

EVALUATION OF WATERLOGGED TOLERANT MAIZE (*Zea mays* L.) HYBRIDS IN BANGLADESH

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Abstract

Four imported and popular hybrids along with one new hybrid of CIMMYT (Pacific-60, Pinnacle, 900M Gold, Uttaran-2 and CML254XCML247) were evaluated to develop waterlog tolerant maize variety during Kharif-I season in 2013. This experiment was conducted at Bangladesh Agricultural Research Institute (BARI), Joydebpur and four more regional stations of BARI with RCBD experimental design. The entries (30 commercial hybrid varieties of private seed companies, NGOs and BARI, and more than 200 inbreds from CIMMYT and BARI own developed germplasms) were initially screened out through cup method in control condition at Joydebpur to find the excess water tolerant varieties and lines for last consecutive two years. From cup screening results, these five hybrids were found water stress tolerant and taken to multi-location performance over five locations in Bangladesh. Days to maturity, Plant height, Ear height and Yield found statistically significant over the locations. Among the hybrids Uttaran-2 found the highest yielder (7.10 t/ha) followed by 900 M Gold (6.77 t/ha) and Pinnacle (6.43 t/ha). In case of days to maturity, Pinnacle found the shortest duration (95.2 days) followed by Pacific60 and Uttaran-2. For the Kharif season, Burirhat, Rangpur region found more suitable location for waterlog tolerant maize production compared to others. From the results of qualitative characters like leaf rolling, leaf yellowing, number of brace root etc. Uttaran-2, 900M Gold and Pinnacle found capable surviving in the water logged condition. Considering the yield and yield contributing characters Uttaran-2, 900M Gold and Pinnacle found promising hybrids and Burirhat could be good choice for farmers producing summer maize hybrids.

Keywords: water stress, inbred lines, hybrid evaluation, summer maize.

Introduction

Maize (*Zea mays* L.) plays a significant role in human and livestock nutrition worldwide. In Bangladesh it is an important cereal crop ranks third and first position in terms of acreage and production, respectively. Due to high yield potentiality, versatile uses, and almost year round growth ability and higher per acre yield compare to other cereals, area and production of maize is increasing day by day in our country. Its production also has increased significantly in the country because of the fast growing poultry and poultry feed industry, and price hike of food materials.

In Bangladesh, maize crops grown during the Kharif I and Kharif II (summer-rainy) season occasionally face extreme climatic conditions and biotic/abiotic pressure that limits crop growth

and development, and eventually limits yield potential. Among the abiotic stresses, excessive soil moisture, caused by flooding, water logging or high water table, is one of the most important constraints for maize production and productivity. More than 5-10% of the total maize growing area is affected by floods and water-logging problems in Bangladesh.

However, considerable genetic variability has been observed in maize for tolerance to excess moisture. That variability may be exploited to develop maize varieties tolerant to excess soil moisture condition. Inability of non-wetland crop species, including maize, to withstand excessive soil moisture conditions in the rhizosphere, caused by water-logging or any other factor, results in substantial yield losses. Maize crops grown during the summer-rainy season in the tropics occasionally face extreme climatic

conditions and a variety of biotic and abiotic pressures that limit yield potential. Among abiotic stresses, water-logging, caused by contingent flooding, continuous rainfall coupled with inadequate drainage or a high water table, is one of the most important constraints for maize production in Asia and many other parts of the world. In South and Southeast Asia alone, over 18% of the total maize growing areas are frequently affected by floods and water-logging problems (Zaidi *et al.*, 2009). Excessive moisture or submergence leads to reduced gas exchange between root tissues and the atmosphere because the diffusion rate of gases in flooded soil is approximately 100 times lower than in air (Kennedy *et al.*, 1992). Respiration by plant roots, soil micro-flora and fauna leads to a rapid exhaustion of soil oxygen, resulting in hypoxia followed by anoxia. Unlike rice plants, maize plants have no naturally occurring air spaces in their roots. Therefore, as a result of the gradual decline in oxygen, plant roots suffer hypoxia (low oxygen) followed by anoxia (no oxygen) when faced with prolonged (>3 days) excess soil moisture (Dennis *et al.*, 2000; Zaidi and Singh, 2002). However, the extent of damage due to water-logging stress varies significantly with the developmental stage of the crop. Previous studies have shown that maize is comparatively more susceptible to water-logging from the early seedling stage to the tasseling stage (Mukhtar *et al.*, 1990; Zaidi *et al.*, 2004). However, significant genetic variability has been observed in the tolerance of maize to water-logging stress (Torbert *et al.*, 1993; Rathore *et al.*, 1996, 1997; Zaidi *et al.*, 2002, 2003, 2007a). This variability could be exploited to develop maize varieties tolerant to contingent/ intermittent water-logging stress during the summer-rainy season in the tropics. An effective breeding strategy for developing water-logging tolerant cultivars primarily depends on a sound knowledge and understanding of the inheritance mechanism of the stress tolerance in tropical maize. Studies on the combining ability of water-logging stress tolerance in Indian maize have been attempted (Khera *et al.*, 1990; Hossain, 2001), however, only limited information on some location-specific germplasm is available. We selected maize inbred lines from wide genetic background, including Indian maize program and CIMMYT lines from diverse sources. Thus the objective of present

study was to determine water stress tolerant variety development for Bangladesh rain fed condition.

Materials and Methods

Performance of five hybrids Pacific-60, Pinacle, CML254XCML247, 900M Gold and Uttaran-2 was examined at Barisal, Burirhat (Rangpur), Gazipur, Jamalpur and Satkhira of Bangladesh from March to July 2013 following randomized complete block design with 3 replications to examine their waterlogging tolerance. Each plot comprises of 5 rows of 5 meter long. Fertilizers were applied at the rate of 150 kg N, 32 kg P, 64 kg K, 20 kg S, 2.8 kg Zn, respectively. 50 % N was applied at the time of sowing and remaining 50% at about V9-V10 stage (40 DAS). After 35-40 DAS water logging condition was created for 5 days and then the water was drained out. All weeds and pests and diseases were controlled as and when required. Data on yield and other desirable characters were recorded on days to tasseling, days to silking, days to maturity, plant height and ear height. Yield was taken as whole plot basis. For convenience, plot yield was adjusted with moisture percentage and optimum plant number and it was converted to t/ha. Some qualitative traits like brace roots and their position, leaf senescence (LS), root lodging (RL) and stalk lodging (SL) along with some disease incident like leaf rolling (LR) and Leaf yellowing were also recorded. Data were analyzed with Cropstat 7.2 software.

Results and Discussion

As the climatic variation was high in this season the experiment could not set up at a time over all the locations. But due to heavy shower through out the Kharif season of this year the varieties gone under typical water stress and the data were taken around the crop growing season. Both qualitative and quantitative data were addressed in this experiment.

From table 1, six most important characters of maize show the significant variation in different combinations. Days to maturity, plant height, ear height and yield showed highly significant variation over locations and location-genotype interactions. Time taken up to tasseling was 50.22 days where Pacific60 taken the lowest duration

(49.20 days) and CML254XCML247 taken highest time (51.73 days) after sowing. In case of days to maturity, Pinnacle showed little bit earlier tendency (95.2 days) where 900M Gold took few more time (98.2 days). Among the five hybrids Uttaran-2 found the tallest one (222.7 cm) and Pacific60 with dwarf stature (185.86 cm). Considering yield potential, Uttaran-2 is the highest yielder (7.10 t/ha) followed by 900M Gold (6.77 t/ha) and Pinnacle (6.43 t/ha) (Table-2).

From table 3, it is found that Burirhat (Rangpur) region is suitable (7.23 t/ha) for maize production in Kharif season followed by Barisal (6.97 t/ha) and Jamalpur (6.53 t/ha). Gazipur location is not suitable for Kharif maize and produced only 5.33 t/ha. Uttaran showed highest yield in Jamalpur (8.18 t/ha) and lowest in Satkhira (5.88 t/ha).

900M Gold found highest yielding in Burirhat (8.11 t/ha) and lowest in Gazipur (5.51 t/ha). Pinnacle is also good in Burirhat (7.90 t/ha) and poor in Barisal (5.48 t/ha).

Quantitative characters like leaf rolling, leaf yellowing and leaf senescence were not found in Uttaran-2 except Satkhira location. Considering all the qualitative characters the variety Uttaran-2 is found stable over all the locations followed by 900M Gold and Pinnacle. But the cross of CML254 and CML247 is responsive to all the locations. Pacific60 is medium tolerant to excess water considering all the locations. Uttaran-2 produced good number of brace roots and brace root producing nodes, which are the most important indication to survive under water stress.

Table 1. Pooled analysis of variance for different characters in maize over five locations

Sources of variation	df	Mean sum of squares					
		Days to tasseling	Days to silking	Days to maturity	Plant height (cm)	Ear height (cm)	Yield (t/ha)
Location	4	29.68	63.68	199.52**	4387.56**	4226.12**	39.28**
Genotype	4	53.54*	56.88	99.25**	13431.0**	1264.09**	23.71**
Loc*Geno	16	139.92	118.45	127.68*	8861.25**	3563.02**	51.51**
Loc*Geno*Rep	50	264.00	275.33	191.33*	810.02*	709.65*	44.40*

**Significant level at $p < 0.01$, *Significant level at $p < 0.05$

Table 2. Mean performance of the test hybrids for different characters

Genotype	Days to tasseling	Days to silking	Days to maturity	Plant height (cm)	Ear height (cm)	Yield (t/ha)
Pacific60	49.20	52.13	95.33	185.86	89.19	5.97
Pinnacle	49.73	52.93	95.2	214.6	100.98	6.43
CML254×CML247	51.73	54.73	97.2	208.96	95.87	5.51
900M Gold	50.2	52.73	98.2	221.39	98.19	6.77
Uttaran-2	50.26	52.93	96.0	222.77	99.28	7.10
Overall mean	50.22	53.09	96.38	210.71	96.7	6.35
LSD (5%)	1.68	1.72	1.43	2.95	2.76	0.69

Table 3. Location wise yield (t/ha) performance of five hybrids

Variety	Location				
	Barisal	Burirhat	Gazipur	Jamalpur	Satkhira
Pacific60	7.07	5.85	4.38	5.07	7.55
Pinnacle	5.48	7.90	5.89	6.90	6.0
CML254XCML247	7.53	6.29	4.82	5.71	3.22
900M Gold	7.43	8.11	5.51	6.79	5.99
Uttaran-2	7.38	8.0	6.04	8.18	5.88
Overall mean	6.97	7.23	5.33	6.53	5.73
LSD (5%)	0.27	0.84	2.09	3.0	0.93

Table 4. Qualitative characters of five maize hybrids under water stress

Location	Variety	Qualitative characters						
		LR	LY	LS	BR	NBR	RL (%)	SL (%)
Barisal	Pacific60	0	2	0	2	4	9.84	18.14
	Pinacle	1	1	0	1	4	9.3	14.89
	CML254XCML247	1	2	1	2	2	11.54	9.54
	900M Gold	1	0	0	2	3	15.1	11.3
	Uttaran-2	0	0	0	1	3	10.56	8.03
Burirhat	Pacific60	0	2	0	2	4	9.3	12.2
	Pinacle	1	1	0	2	4	8.6	10.3
	CML254XCML247	1	2	1	2	2	10.75	10.6
	900M Gold	1	0	0	2	3	14.3	12.3
	Uttaran-2	0	0	0	2	3	9.3	5.8
Gazipur	Pacific60	0	1	0	1	4	7.5	5.2
	Pinacle	0	1	0	2	3	8.2	6.4
	CML254XCML247	1	2	0	1	2	12.3	7.8
	900M Gold	1	0	0	2	3	9.5	5.5
	Uttaran-2	0	0	0	1	3	7.6	4.8
Jamalpur	Pacific60	1	1	0	1	3	10.9	6.5
	Pinacle	0	1	0	2	3	9.6	7.4
	CML254XCML247	2	2	1	2	2	11.3	8.3
	900M Gold	1	1	0	2	3	8.6	5.8
	Uttaran-2	0	0	0	1	4	8.2	6.2
Satkhira	Pacific60	1	1	0	2	4	12.4	5.8
	Pinacle	0	2	1	3	3	10.6	9.2
	CML254XCML247	1	1	0	2	3	15	10.2
	900M Gold	1	1	0	1	4	8.3	6.2
	Uttaran-2	1	1	0	1	4	6.2	6.4

Note: Mean value of the qualitative characters of three replications. Leaf rolling (LR): 0 for no rolling, 5 for 100% rolling, Leaf yellowing (LY): 0 for no yellowing, 5 for 100% yellowing, Leaf senescence (LS): 0 for no senescence, 10 for 100% senescence, Brace root (BR): 1 for high brace root, 5 for no brace root, Nodes for brace root (NBR): 1 for 1st node, 5 for up to 5th, Root lodging (RL): Root lodging (%) and Stalk lodging (SL) : Stalk lodging (%)

Conclusion

Hybrid maize can grow all the year round, but excess water during Kharif season is a limiting factor in Bangladesh. A vast area remains under cover of waterlogged condition. Excess water tolerant hybrid maize varieties could be the better alternative to the farmer increasing the maize production in Bangladesh. Considering all the maize yield contributing characters to excess water tolerant parameters Uttaran-2, 900M Gold and Pinacle can be recommended as less susceptible to excess water stress varieties. For more authentications similar experiment can be taken with these varieties in Kharif season with few other more locations.

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