

PERFORMANCE OF HYBRID MAIZE VARIETIES AS INFLUENCED BY IRRIGATION LEVELS

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Abstract

The present piece of research work was carried out at the field of Sher-e-Bangla Agricultural University, Dhaka-1207, from December 2010 to May 2011 to determine optimum irrigation levels for the hybrid maize varieties. There were four hybrid maize varieties: V₁ (BARI Hybrid Maize-5), V₂ (Pacific 60), V₃ (NK 40) and V₄ (Ajanta) and three levels of irrigation: I₁ = Two irrigations at 25 and 50 DAS, I₂ = Three irrigations at 25, 50 and 75 DAS and I₃ = Four irrigations at 25, 50, 75 and 100 DAS, respectively. Almost all the plant and yield contributing characters showed significant variation except days to 6 leaf stage and days to bud initiation stage. The maximum yields were recorded in V₁I₃ (7.92 t ha⁻¹) which was statistically identical to V₄I₃ (7.83 t ha⁻¹), V₂I₃ (7.45 t ha⁻¹), V₁I₂ (7.40 t ha⁻¹), V₂I₂ (6.87 t ha⁻¹) and V₄I₂ (6.80 t ha⁻¹), respectively. The highest benefit cost ratio (BCR) was observed (2.37) in both V₁I₃ and V₁I₂ treatment combination. Moreover, total average water saving in one hectare land for maize cultivation by adopting I₂ irrigation treatment over I₃ is 4,49,837 gallons. Among the treatment combinations, V₁I₃ (BARI Hybrid Maize-5 with three irrigations at 25, 50 and 75 DAS) was the suitable combination in terms of grain yield and economic return for maize cultivation.

Introduction

Maize (*Zea mays* L.) is considered as the third cereal crop in Bangladesh after rice and wheat. Its position is the first among the cereals in terms of yield, but area and production ranks third after rice and wheat. It covers about 4,09,000 acres of land producing 10,18,000 tons of grains in 2010-11 (BBS, 2011) in Bangladesh.

Hybrid maize cultivation area has increased at the rate of about 20-25% per year since nineties. Now-a-days, there are many government and non government organizations are working for increasing maize production in Bangladesh. Besides, Bangladesh Agricultural Research Institute (BARI) has released eleven promising hybrid maize varieties. Variety plays an important role in producing high yield and good quality maize. Different varieties respond differently to input supply, cultivation practices and prevailing environment etc. during the growing season. Higher yield up to 9-11 t ha⁻¹ can be obtained using hybrid seeds, balanced fertilizers and better management practices (Mondal *et al.*, 2014). The average yield of maize in Bangladesh is rather low compared with leading maize growing countries of the world. Availability as well as the cost of management of irrigation water is one of the most expensive inputs for maize cultivation. Moreover, at present, the farmers are facing the problem of getting available irrigation water and may be acute in future because of the lowering water table day by day. Proper growth and development of maize needs

favorable soil moisture up to its root zone. Limited water supply during the growing season results in soil and plant water deficits and reduces maize yields (Gordon, *et al.*, 1995; Patel *et al.*, 2006). Irrigation scheduling is necessary for the most effective use of valuable water for optimizing maize production. Proper water management reduces irrigation cost. So, for proper growth and development of hybrid maize, appropriate irrigation scheduling is needed (Lafound *et al.*, 1992; Arshad *et al.*, 1995). Improper scheduling of irrigation results not only in wastage of water but decrease the crop growth and in yield.

In these circumstances, a research work was undertaken to find out the suitable maize hybrid variety (s) with lower water requirement and to find out the best irrigation management practices for higher economic return.

Materials and Methods

The study was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka-1207, during December 2010 to May 2011. The location of the experimental site was situated at 23° 77' N latitude and 90° 3' E longitudes with an elevation of 8.6 meter from the sea level. The experimental site was situated in the subtropical zone. The soil of the experimental site belongs to Madhupur Tract of Agro Ecological Zone (AEZ-28) (FAO, 1988). The soil was clay loam in texture and olive gray with common fine to medium distinct dark yellowish brown mottles. The pH was 5.47 to 5.63. The organic matter and K content of the soil is low but status of CEC and P is medium (BARC, 2005). The experiment was set up in a split plot design with three replications where Variety (V_1 = BARI Hybrid Maize-5, V_2 = Pacific-60, V_3 = NK-40 and V_4 = Ajanta) in main plot and Irrigation level (I_1 =Two irrigations at 25 and 50 DAS, I_2 = Three irrigations at 25, 50 and 75 DAS and I_3 = Four irrigations at 25, 50, 75 and 100 DAS, respectively) in sub-plot. Irrigation have been applied to reach the soil moisture upto field capacity so no infiltrations have been occurred. The dosages of fertilizer (512-275-200-222-14-6 kg/ha Urea-TSP-MoP-Gypsum-ZnSO₄-Boric Acid) were applied according to FRG, 2005, BARC. Seeds were sown by hand at 75 cm apart line to line and 25 cm plant to plant. Post sowing light irrigation was given for proper germination of seeds.

Two weedings were done at 24 and 49 days after sowing (DAS) and two thinning were done also at 24 and 49 DAS, keeping one plant per hill. The mixture of Diazinon 60 EC @ 2 ml/L and Ripcord 10 EC @ 1 ml/L of water was applied to control leaf cutting caterpillar at 6-8 leaf stage for two times, seven days interval. The water requirement for maize cultivation is determined by measuring the soil moisture. The depth or water requirement can be determined by the following equation-

$$\text{Irrigation depth, } d = \frac{\text{FC (\%)} - \text{MCi (\%)}}{100} \times \rho \times D \quad \text{-----(1)}$$

Where, d= Depth of water to be applied (cm), FC= Field capacity of the soil (%), MCi= Moisture content of the soil at the time of irrigation (%), ρ = Bulk density of the soil (gm / cc), D= Root zone depth (cm)

The collected data were statistically analyzed using MSTAT-C statistical programme with Least Significant Difference (LSD) by Gomez and Gomez (1984).

Results and Discussion

Interaction effects of variety and irrigation levels on plant characters of hybrid maize

Performance of Hybrid Maize Varieties as Influenced by Irrigation Levels

Interaction effect of variety and irrigation levels varied significantly except days to 6 leaf stage and days to bud initiation stage (Table 1). All the combinations took 44-46 days to open the first 6 –leaf stage. The maximum days (82) were needed in V_4I_1 in 12 leaf stage and while other combination took almost similar days (76-77). The variation on days to bud initiation was insignificant while days to tassel emergence t range maximum and minimum days (87 and 83). Days to tassel flowering were observed in different treatment combination from 86 to 89 days. Silk emerged just after the tassel flowering which also varied significantly, while The maximum days (90) in V_2I_3 , V_3I_1 and V_3I_3 and the minimum days (88). Days to pollen shedding were statistically significant where V_3I_3 needed the maximum day (92) while the minimum days (89) in V_1I_3 . Nizam-uddin *et al.*, (2010) and Malik *et al.*, (2010) supported the above findings and stated that; cultivars differed significantly for all parameters.

Interaction effects of variety and irrigation levels on yield and yield contributing characters of hybrid maize

Interaction effect of different variety and irrigation levels treatment on yield and yield contributing characters of hybrid maize shown in Table 2. Plant height increases with increase the number of irrigation among all the varieties. Cob height showed almost the same trend of result found from the plant height. The nearest cob (66 cm) from the ground was found from V_3I_1 and the farthest cob (97 cm) in V_1I_3 . The longest distance (85 cm) was found in V_1I_2 followed by V_4I_3 (83cm) and V_1I_3 (81 cm) whereas the shortest in V_4I_1 (60 cm) followed by V_3I_1 (61 cm) and V_1I_1 (64 cm). Number of cobs increased with the application of irrigation water. Among the variety, the maximum number of cobs (1.2) were found in V_2 and V_4 followed by V_1 (1.17) in I_3 irrigation treatment. The highest cob length (16.7 cm) was found from V_1I_3 while the lowest cob length (13.3 cm) from V_2I_1 and V_4I_1 .

The grain weight per cob in the treatment combination V_4I_2 , V_1I_2 and V_2I_2 , were 142, 141 and 139, respectively followed by V_3I_3 (140 g). 1000-grains weight increased with the number of application of irrigation water. However, the maximum 1000-grain weight was recorded in the treatment combination V_3I_3 which was statistically identical with V_3I_2 , V_4I_3 , V_4I_2 and V_1I_3 . The grain yield of different treatment combination varied significantly where the highest grain yields was obtained in four irrigation (I_3) and the lowest in two irrigation (I_1) in all the variety. A gradual increasing trend was observed in every variety with the increase of irrigation level. Therefore, it is evident that, irrigation has a great effect on hybrid maize yield regardless of variety. Among the treatment combination, variety V_3 with all the irrigation levels gave the lowest yield, even its highest yield (6.22 t ha^{-1}) in I_3 was statistically at par with the I_2 irrigation level of other varieties. The lowest yields (4.89 , 5.01 , 5.53 and 5.65 t ha^{-1} , respectively) were recorded with I_1 irrigation level in V_3 , V_4 , V_1 , and V_2 , respectively. The yield increased in V_1 from I_1 to I_2 was 34% and I_2 to I_3 7%, in V_2 from I_1 to I_2 was 21% and I_2 to I_3 8%, in V_3 from I_1 to I_2 was 24% and I_2 to I_3 2% and in V_4 from I_1 to I_2 was 35% and I_2 to I_3 15%, respectively. It was also observed that, incase of V_1 the yield in I_2 was better than the yield of other varieties in I_2 irrigation. Aziz *et al.*, (2011) observed that, among the varieties BARI Hybrid Maize-5 produced maximum grain yield. Islam and Mian (2004) showed that, varieties had significant variation on yield and yield contributing characters. Biological yield of different treatment combination also varied significantly. The highest biological yield was obtained from V_1I_3 while lowest from V_1I_1 .

Irrigation water utilization and economic analysis of different treatment combinations

The average irrigation water used in I_1 was 1209725 gallons ha^{-1} with the average grain yield of 5.27 t/ha whereas in I_3 , 2079587 gallons ha^{-1} with the grain yield of 7.36 t ha^{-1} . In I_2 , moderate yield of 6.79 t ha^{-1} was observed with 1629750 gallons ha^{-1} irrigation water which

was statistically identical to I_3 . Moreover, 4, 49,837 gallons of water can be saved by using I_2 irrigation treatment without reducing significant quantity of grain yield. Among the varieties V_1 gave the highest yield (7.40 t ha^{-1}) with I_2 treatment. Therefore, the treatment combination of V_1I_2 gave higher yield with moderate level of irrigation water (Table 3). In I_3 irrigation treatment higher amount water was used but yield was not statistically different from I_2 . Total average water saving in one hectare of land for maize cultivation by adopting I_2 irrigation treatment over I_3 irrigation treatment was $(20,79,587 - 16,29,750) = 4,49,837$ gallons. Therefore, I_2 irrigation treatment was optimum irrigation practices for maize cultivation considering yields and water saving aspect.

Cost Benefit Analysis

Effect of variety and irrigation combination on cost and economic benefit of the hybrid maize production has shown in Table 4. The highest total variable cost (Tk. 69028/ha) was observed in the I_3 treatment and the lowest total variable cost (Tk. 59028/ha) in I_1 treatment with all the varieties. The increment of cost (Tk. 4500/ha) and (Tk. 5500/ha) was found in I_2 from I_1 and I_3 from I_2 , respectively. The highest human labor cost (Tk. 10500/ha) was found in I_3 irrigation treatment followed by I_2 (Tk. 10000/ha) and I_1 (Tk. 9500/ha), respectively. One time higher irrigation level increased the cost Tk. 1000 ha. The highest irrigation cost (Tk. 17000/ha) was observed in the I_3 treatment whereas the lowest irrigation cost (Tk. 10000/ha) was observed in I_1 treatment. The highest gross return (Tk. 163870/ha) was found in V_1I_3 treatment combination which was similar to V_4I_3 (Tk.161115/ha) and the lowest gross return (Tk. 100710/ha) was in V_3I_1 . The highest net return (Tk. 94842/ha) was found in V_1I_3 t which was followed by V_4I_3 (Tk. 92087/ha) treatment combination. The lowest net return was found in V_3I_1 (Tk. 41682/ha). The highest benefit cost ratio (BCR) 2.37 was observed in V_1I_2 and V_1I_3 treatment combination with three and four irrigations. The lowest BCR (1.71) was observed in V_3I_1 treatment combination followed by V_4I_1 (1.74) and V_1I_1 (1.90), respectively. Therefore, it was observed that I_2 irrigation treatment produced almost similar returns and benefit cost ratio with I_3 irrigation level. Moreover, a huge quantity of irrigation water can be saved by utilizing I_2 instead of I_3 irrigation level. So, I_2 irrigation treatment was the most effective treatment because yields and yield contributing characters of maize were very much similar with I_3 irrigation treatment. In I_1 irrigation treatment maize yields was lower with lower yield contributing characters.

Two, three and four irrigation increased yields by an additional 16.9, 6.7 and 4.3% respectively. Water savings can be achieved by applying two or three irrigations which should increase yield without significantly reducing yield compared to four irrigations. Pandey *et al.* (2000) observed that yield reduction (22.6 - 26.4%) were found with deficit irrigation and this was associated with decrease in kernel number and weight. Karim *et al.*, (2010) found that the coefficient of human labour, land preparation, irrigation, urea and borax have significantly impact on gross return.

Table 1. Interaction effect of variety and irrigation on different plant characters of hybrid maize

Treatment Combination	Days to 6 leaf	Days to 12 leaf	Days to bud initiation	Days to tassel emergenc	Days to tassel flowering	Days to silk emergenc	Days to pollen shedding
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Performance of Hybrid Maize Varieties as Influenced by Irrigation Levels

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V ₁ I ₁	44	78	83	83	87	89	90
V ₁ I ₂	45	76	82	85	88	89	90
V ₁ I ₃	47	78	84	86	87	88	89
V ₂ I ₁	44	77	82	84	87	89	90
V ₂ I ₂	45	78	85	87	88	89	91
V ₂ I ₃	46	76	82	86	88	90	90
V ₃ I ₁	44	78	84	85	89	90	90
V ₃ I ₂	46	79	84	86	87	89	90
V ₃ I ₃	45	78	85	87	89	90	92
V ₄ I ₁	45	82	83	83	87	89	90
V ₄ I ₂	46	79	81	84	86	88	90
V ₄ I ₃	47	77	82	85	87	89	90
LSD (0.05)	NS	3.96	NS	2.78	2.11	1.97	1.46
CV (%)	2.70	3.00	2.57	1.93	1.43	1.30	0.96

Table 2. Interaction effect of variety and irrigation on yield and yield contributing characters of hybrid maize

Treatment Combination	Plant height (cm)	Cob height (cm)	Cob length (cm)	Grain weight / Cob (g)	1000-grain weight (g)	Grain yield (t/ha)	Biological yield (t/ha)
V ₁ I ₁	142	77	13.7	116	268	5.53	9.02
V ₁ I ₂	170	84	15.0	131	290	6.60	12.14
V ₁ I ₃	178	97	16.7	156	318	8.44	18.86
V ₂ I ₁	149	81	13.3	119	297	5.95	10.00
V ₂ I ₂	163	89	13.7	139	303	6.87	11.23
V ₂ I ₃	170	92	15.3	145	309	7.94	15.22
V ₃ I ₁	127	66	13.7	103	284	4.89	10.71
V ₃ I ₂	156	80	15.0	127	339	6.11	13.20
V ₃ I ₃	163	91	15.3	140	340	6.63	16.53
V ₄ I ₁	141	82	13.3	102	270	5.01	10.98
V ₄ I ₂	159	91	14.7	142	319	6.8	13.99
V ₄ I ₃	179	96	15.7	150	335	8.35	16.86
LSD (0.05)	10.3	7.43	0.60	10.8	19.9	0.74	1.72
CV (%)	7.76	10.3	4.83	9.76	7.69	13.40	15.30

V₁= BARI Hybrid Maize-5, V₂= Pacific-60, V₃= NK-40 and V₄= Ajanta

I₁=Two irrigations at 25 and 50 DAS, I₂= Three irrigations at 25, 50 and 75 DAS and I₃= Four irrigations at 25, 50, 75 and 100 DAS

Table 3. Total average irrigation water applied in different treatment combination maize yield

Treatment combination	Total average water used (cm)	Total irrigation water used (gallons/ha)	Grain yield (t/ha)
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I ₁ V ₁	45.8	1213700	5.53
I ₁ V ₂	46.3	1226950	5.65
I ₁ V ₃	46.3	1226950	4.89
I ₁ V ₄	44.2	1171300	5.01
I ₂ V ₁	61.5	1629750	7.40
I ₂ V ₂	61.4	1627100	6.87
I ₂ V ₃	62.6	1658900	6.11
I ₂ V ₄	60.5	1603250	6.80
I ₃ V ₁	80.9	2143850	7.92
I ₃ V ₂	78.4	2090850	7.45
I ₃ V ₃	76.7	2032550	6.22
I ₃ V ₄	77.4	2051100	7.83

V₁= BARI Hybrid Maize-5, V₂= Pacific-60, V₃= NK-40 and V₄= Ajanta

I₁=Two irrigations at 25 and 50 DAS, I₂= Three irrigations at 25, 50 and 75 DAS and I₃= Four irrigations at 25, 50, 75 and 100 DAS

Table 4. Effect of variety and irrigation on cost and economic benefit

Cost items	Treatment combination											
	V ₁ I ₁	V ₁ I ₂	V ₁ I ₃	V ₂ I ₁	V ₂ I ₂	V ₂ I ₃	V ₃ I ₁	V ₃ I ₂	V ₃ I ₃	V ₄ I ₁	V ₄ I ₂	V ₄ I ₃
H.	9500	10000	10500	9500	10000	10500	9500	10000	10500	9500	10000	10500
Labors (Tk./ha)*												
Fuel (Tk./ha)	3000	4000	5000	3000	4000	5000	3000	4000	5000	3000	4000	5000
Manure (Tk./ha)	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Urea (Tk./ha)	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
TSP (Tk./ha)	9612	9612	9612	9612	9612	9612	9612	9612	9612	9612	9612	9612
MP (Tk./ha)	10656	10656	10656	10656	10656	10656	10656	10656	10656	10656	10656	10656
Gypsum (Tk./ha)	660	660	660	660	660	660	660	660	660	660	660	660
Boric acid (Tk./ha)	600	600	600	600	600	600	600	600	600	600	600	600
Irrigation (Tk./ha)	10000	13000	17000	10000	13000	17000	10000	13000	17000	10000	13000	17000
Seeds (Tk./ha)	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000	3000
TVC (Tk./ha)#	59028	63528	69028	59028	63528	69028	59028	63528	69028	59028	63528	69028
Gross return (Tk./ha)	112345	150370	163870	115175	139580	152885	100710	125690	129555	103185	139595	161115
Net return (Tk./ha)	53317	86842	94842	56147	76052	83857	41682	62162	60527	44154	76067	92087
Benefit cost ratio	1.90	2.37	2.37	1.95	2.19	2.21	1.71	1.98	1.88	1.74	2.19	2.33

a) Maize =20.00 Tk./kg b) Labor = 250 Tk./day *H. Labors= Human Labors, #TVC=Total Variable Cost

Conclusion

From the above findings, it may be concluded that, all the selected hybrid maize varieties viz., BARI Hybrid Maize-5, Pacific-60 and Ajanta except NK-40 gave higher benefits in three irrigation levels at 25 , 50 and 75 days after seeding (DAS). But it may be noted that, maize

Performance of Hybrid Maize Varieties as Influenced by Irrigation Levels

variety (BARI Hybrid Maize-5 with three irrigation levels at 25, 50 and 75 DAS was the best in terms of grain yield and return among all the treatment combination.

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