GROWTH AND YIELD RESPONSE OF WHITE MAIZE (SAUWMOP T61G) TO DIFFERENT SPACING AND IRRIGATION FREQUENCIES IN RABI SEASON

SHAH IFTEKHAR AHMED

DEPARTMENT OF AGRONOMY

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JANUARY, 2021

GROWTH AND YIELD RESPONSE OF WHITE MAIZE (SAUWMOP T61G) TO DIFFERENT SPACING AND IRRIGATION FREQUENCIES IN RABI SEASON

BY

SHAH IFTEKHAR AHMED

REGISTRATION NO: 14-06137

A Thesis

Submitted to the Faculty of Agriculture,

Sher-e-Bangla Agricultural University, Dhaka,

in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE (M.S.)

IN

AGRONOMY

SEMESTER: JANUARY - JUNE, 2021

Approved by:

Prof. Dr. Md. Jafar Ullah	**Prof. Dr. H. M. M. Tariq Hossain**
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 AND YIELD RESPONSE OF WHITE MAIZE (SAUWMOP T61G) TO DIFFERENT SPACING AND IRRIGATION FREQUENCIES IN RABI SEASON" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by SHAH IFTIKHAR AHMED, **Registration no.14-06137**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: 21-06-2022

Place: Dhaka, Bangladesh

Prof. Dr. Md. Jafar Ullah

Department of Agronomy

Sher-e-Bangla Agricultural University,

Dhaka-1207

Dedicated To

My Beloved Parents

And Respected

Teachers

Whose Prayers,

Efforts And

Wishes Are an

Inspiration

ACKNOWLEDGEMENTS

All praises to the Almighty Allah, the great, the gracious, merciful, and supreme ruler of the universe who enables me to complete this present piece of work for the degree of Master of Science (M.S.) in the Department of Agronomy.

The author would like to express his deepest sense of gratitude, and respect to his research supervisor, ***Prof. Dr. Md. Jafar Ullah****, Department of Agronomy, Sher- e-Bangla Agricultural University, for his kind and scholastic guidance, untiring effort, valuable suggestions, inspiration, extending generous help and encouragement during the research work and guidance in preparation of manuscript of the thesis.*

The author sincerely expresses his deepest respect and boundless gratitude to his co-supervisor ***Prof. Dr. H. M. M. Tariq Hossain*** *Department of Agronomy, for his helpful suggestion and valuable advice during the preparation of this manuscript.*

It is highly appreciating words for ***Prof. Dr. Tuhin Suvra Roy*** *Chairman, Department of Agronomy, Sher-e-Bangla Agricultural University, for the facilities provided, in carrying out this work. The author also acknowledges with deep regards the help and cooperation received from her respected teachers and stuff of the Department of Agronomy, Sher-e-Bangla Agricultural University while carrying out this work.*

The author feels proud to express his sincere appreciation and gratitude to Ministry of Science and Technology, The People's Republic of Bangladesh for awarding him National Science and Technology (NST) fellowship.

At last, but not the least, the author feels indebtedness to his beloved parents and brother whose sacrifice, inspiration, encouragement and continuous blessing paved the way to his higher education and reach at this stage. May Allah bless us all.

GROWTH AND YIELD RESPONSE OF WHITE MAIZE (SAUWMOP T61G) TO DIFFERENT SPACING AND IRRIGATION FREQUENCIES IN RABI SEASON

ABSTRACT

An experiment was conducted at the Agronomy field of Sher-e-Bangla Agricultural University Dhaka, from October-2019 to March-2020 to investigate the effect of growth and yield response of white maize (SAUWMOP T61G) to different spacing and irrigation frequencies in Rabi season. The experiment consisted of two factors. Factor A: Irrigation frequencies (3) *viz*; I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval and Factor B: Different spacings (4) *viz*; S_1: 50 cm × 20 cm, S_2: 50cm × 25cm, S_3: 60cm × 20cm and S_4: 60 cm × 25cm. The experiment was laid out in Split Plot Design with three replications. Results indicate intervals that different irrigation frequencies, spacings, and their combination had a significant effect on growth, yield, and yield contributing characters of white maize. In the case of different irrigation frequencies, the maximum cob length plant^{-1} (17.37cm), cob circumference plant^{-1} (15.62cm), number of rows cob^{-1} (14.37), number of grains row^{-1} (27.88), number of grains cob^{-1} (390.29), 1000 grains weight (378.67g), chaff weight cob^{-1} (11.86g), shell weight cob^{-1} (18.45g), grain weight cob^{-1} (93.99g), cob weight plant^{-1} (124.30 g), grain yield (7.67 t ha^{-1}), stover yield (8.79 t ha^{-1}) and biological yield (16.46 t ha^{-1}) were observed in I_1 (Irrigation given at 20 days interval) treatment. In respect of different spacings, the maximum grain yield (8.19 t ha^{-1}) was observed in S_3 (60 cm × 20 cm) treatment compared to other treatments. In the case of different treatment combinations, I_1S_3 treatment combinations performed best in respect of maximum grain yield (8.66 t ha^{-1}) production compared to other treatment combinations and can be used as a recommended treatment for the production of highest grain yield in the AEZ 28 (Agro-ecological zone) soils of Bangladesh.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

LIST OF FIGURES (Cont'd)

LIST OF APPENDICES

LIST OF PLATES

ABBREVIATIONS

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

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 1stin 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 (Hamid *et al.*, 2019). 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). The yield variability depends on adopting improved agronomic managements (Salam *et al.*, 2010; Ranu *et al.*, 2018; *Mannan et al.*, 2019; Islam *et al.*, 2020a; Islam *et al.*, 2020b). Introduction of maize in Bangladesh as human food can be a viable alternative for sustaining food security as the productivity of maize is 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 2017 growing 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 maizes in the south east hills those have also not improved for having higher yields (Ullah *et al.*, 2016). Maize currently grown in Bangladesh is of yellow type and is used in the feed industry. Hybrid maize cultivation area has increased at the rate of about 20-25% per year since nineties as the yield potential of hybrid maize is greater than those of local races (Ullah *et al*., 2017a; Ullah *et al.* 2017b; Fatima *et al.,* 2019; Shompa *et al*., 2020). Now-a-days, there are many governments and non-government organizations are working for increasing maize production in Bangladesh. 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). Different varieties respond differently to input supply, cultivation practices and prevailing environment etc during the growing season (Ullah *et el.,* 2018a; Ullah *et el.,* 2018b; Ullah *et el.,* 2018d; Bithy and Ahamed, 2018). The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices (such as proper management of planting configuration, irrigation interval, weeding, thinning, earthing up etc), 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*., 2017a).

One of the most important considerations in increasing and stabilizing agricultural production is through irrigation and drainage development, reclamation of degraded lands, and wise use of water resources (Mintesinot, Verplancke, Van Ranst, Mitiku, Seckler, & David, 1998). Higher yield up to 9-11 t $ha\text{-}^{1}$ can be obtained using hybrid seeds, balanced fertilizers and better management practices (Mondal *et al.*, 2014).

The development of irrigation and agricultural water management holds significant potential to improve productivity and reduce vulnerability to climactic volatility in any country (Heydari, 2014; Ullah *et al.,* 2019). Irrigation implies the application of suitable water to crops in sufficient amount at the suitable time (Molden *et al*. 2010; Islam et al., 2020). Salient features of any improved method of irrigation are the controlled application of the required amount of water at desired time, which leads to minimization of range of variation of the moisture content in the root zone, thus reducing stress on the plants. Irrigation scheduling is the process of determining when to irrigate and hWajid, Ahmaow much irrigation water to apply (Ahmad, *et al* 2019; Filintas*et al*., 2007; Guo, *et al*; 2015). The depth of irrigation water which can be given during one irrigation application is however limited. The maximum depth which can be given has to be determined and may be influenced by the soil type and the root zone depth. Thus, just after planting or sowing, the crop needs smaller and more frequent water applications than when it is fully developed.

Agronomic management, especially spacing which significantly influence on yield, since it is ultimately correlated with plant population, root development, plant growth and fruiting (Davi *et al.,* 1995; Ahmmed *et al.,* 2020; Akbar *et al*. 2016;). The relationship between yield and spacing is intricate. Salam *et al.* (2006) reported the highest grain yield of BARI hybrid maize 3 when sown at 75x25 cm spacing. Biswas (2019) tested two hybrid white maize at three different spacings (50x25 cm, 60x25 cm and 70x25 cm) at Dhamrai during rabi 2015-16 and reported the highest grain yields at the closer spacings. Ullah *et al*. (2018c) tested eight different hybrid white maize varieties at two different spacings (60x25 cm and 75x25 cm) at the Sher-e-Bangla Agricultural University Farm during rabi season of 2015-16 and reported the highest grain yield (7.551 t ha^{-1}) at 60x25 cm spacing which was significantly higher than that (5.832 t ha^{-1}) of the 75x25 cm treatment. In another trial at Dhamrai of Dhaka in the same season, they tested two different hybrid white maize varieties and observed that the comparable grain yield (8.740 t ha-1) was from the closest spacing (50x20 cm) as was from the paired rows with 70 cm spacing (8.773 t ha-1) which were significantly higher than that (7.920 t ha^{-1}) from the spacing (60x20) cm. In the same season, they also carried out another separate experiment at Rangpur Sadar with two hybrid white maize varieties planted at three different planting configurations. Results showed that the closer spacing of 50x20 cm produced greatest grain yield (6.670 t ha^{-1}) and compared to the yields of 5.198 and 6.626 t ha^{-1} obtained, respectively from the wider spacings of 60x20 cm and inter paired rows spacing of 70 cm spacing. They also set another experiment at Rangpur with a hybrid white maize variety PSC-121 at different planting configurations (row to row 50 to 80 cm and plant to plant 20-40 cm) and reported the highest grain yields from the 80x20 cm spacing. In another separate trial set at Bandarban with two different hybrid white maize varieties plant at different planting configurations (row to row spacing 50-70 cm and paired rows. Plant to plant distance within the row 25 cm), it was observed that the planting configuration with the highest population density (80,000 t ha^{-1}) showed the highest grain yield (10.396 t ha^{-1}) which was comparable to that (10.612 t ha^{-1}) obtained from paired row but significantly higher than those (8.733 – 9.610 t ha^{-1}) obtained from other planting configurations. From the review of the results from the above trials, it may be concluded that the higher grain yields were mostly obtained from row to row spacing either of 60 cm or below this. The researchers (Biswas, 2019; Ullah *et al*. 2018c; Ullah et al. 2018d) opined that the grain yield of an individual maize plant increases with gradual increase in row spacing and plant to plant spacing within a row. But the grain yield in a community level (per hectare) depends on the plant population density and the plant characters such as plant height, leaf area, leaf orientation and leaf erectness.

Optimum plant population is vital for maintaining to exploit maximum natural resources such as nutrient, sunlight, soil moisture and to ensure maximum economic grain yield per production area. It exerts decisive influence on maize growth and yield, which outcome timely inception of vegetative and reproductive development. Maize differs in its responses to plant density (Luque *et al.,* 2006). Closer spacing leading to overcrowding, enhanced interplant competition for incident photosynthetic photon flux density and soil rhizosphere resource, resulting reduction yield per plant because it’s influence hormonally mediated apical dominance, exaggerated barrenness, and finally decreases the number of ears produced per plant and kernels set per ear (Sangoi, 2001). Wider spacing causes low density of population promotes dense vegetative growth, increased weed density due to more feeding area available and remain nutrient and moisture unutilized thereby decrease in total yield. However, under high population density, cumulative yield is higher per production area, but drops yield per plant. The appropriate spacing outcome optimum plant population per area for optimum yield. The best optimum spacing is one, which enables the plants to make the better use of the conditions at their disposal (Lawson & Topham, 1985). Keeping all points in minds mentioned above, the proposed research work was undertaken to achieve the following objectives:

Objectives:

i. To study the effect of irrigation frequency on the growth, yield and yield contributing characters of white maize line SAUWMOPT61G.
ii. To study the effect of different spacing on the growth and productivity of white maize line SAUWMOPT61G and
iii. To study the combined effect of irrigation frequency and spacing on the growth and yield of white maize line SAUWMOPT61G.

CHAPTER II

REVIEW OF LITERATURE

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

2.1 Effect of irrigation frequencies

2.1.1 Plant height

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Statistically significant variations were also observed in plant height except at 30 DAS by different irrigation timings (Table 2) having the longest plants (41.41, 71.62, 183.6 and 186.1 cm) with I_4 and the shortest plants (33.83, 44.77, 122.7 and 127.4 cm) with I_0 treatment at the respective growth stages. I_3 treatment showed second highest plant height (38.88, 68.23, 173.9 and 181.1 cm) which was very close to I_4 treatment.

Baloch *et al*. (2014) carried out a field study during 2013 season to investigate the effect of different irrigation intervals on fodder maize yield. Randomized complete block design (RCBD) was used, with three replicates. Four irrigation regimes were executed T_1=3 irrigations (1st 20 Day After Sowing (DAS), 2nd 35 DAS and 3rd 50 DAS), T_2=3 irrigations (1st 20 DAS, 2nd 40 DAS and 3rd 60 DAS), T_3=3 irrigations (1st 25 DAS, 2nd 40 DAS and 3rd 55 DAS), and T_4=3 irrigations (1st 30 DAS, 2nd 45 DAS and 3rd 60 DAS). The experiment was conducted at Agriculture Research District Washuk, Balochistan. The experiment was laid out in three replicates in Randomized Complete Block Design (RCBD), keeping a plot size of 6m x 5m ($30m^2$). The variety "Akbar" was used for planting materials. It is evident from the results that significantly maximum plant height (185.33 cm) on average was recorded in T_1 treatment when the crop was given 1st irrigation at 20 days after sowing, 2nd at

35 days and 3rd after 50 days of sowing (T_1); while the plant height slightly reduced (182.00 cm) in (T_3). Maize crop recorded the minimum plant height (157.33 cm) in (T_4) treatment. The differences in plant height between T_1 (1st irrigation at 20 days after sowing, 2nd at 35 days, and 3rd after 50 days of sowing) and T_3 (1st irrigation at 25 days after sowing, 2nd at 40 days, and 3rd after 55 days of sowing) were non-significant. We concluded that delayed 1st irrigation up to 30 days after sowing impacted the plant height adversely.

Abd El-Halim and Abd El-Razek (2013) conducted a field experiment in 2010 and 2011 (maize growth seasons) to study the effects of DRFI with two irrigation intervals 7 days and 14 days on maize yield, water saving, water productivity and some economic parameters such as net return and investment ratio compared with the conventional ridged-furrow planting technique (RFI) with irrigation at 14-day intervals. Optimal irrigation interval for maize under DRFI was also determined. Regardless of irrigation intervals, smaller depth of applied water was observed with DRFI treatments compared to RFI treatment. Consequently, with DRFI treatments, more water could be saved compared with RFI treatment in both seasons. Double ridged-furrow planting with irrigation at 7-day intervals proved superior to increase plant height (2.96 & 2.98 m) and water productivity in both years compared to the 14-day interval and the conventional treatment.

Elzubeirand Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman-Monteith equation (1998) for estimating crop evapo-transpiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that 10 days irrigation interval gave the highest values of plant height (201 & 205 cm) compeered to others irrigation intervals in both years.

Ibrahim and Hala Kandil (2007) found that the highest values of plant height, ear characters (length, diameter and weight) as well as grains yield of corn plants were obtained under an irrigation interval of 10 days followed by 14 and18 days; generally prolonging the irrigation interval to18 days decreased the growth, yield and chemical constituent of corn plants.

2.1.2 Number of leaves

Ullah *et al*. (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Irrigation frequency showed a significant variation on leaf area index at 60, 90 DAS and harvesting stage and non-significant variation at 30 DAS (Table 8). At 30 DAS, I_4 showed the maximum leaf area index (0.81) and I_0 showed the lowest leaf area index (0.57); whereas at 60, 90 DAS and harvesting stage, the highest leaf area index was (2.525, 4.295 and 3.777) which were statistically similar with treatment I_3 and the lowest leaf area index were (1.292, 2.505 and 2.270).

Baloch *et al*. (2014) carried out a field study during 2013 season to investigate the effect of different irrigation intervals on fodder maize yield. Randomized complete block design (RCBD) was used, with three replicates. Four irrigation regimes were executed T_1=3 irrigations (1st 20 Day After Sowing (DAS), 2nd 35 DAS and 3rd 50 DAS), T_2=3 irrigations (1st 20 DAS, 2nd 40 DAS and 3rd 60 DAS), T_3=3 irrigations (1st 25 DAS, 2nd 40 DAS and 3rd 55 DAS), and T_4=3 irrigations (1st 30 DAS, 2nd 45 DAS and 3rd 60 DAS). The experiment was conducted at Agriculture Research District Washuk, Balochistan. The experiment was laid out in three replicates in Randomized Complete Block Design (RCBD), keeping plot size of 6m x 5m ($30m^2$). The variety “Akbar” was used for planting materials. Number of green leaves in maize for fodder production is a quantity parameter; but this trait is generally influenced by level of input application. The results in regards to the number of green leave $plant^{-1}$ of fodder maize as influenced by different irrigation intervals. From the experiment results showed that maximum number of green leaves $plant^{-1}$ (13.42) on average was achieved in crop given 1st irrigation at 20 days after sowing, 2nd at 35 days and 3rd after 50 days of sowing (T_1); by the delay in the first irrigation the number of green leaves plant^{-1} slightly decreased to (12.70) and (11.10) in T_3 and T_4 treatments, respectively.

2.1.3 Dry matter weight

Shen *et al.* (2020) conducted a field experiment during the maize growing season (April to October) in 2016 and 2017 at Qitai Farm (43°50' N, 89°46' E, altitude: 1020 m a.s.l.), located in the Xinjiang Uygur Autonomous Region, China to known the effect of optimal irrigation interval on the photosynthetic rate (Pn) and dry matter accumulation (DM) of closely planted super-high-yield maize under drip irrigation under mulch. experiment was conducted using three irrigation intervals in 2016 namely, six days (D6), nine days (D9), and 12 days (D12) and five irrigation intervals in 2017 namely, three days (D3), six days (D6), nine days (D9), 12 days (D12), and 15 days (D15). The Xianzu 335 high-yield maize hybrid was used in the test; the planting density was set to 12×10^4 plants ha^{-1}, and an optimal irrigation quota of 540 mm was used. From the experiment result revealed that the maximum total dry matter weight (4.46 & 4.37 kg m^{-2}) was observed in D6 treatment compared to others treatment in both years.

Tefera (2020) conducted a study to determine the optimal irrigation scheduling and fertilizer rate for better water use efficiency under irrigated agriculture. The effects of irrigation interval on maize yield and other crop properties were also assessed. The study was conducted in Pawe woreda of Metekel zone of Benishangul Regional State, North-West of Ethiopia. The experiment was carried in the randomized completed block design experimental design with a combination of five levels of irrigation treatments [(1) 21 days of irrigation interval; (2) 17 days of irrigation interval; (3) 14 days of irrigation interval; (4) 11 days of irrigation interval; (5) 7 days of irrigation interval] and three levels of fertilizer rate with three replications of the treatments. The result revealed that the plot received an optimal irrigation interval of 14 days in a combination of 25% more than the recommended fertilizer rate (292.24 kg ha^{-1}) had significantly higher effects on above-ground biomass (18.25 t ha^{-1}) and on grain yield (4.8 t ha^{-1}) of irrigated maize in the study area. However, the maximum water use efficiency of 2.05 kg/m^3 was obtained at the irrigation interval of 14 days, and the highest level of fertilizer rate. Hence, the use of 14 days of optimal irrigation interval and 25% more fertilizer than the recommended rate is advisable because the grain yield and crop water use efficiency had been improved in the study area.

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Dry matter content plant^{-1}of white maize showed significant variation due to different levels of irrigation frequency at 60, 90 DAS and harvesting stages. However, it was not significant at 30 DAS. At 30 DAS, the highest (0.922 g) dry weight plant^{-1} was recorded from treatment I_4 and the corresponding lowest dry weight 0.718 g which was found in treatment P_0. At 60 DAS, the highest (25.28 g) dry weight plant^{-1} was found in I_4 treatment which was statistically similar with I_3 (24.84 g). The lowest (8.78 g) dry weight plant^{-1}was found in I_0 treatment. At 90 DAS, the highest (37.40 g) dry weight plant^{-1} was also found in I_4treatment which was statistically similar with I_3 (36.70 g). The lowest (18.28 g) dry weight plant^{-1}was found inI_0 treatment. At harvesting stage, the highest (91.80 g) dry weight plant^{-1} was found in I_4 treatment. The lowest dry weight plant^{-1}was found in I_0 (50.33 g) treatment.

Taiz and Zeiger (2009) reported that the low availability of water may interfere with the photosynthetic activity, reducing the growth and, consequently reducing the biomass accumulation of the plants.

2.1.4 Cob length

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Cob length of maize was significantly different due to the irrigation frequencies (Table 10). Cob length of maize ranged from 26.52 to 19.59 cm; longest cob was found in I_4 treatment which is not statistically similar to others treatments. The lowest cob length 19.59 cm was recorded treatment I_0. The treatment I_4 was statistically superior to I_0, I_1, I_3 treatments in terms of cob length.

Elzubeirand Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman- Monteith equation (1998) for estimating crop evapotranspiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that prolonging irrigation intervals reduce cob length. Experiment result indicated that 10 days irrigation interval gave the highest values of cob length (17 & 17 cm) compeered to others irrigation intervals in both years.

2.1.5 No of row cob^{-1}

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30, and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. The irrigation frequency exerted a significant variation in respect of the no. of row cob^{-1}. Irrigation frequency (I_4) showed the maximum no. of row cob^{-1} (14.73) which was statistically similar with treatment I_3 (14.61); whereas I_0 showed the minimum no. of row cob1 (11.30) which was statistically different from others.

Elzubeir and Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman- Monteith equation (1998) for estimating crop evapotranspiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that 10 days irrigation interval gave the highest number of rows cob^{-1} (14 & 15) compared to others irrigation intervals in both years.

2.1.6 No. of grains cob^{-1}

Shen *et al.* (2020) conducted a field experiment during the maize growing season (April to October) in 2016 and 2017 at Qitai Farm (43°50' N, 89°46' E, altitude: 1020 m a.s.l.), located in the Xinjiang Uygur Autonomous Region, China to known the effect of optimal irrigation interval on the photosynthetic rate (Pn) and dry matter accumulation (DM) of closely planted super-high-yield maize under drip irrigation under mulch. experiment was conducted using three irrigation intervals in 2016 namely, six days (D6), nine days (D9), and 12 days (D12) and five irrigation intervals in 2017 namely, three days (D3), six days (D6), nine days (D9), 12 days (D12), and 15 days (D15). The Xianyu 335 high-yield maize hybrid was used in the test; the planting density was set to 12×10^4 plants ha^{-1}, and an optimal irrigation quota of 540 mm was used. From the experiment result revealed that the highest number of grains cob^{-1} (524.6 & 540.6) was observed in D6 treatment compared to others treatment in both years.

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. The irrigation frequency exerted a significant variation in respect of the no. of row cob^{-1}. Irrigation frequency (I_4) showed the maximum no. of row cob^{-1} (14.73) which was statistically similar to treatment I_3 (14.61); whereas I_0 showed the minimum no. of row cob1 (11.30) which was statistically different from others.

Elzubeir and Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman-Monteith equation (1998) for estimating crop evapotranspiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that 10 days irrigation interval gave the maximum number of grains cob^{-1} (281 & 397) compared to others irrigation intervals in both years.

2.1.7 1000-grain weight

Shen *et al.* (2020) conducted a field experiment during the maize growing season (April to October) in 2016 and 2017 at Qitai Farm (43°50' N, 89°46' E, altitude: 1020 m a.s.l.), located in the Xinjiang Uygur Autonomous Region, China to known the effect of optimal irrigation interval on the photosynthetic rate (Pn) and dry matter accumulation (DM) of closely planted super-high-yield maize under drip irrigation under mulch. experiment was conducted using three irrigation intervals in 2016 namely, six days (D6), nine days (D9), and 12 days (D12) and five irrigation intervals in 2017 namely, three days (D3), six days (D6), nine days (D9), 12 days (D12), and 15 days (D15). The Xianyu 335 high-yield maize hybrid was used in the test; the planting density was set to 12×10^4 plants ha^{-1}, and an optimal irrigation quota of 540 mm was used. From the experiment result revealed that the maximum 1000 grain weight (385. & 422 g) was observed in D6 treatment compared to others treatment in both years.

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Significant variation was recorded in weight of 100-grain of maize due to different irrigation frequency. The treatment I_4 produced significantly the highest 100 grain weight of 33.90g which was similar with I_3 while I_0 produced significantly the lowest 100-grain weight of 29.68g which was at par with I_1 and I_2 (30.59 and 31.55g).

Abd El-Halim and Abd El-Razek (2013) conducted a field experiment in 2010 and 2011 (maize growth seasons) to study the effects of DRFI with two irrigation intervals of 7 days and 14 days on maize yield, water saving, water productivity, and some economic parameters such as net return and investment ratio compared with the conventional ridged-furrow planting technique (RFI) with irrigation at 14-day intervals. Optimal irrigation interval for maize under DRFI was also determined. Regardless of irrigation intervals, smaller depth of applied water was observed with DRFI treatments compared to RFI treatments. Consequently, with DRFI treatments, more water could be saved compared with RFI treatments in both seasons. Double ridged-furrow planting with irrigation at 7-day intervals proved superior increasing 1000-grain weight (369.3 & 372.5 g) and water productivity in both years compared to the 14-day interval and the conventional treatment.

Elzubeirand Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman- Monteith equation (1998) for estimating crop evapotranspiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that 10 days irrigation interval gave the highest values 1000 seed yield (220 & 200 g) compared to others irrigation intervals in both years.

2.1.8 Grain yield

Tefera (2020) conducted a study to determine the optimal irrigation scheduling and fertilizer rate for better water use efficiency under irrigated agriculture. The effects of irrigation interval on maize yield and other crop properties were also assessed. The study was conducted in Pawe woreda of Metekel zone of Benishangul Regional State, North-West of Ethiopia. The experiment was carried in the randomized completed block design experimental design with a combination of five levels of irrigation treatments and three levels of fertilizer rate with three replications of the treatments. The result revealed that the plot received an optimal irrigation interval of 14 days in a combination of 25% more than the recommended fertilizer rate (292.24 t ha^{-1}) had significantly higher effects on above-ground biomass (18.25 t ha^{-1}) and on grain yield (4.8 t ha-1) of irrigated maize in the study area. However, the maximum water use efficiency of 2.05 kg m^{-3} was obtained at the irrigation interval of 14 days, and the highest level of fertilizer rate. Hence, the use of 14 days of optimal irrigation interval and 25% more fertilizer than the recommended rate is advisable because the grain yield and crop water use efficiency had been improved in the study area.

Shen *et al.* (2020) conducted a field experiment during the maize growing season (April to October) in 2016 and 2017 at Qitai Farm (43°50' N, 89°46' E, altitude: 1020 m a.s.l.), located in the Xinjiang Uygur Autonomous Region, China to known the effect of optimal irrigation interval on the photosynthetic rate (Pn) and dry matter accumulation (DM) of closely planted super-high-yield maize under drip irrigation under mulch. An experiment was conducted using three irrigation intervals in 2016 namely, six days (D6), nine days (D9), and 12 days (D12) and five irrigation intervals in 2017 namely, three days (D3), six days (D6), nine days (D9), 12 days (D12), and 15 days (D15). The Xianyu 335 high-yield maize hybrid was used in the test; the planting density was set to 12×10^4 plants ha^{-1}, and an optimal irrigation quota of 540 mm was used. From the experiment, result revealed that the grain yield of treatment D6 was the highest (20.6–21.0 t ha^{-1}) in both years. In 2016, the grain yield of D6 was 3.8% and 10.1% higher than that of D9 and D12, respectively; in 2017, the grain yield of D6 was 6.6%, 5.0%, 9.4%, and 22.1% higher than that of D3, D9, D12, and D15, respectively.

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Significant variation was observed on grain yield in case of frequent irrigation in the field. It was found that the highest grain yield (10.61 t ha^{-1}) was achieved from I_4 and it was statistically similar with I_3 treatment showing the grain yield of 10.54 t ha^{-1}. On the other hand, the lowest grain yield (5.00 t ha^{-1}) was found in I_0 (control).

Surface irrigation is the traditional irrigation method applied in about 80% of the irrigated area in Egypt with greater water losses leading to profile drainage. The double ridge-furrow planting technique (DRFI) uses a practical way to reduce the applied water quantities. Therefore, Abd El-Halim and Abd El-Razek (2013) conducted a field experiment in 2010 and 2011 (maize growth seasons) to study the effects of DRFI with two irrigation intervals 7 days and 14 days on maize yield, water saving, water productivity and some economic parameters such as net return and investment ratio compared with the conventional ridged-furrow planting technique (RFI) with irrigation at 14-day intervals. Optimal irrigation interval for maize under DRFI was also determined. Regardless of irrigation intervals, smaller depth of applied water was observed with DRFI treatments compared to RFI treatment. Consequently, with DRFI treatments, more water could be saved compared with RFI treatment in both seasons. Double ridged-furrow planting with irrigation at 7-day intervals proved superior to increase the grain yield (7133 kg ha^{-1}) and water productivity compared to the 14-day interval and the conventional treatment.

Dahmardeh (2011) found that ‘the highest seed yield was obtained under irrigation interval of 9 days but the highest biological yield under irrigation interval of 7 days, generally, yield of corn plants was decreased by temporal extent the irrigation interstice to 15 days.

Elzubeirand Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman-Monteith equation (1998) for estimating crop evapo-transpiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that 10 days irrigation interval gave the highest values of grain yield (4540 & 6074 kg ha^{-1}) compared to others irrigation intervals in both years.

Parvizi *et al.* (2011) reported that for optimum irrigation management and increasing water use efficiency increase yield of maize and suggested that irrigation interval is 6 days during the last vegetation growth stage and initial tussling stage, and 8 days in the other growth stages increase yield of maize

Ibrahim and Hala Kandil (2007) found that the highest values of plant height, ear characters (length, diameter and weight) as well as grains yield of corn plants were obtained under an irrigation interval of 10 days followed by 14 and18 days; generally prolonging the irrigation interval to18 days decreased the growth, yield and chemical constituent of corn plants.

2.1.9 Stover yield

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Straw yield of maize showed statistically significant variation due to different levels of irrigations (Table 14). The highest straw yield of 15.13 t ha^{-1} was recorded from I_4treatment which was statistically similar with I_3 treatment. On the other hand, the lowest straw yield 8.583 t ha^{-1} was observed from I_0 treatment.

Elzubeirand Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman-Monteith equation (1998) for estimating crop evapotranspiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that 10 days irrigation interval gave the highest values of stover yield (4.8 & 4.6 t ha^{-1}) compared to other irrigation intervals in both years.

2.1.10 Harvest index

Shen *et al.* (2020) conducted a field experiment during the maize growing season (April to October) in 2016 and 2017 at Qitai Farm (43°50' N, 89°46’ E, altitude: 1020 m a.s.l.), located in the Xinjiang Uygur Autonomous Region, China to known the effect of optimal irrigation interval on the photosynthetic rate (Pn) and dry matter accumulation (DM) of closely planted super-high-yield maize under drip irrigation under mulch. experiment was conducted using three irrigation intervals in 2016 namely, six days (D6), nine days (D9), and 12 days (D12) and five irrigation intervals in 2017 namely, three days (D3), six days (D6), nine days (D9), 12 days (D12), and 15 days (D15). The Xianyu 335 high-yield maize hybrid was used in the test; the planting density was set to 12×10^4 plants ha^{-1}, and an optimal irrigation quota of 540 mm was used. From the experiment result revealed that the maximum harvest index was (53 & 53 %) was observed in D6 treatment compared to others treatment in both years.

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015-16. Four irrigation frequencies constituted the irrigation treatment (I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Data revealed that there was significant variation for harvest index of maize due to different irrigation frequency (Figure 13). Numerically, the highest harvest index (40.98%) was observed from I_4 treatment which was statistically similar with I_3 and I_2 treatments and the lowest 36.93% was from I_0 treatment which was statistically similar with I_1 treatment.

Elzubeir and Mohamed (2011) conducted a field experiment for two consecutive summer seasons; 2005/06 and 2006/07, at Dongola area- Northern State (Sudan). The objectives were to investigate the effect of irrigation regimes; irrigation water amounts and irrigation intervals, on maize (*Zea mays* L.) growth and yield in addition to their effect on the soil moisture content. Irrigation water amounts were determined using FAO Penman-Monteith equation (1998) for estimating crop evapotranspiration (ET_c). Three levels of ET_c were used; 100%, 75%, and 50% ET_c. Three irrigation intervals were imposed; 10, 15, and 20 days. The application of irrigation treatments was started at the third irrigation. The results indicated that 10 days irrigation interval gave the highest values of harvest index (30 & 50 %) compared to others irrigation intervals in both years.

2.2 Effect of different spacing

2.2.1 Plant height

Ahmmed *et al.* (2020) conducted 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 spacing and integrated fertilizer management. The experiment comprised varying spacings *viz.* S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application *viz.* T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The highest plant height at 45, 90 DAS and at harvest were 37.25, 177.94 and 197.91 cm respectively with S_1 (60 cm × 20 cm) where the lowest were 35.889, 172.81 and 186.70 cm respectively with S_2 (40 cm × 20 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 at the Entomology Field Laboratory, Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh during Rabi season of 2016-17. The research work was carried out in randomized complete block design (RCBD) with three replications. Maize var. BARI Hybrid Butta-09 was used as the test crop. Five spacing techniques (Distance of row to row and plant to plant, respectively were 50 cm×20 cm (T_1), 55 cm×25 cm (T_2), 60 cm×30 cm (T_3), 65 cm×35 cm (T_4) and 70 cm×40 cm (T_5). All 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 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 was laid out in two Factorial Randomized complete Block Design

(RCBD) comprising of spacing: 60×15 cm and 60×25 cm and nitrogen: 30, 60, 90 and 120 kg/ha level as treatment with three replications. “Arun-2” variety of maize was planted on clay loam and acidic soil (pH 5.3) having medium in total nitrogen (0.15%), medium in soil available phosphorus (48.1 kg ha^{-1}), medium in soil available potassium (218.8 kg ha^{-1}) and medium in organic matter content (2.92%). 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^{-1}

Akbar *et al.* (2016) conducted an on-farm experiments in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food. Yield response of two maize hybrids (PSC121 and KS510) planted in three different row arrangements (row to row distance 50 and 60 cm with plant-to-plant distance of 25 cm along with a twin row arrangement) was evaluated in one experiment. Twin row had the maximum plant height (288 cm) whereas the 60 x25 cm spacing had the shortest plants (242 cm).

Enujeke (2013 a) carried out a field study to evaluate the effects of variety and spacing on growth characters of hybrid maize. Three hybrid maize varieties were evaluated under three different plants spacing for growth characters like plant height, number of leaves, leaf area and stem diameter. Result 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.

2.2.2 No. of leaves

Ahmmed *et al.* (2020) conducted an experiment during December, 2017 to May, 2018 at the Agronomy field of Shere-Bangla Agricultural University, Dhaka to evaluate the performance of white maize variety under different spacing and integrated fertilizer management. The experiment comprised two different factors; (1) two plants spacing viz. S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application viz. T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The experiment was set up in split plot design with three replications. Results revealed that spacing effect on number of functional leaves (green leaves above the ground) per plant at different growth stages during experimentation. Data showed that higher leaves number plant^{-1} was achieved with higher plant spacing where lower plant spacing showed lower leaf number plant^{-1}. The highest leaves number plant^{-1}at 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. The results 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.

2.2.3 Leaf area

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 such as plant heights, stem girths, number of leaves, number of nodes and leaf area and for the yield, data were collected on cob length, cob weight, cob + husk weight, cob circumference and 1000-grain weight (yield). The results obtained 56 days after planting (DAP) in the two years of study showed significant differences ($p < 0.05$) in 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) carried out a study to evaluate the effects of variety and spacing on growth characters of hybrid maize. Three hybrid maize varieties were evaluated under three different plants spacing for growth characters as plant height, number of leaves, leaf area and stem girth. 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).

2.2.4 Dry matter weight

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. The experiment was arranged in a factorial combination of the three intra-rows (20, 25 and 30 cm) spacing and five inter-rows spacing (45, 55, 65, 75 and 85 cm) spacing which were laid out in RCBD with three replication using maize (*Zea mays* L.) BH 660 variety. The results had shown that the highest above ground dry biomass yields per plant was occurred at the widest inter and intra-row spacing might be due to high stem diameter and high leaf area because there is more availability of growth factors and better penetration of light at wider row spacing.

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, which was significantly better than all other treatments with the least dry matter accumulation (10 g plant^{-1}) obtained in the sole maize crop.

2.2.5 Cob length

Ahmmed *et al.* (2020) conducted 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 spacing and integrated fertilizer management. The experiment comprised varying spacings *viz.* S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application *viz*. T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. Results represented in indicated that the longest cob (15.99cm) was attained with S_1 (60 cm × 20 cm) where the shortest (14.62 cm) was with S_2 (40 cm × 20 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 at the Entomology Field Laboratory, Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh during Rabi season of 2016-17. The research work was carried out in randomized complete block design (RCBD) with three replications. Maize var. BARI Hybrid Butta-09 was used as the test crop. Five spacing techniques (Distance of row to row and plant to plant, respectively were 50 cm×20 cm (T_1), 55 cm×25 cm (T_2), 60 cm×30 cm (T_3), 65 cm×35 cm (T_4) and 70 cm×40 cm (T_5). All 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 60cm×30cm (T_3). This treatment also showed the highest cob length that was 22.20 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. Four levels of spacings (boardcasting and three row spacings of 45, 60 and 75 cm) and two maize varieties (Rampur Composite and Arun-2) were evaluated using randomized complete block design with three replications. 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) 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. Experiment was designed in Randomized Complete Block Design (RCBD) with factorial arrangements having 3 replications with net plot size of 5 m × 3 m. Study comprised two factors, three maize hybrids i.e., NT-6621, DEKALB-919, HYCORN 11 PLUS and three plant spacings i.e., 6 inches, 9 inches and 12 inches, respectively. The data related to crop yield was recorded using standard procedures. data showed 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.

Akbar *et al.* (2016) conducted an on-farm experiments in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food. Yield response of two maize hybrids (PSC121 andKS510) planted in three different row arrangements (row to row distance 50 and 60 cm with plant-to-plant distance of 25 cm along with a twin row arrangement) was evaluated in one experiment. Twin row had the maximum cob length (1998 cm) whereas the 60x25 cm spacing had the shortest plants (242 cm).

2.2.6 Cob circumference

Ahmmed *et al.* (2020) conducted 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 spacing and integrated fertilizer management. The experiment comprised varying spacings *viz.* S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application *viz*. T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The results showed significantly different results in respect of the highest and the lowest value of cob circumference. Maximum cob circumference observed in S_1 (60 cm × 20 cm) treatment combination.

Koirala *et al*. (2020) carried out an field experiment to study the Effect of row to row spacings 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. Four levels of spacings (boardcasting and three row spacings of 45, 60 and 75 cm) and two maize varieties (Rampur Composite and Arun-2) were evaluated using randomized complete block design with three replications. 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 Circumference was reported when maize was planted in the row spacing 60×25cm.

Hasan *et al*. (2018) carried out an experiment at the Agronomy Field Laboratory, Agricultural University, Mymensingh in Bangladesh during December 2015 to April 2016 to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised five varieties viz., Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and five plants spacing viz., 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The experiment was laid out in a randomized complete block design with three replications. Results revealed that variety and plant spacing had significant effect on the studied crop characters and yield. Maximum diameter of cob was observed in the spacing of 75 cm × 25 cm.

2.2.7 No. of grain rows cob^{-1}

Koirala *et al*. (2020) carried out a field experiment to study the Effect of row to row spacings 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. Four levels of spacings (boardcasting and three row spacings of 45, 60 and 75 cm) and two maize varieties (Rampur Composite and Arun-2) were evaluated using randomized complete block design with three replications. 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 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. Experiment was designed in Randomized Complete Block Design (RCBD) with factorial arrangements having 3 replications with net plot size of 5 m × 3 m. Study comprised two factors, three maize hybrids i.e., NT-6621, DEKALB-919, HYCORN 11 PLUS and three plant spacings i.e. 6 inches, 9 inches and 12 inches, respectively. The data related to crop yield was recorded using standard procedures. 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) 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 experiment comprised three nitrogen levels viz. 50, 100 and 150 kg N ha-^{1} and five plant spacings viz. 75 cm × 25 cm, 75 cm × 20 cm, 50 cm × 25 cm, 50 cm × 20 cm and 100 cm × 20 cm. The experiment was laid out in a randomized complete block design with three replications. Results revealed 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.

2.2.8 No. of grains row^{-1}

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. Four plant row spacing (45 cm, 55 cm, 65 cm and 75 cm) and three maize varieties (‘BH-540’, Lemu ‘P3812W’ and Jabi ‘PHB 3253’) were tested. 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 experiment comprised three nitrogen levels viz. 50, 100 and 150 kg N ha-1 and five plant spacings viz. 75 cm × 25 cm, 75 cm × 20 cm, 50 cm × 25 cm, 50 cm × 20 cm and 100 cm × 20 cm. The experiment was laid out in a randomized complete block design with three replications. Results revealed that nitrogen levels and plant spacing had significant effect on yield attributes and yield of Khai bhutta. The highest number of, grain per row was recorded at 75 cm × 25 cm spacing.

Akbar *et al* (2016) conducted an on-farm experiments in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food. Yield response of two maize hybrids (PSC121 and KS510) planted in three different row arrangements (row to row distance 50 and 60 cm with plant-to-plant distance of 25 cm along with a twin row arrangement) was evaluated in one experiment. The row 50 x25 had the maximum number of grain row on a cob (over 14) whereas the other spacings had the least numbers (below 14).

2.2.9 No. of grains cob^{-1}

Ahmmed *et al.* (2020) conducted 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 spacing and integrated fertilizer management. The experiment comprised varying spacings *viz.* S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application *viz.* T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The highest grains cob^{-1} (372.19) was attained with S_1 (60 cm × 20 cm) where the lowest (340.72) was with S_2 (40 cm × 20 cm). Higher spacing gave the highest number of grains cob^{-1}.

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 at the Entomology Field Laboratory, Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh during Rabi season of 2016-17. The research work was carried out in randomized complete block design (RCBD) with three replications. Maize var. BARI Hybrid Butta-09 was used as the test crop. Five spacing techniques (Distance of row to row and plant to plant, respectively were 50cm×20cm (T_1), 55 cm × 25 cm (T_2), 60 cm × 30 cm (T_3), 65 cm × 35 cm (T_4) and 70 cm × 40 cm (T_5). All 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.

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. Experiment was designed in Randomized Complete Block Design (RCBD) with factorial arrangements having 3 replications with net plot size of 5 m × 3 m. Study comprised two factors, three maize hybrids i.e., NT-6621, DEKALB-919, HYCORN 11 PLUS and three plant spacings i.e., 6 inches, 9 inches and 12 inches, respectively. The data related to crop yield was recorded using standard procedures. Data showed 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.

Salam *et al.* (2010) carried out a trial at the central farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to July 2006 to study the effect of different levels of nitrogen and spacing on growth and yield of hybrid maize. Three levels of Nitrogen (180, 220 and 260 kg N ha^{-1}) and plant spacing (60cm × 25cm, 75cm × 25cm and 90cm × 25cm) were the treatment variables in the experiment. Results showed that significantly higher number of grains cob^{-1} (300.33) was found in 75cm × 25cm spacing.

Akbar *et al* (2016) conducted an on-farm experiments in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food. Yield response of two maize hybrids (PSC121 andKS510) planted in three different row arrangements (row to row distance 50 and 60 cm with plant-to-plant distance of 25 cm along with a twin row arrangement) was evaluated in one experiment. Twin row had the maximum number of grains per cob (516) whereas the 60x25 cm spacing had the least (468).

A study was carried out by Ullah *et al.* (2016) at Sher-e-Bangla Agricultural University farm to evaluate the performance of seedling transplantation of four white maize hybrids (Changnuo-1, Q-Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D_1 =Row to row spacing 75 cm and plant to plant spacing within each row 25 and D_2 = Row to row spacing 60 cm and plant to plant spacing within each row 25). D_1 had 55 whereas D_2 had 66.666 thousand plants per hectare. Results showed that varieties differed significantly in days to maturity showing the earliest (108 days) with the Yangnuo-7. Other varieties matured in between 135-137 days. Planting configuration D_2 had significantly greater number of grains per cob (370) whereas the D1 had the least (337).

2.2.10 1000-grain weight

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. Four levels of spacings (boardcasting and three row spacings of 45, 60 and 75 cm) and two maize varieties (Rampur Composite and Arun-2) were evaluated using randomized complete block design with three replications. 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. 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) carried out an experiment at the Agronomy Field Laboratory, Agricultural University, Mymensingh in Bangladesh during December 2015 to April 2016 to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised five varieties viz., Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and five plants spacing viz., 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The experiment was laid out in a randomized complete block design with three replications. Results revealed that variety and plant spacing had significant effect on the studied crop characters and yield. The highest 1000-grain weight was observed in the spacing of 75 cm × 25 cm.

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. Experiment was designed in Randomized Complete Block Design (RCBD) with factorial arrangements having 3 replications with net plot size of 5 m × 3 m. Study comprised two factors, three maize hybrids i.e., NT-6621, DEKALB-919, HYCORN 11 PLUS and three plant spacings i.e., 6 inches, 9 inches and 12 inches, respectively. The data related to crop yield was recorded using standard procedures. Data 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.

Akbar *et al* (2016) conducted an on-farm experiments in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food. Yield response of two maize hybrids (PSC121 andKS510) planted in three different row arrangements (row to row distance 50 and 60 cm with plant-to-plant distance of 25 cm along with a twin row arrangement) was evaluated in one experiment. Twin row had the maximum 100 seed weight (above 34 g) whereas the others had the 100 seed weight around or below 34 g.

A study was carried out by Ullah *et al.* (2016) at Sher-e-Bangla Agricultural University farm to evaluate the performance of seedling transplantation of four white maize hybrids (Changnuo-1, Q-Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D_1 =Row to row spacing 75 cm and plant to plant spacing within each row 25 and D_2 = Row to row spacing 60 cm and plant to plant spacing within each row 25).

D_1 had 55 whereas D_2 had 66.666 thousand plants per hectare. Results showed that varieties differed significantly in days to maturity showing the earliest (108 days) with the Yangnuo-7. Other varieties matured in between 135-137 days. Planting configuration D_2 had significantly greater 100 seed weight (31.42 g) and the D1 had lower values (30.40 g).

Salam *et al*. (2010) carried out a trial at the central farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to July 2006 to study the effect of different levels of nitrogen and spacing on growth and yield of hybrid maize. Three levels of Nitrogen (180, 220 and 260 kg N ha^{-1}) and plant spacing (60cm × 25cm, 75cm × 25cm and 90cm × 25cm) were the treatment variables in the experiment. Results showed that significantly higher 1000- grain weight (446.13g) was found in 75cm × 25cm spacing.

2.2.11 Grain weight

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 at the Entomology Field Laboratory, Department of Entomology, Bangladesh Agricultural University (BAU), Mymensingh during Rabi season of 2016-17. The research work was carried out in randomized complete block design (RCBD) with three replications. Maize var. BARI Hybrid Butta-09 was used as the test crop. Five spacing techniques (Distance of row to row and plant to plant, respectively were 50 cm×20 cm (T_1), 55 cm×25 cm (T_2), 60 cm×30 cm (T_3), 65 cm×35 cm (T_4) and 70 cm×40 cm (T_5). All 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 height grain weight cob^{-1} was 230.67g.

Akbar *et al.* (2016) conducted an on-farm experiments in the Bandarban valley during dry season, October 2015 through March, 2016 to investigate the possibility of introducing white maize as human food. Yield response of two maize hybrids (PSC121 andKS510) planted in three different row arrangements (row to row distance 50 and 60 cm with the plant-to-plant distance of 25 cm along with a twin row arrangement) was evaluated in one experiment. The effect of row spacing was found to be inconsistent in terms of grain weight per plant showing a range of 195-209 g.

A study was carried out by Ullah *et al.* (2016) at Sher-e-Bangla Agricultural University farm to evaluate the performance of seedling transplantation of four white maize hybrids (Changnuo-1, Q-Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D_1 =Row to row spacing 75 cm and plant to plant spacing within each row 25 and D_2 = Row to row spacing 60 cm and plant to plant spacing within each row 25). D_1 had 55 whereas D_2 had 66.666 thousand plants per hectare. Results showed that varieties differed significantly in days to maturity showing the earliest (108 days) with the Yangnuo-7. Other varieties matured in between 135-137 days. Planting configuration D_2 had significantly greater yield (7.551 t ha^{-1}), whereas the D1 produced (5.832 t ha^{-1})

Salam *et al.* (2010) carried out a trial at the central farm of Sher-e-Bangla Agricultural University, Dhaka during the period from April to July 2006 to study the effect of different levels of nitrogen and spacing on growth and yield of hybrid maize. Three levels of Nitrogen (180, 220 and 260 kg N ha^{-1}) and plant spacing (60cm × 25cm, 75cm × 25cm and 90cm × 25cm) were the treatment variables in the experiment. Results showed that significantly higher grain yield (7.354 t ha^{-1}) was found in 75cm × 25cm spacing.

2.2.12 Cob weight

Ukonze *et al*. (2016) carried out a study to compare and analyze how spacing influenced the performance and yield of late maize in Egwi, Etche Local Government Area (LGA) of Rivers State, Nigeria between September-December in 2013 and 2014. The study adopted experimental research design. The experiment was laid out in a randomized complete block design (RCBD) with three replicates. One maize variety was evaluated under three spacing for performance data such as plant heights, stem girths, number of leaves, number of nodes and leaf area and for the yield, data were collected on cob length, cob weight, cob + husk weight, cob diameter and 1000-grain weight (yield). The results obtained 56 days after planting (DAP) in the two years of study showed significant differences ($p < 0.05$) in plant height, stem girth and leaf area. The 70 x 30 and 60 x 40 cm spacing gave higher values of the morphological parameters than 80 x 20 cm. With regard to yield, 80 x 20 cm gave the highest average cob weight of 0.74 kg and 1000-grain weight (yield) of 0.27t ha^{-1}.

Nand (2015) conducted a field experiment to evaluate the effect of spacing and fertility levels on protein content and yield of hybrid and composite maize (*Zea mays* L.). Eighteen treatment combinations were involved. The main plots were allotted to maize hybrid (DHM-117) and composite (Madhuri) along with three spacing viz., 45 cm × 20 cm, 60 cm × 20 cm and 60 cm × 25 cm. In addition, sub-plots were tested for three fertility levels viz., F1 - NPK and Zn of (120 :60 : 40 and 15 kg ha^{-1}) F2 - NPK and Zn of (160 : 80 : 60 and 20 kg ha^{-1}) and F3 - NPK and Zn of (180 : 100 : 80 and 25 kg ha^{-1}). 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.

2.2.13 Shelling percentage (%)

Ahmmed *et al.* (2020) 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. The experiment comprised two different factors; (1) two different plant spacings viz. S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application viz. T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The experiment was set up in split plot design with three replications. Results revealed 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 showed highest plant shelling percentage compared to other treatments.

Mukhtar *et al*. (2012) conducted a study at Maize and Millets Research Institute, Yusafwala, Sahiwal, Pakistan during summer season 2009 to evaluate the effect of plant spacing on growth and yield of four maize hybrids. The experiment was laid out in randomized complete block design with split plot arrangement having three replications. The maize hybrids (Yusafwala Hybrid, YH-1898, YH-1850 and FH793) were sown at plant spacings of 10, 12.50, 15 and 17.50 cm. The results indicated that maize hybrids and plant spacings had significant effect on growth, yield and yield components. Plant spacing had significant effect on shelling percentage while hybrids and hybrid x spacing interaction showed non-significant effect. 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.

2.2.14 Grain yield

Ahmmed *et al.* (2020) conducted 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 spacing and integrated fertilizer management. The experiment comprised varying spacings *viz.* S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application *viz.* T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The highest grain yield (8.62 t ha^{-1}) was obtained with S_2 (40 cm × 20 cm) where the lowest (7.30 t ha^{-1}) was with S_1 (60 cm × 20 cm).

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. The experiment consisted of the factorial combinations of two hybrid maize varieties ("BH-661" and "BH-QPY-545"), two inter-rows spacing (65 and 75 cm) and three intra-rows spacing (25, 30 and 35 cm) in a 3 × 2 × 2 factorial in a randomized complete block design experiment with three replications of each treatment combination. Result reviled that Grain yield was significantly ($p < 0.01$) affected by the interactions of variety × inter-row spacing and inter-row × intra row spacing × year. Accordingly, 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 a smaller number of plants per unit.

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. Four plant row spacing (45 cm, 55 cm, 65 cm and 75 cm) and three maize varieties ('BH-540', Lemu 'P3812W' and Jabi 'PHB 3253') were tested. The results indicated that grain yield per hectare was significantly influenced by the interaction effect of row spacing and varieties. Significantly the highest grain yield was produced by maize variety Lemu grown at row spacing of 65 cm, which was statistically similar with variety BH-540 grown at row spacing of 65and 75 cm and also the same variety grown at row spacing of 75 cm. The lowest grain yield per hectare was recorded from variety Jabi grown at row spacing of45 cm. Based on these results, it can be 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) conducted a field experiment to determine the optimum rateof nitrogen fertilization and intra row spacing. Three intra-rows spacing *viz.*, 75cm × 40 cm, 75 cm × 30 cm and 75 cm × 20 cm accommodating 33333, 44444and 66666 plants ha^{-1} respectively, with six nitrogen fertilizer levels *viz.* 0, 23,46, 69, 92 and 115 kg ha^{-1} were assigned to the experimental plot by factorial combinations. Based on the results, the maximum grain yield (10,207.8 kg ha^{-1}) was obtained when the hybrid was sown at the closest intra row spacing (20 cm) with application of the highest rate of nitrogen (115 kg ha^{-1}). This result showed8.90 % yield advantages compared to the standard check. However, statistically similar grain yield (9,887 kg $ha^{-1)}$ was also obtained under application of 92 kg nitrogen ha^{-1} in the same intra spacing (20 cm). It was 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) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised 5 varieties of maize *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and five plants spacing *viz.*, 75 cm × 20 cm, 75cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. Results revealed that variety and plant spacing had significant effect on the studied crop characters and yield. The maximum grain yield was observed in the spacing of 75 cm × 25cm. In contrast, the spacing of 75 cm × 30 cm showed the lowest grain yield. Concerning interaction effect of variety and spacing, the highest grain yield 9.04 t ha^{-1} was observed at the spacing of 75 cm × 25 cm with BARI hybrid maize7. 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) conducted on-farm experiments to investigate the possibility of introducing white maize as human food evaluating seed yields under varying plant spacings. Yield response of two maize hybrids (PSC-121 and KS-510) planted in three different row arrangements was evaluated in the experiment. Grain yield ranged between 7,103 kg and 10,126 kg per ha across hybrids and planting arrangements. Hybrid PSC-121 recorded 19 % more yield than KS-510.Generally, grain yield increased with increasing planting density. Planting in twin-rows giving 80,000 plants per ha and produced 17.7 % higher yield compared with planting in single rows 60 cm apart giving 66,667 plants ha^{-1}. Planting in twin-rows produced higher yield significantly compared with single rows. Increase in maize grain yield was associated with the number of grains per ear and individual grain weight.

2.2.15 Stover yield

Ahmmed *et al.* (2020) conducted an experiment during December, 2017 to May, 2018 at the Agronomy field of Shere-Bangla Agricultural University, Dhaka to evaluate the performance of white maize variety under different spacing and integrated fertilizer management. The experiment comprised two different factors; (1) two plants spacing viz. S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application viz. T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The experiment was set up in split plot design with three replications. 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) conducted a field experiment to determine the optimum N level and PD (plant density), field experiments were conducted in the 2014 and 2015 rainy seasons. A factorial arrangement of three N levels (120, 240 and 360 kg ha^{-1}) and four PD (53,333, 61,538, 83,333 and 90,900 plants ha^{-1} with a corresponding plant spacing of 75 × 25, 60 × 25, 60 × 20 and 55 × 20 cm, respectively) were compared using randomized complete block design with three replications. result 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 comprised 5 varieties *viz.*, Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C-1921, P-3396 and five plants spacing *viz.*, 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The 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.

2.2.16 Biological yield

Ahmmed *et al.* (2020) conducted 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 spacing and integrated fertilizer management. The experiment comprised varying spacings *viz.* S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application *viz.* T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. The highest biological yield (18.54 t ha^{-1}) was obtained with S_2 (40cm × 20 cm) where the lowest (14.59 t ha^{-1}) was with S_1 (60 cm × 20 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 was laid out in two Factorial Randomized complete Block Design (RCBD) comprising of spacing: 60×15 cm and 60×25 cm and nitrogen: 30, 60, 90 and 120 kg ha^{-1} level as treatment with three replications. “Arun-2” variety of maize was planted on clay loam and acidic soil (pH 5.3) having medium in total nitrogen (0.15%), medium in soil available phosphorus (48.1 kg/ha), medium in soil available potassium (218.8 kg ha^{-1}) and medium in organic matter content (2.92%). Result shows that biological yield (mt ha-1) as influenced by different spacing and nitrogen level. 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^{-1}) produced under 60×15 cm spacing and the lowest biological yield (9.24 Mt ha^{-1}) produced under 60×25 cm spacing.

Hossain (2015) carried out a research work to study the effect of planting configuration on the growth and yield of white maize. The experiment comprised two factors *viz*. factor A: Two white maize varieties (V_1 = KS-510 and V_2 = PSC-121) and factor B: five plants spacing (T_1 = 40 cm × 25 cm spacing, T_2 = 50 cm × 25 cm spacing, T_3 = 60 cm × 25 cm spacing, T_4 = 70 cm × 25 cm spacing and T_5 = Double rows of 50 cm × 25 cm spacing). Plant spacing of double rows of 50 cm × 25 cm performed the best among five plants spacing in case of biological yield (23.30 t ha^{-1}). Plant spacing of 40 cm × 25 cm showed the lowest result in all yield and yield contributing characters. Interaction of variety PSC- 121 with double rows of 50 cm × 25 cm plant spacing gave 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.

2.2.17 Harvest index (%)

Ahmmed *et al.* (2020) conducted 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 spacing and integrated fertilizer management. The experiment comprised varying spacings *viz.* S_1 (60 cm × 20 cm) and S_2 (40 cm × 20 cm) and (2) four levels of integrated fertilizer application *viz*. T_1: All chemical fertilizer (recommended dose), T_2: maize straw compost +½ of recommended dose, T_3: cowdung+½ of recommended dose and T_4: vermicompost +½ of recommended dose. Results represented in Figure 21 indicated that the numerically highest harvest index (49.82 %) was attained with S_1 (60 cm × 20 cm) where the lowest (46.51 %) was with S_2 (40 cm × 20 cm).

Mechi (2015) conducted a field experiment to assess the response of maize hybrid variety “BH-661” to nitrogen (N) fertilizer and inter row spacing. The experiment was arranged in a factorial combination of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}) and four inter row spacing (55, 65, 75 and 85 cm). Results indicated 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.

CHAPTER III

MATERIALS AND METHODS

This part presents a concise depiction about the duration of the experimental period, site description, climatic state of the area, harvest or planting materials that are being utilized in the test, treatments, design, crop growing procedure, intercultural activities, data collection and statistical analyses.

3.1 Experimental period

The experiment was conducted during the period from October; 2019 to February; 2020 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The experiment was done at the Agronomy field of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar Agargong Dhaka, Bangladesh. The experimental site is topographically situated at 23°77′ N scope and 90°33′ E longitude at an elevation of 8.6 meter above ocean 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 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-II.

3.4 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-III. (Banglapedia, 2014 and Biswaset *al*., 2019).

3.5 Planting materials

In this research work, "SAUWM 12-3-3" genotype 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

"SAUWMOP T61G" genotype of white maize was used as planting material for the present study. This variety was recommended for Rabi and kharif season. The feature of this variety was presented below:

Name of Variety: White maize (**SAUWMOP T61G)**	
Identifying character: Bold grain quality and drought tolerant	**Suitable area**: All over Bangladesh
Type: Medium duration, Open pollinated	**Number of cobs plant-^{1}**: Mainly one
Height: 180–215 cm	**Cob colour:** White colour.
Crop duration: 110–120 days	**Grain colour**: White
Leaf colour at Maturity: Light Green color at maturity	**Yield** :7-9 t ha^{-1}

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

3.7 Major diseases and management

Diseases: At vegetative stage of white maize leaf blight disease occurs.

Management: Clean cultivation with timely sowing and maintaining 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.

3.8 Experimental details

Land preparation Date: 19 October 2019

Seed Sowing Date: 20 October 2019

Spacing: According to the treatment assigned.

Fertilizer apply Date: All the fertilizers were applied on 19 October 2019 during final land preparation except urea

Flowering date: 24 December 2019

Silking Date: 2 January 2020

Harvesting Date: 22 February 2020

3.9 Experimental treatment details and combinations

3.9.1 Experimental treatment

There were two sets of treatments in the experiment. The treatments were irrigation frequencies and spacing. Those are shown below:

Factor A: Irrigation frequencies (3) *viz:*

I_1: Irrigation at 20 days interval

I_2: Irrigation at 25 days interval

I_3: Irrigation at 30 days interval and

Factor B: Different spacings (4) *viz:*

S_1: 50 cm × 20 cm

S_2: 50 cm × 25 cm

S_3: 60 cm × 20 cm

S_4: 60 cm × 25 cm

3.9.2 Treatment combinations

These two factor experiments were included 12 treatment combinations.

I_1S_1, I_1S_2, I_1S_3, I_1S_4, I_2S_1, I_2S_2, I_2S_3, I_2S_4, I_3S_1, I_3S_2, I_3S_3, I_3S_4

3.9.3 Experimental design

The experiment was laid out in the split plot design with three replications. The field was divided into 3 blocks to represent 3 replications. Total of 36-unit plots were made for the experiment with 12 treatments. The size of each unit plot was 3.89 m^2 (3.17 m × 1.23 m). Distance maintained between replication and plots were 1.0 m and 0.50 m, respectively. 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 (19 October 2019) 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 (19 October 2019) according to experimental specification. Individual plots were cleaned and finally the plot was prepared.

3.10.2 Fertilizer application

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

3.10.3 Seed sowing and maintaining spacing

The white maize seeds were sown in lines maintaining spacing as per treatments having 2 seeds $hole^{-1}$ under direct sowing in the well-prepared plot on 20 October 2019.

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 30 October 2019 which was 10 days after sowing (DAS). Thinning was done on 4 November 2019 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 14 November 2019 and 4 December 2018, which was 25 and 45 days after sowing, respectively.

3.11.3 Earthing up

Earthing up was done on (date and year) 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 given as per treatments requirement.

3.11.5 Pest and disease control

Major insect/pest and management

Insect pests: Cut worm and stem borer attack at vegetative stage of maize. 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.

3.11.6 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.

3.11.7 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 22 February 2020.

3.11.8 Drying

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

3.12 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.

3.13 Data collection

The data were recorded on the following parameters

A. Crop growth characters

i. Plant height (cm)
ii. Number of leaves plant^{-1}
iii. Leaf area plant^{-1} (cm^2)
iv. Total dry matter plant^{-1} (g)

B. Yield contributing characters

v. Cob length plant^{-1} (cm)
vi. Cob circumference plant^{-1} (cm)
vii. Number of rows cob^{-1}
viii. Number of grains row^{-1}
ix. Number of grains cob^{-1}
x. 1000 grains weight cob^{-1} (g)
xi. Chaff weight plant^{-1} (g)
xii. Shell weight plant^{-1} (g)

xiii. Grain weight cob^{-1} (g)

xiv. Cob weight plant^{-1} (g)

xv. Shelling percentage (%)

C. Yield characters

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

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

xviii. Biological (t ha^{-1})

xix. Harvest index (%)

3.14 Procedure of recording data

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

3.14.1 Plant height (cm) at different DAS (30, 60, 90 DAS and harvest respectively)

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

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

At different stages of crop growth (30, 60, 90 DAS and at harvest) 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.

3.14.3 Leaf area plant^{-1} (cm^2) at different DAS (30, 60, 90 DAS and at harvest) (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 harvest respectively.

Leaf area plant^{-1} =

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

3.14.4 Dry matter weight plant $^{-1}$ at different DAS (30, 60, 90 DAS and at harvest respectively)

At 30, 60, 90 DAS 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 total dry matter of a plant was calculated for each plot. It was performed at 30, 60, 90 DAS and harvest respectively.

3.14.5 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.

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

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

3.14.7 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.

3.14. 8 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.

3.14. 9 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.

3.14. 10 Weight of 1000-grain

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-seed were calculated and the weight was measured by an electrical balance. It was recorded in gram.

3.14.11 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.

3.14.12 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.

3.14.13 Grain weight cob-^{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.

3.14. 14 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.

3.14. 15 Shelling percentage

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

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

3.14. 16 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. The grain yield t ha^{-1} was measured by the following formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Grain yield per plot (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.14. 17 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}. The straw yield t ha^{-1} was measured by the following formula:

$$\text{Stover yield (t ha}^{-1}\text{)} = \frac{\text{Stover yield per plot (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.14. 18 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 yield (t ha^{-1}) + stover yield (t ha^{-1})

3.14. 19 Harvest Index (%)

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

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

3.15 Statistical data analysis

The collected data were compiled and analysed 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

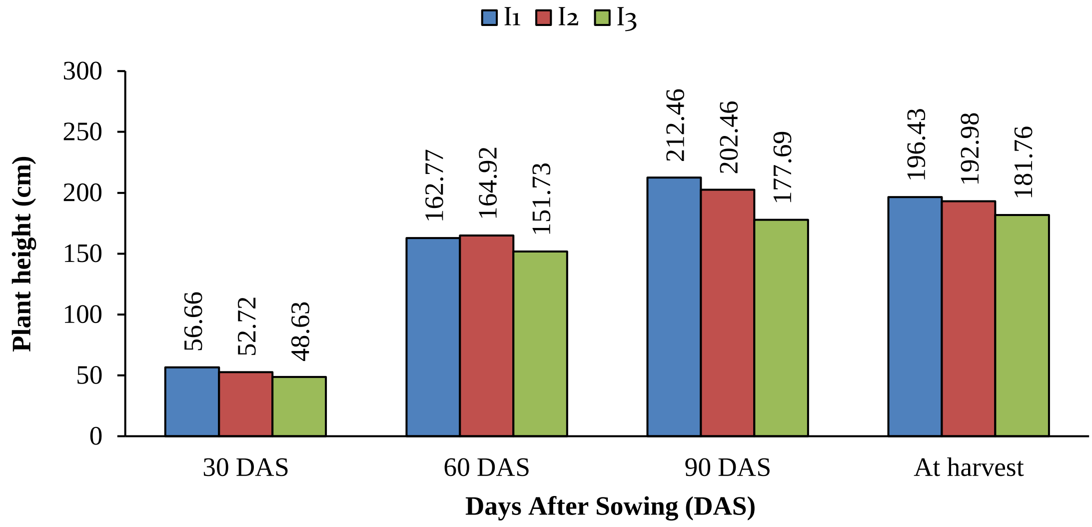
The data on different growth, yield contributing characters and yield were recorded to find out the compatible irrigation frequency and spacing on white maize. The results have been presented and discussed and possible explanation have been given under the following headings:

4.1 Plant growth parameters

4.1.1 Plant height (cm)

4.1.1.1 Effect of irrigation frequency

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. From this experiment, result revealed that different irrigation frequencies showed significant effect on plant height of white maize at different days after sowing (Figure 1 and Appendix V). The maximum plant height (56.66 cm) at 30 DAS was observed in I_1 treatment. At 60 DAS the maximum plant height (164.92 cm) was observed in I_2 treatment which was statistically similar with I_1 (162.77 cm) treatment. At 90 DAS and at harvest respectively the maximum plant height (212.46 and 196.43 cm) was observed in I_1 treatment which was statistically similar with I_2 (202.46 and 192.98 cm) treatment at 90 DAS and at harvest respectively. Whereas the minimum plant height (48.63, 151.73, 177.69 and 181.76 cm at 30, 60, 90 DAS and at harvest respectively) was observed in I_3 treatment. Baloch *et al*. (2014) reported that delayed 1st irrigation up to 30 days after sowing impacted the plant height adversely. Elzubeir and Mohamed (2011) also reported that 10 days irrigation interval gave the highest values of plant height (201 & 205 cm) compeered to others irrigation intervals in both years (2005/06 and 2006/07).

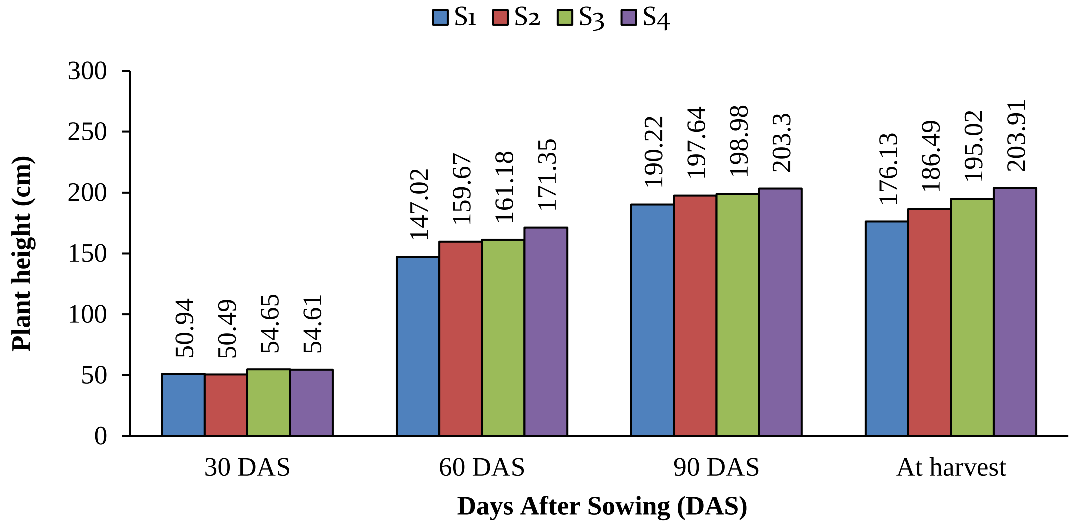


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 1 Effect of irrigation frequencies on plant height of white maize at different DAS (LSD $_{(0.05)}$ =3.55, 10.32, 11.92 and 5.08 cm at 30, 60, 90 DAS and at harvest, respectively).

4.1.1.2 Effect of spacing

Different spacing showed significant effect on plant height of white maize at different days after sowing (Figure 2 and Appendix V). From the experiment result it is revealed that the maximum plant height (54.65 cm) at 30 DAS was observed in S_3 treatment which was statistically similar with S_4 (54.61 cm) treatment. At 60, 90 DAS and at harvest respectively the maximum plant height (171.35, 203.30 and 203.91 cm) was observed in S_4 treatment which was statistically similar with S_3 (198.98 cm) and S_4 (197.64 cm) treatment at 90 DAS. Whereas at 30 DAS the minimum plant height (50.49 cm) was observed in S_2 treatment which was statistically similar with S_1 (50.94 cm) treatment. At 60, 90 DAS and at harvest, respectively the minimum plant height (147.02, 190.22 and 176.13 cm) was observed in S_1 treatment. Alam *et al*. (2020) and Ahmmed *et al*. (2020) also found similar result which supported the present study.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 2 Effect of spacing on plant height of white maize at different DAS (LSD $_{(0.05)}$ = 2.68, 10.06, 6.85 and 4.18 cm at 30, 60, 90 DAS and at harvest, respectively).

4.1.1.3 Combined effect of irrigation frequency and spacing

Combined effect of irrigation frequency and spacing showed significant effect on plant height of white maize (Table 1). From the experiment result it is exhibited that the maximum plant height (58.84 cm) at 30 DAS was observed in I_1S_3 treatment combination which was statistically similar with I_1S_1 (56.38 cm), I_1S_2 (56.15 cm), I_2S_4 (55.80 cm) and I_1S_4 (55.28 cm) treatment combination. At 60, 90 DAS and at harvest, respectively the maximum plant height (186.16, 217.39 and 213.80 cm) was observed in I_1S_4 treatment combination which was statistically similar with I_2S_4 (171.73 cm), I_1S_3 (169.86 cm), I_2S_1 (168.93 cm) and I_3S_2 (168.86 cm) at 60 DAS; with I_1S_2 (216.29 cm), I_1S_3 (210.19 cm) , I_2S_4 (208.46) , and I_1S_1 (205.96 cm) treatment combination at 90 DAS; and with I_2S_4 (207.02 cm) treatment combination at harvest, respectively. Whereas the minimum plant height (43.99 cm) at 30 DAS was observed in I_3S_2 treatment combination which was statistically similar with I_3S_1 (45.23 cm) treatment combination. At 60, 90 DAS and at harvest, respectively the minimum plant height (129.27, 161.39 and 173.53 cm) was observed in I_3S_1 treatment combination which was statistically similar with I_1S_1 (142.86 cm) treatment combination at 60 DAS; with

I_2S_1 (174.51 cm), I_3S_2 (178.55 cm) and I_1S_1 (180.35 cm) treatment combination at harvest respectively.

Table 1: Combined effect of different irrigation frequencies and spacings on plant height of white maize at different DAS

Treatment combinations	Plant height (cm) at			
	30 DAS	60 DAS	90 DAS	At harvest
I_1S_1	56.38 ab	142.86 ef	205.96 ab	180.35 ef
I_1S_2	56.15 ab	152.19 de	216.29 a	189.67 d
I_1S_3	58.84 a	169.86 a-c	210.19 ab	201.89 bc
I_1S_4	55.28 a-c	186.16 a	217.39 a	213.80 a
I_2S_1	51.22 c	168.93 a-d	203.29 b	174.51 f
I_2S_2	51.33 c	157.95 b-e	198.79 bc	191.25 d
I_2S_3	52.55 bc	161.06 b-d	199.29 bc	199.15 c
I_2S_4	55.80 a-c	171.73 ab	208.46 ab	207.02 ab
I_3S_1	45.23 d	129.27 f	161.39 e	173.53 f
I_3S_2	43.99 d	168.86 a-d	177.83 d	178.55 ef
I_3S_3	52.56 bc	152.63 c-e	187.46 cd	184.03 de
I_3S_4	52.75 bc	156.16 b-e	184.06 d	190.91 d
LSD (0.05)	4.65	17.42	11.86	7.24
CV (%)	5.14	6.35	3.50	2.22

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

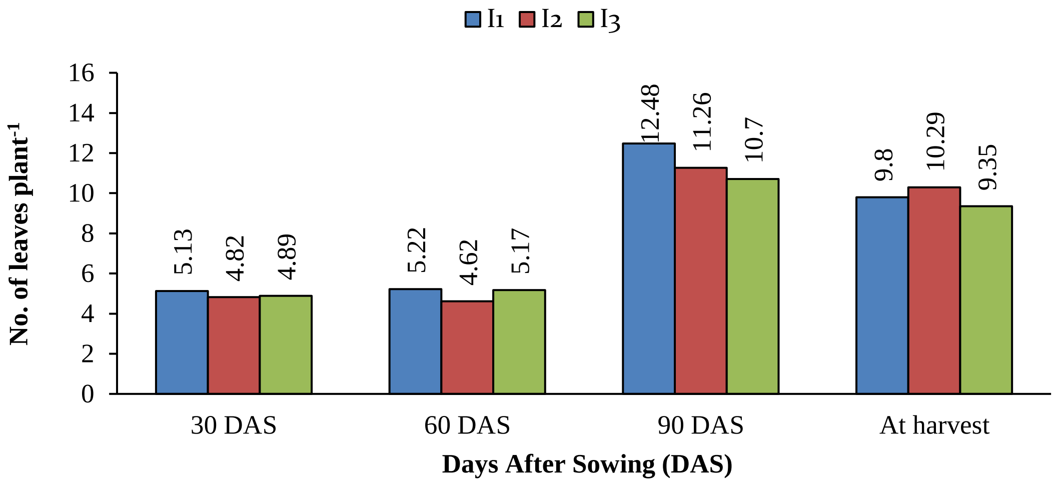
NS: Non-significant
I_1: Irrigation at 20 days interval
I_2: Irrigation at 25 days interval
I_3: Irrigation at 30 days interval

S_1: 50 cm × 20 cm
S_2: 50 cm × 25 cm
S_3: 60 cm × 20 cm
S_4: 60 cm × 25 cm

4.1.2 No. of leaves plant^{-1}

4.1.2.1 Effect of irrigation frequency

A leaf is the principal lateral appendage of the vascular plant stem, usually borne above ground and specialized for photosynthesis. Different irrigation frequencies showed significant variation on number of leaves plant^{-1} of white maize at different days after sowing (Figure 3 and Appendix VI). From the experiment result it is observed that the maximum number of leaves plant^{-1} (5.13, 5.22 and 12.48 at 30, 60 and 90 DAS) was observed in I_1 treatment which was statistically similar with I_3 (4.89 and 5.17) treatment at 30 and 60 DAS. At harvest respectively the maximum number of leaves plant^{-1} (10.29) was observed in I_2 treatment. Whereas the minimum number of leaves plant^{-1} (4.82 and 4.62) at 30 and 60 DAS was observed in I_2 treatment, at 90 DAS and at harvest, respectively the minimum number of leaves plant^{-1} (10.70 and 9.35) was observed in I_3 treatment which was statistically similar with I_2 (11.26) treatment at 90 DAS. Baloch *et al*. (2014) reported that number of green leaves in maize for fodder production is a quantity parameter; but this trait is generally influenced by level of input application. The results in regards to the number of green leave plant^{-1} of fodder maize as influenced by different irrigation intervals. They revealed that the maximum number of green leaves plant^{-1} (13.42) on average was achieved in crop given 1st irrigation at 20 days after sowing, 2nd at 35 days and 3rd after 50 days of sowing (T_1); by the delay in the first irrigation the number of green leaves plant^{-1} slightly decreased to (12.70) and (11.10) in T_3 and T_4 treatments, respectively. The result was similar to the present study and found that delayed irrigation time exerted impact on number of leaves plant^{-1} of white maize.

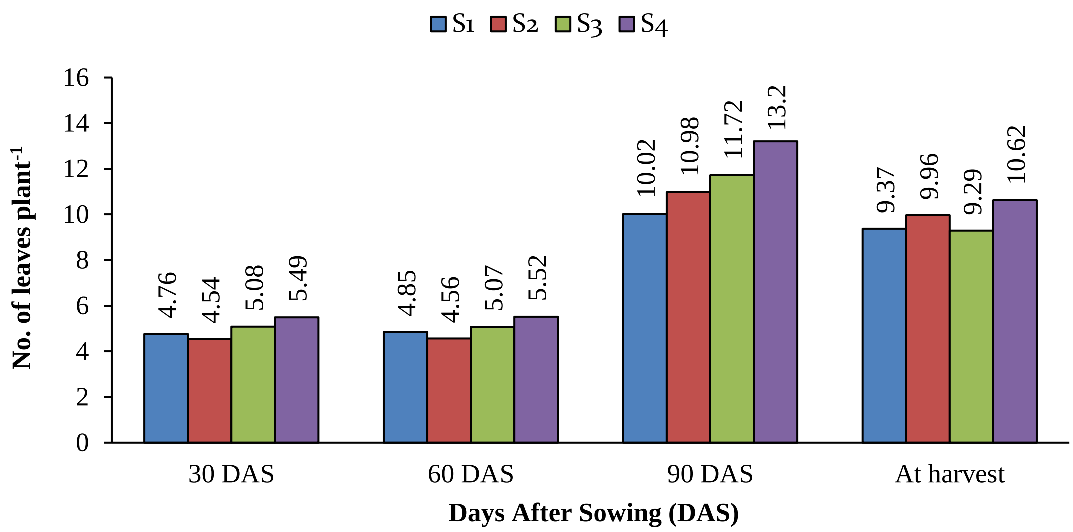


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 3 Effect of irrigation frequencies on number of leaves plant^{-1} of white maize at different DAS (LSD $_{(0.05)}$ =0.26 , 0.33, 1.03 and 0.37at 30, 60, 90 DAS and at harvest, respectively).

4.1.2.2 Effect of spacing

Different spacing showed significant effect on number of leaves plant^{-1} of white maize at various days after sowing (Figure 4 and Appendix VI). The maximum number of leaves plant^{-1} of white maize (5.49, 5.52, 13.20 and 10.62 at 30, 60, 90 DAS and at harvest, respectively) was observed in S_4 treatment. Whereas the minimum number of leaves plant^{-1} of white maize (4.54 and 4.56 at 30 and 60 DAS) was observed in S_2 treatment, at 90 DAS the minimum number of leaves plant^{-1} of white maize (10.02) was observed in S_1 treatment and at harvest respectively the minimum number of leaves plant^{-1} of white maize (9.29) was observed in S_3 treatment which was statistically similar with S_1 (9.37) treatment.Ahmed *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.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 4 Effect of spacing on number of leaves plant^{-1} of white maize at different DAS (LSD $_{(0.05)}$ = 0.21, 0.26, 0.81 and 0.31at 30, 60, 90 DAS and at harvest, respectively).

4.1.2.3 Combined effect of irrigation frequency and spacing

Combined effect of different irrigation frequency and spacing showed significant effect on number of leaves plant^{-1} of white maize at various days after sowing (Table 2). From the experiment result exhibited that the maximum number of leaves plant^{-1} of white maize (5.85, 6.11, 14.75 and 11.06 at 30, 60, 90 DAS and at harvest respectively) was observed in I_1S_4 treatment combination, which was statistically similar with I_2S_2 (11.06) and I_2S_4 (10.62) treatment combination at harvest. Whereas the minimum number of leaves plant^{-1} of white maize (4.32 and 4.12 at 30 and 60 DAS) was observed in I_2S_2 treatment combination which was statistically similar with I_3S_1 (4.34), I_1S_2 (4.62) and I_3S_2 (4.68) treatment combination at 30 DAS and with I_2S_1 (4.12) treatment combination at 60 DAS. At 90 DAS the minimum number of leaves plant^{-1} of white maize (9.87) was observed in I_3S_1 treatment combination which was statistically similar with I_2S_2 (10.09), I_2S_1 (10.09), I_3S_2 (10.09), I_1S_1 (10.09) and I_3S_3 (10.31) treatment combination. And at harvest respectively the minimum number of leaves plant^{-1} of white maize (9.06) was observed in I_3S_3 treatment combination which was statistically similar with I_3S_1(9.08), I_3S_2(9.08), I_1S_3 (9.08) and I_1S_1 (9.30) treatment combination.

Table 2: Combined effect of irrigation frequency and spacing on number of plant^{-1} of white maize at different DAS

Treatment combinations	Number of leaves at			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
I_1S_1	5.06 bc	5.00 bc	10.09 c	9.30 de
I_1S_2	4.62 ef	4.78 c	12.75 b	9.74 cd
I_1S_3	4.99 cd	5.00 bc	12.31 b	9.08 e
I_1S_4	5.85 a	6.11 a	14.75 a	11.06 a
I_2S_1	4.89 c-e	4.12 d	10.09 c	9.74 cd
I_2S_2	4.32 f	4.12 d	10.09 c	11.06 a
I_2S_3	5.10 bc	5.22 bc	12.53 b	9.74 cd
I_2S_4	4.96 c-e	5.00 bc	12.31 b	10.62 ab
I_3S_1	4.34 f	5.44 b	9.87 c	9.08 e
I_3S_2	4.68 d-f	4.78 c	10.09 c	9.08 e
I_3S_3	5.16 bc	5.00 bc	10.31 c	9.06 e
I_3S_4	5.38 b	5.44 b	12.53 b	10.18 bc
LSD (0.05)	0.36	0.45	1.40	0.53
CV (%)	4.18	5.27	7.11	3.16

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

NS: Non-significant

I_1: Irrigation at 20 days interval

I_2: Irrigation at 25 days interval

I_3: Irrigation at 30 days interval

S_1: 50 cm × 20 cm

S_2: 50 cm × 25 cm

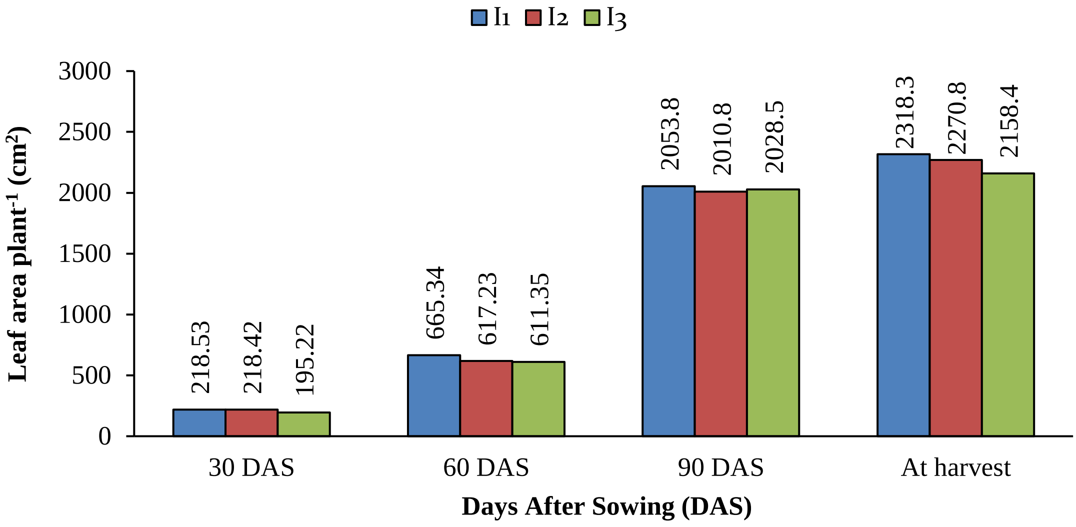
S_3: 60 cm × 20 cm

S_4: 60 cm × 25 cm

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

4.1.3.1 Effect of irrigation frequency

Leaves are one of the most important organs that plants have. Photosynthesis is the process by which plants produce food using light, carbon dioxide (CO_2), and water, takes place in leaves. The structure and makeup of leaves are designed for photosynthesis. Light is captured by chloroplasts in leaves, if the leaf area increases it captures more light energy to produce food. Carbon dioxide is taken in through stomata, or openings on the underside of leaves. Higher concentrations of carbon dioxide make plants more productive because photosynthesis relies on using the sun's energy to synthesis sugar out of carbon dioxide and water. Plants and ecosystems use the sugar both as an energy source and as the basic building block for growth. Leaf area influence the carbon dioxide uptake by plant and thus influence growth of the plant. Due to different irrigation frequencies, significant effect was observed only at 30, 60 DAS and harvest, in leaf area plant^{-1} (cm^2) of white maize (Figure 5 and Appendix VII). From the experiment result showed that the maximum leaf area plant^{-1} (218.53, 665.34, 2053.8 and 2318.3 at 30, 60, 90 DAS and at harvest, respectively) was observed in I_1 treatment which was statistically similar with I_2 (218.42 and 2270.8) treatment at 30 DAS and at harvest, respectively. Whereas the minimum leaf area plant^{-1} (195.22 and 611.35b cm^2 at 30 and 60 DAS) was I_3 treatment which was statistically similar with I_2 (617.23 cm^2) treatment at 60 DAS. At 90 DAS the minimum leaf area plant^{-1} (2010.8 cm^2) was observed in I_2 treatment. And at harvest the minimum leaf area plant^{-1} (2158.4 cm^2) was observed in I_3 treatment. Appropriate irrigation frequency reduces water stress condition of the plant. If the irrigation frequency delayed it will cause water stress and reduction of soil moisture resulted in reduction of the total amount of leaf area developed which ultimately impact on dry matter production and reduction of the yield of the plant.

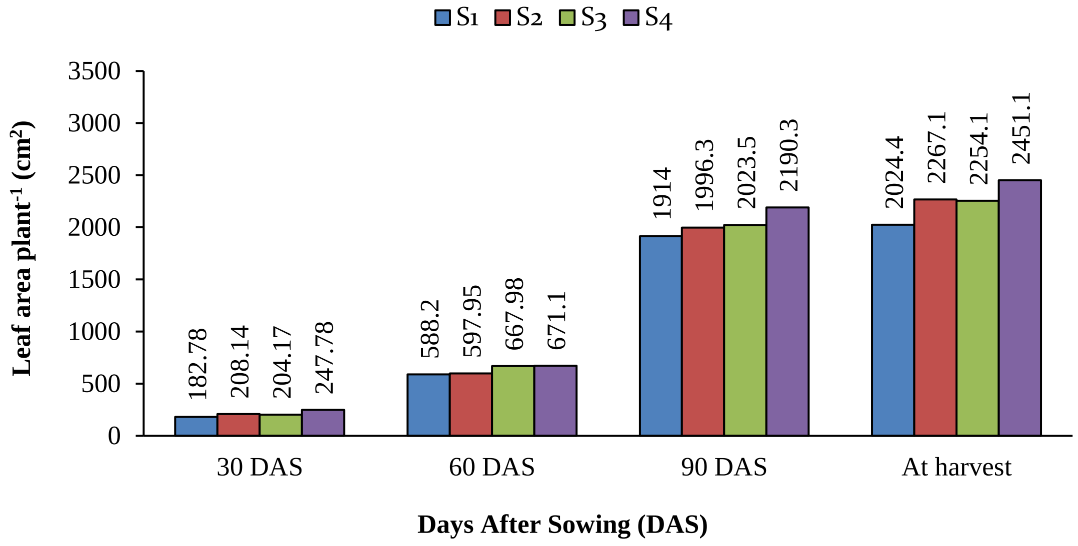


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 5 Effect of irrigation frequencies on leaf area plant^{-1} of white maize at different DAS (LSD $_{(0.05)}$ =4.22, 38.16, NS and 103.47cm^2 at 30, 60, 90 DAS and at harvest, respectively).

4.1.3.2 Effect of spacing

Different spacing showed significant effect on leaf area plant^{-1} of white maize at various days after sowing (Figure 6 and Appendix VII). From the experiment result exhibited that the maximum leaf area plant^{-1} (247.78, 671.10, 2190.3 and 2451.1 cm^2 at 30, 60, 90 DAS and at harvest respectively) was observed in S_4 treatment, which was statistically similar with S_3 (667.98 cm^2) treatment at 60 DAS. Whereas the minimum leaf area plant^{-1} (182.78, 588.20, 1914.0 and 2024.4 cm^2 at 30, 60, 90 DAS and at harvest respectively) was observed in S_1 treatment, which was statistically similar with S_2 (597.95 cm^2) treatment at 60 DAS. Different spacing influence on leaf area of the plant. 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 Enujeke (2013 a).



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 6 Effect of spacing on leaf area plant^{-1}of white maize at different DAS (LSD $_{(0.05)}$ = 3.33, 30.79, 63.93 and 80.87at 30, 60, 90 DAS and at harvest, respectively).

4.1.3.3 Combined effect of irrigation frequency and spacing

Combined effect of irrigation frequency and spacing showed significant effect on leaf area plant^{-1} (cm^2) of white maize at various days after sowing (Table 3). From the experiment result showed that the maximum leaf area plant^{-1} (272.81, 736.24, 2407.5 and 2780.1 cm^2 at 30, 60, 90 DAS and at harvest respectively) was observed in I_1S_4 treatment combination, which was statistically similar with I_1S_3 (721.97 cm^2) treatment combination at 60 DAS. Whereas the minimum leaf area plant^{-1} (106.07, 560.27, 1820.9 and 1935.1 cm^2 at 30, 60, 90 DAS and at harvest respectively) was observed in I_3S_1 treatment combination, which was statistically similar with I_3S_2 (581.19 cm^2), I_1S_1 (598.40 cm^2), I_1S_2 (604.74 cm^2), I_2S_1 (605.91 cm^2) and I_2S_2 (607.92 cm^2) treatment combination at 60 DAS; with I_1S_3 (1890.6 cm^2) treatment combination at 90 DAS; and with I_1S_1 (1988.6 cm^2), I_3S_2 (2030.4 cm^2) I_1S_3 (2082.1 cm^2) treatment combination at harvest, respectively.

Table 3: Combined effect of irrigation frequency and spacing on leaf area plant^{-1} of white maize at different DAS

Treatment combinations	Plant leaf area at			
	30 DAS	60 DAS	90 DAS	At harvest
I_1S_1	197.32 f	598.40 cd	1948.0 cd	1988.6 fg
I_1S_2	184.99 g	604.74 b-d	1969.1 cd	2422.6 b
I_1S_3	218.99 d	721.97 a	1890.6 de	2082.1 ef
I_1S_4	272.81 a	736.24 a	2407.5 a	2780.1 a
I_2S_1	244.96 c	605.91 b-d	1973.0 cd	2149.4 de
I_2S_2	222.34 d	607.92 b-d	1979.7 cd	2348.3 bc
I_2S_3	187.32 g	631.34 bc	2057.8 bc	2318.1 bc
I_2S_4	219.05 d	623.75 bc	2032.5 bc	2267.3 cd
I_3S_1	106.07 h	560.27 d	1820.9 e	1935.1 g
I_3S_2	217.10 d	581.19 cd	2040.0 bc	2030.4 e-g
I_3S_3	206.21 e	650.63 b	2122.1 b	2362.1 bc
I_3S_4	251.48 b	653.30 b	2131.0 b	2305.9 bc
LSD $_{(0.05)}$	5.78	53.33	110.73	140.06
CV (%)	1.60	4.92	3.18	3.63

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

NS: Non-significant

I_1: Irrigation at 20 days interval

I_2: Irrigation at 25 days interval

I_3: Irrigation at 30 days interval

S_1: 50 cm × 20 cm

S_2: 50 cm × 25 cm

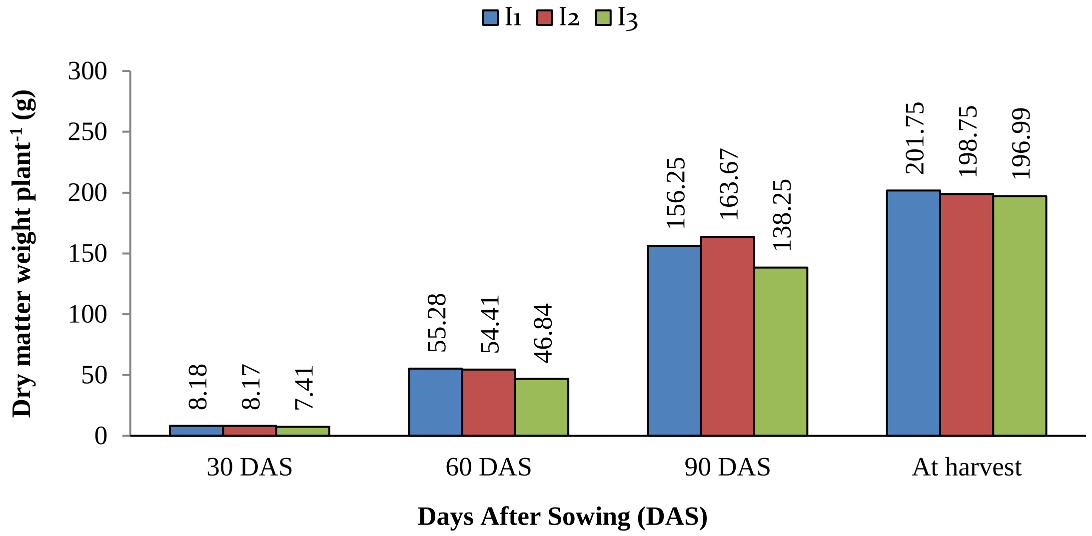
S_3: 60 cm × 20 cm

S_4: 60 cm × 25 cm

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

4.1.4.1 Effect of irrigation frequency

The dry matter of plant consists of all its constituents excluding water. Irrigation frequency showed significant effect on dry matter weight plant^{-1} of white maize at various days after sowing (Figure 7 and Appendix VIII). From the result of the experiment, it is observed that the maximum dry matter plant^{-1} (8.18 and 55.28 g at 30 and 60 DAS) was observed in I_1 treatment which was statistically similar with I_2 (8.17 and 54.41 g) treatment at 30 and 60 DAS. At 90 DAS the maximum dry matter plant^{-1} (163.67 g) was observed in I_2 treatment which was statistically similar with I_1 (156.25 g) treatment. And at harvest the maximum dry matter plant^{-1} (201.75 g) was observed in I_1 treatment which was statistically similar with I_2 (198.75 g) treatment. Whereas the minimum dry matter plant^{-1} (7.41, 46.84, 138.25 and 196.99 g at 30, 60, 90 DAS and at harvest respectively) was observed in I_3 treatment. Irrigation frequency established a nearly constant water regime in the root zone and ensured that plants grew under proper soil water conditions for optimum production of the dry biomass of the plant which ultimately influence proper growth and development of the plant. Taiz and Zeiger (2009) reported that the low availability of water may interfere with the photosynthetic activity, reducing the growth and, consequently reducing the biomass accumulation of the plants.

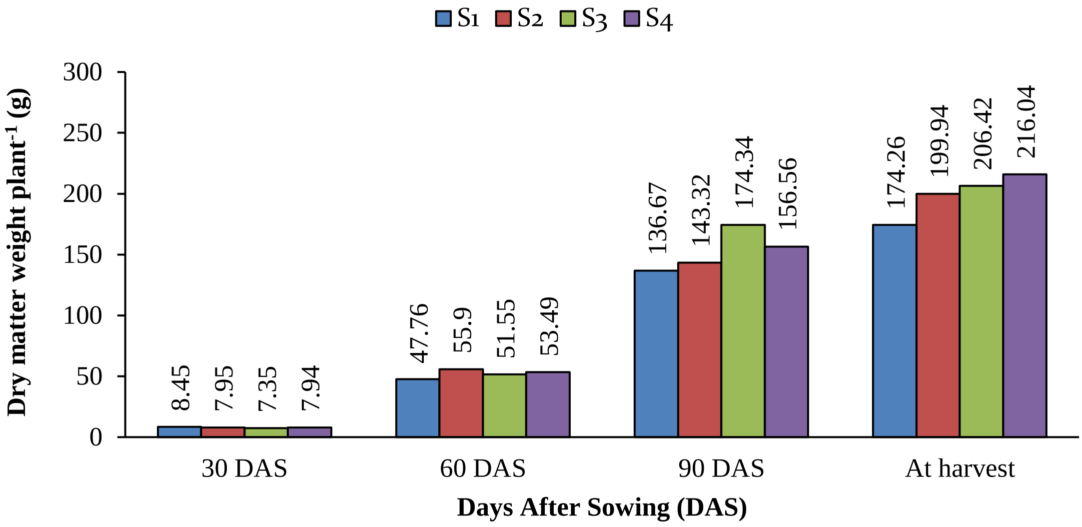


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 7 Effect of irrigation frequencies on dry matter weight plant^{-1} of white maize at different DAS (LSD $_{(0.05)}$ = 0.56, 4.37, 11.26 and 4.45 g at 30, 60, 90 DAS and at harvest, respectively).

4.1.4.2 Effect of spacing

Spacing showed significant effect on dry matter weight plant^{-1} of white maize at various days after sowing (Figure 8 and Appendix VIII). From the experiment result exhibited that the maximum dry matter weight plant^{-1} (8.45 g at 30 DAS) was observed in S_1 treatment which was statistically similar with S_2 (7.95 g) and S_4 (7.94 g) treatment. At 60 DAS the maximum dry matter weight plant^{-1} (55.90 g) was observed in S_2 treatment which was statistically similar with S_4 (53.49 g). At 90 DAS the maximum dry matter weight plant^{-1} (174.34 g) was observed in S_3 treatment and finally at harvest the maximum dry matter weight plant^{-1} (216.04 g) was observed in S_4 treatment. Whereas the minimum dry matter weight plant^{-1} (7.35 g at 30 DAS) was observed in S_3 treatment. At 60, 90 DAS and at harvest, respectively the minimum dry matter weight plant^{-1} (47.76, 136.67 and 174.26 g) was observed in S_1 treatment which was statistically similar with S_3 (51.55 g) at 60 DAS; and with S_2 (143.32) treatment at 90 DAS. Getaneh *et al.* (2016) reported that the highest above ground dry biomass yields plant^{-1} was occurred at the widest inter and intra-row spacing, might be due to high stem diameter and high leaf area because there is more availability of growth factors and better penetration of light at wider row spacing.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 8 Effect of spacing on dry matter weight plant^{-1}of white maize at different DAS (LSD $_{(0.05)}$ = 0.53, 3.85, 9.91 and 4.45 g at 30, 60, 90 DAS and at harvest, respectively).

4.1.4.3 Combined effect of irrigation frequency and spacing

The dry matter weight plant^{-1} of white maize at different days after sowing varied significantly for the combined application of irrigation frequencies and spacing (Table 4). From the experiment result showed that the maximum dry matter weight plant^{-1} (9.92 g at 30 DAS) was observed in I_2S_1 treatment combination which was statistically similar with I_1S_1 (9.91 g), I_3S_4(9.43 g) and I_2S_2 (9.37 g) treatment combination. At 60 DAS the maximum dry matter weight plant^{-1} (59.28 g) was observed in I_2S_1 treatment combination which was statistically similar with I_1S_2 (58.73 g), I_1S_3 (58.04 g), I_1S_4(57.77 g), I_2S_4 (54.73 g), I_2S_2 (54.55 g) and I_3S_2 (54.43 g) treatment combination. At 90 DAS the maximum dry matter weight plant^{-1} (179.10 g) was observed in I_1S_3 treatment combination which was statistically similar with I_3S_3(176.76 g), I_2S_4(174.69 g), I_1S_4(171.40 g), I_2S_3 (167.18 g) and I_2S_2 (163.92 g) treatment combination. And at harvest the maximum dry matter weight plant^{-1} (218.31 g) was observed in I_1S_4 treatment combination which was statistically similar with I_2S_4 (215.69 g) and I_3S_4 (214.12 g) treatment combination. Whereas the minimum dry matter weight plant^{-1} (5.51 and 37.43 g at 30 and 60 DAS) was observed in I_3S_1 treatment combination. At 90 DAS the minimum dry matter weight plant^{-1} (123.50 g) was observed in I_3S_2 treatment combination which was statistically similar with I_3S_4 (123.60 g), I_3S_1 (129.15 g), and I_1S_1 (131.97 g) treatment combination at 90 DAS. And at harvest the minimum dry matter weight plant^{-1} (169.59 g) was observed in I_2S_1 treatment combination which was statistically similar with I_1S_1(173.99 g) treatment combination.

Table 4: Combined effect of irrigation frequency and spacing on dry matter plant^{-1} of white maize at different DAS

Treatment combinations	Plant dry matter (g) at			
	30 DAS	60 DAS	90 DAS	At harvest
I_1S_1	9.91 a	46.57 d	131.97 c-e	173.99 fg
I_1S_2	7.34 b-d	58.73 a	142.55 cd	206.08 cd
I_1S_3	8.04 b	58.04 a	179.10 a	208.63 bc
I_1S_4	7.44 bc	57.77 a	171.40 a	218.31 a
I_2S_1	9.92 a	59.28 a	148.88 bc	169.59 g
I_2S_2	9.37 a	54.55 a-c	163.92 ab	200.84 d
I_2S_3	6.44 d	49.08 b-d	167.18 a	208.90 bc
I_2S_4	6.94 cd	54.73 ab	174.69 a	215.69 ab
I_3S_1	5.51 e	37.43 e	129.15 de	179.21 f
I_3S_2	7.13 b-d	54.43 a-c	123.50 e	192.90 e
I_3S_3	7.56 bc	47.55 d	176.76 a	201.73 cd
I_3S_4	9.43 a	47.96 cd	123.60 e	214.12 ab
LSD (0.05)	0.91	6.66	17.16	7.71
CV (%)	6.73	7.45	6.55	2.26

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

NS: Non-significant
I_1: Irrigation at 20 days interval
I_2: Irrigation at 25 days interval
I_3: Irrigation at 30 days interval

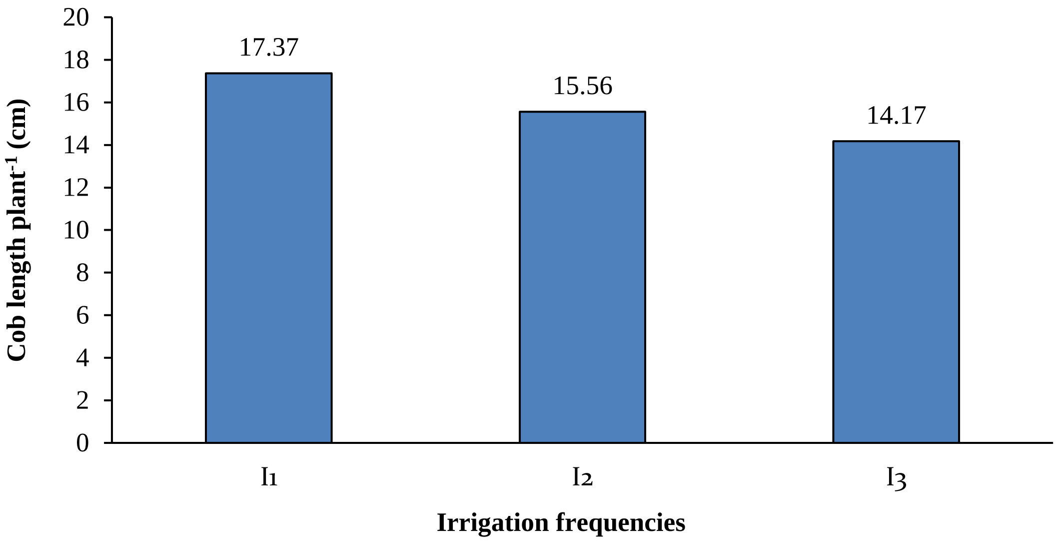
S_1: 50 cm × 20 cm
S_2: 50 cm × 25 cm
S_3: 60 cm × 20 cm
S_4: 60 cm × 25 cm

4.2 Yield contributing characters

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

4.2.1.1 Effect of irrigation frequency

Irrigation frequency showed significant variation in respect of cob length plant^{-1} of white maize (Figure 9 and Appendix IX). From the experiment result revealed that the maximum cob length plant^{-1} (17.37 cm) was observed in I_1 treatment whereas the minimum cob length plant^{-1} (14.17 cm) was observed in I_3 treatment. Elzubeir and Mohamed (2011) reported that prolonging irrigation intervals reduce cob length. The result was similar with the present study.

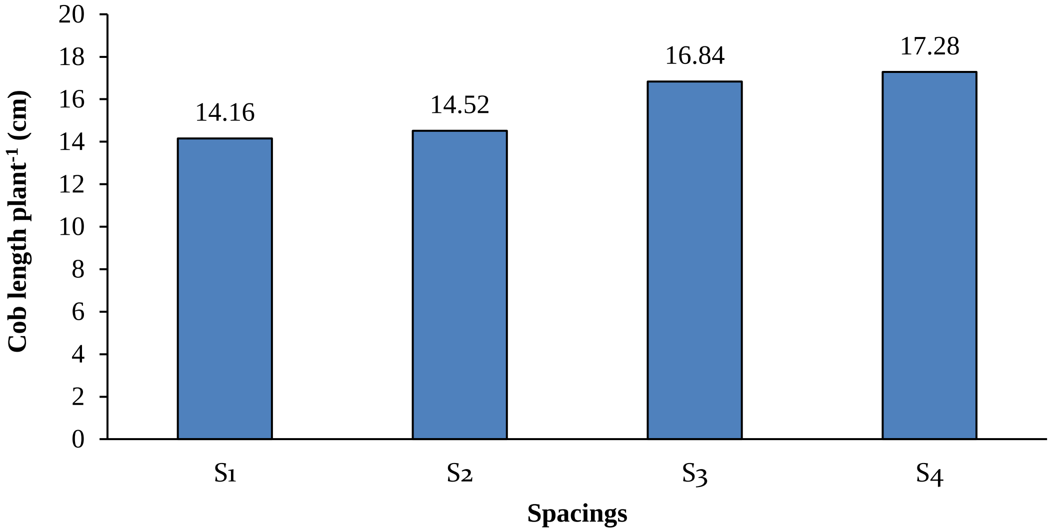


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 9 Effect of irrigation frequencies on cob length plant^{-1} of white maize (LSD $_{(0.05)}$ = 1.15).

4.2.1.2 Effect of spacing

Spacing showed significant variation in respect of cob length plant^{-1} of white maize (Figure 10 and Appendix IX). The experiment result revealed that the maximum cob length plant^{-1} (17.28 cm) was observed in S_4 treatment which was statistically similar with S_3 (16.84 cm) treatment whereas the minimum cob length plant^{-1} (14.16 cm) was observed in S_1 treatment which was statistically similar with S_2 (14.52 cm) treatment. These results agreed with Alam *et al*. (2020) and Koirala *et al*. (2020).



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 10 Effect of spacings on cob length plant^{-1} of white maize (LSD $_{(0.05)}$ = 0.67).

4.2.1.3 Combined effect of irrigation frequency and spacing

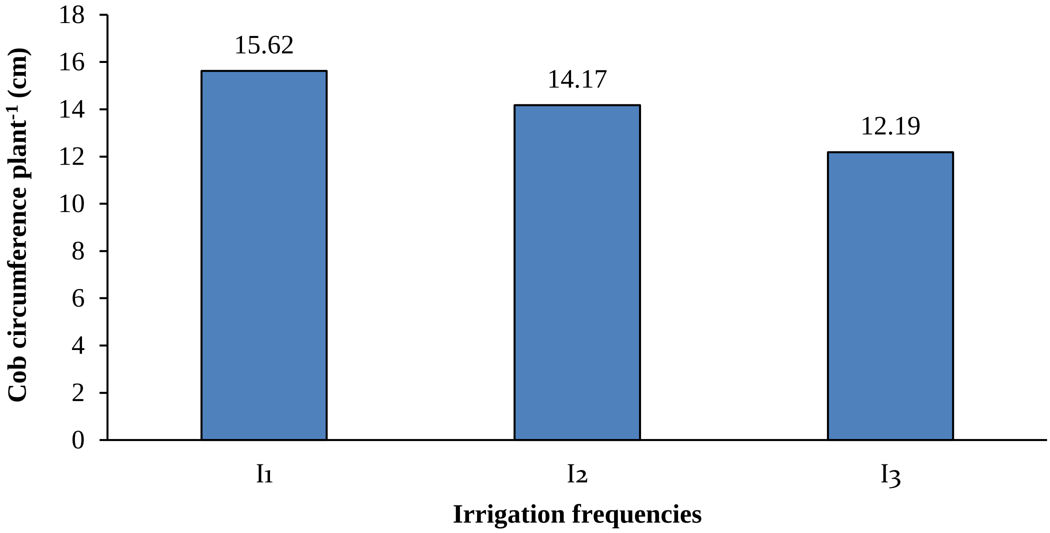
The combined effect of irrigation frequency and spacing showed significant variation in respect of cob length plant^{-1} of white maize (Table 5). From the experiment result exhibited that the maximum cob length plant^{-1} (18.00 cm) was observed in I_1S_4 treatment combination which was statistically similar with I_1S_3 (17.99 cm), I_2S_4 (17.61 cm) and I_1S_2 (17.07 cm) treatment combination. Whereas the minimum cob length plant^{-1} (12.38 cm) was observed in I_3S_1 treatment combination which was statistically similar with I_3S_2 (12.38) treatment combination.

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

4.2.2.1 Effect of irrigation frequency

Irrigation frequency showed significant variation in respect of cob circumference plant^{-1} of white maize (Figure 11 and Appendix IX). From the experiment result revealed that the maximum cob circumference plant^{-1} (15.62 cm) was observed in I_1

treatment. Whereas the minimum cob circumference plant^{-1} (12.19 cm) was observed in I_3 treatment.

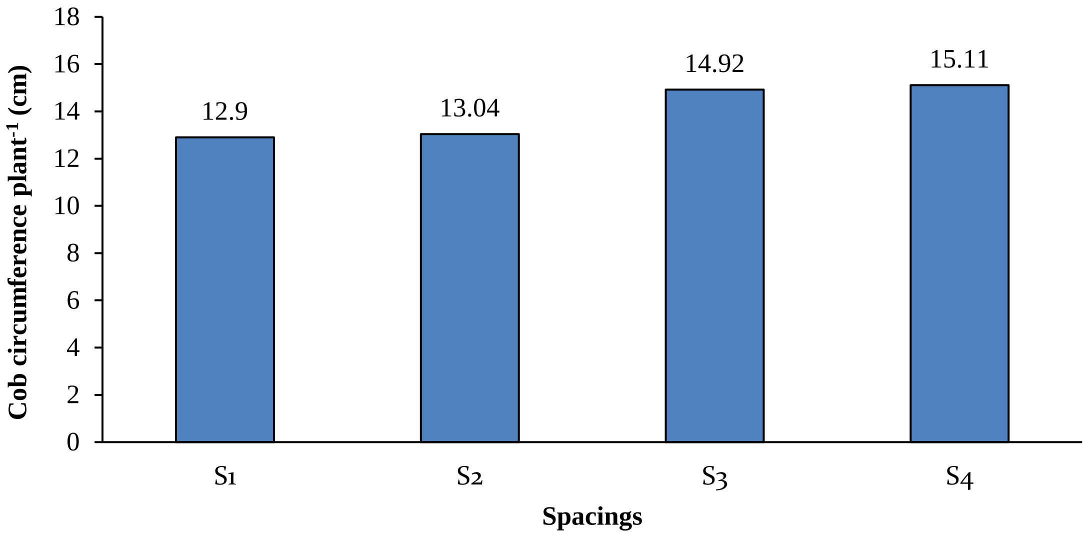


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 11 Effect of irrigation frequencies on cob circumference plant^{-1} of white maize (LSD $_{(0.05)}$ = 1.14).

4.2.2.2 Effect of spacing

Spacing showed significant variation in respect of cob circumference plant^{-1} of white maize (Figure 12 and Appendix IX). From the experiment result revealed that the maximum cob circumference plant^{-1} (15.11 cm) was observed in S_4 treatment which was statistically similar with S_3 (14.92 cm) treatment Whereas the minimum cob circumference plant^{-1} (12.90 cm) was observed in S_1 treatment which was statistically similar with S_2 (13.04 cm) treatment. Ahmmed *et al.* (2020) and Hasan *et al*. (2018) 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.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 12 Effect of spacings on cob circumference plant^{-1} of white maize (LSD $_{(0.05)}$ = 0.66).

4.2.2.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of cob circumference plant^{-1} of white maize (Table 5). From the experiment result exhibited that the maximum cob circumference plant^{-1} (16.20 cm) was observed in I_1S_4 treatment combination which was statistically similar with I_1S_3 (15.85 cm), I_2S_4 (15.66 cm), I_1S_2 (15.61 cm), and I_2S_3 (15.18 cm), treatment combination. Whereas the minimum cob circumference plant^{-1} (10.56 cm) was observed in I_3S_2 treatment combination which was statistically similar with I_3S_1 (11.00 cm) treatment combination.

Table 5: Combined effect of irrigation frequency and spacing on cob length and cob circumference plant^{-1} of white maize

Treatment combinations	Cob length plant^{-1}	Cob circumference plant^{-1}
I_1S_1	16.43 cd	14.82 bc
I_1S_2	17.07 a-c	15.61 ab
I_1S_3	17.99 a	15.85 ab
I_1S_4	18.00 a	16.20 a
I_2S_1	13.83 e	12.88 d
I_2S_2	14.10 e	12.95 d
I_2S_3	16.69 b-d	15.18 ab
I_2S_4	17.61 ab	15.66 ab
I_3S_1	12.23 f	11.00 e
I_3S_2	12.38 f	10.56 e
I_3S_3	15.83 d	13.72 cd
I_3S_4	16.23 cd	13.47 d
$LSD_{(0.05)}$	1.16	1.14
CV (%)	4.29	4.81

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

NS: Non-significant

I_1: Irrigation at 20 days interval

I_2: Irrigation at 25 days interval

I_3: Irrigation at 30 days interval

S_1: 50 cm × 20 cm

S_2: 50 cm × 25 cm

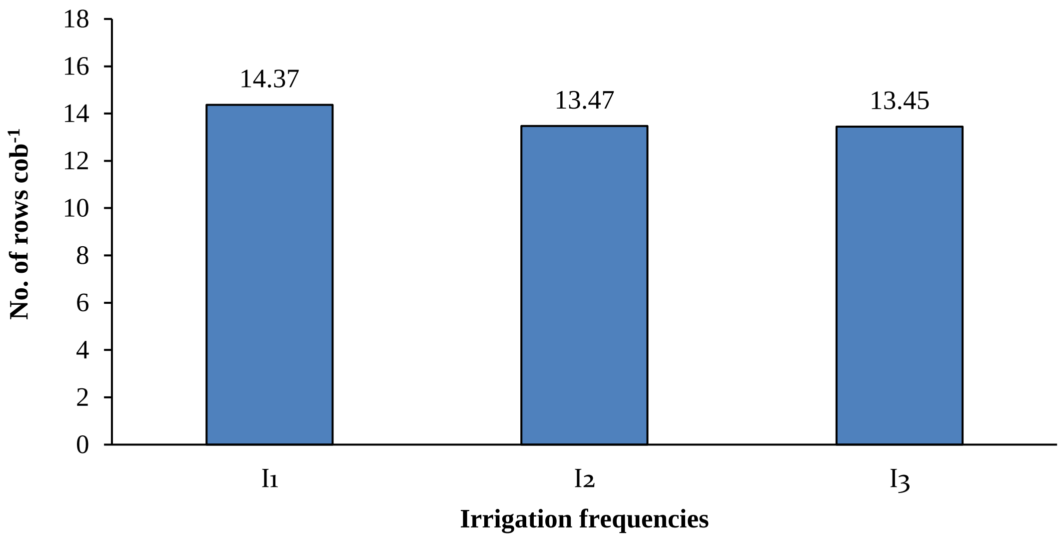
S_3: 60 cm × 20 cm

S_4: 60 cm × 25 cm

4.2.3 No. of rows cob^{-1}

4.2.3.1 Effect of irrigation frequency

Irrigation frequency showed significant effect on number of rows cob^{-1} of white maize (Figure 13 and Appendix X). From the experiment it is result revealed that the maximum number of rows cob^{-1} (14.37) was observed in I_1 treatment. Whereas the minimum number of rows cob^{-1} (13.45) was observed in I_3 treatment which was statistically similar with I_2 (13.47) treatment. Elzubeir and Mohamed (2011) reported that prolonging watering intervals reduced the number of rows cob^{-1}, this reduction was due to the reason that prolonging watering intervals causes water stress/ low water levels condition surrounding by the root zone of the plant. With low water levels condition it reducing the plant's ability to photosynthesize, the plant's system processes slow down, causing reduced or delayed growth and discoloration of leaves, as well as flower or fruit drop, since the plant can't support this extra baggage which ultimately impact grain production as a result it causes reduction of number of rows cob^{-1}.

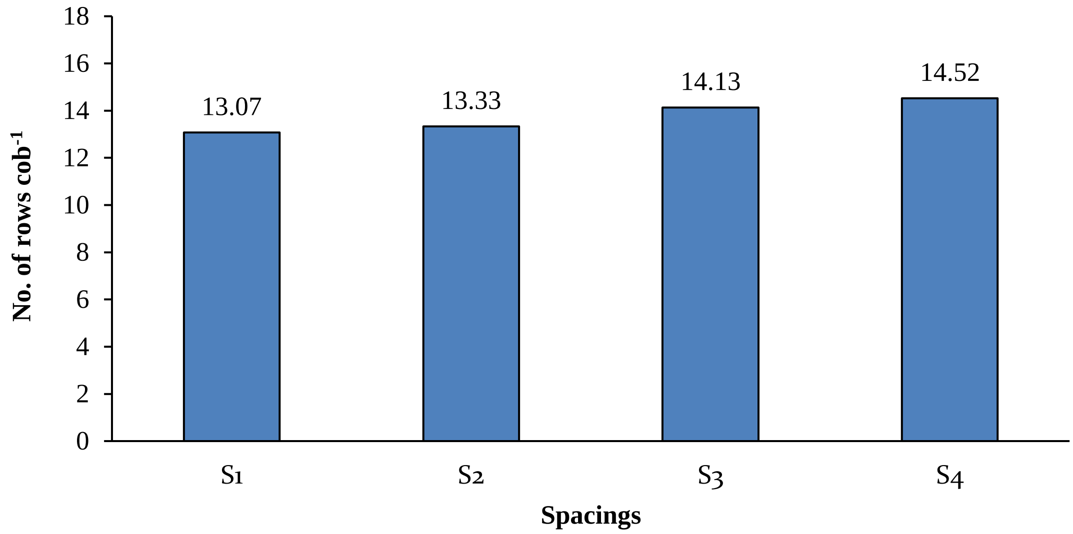


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 13 Effect of irrigation frequencies on number of rows cob^{-1} of white maize (LSD $_{(0.05)}$ = 0.42).

4.2.3.2 Effect of spacing

Spacing showed significant effect on number of rows cob^{-1} of white maize (Figure 14 and Appendix X). From the experiment result revealed that the maximum number of rows cob^{-1} (14.52) was observed in S_4 treatment. Whereas the minimum number of rows cob^{-1} (13.07) was observed in S_1 treatment which was statistically similar with S_2 (13.33) treatment. This could be due to the fact that at closer spacing or high plant densities, there may be intense intra plant 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 cobs 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}. Azam (2017) and Rahman *et al*. (2016) also found similar result which supported the present finding.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 14 Effect of spacings on number of rows cob^{-1} of white maize (LSD $_{(0.05)}$ = 0.36).

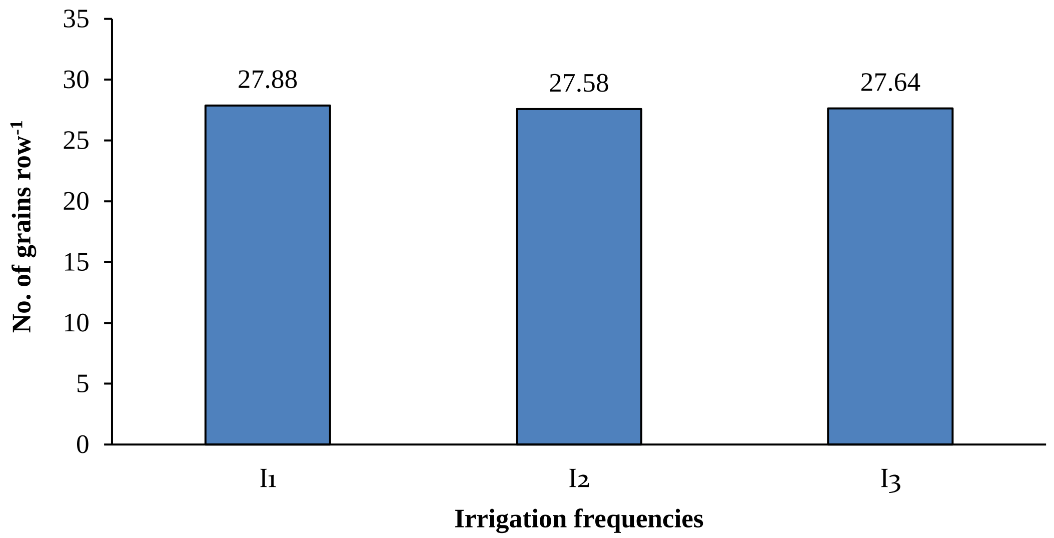
4.2.3.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of number of rows cob^{-1} of white maize (Table 6). From the experiment result exhibited that the maximum number of rows cob^{-1} (15.67) was observed in I_1S_4 treatment combination which was statistically similar with I_1S_3 (15.28) treatment combination. Whereas the minimum number of rows cob^{-1} (13.00) was observed in I_3S_1treatment combination which was statistically similar with all other treatment except I_2S_4 (13.89), I_3S_4(14.00), I_1S_3(15.28) and I_1S_4 (15.67) treatment combination.

4.2.4 No. of grains row^{-1}

4.2.4.1 Effect of irrigation frequency

Non-significant variation was observed on number of grains row^{-1} of white maize due to irrigations frequencies (Figure 15 and Appendix X). From the experiment result iit is revealed that the maximum number of grains row^{-1} (27.88) was observed in I_1 treatment. Whereas the minimum number of grains row^{-1}(27.64) was observed in I_3 treatment.

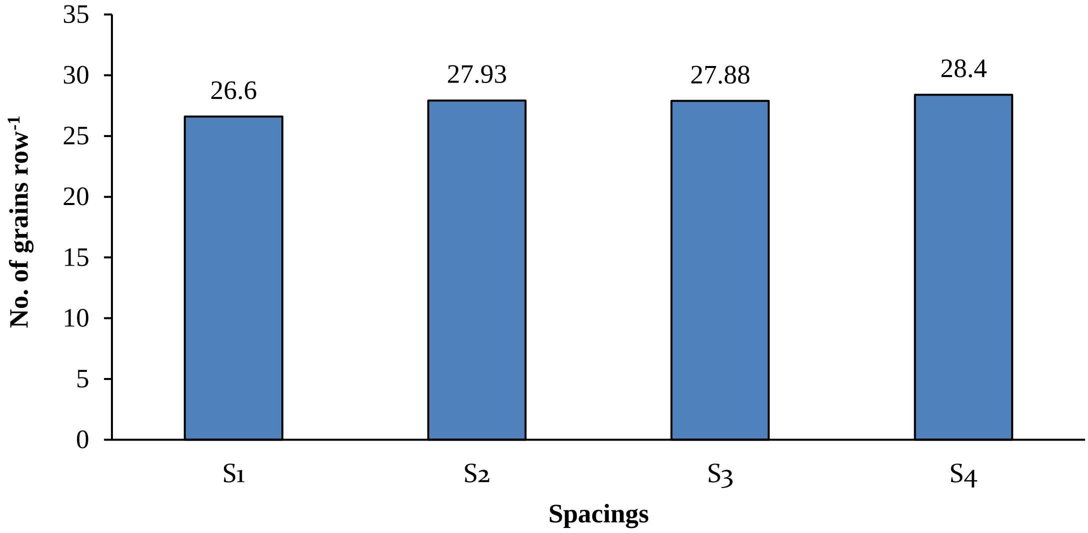


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 15 Effect of irrigation frequencies on number of grains row^{-1} of white maize (LSD $_{(0.05)}$ = NS).

4.2.4.2 Effect of spacing

Spacing showed significant effect on number of grains row^{-1} of white maize (Figure 16 and Appendix X). Experiment result revealed that the maximum number of grains row^{-1} (28.40) was observed in S_4 treatment. Whereas the minimum number of grains row^{-1} (26.60) was observed in S_1 treatment. Eyasu *et al.* (2018) and Rahman *et al.* (2016) also found similar result which supported the present finding.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 16 Effect of spacings on number of grains row^{-1} of white maize (LSD $_{(0.05)}$ = 0.44).

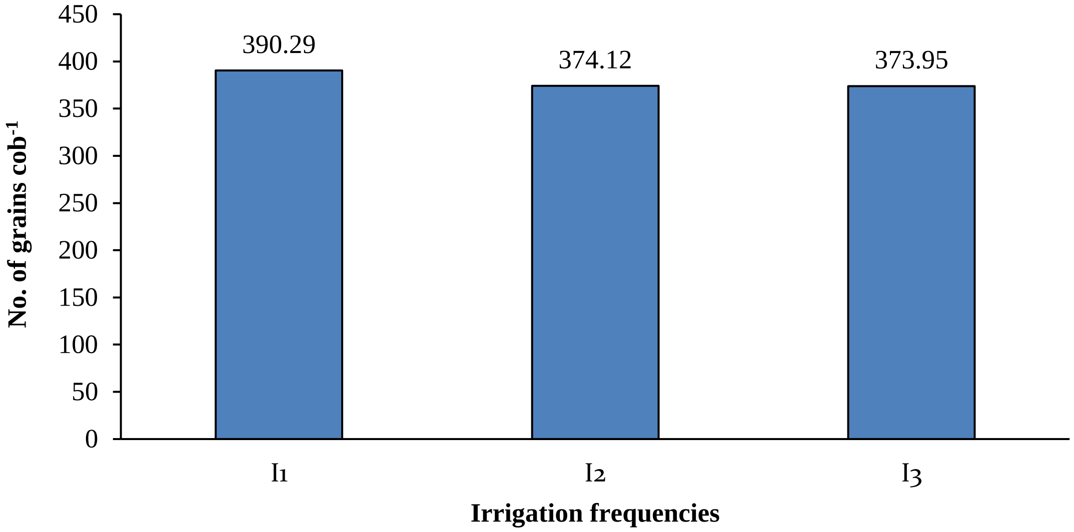
4.2.4.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of number of grains row^{-1} of white maize (Table 6). Experiment result exhibited that the maximum number of grains row^{-1} (28.66) was observed in I_1S_4 treatment combination which was statistically similar with I_3S_3 (28.56), I_1S_2 (28.44), I_2S_4 (28.33), I_3S_4 (28.22) and I_2S_2 (27.89) treatment combination. Whereas the minimum number of grains row^{-1} (26.34) was observed in I_3S_1 treatment combination which was statistically similar with I_1S_1 (26.56), and I_2S_1 (26.89) treatment combination.

4.2.5 No. of grains cob^{-1}

4.2.5.1 Effect of irrigation frequency

Significant variation was observed on number of grains cob^{-1} of white maize due to irrigations frequencies (Figure 17 and Appendix X). Experiment result revealed that the maximum number of grains cob^{-1} (390.29) was observed in I_1 treatment. Whereas the minimum number of grains cob^{-1} (373.95) was observed in I_3 treatment which was statistically similar with I_2 (374.12) treatment. Elzubeir and Mohamed (2011) reported that frequent/short irrigation interval would provide the crop with adequate moisture in the surface layer in which most of the maize roots exists, thus resulting in better crop nourishment and consequently higher yield. Also, the final grain yield depends upon the number of seeds/cobs produced and extent to which the grains are filled. Water deficits affected the number of seeds/cobs thereby compounding the effects on final grain yield. These results agreed with the present study.

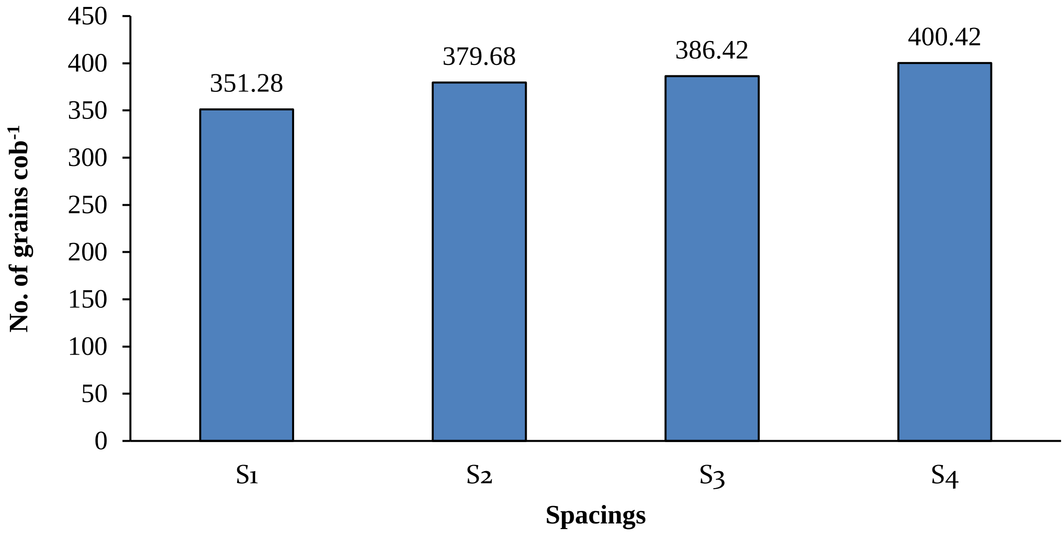


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 17 Effect of irrigation frequencies on number of grains cob^{-1} of white maize (LSD $_{(0.05)}$ = 16.03).

4.2.5.2 Effect of spacing

Spacing showed significant effect on number of grains cob^{-1} of white maize (Figure 18 and Appendix X). From the experiment result revealed that the maximum number of grains cob^{-1} (400.42) was observed in S_4 treatment. Whereas the minimum number of grains cob^{-1} (351.28) was observed in S_1 treatment. Ahmmed *et al.* (2020) concluded that in respect of the spacing effect, the wider spacing showed the highest number of grains per cob compared to other spacings.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 18 Effect of spacings on number of grains cob^{-1} of white maize (LSD $_{(0.05)}$ = 10.40).

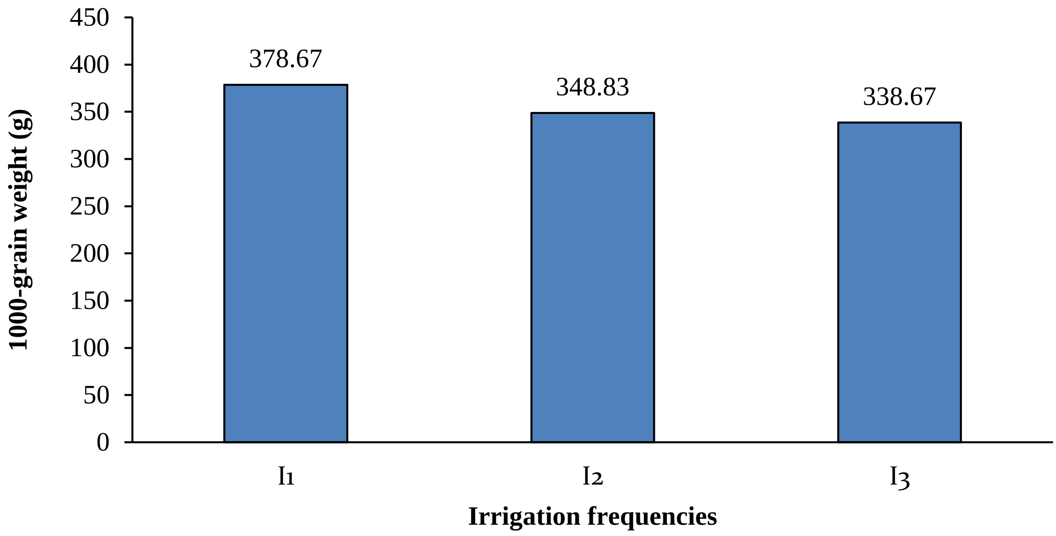
4.2.5.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of number of grains cob^{-1} of white maize (Table 6). From the experiment result exhibited that the maximum number of grains cob^{-1} (419.22) was observed in I_1S_4 treatment combination which was statistically similar with I_1S_3 (414.72) and I_3S_4 (404.32) treatment combination. Whereas the minimum number of grains cob^{-1} (341.75) was observed in I_3S_1 treatment combination which was statistically similar with I_1S_1 (347.61) treatment combination.

4.2.6 1000-grain weight (g)

4.2.6.1 Effect of irrigation frequency

Significant variation was observed on 1000 grains weight (g) of white maize due to irrigations frequencies (Figure 19 and Appendix X). Experiment result revealed that the maximum 1000-grain weight (378.67 g) was observed in I_1 treatment. Whereas the minimum 1000-grain weight (338.67 g) was observed in I_3 treatment which was statistically similar with I_2 (348.83 g) treatment. This happened due to the timely unhindered supply of irrigation water which kept soil as moist condition in the root zone of the plant and helps in uptake proper nutrient and reduce stress condition which ultimately increased the 1000-seed weight as well as seed yield of the plant. Shen *et al.* 2020, Abd El-Halim and Abd El-Razek (2013) and Elzubeir and Mohamed (2011) also found similar result which supported the present finding.

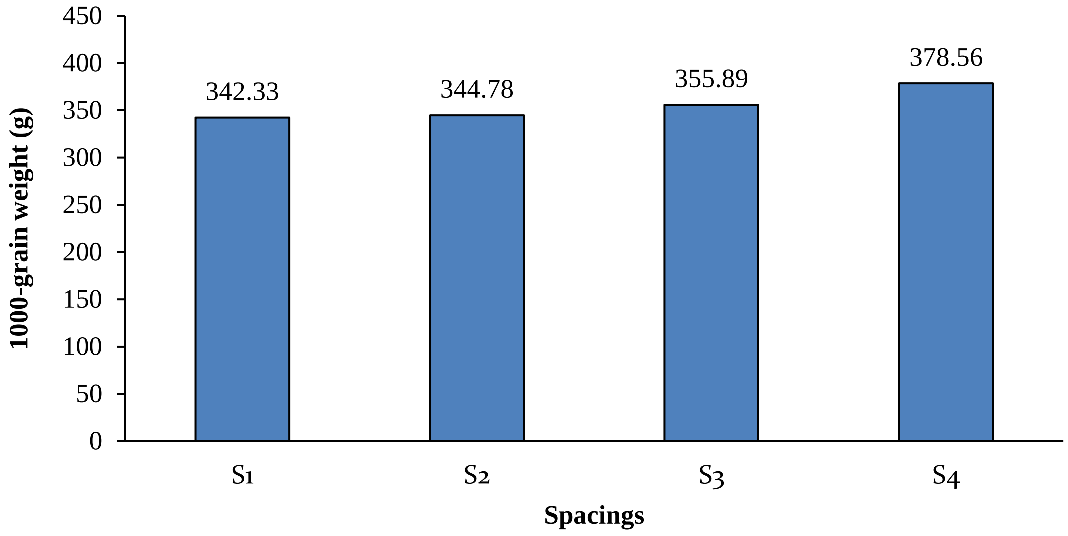


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 19 Effect of irrigation frequencies on 1000 grains weight (g) of white maize (LSD $_{(0.05)}$ = 12.54).

4.2.6.2 Effect of spacing

On 1000 grains weight (g) of white maize, spacing had a significant influence (Figure 20 and Appendix X). The maximum 1000 grain weight (396.67 g) was observed in the S4 treatment, according to the experiment results. In the S1 treatment, the minimum 1000 grain weight (372.22 g) was observed. Similar results were observed by Koirala et al. (2020), Hasan et al. (2018), and Azam (2017), which validated the current investigation.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 20 Effect of spacings on 1000-grain weight (gm) of white maize (LSD $_{(0.05)}$ = 9.89).

4.2.6.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of 1000 grains weight (g) of white maize (Table 6). From the experiment result it is exhibited that the maximum 1000 grains weight (413.67 g) was observed in I_1S_4 treatment combination. Whereas the minimum 1000 grains weight (320.33 g) was observed in I_3S_1 treatment combination which was statistically similar with I_3S_2 (333.67 g) and I_2S_2 (333.67 g) treatment combination.

Table 6: Combined effect of irrigation frequency and spacing on no. of row cob^{-1}, no. grains row^{-1}, no. of grains cob^{-1} and 1000 grains weight of white maize

Treatment combinations	No. of row cob^{-1}	No. grains row^{-1}	Total no. of grains cob^{-1}	1000 grains weight (g)
I_1S_1	13.09 d	26.56 fg	347.61 ef	360.33 b-d
I_1S_2	13.45 b-d	28.44 ab	379.59 cd	367.00 bc
I_1S_3	15.28 a	27.87 b-d	414.72 a	373.67 b
I_1S_4	15.67 a	28.66 a	419.22 a	413.67 a
I_2S_1	13.11 d	26.89 e-g	364.49 de	346.33 de
I_2S_2	13.33 cd	27.89 a-d	387.35 bc	333.67 ef
I_2S_3	13.56 b-d	27.22 d-f	366.91 d	347.00 de
I_2S_4	13.89 bc	28.33 ab	377.73 cd	368.33 bc
I_3S_1	13.00d	26.34 g	341.75 f	320.33 f
I_3S_2	13.22 d	27.45 c-e	372.10 cd	333.67 ef
I_3S_3	13.56 b-d	28.56 ab	377.63 cd	347.00 de
I_3S_4	14.00 b	28.22 a-c	404.32 ab	353.67 cd
LSD $_{(0.05)}$	0.62	0.77	18.00	17.13
CV (%)	2.64	1.61	2.77	2.81

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

NS: Non-significant

I_1: Irrigation at 20 days interval

I_2: Irrigation at 25 days interval

I_3: Irrigation at 30 days interval

S_1: 50 cm × 20 cm

S_2: 50 cm × 25 cm

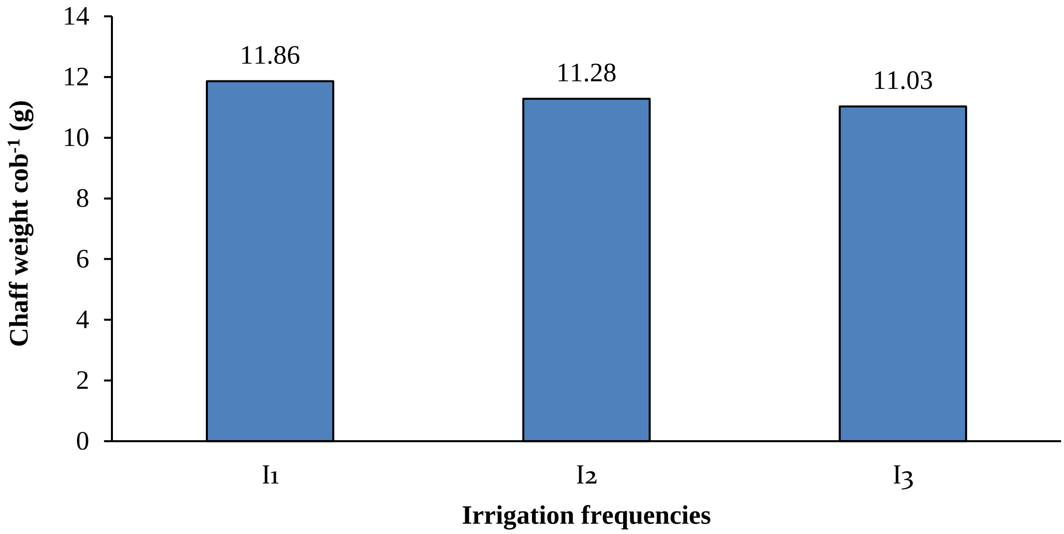
S_3: 60 cm × 20 cm

S_4: 60 cm × 25 cm

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

4.2.7.1 Effect of irrigation frequency

Different irrigation frequencies showed significant effect on chaff weight cob^{-1} (g) of white maize (Figure 21 and Appendix XI). From the experiment result it is exhibited that the maximum chaff weight cob^{-1} (11.86 g) was observed in I_1 treatment, which was statistically similar with I_2 (11.28 g) treatment, whereas the minimum chaff weight cob^{-1} (11.03 g) was observed in I_3 treatment.

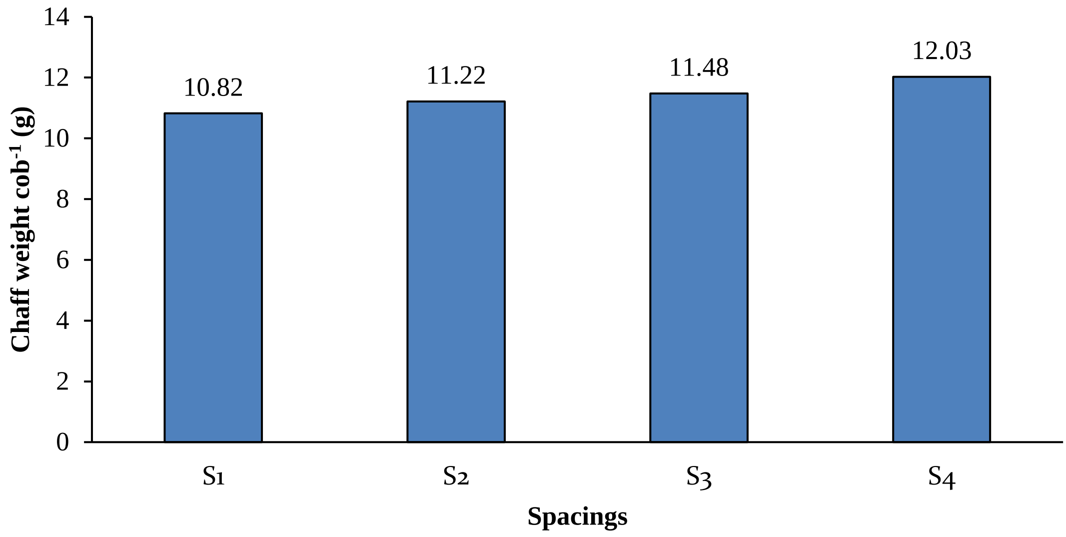


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 21 Effect of irrigation frequencies on chaff weight cob^{-1} (g) of white maize (LSD $_{(0.05)}$ = 0.64).

4.2.7.2 Effect of spacing

Different spacing had a significant effect on white maize chaff weight cob-1 (g) (Figure 22 and Appendix XI). The S4 treatment yielded the highest chaff weight cob^{-1} (12.03 g) in the experiment. The S1 treatment had the lowest chaff weight cob^{-1} (10.82 g), which was statistically similar to the S2 (11.22 g) treatment.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 22 Effect of spacings on chaff weight cob^{-1} (g) of white maize (LSD $_{(0.05)}$ = 0.52).

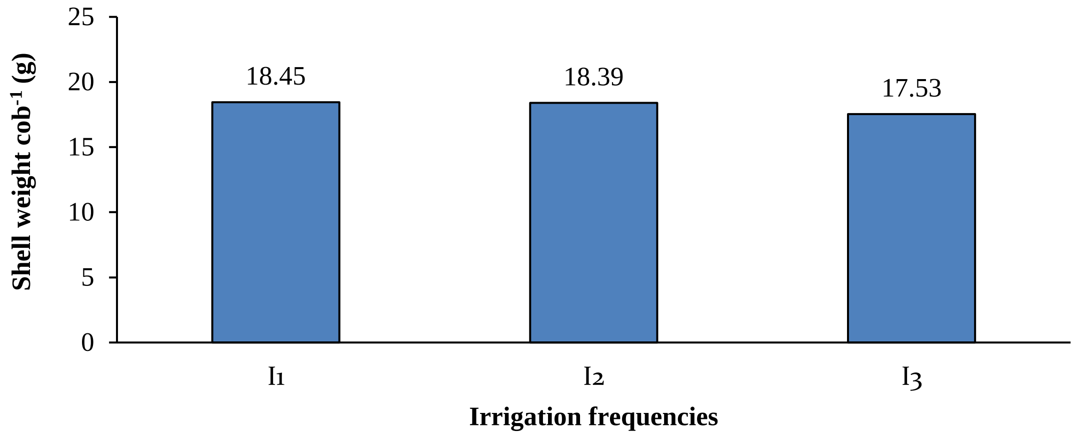
4.2.7.3 Combined effect of irrigation frequency and spacing

In terms of chaff weight cob-1 (g) of white maize, the combined effect of varying irrigation frequency and spacings exhibited significant variance (Table 7). The maximum chaff weight cob-1 (13.20 g) was seen in the I1S4 treatment combination, according to the results of the experiment. The least chaff weight cob-1 (10.67 g) was found in the I3S1 treatment combination, which was statistically similar to all other treatment combinations except I1S4 and I1S3 (11.78 g).

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

4.2.8.1 Effect of irrigation frequency

Different irrigation frequencies showed significant effect on shell weight cob^{-1} (g) of white maize (Figure 23 and Appendix XI). Experiment result exhibited that the maximum shell weight cob^{-1} (18.45 g) was observed in I_1 treatment, which was statistically similar with I_2 (18.39 g) treatment, whereas the minimum shell weight cob^{-1} (17.53 g) was observed in I_3 treatment.

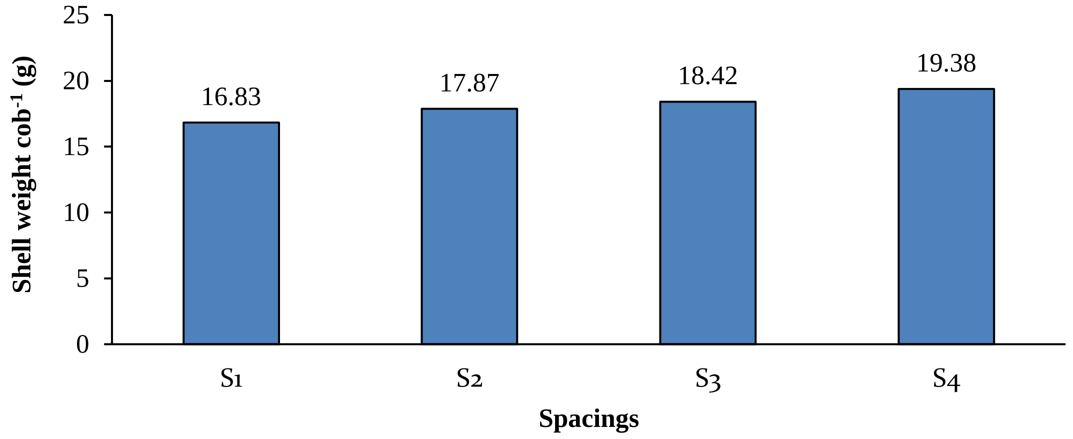


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 23 Effect of irrigation frequencies on shell weight cob^{-1} (g) of white maize (LSD $_{(0.05)}$ = 0.65).

4.2.8.2 Effect of spacing

The shell weight cob^{-1} (g) of white maize was significantly affected by different spacings (Figure 24 and Appendix XI). The largest shell weight cob^{-1} (19.38 g) was found in the S_4 treatment, according to the experiment results. In the S_1 treatment, the minimum shell weight cob^{-1}(16.83g) was recorded.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 24 Effect of spacings on shell weight cob^{-1} (g) of white maize (LSD $_{(0.05)}$ = 0.51).

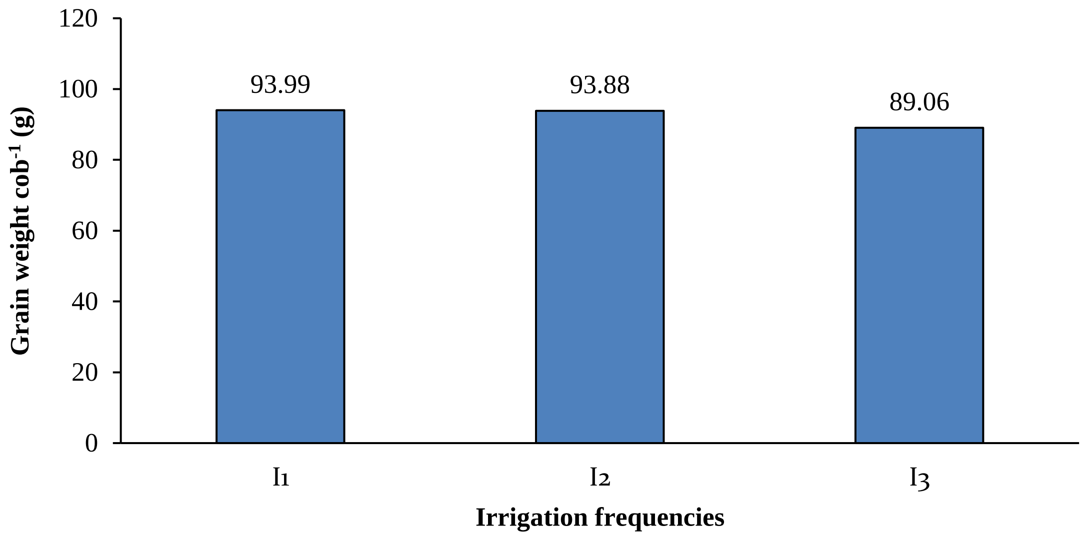
4.2.8.3 Combined effect of irrigation frequency and spacing

The combined effect of different irrigation frequencies and spacings showed significant variation in respect of shell weight cob^{-1} (g) of white maize (Table 7). From the experiment result exhibited that the maximum shell weight cob^{-1} (19.70 g) was observed in I_1S_4 treatment combination which was statistically similar with I_2S_4 (19.53 g) and I_1S_3 (18.92 g) treatment combination. Whereas the minimum shell weight cob^{-1} (15.43 gm) was observed in I_3S_1 treatment combination.

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

4.2.9.1 Effect of irrigation frequency

Because of the frequency of irrigations, significant fluctuation in grain weight cob^{-1} (g) of white maize was found (Figure 25 and Appendix XI). The largest grain weight cob^{-1} (93.99 g) was found in I_1 treatment, which was statistically equivalent to I2 (93.88 g) treatment, according to the experiment results. In the I_3 treatment, the minimum grain weight cob^{-1} (89.06 g) was recorded.

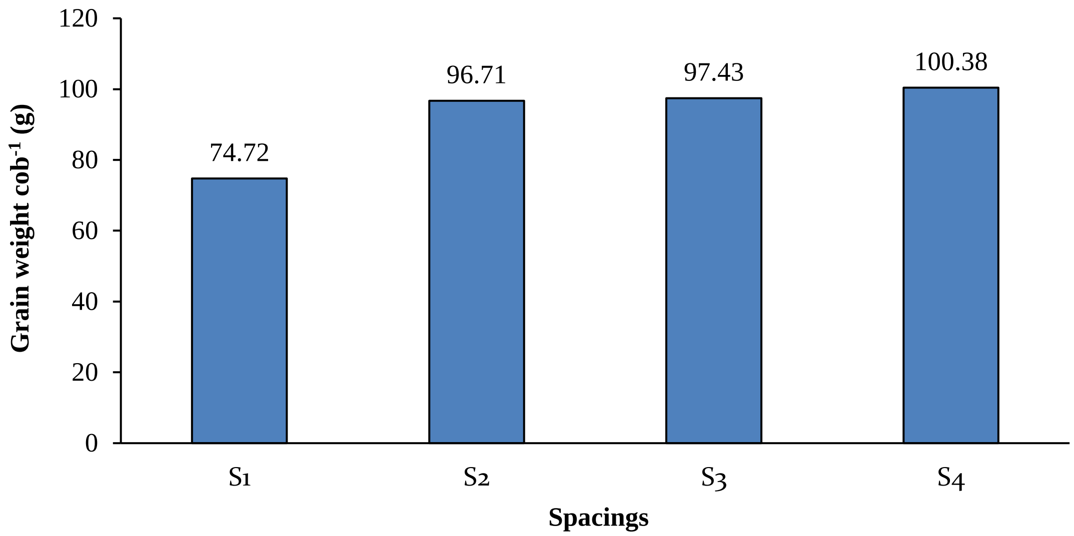


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 25 Effect of irrigation frequencies on grain weight cob^{-1} (g) of white maize (LSD $_{(0.05)}$ = 2.52).

4.2.9.2 Effect of spacing

Spacing showed significant effect on grain weight cob^{-1} (g) of white maize (Figure 26 and Appendix XI). From the experiment result revealed that the maximum grain weight cob^{-1} (100.38 g) was observed in S_4 treatment which was statistically similar with S_3 (97.43 g) treatment. Whereas the minimum grain weight cob^{-1} (74.72 g) was observed in S_1 treatment. Alam *et al*. (2020) found similar result which supported the present study.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 26 Effect of spacings on grain weight cob^{-1} (g) of white maize (LSD $_{(0.05)}$ = 3.54).

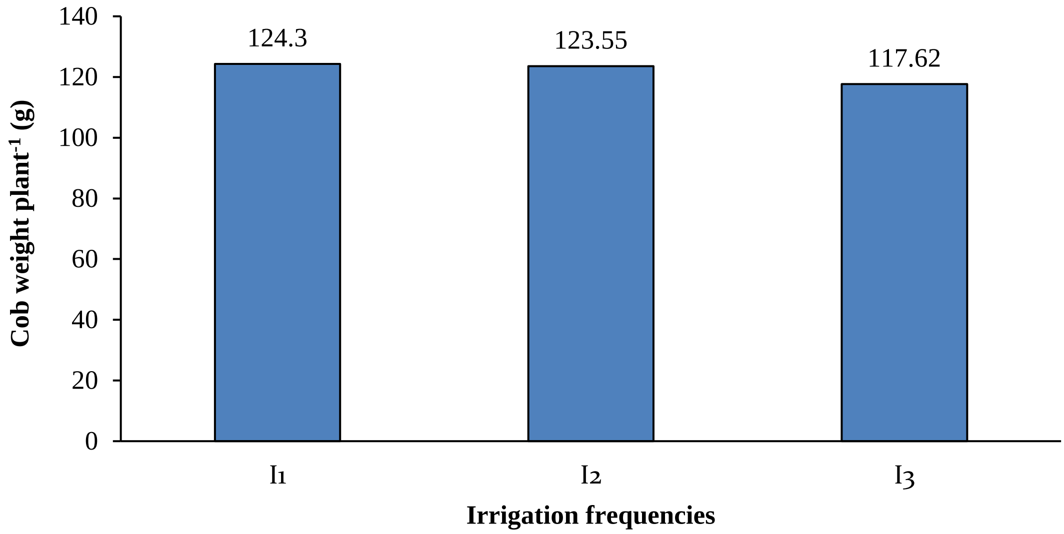
4.2.9.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of grain weight cob^{-1} of white maize (Table 7). From the experiment result exhibited that the maximum grain weight cob^{-1} (102.81 g) was observed in I_1S_4 treatment combination which was statistically similar with I_1S_3 (101.21 g), I_1S_2 (100.94 g), I_2S_4 (100.76 g), I_2S_2 (97.74 g) and I_3S_4 (97.58 g) treatment combination. Whereas the minimum grain weight cob^{-1} (70.99 g) was observed in I_1S_1 treatment combination which was statistically similar with I_3S_1 (72.42 g) treatment combination.

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

4.2.10.1 Effect of irrigation frequency

The frequency of irrigation had a significant impact on the cob weight plant^{-1} (g) of white maize (Figure 27 and Appendix XI). The maximum cob weight plant^{-1} (124.30 g) was seen in I_1 treatment, which was statistically similar to I_2 (123.55 g) treatment, according to the experiment results. In the I_3 treatment, the minimum cob weight plant^{-1} (117.62 g) was recorded.

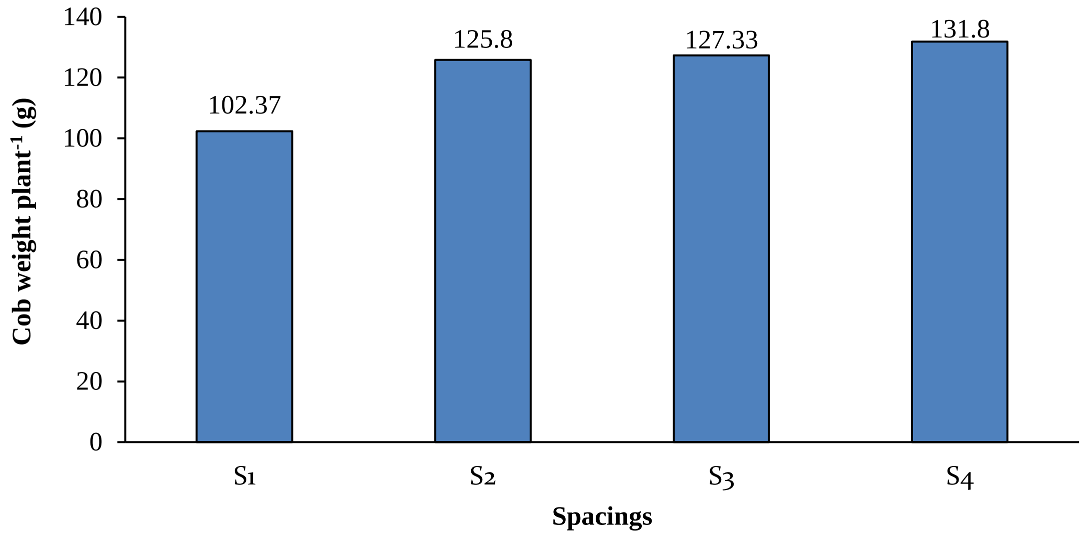


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 27 Effect of irrigation frequencies on cob weight plant^{-1} (g) of white maize (LSD $_{(0.05)}$ = 3.19).

4.2.10.2 Effect of spacing

The cob weight plant^{-1} (g) of white maize was significantly affected by spacing (Figure 28 and Appendix XI). The largest cob weight plant^{-1} (131.80 g) was found in the S_4 treatment, according to the experiment results. In the S_1 condition, the minimum cob weight plant^{-1} (102.37 g) was recorded. Ukonze *et al*. (2016) and Nanda *et al*. (2016) both reported similar findings (2015).



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 28 Effect of spacings on cob weight plant^{-1} (g) of white maize (LSD $_{(0.05)}$ = 3.71).

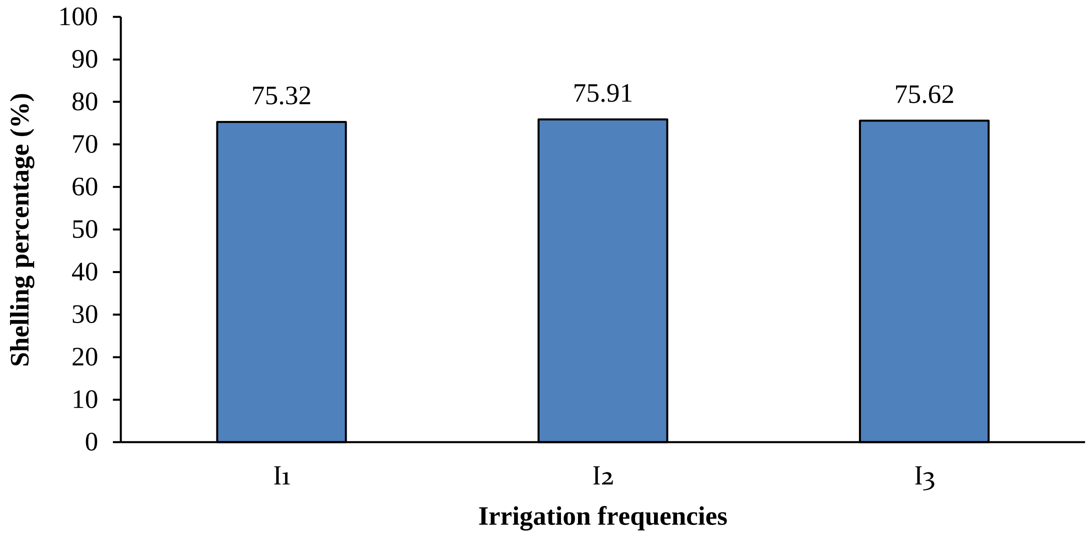
4.2.10.3 Combined effect of irrigation frequency and spacing

In terms of cob weight plant-1 of white maize, the combined effect of irrigation frequency and spacing exhibited significant variation (Table 7). According to the results of the experiment, the I_1S_4 treatment combination had the highest cob weight plant^{-1} (135.71 g), which was statistically similar to the I_2S_4 (131.74 g), I_1S_3 (131.73 g), and I1S2 (130.25 g) treatment combinations. In contrast, the I_3S_1 treatment combination had the lowest cob weight plant^{-1} (98.51 g), which was statistically similar to the I_1S_1 (99.51 g) treatment combination.

4.2.11 Shelling percentage (%)

4.2.11.1 Effect of irrigation frequency

Non-significant variation was observed on shelling percentage (%) of white maize due to irrigations frequency (Figure 29 and Appendix XI). From the experiment result revealed that the maximum shelling percentage (75.91%) was observed in I_2 treatment. Whereas the minimum shelling percentage (75.32 %) was observed in I_1 treatment.

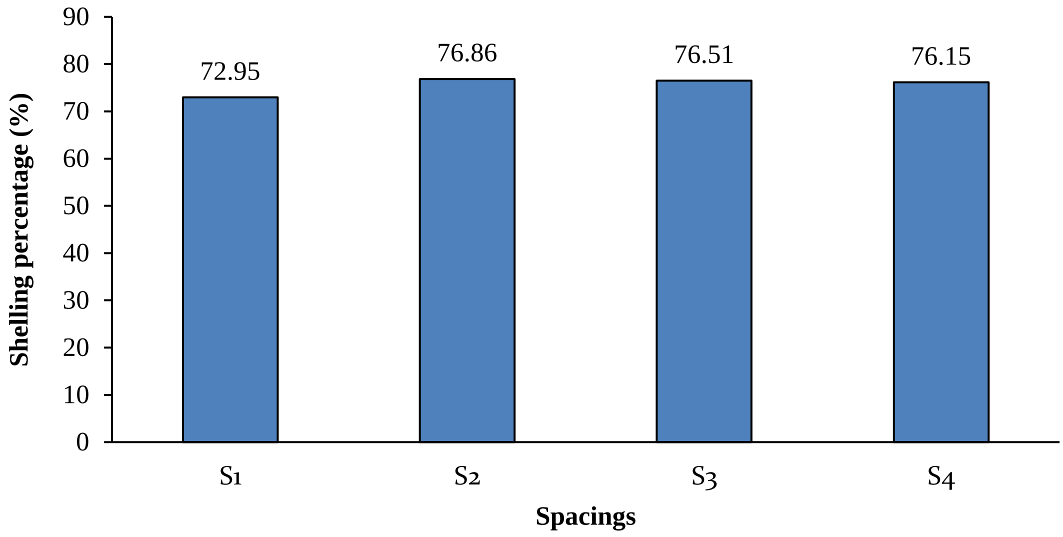


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 29 Effect of irrigation frequencies on shelling percentage (%) of white maize (LSD $_{(0.05)}$ = NS)

4.2.11.2 Effect of spacing

Spacing showed significant effect on shelling percentage (%) of white maize (Figure 30 and Appendix XI). From the experiment result revealed that the maximum shelling percentage (76.86 %) was observed in S_2 treatment which was statistically similar with S_3 (76.51 %) and S_4 (76.15 %) treatment. Whereas the minimum shelling percentage (72.95 %) was observed in S_1 treatment. Ahmmed *et al*. (2018) reported that in respect of the spacing effect, the wider spacing showed highest plant shelling percentage compared to other treatments. Mukhtar *et al*. (2012) also found similar result which supported the present finding.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 30 Effect of spacings on shelling percentage (%) of white maize (LSD $_{(0.05)}$ = 1.00 %).

4.2.11.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of shelling percentage (%) of white maize (Table 7). From the experiment result it is exhibited that the maximum shelling percentage (77.50 %) was observed in I_1S_2 treatment combination which was statistically similar with I_1S_3 (76.83 %), I_2S_2 (76.77 %), I_2S_4 (76.48 %), I_2S_3 (76.37 %), I_3S_3 (76.34 %), I_3S_2 (76.31 %) and I_3S_4 (76.27 %) treatment combination. Whereas the minimum shelling percentage (71.26 %) was observed in I_1S_1 treatment combination.

Table 7: Combined effect of irrigation frequency and spacing on chaff weight cob^{-1}(g), shell weight cob^{-1} (g), grain weight cob^{-1}(g), cob weight $plant^{-1}$ (g) and shelling percentage (%) of white maize at harvest

Treatment combinations	Chaff weight cob^{-1} (g)	Shell weight cob^{-1} (g)	Grain weight cob^{-1} (g)	Cob weight $plant^{-1}$ (g)	Shelling percentage (%)
I_1S_1	10.90 bc	17.62 de	70.99 f	99.51 f	71.26 e
I_1S_2	11.55 bc	17.76 de	100.94 a-c	130.25 a-c	77.50 a
I_1S_3	11.78 b	18.74 bc	101.21 ab	131.73 ab	76.83 ab
I_1S_4	13.20 a	19.70 a	102.81 a	135.71 a	75.69 bc
I_2S_1	10.89 bc	17.44 e	80.76 e	109.09 e	74.03 cd
I_2S_2	11.33 bc	18.25 c-e	97.74 a-c	127.32 bc	76.77 ab
I_2S_3	11.44 bc	18.34 cd	96.27 b-d	126.05 b-d	76.37 ab
I_2S_4	11.45 bc	19.53 ab	100.76 a-c	131.74 ab	76.48 ab
I_3S_1	10.67 c	15.43 f	72.42 f	98.51 f	73.56 d
I_3S_2	10.78 c	17.60 de	91.44 d	119.82 d	76.31 ab
I_3S_3	11.22 bc	18.17 c-e	94.81 cd	124.20 cd	76.34 ab
I_3S_4	11.44 bc	18.92 a-c	97.58 a-c	127.94 bc	76.27 ab
LSD $_{(0.05)}$	0.90	0.89	6.13	6.42	1.74
CV (%)	4.63	2.85	3.87	3.07	1.34

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

NS: Non-significant

I_1: Irrigation at 20 days interval

I_2: Irrigation at 25 days interval

I_3: Irrigation at 30 days interval

S_1: 50 cm × 20 cm

S_2: 50 cm × 25 cm

S_3: 60 cm × 20 cm

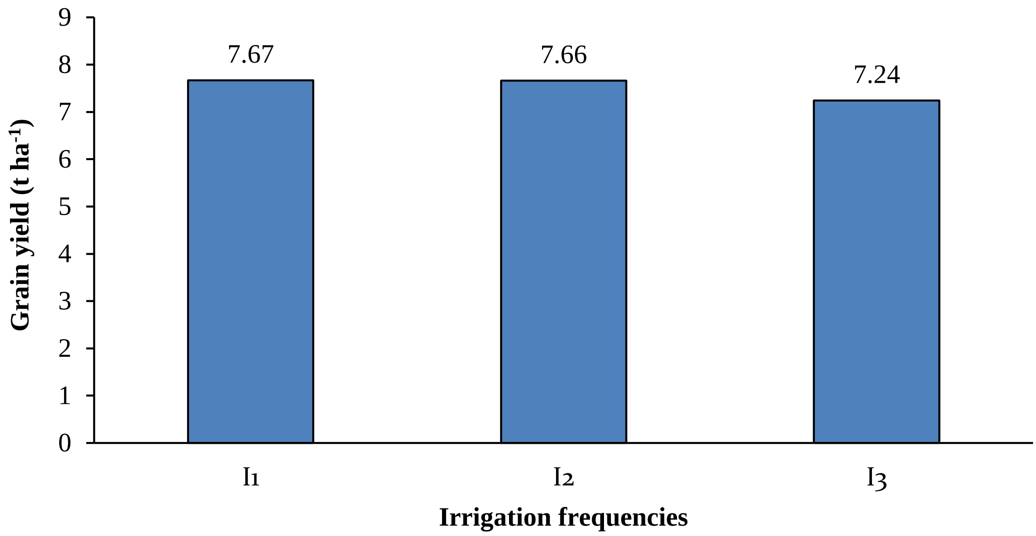
S_4: 60 cm × 25 cm

4.3 Yield characters

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

4.3.1.1 Effect of irrigation frequency

Grain yield (t ha^{-1}) of white maize showed significant variation due to application of different irrigation frequencies (Figure 31 and Appendix XII). From the experiment result it is revealed that the maximum grain yield (7.67 t ha^{-1}) was observed in I_1 treatment which was statistically similar with I_1 (7.66 t ha^{-1}) treatment. Whereas the minimum grain yield (7.24 t ha^{-1}) was observed in I_3 treatment. Parvizi *et al.* (2011) reported that optimum irrigation management and increasing water use efficiency increase yield of maize.

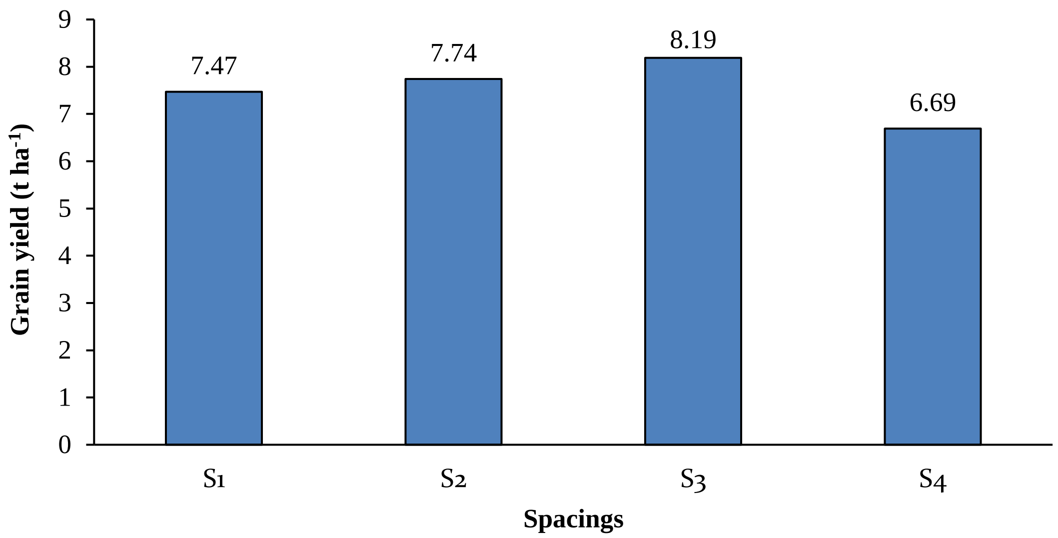


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 31 Effect of irrigation frequencies on grain yield (t ha^{-1}) of white maize (LSD $_{(0.05)}$ = 0.32).

4.3.1.2 Effect of spacing

Different spacing showed significant effect on grain yield (t ha^{-1}) of white maize (Figure 32 and Appendix XII). Experiment result revealed that the maximum grain yield (8.19 t ha^{-1}) was observed in S_3 treatment. Whereas the minimum grain yield (6.69 t ha^{-1}) was observed in S_4 treatment. The possible reason for the lowest grain yield at widest spacing might be due to the presence of a smaller number of plants per unit area. Golla *et al.* (2018) and Hasan *et al.* (2018) also found similar result which supported the present finding.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 32 Effect of spacings on grain yield (t ha^{-1}) of white maize (LSD $_{(0.05)}$ = 0.28).

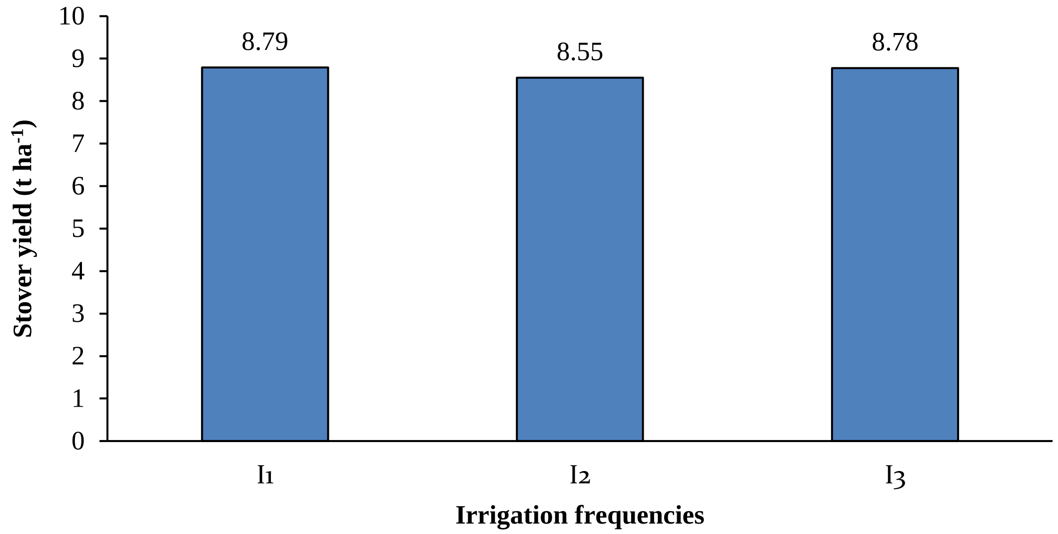
4.3.1.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of grain yield (t ha^{-1}) of white maize (Table 8). Experiment result exhibited that the maximum grain yield (8.66 t ha^{-1}) was observed in I_1S_3 treatment combination. Whereas the minimum grain yield (6.51 t ha^{-1}) was observed in I_3S_4 treatment combination which was statistically similar with I_2S_4 (6.72 t ha^{-1}) and I_1S_4 (6.85 t ha^{-1}) treatment combination.

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

4.3.2.1 Effect of irrigation frequency

Stover yield (t ha^{-1}) of white maize showed significant variation due to application of different irrigation frequencies (Figure 33 and Appendix XII). From the experiment result it is revealed that the maximum stover yield (8.79 t ha^{-1}) was observed in I_1 treatment which was statistically similar with I_3 treatment (8.78 t ha^{-1}). Whereas the minimum stover yield (8.55 t ha^{-1}) was observed in I_2 treatment. Elzubeir and Mohamed (2011) reported that as irrigation intervals were prolonged, stover yield decreased. This may be due to the fact that water stress reduced dry matter accumulation of vegetative components of maize.

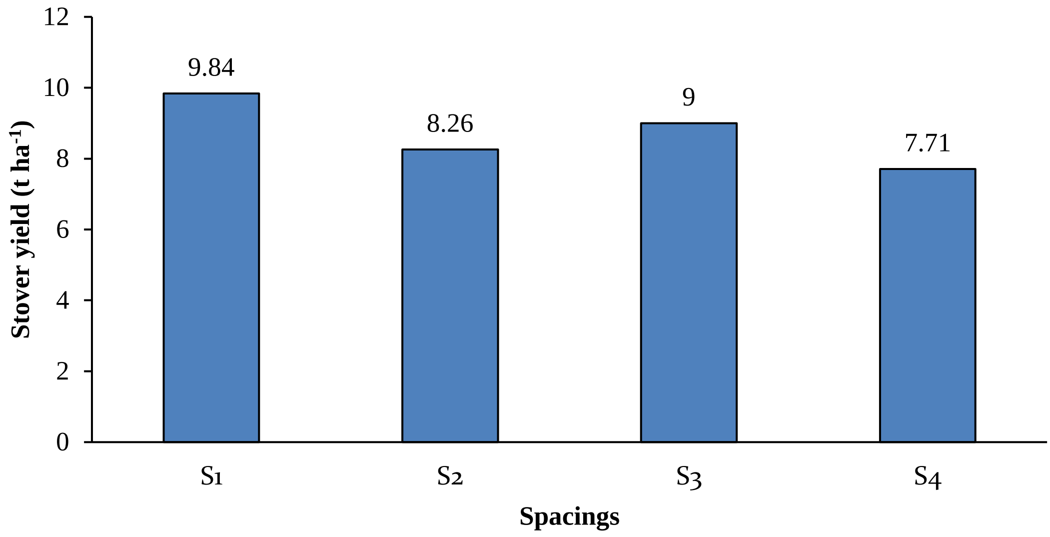


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 33 Effect of irrigation frequencies on stover yield (t ha^{-1}) of white maize (LSD $_{(0.05)}$ = 0.22).

4.3.2.2 Effect of spacing

Different spacing showed significant effect on stover yield (t ha^{-1}) of white maize (Figure 34 and Appendix XII). Experiment result revealed that the maximum stover yield (12.16 t ha^{-1}) was observed in S_1 treatment. Whereas the minimum stover yield (9.56 t ha^{-1}) was observed in S_4 treatment. Worku and Derebe (2020) 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.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 34 Effect of spacings on stover yield (t ha^{-1}) of white maize ($LSD_{(0.05)}$=0.30).

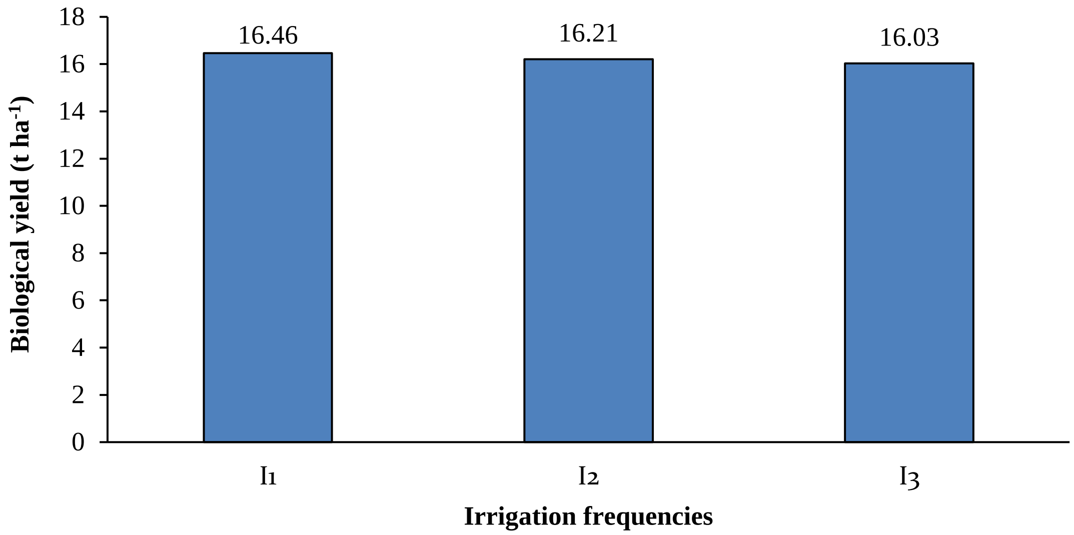
4.3.2.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of stover yield (t ha^{-1}) of white maize (Table 8). Experiment result exhibited that the maximum stover yield (10.34 t ha^{-1}) was observed in I_3S_1 treatment combination which was statistically similar with I_3S_4(10.30 t ha^{-1}) treatment combination. Whereas the minimum stover yield (7.66 t ha^{-1}) was observed in I_2S_4 treatment combination which was statistically similar with I_1S_4 (7.70 t ha^{-1}), I_3S_4 (7.77 t ha^{-1}) and I_3S_2 (8.12 t ha^{-1}) treatment combination.

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

4.3.3.1 Effect of irrigation frequency

Biological yield (t ha^{-1}) of white maize showed significant variation due to application of different irrigation frequencies (Figure 35 and Appendix XII). From the experiment result revealed that the maximum biological yield (16.46 t ha^{-1}) was observed in I_1 treatment. Whereas the minimum biological yield (16.03 t ha^{-1}) was observed in I_3 treatment.

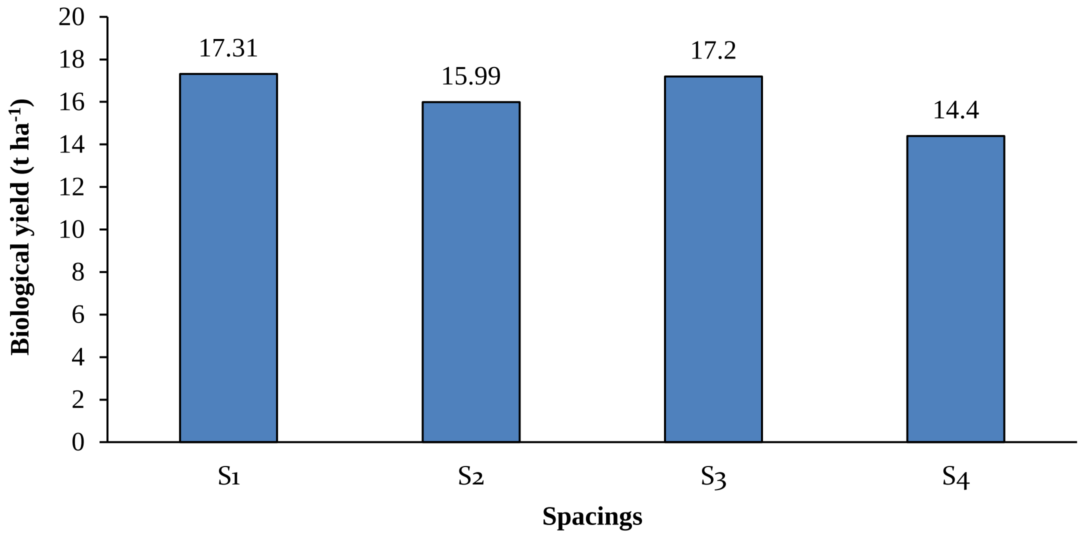


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 35 Effect of irrigation frequencies on biological yield (t ha^{-1}) of white maize (LSD $_{(0.05)}$ =0.16).

4.3.3.2 Effect of spacing

Different spacing showed significant effect on biological yield (t ha^{-1}) of white maize (Figure 36 and Appendix XII). Experiment result revealed that the maximum biological yield (17.31 t ha^{-1}) was observed in S_1 treatment which was statistically similar with S_3 (17.20 t ha^{-1}) treatment. Whereas the minimum biological yield (14.40 t ha^{-1}) was observed in S_4 treatment. Result revealed that spacing influences the biological yield of the plant. Gaire *et al*. (2020) and Hossain (2015 also found similar result which supported the present finding.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 36 Effect of spacings on biological yield (t ha^{-1}) of white maize (LSD $_{(0.05)}$ =0.35).

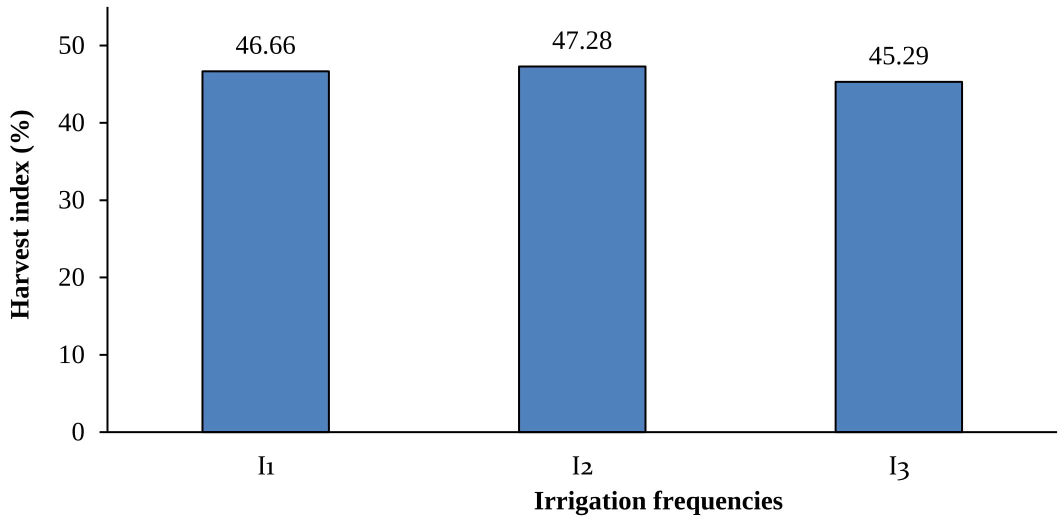
4.3.3.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of biological yield (t ha^{-1}) of white maize (Table 8). Experiment result exhibited that the maximum biological yield (17.58 t ha^{-1}) was observed in I_3S_1 treatment combination which was statistically similar with I_2S_3 (17.41 t ha^{-1}), I_1S_1 (17.40 t ha^{-1}) and I_1S_3 (17.39 t ha^{-1}) treatment combination. Whereas the minimum biological yield (14.28 t ha^{-1}) was observed in I_3S_4 treatment combination which was statistically similar with I_2S_4 (14.38 t ha^{-1}) and I_1S_4 (14.55 t ha^{-1}) treatment combination.

4.3.4 Harvest index (%)

4.3.4.1 Effect of irrigation frequency

Harvest index (%) of white maize showed non-significant variation due to application of different irrigation frequencies (Figure 37 and Appendix XII). Experiment result it is revealed that the maximum harvest index (47.28 %) was observed in I_2 treatment which was statistically similar with I_1 (46.66a %) treatment. Whereas the minimum harvest index (45.29 %) was observed in I_3 treatment.

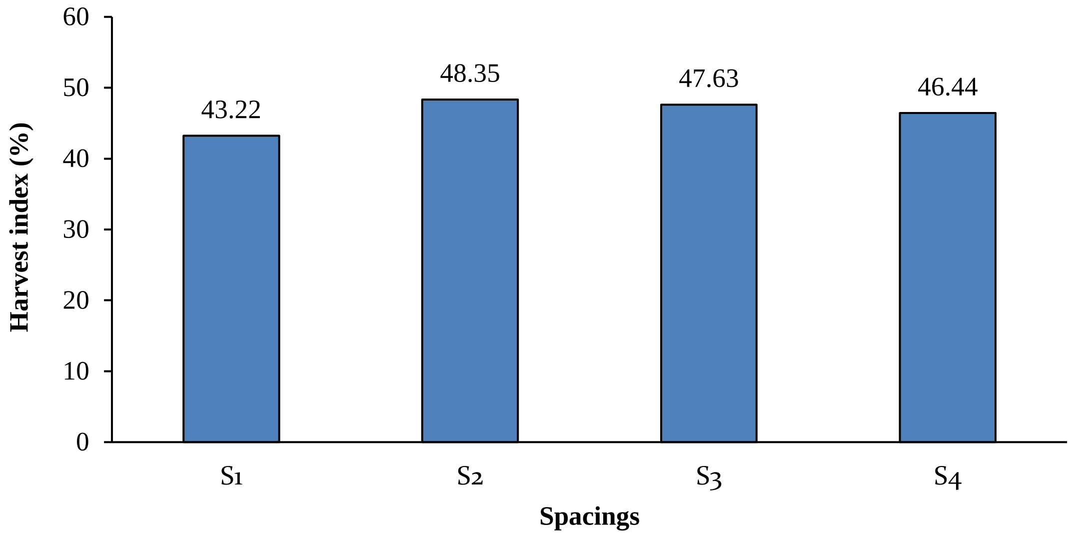


Irrigation frequencies *viz.* I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval.

Figure 37 Effect of irrigation frequencies on harvest index (%) of white maize (LSD $_{(0.05)}$ = 1.53 %).

4.3.4.2 Effect of spacing

Different spacing showed significant effect on harvest index (%) of white maize (Figure 38 and Appendix XII). From the experiment result it is revealed that the maximum harvest index (48.35 %) was observed in S_2 treatment which was statistically similar with S_3 (47.63 %) treatment. Whereas the minimum harvest index (43.22 %) was observed in S_4 treatment. The result obtained from the present study was similar with the findings of Ahmmed *et al.* (2020) who reported that highest harvest varied due to different spacing.



Spacings *viz.* S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm.

Figure 38 Effect of spacings on harvest index (%) of white maize (LSD $_{(0.05)}$ = 1.37 %).

4.3.4.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of harvest index (%) of white maize (Table 8). Experiment result exhibited that the maximum harvest index (49.81 %) was observed in I_1S_3 treatment combination which was statistically similar with I_1S_2 (48.98 %), I_2S_2 (48.66 %) and I_2S_1 (47.66 %) treatment combination. Whereas the minimum harvest index (40.80 %) was observed in I_1S_1 treatment combination which was statistically similar with I_3S_1 (41.18 %) treatment combination.

Table 8: Combined effect of irrigation frequencies and spacing on grain yield, stover yield, biological yield and harvest index of white maize at harvest

Treatment combinations	Grain yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
I_1S_1	7.1 cd	10.30 a	17.40 ab	40.80 d
I_1S_2	8.08 b	8.41 c-e	16.49 cd	48.98 ab
I_1S_3	8.66 a	8.73 cd	17.39 ab	49.81 a
I_1S_4	6.85 c-e	7.70 g	14.55 f	47.05 bc
I_2S_1	8.08 b	8.88 bc	16.96 bc	47.66 a-c
I_2S_2	7.82 b	8.25 d-f	16.07 d	48.66 ab
I_2S_3	8.02 b	9.39 b	17.41 ab	46.08 c
I_2S_4	6.72 de	7.66 g	14.38 f	46.71 bc
I_3S_1	7.24 c	10.34 a	17.58 a	41.18 d
I_3S_2	7.32 c	8.12 e-g	15.43 e	47.41 bc
I_3S_3	7.9 b	8.91 bc	16.81 bc	47.00 bc
I_3S_4	6.51 e	7.77 fg	14.28 f	45.57 c
LSD (0.05)	0.48	0.52	0.60	2.38
CV (%)	3.74	3.45	2.15	2.99

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

NS: Non-significant

I_1: Irrigation at 20 days interval

I_2: Irrigation at 25 days interval

I_3: Irrigation at 30 days interval

S_1: 50 cm × 20 cm

S_2: 50 cm × 25 cm

S_3: 60 cm × 20 cm

S_4: 60 cm × 25 cm

CHAPTER V

SUMMARY AND CONCLUSION

The present research work was carried out at the Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2019 to March 2020, to investigate the effect of growth and yield response of white maize (SAUWMOP T61G) to different spacing and irrigation frequencies in rabi season. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consisted of two factors, and followed split plot design. Factor A: Irrigation frequencies (3); I_1: Irrigation at 20 days interval, I_2: Irrigation at 25 days interval and I_3: Irrigation at 30 days interval and Factor B: Different spacings (4); S_1: 50 cm × 20 cm, S_2: 50 cm × 25 cm, S_3: 60 cm × 20 cm and S_4: 60 cm × 25 cm. The total numbers of unit plots were 36. The size of unit plot was 3.89 m^2 (3.17m × 1.23 m). Cow dung 5 t ha^{-1} was used before final land preparation. The field was fertilized with nitrogen, phosphate, potash, sulphur, zinc and boron at the rate of 500-250-200-250-15-5 kg ha^{-1} of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid, respectively (BARI, 2014). The whole amounts of fertilizers were applied as basal doses except Urea. Only one third Urea was applied as basal doses and the rest amount was applied at 15 DAS interval for three installments. Data on different yield contributing characters and yield were recorded to find out the appropriate irrigation frequency and optimum level of spacing for the highest yield of White maize.

Growth, yield and yield contributing characters were significantly influenced by different irrigation frequencies, spacings and their combination.

In case of different irrigation frequencies, the maximum plant height (56.66 cm) at 30 DAS was observed in I_1 treatment. At 60 DAS the maximum plant height (164.92 cm) was observed in I_2 treatment. At 90 DAS and at harvest respectively the maximum plant height (212.46 and 196.43 cm) was observed in I_1 treatment. The maximum number of leaves plant^{-1} (5.13, 5.22 and 12.48 at 30, 60 and 90 DAS), leaf area plant^{-1} (218.53, 665.34, 2053.8 and 2318.3 at 30, 60, 90 DAS and at harvest respectively) were observed in I_1 treatment. The maximum dry matter plant^{-1} (8.18 and 55.28 g at 30 and 60 DAS) was observed in I_1 treatment. At 90 DAS the maximum dry matter plant^{-1} (163.67 g) was observed in I_2 treatment. And at harvest respectively the maximum dry matter plant^{-1} (201.75 g) was observed in I_1 treatment. The maximum cob length plant^{-1} (17.37 cm), cob circumference plant^{-1} (15.62 cm), number of rows cob^{-1} (14.37), number of grains row^{-1} (27.88), number of grains cob^{-1} (390.29), 1000 grains weight (378.67 g), chaff weight cob^{-1} (11.86 g), shell weight cob^{-1} (18.45 g), grain weight cob^{-1} (93.99 g) and cob weight plant^{-1} (124.30 g) were observed in I_1 treatment. The maximum shelling percentage (75.91%) was observed in I_2 treatment. The maximum grain yield (7.67 t ha^{-1}), stover yield (8.79 t ha^{-1}) and biological yield (16.46 t ha^{-1}) were observed in I_1 treatment. The experiment result revealed that the maximum harvest index (47.28 %) was observed in I_2 treatment.

The minimum plant height (48.63, 151.73, 177.69 and 181.76 cm at 30, 60, 90 DAS and at harvest, respectively) was observed in I_3 treatment. The minimum number of leaves plant^{-1} (4.82 and 4.62) at 30 and 60 DAS was observed in I_2 treatment, at 90 DAS and at harvest respectively the minimum number of leaves plant^{-1} (10.70 and 9.35) was observed in I_3 treatment. The minimum leaf area plant^{-1} (195.22 and 611.35b cm^2 at 30 and 60 DAS respectively) was I_3 treatment. At 90 DAS the minimum leaf area plant^{-1} (2010.8 cm^2) was observed in I_2 treatment. And at harvest the minimum leaf area plant^{-1} (2158.4 cm^2) was observed in I_3 treatment. The minimum dry matter plant^{-1} (7.41, 46.84, 138.25 and 196.99 g at 30, 60, 90 DAS and at harvest, respectively) was observed in I_3 treatment. The minimum cob length plant^{-1} (14.17 cm), cob circumference plant^{-1} (12.19 cm), number of rows cob^{-1} (13.45), number of grains row^{-1}(27.64), number of grains cob^{-1} (373.95), 1000 grains weight (338.67 g), chaff weight cob^{-1} (11.03 g), shell weight cob^{-1} (17.53 g), grain weight cob^{-1} (89.06 g), cob weight plant^{-1} (117.62 g) were observed in I_3 treatment. The minimum shelling percentage (75.32 %) was observed in I_1treatment.The minimum grain yield (7.24 t ha^{-1}) was observed in I_3 treatment. The minimum stover yield (8.55 t ha^{-1}) was observed in I_2 treatment. The minimum biological yield (16.03 t ha^{-1}) and harvest index (45.29 %) were observed in I_3 treatment.

In case of different spacings, the maximum plant height (54.65 cm) at 30 DAS was observed in S_3 treatment. At 60, 90 DAS and at harvest, respectively the maximum plant height (171.35, 203.30 and 203.91cm) was observed in S_4 treatment. the maximum number of leaves plant^{-1} of white maize (5.49, 5.52, 13.20 and 10.62 at 30, 60, 90 DAS and at harvest, respectively) was observed in S_4 treatment. The maximum leaf area plant^{-1} (247.78, 671.10, 2190.3 and 2451.1 cm^2 at 30, 60, 90 DAS and at harvest, respectively) was observed in S_4 treatment. The maximum dry matter weight plant^{-1} (8.45 g at 30 DAS) was observed in S_1 treatment. At 60 DAS the maximum dry matter weight plant^{-1} (55.90 g) was observed in S_2 treatment. At 90 DAS the maximum dry matter weight plant^{-1} (174.34 g) was observed in S_3 treatment and finally at harvest the maximum dry matter weight plant^{-1} (216.04 g) was observed in S_4 treatment. The maximum cob length plant^{-1} (17.28 cm), cob circumference plant^{-1} (15.11 cm), number of rows cob^{-1} (14.52), number of grains row^{-1} (28.40), number of grains cob^{-1} (400.42), 1000 grains weight (396.67 g), chaff weight cob^{-1} (12.03 g), shell weight cob^{-1} (19.38 g), grain weight cob^{-1} (100.38 g), cob weight plant^{-1} (131.80 g) were observed in S_4 treatment. The maximum shelling percentage (76.86 %) was observed in S_2 treatment. The maximum grain yield (8.19 t ha^{-1}) was observed in S_3 treatment. The maximum stover yield (12.16 t ha^{-1}) and biological yield (17.31 t ha^{-1}) were observed in S_1 treatment and the maximum harvest index (48.35 %) was observed in S_2 treatment.

The minimum plant height (50.49 cm) was observed in S_2 treatment at 30 DAS. At 60, 90 DAS and at harvest respectively the minimum plant height (147.02, 190.22 and 176.13 cm) was observed in S_1 treatment. The minimum number of leaves plant^{-1} of white maize (4.54 and 4.56 at 30 and 60 DAS) was observed in S_2 treatment, at 90 DAS the minimum number of leaves plant^{-1} of white maize (10.02) was observed in S_1 treatment and at harvest respectively the minimum number of leaves plant^{-1} of white maize (9.29) was observed in S_3 treatment. The minimum leaf area plant^{-1} (182.78, 588.20, 1914.0 and 2024.4 cm^2 at 30, 60, 90 DAS and at harvest respectively) was observed in S_1 treatment. The minimum dry matter weight plant^{-1} (7.35 g at 30 DAS) was observed in S_3 treatment. At 60, 90 DAS and at harvest, respectively the minimum dry matter weight plant^{-1} (47.76, 136.67 and 174.26 g) was observed in S_1 treatment. The minimum cob length plant^{-1} (14.16 cm), cob circumference plant^{-1} (12.90 cm), number of rows cob^{-1} (13.07), grains row^{-1} (26.60), number of grains cob^{-1} (351.28), 1000 grains weight (372.22 g), shell weight cob^{-1} (16.83 g), grain weight cob^{-1} (74.72 g), cob weight plant^{-1} (102.37 g) and shelling percentage (72.95 %) were observed in S_1 treatment. The minimum grain yield (6.69 t ha^{-1}), stover yield (9.56 t ha^{-1}), biological yield (14.40 t ha^{-1}) and harvest index (43.22 %) were observed in S_4 treatment.

In case of combined effect, the maximum plant height (58.84 cm) at 30 DAS was observed in I_1S_3 treatment combination. At 60, 90 DAS and at harvest respectively the maximum plant height (186.16, 217.39 and 213.80 cm) was observed in I_1S_4 treatment combination. The maximum number of leaves plant^{-1} of white maize (5.85, 6.11, 14.75 and 11.06 at 30, 60, 90 DAS and at harvest, respectively) was observed in I_1S_4 treatment combination. The maximum leaf area plant^{-1} (272.81, 736.24, 2407.5 and 2780.1 cm^2 at 30, 60, 90 DAS and at harvest, respectively) was observed in I_1S_4 treatment combination. The maximum dry matter weight plant^{-1} (9.92 g at 30 DAS) was observed in I_2S_1 treatment combination. At 60 DAS the maximum dry matter weight plant^{-1} (59.28 g) was observed in I_2S_1 treatment combination. At 90 DAS the maximum dry matter weight plant^{-1} (179.10 g) was observed in I_1S_3 treatment combination. And at harvest respectively the maximum dry matter weight plant^{-1} (218.31 g) was observed in I_1S_4 treatment combination. The maximum cob length plant^{-1} (18.00 cm), cob circumference plant^{-1} (16.20 cm), number of rows cob^{-1} (15.67), number of grains row^{-1} (28.66), number of grains cob^{-1} (419.22), 1000 grains weight (413.67 g), chaff weight cob^{-1} (13.20 g), shell weight cob^{-1} (19.70 gm), grain weight cob^{-1} (102.81 g), cob weight plant^{-1} (135.71 g) were observed in I_1S_4 treatment combination. The maximum shelling percentage (77.50 %) was observed in I_1S_2 treatment combination. The maximum grain yield (8.66 t ha^{-1}) was observed in I_1S_3 treatment combination. The maximum stover yield (10.34 t ha^{-1}) and biological yield (17.58 t ha^{-1}) was observed in I_3S_1 treatment combination. The maximum harvest index (49.81 %) was observed in I_1S_3 treatment combination.

Whereas the minimum plant height (43.99 cm) at 30 DAS was observed in I_3S_2 treatment combination. At 60, 90 DAS and at harvest respectively the minimum plant height (129.27, 161.39 and 173.53 cm) was observed in I_3S_1 treatment combination. The minimum number of leaves plant^{-1} of white maize (4.32 and 4.12 at 30 and 60 DAS) was observed in I_2S_2 treatment combination. At 90 DAS the minimum number of leaves plant^{-1} of white maize (9.87) was observed in I_3S_1 treatment combination.

And at harvest respectively the minimum number of leaves plant^{-1} of white maize (9.06) was observed in I_3S_3 treatment combination. The minimum leaf area plant^{-1} (106.07, 560.27, 1820.9 and 1935.1 cm^2 at 30, 60, 90 DAS and at harvest, respectively) was observed in I_3S_1 treatment combination. The minimum dry matter weight plant^{-1} (5.51 and 37.43 g at 30 and 60 DAS) was observed in I_3S_1 treatment combination. At 90 DAS the minimum dry matter weight plant^{-1} (123.50 g) was observed in I_3S_2 treatment combination. And at harvest respectively the minimum dry matter weight plant^{-1} (169.59 g) was observed in I_2S_1 treatment combination. The minimum cob length plant^{-1} (12.38 cm) was observed in I_3S_1 treatment combination. The minimum cob circumference plant^{-1} (10.56 cm) was observed in I_3S_2 treatment combination. The minimum number of rows cob^{-1} (13.00), number of grains row^{-1} (26.34), number of grains cob^{-1} (341.75), 1000 grains weight (320.33 g), chaff weight cob^{-1} (10.67 g), shell weight cob^{-1} (15.43 gm) were observed in I_3S_1 treatment combination. The minimum grain weight cob^{-1} (70.99 g) was observed in I_1S_1 treatment combination. The minimum cob weight plant^{-1} (98.51 g) was observed in I_3S_1 treatment combination. The minimum shelling percentage (71.26 %) was observed in I_1S_1 treatment combination. The minimum grain yield (6.51 t ha^{-1}) was observed in I_3S_4 treatment combination. The minimum stover yield (7.66 t ha^{-1}) was observed in I_2S_4 treatment combination. The minimum biological yield (14.28 t ha^{-1}) was observed in I_3S_4 treatment combination and the minimum harvest index (40.80 %) was observed in I_1S_1 treatment combination.

CONCLUSION

Based on the above results of the present study, the following conclusions may be drawn-

i. In case of different irrigation frequencies, the maximum cob length plant^{-1} (17.37 cm), cob circumference plant^{-1} (15.62 cm), number of rows cob^{-1} (14.37), number of grains row^{-1} (27.88), number of grains cob^{-1} (390.29), 1000 grains weight (378.67 g), chaff weight cob^{-1} (11.86 g), shell weight cob^{-1} (18.45 g), grain weight cob^{-1} (93.99 g), cob weight plant^{-1} (124.30 g), grain yield (7.67 t ha^{-1}),stover yield (8.79 t ha^{-1}) and biological yield (16.46 t ha^{-1}) were observed in I_1 (Irrigation given at 20 days interval) treatment.

ii. In respect of different spacings, the maximum grain yield (8.19 t ha^{-1}) was observed in S_3 (60 cm × 20 cm) treatment compared to other treatments due to the reason that optimum spacing increasing yield production which ultimately impact on unit area production.

iii. In case of different treatment combination, I_1 (irrigation interval at 20 DAS) treatment along with S_3 (60 cm × 20 cm) treatment *i.e.* I_1S_3 treatment combination perform best in respect of maximum grain yield (8.66 t ha^{-1}) production compared to others treatment combinations.

Thus, for the cultivation of “White maize”, 20 days irrigation interval (I_1) along with (60 × 20 cm) (S_3) spacing can be used as recommended treatment for the production of highest grain yield in the AEZ 28 (Agro-ecological zone) soils of Bangladesh.

Recommendations

- ❖ Studies of similar nature could be carried out in different Agro Ecological Zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.

REFERENCES

Abd El-Halim, A. and Abd El-Razek, U. (2013). Effect of different irrigation intervals on water saving, water productivity and grain yield of maize (Zea mays L.) under the double ridge-furrow planting technique. *Archives. Agron. Soil Sci.* Pp. 1-10.

Ahmad, I., Wajid, S. A., Ahmad, A., Cheema, M. J. M. and Judge, J. (2019). Optimizing irrigation and nitrogen requirements for maize through empirical modeling in semiarid environment. *Environ. Sci. Pollut. Res. Int.* **26**(2): 1227-1237.

Ahmmed, T., Ullah, M. J., Mannan, M. A. and Akter, M. S. (2020). Performance of White Maize under Different Spacing and Integrated Fertilizer Management. *Asian Plant Res. J.* **6**(2): 23-32. https://doi.org/10.9734/aprj/2020/v6i230124

Akbar, M. A., Siddique, M. A., Marma, M. S., Rahman, M. M., Molla, M. R. I., Rahman, M.M., Ullah. M.J., Hossain, M.A. and Hamid, A. (2016). Planting Arrangement, Population Density and Fertilizer Application Ratefor White Maize (ZeamaysL.) Production in Bandarban Valley. *J. Agric. Forest. Fisher* .**5**(6): 215-224. http://doi:10.11648/j.aff.20160506.12

Alam, M. J., Uddin, M. A., Nahar, M. K., Ali, M. Y. and Ahmed, K. S. (2020). Enhancement Of Maize Productivity Through Using ImproveedTechniqesOf Spacing. *J. Expt. Biosci.* **11**(2): 27-34.

Anonymous, (1989). Annual Weather Report, meteorological Station, Dhaka, Bangladesh.

Anonymous. (1988 a). The Year Book of Production. FAO, Rome, Italy.

Anonymous. (1988 b). Land resources appraisal of Bangladesh for agricultural development. Report No.2. Agro-ecological regions of Bangladesh, UNDP and FAO. pp. 472–496.

Anonymous. (2004). Effect of seedling throwing on the grain yield of wart landrice compared to other planting methods. Crop Soil Water Management Program Agronomy Division, BRRI, Gazipur-1710.

Azam, M. (2017). Production potential of various maize (*Zea mays* l.) hybrids under different intra-row plant spacing. *Pakistan J. Agric. Sci.* **54**(1): 117-121.

Baloch, S. K. Yang, Y., Baloch, S. S. and Bashir, W. (2014). The Effect of Different Irrigation Regimes on the Yield of Fodder Maize (*Zea mays*). *J. Nat. Sci. Res*. **4**(20). 57-63.

Banglapedia. (2014). National Encyclopedia of Bangladesh.

http://en.banglapedia.org/index.php.title=Agroecological_Zone.

BARI (Bangladesh Agricultural Research Institute). (2014). 'Krishi ProjuktiHathboi'. Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. p. 54.

BBS (Bangladesh Bureau of Statistics). (2016). Yearbook of Agricultural Statistics 2014. Ministry of Planning, Government of Bangladesh, Dhaka.

Belay, M. K. (2019) Effect of Inter and Intra Row Spacing on Growth, Yield Components and Yield of Hybrid Maize (*Zea mays* L.) Varieties at Haramaya, Eastern Ethiopia. *American J. Plant Sci.* **10**: 1548-1564.

Biswas, J. C., Maniruzzaman, M., Nahar, U. A., Zahan, T., Haque, M. M., Ali, MH., Kabir, N. K. and Rahnamayan, S. (2019). Prospect of Developing Soil Health Index in Bangladesh. *Curr. Inves. Agri. Curr. Res* .6(2): 799-807.

Biswas, M. M. I. (2019). Optimizing planting geometry nitrogen and irrigation for white maize in different agro-climatic regions of Bangladesh. Ph. D thesis, Reg. No. 15-06898. Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Bithy, P. A. and Ahamed, K. U. (2018). Varietal effect on growth, yield and yield contributing parameters of white maize (*Zea mays*). *J. Expt. Biosci.* **9**(2): 1-6.

Chowdhury, M. K. and Islam, M. A. (1993). Production and use of maize On-Farm Research Division, Bangladesh Agricultural Research Institute. Joydebpur, Gazipur, Bangladesh. Pp. 8–57.

Dahmardeh, M. (2011). Economical and biological yield of corn (*Zea mays* L.) as affected by nitrogen fertilization under different irrigation interstices. *J. Food Agr. Environ.* **9**: 472–474.

Davi, C. M., Reddy, B. R., Reddy, P. M. and Reddy S. C. S. (1995). Effects on Nitrogen levels and plant density on yield and quality of JKHY-1 cotton. *Current Agric. Res. J.* **8**(3/4): 144-146.

Edris, K. M., Islam, A. M. T., Chowdhury, M. S. and Haque, A. K. M. M. (1979). Detailed Soil Survey of Bangladesh, Dept. Soil Survey, BAU and Govt. Peoples Republic of Bangladesh. p 118.

Elzubeir, A. and Mohamed, A. (2011). Irrigation scheduling for maize (*Zea mays* L.) under desert area conditions- North of Sudan. *Agric. Bio. J. North America*. **2**(4): 645-651.

Enujeke, E. C. (2013). Effects of variety and spacing on growth characters of Eyasu, E., Shanka, D., Dalga, D. and Elias, E. (2018). Yield response of maize (*Zea mays* L.) varieties to row spacing under irrigation at Geleko, Ofa Woreda, Wolaita Zone, Southern Ethiopia. *J. Expt. Agric. Int.* **20**(1): 1–10.

Eyasu, E., Shanka, D., Dalga, D. and Elias, E. (2018). Yield response of maize (Zea mays L.) varieties to row spacing under irrigation at Geleko, Ofa Woreda, Wolaita Zone, Southern Ethiopia. *J. Expt. Agric. Int*. **20**(1): 1–10.

FAO (Food and Agriculture Organization of the United Nations). (2002). Fertilizer and the future. IFA/FAO Agriculture Conference on Global food security and the role of Sustainability Fertilization. Rome, Italy. 16th–20th March 2003. pp. 1–2.

FAO (Food and Agriculture Organization of the United Nations). (2019). Production Statistics-Crops, Crops Processed. FAOSTAT Annual Publication. 18 January 2019.

Fatima, K., Biswas, M. M., Mahmud, M. S., Ullah, M. J. and Rahman, J. (2019). Comparing yield performance of CIMMYT's white maize lines with other exotic and inland genotypes in different agro ecological zones of Bangladesh. *J. Expt. Biosci*. **10**(2):73-86.

Filintas, Ag., Dioudis, P., Pateras, D., Koutseris, E., Hatzopoulos, J. and Toulios, L. (2007). Irrigation water and applied nitrogensfertilizer effects in soils nitrogen depletion and nitrates GISmapping.Paper presented at the Proc. of First International Conference on Environmental Management, Engineering, Planning and Economics CEMEPE/SECOTOX.

Gaire, R., Pant, C., Sapkota, N., Dhamaniya, R. and Bhusal, T. (2020). Effect of Spacing and Nitrogen Level on Growth and Yield of Maize (*Zea mays* L.) in Mid hill of Nepal. *Malays. J. Halal Res.* **3**(2): 50-55.

Getaneh, L., Belete, K. and Tana, T. (2016). Growth and Productivity of Maize (Zea mays L.) as Influenced by Inter- and Intra-Row Spacing in Kombolcha, Eastern Ethiopia. *J. Bio. Agric. Health.* **6**(13): 90-101.

Gomez, M. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. John Wiley and sons. New York, Chichester, Brisbane, Toronto. Pp. 97–129, 207–215.

Guo, B. Y., Gao, H., Tang, C., Liu, T. and Chu, G. X. (2015). Response of water coupling with N supply on maize nitrogen uptake, water and N use efficiency, and yield in drip irrigation condition. *Ying Yong Sheng Tai Xue Bao.* **26**(12): 3679-3686.

Hailare, L. (2000). Corn: An American Native. Spanning the Gap, The newsletter of Delaware Water Gap National Recreation Area Vol. 22 No. 1 Spring, 2000. U.S. Dept. of the Interior National Park Service.

Hamid, A., Akbar, M. A., Marma, M. S., Islam, M. M., Ullah, M. J., MollahM. A. M. and Neogi, M. G. (2019). Spatiotemporal Variations in Temperature Accumulation, Phenological Development and Grain Yield of Maize (*Zea mays* L.) in Bangladesh. *J. Agric. Sci.* **12**(1): 46-57.

Hasan, M. R., Rahman, M. R., Hasan, A. K., Paul, S. K. and Alam, A. H. M. J. (2018). Effect of variety and spacing on the yield performance of maize (*Zea mays* L.) in old Brahmaputra floodplain area of Bangladesh. *Arch. Agric. Environ. Sci.* **3**(3): 270–274.

Heydari, N. 2014. Water productivity in agriculture: challenges in concepts, terms and values. *Irrigation and Drainage.* **63(**1). 22-28.

Hossain, M. A. (2015). Effect of planting configuration on the growth and yield of white maize. M.S. Thesis, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka−1207, Bangladesh. hybrid maize. *Asian J. Agric. Rural Dev.* **3**(5): 296–310.

Ibrahim, S. and Hala Kandil. 2007. Growth, yield and chemical constituents of corn (*Zea mays* L.) as affected by nitrogen and phosphors fertilization under different irrigation intervals. *J. Appl. Sci. Res*. **3**: 1112–1120.

Islam, M. S., Ullah, M.J., Sultana, N., Runia, M. J. and Hasan, N. (2020b). Effect of alternate furrow irrigation and different fertilizer management on the yield performance of baby corn**.** *J. Expt. Biosci*. **11**(1):35-42.

Islam, M. S., Ullah, M. J., Sultana, N., Runia, M. J. and Shithi, N. (2020a). Plant traits of baby corn as influenced by alternate furrow irrigation and different fertilizer managements. *J. Expt. Biosci.***11**(1):25-34.

Jaliya, A. M., Falaki, A. M., Mahmud, M. and Sani, Y. A. (2008). Effects of sowing date and NPK fertilizer rate on yield and yield components of quality protein maize (*Zea mays* L.). *ARPN J. Agric. Biol. Sci.* **2**: 23–29.

Jula, L. S. W., Joseph, T., Zamani, D. L. and Ayodeji, O. D. (2013). Evaluation of the effects of intra-row spacing on the growth and yield of maize (Zeamays L.) in maize-ginger intercrop in samaru, northern guinea savanna of Nigeria. *Agric. Biol. J. N. Amer*. **4**(3): 175–180.

Kandil, E. E. (2013). Response of some maize hybrids (*Zea mays* L.) to different levels of nitrogenous fertilization. *J. App. Sci. Res*. **9**(3): 1902–1908.

Keulen, A. O. and Wolf, K. D. F. (1986). Production potential and nitrogen-use efficiency of sweetcorn (*Zea mays*) as influenced by different planting densities and nitrogen levels. *Indian J. Agril. Sci*. **79**: 351–355.

Koirala, S., Dhakal, A., Niraula, D., Bartaula, S., Panthi, U., and Mahato, M. (2020). Effects of row spacings and varieties on grain yield and economics of maize. *J. Agric. Nat. Resour.* **3**(1): 209-218.

Lawson, H. M., and Topham, P. B. (1985). Competition between annual weeds and vining peas grown at a range of population densities: Effects on the weeds. *Weed Res. J*. **25**: 221-229.

Luque, S. F., Cirilo, A. G., and Otegui, M. E. (2006). Genetic gains in grain yield and related physiological attributes in Argentine maize hybrids. *Field Crop Res*. **95**: 383-397.

Mannan, M. A.; Ullah, M. J., Biswas, M. M. I., Ahmed, T. and Akter, M. S. A. (2019). Varietal performance of white maize as influenced by different weed management practices. *J. Expt. Biosci.* **10**(1):67-78.

Mechi, K. (2015). Effect of nitrogen rates and inter row spacing on growth, yield and yield components of maize (*Zea mays* L.) at Nejo, Western Ethiopia. M.Sc. Thesis, Haramaya University, Dire Dawa, Ethiopia.

Mintesinot, B., Verplancke, H., Van Ranst, Eric. and Mitiku, H. (2004). Examining traditional irrigation methods, irrigation scheduling and alternate furrows irrigation on vertisols in northern Ethiopia. Agricultural Water Management. **64**(1): 17-27.

Molden., David., Oweis., Theib., Steduto., Pasquale., Bindraban., Prem., Hanjra., Munir, A. and Kijne, J. (2010). Improving agricultural water productivity: Between optimism and caution. *Agric. Water Management*. **97**(4): 528-535.

Mondal, M. R. I., M. K. Sultan, S. Nur, M. J. U. Sarkar, M. S. Alam and M. H. H. Rahman. (2014). KRISHI PROJUKTI HATBOI (Handbook on Agro-technology), 6 th edition. Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh.

Mukhtar, T., Arif, M., Hussain, S., Atif, M., Rehman, S. and Hussain, K. (2012). Yield and yield components of maize hybrids as influenced by plant spacing. *J. Agric. Res.* **50**(1): 59-69.

Nand, V. (2015). Effect of spacing and fertility levels on protein content and yield of hybrid and composite maize (*Zea mays* L.) grown in Rabi season. *J. Agric. Vet. Sci.* **8**(9): 26–31.

Nasim, W., Ahmad, A., Khaliq, T., Wajid, A., Munis, M. F. H., Chaudhry, H. J., and Hammad, H. M. (2012). Effect of organic and inorganic fertilizer on maize hybrids under agro-environmental conditions of Faisalabad-Pakistan. *African J. Agric. Res.* **7**(17): 2713–2719.

Parvizi, Y., Ghaitori, M., Nazari, K. and Vahedi, M. (2011). Evaluation the effects of organic fertilizer and irrigation interval on water need, water use efficiency, and quality and quantity of maize yield. ICID 21st International Congress on Irrigation and Drainage, 2011 Oct 15–23; Tehran, R.56.4/ Poster/12.

Poehlman, J. M. and Sleper, D. A. (1995). Breeding Field Crops. Fourth Ed. IowaState University Press, Ames, USA.

Rahman, M., Paul, S., and Rahman, M. (2016). Effects of spacing and nitrogen levels on yield and yield contributing characters of maize. *J. Bangladesh Agril. Univ*. **14**(1): 43–48.

Ranu S. A. and Ahamed, K. U. (2018). Effect of indigenous and artificial mulches on yield attributes and yield of white maize (Zea mays L.). *Intl. J. Biosci.* **12**(6): 282:298.

Ray, D. K., Mueller, N. D., West, P. C. and Foley, J. A. (2013). Yield trends are insufficient to double global crop production by 2050. *Plos One*. **8**(6): 1–4.

Salam, M. A., Sarder, M. S. A., Ullah, M. J., Kawochar, M.A., and Islam, M.K. (2010). Effect of different spacing and levels of nitrogen fertilizer on the yield attributes and yield of hybrid maize. *J. Expt. Biosci*. **1**(2): 57-62.

Sangoi, L. (2001). Understanding plant density effects on maize growth and development: An important issue to maximize grain yield. *Ciencia Rural*. **31**(1): 159-168.

Seckler, William, D. 1998. World water demand and supply, 1990 to 2025: *Scenarios and Issues.* **19**(1): 1-39.

Shen, D., Zhang, G., Xie, R., Ming, B., Hou, P., Xue, J., Li, S. and Wang, K.(2020). Improvement in Photosynthetic Rate and Grain Yield in Super-High-Yield Maize (*Zea mays* L.) by Optimizing Irrigation Interval under Mulch Drip Irrigation. *Agronomy*. **10**(11): 1778.

Shompa, B. N., Fatima, K., Jony, M., Sarker, S., Ullah, M. J., Chowdhury, A. K. and Rahman, J. 2020. Selection of dwarf stature yield potential lines from F3 populations of white maize (*Zea mays* L.). *J. Genet. Resour.* **6**(2): 95-105. doi: 10.22080/jgr.2020.18610.1181

Taiz, L. and Zeiger, E. (2009). Fisiologia vegetal. 4th edition. Artmed Porto Alegre. Brasil. pp. 819.

Tefera, A. H. (2020). Optimization of irrigation scheduling and nitrogen rate of maize to improve yield and water use efficiency under irrigated agriculture. *Int. J. Cur. Res.* **12**(11): 14802-14808.

Timsina, J., Jat, M. L. and Majumdar, K. (2010). Rice-maize systems of South Asia: current status, future prospects and research priorities for nutrient management. *Plant Soil*. **335**: 65–82.

Ukonze, J. A., Akor, V. O. and Ndubuaku, U. M. (2016). Comparative analysis of three different spacing on the performance and yield of late maize cultivation in Etche local government area of Rivers State, Nigeria. *Afr. J. Agric. Res.* **11**(13): 1187–1193.

Ullah, M. J., Islam,M. M., Fatima., K., Mahmud, M.S. and Rahman, J. (2016). Evaluating yield and yield performance of transplanted white maize varieties under varying planting geometry. *J. Expt. Biosci.* **7**(2): 21-30**.**

Ullah, M. J, Islam, M. M., Fatima, K., Mahmud, M. S., Akhter, S., Rahman, J. and Quamruzzaman, M. M. (2017a). Comparing modern varieties of white maize with land races in Bangladesh: phenotypic traits and plant characters. *J. Expt. Biosci.* **8**(1): 27–40.

Ullah M. J., Islam, M. M, Fatima, K., Mahmud, S., Rahman, J. and Akhter, S. (2017b). Comparing modern varieties of white maize with local races: ear characters. *J. Expt. Biosci*. **8**(2): 49-58.

Ullah M. J., Islam, M. M, Fatima, K., Mahmud, S. and Mannan, M. A. (2018a). Performance of two exotic white maize hybrids as influenced by varying soil moisture regimes during seedling transplantation. *J. Expt. Biosci*. **9**(2): 59-70.

Ullah M. J., Islam, M. M., Fatima, K., Mahmud, M. S. and Islam, R. I. (2018b). Yield and yield attributes of two exotic white maize hybrids at different agro climatic regions of Bangladesh under varying fertilizer doses. *Adv. Agric. Environ. Sci.* **2**(2): 65-71. DOI: 10.30881/aaeoa.00024

Ullah, M.J., Akbar, M. A. and Sarker, A. Z. (2018c). Prospect and cultivation practices of white maize: a secondary staple crop for Bangladesh). Published by the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

Ullah M. J., Islam, M. M., Fatima, K., Mahmud, M. S. and Islam, R. I. (2018d). Yield and yield attributes of two exotic white maize hybrids at different agro climatic regions of Bangladesh under varying fertilizer doses. *Adv. Agric. Environ. Sci.* **2**(2): 65-71. DOI: 10.30881/aaeoa.00024

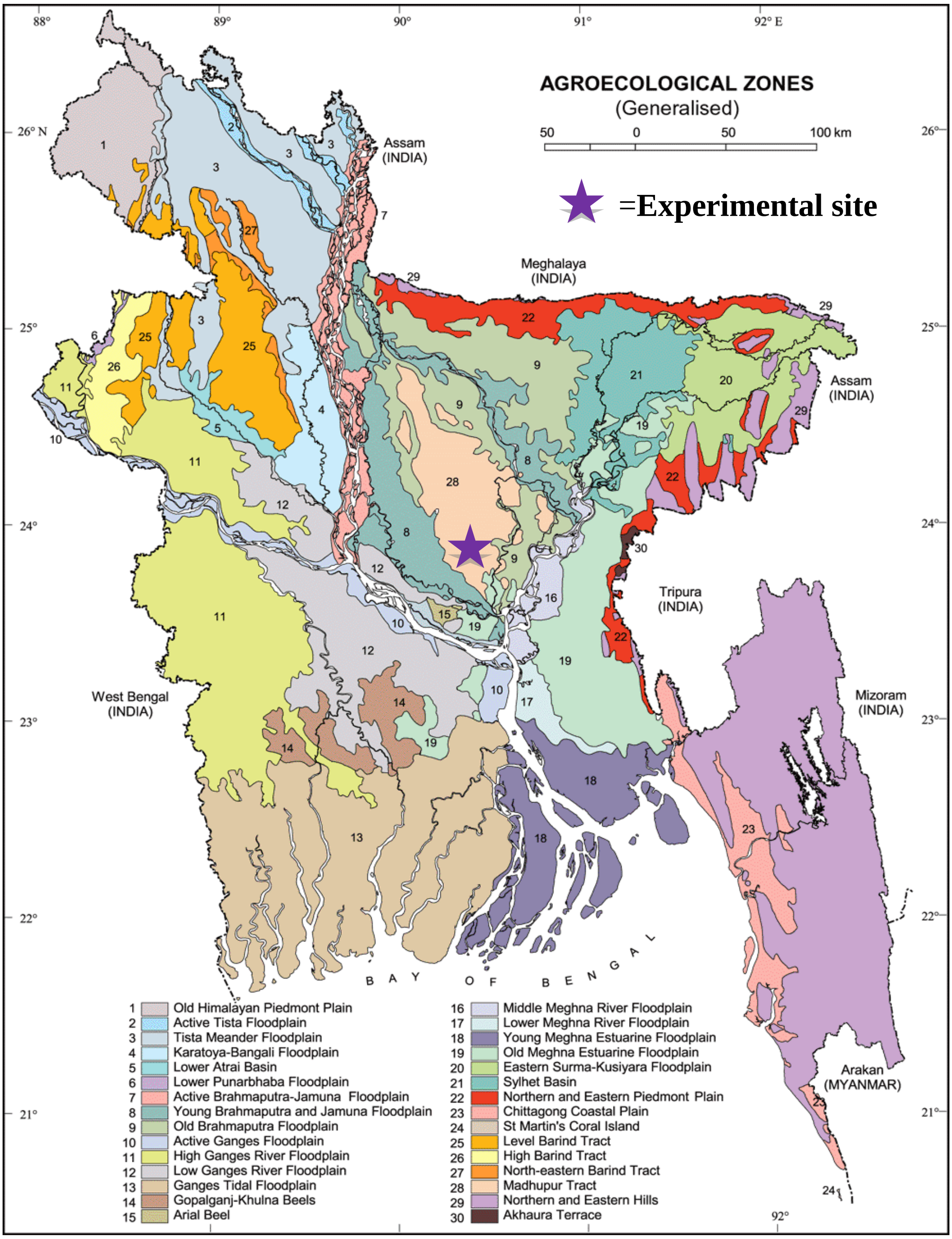
Ullah, M. J., Linu, S. B.B., Islam, M. M., Fatima, K. and Mahmud, M. S. (2019). Irrigation water management through using polyethylene mulch material. *Adv Agr Environ Sci.***2**(2): 74-83. DOI: 10.30881/aaeoa.00024

Worku, A. and Derebe, B. (2020). Response of maize (*Zea mays* L.) to nitrogen and planting density in Jabitahinan district, Western Amhara region. Cogent Food Agric. *Soil Crop Sci.* **6**: 1-14.

Zamir, M. S. I., Yasin, G., Javeed, H. M. R., Ahmad, A. U. H., Tanveer, A. and Yaseen, M. (2013). Effect of different sowing techniques and mulcheson the growth and yield behavior of spring planted maize *(Zea mays* L.). *Cercetări Agronomice în Moldova.* **153**(1): 77–82.

APPENDICES

Appendix I. Map showing the experimental location under study



Appendix II. Monthly meteorological information during the period from October, 2019 to March, 2020.

Year	Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	October	31.2	23.9	76	52
	November	29.6	19.8	53	00
	December	28.8	19.1	47	00
2020	January	25.5	13.1	41	00
	February	25.9	14	34	7.7
	March	31.9	20.1	38	71

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

Appendix III. Characteristics of soil of experimental field

A. Morphological characteristics 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)

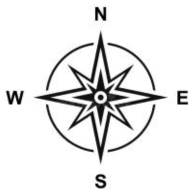
Physical characteristics

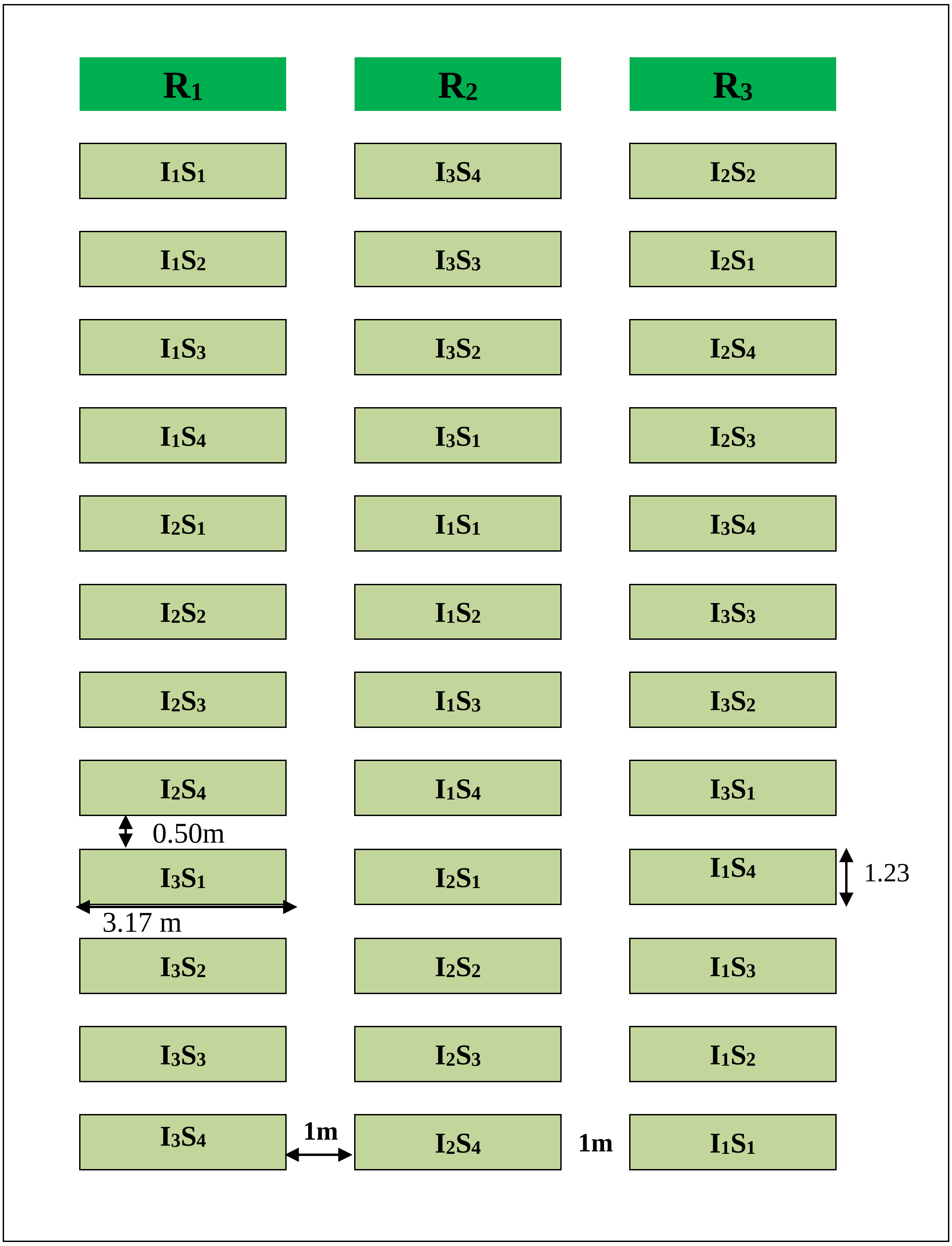
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

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 IV. Layout of the experimental field





LEGENDS

R: Replication, $\mathbf{I_1}$: Irrigation at 20 days interval, $\mathbf{I_2}$: Irrigation at 25 days interval, $\mathbf{I_3}$: Irrigation at 30 days interval and spacing $\mathbf{S_1}$: 50 cm × 20 cm, $\mathbf{S_2}$: 50 cm×25 cm, $\mathbf{S_3}$: 60 cm× 20 cm, and $\mathbf{S_4}$: 60 cm× 25 cm

Appendix V. Analysis of variance of the data of plant height of white maize at different DAS

Source of variation	DF	Mean square value of plant height (cm) of white maize			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	2.33	75.44	34.11	3.08
Irrigation frequencies (A)	2	193.39*	600.78*	3846.20*	706.33*
Error-I	4	9.83	82.94	110.61	20.08
Spacing (B)	3	46.22*	895.98*	266.90*	1268.20*
(A × B)	6	19.93*	576.89*	140.66*	56.77*
Error-II	18	7.33	103.11	47.78	17.82
Total	35				

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of number of leaves of white maize at different DAS

Source of variation	DF	Mean square value of number of leaves of white maize			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	0.02	0.04	0.33	0.080
Irrigation frequencies (A)	2	0.32*	1.35*	9.89*	2.65*
Error-I	4	0.05	0.08	0.83	0.10
Spacing (B)	3	1.26*	1.46*	16.19*	3.41*
(A × B)	6	0.28*	0.48*	2.39*	0.58*
Error-II	18	0.04	0.069	0.67	0.096
Total	35				

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of plant leaf area of white maize at different DAS

Source of variation	DF	Mean square value of plant leaf area of white maize			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	6.33	633.3	2500	3333
Irrigation frequencies (A)	2	2163.51*	10528.4*	5616^{NS}	80958*
Error-I	4	13.83	1133.3	5000	8333
Spacing (B)	3	6611.16*	17698.9*	121024*	274986*
(A × B)	6	5655.45*	2983.2*	58305*	133064*
Error-II	18	11.33	966.7	4167	6667
Total	35				

NS: Non significant
*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of dry matter weight of white maize at different DAS

Source of variation	DF	Mean square value of dry matter weight of white maize			
		30 DAS	60 DAS	90 DAS	At harvest
Replication	2	0.35871	15.549	102.74	29.78
Irrigation frequencies (A)	2	2.36202*	258.276*	2049.90*	69.59*
Error-I	4	0.24671	14.861	98.74	15.44
Spacing (B)	3	1.81760*	106.453*	2485.00*	2874.61*
(A × B)	6	9.63679*	97.679*	696.82*	65.03*
Error-II	18	0.28404	15.090	100.07	20.22
Total	35				

*: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data of yield contributing characters of white maize

Source of variation	DF	Mean square value of yield contributing characters of white maize	
		Cob length	Cob circumference
Replication	2	0.86	0.86
Irrigation frequencies (A)	2	31.04*	35.55*
Error-I	4	1.03	1.03
Spacing (B)	3	22.64*	12.69*
(A × B)	6	1.83*	1.44*
Error-II	18	0.45	0.45
Total	35		

*: Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data of yield contributing characters of white maize.

Source of variation	DF	Mean square value of yield contributing characters of white maize			
		Row cob^{-1}	Grain row^{-1}	No. of grains cob^{-1}	1000 grains weight
Replication	2	0.32455	0.08333	48.11	48.11
Irrigation frequencies (A)	2	3.34*	0.30240^{NS}	1056.28	1056.28
Error-I	4	0.14	0.21	200.11	200.11
Spacing (B)	3	4.13*	5.39*	3845.53*	3845.53*
(A × B)	6	0.88*	0.72*	916.53*	916.53*
Error-II	18	0.13	0.19	110.19	110.19
Total	35				

NS: Non significant
*: Significant at 0.05 level of probability

Appendix XI. Analysis of variance of the data of yield contributing characters of white maize

Source of variation	DF	Mean square value of yield contributing characters of white maize				
		Chaff weight cob^{-1}	Shell weight cob^{-1}	Grain weight cob^{-1}	Cob weight Plant^{-1}	Shelling %
Replication	2	0.19	0.1469	4.86	8.62	0.21
Irrigation frequencies (A)	2	2.18*	3.20*	95.00*	160.75*	1.06^{NS}
Error-I	4	0.32	0.32	4.95	7.93	0.31
Spacing (B)	3	2.32*	10.23*	1260.02*	1571.63*	29.23*
(A × B)	6	0.56*	0.78*	37.73*	39.94*	2.44*
Error-II	18	0.28	0.2664	12.77	14.01	1.02
Total	35					

NS: Non significant
*: Significant at 0.05 level of probability

Appendix XII. Analysis of variance of the data of yield characters of white maize

Source of variation	DF	Mean square value of yield contributing characters of white maize			
		Grain yield	Stover yield	Biological yield	Harvest index
Replication	2	0.08	0.21	0.33	1.84
Irrigation frequencies (A)	2	0.72*	0.23*	0.57*	12.41*
Error-I	4	0.08	0.04	0.02	1.83
Spacing (B)	3	3.57*	7.71*	16.54*	46.35*
(A × B)	6	0.38*	0.76*	0.33*	15.79*
Error-II	18	0.08	0.09	0.12	1.92
Total	35				

*: Significant at 0.05 level of probability

APPENDIX: PLATES

Plate 1: Photograph showing seedlings of white maize

Plate 2: Photograph showing weeding and thinning of the experimental field

Plate 3: Photograph showing vegetative stage of white maize

Plate 4: Photograph showing field inspection by supervisor

Plate 5: Photograph showing siliking time of white maize

Plate 6: Photograph showing harvesting of white maize