# GROWTH AND YIELD OF SAU SHADA BHUTTA-3 UNDER DIFFERENT SPACING AND IRRIGATION FREQUENCY IN RABI SEASON

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***CERTIFICATE***

*This is to certify that thesis entitled, "**GROWTH AND YIELD OF SAU SHADA BHUTTA-3 UNDER DIFFERENT SPACING AND IRRIGATION FREQUENCY IN RABI SEASON**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MAKSUDA CHOWDHURY**, **Registration no. 14-06278** 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.*

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*Dedicated To*

*My Beloved*

*Parents And*

*Respected*

*Teachers Whose*

*Prayers, Efforts*

*And Wishes Are*

*an Inspiration*

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## ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University farm, Dhaka to investigate the effect of different spacing and irrigation frequency on the growth and yield response of Shada bhutta-3 during October-2019 to February-2020. The experiment was consisted of two factors. Factor A: Irrigation frequencies (3) *viz* ; $I_1$: Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and Factor B: Different spacings (4) *viz* ; $S_1$: 40 cm × 20 cm, $S_2$: 40 cm × 25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm. The experiment was laid out in split plot design with three replications. Results indicated that irrigation frequency, different spacing and their combination had significant effect on growth, yield and yield contributing characters of Shada bhutta-3. In case of irrigation frequencies the maximum cob length plant$^{-1}$ (17.26 cm), cob circumference plant$^{-1}$ (14.94 cm), grain weight cob$^{-1}$ (90.44 g) and grain yield (9.04 t ha$^{-1}$) were observed in $I_1$ treatment. At different spacing the maximum cob length plant$^{-1}$ (17.26 cm), cob circumference plant$^{-1}$ (15.44 cm), number of rows cob$^{-1}$ (14.52), number of grains row$^{-1}$ (28.40), and 1000 grains weight (396.67 g) were observed in $S_4$ treatment. The maximum grain yield (9.37 t ha$^{-1}$) was observed in $S_1$ treatment. In case of combination, maximum grain yield (9.54 t ha$^{-1}$) was observed in $I_1S_1$ ($I_1$: 30 days irrigation interval along with spacing $S_1$ :40 × 20 cm) treatment combination whereas minimum grain yield (7.45 t ha$^{-1}$) was observed in $I_3S_4$ treatment combination.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| AEZ | Agro-Ecological Zone |
| AIS | Agriculture Information Service |
| Anon. | Anonymous |
| BARC | Bangladesh Agricultural Research Council |
| BARI | Bangladesh Agricultural Research Institute |
| BBS | Bangladesh Bureau of Statistics |
| BINA | Bangladesh Institute of Nuclear Agriculture |
| BNNC | Bangladesh National Nutrition Council |
| CIMMYT | International Maize and Wheat Improvement Center |
| CV % | Percent of Coefficient of Variance |
| cv. | Cultivar (s) |
| DAS | Days After Sowing |
| eds. | Editors |
| et al. | et alii (and others) |
| etc. | et cetera (and other similar things) |
| FAO | Food and Agriculture Organization |
| HI | Harvest Index |
| i.e. | id est (that is) |
| IARI | Indian Agricultural Research Institute |
| ICAR | Indian Council of Agricultural Research |
| IRRI | International Rice Research Institute |
| L. | Linnaeus |
| LSD | Least Significant Difference |
| MOP | Muriate of Potash |
| NPTs | New Plant Types |
| SAU | Sher-e-Bangla Agricultural University |
| SRDI | Soil Resources and Development Institute |
| TDM | Total Dry Matter |
| TSP | Triple Super Phosphate |
| UNDP | United Nations Development Programme |
| var. | Variety |
| viz. | Namely |

# 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 1$^{st}$ in respect of yield per unit area, 2$^{nd}$ in respect total production and 3$^{rd}$ 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 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 maize 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 government 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.,* 2018c; Bithy and Ahamed, 2018). The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices (such as proper management of planting configuration, irrigation interval, 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.*, 2017).

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, 2004; Seckler, 1998). Higher yield up to 9-11 t $ha^{-1}$ 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 is 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 how much irrigation water to apply (Ahmad, Wajid, Ahmad, Cheema, & Judge, 2019; Filintas *et al*., 2007; Guo, Gao, Tang, Liu, & Chu, 2015).

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; ). Maize differs in its responses to plant spacing (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. 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:**

1. To examine the effect of irrigation frequency on the growth, yield and yield contributing characters of white maize variety SAU Shada Bhutta-3.
2. To study the effect of different spacing on the growth and productivity of white maize variety SAU Shada Bhutta-3.
3. To evaluate the combined effect of irrigation frequency and spacing on the growth and yield of white maize variety SAU Shada Bhutta-3.

## 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 founded significant variations in respect of plant height at different irrigation timings. The longest plants (41.41, 71.62, 183.6 and 186.1 cm) with $I_4$ treatment (Four irrigations at 15, 30, 60 and 90 DAS) and the shortest plants (33.83, 44.77, 122.7 and 127.4 cm) with $I_0$ (control) treatment at the respective growth stages.

Baloch *et al*. (2014) reported 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 experiments in 2010 and 2011 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 and optimal irrigation interval for maize under DRFI (Double ridge-furrow planting technique) was also determined. Result showed that, 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 year compared to the 14-day interval and the conventional treatment.

Elzubeir and Mohamed (2011) indicated that 10 days irrigation interval gave the highest values of plant height (201 & 205 cm) compeered to others irrigation intervals in both year.

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 reported that number of leaves plant$^{-1}$ due to the effect of irrigation interval.

Baloch *et al*. (2014) 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 revealed that the maximum total dry matter weight (4.46 & 4.37 kg m$^{-2}$) was observed in six days irrigation intervals 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 and reported 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) had significantly higher effects on above-ground biomass (18.25 t /ha) and on grain yield (4.8 t/ha) of irrigated maize in the study area.

Ullah *et al.* 2019 reported that the highest dry weight plant$^{-1}$ was found in $I_4$ (Four irrigations at 15, 30, 60 and 90 DAS) 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 reported that cob length of maize ranged from 26.52 to 19.59 cm, and the longest cob was found in $I_4$ (Four irrigations at 15, 30, 60 and 90 DAS) treatment. The lowest cob length 19.59 cm was recorded treatment $I_0$ (Control).

Elzubeir and Mohamed (2011) reported 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 year.

### 2.1.5 No of row cob$^{-1}$

Ullah *et al.* 2019 reported that different irrigation frequency effect on number of row cob$^{-1}$ and the maximum number of row cob$^{-1}$ was found in $I_4$ (Four irrigations at 15, 30, 60 and 90 DAS) treatment.

Elzubeir and Mohamed (2011) reported that 10 days irrigation interval gave the highest number of rows cob$^{-1}$ (14 & 15 ) compared to others irrigation intervals in both year.

### 2.1.6 No. of grains cob$^{-1}$

Shen *et al.* 2020 reported that that the highest number of grains cob$^{-1}$ (524.6 & 540.6) was observed in six days irrigation intervals (D6 treatment) compared to others treatment in both years.

Ullah *et al.* 2019 reported that among different Irrigation frequencies, four irrigations at 15, 30, 60 and 90 DAS ($I_4$) showed the maximum no. of row cob$^{-1}$ (14.73).

Elzubeir and Mohamed (2011) reported that 10 days irrigation interval gave the maximum number of grains cob$^{-1}$ (281 & 397) compared to others irrigation intervals in both year.

### 2.1.7 1000 grain weight

Shen *et al.* 2020 revealed that the maximum 1000 grain weight (385.& 422 g) was observed in six days irrigation intervals (D6) treatment compared to others treatment in both years.

Ullah *et al.* 2019 founded significant variation in respect of 100-grain of maize due to different irrigation frequency.

Abd El-Halim and Abd El-Razek (2013) conducted a field experiments 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. Result revealed that double ridged-furrow planting with irrigation at 7-day intervals proved superior to increase 1000 grain weight (369.3 & 372.5 g) and water productivity in both year compared to the 14-day interval and the conventional treatment.

Elzubeir and Mohamed (2011) reported that 10 days irrigation interval gave the highest values 1000 seed yield (220 & 200 g) compared to others irrigation intervals in both year.

### 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. Experimental result revealed that 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 revealed that the six irrigation intervals (D6) recorded 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 founded 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 experiments 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.

Elzubeir and Mohamed (2011) 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 year.

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. The highest straw yield of 15.13 t $ha^{-1}$ was recorded from $I_4$ treatment 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.

Elzubeir and Mohamed (2011) reported that 10 days irrigation interval gave the highest values of stover yield (4.8 & 4.6 t $ha^{-1}$ ) compared to others irrigation intervals in both year.

### 2.1.10 Harvest index

Shen *et al.* 2020 conducted a field experiments 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 and founded 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 and founded that the highest harvest index (40.98%) was observed from $I_4$ (Four irrigations at 15, 30, 60 and 90 DAS) 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) reported that 10 days irrigation interval gave the highest values of harvest index (30 & 50 %) compared to others irrigation intervals in both year.

## 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 and showed that 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) 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) reported 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.

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 plant height (288 cm) whereas the 60 x25 cm spacing had the shortest plants (242 cm).

Enujeke (2013 a) reported 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 to evaluate the performance of white maize variety under different spacing and integrated fertilizer management and reported that higher leaves number plant$^{-1}$ was achieved with higher plant spacing where lower plant spacing showed lower leaf number plant$^{-1}$. The highest leaves number plant$^{-1}$at 8.00, 10.04 and 11.93 respectively at $S_1$ where the lowest were 7.81,
9.19 and 11.57 respectively which was with $S_2$.

Jula *et al*. (2013) carried out a field experiment to evaluate the effects of various intra-row spacing on the growth and yield of maize intercropped into ginger. 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 and reported that 70 cm × 30 cm and 60 cm × 40 cm spacing gave higher values of the morphological parameters (leaf area plant$^{-1}$ ) than 80 cm × 20 cm.

Enujeke (2013 a) 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) reported that the highest above ground dry biomass yields per plant was occurred at the widest inter and intra-row spacing might be due to high stem diameter and high leaf area because there is more availability of growth factors and better penetration of light at wider row spacing.

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) reported that the longest cob (15.99 cm) 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) reported 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) founded that the highest grain yield was found in Rampur Composite and Arun-2 while they were planted with row spacing of 60 cm with plant to plant spacing of 25 cm. The highest cob length was reported when maize was planted in the row spacing 60×25 cm.

Azam (2017) conducted a field study to investigate the effect of various intra-row plant spacings on the yield of different maize hybrids and 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) reported that 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) founded 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 spacingss on different maize varieties and founded the highest cob Circumference was reported when maize was planted in the row spacing 60×25cm.

Hasan *et al*. (2018) reported 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) reported that the highest number of rows per cob was reported when maize was planted in the row spacing 60×25cm.

Azam (2017) 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) 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) found 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) reported that 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 and reported 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) 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 an 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 thousands 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 grains weight

Koirala *et al*. (2020) reported that highest average thousand grain weight was reported when maize was planted in the row spacing 60×25 cm.

Hasan *et al*. (2018) founded 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) reported 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 thousands 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 an 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) reported 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 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 thousands 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), whereas the D1 produced (5.832 t/ha)

Salam *et al.* (2010) carried out an 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) reported that 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.

Nand (2015) reported that 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) 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) founded that 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) reported that 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. 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.

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 were 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 of 45 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-row 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 $ha^{-1}$ ).

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize and reported that variety and plant spacing had significant effect on the studied crop charactersand yield. The maximum grain yield was observed in the spacing of 75 cm × 25cm. The lowest grain yield was recorded from the plant spacing of 75 cm × 35 cm with Khoi bhutta.

Akbar *et al.* (2016) reported that planting in twin-rows giving 80,000 plants per ha and produced 17.7 % higher yield compared with planting in single rows 60 cm apart giving 66,667 plants $ha^{-1}$.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) reported that different spacing had significant effect on stover yield of maize Results revealed that highest stover yield 9.92 t $ha^{-1}$ was attained with $S_2$ where the lowest 7.28 t $ha^{-1}$ was with $S_1$.

Worku and Derebe (2020) conducted a field experiments 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) reported that 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) reported that the variation in biological yield due to each increment in nitrogen level and spacing was significant ($p<0.01$). The highest biological yield (12.37 mt/ha) produced under 60×15 cm spacing and the lowest biological yield (9.24 mt/ha) produced under 60×25 cm spacing.

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

### 2.2.17 Harvest index (%)

Ahmmed *et al.* (2020) reported 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 directed 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 Biswas *et 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

"**SAU Shada Bhutta-3**" genotype of white maize used as planting material for the present study. These variety was recommended for Rabi and kharif season. The feature of this variety was presented below:

| **Name of Variety** : **SAU Shada Bhutta-3** | |
|---|---|
| **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** : 180–200 cm | **Cob colour :** White colour. |
| **Crop duration** : 110–120 days | **Grain colour** : White |
| **Leaf colour at Maturity** : Light Green color at maturity | **Yield** : 9-9.50 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 maintain balance fertilizer application. Seed treatment with vitavax-200 @ 2.50 g $kg^{-1}$ seed, spraying with Tilt or Folicure @ 0.5% and burning of crop residues.

**Major insect/pest and management**

**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.

### 3.8 Experimental details

**Land preparation Date:** 19 October 2019

**Seed Sowing Date:** 20 October 2019

**Spacing:** According to the treatment requirement

**Fertilizer apply Dat**e: All the fertilizers were applied at 19 October 2019 during final land preparation except total urea

**Flowering date:** 24 December 2019

**Silking Date:** 2 January

**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 (Three levels) | **Factor B:** Different spacings (Four levels) |
|---|---|
| **$I_1$**: Irrigation at 30 days interval | **$S_1$**: 40 cm × 20 cm |
| **$I_2$**: Irrigation at 35 days interval | **$S_2$**: 40 cm× 25 cm |
| **$I_3$**: Irrigation at 40 days interval | **$S_3$**: 50 cm× 20 cm |
| | **$S_4$**: 50 cm× 25 cm |

### 3.9.2 Treatment combinations

This 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 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 were 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 shada bhutta seeds were sown in lines maintaining sapcing 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

As described in section 3.7.

### 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$^{-1}$ (no.)
viii. Number of grains row$^{-1}$(no)
ix. Number of grains cob$^{-1}$(no)

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$^{-1}$ =

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

**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 calculate the total dry matter of a plant 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 grains

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

### 3.14.11 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:

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

### 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 weight (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:

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

### 3.15 Statistical data analysis

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

# CHAPTER IV

# RESULTS AND DISCUSSION

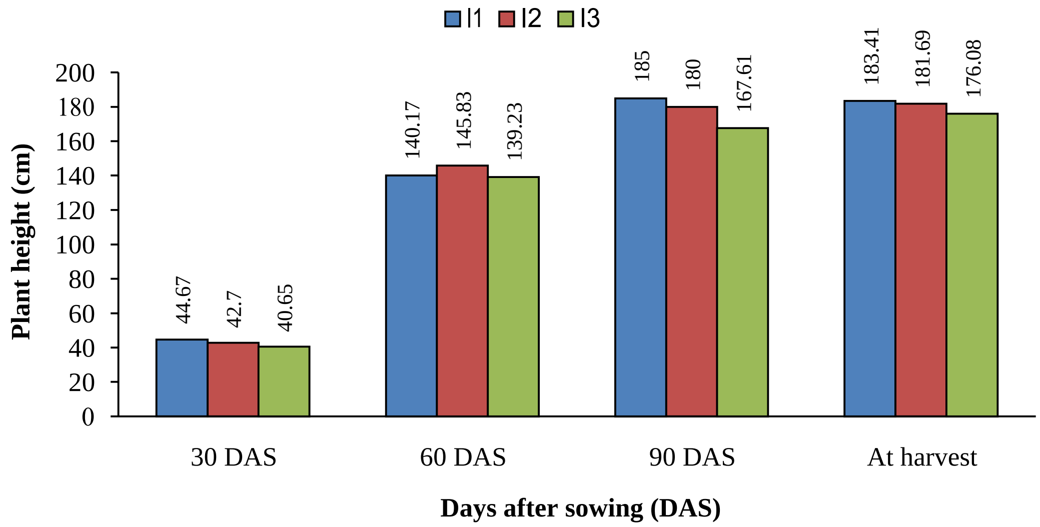
The data on different growth, yield contributing characters and yield were recorded to find out the compatible irrigation frequency and spacing on white maize. The results have been presented and discussed and possible explanation have been given under the following headings:

## 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 shada bhutta at different days after sowing (Figure 1 and Appendix V). The maximum plant height (44.67 cm) at 30 DAS was observed in $I_1$ treatment. At 60 DAS the maximum plant height (145.83 cm) was observed in $I_2$ treatment. At 90 DAS and at harvest respectively the maximum plant height (185.0 and 183.41 cm) was observed in $I_1$ treatment which was statistically similar with $I_2$ (180.00 and 181.69 cm) treatment at 90 DAS and at harvest respectively. Whereas the minimum plant height (40.65, 139.23, 167.61 and 176.08 cm at 30, 60, 90 DAS and at harvest respectively) was observed in $I_3$ treatment which was statistically similar with $I_1$ (140.17 cm) treatment at 60 DAS. 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 year (2005/06 and 2006/07).

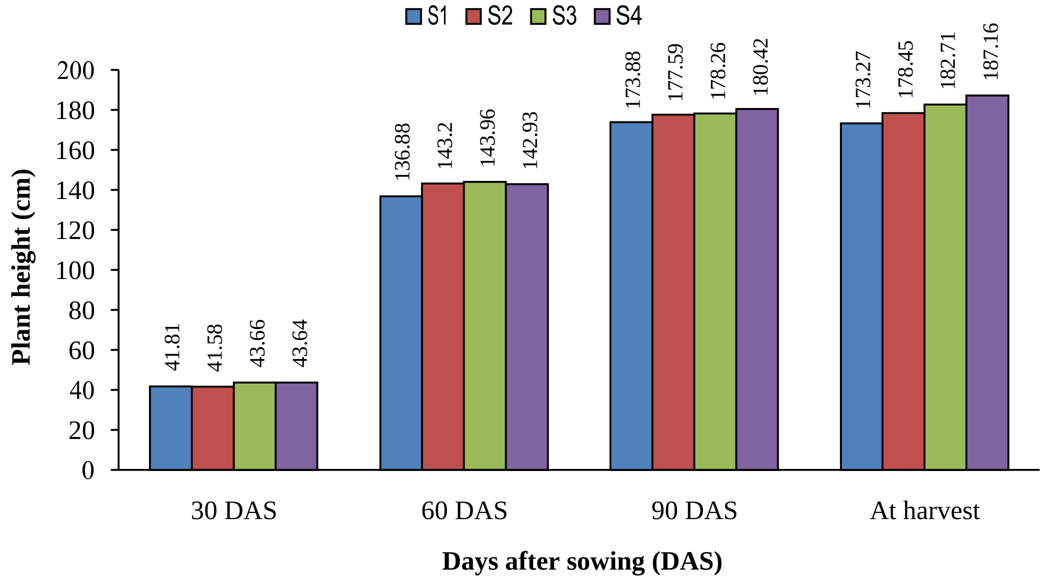



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 1. Effect of irrigation frequencies on plant height of shada bhutta at different DAS ($LSD_{(0.05)}$=1.78, 5.26, 5.96 and 2.53 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 shada bhutta at different days after sowing (Figure 2 and Appendix V). From the experiment result revealed that the maximum plant height (43.66 and 143.96 cm) at 30 and 60 DAS was observed in $S_3$ treatment which was statistically similar with $S_4$ ( 43.64 cm) treatment at 30 DAS; with $S_2$ ( 143.20 cm) and $S_4$ (142.93 cm) treatment at 60 DAS. At 90 DAS and at harvest respectively the maximum plant height (180.42 and 187.16 cm) was observed in $S_4$ treatment which was statistically similar with $S_3$ (178.26 cm) and $S_2$ (177.59 cm) treatment at 90 DAS. Whereas the minimum plant height (41.81, 136.88, 173.88 and 173.27 cm at 30, 60 90 DAS and at harvest respectively) was observed in $S_1$ treatment which was statistically similar with $S_2$ (41.58 cm) treatment at 30 DAS. Alam *et al*. (2020) and Ahmmed *et al*. (2020) also found similar result which supported the present study.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 2. Effect of spacing on plant height of shada bhutta at different DAS ($LSD_{(0.05)}$=1.34, 5.10, 3.42 and 2.08 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 shada bhutta (Table 1 ). From the experiment result exhibited that the maximum plant height (45.75 cm) at 30 DAS was observed in $I_1S_3$ treatment combination which was statistically similar with $I_1S_1$ (44.52 cm), $I_1S_2$ (44.41 cm), $I_2S_4$ (44.23 cm) and $I_1S_4$ (43.98 cm) treatment combination. At 60 DAS the maximum plant height (149.23 cm) was observed in $I_2S_4$ treatment combination which was statistically similar with $I_1S_3$ (148.30 cm), $I_2S_1$ (147.83 cm), $I_3S_2$ (147.80 cm) , $I_2S_3$ (143.90 cm) , $I_2S_2$ (142.35 cm) and $I_3S_4$ (141.45 cm) treatment combination. At 90 DAS and at harvest respectively the maximum plant height (187.47 and 192.10 cm) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_1S_2$ (186.92 cm), $I_1S_3$ (183.87 cm) , $I_2S_4$ (183.00) , and $I_1S_1$ (181.75 cm) treatment combination at 90 DAS; and with $I_2S_4$ (188.71 cm) treatment combination at harvest respectively. Whereas the minimum plant height (38.33 cm) at 30 DAS was observed in $I_3S_2$ treatment combination which was statistically similar with $I_3S_1$ (38.95 cm) treatment combination. At 60, 90 DAS and at harvest respectively the minimum plant height (128.01, 159.47 and 171.97 cm) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_1S_1$ (134.80 cm) treatment combination at 60 DAS; with $I_2S_1$ (172.46 cm), $I_3S_2$ (174.48 cm) and $I_1S_1$ (175.38 cm) treatment combination at harvest respectively.

**Table 1: Combined effect of different irrigation frequencies and plant spacing on plant height of shada bhutta at different DAS**

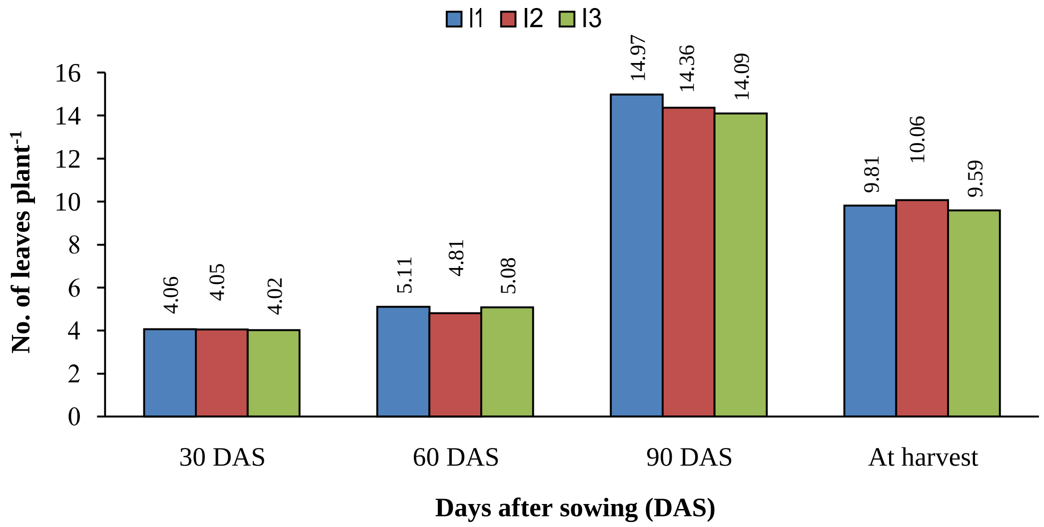
| Treatments combination | Plant Height (cm) at | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| **$I_1S_1$** | 44.52 ab | 134.80 de | 181.75 ab | 175.38 fg |
| **$I_1S_2$** | 44.41 ab | 139.47 b-d | 186.92 a | 180.04 de |
| **$I_1S_3$** | 45.75 a | 148.30 ab | 183.87 ab | 186.14 bc |
| **$I_1S_4$** | 43.98 a-c | 138.12 cd | 187.47 a | 192.10 a |
| **$I_2S_1$** | 41.94 c | 147.83 ab | 180.42 b | 172.46 g |
| **$I_2S_2$** | 42.00 c | 142.35 a-d | 178.17 bc | 180.82 d |
| **$I_2S_3$** | 42.61 bc | 143.90 a-c | 178.42 bc | 184.78 c |
| **$I_2S_4$** | 44.23 a-c | 149.23 a | 183.00 ab | 188.71 ab |
| **$I_3S_1$** | 38.95 d | 128.01 e | 159.47 e | 171.97 g |
| **$I_3S_2$** | 38.33 d | 147.80 ab | 167.68 d | 174.48 fg |
| **$I_3S_3$** | 42.61 bc | 139.68 b-d | 172.50 cd | 177.21 ef |
| **$I_3S_4$** | 42.71 bc | 141.45 a-d | 170.80 d | 180.66 de |
| **$LSD_{(0.05)}$** | 2.32 | 8.83 | 5.92 | 3.60 |
| **CV(%)** | 3.17 | 3.63 | 1.95 | 1.16 |

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. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 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 only at 60 and 90 DAS on number of leaves plant$^{-1}$ of shada bhutta (Figure 3 and Appendix VI). From the experiment result showed that the maximum number of leaves plant$^{-1}$ (4.06, 5.11 and 14.97 at 30, 60 and 90 DAS) was observed in $I_1$ treatment which was statistically similar with $I_3$ (5.08) treatment at 60 DAS. At harvest respectively the maximum number of leaves plant$^{-1}$ (10.06) was observed in $I_2$ treatment. Whereas the minimum number of leaves plant$^{-1}$ (4.02) at 30 DAS was observed in $I_3$ treatment, at 60 DAS the minimum number of leaves plant$^{-1}$ (4.81) was observed in $I_2$ treatment, at 90 DAS and at harvest respectively the minimum number of leaves plant$^{-1}$ (14.09 and 9.59) was observed in $I_3$ treatment which was statistically similar with $I_2$ (14.36) 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 impact on number of leaves plant$^{-1}$ of white maize.

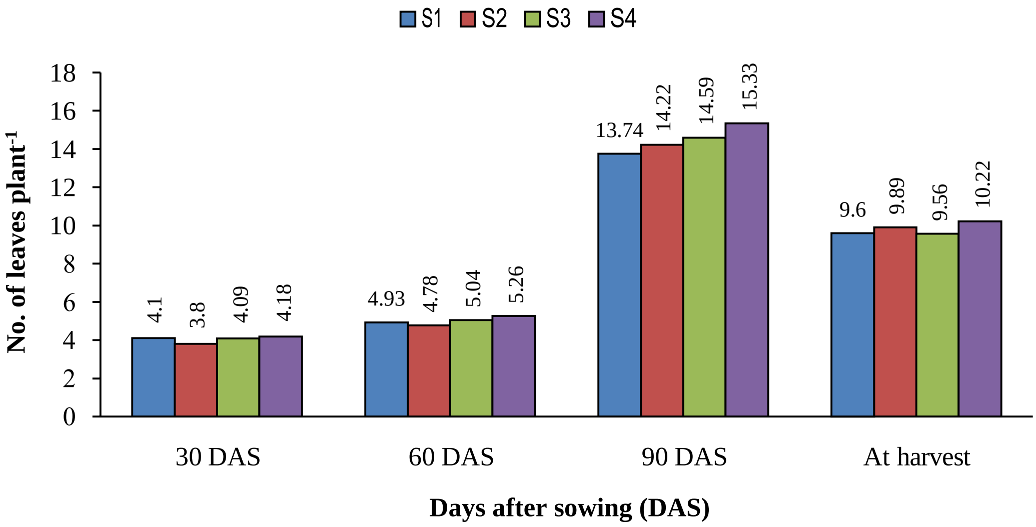



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 3. Effect of irrigation frequencies on number of leaves plant$^{-1}$ of shada bhutta at different DAS ($LSD_{(0.05)}$=0.12, 0.16, 0.52 and 0.52 at 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 shada bhutta at various days after sowing (Figure 4 and Appendix VI). From the experiment result showed that the maximum number of leaves plant$^{-1}$ of shada bhutta (4.18, 5.26, 15.33 and 10.22 at 30, 60, 90 DAS and at harvest respectively) was observed in $S_4$ treatment which was statistically similar with $S_1$ (4.10) and $S_3$ (4.09) treatment at 30 DAS; and with $S_3$ (9.89) treatment at harvest respectively. Whereas the minimum number of leaves plant$^{-1}$ of shada bhutta (3.80 and 4.78 at 30 and 60 DAS) was observed in $S_2$ treatment, at 90 DAS the minimum number of leaves plant$^{-1}$ of shada bhutta (13.74) was observed in $S_1$ treatment and at harvest respectively the minimum number of leaves plant$^{-1}$ of shada bhutta (9.56) was observed in $S_3$ treatment which was statistically similar with $S_1$ (9.60) treatment. Ahmmed *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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 4. Effect of spacing on number of leaves plant$^{-1}$ of shada bhutta at different DAS (LSD$_{(0.05)}$=0.09, 0.13, 0.40 and 0.40 at 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 shada bhutta at various days after sowing (Table 2). From the experiment result exhibited that the maximum number of leaves plant$^{-1}$ of shada bhutta (4.37 at 30 DAS) was observed in $I_2S_1$ treatment combination, which was statistically similar with $I_1S_4$ (4.34) treatment combination. At 60, 90 DAS and at harvest respectively the maximum number of leaves plant$^{-1}$ of shada bhutta (5.55, 16.11 and 10.44) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_2S_2$ (10.44), $I_2S_4$ (10.22), $I_3S_4$ (10.00), $I_2S_1$ (9.78), $I_2S_3$ (9.78)
and $I_1S_2$ (9.78) treatment combination at harvest respectively. Whereas the minimum number of leaves plant$^{-1}$ of shada bhutta (3.77 at 30 DAS) was observed in $I_1S_2$ treatment combination which was statistically similar with $I_2S_2$ (3.80), $I_3S_1$ (3.83) and $I_3S_2$ (3.83) treatment combination. At 60 DAS the minimum number of leaves plant$^{-1}$ of shada bhutta (4.56) was observed in $I_2S_2$ treatment combination which was statistically similar with $I_2S_1$ (4.56) treatment combination. At 90 DAS the minimum number of leaves plant$^{-1}$ of shada bhutta (13.67) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_2S_2$ (13.78), $I_2S_1$ (13.78), $I_3S_2$(13.78), $I_1S_1$ (13.78) and $I_3S_3$ (13.89) treatment combination. And at harvest respectively the

minimum number of leaves plant$^{-1}$ of shada bhutta (9.44) was observed in $I_3S_3$ treatment combination which was statistically similar with $I_3S_1$(9.45), $I_3S_2$(9.45), $I_1S_3$ (9.45) and $I_1S_1$ (9.56) treatment combination.

**Table 2: Combined effect of irrigation frequency and spacing on number of plant$^{-1}$ of shada bhutta at different DAS**

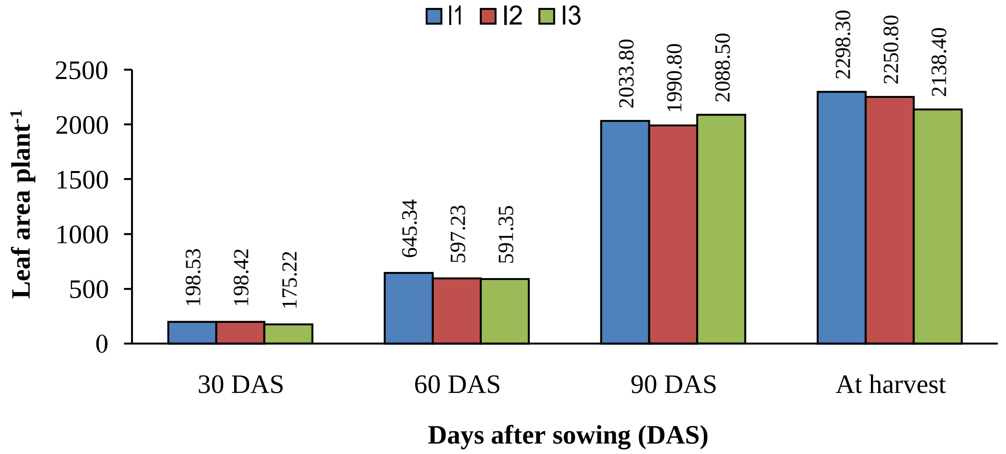
| Treatments combination | Number of leaves plant$^{-1}$ of white maize | | | |
|---|---|---|---|---|
| | **30 DAS** | **60 DAS** | **90 DAS** | **At harvest** |
| **$I_1S_1$** | 4.10 cd | 5.00 bc | 13.78 c | 9.56 bc |
| **$I_1S_2$** | 3.77 e | 4.89 c | 15.11 b | 9.78 a-c |
| **$I_1S_3$** | 4.03 d | 5.00 bc | 14.89 b | 9.45 c |
| **$I_1S_4$** | 4.34 ab | 5.55 a | 16.11 a | 10.44 a |
| **$I_2S_1$** | 4.37 a | 4.56 d | 13.78 c | 9.78 a-c |
| **$I_2S_2$** | 3.80 e | 4.56 d | 13.78 c | 10.44 a |
| **$I_2S_3$** | 4.03 d | 5.11 bc | 15.00 b | 9.78 a-c |
| **$I_2S_4$** | 4.00 d | 5.00 bc | 14.89 b | 10.22 ab |
| **$I_3S_1$** | 3.83 e | 5.22 b | 13.67 c | 9.45 c |
| **$I_3S_2$** | 3.83 e | 4.89 c | 13.78 c | 9.45 c |
| **$I_3S_3$** | 4.20 bc | 5.00 bc | 13.89 c | 9.44 c |
| **$I_3S_4$** | 4.20 c | 5.22 b | 15.00 b | 10.00 a-c |
| **$LSD_{(0.05)}$** | 0.16 | 0.23 | 0.70 | 0.70 |
| **CV(%)** | 2.30 | 2.64 | 2.82 | 4.16 |

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. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 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 increase its capture 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 synthesise 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 on the plant. Due to different irrigation frequencies, significant effect was observed in leaf area plant$^{-1}$ (cm$^2$) of shada bhutta at various days after sowing (Figure 5 and Appendix VII). From the experiment result showed that the maximum leaf area plant$^{-1}$ (198.53 and 645.34 cm$^2$ at 30 and 60 DAS) was observed in $I_1$ treatment which was statistically similar with $I_2$ (198.42) treatment at 30 DAS. At 90 DAS the maximum leaf area plant$^{-1}$ (2088.50 cm$^2$) was observed in $I_3$ treatment which was statistically similar with $I_1$ (2033.80 cm$^2$) treatment. And at harvest the maximum leaf area plant$^{-1}$ (2298.30 cm$^2$) was observed in $I_1$ treatment which was statistically similar with $I_2$ (2250.80 cm$^2$) treatment. Whereas the minimum leaf area plant$^{-1}$ (175.22 and 591.35 cm$^2$ at 30 and 60 DAS) was $I_3$ treatment which was statistically similar with $I_2$ (597.23 cm$^2$) treatment at 60 DAS. At 90 DAS the minimum leaf area plant$^{-1}$ (1990.80 cm$^2$) was observed in $I_2$ treatment. And at harvest the minimum leaf area plant$^{-1}$ (2138.40 cm$^2$) was observed in $I_3$ treatment. Appropriate irrigation frequency reduce 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.

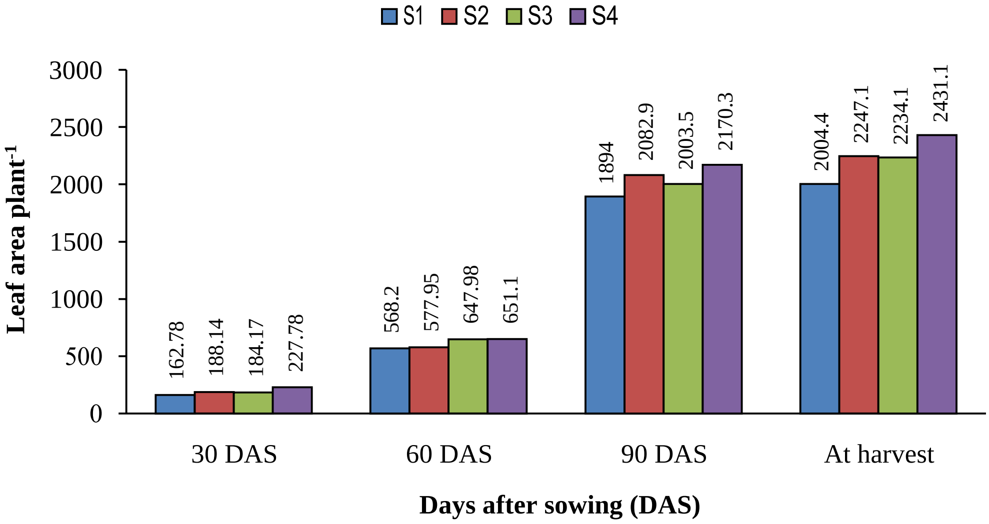



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 5. Effect of irrigation frequencies on leaf area plant$^{-1}$ of shada bhutta at different DAS (LSD$_{(0.05)}$=4.22, 38.16, 80.15 and 103.47 cm$^2$ 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 shada bhutta at various days after sowing (Figure 6 and Appendix VII). From the experiment result exhibited that the maximum leaf area plant$^{-1}$ (227.78, 651.10, 2170.3 and 2431.1 cm$^2$ at 30, 60, 90 DAS and at harvest respectively) was observed in $S_4$ treatment, which was statistically similar with $S_3$ (647.98 cm$^2$) treatment at 60 DAS. Whereas the minimum leaf area plant$^{-1}$ (162.78, 568.20, 1894.0 and 2004.4 cm$^2$ at 30, 60, 90 DAS and at harvest respectively) was observed in $S_1$ treatment, which was statistically similar with $S_2$ (577.95 cm$^2$) treatment at 60 DAS. 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 6. Effect of spacing on leaf area plant$^{-1}$of shada bhutta at different DAS (LSD$_{(0.05)}$= 3.33, 30.79, 63.93 and 80.87cm$^2$ at 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 shada bhutta at various days after sowing (Table 3). From the experiment result showed that the maximum leaf area plant$^{-1}$ (252.81, 716.24, 2387.5 and 2760.1 cm$^2$ at 30, 60, 90 DAS and at harvest respectively) was observed in $I_1S_4$ treatment combination, which was statistically similar with $I_1S_3$ (701.97 cm$^2$) treatment combination at 60 DAS; and with $I_3S_2$ (2339.9 cm$^2$) treatment combination at 60 DAS. Whereas the minimum leaf area plant$^{-1}$ (177.32 cm$^2$ at 30 DAS) was observed in $I_1S_2$ treatment combination, which was statistically similar with $I_2S_3$ (167.32 cm$^2$) treatment combination at 30 DAS. At 60, 90 DAS and at harvest respectively the minimum leaf area plant$^{-1}$ (540.27, 1800.9 and 1915.1 cm$^2$) was observed in $I_3S_1$ treatment combination, which was statistically similar with $I_3S_2$ (561.19 cm$^2$), $I_1S_1$ (578.40 cm$^2$), $I_1S_2$ (584.74 cm$^2$), $I_2S_1$ (585.91 cm$^2$)and $I_2S_2$ (587.92 cm$^2$) treatment combination at 60 DAS; with $I_1S_3$ (1870.6 cm$^2$) treatment combination at 90 DAS; and with $I_1S_1$ (1968.6 cm$^2$)and $I_3S_2$ (2010.4 cm$^2$) treatment combination at harvest respectively.

**Table 3: Combined effect of irrigation frequency and spacing on leaf area plant$^{-1}$ of shada bhutta at different DAS**

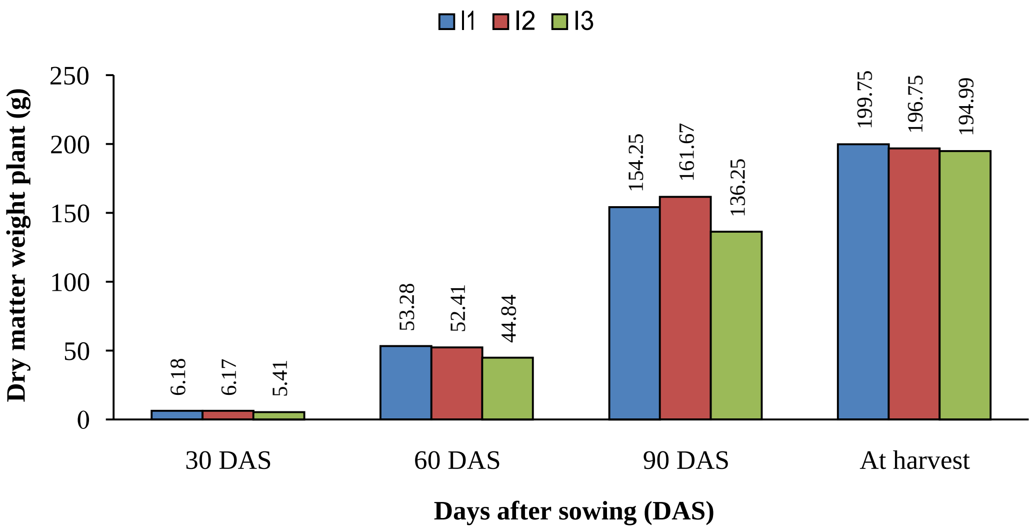
| Treatments combination | Plant leaves area ($cm^2$) at | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| $I_1S_1$ | 177.32 f | 578.40 c-e | 1928.0 cd | 1968.6 fg |
| $I_1S_2$ | 164.99 g | 584.74 b-e | 1949.1 cd | 2402.6 b |
| $I_1S_3$ | 198.99 d | 701.97 a | 1870.6 de | 2062.1 ef |
| $I_1S_4$ | 252.81 a | 716.24 a | 2387.5 a | 2760.1 a |
| $I_2S_1$ | 224.96 c | 585.91 b-e | 1953.0 cd | 2129.4 de |
| $I_2S_2$ | 202.34 d | 587.92 b-e | 1959.7 cd | 2328.3 bc |
| $I_2S_3$ | 167.32 g | 611.34 b-d | 2037.8 bc | 2298.1 bc |
| $I_2S_4$ | 199.05 d | 603.75 b-d | 2012.5 bc | 2247.3 cd |
| $I_3S_1$ | 86.07 h | 540.27 e | 1800.9 e | 1915.1 g |
| $I_3S_2$ | 197.10 d | 561.19 de | 2339.9 a | 2010.4 e-g |
| $I_3S_3$ | 186.21 e | 630.63 bc | 2102.1 b | 2342.1 bc |
| $I_3S_4$ | 231.48 b | 633.30 b | 2111.0 b | 2285.9 bc |
| $LSD_{(0.05)}$ | 5.78 | 53.33 | 110.73 | 140.06 |
| CV(%) | 1.77 | 5.09 | 3.17 | 3.66 |

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. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 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 shada bhutta at various days after sowing (Figure 7 and Appendix VIII). From the experiment result showed that the maximum dry matter plant$^{-1}$ (6.18 and 53.28 g at 30 and 60 DAS) was observed in $I_1$ treatment which was statistically similar with $I_2$ (6.17 and 52.41 g) treatment at 30 and 60 DAS. At 90 DAS the maximum dry matter plant$^{-1}$ (161.67 g) was observed in $I_2$ treatment which was statistically similar with $I_1$ (154.25 g) treatment. And at harvest respectively the maximum dry matter plant$^{-1}$ (199.75 g) was observed in $I_1$ treatment which was statistically similar with $I_2$ (196.75 g) treatment. Whereas the minimum dry matter plant$^{-1}$ (5.41, 44.84, 136.25 and 194.99 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.

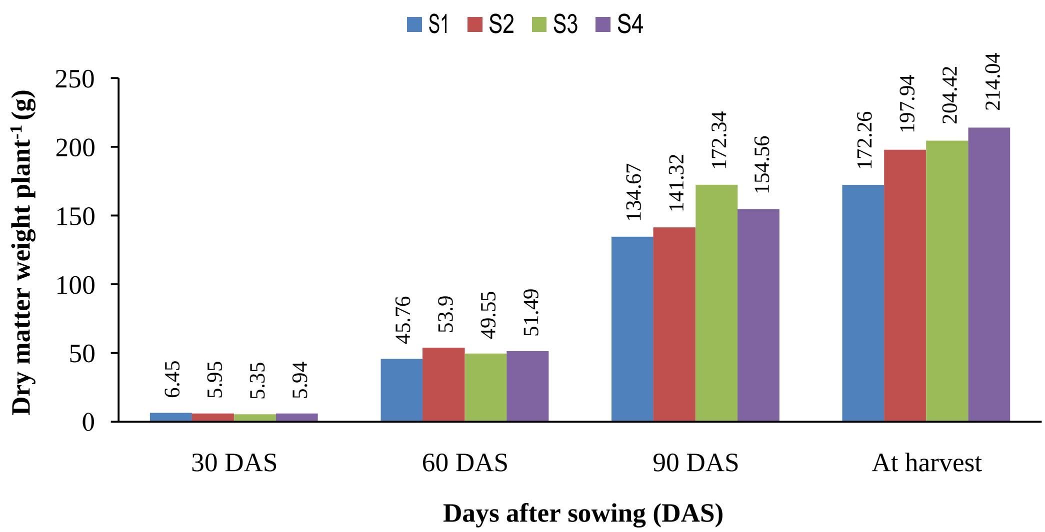



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 7. Effect of irrigation frequencies on dry matter weight plant$^{-1}$ of shada bhutta at different DAS (LSD$_{(0.05)}$= 0.56, 4.37 , 11.26 and 4.46 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 shada bhutta at various days after sowing (Figure 8 and Appendix VIII). From the experiment result exhibited that the maximum dry matter weight plant$^{-1}$ (6.45 g at 30 DAS) was observed in $S_1$ treatment which was statistically similar with $S_2$ (5.95 g) and $S_4$ (5.94 g) treatment. At 60 DAS the maximum dry matter weight plant$^{-1}$ (53.90 g) was observed in $S_2$ treatment which was statistically similar with $S_4$ (51.49 g). At 90 DAS the maximum dry matter weight plant$^{-1}$ (172.34 g) was observed in $S_3$ treatment and finally at harvest the maximum dry matter weight plant$^{-1}$ (214.04 g) was observed in $S_4$ treatment. Whereas the minimum dry matter weight plant$^{-1}$ (5.35 g at 30 DAS) was observed in $S_3$ treatment. At 60, 90 DAS and at harvest respectively the minimum dry matter weight plant$^{-1}$ (45.76, 134.67 and 172.26 g) was observed in $S_1$ treatment which was statistically similar with $S_3$ (49.55 g) at 60 DAS; and with $S_2$ (141.32) 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 8. : Effect of spacing on dry matter weight plant$^{-1}$of shada bhutta 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 shada bhutta 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$^{-1}$ (7.92 g at 30 DAS) was observed in $I_2S_1$ treatment combination which was statistically similar with $I_1S_1$ (7.91 g), $I_3S_4$(7.43 g) and $I_2S_2$ (7.37 g)treatment combination. At 60 DAS the maximum dry matter weight plant$^{-1}$ (57.28 g) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_1S_2$(56.73 g), $I_1S_3$ (56.04 g), $I_1S_4$(55.77 g), $I_2S_4$ (52.73 g), $I_2S_2$ (52.55 g) and $I_3S_3$ (52.43 g) treatment combination. At 90 DAS the maximum dry matter weight plant$^{-1}$ (177.10 g) was observed in $I_1S_3$ treatment combination which was statistically similar with $I_3S_3$(174.76 g), $I_2S_4$(172.69 g), $I_1S_4$(169.40 g), $I_2S_3$ (165.18 g) and $I_2S_2$ (161.92 g) treatment combination. And at harvest respectively the maximum dry matter weight plant$^{-1}$ (216.31 g) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_2S_4$ (213.69 g) and $I_3S_4$ (212.12 g) treatment combination. Whereas the minimum dry matter weight plant$^{-1}$(3.51 g at 30 DAS) was observed in $I_3S_1$ treatment combination. At 60 and 90 DAS the minimum dry matter weight plant$^{-1}$ (35.43 and 121.50 g) was observed in $I_3S_2$ treatment combination which was statistically similar with $I_3S_4$ (121.60 g), $I_3S_1$ (127.15 g), and $I_1S_1$ (129.98 g) treatment combination at 90 DAS. And at harvest respectively the minimum dry matter weight plant$^{-1}$ (167.59 g) was observed in $I_2S_1$ treatment combination which was statistically similar with $I_1S_1$(171.99 g) treatment combination.

**Table 4: Combined effect of irrigation frequency and spacing on dry matter plant$^{-1}$ of shada bhutta at different DAS**

| Treatments combination | Dry matter plant$^{-1}$ (g) at | | | |
|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest |
| $I_1S_1$ | 7.91 a | 44.57 d | 129.98 c-e | 171.99 fg |
| $I_1S_2$ | 5.34 b-d | 56.73 a | 140.55 cd | 204.08 cd |
| $I_1S_3$ | 6.04 b | 56.04 a | 177.10 a | 206.63 bc |
| $I_1S_4$ | 5.44 bc | 55.77 a | 169.40 a | 216.31 a |
| $I_2S_1$ | 7.92 a | 45.96 cd | 146.88 bc | 167.59 g |
| $I_2S_2$ | 7.37 a | 52.55 a-c | 161.92 ab | 198.84 d |
| $I_2S_3$ | 4.44 d | 47.08 b-d | 165.18 a | 206.90 bc |
| $I_2S_4$ | 4.94 cd | 52.73 ab | 172.69 a | 213.69 ab |
| $I_3S_1$ | 3.51 e | 57.28 a | 127.15 de | 177.21 f |
| $I_3S_2$ | 5.13 b-d | 35.43 e | 121.50 e | 190.90 e |
| $I_3S_3$ | 5.56 bc | 52.43 a-c | 174.76 a | 199.73 cd |
| $I_3S_4$ | 7.43 a | 45.55 d | 121.60 e | 212.12 ab |
| $LSD_{(0.05)}$ | 0.91 | 6.66 | 17.16 | 7.71 |
| CV(%) | 9.0 | 7.74 | 6.64 | 2.28 |

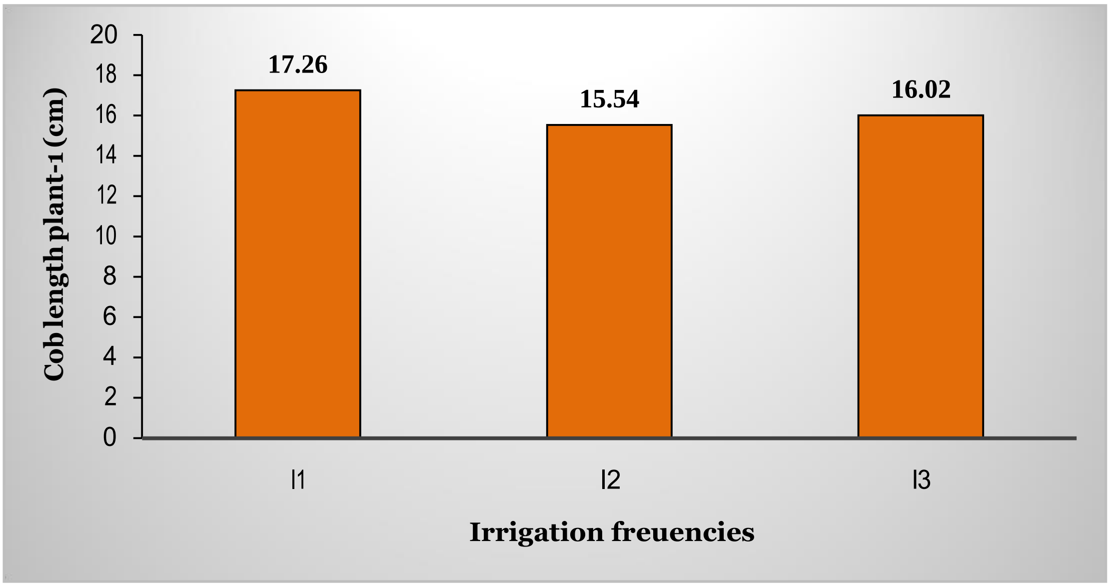
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

## 4.2 Yield contributing characters

### 4.2.1 Cob length plant$^{-1}$

#### 4.2.1.1 Effect of irrigation frequency

Irrigation frequency showed significant variation in respect of cob length plant$^{-1}$ of shada bhutta (Figure 9 and Appendix IX). From the experiment result revealed that the maximum cob length plant$^{-1}$ (17.26 cm) was observed in $I_1$ treatment whereas the minimum cob length plant$^{-1}$ (15.536 cm) was observed in $I_2$ treatment which was statistically similar with $I_3$ (16.02 cm) treatment. Elzubeir and Mohamed (2011) reported that prolonging irrigation intervals reduce cob length. The result was similar with the present study.

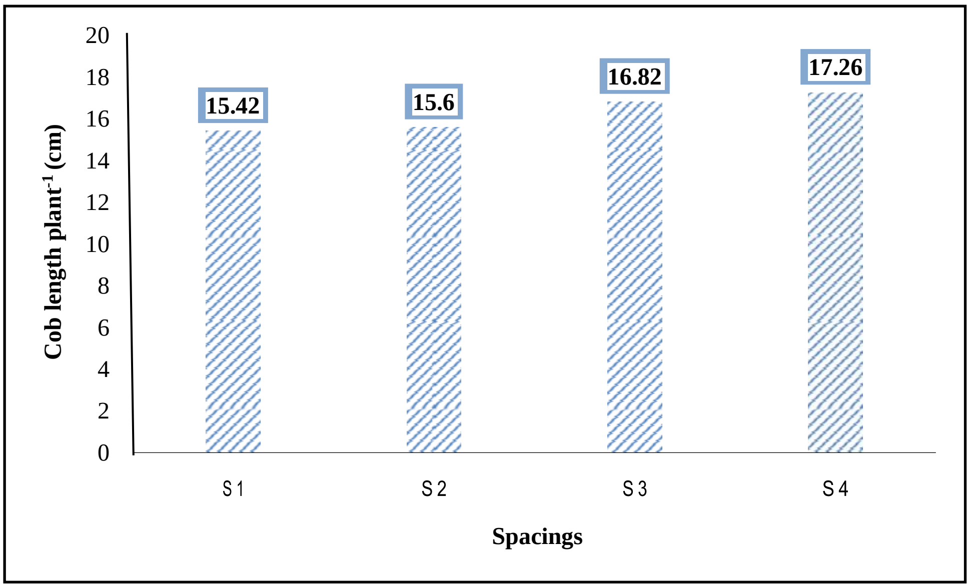



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 9. Effect of irrigation frequencies on cob length plant$^{-1}$ of shada bhutta (LSD$_{(0.05)}$= 0.76 cm)**

#### 4.2.1.2 Effect of spacing

Spacing showed significant variation in respect of cob length plant$^{-1}$ of shada bhutta (Figure 10 and Appendix IX). From the experiment result revealed that the maximum cob length plant$^{-1}$ (17.26 cm) was observed in $S_4$ treatment which was statistically similar with $S_3$ (16.82 cm) treatment whereas the minimum cob length plant$^{-1}$ (15.42 cm) was observed in $S_1$ treatment which was statistically similar with $S_2$ (15.60 cm) treatment. These results agreed with Alam *et al*. (2020) and Koirala *et al*. (2020).




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 10. Effect of spacings on cob length plant$^{-1}$ of shada bhutta (LSD$_{(0.05)}$= 0.61 cm)**

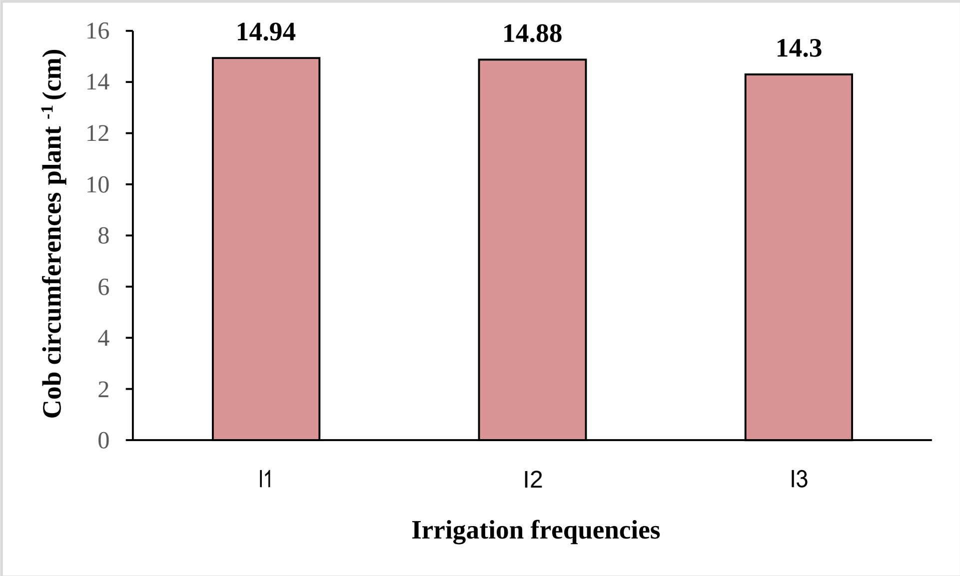
#### 4.2.1.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of cob length plant$^{-1}$ of shada bhutta (Table 5). From the experiment result exhibited that the maximum cob length plant$^{-1}$ (18.12 cm) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_1S_3$ (17.95 cm) and $I_3S_4$ (17.42 cm) treatment combination. Whereas the minimum cob length plant$^{-1}$ (14.90 cm) was observed in $I_2S_1$ treatment combination which was statistically similar with $I_2S_2$ (14.98 cm), $I_3S_1$ (15.04 cm) and $I_3S_2$ (15.17 cm) treatment combination.

### 4.2.2 Cob circumference plant$^{-1}$

#### 4.2.2.1 Effect of irrigation frequency

Irrigation frequency showed significant variation in respect of cob circumference plant$^{-1}$ of shada bhutta (Figure 11 and Appendix IX). From the experiment result revealed that the maximum cob circumference plant$^{-1}$ (14.94 cm) was observed in $I_1$ treatment which was statistically similar with $I_2$ (14.88 cm) treatment. Whereas the minimum cob circumference plant$^{-1}$ (14.30 cm) was observed in $I_3$ treatment.

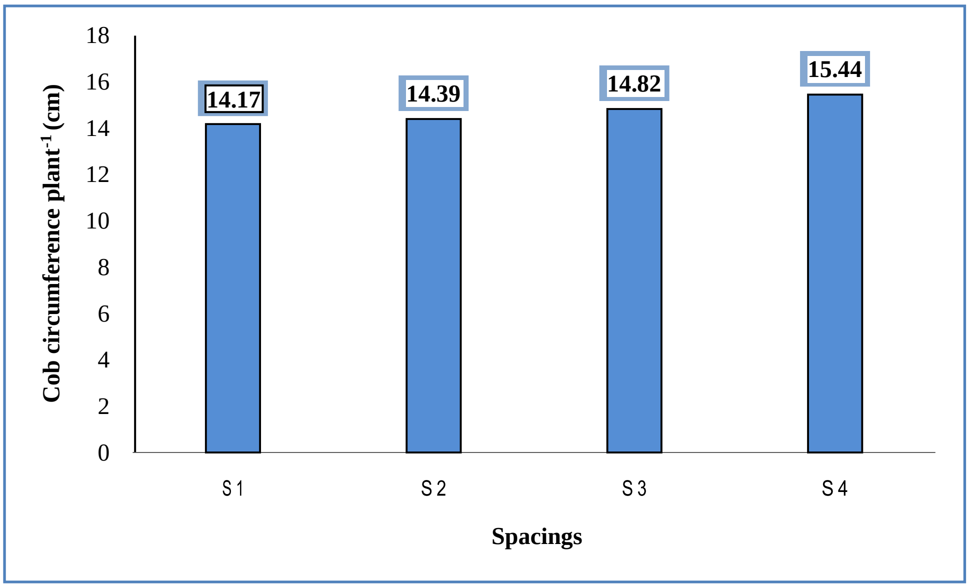



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 11. Effect of irrigation frequencies on cob circumference plant$^{-1}$ of shada bhutta ($LSD_{(0.05)}$= 0.52 cm)**

#### 4.2.2.2 Effect of spacing

Spacing showed significant variation in respect of cob circumference plant$^{-1}$ of shada bhutta (Figure 12 and Appendix IX).From the experiment result revealed that the maximum cob circumference plant$^{-1}$ (15.44 cm) was observed in $S_4$ treatment. Whereas the minimum cob circumference plant$^{-1}$ (14.17 cm) was observed in $S_1$ treatment which was statistically similar with $S_2$ (14.39 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 12. Effect of spacings on cob circumference plant$^{-1}$ of shada bhutta (LSD$_{(0.05)}$= 0.61 cm)**

### 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 shada bhutta (Table 5). From the experiment result exhibited that the maximum cob circumference plant$^{-1}$ (15.81 cm) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_2S_3$ (15.67 cm) treatment combination. Whereas the minimum cob circumference plant$^{-1}$ (13.87 cm) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_3S_2$ (14.06 cm), $I_2S_1$ (14.14 cm), $I_1S_2$ (14.38 cm), $I_3S_3$ (14.42 cm) and $I_1S_1$ (14.52 cm) treatment combination.

**Table 5: Combined effect of irrigation frequency and spacing on cob length and cob circumference plant$^{-1}$ of shada bhutta**

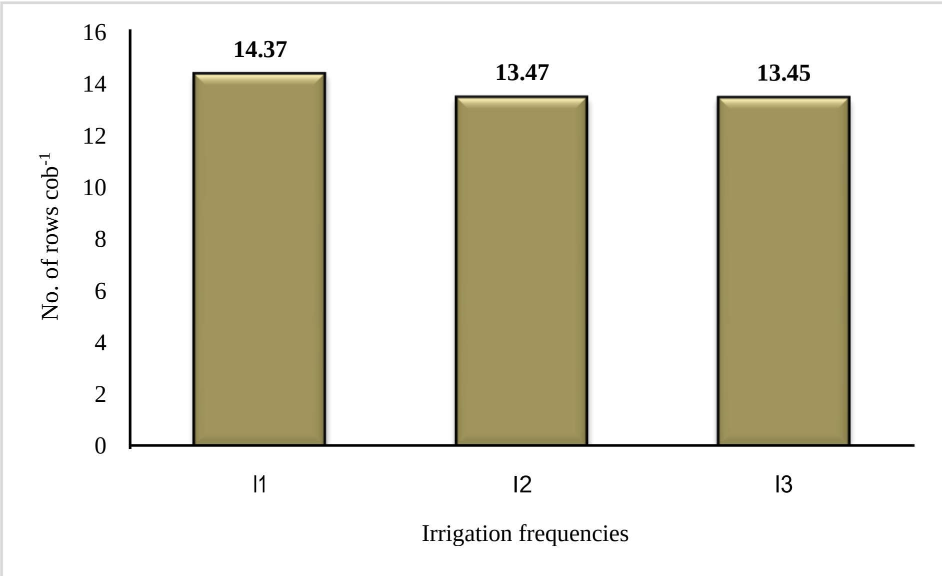
| Treatments combination | Cob length plant$^{-1}$ | Cob circumference plant$^{-1}$ |
|---|---|---|
| $I_1S_1$ | 16.33 c | 14.52 c-e |
| $I_1S_2$ | 16.66 bc | 14.38 c-e |
| $I_1S_3$ | 17.95 a | 15.04 bc |
| $I_1S_4$ | 18.12 a | 15.81 a |
| $I_2S_1$ | 14.90 e | 14.14 de |
| $I_2S_2$ | 14.98 de | 14.73 cd |
| $I_2S_3$ | 16.03 cd | 15.00 bc |
| $I_2S_4$ | 16.23 c | 15.67 ab |
| $I_3S_1$ | 15.04 de | 13.87 e |
| $I_3S_2$ | 15.17 de | 14.06 de |
| $I_3S_3$ | 16.47 bc | 14.42 c-e |
| $I_3S_4$ | 17.42 ab | 14.85 c |
| $LSD_{(0.05)}$ | 1.05 | 0.70 |
| CV(%) | 3.76 | 2.78 |

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. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm × 25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 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 shada bhutta (Figure 13 and Appendix X). From the experiment 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, 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 its 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 cause reduction of number of rows/cob.

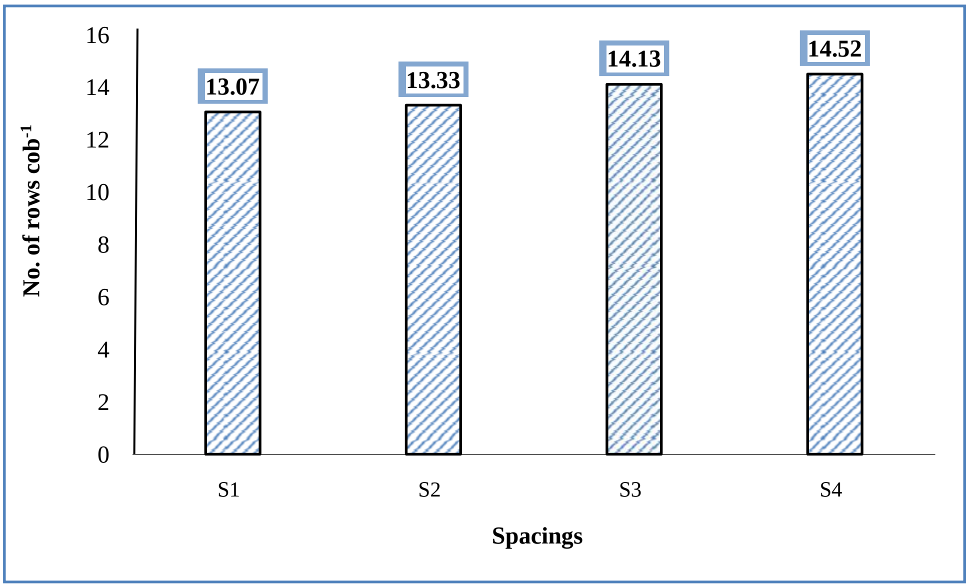



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 13. Effect of irrigation frequencies on number of rows cob$^{-1}$ of shada bhutta ($LSD_{(0.05)}$= 0.42 )**

### 4.2.3.2 Effect of spacing

Spacing showed significant effect on number of rows cob$^{-1}$ of shada bhutta (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 specific competition among plants for growth resources like nutrients, soil moisture, light, and carbon dioxide, thus, the supply of growth resources to growing cob is reduced in turn to reduce the number of cob per plant. High plant density creates competition for light, aeration, nutrients and consequently compelling the plants to undergo less reproductive growth which ultimately cause reduction of rows $cob^{-1}$. Azam (2017) and Rahman *et al*. (2016) also found similar result which supported the present finding.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 14. Effect of spacings on number of rows $cob^{-1}$ of shada bhutta ($LSD_{(0.05)}$= 0.36 )**

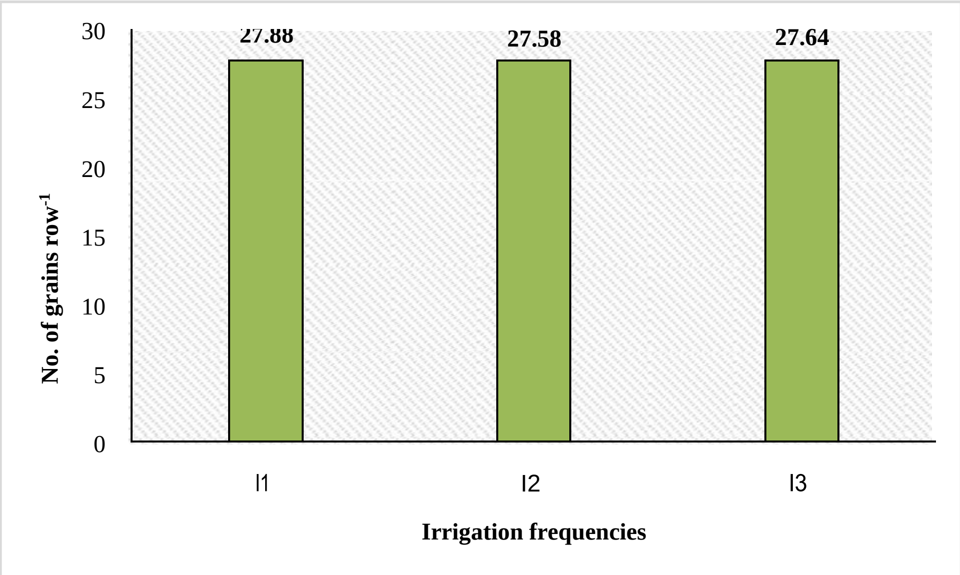
### 4.2.3.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of number of rows $cob^{-1}$ of shada bhutta (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 $I_3S_1$ treatment 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 shada bhutta due to irrigations frequencies (Figure 15 and Appendix X). From the experiment result 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.

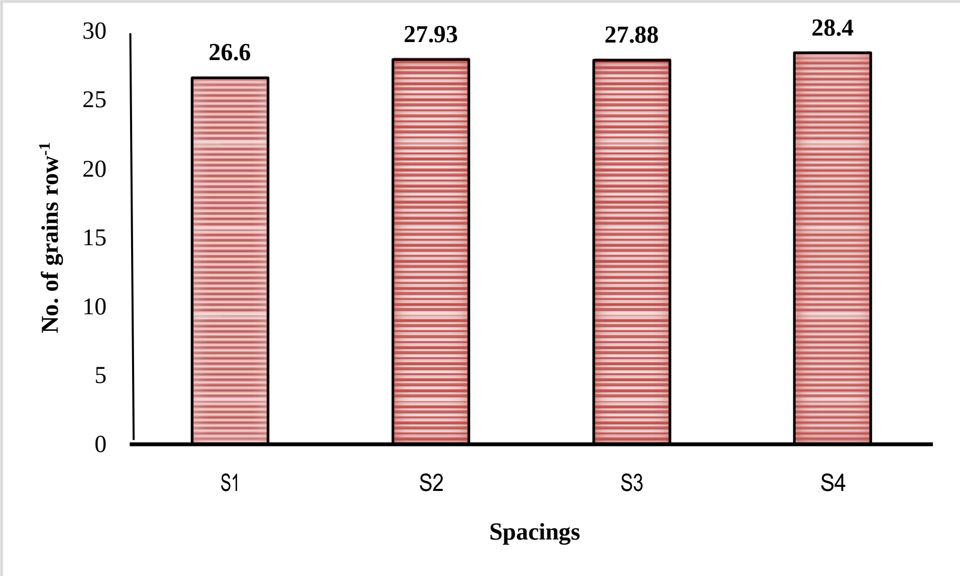



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 15. Effect of irrigation frequencies on number of grains $row^{-1}$ of shada bhutta ($LSD_{(0.05)}$= NS)**

#### 4.2.4.2 Effect of spacing

Spacing showed significant effect on number of grains $row^{-1}$ of shada bhutta (Figure 16 and Appendix X). From the 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

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

#### 4.2.4.3 Combined effect of irrigation frequency and spacing

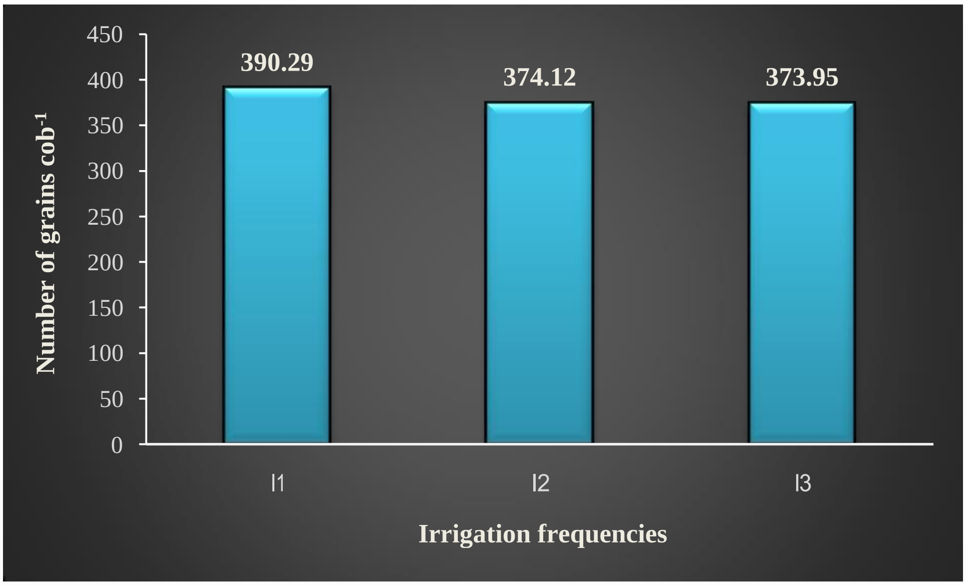
The combined effect of irrigation frequency and spacing showed significant variation in respect of number of grains row$^{-1}$ of shada bhutta (Table 6). From the experiment result exhibited that the maximum number of grains row$^{-1}$ (28.66) was observed in $I_1S_4$ treatment combination which was 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 shada bhutta due to irrigations frequencies (Figure 17 and Appendix X). From the 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 provides 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/cob produced and extent to which the grains are filled. Water deficits affected the number of seeds/cob thereby compounding the effects on final grain yield. These results agreed with the present study.

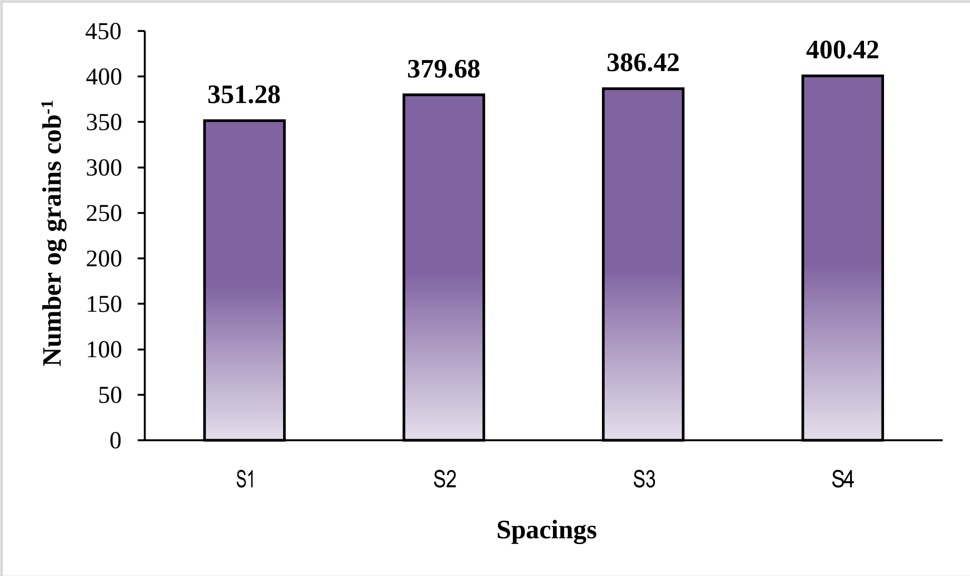



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 17. Effect of irrigation frequencies on number of grains cob$^{-1}$ of shada bhutta ($LSD_{(0.05)}$= 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 grain per cob compared to other spacings.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

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

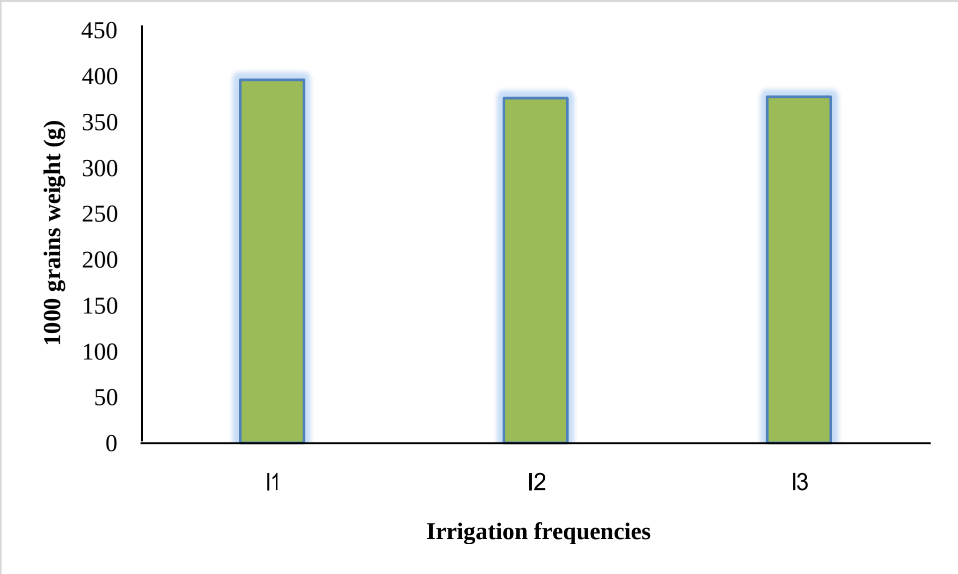
### 4.2.5.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of number of grains cob$^{-1}$ of shada bhutta (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 grains weight (g)

### 4.2.6.1 Effect of irrigation frequency

Significant variation was observed on 1000 grains weight (g) of shada bhutta due to irrigations frequencies (Figure 19 and Appendix X). From the experiment result revealed that the maximum 1000 grains weight (395.83 g) was observed in $I_1$ treatment. Whereas the minimum 1000 grains weight (375.83 g) was observed in $I_2$ treatment which was statistically similar with $I_3$ (377.50 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.

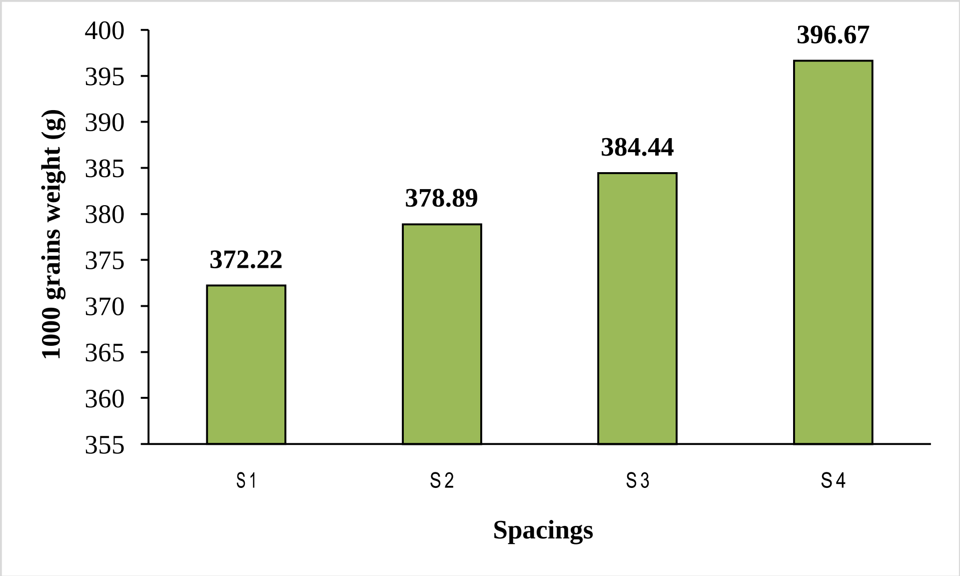



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 19. Effect of irrigation frequencies on 1000 grains weight (g) of shada bhutta ($LSD_{(0.05)}$= 8.01 g)**

### 4.2.6.2 Effect of spacing

Spacing showed significant effect on 1000 grains weight (gm) of shada bhutta (Figure 20 and Appendix X).From the experiment result revealed that the maximum 1000 grains weight (396.67 g) was observed in $S_4$ treatment. Whereas the minimum 1000 grains weight (372.22 g) was observed in $S_1$ treatment. Koirala *et al*. (2020); Hasan *et al*. (2018) and Azam (2017) found similar result which supported the present study.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 20. Effect of spacings on 1000 grains weight (gm) of shada bhutta ($LSD_{(0.05)}$= 4.37 g)**

#### 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 shada bhutta (Table 6). From the experiment result exhibited that the maximum 1000 grains weight (413.33 g) was observed in $I_1S_4$ treatment combination. Whereas the minimum 1000 grains weight (363.33 g) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_2S_1$ (366.67 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 shada bhutta**

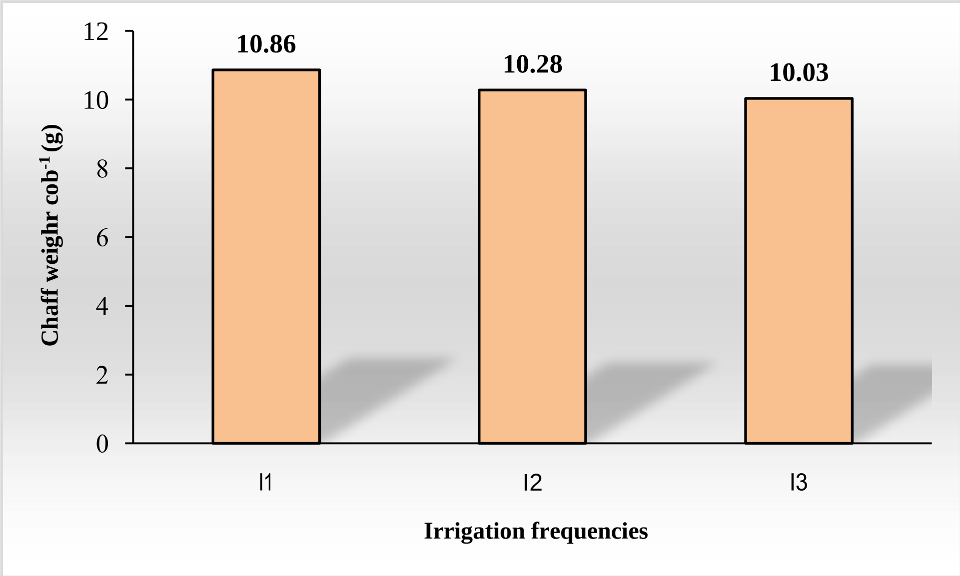
| Treatments combination | No. of row cob$^{-1}$ | No. grains row$^{-1}$ | No. of grains cob$^{-1}$ | 1000 grains weight (gm) |
|---|---|---|---|---|
| **$I_1S_1$** | 13.09 d | 26.56 fg | 347.61 ef | 386.67 b-d |
| **$I_1S_2$** | 13.45 b-d | 28.44 ab | 379.59 cd | 390.00 bc |
| **$I_1S_3$** | 15.28 a | 27.87 b-d | 414.72 a | 393.33 b |
| **$I_1S_4$** | 15.67 a | 28.66 a | 419.22 a | 413.33 a |
| **$I_2S_1$** | 13.11 d | 26.89 e-g | 364.49 de | 366.67 fg |
| **$I_2S_2$** | 13.33 cd | 27.89 a-d | 387.35 bc | 373.33 ef |
| **$I_2S_3$** | 13.56 b-d | 27.22 d-f | 366.91 d | 380.00 de |
| **$I_2S_4$** | 13.89 bc | 28.33 ab | 377.73 cd | 383.33 cd |
| **$I_3S_1$** | 13.00 d | 26.34 g | 341.75 f | 363.33 g |
| **$I_3S_2$** | 13.22 d | 27.45 c-e | 372.10 cd | 373.33 ef |
| **$I_3S_3$** | 13.56 b-d | 28.56 ab | 377.63 cd | 380.00 de |
| **$I_3S_4$** | 14.00 b | 28.22 a-c | 404.32 ab | 393.33 b |
| **$LSD_{(0.05)}$** | 0.62 | 0.77 | 18.0 | 7.56 |
| **CV(%)** | 2.64 | 1.61 | 2.77 | 1.15 |

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. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 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 shada bhutta (Figure 21 and Appendix XI). From the experiment result exhibited that the maximum chaff weight cob$^{-1}$ (10.86 g) was observed in $I_1$ treatment, which was statistically similar with $I_2$ (10.28 g) treatment, whereas the minimum chaff weight cob$^{-1}$ (10.03 g) was observed in $I_3$ treatment.

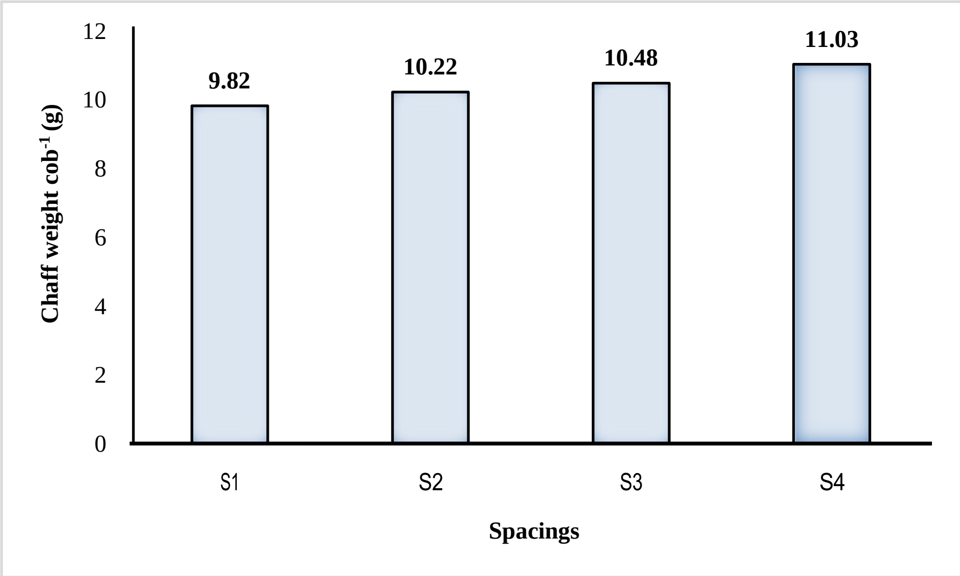



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

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

### 4.2.7.2 Effect of spacing

Different spacing showed significant effect on chaff weight cob$^{-1}$ (g) of shada bhutta (Figure 22 and Appendix XI).From the experiment result revealed that the maximum chaff weight cob$^{-1}$ (11.03 g) was observed in $S_4$ treatment. Whereas the minimum chaff weight cob$^{-1}$ (9.82 g) was observed in $S_1$ treatment which was statistically similar with $S_2$ (10.22 g) treatment.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

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

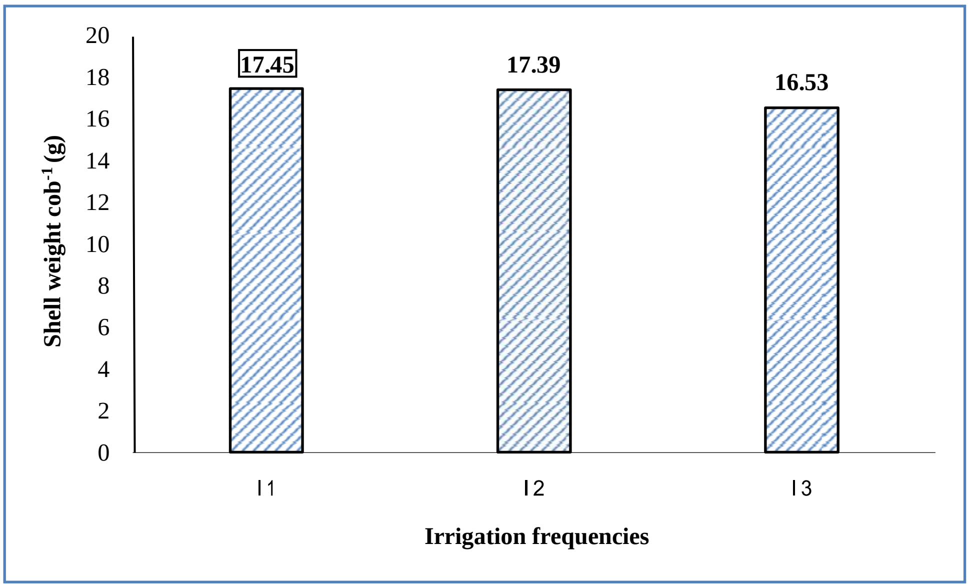
#### 4.2.7.3 Combined effect of irrigation frequency and spacing

The combined effect of different irrigation frequencies and spacings showed significant variation in respect of chaff weight cob$^{-1}$ (g) of shada bhutta (Table 7). From the experiment result exhibited that the maximum chaff weight cob$^{-1}$ (12.20 g) was observed in $I_1S_4$ treatment combination. Whereas the minimum chaff weight cob$^{-1}$ (9.67 g) was observed in $I_3S_1$ treatment combination which was statistically similar with all other treatment except $I_1S_4$ and $I_1S_3$ (10.78 g) treatment combination.

### 4.2.8 Shell weight cob$^{-1}$

#### 4.2.8.1 Effect of irrigation frequency

Different irrigation frequencies showed significant effect on shell weight cob$^{-1}$ (g) of shada bhutta (Figure 23 and Appendix XI). From the experiment result exhibited that the maximum shell weight cob$^{-1}$ (17.45 g) was observed in $I_1$ treatment, which was statistically similar with $I_2$ (17.39 g) treatment, whereas the minimum shell weight cob$^{-1}$ (16.53 g) was observed in $I_3$ treatment.

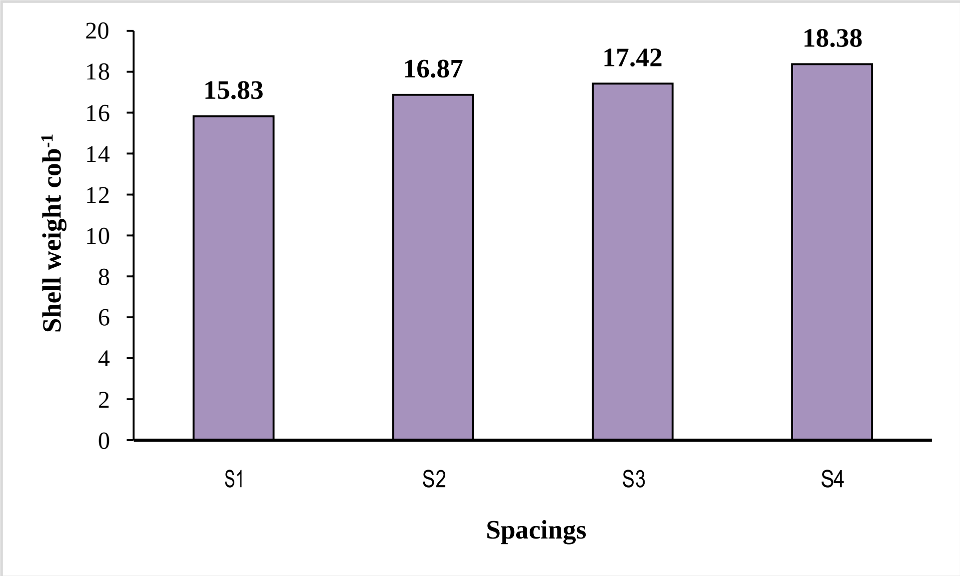



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 23. Effect of irrigation frequencies on shell weight cob$^{-1}$ (g) of shada bhutta ($LSD_{(0.05)}$= 0.65 g)**

### 4.2.8.2 Effect of spacing

Different spacing showed significant effect on shell weight cob$^{-1}$ (g) of shada bhutta (Figure 24 and Appendix XI).From the experiment result revealed that the maximum shell weight cob$^{-1}$ (18.38 g) was observed in $S_4$ treatment. Whereas the minimum shell weight cob$^{-1}$ (15.83 g) was observed in $S_1$ treatment.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

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

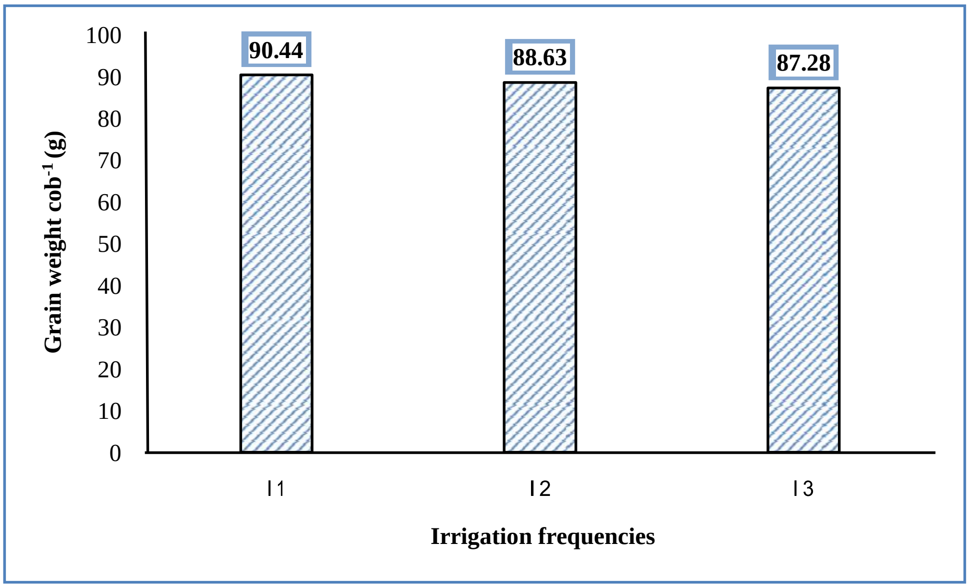
#### 4.2.8.3 Combined effect of irrigation frequency and spacing

The combined effect of different irrigation frequencies and spacings showed significant variation in respect of shell weight cob$^{-1}$ (gm) of shada bhutta (Table 7). From the experiment result exhibited that the maximum shell weight cob$^{-1}$ (18.70 gm) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_2S_4$ (18.53 gm) and $I_1S_3$ (17.92 gm) treatment combination. Whereas the minimum shell weight cob$^{-1}$ (14.43 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

Significant variation was observed on grain weight cob$^{-1}$ (g) of shada bhutta due to irrigations frequency (Figure 25 and Appendix XI). From the experiment result revealed that the maximum grain weight cob$^{-1}$ (90.44 g) was observed in $I_1$ treatment. Whereas the minimum grain weight cob$^{-1}$ (87.28 g) was observed in $I_3$ treatment.

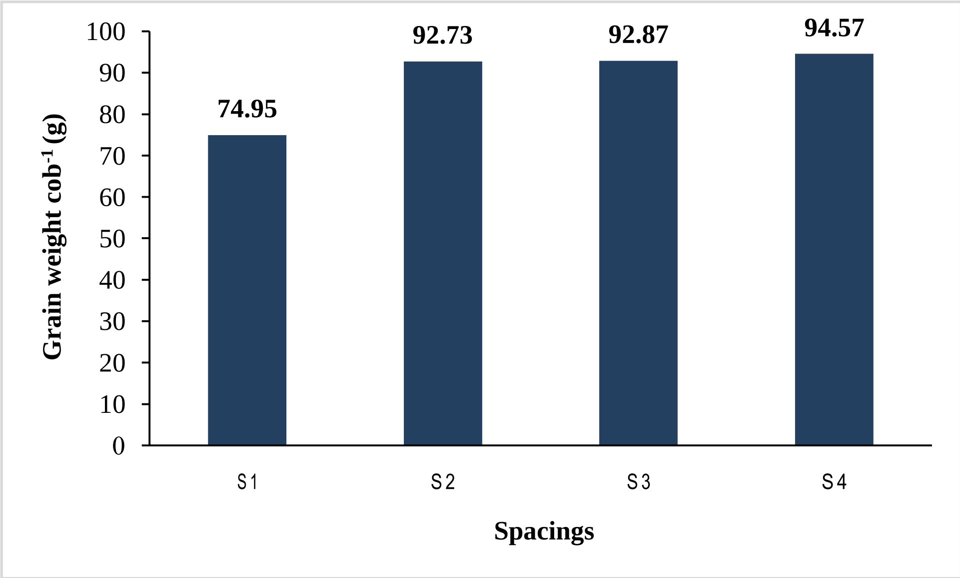



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 25. Effect of irrigation frequencies on grain weight cob$^{-1}$ (g) of shada bhutta (LSD$_{(0.05)}$= 1.31 g)**

### 4.2.9.2 Effect of spacing

Spacing showed significant effect on grain weight cob$^{-1}$ (g) of shada bhutta (Figure 26 and Appendix XI).From the experiment result revealed that the maximum grain weight cob$^{-1}$ (94.57 g) was observed in $S_4$ treatment. Whereas the minimum grain weight cob$^{-1}$ (74.95 g) was observed in $S_1$ treatment. Alam *et al*. (2020) found similar result which supported the present study.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 26. Effect of spacings on grain weight cob$^{-1}$ (g) of shada bhutta (LSD$_{(0.05)}$= 0.70 g)**

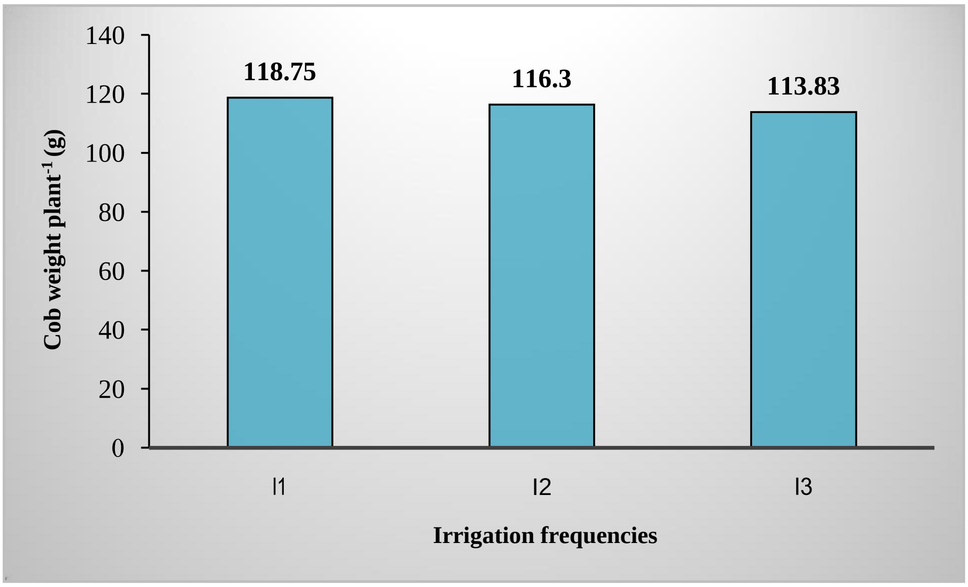
#### 4.2.9.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of grain weight cob$^{-1}$ of shada bhutta (Table 7). From the experiment result exhibited that the maximum grain weight cob$^{-1}$ (95.78 g) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_1S_2$ (94.85 g), $I_1S_3$ (94.82 g), $I_2S_4$ (94.76 g) and $I_2S_2$ (93.25 g) treatment combination. Whereas the minimum grain weight cob$^{-1}$ (74.22 g) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_2S_1$ (74.33 g) and $I_1S_1$ (76.30 g) treatment combination.

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

#### 4.2.10.1 Effect of irrigation frequency

Significant variation was observed on cob weight plant$^{-1}$ (g) of shada bhutta due to irrigations frequency (Figure 27 and Appendix XI). From the experiment result revealed that the maximum cob weight plant$^{-1}$ (118.75 g) was observed in $I_1$ treatment. Whereas the minimum cob weight plant$^{-1}$ (113.83 g) was observed in $I_3$ treatment.

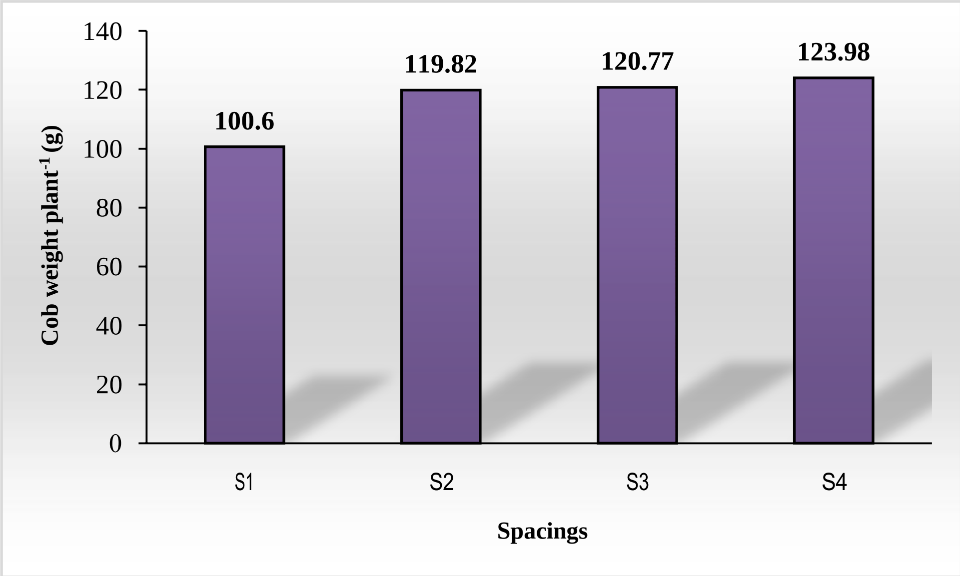



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 27. Effect of irrigation frequencies on cob weight plant$^{-1}$ (g) of shada bhutta ($LSD_{(0.05)}$= 1.77 g)**

### 4.2.10.2 Effect of spacing

Spacing showed significant effect on cob weight plant$^{-1}$ (g) of shada bhutta (Figure 28 and Appendix XI).From the experiment result revealed that the maximum cob weight plant$^{-1}$ (123.98 g) was observed in $S_4$ treatment. Whereas the minimum cob weight plant$^{-1}$ (100.60 g) was observed in $S_1$ treatment. Similar findings were reported by Ukonze *et al*. (2016) and Nand (2015).




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 28. Effect of spacings on cob weight plant$^{-1}$ (g) of shada bhutta (LSD$_{(0.05)}$= 2.01 g)**

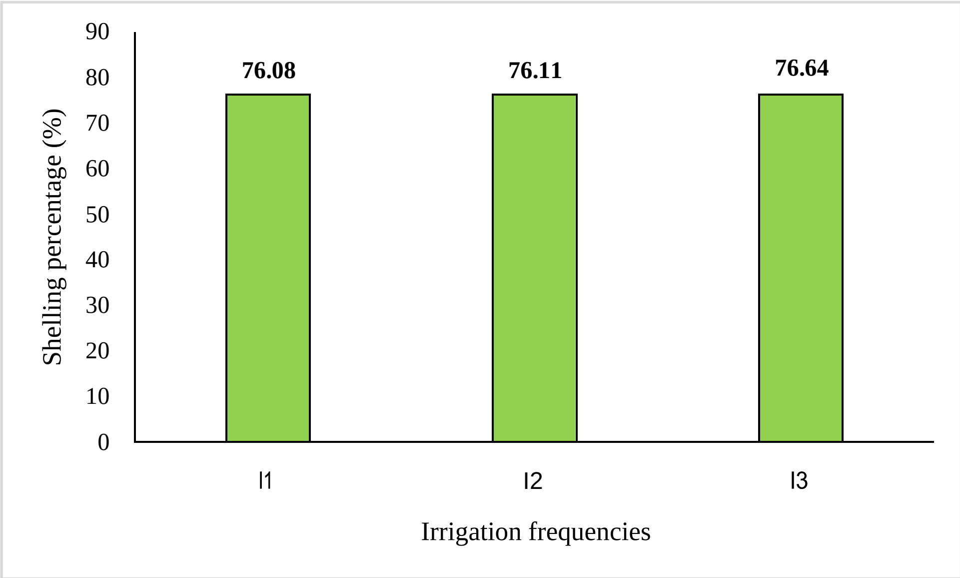
### 4.2.10.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of cob weight plant$^{-1}$ of shada bhutta (Table 7). From the experiment result exhibited that the maximum cob weight plant$^{-1}$ (126.68 g) was observed in $I_1S_4$ treatment combination which was statistically similar with $I_2S_4$ (123.74 g) and $I_2S_2$ (123.34 g) treatment combination. Whereas the minimum cob weight plant$^{-1}$ (98.31 g) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_2S_1$ (100.66 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 shada bhutta due to irrigations frequency (Figure 29 and Appendix ). From the experiment result revealed that the maximum shelling percentage (76.64 %) was observed in $I_3$ treatment. Whereas the minimum shelling percentage (76.08 %) was observed in $I_1$ treatment.

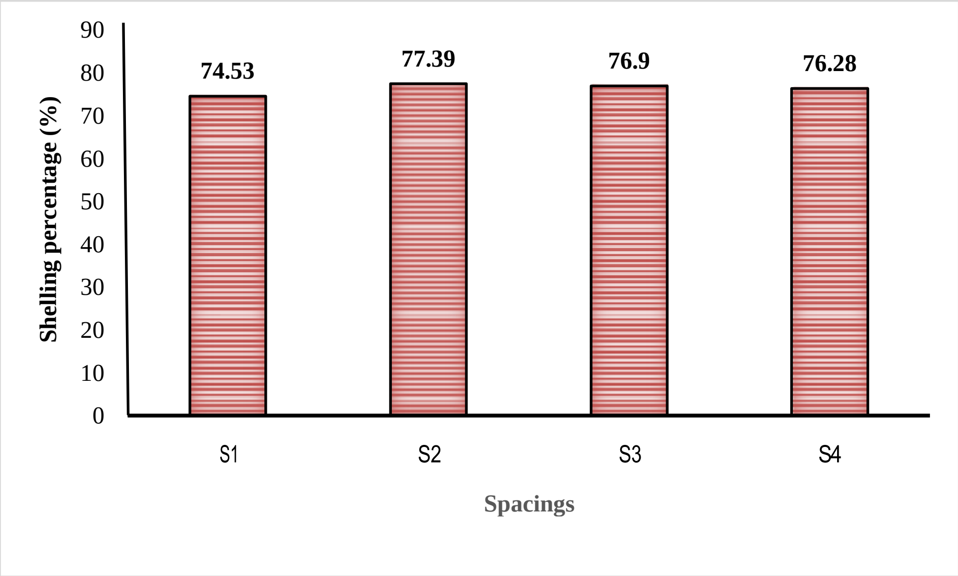



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 29. Effect of irrigation frequencies on shelling percentage (%) of shada bhutta ($LSD_{(0.05)}$= NS)**

### 4.2.11.2 Effect of spacing

Spacing showed significant effect on shelling percentage (%) of shada bhutta (Figure 30 and Appendix XI).From the experiment result revealed that the maximum shelling percentage (77.39 %) was observed in $S_2$ treatment which was statistically similar with $S_3$ (76.90 %) treatment. Whereas the minimum shelling percentage (74.53 %) 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 30. Effect of spacings on shelling percentage (%) of shada bhutta ($LSD_{(0.05)}$= 1.03 %)**

### 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 shada bhutta (Table 7). From the experiment result exhibited that the maximum shelling percentage (77.64 %) was observed in $I_1S_2$ treatment combination which was statistically similar with $I_3S_2$ (77.35 %), $I_2S_2$ (77.16 %), $I_3S_3$ (76.99 %), $I_1S_3$ (76.88 %), $I_2S_3$ (76.84 %) and $I_2S_4$ (76.66 %) treatment combination. Whereas the minimum shelling percentage (73.84 %) was observed in $I_2S_1$ treatment combination which was statistically similar with $I_1S_1$ (74.21 %) $I_3S_1$ (75.54 %) and $I_1S_4$ (75.60 %) 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 shada bhutta at harvest**

| Treatments combination | Chaff weight $cob^{-1}$ (g) | Shell weight $cob^{-1}$ (g) | Grain weight $cob^{-1}$ (g) | Cob weight $plant^{-1}$ (g) | Shelling % |
|---|---|---|---|---|---|
| **$I_1S_1$** | 9.90 bc | 16.62 de | 76.30 e | 102.82 f | 74.21 d |
| **$I_1S_2$** | 10.55 bc | 16.76 de | 94.85 ab | 122.16 b-d | 77.64 a |
| **$I_1S_3$** | 10.78 b | 17.74 bc | 94.82 ab | 123.34 a-c | 76.88 a-c |
| **$I_1S_4$** | 12.20 a | 18.70 a | 95.78 a | 126.68 a | 75.60 b-d |
| **$I_2S_1$** | 9.89 bc | 16.44 e | 74.33 e | 100.66 fg | 73.84 d |
| **$I_2S_2$** | 10.33 bc | 17.25 c-e | 93.25 a-c | 120.83 b-d | 77.16 a-c |
| **$I_2S_3$** | 10.44 bc | 17.34 cd | 92.18 cd | 119.96 c-e | 76.84 a-c |
| **$I_2S_4$** | 10.45 bc | 18.53 ab | 94.76 ab | 123.74 ab | 76.58 a-c |
| **$I_3S_1$** | 9.67 c | 14.43 f | 74.22 e | 98.31 g | 75.54 cd |
| **$I_3S_2$** | 9.78 c | 16.60 de | 90.10 d | 116.48 e | 77.35 ab |
| **$I_3S_3$** | 10.22 bc | 17.17 c-e | 91.62 cd | 119.01 de | 76.99 a-c |
| **$I_3S_4$** | 10.44 bc | 17.92 a-c | 93.17 bc | 121.53 b-d | 76.66 a-c |
| **$LSD_{(0.05)}$** | 0.90 | 0.89 | 2.56 | 3.48 | 1.76 |
| **CV(%)** | 5.07 | 3.01 | 1.68 | 1.74 | 1.36 |

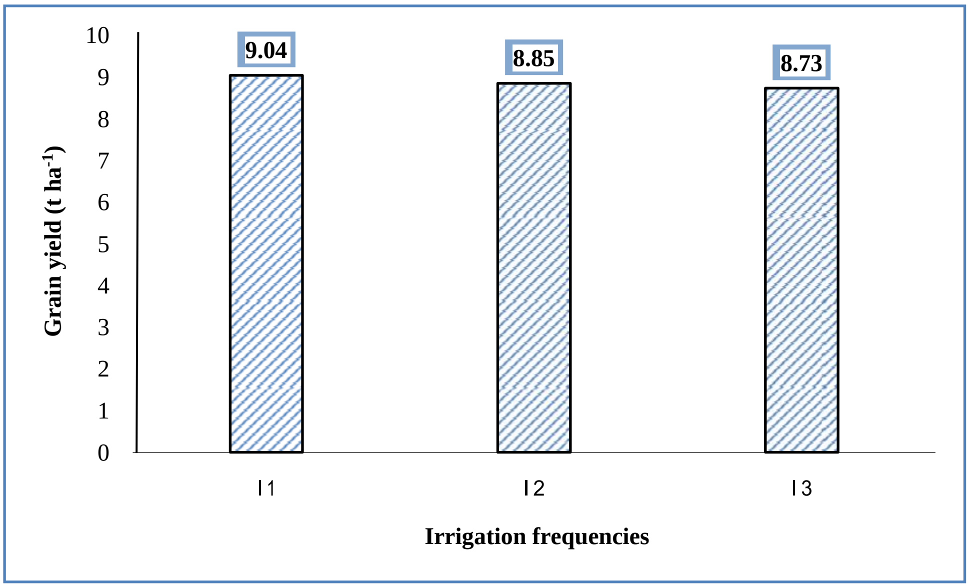
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 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 shada bhutta showed significant variation due to application of different irrigation frequencies (Figure 31 and Appendix XII). From the experiment result revealed that the maximum grain yield (9.04 t ha$^{-1}$) was observed in $I_1$ treatment. Whereas the minimum grain yield (8.73 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.

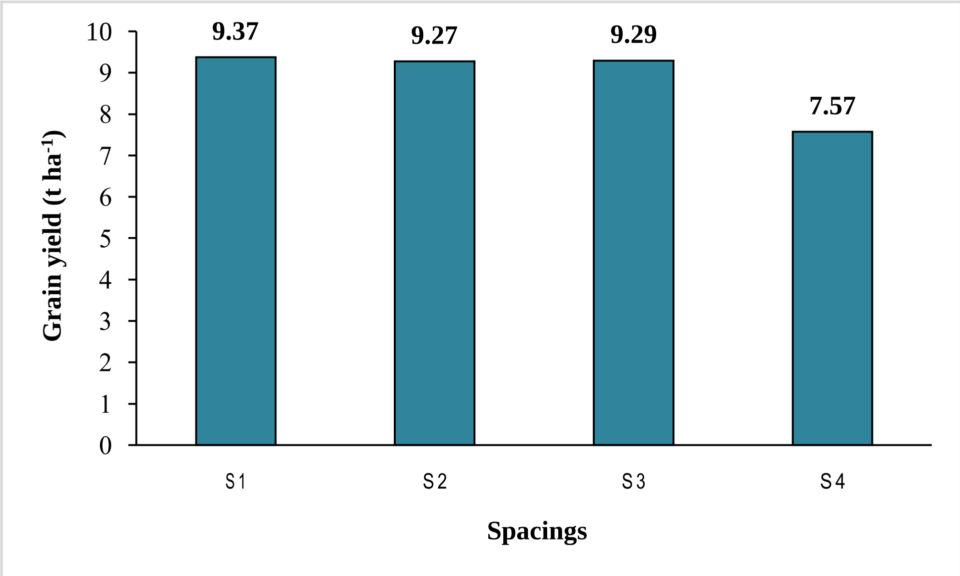



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 31. Effect of irrigation frequencies on grain yield (t ha$^{-1}$) of shada bhutta (LSD$_{(0.05)}$= 0.11 t ha$^{-1}$)**

#### 4.3.1.2 Effect of spacing

Different spacing showed significant effect on grain yield (t ha$^{-1}$) of shada bhutta (Figure 32 and Appendix XII).From the experiment result revealed that the maximum grain yield (9.37 t ha$^{-1}$) was observed in $S_1$ treatment which was statistically similar with $S_3$(9.29 t ha$^{-1}$) and $S_2$(9.27 t ha$^{-1}$) treatment. Whereas the minimum grain yield (7.57 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 less 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 32. Effect of spacings on grain yield (t ha$^{-1}$) of shada bhutta (LSD$_{(0.05)}$= 0.13 t ha$^{-1}$)**

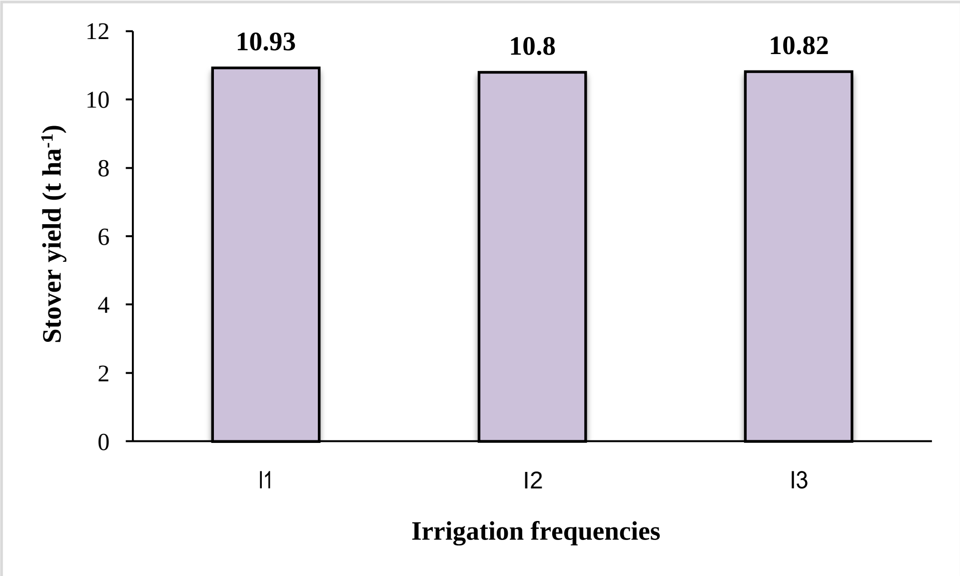
#### 4.3.1.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of grain yield (t ha$^{-1}$) of shada bhutta (Table 8). From the experiment result exhibited that the maximum grain yield (9.54 t ha$^{-1}$) was observed in $I_1S_1$ treatment combination which was statistically similar with $I_1S_2$ (9.49 t ha$^{-1}$),$I_1S_3$ (9.48 t ha$^{-1}$) and $I_2S_2$ (9.33 t ha$^{-1}$) treatment combination. Whereas the minimum grain yield (7.45 t ha$^{-1}$) was observed in $I_3S_4$ treatment combination which was statistically similar with $I_2S_4$ (7.58 t ha$^{-1}$) and$I_1S_4$ (7.66 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 shada bhutta showed non significant variation due to application of different irrigation frequencies (Figure 33 and Appendix XII). From the experiment result revealed that the maximum stover yield (10.93 t ha$^{-1}$) was observed in $I_1$ treatment. Whereas the minimum stover yield (10.80 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.

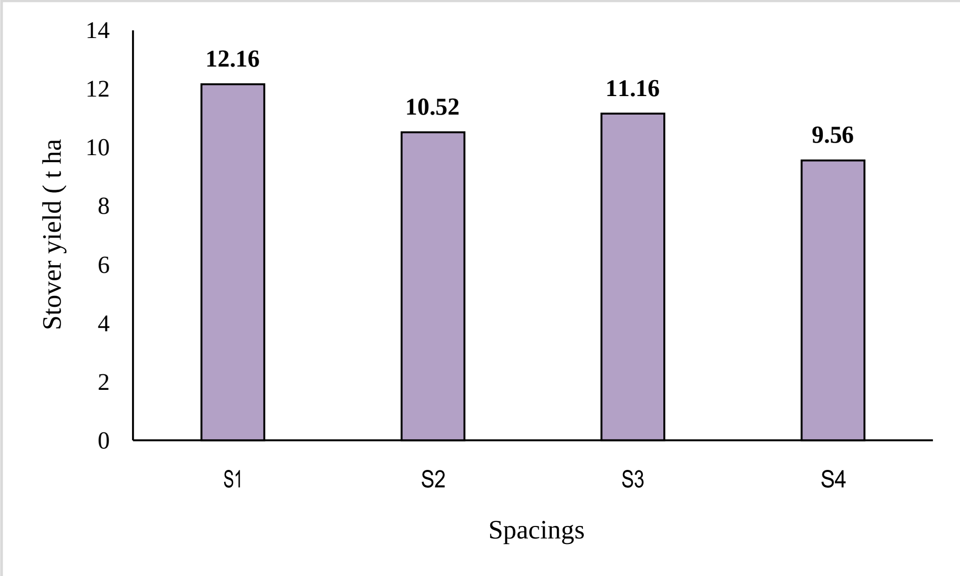



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 33. Effect of irrigation frequencies on stover yield (t $ha^{-1}$) of shada bhutta ($LSD_{(0.05)}$=NS)**

### 4.3.2.2 Effect of spacing

Different spacing showed significant effect on stover yield (t $ha^{-1}$) of shada bhutta (Figure 34 and Appendix XII).From the 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 and grain yields were 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 34. Effect of spacings on stover yield (t ha$^{-1}$) of shada bhutta (LSD$_{(0.05)}$=0.33 t ha$^{-1}$)**

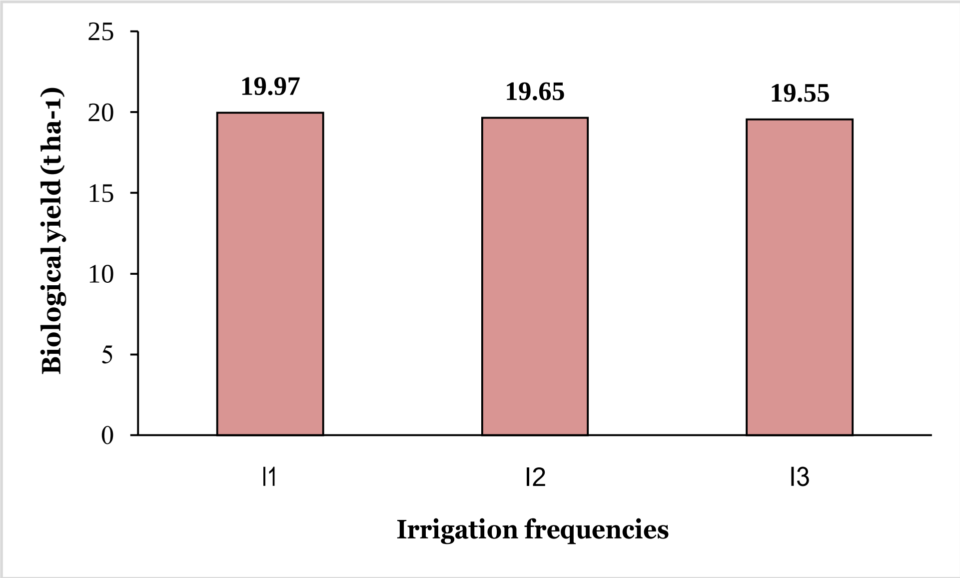
### 4.3.2.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of stover yield (t ha$^{-1}$) of shada bhutta (Table 8). From the experiment result exhibited that the maximum stover yield (12.87 t ha$^{-1}$) was observed in $I_3S_1$ treatment combination. Whereas the minimum stover yield (9.51 t ha$^{-1}$) was observed in $I_2S_4$ treatment combination which was statistically similar with $I_3S_4$ (9.52 t ha$^{-1}$),$I_1S_4$ (9.64 t ha$^{-1}$) and$I_3S_2$ (10.08 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 shada bhutta 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 (19.97 t ha$^{-1}$) was observed in $I_1$ treatment which was statistically similar with $I_2$ (19.65 t ha$^{-1}$) treatment. Whereas the minimum biological yield (19.55 t ha$^{-1}$) was observed in $I_3$ treatment.

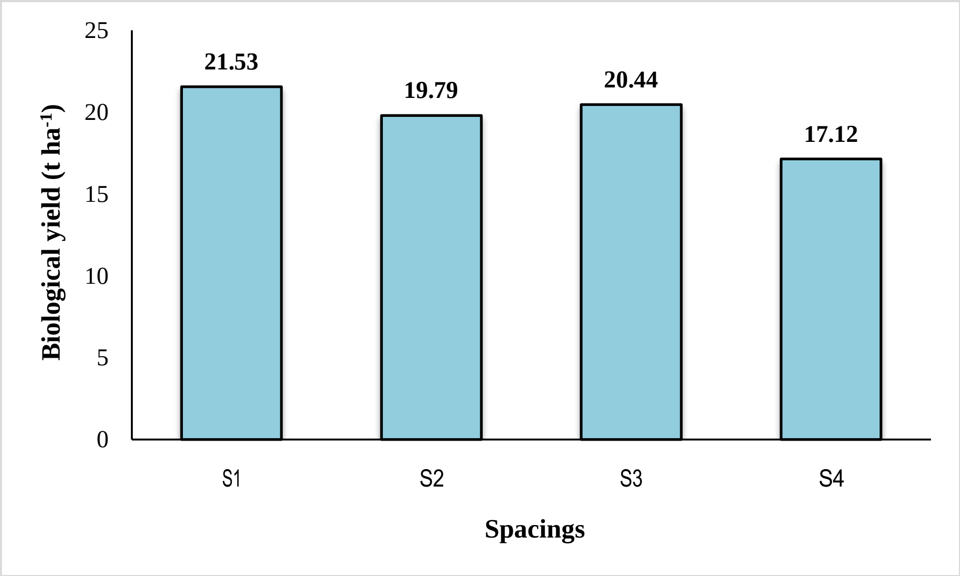



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 35. Effect of irrigation frequencies on biological yield (t ha$^{-1}$) of shada bhutta ($LSD_{(0.05)}$=0.38 t ha$^{-1}$)**

#### 4.3.3.2 Effect of spacing

Different spacing showed significant effect on biological yield (t ha$^{-1}$) of shada bhutta (Figure 36 and Appendix XII).From the experiment result revealed that the maximum biological yield (21.53 t ha$^{-1}$) was observed in $S_1$ treatment. Whereas the minimum biological yield (17.12 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.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 36. Effect of spacings on biological yield (t ha$^{-1}$) of shada bhutta (LSD$_{(0.05)}$=0.39 t ha$^{-1}$)**

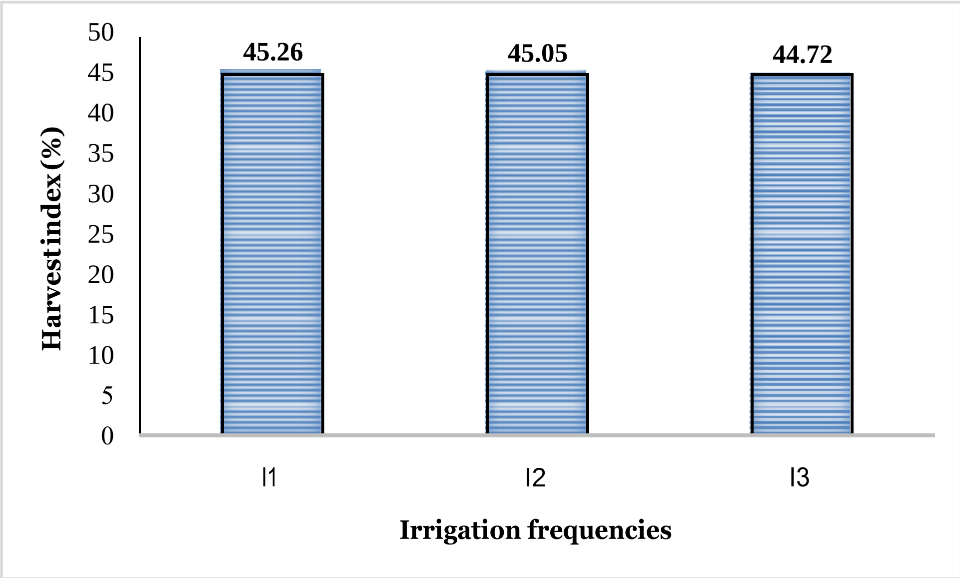
#### 4.3.3.3 Combined effect of irrigation frequency and spacing

The combined effect of irrigation frequency and spacing showed significant variation in respect of biological yield (t ha$^{-1}$) of shada bhutta (Table 8). From the experiment result exhibited that the maximum biological yield (22.15 t ha$^{-1}$) was observed in $I_3S_1$ treatment combination which was statistically similar with $I_1S_1$ (21.50 t ha$^{-1}$) treatment combination. Whereas the minimum biological yield (16.97 t ha$^{-1}$) was observed in $I_3S_4$ treatment combination which was statistically similar with $I_2S_4$ (17.10 t ha$^{-1}$) and$I_1S_4$ (17.31 t ha$^{-1}$) treatment combination.

### 4.3.4 Harvest index (%)

#### 4.3.4.1 Effect of irrigation frequency

Harvest index (%) of shada bhutta showed non significant variation due to application of different irrigation frequencies (Figure 37 and Appendix XII). From the experiment result revealed that the maximum harvest index (45.26 %) was observed in $I_1$ treatment. Whereas the minimum harvest index (44.72 %) was observed in $I_3$ treatment.

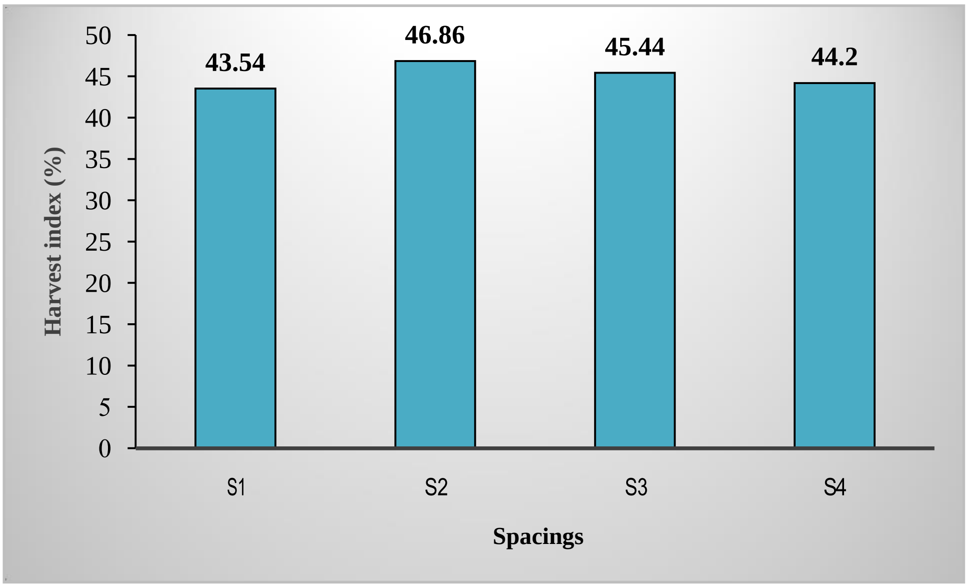



Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval

**Figure 37. Effect of irrigation frequencies on harvest index (%) of shada bhutta ($LSD_{(0.05)}$=NS)**

### 4.3.4.2 Effect of spacing

Different spacing showed significant effect on harvest index (%) of shada bhutta (Figure 38 and Appendix XII). From the experiment result revealed that the maximum harvest index (46.86 %) was observed in $S_2$ treatment. Whereas the minimum harvest index (44.20 %) was observed in $S_4$ treatment which was statistically similar with $S_1$ (43.54 %) treatment. This finding disagreed with Ahmmed *et al*. (2020) who reported that highest harvest index occur at wider spacing.




Spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

**Figure 38. Effect of spacings on harvest index (%) of shada bhutta ($LSD_{(0.05)}$=0.70 %)**

### 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 shada bhutta (Table 8). From the experiment result exhibited that the maximum harvest index (47.20 %) was observed in $I_3S_2$ treatment combination which was statistically similar with $I_2S_2$ (46.90 %), $I_1S_2$ (46.48 %) and $I_1S_3$ (45.89 %) treatment combination. Whereas the minimum harvest index (41.89 %) was observed in $I_3S_1$ treatment combination.

**Table 8 : Combined effect of irrigation frequencies and spacing on grain yield, stover yield, biological yield and harvest index of shada bhutta at harvest**

| Treatments Combination | Grain yield (t $ha^{-1}$) | Stover yield (t $ha^{-1}$) | Biological yield (t $ha^{-1}$) | Harvest index (%) |
|---|---|---|---|---|
| **$I_1S_1$** | 9.54 a | 11.96 b | 21.50 ab | 44.36 c |
| **$I_1S_2$** | 9.49 ab | 10.92 de | 20.41 cd | 46.48 ab |
| **$I_1S_3$** | 9.48 ab | 11.18 c-e | 20.66 c | 45.89 ab |
| **$I_1S_4$** | 7.66 e | 9.64 g | 17.31 f | 44.32 c |
| **$I_2S_1$** | 9.29 bc | 11.66 bc | 20.95 bc | 44.39 c |
| **$I_2S_2$** | 9.33 a-c | 10.56 f | 19.88 d | 46.90 ab |
| **$I_2S_3$** | 9.22 cd | 11.47 b-d | 20.69 c | 44.55 c |
| **$I_2S_4$** | 7.58 e | 9.51 g | 17.10 f | 44.35 c |
| **$I_3S_1$** | 9.28 bc | 12.87 a | 22.15 a | 41.89 d |
| **$I_3S_2$** | 9.01 d | 10.08 fg | 19.09 e | 47.20 a |
| **$I_3S_3$** | 9.16 cd | 10.81 e | 19.97 d | 45.87 b |
| **$I_3S_4$** | 7.45 e | 9.52 g | 16.97 f | 43.92 c |
| **$LSD_{(0.05)}$** | 0.23 | 0.58 | 0.68 | 1.22 |
| **CV(%)** | 1.53 | 3.10 | 2.0 | 1.58 |

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. Irrigation frequencies *viz.* $I_1$:Irrigation at 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and spacings *viz.* $S_1$: 40 cm × 20 cm, $S_2$: 40 cm ×25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 cm × 25 cm.

# CHAPTER V

## SUMMARY AND CONCLUSION

The present piece of work was carried out at the Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during October 2019 to February 2020, to investigate the effect of irrigation frequencies and different spacing on the growth and yield of white maize. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, 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 30 days interval, $I_2$: Irrigation at 35 days interval and $I_3$: Irrigation at 40 days interval and Factor B: Different spacings (4); $S_1$: 40 cm × 20 cm, $S_2$: 40 cm × 25 cm, $S_3$: 50 cm × 20 cm and $S_4$: 50 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. From the experiment, result revealed that the maximum plant height (44.67 cm) at 30 DAS was observed in $I_1$ treatment. At 60 DAS the maximum plant height (145.83 cm) was observed in $I_2$ treatment. At 90 DAS and at harvest respectively the maximum plant height (185.0 and 183.41 cm) was observed in $I_1$ treatment, the maximum number of leaves $plant^{-1}$ (4.06, 5.11 and 14.97 at 30, 60 and 90 DAS) was observed in $I_1$ treatment. At harvest respectively the maximum number of leaves $plant^{-1}$ (10.06) was observed in $I_2$ treatment. The maximum leaf area $plant^{-1}$ (198.53 and 645.34 $cm^2$ at 30 and 60 DAS) was observed in $I_1$ treatment. At 90 DAS the maximum leaf area $plant^{-1}$ (2088.5 $cm^2$) was observed in $I_3$ treatment. And at harvest the maximum leaf area plant$^{-1}$ (2298.3 $cm^2$) was observed in $I_1$ treatment, the maximum dry matter plant$^{-1}$ (6.18 and 53.28 g at 30 and 60 DAS) was observed in $I_1$ treatment. At 90 DAS the maximum dry matter plant$^{-1}$ (161.67 g) was observed in $I_2$ treatment. And at harvest respectively the maximum dry matter plant$^{-1}$ (199.75 g) was observed in $I_1$ treatment. The maximum cob length plant$^{-1}$ (17.26 cm), cob circumference plant$^{-1}$ (14.94 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 (395.83 g), chaff weight cob$^{-1}$ (10.86 g), shell weight cob$^{-1}$ (17.45 g) , grain weight cob$^{-1}$ (90.44 g), cob weight plant$^{-1}$ (118.75 g) were observed in $I_1$ treatment. The maximum shelling percentage (76.64 %) was observed in $I_3$ treatment. The maximum grain yield (9.04 t ha$^{-1}$), stover yield (10.93 t ha$^{-1}$), biological yield (19.97 t ha$^{-1}$) and harvest index (45.26 %) were observed in $I_1$ treatment. Whereas the minimum plant height (40.65, 139.23, 167.61 and 176.08 cm at 30, 60, 90 DAS and at harvest respectively) was observed in $I_3$ treatment. The minimum number of leaves plant$^{-1}$ (4.02) at 30 DAS was observed in $I_3$ treatment, at 60 DAS the minimum number of leaves plant$^{-1}$ (4.81) was observed in $I_2$ treatment, at 90 DAS and at harvest respectively the minimum number of leaves plant$^{-1}$ (14.09 and 9.59) was observed in $I_3$ treatment. The minimum leaf area plant$^{-1}$ (175.22 and 591.35 $cm^2$ at 30 and 60 DAS) was $I_3$ treatment. At 90 DAS the minimum leaf area plant$^{-1}$ (1990.8 $cm^2$) was observed in $I_2$ treatment. And at harvest the minimum leaf area plant$^{-1}$ (2138.4 $cm^2$) was observed in $I_3$ treatment. The minimum dry matter plant$^{-1}$ (5.41, 44.84, 136.25 and 194.99 g at 30, 60, 90 DAS and at harvest respectively) was observed in $I_3$ treatment. The minimum number of rows cob$^{-1}$ (13.45), number of grains row$^{-1}$ (27.64), number of grains cob$^{-1}$ (373.95), were observed in $I_3$ treatment. The minimum 1000 grains weight (375.83) was observed in $I_2$ treatment. The minimum chaff weight cob$^{-1}$ (10.03 g), shell weight cob$^{-1}$ (16.53 g), grain weight cob$^{-1}$ (87.28 g), cob weight plant$^{-1}$ (113.83 g) were observed in $I_3$ treatment. The minimum shelling percentage (76.08 %) was observed in $I_1$ treatment. The minimum grain yield (8.73 t ha$^{-1}$) was observed in $I_3$ treatment. The minimum stover yield (10.80 t ha$^{-1}$) was observed in $I_2$ treatment. The minimum biological yield (19.55 t ha$^{-1}$) and harvest index (44.72 %) were observed in $I_3$ treatment.

Different spacing significantly effect on growth, yield and yield contributing characters of white maize. From the experiment, result revealed that, the maximum plant height (43.66 and 143.96 cm) at 30 and 60 DAS was observed in $S_3$ treatment. At 90 DAS and at harvest respectively the maximum plant height (180.42 and 187.16 cm) was observed in $S_4$ treatment. The maximum number of leaves plant$^{-1}$ of shada bhutta (4.18, 5.26, 15.33 and 10.22 at 30, 60, 90 DAS and at harvest respectively),
leaf area plant$^{-1}$ (227.78, 651.10, 2170.3 and 2431.1 cm$^2$ at 30, 60, 90 DAS and at harvest respectively) were observed in $S_4$ treatment. The maximum dry matter weight plant$^{-1}$ (6.45 g at 30 DAS) was observed in $S_1$ treatment. At 60 DAS the maximum dry matter weight plant$^{-1}$ (53.90 g) was observed in $S_2$ treatment. At 90 DAS the maximum dry matter weight plant$^{-1}$ (172.34 g) was observed in $S_3$ treatment and finally at harvest the maximum dry matter weight plant$^{-1}$ (214.04 g) was observed in $S_4$ treatment. The maximum cob length plant$^{-1}$ (17.26 cm), cob circumference plant$^{-1}$ (15.44 cm), number of rows cob$^{-1}$ (14.52), number of grains row$^{-1}$ (28.40), 1000 grains weight (396.67 g), chaff weight cob$^{-1}$ (11.03 g), shell weight cob$^{-1}$ (18.38 g), grain weight cob$^{-1}$ (94.57 g), cob weight plant$^{-1}$ (123.98 g) were observed in $S_4$ treatment. The maximum shelling percentage (77.39 %) was observed in $S_2$ treatment. The maximum grain yield (9.37 t ha$^{-1}$), stover yield (12.16 t ha$^{-1}$ and biological yield (21.53 t ha$^{-1}$) were observed in $S_1$ treatment. The maximum harvest index (46.86 %) was observed in $S_2$ treatment. Whereas the minimum plant height (41.81, 136.88,
173.88 and 173.27 cm at 30, 60 90 DAS and at harvest respectively) was observed in $S_1$ treatment. The minimum number of leaves plant$^{-1}$ of shada bhutta (3.80 and 4.78 at 30 and 60 DAS) was observed in $S_2$ treatment, at 90 DAS the minimum number of leaves plant$^{-1}$ of shada bhutta (13.74) was observed in $S_1$ treatment and at harvest respectively the minimum number of leaves plant$^{-1}$ of shada bhutta (9.56) was observed in $S_3$ treatment. The minimum leaf area plant$^{-1}$ (162.78, 568.20, 1894.0 and 2004.4 cm$^2$ at 30, 60, 90 DAS and at harvest respectively) was observed in $S_1$ treatment. The minimum dry matter weight plant$^{-1}$ (5.35 g at 30 DAS) was observed in $S_3$ treatment. At 60, 90 DAS and at harvest respectively the minimum dry matter weight plant$^{-1}$ (45.76, 134.67 and 172.26 g) was observed in $S_1$ treatment. The minimum cob length plant$^{-1}$ (15.42 cm), cob circumference plant$^{-1}$ (14.17 cm), number of rows cob$^{-1}$ (13.07), number of grains row$^{-1}$ (26.60), number of grains cob$^{-1}$ (351.28), 1000 grains weight (372.22 g), chaff weight cob$^{-1}$ (9.82 g), shell weight cob$^{-1}$ (15.83 g), grain weight cob$^{-1}$ (74.95 g) and shelling percentage (74.53 %) were

observed in $S_1$ treatment. The minimum grain yield (7.57 t $ha^{-1}$), stover yield (9.56 t $ha^{-1}$) , biological yield (17.12 t $ha^{-1}$) and harvest index (44.20 %) were observed in $S_4$ treatment.

Combined effect of irrigation frequency and different spacing showed significant effect on growth, yield and yield contributing characters of white maize. From the experiment, result revealed that the maximum plant height (45.75 cm) at 30 DAS was observed in $I_1S_3$ treatment combination. At 60 DAS the maximum plant height (149.23 cm) was observed in $I_2S_4$ treatment combination. At 90 DAS and at harvest respectively the maximum plant height (187.47 and 192.10 cm) was observed in $I_1S_4$ treatment combination .The maximum number of leaves $plant^{-1}$ of shada bhutta (4.37 at 30 DAS) was observed in $I_2S_1$ treatment combination. At 60, 90 DAS and at harvest respectively the maximum number of leaves $plant^{-1}$ of shada bhutta (5.55, 16.11 and 10.44) was observed in $I_1S_4$ treatment. The maximum leaf area $plant^{-1}$ (252.81, 716.24, 2387.5 and 2760.1 $cm^2$ at 30, 60, 90 DAS and at harvest respectively) was observed in $I_1S_4$ treatment combination. The maximum dry matter weight $plant^{-1}$ (7.92 g at 30 DAS) was observed in $I_2S_1$ treatment combination At 60 DAS the maximum dry matter weight $plant^{-1}$ (57.28 g) was observed in $I_3S_1$ treatment combination. At 90 DAS the maximum dry matter weight $plant^{-1}$ (177.10 g) was observed in $I_1S_3$ treatment combination. And at harvest respectively the maximum dry matter weight $plant^{-1}$ (216.31 g) was observed in $I_1S_4$ treatment combination. The maximum cob length $plant^{-1}$ (18.12 cm), cob circumference $plant^{-1}$ (15.81 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 (413.33 g), chaff weight $cob^{-1}$ (12.20 g), shell weight $cob^{-1}$ (18.70 g), grain weight $cob^{-1}$ (95.78 g), cob weight $plant^{-1}$ (126.68 g) were observed in $I_1S_4$ treatment combination. The maximum shelling percentage (77.64 %) was observed in $I_1S_2$ treatment combination. The maximum grain yield (9.54 t $ha^{-1}$) was observed in $I_1S_1$ treatment combination. The maximum stover yield (12.87 t $ha^{-1}$) was observed in $I_3S_1$ treatment combination. the maximum biological yield (22.15 t $ha^{-1}$) was observed in $I_3S_1$ treatment combination, and the maximum harvest index (47.20 %) was observed in $I_3S_2$ treatment combination. Whereas the minimum plant height (38.33 cm) at 30 DAS was observed in $I_3S_2$ treatment combination .At 60, 90 DAS and at harvest respectively the minimum plant height (128.01, 159.47 and 171.97 cm) was observed in $I_3S_1$ treatment combination. The minimum number of leaves plant$^{-1}$ of shada bhutta (3.77 at 30 DAS) was observed in $I_1S_2$ treatment combination. At 60 DAS the minimum number of leaves plant$^{-1}$ of shada bhutta (4.56) was observed in $I_2S_2$ treatment combination. At 90 DAS the minimum number of leaves plant$^{-1}$ of shada bhutta (13.67) was observed in $I_3S_1$ treatment combination. And at harvest respectively the minimum number of leaves plant$^{-1}$ of shada bhutta (9.44) was observed in $I_3S_3$ treatment combination. Whereas the minimum leaf area plant$^{-1}$ (177.32 cm$^2$ at 30 DAS) was observed in $I_1S_2$ treatment combination. At 60, 90 DAS and at harvest respectively the minimum leaf area plant$^{-1}$ (540.27, 1800.9 and 1915.1 cm$^2$) was observed in $I_3S_1$ treatment combination. The minimum dry matter weight plant$^{-1}$(3.51 g at 30 DAS) was observed in $I_3S_1$ treatment combination. At 60 and 90 DAS the minimum dry matter weight plant$^{-1}$ (35.43 and 121.50 g) was observed in $I_3S_2$ treatment combination. And at harvest respectively the minimum dry matter weight plant$^{-1}$ (167.59 g) was observed in $I_2S_1$ treatment combination. The minimum cob length plant$^{-1}$ (14.90 cm) was observed in $I_2S_1$ treatment combination, the minimum cob circumference plant$^{-1}$ (13.87 cm) was observed in $I_3S_1$ treatment. 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 (363.33 g), chaff weight cob$^{-1}$ (9.67 g), shell weight cob$^{-1}$ (14.43 g), grain weight cob$^{-1}$ (74.22 g), grain weight cob$^{-1}$ (98.31 g) were observed in $I_3S_1$ treatment combination. The minimum shelling percentage (73.84 %) was observed in $I_2S_1$ treatment combination. The minimum grain yield (7.45 t ha$^{-1}$) was observed in $I_3S_4$ treatment combination. The minimum stover yield (9.51 t ha$^{-1}$) was observed in $I_2S_4$ treatment combination. The minimum biological yield (16.97 t ha$^{-1}$) was observed in $I_3S_4$ treatment combination and the minimum harvest index (41.89 %) was observed in $I_3S_1$ treatment combination.

## CONCLUSION

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

i. Maximum value of growth, yield and yield contributing characters were observed in $I_1$ treatment (irrigation interval at 30 DAS) compared to other treatments.

ii. Maximum grain yield (9.37 t $ha^{-1}$), stover yield (12.16 t $ha^{-1}$) and biological yield (21.53 t $ha^{-1}$) were observed in $S_1$ treatment (40 cm × 20 cm) compared to other treatments due to the reason that close spacing reducing yield production $plant^{-1}$ but increasing unit area yield production.

iii. $I_1$ treatment (irrigation interval at 30 DAS) along with $S_1$ treatment (40 cm × 20 cm) i.e. $I_1S_1$ treatment combination perform best in terms of maximum grain yield (9.54 t $ha^{-1}$) production compared to others treatment combinations.

Thus for the cultivation of "SAU shada bhutta", 30 days irrigation interval ($I_1$) along with (40 × 20 cm) ($S_1$) 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.

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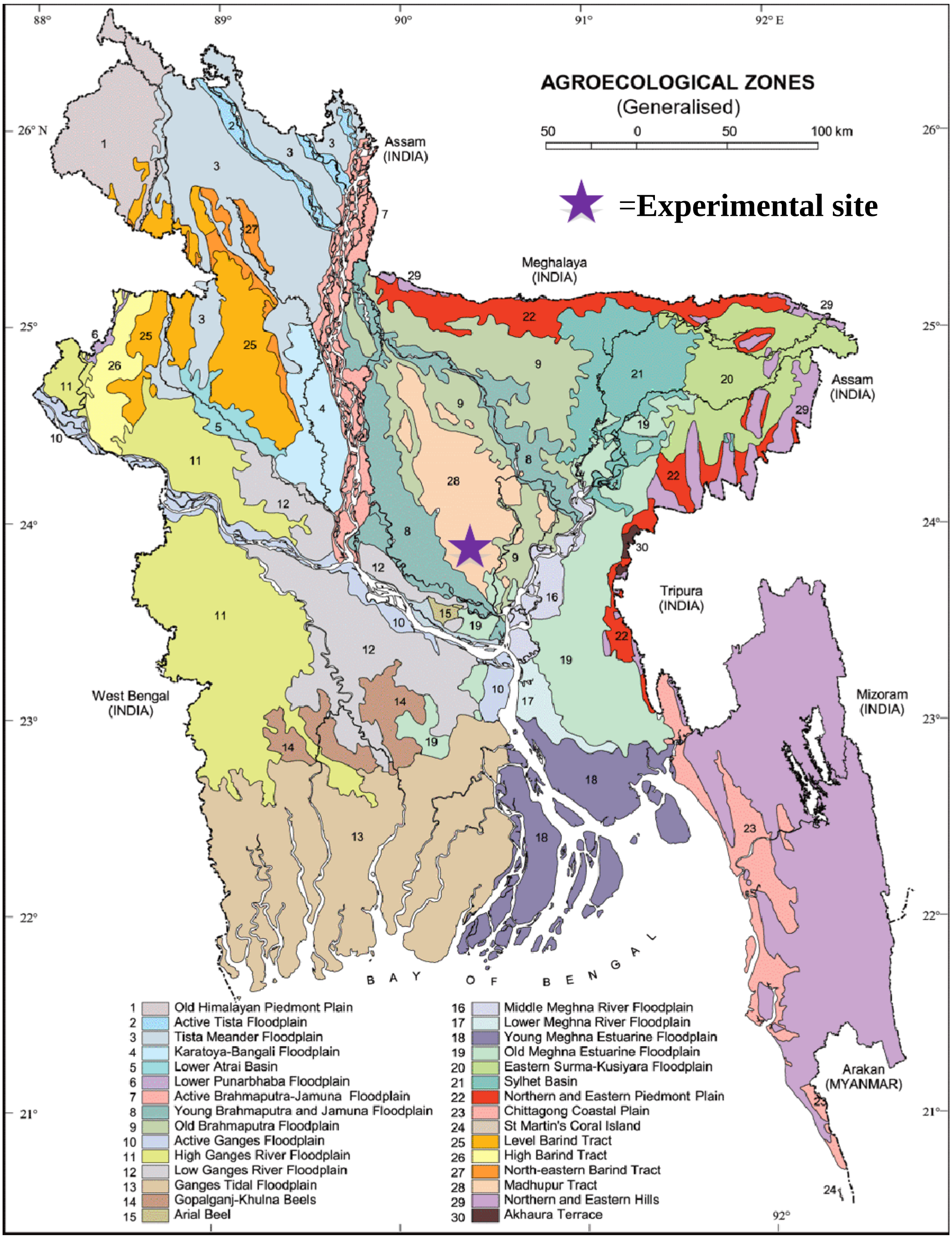
## APPENDICES

### 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 ($^0C$) | | 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)

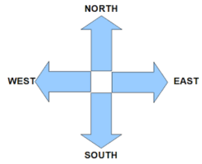
**Appendix III. Soil Characteristics of the experimental field**

**A. Morphological characteristics of the experimental field**

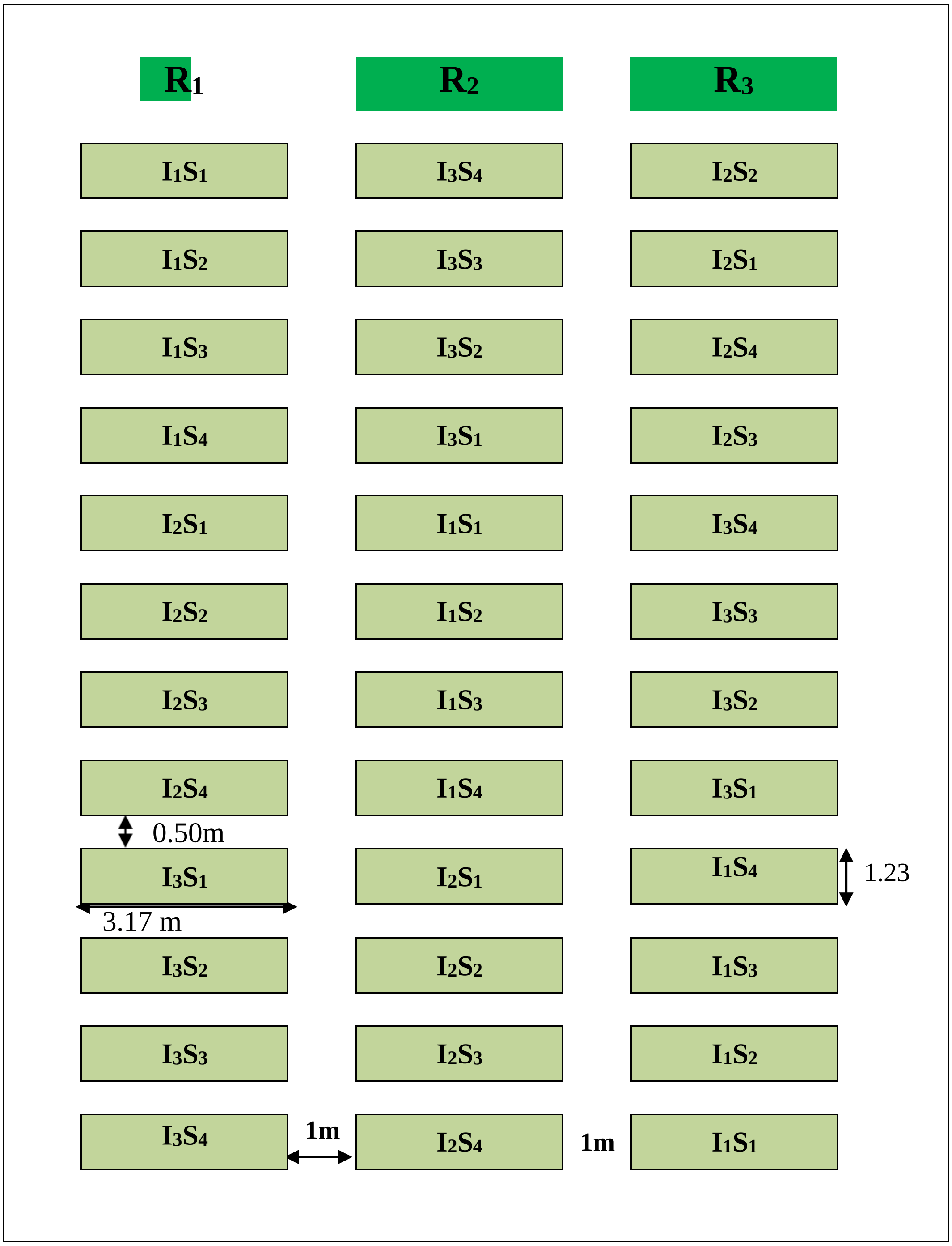
| Morphological features | Characteristics |
|---|---|
| Location | Sher-e-Bangla Agricultural University Agronomy research field, Dhaka |
| AEZ | AEZ-28, Modhupur Tract |
| General Soil Type | Shallow Red Brown Terrace Soil |
| Land type | High land |
| Soil series | Tejgaon |
| Topography | Fairly 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, **$I_1$**: Irrigation at 30 days interval, **$I_2$**: Irrigation at 35 days interval, **$I_3$**: Irrigation at 40 days interval and spacing **$S_1$**: 40 cm × 20 cm, **$S_2$**: 40 cm ×25 cm, **$S_3$**: 50 cm × 20 cm, and **$S_4$**: 50 cm × 25 cm

**Appendix V. Analysis of variance of the data of plant height of shada bhutta at different DAS**

| Source of variation | DF | Mean square value of plant height (cm) of shada bhutta at | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | At harvest |
| **Replication** | 2 | 0.58 | 19.00 | 8.53 | 1.00 |
| **Irrigation frequencies (A)** | 2 | 48.35* | 152.72* | 961.55* | 176.58* |
| **Error** | 4 | 2.46 | 21.50 | 27.65 | 5.00 |
| **Spacing (B)** | 3 | 11.56* | 96.38* | 66.72* | 317.05* |
| **(A × B)** | 6 | 4.98* | 119.65* | 35.17* | 14.19* |
| **Error** | 18 | 1.83 | 26.52 | 11.94 | 4.41 |
| **Total** | 35 | | | | |

*: Significant at 0.05 level of probability

**Appendix VI. Analysis of variance of the data of number of leaves of shada bhutta at different DAS**

| Source of variation | DF | Mean square value of number of leaves of shada bhutta at | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | At harvest |
| **Replication** | 2 | 0.0036 | 0.01 | 0.08 | 0.08 |
| **Irrigation frequencies (A)** | 2 | $0.01^{NS}$ | 0.34* | 2.47* | $0.66^{NS}$ |
| **Error** | 4 | 0.011 | 0.02 | 0.21 | 0.21 |
| **Spacing (B)** | 3 | 0.23* | 0.37* | 4.05* | 0.85* |
| **(A × B)** | 6 | 0.11* | 0.12* | 0.60* | 0.15* |
| **Error** | 18 | 0.01 | 0.02 | 0.16 | 0.17 |
| **Total** | 35 | | | | |

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

**Appendix VII. Analysis of variance of the data of plant leaf area of shada bhutta at different DAS**

| Source of variation | DF | Mean square value of plant leaf area of shada bhutta at | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | At harvest |
| **Replication** | 2 | 6.33 | 633.3 | 2500 | 3333 |
| **Irrigation frequencies (A)** | 2 | 2163.51* | 10528.4* | 28779* | 80958* |
| **Error** | 4 | 13.83 | 1133.3 | 5000 | 8333 |
| **Spacing (B)** | 3 | 6611.16* | 17698.9* | 124380* | 274986* |
| **(A × B)** | 6 | 5655.45* | 2983.2* | 98685* | 133064* |
| **Error** | 18 | 11.33 | 966.7 | 4167 | 6667 |
| **Total** | 35 | | | | |

*: Significant at 0.05 level of probability

**Appendix VIII . Analysis of variance of the data of dry matter weight of shada bhutta at different DAS**

| Source of variation | DF | Mean square value of dry matter weight of shada bhutta at | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | At harvest |
| **Replication** | 2 | 0.36 | 15.55 | 102.74 | 29.78 |
| **Irrigation frequencies (A)** | 2 | 2.36* | 258.28* | 2049.90* | 69.59* |
| **Error** | 4 | 0.25 | 14.86 | 98.74 | 15.44 |
| **Spacing (B)** | 3 | 1.82* | 106.45* | 2485.00* | 2874.61* |
| **(A × B)** | 6 | 9.64* | 97.68* | 696.82* | 65.03* |
| **Error** | 18 | 0.28 | 15.09 | 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 shada bhutta**

| Source of variation | DF | Mean square value of yield contributing characters of shada bhutta | |
|---|---|---|---|
| | | Cob length | Cob circumference |
| **Replication** | 2 | 0.21 | 0.08 |
| **Irrigation frequencies (A)** | 2 | 9.53* | 1.50* |
| **Error** | 4 | 0.45 | 0.21 |
| **Spacing (B)** | 3 | 7.32* | 2.82* |
| **(A × B)** | 6 | 0.21* | 0.11* |
| **Error** | 18 | 0.37 | 0.17 |
| **Total** | 35 | | |

*: Significant at 0.05 level of probability

**Appendix X. Analysis of variance of the data of yield contributing characters of shada bhutta**

| Source of variation | DF | Mean square value of yield contributing characters of shada bhutta | | | |
|---|---|---|---|---|---|
| | | Row cob$^{-1}$ | Grain row$^{-1}$ | No. of grains cob$^{-1}$ | 1000 grains weight |
| **Replication** | 2 | 0.33 | 0.08 | 48.11 | 25.00 |
| **Irrigation frequencies (A)** | 2 | 3.34* | 0.30$^{NS}$ | 1056.28* | 1477.78* |
| **Error** | 4 | 0.14 | 0.21 | 200.11 | 50.00 |
| **Spacing (B)** | 3 | 4.13* | 5.39* | 3845.53* | 965.74* |
| **(A × B)** | 6 | 0.88* | 0.72* | 916.53* | 51.85* |
| **Error** | 18 | 0.13 | 0.20 | 110.19 | 19.44 |
| **Total** | 35 | | | | |

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

**Appendix XI. Analysis of variance of the data of yield contributing characters of shada bhutta**

| Source of variation | DF | Mean square value of yield contributing characters of shada bhutta | | | | |
|---|---|---|---|---|---|---|
| | | Chaff weight $cob^{-1}$ | Shell weight $cob^{-1}$ | Grain weight $cob^{-1}$ | Cob weight $Plant^{-1}$ | Shelling % |
| **Replication** | 2 | 0.19 | 0.15 | 4.00 | 7.46 | 0.58 |
| **Irrigation frequencies (A)** | 2 | 2.18* | 3.20* | 30.20* | 72.55* | 1.17* |
| **Error** | 4 | 0.32 | 0.33 | 1.33 | 2.43 | 1.33 |
| **Spacing (B)** | 3 | 2.32* | 10.23* | 771.66* | 1014.02* | 14.05* |
| **(A × B)** | 6 | 0.56* | 0.78* | 1.80* | 1.59* | 0.82* |
| **Error** | 18 | 0.288 | 0.27 | 2.22 | 4.11 | 1.08 |
| **Total** | 35 | | | | | |

*: Significant at 0.05 level of probability

**Appendix XII. Analysis of variance of the data of yield characters of shada bhutta**

| Source of variation | DF | Mean square value of yield contributing characters of shada bhutta | | | |
|---|---|---|---|---|---|
| | | Grain yield | Stover yield | Biological yield | Harvest index |
| **Replication** | 2 | 0.04 | 0.096 | 0.25 | 0.09 |
| **Irrigation frequencies (A)** | 2 | 0.30* | $0.06^{NS}$ | 0.58* | $0.89^{NS}$ |
| **Error** | 4 | 0.01 | 0.12 | 0.11 | 0.71 |
| **Spacing (B)** | 3 | 6.86* | 10.80* | 31.67* | 19.19* |
| **(A × B)** | 6 | 0.019* | 0.68* | 0.80* | 2.54* |
| **Error** | 18 | 0.018 | 0.11 | 0.16 | 0.50 |
| **Total** | 35 | | | | |

*: Significant at 0.05 level of probability

**PLATES**

**Plate 1: Shada bhutta seed showing in the experimental field**


**Plate 2: Shada bhutta plant at seedling stage**

**Plate 3: Weeding of the experimental field of shada bhutta**

**Plate 4: Shada bhutta at vegtative stage**

**Plate 5: Field exhibition by honorable supervisor**

**Plate 6: Tassel formation of shada bhutta**


**Plate 7: General view of the experimental plot with sign board**

**Plate 8: Shada bhutta at maturity stage**