GROWTH, YIELD AND YIELD ATTRIBUTES OF WHITE MAIZE (SAUWMT 12-3-3) UNDER DIFFERENT PLANTING GEOMETRY

MD. SHABBIR AKHTAR

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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BY

MD. SHABBIR AKHTAR

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Approved by:

Prof. Dr. Md. Jafar Ullah	**Prof. Dr. Parimal Kanti Biswas**
Supervisor	**Co-Supervisor**

Prof. Dr. Tuhin Suvra Roy

Chairman

Examination Committee

DEPARTMENT OF AGRONOMY

Sher-e-Bangla Agricultural University

Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

*This is to certify that thesis entitled, "**GROWTH, YIELD AND YIELD ATTRIBUTES OF WHITE MAIZE (SAUWMT 12-3-3) UNDER DIFFERENT PLANTING GEOMETRY**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MD. SHABBIR AKHTAR**, Registration no. **13-05322** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Date:

Place: Dhaka, Bangladesh

Prof. Dr. Md. Jafar Ullah

Department of Agronomy

Sher-e-Bangla Agricultural University,

Dhaka-1207

Dedication

Every challenging work needs self efforts as well as guidance of elder especially those who were very close to our heart.

My humble effort I dedicate to my sweet and loving

Father & Mother,

whose affection, love, encouragement and prays of day and night make me able to get such success and honor,

Along with all hard working

and respected

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The Author

GROWTH, YIELD AND YIELD ATTRIBUTES OF WHITE MAIZE (SWMT 12-3-3) UNDER DIFFERENT PLANTING GEOMETRY

ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University Dhaka, during October 2018 to February 2019 to evaluate the growth, yield and yield attributes of white maize (Genotype SAUWMT 12-3-3) under different planting geometry. The experiment was consisted of two different factors. Factor A: Row spacings (5) *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm, S_5: 60 cm, and Factor B: Plant spacings (3) *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm. The experiment was set up in randomized complete block design (factorial) with three replications. Results revealed that, growth, yield and yield attributes of white maize were significantly influenced due to different planting geometry. In case of row spacings result revealed that, the maximum cob length plant^{-1} (18.28 cm), cob circumference plant^{-1} (19.70 cm), number of grain rows cob^{-1} (16.77), number of grains row^{-1} in cob (29.37), number of grains cob^{-1} (492.70), 1000 grains weight (301.33 g), chaff weight cob^{-1} (8.92 g), shell weight cob^{-1} (17.53 g), grains weight cob^{-1} (122.49 g), cob weight plant^{-1} (148.93 g), shelling percentage (82.05 %) and grain yield (10.35 t ha^{-1}), were recorded in S_5 treatment. In case of plant spacings result revealed that, the maximum cob length plant^{-1} (16.97 cm), cob circumference plant^{-1} (18.42 cm), number of grain rows cob^{-1} (15.33), number of grains row^{-1} in cob (26.39), grains cob^{-1} (408.56), 1000 grains weight (284.26 g), chaff weight cob^{-1} (8.54 g), shell weight cob^{-1} (16.39 g), grain weight cob^{-1} (110.13 g), cob weight plant^{-1} (135.06 g), shelling percentage (81.41 %), were recorded in T_3 treatment, and maximum grain yield (10.07 t ha^{-1}) was recorded in T_2 treatment. In case of combined effect, S_5T_2 (60 cm × 20 cm) treatment combination performed best in producing the maximum grain yield (11.07 t ha^{-1}) and suitable for grain production of white maize comparable to other treatment combination. The corresponding lowest grain yield and yield attributes were recorded in S_1T_1 (40 cm × 15 cm) treatment combination.

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ABBREVIATIONS

Full word	Abbreviations	Full word	Abbreviations
Agriculture	Agric.	Milliequivalents	Meqs
Agro-Ecological Zone	AEZ	Triple super phosphate	TSP
And others	et al.	Milligram(s)	mg
Applied	App.	Millimeter	mm
Asian Journal of Biotechnology and Genetic Engineering	AJBGE	Mean sea level	MSL
Bangladesh Agricultural Research Institute	BARI	Metric ton	MT
Bangladesh Bureau of Statistics	BBS	North	N
Biology	Biol.	Nutrition	Nutr.
Biotechnology	Biotechnol.	Randomized Complete Block Design	RCBD
Botany	Bot.	Regulation	Regul.
Centimeter	Cm	Research and Resource	Res.
Cultivar	Cv.	Review	Rev.
Degree Celsius	°C	Science	Sci.
Department	Dept.	Society	Soc.
Development	Dev.	Soil plant analysis development	SPAD
Dry Flowables	DF	Soil Resource Development Institute	SRDI
East	E	Technology	Technol.
Editors	Eds.	Tropical	Trop.
Emulsifiable concentrate	EC	Thailand	Thai.
Entomology	Entomol.	United Kingdom	U.K.
Environments	Environ.	University	Univ.
Food and Agriculture Organization	FAO	United States of America	USA
Gram	g	Wettable powder	WP
Horticulture	Hort.	Serial	Sl.
International	Intl.	Percentage	%
Journal	J.	Number	No.
Kilogram	kg	Microgram	µ
Least Significant Difference	LSD		
Liter	L		
Milliliter	mL		

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) is the world's widely grown highland cereal and primary staple food crop in many developing countries (Kandil, 2013). It was originated in America and first cultivated in the area of Mexico more than 7,000 years ago, and spread throughout North and South America (Hailare, 2000). This cereal crop belongs to the family Poaceae. It is a typical monoecious plant highly cross-pollinated (95%), self-pollination may reach up to 5% (Poehlman and Sleper, 1995). It has very high yield potential, there is no cereal on the earth, which has so immense potentiality and that is why it is called "Queen of cereals" (FAO, 2002). It ranks 1st in respect of yield per unit area, 2nd in respect total production and 3rd after wheat and rice in respect of acreage in cereal crops (Zamir *et al.*, 2013).

Maize is grown as a fodder, feed and food crop. It is also used as raw material for manufacturing pharmaceutical and industrial products. Wheat, rice and maize are the most important cereal crops in the world but maize is the most popular due to its high yielding, easy of processing, readily digested and costs less than other cereals (Jaliya *et al*., 2008). Maize grain contains 70% carbohydrate, 10% protein, 4% oil, 10.4% albumin, 2.3% crude fiber, 1.4% ash (Nasim *et al*., 2012). Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains (Chowdhury and Islam, 1993). Maize oil is used as the best quality edible oil.

Its world average yield is 27.80 q ha^{-1} maize ranks first among the cereals and is followed by rice, wheat, and millets, with average grain yield of 22.5, 16.3 and 6.6 q ha^{-1}, respectively (Nasim *et al*., 2012). Introduction of maize in Bangladesh as human food can be a viable alternative for sustaining food security as the productivity of maize much higher than rice and wheat (Ray *et al.*, 2013). It provides many of the B vitamins and essential minerals along with fibre, but lacks some other nutrients, such as vitamin $B_{12}$and vitamin C. Maize has been a recent introduction in Bangladesh. Rice maize cropping system has been expanded (Timsina *et al.*, 2010) rapidly in the northern districts of Bangladesh mainly in response to increasing demand for poultry feed (BBS, 2016). Maize production of Bangladesh increased from 3,000 tons in 1968 to 3.03 million tons in 2017growing at an average annual rate of 28.35 % (FAO, 2019).

There are two kinds of maize in respect of grain colour; yellow and white. Worldwide, the yellow maize is mainly used as fodder while the white ones are consumed as human food (FAO, 2002). The currently grown maize in this country is yellow type, which is mainly adapted importing genetic materials from CIMMYT. Again, although there are some indigenous local maize in the south east hills those have also not improved for having higher yields (Ullah *et al.*, 2016).World production of white maize is currently estimated to be around 65 to 70 million tons. Among the individual geographical regions of the developing countries, white maize production has a paramount importance in Bangladesh. The major producers are the United States, Brazil, France, India and Italy. The main white maize producers in Africa include Kenya, Tanzania, Zambia and Zimbabwe (Kidist, 2013).

There are two types of white maize named Dent maize and Flint maize. They are largely associated with certain types of food products and dishes. Dent maize is soft and floury and is primarily used for making soups and porridges. Recently white maize is becoming popular very rapidly as soup, pakora, chutney, cutlets chat, dry vegetable, kofta curry, masala, manchurian, chilly, raita, pickle, candy, jam, murabba, burfi, halwa, kheer, laddo and other favorite dishes for different Chinese hotels and restaurants in Bangladesh (Ahmed, 1994).

Maize currently grown in Bangladesh is of yellow type and is used in the feed industry. White maize covers only 12% of the total acreage of the world, which is mostly used as human food (FAO-CIMMYT, 1997). During 1970s, the productivity of grown white maize was lower compared to those of yellow ones. With the advanced breeding approaches, worldwide, recent reports demonstrate that the yield productivity of white maize is almost at par with those of the yellow ones (Akbar *et al.,* 2016). Bangladesh Agricultural Research Institute (BARI) has developed seven open pollinated and 11 hybrid varieties whose yield potentials are 5.50–7.00 t ha^{-1} and 7.40–12.00 t ha^{-1}, respectively, which are well above the world average of 3.19 t ha^{-1} (Nasim *et al*., 2012). The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices, and limited use of input, insufficient technology generation, poor seed quality, disease, insect, pest and weeds. In general the yield productivity of any crop in this country is low which is generally attributed to the poor agronomic management (Ullah *et al.*, 2017).

Among the agronomical management practices, setting the optimum plant density by maintaining proper spacing is one of the most important cultural practices which determining grain yield, as well as other important agronomic attributes of this crop (Sangoi, 2001).

Stand density affects plant architecture, alters growth and developmental patterns and influences carbohydrate production and partition (Casal *et al.*, 1985). Plant density and arrangement of plants in a unit area greatly determine resource utilization such as light, nutrients, and water; it affects the rate and extent of vegetative growth and development of crops particularly that of leaf area index, plant height, root length and density, yield and yield components, development of important diseases and pests, and the seed cost (Jettner *et al*., 1998).

Crop production that is grain yield is higher when the plant competition in very low. Competition between the plant alter the morphology of the plant in various ways. Researchers have shown that plants become sterile when spacing is very low. This plants cannot utilize the resources due to huge plant competition and thus become weaker and sterile as a result its produce lower yield. Moreover nutrient availability also depends on proper spacing. Resource, on the other hand, will simply be misuse under improper plant spacing (Ahmed and Muhammad, 1999; Sabir *et al.*, 2001). So proper spacing is important for increasing yield of maize crop. Adjustment of spacing on maize field is important to ensure maximum utilization of the solar radiation and reduces evaporation of soil moisture.

Bangladesh is a developing country. The land area of Bangladesh for agricultural cultivation is being reducing day by day due to the increasing population as a result maximum potential yield exploitation of a crop must be ensured by adopting appropriate agronomical management in which proper spacing in one of the main key management of agronomical management practices. Proper spacing that is row to row spacing and plant to plant spacing is an important agronomical management practices which makes more efficient use of available resources by setting plant in a specific unit area and thus increase productivity by utilizing minimum land area and increasing productivity of a specific crop.

In our country, very few research works have been carry out with this present work. Thus considering the above facts the present work was conducted on white maize production with the following objectives:-

i. To identify the optimum row spacing for white maize production.
ii. To identify the optimum plant spacing for white maize production.

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CHAPTER II

REVIEW OF LITERATURE

An attempt was made in this section to collect and study relevant information available regarding the effect of different row and plant spacing on the growth and yield of white maize to gather knowledge helpful in conducting the present piece of work.

2.1 Review of different spacing

2.1.1 Review on growth parameters

2.1.1.1 Plant height (cm)

Alam *et al*. (2020) conducted an experiment to examine the effect of suitable spacing technique(s) of maize on the morpho-physiology, yield attributes, yield and nutrient composition of maize and revealed that the maximum morpho-physiological characters, yield attributes and yield was obtained with higher composition of nutrients by using technique of 60 cm × 30 cm (T3). This treatment also showed the highest plant height that was 223.45 cm.

Gaire *et al*. (2020) conducted a field experiment to study the effect of spacing and nitrogen level on growth and yield of maize in Parbat from February to July, 2019. The experiment result revealed that the plant height and leaf area index were significantly high at close spacing (60×15 cm) and at 120 kg N/ha.

Ahmmed (2018) carried out an experiment to evaluate the performance of white maize variety under different spacings and integrated fertilizer management and reported that the wider spacing R_1 (60 cm × 20 cm) showed the highest plant height and numbers of leaves per plant.

Enujeke (2013 a) revealed that the tallest plant 176.7 cm was recorded from plants sown in 75 cm × 15 cm and the shortest one 152.7 cm was recorded from plants sown in 75 cm × 35 cm spacing.

2.1.1.2 Number of leaves plant^{-1}

Ullah *et al.* (2020) conducted an experiment to evaluate the performance of white maize variety under different spacing and integrated fertilizer management and reported that higher leaves number plant^{-1} was achieved with higher plant spacing where lower plant spacing showed lower leaf number plant^{-1}. The highest leaves number plant^{-1}at 8.00, 10.04 and 11.93 respectively at S_1 where the lowest were 7.81, 9.19 and 11.57 respectively which was with S_2.

Jula *et al*. (2013) carried out a field experiment to evaluate the effects of various intra-row spacing on the growth and yield of maize intercropped into ginger and showed that, the highest number of leaves plant^{-1} (12.33) was recorded from maize intercrop planted at 75 cm × 75 cm and the lowest number of leaves plant^{-1}(8.00) was reported from sole maize crop treatment at 75 cm × 25 cm spacing.

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

Ukonze *et al.* (2016) carried out a study to compare and analyses how spacing influenced the performance and yield of late maize. One maize variety was evaluated under three spacing for performance data and showed significant differences ($p < 0.05$) in leaf area. The 70 cm × 30 cm and 60 cm × 40 cm spacing gave higher values of the morphological parameters (leaf area plant^{-1}) than 80 cm × 20 cm.

Enujeke (2013 a) carried out a study to evaluate the effects of variety and spacing on growth characters of hybrid maize. Experimental result showed that plants sown on 75 cm × 35 cm spacing had the maximum leaf area (713.70 cm^2) whereas plants sown on 75 cm × 15 cm spacing had the minimum leaf area (587.30 cm^2).

2.1.1.4 Leaf area index

Gaire *et al*. (2020) conducted a field experiment to study the effect of spacing and nitrogen level on growth and yield of maize in Parbat from February to July, 2019. The result revealed that different spacing and nitrogen level significantly affect the plant height and leaf area index. The plant height and leaf area index were significantly high at close spacing (60×15 cm) and at 120 kg N/ha.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties and reported that highest leaf area index was observed in planting density of 65,000 plants $ha^{-1}$and the lowest LAI was observed in planting density of 45,000 plants ha^{-1}.

Abuzar *et al*. (2011) reported that 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 40,000 plants ha^{-1}.

2.1.1.5 Stem base circumference $plant^{-1}$ (cm)

Alam *et al*. (2020) conducted an experiment to examine the effect of suitable spacing technique(s) of maize on the morpho-physiology, yield attributes, yield and nutrient composition of maize and found that spacing techniques showed significantly different performance on yield. The maximum morpho-physiological characters, yield attributes and yield was obtained with higher composition of nutrients by using technique of 60cm×30cm (T_3). This treatment also showed the highest stem diameter was 8.10cm.

Ukonze *et al.* (2016) observed that 70 cm × 30 cm and 60 cm × 40 cm spacing gave higher values of the morphological parameters than 80 cm × 20 cm.

Enujeke (2013 a) carried out a study to evaluate the effects of variety and spacing on growth characters of hybrid maize and found that spacing of 75 cm × 35 cm could be used to enhance increased stem girth and leaf area whose photosynthetic activities could positively influence maize yield.

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

Getaneh *et al*. (2016) conducted an experiment at Kombolcha, Eastern Ethiopia in 2014 to determine the of Effect of intra- and inter-row spacing on growth, yield components and grain yield of maize and shown that the highest above ground dry biomass yields per plant at the widest inter and intra-row spacing might be due to high stem diameter and high leaf area because there is more availability of growth factors and better penetration of light at wider row spacing.

Jula *et al*. (2013) conducted a field experiment to evaluate the effects of various intra-row spacing on the growth and yield of maize intercropped into ginger. The results showed that the dry matter accumulation was the highest (29.17 g $plant^{-1}$) for maize intercrop planted at 75 cm × 25 cm.

2.1.2 Review on yield contributing characters

2.1.2.1 Cob length plant^{-1} (cm)

Alam *et al*. (2020) conducted an experiment to examine the effect of suitable spacing technique(s) of maize on the morpho-physiology, yield attributes, yield and nutrient composition of maize and reported that yield attributes and yield was obtained with higher composition of nutrients by using technique of 60cm×30cm (T_3).This treatment also showed the highest cob length that was 22.20 cm.

Koirala *et al*. (2020) reported that the highest grain yield was found in Rampur Composite and Arun-2 while they were planted with row spacing of 60 cm with plant to plant spacing of 25 cm. The highest cob length was reported when maize was planted in the row spacing 60×25 cm.

Azam (2017) reported that intra-row spacing had statistically significant effect on yield and yield components of Maize. Greater cob length (19.86 cm), was recorded where 12 inches plant spacing.

2.1.2.2 Cob circumference (cm)

Koirala *et al*. (2020) carried out an field experiment to study the Effect of row to row spacingss on different maize varieties at Deupur, Lamahi municipality of the dang district in province No. 5, Nepal during the rainy season from June to September, 2018 and found that the highest cob Circumference was reported when maize was planted in the row spacing 60 × 25 cm.

Ahmmed (2018) reported that in respect of the spacing effect, the wider spacing R_1 (60 cm × 20 cm) showed the highest cob circumference.

Hasan *et al*. (2018) revealed that variety and plant spacing had significant effect on the studied crop characters and yield. Maximum diameter of cob was observed in the spacing of 75 cm × 25 cm.

2.1.2.3 Number of grain rows cob^{-1}

Koirala *et al*. (2020) carried out an field experiment to study the Effect of row to row spacingss on different maize varieties at Deupur, Lamahi municipality of the dang district in province No. 5, Nepal during the rainy season from June to September, 2018 and reported that the highest number of rows per cob was reported when maize was planted in the row spacing 60×25cm.

Azam (2017) conducted a field study to investigate the effect of various intra-row plant spacings on the yield of different maize hybrids at the Agronomic Research Area, University of Agriculture, Faisalabad. Experimental data showed that intra-row spacing had statistically significant effect on yield and yield components of Maize. Highest number of rows per cob (14.31), cm), was recorded where 12 inches plant spacing was kept.

Rahman *et al*. (2016) reported that nitrogen levels and plant spacing had significant effect on yield attributes and yield of Khaibhutta. The highest number of, grain rows per cob was recorded at 75 cm × 25 cm spacing.

2.1.2.4 Number of grains row^{-1} in cob

Eyasu *et al.* (2018) conducted a field study with the objective of evaluating different varieties and row spacing on growth, yield and yield components of maize. The results indicated that number of kernels per rows was significantly influenced by the interaction effect of row spacing and varieties.

Rahman *et al*. (2016) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2014 to April 2015 to investigate the effect of planting spacing and nitrogen levels on yield attributes and yield of maize, that is Khaibhutta. The experimental results revealed that nitrogen levels and plant spacing had significant effect on yield attributes and yield of Khaibhutta. The highest number of, grain per row was recorded at 75 cm × 25 cm spacing.

2.1.2.5 Number of grains cob^{-1}

Alam *et al*. (2020) reported that the spacing techniques showed significantly different performance on yield. It was revealed that the maximum morpho-physiological characters, yield attributes and yield was obtained with higher composition of nutrients by using technique of 60 cm × 30 cm (T_3). This treatment also showed the highest number of grain cob^{-1} was 710.13.

Ahmmed (2018) conducted an experiment to evaluate the performance of white maize variety under different spacings and integrated fertilizer management. In respect of the spacing effect, the wider spacing R_1(60 cm × 20 cm) showed the highest number of grain per cob.

Azam (2017) reported that intra-row spacing had statistically significant effect on yield and yield components of Maize. Highest number of grains per cob (501) was recorded where 12 inches plant spacing was kept.

2.1.2.6 1000 grains weight (g)

Koirala *et al*. (2020) carried out an field experiment to study the Effect of row to row spacingss on different maize varieties at Deupur, Lamahi municipality of the dang district in province No. 5, Nepal during the rainy season from June to September, 2018. Result revelled that highest average thousand grain weight was reported when maize was planted in the row spacing 60 × 25 cm.

Hasan *et al*. (2018) reported that variety and plant spacing had significant effect on the studied crop characters and yield. The highest 1000-grain weight was observed in the spacing of 75 cm × 25 cm.

Azam (2017) showed that intra-row spacing had statistically significant effect on yield and yield components of Maize. 1000-grain weight (339 g) was recorded where 12 inches plant spacing was kept.

Rahman *et al*. (2016) carried out an experiment at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during November 2014 to April 2015 to investigate the effect of planting spacing and nitrogen levels on yield attributes and yield of maize, that is Khaibhutta. The highest 1000-grain weight was observed in the spacing of 75 cm × 25 cm. In contrast, the closest spacing of 50 cm x 20 cm produced the lowest 1000-grain weigh.

2.1.2.7 Grain weight (g)

Alam *et al*. (2020) revealed that the maximum morpho-physiological characters, yield attributes and yield was obtained with higher composition of nutrients by using technique of 60 cm ×30 cm (T_3). This treatment also showed the height grain weight cob^{-1} was 230.67g.

Dalvi (1984) conducted a field experiment to study the effect of various spacings and nitrogen levels on growth, yield and quality of two varieties of maize (*Zea mays* L.) during Rabi season. He revealed that the spacing of 60 cm × 30 cm showed significantly higher weight of grains per cob than other narrow spacings of 45 cm × 30 cm and 30 cm × 30 cm.

2.1.2.8 Cob weight (g)

Ukonze *et al*. (2016) reported that with regard to yield, 80 × 20 cm gave the highest average cob weight of 0.74 kg and 1000-grain weight (yield) of 0.27t/ha.

Nand (2015) the spacing of 60 cm × 20 cm significantly increased the cob weight (205.90 and 205.90 g) than the spacing of 60 cm × 25 cm and 45 cm × 20 cm, respectively.

2.1.2.9 Shelling percentage (%)

Ahmmed (2018) carried out an experiment during December, 2017 to May, 2018 at the Agronomy field of Sher-e-Bangla Agricultural University, Dhaka to evaluate the performance of white maize variety under different spacings and integrated fertilizer management and observed that both the individual and the interaction treatments had effect on different growth and yield parameters of white maize. In respect of the spacing effect, the wider spacing S_1 (60 cm × 20 cm) showed highest plant shelling percentage.

Mukhtar *et al*. (2012) reported that in case of plant spacings, maximum shelling percentage 86.63% was observed in maximum plant spacing that was 17.50 cm which was statistically at par with 15.00 and 12.50 cm spacings.

2.1.3 Review on yield characters

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

Belay (2019) conducted a field experiment under rainfed conditions in 2015 and 2016 during the main cropping season at Haramaya to determine the effects of inter and intra row spacing on growth, yield components, and yield of hybrid maize varieties. Result reviled that the highest grain yield 11.67 t ha^{-1} was obtained in combination of 75 cm × 25 cm in 2016 cropping season, while the lowest grain yield 8.66 tha^{-1} was obtained at wider inter and widest intra row spacing combination (75 cm × 35 cm) in

2015 cropping season .The possible reason for the lowest grain yield at widest spacing might be due to the presence of less number of plants per unit.

Eyasu *et al.* (2018) concluded that under irrigated condition Lemu and BH-540 maize varieties at 65–75 cm row spacing resulted higher biomass and grain yield of maize.

Golla *et al.* (2018) concluded that application of 115 kg N ha^{-1} on maize hybrid planted at 20 cm intra row spacing was the most profitable agronomic practice as compared to other combinations.

Hasan *et al.* (2018) reported the lowest grain yield was recorded from the plant spacing of 75 cm × 35 cm with Khoi bhutta. Based on the experimental results, it may be concluded that maize (cv. BARI hybrid maize 7) can be cultivated with a spacing of 75 cm × 25cm for appreciable grain yield.

Akbar *et al.* (2016) reported that, planting in twin-rows giving 80,000 plants per ha and produced 17.7 % higher yield compared with planting in single rows 60 cm apart giving 66,667 plants ha^{-1}.

Hossain (2015) double rows of 50 cm × 25 cm performed the best among different plant spacing treatments in case of grain yield (9.68 t ha^{-1}). Plant spacing of 40 cm × 25 cm showed the lowest result in all yield and yield contributing characters.

Mechi (2015) 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.

Nand (2015) reported that the spacing of 60 cm × 20 cm significantly increased the grain yield (6.62 and6.75 t ha^{-1}), protein content (8.78 and 8.87 %) and protein yield (58.20 and 60.00kg ha^{-1}) than the spacing of 60 cm × 25 cm and 45 cm × 20 cm, respectively. The interaction effect between variety × spacing was found significant ($P < 0.05$)on protein yield.

Enujeke (2013 a) carried out a study to evaluate the effects of variety and spacing on growth characters of hybrid maize. Based on the findings of this study, it was recommended that (i) hybrid variety 9022-13 be grown to enhance growth characters which interplay to improve grain yield of maize (ii) spacing of 75 cm × 35 cm be used to enhance increased stem girth and leaf area whose photosynthetic activities could positively influence maize yield.

Enujeke (2013 b) carried out a study to evaluate the effects of variety and spacing on yield indices of Open-pollinated maize. The results indicated that plants sown on 75 cm × 15 cm had the highest grain weight (5.0 t ha^{-1}) in 2008 and (5.2 tha^{-1}) in 2009, while plants sown at 75 cm × 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) reported that, grain yield was the highest (3.98 t ha^{-1}) for maize inter crop planted at 75 cm × 75 cm, on the other hand the lowest grain yield (2.22 t ha^{-1}) obtained in the sole maize crop treatment at 75 cm × 25 cm spacing.

Sharifai *et al*. (2012) showed that the highest grain yield (2.32 t ha^{-1}) was recorded from intra-row spacing of 25cm whereas the lowest grain yield (1.97 t ha^{-1}) was found from intra-row spacing of 30 cm.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties. They reported that, plant population of 65,000 plants ha^{-1} had significantly the highest yield whereas; the lowest yield was recorded from plant population of 55000 plants ha^{-1}.

Abuzar *et al*. (2011) carried out a field experiment to determine the effect of plant population densities on maize. Result revealed that the maximum grain yield 2604 kg ha^{-1} was recorded in T_2 (60,000 plants ha^{-1}) followed by T_3 (80,000 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}.

Yukui *et al.* (2011) conducted an experiment where four cropping patterns *viz,* 65 cm × 65 cm, 40 cm × 90 cm, 30 cm × 100 cm and 20 cm × 110 cm, respectively were studied. The results showed that all wide and narrow rows patterns and free-sow patterns have higher yield than the same spacing patterns and 30 cm × 100 cm is the optimal pattern to obtain the highest yield, followed by 20 cm × 110 cm, 40 cm × 90 cm and 65 cm × 65 cm, respectively.

Fanadzo *et al.* (2010) conducted a study to determine the effects of inter-row spacing (45 and 90 cm) and plant population (40,000 and 60,000 plants ha^{-1}) on weed biomass and the yield of both green and grain materials of maize plants. The study demonstrated that growers could obtain higher green plants and grain yield by increasing plant population from the current practice of 40,000 to 60,000 plants ha^{-1} and through use of narrow rows.

Alvarez (2006) reported that grain yield increased with increasing sowing density and decreasing row spacing. The hybrids AG9010 and DKB440 was associated with the highest grain yield regardless of planting density.

Muhammad *et al*. (2006) recommend 60 cm by 10 or 15 cm plant spacing for maximum yield.

Sener (2004) concluded that the highest grain yields were obtained from Pioneer3223 and Dracma at 15.0 cm intra-row spacing (11,718 and 11,180 kg ha^{-1} respectively).

Asafu-Agyei (1990) conducted four field studies to determine the effect of seven planting densities: 10, 20, 30, 40, 50, 60 and 70 × 103 plants ha^{-1} 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 ×103 plants ha^{-1} and the lowest grain yield (2.10 t ha^{-1}) from 10 × 103 plants ha^{-1}.

Gardner (1985) 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}

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

Ullah *et al*. (2020) observed that different spacing had significant effect on stover yield of maize Results revealed that highest stover yield 9.92 t ha^{-1} was attained with S_2 where the lowest 7.28 t ha^{-1} was with S_1.

Worku and Derebe (2020) reviled that stover and grain yields were significantly increased with increasing PD from 53,333 to 90,900 plants ha^{-1}.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment showed that the maximum stover yield was observed in the spacing of 75 cm × 25 cm. In contrast, the spacing of 75 cm × 30 cm produced the lowest stover yield.

Hossain (2015) reported that plant spacing of double rows of 50 cm × 25 cm performed the best among the 5 plant spacing in case of stover yield (13.62 t ha^{-1}). Plant spacing of 40 cm × 25 cm showed the lowest result in case of stover yield.

Mechi (2015) revealed that, the highest stover yield (15.50 t ha^{-1}) was recorded from inter row spacing of 65 cm and the lowest stover yield (14.33 t ha^{-1}) was obtained from inter row spacing of 55 cm.

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

Gaire *et al*. (2020) reported that the highest biological yield (12.37 mt/ha) produced under 60×15 cm spacing and the lowest biological yield (9.24 mt/ha) produced under 60 × 25 cm spacing .

Hossain (2015) reported that interaction of variety PSC- 121 with double rows of 50 cm × 25 cm plant spacing gave the highest biological yield (24.51 t ha^{-1}). On the other hand, interaction of variety PSC-121 with plant spacing of 40 cm × 25 cm showed the lowest results.

Shafi *et al.* (2012) conducted an experiment to investigate the effect of planting density on plant growth and yield of maize varieties. They reported that, the highest biological yield was recorded from the treatment of 65,000 plants ha^{-1} and the lowest biological yield was recorded from plant population of 45,000 plants ha^{-1}.

2.1.3.4 Harvest index (%)

Ahmmed (2018) concluded that, in respect of the spacing effect, the wider spacing of 60 cm × 20 cm planting configuration showed the highest harvest index.

Mechi (2015) reported that, the highest harvest index (53.16 %) was recorded from inter row spacing of 85 cm and the lowest harvest index (42.91 %) was obtained from inter row spacing of 55 cm.

Shafi *et al.* (2012) reported that, the highest harvest index was observed in the treatment of 65,000 plants ha-^{1} and the lowest in 45,000 plants ha^{-1}.

Ma *et al*. (2003) found that, harvest index was significantly higher under the 0.51 m spacing than the other spacing treatments.

CHAPTER III

MATERIALS AND METHODS

This section presents a brief description about the duration of the experimental period, site description, climatic condition of the area, crop or planting materials that are being used in the experiment, treatments, experimental design, crop growing procedure, intercultural operations, data collection and statistical analyses.

3.1 Experimental period

The experiment was conducted during the period from October 2018 to February 2019 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University (SAU). Sher-e-Bangla Nagar Agargong Dhaka, Bangladesh. 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 (Anon., 2004).

3.2.2 Agro-Ecological Zone

The experimental field belongs to the Agro-ecological zone (AEZ) of “The Modhupur Tract”, AEZ-28 (Anon., 1988 a). 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 (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I. (Banglapedia, 2014).

3.3 Soil

The soil of the experimental pots belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.6 (Anon., 1989). The land was above flood level and sufficient sunshine was available during the experimental period. The morphological, physical and chemical characteristics of the experimental soil have been presented in Appendix-II. (Banglapedia, 2014 and Biswas *et al*., 2019).

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

3.5 Planting materials

In this research work, “SAUWMT 12-3-3” variety of white maize seed was used as planting materials, which was collected from Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.6 Description of the variety

The genotype of white maize SAUWMT 12-3-3, used as planting material for the present study. These variety was recommended for Rabi and kharif season. The feature of this variety was presented below:

Name of Variety : SAUWMT 12-3-3

Identifying character : Bold grain quality and drought tolerant

Type : Medium duration, Open pollinated

Height : 180–220 cm

Crop duration : 110–120 days

Leaf colour at Maturity : Light Green color at maturity

Suitable area : All over Bangladesh

Number of cobs plant-^{1} : Mainly one

Cob colour : White colour.

Grain colour : White

Yield : 8-12 t ha^{-1}

Source : Personal Communication: Prof. Dr. Md. Jafar Ullah, Dept. Of Agronomy, SAU, Dhaka.

3.7 Major diseases and pest management

Diseases: No specific disease was observed, except minor leaf blight.

Management: Clean cultivation with timely sowing and balance fertilizer application. Seed treatment with vitavax-200 @ 2.50 g kg^{-1} seed, spraying with Tilt or Folicure @ 0.5% and burning of crop residues.

Major insect/pest and management

Diseases: Mainly leaf blight disease occurs at vegetative stage.

Management: Clean cultivation with timely sowing and balance fertilizer application. Seed treatment with vitavax- 200 @ 2.5g kg^{-1} seed, spraying with Tilt or Folicure @ 0.5% and burning of crop residues.

Major insect/pest and Management

Insect pests: Cut worm and Stem borer attack at vegetative stage of maize as well as Earworm attack in cob at reproductive stage in maize.

Management

For cutworm: The larvae were killed after collecting from soil near the cut plants in morning. Dursban or Pyrifos 20 EC 5 ml $liter^{-1}$ water sprayed especially at the base of plants to control cutworms.

For ear worm: The larvae are killed after collecting from the infested cobs. Cypermethrin (Ripcord 10 EC/Cymbush 10 EC) @ 2 ml $litre^{-1}$ water sprayed to control this pest.

For stem borer: Marshall 20 EC or Diazinon 60 EC @ 2 ml $litre^{-1}$ water sprayed properly to control the pest. Furadan 5 G or Carbofuran 5 G @ 20kg ha^{-1} applied on top of the plants in such a way so that the granules stay between the stem and leaf base. Such type of application of insecticides is known as whorl application.

3.8 Experimental details

Sowing Date: 24 October, 2018

Silking Date: 24 December 2018

Harvesting Date: 23 February 2019.

3.9 Experimental treatments

There were two sets of treatments in the experiment. The treatments were row spacings and -plant spacings. Those are shown below:

Factor A: Row spacings (5) *viz*:

i. S_1 – 40 cm.
ii. S_2 – 45 cm.
iii. S_3 – 50 cm.
iv. S_4 – 55 cm and
v. S_5 – 60 cm.

Factor B: Plant spacings (3) *viz*:

i. T_1 – 15 cm.
ii. T_2 – 20 cm. and
iii. T_2 – 25 cm.

3.9.1 Treatment combinations

This two factor experiments were included 15 treatment combinations.

S_1T_1, S_1T_2 ,S_1T_3 ,S_2T_1, S_2T_2, S_2T_3, S_3T_1, S_3T_2, S_3T_3, S_4T_1, S_4T_2 ,S_4T_3, S_5T_1, S_5T_2 and **S_5T_3**

3.9.2 Plant density (No. m^{-2})

Data on plant density were collected from vegetable stage of the white maize plants. Plants grown in the quadrate (1 m × 1 m) were identified and the quadrate was placed randomly at three places in each plot as following by Cruz *et al*. (1986) method. The plants within the quadrate were counted and converted to number m^{-2} by the average number of two samples.

$$\text{Plant density (Number m}^{-2}\text{)} = \frac{\text{Total number of plants}}{\text{Total surveyed unit area}}$$

Table 1: Table shows the plant density m^{-2} at different planting geometry

Treatment combinations	Plant density m^{-2}
S_1T_1	16.67
S_1T_2	12.50
S_1T_3	10.00
S_2T_1	14.81
S_2T_2	11.11
S_2T_3	8.89
S_3T_1	13.33
S_3T_2	10.00
S_3T_3	8.00
S_4T_1	12.12
S_4T_2	9.09
S_4T_3	7.27
S_5T_1	11.11
S_5T_2	8.33
S_5T_3	6.67

3.9.3 Experimental design

The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. Total 45 unit plots were made for the experiment with 15 treatments. The size of each unit plot was 6.30 m^2 (3.50 m × 1.80 m). Replication and plots were 1.0 m and 0.75 m, respectively. The treatments were assigned in plot at random. Layout of the experimental field was presented in Appendix IV.

3.10 Detail of experimental preparation

3.10.1 Preparation of experimental land

The land was opened with the help of a tractor drawn disc harrow on 17 October, 2018 and then ploughed with rotary plough twice followed by laddering to achieve a medium tilth required for the crop under consideration. All weeds and other plant residues of previous crop were removed from the field. Immediately after final land preparation, the field layout was made on 23 October 2018 according to experimental specification. Individual plots were cleaned and finally the plot were prepared.

3.10.2 Fertilizer application

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

3.10.3 Seed sowing

The white maize seeds were sown in lines maintaining row-to-row distance and plant to plant distance as per treatments having 2 seeds per hole under direct sowing in the well prepared plot on 24 October 2018.

3.11 Intercultural operations

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

3.11.1 Gap filling and thinning

Gap filling was done on 3 November 2018, which was 10 days after sowing (DAS). Thinning was done on 7 November 2018, which was 15 days after sowing.

3.11.2 Weeding

The hand weeding was done as when necessary to keep the plot free from weeds. During plant growth period two weeding were done. The weeding was done on 17 November 2018 and 7 December 2018, which was 25 and 45 days aftersowing, respectively

3.11.3 Earthing up

Earthing up was done on 23 November 2018 which was 30 days after sowing. It was done to protect the plant from lodging and for better irrigation management
and nutrition uptake.

3.11.4 Application of irrigation water

Irrigation water was added to each plot, first irrigation was done as pre-sowing and other four were given at 20, 40, 65 and 85 days after sowing (DAS). First irrigation was given on 13 November 2018, which was 20 days after sowing. Second irrigation was given on 3 December 2018, which was 40 days after sowing. Third irrigation was given on 28 December 2018, which was 65 days after sowing, and fourth irrigation was given on, 17 January 2019, which was 85 days after sowing.

3.11.5 Drainage

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

3.11.6 Pest and disease control

As described in section 3.7.

3.11.7 General observations of the experimental site

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

3.12 Harvesting, threshing and cleaning

The mature cobs were harvested when the husk cover was completely dried and black coloration was found in the grain base (black band).The cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data. Harvesting was done on 23 February 2019.

3.13 Drying

The harvested products were taken on the threshing floor and it was dried for about 4–5 days.

3.14 Crop sampling

During 30, 60, 90 Days and harvesting period 5 plants was cutting from the soil base which was selected for crop sampling for taking various parameters data of the plant.

3.15 Data collection

The data were recorded on the following parameters

A. Crop growth characters

i. Plant height (cm)
ii. Plant density (No. m^{-2})
iii. Number of leaves $plant^{-1}$
iv. Leaf area $plant^{-1}$ (cm^2)
v. Leaf area index $plant^{-1}$
vi. Stem base diameter(cm)
vii. Total dry matter $plant^{-1}$ (g)

B. Yield contributing characters

viii. Cob length $plant^{-1}$ (cm)
ix. Cob circumference $plant^{-1}$ (cm)
x. Number of rows cob^{-1} (no.)
xi. Number of grains row^{-1}(no)
xii. Total number of grains cob^{-1}(no)
xiii. 1000 grains weight cob^{-1}(g)
xiv. Chaff weight $plant^{-1}$ (g)
xv. Shell weight $plant^{-1}$ (g)
xvi. Grain weight cob^{-1} (g)
xvii. Total cob weight $plant^{-1}$ (g)
xviii. Shelling Percentage (%)

C. Yield characters

xix. Grain yield (t ha^{-1})
xx. Stover yield (t ha^{-1})
xxi. Biological (t ha^{-1})
xxii. Harvest index (%)

3.16 Procedure of recording data

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

3.16.1 Plant height (cm)

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

3.16.3 Number of leaves plant^{-1} (No.)

At different stages of crop growth (30, 60, 90 DAS and at harvest respectively) the number of leaves of five randomly selected plants from the inner rows per plot was measured by counting the number of leaves of the plant and the mean value of the number of leaves was recorded.

3.16.4 Leaf Area plant^{-1} (cm^2)

Leaf area was estimated manually by counting the total number of leaves plant^{-1} 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 and at harvest respectively.

Leaf area plant^{-1} =

$$\frac{\text{Surface area of leaf sample } (\text{cm}^2) \times \text{No. of leaves plant}^{-1} \times \text{Correction factor}}{\text{No. of leaves sampled}}$$

3.16.5 Leaf Area Index plant^{-1} (LAI)

Leaf area index were 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 (Kluen and Wolf, 1986). It was done at 45, 90 days after sowing (DAS) and at harvest.

$$\text{Leaf area index plant}^{-1} = \frac{\text{Surface area of leaf sample } (\text{cm}^2) \times \text{Correction factor}}{\text{Ground area from where the leaves were collected}}$$

3.16.6 Stem base circumference plant^{-1}

From each plot 5 plants were uprooted randomly. Then the diameter was taken from the base portion of each plant. Then average result was recorded in cm.

3.16.7 Dry matter weight plant $^{-1}$

At 30,60 and 90DAS and harvest respectively 5 plants from each plot were uprooted randomly. Then the plant was cut into pieces. Then the various pieces of the plant were put into a paper packet ,in case of harvesting, cob was also put into a packet and placed in oven maintaining 70^0 C for 72 hours. Then the sample was transferred into desiccators and allowed to cool down at room temperature. Then the sample weight was taken and then calculate the total dry matter of a plant for each plot. It was performed at 30,60, 90 DAS and harvest respectively.

3.16.8 Cob length plant^{-1} (cm)

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

3.16.9 Cob circumference plant^{-1} (cm)

Five cobs were randomly selected per plot and the circumference was taken fromeach cob. Then average result was recorded in cm.

3.16.10 Number of grain rows cob^{-1}

Five cobs from each plot were selected randomly and the number of grain rows per cob was counted. Then the average result was recorded.

3.16. 11 Number of grains row^{-1} in cob

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

3.16. 12 Number of grains cob^{-1}

The numbers of grains per cob was measured from the base to tip of the ear collected from five randomly selected cobs of each plot and finally average result was recorded.

3.16. 13 Weight of 1000 grains

After removing the grain from each cob from each plot grains are stored in a specific grain stock or pot. From the seed stock of each plot 1000 seeds were calculated and the weight was measured by an electrical balance. It was recorded in gram.

3.16.14 Chaff weight plant^{-1} (g)

Whole chaff without grains of five cobs were randomly taken from each plot and the weight was taken in an electrical balance. The average chaff weight was recorded in gram.

3.16.15 Shell weight plant^{-1} (g)

After removing the grain from cobs shell of five cobs were randomly taken from each plot and the weight was taken in an electrical balance. The average shell weight was recorded in gram.

3.16.16 Total Grain weight plant^{-1} (g)

Whole grains of five cobs were randomly taken from each plot and the weight was taken in an electrical balance. The average grain weight was recorded in gram.

3.16. 17 Total cob weight plant^{-1} (g)

Cob weight (Includes chaff, shell and total grain weight of a cob) of five randomly selected cobs from the five selected plants in each plot was taken in an electrical balance and the average weight was recorded in gram.

3.16. 18 Shelling percentage

Five cobs were randomly selected from each plot and shelling percentage was calculated by using the following formula

$$\text{Shelling percentage} = \frac{\text{Grain weight of each cob}}{\text{Cob weight of each cob}} \times 100$$

3.16. 19 Grain yield (t ha^{-1})

After removing the grain from the cob grain yield was calculated. Grain yield was calculated from cleaned and well dried grains collected from 1m^2 area of each plot and expressed as t ha^{-1}. Finally grain yield was adjusted at 14% moisture.

3.16. 20 Stover yield (t ha^{-1})

After removing the grains from the cob various parts of the plants without grain part was weighted and well dried stover were collected from each plot were taken and converted into hectare and were expressed in t ha^{-1}.

3.16. 21 Biological yield (t ha^{-1})

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

Biological yield (t ha^{-1}) = grain weight (t ha^{-1}) + stover yield (t ha^{-1})

3.16. 22 Harvest Index (%)

Harvest Index indicate the ratio of economic yield (grain yield) to biological yield and was calculated with the following formula:

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

3.17 Statistical analysis

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

CHAPTER IV

RESULTS AND DISCUSSION

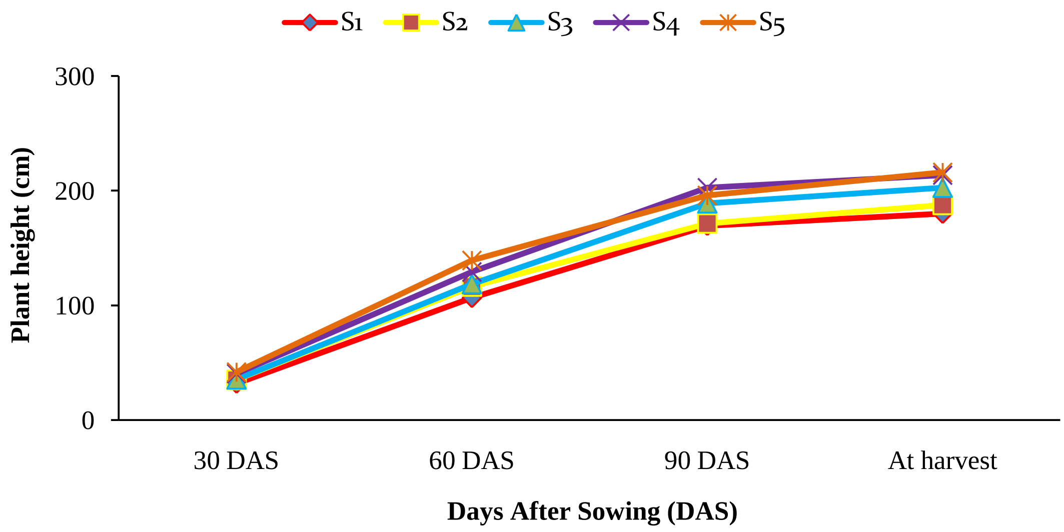
The data on different growth, yield contributing characters and yield were recorded to find out the appropriate spacing on white maize. The results have been presented and discussed and possible explanations have been given under the following headings:

4.1.1 Review on growth parameters

4.1.1 Plant height (cm)

4.1.1.1 Effect of row spacings

Plant height is an important morphological character that acts as a main indicator of availability of growth resources in its approach. Plant height of white maize was greatly influenced by different row spacing at different days after sowing (DAS) under the present study (Figure 3 and Appendix VI). Result revealed that, the maximum plant height (41.75 and 139.21 cm) at 30 and 60 DAS was recorded in S_5 treatment which was statistically similar with S_4 treatment and recorded plant height (40.49 cm) at 30 DAS. At 90 DAS the maximum plant height (202.63 cm) was recorded in S_4 treatment which was statistically similar with S_5 treatment and recorded plant height (195.87 cm). At harvest respectively the maximum plant height (216.00 cm) was recorded in S_5 treatment which was statistically similar with S_4 treatment and recorded plant height (213.67 cm). Whereas the minimum plant height (31.933, 106.53, 169.42 and 180 cm) at 30, 60, 90 DAS and harvest respectively were recorded from S_1 treatment which was statistically similar with S_2 treatment and recorded plant height (171.44 and 187.67cm) at 90 DAS and harvest respectively.

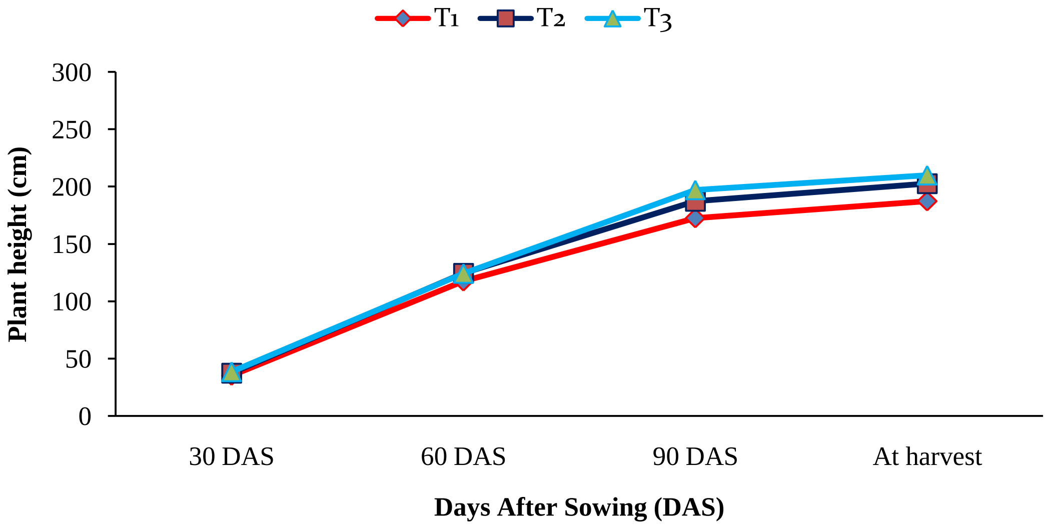


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 1. Effect of row spacings on plant height of white maize at different DAS ($LSD_{(0.05)}$=3.08, 5.85, 7.36 and 11.69 cm at 30, 60, 90 DAS and at harvest respectively)

4.1.2.2 Effect of plant spacings

Different plant spacing showed significant effect on plant height of white maize at different days after sowing. (Figure 4 and Appendix VI). Result revealed that the highest plant height (38.38, 124.20, 197.21, and 210 cm) at 30, 60, 90 DAS and at harvest respectively were recorded in T_3 treatment which was statistically similar with T_2 treatment recorded plant height (37.292, 124.36, and 202.60 cm) at 30 DAS, 60 DAS and harvest respectively. Whereas the lowest plant height (35.176, 117.41, 172.56, and 187.40 cm) at 30, 60, 90 DAS and at harvest respectively were recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 2. Effect of plant spacings on plant height of white maize at different DAS ($LSD_{(0.05)}$= 2.39, 4.53, 5.70, 9.06 cm at 30, 60, 90 DAS and at harvest respectively)

4.1.1.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant effect on plant height of white maize at different days after sowing (Table 2 and Appendix VI). Experiment result revealed that, the highest plant height (43, 142.95, 216.50 and 222 cm) at 30, 60, 90 DAS and at harvest respectively were recorded in S_5T_3 treatment combination which was statistically similar with S_4T_3 (42.80 cm), S_5T_2 (41.84 cm), S_5T_1(40.40 cm), S_4T_2 (40.20 cm) and S_4T_1 (38.48 cm) at 30 DAS; with S_5T_2 (138.75 cm), S_5T_1 (135.94 cm) and S_4T_2 (135.27 cm) treatment combination at 60 DAS, with S_4T_3 (211.53 cm) and S_4T_2 (204.64 cm) treatment combination at 90 DAS and with S_4T_3 (220 cm), , S_4T_2 (219 cm), S_3T_3 (218 cm), S_5T_2 (216 cm), S_5T_1 210 cm),, S_3T_2 (210 cm) and S_4T_1 (202 cm) treatment combination at harvest respectively. Whereas the minimum plant height (28.40, 93.47 ,154.58, and 160 cm) at 30, 60, 90 and at harvest respectively were recorded in S_1T_1 treatment combination which was statistically similar with the treatment combination of S_1T_2 (33.20 cm) treatment combination at 30 DAS; with S_2T_1 (166.20 cm) at 90 DAS and with S_1T_2 (180 cm) and S_3T_1 (180 cm) at harvest respectively. The result obtained from the present study was similar with the findings of Alam *et al*. (2020) and Ahmmed (2018).

Table 2: Combined effect of row and plant spacings on plant height of white maize at different DAS

Treatment combinations	Plant height (cm) at			
	30 DAS	60 DAS	90 DAS	At harvest
S_1T_1	28.40 d	93.47 f	154.58 g	160 f
S_1T_2	33.20 cd	111.89 e	173.00 ef	180 ef
S_1T_3	34.20 c	114.23 de	180.69 de	200 b-e
S_2T_1	34.40 c	114.90 de	166.20 fg	185 de
S_2T_2	35.12 bc	115.30 de	169.45 ef	188 de
S_2T_3	35.60 bc	118.90 c-e	178.66 ef	190 c-e
S_3T_1	34.20 c	114.23 de	176.22 ef	180 ef
S_3T_2	36.10 bc	120.57 c-e	191.98 b-d	210 a-c
S_3T_3	36.30 bc	121.24 c-e	198.67 bc	218 ab
S_4T_1	38.48 a-c	128.52 bc	191.67 cd	202 a-d
S_4T_2	40.20 ab	135.27 ab	204.68 ab	219 ab
S_4T_3	42.80 a	123.68 cd	211.53 a	220 ab
S_5T_1	40.40 ab	135.94 ab	174.12 ef	210 a-c
S_5T_2	41.84 a	138.75 a	196.98 bc	216 ab
S_5T_3	43.00 a	142.95 a	216.50 a	222 a
$LSD_{(0.05)}$	5.33	10.13	12.75	20.26
CV(%)	8.63	4.96	4.11	6.06

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

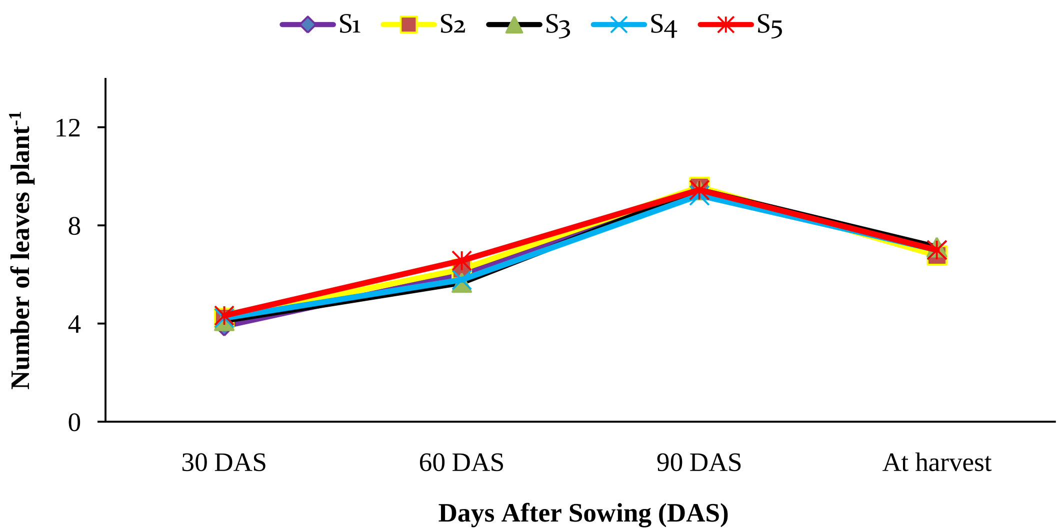
Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

4.1.2 Number of leaves plant^{-1}

4.1.2.1 Effect of row spacings

Only at 30 and 60 days after sowing, row spacings showed significant variation in respect of number of leaves plant^{-1} of white maize (Figure 5 and Appendix VII). Experiment result revealed that, the highest number of leaves plant^{-1} (4.33 and 6.55 at 30 and 60 DAS respectively) was recorded in S_5 treatment which was statistically similar with all other treatment except S_1 (3.88) treatment at 30 DAS and with S_2 (6.22) at 60 DAS. At 90 DAS the highest number of leaves plant^{-1} (9.56) was recorded in S_2 treatment. At harvest respectively the highest number of leaves plant^{-1} (7.11) was recorded in S_3 treatment. Whereas the lowest number of leaves plant^{-1} (3.89) was recorded in S_1 treatment at 30 DAS. At 60 DAS lowest number of leaves plant^{-1} (5.67) was recorded in S_3 treatment. At 90 DAS lowest number of leaves plant^{-1} (9.2) was recorded in S_4 treatment; and at harvest respectively lowest number of leaves plant^{-1} (6.78) was recorded in S_2 treatment.

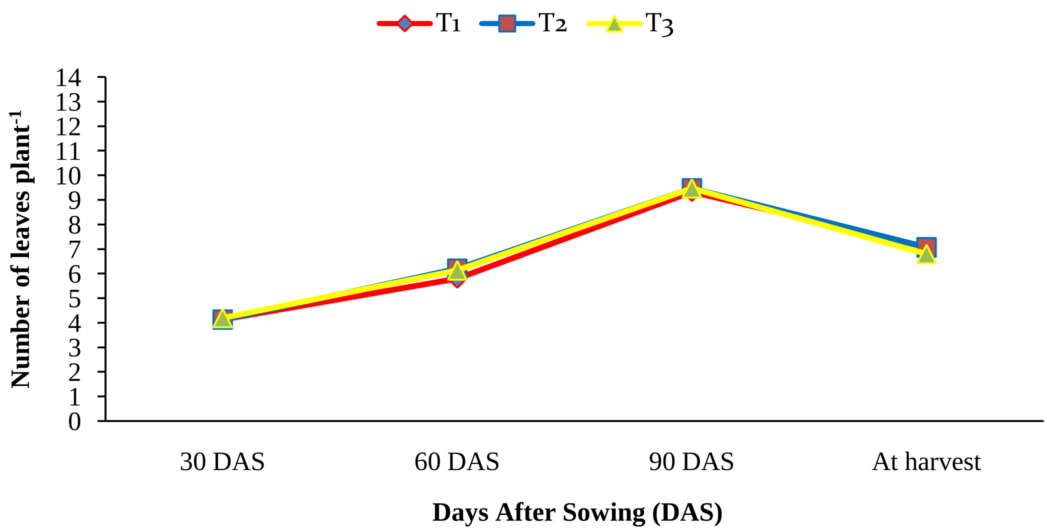


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 3: Effect of row spacings on number of leaves plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$=0.41, 0.52, NS and NS at 30, 60, 90 DAS and at harvest respectively)

4.1.2.2 Effect of plant spacings

Plant spacings showed non significant effect on number of leaves plant^{-1} of white maize at different days after sowing. (Figure 6 and Appendix VII). Experiment result showed that, the highest number of leaves plant^{-1} (4.20 and 9.47 at 30 and 90 DAS respectively) was recorded in T_3 treatment. At 60 DAS and at harvest respectively, the highest number of leaves plant^{-1} (6.20 and 7.067) was recorded in T_2 treatment. Whereas the lowest number of leaves plant^{-1} (4.13, 5.8, and 9.33) at 30, 60 and 90 DAS were recorded in T_1 treatment. At harvest respectively the lowest number of leaves plant^{-1} (6.8) was recorded in T_3 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 4: Effect of plant spacings on number of leaves plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$= NS at 30, 60, 90 and at harvest respectively)

4.1.2.3 Combined effect of row and plant spacings

Significant variation was observed at 30, 60 DAS and at harvest in respect of number of leaves plant^{-1} of white maize which was influenced by the combined effect of row and plant spacings (Table 3 and Appendix VII). Experiment result revealed that the highest number of leaves plant^{-1} (4.67) at 30 DAS was recorded in S_2T_3 treatment combination of which was statistically similar with all other treatment combination except S_1T_1 (3.67) treatment combination. At 60 DAS the highest number of leaves plant^{-1} (7.0) was recorded in S_5T_2 treatment combination which was statistically similar with S_2T_1 (6.67), S_5T_3 (6.33), and S_5T_1 (6.33) treatment combination. At 90 DAS the highest number of leaves plant^{-1} (9.67) was recorded in S_4T_3 treatment combination and at harvest respectively the highest number of leaves plant^{-1} (7.67) was recorded in S_1T_2 treatment combination which was statistically similar with all other treatment except S_4T_2 (6.33) treatment combination.. Whereas the lowest number of leaves plant^{-1} (3.66) at 30 DAS was recorded in S_1T_1 treatment combination. At 60 DAS the lowest number of leaves plant^{-1} (5.0) was recorded in S_3T_1 treatment combination which was statistically similar with S_4T_1 (5.33), and S_1T_1 (5.67) treatment combination. At 90 DAS the lowest number of leaves plant^{-1} (9.0) was recorded in S_4T_1 (9.0) treatment combination and at harvest respectively the lowest number of leaves plant^{-1} (6.33) was recorded in S_4T_2 treatment combination. Ullah *et al.* (2020) stated that higher leaves number plant^{-1} was achieved with higher plant spacing where lower plant spacing showed lower leaf number plant^{-1}. Jula *et al*. (2013) also found similar result which supported the present finding.

Table 3: Combined effect of row and plant spacings on number of leaves plant^{-1} of white maize at different DAS

Treatment combinations	Number of leaves at			
	30 DAS	60 DAS	90 DAS	At harvest
S_1T_1	3.67 b	5.67 c-e	9.33	7.0 ab
S_1T_2	4.0 ab	6.0 b-d	9.67	7.67 a
S_1T_3	4.0 ab	6.33 a-c	9.33	6.33 b
S_2T_1	4.0 ab	6.67 ab	9.33	7.0 ab
S_2T_2	4.0 ab	6.0 b-d	9.67	6.67 ab
S_2T_3	4.67 a	6.00 b-d	9.67	6.67 ab
S_3T_1	4.33 ab	5.0 e	9.33	6.67 ab
S_3T_2	4.0 ab	6.0 b-d	9.67	7.67 a
S_3T_3	4.0 ab	6.0 b-d	9.33	7.0 ab
S_4T_1	4.3 ab	5.33 de	9.0	7.33 ab
S_4T_2	4.3 ab	6.0 b-d	9.0	6.33 b
S_4T_3	4.0 ab	6.0 b-d	9.67	7.33 ab
S_5T_1	4.3 ab	6.33 a-c	9.67	7.33 ab
S_5T_2	4.3 ab	7.0 a	9.33	7.0 ab
S_5T_3	4.33 ab	6.33 a-c	9.33	6.67 ab
$LSD_{(0.05)}$	0.71	0.89	Ns	1.12
CV(%)	10.19	8.89	5.70	9.57

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

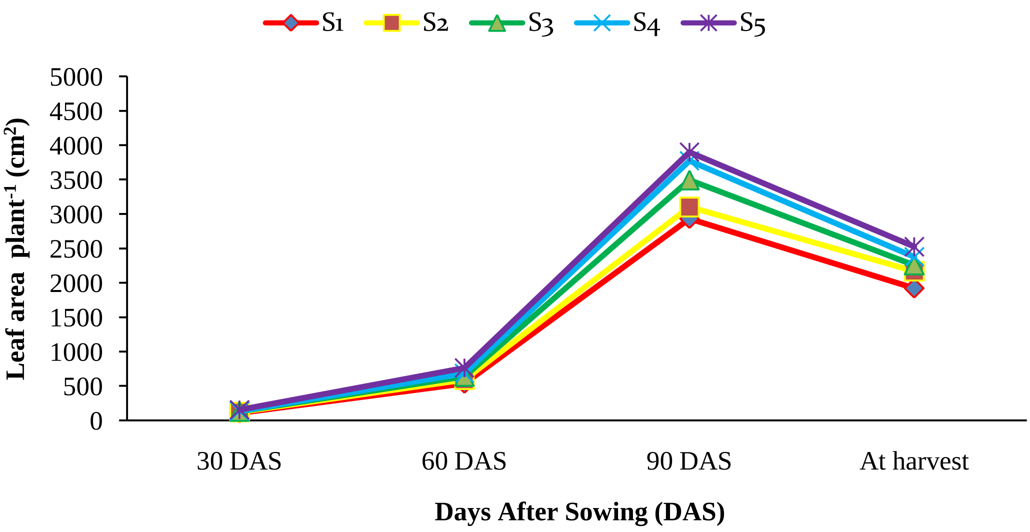
Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

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

4.1.3.1 Effect of row spacings

Leaf area plant^{-1} was significantly influenced by different row spacings at different days after sowing (Figure 7 and Appendix VIII). Experiment result revealed that the maximum leaf area plant^{-1} (153.29, 763.57, 3899 and 2524.3 cm^2) at 30, 60, 90 DAS and at harvest respectively were recorded in S_5 treatment which was statistically similar with S_4 treatment recorded leaf area plant^{-1} (3773.8 and 2378.5 cm^2) at 90 DAS and harvest respectively. Whereas the minimum leaf area plant^{-1} (108.28, 536.23, 2931, and 1920.1 cm^2) at 30, 60, 90 DAS and at harvest respectively were recorded in S_1 treatment which was similar with S_2 treatment recorded leaf area plant^{-1} (3102 cm^2) at 90 DAS.



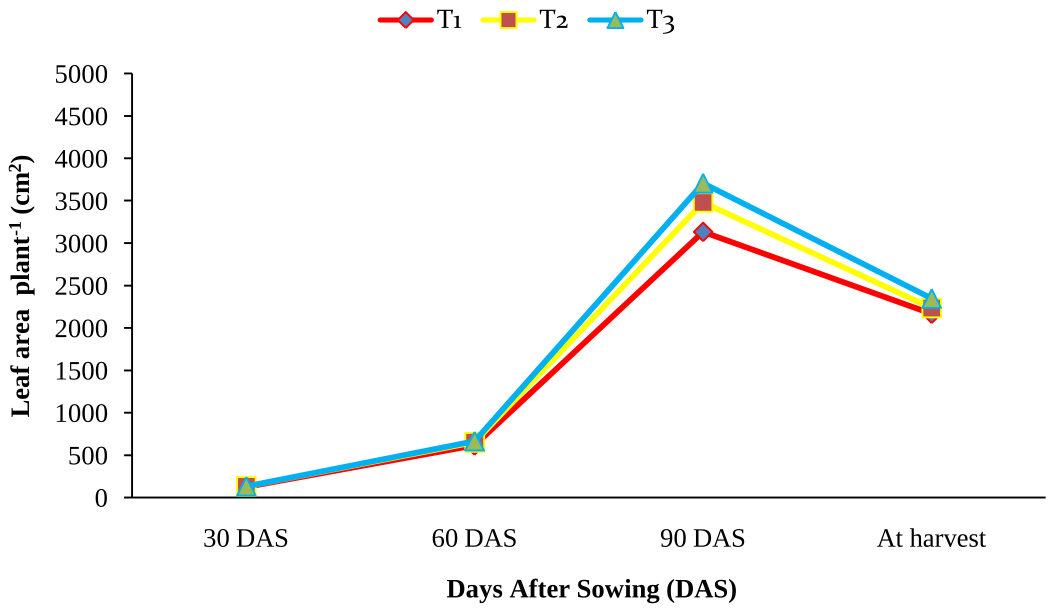
Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 5: Effect of row spacings on leaf area plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$=7.79, 34.62, 204.08 and 156.84 cm^2 at 30, 60, 90 DAS and at harvest respectively)

4.1.3.2 Effect of plant spacings

Leaf area plant^{-1} was significantly influenced by different plant spacings at different days after sowing (Figure 8 and Appendix VIII). Experiment result revealed that the maximum leaf area plant^{-1} (132.68, 664.67, 3705.8 and 2346.7 cm^2) at 30, 60, 90 DAS and at harvest respectively were recorded in T_3 treatment which was statistically similar with T_2 treatment recorded leaf area (130.80, 651.45 and 2235.3 cm^2) at 30, 60

DAS and at harvest respectively. Whereas the minimum leaf area plant^{-1} (124.01, 614.25, 3133.4, and 2166.8 cm^2) at 30, 60, 90 DAS and at harvest respectively were recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 6: Effect of plant spacings on leaf area plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$= 6.04, 26.82, 158.08 and 121.49 cm^2 at 30, 60, 90 and at harvest respectively)

4.1.3.3 Combined effect of row to row and plant to plant spacings

Combined effect of row and plant spacings showed significant variation in respect of leaf area plant^{-1} of white maize at different days after sowing (Table 4 and Appendix VIII). Experiment result revealed that, the maximum leaf area plant^{-1} (154.48, 772.41, 4142.6 and 2640.5 cm^2) at 30, 60, 90 and at harvest respectively were recorded in S_5T_3 treatment combination which was statistically similar S_5T_2 (153.43 cm^2), S_5T_1(151.96 cm^2) and S_4T_3(150.24 cm^2) treatment combination at 30 DAS; with S_5T_2 (767.13 cm^2), S_5T_1 (751.18 cm^2), and S_4T_3 (759.81 cm^2) treatment combination at 60 DAS; with S_4T_2 (3947.7 cm^2), S_4T_3 (3911.5 cm^2), S_5T_2 (3825.1 cm^2), and S_3T_3 (3792.5 cm^2) treatment combination at 90 DAS; and with S_4T_3 (2486.8 cm^2), S_5T_2 (2472.1 cm^2), S_5T_1 (2460.4 cm^2), S_4T_2 (2442.8 cm^2) and S_3T_3 (2377.3 cm^2) treatment combination at harvest respectively. Whereas the minimum leaf area plant^{-1} (104.53, 522.18, 2556.7 and 1892.5 cm^2) at 30, 60, 90 DAS and harvest respectively were recorded in S_1T_1 treatment combination which was similar with the treatment combination of S_1T_2 (107.37 cm^2), S_1T_3 (112.93 cm^2), S_2T_1 (116.57 cm^2), and S_2T_3 (116.91 cm^2) at 30 DAS; with S_1T_2 (536.84 cm^2), S_1T_3 (549.66 cm^2) and S_2T_1 (562.85 cm^2) at 60 DAS; with S_1T_2 (2693.4 cm^2) and S_2T_1 (2807.6 cm^2) at 90 DAS and with S_1T_2 (1924.1 cm^2) S_1T_3 (1943.9 cm^2), S_2T_1 (2106.6 cm^2) and S_2T_2 (2110.5 cm^2) treatment combination at harvest respectively Closer spacing reduced the leaf area due to an increased intra plant competition. So proper spacing must be maintain to reduce intra plant competition which ultimately influence on the leaf area of the plant. The result obtained from the present study was similar with the findings of Ukonze *et al.* (2016) who reported that the 70 cm × 30 cm and 60 cm × 40 cm spacing gave higher values of the morphological parameters (leaf area $plant^{-1}$) than 80 cm × 20 cm. Enujeke (2013 a) also found similar results with the present study.

Table 4: Combined effect of row and plant spacings on leaf area plant^{-1} of white maize at different DAS

Treatment combinations	Plant leaf area (cm^2) at			
	30 DAS	60 DAS	90 DAS	At harvest
S_1T_1	104.53 e	522.18 g	2556.7 i	1892.5 g
S_1T_2	107.37 e	536.84 fg	2693.4 i	1924.1 fg
S_1T_3	112.93 de	549.66 fg	3542.8 d-f	1943.9 e-g
S_2T_1	116.57 c-e	562.85 e-g	2807.6 hi	2106.6 d-g
S_2T_2	126.03 b-d	630.14 b-d	3358.5 fg	2110.5 d-g
S_2T_3	116.91 c-e	584.55 d-f	3139.7 gh	2285.2 b-d
S_3T_1	123.34 b-d	616.70 c-e	3111.0 gh	2168.3 d-f
S_3T_2	131.38 b	644.27 b-d	3576.1 c-f	2227.1 b-d
S_3T_3	128.85 bc	656.92 bc	3792.5 a-e	2377.3 a-d
S_4T_1	123.67 b-d	618.35 c-e	3462.1 e-g	2206.0 c-e
S_4T_2	135.77 b	678.86 b	3947.7 ab	2442.8 a-c
S_4T_3	150.24 a	759.81 a	3911.5 a-c	2486.8 ab
S_5T_1	151.96 a	751.18 a	3729.5 b-e	2460.4 a-c
S_5T_2	153.43 a	767.13 a	3825.1 a-d	2472.1 a-c
S_5T_3	154.48 a	772.41 a	4142.6 a	2640.5 a
$LSD_{(0.05)}$	13.509	59.971	353.48	271.65
CV(%)	6.25	5.57	6.14	7.22

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

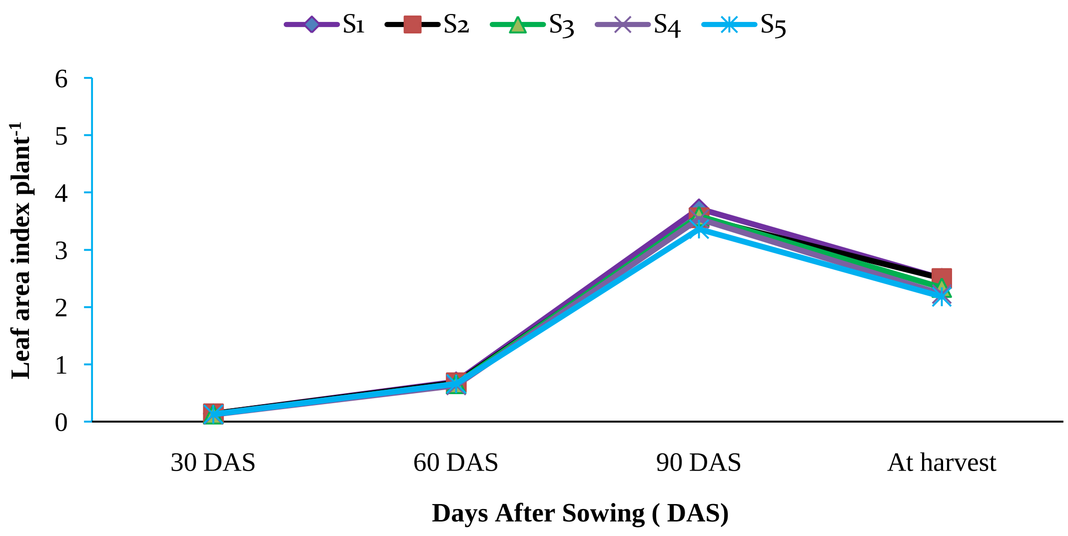
Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

4.1.4 Leaf area index plant^{-1}

4.1.4.1 Effect of row spacings

Different row spacings showed significant variation in respect of leaf area index of white maize at different days after sowing (Figure 9 and Appendix IX). Experiment result revealed that, the maximum leaf area index plant^{-1} (0.14, 0.70, 3.72 and 2.50 at 30, 60, 90 DAS and at harvest respectively were recorded in S_1 treatment which was statistically similar with S_2 (0.14) treatment at 30 DAS; with S_2 (0.68) and S_3 (0.66) treatment at 60 DAS; with S_2 (3.56), S_3 (3.59) and S_4 (3.54) treatment at 90 DAS and with S_2 (2.50) and S_3 (2.34) treatment at harvest respectively. Whereas the minimum leaf area index plant^{-1} (0.12) was recorded in S_4 treatment at 30 DAS which was statistically similar with S_3 (0.13) and S_5 (0.13 treatment. At 60 DAS the minimum leaf area index plant^{-1} (0.63) was recorded in S_4 treatment. At 90 DAS and harvest respectively minimum leaf area index plant^{-1} (3.36 and 2.18) was recorded in S_5 treatment which was statistically similar with S_4 (2.23) treatment at harvest respectively.

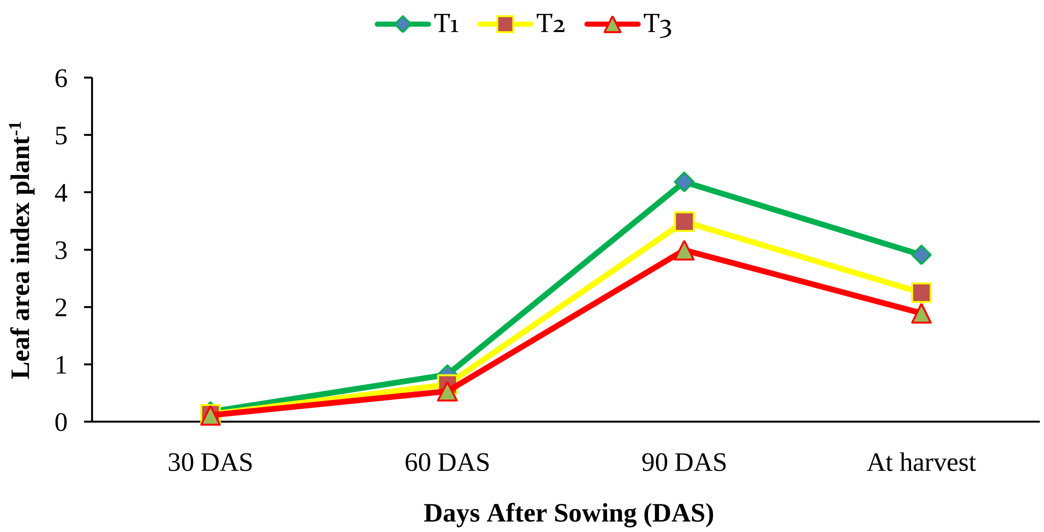


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 7: Effect of row spacings on leaf area index plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$=0.0006 , 0.04, 0.21 and 0.18 at 30, 60, 90 DAS and harvest respectively)

4.1.4.2 Effect of plant spacings

Different plant spacings showed significant variation in respect of leaf area index of white maize at different days after sowing (Figure 10 and Appendix IX). Result revealed that the maximum leaf area index plant^{-1} (0.17, 0.82, 4.18 and 2.91) at 30, 60, 90 DAS and at harvest respectively were recorded in T_1 treatment. whereas the minimum leaf area index per plant (0.11, 0.53, 2.99 and 1.89 at 30, 60, 90 DAS and at harvest respectively were recorded in T_3 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 8: Effect of plant spacings on leaf area index plant $^{-1}$ of white maize at different DAS (LSD$_{(0.05)}$=0.0004 , 0.03, 0.16 and 0.14 at 30, 60, 90 DAS and at harvest respectively)

4.1.4.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of leaf area index plant^{-1} of white maize at different days after sowing (Table 5 and Appendix IX). Experiment result revealed that the maximum leaf area index plant^{-1} (0.17, 0.87, 4.26 and 3.15) at 30, 60, 90 DAS and at harvest respectively were recorded in S_1T_1 treatment combination which was statistically similar with S_2T_1 (0.17 and 0.83), S_5T_1 (0.17 and 0.83) and S_3T_1 (0.16 and 0.82) treatment combination at 30 and 60 DAS; with S_4T_1 (4.20), S_2T_1 (4.16), S_3T_1 (4.15) and S_5T_1 (4.14) treatment combination at 90 DAS; and with S_2T_1 (3.12) and S_3T_1 (2.89) treatment combination at harvest respectively. Whereas the minimum leaf area index plant^{-1} (0.10, 0.51, 2.76 and 1.76) at 30, 60, 90 DAS and at harvest respectively were recorded in S_5T_3 treatment combination which was statistically similar with S_3T_3 (0.10), S_2T_3 (0.10), S_4T_3 (0.11) and S_1T_3 (0.11) treatment combination at 30 DAS; with S_2T_3 (0.52) S_3T_3 (0.53), S_1T_3 (0.55) and S_4T_3 (0.55) treatment combination at 60 DAS; with S_2T_3 (2.79), S_4T_3 (2.84) and S_3T_3 (3.03) treatment combination at 90 DAS; and with S_4T_3(1.81), S_3T_3 (1.90), S_1T_3 (1.94), S_2T_3 (2.03) and S_5T_2 (2.06) treatment combination at harvest respectively. As leaf area index depend on surface area of plant increasing surface area gradually decreasing leaf area index. The result obtained from the present study was similar with the findings of Gaire *et al*. (2020) reported that the leaf area index was significantly high at close spacing (60×15 cm) and at 120 kg N/ha. Abuzar *et al*. (2011) also 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 40,000 plants ha^{-1}.

Table 5: Combined effect of row and plant spacings on leaf area index plant^{-1} of white maize at different DAS

Treatment combinations	Plant leaf area index at			
	30 DAS	60 DAS	90 DAS	At harvest
S_1T_1	0.17 a	0.87 a	4.26 a	3.15 a
S_1T_2	0.13 cd	0.67 de	3.37 b-d	2.41 cd
S_1T_3	0.11 ef	0.55 fg	3.54 bc	1.94 fg
S_2T_1	0.17 a	0.83 a	4.16 a	3.12 a
S_2T_2	0.14 bc	0.70 cd	3.73 b	2.35 de
S_2T_3	0.10 f	0.52 g	2.79 f	2.03 e-g
S_3T_1	0.16 a	0.82 ab	4.15 a	2.89 ab
S_3T_2	0.13 cd	0.64 de	3.57 b	2.23 d-f
S_3T_3	0.10 f	0.53 g	3.03 d-f	1.90 g
S_4T_1	0.15 b	0.75 bc	4.20 a	2.67 bc
S_4T_2	0.12 de	0.62 ef	3.59 b	2.22 d-f
S_4T_3	0.11 f	0.55 fg	2.84 ef	1.81 g
S_5T_1	0.17 a	0.83 a	4.14 a	2.73 b
S_5T_2	0.13 d	0.64 de	3.19 c-e	2.06 e-g
S_5T_3	0.10 f	0.51 g	2.76 f	1.76 g
$LSD_{(0.05)}$	0.01	0.08	0.37	0.32
CV(%)	4.91	6.84	6.20	8.07

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

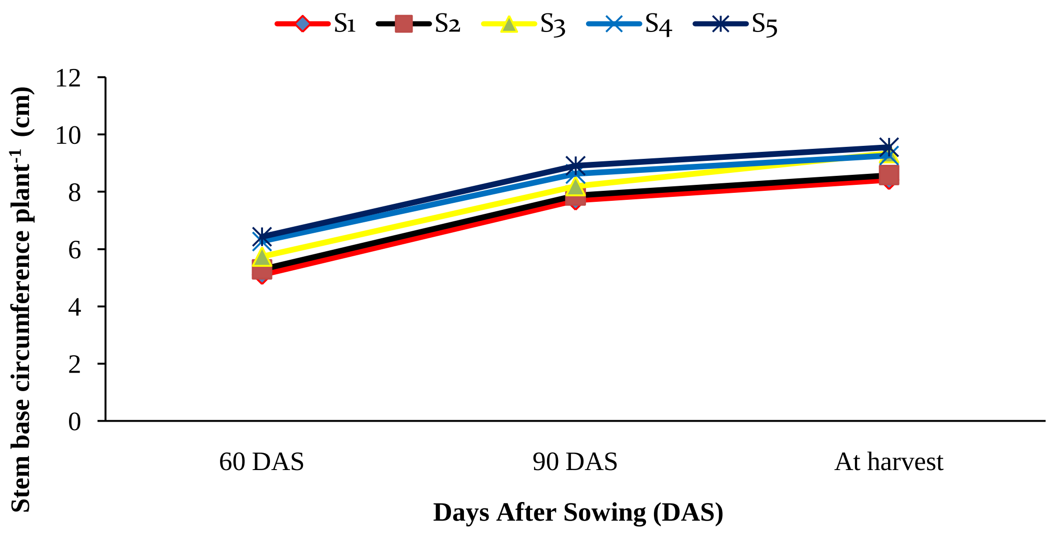
Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

4.1.5 Stem base circumference plant^{-1} (cm)

4.1.5.1 Effect of row spacings

Different row spacings showed significant variation in respect of stem base circumference of white maize at different days after sowing (Figure 11 and Appendix X). Experiment result showed that the maximum stem base circumference plant^{-1} (6.43, 8.91 and 9.56 cm) at 60, 90 DAS and at harvest respectively were recorded in S_5 treatment which was statistically similar with S_4 treatment recoded stem base circumference plant^{-1} (6.27, 8.63 and 9.27) at 60, 90 DAS and at harvest respectively and with S_3 treatment recoded stem base circumference plant^{-1} (9.35) at harvest respectively. Whereas the minimum stem base circumference plant^{-1} (5.10, 7.70 and 8.42 cm) at 60, 90 DAS and harvest respectively were recorded in S_1 treatment which was statistically similar with S_2 treatment recoded stem base circumference plant^{-1} (5.29 and 7.87) at 60 and 90 DAS.

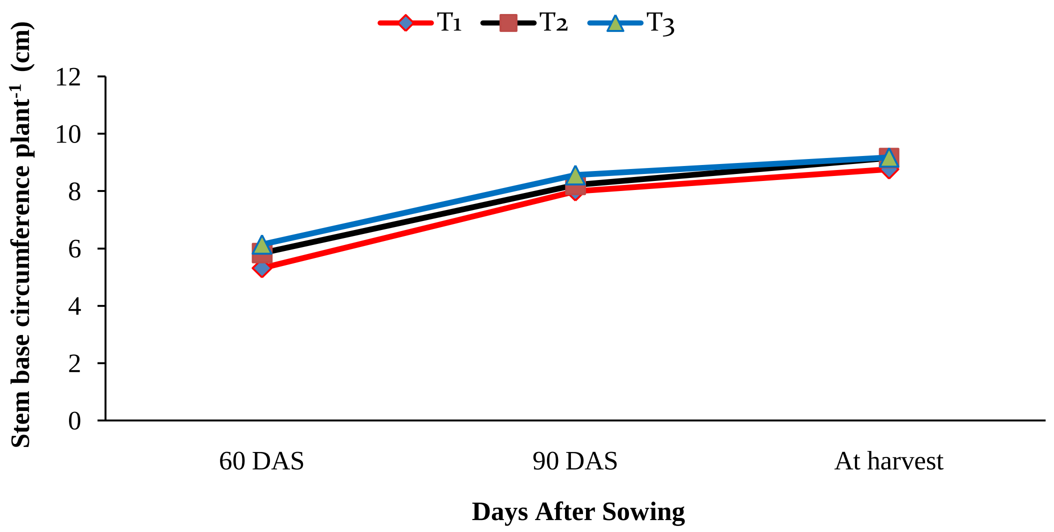


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm

Figure 9: Effect of row spacings on stem base circumference plant^{-1} of white maize at different DAS ($LSD_{(0.05)}$=0.36, 0.43 and 0.55 cm at 60, 90 DAS and at harvest respectively)

4.1.5.2 Effect of plant spacings

At 60 and 90 DAS plant spacings showed significant variation in respect of stem base circumference of white maize (Figure 12 and Appendix X). At harvest non significant effect was recorded on stem base circumference of white maize. Result showed that the maximum stem base circumference plant^{-1} (6.14, 8.56 and 9.18 cm) at 60, 90 DAS and at harvest respectively were recorded in T_3 treatment. Whereas the minimum stem base circumference plant^{-1} (5.32, 8.00 and 8.76 cm at 60, 90 DAS and harvest respectively were recorded in T_1 treatment which was statistically similar with T_2 (8.22 cm) treatment at 90 DAS.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 10: Effect of plant spacings on stem base circumference plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$= 0.28, 0.33 and Ns cm at 60, 90 DAS and at harvest respectively)

4.1.5.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation with advances of growth period in respect of base circumference of white maize (Table 6 and Appendix X). Experiment result revealed that the highest base circumference plant^{-1} of white maize (7.0, 9.12 and 9.88 cm) at 60, 90 DAS and harvest respectively were recorded in S_5T_3 treatment combination which was statistically similar with S_4T_3 (6.8 cm) and S_4T_2 (6.7 cm) treatment combination at 60 DAS; with S_4T_3 (9.0 cm), S_5T_2 (8.9 cm), S_5T_1 (8.7 cm), S_4T_2 (8.7 cm) and S_3T_3 (8.5 cm) treatment combination at 90 DAS, and with S_5T_2 (9.60 cm), S_4T_2 (9.55 cm),, S_3T_3 (9.55 cm),, S_3T_2 (9.50 cm),, S_5T_1 (9.20 cm),, S_4T_3 (9.13 cm),, S_4T_1 (9.12 cm) and S_3T_1 (9.00 cm) treatment combination at harvest respectively. Whereas the minimum stem base circumference plant^{-1} (5.0 cm) was recorded in S_1T_2 treatment combination which was statistically similar with S_1T_1 (5.01 cm) followed by S_2T_1 (5.07 cm), S_2T_2 (5.20 cm) ,S_3T_1 (5.20 cm), S_1T_3 (5.30 cm), S_4T_1 (5.30 cm), and S_2T_3 (5.60 cm) treatment combination at 60 DAS. At 90 DAS the minimum stem base circumference plant^{-1} (7.5 cm) was recorded in S_1T_1 treatment combination which was statistically similar with S_1T_2 (7.6 cm), S_2T_1 (7.6 cm), S_2T_2(7.8 cm), S_1T_3(8.0 cm), S_3T_1 (8.00 cm), S_3T_2 (8.10 cm), S_2T_3 (8.2 cm) and S_4T_1 (8.2 cm) treatment combination and at harvest respectively the minimum stem base circumference plant^{-1} (8.1 cm) was recorded in S_1T_1 treatment combination which was statistically similar with S_2T_1 (8.4 cm) followed by treatment combination of S_1T_2 (8.5 cm), S_1T_3 (8.67 cm), S_2T_2 (8.67 cm) and S_2T_3 (8.67 cm). Alam *et al*. (2020), Ukonze *et al.* (2016) and Enujeke (2013 a) also found similar results with the present study.

Table 6: Combined effect of row and plant spacings on stem base circumference plant^{-1} (cm) of white maize at different DAS

Treatment combinations	Steam base circumference plant^{-1} (cm) at		
	60 DAS	90 DAS	At harvest
S_1T_1	5.01 e	7.5 e	8.1 d
S_1T_2	5.0 e	7.6 e	8.5 cd
S_1T_3	5.3 e	8.0 c-e	8.67 b-d
S_2T_1	5.07 e	7.6 e	8.4 cd
S_2T_2	5.2 e	7.8 de	8.67 b-d
S_2T_3	5.6 de	8.2 b-e	8.67 b-d
S_3T_1	5.2 e	8 c-e	9.0 a-d
S_3T_2	6. cd	8.1 c-e	9.5 ab
S_3T_3	6.01 cd	8.5 a-d	9.55 ab
S_4T_1	5.3 e	8.2 b-e	9.12 a-c
S_4T_2	6.7 ab	8.7a-c	9.55 ab
S_4T_3	6.8 ab	9.0 a	9.13 a-c
S_5T_1	6.0 cd	8.7 a-c	9.2 a-c
S_5T_2	6.3 bc	8.9 ab	9.60 ab
S_5T_3	7.0 a	9.12 a	9.88 a
$LSD_{(0.005)}$	0.62	0.74	0.95
CV(%)	6.44	5.35	6.30

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

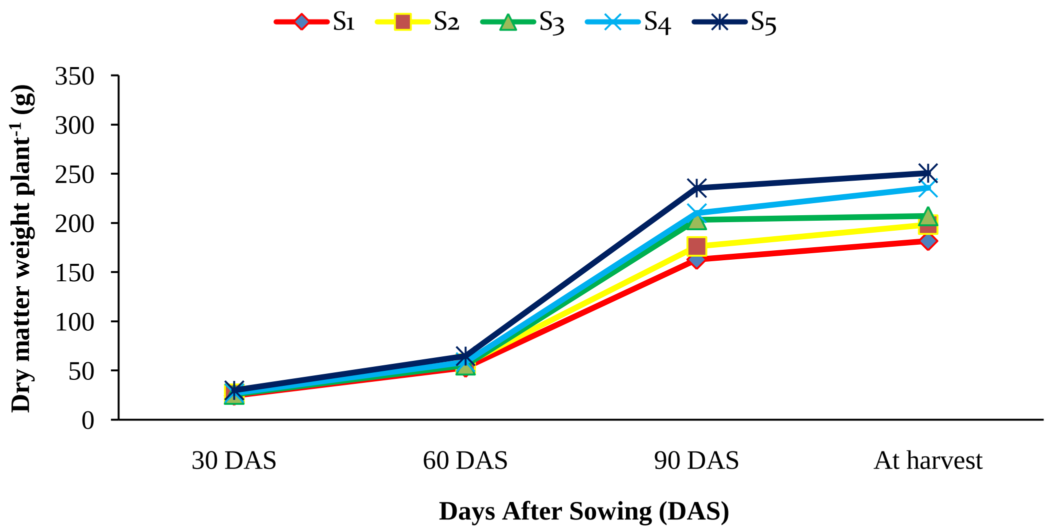
Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

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

4.1.6.1 Effect of row spacings

Different row spacings showed significant effect on dry matter weight plant^{-1} of white maize at different days after sowing (Figure 13 and Appendix). Experiment result revealed that, the maximum dry matter weight plant^{-1} (29.79, 64.66, 235.56, and 250.66 g) at 30, 60, 90 DAS and at harvest respectively was recorded in S_5 treatment. Whereas the minimum dry matter plant^{-1} (24.46, 52.94, 162.76 and 181.85 g) at 30, 60, 90 DAS and at harvest respectively was recorded in S_1 treatment which was statistically similar with S_3 treatment (25.58 g and 55.38 g) at 30 and 60 DAS respectively.

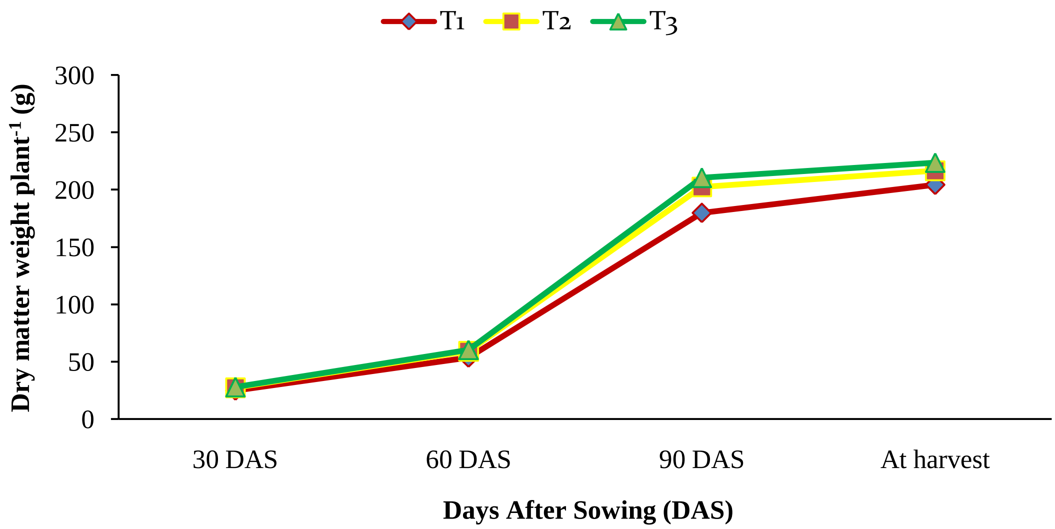


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm

Figure 11: Effect of row spacings on dry matter weight plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$=1.39, 3.47, 10.51 and 10.77 g at 30, 60, 90 DAS and at harvest respectively)

4.1.6.2 Effect of plant spacings

Significant variation was recorded in respect of dry matter weight plant^{-1} of white maize at different days after sowing (Figure 14 and Appendix). Experiment result revealed that the maximum dry matter weight plant^{-1} (27.79, 60.25, 210.38 and 223.57 g) at 30, 60, 90 DAS and at harvest respectively was recorded in T_3 treatment which was statistically similar with T_2 treatment recorded dry matter weight plant^{-1} (27.29, 59.08, 202.39 and 216.57 g) at 30, 60, 90 DAS and at harvest respectively. Whereas the minimum dry weight plant^{-1} (24.80, 53.69, 179.83 and 204.25 g at 30, 60, 90 DAS and at harvest respectively was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 12: Effect of plant spacings on dry matter weight plant $^{-1}$ of white maize at different DAS ($LSD_{(0.05)}$=1.07, 2.69, 8.14 and 8.34 g at 30, 60, 90 DAS and at harvest respectively)

4.1.6.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of dry matter weight plant^{-1} at various days after sowing (Table 7 and Appendix). Result revealed that, the maximum dry matter weight plant^{-1} (31.46, 68.61, 238.41 and 258.90 g) at 30, 60, 90 DAS and at harvest respectively were recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (30.22 and 65.42) at 30 and 60 DAS; with S_5T_2 (237.78 g), S_5T_1 (230.48 g), and S_3T_3 (222.74 g) treatment combination at 90 DAS and with S_5T_2 (250.91 g), S_5T_1 (242.17 g), S_4T_3 (250.84 g), and S_4T_2(243.58 g) at harvest respectively. Whereas the minimum dry matter weight plant^{-1} (21.44, 46.42, 145.95 and 174.91 g) at 30, 60, 90 DAS and at harvest respectively were recorded in S_1T_1 treatment combination which was statistically similar with S_3T_1 (51.705 g) and S_2T_1 (51.762 g) treatment combination at 60 DAS; with S_2T_1 (154.13 g) and S_1T_2 (160.71 g) treatment combination at 90 DAS and with S_1T_2 (181.55 g) followed by S_1T_3 (189.10 g) and S_2T_1 (190.53 g) at harvest respectively. Getaneh *et al*. (2016) found that the highest above ground dry biomass yields per plant at the widest inter and intra-row spacing might be due to high stem diameter and high leaf area because there is more availability of growth factors and better penetration of light at wider row spacing. Jula *et al*. (2013) found similar result which supported the present study.

Table 7: Combined effect of row and plant spacings on plant dry matter weight plant^{-1} of white maize at different DAS

Treatment combinations	Dry matter weight plant^{-1} (g) at			
	30 DAS	60 DAS	90 DAS	At harvest
S_1T_1	21.44 f	46.42 e	145.95 g	174.91 f
S_1T_2	26.35 cd	57.04 cd	160.71 fg	181.55e f
S_1T_3	25.57 de	55.36 cd	181.63 de	189.10 d-f
S_2T_1	23.91 e	51.76 de	154.13 g	190.53 c-f
S_2T_2	27.79 cd	60.15 bc	181.75 de	198.96 b-e
S_2T_3	27.21 cd	58.90 c	192.77 d	205.39 b-d
S_3T_1	23.89 e	51.71 de	172.58 ef	200.44 b-d
S_3T_2	26.32 cd	56.97 cd	214.09 bc	207.84 bc
S_3T_3	26.55 cd	57.48 cd	222.74 ab	213.60 b
S_4T_1	27.07 cd	58.60 c	196.03 cd	213.21 b
S_4T_2	25.79 c-e	55.83 cd	217.59 b	243.58 a
S_4T_3	28.13 bc	60.89 bc	216.37 b	250.84 a
S_5T_1	27.69 cd	59.94 bc	230.48 ab	242.17 a
S_5T_2	30.22 ab	65.42 ab	237.78 a	250.91 a
S_5T_3	31.46 a	68.61 a	238.41 a	258.90 a
$LSD_{(0.05)}$	2.40	6.01	18.20	18.65
CV(%)	5.39	6.23	5.51	5.19

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Plant spacings

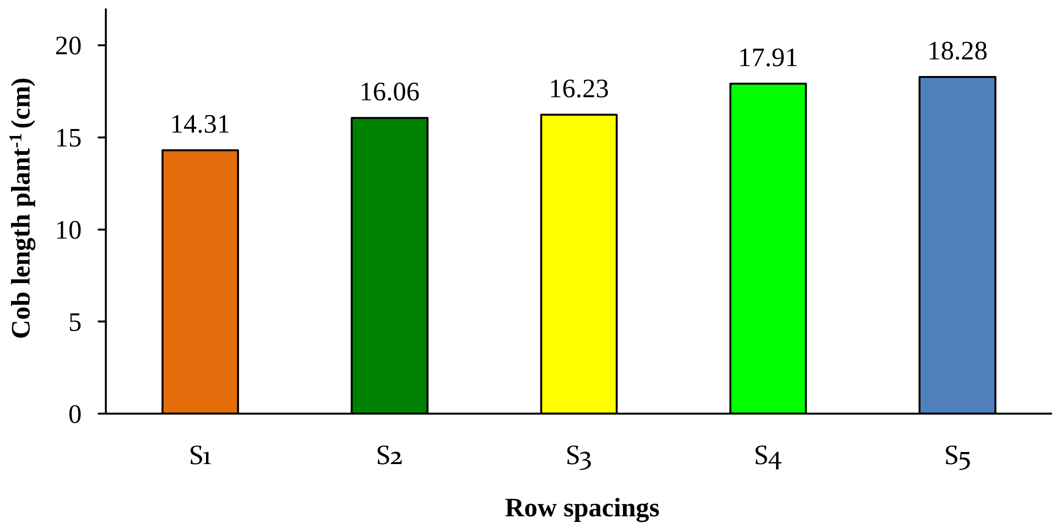
T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

4.2 Yield contributing characters

4.2.1 Cob length plant^{-1} (cm)

4.2.1.1 Effect of row spacings

Significant variation was observed on cob length plant^{-1} of white maize for different row spacing (Figure 15 and Appendix XII). Experiment result revealed that, the highest cob length plant^{-1} (18.28 cm) was recorded in S_5 treatment which was statistically similar with S_4 (17.91 cm) treatment. Whereas lowest cob length plant^{-1} (14.31 cm) was recorded in S_1 treatment.

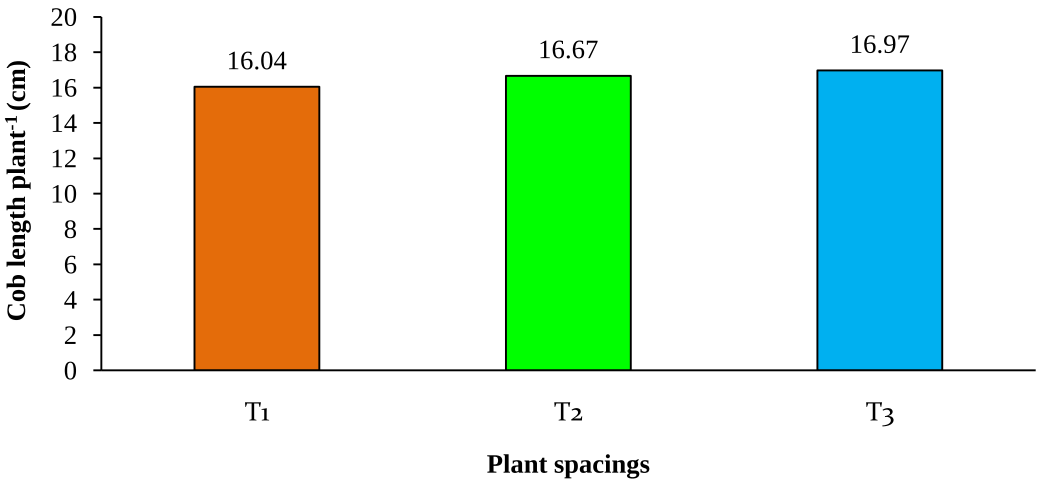


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm

Figure 13: Effect of row spacings on cob length plant $^{-1}$ of white maize ($LSD_{(0.05)}$= 0.72 cm)

4.2.1.2 Effect of plant spacings

Different plant spacings significantly influenced on cob length plant^{-1} of white maize (Figure 16 and Appendix XII). From the experiment result revealed that, the highest cob length plant^{-1} (16.97 cm) was recorded in T_3 treatment which was statistically similar with T_2 (16.67 cm) treatment. Whereas the lowest cob length per plant (16.04 cm) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 14: Effect of plant spacings on cob length plant^{-1} of white maize (LSD$_{(0.05)}$= 0.56 cm)

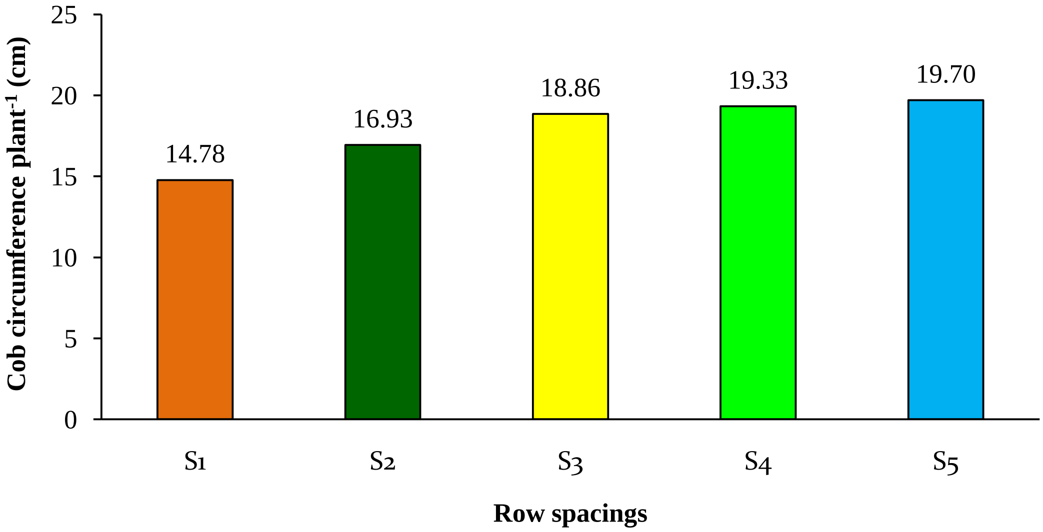
4.2.1.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of cob length plant^{-1} of white maize (Table 8 and Appendix XII). Experiment result exhibited that, the highest cob length plant^{-1} (18.58 cm) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (18.18 cm), S_4T_3 (18.18 cm), S_5T_1 (18.08 cm), S_4T_2 (17.88 cm) and S_4T_1 (17.68 cm) treatment combination. Whereas the lowest cob length plant^{-1} (12.42 cm) was recorded in S_1T_1 treatment combination. treatment combination. Alam *et al*. (2020) , Koirala *et al*. (2020) and Azam (2017) also found similar result which supported the present study.

4.2.2 Cob circumference plant^{-1} (cm)

4.2.2.1 Effect of row spacings

Significant variation was recorded in respect of cob circumference plant^{-1} of white maize for different row spacings (Figure 17 and Appendix XII). Experiment result revealed that, the highest cob circumference plant^{-1} (19.70 cm) was recorded in S_5 treatment which was statistically similar with S_4 (19.33 cm) treatment. Whereas lowest cob circumference plant^{-1} (14.78 cm) was observed from S_1 treatment.

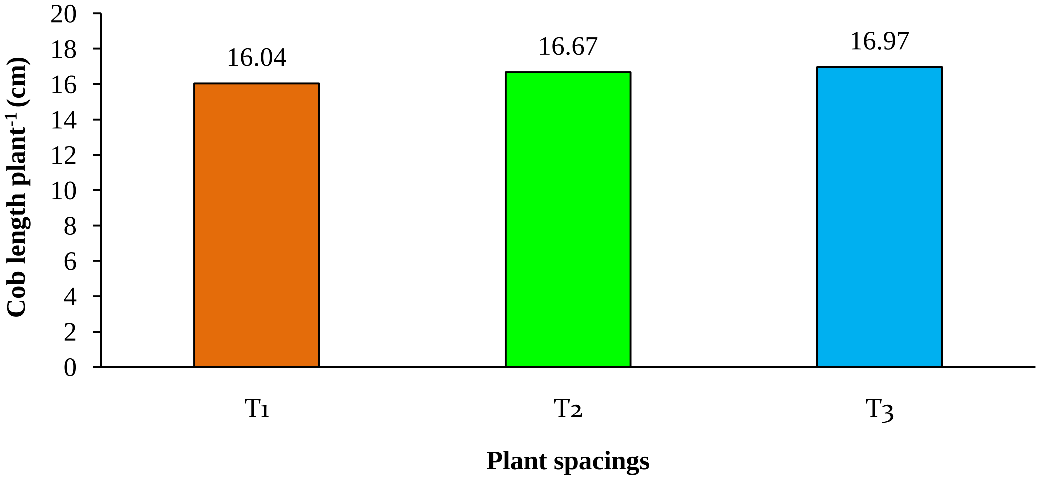


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm

Figure 15: Effect of row to row spacings on cob circumference plant $^{-1}$ of white maize ($LSD_{(0.05)}$= 0.72 cm)

4.2.2.2 Effect of plant spacings

Different plant spacing showed significant effect on cob circumference plant^{-1} of white maize (Figure 18 and Appendix XII). Experiment result revealed that, the highest cob circumference plant^{-1} (18.42 cm) was recorded in T_3 treatment which was statistically similar with T_2 (17.88 cm) treatment. Whereas the lowest cob circumference plant^{-1} (17.45 cm) was recorded in T_1 treatment.



Plant spacings, *viz*. T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 16: Effect of plant spacings on cob circumference plant^{-1} of white maize (LSD$_{(0.05)}$= 0.56 cm)

4.2.2.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of cob circumference plant^{-1} of white maize (Table 8 and Appendix XII). Results exhibited that, the highest cob circumference plant^{-1} (20.20 cm) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (19.70 cm), S_4T_3 (19.70 cm), S_5T_1 (19.19 cm), S_4T_2 (19.19 cm), S_4T_1 (19.09 cm) and S_3T_3 (19.09 cm) treatment combination. Whereas the lowest cob circumference plant^{-1} (14.14 cm) was recorded in S_1T_1 treatment combination which was statistically similar with S_1T_2 (14.65 cm) treatment combination. Koirala *et al*. (2020), Ahmmed (2018) and Hasan *et al*. (2018) found similar result which supported the present study and reported that wider spacing showed the highest cob circumference which is due to the reason that wider spacing reducing the competition among the plants and help in proper utilization of its surrounding resources which ultimately impact on yield contributing characters of the plant.

Table 8: Combined effect of row and plant spacings on cob length and cob circumference plant^{-1} of white maize

Treatment combinations	Cob length (cm)	Cob circumference (cm)
S_1T_1	12.42 e	14.14 h
S_1T_2	15.15 d	14.65 gh
S_1T_3	15.35 cd	15.55 fg
S_2T_1	16.06 cd	16.16 ef
S_2T_2	15.96 cd	17.07 de
S_2T_3	16.16 cd	17.57 cd
S_3T_1	15.96 cd	18.69 bc
S_3T_2	16.16 cd	18.79 bc
S_3T_3	16.56 bc	19.09 ab
S_4T_1	17.68 ab	19.09 ab
S_4T_2	17.88 a	19.19 ab
S_4T_3	18.18 a	19.70 ab
S_5T_1	18.08 a	19.19 ab
S_5T_2	18.18 a	19.70 ab
S_5T_3	18.58 a	20.20 a
$LSD_{(0.05)}$	1.24	1.24
CV(%)	4.49	4.15

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

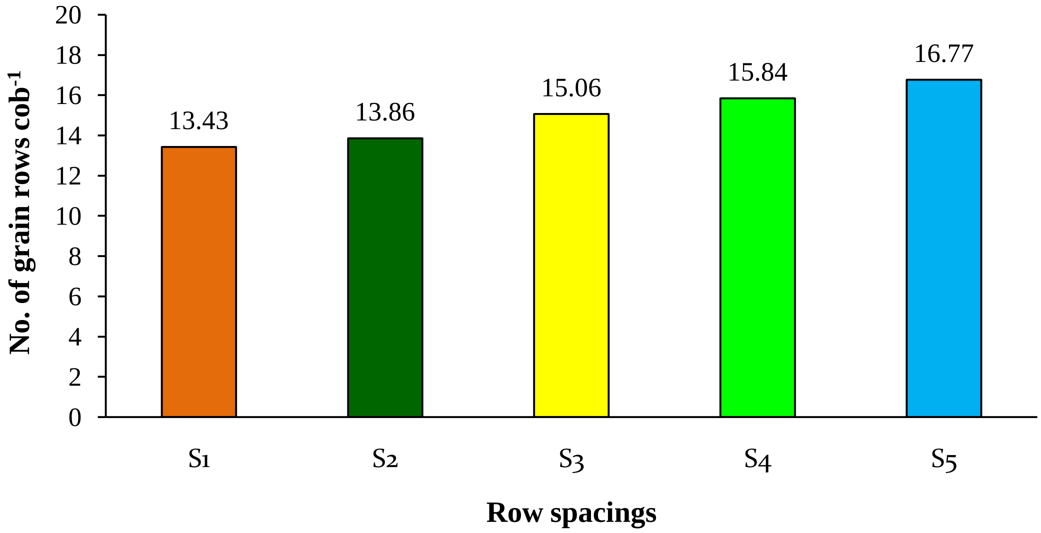
Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

4.2.3 Number of grain rows cob^{-1}

4.2.3.1 Effect of row spacings

Different row spacing showed significant effect on number of grain rows cob^{-1} of white maize (Figure 19 and Appendix XIII). From the experiment result exhibit that the highest number of grain rows cob^{-1} (16.77) was recorded in S_5 treatment. Whereas the lowest number of grain rows cob^{-1} (13.43) was recorded in S_1 treatment which was similar with S_2 (13.86) treatment.

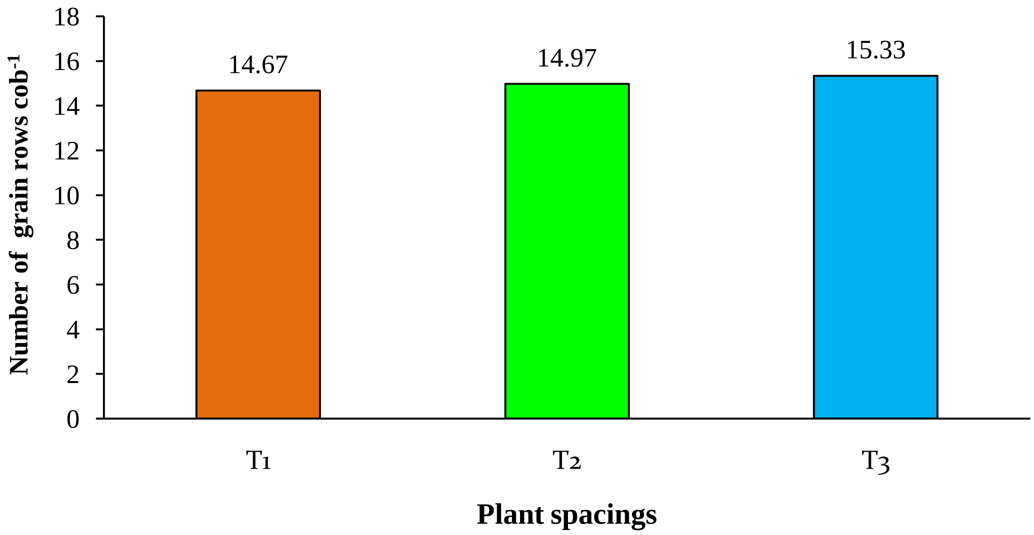


Row spacings, *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 17: Effect of row spacings on number of grain rows cob^{-1} of white maize ($LSD_{(0.05)}$=0.57)

4.2.3.2 Effect of plant spacings

Plant spacings showed significant effect on number of grain rows cob^{-1} of white maize (Figure 20 and Appendix XIII). From the experiment result exhibited that, the highest number of grain rows cob^{-1} (15.33) was recorded in T_3 treatment which was statistically similar with T_2 (14.97) treatment. Whereas the lowest number of rows cob^{-1} (14.67) was recorded in T_1 treatment.



Plant spacings, *viz*. T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 18: Effect of plant to plant spacings on number of rows cob^{-1} of white maize ($LSD_{(0.05)}$=0.44)

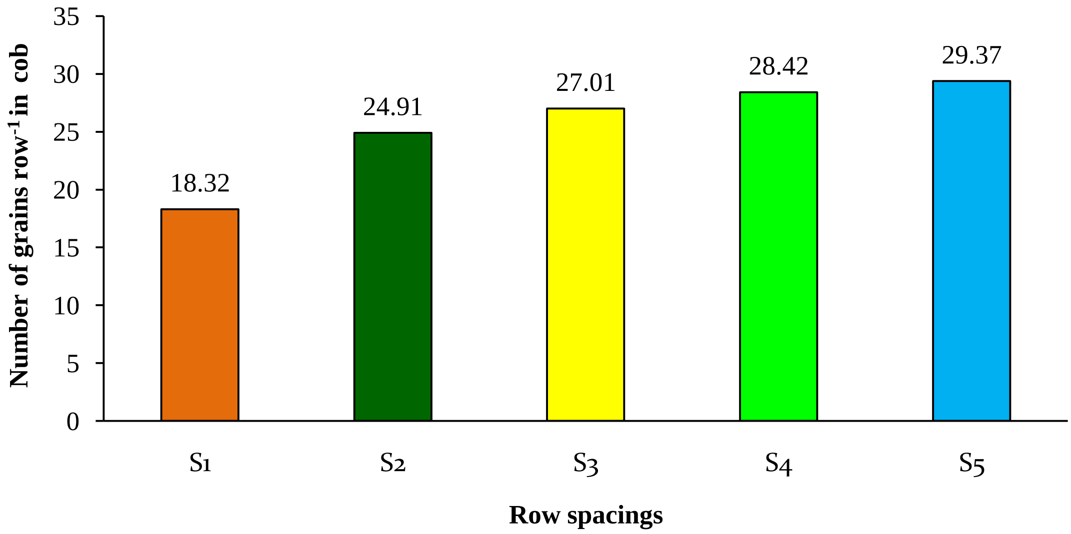
4.2.3.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of number of grain rows cob^{-1} of white maize (Table 9 and Appendix XIII). Result revealed that, the highest number of grain rows cob^{-1} (17.33) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (16.63) treatment combination. Whereas the lowest number of grain rows cob^{-1} (12.97) was recorded in S_1T_1 treatment combination which was statistically similar with S_1T_2 (13.46) S_2T_1 (13.56), S_2T_2 (13.86), and S_1T_3(13.86) treatment combination. This could be due to the fact that at closer spacing or high plant densities, there may be intense intra specific competition among plants for growth resources like nutrients, soil moisture, light, and carbon dioxide, thus, the supply of growth resources to growing cob is reduced in turn to reduce the number of cob per plant. High plant density creates competition for light, aeration, nutrients and consequently compelling the plants to undergo less reproductive growth which ultimately cause reduction of rows cob^{-1}. Koirala *et al*. (2020) reported that the highest number of rows per cob was reported when maize was planted in the row spacing 60 × 25 cm. Azam (2017) and Rahman *et al*. (2016) also found similar results which supported the present study.

4.2.4 Number of grains row^{-1} in cob

4.2.4.1 Effect of row spacings

Different row spacings showed significant effect on number of grain row^{-1} in cob of white maize (Figure 21 and Appendix XIII). From the experiment result exhibited that the highest number of grains row^{-1} in cob (29.37) was recorded in S_5 treatment. Whereas the lowest number of grains row^{-1} in cob (18.32) was recorded in S_1 treatment.

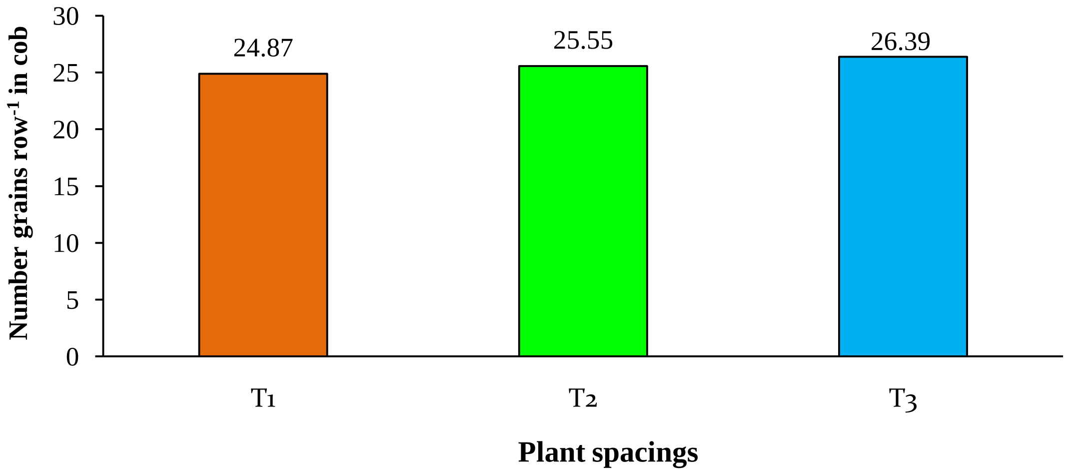


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 19: Effect of row spacing on number of grains row^{-1} in cob of white maize ($LSD_{(0.05)}$=0.91)

4.2.4.2 Effect of plant spacings

Plant spacings showed significant effect on number of grains row^{-1} in cob of white maize (Figure 22 and Appendix XIII). From the experiment result showed that, the highest number of grains row^{-1} in cob (26.39) was recorded in T_3 treatment. Whereas the lowest number of grains row^{-1} in cob (24.87) was recorded in T_1 treatment which was statistically similar with T_2 (24.55) treatment.



Plant spacings, *viz*. T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 20: Effect of plant to plant spacings on number of grains row^{-1} of white maize ($LSD_{(0.05)}$=0.71)

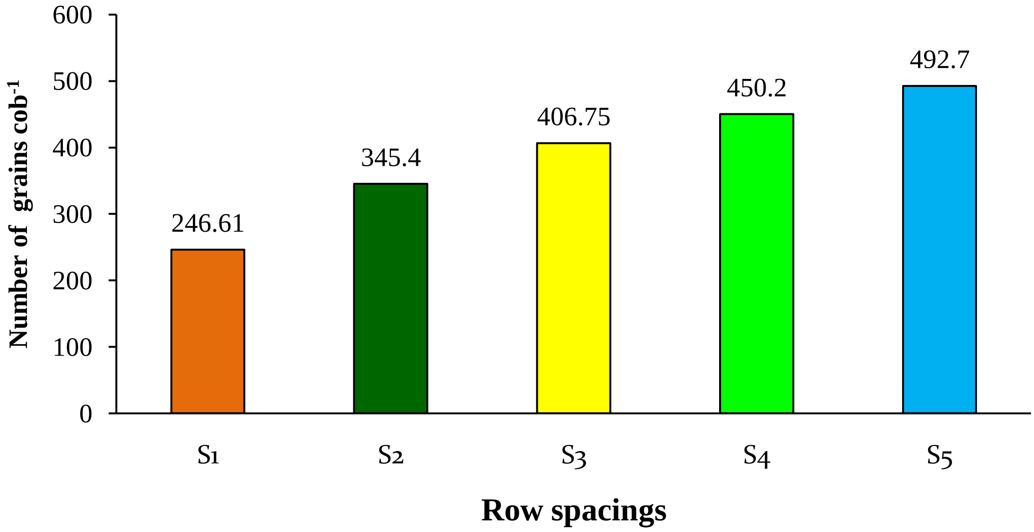
4.2.4.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of number of grains row^{-1} in cob of white maize (Table 9 and Appendix XIII). Experiment result revealed that the highest number of grains row^{-1} in cob (30.2) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (29.30) and S_4T_3 (28.71) treatment combination. Whereas the lowest number of grains row^{-1} in cob (16.24) was recorded in S_1T_1 treatment combination. The result obtained from the present study was similar with the findings of Eyasu *et al.* (2018) who reported that the number of kernels per rows was significantly influenced by the interaction effect of different spacing and varieties. Rahman *et al*. (2016) also suggested that the highest number of, grain per row was recorded at 75 cm × 25 cm spacing.

4.2.5 Number of grains cob^{-1}

4.2.5.1 Effect of row spacings

Different row spacings showed significant effect on number of grains cob^{-1} of white maize (Figure 23 and Appendix XIII). From the experiment, result exhibited that the highest number of grains cob^{-1} (492.70) was recorded in S_5 treatment. Whereas the lowest number of grains cob^{-1} (246.61) was recorded in S_1 treatment.



Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 21: Effect of row spacing on number of grains cob^{-1} of white maize ($LSD_{(0.05)}$=13.26)

4.2.5.2 Effect of plant spacings

Different plant spacings significantly influenced on number of grains cob^{-1} of white maize (Figure 24 and Appendix XIII). From the experiment result showed that the highest number of grains cob^{-1} (408.56) was recorded in T_3 treatment. Whereas the lowest number of grains cob^{-1} (369.95) was recorded in T_1 treatment.

Plant spacings, viz. T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 22: Effect of plant spacings on number of grains cob^{-1} of white maize ($LSD_{(0.05)}$=10.27)

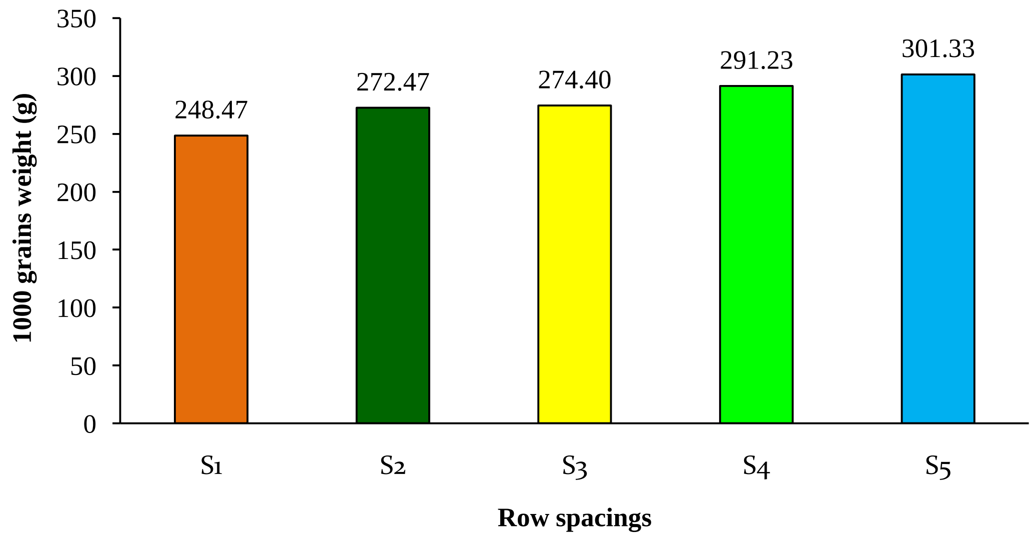
4.2.5.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of number of grains cob^{-1} of white maize (Table 9 and Appendix XIII). Experiment result revealed that the highest number of grains cob^{-1} (523.37) was recorded in S_5T_3 treatment combination. Whereas the lowest number of grains cob^{-1} (210.63) was recorded in S_1T_1 treatment combination which was statistically similar with S_1T_2 (246.59) treatment combination. Alam *et al*. (2020), Ahmmed (2018) and Azam (2017) also found similar results which supported the present finding.

4.2.6 1000 grains weight

4.2.6.1 Effect of row spacings

Different row spacings showed significant effect on 1000 grains weight of white maize (Figure 25 and Appendix XIII). From the experiment result showed that the maximum 1000 grains weight (301.33 g) was recorded in S_5 treatment which was similar with S_4 (291.23 g) treatment. Whereas the minimum 1000 grains weight (248.47) was recorded in S_1 treatment.

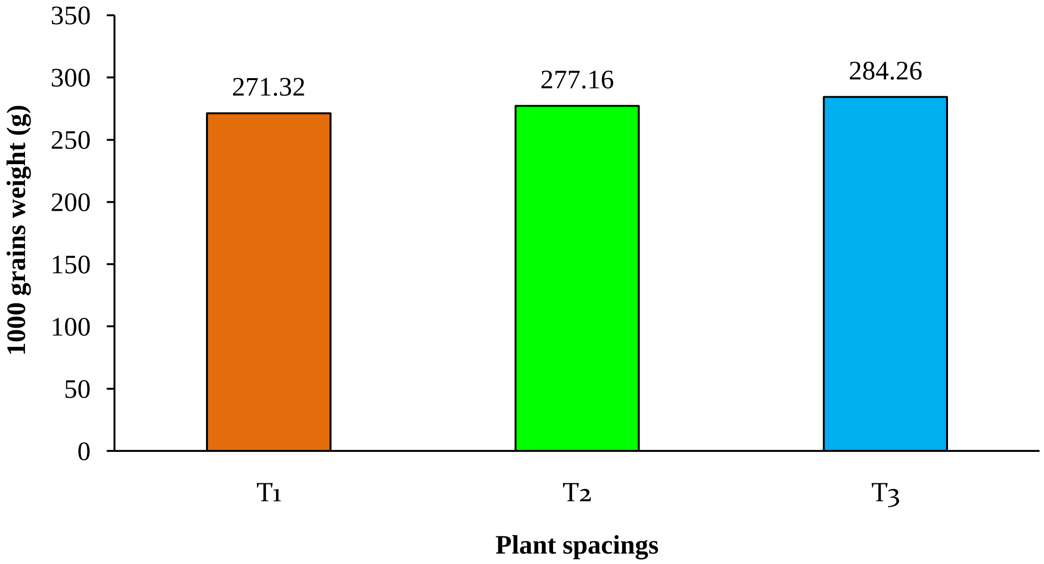


Row spacings, *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 23: Effect of row spacings on 1000 grains weight of white maize ($LSD_{(0.05)}$=10.39 g)

4.2.6.2 Effect of plant spacings

Different plant spacings showed significant effect on 1000 grains weight of white maize (Figure 26 and Appendix XIII). From the experiment result showed that the maximum 1000 grains weight (284.26 g) was recorded in T_3 treatment which was statistically similar with T_2 (277.16 g) treatment. Whereas the minimum 1000 grains weight (271.32 g) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 24: Effect of plant to plant spacing on thousand grains weight of white maize ($LSD_{(0.05)}$=8.04 g)

4.2.6.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation on thousand grains weight of white maize (Table 9 Appendix XIII). Experiment result revealed that the maximum 1000 grains weight (313.10 g) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (303.00 g) treatment combination. Whereas the minimum 1000 grains weight (245.4) was recorded in S_1T_1 treatment combination which was statistically similar with of S_1T_2 (247.50 g) and S_1T_3 (252.50 g) treatment combination. The result obtained from the present study was similar with the findings of Koirala *et al*. (2020), Hasan *et al*. (2018), Azam (2017) and Rahman *et al*. (2016).

Table 9: Combined effect of row and plant spacings on number of row cob^{-1}, number of grains row^{-1}, number of grains cob^{-1} and 1000 grain weight (g) of white maize

Treatment combinations	Grain rows cob^{-1}	Grains row^{-1} in cob	Grains cob^{-1}	1000 grain weight (g)
S_1T_1	12.97 i	16.24 i	210.63 j	245.40 g
S_1T_2	13.46 hi	18.32 h	246.59 i	247.50 g
S_1T_3	13.86 hi	20.39 g	282.61 h	252.50 fg
S_2T_1	13.56 hi	24.45 f	331.54 g	267.70 ef
S_2T_2	13.86 hi	24.85 f	344.42 fg	272.70 de
S_2T_3	14.16 gh	25.44 ef	360.23 f	277.00 de
S_3T_1	14.85 fg	26.83 de	398.43 e	267.70 ef
S_3T_2	15.05 e-g	26.96 de	405.75 e	272.70 de
S_3T_3	15.28 d-f	27.23 cd	416.07 e	282.80 c-e
S_4T_1	15.64 c-f	28.24 b-d	441.67 d	287.90 b-d
S_4T_2	15.84 b-e	28.31 b-d	448.43 cd	289.90 b-d
S_4T_3	16.04 b-d	28.71 a-c	460.51 cd	295.90 a-c
S_5T_1	16.340 bc	28.61 bc	467.49 bc	287.90 b-d
S_5T_2	16.63 ab	29.30 ab	487.26 b	303.00 ab
S_5T_3	17.33 a	30.20 a	523.37 a	313.10 a
$LSD_{(0.05)}$	0.98	1.58	22.97	17.99
CV(%)	3.91	3.70	3.54	3.87

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

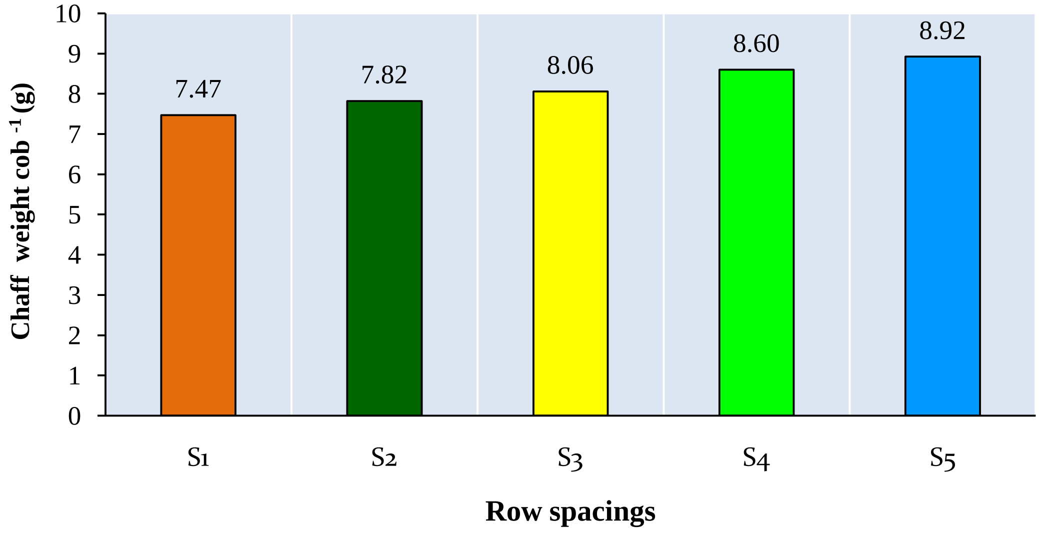
Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

4.2.7 Chaff weight cob^{-1} (g)

4.2.7.1 Effect of row spacings

Different row spacings significantly influenced on chaff weight cob^{-1} of white maize (Figure 27 and Appendix XIV). Experiment result revealed that, the maximum chaff weight cob^{-1} (8.92 g) was recorded in S_5 treatment which was statistically similar with S_4 (8.60 g) treatment. Whereas the lowest chaff weight cob^{-1} (7.47 g) was recorded in S_1 treatment which was statistically similar with S_2 (7.82 g) treatment.

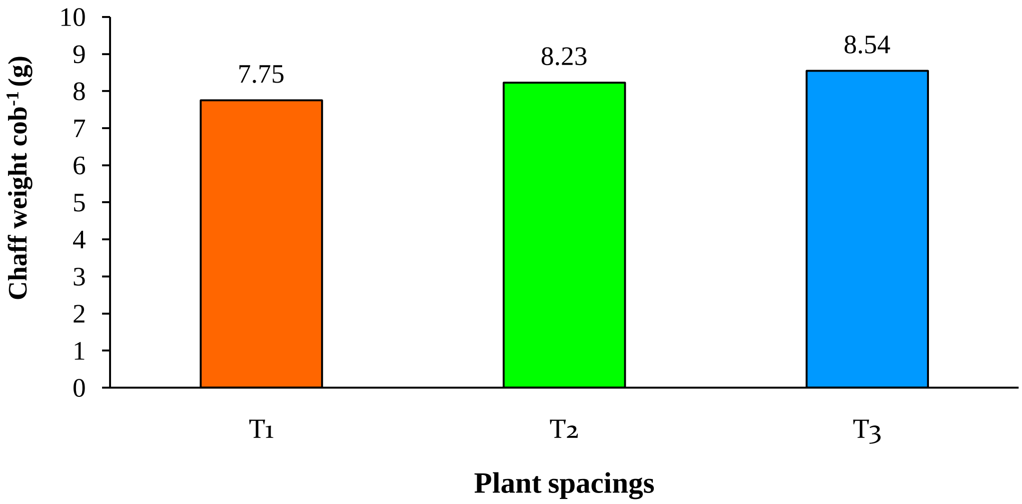


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 25: Effect of row spacings on chaff weight cob^{-1} of white maize (LSD$_{(0.05)}$= 0.57 g)

4.2.7.2 Effect of plant spacings

Different plant spacings significantly influenced on chaff weight cob^{-1} of white maize. (Figure 28 and Appendix XIV). Experiment result revealed that the maximum chaff weight cob^{-1} (8.54 g) was recorded in T_3 treatment which was statistically similar with T_2 (8.23 g) treatment.. Whereas the lowest chaff weight cob^{-1} (7.75 g) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 26: Effect of plant spacings on chaff weight cob^{-1} of white maize (LSD$_{(0.05)}$= 0.44 g)

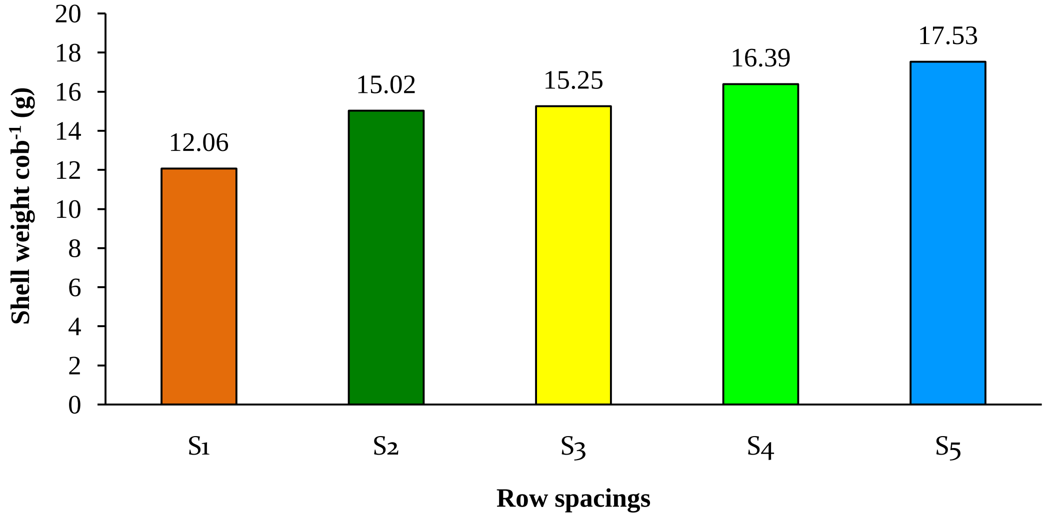
4.2.7.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of chaff weight cob^{-1} of white maize (Table 10 and Appendix XIV). Experiment result revealed that, the highest chaff weight per cob (9.56 g) was recorded in S_5T_3 treatment combination of S_5T_3 which was statistically similar with S_5T_2 (9.08 g), S_4T_3 (9.03 g) and S_4T_2 (8.60 g) treatment combination. Whereas the lowest chaff weight per cob (7.17 g) was recorded in S_1T_1 treatment combination which was statistically similar with S_1T_2 (7.50 g),S_2T_1 (7.50 g), S_1T_3 (7.74 g), , S_3T_1 (7.79 g),, S_2T_2 (7.84 g),, S_2T_3 (8.12 g), S_3T_2 (8.12 g), and S_5T_1 (8.12 g) treatment combination.

4.2.8 Shell weight cob^{-1} (g)

4.2.8.1 Effect of row spacings

Row spacings significantly influenced on shell weight cob^{-1} of white maize (Figure 29 and Appendix XIV). Experiment result revealed that, the height shell weight cob^{-1} (17.53 g) was recorded in S_5 treatment. Whereas the lowest shell weight cob^{-1} (12.06 g) was recorded in S_1 treatment.

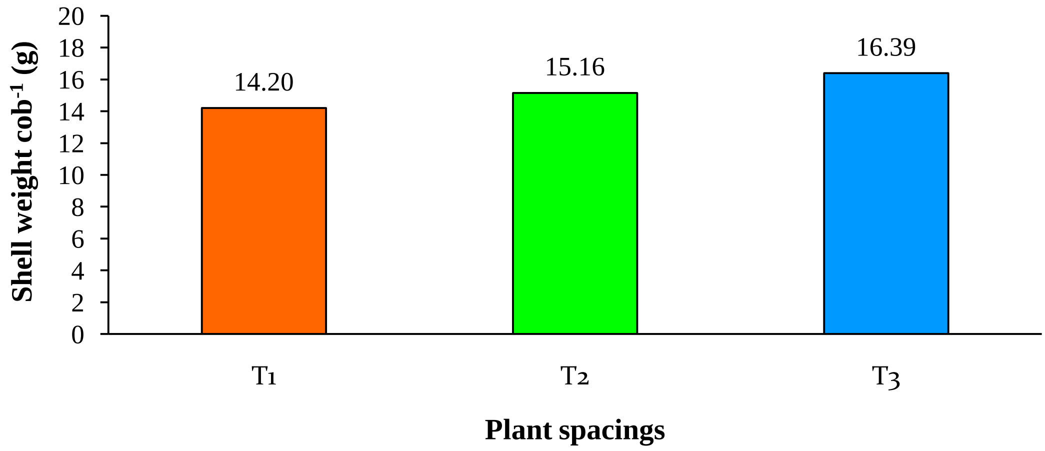


Row spacings, *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 27: Effect of row spacings on shell weight cob^{-1} of white maize (LSD$_{(0.05)}$= 0.91 g)

4.2.8.2 Effect of plant spacings

Different plant spacings significantly influenced on shell weight cob^{-1} of white maize (Figure 30 and Appendix XIV). Result revealed that the height shell weight cob^{-1} (16.39 g) was recorded in T_3 treatment. Whereas the lowest shell weight cob^{-1} (14.20 g) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 28: Effect of plant spacings on shell weight cob^{-1} of white maize (LSD$_{(0.05)}$=0.71 g)

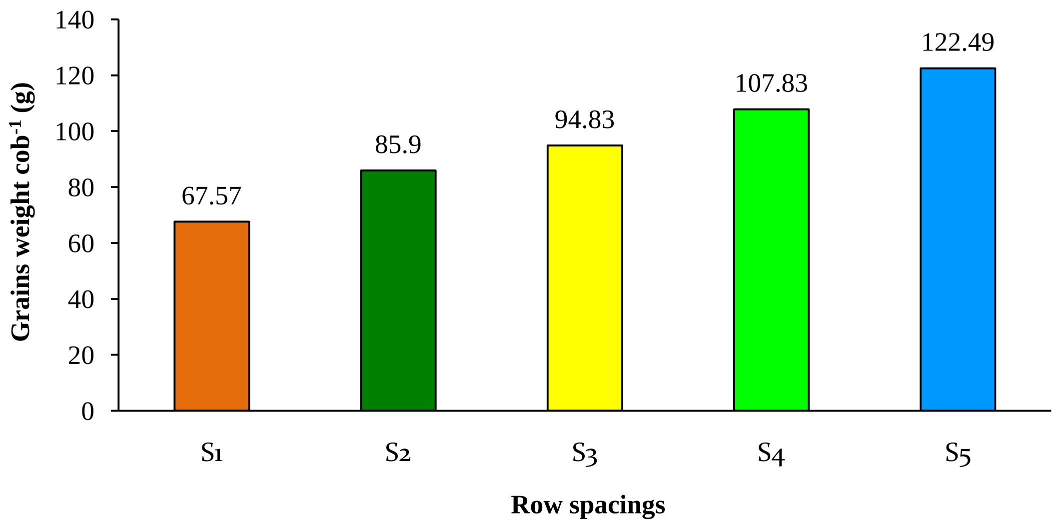
4.2.8.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant effect in respect of shell weight cob^{-1} of white maize (Table 10 and Appendix XIV). Experiment result revealed that, the highest shell weight cob^{-1} (19.12 g) was recorded in S_5T_3 treatment combination. Whereas the lowest shell weight cob^{-1} (10.24 g) was recorded in S_1T_1 treatment combination.

4.2.9 Grains weight cob^{-1} (g)

4.2.9.1 Effect of row spacings

Different row spacings significantly effect on grain weight cob^{-1} of white maize (Figure 31 and Appendix XIV). Experiment result revealed that the height grain weight cob^{-1} (122.49 g) was recorded in S_5 treatment. Whereas the lowest grain weight cob^{-1} (67.57 g) was recorded in S_1 treatment.

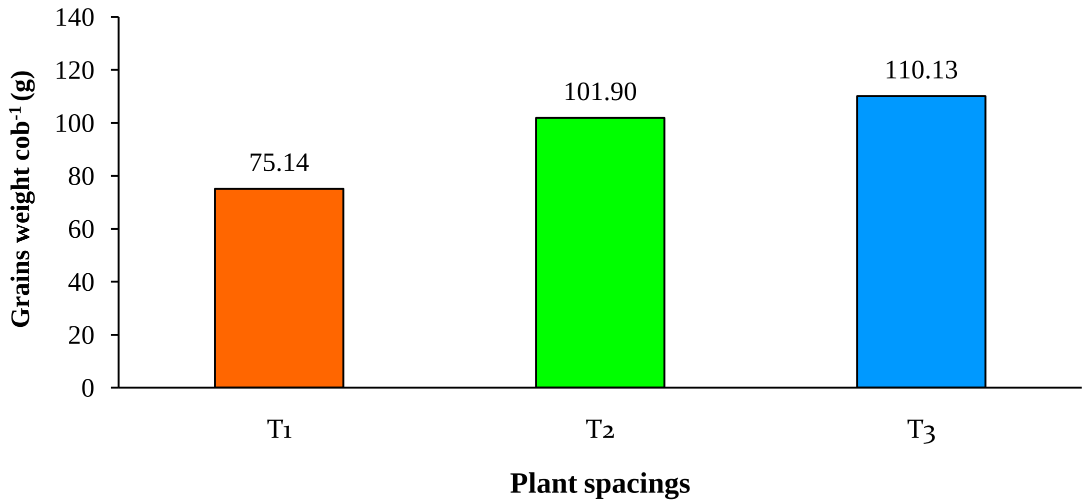


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 29: Effect of row spacings on grains weight cob^{-1} of white maize ($LSD_{(0.05)}$=7.97 g)

4.2.9.2 Effect of plant spacings

Different plant spacings significantly effect on grain weight cob^{-1} of white maize (Figure 32 and Appendix XIV). Experiment result revealed that, the height grain weight cob^{-1} (110.13 g) was recorded in T_3 treatment. Whereas the lowest grain weight cob^{-1} (75.14 g) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 30: Effect of plant spacings on grains weight cob^{-1} of white maize ($LSD_{(0.05)}$= 6.17 g)

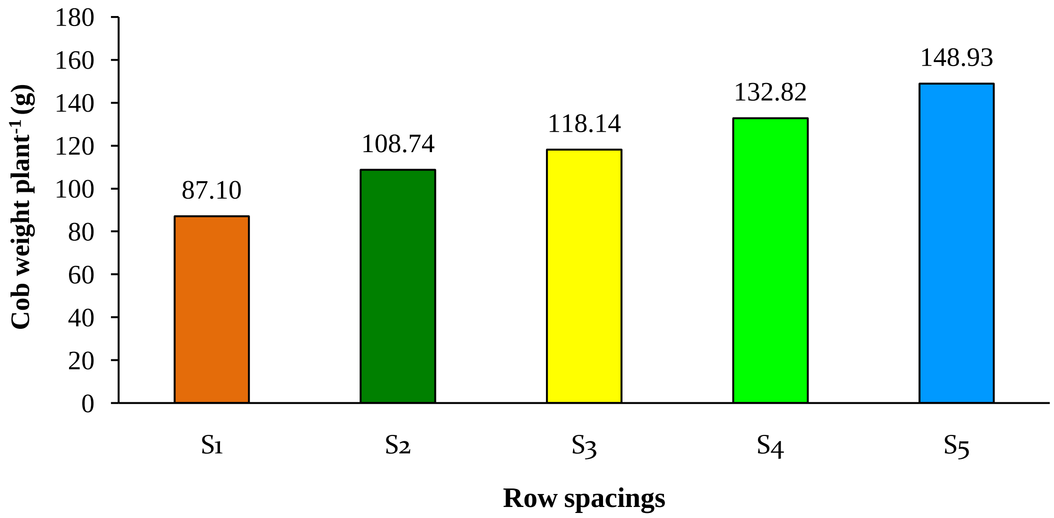
4.2.9.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of grains weight cob^{-1} of white maize (Table 10 and Appendix XIV). Experiment result revealed that, the highest grain weight cob^{-1} (137.37 g) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (132.79 g) .Whereas the lowest grain weight cob^{-1} (49.28 g) was recorded in S_1T_1 treatment combination. The result obtained from the present study was similar with the findings of Alam *et al*. (2020) who reported that, the maximum morpho-physiological characters, yield attributes and yield was obtained with higher composition of nutrients by using planting technique of 60 cm × 30 cm (T_3). This treatment also showed the height grain weight cob^{-1} was (230.67 g). Dalvi (1984) also found similar result which supported the present finding.

4.2.10 Cob weight plant^{-1} (g)

4.2.10.1 Effect of row spacings

Different row spacings significantly influenced on cob weight plant^{-1} of white maize (Figure 33 and Appendix XIV). Experiment result revealed that, the height cob weight plant^{-1} (148.93 g) was recorded in S_5 treatment. Whereas the lowest cob weight plant^{-1} (87.10 g) was recorded in S_1 treatment.

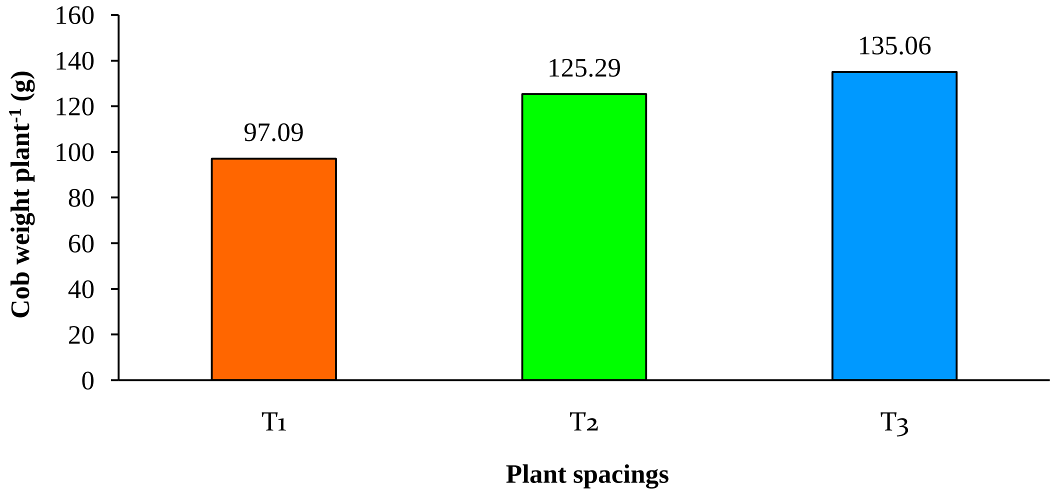


Row spacings, *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 31: Effect of row spacings on cob weight plant^{-1} of white maize (LSD$_{(0.05)}$= 9.14)

4.2.10.2 Effect of plant spacings

Different plant spacings significantly influenced on cob weight plant^{-1} of white maize (Figure 34 and Appendix XIV). Experiment result revealed that the height cob weight plant^{-1} (135.06 g) was recorded in T_3 treatment. Whereas the lowest cob weight plant^{-1} (97.09 g) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 32: Effect of plant spacings on cob weight plant^{-1} of white maize (LSD$_{(0.05)}$= 7.08 g)

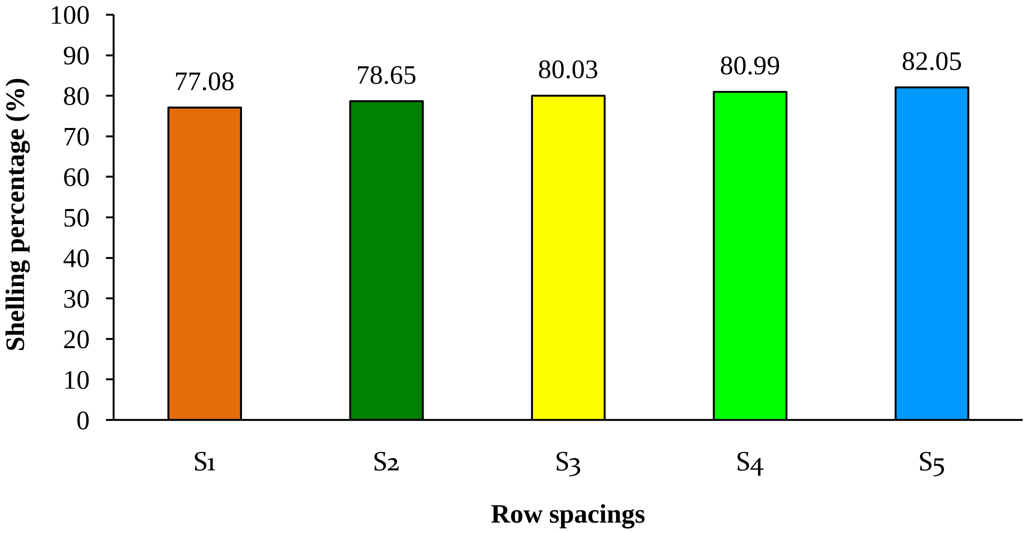
4.2.10.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of cob weight plant^{-1} of white maize (Table 10 and Appendix XIV). Experiment result revealed that the highest cob weight plant^{-1} (166.05 g) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (158.94 g) treatment combination. Whereas the lowest cob weight plant^{-1} (66.69 g) was o recorded in S_1T_1 treatment combination. Ukonze *et al*. (2016) found similar result which supported the present study.

4.2.11 Shelling percentage

4.2.11.1 Effect of row spacings

Different row spacings showed no significant effect on shelling percentage of white maize (Figure 35 and Appendix XIV). Experiment result revealed that, the height shelling percentage (82.051 %) was recorded in S_5 treatment. Whereas the lowest shelling percentage (77.082 %) was recorded in S_1 treatment.

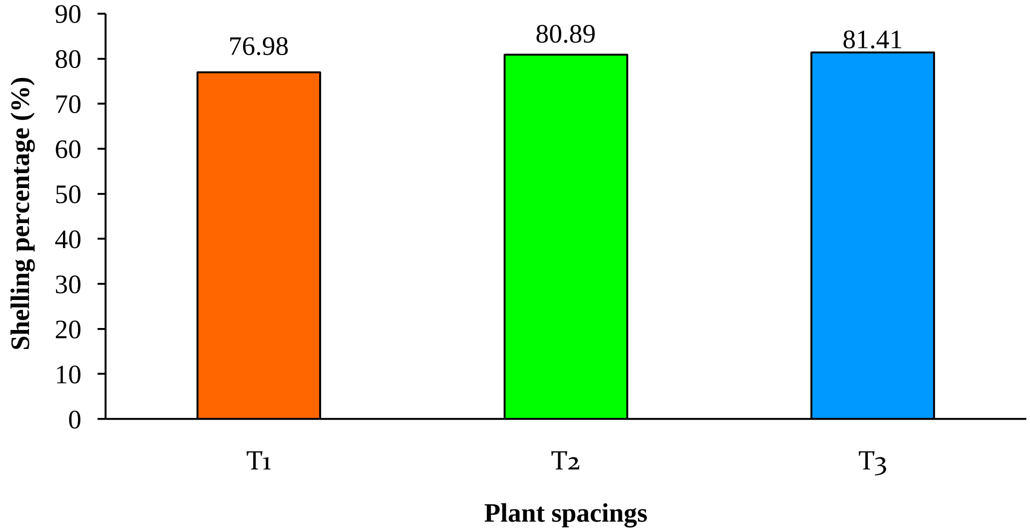


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 33: Effect of row spacing on shelling percentage (%) of white maize ($LSD_{(0.05)}$= Ns)

4.2.11.2 Effect of plant spacings

Different plant spacings showed significant effect on shelling percentage of white maize (Figure 36 and Appendix XIV). Experiment result revealed that, the height shelling percentage (81.41 %) was recorded in T_3 treatment which was statistically similar with T_2 (80.89 %) treatment. Whereas the lowest shelling percentage (76.98 %) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 34: Effect of plant spacings on shelling percentage (%) of white maize ($LSD_{(0.05)}$= 3.87 %)

4.2.11.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of shelling percentage of white maize (Table 10 and Appendix). Experiment result revealed that the highest shelling percentage (83.55 %) was recorded in S_5T_2 treatment combination which was statistically similar with all other the treatment combination except S_1T_1 (73.89 %). Whereas the lowest shelling percentage (73.89 %) was recorded in S_1T_1 treatment combination. Ahmmed (2018) and Mukhtar *et al.* (2012) also found similar results with the present study.

Table 10: Combined effect of row and plant spacings on chaff weight cob^{-1}, shell weight cob^{-1}, grain weight cob^{-1}, cob weight $plant^{-1}$ (g) and shelling percentage (%) of white maize

Treatment combinations	Chaff weight cob^{-1} (g)	Shell weight cob^{-1} (g)	Grain weight cob^{-1} (g)	Cob weight $plant^{-1}$ (g)	Shelling percentage (%)
S_1T_1	7.17 e	10.24 g	49.28 j	66.69 k	73.89 b
S_1T_2	7.50 de	12.29 f	67.01 i	86.80 j	77.20 ab
S_1T_3	7.74 c-e	13.66 ef	86.42 gh	107.82 hi	80.15 ab
S_2T_1	7.50 de	14.34 de	66.55 i	88.39 j	75.29 ab
S_2T_2	7.84 c-e	15.02 c-e	88.77 f-h	111.63 f-i	79.52 ab
S_2T_3	8.12 b-e	15.70 b-d	102.38 ef	126.20 e-g	81.13 ab
S_3T_1	7.79 c-e	14.34 de	75.35 hi	97.48 ij	77.30 ab
S_3T_2	8.12 b-e	15.02 c-e	103.84 de	126.98 d-f	81.78 ab
S_3T_3	8.27 b-d	16.39 bc	105.31 de	129.97 c-e	81.03 ab
S_4T_1	8.17 b-d	15.70 b-d	87.23 gh	111.10 g-i	78.52 ab
S_4T_2	8.60 a-c	16.39 bc	117.09 cd	142.08 cd	82.41 ab
S_4T_3	9.03 ab	17.07 b	119.18 bc	145.28 bc	82.04 ab
S_5T_1	8.12 b-e	16.39 bc	97.30 e-g	121.81 e-h	79.88 ab
S_5T_2	9.08 ab	17.07 b	132.79 ab	158.94 ab	83.55 a
S_5T_3	9.56 a	19.12 a	137.37 a	166.05 a	82.73 a
$LSD_{(0.05)}$	0.98	1.58	13.80	15.83	8.65
CV(%)	7.16	6.20	8.62	7.94	6.48

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Plant spacings

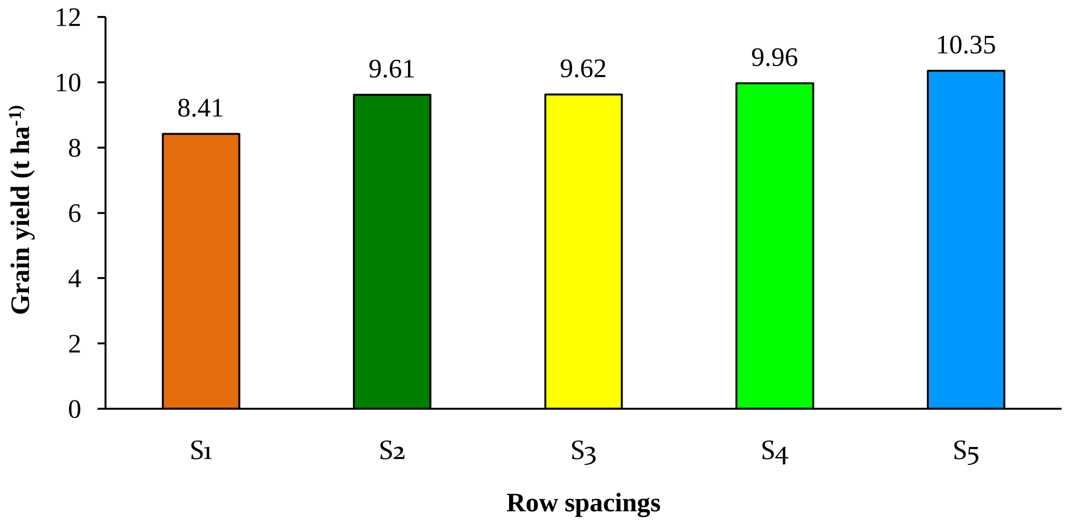
T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

4.3 Yield characters

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

4.3.1.1 Effect of row spacings

Different row spacings showed significant effect on grain yield (t ha^{-1}) of white maize (Figure 37 and Appendix XV). Experiment result revealed that, the maximum grain yield (10.35 t ha^{-1}) was recorded in S_5 treatment. Whereas minimum grain yield (8.410 t ha^{-1}) was recorded in S_1 treatment. Akbar *et al.* (2016) and Mechi (2015) found similar result with the present study.

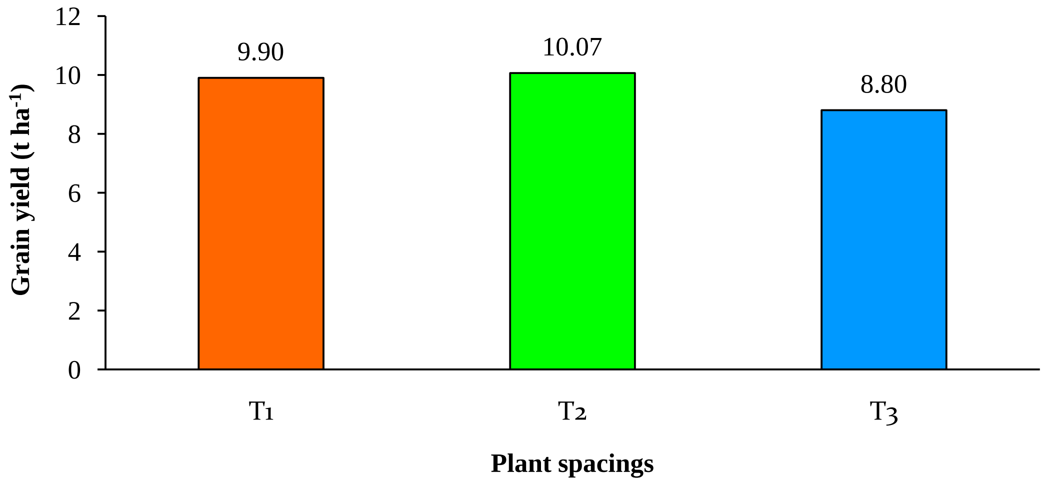


Row spacings, *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 35: Effect of row spacings on grain yield (t ha^{-1}) of white maize (LSD$_{(0.05)}$= 0.36 t ha^{-1})

4.3.1.2 Effect of plant spacings

Different plant spacings showed significant effect on grain yield (t ha^{-1}) of white maize (Figure 38 and Appendix XV). Experiment result revealed that, the maximum grain yield (10.07 t ha^{-1}) was recorded in T_2 treatment which was statistically similar with T_1 (9.90 t ha^{-1}) treatment. Whereas the minimum grain yield (8.80 t ha^{-1}) was recorded in T_3 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 36: Effect of plant spacing on grain yield (t ha^{-1}) of white maize (LSD$_{(0.05)}$=0.28 t ha^{-1})

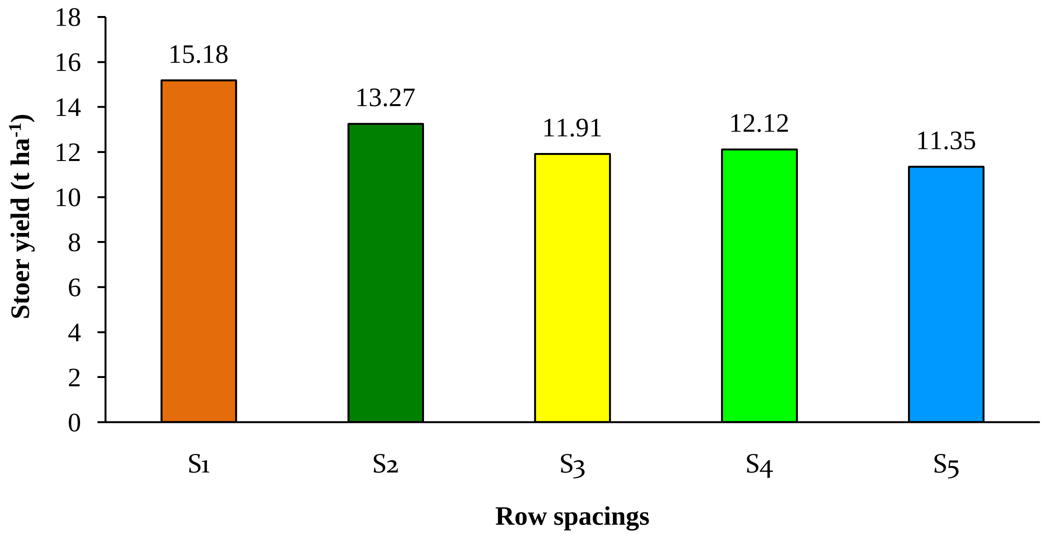
4.3.1.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of grain yield (t ha^{-1}) of white maize (Table 11 and Appendix). Experiment result revealed that, the maximum grain yield (11.07 t ha^{-1}) was recorded in S_5T_2 treatment combination which was statistically similar with S_5T_1 (10.81 t ha^{-1}), followed by S_4T_2 (10.64 t ha^{-1}) and S_4T_1 (10.57 t ha^{-1}) treatment combination. Whereas the minimum grain yield (8.21 t ha^{-1}) was recorded in S_1T_1 treatment combination which was statistically similar with the treatment combination of S_1T_2 (8.38 t ha^{-1}) followed by S_3T_3 (8.43 t ha^{-1}), S_1T_3 (8.64 t ha^{-1}), and S_4T_3 (8.67 t ha^{-1}), treatment combination. Belay (2019), Golla*et al.* (2018), Hasan *et al.* (2018), Nand (2015),Enujeke (2013 a), Jula*et al*. (2013) and Sharifai *et al*. (2012) found similar results which supported the present study.

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

4.3.2.1 Effect of row spacings

Row spacings showed significant effect on stover yield (t ha^{-1}) of white maize (Figure 39 and Appendix XV). Experiment result revealed that, the maximum stover yield (15.18 t ha^{-1}) was recorded in S_1 treatment. Whereas the minimum stover yield (11.35 t ha^{-1}) was recorded in S_5 treatment which was similar with S_3 (11.91 t ha^{-1}) treatment and S_4 (12.12 t ha^{-1}) treatment.

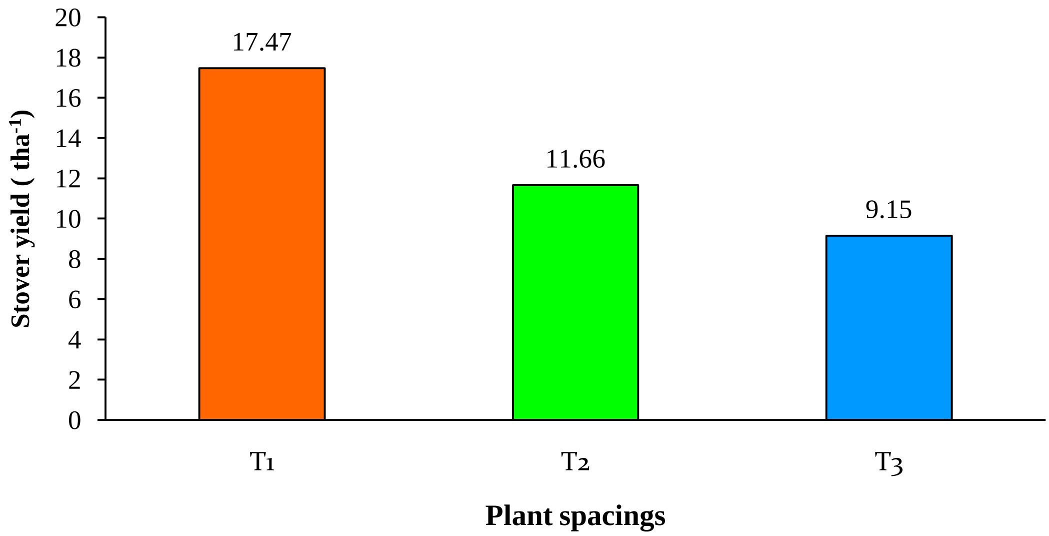


Row spacings, *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 37: Effect of row spacings on stover yield (t ha^{-1}) of white maize (LSD$_{(0.05)}$= 1.13 t ha^{-1})

4.3.2.2 Effect of plant spacings

Different plant spacings showed significant effect on stover yield (t ha^{-1}) of white maize (Figure 40 and Appendix XV). Experiment result revealed that, the maximum stover yield (17.47 t ha^{-1}) was recorded in T_1 treatment. Whereas the minimum stover yield (9.15 t ha^{-1}) was recorded in T_3 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 38 : Effect of plant spacings on stover yield (t ha^{-1}) of white maize (LSD$_{(0.05)}$=0.88 t ha^{-1})

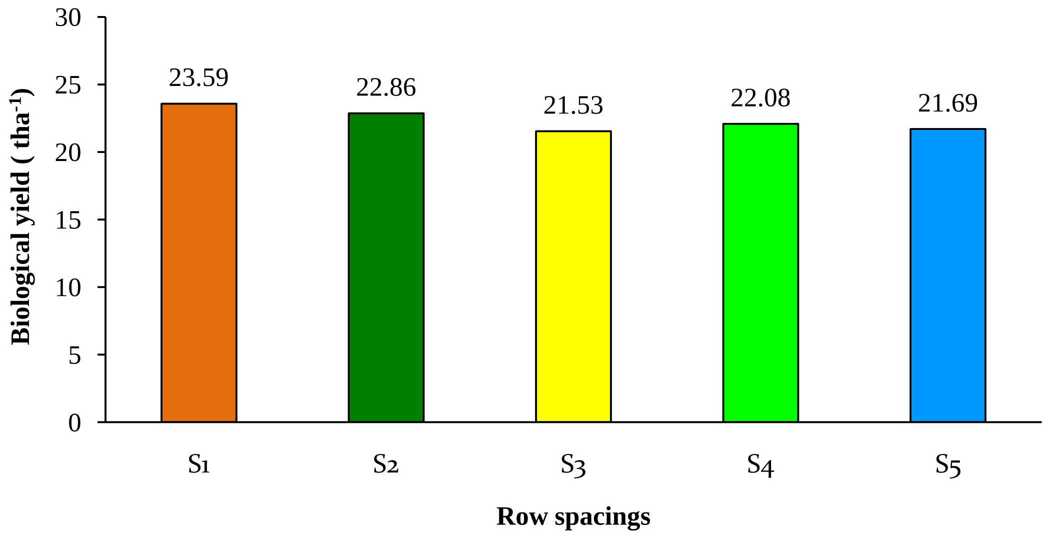
4.3.2.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of stover yield (t ha^{-1}) of white maize (Table 11 and Appendix). Experiment result revealed that, the maximum stover yield (20.94 t ha^{-1}) was recorded in S_1T_1 treatment combination. Whereas the minimum stover yield (8.10 t ha^{-1}) was recorded in S_5T_3 treatment combination which was statistically similar with S_3T_3 (8.66 t ha^{-1}), S_2T_3 (9.16 t ha^{-1}), S_4T_3(9.58 t ha^{-1}) and S_5T_2 (9.84 t ha^{-1}) treatment combination. Ullah *et al*. (2020); Worku and Derebe (2020) and Hossain (2015) found similar results which supported the present study and reported that stover yields was significantly increased with increasing plant density, as plant density is influenced by spacing, wide spacing cause low plant density and narrow spacing cause high plant density which ultimately impact on stover and grain yield of the crop.

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

4.3.3.1 Effect of row spacings

Row spacings showed significant effect on biological yield (t ha^{-1}) of white maize (Figure 41 and Appendix XV). Experiment result revealed that, the maximum biological yield (23.59 t ha^{-1}) was recorded in S_1 treatment which was statistically similar with S_2 (22.86 t ha^{-1}) and S_4 (22.08 t ha^{-1}) treatment. Whereas the minimum biological yield (21.53 t ha^{-1}) was recorded in S_3 treatment which was statistically similar with S_5 (21.69 t ha^{-1}) treatment.

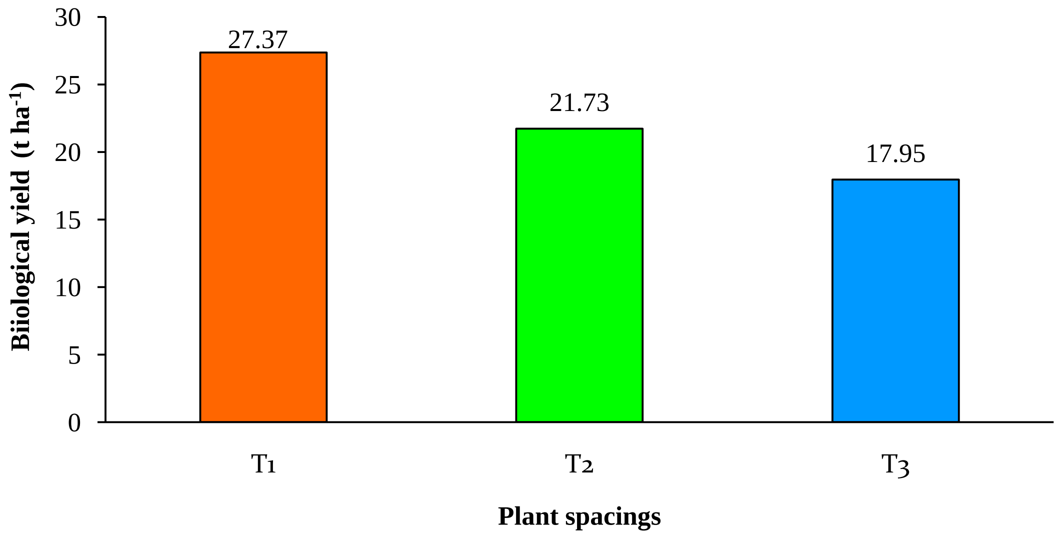


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 39: Effect of row spacings on biological yield (t ha^{-1}) of white maize (LSD$_{(0.05)}$= 1.62 t ha^{-1})

4.3.3.2 Effect of plant spacings

Different plant spacings showed significant effect on biological yield (t ha^{-1}) of white maize (Figure 42 and Appendix XV). Experiment result revealed that, the maximum biological yield (27.37 t ha^{-1}) was recorded in T_1 treatment. Whereas minimum biological yield (17.95 t ha^{-1}) was recorded in T_3 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 40: Effect of plant spacings on biological yield (t ha^{-1}) of white maize (LSD$_{(0.05)}$= 1.26 t ha^{-1})

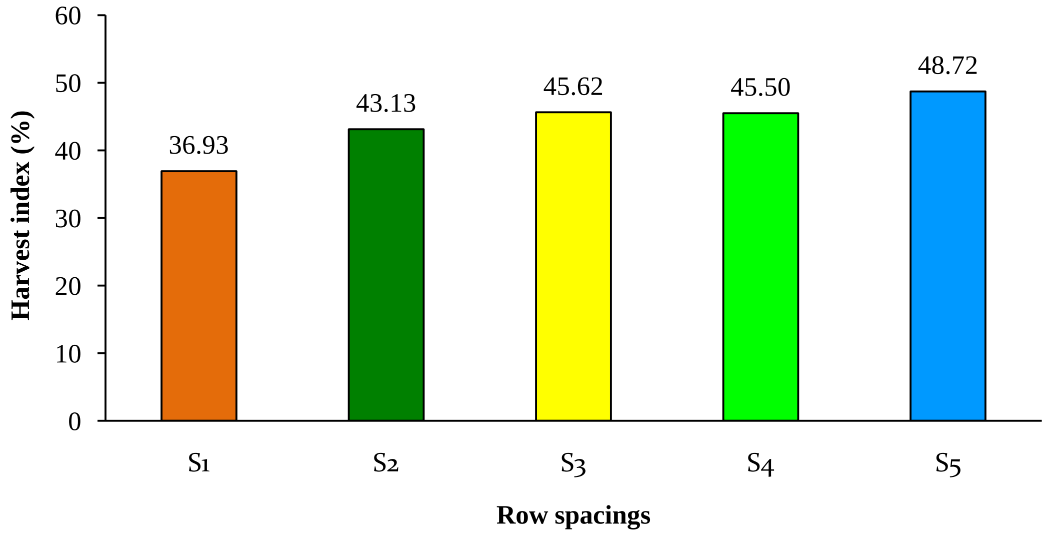
4.3.3.3 Combined effect of row and plant spacings

Different row spacing along with plant spacings showed significant variation in respect of biological yield (t ha^{-1}) of white maize (Table 11 and Appendix XV). Experiment result revealed that, the maximum biological yield (29.15 t ha^{-1}) was recorded in S_1T_1 treatment combination which was statistically similar with S_2T_1 (28.23 t ha^{-1}) and S_5T_1 (26.91 t ha^{-1}). Whereas the minimum biological yield (17.09 t ha^{-1}) was recorded in S_3T_3 treatment combination which was statistically similar with S_5T_3 (17.26 t ha^{-1}), S_4T_3(18.24 t ha^{-1}),, S_2T_3 (18.26 t ha^{-1}), and S_1T_3 (18.91 t ha^{-1}) treatment combination. The result obtained from the present study was similar with the findings of Gaire *et al*. (2020) who reported that the variation in biological yield due to each increment in nitrogen level and spacing was significant ($p<0.01$). The highest biological yield (12.37 mt/ha) produced under 60 × 15 cm spacing and the lowest biological yield (9.24 mt/ha) produced under 60 × 25 cm spacing. Shafi *et al.* (2012) also reported that the highest biological yield was recorded from the treatment of 65,000 plants ha^{-1} and the lowest biological yield was recorded from plant population of 45,000 plants ha^{-1} which supported the present finding.

4.3.4 Harvest index (%)

4.3.4.1 Effect of row spacings

Different row spacings showed significant effect on harvest index (%) of white maize (Figure 43 and Appendix XV). Experiment result revealed that, the maximum harvest index (48.72 %) was recorded in S_5 treatment. Whereas the minimum harvest index (36.93 %) was recorded in S_1 treatment.

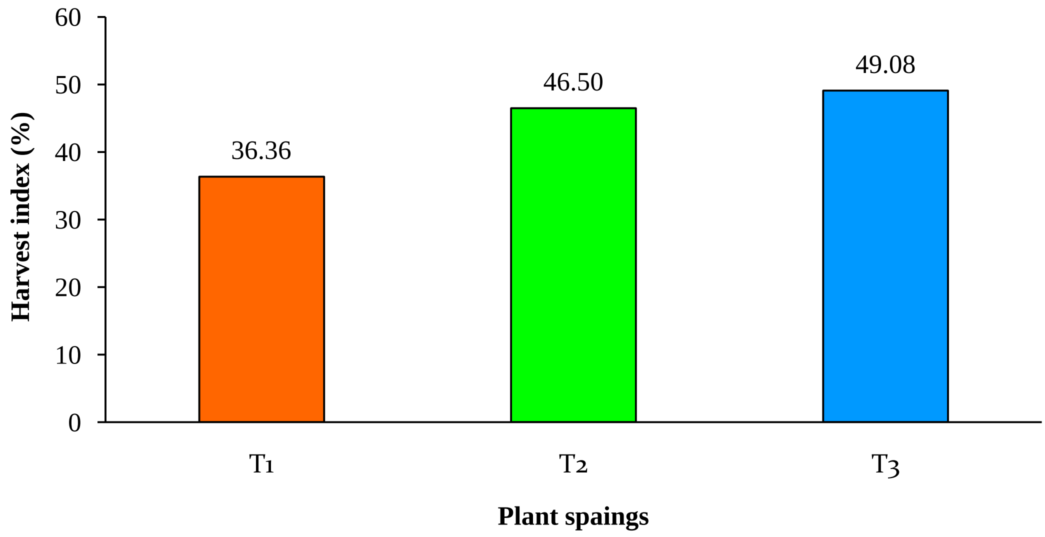


Row spacings, *viz*. S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Figure 41: Effect of row spacings on harvest indec (%) of white maize ($LSD_{(0.05)}$= 2.72 %)

4.3.4.2 Effect of plant spacings

In case of different plant spacings significant effect was showed on harvest index (%) of white maize (Figure 44 and Appendix XV). Experiment result revealed that, the maximum harvest index (49.08 %) was recorded in T_3 treatment. Whereas the minimum harvest index (36.36 %) was recorded in T_1 treatment.



Plant spacings, *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm.

Figure 42: Effect of plant spacings on harvest index (%) of white maize ($LSD_{(0.05)}$=2.11 %)

4.3.4.3 Combined effect of row and plant spacings

Combined effect of row and plant spacings showed significant variation in respect of harvest index (%) of white maize (Table 11 and Appendix XV). Experiment result revealed that, the maximum harvest index (53.06 %) was recorded in S_5T_3 treatment combination which was statistically similar with S_5T_2 (52.92 %), S_3T_2 (49.96 %), S_2T_3 (49.85 %), and S_3T_3 (49.30 %) treatment combination. Whereas the minimum harvest index (28.174 %) was recorded in S_1T_1 treatment combination. Ahmmed (2018) and Mechi (2015) found similar result which supported the present study and reported that harvest index varied due to different spacing.

Table 11: Combined effect of row and plant spacings on grain yield (t ha^{-1}), stover yield (t ha^{-1}), biological yield (t ha^{-1})and harvest index (%) of white maize

Treatment combinations	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index %
S_1T_1	8.21 f	20.94 a	29.15 a	28.17 g
S_1T_2	8.38 f	14.32 d	22.70 c	36.91 ef
S_1T_3	8.64 ef	10.27 fg	18.91 de	45.70 bc
S_2T_1	9.86 d	18.37 b	28.23 ab	34.93 f
S_2T_2	9.86 d	12.24 e	22.10 c	44.62 cd
S_2T_3	9.10 e	9.16 gh	18.26 de	49.85 ab
S_3T_1	10.05 cd	16.68 bc	26.73 ab	37.59 ef
S_3T_2	10.38 b-d	10.40 e-g	20.78 cd	49.96 ab
S_3T_3	8.43 f	8.66 gh	17.09 e	49.30 a-c
S_4T_1	10.57 a-c	15.27 cd	25.84 b	40.91 de
S_4T_2	10.65 a-c	11.49 ef	22.14 c	48.07 bc
S_4T_3	8.67 ef	9.57 f-h	18.24 de	47.51 bc
S_5T_1	10.81 ab	16.10cd	26.91 ab	40.18 de
S_5T_2	11.07 a	9.84 f-h	20.91 cd	52.92 a
S_5T_3	9.16 e	8.10 h	17.26 e	53.06 a
LSD$_{(0.05)}$	0.62	1.96	2.81	4.71
CV(%)	3.88	9.18	7.52	6.40

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

Here,

Row spacings,

S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm and S_5: 60 cm.

Plant spacings

T_1:15 cm, T_2: 20 cm and T_3: 25 cm.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University Dhaka, during October 2018 to February 2019 to evaluate the growth, yield and yield attributes of white maize (Genotype SAUWMT 12-3-3) under different planting geometry. The experiment was consisted of two different factors. Factor A: Row spacings (5) *viz.* S_1: 40 cm, S_2: 45 cm, S_3: 50 cm, S_4: 55 cm, S_5: 60 cm, and Factor B: Plant spacings (3) *viz.* T_1: 15 cm, T_2: 20 cm and T_3: 25 cm. The experiment was set up in randomized complete block design (factorial) with three replications. There were 15 treatment combinations. The total number of unit plots were 45. The size of each unit plot was 6.30 m^2 (3.50 m × 1.80 m). Cowdung was used @ 5 t ha^{-1} before final land preparation. The field was fertilized with nitrogen, phosphate, potash, sulphur, zinc and boron at the rate of 500-250-200-250−15-5 kg ha^{-1} of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. Data were collected on plant density m^{-2}, plant height (cm), number of leaves $plant^{-1}$, leaf area $plant^{-1}$, leaf area index $plant^{-1}$, dry matter weight $plant^{-1}$ (g), cob length $plant^{-1}$, cob circumference $plant^{-1}$, number of grain rows cob^{-1}, number of grains row^{-1} in cob, number of grains cob^{-1}, 1000-grains weight (g), chaff weight cob^{-1}, shell weight cob^{-1}, grains weight cob^{-1}, cob weight $plant^{-1}$ shelling percentage (%), grain yield (t/ha), stover yield (t/ha), biological yield (t/ha) and harvest index (%).

Different row and plant spacings, either individually or combined showed significant effect in respect of various characteristics of white maize.

In case of different row spacings, the maximum plant density (13.06 m^{-2}) was recorded in S_1 treatment. The maximum plant height (41.75 and 139.21 cm) at 30 and 60 DAS were recorded in S_5 treatment. At 90 DAS the maximum plant height (202.63 cm) was recorded in S_4 treatment. At harvest respectively the maximum plant height (216.00 cm) was recorded in S_5 treatment. The highest number of leaves $plant^{-1}$ (4.33 and 6.55 at 30 and 60 DAS respectively) was recorded in S_5 treatment. At 90 DAS the highest number of leaves $plant^{-1}$ (9.56) was recorded in S_2 treatment. At harvest respectively the highest number of leaves $plant^{-1}$ (7.11) was recorded in S_3 treatment. The maximum leaf area $plant^{-1}$ (153.29, 763.57, 3899 and 2524.3 cm^2) at 30, 60, 90

DAS and at harvest respectively were recorded in S_5 treatment. The maximum leaf area index plant^{-1} (0.14, 0.70, 3.72 and 2.50 at 30, 60, 90 DAS and at harvest respectively were recorded in S_1 treatment. The maximum stem base circumference plant^{-1} (6.43, 8.91 and 9.56 cm) at 60, 90 DAS and at harvest respectively, dry matter weight plant^{-1} (29.79, 64.66, 235.56, and 250.66 g) at 30, 60, 90 DAS and at harvest respectively, cob length plant^{-1} (18.28 cm), cob circumference plant^{-1} (19.70 cm), number of grain rows cob^{-1} (16.77), number of grains row^{-1} in cob (29.37), number of grains cob^{-1} (492.70), 1000 grains weight (301.33 g), chaff weight cob^{-1} (8.92 g), shell weight cob^{-1} (17.53 g), grain weight cob^{-1} (122.49 g), cob weight plant^{-1} (148.93 g), shelling percentage (82.051 %), grain yield (10.35 t ha^{-1}) were recorded in S_5 treatment. The maximum stover yield (15.18 t ha^{-1}) and biological yield (23.59 t ha^{-1}) were recorded in S_1 treatment. The maximum harvest index (48.72 %) was recorded in S_5 treatment. Whereas the lowest plant density (8.70 m^{-2}) was recorded in S_5 treatment. The minimum plant height (31.933, 106.53, 169.42 and 180 cm) at 30, 60, 90 DAS and harvest respectively were recorded from S_1 treatment. The lowest number of leaves plant^{-1} (3.89) was recorded in S_1 treatment at 30 DAS. At 60 DAS lowest number of leaves plant^{-1} (5.67) was recorded in S_3 treatment. At 90 DAS lowest number of leaves plant^{-1} (9.2) was recorded in S_4 treatment; and at harvest respectively lowest number of leaves plant^{-1} (6.78) was recorded in S_2 treatment. The minimum leaf area plant^{-1} (108.28, 536.23, 2931, and 1920.1 cm^2) at 30, 60, 90 DAS and at harvest respectively were recorded in S_1 treatment. The minimum leaf area index plant^{-1} (0.12) was recorded in S_4 treatment at 30 DAS. At 60 DAS the minimum leaf area index plant^{-1} (0.63) was recorded in S_4 treatment. At 90 DAS and harvest respectively minimum leaf area index plant^{-1} (3.36 and 2.18) was recorded in S_5 treatment. The minimum stem base circumference plant^{-1} (5.10, 7.70 and 8.42 cm) at 60, 90DAS and harvest respectively, dry matter plant^{-1} (24.46, 52.94, 162.76 and 181.85 g) at 30, 60, 90 DAS and at harvest respectively, cob length plant^{-1} (14.31 cm), cob circumference plant^{-1} (14.78 cm), grain rows cob^{-1} (13.43), number of grains row^{-1} in cob (18.32), number of grains cob^{-1} (246.61), 1000 grains weight (248.47), chaff weight cob^{-1} (7.47 g), shell weight cob^{-1} (12.06 g), grain weight cob^{-1} (67.57 g), cob weight plant^{-1} (87.10 g), shelling percentage (77.082 %), grain yield (8.410 t ha^{-1}) were recorded in S_1 treatment. The minimum stover yield (11.35 t ha^{-1}) was recorded in S_5 treatment. The minimum biological yield (21.53 t ha^{-1}) was recorded in S_3 treatment and the minimum harvest index (36.93 %) was recorded in S_1 treatment.

In case of different plant spacings, the highest plant density (13.61 m^{-2}) was recorded from T_1 treatment. The highest plant height (38.38, 124.20, 197.21, and 210 cm) at 30, 60, 90 DAS and at harvest respectively were recorded in T_3 treatment. The highest number of leaves $plant^{-1}$ (4.20 and 9.47 at 30 and 90 DAS respectively) was recorded in T_3 treatment. At 60 DAS and at harvest respectively, the highest number of leaves $plant^{-1}$ (6.20 and 7.067) was recorded in T_2 treatment. the maximum leaf area $plant^{-1}$ (132.68, 664.67, 3705.8 and 2346.7 cm^2) at 30, 60, 90 DAS and at harvest respectively were recorded in T_3 treatment. The maximum leaf area index $plant^{-1}$ (0.17, 0.82, 4.18 and 2.91) at 30, 60, 90 DAS and at harvest respectively were recorded in T_1 treatment. The maximum stem base circumference $plant^{-1}$ (6.14, 8.56 and 9.18 cm) at 60, 90 DAS and at harvest respectively, the maximum dry matter weight $plant^{-1}$ (27.79, 60.25, 210.38 and 223.57 g) at 30, 60, 90 DAS and at harvest respectively, cob length $plant^{-1}$ (16.97 cm), cob circumference $plant^{-1}$ (18.42 cm), number of grain rows cob^{-1} (15.33), number of grains row^{-1} in cob (26.39), number of grains cob^{-1} (408.56), 1000 grains weight (284.26 g), chaff weight cob^{-1} (8.54 g), shell weight cob^{-1} (16.39 g), grain weight cob^{-1} (110.13 g), cob weight $plant^{-1}$ (135.06 g), shelling percentage (81.41 %) were recorded in T_3 treatment. The maximum grain yield (10.07 t ha^{-1}) was recorded in T_2 treatment. The maximum stover yield (17.47 t ha^{-1}) and biological yield (27.37 t ha^{-1}) were recorded in T_1 treatment. The maximum harvest index (49.08 %) was recorded in T_3 treatment. Whereas the lowest plant density (8.17 m^{-2}) was recorded in T_3 treatment. the lowest plant height (35.176, 117.41, 172.56, and 187.40 cm) at 30, 60, 90 DAS and at harvest respectively were recorded in T_1 treatment. The lowest number of leaves $plant^{-1}$ (4.13, 5.8, and 9.33) at 30, 60 and 90 DAS were recorded in T_1 treatment. At harvest respectively the lowest number of leaves $plant^{-1}$ (6.8) was recorded in T_3 treatment. he minimum leaf area $plant^{-1}$ (124.01, 614.25, 3133.4, and 2166.8 cm^2) at 30, 60, 90 DAS and at harvest respectively were recorded in T_1 treatment. The minimum leaf area index per plant (0.11, 0.53, 2.99 and 1.89 at 30, 60, 90 DAS and at harvest respectively were recorded in T_3 treatment. The minimum stem base circumference $plant^{-1}$ (5.32, 8.00 and 8.76 cm at 60, 90 DAS and harvest respectively, dry weight $plant^{-1}$ (24.80, 53.69, 179.83 and 204.25 g at 30, 60, 90 DAS and at harvest respectively, cob length per plant (16.04 cm), circumference $plant^{-1}$ (17.45 cm), number of rows cob^{-1}, number of grains row^{-1} in cob (24.87), number of grains cob^{-1} (369.95), 1000 grains weight (271.32 g), chaff weight cob^{-1} (7.75 g), shell weight cob^{-1} (14.20 g), grain weight cob^{-1} (75.14 g), cob weight plant^{-1} (97.09 g), shelling percentage (76.98 %) were recorded in T_1 treatment. The minimum grain yield (8.80 t ha^{-1}), stover yield (9.15 t ha^{-1}), biological yield (17.95 t ha^{-1}) were recorded in T_3 treatment and the minimum harvest index (36.36 %) was recorded in T_1 treatment.

In case of combined effect, the highest plant density (16.67 m^{-2}) was recordedin S_1T_1 treatment combination. The highest plant height (43, 142.95, 216.50 and 222 cm) at 30, 60, 90 DAS and at harvest respectively were recorded in S_5T_3 treatment combination.The highest number of leaves plant^{-1} (4.67) at 30 DAS was recorded in S_2T_3 treatment combination. At 60 DAS the highest number of leaves plant^{-1} (7.0) was recorded in S_5T_2 treatment combination. At 90 DAS the highest number of leaves plant^{-1} (9.67) was recorded in S_4T_3 treatment combination and at harvest respectively the highest number of leaves plant^{-1} (7.67) was recorded in S_1T_2 treatment combination. The maximum leaf area plant^{-1} (154.48, 772.41, 4142.6 and 2640.5 cm^2) at 30, 60, 90 and at harvest respectively were recorded in S_5T_3 treatment combination. The maximum leaf area index plant^{-1} (0.17, 0.87, 4.26 and 3.15) at 30, 60, 90 DAS and at harvest respectively were recorded in S_1T_1 treatment combination. The highest base circumference plant^{-1} of white maize (7.0, 9.12 and 9.88 cm) at 60, 90 DAS and harvest respectively were recorded in S_5T_3 treatment combination. The maximum dry matter weight plant^{-1} (31.46, 68.61, 238.41 and 258.90 g) at 30, 60, 90 DAS and at harvest respectively were recorded in S_5T_3 treatment combination. The highest cob length plant^{-1} (18.58 cm), cob circumference plant^{-1} (20.20 cm), number of grain rows cob^{-1} (17.33), number of grains row^{-1} in cob (30.2), number of grains cob^{-1} (523.37), 1000 grains weight (313.10 g), chaff weight per cob (9.56 g), shell weight cob^{-1} (19.12 g), grain weight cob^{-1} (137.37 g), cob weight plant^{-1} (166.05 g), were recorded in S_5T_3 treatment combination. The highest shelling percentage (83.55 %), grain yield (11.07 t ha^{-1}) were recorded in S_5T_2 treatment combination. The maximum stover yield (20.94 t ha^{-1}) and biological yield (29.15 t ha^{-1}) were recorded in S_1T_1 treatment combination. The maximum harvest index (53.06 %) was recorded in S_5T_3 treatment combination. Whereas the lowest plant density (6.67 m^{-2}) was recorded in S_5T_3 treatment combination. The minimum plant height (28.40, 93.47 ,154.58, and 160 cm) at 30, 60, 90 and at harvest respectively were recorded in S_1T_1 treatment combination. The lowest number of leaves plant^{-1} (3.66) at 30 DAS was recorded in S_1T_1 treatment combination. At 60 DAS the lowest number of leaves plant^{-1} (5.0) was recorded in

S_3T_1 treatment combination. At 90 DAS the lowest number of leaves plant^{-1} (9.0) was recorded in S_4T_1 (9.0) treatment combination and at harvest respectively the lowest number of leaves plant^{-1} (6.33) was recorded in S_4T_2 treatment combination.The minimum leaf area plant^{-1} (104.53, 522.18, 2556.7 and 1892.5 cm^2) at 30, 60, 90 DAS and harvest respectively were recorded in S_1T_1 treatment combination. The minimum leaf area index plant^{-1} (0.10, 0.51, 2.76 and 1.76) at 30, 60, 90 DAS and at harvest respectively were recorded in S_5T_3 treatment combination. The minimum stem base circumference plant^{-1} (5.0 cm) was recorded in S_1T_2 treatment combination at 60 DAS. At 90 DAS the minimum stem base circumference plant^{-1} (7.5 cm) was recorded in S_1T_1 treatment combination and at harvest respectively the minimum stem base circumference plant^{-1} (8.1 cm) was recorded in S_1T_1 treatment. The minimum dry matter weight plant^{-1} (21.44, 46.42, 145.95 and 174.91 g) at 30, 60, 90 DAS and at harvest respectively were recorded in S_1T_1 treatment combination. The lowest cob length plant^{-1} (12.42 cm), cob circumference plant^{-1} (14.14 cm), number of grain rows cob^{-1} (12.97), number of grains row^{-1} in cob (16.24), number of grains cob^{-1} (210.63), 1000 grains weight (245.4), chaff weight per cob (7.17 g), shell weight cob^{-1} (10.24 g), grain weight cob^{-1} (49.28 g), cob weight plant^{-1} (66.69 g), shelling percentage (73.89 %), grain yield (8.21 t ha^{-1}) were recorded in S_1T_1 treatment combination. The minimum stover yield (8.10 t ha^{-1}) was recorded in S_5T_3 treatment combination. The minimum biological yield (17.09 t ha^{-1}) was recorded in S_3T_3 treatment combination and the minimum harvest index (28.174 %) was recorded in S_1T_1 treatment combination.

Conclusion

i. Among different row spacing S_5 treatment (60 cm row spacing) perform well in white maize cultivation and recorded the maximum cob length plant^{-1} (18.28 cm), cob circumference plant^{-1} (19.70 cm), number of grain rows cob^{-1} (16.77), number of grains row^{-1} in cob (29.37), number of grains cob^{-1} (492.70), 1000 grains weight (301.33 g), chaff weight cob^{-1} (8.92 g), shell weight cob^{-1} (17.53 g), grain weight cob^{-1} (122.49 g), cob weight plant^{-1} (148.93 g), shelling percentage (82.051 %), grain yield (10.35 t ha^{-1}) were recorded in S_5 treatment.

ii. Among different plant spacing the maximum grain yield (10.07 t ha^{-1}) was recorded in T_2 (20 cm plant spacing) treatment.

iii. In case of combined effect, S_5T_2 (row spacing 60 cm × plant spacing 20 cm) treatment combination performed best in producing the maximum grain yield (11.07 t ha^{-1}) comparable to other treatment combination.

Thus for the cultivation of "White maize", 60 cm row spacing (S_5) along with 20 cm plant spacing (T_2) can be used as recommended treatment for the production of highest grain yield in the AEZ 28 (Agro-ecological zone) soils of Bangladesh.

- **Recommendation for further work**

Before making final conclusion, further trials with the same treatment combinations on different locations of Bangladesh would be useful. However, further investigation is necessary for the other soil types under different AEZ in Bangladesh

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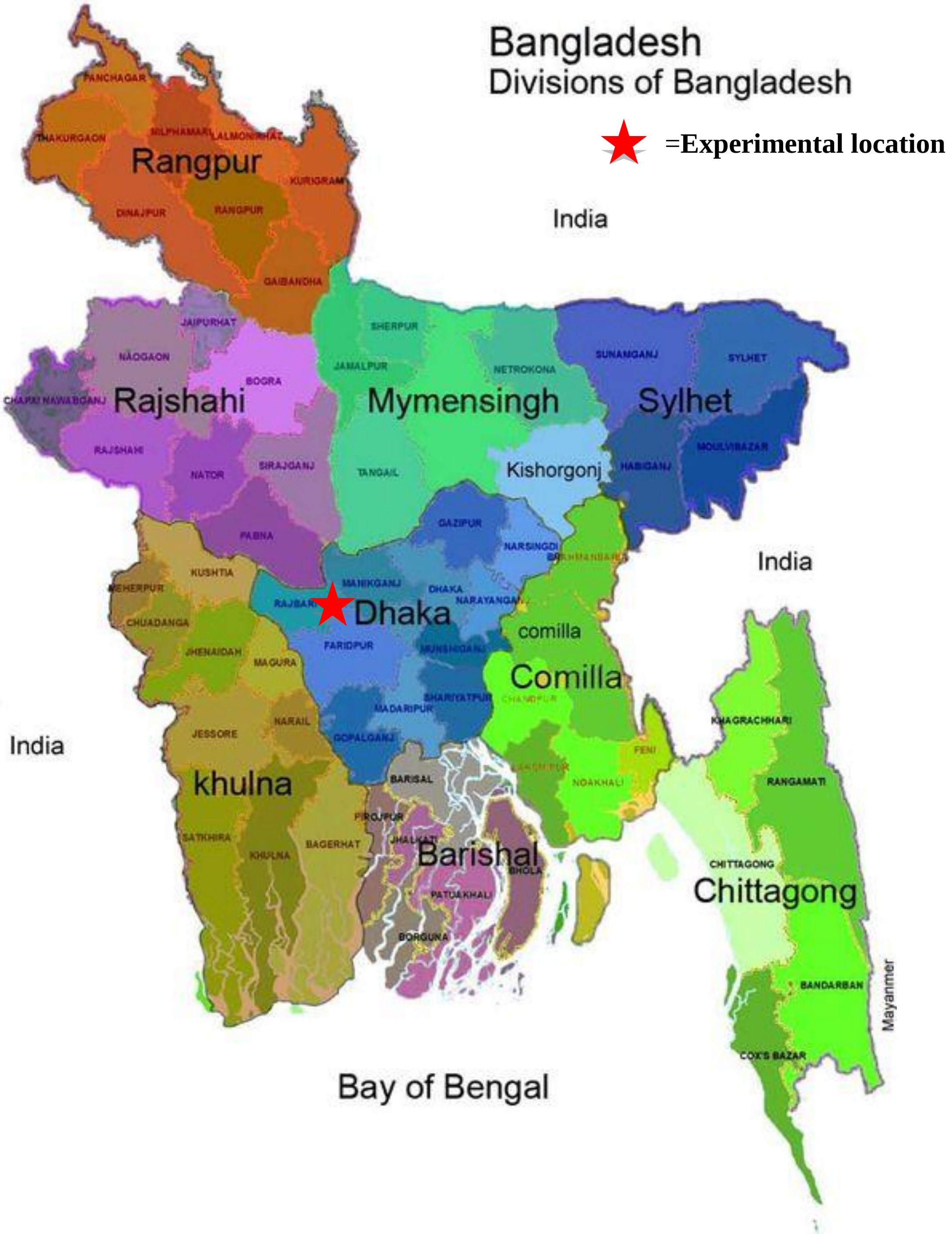
APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

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

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

Physical characteristics

Constituents	**Percent**
Sand	26 %
Silt	45 %
Clay	29 %
Textural class	Silty clay

Chemical characteristics

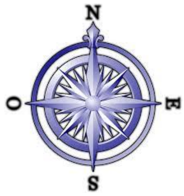
Soil characteristics	**Value**
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.03
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10

Appendix III. Monthly meteorological information during the period from October, 2018 to February, 2019.

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2018	October	27.26	16.30	64	43
	November	25.50	6.70	54.75	0.0
	December	23.80	11.70	46.20	0.0
2019	January	22.75	14.26	37.90	0.0
	February	35.20	21.00	52.44	20.4

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Layout of the experimental field



R_1	R_2	R_3
S_5T_2	S_3T_1	S_4T_1
S_2T_1	S_1T_3	S_1T_2
S_3T_2	S_2T_3	S_5T_1
S_2T_3	S_5T_1	S_2T_3
S_5T_3	S_4T_1	S_2T_2
S_4T_3	S_4T_3	S_2T_1
S_1T_1	S_3T_2	S_4T_3
S_3T_3	S_1T_1	S_3T_3
S_2T_2	S_3T_3	S_3T_2
S_4T_2	S_2T_2	S_4T_2
S_1T_3	S_4T_2	S_5T_3
S_3T_1	S_2T_1	S_5T_2
S_4T_1	S_5T_2	S_3T_1
S_1T_2	S_1T_2	S_1T_3
S_5T_1	S_5T_3	S_1T_1

0.75m

3.50 m

1.80

1m

1m

LEGEND

R= Replication

Row spacings,

S_1: 40 cm,

S_2: 45 cm,

S_3: 50 cm,

S_4: 55 cm and

S_5: 60 cm.

Plant spacings

T_1:15 cm,

T_2: 20 cm and

T_3: 25 cm

Appendix V. Analysis of variance of the data on plant height of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of plant height at			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Replication	2	21.60	86.67	86.67	346.67
Row spacings (A)	4	149.37 *	1416.42*	1954.98*	2254.50*
Plant spacing (B)	2	39.82 *	235.86*	2306.50*	1991.40*
(A ×B)	8	3.36 *	87.60*	103.25*	211.65*
Error	28	10.17	36.67	58.10	146.67

*Significant at 5% level of probability

NS: Non significant

Appendix VI. Analysis of variance of the data on number of leaves plant^{-1} of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of number of leaves plant^{-1} at			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Replication	2	0.16	0.96	0.29	0.42
Row spacings (A)	4	0.26*	1.14*	0.13 ^{NS}	0.13 ^{NS}
Plant spacing (B)	2	0.02^{NS}	0.69 ^{NS}	0.09 ^{NS}	0.36 ^{NS}
(A ×B)	8	0.19*	0.49*	0.20	0.80*
Error	28	0.18	0.29	0.29	0.45

*Significant at 5% level of probability

NS: Non significant

Appendix VII. Analysis of variance of the data on plant leaf area of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of plant leaf area of white maize at			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
Replication	2	86.67	2000.0	24667	40667
Row spacings (A)	4	2613.89*	68221.4*	1571243*	466761*
Plant spacing (B)	2	311.75*	10250.3*	1247165*	123774*
(A ×B)	8	103.93*	2650.7*	140896*	10808*
Error	28	65.24	1285.7	44667	26381

*Significant at 5% level of probability

NS: Non significant

Appendix VIII. Analysis of variance of the data on plant leaf area index of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of plant leaf index area of white maize at			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	0.00007	0.00289	0.03	0.052
Row spacings (A)	4	0.00024*	0.00437*	0.15*	0.19*
Plant spacing (B)	2	0.01343*	0.31724*	5.3*	4.06*
(A ×B)	8	0.00011*	0.00277*	0.16*	0.02*
Error	28	0.00004	0.00210	0.05	0.04

*Significant at 5% level of probability

^{NS}: Non significant

Appendix IX. Analysis of variance of the data on plant stem base circumference plant $^{-1}$ of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of plant stem base diameter of white maize at		
		60 DAS	90 DAS	At harvest
Replication	2	0.07	0.27	0.47
Row spacings (A)	4	3.07*	2.32*	2.27*
Plant spacing (B)	2	2.62*	1.21*	0.83 ^{NS}
(A ×B)	8	0.31*	0.03*	0.08*
Error	28	0.14	0.20	0.32

*Significant at 5% level of probability

^{NS}: Non significant

Appendix X. Analysis of variance of the data on dry matterplant^{-1} of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of dry matterplant^{-1} of white maize at			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	3.20	19.47	275.56	60.00
Row spacings (A)	4	36.11*	174.39*	7415.66*	7075.05*
Plant spacing (B)	2	38.43*	183.87*	3764.93*	1434.22*
(A ×B)	8	4.33*	20.74*	260.98*	104.94*
Error	28	2.06	12.89	118.41	124.29

*Significant at 5% level of probability

^{NS}: Non significant

Appendix XI. Analysis of variance of the data on cob length and circumference plant^{-1} of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of	
		Cob Length	Cob circumference
Replication	2	0.27	0.27
Row spacings (A)	4	23.014*	37.90*
Plant spacing (B)	2	3.35*	3.53*
(A ×B)	8	1.35*	0.19*
Error	28	0.55	0.55

*Significant at 5% level of probability

^{NS}: Non significant

Appendix XII. Analysis of variance of the data on grain rows cob^{-1}, grains row^{-1}, grains cob^{-1} and 1000 grain weight of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of			
		Grain rows cob^{-1} (no.)	Grains row^{-1}(no.)	Grains cob^{-1} (no.)	1000 grain weight (g)
Replication	2	0.20	0.47	260.0	84.27
Row spacings (A)	4	17.09*	174.74*	83227.1*	3677.58*
Plant spacing (B)	2	1.65*	8.70*	5626.9*	629.90*
(A ×B)	8	0.06*	1.80*	448.8*	46.76*
Error	28	0.34	0.90	188.6	115.70

*Significant at 5% level of probability
$^{NS:}$ Non significant

Appendix XIII. Analysis of variance of the data on Chaff weight cob^{-1}, shell weight cob^{-1}, grain weight cob^{-1}, cob weight plant^{-1} and shelling percentage cob^{-1} of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of				
		Chaff weight cob^{-1} (g)	Shell weight cob^{-1} (g)	Grain weight cob^{-1} (g)	Cob weight plant^{-1} (g)	Shelling percentage cob^{-1}
Replication	2	0.20	0.47	46.67	46.67	14.60
Row spacings (A)	4	3.09*	37.54*	3943.86*	4973.14*	34.29^{NS}
Plant spacing (B)	2	2.39*	18.01*	5020.14*	5830.30*	88.26*
(A ×B)	8	0.12*	0.75*	63.41*	64.84*	2.66*
Error	28	0.34	0.89	68.10	89.52	26.74

*Significant at 5% level of probability
^{NS}: Non significant

Appendix XIV. Analysis of variance of the data on grain, stover, biological yield and harvest index of white maize as influenced by different row and plant spacing

Source of variation	Df	Mean square of			
		Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Replication	2	0.07	0.80	1.40	5.07
Row spacings (A)	4	4.73*	20.71*	6.67*	175.29*
Plant spacing (B)	2	7.13*	273.04*	337.08*	678.68*
(A ×B)	8	0.97*	2.87*	1.16*	20.15*
Error	28	0.14	1.37	2.83	7.92

*Significant at 5% level of probability

^{NS}: Non significant

LIST OF PLATES

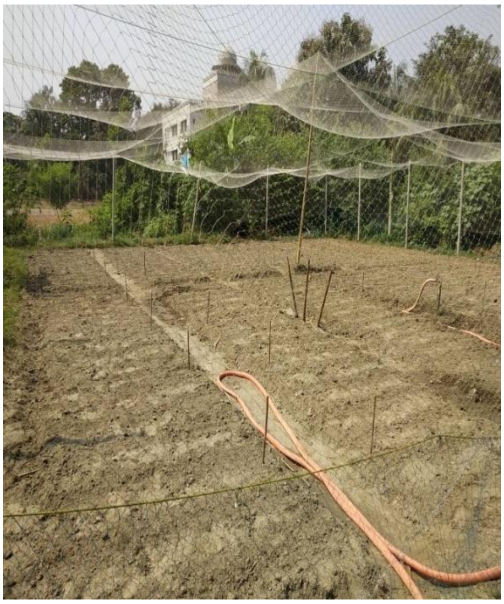


Plate 1: Photograph showing view of experimental plot at final land preparation for white maize cultivation.

Plate 2: Photograph showing view of experimental plot at germination of white maize.

Plate 3: Photograph showing view of experimental plot at vegetative stage of white maize.

Plate 4: Photograph showing view of experimental plot at reproductive stage of white maize


Plate 5: Photograph showing view of experimental plot at maturity stage of white maize.


Plate 6: Photograph showing view of experimental plot data sampling for data collection of white maize.


Plate 7: Photograph showing view of white maize cob harvesting.

Plate 8: Photograph showing general view of experimental plot with signboard