GROWTH AND YIELD OF COMPOSITE AND HYBRID MAIZE AS AFFECTED BY TIME OF IRRIGATION

BY

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CERTIFICATE

This is to certify that the thesis entitled "**Growth and Yield of Composite and Hybrid Maize as Affected by Time of Irrigation**" 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** in **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **Keya Halder**, Registration number: **04-01266** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

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ABSTRACT

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October 2009 to March 2010 to study the growth and yield of composite and hybrid maize as affected by time of irrigation. The experiment comprised as two factors. Factor A: Maize variety - 2 levels; V_1: BARI bhutta-7 and V_2: BARI hybrid bhutta-5. Factor B: Time of irrigation - 8 levels, I_0: No irrigation; I_1: One irrigation at 35 DAS; I_2: One irrigation at tasseling; I_3: One irrigation at silking; I_4: Two irrigations at 35 DAS and tasseling; I_5: Two irrigations at 35 DAS and silking; I_6: Two irrigations at tasseling and silking and I_7: Three irrigations at 35 DAS, tasseling and silking. The experiment was laid out in split-plot design with three replications. Data on different growth parameter, yield attributes and yield were recorded and analyzed. At 40, 60, 80 DAS and at harvest the tallest plant (23.54 cm, 57.98 cm, 106.88 cm and 170.68 cm, respectively) was recorded from V_2, while the shortest plant (21.46 cm, 55.58 cm, 99.93 cm and 161.56 cm, respectively) from V_1. The highest grain yield (7.48 t/ha) was found from V_2, while the lowest (3.96 t/ha) from V_1. At 40, 60, 80 DAS and at harvest, the tallest plant (25.09 cm, 61.46 cm, 111.51 cm and 175.45 cm, respectively) was observed from I_7, again the shortest (18.64 cm, 50.46 cm, 90.56 cm and 147.07 cm, respectively) from I_0. The highest grain yield (6.31 t/ha) was obtained from I_7 and the lowest (4.06 t/ha) from I_0. At 40, 60, 80 DAS and at harvest, the tallest plant (26.53 cm, 63.04 cm, 118.70 cm and 187.10 cm, respectively) was observed from V_2I_7, again the shortest (14.77 cm, 48.27 cm, 78.19 cm and 132.31 cm, respectively) from V_1I_0. The highest cob length (19.63 cm) was found from V_2I_7, while the lowest (11.40 cm) from V_1I_0. The highest cob diameter (3.74 cm) was observed from V_2I_7, again the lowest (2.38 cm) from V_1I_0. The highest 1000 grain weight (423.93 g) was given by V_2I_3, while the lowest (235.23 g) was found in V_1I_0. The highest grain yield (8.48 t/ha) was recorded from V_2I_7 that similar to V_2I_6 (8.04 t/ha) and the lowest (2.55 t/ha) from V_1I_0.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter 1
Introduction

CHAPTER I

INTRODUCTION

Maize (*Zea mays* L.) belongs to the family Gramineae is one of the most important photo-insensitive, cross pollinated cereal crops and ranks 3rd in acreage and production in Bangladesh. As food, it can be consumed directly as green cob, roasted cob or popped grain. Its grain can be used for human consumption in various ways such as corn meal, fried grain and flour. Maize is being cultivated all over the world but the yield of maize is low in Bangladesh as compared to the other maize growing countries. The total area under maize cultivation in 2007-2008 was 55.3 million hectares with estimated production of maize was about 1346,000 metric tons (BBS, 2008).

Its grain has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals. Moreover, 100 g maize grains contain 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin (Chowdhury and Islam, 1993). Maize oil is used as the best quality edible oil. Green parts of the plant and grain are used as the feed of livestock and poultry. Stover and dry leaves are used as good fuel (Ahmed, 1994). The important industrial use of maize includes in the manufacture of starch and other products such as glucose, high fructose sugar, maize oil, alcohols, baby foods and breakfast cereals (Kaul, 1985). This crop has much higher grain protein content than our staple food rice. In Bangladesh the cultivation of maize was started in the late 19th century but the cultivation has started to gain the momentum as requirements of maize grain are being increased as poultry industry in Bangladesh.

Maize is one of the most productive C_4 plant with a high rate of photosynthetic activity. Maize has the highest potential for carbohydrate production per unit area per day. It was the first major cereal to undergo rapid and widespread technological transformation in its cultivation as evidenced by the well documented history of hybrid maize in the United States and later in Europe. The success of science-based technology in maize cultivation stimulated agricultural revolution in many parts of the world. Natural calamities such as drought, flood, cyclone, etc. and above all, the high rate of population explosion is the burning question which cause food crisis around the world. This alarming situation indicates the urgency of making a wide range effort to produce more food globally and particularly in third world country like Bangladesh.

Loamy soil with nearly neutral pH is most suitable for production of maize. It can be grown all the year round in Bangladesh, and fitted in the gap between the main cropping seasons without affecting the major crops. It can also be grown in flood prone areas under no tillage, and with no inputs (Efferson, 1982). With its multipurpose properties, it will undoubtedly play a vital role in reducing the food shortage around the world, especially in Bangladesh. Maize being the highest yielding crop among cereal has high potential for growing in the world as well as Bangladesh. Development of maize varieties having high yields within the shortage time may go a long way to supplement food and fodder shortage in Bangladesh. Yield is a complex character which is dependent on a number of agronomic characters and is highly influenced by many genetic and environmental factors (Joarder *et al.*, 1978).

Water deficiency had adverse effects on plant growth, average yield and crude protein in crops and the growing stage is vulnerable for water stress (Golakiya and Patel, 1992). As the maize plants use the residual soil moisture for its early vegetative growth, the subsequent growth is suffered in most cases. Amelioration of draught environment through management practices like limited irrigation and deeper sowing is needed for the proper germination, emergence, establishment and subsequent satisfactory yield of maize. Environmental factors may have a great effect on some genotypes than others. Comstock and Moll (1963) reported that the interplay of genetic and non-genetic factors on development as genotype-irrigation interaction. To ascertain phenotypic stability, multiplication trials over a number of years are needed. Sometimes, the uni-location trials can also serve the purpose to provide different environments which can be created by planting the experimental materials on different dates of sowing, allowing various irrigations and differential doses of fertilizers and irrigation levels, etc.

With conceiving the above scheme and discussion in mind, the present research work has been undertaken in order to fulfilling the following objectives:

i. To compare the yield performance of composite and hybrid variety,

ii. To find out the optimum time of applying water to maize and

iii. To minimize water use for higher yield potentiality of maize.

Chapter 2
Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Maize is one of the common and most important cereal crops of Bangladesh and as well as many countries of the world. The growth and yield of maize is largely controlled by the environmental variables notably moisture regimes, temperature and varieties. Research works have been done by various workers in many parts of the globe to study the effect of irrigation, and quality variety on the growth and yield of maize. The crop has received much attention by the researchers on various aspects of its production and utilization for different consumer uses. Many studies on the growth and yield have been carried out in many countries of the world. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings so far been done at home and abroad on this aspect have been reviewed in this chapter under the following headings:

2.1 Effect of variety

BARI (1985) conducted a field experiment at Joydebpur during kharif, 1985 and rabi 1986 to study their days to ten growth stages (i.e. collar of 4^{th}, 8^{th} and 12^{th} leaf, tip tassel visible, silk visible, cob full size, kernel dough, kernal partially dented, kernal fully dented and maturity) in four maize varieties (viz., Across7740, Sadaf, Amberpop and Pirsabak 8146). No variation in duration of growth stages was noticed upto 12^{th} leaf stages among the varieties during kharif season. Their maturity period ranged from 78 days (Pirsabak 8146) to 93 days (Across 7740).

Distinct differences were observed from 7th leaf stages during rabi season. The same varieties took 123 days (Pirsabak) to 138 days (Across 7740) to attain maturity in rabi season. The yield ranged from 1.94 to 2.84 ton ha^{-1} in kharif and 4.13 to 5.52 ton ha^{-1} in rabi season. Variations in yield both in kharif and rabi might be due to seasonal variation (BARI, 1988).

Smale *et al.* (1995) reported that farmer adoption of seed/fertilizer technology could be characterized in terms of three simultaneous choices: whether to adopt the components of the recommended package; land allocation to new and old varieties; and the level of inputs such as fertilizer. Two distinctive features of maize technology adoption in Malawi are: land allocation to both traditional and hybrid maize varieties; and application of modern input (fertilizer) to a traditional variety.

Babu *et al.* (1996) reported the performance of maize Ksheeramrutha, derived from South African maize, and its hybrids with Deccan 101, grown in the field at Karnataka during 1975-86. Ksheeramrutha was quick growing, leafy, tall and high yielding compared with the other genotypes tested. It produced good quality fodder, had high protein content and performed well in mixtures with black soya and cowpeas. It was released for cultivation in Karnataka in 1989.

Tusuz and Balabanl (1997) conducted a study in the Antalya-Manavgat region during 1993-94, 8 hybrid maize varieties (P.3165, TTM813, TTM815, TTM81-19 ANT90, ANT-BEY, TUM82-6 and TUM82-7) were grown to determine changes in characters (50% silking date, plant height, ear height and moisture percentage at harvest) affecting grain yield. Over the two years of the experiment, heritability in the broad sense was highest for 50% silking (0.93), and low for plant height (0.12), ear height (0.31), harvest moisture percentage (0.03) and for yield (0.06). Yield was significantly correlated with 50% silking date (r = 0.67), plant height (r = 0.50), ear height (r = 0.42) and harvest moisture percentage (r = 0.43). Adaptation was very good for all of the tested varieties. Grain yield was highest for P.3165 (1343 kg da-1) and ANT90 was the earliest variety. The yield potential of all of the varieties changed from year to year and a significant environmental effect was observed.

Chaudhary *et al.* (2000) conducted a series of on-farm experiments involving 18 farmers during kharif season of 1993 to 1995 under mid-hill sub-humid agro-climate in Mandi district of Himachal Pradesh to assess the relative effect and impact of different technological inputs on maize (*Zea mays L.*) productivity. The treatments consisted of farmers' practices with local variety (control), farmers' practices with improved variety, farmers' practices with improved variety and recommended fertilizer and improved practices with improved variety and recommended fertilizer and improved practices with improved variety and recommended fertilizer. The results indicated that the grain yield (3795 kg ha^{-1}) and net return (Rs. 8069 ha^{-1}) were significantly higher on adoption of improved practices along with improved variety and recommended fertilizer over other treatments and an additional gain in grain yield due to this practice was 1262 kg ha^{-1} with 49.8% increase against farmers' practices with local variety.

Ogunboded *et al.* (2001) evaluated seven early maturing open pollinated (OP) and five yellow hybrid maize varieties in 1996 in 22 locations representing the different agro ecologies of Nigeria. Significant location effects were observed for grain yield in the two sets of maize varieties tested. Grain yield was significantly higher in the northern/southern Guinea savanna agro ecologies when compared to the other agro ecologies. Highly significant varietals differences were found among the OPs and the yellow hybrids. The highest yielding OP variety was TZE Comp.4 DMR BC1 with an average grain yield of 2.43 t ha^{-1} while the best yellow hybrid was 8522-2 with a mean grain yield of 2.82 t ha^{-1}. Comparison of the results of the OPs and the hybrids showed that the hybrid had an average of 18.2% yield advantage over the OPs. The hybrid maize varieties and four of the seven OPs were stable in grain production across the locations.

Olakojo and Iken (2001) evaluated nine improved open pollinated maize varieties and a local cultivar in five locations consisting of four agro-ecologies of Nigeria, for yield performance and stability estimates. The improved maize varieties significantly out yielded the local check entry by between 10.3 and 30.3%, thus ranking TZB and Posa Rica 7843 as the highest yielding varieties. Stability estimates in the tested varieties showed that local variety was the most stable variety with Bi=1.0. Other varieties appeared to be stable in poor environment with stability estimates of <1.0.TZB and Posa Rica 7843 recorded the least (0.38 and 0.64) stability estimates.

Syed *et al.* (2002) conducted the field experiment during 2000 at Malakandher Research Farms, NWFP Agricultural University, Peshawar, Pakistan to study yield and yield components of different cultivars of maize as affected by various combinations of NP. Statistical analysis of the data revealed that days to 50% silking, 1000 grain weight, grain weight and biological yield were significantly affected by different varieties and fertilizer (NP) levels. Similarly, combination between varieties and NP had a significant effect on days to 50% tasselling, days to 50% silking, grain yield and biological yield. Maize variety Azam produced maximum 1000 grain weight, grain yield and biological yield when compared to other varieties. When the effect of different levels of NP was taken into account, it was revealed that plots treated with NP levels of 120:90 kg NP ha^{-1} produced maximum 1000 grain weight, grain yield and biological yield.

Sirisampan and Zoebisch (2005) reported that in northeast Thailand, maize (*Zea mays L.)* was mainly grown under rainfed conditions to identify and assess variety and cultivation-practice effects on the growth and yield of maize under temporary drought stress induced during the flowering stage. Under controlled soil-moisture conditions, three varieties (Suwan5-open-opllinating; Big717 and Big949-single-cross hybrids) and five cultivation practices (conventional (CT)); mungbean (Vigna radiata (L.) Wilzek) residue (Mn); spineless mimosa (*Mimosa invisa*) live mulch (Mi); manure (Ma); and plastic mulch (Pl) were studied for two cropping seasons. The two hybrid varieties produced significantly higher grain yields than the open-pollinating variety, i.e, Big-717> Big-949 > Suwan-5. The effects of cultivation practices were less prominent and the highest average yields were produced by Pl; the lowest by Ma.

Palafox *et al.* (2006) reported that during spring and summer seasons of 2004, four experiments of 3-way quality protein maize (QPM) hybrids, were carried out in Camaron de Tejeda, Medellin de Bravo, Tlalixcoyan and San Andres Tuxtla, State of Veracruz, Mexico to characterize the yield and agronomic features of these hybrids, and identify those with best agronomic behaviour. Eleven QPM, 8 common hybrids and 2 checks were evaluated. Individual analysis for yield, days to tassel, days to silking, plant height and ear length, plant and ear aspect, and combined analysis for yield were conducted. The best hybrids in Medellin de Bravo were HC 1 and HC 2. In Camaron de Tejeda, HC 4 and HC 2 presented the best grain yield of 8-9 t ha^{-1}. HC 7 and HC 2 were the best hybrids in Tlalixcoyan with more than 6 t ha^{-1}. In San Andres Tuxtla, HC 1 and HC 4 registered the highest grain yield. Across the four locations, the best hybrids considering grain yield, adaptation, and plant and ear agronomic characteristics were HC 2, HC 4, and HC 1.

2.2 Effect of irrigation

Islam *et al.* (1980) found out the effect of irrigation regimes on yield of corn. They reported that the highest grain yield (5.94 t per hectare) was obtained by three irrigation applied at seeding, vegetative and tasselling stages.

Talukder (1985) reported that the water requirement of corn was 6.4mm day^{-1} in high land of north-eastern part of Thailand. He further observed the highest yield of 7207 kg per hectare was obtained with maximum irrigation.

Sharma and Pereira (1988) observed the effect of water deficit of maize at Petrolina in Brazil. The crops were supplied with supplied full irrigation or subjected to irrigation deficit at vegetative, silking and grain formation stages. They observed that yield varied with different irrigation regimes. By comparing irrigation deficit between flowering and vegetative stages they also concluded that grain yield was lowest (0.14 t ha^{-1}) with irrigation deficit are flowering and that of the highest (2052 t ha^{-1}) with irrigation deficit during vegetative growth.

Dai *et al.* (1990) reported that growth and development of all cultivars were inhibited at moderate water stress at different growth stages. Drought during reproductive organ formation root growth and adaptability of all cultivars.

Bao *et al.* (1991) studied the effect of water stress on different growth periods of maize. They concluded that water stress at tassel ling or grain filling period decreased leaf water potential, led to abortion of tassels and delayed grain development.

Nesmith and Ritche (1992a) found out the effects of soil water deficits during tassel emergence on development and yield components of maize. They observed that water deficits spanning at 37 days from just before tassel emergence to the start of grain filling , delayed emergence of tassels and silks for more than two weeks , reduced grain yield , increased slightly number of grains per ear and individual grain weight.

Nesmith and Ritche (1992b) worked with the short and long-term responses of maize to soil water deficit. Applying water stress from emergence to 9^{th} leaf to one week before tassels emergence they observed that relative growth of water stressed plants decreased. They also reported that water stress delayed tassel ling, silking and onset of grain filling.

Coscilleula and Faci (1992) studied the effect of water stress on the yield of maize. They observed that grain yield decreased from 10.30 to0.71 t ha^{-1} with 592 mm and without irrigation treatments respectively. Cosculleula and Faci (1992) assessed the effect of water stress on maize yields. They reported that grain yield decreased from 10.3 to 0.71 t ha^{-1} with 592 mm irrigation water and without irrigation, respectively. They also observed that harvest index decreased from 57.5 to 16.19 percent.

Chowdhury and Islam (1993) found out the effect of irrigation schedule on maize yields. They reported that depending on the land and soil types, 2 to 3 irrigation were required for obtaining good yield of maize during rain season. They further reported that the first irrigation should be given 35 to 40 days after germination of seeds (DAGS), the second irrigation 65 to 70 DAGS (just before flowering) and third irrigation 90 to 100 DAGS (during grain formation stages), if required.

Shaozhong and Minggang (1993) studied that maize were found to be most sensitive to water deficit between the leading and milking stages and less sensitive in the seed formation and maturing stages.

Abrecht and Carberry (1995) studied that the influence of water deficit prior to tassel initiation on maize growth and development. They observed that water deficit had little effect on timing of emergence but delayed tassel initiation, silking and reduced plant height during vegetative growth of maize.

Jana and Sana (1995) found that irrigation increased cobs $plant^{-1}$ of maize. Maize as pure stand gave higher dry matter due to irrigation treatment. They also found that three irrigations improved maize yields, giving highest monitory return, 1.5 times of rain fed treatment.

Otegui *et al.* (1995) studied the effect of drought on maize and found that water deficit reduced plant height of maize. They also found that number of grains per ear did not increase properly and silks were deleteriously affected by water stress condition. Gordon *et al.* (1995) observed that acceptable maize yields could be achieved with one or two irrigations if the irrigations were given timely to meet high plant water use demands associated with critical growth stages.

Khristov (1995) found that water deficiency during the extremely critical growth stages such as tasselling, milk ripeness and maturity stages caused average yield reduction. Matzenauer *et al.* (1995) reported that water supply was most critical during the period from silking to commencement of grain. The highest correlation was found between grain yield and water deficit. Zhirkov (1995) found that yields of maize without irrigation, full irrigation and reduced irrigation were 5.13, 13.08 and 10.26 to 11.68 t/ha respectively.

Rajendar *et al.* (1996) observed that water stresses at 30, 55, 65 or 84 days after sowing (knee high, tassel ling, silking and dough stages, respectively) reduced number of grains per ear , grain yield and net returns but number of ears per plant were not affected at these stages.

Bandyopadhyay and Mallick (1996) reported that increasing irrigation water increased grain yield of maize. Yildrim *et al.* (1996) found that the highest (10.85 t ha^{-1}) and lowest (3.47 t ha^{-1}) yields were obtained with full irrigation and without irrigation throughout the whole growing period, respectively. Withholding irrigation during ripening did not significantly affect grain yield, while the greatest sensitivity to water deficit was at flowering stage.

Carp and Maxim (1997) found out the effect of irrigation on maize yield and maize was grown with and without irrigation treatments. They observed that grain yield increased from 7.80 to 9.23 t ha^{-1} with and without irrigation respectively.

Leta *et al.* (1998) evaluated the water stress at different growth stages by decreasing irrigation level of individual growth stage, stress at the vegetative stage had least effect on grain yield, while yield reduction was greatest from stress applied in grain filling.

El-Rahman *et al.* (1998) worked with two irrigation treatments one irrigation to field capacity and other irrigation after 60% depletion of the available soil moisture at the root zone i.e. soil moisture stress. They observed that higher percentage of plant dry mass (leaves + stem + cobs) were achieved by the two irrigation treatments.

Ali *et al.* (1999) in maize varieties were subjected to constant drought, sutured soil moisture or water logging. They reported that plant height, basal diameter, leave number and longevity of the plants were severely affected by drought and water logging in all the cultivars with drought having the greater effect.

Steele *et al.* (1999) observed the effect of irrigation scheduling on maize grain yield from 1990 to 1995 seasons. They reported that maize grain yield was significantly affected by irrigation scheduling for both the current and previous seasons. They also concluded that care full irrigation scheduling offers to reduce inputs costs for irrigated maize production.

Terbea and Ciocazanu (1999) reported that the aim of this study was to establish the influence of limited water supply on some physiological traits in four maize inbred lines (1268H ,1267E,B73, and Mo17S) differing in drought tolerance. The experiments were conducted in a growth chamber, with maize plants are grown in a peat-sand (1:1) mixture in PVC tubes (36 cm long and 9cm diameter). Limited water supply (LWS) in tolerant inbred line 1268H produced a significant increase in photosynthetic rate, root length, and lateral root area. Significant decreases in photosynthetic rate, leaf area, root length, lateral root area, stomata conductance, transpiration rate and chlorophyll content were observed in highly drought sensitive line B73. These results showed that under normal soil moisture, the genetic variability of maize for these parameters was less pronounced than under decreased soil water content. The genotypic responses to soil water content were different.

Norwood (2000) evaluated the effects of various combination of irrigation treatment from zero, one two and three irrigation each consisting of 150 mm of water applied to maize grown with conventional tillage. He concluded that maize would produce adequate yield with one or more irrigations.

Fernandez *et al*. (2000) observed that 23 maize hybrids genotype variability in resistance to drought, salinity and high temperature at the seedling stage, thereby giving an opportunity for the selection for resistance to particular stress. Roots were highly sensitive to salinity. Some hybrids were tolerant to drought and salinity. The hybrids showed better growth under 38^0C and some also to drought. Only a few genotypes were moderately tolerant of salinity.

Begna *et al*. (2000) reported that dry matter and grain yields among the traits most commonly used to evaluate maize (*Zea mays*) hybrid performance. Production of both dry matter and grain yields were often influenced by hybrid size. The efficiency with which a hybrid allocates accumulated dry matter into economic grain yield has a large influence on potential grain production. The objective of this work was to quantity dry matter, grain yield and harvest index of 17 hybrids representing a range of canopy architectures. A field experiment was conducted on clay loam soil at the E. A. lodes Agronomy Research Center, Ste. Anne de Bellevue, Quebec in 1997 and 1998. Hybrids were arranged in a randomized complete block design and included 11 newly developed leafy reduced stature (LRS), four non-leafy reduced-stature (LMBL) hybrids. Moreover grain yields averaged over canopy groups were not different. The shorter hybrids had greater assimilate allocation to the grain than the taller (especially LMBL) hybrids and this was evident in their harvest index values. However, within the LRS group, hybrids differed for both dry matter and grain yield with some being similar to the NLRS hybrids while others were similar to the taller pioneer Brand 3979 hybrid.

Cavero *et al.* (2001) reported that spatial variability of crop yield within a surface-irrigated field is related to spatial variability of available water due to non-uniform irrigation and soil characteristics among other factors (e.g. soil fertility) . The infiltrated depth at each location within the field can be estimated by measurements of opportunity time and infiltration rate or simulated with irrigation models. We investigated the use of the crop growth model EPIC phase to simulate the spatial variability of maize grain yield within a level basin (in Spain) using estimated or simulated (with the irrigation model B2D) infiltrated depth. The relevance of the spatial variability of infiltration rate, opportunity time, and soil surface elevation in the simulation of grain yield spatial variability was also investigated. The measured maize grain yields at 73 locations within the level basin, ranging from 3.16 to 11.54 t ha^{-1} (SD =1.79 t ha^{-1}) were used for comparison. Estimated infiltrated depth considering uniform infiltration rate resulted in poor simulation of the spatial variability of grain yield (SD =0.59 t ha^{-1}, root mean square error (RMSE) =1.98 t ha^{-1}). Simulated infiltrated depth with the irrigation model considering uniform infiltration rate and soil surface elevation resulted in grain yield simulations with lower variability than measured (SD = 0.64 t ha^{-1} RMSE = 1.58 t ha^{-1}).

In a field experiment conducted by Song and Li (2002) under rain-prevention measures, the summer maize variety Shandan 1 was grown with or without irrigation or N supply. Samples were gathered 25, 36, 65, 87 and 101 days after seedling emergence to monitor the dynamics of nutrient accumulation in the plants. Biomass and NPK uptake increased while NPK content (%) of the plants tended to decrease with plant growth. Biomass and NPK uptake of the plants appeared to be a function to time duration. The rate of dry matter accumulation and NPK uptake was greater at the earlier growth stages of the crop. Water and N promoted the transfer of nutrients to the developing grain from the vegetative organs, thus greatly increasing crop yield.

Two field experiments were conducted by Sowalim *et al.* (2003) during 1999 and 2000 in Egypt, to simulate the effect of skipping one or two irrigation(s) at different maize (hybrids SC10, SC152 and TWC321) growth stages. The treatments comprised: skipping the 3rd irrigation (at one week before silking), T_1; skipping the 4th irrigation (during pollination), T_2; skipping the 5th irrigation (early during grain filling), T_3; skipping the 6th irrigation (late during grain filling), T_4; skipping the 3rd and the 5th irrigation, T_5; and skipping the 3rd and the 6th irrigation, T_6. Data were recorded for leaf area index, grain yield, total biomass and number of grains m^{-2}. In T_1, the leaf area index was reduced by 34.62% due to water stress during that phase, where leaf appearance and growth rates were highest. The grain yield was reduced by 18.55%. Grain number per m^{-2} was reduced by 15.622%. In T_2, grain yield was reduced by 44.07%, total biomass was reduced by 32.75% and grain number m^{-2} by 38.13%. In T_3, grain yield was reduced by 16.35%, total biomass by 11.84% and grain number m^{-2} by 6.75%. The reduction in grain yield (12.17%) for T_4 was less than the reduction observed in the other treatments. Severe effect of water stress on maize yield and its attributes occurred when 2 irrigations were skipped, one during vegetative growth and the other during grain filling. However, the effect was less severe on grain yield when the 3rd and 6th irrigation were skipped, where yield was reduced by 36.71% versus 41.52% when the 3rd and 5th irrigation were skipped.

Results are presented and discussed of trials with 35 early maize hybrids in the Arezzo and Macerata areas, with the addition of a further 24 hybrids in the areas of Perugia and Rome by Quaranta *et al.* (2003). Details of the phenology, morphology and yields are given in table form for each of the trial sites and also averages from all the sites. Drought stress due to the generally unfavourable climatic conditions led to poor yields at all except the Rome site. Hybrids PR36B08, DK 440, Cathar and LG 2306 yielded well from the point of view of both quantity and quality, despite the unfavourable conditions, in which just a single irrigation would have been valuable. Further research is needed into the advisability of leaving maize to dry in the field, especially if the weather is damp.

Quaranta *et al.* (2004) carried out Maize trials on a deep alluvial clayey soil with good water retention in central Italy. Of 46 maize hybrids of FAO classes 400, 500 and 600, 33 had been in trials at least once before. Yields were generally lower than in previous years due to the exceptionally prolonged hot, dry weather, but even so, a number of hybrids performed well. Hybrids DK585 and DK 537 scored relatively much better than in 2002, Cecilia was outstanding, confirming its good performance in 11 previous years and making the best use of the available water. Senegal and PR34B23 also performed well with grain humidity at harvest below average. The number of sterile plants was above average, due no doubt to the drought.

An experiment was conducted by Singh and Sudhanshu (2005) to examine the influence of mulching and irrigation on hydrothermal regime of soil with reference to growth and yield of winter maize in Dholi, Bihar, India. Altogether three mulch treatments and three irrigation levels was introduced. The type of mulches were polyethylene sheet 500 gauge (M_2), rice straw at 5 t/ha (M_1) and unmulched (M_0) and the levels of irrigation were 12 IW/CPE (I_3), 0.9 IW/CPE (I_2) and 0.6 IW/CPE (I1) ratio. The recommended dose of fertilizers was applied. With the application of mulch and irrigation, the soil temperature raised towards optimum. The moisture and temperature plays an important role in movement of ions and nutrients, it is evidenced by significantly increased growth parameter, i.e. plant height and leaf area index, which ultimately resulted in higher grain and straw yield, whereas the sequence of level of irrigation were $I_3 > I_2 > I_1$. The effect of irrigation was significant for increasing the leaf area index and yield but for increasing the plant height.

Field trials were conducted by Quaranta *et al.* (2005) in the north of Rome, Italy, with 53 hybrids of which 18 had been tested during 2002-03. Data are tabulated on the class of hybrids and the year of trial (1-5). Data are tabulated on phenotypic, morphological, cultural, productive and qualitative characteristics of the hybrids. Data are presented on the number of hybrids tested during 2000-04, their sowing, emergence, flowering and harvesting dates, the height of plants, yield, humidity of grain at harvest, percentage of broken plants, weight of 1000 seeds and protein content. A diagram is included on the average yield index and its variability for 18 hybrids tested during 2002-04. Evidence was obtained that of 18 hybrids tested during 2002-04, Narbone, Net, Potenza 581, KWS 0551, Helder and Aristo had the highest yield even in drier years.

Iqbal *et al*. (2006) conducted a pot experiment was conducted to evaluate the effect of mulch and irrigation on nutrient uptake of forage maize using clay and loam soils during autumn 2002. Two mulch levels: 0 (control) and 6.7 tonnes ha^{-1} of wheat straw were used. Three irrigation levels: 100, 80 and 60% of total crop water requirement (CWR) was determined at 30 mm deficit. Maize plants were harvested twelve weeks after sowing and shoots were analysed for N, P and K concentration and their uptake was calculated. Results revealed that there was no effect of wheat straw mulch on nutrient concentration and their uptake, while N concentration and uptake in shoot significantly increased in clay than loam soil. Phosphorus concentration and uptake was more in loam soil. Interaction between mulch and soil texture was statistically significant as increase in potassium concentration in shoot was observed.

Alternate partial root-zone irrigation (APRI) was a new water-saving technique and improved crop water use efficiency without much yield reduction reported by Li *et al*. (2007). They investigated if the benefits of APRI on biomass accumulation, water and nitrogen use efficiencies could be modified by different soil fertilization and watering levels in pot-grown maize (*Zea mays* L. cv. supersweet No 28, a local variety). Three irrigation methods, i.e. conventional irrigation (CI), alternate partial root-zone irrigation (APRI, alternate watering on both sides of the pot) and fixed partial root-zone irrigation (FPRI, fixed watering on one side of the pot), two watering levels, i.e. water deficit and well-watered, and two N fertilization levels, i.e. no fertilization and fertilization, were designed. Results showed that APRI and FPRI methods led to more reduction in transpiration than in photosynthesis, and thus increased leaf water use efficiency (leaf WUE, i.e. the ratio of leaf net photosynthetic rate to transpiration rate). Compared to the CI treatment, APRI and FPRI increased leaf WUE by 7.7% and 8.1% before the jointing stage and 3.6% and 4.2% during the jointing stage, respectively. Under the fertilization and well-watered conditions, APRI treatment saved irrigation water by 38.4% and reduced shoot and total dry masses by 5.9% and 6.7%, respectively if compared to the CI treatment.

The response of varied irrigated maize to organic and inorganic fertilizer was evaluated by Fandika *et al.* (2008) at Kasinthula Research Station, 2003-2007. DK8031 maize variety was planted on ridges. It was a split plot replicated three times, with four irrigation scheduling scenarios as main plots and seven fertilizer sources as subplots. Irrigation scenarios comprised: Daily Water balance scheduling at 40% depletion and three fixed irrigation scenarios, 40 mm every 3-4 days, 7 days and 14 days. The Nitrogen sources were compost (C), farmyard manure (FYM), Urea (U) and their mixture at a rate of 120 N kg/ha. Cropwat 4 windows simulated soil water balance and crop water requirement for different irrigation intervals and depth was compared with field data. Three years results showed positive ($P<0.01$) and highly significant interaction between grain yields, crop water productivity (CWP) and Nitrogen use efficiency (NUE). The Daily water balance irrigation scheduling had greatest grain yields (6.42 t ha^{-1}) CWP (11.46 kg mm ha^{-1}) and NUE (53.53 kg N kg ha^{-1}) in FYM: 2U treatments. These results were not significantly different to 40 mm every 3-4 days and 7 days in FYM: 2U, sole urea and 1C:2U treatments. The minimum NUE observed in FYM treatments irrigated every 14 days. The results also showed that long intervals led to significant reduction in yields, water application and its associated deep percolation losses. Generally, the optimal irrigation scenario that maximized grain yields and minimized deep percolation losses was daily soil water balance irrigation schedule scenario in the 2U: FYM and sole urea treatments. Maize fertilized with sole organic N sources had lowest CWP and NUE. An increase in urea ratio increased maize yield and NUE. It was, therefore, concluded that with adequate water and high inorganic N ratio, there is great potential to facilitate N release from organic matter. In times of water shortage, sole urea can better or more easily be utilized than organic nitrogen sources. These results provide information for improved soil water and nutrient management for smallholder farmers in Malawi.

A field trial with 2 varieties Zhengdan 958 and Nongda 108 was conducted by Yi *et al.* (2008) during 2004-05 in the Wuqiao Experiment Station of the China Agriculture University, Hebei, China, to study their response of water use efficiency (WUE) to nitrogen application and precipitation. Three types of N fertilizers (urea, coated urea and compound fertilizer) at 3 rates (0, 90 and 180 kg

N/ha) were designed. The 1/3 and 2/3 urea was applied as base fertilizer and top dressing, and the coated urea and the compound fertilizer was applied as the base fertilizer. The WUE increased with the N level at 0-180 kg N/ha, and significant differences in the WUE were found among different types of N fertilizers and between the 2 varieties. The WUE of Zhengdan 958 was always higher than that of Nongda 108 under no N application and under N application. Extremely significantly positive correlation was found between the WUE and the kernel yield. Significantly positive correlations were noted between the WUE and the photosynthetic rate (or stomatic conductivity or transpiration rate) at filling stage. Moreover, the WUE in 2005 for each variety was higher than that in 2004, which was induced by annual difference in precipitation. The precipitation decrease in the early growth period and the whole growth period reduced kernel yield and water consumption, but the decrease scope of yield was lower than that of precipitation, so the WUE was improved. It is inferred that the WUE of summer maize could be significantly improved by choosing appropriate variety, cultivation under natural drought or moderate limited irrigation and applying N at 180 kg/ha.

The underperformance of many smallholder irrigation schemes in South Africa is largely attributed to socioeconomic constraints, but little attention has been paid to the relationship between farmer agronomic practices and crop productivity reported by Fanadzo *et al*. (2009). Field studies were conducted in South Africa to evaluate the relationship between cultivar, nitrogen (N) fertilizer rate, plant population and planting date on maize grain yield (experiment 1) and compare grain yields of new hybrids to cultivars commonly grown by farmers (experiment 2). The treatments for experiment 1 were maize cultivars (PAN6777 and DKC61-25), N rate (60 and 250 kg N/ha), plant population (40 000 and 90 000 plants/ha) and planting time (early: within the first 28 days of beginning of season on 15 November or late: planting after 15 December). In Experiment 2, eight cultivars were compared; 2 popularly grown by farmers at ZIS and 2 each from the 3 maturity classes (early, medium and late), which were top performers in regional variety trials conducted by the ARC from 2002 to 2004. Regardless of cultivar, higher yields were obtained when maize was planted early and fertilized at 250 kg N/ha. The short-season cultivar DKC61-25 yielded optimally when grown early at 90 000 plants/ha, while the long-season cultivar PAN777 performed better at 40 000 plants/ha. Generally, N rate and planting time had the most significant effects on yield. New hybrids yielded 50-65% more than the cultivars commonly grown by farmers. These preliminary results suggested that lack of viability of smallholder irrigation schemes in South Africa was partly a result of inappropriate agronomic practices for irrigated crop production by farmers.

Chapter 3
Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted during the period from October 2009 to March 2010 to study the growth and yield of composite and hybrid maize as affected by time of irrigation. The materials and methods of this experiment are presented in this chapter under the following headings -

3.1 Experimental site

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh, which is situated in $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude (Anon., 1989).

3.2 Soil of the experimental field

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) corresponding AEZ No. 28 and was shallow red brown terrace soil. The land of the selected experimental plot was medium high under the Tejgaon series. The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Dhaka and has been presented in Appendix I.

3.3 Climate

The climate of 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 experimental period was collected from Bangladesh

Meteorological Department (Climate Division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix II.

3.4 Planting materials

In this research work, the seeds of maize were used. Each of the composite and hybrid variety was collected from Bangladesh Agricultural Research Institute and the purity and germination percentage were leveled as around 98 and above 95, respectively.

3.5 Treatment of the experiment

The experiment comprised as two factors.

Factor A: Maize variety - 2 levels

i. V_1: BARI bhutta-7
ii. V_2: BARI hybrid bhutta-5

Factor B: Time of irrigation - 8 levels

i. I_0: No irrigation
ii. I_1: One irrigation at 35 DAS
iii. I_2: One irrigation at tasseling
iv. I_3: One irrigation at silking
v. I_4: Two irrigations at 35 DAS and tasseling
vi. I_5: Two irrigations at 35 DAS and silking
vii. I_6: Two irrigations at tasseling and silking
viii. I_7: Three irrigations at 35 DAS, tasseling and silking

As such there were 16 (2 × 8) treatment combinations viz., V_1I_0, V_1I_1, V_1I_2, V_1I_3, V_1I_4, V_1I_5, V_1I_6, V_1I_7, V_2I_0, V_2I_1, V_2I_2, V_2I_3, V_2I_4, V_2I_5, V_2I_6 and V_2I_7.

3.6 Layout of the experiment

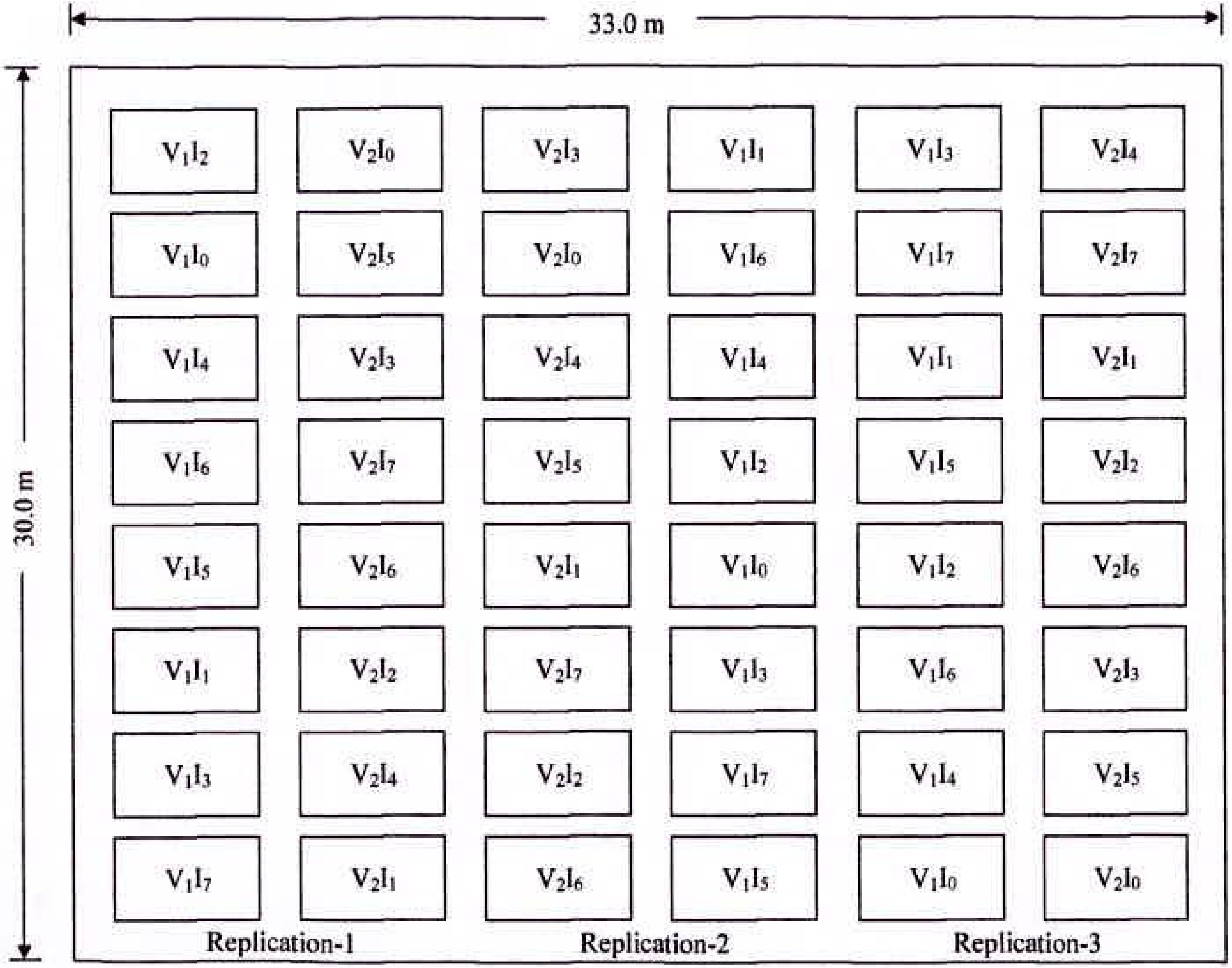
The experiment was laid out in split-plot design with three replications where variety was assigned in the main plot and irrigation levels in the sub-plots. The layout of the experiment was prepared for distributing the combination of variety and time of irrigation of maize. There were 16 plots of size 4.5 m × 3.0 m in each of 3 replications. The variety and irrigation levels of the experiment were assigned at random into main plot and sub-plot respectively for each replication (Figure 1).

3.7 Preparation of the main field

The plot selected for the experiment was opened in the first week of October 2009 with a power tiller, and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and finally obtained a desirable tilth of soil for planting of maize seeds. The experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in 3.6. Recommended doses of well-rotten cowdung manure and chemical fertilizers as indicated in 3.8 were mixed with the soil of each unit plot.

3.8 Application of manure and fertilizers

Green manure and decomposed organic matter were used @ 6.0 ton /hectare before final land preparation. The chemical fertilizers such as Urea, TSP, MOP, Gypsum, Boric acid and Zinc sulphate were applied in the rows at the rate of 170-195-70-100-10 and 10 kg/ha respectively. In case of control plots, the whole amounts of fertilizers were applied as basal dose. For other treatments, fertilizers were splitted equally as basal and side dressing as per treatment.



Plot size = 4.5 m × 3.0 m

Plot spacing: 0.5 m

Between replication: 1.0 m

Factor A: Variety (main plot)

V_1: BARI bhutta-7

V_2: BARI hybrid bhutta-5

Factor B: Time of irrigation (sub-plot)

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

Figure 1. Field layout of the experiment in the split-plot design

3.9 Planting of seeds in the field

The maize seeds were planted in lines maintaining a line to line distance of 75 cm and plant to plant distance of 25 cm having 2 seeds/hole under direct planting in the well prepared plot on 05 November 2009.

3.10 After care

When the seedlings started to emerge in the beds it was always kept under careful observation. After emergence of seedlings, various intercultural operations were accomplished for better growth and development of the maize seedlings.

3.10.1 Irrigation

Irrigation was provided using rubber pipe where each individual plots were saturated to its field capacity level as per individual treatment as designed in the experiment.

3.10.2 Thinning and gap filling

The seedling were thinned out from all of the plots at 10 days after planting (DAP) for maintaining proper spacing of the experimental plants.

3.10.3 Weeding and mulching

Weeding and mulching were done to keep the plots free from weeds, easy aeration of soil and to conserve soil moisture, which ultimately ensured better growth and development. The weeds were uprooted carefully after complete emergence of maize seedlings and also whenever necessary. Breaking the crust of the soil, when needed, was done through mulching.

3.11 Plant protection

After 50 days of planting, first spray of Chloropyriphose was done against sucking pest such as jassid and aphids. Ripcord was applied to control leaf feeder caterpillar during entire vegetative periods at times.

3.12 Harvesting, threshing and cleaning

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

3.13 Data recording

3.13.1 Plant height

The height of plant was recorded in centimeter (cm) at the time of 40, 60, 80 DAS (days after sowing) and at harvest. Data were recorded as the average of 05 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the plant.

3.13.2 Leaf area index

LAI was measured by leaf area meter (LICOR 3000, USA) at the time of 40, 60, 80 DAS and at harvest. Data were recorded as the average of 05 plants selected at random from the inner rows of each plot.

3.13.3 Dry matter content in shoot

Dry matter content in shoot was collected at 40, 60, 80 DAS and at harvest. The shoot sample was collected from randomly selected plant and sliced into very thin pieces those put into envelop and placed in oven maintaining at 70^0C for 72 hours. The shoot sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken.

3.13.4 Dry matter content in root

Dry matter content in root was collected 40 and 60 DAS. The root sample was collected from randomly selected plant and put into envelop and placed in oven maintaining at 70^0C for 72 hours. The root sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken.

3.13.5 Dry matter content ratio in shoot and root

Dry matter content ratio in shoot and root was calculated at 40 and 60 DAS with dividing dry matter content in shoot by dry matter content in root.

3.13.6 Tassel height

Tassel height was measured in centimeters from the base of the tassel to the top portion of tassel at each of the five randomly selected plants in each plot.

3.13.7 Cob to tassel height

The distance between cob and tassel was measured in centimeters from the base of the silk to the base of the tassel.

3.13.8 Days to tasseling

Days to flowering of male was recorded as the number of days from planting date to pollen shedding in 50% of plants in the plot.

3.13.9 Days to silking

The number of days recorded from the date of planting to the emergence of silks in 50% plants in the plots.

3.13.10 Days to maturity

Maturity time was recorded in days from the date of planting to the date of black layer formation of grain base of 50% population.

3.13.11 Cob length

It was measured in centimeter from the base to the tip of the ear.

3.13.12 Cob diameter

Cob diameter measured in centimeter by slide calipers from the base, middle and top portion of the ear and averaged.

3.13.13 Number of grains/cob

It was measured in number of total grain from the base to tip of the ear.

3.13.14 1000-grain weight

From the composite sample of ears of five randomly selected plants in each plot, weight of 1000-grain was taken.

3.13.15 Grain yield per hectare

Weighted cleaned and well dried grains collected from each plot and converted into hectare and were expressed in ton/ha.

3.13.16 Stover yield per hectare

Weighted cleaned and well dried stovers collected from each plot and converted into hectare and were expressed in ton/ha.

3.14 Statistical analysis

The data obtained for different characters were statistically analyzed using MSTAT software to find out growth and yield of composite and hybrid maize as affected by time of irrigation. The mean values of all the characters were evaluated and analysis of variances were performed by the 'F' test. The significance of the difference among the treatment means were estimated by the Least Significance Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the growth and yield of composite and hybrid maize as affected by time of irrigation. Data on different growth and other parameters, yield attributes and yield were recorded. The analyses of variances (ANOVA) of the data on different parameters are presented in Appendix III-VIII. The results have been presented with the help of graphs and table and possible interpretations given under the following headings:

4.1 Plant height

4.1.1 Effect of variety

Plant height showed significant differences at 60 and 80 DAS and non-significant for 40 DAS and at harvest for composite and hybrid bhutta (Figure 2). At 40, 60, 80 DAS and at harvest the tallest plant (23.54 cm, 57.98 cm, 106.88 cm and 170.68 cm), respectively were recorded from V_2 (BARI hybrid bhutta-5), while the shortest plant (21.46 cm, 55.58 cm, 99.93 cm and 161.56 cm) from V_1 (BARI bhutta-7). Ogunboded *et al.* (2001) reported the results of the OPs and the hybrids and showed that the hybrid had an average of 16.1% growth advantage over the OPs. The hybrid maize varieties and four of the seven OPs were stable in growth across the locations. Olakojo and Iken (2001) reported that the improved maize varieties significantly out growth the local check entry by between 10.3 and 30.3%, thus ranking TZB and Posa Rica 7843 as the tallest varieties.

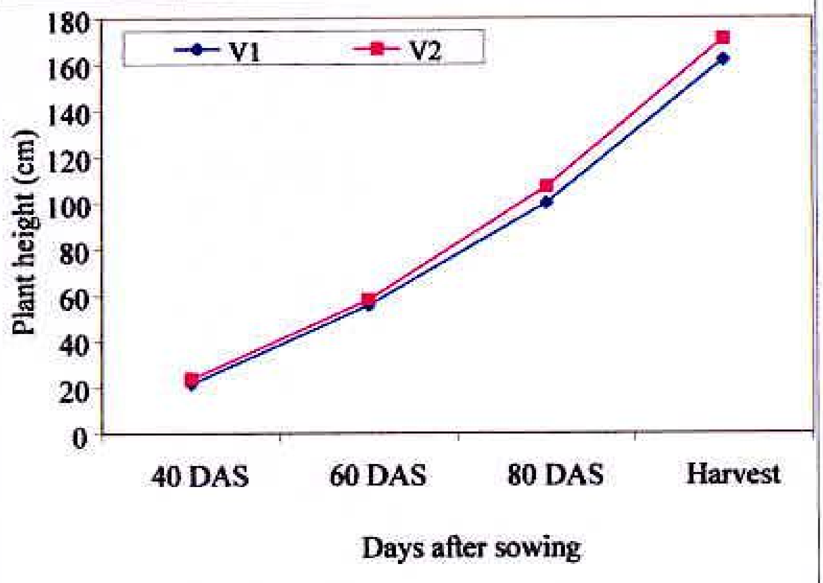


Figure 2. Effect of variety on plant height of maize

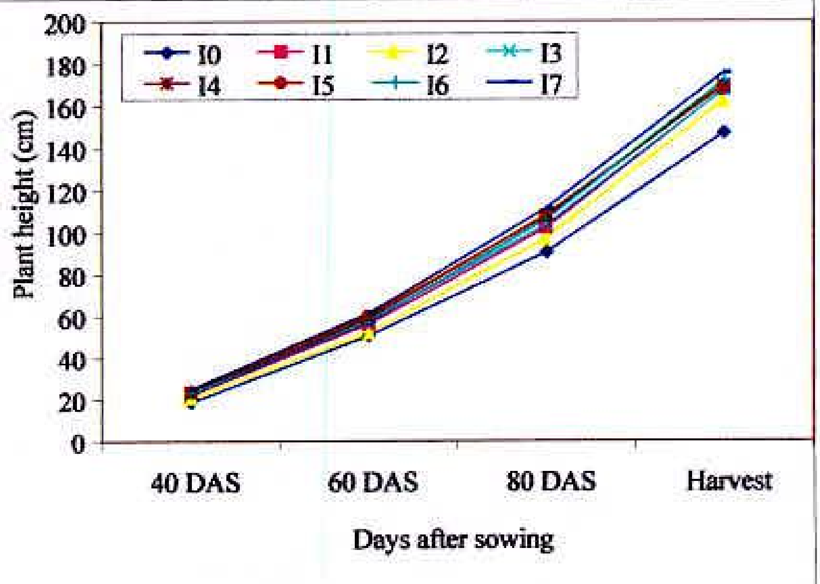


Figure 3. Effect of time of irrigation (*I*) on plant height of maize

4.1.2 Effect of time of irrigation

Different composite and hybrid maize showed significant differences on plant height at 40, 60, 80 DAS and at harvest (Figure 3). At 40, 60, 80 DAS and harvest, the tallest plant (25.09 cm, 61.46 cm, 111.51 cm and 175.45 cm) was observed from I_7 (three irrigations at 35 DAS, tasseling and silking stage), again the shortest (18.64 cm, 50.46 cm, 90.56 cm and 147.07 cm) from I_0 (no irrigation). Golakiya and Patel (1992) reported that water deficiency had adverse effects on plant growth and the growing stage was vulnerable for water stress.

4.1.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on plant height at 40, 60, 80 DAS and at harvest (Table 1). At 40, 60, 80 DAS and harvest, the tallest plant (26.53 cm, 63.04 cm, 118.70 cm and 187.10 cm) was observed from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage), again the shortest (14.77 cm, 48.27 cm, 78.19 cm and 132.31 cm) from V_1I_0 (BARI bhutta-7 + no irrigation). At harvest, there was no significant variation of plant height observed for hybrid variety irrespective of irrigation levels but for composite variety, V_1I_5, V_1I_6, V_1I_7 and V_1I_1 gave higher and similar plant height whereas V_1I_0 showed the lowest (132.31 cm) plant height that similar to V_1I_2.

Table 1. Interaction effect of variety and time of irrigation on plant height of composite and hybrid maize

Treatment	Plant height (cm) at			
	40 DAS	60 DAS	80 DAS	Harvest
V_1I_0	14.77 d	48.27 h	78.19 e	132.31 e
V_1I_1	20.87 bc	54.94 d-g	104.43 a-c	164.96 a-d
V_1I_2	18.09 cd	50.88 gh	85.52 de	145.86 de
V_1I_3	21.80 a-c	56.51 b-f	100.93 bc	160.72 b-d
V_1I_4	21.53 a-c	55.46 c-g	97.77 cd	155.81 cd
V_1I_5	25.02 ab	61.26 ab	113.58 a-c	175.82 a-c
V_1I_6	23.03 a-c	54.25 e-g	103.67 a-c	169.94 a-d
V_1I_7	23.66 ab	59.88 a-d	115.34 ab	163.81 a-d
V_2I_0	22.51 a-c	52.66 f-h	102.92 a-c	161.84 a-d
V_2I_1	23.58 ab	57.32 b-f	100.05 b-d	170.16 a-d
V_2I_2	22.99 a-c	52.77 f-h	108.04 a-c	177.82 a-c
V_2I_3	23.49 ab	59.36 a-d	106.43 a-c	173.98 a-c
V_2I_4	25.31 ab	62.63 a	107.67 a-c	182.27 ab
V_2I_5	22.88 a-c	58.92 a-e	102.12 bc	162.60 a-d
V_2I_6	23.89 ab	60.30 a-c	109.08 a-c	172.95 a-c
V_2I_7	26.53 a	63.04 a	118.70 a	187.10 a
$LSD_{(0.05)}$	4.435	4.480	13.84	21.93
Level of significance	0.05	0.05	0.01	0.01
CV(%)	11.79	4.72	8.00	7.89

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

V_1: BARI composite bhutta-7

V_2: BARI hybrid bhutta-5

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

4.2 Leaf area index

4.2.1 Effect of variety

Significant variations were recorded for leaf area index at 40, 60 and 80 DAS and non-significant at 100 DAS in composite and hybrid maize (Figure 4). BARI hybrid bhutta-5 produced higher leaf area index at all the growth stages studied compared to that in BARI bhutta-7.

4.2.2 Effect of time of irrigation

Leaf area index for different composite and hybrid maize showed significant differences at 40, 60, 80 DAS and 100 DAS (Figure 5). At 40, 60, 80 DAS and at harvest, the highest leaf area index (0.356, 2.85, 5.14 and 5.18, respectively) was found from I_7 (three irrigations at 35 DAS, tasseling and silking stage) and the lowest (0.304, 2.36, 4.31 and 4.30, respectively) from I_0 (no irrigation).

4.2.3 Interaction effect of variety and time of irrigation

Statistically significant variation was recorded for interaction effect of variety and time of irrigation on leaf area index at 40, 60, 80 DAS and 100 DAS (Table 2). At 40, 60, 80 DAS and at harvest, the highest leaf area index (0.367, 2.87, 5.49 and 5.30, respectively) was attained from V_2I_7 (BARI hybrid bhutta-5 + three irrigation at 35 DAS, tasseling and silking stage), while the lowest (0.275, 2.13, 3.73 and 3.97, respectively) from V_1I_0 (BARI bhutta-7 + no irrigation).

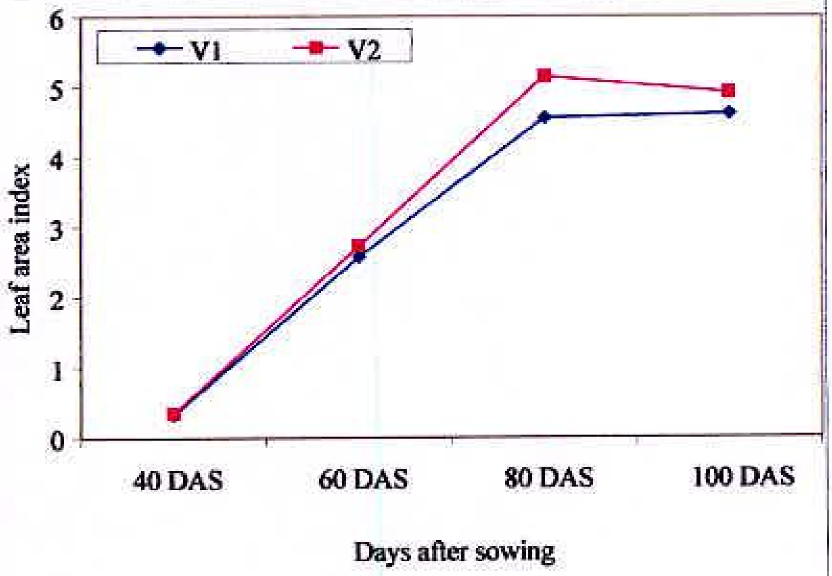


Figure 4. Effect of variety on leaf area index of maize

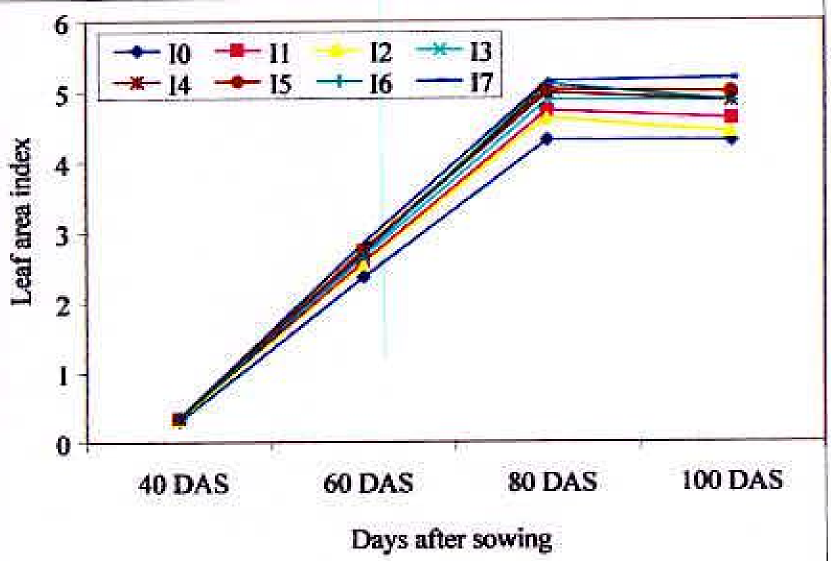


Figure 5. Effect of time of irrigation (I) on leaf area index of maize

Table 2. Interaction effect of variety and time of irrigation on leaf area index (LAI) of composite and hybrid maize

Treatment	Leaf area index (LAI) at			
	40 DAS	60 DAS	80 DAS	100 DAS
V_1I_0	0.275 h	2.13 d	3.73 f	3.97 d
V_1I_1	0.322 fg	2.55 bc	4.57 c-e	4.67 bc
V_1I_2	0.309 g	2.48 c	4.17 ef	4.00 d
V_1I_3	0.327 ef	2.60 bc	4.57 c-e	4.67 bc
V_1I_4	0.339 b-f	2.60 bc	4.47 de	4.54 c
V_1I_5	0.355 ab	2.77 ab	4.98 a-d	5.05 a-c
V_1I_6	0.335 c-f	2.61 bc	4.95 a-d	4.67 bc
V_1I_7	0.345 b-e	2.85 a	4.98 a-d	5.05 a-c
V_2I_0	0.333 c-f	2.60 bc	4.88 b-d	4.63 c
V_2I_1	0.340 b-f	2.61 bc	4.88 b-d	4.54 c
V_2I_2	0.332 d-f	2.60 bc	5.08 a-c	4.84 a-c
V_2I_3	0.351 a-c	2.72 ab	5.18 ab	5.05 a-c
V_2I_4	0.351 a-c	2.85 a	5.29 ab	5.18 ab
V_2I_5	0.343 b-e	2.74 ab	5.08 a-c	4.92 a-c
V_2I_6	0.349 a-d	2.78 ab	5.25 ab	5.05 a-c
V_2I_7	0.367 a	2.87 a	5.49 a	5.30 a
$LSD_{(0.05)}$	0.017	0.198	0.485	0.464
Level of significance	0.01	0.05	0.05	0.01
CV(%)	3.92	4.45	5.99	5.82

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

V_1: BARI composite bhutta-7

V_2: BARI hybrid bhutta-5

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

4.3 Dry matter content in shoot

4.3.1 Effect of variety

Significant variations were observed for dry matter content in shoot at 80 DAS and at harvest and non-significant for 40 and 60 DAS for composite and hybrid bhutta (Figure 6). At 40, 60, 80 DAS and at harvest the maximum dry matter content in shoot (1.24, 1.81, 4.97 and 7.05 g plant^{-1}, respectively) was found from V_2 (BARI hybrid bhutta-5), again the minimum (1.18, 1.65, 4.40 and 6.42 g plant^{-1}, respectively) from V_1 (BARI bhutta-7).

4.3.2 Effect of time of irrigation

Different composite and hybrid maize showed significant differences in terms of dry matter content in shoot at 40, 60, 80 DAS and at harvest (Figure 7). At 40, 60, 80 DAS and at harvest, the maximum dry matter content in shoot (1.30, 1.89, 5.03 and 7.45 g plant^{-1}, respectively) was recorded from I_7 (three irrigations at 35 DAS, tasseling and silking stage), consequently the minimum (1.14, 1.54, 4.05 and 5.67 g plant^{-1}, respectively) was found from I_0 (no irrigation).

4.3.3 Interaction effect of variety and time of irrigation

Dry matter content in shoot showed significant differences due to the interaction effect of variety and time of irrigation at 40, 60, 80 DAS and at harvest (Table 3). At 40, 60, 80 DAS and at harvest, the maximum dry matter content in shoot (1.39, 1.94, 5.52 and 7.81 g plant^{-1}, respectively) was obtained from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage), while the minimum (0.98, 1.26, 3.41 and 4.85 g plant^{-1}, respectively) from V_1I_0 (BARI bhutta-7 + no irrigation). The V_2I_1, V_2I_0, V_1I_2 and V_1I_0 showed the lowest dry matter content of maize at harvest.

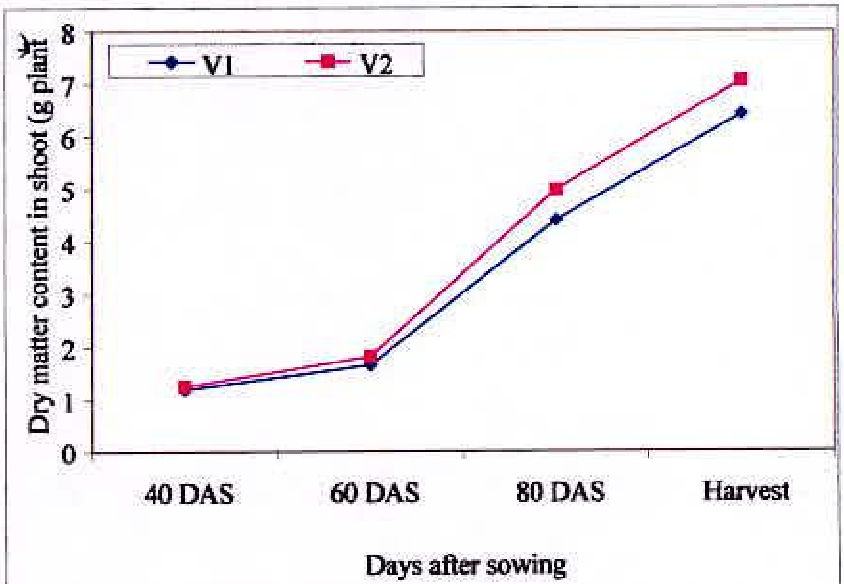


Figure 6. Effect of variety on dry matter content in shoot of maize

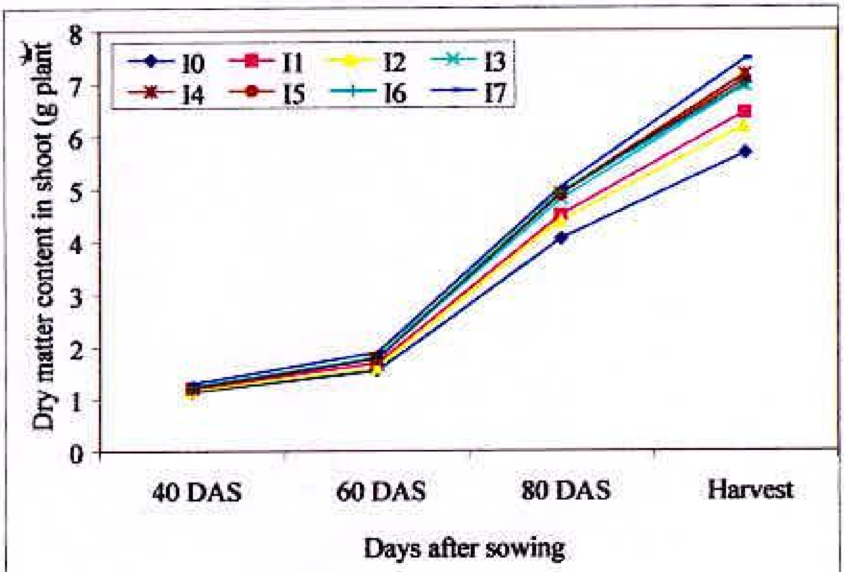


Figure 7. Effect of time of irrigation (I) on dry matter content in shoot of maize

Table 3. Interaction effect of variety and time of irrigation on dry matter content in shoot of composite and hybrid maize

Treatment	Dry matter content in shoot (g plant^{-1})			
	40 DAS	60 DAS	80 DAS	Harvest
V_1I_0	0.98 f	1.26 e	3.41 f	4.85 f
V_1I_1	1.18 c-e	1.70 bc	4.46 cd	6.51 c-e
V_1I_2	1.12 de	1.48 d	3.88 ef	5.46 f
V_1I_3	1.17 c-e	1.75 a-c	4.53 cd	6.45 de
V_1I_4	1.07 ef	1.60 cd	4.29 de	6.50 c-e
V_1I_5	1.31 a-c	1.82 a-c	4.89 bc	7.26 a-c
V_1I_6	1.24 b-d	1.74 a-c	4.71 b-d	6.58 c-e
V_1I_7	1.34 ab	1.89 ab	5.06 a-c	7.73 a
V_2I_0	1.30 a-c	1.83 a-c	4.70 b-d	6.49 c-e
V_2I_1	1.22 b-d	1.69 b-d	4.54 cd	6.36 e
V_2I_2	1.21 cd	1.70 a-c	4.89 bc	6.88 b-e
V_2I_3	1.27 a-c	1.82 a-c	5.06 a-c	7.44 ab
V_2I_4	1.22 b-d	1.89 ab	5.00 a-c	7.18 a-d
V_2I_5	1.12 de	1.74 a-c	4.89 bc	6.87 b-e
V_2I_6	1.24 b-d	1.83 a-c	5.16 ab	7.37 ab
V_2I_7	1.39 a	1.94 a	5.52 a	7.81 a
$LSD_{(0.05)}$	0.118	0.205	0.521	0.675
Level of significance	0.01	0.01	0.01	0.01
CV(%)	5.55	7.13	6.63	6.00

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

V_1: BARI composite bhutta-7

V_2: BARI hybrid bhutta-5

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

4.4 Dry matter content in root

4.4.1 Effect of variety

Composite and hybrid bhutta varied non-significantly for dry matter content in root for 40 and 60 DAS (Table 4). At 40 and 60 DAS the maximum dry matter content in root (0.64 and 1.11 g plant^{-1}, respectively) was observed from V_1 (BARI bhutta-7), whereas the minimum (0.61 and 1.08 g plant^{-1}, respectively) from V_2 (BARI hybrid bhutta-5).

4.4.2 Effect of time of irrigation

Statistically significant variations was recorded for different composite and hybrid maize in terms of dry matter content in root at 40 and 60 DAS (Table 4). At 40 and 60 DAS, the maximum dry matter content in root (0.74 and 1.22 g plant^{-1}, respectively) was found from I_7 (three irrigations at 35 DAS, tasseling and silking stage), again the minimum (0.56 and 1.03 g plant^{-1}, respectively) from I_1 (one irrigation at 35 DAS).

4.4.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation varied significantly in terms of dry matter content in root at 40 and 60 DAS (Table 5). At 40 and 60 DAS the maximum dry matter content in root (0.81 and 1.31 g plant^{-1}, respectively) was recorded from V_1I_7 (BARI bhutta-7 + three irrigations at 35 DAS, tasseling and silking stage), while the minimum (0.54 and 0.99 g plant^{-1}, respectively) from V_1I_0 (BARI bhutta-7 + no irrigation).

Table 4. Effect of variety and time of irrigation on dry matter content in root and shoot and root ratio of composite and hybrid maize

Treatment	Dry matter content in root (g plant^{-1})		Shoot and root ratio	
	40 DAS	60 DAS	40 DAS	60 DAS
Maize variety				
V_1	0.64	1.11	1.89	1.50 b
V_2	0.61	1.08	2.07	1.68 a
$LSD_{(0.05)}$	--	--	--	0.039
Level of significance	NS	NS	NS	0.01
Time of irrigation				
I_0	0.64 ab	1.11 ab	1.82	1.38 d
I_1	0.56 b	1.03 b	2.17	1.65 a-c
I_2	0.60 b	1.07 b	1.98	1.49 cd
I_3	0.60 b	1.07 b	2.06	1.67 ab
I_4	0.58 b	1.02 b	2.14	1.73 a
I_5	0.68 ab	1.15 ab	1.78	1.55 bc
I_6	0.60 b	1.08 b	2.07	1.66 ab
I_7	0.74 a	1.22 a	1.80	1.56 bc
$LSD_{(0.05)}$	0.112	0.112	--	0.154
Level of significance	0.05	0.05	NS	0.01
CV(%)	14.86	8.90	13.76	8.29

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

V_1: BARI composite bhutta

V_2: BARI hybrid bhutta-5

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

Table 5. Interaction effect of variety and time of irritation on dry matter content in root and shoot and root ratio of composite and hybrid maize

Treatment	Dry matter content root (g plant^{-1})		Shoot and root ratio	
	40 DAS	60 DAS	40 DAS	60 DAS
V_1I_0	0.54 c	0.99 d	1.71	1.27 e
V_1I_1	0.58 bc	1.04 cd	2.07	1.64 bc
V_1I_2	0.59 bc	1.07 b-d	1.94	1.38 de
V_1I_3	0.63 bc	1.10 b-d	1.87	1.59 b-d
V_1I_4	0.57 bc	1.02 d	1.97	1.57 b-d
V_1I_5	0.75 ab	1.21 a-c	1.75	1.50 b-e
V_1I_6	0.62 bc	1.11 b-d	2.03	1.58 b-d
V_1I_7	0.81 a	1.31 a	1.76	1.45 c-e
V_2I_0	0.72 a-c	1.23 ab	1.87	1.50 b-e
V_2I_1	0.56 c	1.02 d	2.27	1.66 a-c
V_2I_2	0.60 bc	1.07 b-d	2.03	1.60 b-d
V_2I_3	0.57 bc	1.04 cd	2.26	1.75 ab
V_2I_4	0.59 bc	1.03 cd	2.31	1.89 a
V_2I_5	0.61 bc	1.08 b-d	1.82	1.61 b-d
V_2I_6	0.59 bc	1.05 b-d	2.11	1.75 ab
V_2I_7	0.67 a-c	1.14 a-d	1.89	1.67 a-c
$LSD_{(0.05)}$	0.159	0.159	--	0.218
Level of significance	0.05	0.05	NS	0.01
CV(%)	14.86	8.90	13.76	8.29

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

V_1: BARI composite bhutta-7 V_2: BARI hybrid bhutta-5

I_0: No irrigation I_1: One irrigation at 35 DAS
I_2: One irrigation at tasseling I_3: One irrigation at silking
I_4: Two irrigations at 35 DAS and tasseling I_5: Two irrigations at 35 DAS and silking
I_6: Two irrigations at tasseling and silking I_7: Three irrigations at 35 DAS, tasseling and silking

4.5 Dry matter content ratio for shoot and root

4.5.1 Effect of variety

Dry matter content ratio in shoot and root showed non significant differences at 40 DAS and significant for 60 DAS for composite and hybrid bhutta (Table 4). At 40 and 60 DAS the highest dry matter content ratio in shoot and root (2.07 and 1.68, respectively) were found from V_2 (BARI hybrid bhutta-5), again the lowest (1.89 and 1.50, respectively) from V_1 (BARI bhutta-7).

4.5.2 Effect of time of irrigation

Different composite and hybrid maize showed non-significant differences at 40 DAS and significant for 60 DAS on dry matter content ratio in shoot and root (Table 4). At 60 DAS, the highest dry matter content ratio in shoot and root (1.73) was observed from I_4 (two irrigations at 35 DAS and tasseling stage), while the lowest (1.38) from I_0 (no irrigation).

4.5.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed non-significant differences for 40 DAS and significant for 60 DAS on dry matter content ratio in shoot and root (Table 5). At 60 DAS, the highest dry matter content ratio in shoot and root (1.89) was attained from V_2I_4 (BARI hybrid bhutta-5 + two irrigations at 35 DAS and tasseling stage) and the lowest (1.27) from V_1I_0 (BARI bhutta-7 + no irrigation).

4.6 Tassel height

4.6.1 Effect of variety

Significant variation was recorded in terms of tassel height for composite and hybrid bhutta (Table 6). The longest tassel (44.36 cm) was obtained from V_2 (BARI hybrid bhutta-5), while the shortest (42.41 cm) from V_1 (BARI bhutta-7). Sirisampan and Zoebisch (2005) also reported similar findings earlier from their experiment.

4.6.2 Effect of time of irrigation

Tassel height showed statistically significant variation for different composite and hybrid maize (Table 6). The longest tassel (48.25 cm) was found from I_7 (three irrigations at 35 DAS, tasseling and silking stage) which was closely followed by the other time of irrigation, again the shortest (38.42 cm) from I_0 (no irrigation). It was revealed that maize plants use the residual soil moisture for its early vegetative growth, the subsequent growth was suffered in most cases.

4.6.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences in terms of tassel height (Table 7). The longest tassel (49.70 cm) was recorded from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage) that similar to V_1I_7 (49.27 cm) and the shortest (36.10 cm) from V_1I_0 (BARI bhutta-7 + no irrigation) which was similar to V_2I_0 (40.73 cm) and V_1I_4 (40.23 cm).

Table 6. Effect of variety and time of irrigation on plant characters of composite and hybrid maize

Treatment	Tassel height (cm)	Cob to tassel height (cm)	Days to tasseling	Days to silking	Days to maturity
Maize variety					
V_1	42.41 b	83.42	65.38 b	72.88	112.96
V_2	44.36 a	89.87	71.00 a	70.50	108.75
$LSD_{(0.05)}$	2.013	--	0.822	--	--
Level of significance	0.05	NS	0.01	NS	NS
Time of irrigation					
I_0	38.42 d	76.23 d	67.83 ab	72.83 ab	120.83 a
I_1	39.92 cd	93.48 ab	68.67 ab	73.50 ab	112.17 b
I_2	43.82 b	90.35 bc	68.00 ab	71.00 a-c	105.50 c
I_3	42.95 bc	77.77 d	68.83 ab	72.33 a-c	109.33 bc
I_4	44.97 b	86.87 c	71.33 a	71.50 a-c	108.33 bc
I_5	44.90 b	91.42 bc	64.17 b	69.67 bc	112.33 b
I_6	43.87 b	79.50 d	66.00 b	68.50 c	110.33 bc
I_7	48.25 a	97.55 a	71.00 a	74.17 a	108.00 bc
$LSD_{(0.05)}$	3.248	5.152	4.194	3.758	5.596
Level of significance	0.01	0.01	0.05	0.01	0.01
CV(%)	6.33	5.03	5.20	4.43	4.27

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

V_1: BARI composite bhutta-7
V_2: BARI hybrid bhutta-5

I_0: No irrigation
I_1: One irrigation at 35 DAS
I_2: One irrigation at tasseling
I_3: One irrigation at silking
I_4: Two irrigations at 35 DAS and tasseling
I_5: Two irrigations at 35 DAS and silking
I_6: Two irrigations at tasseling and silking
I_7: Three irrigations at 35 DAS, tasseling and silking

Table 7. Interaction effect of variety and time of irrigation on plant characters of composite and hybrid maize

Treatment	Tassel height (cm)	Cob to tassel height (cm)	Days to tasseling	Days to silking	Days to maturity
V_1I_0	36.10 f	72.40 g	66.33 b-f	74.00 bc	125.67 a
V_1I_1	41.50 c-e	92.23 a-c	65.33 b-f	73.33 b-d	110.33 b-f
V_1I_2	42.03 b-e	87.00 cd	64.00 d-f	72.00 b-e	106.33 d-f
V_1I_3	42.10 b-e	74.27 fg	67.33 b-f	73.33 b-d	111.33 b-f
V_1I_4	40.23 d-f	74.17 fg	63.67 ef	68.00 c-e	107.33 c-f
V_1I_5	44.13 b-d	91.97 a-c	64.00 d-f	72.33 b-e	118.00 ab
V_1I_6	43.93 b-d	76.07 e-g	61.00 f	69.33 b-e	111.33 b-f
V_1I_7	49.27 a	99.27 a	71.33 b	80.67 a	113.33 b-e
V_2I_0	40.73 c-f	80.07 d-g	69.33 b-e	71.67 b-e	116.00 bc
V_2I_1	38.33 ef	94.73 a-c	72.00 b	73.67 b-d	114.00 b-d
V_2I_2	45.60 a-c	93.70 a-c	72.00 b	70.00 b-e	104.67 ef
V_2I_3	43.80 b-d	81.27 d-f	70.33 b-e	71.33 b-e	107.33 c-f
V_2I_4	47.23 ab	95.83 ab	78.33 a	75.00 b	109.33 b-f
V_2I_5	45.67 a-c	90.87 bc	64.33 c-f	67.00 e	106.67 d-f
V_2I_6	43.80 b-d	82.93 de	71.00 bc	67.67 de	109.33 b-f
V_2I_7	49.70 a	99.57 a	70.67 b-d	67.67 de	102.67 f
$LSD_{(0.05)}$	4.593	7.286	5.931	5.314	7.913
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	6.33	5.03	5.20	4.43	4.27

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

V_1: BARI composite bhutta-7

V_2: BARI hybrid bhutta-5

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

4.7 Cob to tassel height

4.7.1 Effect of variety

Cob to tassel height differs non-significantly for composite and hybrid bhutta (Table 6). The maximum cob to tassel height (89.87 cm) was recorded from V_2 (BARI hybrid bhutta-5), whereas the minimum (83.42 cm) from V_1 (BARI bhutta-7). Palafox *et al.* (2006) reported that the best hybrids considering grain cob to tassel height were HC 2, HC 4, and HC 1.

4.7.2 Effect of time of irrigation

Statistically significant variation was recorded for different composite and hybrid maize on cob to tassel height (Table 6). The highest cob to tassel height (97.55 cm) was observed from I_7 (three irrigations at 35 DAS, tasseling and silking stage) that similar to I_1 (93.48 cm) and followed by I_5 and I_2. On the other hand, the lowest (76.23 cm) was recorded from I_0 (no irrigation) that similar to I_3 and I_6.

4.7.3 Interaction effect of variety and time of irrigation

Cob to tassel height showed significant differences for the interaction effect of variety and time of irrigation (Table 7). The highest cob to tassel height (99.57 cm) was observed from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage), consequently the shortest (72.40 cm) from V_1I_0 (BARI bhutta-7 + no irrigation).

4.8 Days to tasseling

4.8.1 Effect of variety

Days to tasseling showed significant variation for composite and hybrid bhutta (Table 6). The maximum days to tasseling (71.00 days) was required for V_2 (BARI hybrid bhutta-5) and the minimum (65.38 days) from V_1 (BARI bhutta -7).

4.8.2 Effect of time of irrigation

The composite and hybrid maize varied significantly in terms of days to tasseling (Table 6). The maximum days to tasseling (71.33 days) was found from I_4 (two irrigations at 35 DAS and tasseling stage) which was followed by I_7, I_3, I_1, I_2 and I_6, while the minimum (66.00 days) from I_5 (two irrigations at 35 DAS and silking stage) which was statistically similar (66.00 days) with I_6 (two irrigations at tasseling and silking stage).

4.8.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on days to tasseling (Table 7). The maximum days to tasseling (78.33 days) was observed from V_2I_4 (BARI hybrid bhutta-5 + two irrigations at 35 DAS and tasseling stage), whereas the minimum (61.00) from V_1I_6 (BARI bhutta-7 + two irrigations at tasseling and silking stage).

4.9 Days to silking

4.9.1 Effect of variety

Composite and hybrid bhutta showed non-significant differences for days to silking (Table 6). The maximum days to silking (72.88 days) was needed for V_1 (BARI bhutta-7), while the minimum (70.50 days) for V_2 (BARI hybrid bhutta-5).

4.9.2 Effect of time of irrigation

The composite and hybrid maize varied significantly on days to silking (Table 6). The maximum days to silking (74.17 days) was found from I_7 (three irrigations at 35 DAS, tasseling and silking stage) which was statistically similar with I_1, I_0, I_3, I_4 and I_2, again the minimum (68.50 days) from I_6 (two irrigations at tasseling and silking stage) which was statistically similar (69.67) with I_5 (two irrigations at 35 DAS and silking stage).

4.9.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on days to tasseling (Table 7). The maximum days to tasseling (80.67 days) was recorded from V_1I_7 (BARI bhutta-7 + three irrigations at 35 DAS, tasseling and silking stage), while the minimum (67.00 days) from V_2I_5 (BARI hybrid bhutta-5 + two irrigations at 35 DAS and silking stage).

4.10 Days to maturity

4.10.1 Effect of variety

Days to maturity did not show any significant differences for composite and hybrid bhutta (Table 6). The maximum days to maturity (112.96 days) was recorded from V_1 (BARI bhutta-7) and the minimum (108.75 days) was found from V_2 (BARI hybrid bhutta-5).

4.10.2 Effect of time of irrigation

The composite and hybrid maize showed significant differences on days to maturity (Table 6). The longest duration to maturity (120.83 days) was observed from I_0 (no irrigation) which was closely followed by I_1 and I_5, whereas the minimum (105.50 days) from I_2 (one irrigation at tasseling stage) which was statistically similar with I_7, I_4, I_3 and I_6.

4.10.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on days to maturity (Table 7). The maximum days to maturity (125.67 days) was observed from V_1I_0 (BARI bhutta-7 + no irrigation), while the minimum (102.67 days) from V_2I_7 (BARI hybrid bhutta-5 + two irrigations at 35 DAS and silking stage).

4.11 Cob length

4.11.1 Effect of variety

Statistically significant variation was recorded in terms of cob length for composite and hybrid bhutta (Table 8). The highest cob length (17.85 cm) was observed from V_2 (BARI hybrid bhutta-5). On the other hand the lowest (15.88 cm) was found from V_1 (BARI bhutta-7).

4.11.2 Effect of time of irrigation

Cob length showed statistically significant variation for different composite and hybrid maize (Table 8). The highest cob length (19.10 cm) was recorded from I_7 (three irrigations at 35 DAS, tasseling and silking stage) which was statistically similar (18.15 cm) with I_6 (two irrigations at tasseling and silking stage), whereas the lowest (12.60 cm) from I_0 (no irrigation). It was revealed that maize plants use the residual soil moisture for its early vegetative growth, the subsequent growth is suffered in most cases.

4.11.3 Interaction effect of variety and time of irrigation

Statistically significant variation was recorded for interaction effect of variety and time of irrigation in terms of cob length (Table 9). The highest cob length (19.63 cm) was found from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage), while the lowest (11.40 cm) from V_1I_0 (BARI bhutta-7 + no irrigation).

Table 8. Effect of variety and time of irrigation on palnt characters of composite and hybrid maize

Treatment	Cob length (cm)	Cob diameter (cm)	Weight of 1000 grains	Grain yield (t/ha)	Stover yield (t/ha)
Maize variety					
V_1	15.88 b	2.98 b	326.70	3.96 b	3.61 b
V_2	17.85 a	3.27 a	358.64	7.48 a	7.18 a
$LSD_{(0.05)}$	0.810	0.012	--	0.786	0.226
Level of significance	0.01	0.01	--	0.01	0.01
Time of irrigation					
I_0	12.60 d	2.51 c	242.82 e	4.06 d	3.75 c
I_1	17.10 b	3.11 b	373.63 ab	5.72 bc	4.16 c
I_2	17.33 b	3.05 b	339.85 cd	5.54 c	5.42 b
I_3	17.28 b	3.15 b	387.78 a	6.19 ab	6.51 a
I_4	17.52 b	3.46 a	327.48 d	5.96 a-c	6.23 a
I_5	15.87 c	3.09 b	360.35 bc	5.80 a-c	5.10 b
I_6	18.15 ab	3.17 b	380.25 ab	6.19 ab	6.44 a
I_7	19.10 a	3.43 a	329.20 d	6.31 a	5.56 b
$LSD_{(0.05)}$	1.201	0.183	24.02	0.493	0.466
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	6.02	4.94	5.93	7.30	7.30

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

V_1: BARI composite bhutta-7

V_2: BARI hybrid bhutta-5

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

Table 9. Interaction effect of variety and time of irrigation on plant characters of composite and hybrid maize

Treatment	Cob length (cm)	Cob diameter (cm)	Weight of 1000 grains (g)	Grain yield (t/ha)	Stover yield (t/ha)
V_1I_0	11.40 i	2.38 h	235.23 f	2.55 f	2.35 g
V_1I_1	16.73 d-f	3.02 d-f	333.47 c-e	3.92 de	2.83 g
V_1I_2	15.77 e-g	2.81 fg	327.57 de	3.41 e	2.84 g
V_1I_3	16.87 d-f	2.92 ef	351.63 cd	4.68 d	4.70 d
V_1I_4	15.67 fg	3.18 c-e	307.80 e	4.48 d	4.13 d-f
V_1I_5	14.23 gh	2.98 ef	348.73 cd	4.17 de	3.52 f
V_1I_6	16.77 d-f	2.96 ef	366.73 bc	4.33 d	4.55 de
V_1I_7	18.57 a-d	3.55 ab	342.43 c-e	4.14 de	3.95 ef
V_2I_0	13.80 ij	2.64 g	250.40 f	5.57 c	4.67 d
V_2I_1	17.47 c-f	3.19 c-e	413.80 a	7.52 b	5.97 c
V_2I_2	18.90 a-c	3.29 b-d	352.13 cd	7.67 b	8.00 a
V_2I_3	17.70 b-e	3.39 bc	423.93 a	7.70 b	8.32 a
V_2I_4	19.37 a-c	3.31 b-d	347.17 cd	7.44 b	8.33 a
V_2I_5	17.50 c-f	3.20 c-e	371.97 bc	7.43 b	6.69 b
V_2I_6	19.53 ab	3.39 bc	393.77 ab	8.04 ab	8.34 a
V_2I_7	19.63 a	3.74 a	315.97 de	8.48 a	7.17 b
$LSD_{(0.05)}$	1.699	0.259	33.96	0.698	0.659
Level of significance	0.01	0.01	0.01	0.05	0.01
CV(%)	6.02	4.94	5.93	7.30	7.30

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

V_1: BARI composite bhutta-7

V_2: BARI hybrid bhutta-5

I_0: No irrigation

I_1: One irrigation at 35 DAS

I_2: One irrigation at tasseling

I_3: One irrigation at silking

I_4: Two irrigations at 35 DAS and tasseling

I_5: Two irrigations at 35 DAS and silking

I_6: Two irrigations at tasseling and silking

I_7: Three irrigations at 35 DAS, tasseling and silking

4.12 Cob diameter

4.12.1 Effect of variety

Cob diameter varied significantly for composite and hybrid variety of maize (Table 8). The highest cob diameter (3.27 cm) was recorded from V_2 (BARI hybrid bhutta-5), while the lowest (2.98 cm) from V_1 (BARI bhutta-7).

4.12.2 Effect of time of irrigation

Composite and hybrid maize showed statistically significant differences on cob diameter (Table 8). The highest cob diameter (3.46 cm) was observed from I_4 (two irrigations at 35 DAS and tasseling stage) which was statistically similar (3.43 cm) with I_7 (three irrigations at 35 DAS, tasseling and silking stage) and closely followed by other time of irrigation except control and in control that was the lowest (2.51 cm).

4.12.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on cob diameter (Table 9). The highest cob diameter (3.74 cm) was observed from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage) that similar to V_1I_7 (BARI bhutta-7 + three irrigations at 35 DAS, tasseling and silking stage) and the lowest (2.38 cm) from V_1I_0 (BARI bhutta-7 + no irrigation).

4.13 Number of grains per cob

4.13.1 Effect of variety

Number of grains per cob varied non-significantly for composite and hybrid variety of maize (Figure 8). The highest number of grains per cob (571.42) was attained from V_2 (BARI hybrid bhutta-5), while the lowest (540.04) from V_1 (BARI bhutta-7).

4.13.2 Effect of time of irrigation

The composite and hybrid maize showed significant differences on number of grains per cob (Figure 9). The highest number of grains per cob (611.98) was found from I_7 (three irrigations at 35 DAS, tasseling and silking stage), which was followed by other time of irrigations and the lowest (467.67) from I_0 (no irrigation).

4.13.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on number of grains per cob (Figure 10). The highest number of grains per cob (626.30) was obtained from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage), whereas the lowest (426.40) from V_1I_0 (BARI bhutta-7 + no irrigation).

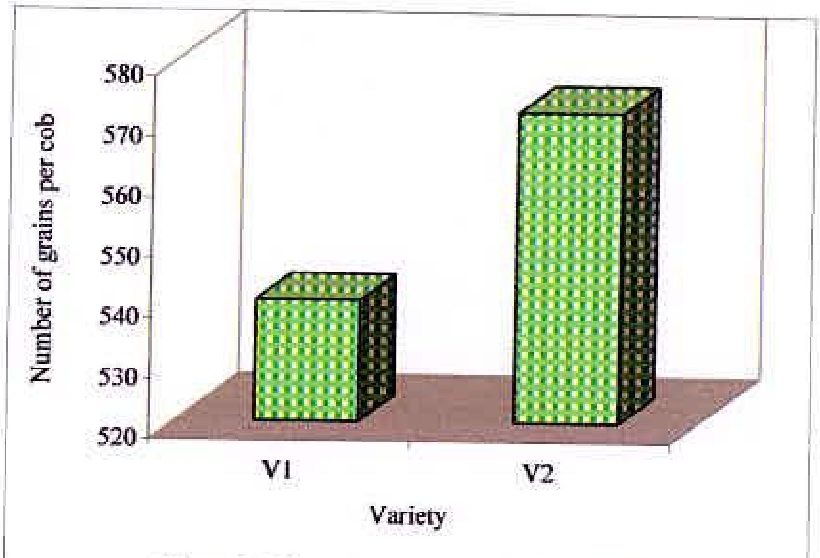


Figure 8. Effect of variety on number of grains per cob of maize

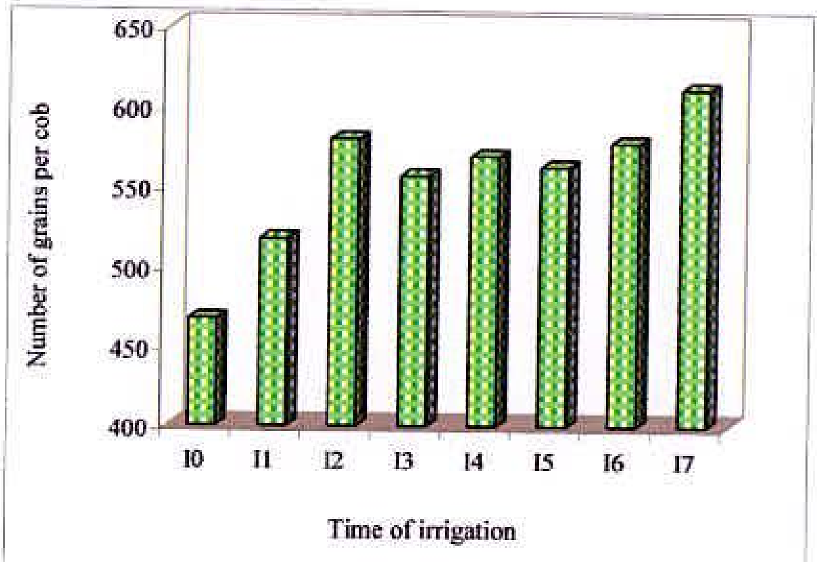


Figure 9. Effect of time of irrigation on number of grains per cob of maize

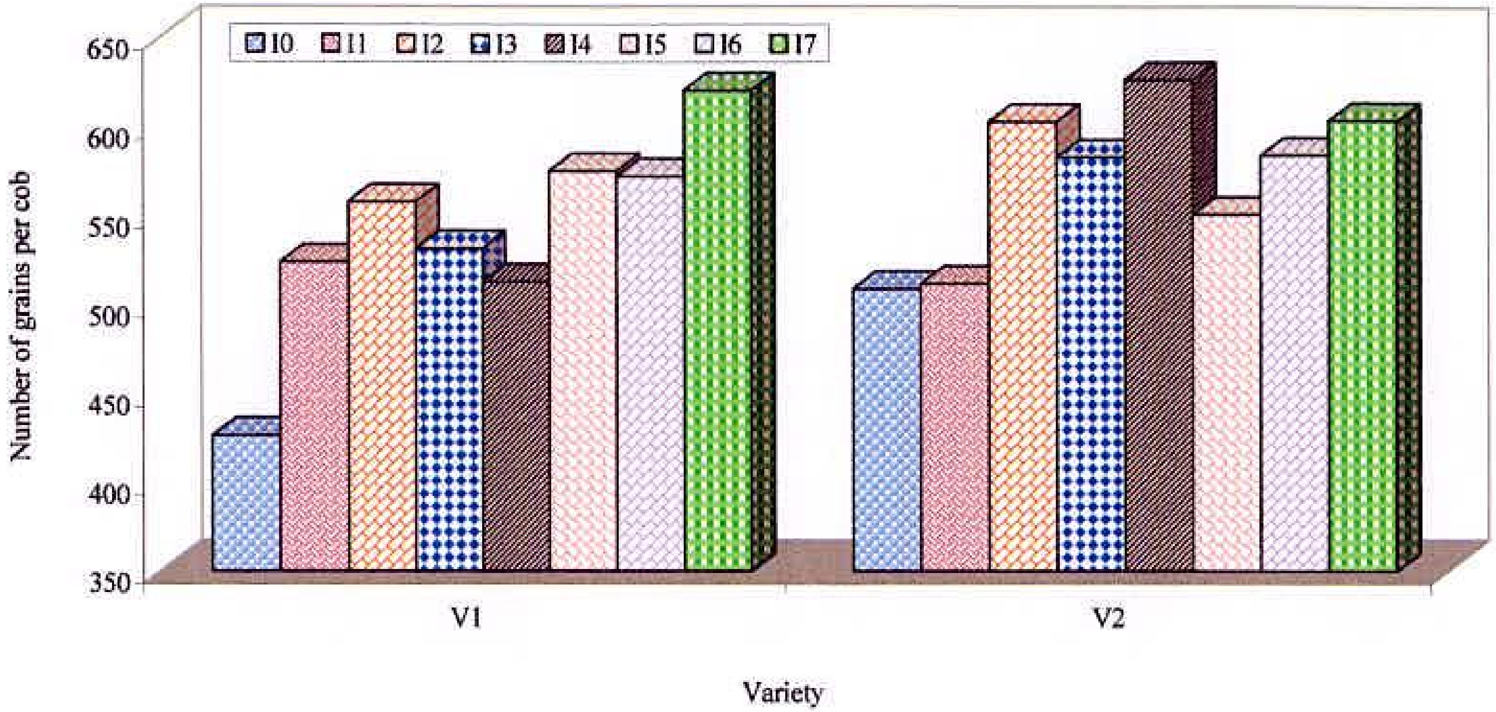


Figure 10. Effect of variety and time of irrigation on number of grains per cob of maize

4.14 Weight of 1000 grains

4.14.1 Effect of variety

Non-significant variation was recorded in terms of weight of 1000 grains for composite and hybrid variety (Table 8). The maximum weight of 1000 grains (358.64 g) was found from V_2 (BARI hybrid bhutta-5) and the minimum (326.70 g) from V_1 (BARI bhutta-7).

4.14.2 Effect of time of irrigation

The composite and hybrid maize showed significant differences on weight of 1000 grains (Table 8). The highest weight of 1000 grains (387.78 g) was recorded from I_3 (one irrigation at silking stage) which was statistically similar (380.25 g and 373.63 g) with I_6 and I_1, again the lowest (242.82 g) from I_0 (no irrigation).

4.14.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on weight of 1000 grains (Table 9). The highest weight of 1000 grains (423.93 g) was recorded from V_2I_3 (BARI hybrid bhutta-5 + one irrigation at silking stage) that similar to V_2I_1 and V_2I_6, whereas the lowest (235.23 g) from V_1I_0 (BARI bhutta-7 + no irrigation).

4.15 Grain yield

4.15.1 Effect of variety

Grain yield showed significant differences for composite and hybrid variety (Table 8). The highest grain yield (7.48 t/ha) was found from V_2 (BARI hybrid bhutta-5), while the lowest (3.96 t/ha) from V_1 (BARI bhutta-7). Chaudhary *et al.*

(2000) recorded maximum yield by using improved variety. Ogunboded *et al.* (2001) reported highest yielding OP variety was TZE Comp.4 DMR BC1 with an average grain yield of 2.43 t ha^{-1} while the best yellow hybrid was 8522-2 with a mean grain yield of 2.82 t ha^{-1}.

4.15.2 Effect of time of irrigation

The composite and hybrid maize showed significant differences on grain yield (Table 8). The highest grain yield (6.31 t/ha) was obtained from I_7 (three irrigations at 35 DAS, tasseling and silking stage) which was statistically similar with other time of irrigations and the lowest (4.06 t/ha) from I_0 (no irrigation). It was revealed that maize plants use the residual soil moisture for its early vegetative growth, the subsequent growth was suffered in most cases. Golakiya and Patel (1992) reported that water deficiency had adverse effects on average yield the growing stage was vulnerable for water stress.

4.15.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on grain yield (Table 9). The highest grain yield (8.48 t/ha) was recorded from V_2I_7 (BARI hybrid bhutta-5 + three irrigations at 35 DAS, tasseling and silking stage) that similar to V_2I_6 (BARI hybrid bhutta-5 + two irrigations at tasseling and silking stage) and the lowest (2.55 t/ha) from V_1I_0 (BARI bhutta-7 + no irrigation). For composite variety, silking stage showed very sensitive to water that resulted higher grain yield (4.68 t/ha) and similar to other treatments of same variety except I_0 and I_2.

4.16 Stover yield

4.16.1 Effect of variety

Stover yield showed significant differences for composite and hybrid variety (Table 8). The highest stover yield (7.18 t/ha) was recorded from V_2 (BARI hybrid bhutta-5) and the lowest (3.61 t/ha) from V_1 (BARI bhutta-7).

4.16.2 Effect of time of irrigation

The composite and hybrid maize showed significant differences on stover yield (Table 8). The highest stover yield (6.51 t/ha) was observed from I_3 (one irrigation at silking stage) which was statistically similar (6.44 t/ha and 6.23 t/ha) with I_6 (two irrigations at tasseling and silking) and I_4 (two irrigations at 35 DAS and tasseling). On the other hand, the lowest (3.75 t/ha) from I_0 (no irrigation) which was statistically similar (4.16 t/ha) with I_1 (one irrigation at 35 DAS).

4.16.3 Interaction effect of variety and time of irrigation

Interaction effect of variety and time of irrigation showed significant differences on stover yield (Table 9). The highest stover yield (8.34 t/ha) was observed from V_2I_6 (BARI hybrid bhutta-5 + two irrigations at tasseling and silking stage) that similar to V_2I_4, V_2I_3 and V_2I_2 and the lowest (2.35 t/ha) from V_1I_0 (BARI bhutta-7 + no irrigation) that similar to V_1I_1 and V_1I_2.

Chapter 5
Summary and Conclusions

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October 2009 to March 2010 to study the growth and yield of composite and hybrid maize as affected by time of irrigation. The experiment comprised as two factors. Factor A: Maize variety - 2 levels; V_1: BARI bhutta-7 and V_2: BARI hybrid bhutta-5. Factor B: Time of irrigation - 8 levels, I_0: No irrigation; I_1: One irrigation at 35 DAS; I_2: One irrigation at tasseling; I_3: One irrigation at silking; I_4: Two irrigations at 35 DAS and tasseling; I_5: Two irrigations at 35 DAS and silking; I_6: Two irrigations at tasseling and silking and I_7: Three irrigations at 35 DAS, tasseling and silking. The experiment was laid out in split-plot design with three replications. Data on different growth parameter, yield attributes and yield were recorded and analyzed.

At 40, 60, 80 DAS and harvest the tallest plant (23.54 cm, 57.98 cm, 106.88 cm and 170.68 cm, respectively) was recorded from V_2, while the shortest plant (21.46 cm, 55.58 cm, 99.93 cm and 161.56 cm, respectively) from V_1. At 40, 60, 80 and 100 DAS the highest leaf area index (0.343, 2.72, 5.14 and 4.91, respectively) was obtained from V_2, whereas the lowest (0.328, 2.57, 4.55 and 4.61, respectively) recorded from V_1. At 40, 60, 80 DAS and harvest the maximum dry matter content in shoot (1.24, 1.81, 4.97 and 7.05 g plant^{-1}, respectively) was found from V_2 and the minimum (1.18, 1.65, 4.40 and 6.42 g plant^{-1}, respectively) from V_1. At 40 and 60 DAS the maximum dry matter content in root (0.64 and 1.11 g plant^{-1}, respectively) was observed from V_1, while the minimum (0.61 and 1.08 g plant^{-1}, respectively) from V_2. At 40 and 60 DAS the highest dry matter content ratio in shoot and root (2.07 and 1.68, respectively) was found from V_2 and the lowest (1.89 and 1.50, respectively) from V_1.

The longest tassel (44.36 cm) was obtained from V_2, while the shortest (42.41 cm) from V_1. The maximum cob to tassel height (89.87 cm) was recorded from V_2, whereas the minimum (83.42 cm) from V_1. The maximum days to tesseling (71.00 days) was observed from V_2 and the minimum (65.38 days) from V_1. The higher days to silking (72.88 days) were obtained from V_1, while the minimum (70.50 days) from V_2. The maximum days to maturity (112.96 days) was recorded from V_1 and the minimum (108.75 days) from V_2. The highest cob length (17.85 cm) was observed from V_2 and the lowest (15.88 cm) was found from V_1. The highest cob diameter (3.27 cm) was recorded from V_2, while the lowest (2.98 cm) from V_1. The maximum number of grains per cob (571.42) was attained from V_2, while the minimum (540.04) from V_1. The maximum weight of 1000 grains (358.64 g) was found from V_2 and the minimum (326.70 g) from V_1. The higher grain yield (7.48 t/ha) was found from V_2, while the lower (3.96 t/ha) from V_1. The highest stover yield (7.18 t/ha) was recorded from V_2, again the lower (3.61 t/ha) from V_1.

At 40, 60, 80 DAS and harvest, the tallest plant (25.09 cm, 61.46 cm, 111.51 cm and 175.45 cm, respectively) was observed from I_7 and the shortest (18.64 cm, 50.46 cm, 90.56 cm and 147.07 cm, respectively) from I_0. At 40, 60, 80 and 100 DAS the highest leaf area index (0.356, 2.85, 5.14 and 5.18, respectively) was found from I_7, again the lowest (0.304, 2.36, 4.31 and 4.30, respectively) from I_0. At 40, 60, 80 DAS and harvest, the maximum dry matter content in shoot (1.30, 1.89, 5.03 and 7.45 g plant^{-1}, respectively) was recorded from I_7, consequently the minimum (1.14, 1.54, 4.05 and 5.67 g plant^{-1}, respectively) was found from I_0. At 40 and 60 DAS, the maximum dry matter content in root (0.74 and 1.22 g plant^{-1}) was found from I_7, again the minimum (0.56 and 1.03 g plant^{-1}) from I_1 and I_4, respectively. At 40 and 60 DAS, the highest dry matter content ratio in shoot and root (2.17 and 1.73) was observed from I_1 and I_4, respectively, while the lowest (1.80 cm and 1.38 cm) from I_7 and I_0 respectively.

The longest tassel (48.25 cm) was found from I_7, again the shortest (38.42 cm) from I_0. The highest cob to tassel height (97.55 cm) was observed from I_7 and the lowest (76.23 cm) was recorded from I_0. The maximum days to tasseling (71.33 days) were found from I_4, while the minimum (66.00 days) from I_5. The maximum days to silking (74.17 days) was found from I_7, again the minimum (68.50 days) from I_6. The maximum days to maturity (120.83 days) was observed from I_0, whereas the minimum (105.50 days) from I_2. The highest cob length (19.10 cm) was recorded from I_7, whereas the lowest (12.60 cm) from I_0. The highest cob diameter (3.46 cm) was observed from I_4 and in control it was lowest (2.51 cm). The maximum number of grains per cob (611.98) was found from I_7 and the minimum (467.67) from I_0. The maximum weight of 1000 grains (387.78 g) was recorded from I_3, again the minimum (242.82 g) from I_0. The highest grain yield (6.31 t/ha) was obtained from I_7 and the lowest (4.06 t/ha) from I_0. The highest stover yield (6.51 t/ha) was observed from I_3 and, the lowest (3.75 t/ha) from I_0.

At 40, 60, 80 DAS and harvest, the tallest plant (26.53 cm, 63.04 cm, 118.70 cm and 187.10 cm, respectively) was observed from V_2I_7, again the shortest (14.77 cm, 48.27 cm, 78.19 cm and 132.31 cm, respectively) from V_1I_0. At 40, 60, 80 and 100 DAS the highest leaf area index (0.367, 2.87, 5.49 and 5.30, respectively) was attained from V_2I_7, while the lowest (0.275, 2.13, 3.73 and 3.97, respectively) was recorded from V_1I_0. At 40, 60, 80 DAS and harvest, the maximum dry matter content in shoot (1.39, 1.94, 5.52 and 7.81 g plant^{-1}, respectively) was obtained from V_2I_7, while the minimum (0.98, 1.26, 3.41 and 4.85 g plant^{-1}, respectively) from V_1I_0. At 40 and 60 DAS the maximum dry matter content in root (0.81 and 1.31 g plant^{-1}, respectively) was recorded from V_1I_7, while the minimum (0.54 and 0.99 g plant^{-1}, respectively) from V_1I_0. At 40 and 60 DAS, the highest dry matter content ratio in shoot and root (2.31 and 1.89, respectively) was attained from V_2I_4, again the lowest (1.71 and 1.27, respectively) from V_1I_0.

The longest tassel (49.70 cm) was recorded from V_2I_7 and the shortest (36.10 cm) from V_1I_0. The highest cob to tassel height (99.57 cm) was observed from V_2I_7, consequently the shortest (72.40 cm) from V_1I_0. The maximum days to flowering of male (80.67 days) was observed from V_1I_7, whereas the minimum (67.00) from V_2I_5. The maximum days to flowering of female (78.33 days) were recorded from V_2I_4, while the minimum (61.00 days) from V_1I_6. The maximum days to maturity

(125.67 days) were observed from V_1I_0, while the minimum (102.67 days) from V_2I_7. The highest cob length (19.63 cm) was found from V_2I_7, while the lowest (11.40 cm) from V_1I_0. The highest cob diameter (3.74 cm) was observed from V_2I_7, again the lowest (2.38 cm) from V_1I_0. The maximum number of grains per cob (626.30) was obtained from V_2I_7, whereas the minimum (426.40) from V_1I_0. The maximum weight of 1000 grains (423.93 g) was recorded from V_2I_3, whereas the minimum (235.23 g) from V_1I_0. The highest grain yield (8.48 t/ha) was recorded from V_2I_7, again the lowest (2.55 t/ha) from V_1I_0. The highest stover yield (8.34 t/ha) was observed from V_2I_6, again the lowest (2.35 t/ha) from V_1I_0.

Considering the results of the present experiment, further studies in the following areas are suggested:

1. Studies of similar nature be carried out in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability;
2. In this study, one composite and one hybrid of maize were tested. It is necessary to carry out experiment with more inbred and hybrid varieties.
3. More number of irrigation may be included for further study.

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Appendices

APPENDICES

Appendix I. Characteristics of soil analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	Medium high land
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Appendix II. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October 2009 to March, 2010

Month	Air temperature (°C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
October, 2009	24.32	17.22	75	13
November, 2009	25.82	16.04	78	00
December, 2009	22.4	13.5	74	00
January, 2010	24.5	12.4	68	00
February, 2010	27.1	16.7	67	30
March, 2010	31.4	19.6	54	11

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance on pant height of maize as influenced by variety and time of irrigation

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		40 DAS	60 DAS	80 DAS	Harvest
Replication	2	4.639	4.058	18.428	26.727
Variety (A)	1	52.112	69.314*	579.562**	997.088*
Error	2	8.884	6.932	4.614	62.690
Time of irrigation (B)	7	25.254**	89.484**	281.136**	444.229*
Interaction (A×B)	7	18.698*	20.110*	308.516**	612.679**
Error	28	7.032	7.175	68.505	171.932

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance on leaf area index (LAI) of maize as influenced by variety and time of irrigation

Source of variation	Degrees of freedom	Mean square			
		Leaf area index (LAI) at			
		40 DAS	60 DAS	80 DAS	Harvest
Replication	2	0.0001	0.004	0.029	0.041
Variety (A)	1	0.003**	0.271**	4.166*	1.061
Error	2	0.0001	0.001	0.132	0.092
Time of irrigation (B)	7	0.002**	0.135**	0.478**	0.518**
Interaction (A×B)	7	0.001**	0.040*	0.231*	0.260**
Error	28	0.000	0.014	0.084	0.077

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix V. Analysis of variance on dry matter content in shoot of maize as influenced by variety and time of irrigation

Source of variation	Degrees of freedom	Mean square			
		Dry matter content in shoot (g $plant^{-1}$)			
		40 DAS	60 DAS	80 DAS	Harvest
Replication	2	0.002	0.009	0.047	0.020
Variety (A)	1	0.038	0.272	3.852*	4.793*
Error	2	0.007	0.031	0.112	0.164
Time of irrigation (B)	7	0.015**	0.079**	0.694**	2.088**
Interaction (A×B)	7	0.050**	0.071**	0.457**	1.135**
Error	28	0.005	0.015	0.097	0.163

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance on dry matter content in root and shoots and root ratio of maize as influenced by time of irrigation and variety

Source of variation	Degrees of freedom	Mean square			
		Dry matter content root (g plant^{-1})		Shoot and root ratio	
		40 DAS	60 DAS	40 DAS	60 DAS
Replication	2	0.002	0.001	0.044	0.002
Variety (A)	1	0.009	0.007	0.403	0.392**
Error	2	0.009	0.009	0.065	0.001
Time of irrigation (B)	7	0.022*	0.026**	0.151	0.077**
Interaction (A×B)	7	0.014	0.023**	0.023	0.113**
Error	28	0.009	0.009	0.074	0.017

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance on plant characters of maize as influenced by variety and time of irrigation

Source of variation	Degrees of freedom	Mean square				
		Tassel height (cm)	Cob to tassel height (cm)	Days to tasseling	Days to silking	Days to maturity
Replication	2	3.428	4.206	14.813	8.313	4.146
Variety (A)	1	45.435*	499.230*	379.69**	67.688*	212.521*
Error	2	3.088	30.964	0.438	5.688	22.771
Time of irrigation (B)	7	56.388**	377.58**	32.211*	22.211*	127.93**
Interaction (A×B)	7	24.201**	113.87**	40.497**	46.640**	50.188*
Error	28	7.541	18.975	12.577	10.095	22.387

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance on yield contributing characters and yield of maize as influenced by variety and time of irrigation

Source of variation	Degrees of freedom	Mean square					
		Cob length (cm)	Cob diameter (cm)	Number of grains /cob	Weight of 1000 grains (g)	Grain yield (t/ha)	Stover yield (t/ha)
Replication	2	0.016	0.037	376.214	21.029	0.139	0.155
Variety (A)	1	46.61**	1.014**	11815.8*	12243.2*	148.62**	153.43**
Error	2	0.425	0.000	1456.68	1129.027	0.400	0.033
Time of irrigation (B)	7	22.89**	0.507**	11747.6**	12950.9**	3.119**	6.331**
Interaction (A×B)	7	4.048**	0.099**	3783.4**	1687.1**	0.457*	1.333**
Error	28	1.032	0.024	507.901	412.345	0.174	0.155

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability