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Reciprocal Effect between Variety and Different Irrigation Levels on Yield and Yield Parameters of Maize (Zea Mays L.) Genotypes

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Abstract:- This study was conducted at the Research field of Plant Breeding Division, Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Rahmatpur, Barisal, Bangladesh during the period from November, 2016 to April, 2017 to screen out the hybrid maize varieties under moisture deficit condition. There were two factors: (1) five irrigation treatments – I_1: Full irrigation at initial,vegetative stage,silking and grain filling stage (20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS),I_2: Full irrigation at initial stage (20-25 DAS) , I_3: 50% irrigation both at initial and vegetative stage (20-25 DAS and 50-60 DAS) and I_4: 75% irrigation both at initial and vegetative stage and silking stage (20-25 DAS,50-60 DAS and 75-80 DAS), I_5: 50% irrigation at initial,vegetative stage, silking ,and grain filling stage(20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS) and (2) five maize varieties, viz. V_1: BARI hybrid maize 9 (BHM−9), V_2: BARI hybrid maize 5 (BHM−5), V_3: BARI hybrid maize 7 (BHM−7) V_4: NK40 and V_5: Pacific 984. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The irrigation treatments were employed in the main plots and the varietal treatments were distributed in the sub-plots. There was no significant (α = 0.05) effect of irrigation and significant effect of varietal treatments on the grain yield of maize. However, irrigation treatments had no significant effect but the variety treatments had significant effect on the production of grain yield of maize. The interaction effect between irrigation and variety had significant effect on the grain yield of maize in most cases. The highest grain yield of 15.68 t/ha was obtained for I_1V_4 and the lowest of 5.94 t/ha was obtained for I_4V_2.On the growth and yield variables, the irrigation and varietal treatments employed different degrees of influence; some variables differed significantly while others differed insignificantly.

***Keywords**:- Maize (Zea mays L.), Genotypes, Irrigation, Yield, Reciprocal and Effect.*

I. INTRODUCTION

Maize (*Zea mays* L.) is one of the main cereal crops in Bangladesh. The total area under maize cultivation in 2015-2016 was 0.39 million hectares with estimated production of maize was about 23.61 metric tons (BBS, 2015).Maize is a versatile crop due to its multifarious uses as feeds, food and industrial raw material.Every part of the maize plant is useful. In Bangladesh, a shortage of cooking oil has reached alarming proportions. Moreover, most of the available cooking oil is not of high nutritional value. Production and use of maize oil could help alleviate this situation, and the byproducts of oil extraction can also be used in bakery products. Animal feed in the country is severely deficient due to the lack of an organized feed industry and non-availability of grazing land. Thus, maize could play an important role as animal feed and fodder fed as stover, green fodder or as silage. One of the important attributes of maize is that even after the cobs are harvested the remaining plant can be utilized as fodder. Thus maize would provide food for humans and feed for the livestock from the same planting and with the same input costs.(agricultural diary 2017). 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. Its growth in recent years has increased faster than any other crop in Bangladesh, probably due to its year round production, higher yield and less susceptible to high temperature and other natural hazards. The intensive efforts of researchers, seed producing agencies, breeders and extension agents in association with international cooperation from institute like CIMMYT have made it possible to take the crop to the farmers' door step of Bangladesh. The total area under maize cultivation in 2014-2015 was 3.95 lakh hectares with estimated production of maize was about 27.59 lakh metric tons (Agricultural diary 2017).

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. Maize is also an excellent poultry feed. Yellow maize provides an additional advantage since it contains the fat soluble vitamin -A precursor, carotene, needed to promote normal growth in animals. At present poultry farmers are importing 2500 tons of maize grain per year for the poultry industry, thus expending valuable foreign exchange (Agricultural diary 2017). No doubt, maize production in the country would reduce the drain of foreign exchange and at the same time contribute to the growth of the poultry industry. Mature, dried maize stalks can also be used as a fuel for cooking in the rural areas. Electricity and natural gas are not available in most parts of the country, and the rural population has been living with a serious shortage of fuel for cooking as well as for other essential needs such as processing of paddy. What is more alarming is the fact that this energy shortage is likely 'to worsen in the coming decades with increasing population pressure. In such a situation maize stalks and husks could serve as fuel in the countryside. In the long-run, maize can also be used for ethanol production as a substitute for petroleum based fuel (year book, 2015). Maize can be grown all year round in Bangladesh and can therefore be fitted in the gap between the main cropping seasons without affecting the major crops. It can be harvested as fodder within 50 days of planting, as green cobs within 60-80 days and as grain within 100-130 days of planting. This flexibility allows the crop to fit easily into the cropping pattern. Another advantage of maize is its capacity to germinate under varying conditions. Maize can be dibbled in the flood prone areas as soon as flood water recedes without waiting for the soil to dry, at a time when no other crop would grow. Maize can be grown in these areas under no tillage and with minimum inputs. This type of land totals around 2 million ha (Year book, 2015). In the winter season in some cases, maize may compete with wheat, pulses, oil seeds and other rabi crops. Pulses, oil seeds, onion, garlic and potatoes can be intercropped with maize. Careful planning can also reduce the competition between maize and wheat since availability of land in the winter is not a problem. Maize can be grown in Bangladesh with other crops in several combinations. Patterns and possible associations of maize with other crops in Bangladesh are shown below: 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 (Kristov, I. 1995.). 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 (BBS, 2015). 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 tor 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). In Bangladesh, maize is being cultivated for a long time, but still it is a minor crop. Periodic attempts were made previously to accelerate maize production. During the last decade, maize has gained an increasingly important attention by the government. This is mainly due to its huge demand for poultry feed industries, fodder and fuel. From maize, 0.55 Mt of fodder and 0.27 Mt of fuel were produced (Ahmed, 1994). So, the researchers, government and farmers have to give more emphasis on maize cultivation. Expanding populations with greater food and energy needs are increasing demand for greater global maize (Zea mays L) production. Unfortunately, environmental limitations such as temperature anddrought continue to restrain maize production levels as they have in earlier decades and in many areas this is predicted to worsen with changing climates. Periodic moisture deficit condition is caused by irregular rainfall, accen-tuated by low water holding capacity of tropical soils, as well as poor cultural practices and lack of appropriate varieties used by farmers, often cause maize crop losses (Klocke et al., 2004). Developing cultivars of maize that can perform well under heat and drought is an important goal throughout the world. Unfortunately, maize researchers and breeders have found that drought tolerance is a complex trait making the search for appropriate selection traits, breeding and screening methods difficult. An initial focus solely on yield stability under time points of water stress has so far resulted in incremental progress. Consequently, this has led to a search for secondary traits. In the case of maize these would ideally be identifiable in inbred lines and inherited to good yielding hybrids. These traits include but are not limited to, shortened anthesis-silking interval (ASI), delayed leaf senescence, increased rooting depth and density, hydraulic lift, high leaf number and short plant height, performance with limited available nitrogen, seedling vigor, and epicuticular wax. Many secondary trait screening methods are still costly when evaluating large numbers of genotypes in a breeding program. Technologies such as molecular markers for marker assisted selection and transgenic lines have been developed and provide another avenue to improve drought tolerance .However, for a trait as complex as drought, using the few identified genes mostly with small effects are unlikely to be a single solution in the near future. Alternatively, improvement in productivity of existing maize cultivars can be achieved through introgression of genes for drought tolerance. The initial step in utilizing germplasm is to screen for desirable characters, which can then be incorporated into existing cultivars. Drought tolerant (DT) maize germplasm

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can be assessed for DT capacity by evaluating them under well-watered and moisture deficit condition (Landi et al., 1995) using already identified traits that are directly or indirectly related to high grain yield under moisture deficit as index of selection in drought tolerant. The objectives of this study is to know the interaction effect between variety and irrigation levels on yield and yield parameters of different maize (*Zea mays* L.).

II. MATERIALS AND METHODS

A field experiment was conducted at the Research field of Plant Breeding Division, Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Rahmatpur, Barisal, Bangladesh during the period from November, 2016 to April, 2017 to screen out the hybrid maize varieties under moisture deficit condition. The experimental materials will consist of 5 diverse genotypes of maize. The experiment will be carried out in a Randomized Complete Block Design (RCBD) with three replication. The experimental field of Regional Agriculture Research Station, Rahmatpur, Barisal lies at the 22°42' North latitude and 90°23' East longitude at an altitude of 4 meter above the sea level. The experimental area is covered by Gangetic Tidal Floodplains and falls under Agro ecological Zone "AEZ–13".The soil of the experimental land belongs to the Non-calcareous Grey Floodplain soils under the Ganges Tidal Alluvium tract. The land was saline, flat, well drained and above flood level. The soil was clay loam in texture having a pH value of 6.35 with moderate organic matter content. The annual rainfall ranges from 1780 to 1875 mm, most of which occurs from May to August and the rainfall is scanty from November, 2016 to April, 2017. Low temperature and plenty of sunshine prevail in the Rabi season (BARI, 1997). In order to maintain good yield in maize, it should be grown in rotation with legumes and green manures to improve and maintain soil health. In Bangladesh conditions, maize is grown in the pattern of maize/green manure or legume crop/transplanted rice. Heavy application of nitrogenous fertilizer before or at the time of planting prior to the monsoon may lead to heavy losses by leaching. First top dressing is at sowing and the 2s top dressing at knee height, with a possible third at tassel emergence. Potassium, zinc and sulphur should be applied at the time of final land preparation if these are required. In Bangladesh recommended rates are 80-120 kg nitrogen, 60 kg P_20_5 and 30-40 kg K_20/ha, 5 kg Zinc and 20 kg sulphur/ha and 5-7 tons/ha of cow dung.

Materials of the Experiment: List of Maize Genotypes With Source Used In This Experiment

Sl. No.		Variety/ Line
01.	V_1	BARI Hybride Maize 9
02.	V_2	BARI Hybride Maize 5
03.	V_3	BARI Hybride Maize 7
04.	V_4	NK40
05.	V_5	Pacific 984

A. Layout and Design of Experiment

The experiment will be carried out in a Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of two factors irrigation and maize variety. Irrigation had 5 levels or treatment. The irrigation treatments were:

I_1=Full irrigation at initial,vegetative stage,silking and grain filling stage (20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS)
I_2=Full irrigation at initial stage (20-25 DAS)

I_3=50% irrigation both at initial and vegetative stage (20-25 DAS and 50-60 DAS)

I_4=75% irrigation both at initial and vegetative stage and silking stage (20-25 DAS,50-60 DAS and 75-80 DAS)

$I_{5=}$ 50% irrigation at initial,vegetative stage, silking ,and grain filling stage(20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS)

For sowing the seeds, 5-6 cm deep furrows were made by using tine hand rakes at a spacing of 60 cm. The seeds were sown on 25 December 2016 at a depth of 5 to 6 cm, and 2 seeds were dropped per hill. The seed to seed distance was 25 cm.

Intensive care was taken during growth period for the adequate growth and development of the crop. Different genotypes matured at different times. So harvesting was completed by 5 May, 2017. Ten plants were collected from each plot by uprooting for data collection. The plants were bundled and tagged separately for each plot.Data were recorded from ten randomly selected plants/row from each experimental unit for all studied characters on yield contributing traits viz. Days to50% tasseling, days to50% silking, days to maturity, plant height, ear height, number of seed rows per cob, number of seeds per row, number of seeds per cob, thousand grain weight and yield (g/plant). The grains were separated from the shell by using a maize Sheller. The grains were cleaned and driedin the sun at 14% (by weight) moisture content. Then the weight of the grains was taken by using a balance. The weight of the grain of collected samples was converted into yield per hectare for each plot. The collected sample plants were dried in the sun at 14 %(by weight) moisture content. After proper sun drying hundred grain weights (g) were weighed by using balance. The weight of dried plants was taken by a balance. The weight of cover of cobs and shell was also taken by using a balance. Then the value was converted into yield per hectare for each plot.Harvest index (HI) is the ration between the grain yield and biological or biomass yield.The biological yield is the sum total of the grain and straw yields. The HI is expressed as

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

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The water use of a crop field is generally described in terms of field water use efficiency (FWUE), which is the ratio of the crop yield to the total amount of water used in the field during the entire growing period of the crop. The FWUE demonstrates the productivity of water in producing crop yield. FWUE for maize was calculate by:

$$FWUE=\frac{Y}{WU}$$

Where,
FWUE= field water use efficiency, kg ha^{-1}cm^{-1}
WU = seasonal water use in the crop field, cm
Y= grain yield, kg ha^{-1}

The collected data were analyzed using MSTAT statistical package and the mean differences were adjusted by LSD.

III. RESULTS

The experiment was conducted to screen out the most tolerant hybrid maize variety through analyzing the effect of deficit moisture on growth and yield characters of maize to expand irrigated agriculture with limited water resources. Among the means to survive the consequences of water scarcity and yet to sustain higher crop production under irrigated agriculture with decreasing share of water, deficient irrigation programs are highly valued and their adoption is widely promoted. The results obtained in the experiment have been presented, interpreted and discussed in this chapter under relevant headings and sub-headings with necessary tables. The effects of different irrigation levels, varieties on maize cultivation have been elaborated.

A. Effect of irrigation and variety on yield and yield parameters

The plant heights although varied to some extent but there were no significant difference among the irrigation treatments. But in case of variety treatment, it can be observed that the treatments were significant. Maize is very sensitive to water stress (Berrett, 1990; Pandey*et al*., 2000) reported that water stress can effect growth, development and physiological processes of maize plants, which reduce biomass yield. Jama, A.O. and M.J. Ottman., 1993 noted that the maize needs for the highest water amount is during the flowering period. Because of this, one of the most important factors that can limit crop production is availability of water. If water stress can be avoided during silking and early ear development, high yield could be expected. Craciun, I. and M. Craclum (1994) in his study on the effect of different irrigation water levels on grain yield, yield components and some quality parameters of silage maize (*Zea mays.)* in marmara region of turkey found that Yield components such as plant height, ear length, thenumber of row per ear, the number of grain per row, the numberof grain per ear and the number of ear per plant of maize grownunder different levels of irrigation andquality parameters including 1000 grain weight, hectoliterweight, crude protein and crude oil in.

B. Plant height

The interaction effect of irrigation and mulch on plant height of maize was statistically significant (Table 1). The highest plant height of 225.6 cm was obtained at I_1V_1 (Framer practice; BHM-9) treatment and the lowest of 139.7 cm was obtained at I_4V_2 (75% irrigation at initial, vegetative stage and silking (20-25 DAS, 50-60 DAS and 75-80 DAS) stages; BHM-5) treatment. In similar experiments (Pandey*et al*., 2000), plant heights were reported to be higher with full irrigation (100% ETc or Epan = 1) and slightly deficit irrigation throughout the crop growing season, which is in agreement with the results of the current study.

C. Cob length and perimeter

The interaction between irrigation and variety exerted significant impact on the length and perimeter of cob (Table 1). The highest cob length (20.50cm) was obtained for I_1V_5 (farmer practice; pacific-984) and the lowest (13.87 cm) was obtained for I_3V_2 (50 % irrigation both at initial and vegetative (20-25 DAS and 50-60 DAS) stages; BHM-5). The highest perimeter of cob (5.48 cm) was obtained for I_2V_4 (Full irrigation at initial stage, 20-25 DAS; NK-40) and the lowest (3.887 cm) was for I_2V_2 (Full irrigation at initial stage, 20-25 DAS; NK-40; BHM-5). Abrecht, D.G. and P.S. Carberry. (1993) found that data obtained from two ycob cobs study showed that cob length was significantly affected by irrigation levels ($p<0.01$). The higher cob length values were obtained from treatments I125 and I100 (20.6 cm in both irrigation levels), while the shortest cob length (16.0 cm) was obtained from treatment I0. Because the cob length affects the number of grain per cob, it is accepted as one of the most important yield components that affects the grain yield. Their findings showed that when the irrigation levels decreased, the cob length decreased too. This result is consistent with the results of Band yopadhyay, P.K. and S. Mallik. 1996. They showed that cob length was affected by different irrigation water levels (12.8-18.8 cm) and reported that the cob length decreased with decreasing water application. Cosculleula, F. and J.M. Faci. (1992) noted that full irrigation during total crop growing season increased the cob length, but deficit irrigation at different phenological stages decreased it. In a similar study, Lanza*et al*. (1980) reported values varying between16.4 and 20.5 for cob length in relation to irrigation water levels

D. Number of grains per cob

The number of grain per cob significantly varied due to the interaction effect between irrigation and variety (Table 1). The highest number of grains per cob (628.0) was obtained for I_1V_1 (farmer practice; BHM-9) and the lowest number (172.0) was for I_5V_3 (50% irrigation at initial, vegetative, silking and grain filling (20-25 DAS, 50-60 DAS, 75-80 DAS and 110-120 DAS) stages.

Prasad, T.N. and U.K Prasad (1989) found that the number of rows per cob was statistically affected by different irrigation water amounts. Results revealed that the higher number of row per cob was found in irrigated treatments whereas the lowest was found in non-irrigated plants. Results are similar with those of Dai *at al*. (1990). In a study carried out by Bryant *et al*. (1992) under the ecological conditions of Iran, the number of row per cob varied between 12.4 and 14.1. This result was lower than ours because of different cultivar and ecological conditions. Similar findings are reported by Cosculleula, F. and J.M. Faci. (1992) who stated that the lowest number of row per cob was obtained from non-irrigated plots. Differences between irrigation treatments were significant for the number of grain per row. Results showed that the number of grain per row increased as irrigation water amount increased up to I75 level. Results were similar with those of Claassen and Shaw (1970) who reported that the water stress decreased the number of grain per row at silking stage. The values of number of grain per row obtained in this study are in agreement with those of other resources on maize (Doorenbos, J. and A.H. Kassam. 1979). Significant differences between irrigation treatments were found in terms of the number of grain per cob for combined data of two cobs. The highest numbers of grain per cob were obtained from I125 and I100 irrigation water amounts, whereas the lowest number of grain per cob was obtained from non-irrigated treatment. The number of grain per cob is related with the cob length, the number of row per cob and the number of grain per row. It was seen that the number of grain per cob increased like the number of grain per row, as the amount of irrigation water was increased. The cob length, the number of row per cob and the number of grain per row gave the highest values when there was no deficit irrigation (I125 and I100 irrigation levels). Denmead, O.T. and R.H. Shaw (1960) also reported that deficit irrigation decreased the number of grain per ear, which was in agreement with our findings.The effect of different irrigation water amounts was statistically important for the number of ear per plant of silage maize. The numbers of cob per plant varied between 0.89 and 0.65 number per plant. The higher number of cob per plant were obtained from I125, I100, I75, I50 and I25 treatments, which were statistically similar (0.89, 0.88, 0.88, 0.86 and 0.83, respectively),while the lowest value was determined at non-irrigated plots(0.65). The soil water stress affected the cob number per plant. Pandey*et al*. (2000) reported that water deficit decreased the cob number per unit area. Results are similar with those of Hanks, R.J. (1974) who reported the stress of water affected the cob number of per plant.

E. Hundred (100)-grains weight

The 100-grain weight was statistically similar due to the interaction effect between irrigation and variety (Table 1). I_5V_1 (50% irrigation at initial, vegetative, silking and grain filling (20-25 DAS, 50-60 DAS, 75-80 DAS and 110-120 DAS; BHM-9) produced the highest 100-grain weight of 39.77g and I_4V_2 produced the lowest 100-grain weight of 10.63g.

Lyle, W.M. and J.P. Bordovsky (1995) in his study found that the effect of different irrigation water amount was statistically important for the 1,000 grain weight of maize for combined data of two years. As shown Table 2, the highest 1,000 grain weights were obtained from satisfactory irrigation while the lowest 1,000 grain weight was obtained from non-irrigated plots. As a result, 1,000 grain weight increased as the amount of irrigation water increased. Results were in agreement with the results of Petrunin, V.M. (1966). They reported that when the amount of water decreased, both the 1,000 grain weight and grain yield were decreased. Similarly, Hossain, M.S. (2009) reported that the application of deficit irrigation on maize at the flowering period decreased the 1,000 grain. Thakur, C.(1980)also stated that the irrigations during milk maturation period increased the 1,000 grain weight.

F. Grain yield

The interaction effect between irrigation and variety had significant effect on the grain yield of maize (Table 1) in most cases. The highest grain yield of 15.03 t/ha was obtained for I_5V_4 (50% irrigation at initial, vegetative, silking and grain filling (20-25 DAS, 50-60 DAS, 75-80 DAS and 110-120 DAS; NK-40) and the lowest of 5.94 t/ha was obtained for I_4V_2 (75% irrigation at initial, vegetative stage and silking (20-25 DAS, 50-60 DAS and 75-80 DAS) stages; BHM-5). Downey, L.A. (19710 found that the effect ofdifferent irrigation water amounts was statistically important for grain yield per hectare for combined data of two years. In general, there was a close relationship between irrigation and grain yield. The relationship was mainly quadratic due to excessive irrigation. Quadratic relationships between grain yield and irrigation were also reported by Silva *et al*. (1992). Huang *et al*. (1999) found that there was a linear relationship between grain yield and seasonal irrigation water amount. The differences among the relationships reported by different researchers are due to different experimental conditions, seasonal rainfall amounts and distribution (Follett *et al*., 1978).In this study, the highest grain yield was obtained in satisfactory soil moisture during the growing period, while the lowest yield was obtained from treatment non irrigated plots. The results for the two years can be summarized by stating that a producer would have obtained the highest grain yield using full irrigation (1.00 × Epan) or slightly excessive irrigation (1.25 ×Epan). These results are consistent with findings of Pandey*et al*. (2000), who showed that grain yield was affected by irrigation water amount.

G. Straw yield

The interaction effect between irrigation and variety on straw yield was significant. The treatment combination I_5V_5 produced the highest straw yield of 14.97 t/ha and I_3V_2 (50 % irrigation both at initial and vegetative (20-25 DAS and 50-60 DAS) stages; BHM-5) produced the lowest yield of 8.417 t/ha (Table 1).

H. Biological yield

The biological yield varied significantly due to the interaction effect between irrigation and variety (Table 1). The highest biological yield of 41.85t/ha was obtained for I_4V_5 (75% irrigation at initial, vegetative stage and silking (20-25

DAS, 50-60 DAS and 75-80 DAS) stages; pacific-984) and the lowest of 21.31 t/ha was obtained for I_2V_3 (Full irrigation at initial stage, 20-25 DAS; BHM-7).

I. Harvest index

The harvest index significantly differed for the interaction effect between irrigation and Variety (Table 1).

The highest harvest index (49.13%) was obtained for I_2V_4 (Full irrigation at initial stage, 20-25 DAS; NK-40) and the lowest (34.01%) was obtained for I_4V_2 (75% irrigation at initial, vegetative stage and silking (20-25 DAS, 50-60 DAS and 75-80 DAS) stages; BHM-5).

Inter-action	Plant height (cm)	Length of cob (cm)	Cob perimeter (cm)	No of grain/ cob	100 grain wt (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	HI (%)
I_1V_1	225.6	19.37	5.16	628.3	39.63	14.66	14.7	40.52	45.16
I_1V_2	170.2	15.03	3.917	218.7	32.1	6.08	8.49	21.69	35.01
I_1V_3	130.8	15.37	3.91	189.1	36.07	6.72	8.47	21.41	39.21
I_1V_4	163	19.17	5.4	456.6	39.73	15.68	13.39	40.05	48.94
I_1V_5	184.1	20.5	5.07	567	39.1	14.34	14.7	40.69	44.01
I_2V_1	218.9	19.77	5.153	601.2	38.73	15.3	14.72	40.81	46.81
I_2V_2	143.4	14.23	3.887	207.9	32.3	6.01	8.473	21.72	34.55
I_2V_3	139.8	14.5	3.953	178.7	36.4	6.82	8.483	21.31	39.97
I_2V_4	187.4	19.1	5.48	463.7	38.13	14.62	13.8	41.26	49.13
I_2V_5	209	20.47	5.11	560.3	39.13	14.99	14.83	41.27	45.32
I_3V_1	212	19.67	5.077	596.5	38.8	15.4	14.67	41.36	46.45
I_3V_2	141.3	13.87	3.887	208.5	31.8	5.99	8.417	21.48	34.88
I_3V_3	142	15.67	3.953	175.8	36.73	6.67	8.767	21.47	38.86
I_3V_4	174.2	19.57	5.457	453.2	38.6	15.18	13.53	39.91	47.55
I_3V_5	174.6	20.4	5.153	577.7	39.3	14.64	14.67	40.68	44.95
I_4V_1	196	19.37	5.087	598.8	38.6	14.62	14.8	40.68	44.88
I_4V_2	139.7	14.53	3.957	255.6	31.63	5.95	8.45	21.8	34.01
I_4V_3	139.9	14.37	3.933	192.8	35.5	6.87	8.7	21.87	39.24
I_4V_4	161.8	18.5	5.43	455.1	39.07	15.29	13.35	39.98	47.83
I_4V_5	179.7	19.6	5.13	582.2	39.2	15.04	14.7	41.85	44.82
I_5V_1	218.2	19.43	5.083	600.6	39.77	12.37	14.92	37.55	40.2
I_5V_2	140.6	15.47	3.937	280.4	32.1	5.95	8.467	21.43	34.57
I_5V_3	140.8	14.1	3.9	172.5	35.73	6.97	8.49	21.42	40.72
I_5V_4	166.3	18.3	5.443	452.3	39.1	15.03	13.53	40.8	48.21
I_5V_5	185.9	19.83	5.043	554.7	39.47	14.08	14.97	40.24	43.68
LSD	28.7	1.379	0.136	51.23	1.784	2.798	0.524	3.147	4.646
Mean	171.408	17.608	4.700	409.13	37.069	11.411	12.019	32.93	42.358
SE(±)	3.418	0.287	0.076	20.372	0.333	0.487	0.341	1.097	0.578
SD	29.608	2.489	0.660	176.43	2.883	4.224	2.955	9.505	5.013
Minimum	130.8	13.87	3.887	172.5	31.63	5.95	8.417	21.31	34.01
Maximum	225.6	20.5	5.48	628.3	39.77	15.68	14.97	41.85	49.13
CV (%)	9.07	2.23	1.73	7.7	2.96	11.96	2.69	5.87	6.74
F-Test	*	*	*	*	*	*	*	*	*

Table 1. Yield and yield parameters of maize under the interaction of variety and irrigation treatments

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TREATMENT	Biomass (leaf) gm	Biomass (root)gm	Biomass(shoot)g	Ear Height cm
I_1V_1	18.35	57.43	18.09	117
I_1V_2	16.67	27.89	8.66	89.1
I_1V_3	16.67	40	7.5	107.25
I_1V_4	17.89	42.73	23.19	101.2
I_1V_5	18.67	35.71	23.93	116.8
I_2V_1	14.67	43.64	21.54	57.8
I_2V_2	14.19	27	11.36	58.4
I_2V_3	23.75	45	10	52.8
I_2V_4	13.75	24	8.5	60.2
I_2V_5	21.11	25	10	64.6
I_3V_1	17.69	27.5	15.79	60.6
I_3V_2	17.39	28.57	7.62	52.6
I_3V_3	15	20	10	58.4
I_3V_4	22.41	41.25	34.17	64.8
I_3V_5	20.337	40	38	63.4
I_4V_1	19.43	45.56	17.73	83
I_4V_2	19.23	27.78	67.39	100
I_4V_3	17.44	35	10	103
I_4V_4	18.263	37.5	9.41	104
I_4V_5	20	24.55	16	92
I_5V_1	16.67	26.67	20	92.8
I_5V_2	18.06	38.13	8.61	81
I_5V_3	12.38	24	15	91.003
I_5V_4	19.05	36.67	8.08	79.2
I_5V_5	19.15	40.59	9.503	72.8
LSD	0.156	0.192	0.002	0.002
SE(±)	0.305	1.051	1.529	2.403
SD	2.649	9.110	13.244	20.817
Minimum	12.38	20	7.5	52.6
Maximum	23.75	57.43	67.39	117
CV(%)	0.528	0.412	0.007	0.003
F-test	*	*	*	*

Table 2. Yield and yield parameters of maize under the interaction of variety and irrigation treatments

J. Biomass (leaf)

The biomass of leaf varied significantly due to the interaction effect between irrigation and variety (Table 2). The highest biomass of leaf 23.75g was obtained for I_2V_3 (full irrigation at initial (20-25 DAS) stages; BHM 7)) and the lowest of 12.38 g was obtained for I_5V_3 (50% irrigation at initial,vegetative stage, silking ,and grain filling stage(20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS); BHM-7)).

K. Biomass (Root)

The biomass of root varied significantly due to the interaction effect between irrigation and variety (Table 2). The highest biomass of root 57.43g was obtained for I_1V_1 (Full irrigation at initial,vegetative stage,silking and grain filling stage (20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS) stages; BHM 9)) and the lowest of 20.00 g was obtained for I_3V_3 (50% irrigation both at initial and vegetative stage (20-25 DAS and 50-60 DAS)); BHM-7)).

L. Biomass (shoot)

The biomass of shoot varied significantly due to the interaction effect between irrigation and variety (Table 2). The highest biomass of shoot 67.39g was obtained for I_4V_2 (75% irrigation both at initial and vegetative stage and silking stage (20-25 DAS,50-60 DAS and 75-80 DAS; BHM 5)) and the lowest of 7.5g was obtained for I_1V_3 (Full irrigation at initial,vegetative stage,silking and grain filling stage (20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS) stages; BHM-9)).

M. Ear height

The ear height varied significantly due to the interaction effect between irrigation and variety (Table 2). The highest ear height of 117cm was obtained for I_1V_1 (Full irrigation at initial,vegetative stage,silking and grain filling stage (20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS) stages; BHM 9)) and the lowest of 52.6cm was obtained for I_3V_2

(50% irrigation both at initial and vegetative stage (20-25 DAS and 50-60 DAS); BHM-5).

N. Cob height

The cob height varied significantly due to the interaction effect between irrigation and variety (Table 2). The highest cob height of 20.5cm was obtained for I_1V_5 (Full irrigation at initial,vegetative stage,silking and grain filling stage (20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS) stages; Pacific 984)) and the lowest of 13.87cm was obtained for I_3V_2 (50% irrigation both at initial and vegetative stage (20-25 DAS and 50-60 DAS); BHM-5).

O. Water requirement and water use efficiency:

The total water use during the whole season and the water productivity that represents the productivity of water in producing crop yields. The highest water productivity for grain production, WP (3.63 kg/m^3), was obtained at I_3 (50 % irrigation both at initial and vegetative; 20-25 DAS and 50-60 DAS stages) and the lowest (1.60 kg/m^3) was obtained at I_1 (Farmer practice). Water productivity decreased with increasing quantity of applied irrigation (Table 3).

Jensen M E. (19680 find that irrigation water use efficiency (IWUE) values varied from 1.11 to 1.72 kg m-3, which are similar to reported values from 1.51 to 2.48 kg m-3 by Bharati*et al*. (1997) and up to 1.62 kg m-3 reported by Sridhar, V. and R.A. Singh. (1989).Differences in the rainfall during growing seasons could be the cause of small differences in the results of IWUE values because the amount of rainfall affects the amount of irrigation water applied. In this study, irrigation water use efficiency increased with decreasing irrigation water applied. In regions where water scarcity exists, irrigation managers should adopt the deficit irrigation approach to achieve sustainable crop production.

Irrigation Treatment	Amount of total irrigation (cm)	Effective Rainfall (cm)	Soil moisture contribution (cm)	Total water use (cm)	Water productivity (kg/m^3)
I_1	71.86	4.17	16.68	92.71	1.60
I_2	21.59	4.17	16.68	42.44	3.38
I_3	19.05	4.17	16.68	39.88	3.63
I_4	26.28	4.17	16.68	47.13	3.06
I_5	37.93	4.17	16.68	58.78	2.34

Table 3. Component of water requirement and water productivity in different treatments

Fig 1 shows that, the comparison of irrigation water applied including rainfall and irrigation water applied without rainfall with grain yield. There was a big deflection between water applied including rainfall and without rainfall. Fig 2 shows that, there was some early rainfall in November and a huge rainfall before monsoon. That early rainfall was good for crops like maize, because it minimizes the production cost and helps to fill the grain properly. But for this kind of experiment, this huge rainfall effects directly to the crop yield. So the difference of grain yield was not observed properly between the stress treatments.

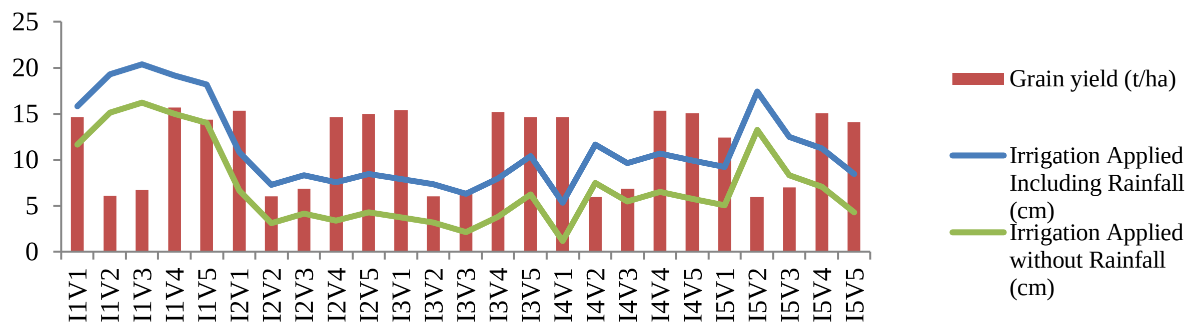

Fig 1:- Component of water requirement and water productivity in different treatments

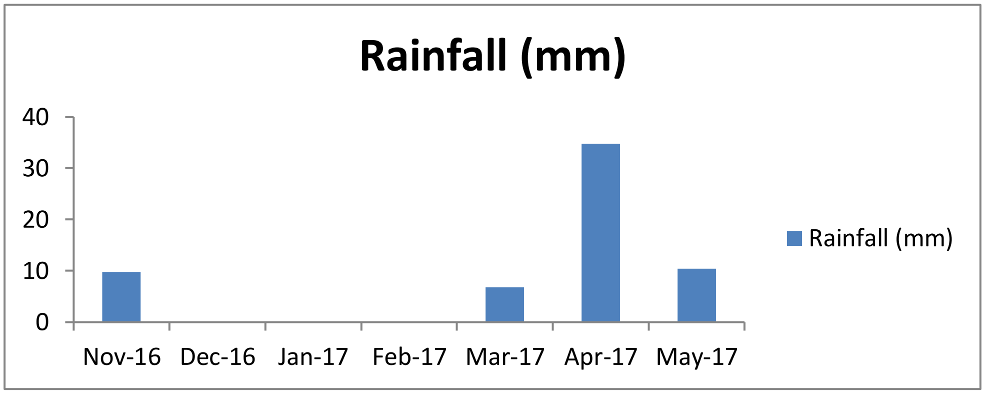

Fig 2:- Rainfall pattern in Barisal district at Rabi Season

IV. CONCLUSIONS

For the interaction between the irrigation and variety, the highest grain yield was 15.68 t ha^{-1} for I_1V_4 (50% irrigation at initial, vegetative, silking and grain filling (20-25 DAS, 50-60 DAS, 75-80 DAS and 110-120 DAS) in NK-40) and the lowest was 5.94 t/ha was obtained for I_4V_2 (75% irrigation at initial, vegetative stage and silking (20-25 DAS, 50-60 DAS and 75-80 DAS) stages in BHM-5).The water productivity/water use efficiency was the highest (3.63 kg/m^3), was obtained at I_3 and the lowest (1.60 kg/m^3) was obtained at I_1 in irrigation treatments. The water productivity was the highest (15.4 kg ha^{-1}cm^{-1}) for I_3V_1 (50% irrigation both at initial and vegetative stage (20-25 DAS and 50-60 DAS) in BARI Hybride Maize 9) and the lowest (5.95 kg ha^{-1}cm^{-1}) for I_4V_2 (75% irrigation both at initial and vegetative stage and silking stage (20-25 DAS,50-60 DAS and 75-80 DAS) inBARI Hybride Maize 5) and for I_5V_2(50% irrigation at initial,vegetative stage, silking ,and grain filling stage(20-25 DAS and 50-60 DAS,75-80 DAS and 110-120 DAS) inBARI Hybride Maize 5) in the interaction effect between irrigation and varietal treatments.

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