to investigate the effect of different NPK rates on growth and yield of maize cultivars; Golden and Sultan.

The experiment was laid out in a randomized complete block design (factorial) with three blocks.

Number of grains cob^{-1}

It is an important yield determining component of maize. The data regarding number of grains cob^{-1} showed that various NPK applications significantly affected number of grains cob-1. Treatment F_3 (250-110-85 NPK kg ha^{-1}) produced more number of grains (425.13) per cob. Treatment F_3 was followed by treatment F_2 (175-80-60 NPK kg ha^{-1}) (421.28), F_1 (100-50-35 NPK kg ha^{-1}) (414.48) and F0 (0-0-0 NPK kg ha^{-1}) produced the lowest number of grains (391.29) per cob. Response of maize crop to various NP levels was studied by Mukhtar et al. (2011) at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during kharif 2009. Six NP rates (0 - 0, 200-100, 250-125, 300-150, 350-175 and 400-200 kg ha^{-1}) were tried non two maize hybrids (YH-1898 and YH-1921) for growth and yield. Results revealed that, maize crop fertilized at 250-125 kg NP produced significantly maximum grains per ear (658.0) against minimum (217.0) in case of control plot.

Onasanya et al. (2009) conducted an experiment to evaluate the effect of twelve different rates of nitrogen and phosphorus fertilizers on growth and yield of maize *(Zea mays L.)* in southern Nigeria between June and October, 2007. The results of the study revealed that, application of 120 kg N ha^{-1} + 40 kg P ha^{-1} (T_{11}) produced the maximum number of grains per ear which was significantly different from all other treatments. The minimum number of grains per ear was obtained in the control (T_1). Grain number varied from 262.28 in the control to 497.30 in T_{11} (120 kg N ha^{-1} + 40 kg P ha^{-1}), respectively.

Kumar et al. (2007**)** conducted a field experiment at Main Agricultural Research Station, Agriculture College, Dharwad, during 2002-03 to study the fertilizer requirement of sweet corn grown on Vertisols of zone-8 of Karnataka. The experiment was laid out in Randomized Block Design (RCBD) with three replications. Recommended disease of fertilizer (RDF) of grain maize was (150:75:37.5 kg ha^{-1} NPK, respectively). Treatment were consisting of varying levels of N, P and K, to study the effect of N, P and K levels on sweet corn. The nutrient levels were, three levels of N (100%, 75% and 50% RDN of grain maize), two P levels (100% and 75% RDP of grain maize) and three K levels (75%, 100% and125% RDK of grain maize) and totally 18 different treatment combinations were laid out. They reported that, the treatment receiving 100% RDN irrespective of levels of P and K (T_1, T_4, T_7, T_{10}, T_{13} and T_{16}) recorded higher number of grains cob^{-1} and were on par with each other. The highest number of grains cob^{-1} was observed in T_{13} (583.00), which was significantly higher than T_{12} which received 50% RDN + 75% RDP + 75% RDK (420.66). 1000 grain weight

Seidel et al. (2016) conducted a study aimed to evaluate production components, yield of maize intercropped with jack bean and soil resistance to penetration using different doses of gypsum. The experimental design was a randomized complete block design in split plots with four replications and was out during season 2013/2014. The main plots were maize intercropped with jack beans and maize sown alone, and the subplots were six doses of gypsum (0, 1, 2, 3, 4, 5 t ha^{-1}).They reported that 1000 grain weight did not significantly influenced by different rate of gypsum. The highest 1000 grain weight (286.34 g) was recorded from 5 t ha^{-1} gypsum and the lowest 1000 grain weight (284.48 g) was recorded from 0 t ha^{-1} gypsum.

Field trials were conducted by Jan et al. (2014) during summer 2011-2012 at New Developmental Farm of The University Agriculture, Peshawar, Pakistan to study the effects of soil amendments on yield and yield attributes of maize (*Zea mays L.)* under different irrigation schedule. The field experiments were layout in randomized complete block design having three replications. Two separated filed experiments were maintained. Treatments were randomized in each field. One filed was specified for 6 irrigations while other had 3 irrigations. The treatments consisted of soil amendments (FYM (10 t ha^{-1}), crop residue (wheat straw 10 t ha^{-1}), gypsum (1000 kg ha^{-1}), qemisoyl (10 kg ha^{-1}) and humic acid (12 kg ha^{-1}) were used. The results of the study revealed that, plots treated with FYM at 10 t ha^{-1} produced heavier 1000 grains weight (287.4 g) and statistically at par when plots treated with humic acid, while minimum 1000 grains weight (164.1 g) were recorded in control plots.

Response of maize crop to various NP levels was studied by Mukhtar et al. (2011) at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during kharif 2009. Six NP rates (0 - 0, 200-100, 250-125, 300-150, 350-175 and 400-200 kg ha^{-1}) were tried non two maize hybrids (YH-1898 and YH- 1921) for growth and yield. Results showed that, maximum 1000-grain weight (430.00 g) was obtained in 250-125 kg NP level against minimum (141.8 g) in case of control plot (0-0 kg ha^{-1}).

A study was conducted by Asghar et al. (2010) to investigate the effect of different NPK rates on growth and yield of maize cultivars; Golden and Sultan. The experiment was laid out in a randomized complete block design (factorial) with three blocks. The NPK application @ 250-110-85 kg ha^{-1} produced highest 1000-grain weight (255.92 g). Next to follow were treatment F_2 (175- 80-60 NPK kg ha^{-1}) and F_1 (100-50-35 NPK kg ha^{-1}) resulted in 253.18 g and 245.13 g, respectively. The minimum 1000-grain weight (236.90 g) was recorded in treatment from plots receiving no fertilizer.

An experiment was carried out by Onasanya et al. (2009) to evaluate the effect of twelve different rates of nitrogen and phosphorus fertilizers on growth and yield of maize (*Zea mays* L.) in southern Nigeria between June and October, 2007. The results of the study revealed that, the treatment T_{11} (120 kg N ha^{-1} + 40 kg P ha^{-1}) produced the maximum 1000-grain weight (265.67 g) which was significantly different from the rest of all the treatments. T8 (60 kg N ha^{-1} + 40 kg P ha^{-1}) also gave a higher 1000-grain weight over others. The minimum weight of 1000 grains (220.93 g) was obtained in T_1 (control). Law-ogbomoa and Law-ogbomo (2009) conducted field trials to estimate the effect of NPK 15:15:15 fertilizer on the growth and yield of maize which were conducted over a two year period. Field trials were carried at Teaching and Research Farms, Benson Idahosa University, Benin City (5004´ N and 5045´ E) between March and June in 2005 and 2006. The trials were laid down in a randomized complete block design. The treatments included four NPK fertilizer rates viz. 0 (0 kg + 0 kg P + 0 kg K), 200 (30 kg + 13.58 kg P + 24.90 kg K), 400 (60 kg + 27.16 kg P + 49.80 kg K) and 600 (90 kg + 40.70 kg P + 74.70 kg K) kg ha^{-1} of compound fertilizer. The results of the trials revealed by Msarmo and Mhango that, the highest 100 grain weight (11.62 g) was recorded from the maize plants that received 400 kg ha^{-1} and the lowest 100 grain weight (9.43 g) was recorded from the maize plants that received no fertilizers.

Grain Yield

A study was conducted (2005) at Bunda College during the 2003/04 crop season to assess the effect of fertilizer application practices on performance of maize with emphasis on improving the efficiency of using urea as a top dressing fertilizer The treatments were laid out as a split- plot in a randomized complete block design (RCBD) with maize varieties as main plots and fertilizer application practices as subplots. There were three maize varieties and three fertilizer application practices. The maize varieties included local maize, Masika (composite) and DK8031 (hybrid) and the application practices were 100 kg ha^{-1} urea as basal and 100 kg ha^{-1} urea as top dressing (P_1), 100 kg ha^{-1} urea as basal and 75 kg ha^{-1} urea as top dressing (P_2) and 100 kg ha^{-1} as basal and 150 kgha^{-1} urea as top dressing (P_3). The result of the study revealed that, P_2 gave the highest 100 seed weight of 39.35 g followed by P_1 (36.96 g) and then P_3 (34.92 g).

Seidel et al. (2016) conducted a study aimed to evaluate production components, yield of maize intercropped with jack bean and soil resistance to penetration using different doses of gypsum. The experimental design was a randomized complete block design in split plots with four replications and was carried out during season 2013/2014. The main plots were maize intercropped with jack beans and maize sown alone, and the subplots were six doses of gypsum (0, 1, 2, 3, 4, 5 t ha^{-1}).They reported that grain yield did not significantly influenced by different rate of gypsum. The highest grain yield (8.24 t ha^{-1}) was recorded from 5 t ha^{-1} gypsum and the lowest grain yield (7.86 t ha^{-1}) was recorded from 0 t ha^{-1} gypsum.

A field nitrogen management trial was conducted by Woldesenbet et al. (2016) to know the maximum productivity of Maize response to high nitrogenous fertilization levels, from this perspective, using five N levels (0, 23, 46, 69 and 92 kg N ha^{-1}) with three replications. The study was conducted in 2015 in Decha District, Modyo Gompers Kebele of Kaffa Zone, SNNPR State. The experiment was laid out in RCBD. The result of this study showed that maximum grain yield (7.55 t ha^{-1}) was recorded from 69 kg N ha^{-1} and minimum grain yield was (7.10 t ha^{-1}) obtained from no N application.

Jan et al. (2014) conducted field trials during summer 2011-2012 at New Developmental Farm of The University Agriculture, Peshawar, Pakistan to study the effects of soil amendments on yield and yield attributes of maize (*Zea mays L.*) under different irrigation schedule. The field experiments were layout in randomized complete block design having three replications. Two separated filed experiments were maintained. Treatments were randomized in each field. One filed was specified for 6 irrigations while other had 3 irrigations. The treatments consisted of soil amendments (FYM (10 t ha^{-1}), crop residue (wheat straw 10 t ha^{-1}), gypsum (1000 kg ha^{-1}), qemisoyl (10 kg ha^{-1}) and humic acid (12 kg ha^{-1}) were used. The results of the study revealed that, soil amendments had significant effect on grain yield. Plots treated with FYM at 10 t ha^{-1} produced maximum grain yield (3896 kg ha^{-1}) and were statistically at par when plots treated with humic acid, while minimum grain yield (2413 kg ha^{-1}) was recorded in control plots.

Response of maize crop to various NP levels was studied by Mukhtar et al. (2011) at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during kharif 2009. Six NP rates (0 - 0, 200-100, 250-125, 300-150, 350-175 and 400-200 kg ha^{-1}) were tried non two maize hybrids (YH 1898 and YH- 1921) for growth and yield. Results revealed that, Maximum grain yield (8.24 t ha^{-1}) was noted in case of NP application of 250-125 kg followed by 300-150 kg NP (7.77 t ha^{-1}). Control plot produced minimum (2.728 t ha^{-1}).

A study was conducted by Asghar et al. (2010) to investigate the effect of different NPK rates on growth and yield of maize cultivars; Golden and Sultan.

The experiment was laid out in a randomized complete block design (factorial) with three blocks. Among different treatment, treatment F_3 (250-110-85 NPK kg ha^{-1}) produced maximum grain yield 6.03 t ha^{-1}. However, yield of plots of treatment F_3 did not differ statistically when compared with the yield of treatment F_2 (175-80-60 NPK kg ha^{-1}) which was 5.90 t ha^{-1}. Next to follow was treatment F_1 (100-50-35 NPK kg ha^{-1}) yield (4.53 t ha^{-1}) and the plots without NPK application produced significantly the lowest grain yield (3.25 t ha^{-1}).

Law-ogbomoa and Law-ogbomo (2009) conducted field trials to estimate the effect of NPK 15:15:15 fertilizer on the growth and yield of maize which were conducted over a two year period. Field trials were carried at Teaching and Research Farms, Benson Idahosa University, Benin City (5004´ N and 5045´ E) between March and June in 2005 and 2006. The trials were laid down in a randomized complete block design. The treatments included four NPK fertilizer rates viz. 0 (0 kg + 0 kg P + 0 kg K), 200 (30 kg + 13.58 kg P + 24.90 kg K), 400 (60 kg + 27.16 kg P + 49.80 kg K) and 600 (90 kg + 40.70 kg P + 74.70 kg K) kg ha^{-1} of compound fertilizer. The results of the trials revealed that, the highest grain yield (7.95 t ha^{-1}) was recorded from the maize plants that received 400 kg ha^{-1} and the lowest grain yield (3.52 t ha^{-1}) was recorded from the maize plants that received no fertilizers.

An experiment was carried out by Onasanya et al. (2009**)** to evaluate the effect of twelve different rates of nitrogen and phosphorus fertilizers on growth and yield of maize (*Zea mays L.*) in southern Nigeria between June and October, 2007. The results of the study revealed that, application of 120 kg N ha^{-1} +40 kg P ha^{-1} (T_{11}) gave the highest significant (P=0.05) grain yield. This was followed by T8 (60 kg N ha^{-1} + 40 kg P ha^{-1}). The lowest yield was recorded in the control plot (T_1). The grain yield ranged from 3.08 t ha^{-1} in the control plot (T_1) to 7.13t ha^{-1} in T_{11} (120 kg N ha^{-1} + 40 kg P ha^{-1}).

Kumar et al. (2007) conducted a field experiment at Main Agricultural Research Station, Agriculture College, Dharwad, during 2002-03 to study the fertilizer requirement of sweet corn grown on Vertisols of zone-8 of Karnataka.

The experiment was laid out in Randomized Block Design (RCBD) with three replications. Recommended disease of fertilizer (RDF) of grain maize was (150:75:37.5 kg ha^{-1} NPK, respectively). Treatment were consisting of varying levels of N, P and K, to study the effect of N, P and K levels on sweet corn. The nutrient levels were, three levels of N (100%, 75% and 50% RDN of grain maize), two P levels (100% and 75% RDP of grain maize) and three K levels (75%, 100% and125% RDK of grain maize) and totally 18 different treatment combinations were laid out. The results of fresh cob yield revealed that cob yield of sweet corn varied with varying fertilizer levels. The treatments which received 100% RDN, irrespective of P and K levels (T_1, T_4, T_7, T_{10}, T_{13} and T_{16}) recorded higher yields of fresh cob than other treatments, the highest cob yield was recorded in T_{13} which received 100% RDN + 100% RDP + 125% RDK (13.72 t ha^{-1}), on the other hand the lowest one was fond in T_{12} which received 50% RDN + 75% RDP + 75% RDK (9.48 t ha^{-1}).

Msarmo and Mhango (2005) conducted a field experiment at Bunda College during the 2003/04 crop season to assess the effect of fertilizer application practices on performance of maize with emphasis on improving the efficiency of using urea as a top dressing fertilizer The treatments were laid out as a split- plot in a randomized complete block design (RCBD) with maize varieties as main plots and fertilizer application practices as subplots. There were three maize varieties and three fertilizer application practices. The maize varieties included local maize, Masika (composite) and DK8031 (hybrid) and the fertilizer application practices were 100 kg ha^{-1} urea as basal and 100 kg ha^{-1} urea as top dressing (P_1), 100 kg ha^{-1} urea as basal and 75 kg ha^{-1} urea as top dressing (P_2) and 100 kg ha^{-1} as basal and 150 kgha^{-1} urea as top dressing (P_3). The result of the study revealed that, a combination of 100 kg ha^{-1} urea as basal and 75 kg ha^{-1} urea as top dressing (P_2 gave the highest grain yield of 6291 kg ha^{-1}. P_1 which was a combination of (100 kg ha^{-1} urea as basal and 100 kg ha^{-1} urea as top dressing) was the second with 5422 kg ha^{-1} and lastly P_3 which was a combination of 100 kg ha^{-1} as basal and 150 kg ha^{-1} urea as top dressing gave the lowest grain yield (4891 kg ha^{-1}).

Stover yield

Law-ogbomoa and Law-ogbomo (2009) presented the highest stover yield (10.36 t ha^{-1}) was recorded from the maize plants that received 600 kg ha^{-1} and the lowest stover yield (4.82 t ha^{-1}) was recorded from the maize plants that received no fertilizers.

Kumar et al. (2007) conducted a field experiment at Main Agricultural Research Station, Agriculture College, Dharwad, during 2002-03 to study the fertilizer requirement of sweet corn grown on Vertisols of zone-8 of Karnataka.

The experiment was laid out in Randomized Block Design (RCBD) with three replications. Recommended disease of fertilizer (RDF) of grain maize was (150:75:37.5 kg ha^{-1} NPK, respectively). Treatment were consisting of varying levels of N, P and K, to study the effect of N, P and K levels on sweet corn. The nutrient levels were, three levels of N (100%, 75% and 50% RDN of grain maize), two P levels

(100% and 75% RDP of grain maize) and three K levels (75%, 100% and125% RDK of grain maize) and totally 18 different treatment combinations were laid out. They reported that, The treatments which received 100% RDN (T_1, T_4, T_7, T_{10}, T_{13} and T_{16}) accounted for higher stover yield than other treatments, the highest being in case of T_{13} which received 100% RDN + 100% RDP + 125% RDK (12.70, 71.04 and 81.40 q ha-1 at 30, 60 DAS and at harvest, respectively). The treatment which received only 50% RDN + 75% RDP + 75% RDK recorded the lowest stover (10.22, 58.06 and 68.33 q ha^{-1} at 30, 60 DAS and at harvest, respectively).

Msarmo and Mhango (2005) conducted a study at Bunda College during the 2003/04 crop season to assess the effect of fertilizer application practices on performance of maize with emphasis on improving the efficiency of using urea as a top dressing fertilizer The treatments were laid out as a split-plot in a randomized complete block design (RCBD) with maize varieties as main plots and fertilizer application practices as subplots. There were three maize varieties and three fertilizer application practices. The maize varieties included local maize, Masika (composite) and DK8031 (hybrid) and the fertilizer application practices were 100 kg ha^{-1} urea as basal and 100 kg ha^{-1} urea as top dressing (P_1), 100 kg ha^{-1} urea as basal and 75 kg ha^{-1} urea as top dressing (P_2) and 100 kg ha^{-1} as basal and 150 kgha^{-1} urea as top dressing (P_3). The result of the study revealed that, a combination of 100 kg ha^{-1} urea as basal and 150 kg ha^{-1} urea as top dressing (P3 gave the highest biomass yield of 16500 kg ha^{-1} and P_1 which was a combination of 100 kg ha^{-1} as basal and 100 kg ha^{-1} urea as top dressing gave the lowest biomass yield (12980 kg ha^{-1}).

Biological yield

A study was conducted by Asghar et al. (2010) to investigate the effect of different NPK rates on growth and yield of maize cultivars; Golden and Sultan. The experiment was laid out in a randomized complete block design (factorial) with three blocks. Among different NPK levels treatment F_3 (250-110-85 NPK kg ha^{-1}) gave more biological yield (16.83 t ha^{-1}) as compared to rest of the treatments. Treatment F_3 was however, statistically at par with treatment F_2 (175-80-60 NPK kg ha^{-1}) (16.23 t ha^{-1}). Next to follow was the treatment F_1 (100-50-35 NPK kg ha^{-1}) (13.69 t ha^{-1}) and minimum biological yield was produced in treatment F0 (10.81 t ha^{-1}).

Harvest index

Jan et al. (2014) conducted field trials during summer 2011-2012 at New Developmental Farm of The University Agriculture, Peshawar, Pakistan to study the effects of soil amendments on yield and yield attributes of maize (*Zea mays* L.) under different irrigation schedule. The field experiments were layout in randomized complete block design having three replications. Two separated filed experiments were maintained. Treatments were randomized in each field. One filed was specified for 6 irrigations while other had 3 irrigations. The treatments consisted of soil amendments (FYM (10 t ha^{-1}), crop residue (wheat straw 10 t ha^{-1}), gypsum (1000 kg ha^{-1}), qemisoyl (10 kg ha^{-1}) and humic acid (12 kg ha^{-1}) were used. The results of the study revealed that, soil amendments had significant effect on harvest index. Plots treated with FYM at 10 t ha^{-1} had maximum harvest index (28.4 %) as compared with control (25.3 %).

2.2Effect of sowing method and spacing

Sabo et al. (2016) was conducted a field experiment at the AbubakarTafawaBalewa 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 differ 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.

Jiang et al. (2013) reported that, the objective of this study was to understand the effects of plant spacing on grain yield and root competition in summer maize (*Zea mays L.*). 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) plant spacing and 24 normal

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 react 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, Dekalb 711 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 spacings on the grain yield and some agronomic characteristics were statistically significant. Hybrid x intra-row spacing interaction 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) stated that, the interest in reducing maize row spacing in the short growing season regions of Brazil is increasing due to potential advantages such as higher radiation use efficiency. This experiment was conducted 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.

Golla et al. (2018) conducted a field experiment at Bako research farm in the year 2017 to determine the optimum rate of nitrogen fertilization and intra row spacing. The experiment was laid out in a Randomized Complete Block Design in factorial arrangement with three replications. Three intra row spacing viz. 75 x 40 cm, 75 x 30 cm and 75 x 20 cm accommodating 33, 333, 44, 444 and 66, 666 plants ha^{-1} respectively, with six nitrogen levels viz. 0, 23, 46, 69, 92 and 115 kg ha^{-1} were assigned to the experimental plot by factorial combinations. Based on the results, the maximum grain yield (10,207.8 kg ha^{-1}) was obtained when the hybrid was sown at the closest intra row spacing (20 centimeters) with application of the highest rate of nitrogen (115 kg ha^{-1}). This result showed 8.9% yield advantages compared to the standard check. However, statistically similar grain yield (9887 kg ha^{-1}) was also obtained under application of 92 kg nitrogen ha^{-1} in the same intra spacing (20 cm). But application of 115 kg N ha^{-1} on maize hybrid planted at 20 cm intra row spacing was the most profitable as compared to other combinations.

Eyasu et al. (2018) conducted a field study at Ofa district-Geleko irrigation site during the off-season of 2016/17 cropping season with the objective of evaluating different varieties and row spacing on growth, yield and yield components of maize. Four plant row spacing (45 cm, 55 cm, 65 cm and 75 cm) and three maize varieties (‘BH-540’, Lemu‘P3812W’and Jabi ‘PHB 3253’) were tested in factorial arrangement laid out in RCBD replicated three times. Data on yield and yield components of the crop were recorded. The result indicated that most of the parameters such as number of ears per plant, ear circumference, 1000 kernel weight, number of kernels per ear, number of kernels per rows, grain yield ha^{-1} were significantly influenced by the interaction effect of row spacing and varieties. Significantly highest grain yield were produced by maize variety Lemu grown at row spacing of 65 cm, which is statistically similar with variety BH-540 grown at row spacing of 65 and 75 cm and also the same variety grown at row spacing of 75 cm, while lowest was recorded for variety rabi grown at row spacing of 45 cm. Based on these results, it can be concluded that under irrigated condition

Limo and BH-540 maize varieties at 65-75 cm row spacing resulted higher biomass and grain yield of maize and may be used by farmers of the 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., Khoibhutta, 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, and 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 Khoibhutta.
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 interaction 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. Ukonze et al. (2016) carried out a study to compare and analyze how spacing influenced the performance and yield of late maize in Geri, Etche Local Government Area (LGA) of Rivers State, Nigeria between September-December in 2013 and 2014. The study adopted experimental research design. The experiment was laid out in a randomized complete block design (RCBD) with three

replicates. One maize variety was evaluated under three spacing for performance data such as plant heights, stem girths, number of leaves, number of nodes and leaf area and for the yield, data were collected on cob length, cob weight, cob + husk weight, cob circumference and 1000-grain weight (yield). The results obtained 56 days after planting (DAP) in the two years of study showed significant differences ($p < 0.05$) in plant height, stem girth and leaf area. The 70 x 30 and 60 x 40 cm spacing gave higher values of the morphological parameters than 80 x 20 cm. With regard to yield, 80 x 20 cm gave the highest average cob weight of 0.74 kg and 1000-grain weight (yield) of 0.27 t ha^{-1}. Based on the findings of the study, the 80 cm x 20 cm spacing was recommended for local farmers in Etche for maximum yield and economic returns.

On-farm experiments were conducted by Akbar et al. (2016) in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food evaluating seed yields under varying plant spacings. Yield response of two maize hybrids (PSC-121 and KS-510) planted in three different row arrangements was evaluated in one experiment. The other experiment determined the optimum fertilizer rate for maize hybrids. Grain yield ranged between 7,103 kg and 10,126 kg ha^{-1} across hybrids and planting arrangements. Hybrid PSC-121 recorded 19% more yield than KS-510. Generally grain yield increased with increasing planting density. Planting in twin-rows giving 80,000 plants per ha produced 17.7% higher yield compared with planting in single rows 60 cm apart giving 66,667 plants ha^{-1}. Planting in twin-rows produced significantly higher yield compared with single rows. Application of fertilizers at 100% and 50% of recommended rate produced identical but significantly higher grain yield compared to 25% of recommended rates. Increase of maize grain yield was associated with the number of grains per ear and individual grain weight.

Nand (2015**)** conducted a field experiment at Agronomy research Farm of C.S. University of Agriculture and Technology, Kanpur (U.P), during rabi season in 2010-11 and 2011-12 to evaluate the effect of spacing and fertility levels on protein content and yield of hybrid and composite maize (*Zea mays L.*) grown in rabi season. The experiment was laid out in split plot design with three replications. Where involved eighteen treatment combinations. The main plots were allotted by maize hybrid (DHM-117) and composite (Madhuri) along with three spacing, 45 cm x 20 cm, 60 cm x 20 cm and 60 cm x 25 cm. And sub plots, were tested three fertility levels viz, F_1- NPK and Zn of (120:60:40 and 15 kg ha^{-1}) F_2 -NPK and Zn of (160:80:60 and 20 kg ha^{-1}) and F_3 - NPK and Zn of (180:100:80 and 25 kg ha^{-1}). The result revealed that the maximum growth parameters likes, plant height (cm), no of leaves $plant^{-1}$, dry weight (g m^{-2}) and LAI were obtained with maize hybrid (DHM-117) followed by composite (Madhuri). The spacing of 60 cm x 20 cm significantly increased the cob length (16.87 and 17.09 cm), cob girth (11.23 and 11.80 cm), cob weight (205.90 and 205.90 g), grains weight cob-1 (170.52 and 173.94 g), grain yield (6.62 and 6.75 t ha^{-1}), protein content (8.78 and 8.87 %) and protein yield (58.20 and 60.00 kg ha^{-1}) than the spacing of 60 cm x 25 cm and 45 cm x 20 cm, respectively. Significantly grain and protein yield was obtained under NPK and Zn of (180:100:80 and 25 kg ha^{-1}) as compare to NPK and Zn of (120:60:40 and 15 kg ha^{-1}) and NPK and Zn of (160:80:60 and 20 kg ha^{-1}). The interaction effect wet been variety x spacing was found significant ($P<0.05$) on protein yield in both the years of experiments.

Enujeke (2013 b) was carried out a study in Teaching and Research Farm of Delta State University, Asaba Campus from March, 2008 to June, 2010 to evaluate the effects of variety and spacing on growth characters of hybrid maize. It was a factorial experiment carried out in a Randomized Complete Block Design (RCBD) with three replicates. Three hybrid maize varieties were evaluated under three different plant spacing for such growth characters as plant height, number of leaves, leaf area and stem girth. The results obtained during the 8th week after sowing indicated that hybrid variety 9022-13 which had mean plant height of 170.0cm number of leaves of 13.2, leaf area of 673.2 cm^2 and stem girth of 99.4 mm was superior to other varieties investigated. With respect to spacing, plants sown on 75 cm x 15 cm had higher mean height and number of leaves of 176.7 cm and 13.8 respectively while plants sown on spacing of 75 cm x 35 cm had higher mean leaf area of 713.7 cm2 and stem girth of 99.4 mm, respectively. Results of interaction showed that variety and spacing were significantly ($P<0.05$) different in 2008 and 2009. Based on the findings of this study, it is recommended that hybrid variety 9022-13 be grown in the study area of enhanced growth characters which interplay to improve grain yield of maize (ii) spacing of 75 cm x 35 cm be used to enhance increased stem girth and leaf area whose photosynthetic activities could positively influence maize yield.

Yukui (2011) conducted an experiment with randomized block design of four cropping patterns and four replicates was used. Four cropping patterns; 65 cm × 65 cm, 40 cm × 90 cm, 30 cm × 100 cm and 20 cm × 110 cm respectively were studied. The results showed that all wide and narrow rows patterns and free-sow patterns have higher yield than the same spacing patterns and 30 cm × 100 cm is the optimal pattern to obtain the highest yield, followed by 20 cm × 110 cm, 40 cm × 90 cm and 65 cm × 65 cm respectively. If all farmers carried out the 30 cm × 100 cm pattern, problems on food security in China would be obviously improved.

Fanadzo et al. (2010) conducted a study to determine the effects of inter-row spacing (45 and 90 cm) and plant population (40000 and 60000 plants ha^{-1}) on weed biomass and the yield of both green and grain materials of maize plants. The experiment was set up as 2 × 2 factorial in a randomized complete block design with three replications. Plant population had no significant effects and interaction among factors was not significant on weed biomass. Narrow rows of 45 cm reduced weed biomass by 58%. Growing maize at 40000 plants ha^{-1} resulted in similar green cob weight regardless of inter-row spacing. Cob length decreased with increase in plant population and with wider rows. Similar grain yield was obtained regardless of inter-row spacing when maize was grown at 40000 plants ha^{-1}, but at 60000 plants ha^{-1}, 45 cm rows resulted in 11% higher grain yield than 90 cm rows. Increasing plant population from 40000 to 60000 plants ha^{-1} resulted in a 30% grain yield increase. The study demonstrated that growers could obtain higher green plants and grain yield by increasing plant population from the current practice of 40000 to 60000 plants ha^{-1} and through use of narrow rows.

Alvarez (2006) conducted a field experiment in Minas Gerais, Brazil during 2001-02. The effects of row spacing (0.7 and 0.9 m) and plant density (55000 and 75000 plants ha^{-1}) on the performance of maize hybrids AG1052, AG9010 and DKB440 were determined. Dry matter and grain yield increased with increasing sowing density and decreasing row spacing. The hybrid AG1051 recorded the highest dry matter yield and ear height regardless of row spacing and experimental year, whereas the hybrids AG9010 and DKB440 recorded the highest grain yield regardless of planting density and experimental year.

Sener (2004) conducted a two-year study at Mustafa Kemal University, Agricultural Faculty, Research Farm, Turkey to determine the optimum intra- row spacing for maize hybrids commercially grown in Eastern Mediterranean Region during 2000 and 2001 growing seasons. Maize hybrids reacted differently to various plant density and intra-row spacing. Main plots were maize hybrids of Dracma, Pioneer 3223, Pioneer 3335, Dekalb 711 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 × intra-row spacing interaction 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 (11 718 and 11 180 kg ha^{-1}, respectively).

Revathi et al. (2017) carried out a field experiment at Agricultural College Farm, Bapatla during rabi season 2014-15 at to study the growth and yield of rabi maize (*Zea mays L*.) at different planting densities and nitrogen levels. The results showed that planting density of 1,00,000 plants ha^{-1} recorded highest growth, yield attributes and yield as compared to plant density of 83,333 plants ha-1 and 66,6666 plants ha^{-1} respectively.

Getaneh et al. (2016) reported that the highest above ground dry biomass yields per plant was occurred at the widest inter and intra-row spacing might be due to high stem diameter and high leaf area because there is more availability of growth factors and better penetration of light at wider row spacing.

Neupane et al. (2011) carried out a field experiment at Agricultural Research Farm, Institute of Agricultural sciences, Banaras Hindu University, Varanasi studied on sandy loam soil during pre- kharif seasons of 2008 and 2009 to evaluate the quality and yield 18 performance of maize (*Zea mays L*.) as influenced by N sources and spacing. The results showed that the spacing of 40 cm × 15 cm were found to be best source of nitrogen and spacing and their combination 75% N through urea + 25% N through FYM + 40 cm × 15 cm spacing showed superior.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University Farm, Dhaka during the period from January 2021 to May 2021. This chapter deals with a brief description on experimental site, climate, soil, land preparation, layout, experimental design, intercultural operations, data recording and their analyses.

3.1 Experimental site

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka - 1207, under the Agro-Ecological Zone of Madhupur Tract (AEZ-28). The land area is situated at 23°41′ N latitude and 90°22′ E longitude at an altitude of 8.6 meter above sea level. The experimental site is shown in the AEZ Map of Bangladesh in Appendix I.

3.2 Climate

The experimental area is under the sub-tropical climate that is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds in Kharif season (April-September) and less rainfall associated with moderately low temperature during the Rabi season (October-March). The details have been presented in Appendix II.

3.3 Soil

The top soil of the experimental site is characterized by olive grey with common fine to medium especially dark yellowish brown mottle with silty clay in texture. Soil pH and organic carbon was sufficient for maize production. The experimental area was of good drainage and irrigation system and above from flood level and the plot of experimental field was medium to high land. The details have been presented in Appendix III.

3.4 Planting material

White Maize (SAUWMOPMT) was used as study material. In this research work, which was collected from Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.5 Treatments

The following treatments were included in this experiment.

Factor A: Fertilizer doses (4 levels)

F_1 =100% of recommended dose

F_2 = 50% of recommended dose

F_3 = 75%of recommended dose

F_4 = 125% of recommended dose

Factor B: Sowing methods

S_1= Sowing in line using planting configuration 50 cm x 25 cm (80000 Plants ha^{-1})

S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm equivalent to 40 cm x 25 cm

S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm equivalent to 50 cm x 25 cm

3.6 Experimental design

The experiment was laid in split plot design with three replications. Each replication was first divided into 12 subplots where treatment combinations were assigned. Thus the total number of unit plots was 12×3=36 .The size of the individual plot was 3 m x 1.5 m. The inter plot spacing was 0.5 m and inters block spacing was 1.5 m. Main plot was 23.5 m x 11 m.

3.7 Crop management

3.7.1 Seed collection

Seeds of white maize variety was collected from Department of Agronomy, SAU.

3.7.2 Land preparation

The plot selected for the experiment was opened in the first week of January 2021with a power tiller, and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for planting of maize seeds. The experimental plot was partitioned into the unit plots in accordance with the experimental design. Recommended doses of well rotten cow dung manure and chemical fertilizers were mixed with the soil of each unit plot.

3.7.3 Manure and fertilizer application

Cow dung 5 t ha^{-1} was used before final land preparation. The field was fertilized with nitrogen, phosphate, potash, sulphur, zinc and boron at the rate of 500-250-200-250-15-5 kg ha^{-1} of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively (BARI, 2014). The whole amounts of fertilizers were applied as basal doses except Urea. Only one third Urea was applied as basal doses and the rest amount was applied at 15 DAS interval for three installments. Fertilizer were applied according with par treatment requirement.

3.7.4 Seed treatment

For each treatment; dry, clean and homogenous air dried seeds were used. Seeds were treated with Provax 200FF @ 0.3% of seed weight.

3.7.5 Seed sowing and transplanting

Some seeds were planted in lines each having a line to line distance of 30cmand 50 cm and plant to plant distance of 25 cm having 3 seeds $hole^{-1}$ under direct sowing in the well prepared plot on 21th January, 2021. The seedlings were raised in seedbed. The plot was kept ready through tractor drawn cultivator for preparing seedbeds. The beds of 3 m long and 2.5 m wide were prepared. The seeds were sown in line keeping the 25 cm apart and covered with soil.

3.8 Intercultural operation

3.8.1 Weeding

Weeding 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 emergence of maize seedlings as and whenever necessary.

3.8.2 Thinning and gap filling

The excess plants were thinned out from all of the plots at 35 days after sowing (DAS) for maintaining optimum population of the experimental plot.

3.8.3 Irrigation

First irrigation was given on 20 days after sowing. Second irrigation was given on 40 days after sowing. Third irrigation was given on 70 days after sowing and fourth irrigation was given on 90 days after sowing.

3.8.4 Plant protection measures

After 30 days of planting, first spray of Dursban 20EC was done against the pest such as cut worm. Ripcord 10EC was applied to control leaf feeder caterpillar during entire vegetative periods at times.

3.8.5 Harvesting, threshing and cleaning

Crops were harvested when 90% of the cob became golden in color. The matured crop was harvested and carried to the threshing floor. The crop was sun dried by spreading on the threshing floor. Seeds were then separated from the plants.

3.8.6 Drying and weighing

Grain and stover thus collected were dried in the sun for a couple of days. Dried grain and stovers of each plot were weighed and subsequently converted into t ha^{-1} weight.

3.9 Data collection

The following data were collected during the experimentation.

3.9.1 Plant height (cm)

3.9.2 Number of leaves $plant^{-1}$

3.9.3 Leaf area (cm^2) and sunshine (lx) below the canopy

3.9.4 Dry matter weight $plant^{-1}$ (g)

3.9.5 Cob length (cm)

3.9.6 Cob circumference (cm)

3.9.7 Shell weight (g)

3.9.8 Number of grain cob^{-1}

3.9.9 100 seed weight (g)

3.9.10 Grain weight $plant^{-1}$

3.9.11Grain yield (ha^{-1})

3.9.12 Stover yield (ha^{-1})

3.9.13 Biological yield (ha^{-1})

3.9.14 Harvest index (%)

3.10 Data recording procedure

A brief outline of the data recording procedure followed during the study period is given below:

3.10.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at the time of 20 DAS, 40 DAS, and 60 DAS and at harvest. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.10.2 Number of leaves plant^{-1}

Number of leaves plant^{-1}was collected at 20 DAS, 40 DAS, and 60 DAS and at harvest .It was collected from 5 randomly selected plants from each plot and then the mean were recorded.

3.10.3 Leaf area (cm^2) and sunshine (lx) below the canopy

Leaf length and leaf breadth was taken carefully at different DAS.

Sunshine data was taken from 5 randomly selected plants from each plot. It was taken from the below of the canopy of maize plant. Sunshine data were taken at 60 DAS with a device named LX-101 LUX METER.

3.10.4 Dry matter weight plant^{-1} (g)

Dry matter weight plant-1 was taken at 60, 80 DAS and at harvest .It was recorded in g. It was collected from 5 randomly selected plants from each plot and then the mean were recorded.

3.10.5 Cob length (cm)

Cob length was measured in cm from the base of the cob to the apex. For this data calculation 5 cobs from each plot were selected then measured and then averaged.

3.10.6 Cob circumference (cm)

Measurement of widest part of the cobs was recorded in cm with the help of slide calipers. For this data calculation 5 cobs from each plot were selected then measured and then averaged.

3.10.7 Shell weight (g)

Shells were collected from 5 kernels of each plot; dried in an oven at 600C for 72 hours and then weighed.

3.10.8 Number of grain cob^{-1}

Number of grain cob $^{-1}$ was recorded from 5 cob from each plot and then averaged.

3.10.9 100 seed weight (g)

100 seed weight was recorded from each plot.

3.10.10 Grain weight plant^{-1}

Grain weight plant $^{-1}$ was recorded in g, which was taken from each plot.

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

Grains obtained from each plot were sun-dried and weighed carefully. The dry weight of grain of the respective plot was recorded carefully and converted to t ha^{-1}.

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

Dry matter without grain was taken and converted it into t ha^{-1}.

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

By summing the grain yield and stover yield biological yield was calculated.

3.10.14 Harvest index (%)

Harvest index was taken by dividing the biological yield by grain yield .It was recorded in percentage.

3.11 Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix 10 software .The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the effect of different level of fertilizer doses and spacing on the yield of white maize. Data on different growth and other parameters, yield attributes and yield were recorded. The results have been presented with the help of graphs and table, and possible interpretations given under the following heading.

4.1 Plant height (cm)

Effect of fertilizer

Effect of fertilizer doses showed a non-significant variation on plant height for all growth stages of maize (Table 1, Appendix III). At 20 DAS, F_4 showed the tallest plant (37.94 cm) which was statistically similar with F_1; whereas F_3 showed the shortest plant (31.28 cm) which was statistically similar with F_2. At 40 DAS, F_2 showed the tallest plant (78.45 cm) which was statistically similar with F_1; whereas F_4 showed the shortest plant (75.1 cm). At 60 DAS F_4 showed the tallest plant (170.87 cm) and F_3 showed the smallest plant (162.37 cm) which was statistically similar with F_1, and F_2.At 80DAS F_4 showed the tallest plant (185.63 cm) which was statistically similar with F_1.Whereas F_3 showed smallest plant height which was statistically similar with F_2.And at harvest, F_4 showed tallest plant and F_3 showed smallest plant. The increase in plant height with different fertilizer doses can be attributed to the fact that fertilizer especially nitrogen source promotes plant growth, increases the number and length of the internodes which results in progressive increase in plant height. Similar results were reported by Sharma (1973), Trukese and Rajendra (1978), Koul (1997), Saigusa et al. (1999) and Gasim (2001). However, the remarkable increase in plant height was attained by recommended dose of fertilizer. This result also is in agreement with the finding of Sahid et al. (1990), Omarajiltwd (1989), Bindra and Kharwara (1994), Elmar (2001) and Gader (2007).

Table 1. Effect of fertilizer treatments on the plant height of maize at different days after sowing

Fertilizer treatments	Plant height (cm) at				
	20DAS	40DAS	60DAS	80DAS	Harvest
F_1	36.833 a	78.08 a	162.64 b	183.83 a	196.86ab
F_2	31.28 b	78.45 a	162.51 b	172.67 b	191.85bc
F_3	30.92 b	76.46 b	162.37 b	169.03 b	189.28 c
F_4	37.94 a	75.1 c	170.87 a	185.63 a	202.02a
LSD(0.05)	2.57	1.29	7.43	5.39	5.7
CV (%)	6.51	1.45	3.92	2.63	2.4

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

Plant height showed statistically non-significant effect due to different spacing of maize cultivation (Table 2 and Appendix III). Due to influence of spacing the highest plant height was recorded in S_1 while lowest cob length was in S_2. The cob length ranges from 32.54 cm to 36.12 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)

Table 2. Effect of spacing treatments on the plant height of maize at different days after sowing

Spacing treatments	Plant height(cm) at				
	20DAS	40DAS	60DAS	80DAS	Harvest
S_1	36.12 a	78.09 a	169.21 a	184 84 a	203.16 a
S_2	32.54 c	77.16 ab	158.95 b	170.60 c	189.64b
S_3	34.07 b	75.82 b	165.63 a	177.93 b	192.21 b
LSD(0.05)	0.99	1.85	4.82	3.36	5.39
CV (%)	3.35	2.78	3.39	2.18	2.84

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Combined effect of fertilizer doses and spacing showed an increasing trend with advances of growth period in respect of plant height (Table 3, Appendix III). The rate of increase was much higher in the early stages of growth 20 DAS to 60 DAS. At 20 DAS, F_4S_1 combination showed the tallest plant (40.16 cm) which was statistically similar with F_1S_1 and F_4S_3; whereas F_2S_2combination showed the shortest plant (20.56cm) which was statistically similar with F_2S_3, F_3S_1, F_3S_2 and F_3S_3. At 40 DAS, F_3S_1 combination showed the tallest plant (82.9cm) which was statistically similar with F_1S_1 and F_2S_3; whereas F_3S_3 combination showed the shortest plant (67.6 cm). At 60 DAS, F_4S_1 combination showed the tallest plant (173.83 cm) which was statistically similar with all other combinations except F_1S_2,F_2S_3 and F_3S_2; whereas F_1S_2 combination showed the shortest plant (151 cm) which was statistically similar with all other combinations except F_2S_2,F_3S_2. At 80 DAS, F_4S_1 combination showed the tallest plant (193.57 cm) which was statistically similar with F_1S_1; whereas F_3S_2 combination showed the shortest plant (165.23 cm) which was statistically similar with F_2S_2 and F_3S_3.At harvest, F_4S_1 showed the tallest plant (208.67 cm) which was similar with F_1S_1, F_2S_1 and F_4S_3; whereas F_3S_2 showed the smallest plant (177.4 cm) which was similar with F_1S_3, F_2S_3, F_3S_1 and F_3S_3.Plant height differed non-significantly at all growth stages for N-levels. Usually N-fertilizer enhances the growth of a crop plant synthesizing more protein and chlorophyll. This helps to increase the plant height and other growth parameters. Plant height increased non-significantly with the increase of N levels was also observed by Singh (2001), Thakur and Sharma (1999) and Thakur et al. (1997).

Table 3. Interaction effect of fertilizer management and spacing on the plant height of maize at different days after sowing

Interaction treatments	Plant height (cm) at				
	20DAS	40DAS	60DAS	80DAS	Harvest
F_1S_1	39.26 a	81.36 ab	171.07 ab	193.07 ab	206.9 a
F_1S_2	34.73 c	77.06 c	151 d	173.1 efg	190.63 cd
F_1S_3	36.5 bc	75.83 c	165.87 abc	185.33 cd	193.03 bcd
F_2S_1	33.67 cd	76.73 c	166.23 abc	179.53cde	202.17 ab
F_2S_2	29.56 e	76.7 c	158.56 cd	166.4 gh	186.83 cd
F_2S_3	30.633 e	81.93 ab	162.73 bc	172.07 fgh	186.56 cd
F_3S_1	31.4 de	82.9 a	165.7 abc	173.2 efg	194.9 bcd
F_3S_2	30.66 de	78.9 bc	158.37 cd	165.23 h	185.43 d
F_3S_3	30.7 de	67.6 e	163.03 abc	168.67 gh	187.cd
F_4S_1	40.16 a	71.36 d	173.83 a	193.57 a	208.67a
F_4S_2	35.2 bc	76.00 c	167.87 abc	177.67 def	195.67 bc
F_4S_3	38.46 ab	77.93 c	170.9 ab	185.67 bc	201.73
LSD(0.05)	1.99	3.7	9.65	6.72	4.8
CV (%)	3.35	2.78	3.39	2.18	2.84

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.2 Number leaves plant^{-1}

Effect of fertilizer

Fertilizer doses showed a non- significant variation on no. of leaves plant-1 of maize at 60 DAS and 80 DAS and harvest (Table 4, Appendix IV). At 60 DAS, F_4 showed the highest number of leaves plant^{-1} (11.77) which was statistically similar with F_2; whereas F_3 showed the lowest number of leaves plant^{-1} (10). At 80 DAS, F_4 showed the highest number of leaves plant^{-1} (11.88); whereas F_2 showed the lowest number of leaves plant^{-1} (10) which was statistically similar with F_1, F_3 .At harvest, F_4 showed maximum number of leaves (12.44) and F_3 showed minimum number of leaves (11). This is similar to the findings of Woldesenbet et al. (2016) who indicated that, there is an increase in number of leaves with an increase in fertilizer level. The increase in the number of leaves per plant could possibly be ascribed to the fact that nitrogen often increases plant growth and plant height and this resulted in more nodes and internodes and subsequently more production of leaves. In this respect, Okajina et al. (1983), Sawi (1993) found that nitrogen fertilization, non- significantly increased the number of leaves and they suggested that the increasing in number of leaves may be as a result of increasing number of nodes.

Table 4. Effect of fertilizer treatments on the of maize no. of leaves plant $^{-1}$ at different days after sowing

Fertilizer treatments	No. of leaves plant $^{-1}$ at		
	60DAS	80DAS	Harvest
F_1	11 b	10.66 b	11.33 b
F_2	11.22 ab	10 b	11.33 b
F_3	10 c	10.33 b	11 b
F_4	11.77 a	11.88 a	12.44 a
LSD(0.05)	0.65	0.96	0.94
CV (%)	5.18	7.77	7.08

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

The spacing effect on number of functional leaves (green leaves above the ground) per plant at different growth stages during experimentation has been presented in Table 5. Data showed that higher leaves number plant^{-1} was achieved with higher plant spacing where lower plant spacing showed lower leaf number plant^{-1}. The highest leaves number plant^{-1} at 60, 80 DAS and at harvest were 12.08, 11.75 and 12.58 respectively with S_1 where the lowest were 9.83, 9.66 and 10.5 respectively which was with S_2. At 80 DAS, the leaves number variation among spacing noticed significantly (Appendix IV). This finding was directly related with Nand (2015. This result also collaborate the findings of Enujeke (2013) and Ukonze et al., (2016).

Table 5. Effect of spacing treatments on number of leaves plant^{-1}of maize at different days after sowing

Spacing treatments	Number of leaves plant^{-1} at		
	60DAS	80DAS	Harvest
S_1	12.08 a	11.75 a	12.58a
S_2	9.83 c	9.66 c	10.5 c
S_3	11.08 b	10.75 b	11.5 b
LSD(0.05)	0.2	0.14	0.14
CV	2.14	1.55	1.45

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Effect of spacing and fertilizer management on leaf number plant^{-1} was represented by Table 6. The treatment combination, F_4S_1 gave the highest leaf number plant^{-1} 13, 13 and 13.66 at 60, 80 DAS and at harvest respectively. The treatment combinationF_1S_2, F_3S_2 at 60 DAS and F_1S_2 at 80 DAS and F_3S_2 at harvest gave the lowest leaf number plant^{-1} (10, 9 and 10 respectively). This finding was indirectly related with Kumar et al. (2018).

Table 6. Interaction effect of fertilizer management and spacing on number of leaves plant^{-1} of maize at different days after sowing

Interaction treatments	Number of leaves plant^{-1}		
	60DAS	80DAS	Harvest
F_1S_1	12 bc	11.67 bc	12.33 b
F_2S_2	10 f	9.66 ghi	10.33 ef
F_1S_3	11 de	10.66 def	11.33 cd
F_2S_1	12.33 ab	11 cde	12.33 b
F_2S_2	10 f	9 i	10.33 ef
F_2S_3	11.33 cd	10 fgh	11.33 cd
F_3S_1	11 de	11.33 bcd	12 bc
F_3S_2	9 g	9.33 hi	10 f
F_3S_3	10 f	10.33 efg	11 de
F_4S_1	13 a	13 a	13.66 a
F_4S_2	10.33 ef	10.66 def	11.33 cd
F_4S_3	12 bc	12 b	12.33 b
LSD (0.05)	0.4	0.28	0.97
CV %	2.14	1.55	1.45

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50cmx 25cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.3. Leaf length x Leaf breadth, leaf area and sunshine (below the canopy)

Effects of fertilizer dose

The leaf length and breath as well area of white maize considerably changed at different DAS due to various dose of fertilizer application treatments (table 8). The results of the experiment indicated that the F_4 treatment (125% recommended dose of fertilizer) had the highest leaf length and leaf area (564.12cm^2) at 80 DAS and 40 DAS. While the F_3 treatment (using 50% of the recommended dose fertilizer dose) had the lowest leaf length and leaf area (446.48 cm$^{2)}$ at 80 DAS. The increase in leaf area with the increase in fertilizer might be due to increase in availability of plant nutrients. Spandana (2012) reported that the growth characters like leaf area index (LAI) increased due to increased level of nitrogen application from 120 to 240 kg ha^{-1}. But at 60 DAS F_1 (100% recommended dose of fertilizer) showed highest leaf length and breath.

In case of sunshine data, F_3 had highest sunshine below the canopy and F_1 showed lowest sunshine below the canopy.

Table 7. Effect of fertilizer application on different plant parameter of white maize

Fertilizer treatment	Leaf length at 40 DAS (cm)	Leaf breadth at 40 DAS (cm)	Leaf length at 60 DAS (cm)	Leaf breadth at 60 DAS (cm)	Leaf length at 80 DAS (cm)	Leaf area/plant at 80 DAS (cm^2)	Sunshine below the canopy (lx)
F_1	50.22	3.86	87.94	8.84	75.72	558.10	2977.78
F_2	43.56	3.57	84.86	8.16	78.52	503.41	3144.44
F_3	47.72	3.38	86.69	7.92	75.74	446.68	3355.56
F_4	54.07	3.63	81.11	8.55	81.18	564.12	3044.44

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose.

Effects of spacing

At various days after sowing, different spacing had a significant effect on the leaf length and breadth as well as leaf area of white maize (table 7). The results of the experiment revealed that the S_1 treatment had the highest leaf length and breadth at 40, 60 DAS and highest leaf area (551.53 cm^2) at 80 DAS. While at 40, 60 and 80 DAS, the S_2 treatment exhibited the lowest leaf length and breadth as well as leaf area. Lower plant spacing increases of plant density which decreased the number of leaves plant^{-1} due to plants at higher densities accumulate less carbon which is not sufficient to support more leaves result in lower leaf area plant^{-1}. Paygonde et al. (2008) reported that, the spacing of 60 cm × 20 cm produced significantly maximum number of functional leaves, dry matter, and higher leaf area per plant and leaf area index as compared to 45 cm × 20 cm spacing level.

In case of sunshine, S_2 spacing showed highest sunshine below the canopy and S_1 spacing had lowest sunshine below the canopy.

Table 8. Effect of spacing on different plant parameter of white maize

Spacing treatment	Leaf length (cm)at 40 DAS	Leaf breadth (cm) at 40 DAS	Leaf length (cm)at 80 DAS	Leaf breadth (cm)at 40 DAS	Leaf length (cm)at 80 DAS	Leaf area (cm^2) plant^{-1} at 80 DAS	Sunshine below the canopy (lx)
S_1	50.22	3.76	89.31	8.69	77.77	551.53	2900.00
S_2	47.99	3.48	80.66	8.02	77.31	466.29	3275.00
S_3	48.47	3.59	85.48	8.40	78.29	536.41	3216.67

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

Interaction effects

Applying different dose of fertilizer and maintaining different spacing's together had shown significant effect on the leaf area as well as leaf length and breadth of white maize at various DAS (Table 9). According to experimental findings, the F_1S_1 treatment combination had the highest leaf length and breadth at 40, 60 and F_4S_1 showed highest leaf area at 80 DAS. However the F_3S_3 treatment combination had the lowest leaf length and breadth at 40 DAS and F_3S_2 treatment showed lowest leaf area at 80 DAS.

F_3S_3 combination had highest sunshine below the canopy and F_1S_1 had lowest sunshine below the canopy

Table 9. Interaction effect of spacing and fertilizer application on different plant parameter of white maize

Interaction treatment	Leaf length (cm)at 40 DAS	Leaf breadth (cm) at 40 DAS	Leaf length (cm)at 80 DAS	Leaf breadth (cm)at 40 DAS	Leaf length (cm)at 80 DAS	Leaf area (cm^2) $plant^{-1}$ at 80 DAS	Sunshine below the canopy (lux)
F_1S_1	56.53	4.13	94.43	9.33	74.53	589.43	2733.33
F_1S_2	46.87	3.57	83.60	8.57	78.33	538.50	3100.00
F_1S_3	47.27	3.89	85.80	8.63	74.30	546.37	3100.00
F_2S_1	44.27	3.57	80.80	8.50	76.00	515.86	2900.00
F_2S_2	43.37	3.63	84.27	7.87	80.60	441.60	3266.67
F_2S_3	43.03	3.50	89.50	8.10	78.97	552.77	3266.67
F_3S_1	50.37	3.50	88.30	8.10	77.47	478.70	3133.33
F_3S_2	47.17	3.23	83.47	7.53	70.06	399.47	3333.33
F_3S_3	45.63	3.40	88.30	8.13	79.70	461.86	3600.00
F_4S_1	49.70	3.83	93.70	8.83	83.07	622.13	2833.33
F_4S_2	54.57	3.50	71.30	8.10	80.27	485.60	3400.00
F_4S_3	57.93	3.57	78.33	8.73	80.20	584.63	2900.00

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.4 Dry matter weight $plant^{-1}$ (g)

Effect of fertilizer doses

Fertilizer doses showed anon-significant variation in respect of dry matter weight $plant^{-1}$ through the growth periods (Table 10, Appendix VII). At 60, F_4 showed the highest dry matter weight plant-1 (89.08 g); whereas F_2 showed the lowest dry matter weight $plant^{-1}$ (69.2 g). At 80 DAS, F_4 showed the highest dry matter weight $plant^{-1}$

(93.68 g) which was statistically similar with F_1 and F_2; whereas F_3 the lowest dry matter weight plant^{-1} (82.42 g) which was statistically similar with F_2. At 9 harvest, F_4 showed the highest dry matter weight plant^{-1} (174.39 g) which was statistically similar with F_1; whereas F_3 showed the lowest dry matter weight plant^{-1} (157.41 g) which was statistically similar with F_2.

Table 10. Effect of fertilizer treatments on dry matter weight plant^{-1} of maize at different days after sowing

Fertilizer treatments	Dry matter weight (g) at		
	60DAS	80DAS	Harvest
F_1	81.43 b	92.52 ab	162.24 ab
F_2	69.2 c	84.52 ab	158.56 b
F_3	84.32 b	82.42 b	157.41 b
F_4	89.08 a	93.68 a	174.39 a
LSD(0.05)	4.62	10.89	15.49
CV (%)	4.95	10.7	8.23

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

Spacing treatments showed significant variation at 60 DAS and non- significant variation at 80DAS and harvest in respect of dry matter weight plant^{-1} through the growth periods (Table 11). At 60, S_1 showed the highest dry matter weight plant^{-1} (95.25g); whereas S_2 showed the lowest dry matter weight plant^{-1} (66.55 g). At 80 DAS, S_1 showed the highest dry matter weight plant^{-1} (94.2 g) which was statistically similar with S_3; whereas S_2 showed the lowest dry matter weight plant-1 (79.69 g). At 9 harvest, S_1 showed the highest dry matter weight plant^{-1} (172.95 g); whereas S_2 showed the lowest dry matter weight plant^{-1} (155.27 g) which was statistically similar with S_3.

Table 11. Effect of Spacing treatments on dry matter weight plant $^{-1}$ of maize at different days after sowing

Spacing treatments	Dry matter weight(g) at		
	60DAS	80DAS	Harvest
S_1	95.25 a	94.2 a	172.95 a
S_2	66.55 c	79.96 b	155.27 b
S_3	81.23 b	90.69 a	161.22 b
LSD(0.05)	4.42	7.58	8.21
CV (%)	6.32	9.92	5.82

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Interaction effect of spacing and fertilizer management

Combined effect of fertilizer and spacing had non- significant effect on dry matter weight plant^{-1} of maize (Table 12 and Appendix VII). At 60DAS, F_4S_1 combination produced the dry matter weight plant^{-1} (120.2 g) which is statistically similar with F_3S_1; whereas F_2S_1 combination produced the lowest dry matter weight plant^{-1} (66.37 g). At 80 DAS, T1S_1 showed highest dry matter weight plant^{-1} (102.67 g) and F_3S_2 showed lowest dry matter weight plant^{-} (65.23 g) and at harvest, F_4S_1 showed highest dry matter weight plant^{-1} (186.41 g) and F_3S_2 showed lowest dry matter weight plant^{-1} (149.21 g).

Table 12. Interaction effect of fertilizer management and spacing on dry matter weight plant $^{-1}$ of maize at different days after sowing

Interaction treatments	Dry matter weight (g) at		
	60DAS	80DAS	Harvest
F_1S_1	89.83 c	102.67 a	173.08ab
F_1S_2	70.63 ef	86.5 bc	153.83 cd
F_1S_3	83.83 cd	88.4 abc	159.75 bcd
F_2S_1	66.37 f	85.67 bc	165.77 bcd
F_2S_2	67.40 f	79.8 cd	152.4 cd
F_2S_3	73.83 ef	88.1 abc	157.52 bcd
F_3S_1	104.6 a	89.9 abc	166.55 abc
F_3S_2	71.63 ef	65.23 d	149.21 cd
F_3S_3	76.75 de	92.13 abc	156.47 bcd
F_4S_1	120.2 a	98.60 ab	186.41 a
F_4S_2	56.53 g	88.33 abc	165.6 bcd
F_4S_3	90.53 c	94.13 abc	171.15 abc
LSD(0.05)	8.56	16.45	16.43
CV (%)	6.32	9.92	5.82

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.5 Cob length (cm)

Effect of fertilizer

Cob length exerted non- significant effect (Table 13, Appendix VIII). Due to application of fertilizer the cob length showed similar trend with fertilizer doses. Numerically, cob length ranges from 14.98 cm to 17.62 cm. The highest cob length (17.62 cm) was recorded in F_4 treatment and lowest cob length (14.98 cm) was recorded in F_3 treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated proper reproductive growth of plant. The present finding close conformity with the findings of Liverpool-Tasie et al. (2017), Woldesenbet and Haileyesus (2016), Ademba et al. (2015), Hill (2014), Nasim et al. (2012), Amin (2011), Orosz et al. (2009), Mugwira et al. (2007).

Table 13. Effect of fertilizer treatments on cob length the of maize

Fertilizer treatments	Cob length(cm)
F_1	16.21 b
F_2	15.45 bc
F_3	14.98 c
F_4	17.62 a
LSD (0.05)	1.06
CV (%)	5.76

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75%of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

Cob length showed statistically significant impact due to different spacing of maize cultivation (Table 14, Appendix VIII). Due to influence of spacing the highest cob length was recorded in S_1 while lowest cob length was in S_2. The cob length ranges from 14.30 cm to 17.43 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).

Table 14. Effect of spacing treatments on cob length of the white maize plant

Spacing treatments	Cob length(cm)
S_1	17.43 a
S_2	14.30 c
S_3	16.46 b
LSD(0.05)	0.93
CV (%)	6.7

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non- significant cob length (Table 15 and Appendix VIII). For combined effect cob length ranges from 13.7 cm to 19.02 cm. The highest cob length was found in F_4S_1 which is statistically similar with F_1S_1 and F_4S_3 whereas lowest cob length was found in F_2S_2 which statistically similar with F_1S_1, F_3S_2 and F_4S_2 combination.

Table 15. Interaction effect of fertilizer management and spacing on cob length of the white maize plant

Interaction treatments	Cob length (cm)
F_1S_1	17.58 abc
F_1S_2	14.45 fg
F_1S_3	16.6 cde
F_2S_1	16.75 bcd
F_2S_2	13.83 g
F_2S_3	15.76 code
F_3S_1	16.36 cde
F_3S_2	13.7 g
F_3S_3	14.88 efg
F_4S_1	19.02 a
F_4S_2	15.25 dig
F_4S_3	18.6 ab
LSD(0.05)	1.86
CV (%)	6.7

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.6 CICUMFERENCE OF COB

Effects of fertilizer

Cob diameter showed positive non- significant difference at different doses of fertilizer application in white maize (Table 16, appendix IX). Due to application of different levels of fertilizer, the range of cob diameter was found 13.47 cm to 17.22 cm. The highest cob circumference was recorded in F_4 (17.22 cm) and lowest cob circumference was recorded in F_3 (13.47 cm) which is statistically similar with F_2. 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).

Table 16. Effect of fertilizer treatments on circumference of maize

Fertilizer treatments	Circumference of cob(cm)
F_1	15.93b
F_2	14.13 c
F_3	13.47 c
F_4	17.22a
LSD(0.05)	0.89
CV (%)	5.1

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

Impact of spacing on maize showed significant effect for cob circumference (Table 17 appendix IX).The highest cob circumference was found in S_1 spacing (16.64 cm) while lowest cob circumference was recorded in S_2 treatment (13.77 cm). The present finding is not agreed with the finding of Sabo et al. (2016), Jiang et al. (2013), Sener et al. (2004) and Sangoi et al. (2001).

Table 17. Effect of Spacing treatments on circumference of maize plant

Spacing treatments	Circumference of cob(cm)
S_1	16.64 a
S_2	13.77 c
S_3	15.16 b
LSD(0.05)	0.44
CV (%)	3.42

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing had non- significant effect on cob circumference of maize (Table 18 and Appendix IX). The cob circumference ranges from 12.1 cm to 18.53 cm while F_4S_1 combination produced the highest cob circumference (18.53 cm) which is statistically similar with F_1S_1; whereas F_3S_2 combination produced the lowest cob circumference (12.1 cm).

Table 18. Interaction effect of fertilizer management and spacing on circumference of the cob of white maize plant

Interaction treatments	Circumference of cob (cm)
F_1S_1	17.73 ab
F_1S_2	14.46 def
F_1S_3	15.61 c
F_2S_1	15.6 cd
F_2S_2	12.68 gh
F_2S_3	14.13 ef
F_3S_1	14.7 cde
F_3S_2	12.1 h
F_3S_3	13.62 fg
F_4S_1	18.53 a
F_4S_2	15.83 c
F_4S_3	17.3 b
LSD(0.05)	0.89
CV (%)	3.42

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.7 SHELL WEIGHT

Effect of fertilizer

Due to application of fertilizer shelling percentage showed positively non- significant result (table 19, Appendix X). The shell weight range from 12.13g to 14.4g among the fertilizer doses. The highest shell weight was recorded in F_4 (25% more than recommended doses of fertilizer) treatment and lowest shell weight was recorded in F_3 (50% less than recommended doses of fertilizer) treatment. Our 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), Soro et al. (2015), MucheruMuna et al (2007), Xu et al (2006) and Adeniyan and Ojeniyi (2005).

Table 19. Effect of fertilizer treatments on shell weight of maize

Fertilizer treatments	Shell wt. (g)
F_1	13.45 b
F_2	12.22 c
F_3	12.13 c
F_4	14.42 a
LSD(0.05)	0.95
CV (%)	6.36

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

The shell weight showed statistically significant impact due to different spacing of maize cultivation (Table 20 and Appendix X). The highest shell weight (15.1g) was recorded in S_1 while lowest shell weight (10.68g) was in S_2. 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).

Table 20. Effect of Spacing treatments on shell weight of maize

Spacing treatments	Shell wt. (g)
S_1	15.1 a
S_2	10.68 c
S_3	13.38 b
LSD(0.05)	1.25
CV (%)	11.07

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non- significant shell weight in maize (Table 21 and Appendix X). For combined effect shell weight ranges from 8.66g to 16.83g due to different combinations. The highest shell weight was found in F_4S_1 combination which was statistically similar with F_1S_1 and F_4S_3. The lowest shell weight was found in F_2S_2 which was statistically similar with F_3S_2.

Table 21. Interaction effect of fertilizer management and spacing on shell weight of white maize plant

Interaction treatments	Shell wt.(g)
F_1S_1	13.76 abc
F_1S_2	11.67 de
F_1S_3	12.7 cd
F_2S_1	13.83 bcd
F_2S_2	8.66 f
F_2S_3	14.16 bc
F_3S_1	13.76 bcd
F_3S_2	10.3 ef
F_3S_3	12.33 cde
F_4S_1	16.83 a
F_4S_2	12.11 cde
F_4S_3	14.33 abc
LSD(0.05)	2.5
CV (%)	11.07

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.8 Number of grains cob^{-1}

Effect of fertilizer

Due to application of fertilizer number of grains cob^{-1} varied non-significantly in maize (Table 22and Appendix XI). Number of seeds cob^{-1} increased steadily with the increment of fertilizer doses from the lowest to highest doses. The number of seeds cob-1 range from 353.89 to 403 due to different levels of fertilizers. The maximum number of seeds cob-1 was recorded in F_4 (50% more than recommended doses of fertilizer) treatment and minimum number of seeds cob^{-1} was recorded in F_3 (50% less than recommended doses of fertilizer) treatment. This might be due to the steady supply of nutrient from F_4 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).

Table 22. Effect of fertilizer treatments on number of grains $cob^{-1}$the of maize

Fertilizer treatments	Number of grains cob^{-1}
F_1	382.78 b
F_2	354.11 c
F_3	353.89 c
F_4	403 a
LSD(0.05)	16.12
CV (%)	3.74

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

Number of seeds cob^{-1} showed statistically positively significant impact due to different spacing of maize cultivation .The significant influence of spacing facilitated maximum number of seeds cob^{-1} (391.83) in S_1 while minimum number of seeds cob^{-1} (351.33) was in S_2. 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).

Table 23. Effect of Spacing treatments on number of grains cob^{-1}

Spacing treatments	Number of $grains^{-1}$
S_1	391.83 a
S_2	351.33 c
S_3	377.17 b
LSD(0.05)	12.29
CV (%)	3.81

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non- significant variation on number of seeds cob^{-1} in maize (Table 24 and Appendix XI). Among the different combinations the number of seeds cob^{-1} ranges from 323.67 to 423). The maximum number of seeds cob^{-1} was found in F_4S_1 which was statistically similar with F_1S_1 and F_4S_3 whereas minimum number of seeds cob^{-1} was found in F_2S_2 which is statistically similar with F_3S_2 combination.

Table 24. Interaction effect of fertilizer management and spacing on number of grains cob^{-1} of white maize plant

Interaction treatments	Number of grains cob^{-1}
F_1S_1	403.67 ab
F_1S_2	363.33 cd
F_1S_3	381.33 bcd
F_2S_1	368 cd
F_2S_2	323.67 f
F_2S_3	370.67 cd
F_3S_1	372.67 cd
F_3S_2	333 ef
F_3S_3	356 de
F_4S_1	423 a
F_4S_2	385.33 bc
F_4S_3	400.67 ab
LSD(0.05)	24.59
CV (%)	3.81

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm

4.9. 100 grain weight (g)

Effect of fertilizer

Weight of 100 seeds exerted non- significant effect due to different levels of fertilizers in maize (Table 25 and Appendix XIII). The weight of 100 seeds increased sharply with the increases of fertilizers levels. The 100 seeds weight ranges from 23.07g to 26.99g among the doses. The highest 100 seeds weight was recorded in F_4 treatment and lowest 100 seeds weight was recorded in F_3 treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated proper dry matter partitioning of plant. Our finding is close conformity 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).

Table 25. Effect of fertilizer treatments on 100 grain weight of white maize

Fertilizer treatments	100 grain wt.(g)
F_1	25.64ab
F_2	24.75 b
F_3	23.076 c
F_4	26.99 a
LSD(0.05)	1.58
CV (%)	5.47

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

The 100 seeds weight showed statistically significant impact due to different spacing of maize cultivation (Table 26 and Appendix XII). The highest 100 seeds weight was recorded in S_1 (26.98 g) spacing while lowest 100 seeds weight was in S_3 (23.23 g) spacing. The present finding is not fully agreed with the finding of Sabo et al. (2016), Jiang et al. (2013), Sener et al. (2004), and Sangoi et al. (2001)

Table 26. Effect of Spacing treatments on 100 grain weight of white maize plant

Spacing treatments	100 grain wt.(g)
S_1	26.98 a
S_2	25.13 b
S_3	23.23 c
LSD(0.05)	0.63
CV (%)	2.9

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non-significant variations in 100 seeds weight of maize (Table 27 and Appendix XIII). The 100 values of seeds weight ranges from 21.63 g to 28.88 g among the combinations. The highest 100 seeds weight was found in F_3S_1 and lowest 100 seeds weight was found in F_3S_2 combination compared to the others combination.

Table 27. Interaction effect of fertilizer management and spacing on 100 grain weight of white maize plant

Interaction treatments	100 grain wt.(g)
F_1S_1	27.59 ab
F_1S_2	23.56 fg
F_1S_3	25.76 cde
F_2S_1	26.6 bcd
F_2S_2	23 fgh
F_2S_3	24.66 ef
F_3S_1	24.84 def
F_3S_2	21.63 h
F_3S_3	22.75 gh
F_4S_1	28.88 a
F_4S_2	24.75 def
F_4S_3	27.35
LSD(0.05)	1.89
CV (%)	2.9

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.10 Grain weight plant^{-1}

Effects of fertilizer

Due to application of fertilizer grain weight plant^{-1} varied non- significantly in maize (Figure 28 and Appendix XII). Grain weight plant^{-1} range from 71.45 to 84.45 due to different levels of fertilizers. The maximum weight plant^{-1} was recorded in F_4 treatment and minimum weight plant^{-1} was recorded in T3 treatment. This might be due to the steady supply of nutrient from F_4 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).

Table 28. Effect of fertilizer treatments on grain weight plant $^{-1}$ of white maize

Fertilizer treatments	Grain wt.plant^{-1} (g)
F_1	80.11 a
F_2	74.11 b
F_3	71.45 b
F_4	84.45 a
LSD(0.05)	4.72
CV (%)	5.28

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

The weight plant $^{-1}$ showed statistically positively non-significant impact due to different spacing of maize cultivation (Table 29 and Appendix XII). The significant influence of spacing facilitated maximum weight of plant^{-1} (80.99g)) in S_1 while minimum weight of plant^{-1} (73.47g)) was in S_2. 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)

Table 29. Effect of Spacing treatments on grain wt. plant^{-1} (g) .

Spacing treatments	Grain wt.plant^{-1} (g)
S_1	80.99 a
S_2	73.47 b
S_3	78.12 a
LSD(0.05)	4.28
CV (%)	6.39

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Combined effect of fertilizer and spacing

Combined effect of fertilizer and spacing produced statistically non- significant variation on weight of plant $^{-1}$ in white maize (Table 30 and Appendix IX 12). Among the different combinations the weight of grain plant $^{-1}$ ranges from 66.16 g to 85.93 g. The maximum weight of grain plant^{-1} was found in F_4S_1 which was statistically with F_1S_1, F_1S_3, F_2S_1, F_4S_2, F_4S_3 combination whereas minimum weight of grain plant^{-1} (66.16 g) was found in F_3S_2 combination.

Table 30: Interaction effect of fertilizer management and spacing on grain weight plant^{-1} of white maize

Interaction treatments	Grain wt.plant^{-1} (g)
F_1S_1	84.33 abc
F_1S_2	77.43 bcd
F_1S_3	78.56 abcd
F_2S_1	77.6 abcd
F_2S_2	68.7 ef
F_2S_3	76.03 cde
F_3S_1	76.1 cde
F_3S_2	66.16 f
F_3S_3	73.1 def
F_4S_1	85.93 a
F_4S_2	82.61abc
F_4S_3	84.8 ab
LSD(0.05)	8.57
CV (%)	6.39

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.11 Grain yield (t ha^{-1}), stover yield and biological yield

Effect of fertilizer doses

The grain yield showed non-significant difference but stover yield biological yield of white maize showed significant difference at different doses of fertilizer application (Table 31 and Appendix XIV, XV). The figure indicated that, the higher doses of fertilizers (F_4) increased stover yield and biological yield significantly than recommended doses. On the others hand, lower doses (F_3) produced lower grain yield, stover yield and biological yield than recommend doses (F_1) in maize. Due to application of different levels of fertilizer, the range of grain yield, stover yield and biological yield of maize was found 6.18 t ha^{-1} to 7.16 t ha^{-1}, 8.37 t ha^{-1} to 11.81 t ha^{-1} and 14.55 t ha^{-1} to 19.08 t ha^{-1} respectively. The highest grain yield, stover yield and biological yield were recorded in F_4 (50% more than recommended doses of fertilizer) while lowest grain yield, stover yield and biological yield were recorded in F_3 (50% less than recommended dos ha^{-1} of fertilizer). This might be due to adequate nutrient was in F_4 treatment. The present finding is agreed with the findings of Abebe and Feyisa (2017), Liverpool-Tasie et al. (2017), Woldesenbet and Haileyesus (2016), Jolokhava et al. (2016), Dong et al. (2016), Admas et al. (2015), Ademba et al. (2015), Soro et al. (2015), Rudnick and Irmak (2014), Hill (2014), Crista et al. (2014), Nasim et al. (2012), Amin (2011), Orosz et al. (2009), Mugwira et al. (2007).

Table 31. Effect of fertilizer treatments on grain yield, stover yield and biological yield of white maize

Fertilizer treatments	Grain wt. ha^{-1} (ton)	Stover yield	Biological yield
F_1	6.92 b	10.74 b	17.66 b
F_2	6.22 c	9.4 c	15.63 c
F_3	6.18 c	8.37 d	14.55 d
F_4	7.16 a	11.81 a	19.08 a
LSD(0.05)	0.23	0.89	0.67
CV (%)	3.03	7.67	3.48

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

EFFECTS OF SPACING

Different spacing significantly affected the result of grain yield of maize (Table 32, Appendix XIV). Results represented in table 36indicated that the highest grain yield (7.25 t ha^{-1}) was obtained with S_2 where the lowest (5.91 t ha^{-1}) was with S_1. Similar results were also found by Sener (2004). Generally grain yield increased with increasing planting density (Akbar et al, 2016).This finding was directly related with

Najd (2015) who reported maximum grain yield observed in S_1. This result also related with the findings of Fanadzo et al. (2010), Golla et al., (2018) and Hasan et al, (2018).

Different spacing had significant effect on stover yield (t ha^{-1}) of maize. Results represented in Figure 19 indicated that the highest stover yield (10.99 t ha^{-1}) was attained with S_2 where the lowest (9.17 t ha^{-1}) was with S_1. The result obtained by Hasan et al., (2018) was similar with the present findings.

Effect of spacing on biological yield of maize was remarkable (Appendix 16). Results represented in table 32 indicated that the highest biological yield (18.25 t ha^{-1}) was obtained with S_2 where the lowest (15.16) was with S_1.

Table 32. Effect of spacing treatments on grain yield, stover yield and biological yield of white maize

Spacing treatments	Grain yield(t ha^{-1})	Stover yield(t ha^{-1})	Biological yield(t ha^{-1})
S_1	5.91 c	9.17 c	15.16 c
S_2	7.25 a	10.99 a	18.25 a
S_3	6.7 b	10.07 b	16.78 b
LSD(0.05)	0.13	0.4	0.38
CV (%)	2.29	4.59	2.66

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Interaction effect of spacing and fertilizer doses

Interaction effect of spacing and integrated fertilizer management influenced non-significantly the grain yield of maize (Appendix XIV, Table 33) showed that the highest grain yield (7.83 t ha^{-1}) was recorded from the combined effect of F_4S_2 where the lowest grain yield (5.53 t ha^{-1}) was observed by F_2S_1. These results are in conformity with Amaral Filho (2009).

Interaction effect of spacing and integrated fertilizer management regulated stover yield of maize. Results in Table 10 showed that the highest stover yield (12.91 t ha^{-1})

was recorded from the combined effect of F_4S_2 where the lowest stover yield (7.73 t ha^{-1}) was observed in F_3S_1.

Interaction effect of spacing and integrated fertilizer management had remarkable effect on biological yield of maize (Appendix 16). Results in Table 10 showed that the highest biological yield (20.74 t ha^{-1}) was recorded from the combined effect of F_4S_2 where the lowest biological yield (13.04 t ha^{-1}) was observed by F_3S_1. The results obtained from all other treatments showed intermediate results compared to the highest and the lowest value of biological yield. This finding was indirectly related with Kumar et al. (2018) and Badr and Othman (2006).

Table 33. Interaction effect of fertilizer management and spacing on grain yield, stover yield and biological yield of white maize

Interaction treatments	Grain wt. ha^{-1} (ton)	Stover yield(t ha^{-1})	Biological yield(t ha^{-1})
F_1S_1	6.09 d	9.63 efg	15.78 f
F_1S_2	7.68 a	11.56 bc	19.24 b
F_1S_3	6.99 bc	10.98 bcd	17.94 c
F_2S_1	5.53 e	9.04 gh	14.56 g
F_2S_2	6.76 c	10.08 def	16.85 de
F_2S_3	6.39 d	9.07 gh	15.49 f
F_3S_1	5.67 e	7.37 i	13.04 h
F_3S_2	6.73 c	9.43 fg	16.17 ef
F_3S_3	6.13 d	8.31 h	14.45 g
F_4S_1	6.36 d	10.57 cde	17.27 cd
F_4S_2	7.83 a	12.91 a	20.74 a
F_4S_3	7.28 b	11.94 b	19.24 b
LSD(0.05)	0.26	0.8	0.91
CV (%)	2.29	4.59	2.66

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm.

4.12 HARVEST INDEX (%)

Effect of fertilizer doses

Different fertilizer doses affected the harvest index of white maize. The highest harvest index of white maize was found in F_3 treatment which is statistically similar with F_1 and F_2 treatment; whereas lowest harvest index was found in F_4 treatment. The ranges of harvest index was 37.13% to 40.38 %.

Table 34. Effect of fertilizer treatments on harvest index of white maize

Fertilizer treatments	Harvest index (%)
F_1	39.23 a
F_2	40 a
F_3	40.38 a
F_4	37.13 b
LSD(0.05)	1.75
CV (%)	3.89

F_1 = Recommended dose (100%); F_2 = 50% of recommended dose; F_3 = 75% of recommended dose; F_4 = 125% of recommended dose

Effect of spacing

Different spacing has non- significant effects on white maize harvest index. S_3 (40.25 %) spacing showed the highest harvest index which is statistically similar with S_2; whereas S_1 showed the lowest harvest index (37.21 %).

Table 35. Effect of spacing treatments on harvest index of white maize

Spacing treatments	Harvest index (%)
S_1	37.21 b
S_2	40.09 a
S_3	40.25 a
LSD(0.05)	1.65
CV (%)	4.87

S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm .

Interaction effect of spacing and doses

Interaction effect of spacing and fertilizer doses on harvest index of maize is presented in Table 36. Results in table 36 showed that the highest harvest index (42.73%) was recorded from the combined effect of F_3S_3 where the lowest harvest index (35.3%) was observed by F_4S_1.

Table 36. Interaction effect of fertilizer management and spacing on harvest index of white maize

Interaction treatments	Harvest index (%)
F_1S_1	38.73 bcde
F_1S_2	40.2 abcd
F_1S_3	38.76 bcde
F_2S_1	38 def
F_2S_2	40.67 abcd
F_2S_3	41.34 abc
F_3S_1	36.81 ef
F_3S_2	41.59 ab
F_3S_3	42.73 a
F_4S_1	35.30 f
F_4S_2	37.92 def
F_4S_3	38.18 cdef
LSD(0.05)	3.2
CV (%)	4.87

F_1 = 100 % of recommended dose; F_2 = 50% of recommended dose; F_3 = 75%of recommended dose; F_4 = 125% of recommended dose, S_1 = Sowing in line using planting configuration 50 cm x 25 cm; S_2 = Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm; S_3= Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm.

Correlation study

Correlation among different plant parameters and yield attributes

Strong and positive correlations were obtained with leaf length at 40 DAS and grain yield plant^{-1} (r=0.6944), leaf length with dry matter at 80 DAS (r=0.6972), leaf breadth at 60 DAS with grain yield plan^{-1} (r=0.8287), dry matter weight at 80 DAS with grain weight plant^{-1} (r=0.8430), dry matter weight at harvest with grain yield plant $^{-1}$ (r=0.8578), biological weight at harvest with grain yield ha^{-1} (r=0.9387), dry matter weight at 60 DAS with dry matter weight at harvest (r=0.7200).

There was also positive correlations between dry matter at 80 DAS with leaf breadth at 60 DAS (r=0.8364), with grain yield plant^{-1} (r=0.8430), and with dry matter at harvest (r=0.7642) (Table 37). The correlations of dry matter plant^{-1} at 80 DAS also had positive correlations with leaf breadth at 60 DAS (r=0.8363), yield plant $^{-1}$ (r=0.8430), and dry matter at harvest (r=0.7200). Likewise, dry matter at harvest had strong positive correlations with leaf breadth at 60DAS, yield plant^{-1} (r=0.8578), dry weight at 60 DAS (r=0.7200) and dry weight at 80 DAS (r=0.7642).

Leaf area at 80 DAS had strong positive correlations with leaf breadth at 60 DAS (r=0.8782), yield plant^{-1} (r=0.8748), dry weight at 80 and harvest (r=0.8071 & 7581. Sunshine below the canopy in most of the cases had negative correlations with almost all the parameter. This was obvious as the plants contributing much to growth and yield had greater leaf area that prevented light to penetrate underneath.

Table 37. Correlation coefficient among different plant parameters and yield attributes of white maize

	Leaf length (cm) at 40 DAS	Leaf breadth(cm) at 40 DAS	Leaf length (cm)at 60 DAS	Leaf breadth(cm) at 60 DAS	Leaf length (cm)at 80 DAS	Yield/ plant (t ha^{-1})
Leaf length at 40 DAS (cm)	1.0000	0.4649	_	0.5229	0.0622	0.6944
Leaf breadth at 40 DAS(cm)	0.3514	1.0000	0.4777	0.8493	0.0703	0.6199
Leaf length at 60 DAS (cm)	_	0.4777	1.0000	0.3610	_	0.0394
Leaf breadth at 60 DAS(cm)	0.5229	0.8493	0.3610	1.0000	0.1510	0.8287
Leaf length at 80 DAS(cm)	0.0622	0.0703	_	0.1510	1.0000	0.4179
Yield $plant^{-1}$	0.6944	0.6199	0.0394	0.8287	0.4179	1.0000
Yield ha^{-1}(t)	0.2802	_	_	_	0.1680	0.1340
Bio yield ha^{-1}(t)	0.4047	0.1057	_	0.1604	0.2591	0.3858
Dry matter plant (g) at 60DAS	0.3132	0.4201	0.6500	0.4648	0.2301	0.4553
Dry matter /plant (g) at 80DAS	0.5037	0.6972	0.3841	0.8364	0.5049	0.8430
Dry matter /plant (g) at Harvest	0.5755	0.5700	0.2694	0.6998	0.4263	0.8578
Single leaf area/leaf at 80 DAS(cm^2)	0.4111	0.7072	0.3513	0.8782	0.3706	0.8748
Sunshine at 60 DAS(lx)			-0.3137	-0.8021	0.0209	-0.6441

Table 37. Correlation coefficient among different plant parameters and yield attributes of white maize

	Yield ha^{-1} (t)	Bio yield ha^{-1} (t)	Dry matter weight/plant (g) at 60DAS	Dry matter weight/plant (g) at 80DAS	Dry matter weight/plant (g) at Harvest
Leaf length at 40 DAS (cm)	0.2802	0.4047	0.3132	0.3132	0.5037
Leaf breadth at 40 DAS(cm)	_	0.1057	0.3132	0.6972	0.5700
Leaf length at 60 DAS	_	_	0.6500	0.3841	0.2694
Leaf breadth at 60 DAS(cm)	_	0.1604	0.4648	0.5037	0.6998
Leaf length at 80 DAS(cm)	0.1680	0.2591	0.2301	0.5049	0.4263
Yield/plant	0.1340	0.3858	0.4553	0.8430	0.8578
Yield / ha (t)	1.0000	0.9387	_	_	_
Bio yield/ha(t)	0.9387	1.0000	_	0.0233	0.0611
Dry matter plant (g) at 60DAS	_	_	1.0000	0.5365	0.7200
Dry matter /plant (g) at 80DAS	_	0.0233	0.5365	1.0000	0.7642
Dry matter /plant (g) at Harvest	_	0.0611	0.7200	0.7642	1.0000
Single leaf area/leaf at 80 DAS(cm^2)	0.0140	0.2432	0.5542	0.8071	0.7581
Sunshine at 60 DAS(lx)	0.2155	-0.0376	-0.5334	-0.5070	-0.6891

Regression analysis

Regression analyses to study the dependence of different plant parameters and yield over leaf area and sunshine were made. It was observed that in most of the cases, data were fitted in simple linear regression model following the model Y=a+bX, where Y is the dependent variable, X is the independent variable, ‘a’ is the intercept and ‘b’ is the slope of the curve. Each curve had regression coefficient ‘R^2’.

At 80 DAS, the relationship between single leaf area and dry matter accumulation plant^{-1} at 80 DAS was found to be linear (Fig. 1) with R^2 value of 0.921 when the data of the spacing treatments were used (Fig. 1). Likewise, relationship between leaf area and dry weight plant^{-1} of the fertilizer treatments were also linear showing R^2 value of 0.912. Similarly, the relationship between leaf area with the dry matter plant^{-1} data obtained with the interaction treatments was also linear with the R value of 0.598.

At harvesting, the dependence of dry matter accumulation was also found to be strong with the leaf area data of the spacing treatments (R^2=0.921) (Fig. 4). On the contrary, when the data of fertilizer treatments were used, the relationship was found to be polygonal showing strong dependency (R2=0.990) (Fig.5). But as was seen in the case using the spacing data, the relationship between leaf area and dry matter plant^{-1} was linear showing R^2 value of 0.427. That is the dependency under the interacted situation, although was positive, was not so strong (Fig.6).

The dependency of the biological yield (t ha^{-1}) was found to be linearly related when spacing treatment’s data were used (Fig.7) showing the R^2 of 0.981). Similar relationship was also observed when the biological yield data as were obtained from fertilizer treatments (R^2=0.757). The linear relationship was also obtained when the data of the interaction treatments were used. However, in that case, the relationship was poorly positive (R^2=0.382).

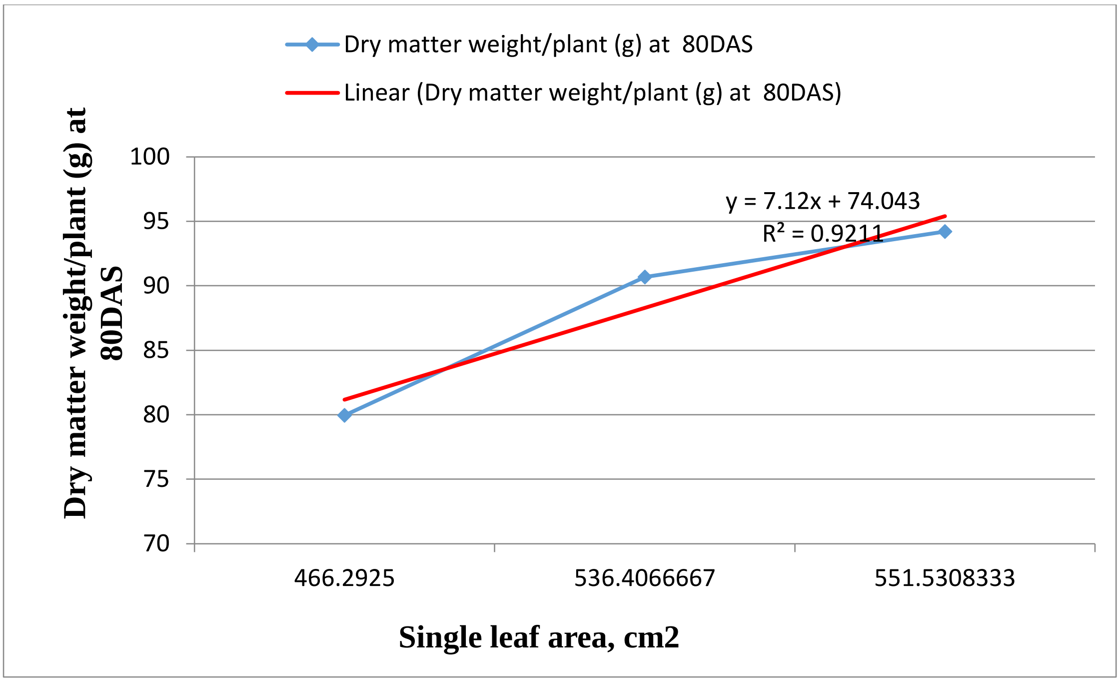

Fig 1. Regression analysis curve with leaf area and dry matter weight plant^{-1} (g) at 80 DAS at varying spacing scenario at the interaction scenario of varying spacing and fertilizer application

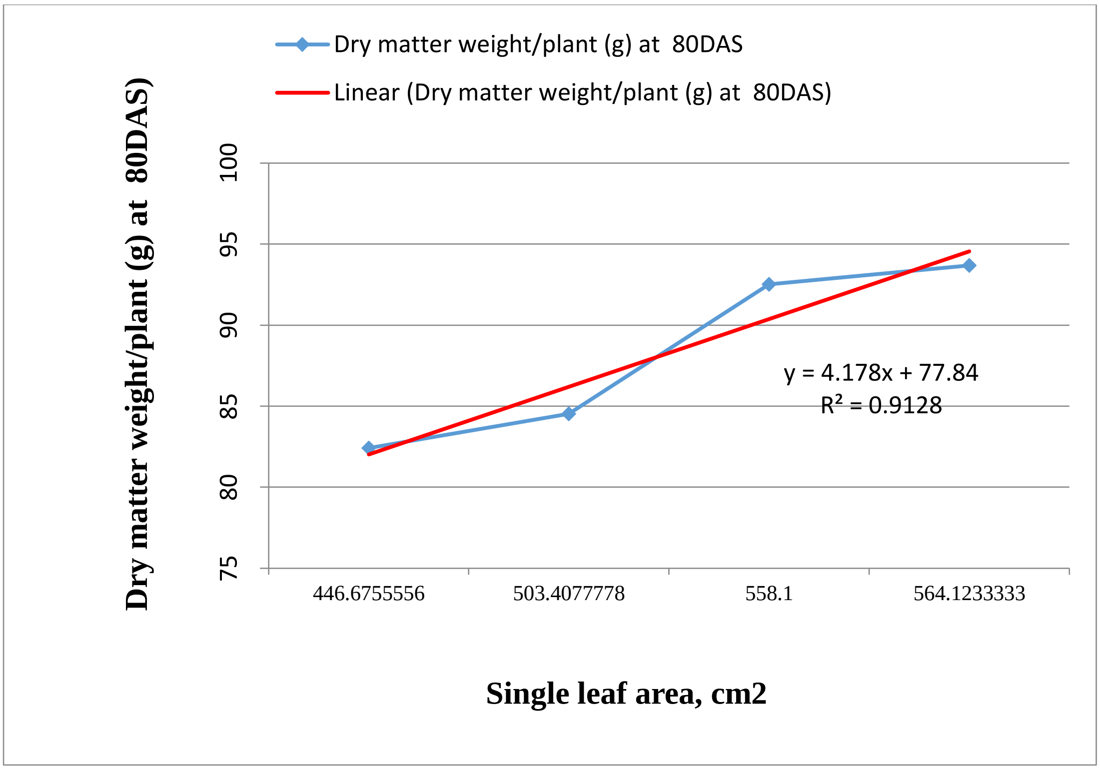

Fig 2. Regression analysis curve with leaf area and dry matter weight plant^{-1} (g) at 80 DAS at varying fertilizer application scenario

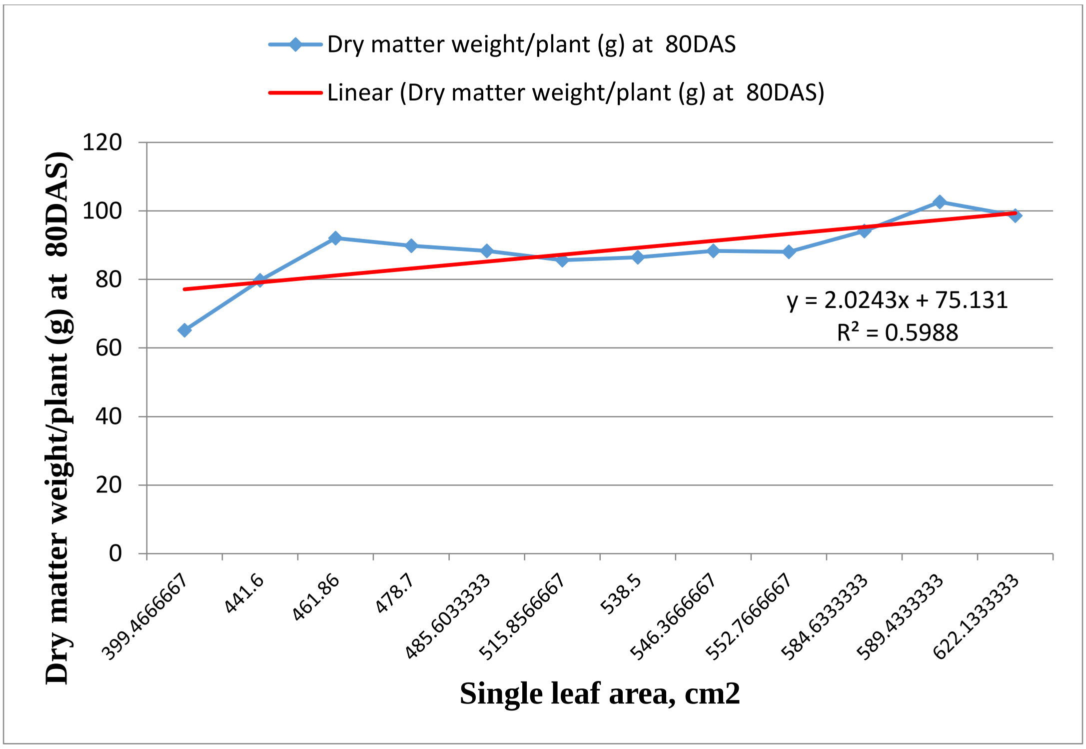

Fig 3. Regression analysis curve with leaf area and dry matter weight plant $^{-1}$ (g) at 80 DAS at the interaction scenario of varying spacing and fertilizer application

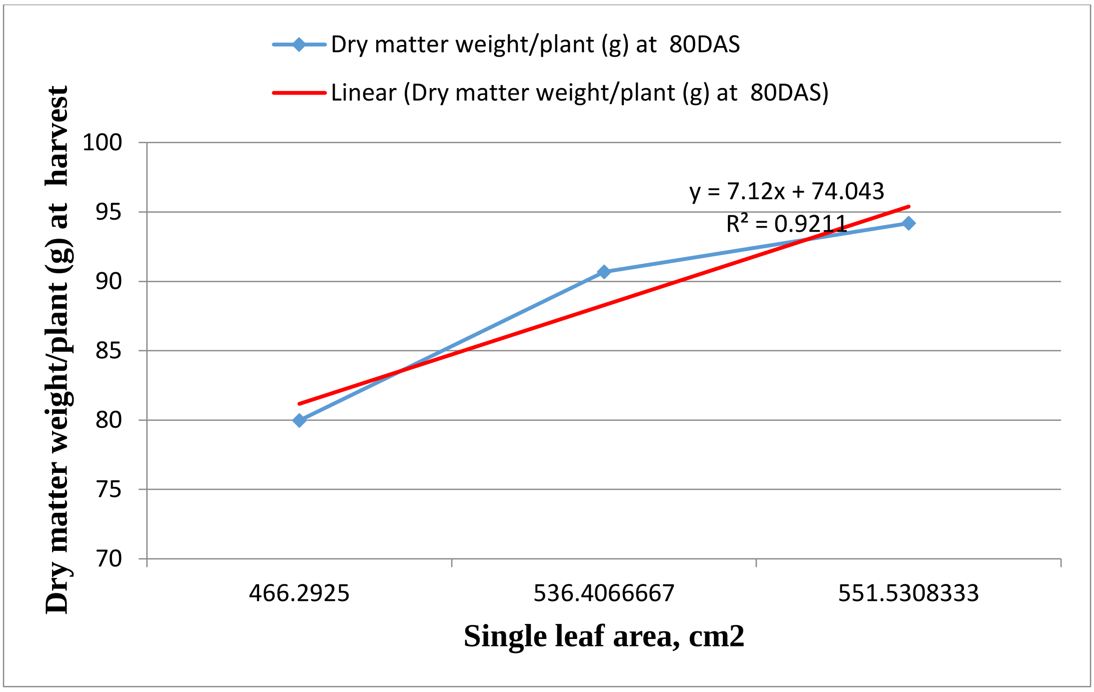

Fig 4. Regression analysis curve with leaf area and dry matter weight plant^{-1} (g) at maturity at varying spacing scenario

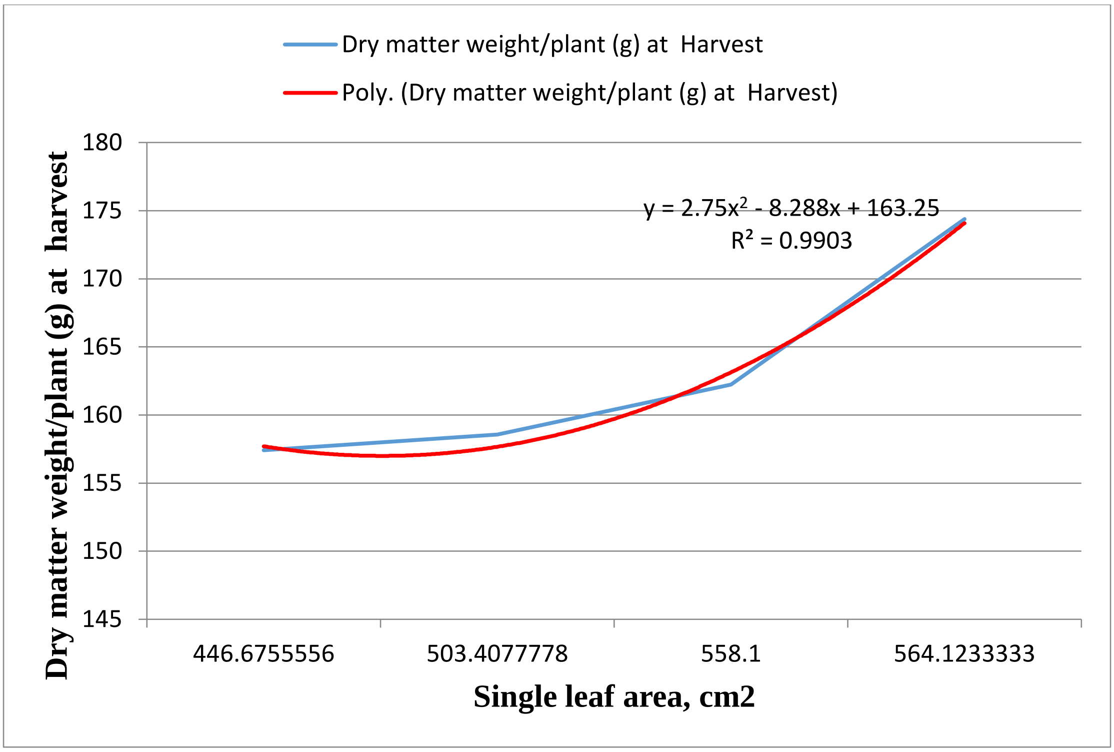

Fig 5. Regression analysis curve with leaf area and dry matter weight plant^{-1} (g) at maturity at varying fertilizer application scenario

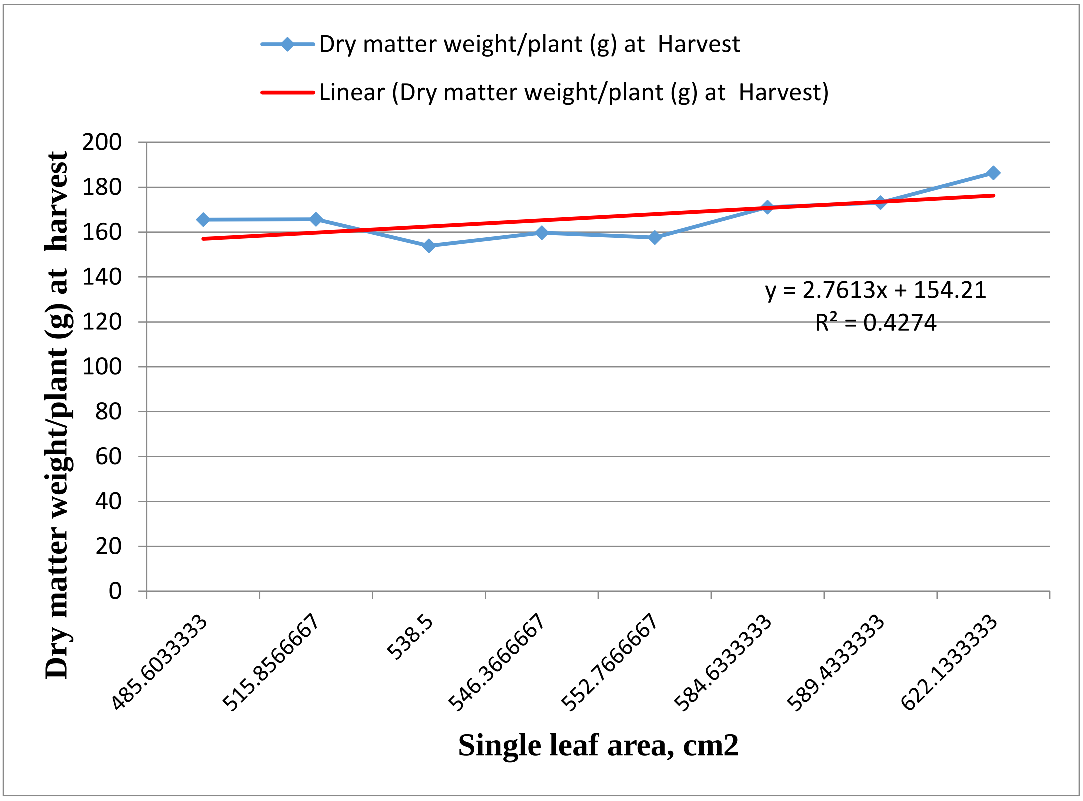

Fig 6. Dry matter weight plant^{-1} (g) at Harvest at the interaction scenario of varying spacing and fertilizer application

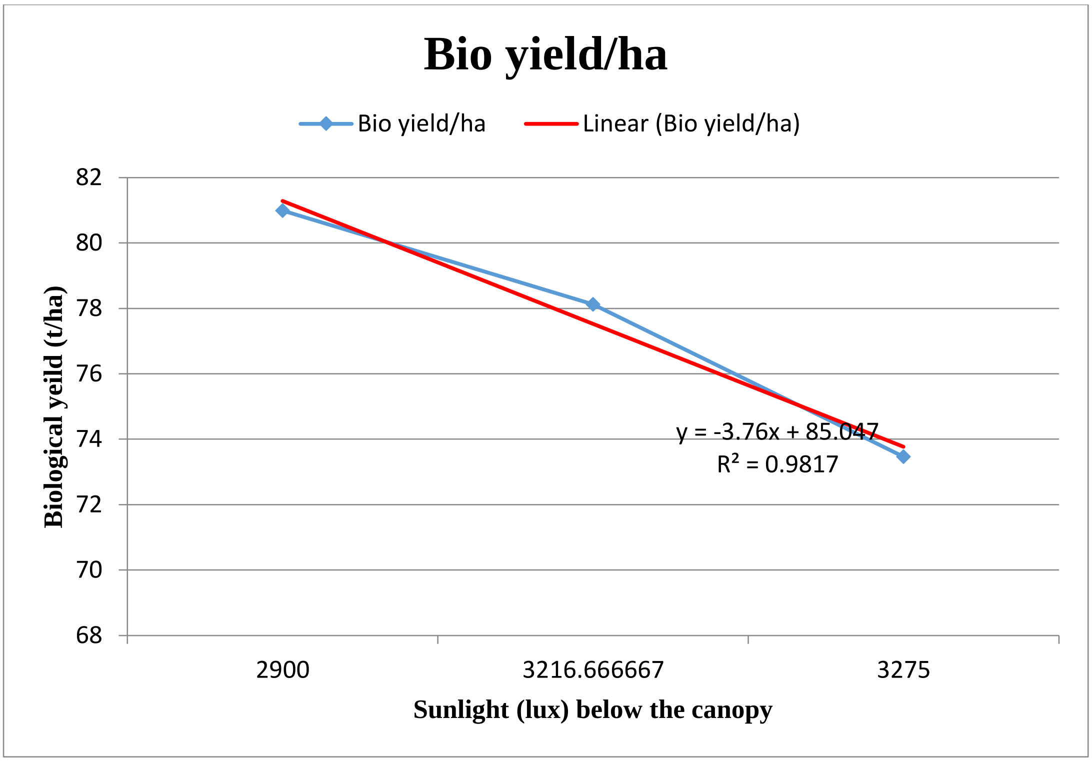

Fig 7. Regression analyses of biological yield (t ha^{-1}) with sunlight below the canopy at varying spacing scenario

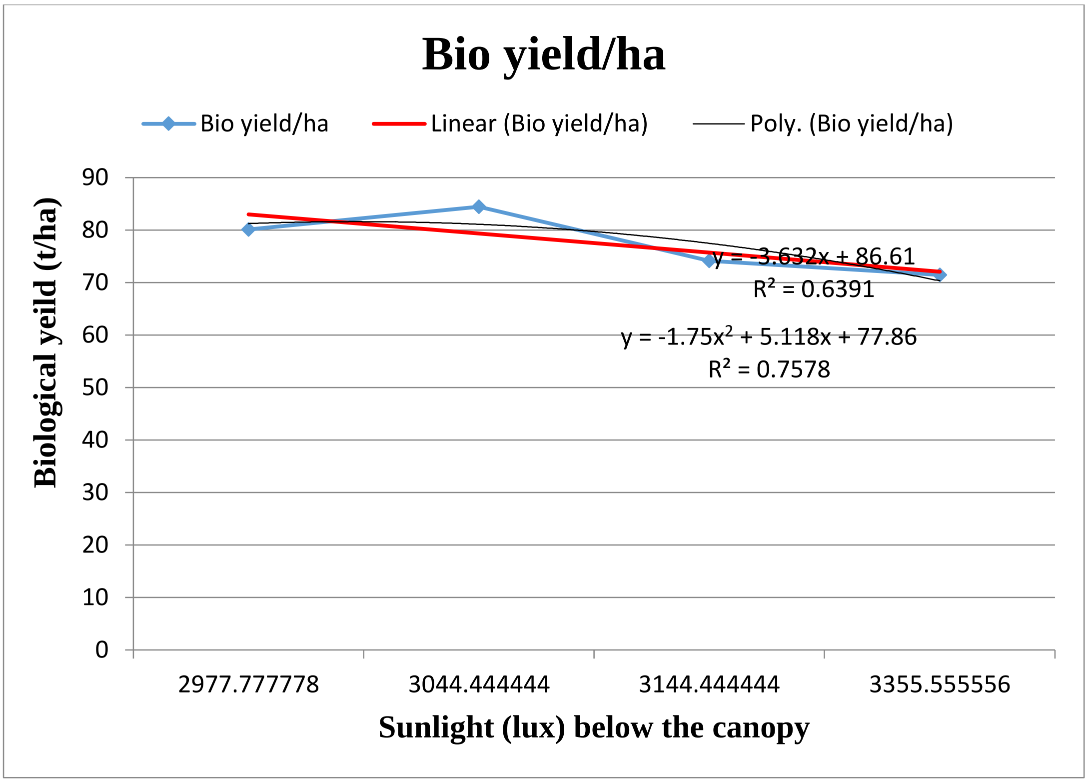

Fig 8. Regression analyses of biological yield (t ha^{-1}) with sunlight below the canopy at varying fertilizer application scenario

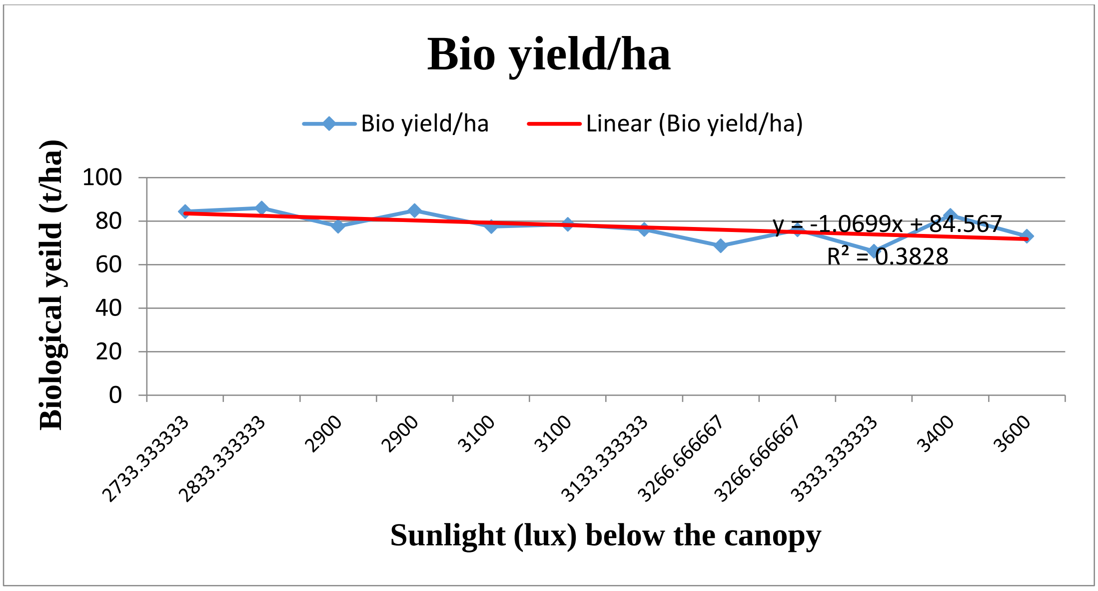

Fig 9. Regression analyses of biological yield (t ha^{-1}) with sunlight below the canopy at the interaction scenario of varying spacing and fertilizer application

CHAPTER 5

SUMMARY AND CONCLUSION

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from January to May 2021 to comparing paired row system with conventional system of planting in white maize under varying fertilizer application The experiment comprised of two factors, Factor A:different fertilizer doses i.e. F_1=100% of recommended doses of fertilizer, F_2 = 25% less than recommended doses of fertilizer, F_3 = 50% less than recommended doses of fertilizer, F_4 =25% more than recommended doses of fertilizer; and factor B Sowing methods: S_1 =sowing in line using planting configuration 50 cm x 25 cm, S_2 = sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm equivalent to 40 cm x 25 cm, S_3 = Sowing in paired rows with 70 cm between two adjacent paired rows with planting configuration of 30 cm x 25 cm equivalent to 50 cm x 25 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. Due the influence of fertilizer treatment, plant height range from 189.28 cm to 202.02 cm. The tallest plant was recorded in F_4 treatment and shortest plant was recorded in F_3 treatment. As having influence of spacing on plant height, the tallest plant (203.16cm) was recorded in S_1 while shortest plant (189.64 cm) was in S_2. For combined effect plant height ranges from 208.67 cm to 185.45 cm. At harvest, F_4S_1 showed the tallest plant (208.67cm) which was similar with F_1S_1, F_2S_1 and F_4S_3; whereas F_3S_2 showed the smallest plant (185.45 cm) which was similar with F_1S_3, F_2S_3, F_3S_1 and F_3S_3. Fertilizer doses showed a non-significant variation on no. of leaves plant^{-1} of maize at 60 DAS and 80 DAS and harvest. At 60 DAS, F_4 showed the highest number of leaves plant^{-1} (11.77) which was statistically similar with F_2; whereas F_3 showed the lowest number of leaves plant^{-1} (10). At 80 DAS, F_4 showed the highest number of leaves plant^{-1} (11.88); whereas F_2 showed the lowest number of leaves plant^{-1} (10) which was statistically similar with F_1, F_3 .At harvest, F_4 showed maximum number of leaves (12.44) and T3 showed minimum number of leaves (11). Data showed that higher leaves number plant^{-1} was achieved with higher plant spacing where lower plant spacing showed lower leaf number plant^{-1}. The highest leaves number plant^{-1} at

60, 80 DAS and at harvest were 12.08, 11.75 and 12.58 respectively with S_1 where the lowest were 9.83, 9.66 and 10.5 respectively which was with S_2.The treatment combination, F_4S_1 gave the highest leaf number plant^{-1} 13, 13 and 13.66 at 60, 80 DAS and at harvest respectively. The treatment combination F_1S_2, F_3S_2 at 60 DAS and F_1S_2 at 80 DAS and F_3S_2 at harvest gave the lowest leaf number plant^{-1} (10, 9 and 10 respectively). Due to application of fertilizer the cob length showed similar trend with fertilizer doses. Fertilizer doses showed a non-significant variation in respect of dry matter weight plant^{-1} through the growth periods. At 60, F_4 showed the highest dry matter weight plant^{-1} (89.08g); whereas F_2 showed the lowest dry matter weight plant^{-1} (69.2 g). At 80 DAS, F_4 showed the highest dry matter weight plant-^{1} (93.68 g) which was statistically similar with F_1 and F_2; whereas F_3 the lowest dry matter weight plant^{-1} (82.42 g) which was statistically similar with F_2. At 9 harvest, F_4 showed the highest dry matter weight plant^{-1} (174.39 g) which was statistically similar with F_1; whereas F_3 showed the lowest dry matter weight plant^{-1} (157.41 g) which was statistically similar with F_2. Spacing treatments showed significant variation at 60 DAS and non- significant variation at 80DAS and harvest in respect of dry matter weight plant^{-1} through the growth periods. At 60, S_1 showed the highest dry matter weight plant^{-1} (95.25 g); whereas S_2 showed the lowest dry matter weight plant^{-1} (66.55 g). At 80 DAS, S_1 showed the highest dry matter weight plant^{-1} (94.2 g) which was statistically similar with S_3; whereas S_2 showed the lowest dry matter weight plant^{-1} (79.69 g). At 9 harvest, S_1 showed the highest dry matter weight plant^{-1} (172.95 g); whereas S_2 showed the lowest dry matter weight plant^{-1} (155.27 g) which was statistically similar with S_3. Combined effect of fertilizer and spacing had non- significant effect on dry matter weight plant^{-1} of maize. At 60DAS, F_4S_1 combination produced the dry matter weight plant^{-1} (120.2 g) which is statistically similar with F_3S_1; whereas F_2S_1 combination produced the lowest dry matter weight plant^{-1} (66.37 g).At 80 DAS,T1S_1 showed highest dry matter weight plant^{-1} (102.67 g) and F_3S_2 showed lowest dry matter weight plant^{-1} (65.23 g) and at harvest,F_4S_1 showed highest dry matter weight plant^{-1} (186.41 g) and F_3S_2 showed lowest dry matter weight plant^{-1} (149.21 g).

Numerically, cob length ranges from 14.98 cm to 17.62 cm. The highest cob length (17.62 cm) was recorded in F_4 treatment and lowest cob length (14.98 cm) was recorded in F_3 treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated proper reproductive growth of plant. Due to influence of spacing the highest cob length was recorded in S_1 while lowest cob length was in S_2. The cob length ranges from 14.30 cm to 17.43 cm. Combined effect of fertilizer and spacing produced statistically non- significant cob length. For combined effect cob length ranges from 13.7 cm to 19.02 cm. The highest cob length was found in F_4S_1 which is statistically similar with F_1S_1 and F_4S_3 whereas lowest cob length was found in F_2S_2 which statistically similar with F_1S_1, F_3S_2 and F_4S_2 combination. Due to application of different levels of fertilizer, the range of cob diameter was found 13.47 cm to 17.22 cm. The highest cob circumference was recorded in F_4 (17.22 cm) and lowest cob circumference was recorded in F_3 (13.47 cm) which is statistically similar with T2. Impact of spacing on maize showed significant effect for cob circumference. The highest cob circumference was found in S_1 spacing (16.64 cm) while lowest cob circumference was recorded in S_2 treatment (13.77 cm). Combined effect of fertilizer and spacing had non- significant effect on cob circumference of maize. The cob circumference ranges from 12.1 cm to 18.53 cm while F_4S_1 combination produced the highest cob circumference (18.53 cm) which is statistically similar with F_1S_1; whereas F_3S_2 combination produced the lowest cob circumference (12.1 cm). The shell weight range from 12.13g to 14.4g among the fertilizer doses. The highest shell weight was recorded in F_4 (25% more than recommended doses of fertilizer) treatment and lowest shell weight was recorded in F_3 (50% less than recommended doses of fertilizer) treatment. The highest shell weight (15.1g) was recorded in S_1 while lowest shell weight (10.68g) was in S_2.). For combined effect shell weight ranges from 8.66 g to 16.83 g due to different combinations. The highest shell weight was found in F_4S_1 combination which was statistically similar with F_1S_1 and F_4S_3. The lowest shell weight was found in F_2S_2 which was statistically similar with F_3S_2.Number of seeds cob^{-1} increased steadily with the increment of fertilizer doses from the lowest to highest doses. The number of seeds cob^{-1} range from 353.89 to 403 due to different levels of fertilizers. The maximum number of seeds cob^{-1} was recorded in F_4 (50% more than recommended doses of fertilizer) treatment and minimum number of seeds cob^{-1} was recorded in F_3 (50% less than recommended doses of fertilizer) treatment. This might be due to the steady supply of nutrient from F_4 treatment facilitated proper growth of plant. The non-significant influence of spacing facilitated maximum number of seeds cob^{-1} (391.83) in S_1 while minimum number of seeds cob^{-1} (351.33) was in S_2. Among the different combinations the number of seeds cob^{-1} ranges from 323.67 to 423). The maximum number of seeds cob^{-1} was found in F_4S_1 which was statistically similar with F_1S_1 and

F_4S_3 whereas minimum number of seeds cob^{-1} was found in F_2S_2 which is statistically similar with F_3S_2 combination. The weight of 100 seeds increased sharply with the increases of fertilizers levels. The 100 seeds weight ranges from 23.07g to 26.99 g among the doses. The highest 100 seeds weight was recorded in F_4 treatment and lowest 100 seeds weight was recorded in F_3 treatment. This might be due to the proper supply of nutrient from F_4 treatment facilitated proper dry matter partitioning of plant. The highest 100 seeds weight was recorded in S_1 (26.98 g) spacing while lowest 100 seeds weight was in S_3 (23.23 g) spacing. The 100 values of seeds weight ranges from 21.63 g to 28.88 g among the combinations. The highest 100 seeds weight was found in F_3S_1 and lowest 100 seeds weight was found in F_3S_2 combination compared to the others combination. Grain weight $plant^{-1}$ range from 71.45 g to 84.45 g due to different levels of fertilizers. The maximum weight $plant^{-1}$ was recorded in F_4 treatment and minimum weight $plant^{-1}$ was recorded in T3 treatment. This might be due to the steady supply of nutrient from F_4 treatment facilitated proper growth of plant. The non-significant influence of spacing facilitated maximum weight of $plant^{-1}$ (80.99 g) in S_1 while minimum weight of $plant^{-1}$ (73.47g) was in S_2. Among the different combinations the weight of grain $plant^{-1}$ ranges from 66.16g to 85.93g. The maximum weight of grain $plant^{-1}$ was found in F_4S_1 which was statistically with F_1S_1, F_1S_3, F_2S_1, F_4S_2, F_4S_3 combination whereas minimum weight of grain plant $^{-1}$ (66.16 g) was found in F_3S_2 combination. , the higher doses of fertilizers (F_4) increased grain yield (non-significantly) and stover yield, biological yield significantly than recommended doses. On the others hand, lower doses (F_3) produced lower grain yield, stover yield and biological yield than recommend doses (F_1) in maize. Due to application of different levels of fertilizer, the range of grain yield, stover yield and biological yield of maize was found 6.18 t ha^{-1} to 7.16 th a^{-1}, 8.37 t ha^{-1} to 11.81 t ha^{-1} and 14.55 t ha^{-1} to 19.08 t ha^{-1} respectively. The highest grain yield, stover yield and biological yield were recorded in F_4 (50% more than recommended doses of fertilizer) while lowest grain yield, stover yield and biological yield were recorded in F_3 (50% less than recommended dos ha^{-1} of fertilizer). This might be due to adequate nutrient was in F_4 treatment. Different spacing had significant effect on stover yield (t ha^{-1}) of maize. Results represented in table 33 indicated that the highest stover yield (10.99 t ha^{-1}) was attained with S_2 where the lowest (9.17 t ha^{-1}) was with S_1. Results in Table 10 showed that the highest grain yield (7.83 t ha^{-1}) was recorded from the combined effect of F_4S_2 where the lowest grain yield (5.53 t ha^{-1}) was observed by F_2S_1. Interaction effect of spacing and integrated fertilizer management regulated stover yield of maize. Result showed that the highest stover yield (12.91 t ha^{-1}) was recorded from the combined effect of F_4S_2 where the lowest stover yield (7.73 t ha^{-1}) was observed in F_3S_1. That the highest biological yield (20.74 t ha^{-1}) was recorded from the combined effect of F_4S_2 where the lowest biological yield (13.04 t ha^{-1}) was observed by F_3S_1. The results obtained from all other treatments showed intermediate results compared to the highest and the lowest value of biological yield. Different fertilizer doses affected the harvest index of white maize. The highest harvest index of white maize was found in F_3 treatment which is statistically similar with F_1 and F_2 treatment; whereas lowest harvest index was found in F_4 treatment. The ranges of harvest index was 37.13 To 40.38. Different spacing has non-significant effects on white maize harvest index.S_3 (40.25) spacing showed the highest harvest index which is statistically similar with S_2; whereas S_1 showed the lowest harvest index (37.21). Interaction effect of spacing and fertilizer doses on harvest index of maize is presented in Table 36. Results in table 36 showed that the highest harvest index (42.73%) was recorded from the combined effect of F_3S_3 where the lowest harvest index (35.3%) was observed by F_4S_1.

Yield and yield contributing parameters were regulated by different treatment combinations. It was evident that the highest plant height (208.67 cm), number of leaves (13.66), dry matter weight at 60 DAS and harvest, cob length (19.02 cm), cob circumference (18.53 cm), number of grains cob^{-1} (423), shell weight (16.83) and 100-grains weight (28.88 g), grain weight per plant (85.93 g) were achieved by F_4S_1 and in case of sunshine below the canopy of the plants F_4S_2 had highest sunshine. The lowest plant height (185.43),no of leaves (10), dry matter weight at 80 DAS and at harvest, cob length (13.7 cm), cob circumference (12.1 cm), 100 grain weight (21.63 g) were achieved by F_3S_2, however lowest shell weight (8.66 g) ,number of per cob(323.67) were obtained from F_2S_2. But in terms of grain yield (7.83 t ha^{-1}), stover yield (12.91 t ha^{-1}) and biological yield (20.74 t ha^{-1}), the highest result was obtained with F_4S_2 where the lowest grain yield (5.67 t ha^{-1}), stover yield (7.37 t ha^{-1}) and biological yield (13.04 t ha^{-1}) were with F_3S_1. In case of harvest index highest result was (42.73%) for F_3S_3 and the lowest result was (35.3%) for F_4S_1. It may be concluded from the results that plant spacing and integrated fertilizer management is very much promising for higher maize yield. The best plant spacing was (50 cm ×25 cm) and 25% more than recommended dose was showed better performance on growth and yield under the present study.

Though the combination of F_4S_2 (Sowing in paired rows with 50 cm between two adjacent paired rows with planting configuration of (30 cm x 25 cm) and 125% recommended dose) performed best in term of producing the highest yield compared to other treatments combination under the present study. This is because, lower spacing contained higher number in plant per area. However, interactions of (50 cm × 25 cm) plant spacing with 125% 0f recommended dose showed its superiority in producing the highest grain of maize. The present research work was carried out at the Sher-e-Bangla Agricultural University and in one season only. Further trial of this work in different locations of the country is needed to justify the present findings and arrive at a definite conclusion.

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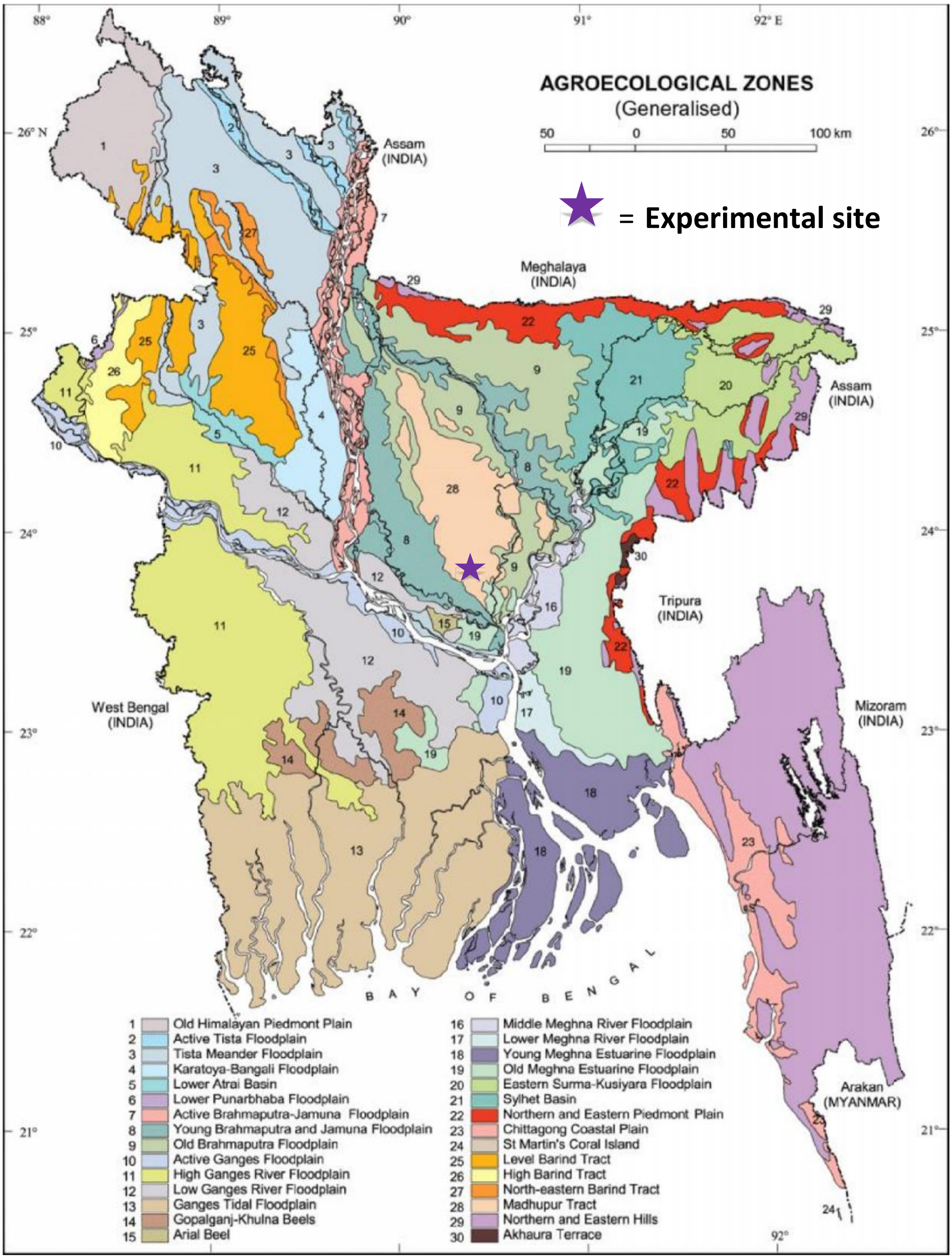
APPENDIX

APPENDIXI 1.

Experimental location on the map of Agro- ecological Zones of Bangladesh



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28 , Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm) 20.54	
Exchangeable K (me/100 g soil) 0.10	

Source: Soil Resource and Development Institute (SRDI), Farmgate, Dhaka

Appendix III

A. Analysis of variance of the data on plant height (cm) at 20 DAS

Source	DF	SS	MS	F	P
rep	2	0.077	0.039		
fertilize	3	361.483	120.494	24.27	0.0009
Error rep*fertilize	6	29.789	4.965		
spacing	2	77.576	38.788	29.46	0.0000
fertilize*spacing	6	20.158	3.360	2.55	0.0629
Error rep*fertilize*spacing	16	21.067	1.317		
Total	35	510.150			
Grand Mean	34.247				
CV(rep*fertilize)	6.51				
CV(rep*fertilize*spacing)	3.35				

B. Analysis of variance of the data on plant height (cm) at 40 DAS

Source	DF	SS	MS	F	P
rep	2	9.987	4.9936		
fertilize	3	64.761	21.5870	17.25	0.0024
Error rep*fertilize	6	7.511	1.2518		
spacing	2	31.174	15.5869	3.41	0.0585
fertilize*spacing	6	519.991	86.6651	18.95	0.0000
Error rep*fertilize*spacing	16	73.189	4.5743		
Total	35	706.612			
Grand Mean	77.028				
CV(rep*fertilize)	1.45				
CV(rep*fertilize*spacing)	2.78				

C. Analysis of variance of the data on plant height (cm) at 60DAS

Source	DF	SS	MS	F	P
rep	2	65.58	32.792		
fertilize	3	472.02	157.340	3.78	0.0778
Error rep*fertilize	6	249.48	41.580		
spacing	2	650.72	325.362	10.46	0.0012
fertilize*spacing	6	224.47	37.411	1.20	0.3544
Error rep*fertilize*spacing	16	497.68	31.105		
Total	35	2159.95			
Grand Mean	164.60				
CV(rep*fertilize)	3.92				
CV(rep*fertilize*spacing)	3.39				

D. Analysis of variance of the data on plant height (cm) at 80 DAS

Source	DF	SS	MS	F	P
rep	2	167.36	83.680		
fertilize	3	1808.71	602.903	27.52	0.0007
Error rep*fertilize	6	131.43	21.906		
spacing	2	1217.31	608.656	40.38	0.0000
fertilize*spacing	6	126.19	21.031	1.40	0.2759
Error rep*fertilize*spacing	16	241.19	15.074		
Total	35	3692.19			
Grand Mean	177.79				
CV(rep*fertilize)	2.63				
CV(rep*fertilize*spacing)	2.18				

E. Analysis of variance of the data on plant height (cm) at harvest

Source	DF	SS	MS	F	P
rep	2	294.87	147.434		
fertilize	3	858.66	286.221	13.09	0.0048
Error rep*fertilize	6	131.21	21.868		
spacing	2	1236.93	618.465	20.10	0.0000
fertilize*spacing	6	107.10	17.851	0.58	0.7410
Error rep*fertilize*spacing	16	492.33	30.770		
Total	35	3121.10			
Grand Mean	195.00				
CV(rep*fertilize)	2.40				
CV(rep*fertilize*spacing)	2.84				

Appendix IV

A. Analysis of variance of the data on number of leaves at 60 DAS

Source	DF	SS	MS	F	P
rep	2	1.1667	0.5833		
fertilize	3	14.8889	4.9630	15.31	0.0032
Error rep*fertilize	6	1.9444	0.3241		
spacing	2	30.5000	15.2500	274.50	0.0000
fertilize*spacing	6	0.6111	0.1019	1.83	0.1556
Error rep*fertilize*spacing	16	0.8889	0.0556		
Total	35	50.0000			
Grand Mean	11.000				
CV(rep*fertilize)	5.18				
CV(rep*fertilize*spacing)	2.14				

B. Analysis of variance of the data on number of leaves at 80 DAS

Source	DF	SS	MS	F	P
rep	2	0.0556	0.0278		
fertilize	3	18.3333	6.1111	8.80	0.0129
Error rep*fertilize	6	4.1667	0.6944		
spacing	2	26.0556	13.0278	469.00	0.0000
fertilize*spacing	6	0.1667	0.0278	1.00	0.4586
Error rep*fertilize*spacing	16	0.4444	0.0278		
Total	35	49.2222			
Grand Mean	10.722				
CV(rep*fertilize)	7.77				
CV(rep*fertilize*spacing)	1.55				

C. Analysis of variance of the data on no. of leaves at harvest

Source	DF	SS	MS	F	P
rep	2	1.5556	0.7778		
fertilize	3	10.7500	3.5833	5.37	0.0389
Error rep*fertilize	6	4.0000	0.6667		
spacing	2	26.0556	13.0278	469.00	0.0000
fertilize*spacing	6	0.1667	0.0278	1.00	0.4586
Error rep*fertilize*spacing	16	0.4444	0.0278		
Total	35	42.9722			
Grand Mean	11.528				
CV(rep*fertilize)	7.08				
CV(rep*fertilize*spacing)	1.45				

Appendix V

A. Analysis of variance of the data on dry weight plant^{-1} at 60 DAS

Source	DF	SS	MS	F	P
rep	2	7.8	3.91		
fertilize	3	1943.4	647.82	40.27	0.0002
Error rep*fertilize	6	96.5	16.09		
spacing	2	4943.1	2471.53	94.35	0.0000
fertilize*spacing	6	3712.0	618.67	23.62	0.0000
Error rep*fertilize*spacing	16	419.1	26.20		
Total	35	11122.0			
Grand Mean	81.013				
CV(rep*fertilize)	4.95				
CV(rep*fertilize*spacing)	6.32				

B. Analysis of variance of the data on dry weight plant^{-1} at 80 DAS

Source	DF	SS	MS	F	P
rep	2	45.16	22.580		
fertilize	3	861.18	287.060	3.22	0.1040
Error rep*fertilize	6	535.65	89.275		
spacing	2	1320.87	660.435	8.60	0.0029
fertilize*spacing	6	752.90	125.484	1.63	0.2017
Error rep*fertilize*spacing	16	1228.47	76.779		
Total	35	4744.24			
Grand Mean	88.289				
CV(rep*fertilize)	10.70				
CV(rep*fertilize*spacing)	9.92				

C. Analysis of variance of the data on dry weight plant^{-1} at harvest

Source	DF	SS	MS	F	P
rep	2	876.09	438.044		
fertilize	3	1630.39	543.465	3.01	0.1162
Error rep*fertilize	6	1082.46	180.409		
spacing	2	1943.06	971.529	10.78	0.0011
fertilize*spacing	6	63.33	10.555	0.12	0.9928
Error rep*fertilize*spacing	16	1441.91	90.120		
Total	35	7037.24			
Grand Mean	163.15				
CV(rep*fertilize)	8.23				
CV(rep*fertilize*spacing)	5.82				

Appendix V I

Analysis of variance of the data for cob length

Source	DF	SS	MS	F	P
rep	2	17.459	8.7293		
fertilize	3	36.066	12.0219	14.02	0.0040
Error rep*fertilize	6	5.143	0.8572		
spacing	2	61.312	30.6562	26.43	0.0000
fertilize*spacing	6	3.658	0.6097	0.53	0.7808
Error rep*fertilize*spacing	16	18.560	1.1600		
Total	35	142.198			
Grand Mean	16.067				
CV(rep*fertilize)	5.76				
CV(rep*fertilize*spacing)	6.70				

Appendix V II

Analysis of variance of the data for cob circumference

Source	DF	SS	MS	F	P
rep	2	3.764	1.8818		
fertilize	3	78.682	26.2275	43.69	0.0002
Error rep*fertilize	6	3.602	0.6004		
spacing	2	49.462	24.7311	91.80	0.0000
fertilize*spacing	6	0.971	0.1619	0.60	0.7258
Error rep*fertilize*spacing	16	4.310	0.2694		
Total	35	140.792			
Grand Mean	15.193				
CV(rep*fertilize)	5.10				
CV(rep*fertilize*spacing)	3.42				

Appendix V III

Analysis of variance of the data for Shell weight

Source	DF	SS	MS	F	P
rep	2	13.933	6.9667		
fertilize	3	32.291	10.7636	15.58	0.0031
Error rep*fertilize	6	4.145	0.6908		
spacing	2	119.148	59.5738	28.51	0.0000
fertilize*spacing	6	20.261	3.3768	1.62	0.2067
Error rep*fertilize*spacing	16	33.437	2.0898		
Total	35	223.214			
Grand Mean	13.060				
CV(rep*fertilize)	6.36				
CV(rep*fertilize*spacing)	11.07				

Appendix I X

Analysis of variance of the data for number of grain cob^{-1}

Source	DF	SS	MS	F	P
rep	2	32.7	16.36		
fertilize	3	15451.6	5150.52	26.37	0.0007
Error rep*fertilize	6	1171.9	195.32		
spacing	2	10090.9	5045.44	24.99	0.0000
fertilize*spacing	6	1073.1	178.85	0.89	0.5276
Error rep*fertilize*spacing	16	3230.7	201.92		
Total	35	31050.9			
Grand Mean	373.44				
CV(rep*fertilize)	3.74				
CV(rep*fertilize*spacing)	3.81				

Appendix X

Analysis of variance of the data for grain weight cob^{-1}

Source	DF	SS	MS	F	P
rep	2	238.89	119.446		
fertilize	3	928.23	309.409	18.45	0.0020
Error rep*fertilize	6	100.62	16.769		
spacing	2	344.96	172.478	7.03	0.0065
fertilize*spacing	6	81.16	13.527	0.55	0.7623
Error rep*fertilize*spacing	16	392.71	24.545		
Total	35	2086.57			
Grand Mean	77.532				
CV(rep*fertilize)	5.28				
CV(rep*fertilize*spacing)	6.39				

Appendix X I

Analysis of variance of the data for 100 seed weight

Source	DF	SS	MS	F	P
rep	2	8.528	4.2641		
fertilize	3	72.944	24.3146	12.88	0.0050
Error rep*fertilize	6	11.330	1.8884		
spacing	2	83.949	41.9746	77.54	0.0000
fertilize*spacing	6	1.932	0.3220	0.59	0.7303
Error rep*fertilize*spacing	16	8.661	0.5413		
Total	35	187.344			
Grand Mean	25.118				
CV(rep*fertilize)	5.47				
CV(rep*fertilize*spacing)	2.93				

Appendix X II

Analysis of variance of the data for grain yield ha^{-1}

Source	DF	SS	MS	F	P
rep	2	0.3395	0.16973		
fertilize	3	6.5959	2.19864	54.66	0.0001
Error rep*fertilize	6	0.2413	0.04022		
spacing	2	10.8683	5.43416	235.41	0.0000
fertilize*spacing	6	0.3606	0.06010	2.60	0.0590
Error rep*fertilize*spacing	16	0.3693	0.02308		
Total	35	18.7750			
Grand Mean	6.6233				
CV(rep*fertilize)	3.03				
CV(rep*fertilize*spacing)	2.29				

Appendix X III

(Analysis of variance of the data for stover yield)

Source	DF	SS	MS	F	P
rep	2	42.037	21.0186		
fertilize	3	61.231	20.4102	34.15	0.0004
Error rep*fertilize	6	3.586	0.5977		
spacing	2	20.002	10.0012	46.68	0.0000
fertilize*spacing	6	2.233	0.3721	1.74	0.1765
Error rep*fertilize*spacing	16	3.428	0.2142		
Total	35	132.517			
Grand Mean	10.083				
CV(rep*fertilize)	7.67				
CV(rep*fertilize*spacing)	4.59				

Appendix X IV

Analysis of variance of the data for biological yield

Source	DF	SS	MS	F	P
rep	2	45.951	22.9753		
fertilize	3	111.012	37.0039	109.23	0.0000
Error rep*fertilize	6	2.033	0.3388		
spacing	2	57.082	28.5409	143.5	0.0000
fertilize*spacing	6	1.976	0.3293	1.6	0.1960
Error rep*fertilize*spacing	16	3.181	0.1988		
Total	35	221.234			
Grand Mean	16.734				
CV(rep*fertilize)	3.48				
CV(rep*fertilize*spacing)	2.66				

Appendix X V

Analysis of variance of the data for harvest index

Source	DF	SS	MS	F	P
rep	2	129.940	64.9699		
fertilize	3	56.651	18.8836	8.14	0.0155
Error rep*fertilize	6	13.917	2.3196		
spacing	2	70.377	35.1884	9.67	0.0018
fertilize*spacing	6	26.883	4.4806	1.23	0.3418
Error rep*fertilize*spacing	16	58.249	3.6406		
Total	35	356.017			
Grand Mean	39.189				
CV(rep*fertilize)	3.89				
CV(rep*fertilize*spacing)	4.87				

PLATES

Plate 1. Photograph showing general view of experimental plot

Plate 2. Photograph showing general view of experimental plot at seedling stage

Plate 3. Photograph showing general view of experimental plot at vegetative stage