EFFECT OF PLANTING CONFIGURATION ON THE GROWTH AND YIELD OF WHITE MAIZE

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CERTIFICATE

*This is to certify that the thesis entitled **"EFFECT OF PLANTING CONFIGURATION ON THE GROWTH AND YIELD OF WHITE MAIZE"** 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 (MS)** in **AGRONOMY,** embodies the results of a piece of bona fide research work carried out by **MD. AZAD HOSSAIN,** Registration. No.* ***10-03774*** *under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

Dated:

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DEDICATED

TO

MY BELOVED PARENTS

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The author

EFFECT OF PLANTING CONFIGURATION ON THE GROWTH AND YIELD OF WHITE MAIZE

ABSTRACT

The present piece of work was performed at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2015 to April, 2016 to study effect of effect of planting configuration on the growth and yield of white maize. The experiment comprised of two factors *viz*. factor A: Two white maize varieties (V_1 = KS-510 and V_2 = PSC-121) and factor B: five plant spacing (T_1= 40 cm × 25 cm spacing, T_2= 50 cm × 25 cm spacing, T_3= 60 cm × 25 cm spacing, T_4= 70 cm × 25 cm spacing and T_5= Double rows of 50 cm × 25 cm spacing). The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The results of the experiment revealed that, both varieties of white maize showed similar result in most of the plant characters. The highest grains cob^{-1} (506.5), grains row^{-1} (36.05) and rows cob^{-1} (14.11) were recorded from plant spacing 70 cm × 25 cm. Plant spacing double rows of 50 cm × 25 cm performed best among five plant spacing in case of 100 grain weight (40.17 g**)**, grain yield (9.68 t ha^{-1}**),** stover yield (13.62 t ha^{-1}**),** biological yield (23.30 t ha^{-1}**)** and harvest index (41.47 %). Plant spacing 40 cm × 25 cm showed the lowest result in all yield and yield contributing characters. Interaction of variety PSC-121 with double rows of 50 cm × 25 cm plant spacing gave highest 100 grain weight (40.33 g**)**, grain yield (10.50 t ha^{-1}**),** stover yield (14.01 t ha^{-1}**),** biological yield (24.51 t ha^{-1}**)** and harvest index (42.84 %). On the other hand interaction of variety PSC-121 with plant spacing 40 cm × 25 cm showed the lowest results. So, it may be concluded that white maize variety PSC-121along with double rows of 50 cm × 25 cm plant spacing might be suggested to be followed in white maize production.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
BBS	=	Bangladesh Bureau of Statistics
LAI	=	Leaf area index
ppm	=	Parts per million
et al.	=	And others
N	=	Nitrogen
TSP	=	Triple Super Phosphate
MP	=	Muriate of Potash
RCBD	=	Randomized complete block design
DAS	=	Days after sowing
ha^{-1}	=	Per hectare
G	=	Gram (g)
Kg	=	Kilogram
µg	=	Micro gram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
HI	=	Harvest Index
No.	=	Number
WUE	=	Water use efficiency
Wt.	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Non significant
mm	=	Millimeter
Max	=	Maximum
Min	=	Minimum
%	=	Percent
cv.	=	Cultivar
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of coefficient of variance
Hr	=	Hour
T	=	Ton
viz.	=	Videlicet (namely)

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L) is one of the major cereal crops grown in the humid tropics and Sub-Saharan Africa but at present it is being cultivated extensively with equal success in temperate, tropical and sub-tropical regions of world. It is a versatile crop and ranks third following wheat and rice in world production as reported by Food and Agriculture Organization (FAO, 2002). Maize crop is a key source of food and livelihood for millions of people in many countries of the world. In advanced countries, it is an important source of many industrial products such as corn sugar, corn oil, corn flour, starch, syrup, brewer's grit and alcohol (Dutt, 2005). Corn oil is used for salad, soap-making and lubrication. Maize is a major component of livestock feed and it is palatable to poultry, cattle and pigs as it supplies them energy (Iken *et al*., 2001). The stalk, leaves, grain and immature ears are cherished by different species of livestock (Dutt, 2005). Between 2010 and 2050, the demand for maize in the developing world will double, and by 2025, maize is likely to become the crop with the greatest production globally (Rosegrant *et al.,* 2010).

There are a number of well recognized biotic and abiotic factors like improved varieties, irrigation, sowing time, plant population and balanced use of fertilizers each has an effective role in enhancing the yield of crop. In cereal crops maize presents the highest grain yield potential. In order to fully explore its capacity in grain production, it is necessary to understand how plants interact morphologically and physiologically in a community and to identify management practices which allow them to maximize the use of growth requirements in their environment.

Variety is an important feature for obtaining maximum production. Maximum crop production can be achieved by development of improved crop varieties and suitable growing environment and soil with optimum plant population ha^{-1}. Tolera *et al*. (1999) suggested that farmers should select maize varieties that combine high grain yield and desirable stover characteristics because of large differences that exist between cultivars. Odeleye and Odeleye (2001) reported that maize varieties differ in their growth characters, yield and its components, and therefore suggested that farmers must select most promising combiners during commercial cultivation of maize.

Plant density is one of the most important cultural practices which determine grain yield as well as other important agronomic attributes of this crop (Songoai, 2001). Vega *et al.* (2001) and (Luque *et al.*, 2006) also reported that other member of the grass family, maize differs in its responses to plant density. Optimum plant population is the prerequisite for obtaining maximum yield (Trenton and Joseph 2007; Gustavo *et al*., 2006). Liu *et al*. (2004) also reported that maize yield differs significantly under varying plant density levels due to difference in genetic potential. Correspondingly maize also responds differently in quality parameters like crude starch, protein and oil contents in grains (Munamava *et al*., 2006). Plant populations affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants (Sangakkara *et al*., 2004).

The grain yield per plant is decreased in response to decreasing light and other environmental resources available to each plant (Ali *et al*., 2003). Stand density affects plant architecture, alters growth and developmental patterns and influences carbohydrate production. At low densities, many modern maize varieties do not tiller effectively and quite often produce only one ear per plant. Whereas, the use of high population increases interplant competition for light, water and nutrients, which may be detrimental to final yield because it stimulates apical dominance, induces barrenness, and ultimately decreases the number of ears produced per plant and kernels set per ear (Sangoi, 2001). In dense population most plants remain barren ear and ear size remain smaller, crop become susceptible to lodging, disease and pest, while plant population at sub-optimum level resulted lower yield per unit area (Nasir, 2000). High plant population leads to lodging of maize plants (Trenton and Joseph, 2007). In case of low plant density, yield per unit area is reduced because of lesser than optimum plants (Cardwell, 1982).

Plant population and row width determine light interception and consequently photosynthesis and yield (Stewart *et al*., 2003). Papadopoulos and Pararajasingham (1997) noted that it is possible to manipulate plant spacing to maximize light interception in any crop. Nafziger (2006) observed that, within the normal range of crop population, the increase in crop yield from increasing plant population is related to the increase in light interception. He further noted that maximizing light interception during grain production is of paramount importance to optimum grain yield. Board *et al*. (1992) observed greater light interception in the narrow row culture (0.5m) compared to the wide row culture (1m). They noted that this occurred during vegetative and early reproductive periods of plant growth. Similarly, Zhang *et al*. (2008) reported that the best distribution of light is attained in systems with narrow strips and high plant densities. Increasing plant density through narrow row planting of maize could increase light interception and consequently increase grain yield. Just like other resources, nitrogen (N) uptake seems to be closely related to plant spacing. Ciampitti and Vyn (2011) reported high N uptake and use efficiency in narrow rows with a high plant density. Narrowing maize rows enables plants to occupy spaces between plants, utilizing the applied N fertilizer that would otherwise be lost. A similar study by Barbieri *et al.* (2008) found that N uptake increased with narrow row spacing. They realized a 15% increase in N uptake expressed as grain yield with narrow maize rows. Many studies have been conducted on varietal variation, crop spacing. However, little attempt has been made to explain the relationship and interaction between these factors and the resulting effects on maize grain yield.

Keeping this in view, the present study was formulated under following objectives:

i. To observe the varietal performance of two varieties of white maize.
ii. To determine the optimum spacing for higher growth and yield of white maize.
iii. To determine the responses of growth and yield characters of white maize to variety and plant spacing.

CHAPTER II

REVIEW OF LITERATURE

Variety is an important factor as it influences the plant population per unit area, availability of sunlight, nutrient competition, photosynthesis, respiration etc. which ultimately influence the growth and development of the crops. In agronomic point of view spacing for modern maize cultivation has become an important issue. Considering the above points, available literature was reviewed under different maize variety and spacing management of maize.

2.1Effect of variety

Plant height

The experiment was carried out by Asaduzzaman *et al*. (2014) to find out the suitable variety and N fertilizer rate for baby corn production at the Regional Station under Bangladesh Agricultural Research Institute at Jamalpur, Bangladesh during rabi season of 2008-09. Four baby corn varieties *viz*. Hybrid baby corn-271, Shuvra, Khoibhutta and BARI sweet corn-1 were planted at five N fertilizer rates viz. 0, 80, 120, 160 and 200 kg N ha^{-1} in the experiment. They reported that, variety Shuvra produced the tallest plant (179.1 cm) and BARI sweet corn-1 produced the shortest plant (149.3 cm).

A study was carried out by Enujeke (2013a) 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 diameter. The results obtained during the 8^{th} week after sowing indicated that hybrid variety 9022-13 which had higher plant height of 170.0cm where as the Oba Super 2 gave the lowest plant height 156.3 cm.

Studies were conducted by Asafu-Agyei (1990) in four locations in Ghana in 1986 to determine the effect of seven planting densities: 10, 20, 30, 40, 50, 60 and 70 x 10^3 $plants^{-1}$ ha on grain yield of three maize varieties differing in maturity: early, medium and full season. He reported that, the highest plant height (223 cm) was recorded from Dobidi variety and the lowest one (170 cm) from Dorke variety.

Number of leaves $plant^{-1}$

Enujeke (2013a) conducted an experiment 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 diameter. The results obtained during the 8th week after sowing revealed that hybrid variety 9022-13 which gave highest number of leaves of 13.2 and the lowest number of leaves 12.2 was recorded from Oba Super 2.

Leaf area

The experiment was carried out by Asaduzzaman *et al*. (2014) to find out the suitable variety and N fertilizer rate for baby corn production at the Regional Station under Bangladesh Agricultural Research Institute at Jamalpur, Bangladesh during *rabi* season of 2008-09. Four baby corn varieties viz. Hybrid baby corn-271, Shuvra, Khoibhutta and BARI sweet corn-1 were planted at five N fertilizer rates viz. 0, 80, 120, 160 and 200 kg N ha^{-1} in the experiment. They reported that, Shuvra gave the highest LAI (5.50) and the lowest one (3.10) was noted for BARI sweet corn-1.

A study was conducted by Enujeke (2013a) 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 recorded during the 8th week after sowing indicated that the maximum leaf area 673.2cm^2 was recorded from hybrid variety 9022-13 where as the lowest one 576.5 cm^2 was recorded from Oba Super 2.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. Result showed that the highest leaf area index was recorded by Sarhad white and the lowest one was recorded from Pahari.

Dry matter content plant^{-1}

The experiment was carried out by Asaduzzaman *et al*. (2014) to find out the suitable variety and N fertilizer rate for baby corn production at the Regional Station under Bangladesh Agricultural Research Institute at Jamalpur, Bangladesh during *rabi* season of 2008-09. Four baby corn varieties viz. Hybrid baby corn-271, Shuvra, Khoibhutta and BARI sweet corn-1 were planted at five N fertilizer rates viz. 0, 80, 120, 160 and 200 kg N ha^{-1} in the experiment. They reported that, Hybrid baby corn-271 produced the highest (160.50 g) dry matter plant^{-1}.On the other hand Khoibhutta had the lowest dry matter plant^{-1}(122.13 g) accumulation

Stem diameter

A study was carried out by Enujeke (2013a) 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 diameter. The results obtained during the 8th week after sowing indicated that hybrid variety 9022-13 gave the highest stem diameter of 99.4mm and the lowest stem diameter 81.6 mm was given by Oba Super 2.

Number of grains ear^{-1}

A study was carried out by Enujeke (2013b) in the Teaching and Research Farm of Delta State University, Asaba Campus (Nigeria) from March to December in 2008 and replicated between March and December, 2009, to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. It was a factorial experiment carried out in a Randomized Complete Block Design (RCBD) with four replicates. Four open-pollinated varieties (Suwan -1- SR, ACR97, BR9922-DMRSF$_2$ and AMATZBRC$_2$WB) were evaluated under three different plant spacing (75 cm x 15 cm, 75 cm x 25 cm and 75 cm x 35 cm) for such yield indices as number of cobs/plant, cob length, grain weight and number of grains/cob of maize. The results obtained from the experiments indicated that the number of grains cob^{-1} of variety BR9922-DMRSF$_2$ were highest (460.0) in 2008 and (467.7) in 2009 and the lowest number of grains cob^{-1} were recorded from variety AMATZBRC$_2$WB (329.3) in 2008 and (334.13) in 2009.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that among varieties, highest number of grains ear^{-1} was recorded for Sarhad white while minimum was recorded from Pahari.

Grain yield

The experiment was carried out by Asaduzzaman *et al*. (2014) to find out the suitable variety and N fertilizer rate for baby corn production at the Regional Station under Bangladesh Agricultural Research Institute at Jamalpur, Bangladesh during *rabi* season of 2008-09. Four baby corn varieties viz. Hybrid baby corn-271, Shuvra, Khoibhutta and BARI sweet corn-1 were planted at five N fertilizer rates viz. 0, 80, 120, 160 and 200 kg N ha^{-1} in the experiment. They reported that, significantly highest corn yield without husk (1.90 t ha^{-1}) was obtained from BARI sweet corn-1 which was statistically similar to Hybrid Baby Corn-271 (1.8 t ha^{-1}) and Khoibhutta (1.80 t ha^{-1}) and the minimum ear yield (1.70 t ha^{-1}) without husk was recorded in Shuvra. The maximum ear yield with husk (12.80 t ha^{-1}) was recorded in Hybrid Baby Corn-271 and the minimum (9.70 t ha^{-1}) was recorded in Shuvra.

A study was carried out by Enujeke (2013b) in the Teaching and Research Farm of Delta State University, Asaba Campus (Nigeria) from March to December in 2008 and replicated between March and December, 2009, to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. It was a factorial experiment carried out in a Randomized Complete Block Design (RCBD) with four replicates. Four open-pollinated varieties (Suwan -1- SR, ACR97, BR9922-$DMRSF_2$ and $AMATZBRC_2WB$) were evaluated under three different plant spacing (75 cm x 15 cm, 75 cm x 25 cm and 75 cm x 35 cm) for such yield indices as number of cobs/plant, cob length, grain weight and number of grains/cob of maize. The results obtained from the study indicated that the grain yield of variety BR9922-$DMRSF_2$ were highest (4.7 t ha^{-1}) in 2008 and (4.9 t ha^{-1}) in 2009 and the lowest grain yield were recorded from variety $AMATZBRC_2WB$ (3.5 t ha^{-1}) in 2008 and (3.7 t ha^{-1}) in 2009.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that the data showed that maximum grain yield was produced by Sarhad white and minimum grain yield was gained by Pahari.

Studies were conducted by Asafu-Agyei (1990) in four locations in Ghana in 1986 to determine the effect of seven planting densities: 10, 20, 30, 40, 50, 60 and 70 x 10^3 $plants^{-1}$ ha on grain yield of three maize varieties differing in maturity: early, medium and full season. He reported that, the highest grain yield (6.0 t ha^{-1}) was recorded from Dobidi variety and the lowest grain yield (4.50 t ha^{-1}) was recorded from Dorke variety.

Stover yield

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that, in case of varieties, maximum stover yield was produced by Sarhad white and the minimum stover yield was produced by Pahari.

Biological yield

An experiment was conducted by Shafi *et al.* (2012) to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that the data showed that maximum biological yield was produced by Sarhad white and minimum by Pahari.

Harvest index

Shafi *et al.* (2012) performed a research worke to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that, maximum harvest index was recorded from Sarhad white when compared with other varieties.

2.2 Effect of spacing

Plant height

A field experiment was conducted by Mechi (2015) to assess the response of maize hybrid variety “BH-661” to nitrogen (N) fertilizer and inter row spacing in the main cropping season of 2014 at Nejo. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85cm) in randomized complete block design (RCBD) with three replications. Result revealed that, the highest plant height (291.7 cm) was recorded from inter row spacing 85 cm and the lowest plant height (240.7 cm) was recorded from inter row spacing 55 cm.

A study was carried out by Enujeke (2013a) 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 diameter. Result revealed that the highest plant height 176.7 cm was recorded from plants sown on 75 cm x 15 cm and the lowest one 152.7 cm was recorded from plants sown on 75 cm x 35 cm spacing.

Jula *et al*. (2013) conducted a field experiment during the cropping seasons of 2009 and 2010 in Samaru, Zaria, Nigeria to evaluate the effects of various intra-row spaces on the growth and yield of maize intercropped into ginger. The experiment consisted of six treatments laid out in a Randomized Complete Block Design and replicated three times. The results showed that, plant heights in intercropped spacing 75× 75 cm were taller (158.8 cm) ($P<0.05$) than the sole maize plants treatment (89.27 cm).

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. Result showed that the maximum plant height was recorded from the treatment of 65000 plants ha^{-1}. Minimum plant height was attained by 45000 plants ha^{-1}.

Abuzar *et al*. (2011) conducted a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants $ha^{–1}$), T_2 (60000 plant $ha^{–1}$), T_3 (80000 plants $ha^{–1}$), T_4 (100000 plants $ha^{–1}$), T_5 (120,000 plants $ha^{–1}$) and T_6 (140,000 plants $ha^{–1}$) was investigated using maize variety Azam. Result showed that the tallest plants (197.2cm) were recorded in T_4 (100000 plants ha^{-1}), which were, however, statistically at par (193.0cm) with T_3 (80000 plants ha^{-1}). Short statured plants (150.8cm) were recorded in T6 (140,000 plants ha^{-1}) due to crowding effect of the plant and higher intra-specific competition for resources.

Studies were conducted by Asafu-Agyei (1990) in four locations in Ghana in 1986 to determine the effect of seven planting densities: 10, 20, 30, 40, 50, 60 and 70 x 10^3 plants^{-1} ha on grain yield of three maize varieties differing in maturity: early, medium and full season. He found that, the highest plant height (200 cm) was recorded from 40 $\times 10^3$ plants ha $^{-1}$ and the lowest one (180 cm) from 10 $\times 10^3$ plants ha $^{-1}$.

Number of leaves plant^{-1}

A study was carried out by Enujeke (2013a) 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. Result revealed that plants sown on 75 cm x 15 cm gave the highest number of leaves plant^{-1} (13.8) where as plants sown on 75 cm x 35 gave the lowest number of leaves plant^{-1} (12.2).

A field experiment was carried out by Jula *et al*. (2013) during the cropping seasons of 2009 and 2010 in Samaru, Zaria, Nigeria to evaluate the effects of various intra-row spaces on the growth and yield of maize intercropped into ginger. The experiment consisted of six treatments laid out in a Randomized Complete Block Design and replicated three times. The results showed that, the highest number of leaves plant^{-1} (12.33) was recorded from maize intercrop planted at 75 × 75cm and the lowest number of leaves plant^{-1} (8.00) was reported for sole maize crop treatment at 75 × 25 cm spacing.

Leaf area

A field experiment was conducted by Mechi (2015) to assess the response of maize hybrid variety "BH-661" to nitrogen (N) fertilizer and inter row spacing in the main cropping season of 2014 at Nejo. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85cm) in randomized complete block design (RCBD) with three replications. Result revealed that, the maximum leaf area index (LAI) (3.38 cm) was recorded from inter row spacing 85 cm and the minimum LAI (2.85) was recorded from inter row spacing 55 cm.

A study was carried out by Enujeke (2013a) 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. Result showed that plants sown on 75 cm x 35 cm gave the maximum leaf area (713.7 cm^2) where as plants sown on 75 cm x 15 gave the minimum leaf area (587.3 cm^2).

Abuzar *et al.* (2011) conducted a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants ha^{-1}), T_2 (60000 plant ha^{-1}), T_3 (80000 plants ha^{-1}), T_4 (100000 plants ha^{-1}), T_5 (120,000 plants ha^{-1}) and T_6 (140,000 plants ha^{-1}) was investigated using maize variety Azam. They reported that the treatments having plant population of 120,000 and 140,000 plants ha^{-1} produced higher LAI of 2.77 and 2.52, respectively. The lowest LAI was obtained with population of 40000 plants ha^{-1}.

Jula *et al*. (2013) conducted a field experiment during the cropping seasons of 2009 and 2010 in Samaru, Zaria, Nigeria to evaluate the effects of various intra-row spaces on the growth and yield of maize intercropped into ginger. The experiment consisted of six treatments laid out in a Randomized Complete

Block Design and replicated three times. The results showed that, maximum leaf area plant^{-1} (559.24 cm^2) was recorded from intercropped spacing 75 X 75 cm where as the minimum leaf area plant^{-1} (221.90 cm^2) was reported for sole maize crop treatment at 75 × 25 cm spacing.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. Results indicated that highest leaf area index was observed in planting density of 65000 plants ha^{-1} and the lowest LAI was observed in planting density of 45000 plants ha^{-1}.

Studies were carried out by Asafu-Agyei (1990) in four locations in Ghana in 1986 to determine the effect of seven planting densities: 10, 20, 30, 40, 50, 60 and 70 x 10^3 plants^{-1} ha on grain yield of three maize varieties differing in maturity: early, medium and full season. Result revealed that, the maximum leaf area index (LAI) (3.00) was recorded from 60 ×10^3 plants ha $^{-1}$ and the minimum LAI (0.80) from 10 ×10^3 plants ha $^{-1}$.

Stem diameter

A study was carried out by Enujeke (2013a) 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. Result showed that plants sown on 75 cm x 35 cm gave the maximum stem diameter (99.4 mm) where as plants sown on 75 cm x 15 gave the minimum stem diameter (76.6 mm).

Dry matter plant^{-1}

Jula *et al*. (2013) conducted a field experiment during the cropping seasons of 2009 and 2010 in Samaru, Zaria, Nigeria to evaluate the effects of various intra-row spaces on the growth and yield of maize intercropped into ginger. The experiment consisted of six treatments laid out in a Randomized Complete Block Design and replicated three times. The results showed that the dry matter accumulation was highest (29.17 g plant^{-1}) for maize intercrop planted at 75 × 25cm, which was significantly better than all other treatments with the least dry matter accumulation (10 g plant^{-1}) obtained in the sole maize crop treatment at 75 × 25 cm spacing.

Number of rows cob^{-1}

Field trials were conducted by Sharifai *et al*. (2012) during the rainy seasons of 2006, 2007 and 2008 at the Institute for Agricultural Research (I.A.R.) Farm, Samaru to determine the performance of extra early maize (Zea mays L.) as affected by intra-row spacing, nitrogen and poultry manure rates. The treatments consisted of factorial combinations of three intra-row spacing (20, 25 and 30 cm), three rates of nitrogen (40, 80 and 120 kg ha^{-1}) and four rates of poultry manure (0, 2, 4 and 6 t ha^{-1}). The treatments were laid out in a split-plot design with three replications. Combinations of nitrogen and poultry manure rates were assigned to main plot, while intra-row spacing was assigned to the sub plot. The results showed that the highest number of rows cob^{-1} (14.14) was recorder for intra-row spacing 30 cm where as the lowest number of rows cob^{-1} (13.39) was found for intra-row spacing 20 cm.

Abuzar *et al.* (2011) conducted a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants ha^{-1}), T_2 (60000 plant ha^{-1}), T_3 (80000 plants ha^{-1}), T_4 (100000 plants ha^{-1}), T_5 (120,000 plants ha^{-1}) and T_6 (140,000 plants ha^{-1}) was investigated using maize variety Azam. They reported that the treatments having population of 60000 and 80000 plants ha^{-1} produced the highest number of rows per cob of 15.44 each. While the lowest number of rows per cob (13.44) was recorded with 140,000 plants ha^{-1}.

Number of grains $rows^{-1}$

Abuzar *et al.* (2011) carried out a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants ha^{-1}), T_2 (60000 plant ha^{-1}), T_3 (80000 plants ha^{-1}), T_4 (100000 plants ha^{-1}), T_5 (120,000 plants ha^{-1}) and T_6 (140,000 plants ha^{-1}) was investigated using maize variety Azam. Result revealed that the maximum number of grains per row (32.33) was recorded in T_1 (40000 plants ha^{-1}) followed by T_2 (60000 plants ha^{-1}) with 29.77 number of grains per row. The lowest number of grains per row (18.78) was recorded in T_6 (140,000 plants ha^{-1}), possibly due to less availability of nutrients to grain formation.

Number of grains cob^{-1}

A field experiment was conducted by Mechi (2015) to asses the response of maize hybrid variety “BH-661” to nitrogen (N) fertilizer and inter row spacing in the main cropping season of 2014 at Nejo. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85cm) in randomized complete block design (RCBD) with three replications. Result revealed that, the highest number of grains cob^{-1} (564.9) was recorded from inter row spacing 75 cm and the lowest number of grains cob^{-1} (489.3) was given by inter row spacing 65 cm.

A study was carried out by Enujeke (2013b) in the Teaching and Research Farm of Delta State University, Asaba Campus (Nigeria) from March to December in 2008 and replicated between March and December, 2009, to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. It was a factorial experiment carried out in a Randomized Complete Block Design (RCBD) with four replicates. Four open-pollinated varieties (Suwan -1- SR, ACR97, BR9922-DMRSF$_2$ and AMATZBRC$_2$WB) were evaluated under three different plant spacing (75 cm x 15 cm, 75 cm x 25 cm and 75 cm x 35 cm) for such yield indices as number of cobs/plant, cob length, grain weight and number of grains/cob of maize. The results obtained indicated that plants sown on 75 cm x 35 cm had the highest number of grains cob^{-1} (432.0) in 2008 and (440.5) in 2009, while plants sown at 75 cm x 15 cm had the lowest number of grains cob^{-1} (363.0) in 2008 and (369.0) in 2009.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms, Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that the highest plant density negatively affected number of grains ear^{-1}. With increasing plant population, number of grains ear^{-1} decreased in a linear manner. Maximum number of grains ear^{-1} was observed at plant density of 45000 plants ha^{-1} when compared with other treatments.

Abuzar *et al.* (2011) conducted a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants ha^{-1}), T_2 (60000 plant ha^{-1}), T_3 (80000 plants ha^{-1}), T_4 (100000 plants ha^{-1}), T_5 (120,000 plants ha^{-1}) and T_6 (140,000 plants ha^{-1}) was investigated using maize variety Azam. Result revealed that the treatments with 40000 plants ha^{-1} produced the highest number of grains per cob (447.3) followed by T_2 (400.8) having population of 60000 plants ha^{-1}. The lowest number of grains per cob (253.1) was recorded in treatment having 140,000 plants ha^{-1}.

1000 grain weight

A field experiment was conducted by Mechi (2015) to asses the response of maize hybrid variety "BH-661" to nitrogen (N) fertilizer and inter row spacing in the main cropping season of 2014 at Nejo. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85cm) in randomized complete block design (RCBD) with three replications. Result revealed that, the highest 1000 grain weight (332.6 g) was recorded from inter row spacing 85 cm and the lowest 1000 grain weight (300.9 g) was given by inter row spacing 65 cm.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that, increasing planting density had a negative impact on thousand grain weight. Increasing plant population decreased thousand grain weights. Maximum thousand grain weight was produced by planting density of 45000 plants ha^{-1} when compared with other treatments.

Field trials were conducted by Sharifai *et al.* (2012) during the rainy seasons of 2006, 2007 and 2008 at the Institute for Agricultural Research (I.A.R.) Farm, Samaru to determine the performance of extra early maize (Zea mays L.) as affected by intra-row spacing, nitrogen and poultry manure rates. The treatments consisted of factorial combinations of three intra-row spacing (20, 25 and 30 cm), three rates of nitrogen (40, 80 and 120 kg ha^{-1}) and four rates of poultry manure (0, 2, 4 and 6 t ha^{-1}). The treatments were laid out in a split-plot design with three replications. Combinations of nitrogen and poultry manure rates were assigned to main plot, while intra-row spacing was assigned to the sub plot. The results showed that the highest 100 grain weight (20.51 g) was recorder for intra-row spacing 30 cm where as the lowest number of rows cob^{-1} (19.64 g) was found for intra-row spacing 20 cm.

Abuzar *et al.* (2011) conducted a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants ha^{-1}), T_2 (60000 plant ha^{-1}), T_3 (80000 plants ha^{-1}), T_4 (100000 plants ha^{-1}), T_5 (120,000 plants ha^{-1}) and T_6 (140,000 plants ha^{-1}) was investigated using maize variety Azam. Result revealed that the treatment having population of 80000 and 40000 plants ha^{-1} produced the highest grain weight of 350.0 and 333.0g, respectively. The lowest grain weight (166.7g) was recorded in treatment having plant population of 140,000 plants ha^{-1}.

Grain yield

A field experiment was conducted by Mechi (2015) to asses the response of maize hybrid variety "BH-661" to nitrogen (N) fertilizer and inter row spacing in the main cropping season of 2014 at Nejo. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85cm) in randomized complete block design (RCBD) with three replications. Result revealed that, the highest grain yield (9.19 t ha^{-1}) was recorded from inter row spacing 85 cm and the lowest grain yield (6.84 t ha^{-1}) was given by inter row spacing 55 cm.

A study was carried out by Enujeke (2013b) in the Teaching and Research Farm of Delta State University, Asaba Campus (Nigeria) from March to December in 2008 and replicated between March and December, 2009, to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. It was a factorial experiment carried out in a Randomized Complete Block Design (RCBD) with four replicates. Four open-pollinated varieties (Suwan -1- SR, ACR97, BR9922-DMRSF$_2$ and AMATZBRC$_2$WB) were evaluated under three different plant spacing (75 cm x 15 cm, 75 cm x 25 cm and 75 cm x 35 cm) for such yield indices as number of cobs/plant, cob length, grain weight and number of grains/cob of maize. The results obtained indicated that plants sown on 75 cm x 15 cm had the highest grain weight (5.0 t ha) in 2008 and (5.2 t ha^{-1}) in 2009, while plants sown at 75 cm x 35 cm had the lowest grain weight (3.00 t ha^{-1}) in 2008 and (3.2 t ha^{-1}) in 2009.

Jula *et al*. (2013) conducted a field experiment during the cropping seasons of 2009 and 2010 in Samaru, Zaria, Nigeria to evaluate the effects of various intra-row spaces on the growth and yield of maize intercropped into ginger. The experiment consisted of six treatments laid out in a Randomized Complete Block Design and replicated three times. The results indicated that, grain yield was highest (3.98 t ha^{-1}) for maize intercrop planted at 75 × 75cm, on the other hand the lowest grain yield (2.22 t ha^{-1}) obtained in the sole maize crop treatment at 75 × 25 cm spacing.

Field trials were conducted by Sharifai *et al*. (2012) during the rainy seasons of 2006, 2007 and 2008 at the Institute for Agricultural Research (I.A.R.) Farm, Samaru to determine the performance of extra early maize (Zea mays L.) as affected by intra-row spacing, nitrogen and poultry manure rates. The treatments consisted of factorial combinations of three intra-row spacing (20, 25 and 30 cm), three rates of nitrogen (40, 80 and 120 kg ha^{-1}) and four rates of poultry manure (0, 2, 4 and 6 t ha^{-1}). The treatments were laid out in a split-plot design with three replications. Combinations of nitrogen and poultry manure rates were assigned to main plot, while intra-row spacing was assigned to the sub plot. The results showed that the highest grain yield (2.32 t ha^{-1}) was recorder for intra-row spacing 25 cm where as the lowest grain yield (1.97 t ha^{-1}) was found for intra-row spacing 30 cm.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that, plant population of 65000 plants ha^{-1} had significantly gave highest yield and the lowest yield was recorded from plant population 55000 plants ha^{-1}.

Abuzar *et al.* (2011) conducted a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants ha^{-1}), T_2 (60000 plant ha^{-1}), T_3 (80000 plants ha^{-1}), T_4 (100000 plants ha^{-1}), T_5 (120,000 plants ha^{-1}) and T_6 (140,000 plants ha^{-1}) was investigated using maize variety Azam. Result revealed that the maximum grain yield (2604 kg ha^{-1}) was recorded in T_2 (60000 plants ha^{-1}) followed by T_3 (80000 plants ha^{-1}) which produced grain yield of 2346 kg ha^{-1}. The minimum grain yield of 746.3 kg ha^{-1} was recorded in T_6 having population of 140,000 plants ha^{-1}.

Muhammad *et al*. (2006) indicated that there was maximum grain yield 6.6 t ha^{-1} of maize against the minimum 3.28 t ha^{-1} at narrow spacing, although narrow plant spacing (10-15 cm) caused substantial reduction in yield components such as grain cob^{-1} and 1000 kernel weight compared to the wide plant spacing, accordingly they recommend 60 cm by 10 or 15 cm plant spacing for maximum yield.

Studies were conducted by Asafu-Agyei (1990) in four locations in Ghana in 1986 to determine the effect of seven planting densities: 10, 20, 30, 40, 50, 60 and 70 x 10^3 $plants^{-1}$ ha on grain yield of three maize varieties differing in maturity: early, medium and full season. Result revealed that, the highest grain yield (5.8 t ha^{-1}) was recorded from 50 $\times 10^3$ plants ha^{-1} and the lowest grain yield (2.10 t ha^{-1}) from 10 $\times 10^3$ plants ha^{-1}.

Gardner (1988) found that kernel yield per unit area increased to a maximum yield of 1080 g m^{-2} at the density of about 10 plants m^{-2}, whereas total dry matter yield asymptotically increased up to 12.5 plants m^{-2}.

Stover yield

A field experiment was conducted by Mechi (2015) to asses the response of maize hybrid variety “BH-661” to nitrogen (N) fertilizer and inter row spacing in the main cropping season of 2014 at Nejo. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85cm) in randomized complete block design (RCBD) with three replications. Result revealed that, the highest stover yield (15.50 t ha^{-1}) was recorded from inter row spacing 65 cm and the lowest stover yield (14.33 t ha^{-1}) was given by inter row spacing 55 cm.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that highest stover yield was recorded from the treatment of 65000 plants ha^{-1} and lowest from the treatment of 45000 plants ha^{-1}.

Abuzar *et al.* (2011) conducted a field experiment to determine the effect of plant population densities on maize was conducted at the Agricultural Research Institute, Dera Ismail Khan, in mid July 2009. The effect of six plant population densities i.e. T_1 (40000 plants ha^{-1}), T_2 (60000 plant ha^{-1}), T_3 (80000 plants ha^{-1}), T_4 (100000 plants ha^{-1}), T_5 (120,000 plants ha^{-1}) and T_6 (140,000 plants ha^{-1}) was investigated using maize variety Azam. Result revealed that treatments having population of 60000 and 80000 plants ha^{-1} produced the maximum biomass yield of 16890 kg ha^{-1} each, while the lowest biomass yield (13330 kg ha^{-1}) was recorded with population of 140,000 plants ha^{-1}.

Biological yield

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that, highest biological yield was recorded from the treatment of 65000 plants ha^{-1} and the lowest biological yield was recorded from plant population 45000 plants ha^{-1}.

Harvest index

A field experiment was conducted by Mechi (2015) to asses the response of maize hybrid variety "BH-661" to nitrogen (N) fertilizer and inter row spacing in the main cropping season of 2014 at Nejo. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85cm) in randomized complete block design (RCBD) with three replications. Result revealed that, the highest harvest index (53.16%) was recorded from inter row spacing 85 cm and the lowest harvest index (42.91%) was given by inter row spacing 55 cm.

Shafi *et al*. (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that, highest harvest index was observed in the treatment of 65000 plants ha^{-1} and lowest in 45000 plants ha^{-1}.

Field experiments were conducted by Ma *et al*. (2002) to evaluate maize response to row spacing and N fertility over a 4-yr period (1997–2000). A randomized complete block design, arranged in a split plot was used with four replications each year with modifications of treatments over years. Row spacing of 0.51 m, 0.76 m and 0.76 m paired row alone or in combination with hybrid were tested in the subplot whereas combination of fertilizer N by population density (1997 and 1998) or N alone was assigned to the main plot. In 1997 and 1998, combinations of N by density consisted of 0, 60, 120, 180 and 240 kg N ha^{-1} at 89 000 plants ha^{-1}, and 60 and 180 kg N ha^{-1} at 69 000 plants ha^{-1} using a single hybrid, Pioneer 3893. In 1999 and 2000, N fertility levels of 0, 80 and 180 kg N ha^{-1} were the main plots and six combinations of hybrids (Pioneer 3893 and Pioneer 38P06 Bt) by row spacing were grown in the subplots at 69 000 plants ha^{-1}.They found that, harvest index was significantly higher under the 0.51 m spacing than the other spacing treatments.

2.3 Interaction effect of variety and spacing

Grain yield

Adhikari *et al*. (2004) reported that the highest grain yield of 9,352 kg ha^{-1} was produced when the crop was fertilized with 120 kg N ha^{-1} on the crop planted under the plant population of 53,333 plants ha^{-1} and they noted the lowest yield (6,657 kg ha^{-1}) with the crop supplied with 60 kg ha^{-1} under plant population of 44,444 plants ha^{-1}.

Field experiments were conducted by Ma *et al*. (2002) to evaluate maize response to row spacing and N fertility over a 4-yr period (1997–2000). A randomized complete block design, arranged in a split plot was used with four replications each year with modifications of treatments over years. Row spacing of 0.51 m, 0.76 m and 0.76 m paired row alone or in combination with hybrid were tested in the subplot whereas combination of fertilizer N by population density (1997 and 1998) or N alone was assigned to the main plot. In 1997 and 1998, combinations of N by density consisted of 0, 60, 120, 180 and 240 kg N ha^{-1} at 89 000 plants ha^{-1}, and 60 and 180 kg N ha^{-1} at 69 000 plants ha^{-1} using a single hybrid, Pioneer 3893. In 1999 and 2000, N fertility levels of 0, 80 and 180 kg N ha^{-1} were the main plots and six combinations of hybrids (Pioneer 3893 and Pioneer 38P06 Bt) by row spacing were grown in the subplots at 69 000 plants ha^{-1}. They reported that there were significant interactions between row spacing and N rates ($P < 0.01$); grain yield of Pioneer 38P06 Bt maize with the 80 kg N ha^{-1} fertilizer treatment was significantly greater (14.6%) at the 0.51 m row spacing than at the conventional 0.76 m row spacing. Yield of Pioneer 3893 was only 1.5% greater at the 0.51 m row spacing than at the 0.76 m row spacing. In 2000, yields were less than half those recorded in 1997-1999. Paired rows (0.76 m pair) showed significantly lower yields than either single 0.76 m spacing or 0.51 m spacing.

Stover yield

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties at Agricultural Research Farms Khyber Pukhtunkhwa Agricultural University Peshawar, Pakistan using randomized complete block (RCB) design with split plot arrangement having four replications. The experiment consist of four maize varieties viz., Azam, Pahari, Jalal-2003 and Sarhad white as main plot factor and three plant densities of 45000, 55000 and 65000 plants ha^{-1} as sub plot factor. They reported that, maximum stover yield was produced by Sarhad white at planting density of 65000 plants ha^{-1} and the minimum stover yield was produced by Pahari at planting density of 65000 plants ha^{-1}.

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken during November, 2015 to April, 2016 to study the effect of effect of planting configuration on the growth and yield of white maize**.** The materials and methods of this experiment are presented in this chapter under the following headings.

3.1 Experimental Site

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain. For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2 Climate

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix- II.

3.3 Soil

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

3.4 Treatments

The experiment consisted of two factors as mentioned below:

Factor A: Varieties

- V_1 = KS-510
- V_2 = PSC-121

Factor B: Plant spacing (5 levels)

- T_1= 40 cm × 25 cm spacing
- T_2= 50 cm × 25 cm spacing
- T_3= 60 cm × 25 cm spacing
- T_4= 70 cm × 25 cm spacing
- T_5= Double rows of 50 cm × 25 cm spacing

The treatment combinations are as follows:

V_1T_1, V_1T_2, V_1T_3, V_1T_4, V_1T_5, V_2T_1, V_2T_2, V_2T_3, V_2T_4 and V_2T_5

3.5 Plant materials

Maize cv. KS-510 and PSC-121 were used as plant materials for the present study. These varieties are recommended for *Robi* season.

The description of the variety is given below:

KS-510

- Identifying character: Double cross hybrid, bold grain quality, stays green at maturity, good crop standibility and drought tolerant.
- Developed by: Proline seed company, India.
- Crop duration: Medium, Maturity period 90-100 Days
- Yield : 7-7.5 t ha^{-1}
- Sowing time: Ideal for kharif season
- Harvesting time: After attaining physiological maturity.

PSC-121

- Identifying character: Double cross hybrid, bold grain quality, stays green at maturity, good crop standibility and drought tolerant.
- Developed by: Proline seed company, India.
- Crop duration: Medium, Maturity period 90-100 Days
- Yield : 7-7.5 t ha^{-1}
- Sowing time: Ideal for kharif season
- Harvesting time: After attaining physiological maturity.

3.6 Layout of the experiment

The experiment was laid out according to the experimental design (RCBD). The field was divided into 3 blocks to represent 3 replications. There were 30 unit plots altogether in the experiment. The size of each unit plot was 12 m^2 (4m × 3m). Distance maintained between replication and plots were 1.0m and 0.75m, respectvely. The treatments were assigned in plot at random. Details layout of the experimental plot has been presented below.

Rep. 1	**Rep. 2**	**Rep. 3**
V_1T_1	V_2T_2	V_1T_3
V_1T_4	V_2T_5	V_1T_1
V_1T_2	V_2T_3	V_1T_4
V_1T_5	V_2T_1	V_1T_2
V_1T_3	V_2T_4	V_1T_5
V_2T_1	V_1T_2	V_2T_3
V_2T_4	V_1T_5	V_2T_1
V_2T_2	V_1T_3	V_2T_4
V_2T_5	V_1T_1	V_2T_2
V_2T_3	V_1T_4	V_2T_5

Plate 1. Layout of the experimental plot

3.7 Crop Management

3.7.1 Seed collection

Healthy seeds of KS-510 and PSC-121 were collected from a private organization.

3.7.2 Land preparation

The plot selected for the experiment was opened in the second week of November, 2015 with 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.

3.7.3 Fertilizer application

The field was fertilized with nitrogen, phosphate, potash, sulphur and zinc at the rate of 230-50-100-31.25-3.5 kg ha^{-1}, respectively in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate. The whole amount of all the fertilizers except urea were applied at the time of final land preparation and thoroughly incorporated with soil with the help of a spade. Urea was top dressed in three equal splits on 15, 30, and 45 DAS.

3.7.4 Seed sowing

Seeds of the variety KS-510 and PSC-121were sown on 20 November, 2015 in line maintaining a line to line distance as per treatments having 2 seeds $hole^{-1}$ in the well prepared plot.

3.7.5 Intercultural operations

3.7.5.1 Irrigation

First irrigation was given on 4 December, 2015 which was 15 days after sowing. Second irrigation was given on 20 December, 2015 which was 31 days after sowing. Third irrigation was given on 24 January, 2016 which was 65 days after sowing and fourth irrigation was given on 14 February, 2016 which was 85 days after sowing.

3.7.5.2 Gap filling, thinning, and weeding

Gap filling was done on 29 November, 2015 which was 10 days after sowing. During plant growth period one thinning and two weeding were done, thinning was done on 5 December, 2015 which was 16 days after sowing and the weeding was done on 19 December, 2015 and 20 January, 2016 which was 30 and 60 days after sowing, respectively.

3.7.5.3 Earthing up

Earthing up was done on 25 December, 2015 which was 35 days after sowing. It was done to protect the plant from lodging and for better nutrition uptake.

3.7.5.4 Plant protection measures

Insecticides Diazinon 60 EC @ 2 ml litre^{-1} water was sprayed to control Stem borer on 4, 14 and 23 February, 2016 and Ripcord 10 EC @2 ml litre^{-1} water were sprayed to control earthworm on 9 and 16 March, 2016 to protect the crop.

3.7.6 Harvesting

The crops were harvested when the husk cover was completely dried and black coloration was found in the grain base. The cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data. The inner two lines were harvested for recording grain yield and stover yield. Harvesting was done on 24 April, 2016.

3.7.7 Drying

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

3.8 Collection of data

Data were collected on the following parameters-

A. Crop growth characters

1. Plant height (cm) at 30, 60, 90 Days after sowing (DAS) and at harvest
2. Collar Leaf no. plant^{-1} at 30, 60, 90 DAS and at harvest
3. Leaf Area (cm^{2}) at 30, 60, 90 DAS and at harvest
4. Base diameter (cm) at 60, 90 DAS and at harvest
5. Dry matter weight plant^{-1} (g) at 60, 90 DAS and at harvest

B. Yield contributing characters and yield data

1. Grain cob^{-1} (no.)
2. Grain row^{-1} (no.)
3. Row cob^{-1} (no.)
4. Weight of 100 grains (g)
5. Grain yield (t ha^{-1})
6. Stover yield (t ha^{-1})
7. Biological yield (t ha^{-1})
8. Harvest index (%)

3.9 Procedure of recording data

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

3.9.1 Plant height at different DAS (30, 60, 90 DAS and at harvest)

At different stages of crop growth (30, 60, 90 DAS and at harvest), the height of five randomly selected plants from the inner rows plot^{-1} was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in cm.

3.9.2 Collar Leaf no. plant^{-1} at different DAS (30, 60, 90 DAS and at harvest)

At different stages of crop growth (30, 60, 90 DAS and at harvest), the total number of collar leaf of five randomly selected plants from the inner rows plot^{-1} was counted and the mean value of the number of collar leaf was recorded in cm.

3.9.3 Leaf Area at different DAS (30, 60, 90 DAS and at harvest)

Leaf area was estimated manually by counting the total number of leaves per plant and measuring the length and average width of leaf and multiplying by a factor of 0.70 (Keulen and Wolf, 1986). It was done at 30, 60, 90 days after sowing (DAS) and at harvest.

$$\text{Leaf area} = \frac{\text{Surface area of leaf sample } (\text{m}^2) \times \text{correction factor}}{\text{Ground area from where the leaves were collected}}$$

3.9.4 Base diameter at different DAS (60, 90 DAS and at harvest)

From each plot 3 plants were uprooted randomly. Then the diameter was taken from the base portion of each plant. Then average result was recorded in cm.

3.9.5 Dry matter weight plant^{-1} at different DAS (60, 90 DAS and at harvest)

From each plot 3 plants were uprooted randomly. Then the stem, leaves and roots were separated. The shoot sample (stem and leaves) was sliced into very thin pieces and put into envelop and placed in oven maintaining 70^0 C for 72 hours. Then the shoot sample was transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. It was performed at 60, 90 DAS and at harvest.

3.9.6 Number of grains cob^{-1}

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

3.9.7 Number of grain rows^{-1}

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

3.9.8 Number of rows cob^{-1}

Ten cobs from each plot were selected randomly and the number of rows was counted and then the average result was recorded.

3.9.9 Weight of 100 grains

From the seed stock of each plot 100 seeds were counted and the weight was measured by an electrical balance. It was recorded in gram.

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

Grain yield was calculated from cleaned and well dried grains collected from the central 2 m^2 area of the each plot leaving two boarder rows and expressed as t ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture tester.

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

Stover yield was determined from the central 2 m length of the each plot. After threshing, the sub sample was oven dried to a constant weight and finally converted to t ha^{-1}.

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

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

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

3.9.13 Harvest index (HI)

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

Harvest Index (%) = $\frac{\text{Economic yield (t/ ha)}}{\text{Biological yield (t/ ha)}} \times 100$

3.10 Chemical Analysis of Soil samples

Soil samples were analyzed for both physical and chemical properties in the laboratory of the Soil Resource Development Institute (SRDI), Farmgate, Dhaka-1215. The properties studied included texture, pH, organic matter, total N, available P, S and exchangeable K. The soil was analyzed following standard methods. Particle-size analysis of soil was done by Hydrometer method. These results have been presented in Appendix II.

3.10.1 Soil pH

Soil pH was measured with the help of a glass electrode pH meter using soil water suspension ratio being maintained at 1:2.5 (Jackson, 1962).

3.10.2 Organic matter content

Organic carbon in soil sample was determined by wet oxidation method. The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_20_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_20_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.10.3 Total nitrogen

One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 g catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se=100: 10: 1), 2 mL 30% H_2O_2 and 5 mL H_2SO_4 were added. The flasks were swirled and allowed to stand for about 10 minutes. Then heating was continued until the digest was clear and colorless. After cooling, the content was taken into 100 mL volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digest was used for nitrogen determination. After completion of digestion, 40% NaOH was added with the digest for distillation. The evolved ammonia was trapped into 4% H_3BO_3 solution and 5 drops of mixed indicator of bromocressol green ($C_{21}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution. Finally the distillate was titrated with standard 0.01 NH_2SO_4 until the color changed from green to pink (Bremner and Mulvaney, 1982).

The amount of N was calculated using the following formula.

$$\% \text{ N } = \frac{(\text{T} - \text{B}) \times \text{N} \times 0.014 \times 100}{\text{S}}$$

Where, T = Sample titration value (mL) of standard H_2SO_4

B = Blank titration value (mL) of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.10.4 Available phosphorous

Available phosphorus was extracted from the soil samples by shaking with 0.5 M $NaHCO_3$ solution at pH 8.5 following Olsen method (Olsen *et al.*, 1954). The extracted phosphorus was determined by developing blue color by $SnCl_2$ reduction of phosphomolybdate complex and measuring the intensity of color colorimetrically at 660 nm wavelength and the readings were calibrated to the standard P curve.

3.10.5 Available sulphur

Available S content was determined following the procedure of CaH_2PO_4 extracting method (Page *et al.*, 1982).

3.10.6 Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction method and by using flame photometer and calibrated with a standard curve (Black, 1965).

3.11 Statistical analysis

The obtained data for different characters were statistically analyzed with the computer based software MSTAT-C to find out feasibility of replacing chemical fertilizer by using organic fertilizer on the performance of maize and the mean values of all characters were evaluated and analysis of variances were performed by the F-test. The significance of the difference among treatment means were estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

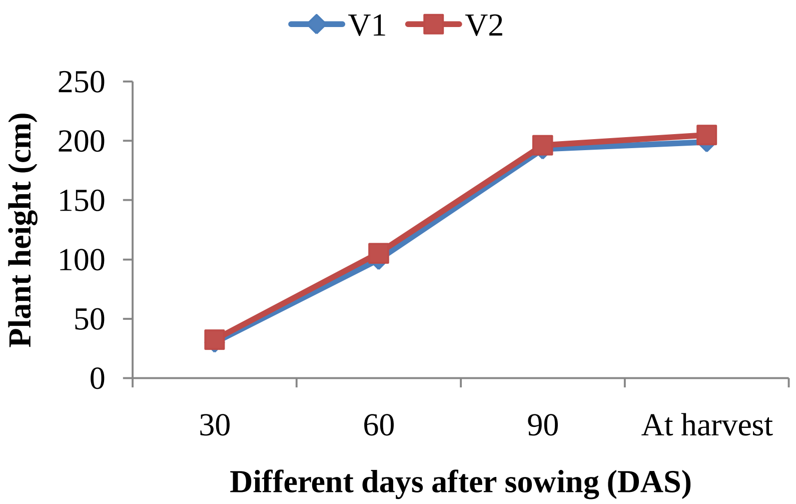
RESULTS AND DISCUSSION

The experiment was conducted to study the effect of variety and plant spacing on the growth and yield of maize. Data on different growth, yield contributing characters and yield of maize were recorded. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix IV-XII. The results have been presented and discussed and possible interpretations have been given under the following headings.

4.1 Plant height

4.1.1 Effect of variety

Maize variety exhibited non-significant difference on plant height at different growth stages (Figure 1). Among the varieties, PSC-121 (V_2) showed the tallest plant (32.42, 105.09, 196.15 and 204.73 cm at 30, 60, 90 DAS and harvest, respectively) and KS-510 (V_1) showed the shortest plant (29.98, 99.73, 192.78 and 198.82 cm at 30, 60, 90 DAS and harvest, respectively).

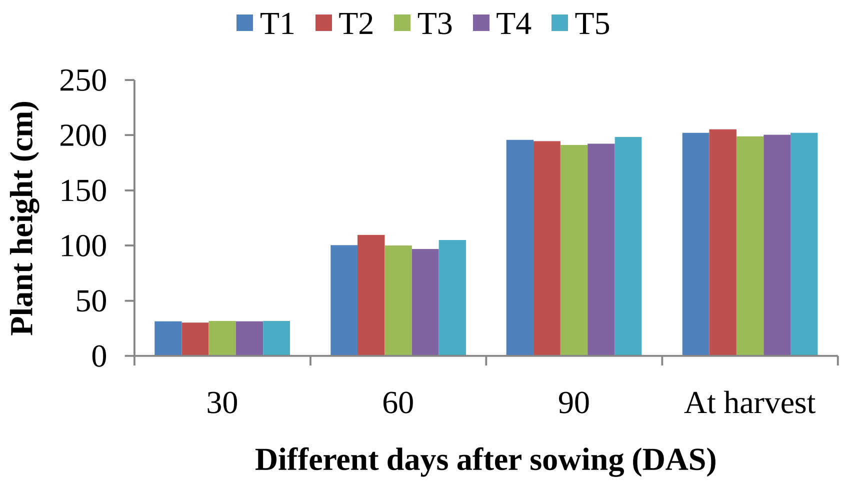


V_1: KS-510 and V_2: PSC-121

Figure 1. Effect of variety on the plant height of maize at different days after sowing (LSD $_{(0.05)}$ = NS, NS, NS and NS at 30, 60, 90 DAS and at harvest, respectively)

4.1.2 Effect of plant spacing

Effect of plant spacing showed a non-significant variation on plant height for all growth stages of maize except 60 DAS (Figure 2). At 60 DAS, 50 cm × 25 cm spacing (T_2) showed the tallest plant (109.6 cm) which was statistically similar with T_1, T_3 and T_5; whereas plant spacing 70 cm × 25 cm (T_4) showed the shortest plant (96.83 cm) which was statistically similar with T_1, T_3 and T_5. Enujeke (2013a) and Ibeawuchi *et al.* (2008) found that the different plant spacing with different plant densities generally influenced maize plant height. Close spacing causes competition and removal of nutrients for growth and genetic makeup either for tallest or shortness for the particular plant.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 2. Effect of plant spacing on the plant height of maize at different days after sowing (LSD $_{(0.05)}$ = NS, 9.85, NS and NS at 30, 60, 90 DAS and at harvest, respectively)

4.1.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed an increasing trend with advances of growth period in respect of plant height (Table 1). The rate of increase was much higher in the early stages of growth 30 DAS to 90 DAS. At 90 DAS and harvest, interaction of variety and plant spacing showed non-significant variation. However, the tallest plant (116.0 cm at 60 DAS) was found in V_1T_2 which was statistically similar with V_2T_1, V_2T_2, V_2T_3, V_2T_4 and V_2T_5. The shortest plant (88.57 cm at 60 DAS) was found in V_1T_4 which was statistically similar with V_1T_1, V_1T_3, V_1T_5 and V_2T_3. Enujeke (2013a) found the similar result to evaluate the effects of variety and spacing on growth characters of hybrid maize. The differential growth with respect to plant height observed among the varieties may be attributed to differences in genetic characteristics of the individual varieties, including rapid growth rates, tallness or shortness of species. This is similar to the findings of Majambu *et al.*, (1996) and Ibrahim *et al.*, (2000) that attributed the differences in growth indices of crops to genetic constitution. Maize plants spaced 10cm grew taller than other plants possibly because of increased competition for space, sunlight and available nutrients. This is similar to the findings of Teasdale (1995), Widdicombe and Thelen (2002), and Dalley *et al.* (2006) who attributed the increased growth rates and earlier canopy closure of narrow row spaced crops to quest for increased light interception as well as increased availability of soil moisture because of equidistant distribution of crop plants.

Table 1. Interaction effect of variety and plant spacing on plant height of maize at different days after sowing

Treatment combinations	Days after sowing (DAS)			
	30	60	90	At Harvest
V_1T_1	29.95	97.46 bc	193.8	198.1
V_1T_2	29.95	116.0 a	193.7	198.3
V_1T_3	30.87	97.90 bc	190.9	199.5
V_1T_4	30.25	88.57 c	191.2	195.9
V_1T_5	28.86	98.70 bc	194.3	202.2
V_2T_1	32.55	103.3 ab	197.9	206.0
V_2T_2	30.19	103.2 ab	195.2	212.3
V_2T_3	32.30	102.5 abc	191.2	198.5
V_2T_4	32.53	105.1 ab	193.7	205.0
V_2T_5	34.51	111.3 ab	202.7	201.9
$LSD_{(0.05)}$	**5.881**	**13.93**	**NS**	**NS**
CV (%)	**10.99**	**7.93**	**6.07**	**8.68**

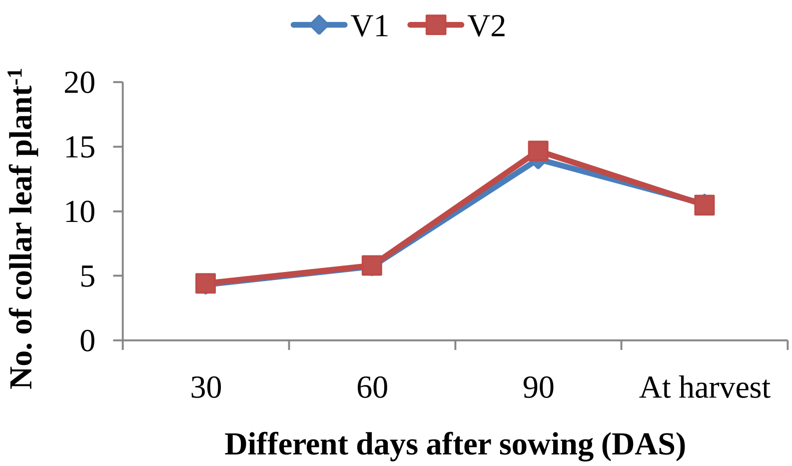
V_1: KS-510 and V_2: PSC-121

T_1 = 40 cm × 25 cm spacing ; T_2 = 50 cm × 25 cm spacing ; T_3 = 60 cm × 25 cm spacing
T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

4.2 Collar Leaf no. plant^{-1}

4.2.1 Effect of variety

Non-significant difference was observed on collar leaf no. plant^{-1} at different growth stages (Figure 3). Among the varieties, PSC-121 (V_2) showed the highest number of collar leaf plant^{-1} (4.41, 5.8 and 14.67 at 30, 60 and 90 DAS, respectively) and KS-510 (V_1) showed the lowest number of collar leaf plant^{-1} (4.31, 5.73 and 14.01 at 30, 60 and 90 DAS, respectively). At harvest, V_1 and V_2 showed the highest (10.55) and lowest (10.47) number of collar leaf plant^{-1}, respectively.

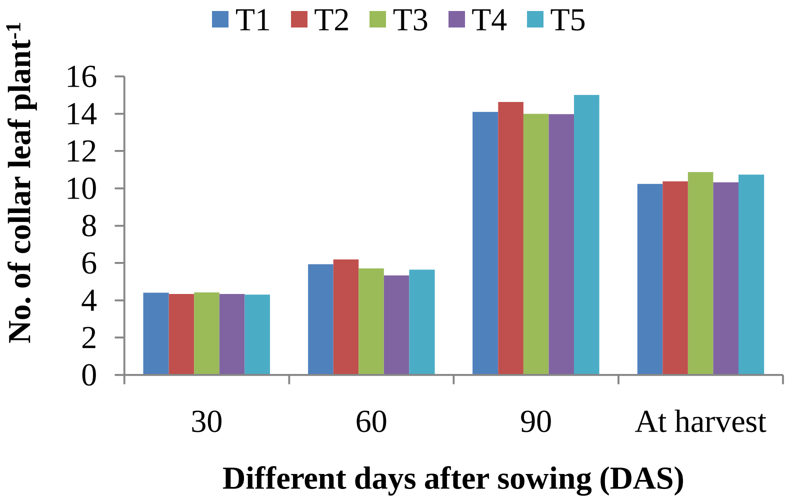


V_1: KS-510 and V_2: PSC-121

Figure 3. Effect of variety on the no. of collar leaf plant^{-1} of maize at different days after sowing (LSD $_{(0.05)}$ = NS, NS, NS and NS at 30, 60, 90 DAS and at harvest, respectively)

4.2.2 Effect of plant spacing

Plant spacing showed a non-significant variation on collar leaf no. plant^{-1} for all growth stages of maize except 60 DAS (Figure 4). At 60 DAS, 50 cm × 25 cm spacing (T_2) showed the highest number of collar leaf plant^{-1} (6.19) which was statistically similar with T_1, T_3 and T_5; whereas plant spacing 70 cm × 25 cm (T_4) showed the lowest number of collar leaf plant^{-1} (5.33) which was statistically similar with T_1, T_3 and T_5. This is similar to the findings of Enujeke (2013a).



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 4. Effect of plant spacing on the no. of collar leaf plant^{-1} of maize at different days after sowing (LSD $_{(0.05)}$ = NS, 0.61, NS and NS at 30, 60, 90 DAS and at harvest, respectively)

4.2.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed an increasing trend with advances of growth period in respect of collar leaf no. plant^{-1} (Table 2). The rate of increase was much higher in the early stages of growth 30 DAS to 90 DAS. After that the rate was decreasing up to harvest. At 30 DAS, the highest number of collar leaf plant^{-1} (4.60) was observed in V_1T_3 and V_2T_1 which was statistically similar with all other interactions except V_1T_1 and V_1T_5; whereas the lowest number of collar leaf plant^{-1} (4.20) was observed in V_1T_1 and V_1T_5 which was statistically similar with all other interactions except V_1T_3 and V_2T_1. At 60 DAS, the highest number of collar leaf plant^{-1} (6.24) was observed in V_1T_2 which was statistically similar with all other interactions except V_1T_4; whereas the lowest number of collar leaf plant^{-1} (5.10) was observed in V_1T_4 which was statistically similar with all other interactions except V_1T_1, V_1T_2 and V_2T_2. At 90 DAS, the highest number of collar leaf plant^{-1} (15.57) was observed in V_2T_5 which was statistically similar with all other interactions except V_1T_1, V_1T_4 and V_2T_3; whereas the lowest number of collar leaf plant^{-1} (13.63) was observed in V_1T_1 which was statistically similar with all other interactions except V_2T_5. At harvest, the highest number of collar leaf plant^{-1} (11.20) was observed in V_1T_3 which was statistically similar with all other interactions except V_1T_1; whereas the lowest number of collar leaf plant^{-1} (9.90) was observed in V_1T_1 which was statistically similar with all other interactions except V_1T_3. The differences observed in the number of leaves of maize may be attributed to differences in growth characters which are being influenced by genetic make-up of the plants. This is similar to the findings of Sajjan *et al*., (2002) who reported that growth characters of crops varied because of differences in their genetic make-up. Maize plant sown on 10cm spacing had higher number of leaves than their counterparts which were sown at wider spacing possibly because of increased growth rate in search for space, sunlight and other environmental resources. This is consistent with the findings of Al-Rudha and Al-Youmis (1998) and Ali *et al*. (2003) that made similar reports on 10cm-spaced maize plants.

Table 2. Interaction effect of variety and plant spacing on collar leaf no. plant^{-1} of maize at different days after sowing

Treatment combinations	Days after sowing (DAS)			
	30	60	90	At Harvest
V_1T_1	4.20 b	6.10 a	13.63 b	9.900 b
V_1T_2	4.27 ab	6.24 a	14.13 ab	10.57 ab
V_1T_3	4.60 a	5.67 ab	14.20 ab	11.20 a
V_1T_4	4.27 ab	5.10 b	13.67 b	10.33 ab
V_1T_5	4.20 b	5.53 ab	14.43 ab	10.77 ab
V_2T_1	4.60 a	5.77 ab	14.57 ab	10.57 ab
V_2T_2	4.40 ab	6.13 a	15.13 ab	10.20 ab
V_2T_3	4.27 ab	5.77 ab	13.80 b	10.57 ab
V_2T_4	4.40 ab	5.57 ab	14.30 ab	10.33 ab
V_2T_5	4.40 ab	5.77 ab	15.57 a	10.70 ab
LSD $_{(0.05)}$	**0.34**	**0.87**	**1.69**	**1.23**
CV (%)	**4.54**	**8.77**	**6.85**	**6.81**

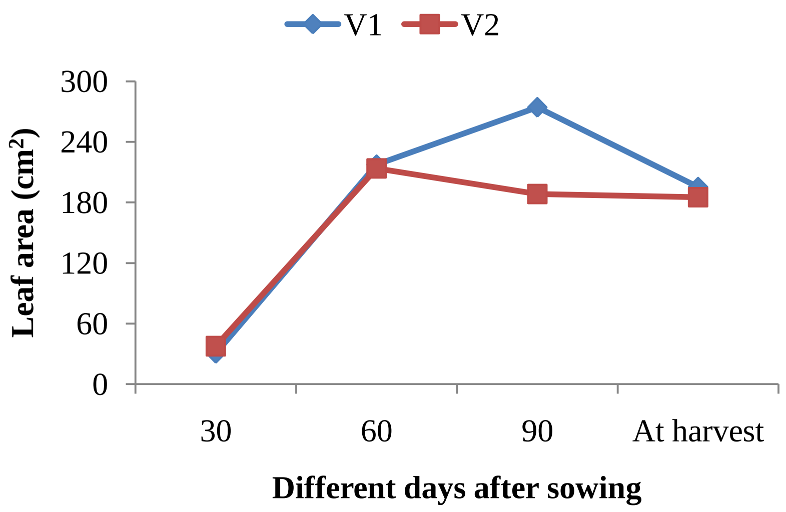
V_1: KS-510 and V_2: PSC-121

T_1 = 40 cm × 25 cm spacing ; T_2 = 50 cm × 25 cm spacing ; T_3 = 60 cm × 25 cm spacing T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

4.3 Leaf Area (cm^2)

4.3.1 Effect of variety

Maize variety exhibited significant difference on leaf area at 30 and 90 DAS (Figure 5). Among the varieties, PSC-121 (V_2) showed the maximum leaf area (37.72 cm^2 at 30 DAS) and KS-510 (V_1) showed the minimum leaf area (30.45 cm^2 at 30 DAS). At 90 DAS, V_1 and V_2 showed the highest (274.11 cm^2) and lowest (188.42 cm^2) leaf area, respectively. This is similar to the findings of Asaduzzaman *et al*. (2014), Enujeke (2013a) and Shafi *et al.* (2012). The differences observed in leaf area of the varieties of maize sown could be attributed to the differences in leaf arrangement, photosynthetic activities of leaves, differences in chlorophyll content and activity of photosynthetic enzymes. This is similar to the findings of Gwizdek (1989) who attributed the differences between the leaf area and other growth characters of maize genotypes to differences in photosynthetic activity of leaves, leaf arrangement, chlorophyll content, stomatal conductance value and activity of photosynthetic enzymes. The differences observed in leaf area is also similar to the findings of Akinfoesoye *et al*., (1997).

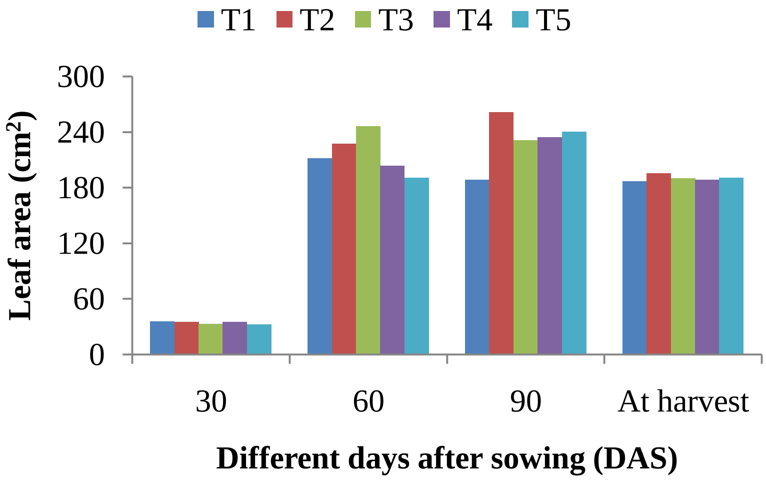


V_1: KS-510 and V_2: PSC-121

Figure 5. Effect of variety on the leaf area of maize at different days after sowing (LSD $_{(0.05)}$ = 5.05, NS, 21.08 and NS at 30, 60, 90 DAS and at harvest, respectively)

4.3.2 Effect of plant spacing

Plant spacing showed a significant variation on leaf area at 60 and 90 DAS (Figure 6). At 60 DAS, 60 cm × 25 cm spacing (T_3) showed the maximum leaf area (246.2 cm^2) which was statistically similar with T_2; whereas plant spacing 50 cm × 25 cm (T_5) double rows showed the minimum leaf area (190.20 cm^2) which was statistically similar with T_1 and T_4. At 90 DAS, 50 cm × 25 cm spacing (T_2) showed the maximum leaf area (261.70 cm^2) which was statistically similar with all other treatments except T_1; whereas plant spacing 40 cm × 25 cm (T_1) showed the minimum leaf area (188.80 cm^2). Increased spacing resulted in larger leaf area possibly because there was a reduction in competition for space, sunlight and nutrients within the wider spaced plants. This is similar to the findings of Ali *et al.*, (2003) who reported that competition between maize plants for light, soil fertility and other environmental factors were markedly increased with highest population but decreased with lower plant population.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 6. Effect of plant spacing on the leaf area of maize at different days after sowing (LSD $_{(0.05)}$ = NS, 33.98, 33.33 and NS at 30, 60, 90 DAS and at harvest, respectively)

4.3.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation with advances of growth period in respect of leaf area except at harvest (Table 3). At 30 DAS, the maximum leaf area (40.11 cm^2) was observed in V_2T_1 which was statistically similar with all other interactions except V_1T_5; whereas the minimum leaf area (25.29 cm^2) was observed in V_1T_5 which was statistically similar with all other interactions except V_2T_1, V_2T_4 and V_2T_5. At 60 DAS, the maximum leaf area (266.20 cm^2) was observed in V_1T_2 which was statistically similar with V_1T_3, V_2T_1 and V_2T_3; whereas the minimum leaf area (179.10 cm^2) was observed in V_1T_5 which was statistically similar with all other interactions except V_1T_2, V_1T_3 and V_2T_3. At 90 DAS, the maximum leaf area (314.20 cm^2) was observed in V_1T_2 which was statistically similar with V_1T_3, V_1T_4 and V_1T_5; whereas the minimum leaf area (159.40 cm^2) was observed in V_2T_1 which was statistically similar with V_2T_3, V_2T_4 and V_2T_5. This is similar to the findings of Enujeke, (2013a).

Table 3. Interaction effect of variety and plant spacing on leaf area of maize at different days after sowing

Treatment combinations	Days after sowing (DAS)			
	30	60	90	At Harvest
V_1T_1	31.03 ab	204.1 bc	218.2 b	194.7
V_1T_2	33.05 ab	266.2 a	314.2 a	203.5
V_1T_3	32.72 ab	249.3 ab	268.9 a	192.9
V_1T_4	30.12 ab	189.6 c	283.2 a	191.1
V_1T_5	25.29 b	179.1 c	286.0 a	194.5
V_2T_1	40.11 a	218.8 a-c	159.4 c	178.2
V_2T_2	36.38 ab	188.5 c	209.1 b	187.9
V_2T_3	33.27 ab	243.1 ab	193.7 bc	187.2
V_2T_4	39.57 a	217.6 bc	185.5 bc	186.6
V_2T_5	39.25 a	201.4 bc	194.4 bc	186.5
LSD $_{(0.05)}$	**11.3**	**48.05**	**47.13**	**NS**
CV (%)	**19.32**	**12.98**	**11.88**	**10.33**

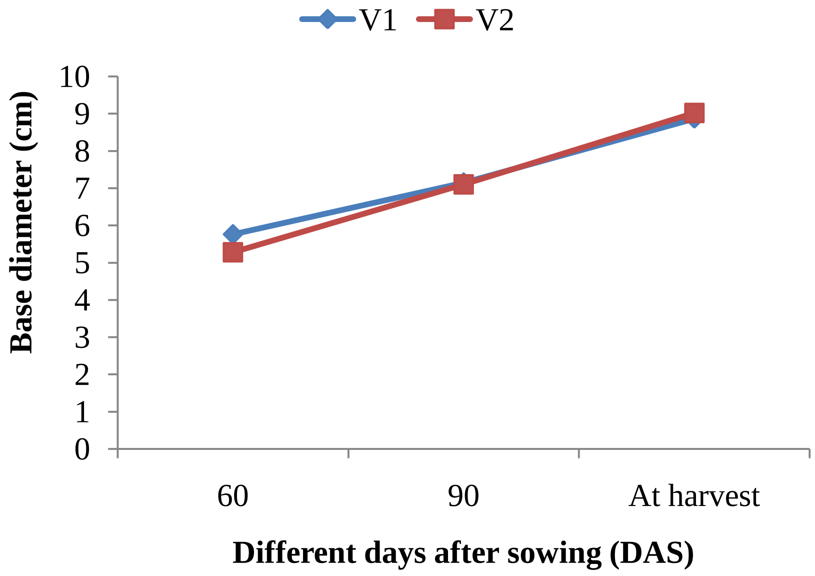
V_1: KS-510 and V_2: PSC-121

T_1 = 40 cm × 25 cm spacing ; T_2 = 50 cm × 25 cm spacing ; T_3 = 60 cm × 25 cm spacing T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

4.4 Base diameter (cm)

4.4.1 Effect of variety

Significant difference was observed on base diameter of maize at 60 DAS (Figure 7). Among the varieties, KS-510 (V_1) showed the highest base diameter (5.76 cm at 60 DAS) and PSC-121 (V_2) showed the lowest base diameter (5.28 cm at 60 DAS). At 90 DAS and harvest, non-significant difference was observed on base diameter of maize. This is similar to the findings of Enujeke (2013a), Obi (1999), Kim (1997) and Udoh (2005) who reported that base diameter might be differed with varietal variation.

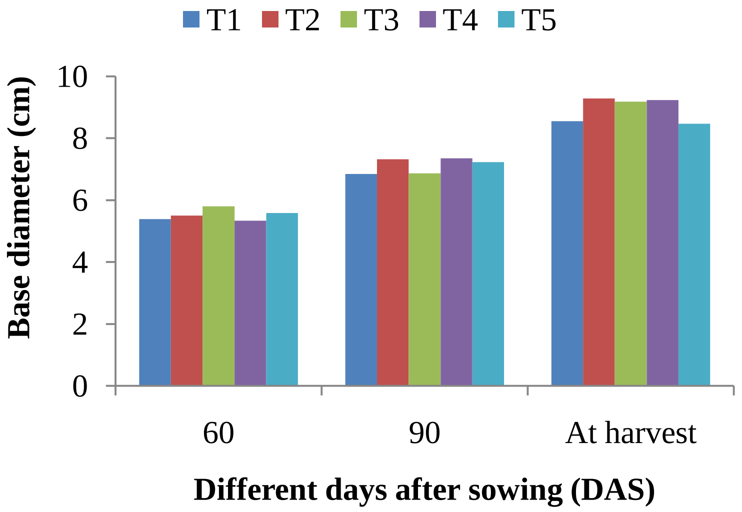


V_1: KS-510 and V_2: PSC-121

Figure 7. Effect of variety on the base diameter of maize at different days after sowing (LSD $_{(0.05)}$ = 0.36, NS and NS at 60, 90 DAS and at harvest, respectively)

4.4.2 Effect of plant spacing

Plant spacing showed a significant variation on base diameter at 90 DAS (Figure 8). At 90 DAS, 70 cm × 25 cm spacing (T_4) showed the highest base diameter (7.35 cm) which was statistically similar with all other treatments; whereas plant spacing 40 cm × 25 cm (T_1) showed the lowest base diameter (6.85 cm) which was statistically similar with all other treatments. At 60 DAS and harvest, non-significant difference was observed on base diameter of maize. This is similar to the findings of Enujeke (2013a), Barbier *et al*. (2000); Hamayan (2003); Dalley *et al*. (2006) and Azam *et al*. (2007) who reported that wider-spaced maize plants obtained more soil moisture and nutrients than narrower plants, thus base diameter might be increased.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 8. Effect of plant spacing on the base diameter of maize at different days after sowing (LSD $_{(0.05)}$ = NS, NS and NS at 60, 90 DAS and at harvest, respectively)

4.4.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation with advances of growth period in respect of base diameter (Table 4). At 60 DAS, the highest base diameter (6.30 cm) was observed in V_2T_2 which was statistically similar with V_1T_1, V_1T_3, V_1T_4 and V_1T_5; whereas the lowest base diameter (4.667 cm) was observed in V_2T_1 which was statistically similar with V_1T_2, V_2T_3, V_2T_4 and V_2T_5. At 90 DAS, the highest base diameter (7.50 cm) was observed in V_1T_4 which was statistically similar with all other interactions except V_2T_3; whereas the lowest base diameter (6.567 cm) was observed in V_2T_3 which was statistically similar with all other interactions except V_1T_4 and V_2T_2. At harvest, the highest base diameter (9.933 cm) was observed in V_2T_4 which was statistically similar with all other interactions except V_1T_4, V_2T_1 and V_2T_5; whereas the lowest base diameter (8.033 cm) was observed in V_2T_5 which was statistically similar with all other interactions except V_2T_2 and V_2T_4. This is similar to the findings of Enujeke (2013a).

Table 4. Interaction effect of variety and plant spacing on base diameter of maize at different days after sowing

Treatment combinations	Days after sowing (DAS)		
	60	90	At Harvest
V_1T_1	6.100 ab	6.767 ab	8.667 abc
V_1T_2	4.700 c	7.167 ab	9.000 abc
V_1T_3	6.267 a	7.167 ab	9.233 abc
V_1T_4	5.967 ab	7.500 a	8.533 bc
V_1T_5	5.767 ab	7.133 ab	8.900 abc
V_2T_1	4.667 c	6.933 ab	8.433 bc
V_2T_2	6.300 a	7.467 a	9.567 ab
V_2T_3	5.333 bc	6.567 b	9.133 abc
V_2T_4	4.700 c	7.200 ab	9.933 a
V_2T_5	5.400 bc	7.333 ab	8.033 c
LSD $_{(0.05)}$	**0.7991**	**0.7842**	**1.306**
CV (%)	**8.44**	**6.42**	**8.51**

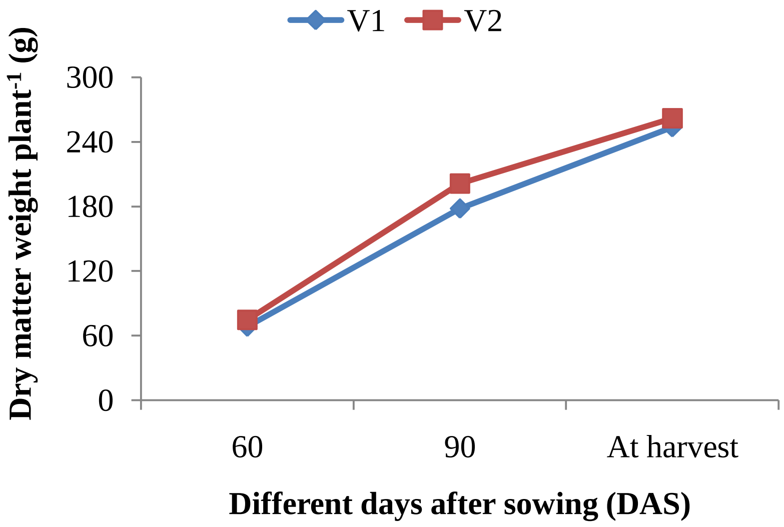
V_1: KS-510 and V_2: PSC-121

T_1 = 40 cm × 25 cm spacing ; T_2 = 50 cm × 25 cm spacing ; T_3 = 60 cm × 25 cm spacing
T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

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

4.5.1 Effect of variety

Maize variety exhibited significant difference on dry matter weight plant^{-1} at 60 and 90 DAS (Figure 9). Among the varieties, PSC-121 (V_2) showed the highest dry matter weight plant^{-1} (74.80 and 201.40 g at 60 and 90 DAS, respectively) and KS-510 (V_1) showed the lowest dry matter weight plant^{-1} (68.33 and 178.20 g at 60 and 90 DAS, respectively). At harvest, maize variety exhibited non-significant difference on dry matter weight plant^{-1}. This might be due t the genetic variation. This is similar to the findings of Asaduzzaman *et al*. (2014).

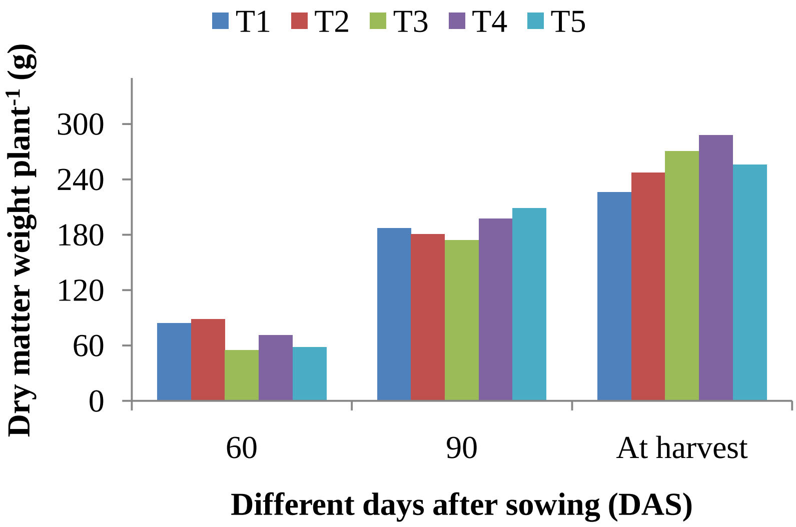


V_1: KS-510 and V_2: PSC-121

Figure 9. Effect of variety on the dry matter weight plant^{-1} of maize at different days after sowing (LSD $_{(0.05)}$ = 5.96, 11.14 and NS at 60, 90 DAS and at harvest, respectively)

4.5.2 Effect of plant spacing

Plant spacing showed a significant variation with advances of growth period in respect of dry matter weight plant^{-1} (Figure 10). At 60 DAS, 50 cm × 25 cm spacing (T_2) showed the highest dry matter weight plant^{-1} (88.83 g) which was statistically similar with T_1; whereas plant spacing 60 cm × 25 cm (T_3) showed the lowest dry matter weight plant^{-1} (55.00 g) which was statistically similar with T_5. At 90 DAS, 50 cm × 25 cm double rows spacing (T_5) showed the highest dry matter weight plant^{-1} (209.00 g) which was statistically similar with T_4; whereas plant spacing 60 cm × 25 cm (T_3) showed the lowest dry matter weight plant^{-1} (174.20 g) which was statistically similar with T_1 and T_2. At harvest, 70 cm × 25 cm spacing (T_4) showed the highest dry matter weight plant^{-1} (288.00 g) which was statistically similar with T_3; whereas plant spacing 50 cm × 25 cm (T_2) showed the lowest dry matter weight plant^{-1} (247.80 g) which was statistically similar with T_5. A plant forms adequate number of leaves and branches when it has adequate supplies of light, nutrients and water. Closer spacing in a cropped field, may lead to greater reduction in dry matter accumulation as a result of competition for nutrients and other growth factors. Earlier reports of Makinde and Alabi (2002), and Sterner (1984) support this observation.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 10. Effect of plant spacing on the dry matter weight plant^{-1} of maize at different days after sowing (LSD $_{(0.05)}$ = 9.43, 17.61 and 18.63 at 60, 90 DAS and at harvest, respectively)

4.5.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation with advances of growth period in respect of dry matter weight plant^{-1} (Table 5). At 60 DAS, the highest dry matter weight plant^{-1} (92.33 g) was observed in V_2T_2 which was statistically similar with V_1T_2, V_2T_1 and V_2T_4; whereas the lowest dry matter weight plant^{-1} (44.33 g) was observed in V_2T_3 which was statistically similar with V_1T_5. At 90 DAS, the highest dry matter weight plant^{-1} (231.70 g) was observed in V_2T_5 which was statistically similar with V_2T_4; whereas the lowest dry matter weight plant^{-1} (165.30 g) was observed in V_1T_2 which was statistically similar with all other interactions except V_2T_2, V_2T_4 and V_2T_5. At harvest, the highest dry matter weight plant^{-1} (288.70 g) was observed in V_2T_4 which was statistically similar with V_1T_4, V_2T_3 and V_2T_5; whereas the lowest dry matter weight plant^{-1} (222.70 g) was observed in V_2T_1 which was statistically similar with V_1T_1, V_1T_2 and V_1T_5. This is similar to the findings of Makinde and Alabi (2002), and Sterner (1984) who reported that closer spacing and different maize varieties in a cropped field, may lead to greater reduction in dry matter accumulation as a result of competition for nutrients and other growth factors.

Table 05. Interaction effect of variety and plant spacing on dry matter weight plant^{-1} of maize at different days after sowing

Treatment combinations	Days after sowing (DAS)		
	60	**90**	**At Harvest**
V_1T_1	78.33 bc	186.3 bc	229.7 de
V_1T_2	85.33 ab	165.3 c	246.3 cde
V_1T_3	65.67 cd	181.3 bc	258.3 bc
V_1T_4	61.33 de	171.7 bc	287.3 a
V_1T_5	51.00 ef	186.3 bc	246.0 cde
V_2T_1	90.33 ab	188.3 bc	222.7 e
V_2T_2	92.33 a	196.3 b	249.3 cd
V_2T_3	44.33 f	167.0 c	283.0 ab
V_2T_4	81.67 ab	223.7 a	288.7 a
V_2T_5	65.33 cd	231.7 a	265.7 abc
LSD $_{(0.05)}$	**13.33**	**24.9**	**26.35**
CV (%)	**10.86**	**7.65**	**5.96**

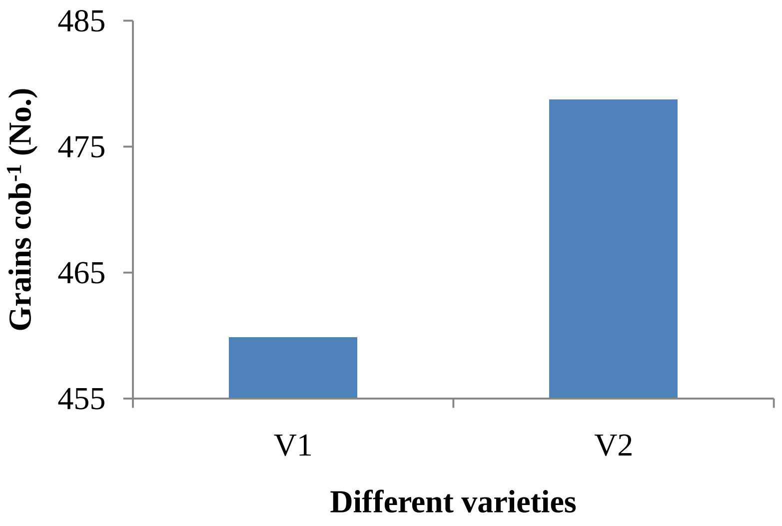
V_1: KS-510 and V_2: PSC-121

T_1 = 40 cm × 25 cm spacing ; T_2 = 50 cm × 25 cm spacing ; T_3 = 60 cm × 25 cm spacing T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

4.6 Grain cob^{-1}

4.6.1 Effect of variety

Maize variety exhibited non-significant difference in respect of the no. of grain cob^{-1} (Figure 11). Among the varieties, PSC-121 (V_2) showed the maximum no. of grain cob^{-1} (478.73) and KS-510 (V_1) showed the minimum no. of grain cob^{-1} (459.87).

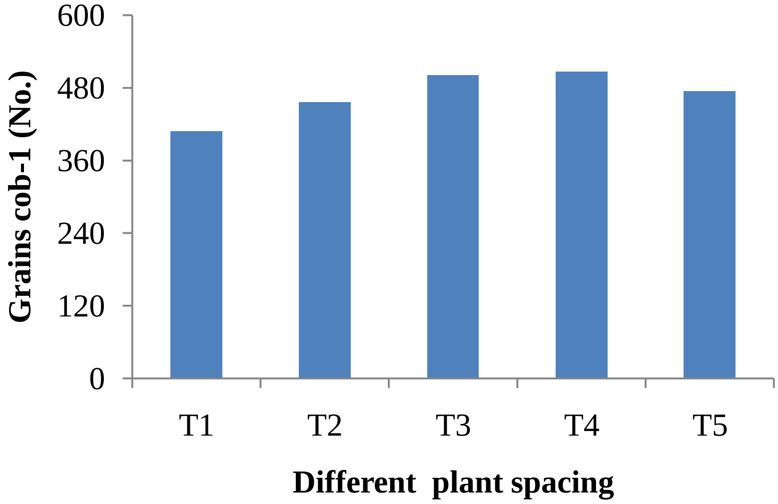


V_1: KS-510 and V_2: PSC-121

Figure 11. Effect of variety on the grins cob^{-1} of maize (LSD $_{(0.05)}$ = NS)

4.6.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of the no. of grain cob^{-1} (Figure 12). 70 cm × 25 cm spacing (T_4) showed the maximum no. of grain cob^{-1} (506.50) which was statistically similar with T_3 and T_5; whereas plant spacing 40 cm × 25 cm (T_1) showed the minimum no. of grain cob^{-1} (408.80) which was statistically similar with T_2. This is similar to the findings of Mechi (2015), Enujeke (2013b), Shafi *et al.* (2012) and Abuzar *et al.* (2011) who reported that the highest plant density negatively affected number of grains cob^{-1}. With increasing plant population, number of grains cob^{-1} decreased in a linear manner.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 12. Effect of plant spacing on the grins cob^{-1} of maize (LSD $_{(0.05)}$ = 47.95)

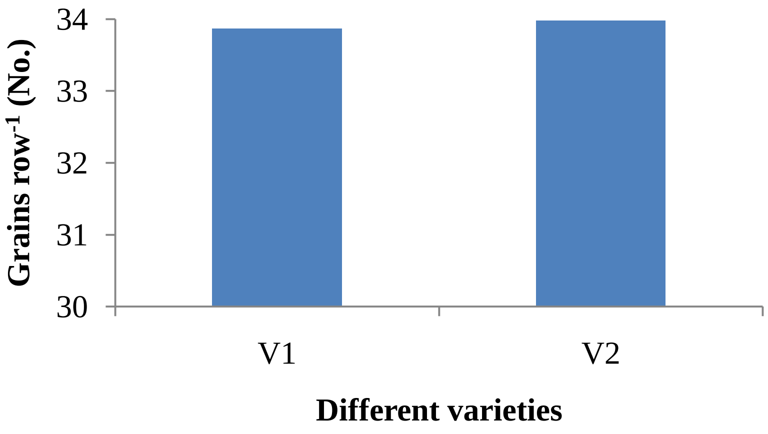
4.6.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of the no. of grain cob^{-1} (Table 6). The maximum no. of grain cob^{-1} (518.70) was observed in V_2T_4 which was statistically similar with all other interactions except V_1T_1 and V_2T_1; whereas the minimum no. of grain cob^{-1} (401.00) was observed in V_1T_1 which was statistically similar with V_1T_2, V_1T_5, V_2T_1 and V_2T_2.

4.7 Grain row^{-1}

4.7.1 Effect of variety

Maize variety exhibited non-significant difference in respect of the no. of grain row^{-1} (Figure 13). Among the varieties, PSC-121 (V_2) showed the maximum no. of grain row^{-1} (33.98) and KS-510 (V_1) showed the minimum no. of grain row^{-1} (33.87).

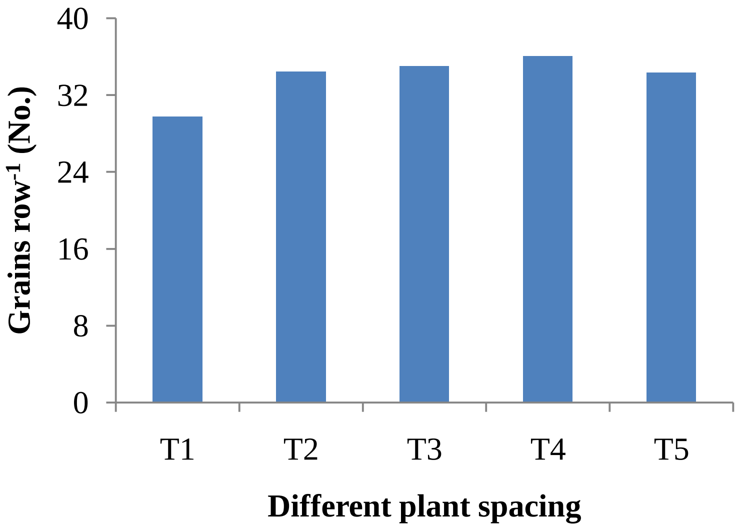


V_1: KS-510 and V_2: PSC-121

Figure 13. Effect of variety on the grains row^{-1} of maize (LSD $_{(0.05)}$ = NS)

4.7.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of the no. of grain row^{-1} (Figure 14). 70 cm × 25 cm spacing (T_4) showed the maximum no. of grain row^{-1} (36.05) which was statistically similar with all other treatments except T_1; whereas plant spacing 40 cm × 25 cm (T_1) showed the minimum no. of grain row^{-1} (29.78) which was statistically different from others. This is similar to the findings of Abuzar *et al.* (2011) who reported that the highest plant density negatively affected number of grains row^{-1}.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 14. Effect of plant spacing on the grains row^{-1} of maize (LSD $_{(0.05)}$ = 3.26)

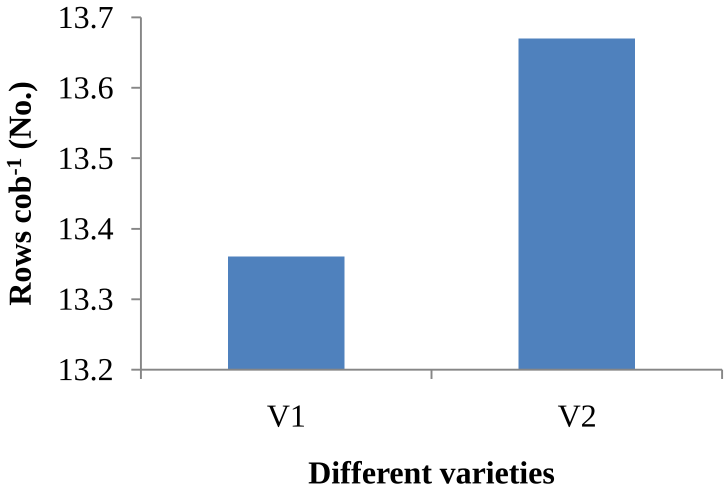
4.7.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of the no. of grain row^{-1} (Table 6). The maximum no. of grain row^{-1} (36.76) was observed in V_2T_4 which was statistically similar with all other interactions except V_1T_1 and V_2T_1; whereas the minimum no. of grain row^{-1} (29.23) was observed in V_2T_1 which was statistically similar with V_1T_1.

4.8 Rows cob^{-1}

4.8.1 Effect of variety

Maize variety exhibited non-significant difference in respect of the no. of row cob^{-1} (Figure 15). Among the varieties, PSC-121 (V_2) showed the maximum no. of row cob^{-1} (13.67) and KS-510 (V_1) showed the minimum no. of row cob^{-1} (13.36).

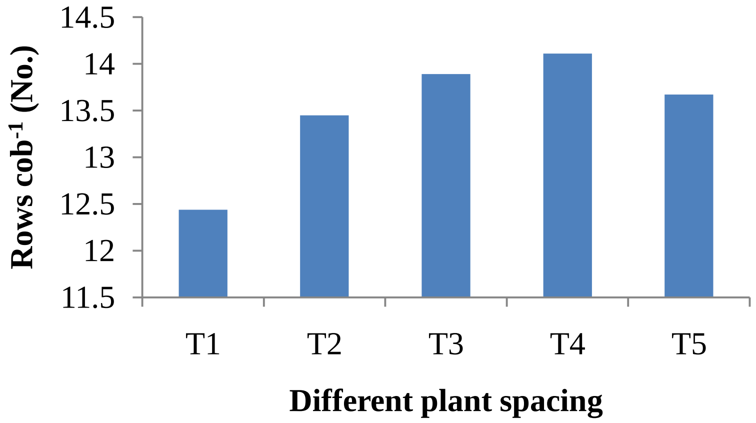


V_1: KS-510 and V_2: PSC-121

Figure 15. Effect of variety on the rows cob^{-1} of maize (LSD $_{(0.05)}$ = NS)

4.8.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of the no. of row cob^{-1} (Figure 16). 70 cm × 25 cm spacing (T_4) showed the maximum no. of row cob^{-1} (14.11) which was statistically similar with all other treatments except T_1; whereas plant spacing 40 cm × 25 cm (T_1) showed the minimum no. of row cob^{-1} (12.44) which was statistically different from others. This is similar to the findings of Sharifai *et al*. (2012) and Abuzar *et al.* (2011) who reported that the treatments having less population produced the highest number of rows cob^{-1}.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 16. Effect of plant spacing on the rows cob^{-1} of maize (LSD $_{(0.05)}$ = 0.99)

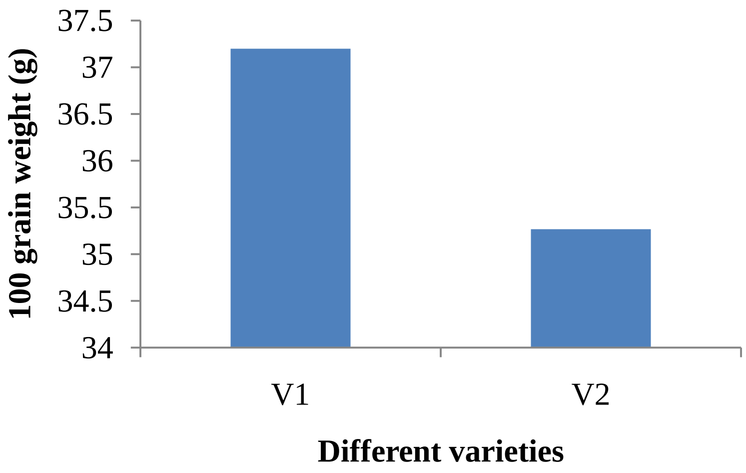
4.8.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of the no. of row cob^{-1} (Table 6). The maximum no. of row cob^{-1} (14.22) was observed in V_2T_4 which was statistically similar with all other interactions except V_1T_1 and V_2T_1; whereas the minimum no. of row cob^{-1} (12.33) was observed in V_1T_1 which was statistically similar with V_1T_2, V_1T_5, V_2T_1 and V_2T_2.

4.9 100 grain wt (g)

4.9.1 Effect of variety

Maize variety exhibited non-significant difference in respect of 100 grain weight (Figure 17). Among the varieties, KS-510 (V_1) showed the maximum 100 grain weight (37.20 g) and PSC-121 (V_2) showed the minimum 100 grain weight (35.27 g).

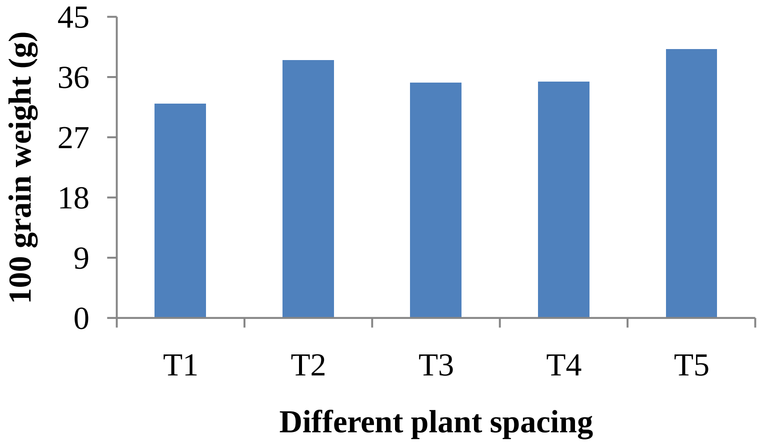


V_1: KS-510 and V_2: PSC-121

Figure 17. Effect of variety on the 100 grain weight of maize (LSD $_{(0.05)}$ = NS)

4.9.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of 100 grain weight (Figure 18). Double rows of 50 cm × 25 cm spacing (T_5) showed the maximum 100 grain weight (40.17 g) which was statistically similar with T_2; whereas plant spacing 40 cm × 25 cm (T_1) showed the minimum 100 grain weight (32.00 g) which was statistically similar with T_3. This is similar to the findings of Mechi (2015), Shafi *et al.* (2012), Sharifai *et al*. (2012) and Abuzar *et al.* (2011) who reported that the increasing planting density had a negative impact on 100 grain weight. Increasing plant population decreased 100 grain weights.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 18. Effect of plant spacing on the 100 grain weight of maize (LSD $_{(0.05)}$ = 3.22)

4.9.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of 100 grain weight (Table 6). The maximum 100 grain weight (40.33 g) was observed in V_2T_5 which was statistically similar with V_1T_2, V_1T_3, V_1T_4, V_1T_5 and V_2T_2; whereas the minimum 100 grain weight (31.67 g) was observed in V_2T_1 which was statistically similar with V_1T_1, V_2T_3 and V_2T_4.

Table 06. Interaction effect of variety and plant spacing on grain cob^{-1}, grain row^{-1}, row cob^{-1} and 100 grain weight of maize

Treatment combinations	Grain cob^{-1}	Grain row^{-1}	Row cob^{-1}	100 grain weight (g)
V_1T_1	401.0 b	30.33 bc	12.33 c	32.33 b
V_1T_2	458.0 ab	34.90 ab	13.34 abc	38.33 a
V_1T_3	487.0 a	34.67 ab	13.78 ab	37.67 a
V_1T_4	494.3 a	35.35 a	14.00 a	37.67 a
V_1T_5	459.0 ab	34.11 ab	13.33 abc	40.00 a
V_2T_1	416.7 b	29.23 c	12.56 bc	31.67 b
V_2T_2	454.0 ab	34.00 ab	13.56 abc	38.67 a
V_2T_3	514.3 a	35.34 a	14.00 a	32.67 b
V_2T_4	518.7 a	36.76 a	14.22 a	33.00 b
V_2T_5	490.0 a	34.56 ab	14.00 a	40.33 a
LSD $_{(0.05)}$	**67.81**	**4.61**	**1.40**	**4.55**
CV (%)	**8.42**	**7.92**	**6.04**	**7.32**

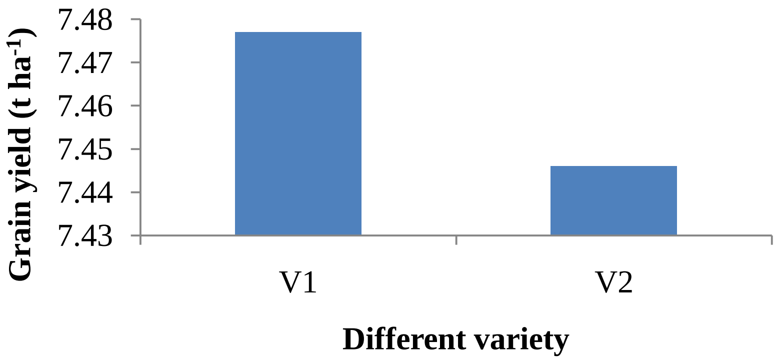
V_1: KS-510 and V_2: PSC-121

T_1 = 40 cm × 25 cm spacing ; T_2 = 50 cm × 25 cm spacing ; T_3 = 60 cm × 25 cm spacing T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

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

4.10.1 Effect of variety

Maize variety exhibited non-significant difference in respect of grain yield (Figure 19). Among the varieties, KS-510 (V_1) showed the highest grain yield (7.48 t ha^{-1}) and PSC-121 (V_2) showed the lowest grain yield (7.45 t ha^{-1}).

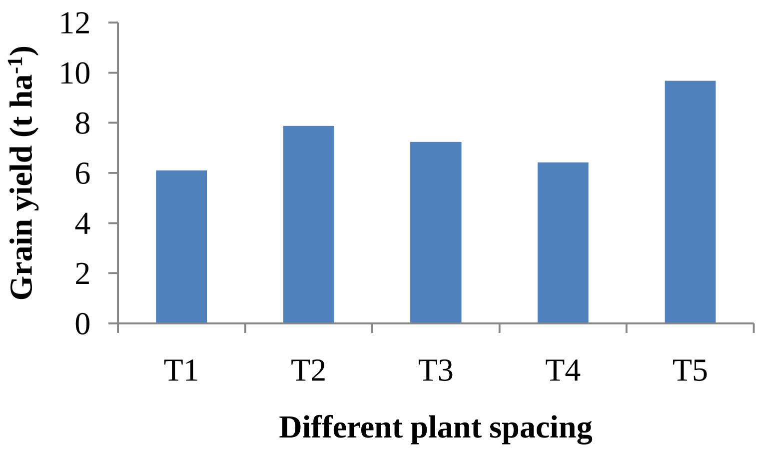


V_1: KS-510 and V_2: PSC-121

Figure 19. Effect of variety on the grain yield of maize (LSD $_{(0.05)}$ = NS)

4.10.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of grain yield (Figure 20). Double rows of 50 cm × 25 cm spacing (T_5) showed the highest grain yield (9.68 t ha^{-1}) which was statistically different from others; whereas plant spacing 40 cm × 25 cm (T_1) showed the lowest grain yield (6.10 t ha^{-1}) which was statistically similar with T_4. This is similar to the findings of Mechi (2015), Enujeke (2013b), Jula *et al*. (2013), Shafi *et al.* (2012) and Abuzar *et al.* (2011) who reported that the increasing planting density had a negative impact on grain yield. Increasing plant population decreased the production of grain due to the competition for nutrients and other growth factors.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 20. Effect of plant spacing on the grain yield of maize (LSD $_{(0.05)}$ = 0.86)

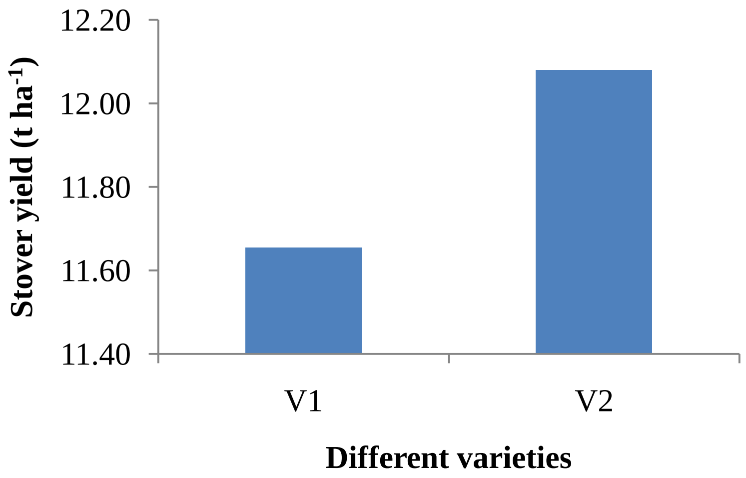
4.10.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of grain yield (Table 7). The highest grain yield (10.50 t ha^{-1}) was observed in V_2T_5 which was statistically different from others; whereas the lowest grain yield (5.65 t ha^{-1}) was observed in V_2T_1 which was statistically similar with V_1T_1 and V_2T_4.

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

4.11.1 Effect of variety

Maize variety exhibited non-significant difference in respect of stover yield (Figure 21). Among the varieties, PSC-121 (V_2) showed the highest stover yield (12.08 t ha^{-1}) and KS-510 (V_1) showed the lowest stover yield (11.65 t ha^{-1}).

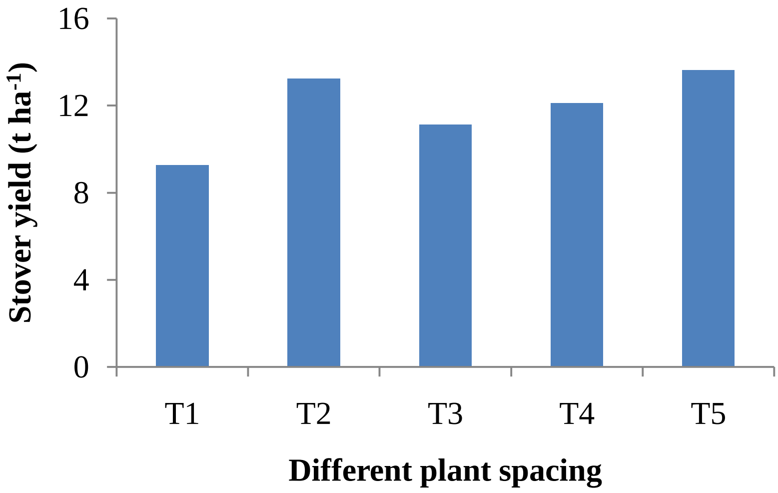


V_1: KS-510 and V_2: PSC-121

Figure 21. Effect of variety on the stover yield of maize (LSD $_{(0.05)}$ = NS)

4.11.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of stover yield (Figure 22). Double rows of 50 cm × 25 cm spacing (T_5) showed the highest stover yield (13.62 t ha^{-1}) which was statistically similar with T_2; whereas plant spacing 40 cm × 25 cm (T_1) showed the lowest stover yield (9.26 t ha^{-1}) which was statistically different from others. This is similar to the findings of Mechi (2015), Shafi *et al.* (2012) and Abuzar *et al.* (2011) who reported that the increasing planting density had a negative impact on stover yield. Increasing plant population decreased the stover due to the competition for nutrients and other growth factors.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 22. Effect of plant spacing on the stover yield of maize (LSD $_{(0.05)}$ = 0.90)

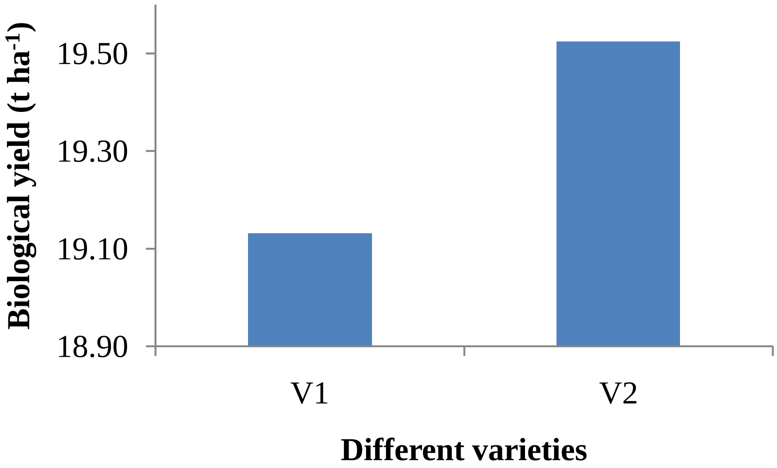
4.11.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of stover yield (Table 7). The highest stover yield (14.01 t ha^{-1}) was observed in V_2T_5 which was statistically similar with V_1T_5 and V_2T_2; whereas the lowest stover yield (8.89 t ha^{-1}) was observed in V_2T_1 which was statistically similar with V_1T_1. This is similar to the findings of Shafi *et al.* (2012) who reported that the different maize varieties had a significant variation with different plant spacing due to the competition for nutrients and other growth factors.

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

4.12.1 Effect of variety

Maize variety exhibited non-significant difference in respect of biological yield (Figure 23). Among the varieties, PSC-121 (V_2) showed the highest biological yield (19.53 t ha^{-1}) and KS-510 (V_1) showed the lowest biological yield (19.13 t ha^{-1}).

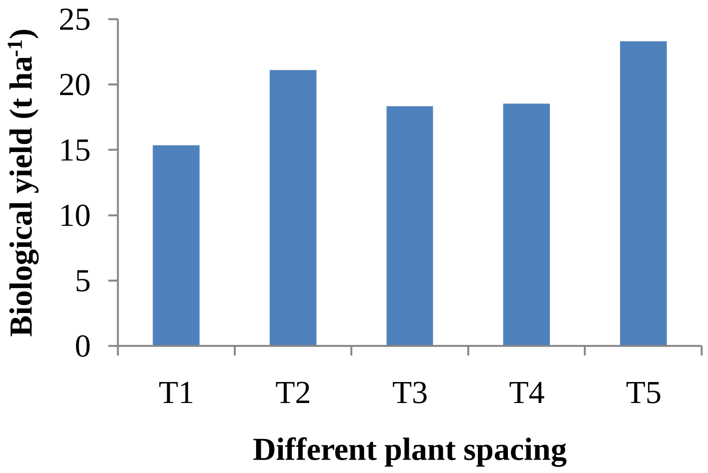


V_1: KS-510 and V_2: PSC-121

Figure 23. Effect of variety on the biological yield of maize (LSD $_{(0.05)}$ = NS)

4.12.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of biological yield (Figure 24). Double rows of 50 cm × 25 cm spacing (T_5) showed the highest biological yield (23.30 t ha^{-1}) which was statistically different from others; whereas plant spacing 40 cm × 25 cm (T_1) showed the lowest biological yield (15.36 t ha^{-1}) which was statistically different from others.



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 24. Effect of plant spacing on the biological yield of maize (LSD $_{(0.05)}$ =1.37)

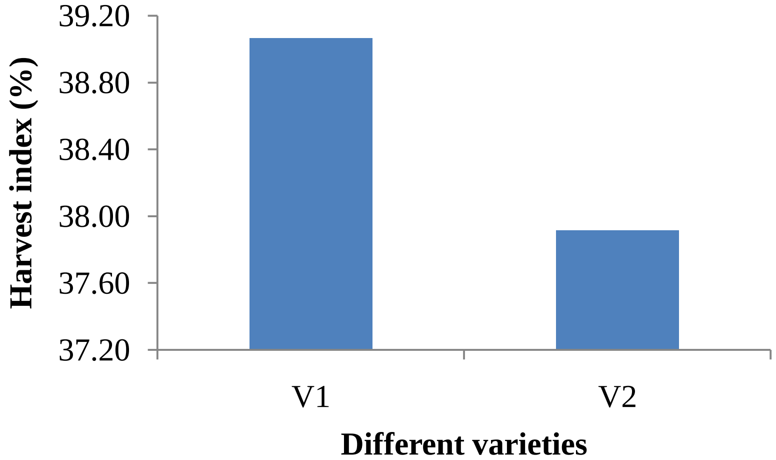
4.12.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of biological yield (Table 7). The highest biological yield (24.51 t ha^{-1}) was observed in V_2T_5 which was statistically different from others; whereas the lowest biological yield (14.54 t ha^{-1}) was observed in V_2T_1 which was statistically similar with V_1T_1.

4.13 Harvest index (%)

4.13.1 Effect of variety

Maize variety exhibited non-significant difference in respect of harvest index (Figure 25). Among the varieties, KS-510 (V_1) showed the highest harvest index (39.07%) and PSC-121 (V_2) showed the lowest harvest index (37.92%).

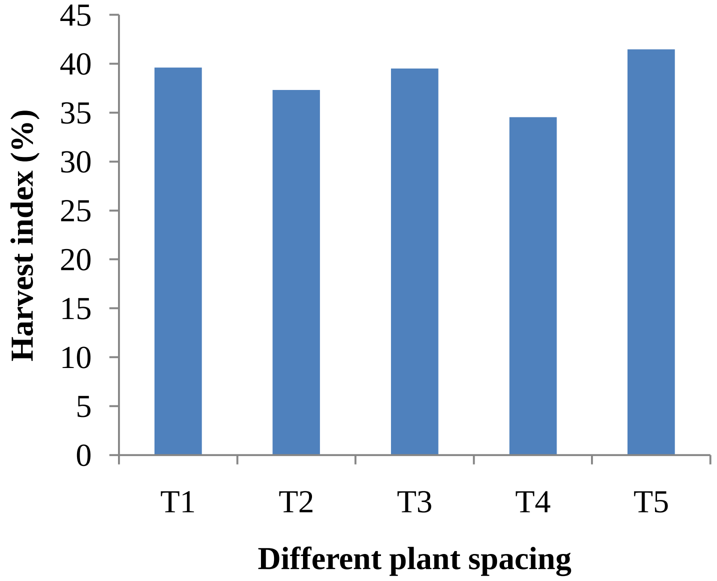


V_1: KS-510 and V_2: PSC-121

Figure 25. Effect of variety on the harvest index of maize (LSD $_{(0.05)}$ = NS)

4.13.2 Effect of plant spacing

Plant spacing showed a significant variation in respect of harvest index (Figure 24). Double rows of 50 cm × 25 cm spacing (T_5) showed the highest harvest index (41.47%) which was statistically similar with T_1 and T_3; whereas plant spacing 70 cm × 25 cm (T_4) showed the lowest harvest index (34.53%) which was statistically similar with T_2. This is similar to the findings of Mechi (2015).



T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

Figure 26. Effect of plant spacing on the harvest index of maize (LSD $_{(0.05)}$ = 2.97)

4.13.3 Interaction effect of variety and plant spacing

Interaction of variety and plant spacing showed significant variation in respect of harvest index (Table 7). The highest harvest index (42.84%) was observed in V_2T_5 which was statistically similar with V_1T_1, V_1T_3, V_1T_5, V_2T_1 and V_2T_3; whereas the lowest harvest index (32.31%) was observed in V_2T_4 which was statistically different from others.

Table 7. Interaction effect of variety and plant spacing on grain yield, stover yield, biological yield and harvest index of maize

Treatment combinations	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1T_1	6.550 def	9.623 e	16.17 e	40.37 ab
V_1T_2	7.737 bcd	12.51 bc	20.25 bc	38.16 b
V_1T_3	7.277 cd	10.97 d	18.25 d	39.94 ab
V_1T_4	6.970 cde	11.93 cd	18.90 cd	36.76 b
V_1T_5	8.853 b	13.24 ab	22.09 b	40.10 ab
V_2T_1	5.650 f	8.893 e	14.54 e	38.85 ab
V_2T_2	8.023 bc	13.93 a	21.96 b	36.50 b
V_2T_3	7.193 cd	11.26 cd	18.46 cd	39.08 ab
V_2T_4	5.860 ef	12.30 bc	18.16 d	32.31 c
V_2T_5	10.50 a	14.01 a	24.51 a	42.84 a
LSD $_{(0.05)}$	**1.21**	**1.269**	**1.942**	**4.193**
CV (%)	**9.44**	**6.23**	**5.86**	**6.35**

V_1: KS-510 and V_2: PSC-121

T_1 = 40 cm × 25 cm spacing ; T_2 = 50 cm × 25 cm spacing ; T_3 = 60 cm × 25 cm spacing T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing

CHAPTER V

SUMMARY AND CONCLUSION

The present research work was conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November, 2015 to April, 2016 to study the effect of effect of planting configuration on the growth and yield of white maize. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors. Factor A: Varieties (2 levels); V_1: KS-510 and V_2: PSC-121, and factor B: Plant spacing (5 levels); T_1: 40 cm × 25 cm spacing, T_2: 50 cm × 25 cm spacing, T_3: 60 cm × 25 cm spacing, T_4: 70 cm × 25 cm spacing and T_5: Double rows of 50 cm × 25 cm spacing. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 10 treatment combinations. The total numbers of unit plots were 30. The size of unit plot was 12 m^2 (4 m × 3 m). The field was fertilized with nitrogen, phosphate, potash, sulphur and zinc at the rate of 230-50-100-31.25-3.5 kg ha^{-1}, respectively in the form of urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate.

Results showed that a significant influence was observed among the treatments regarding all of the parameters observed. The collected data were statistically analyzed for evaluation of the treatment effect.

Among the varieties, PSC-121 (V_2) showed the tallest plant (204.73 cm at harvest) and KS-510 (V_1) showed the shortest plant (198.82 cm at harvest). At harvest, V_1 and V_2 showed the highest (10.55) and lowest (10.47) number of collar leaf $plant^{-1}$, respectively. At 90 DAS, V_1 and V_2 showed the highest (274.11 cm^2) and lowest (188.42 cm^2) leaf area, respectively. At harvest, V_2 showed the highest base diameter (9.02 cm) and V_1 showed the lowest base diameter (8.87 cm). At harvest, V_2 showed the highest shoot dry weight $plant^{-1}$

(261.87 g) and V_1 showed the lowest shoot dry weight plant^{-1} (253.53 g). KS-510 (V_1) showed the maximum 100 grain weight (37.20 g) and PSC-121 (V_2) showed the minimum 100 grain weight (35.27 g). Among the varieties, PSC-121 (V_2) showed the maximum no. of grain cob^{-1} (478.73), maximum no. of grain row^{-1} (33.98), maximum no. of row cob^{-1} (13.67); whereas KS-510 (V_1) showed the minimum no. of grain cob^{-1} (459.87), minimum no. of grain row^{-1} (33.87), and minimum no. of row cob^{-1} (13.36). KS-510 (V_1) showed the highest grain yield (7.48 t ha^{-1}) and PSC-121 (V_2) showed the lowest grain yield (7.45 t ha^{-1}). PSC-121 (V_2) showed the highest stover yield (12.08 t ha^{-1}) and biological yield (19.53 t ha^{-1}); whereas KS-510 (V_1) showed the lowest stover yield (11.65 t ha^{-1}) and biological yield (19.13 t ha^{-1}). Among the varieties, KS-510 (V_1) showed the highest harvest index (39.07%) and PSC-121 (V_2) showed the lowest harvest index (37.92%).

Among the plant spacing, T_2 showed the tallest plant (205.3 cm at harvest) and T_3 showed the shortest plant (199.0 cm at harvest). At harvest, T_3 and T_1 showed the highest (10.88) and lowest (10.23) number of collar leaf plant^{-1}, respectively. At 90 DAS, 50 cm × 25 cm spacing (T_2) showed the maximum leaf area (261.70 cm^2) and plant spacing 40 cm × 25 cm (T_1) showed the minimum leaf area (188.80 cm^2). At harvest, T_2 showed the highest base diameter (9.28 cm) and T_5 showed the lowest base diameter (8.47 cm). At harvest, T_4 showed the highest shoot dry weight plant^{-1} (288.00 g) and T_2 showed the lowest shoot dry weight plant^{-1} (247.80 g). Among the plant spacing, T_5 showed the maximum 100 grain weight (40.17 g) and T_1 showed the minimum 100 grain weight (32.00 g). Among the plant spacing, T_4 showed the maximum no. of grain cob^{-1} (506.50), maximum no. of grain row^{-1} (36.05), maximum no. of row cob^{-1} (14.11); whereas T_1 showed the minimum no. of grain cob^{-1} (408.80), minimum no. of grain row^{-1} (29.78), and minimum no. of row cob^{-1} (12.44). Among the plant spacing, T_5 showed the highest grain yield (9.68 t ha^{-1}), stover yield (13.62 t ha^{-1}) and biological yield (23.30 t ha^{-1}); whereas T_1 showed the lowest grain yield (6.10 t ha^{-1}), stover yield (9.26 t ha^{-1})

and biological yield (15.36 t ha^{-1}). Double rows of 50 cm × 25 cm spacing (T_5) showed the highest harvest index (41.47%); whereas plant spacing 70 cm × 25 cm (T_4) showed the lowest harvest index (34.53%).

Among the interaction of variety and plant spacing, V_2T_2 showed the tallest plant (212.3 cm at harvest) and V_1T_1 showed the shortest plant (198.1 cm at harvest). At harvest, the highest number of collar leaf $plant^{-1}$ (11.20) was observed in V_1T_3 and the lowest number of collar leaf $plant^{-1}$ (9.90) was observed in V_1T_1. At 90 DAS, the maximum leaf area (314.20 cm^2) was observed in V_1T_2 and the minimum leaf area (159.40 cm^2) was observed in V_2T_1. At harvest, the highest base diameter (9.933 cm) was observed in V_2T_4 and the lowest base diameter (8.033 cm) was observed in V_2T_5. At harvest, the highest shoot dry weight $plant^{-1}$ (288.70 g) was observed in V_2T_4 and the lowest shoot dry weight $plant^{-1}$ (222.70 g). The maximum 100 grain weight (40.33 g) was observed in V_2T_5 and the minimum 100 grain weight (31.67 g) was observed in V_2T_1. The maximum no. of grain cob^{-1} (518.70) was observed in V_2T_4 and the minimum no. of grain cob^{-1} (401.00) was observed in V_1T_1. The maximum no. of grain row^{-1} (36.76) was observed in V_2T_4 and the minimum no. of grain row^{-1} (29.23) was observed in V_2T_1. The maximum no. of row cob^{-1} (14.22) was observed in V_2T_4 and the minimum no. of row cob^{-1} (12.33) was observed in V_1T_1. The highest grain yield (10.50 t ha^{-1}), stover yield (14.01 t ha^{-1}) and biological yield (24.51 t ha^{-1}) was observed in V_2T_5; whereas the lowest grain yield (5.65 t ha^{-1}), stover yield (8.89 t ha^{-1}) and biological yield (14.54 t ha^{-1}) was observed in V_2T_1. The highest harvest index (42.84%) was observed in V_2T_5; whereas the lowest harvest index (32.31%) was observed in V_2T_4.

The results in this study indicated that the plants performed better in respect of grain yield in V_2T_5 treatment than V_2T_1 showed the least performance. It can be therefore, concluded from the above study that the treatment combination of PSC-121 variety and double rows of 50 cm × 25 cm plant spacing was found to be the most suitable combination for the highest yield of maize.

To reach a specific conclusion and recommendation, more research work on maize should be done in different Agro-ecological zones of Bangladesh with this treatment variable.

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