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Effect of Waterlogging on Yield and Yield Components in Maize Hybrids

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ABSTRACT

A field experiment was conducted at Agricultural College Farm, Bapatla during *kharif* 2014-15 to study the effect of waterlogging on yield and yield components in eight maize hybrids. The results revealed that waterlogging for six days decreased the yield and yield attributes. Waterlogging for six days decreased the cob length, cob weight, 100 seed weight, number of kernels per row, cob yield and kernel yield by 24.21, 37.98, 3.48, 29.99, 55.26 and 48.26 per cent respectively, over control. The cob girth and number of kernel rows per cob were not much influenced by waterlogging. Among the hybrids, Lakshmi-2277 maintained higher yield and its attributes followed by Bharati-99 and SY-280 where as CN-117 showed lower values of all the parameters. Hence Lakshmi-2277 followed by Bharati-99 and SY-280 are considered to posses waterlogging tolerance among the eight hybrids studied in the experiment.

Key words : Cob,Hybrids, Kernel, Maize, Waterlogging, Yield.

Maize [*Zea mays* L.] is the third most important cereal crop after rice and wheat and is known as "queen of cereals" because it has the highest genetic yield potential among the cereals. Maize ranks first in world production (868 Mt from 168 M ha) followed by wheat (691 Mt) and rice (461 Mt). This represents 38% of the total grain production as compared to 30 % for wheat and 20% for rice (Farmers Portal). In South and Southeast Asia, over 18% of the total maize growing areas are frequently affected by floods and water-logging problems (Zaidi *et al*, 2009). Out of the total 6.6 M ha area of maize, about 2.5 M ha is affected by excess soil moisture (ESM) problem that causes on an average 25-30% loss of national maize production almost every year (Rathore *et al*, 1996). Waterlogging significantly reduced the maize yield as well as its nutrient composition. Waterlogging also reduced the uptake of N, P, K, Fe, Mn and Zn by the crop (Savita and Shekhar 2008). Waterlogging stress in maize reduced the weight of 100 seeds and kernel yield but did not affect the number of kernel rows (Ferreira *et al.,* 2007). Keeping these aspects in view, the present study was taken up to study the effect of water logging on yield and yield components of maize hybrids.

MATERIAL AND METHODS

A field experiment was conducted at Agricultural College Farm, Bapatla during *kharif* 2014-15. The experiment was laid out in sandy clay loam soil in a split plot design with two main treatments and eight maize hybrids as sub plots and replicated thrice. Treatments consisted of waterlogging treatments as main plots, M_1- Control (No waterlogging), M_2 -Waterlogging for 6 days (at knee height stage *i.e*., 30 DAS) and maize hybrids as subplots (*viz*., 33A96, King-3063, Bharati-99, Sandya-666, Lakshmi-2277, CN-117, JKMH-4545 and SY-280). The plot size was 4mx3m with spacing of 60cmx20cm. Waterlogging was imposed at knee height stage *i.e*., at 30 DAS for six days (from 30 to 35 DAS) and control plants were maintained under normal irrigation. Waterlogging was administered by applying heavy irrigation to the plots and the soil was kept saturated with water above field capacity by continuous flooding, usually every day twice to create an oxygen deficient environment. The crop was grown following the recommended package of practices and timely plant protection measures were adopted. The data on yield and yield components were recorded separately plot wise at harvest and analyzed as per the standard statistical procedures described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Significant differences were observed between waterlogging treatments and maize hybrids with regards to cob length, cob girth and cob weight but the interaction was non-significant (Table 1). The cob length, girth and weight were decreased by 24.2, 10.4 and 38.0 per cent, respectively over control plants at harvest. Similar results were also reported in maize (Ajaz and Warsi, 2009 and Zaidi *et al*., 2003). Ferriera *et al*. (2008) reported that waterlogging stress induced low oxygen concentration in soil (hypoxia) or complete absence of oxygen (anoxia) which affected the nutrient uptake, synthesis and translocation of growth regulators, photosynthesis, respiration and carbohydrate partitioning and decreased the yield of crops. Among the hybrids tested, Lakshmi-2277 recorded higher cob length (16.6 cm) and cob weight (156 g) and it was on a par with Bharati and SY-280, where as lower cob length (14.9) and cob weight (136.2 g) were recorded by CN-117. Maize hybrids did not significantly differ pertaining to cob girth.

Maize hybrids grown under waterlogged condition recorded 10.4, 30.0 and 3.5 per cent reduction with regards to number of kernel rows per cob, number of kernels per row and 100 grain weight, respectively over control plants (Table 2). Among the maize hybrids tested, Lakshmi-2277 recorded higher number of kernels per row (31.2) and 100 grain weight (30.3 g) and it was on a par with all other hybrids except CN-117, which recorded lower number of kernels per row (26.0) and 100 grain weight (29.5 g). No significant difference was observed among the maize hybrids with respect to number of kernel rows per cob.

Among the interactions, under waterlogging condition the maize hybrids Lakshmi-2277 and Bharati-99 recorded higher number of kernels per row, whereas CN-117 recorded lower number of kernels per row. Under non-waterlogged condition, Sandya-666 and 33A96 recorded higher number of kernels per row where as CN-117 recorded lower number of kernels per row.

Significant differences were observed between waterlogging treatments and maize hybrids with regards to cob yield and kernel yield but the interaction was non-significant (Table 2). The cob yield and kernel yield were reduced by 55.3 and 48.3 per cent respectively due to waterlogging over control. Similar results were also reported in maize (Ajaz and Warsi, 2009 and Zaidi *et al*., 2003). The maize hybrid Lakshmi-2277 recorded higher cob yield (7301.8 Kg ha^{-1}) and kernel yield (3880.1 Kg ha^{-1}) followed by Bharati-99 and SY-280. The lowest cob yield (6188.3 Kg ha^{-1}) and kernel yield (2936.0 Kg ha^{-1}) were recorded by the maize hybrid CN-117.

Reduction in yield in waterlogging treatment was due to oxygen deficiency, anaerobic conditions and less root activity which can impair the water absorbing ability of the plants as well as translocation of dry matter possibly due to damage caused to the root system. Such inhibition may also be due to adverse effects of waterlogging on water and mineral uptake (Hocking *et al.,* 1987). Waterlogging stress induced low oxygen concentration in soil (hypoxia) or complete absence of oxygen (anoxia) which affected the nutrient uptake, synthesis and translocation of growth regulators, photosynthesis, respiration and carbohydrate partitioning and decreased the yield of crops (Ferreira *et al.*, 2008*).* Similar results were also reported in greengram (Laosuwan *et al.,* 1994) and in wheat (Olgun *et al.,* 2008).

Higher kernel yield in Lakshmi-2277 might be due to higher leaf number and leaf area, higher Spad Chlorophyll Meter Reading values, higher total dry matter and quick recovery of photosynthesis after waterlogging and more translocation of assimilates to reproductive parts. It also showed lesser increase in Anthesis -silking Interval (3.60 days). Ajaz and Warsi, (2009) reported a positive relationship between plant height and SCMR values with yield and negative relationship between increase in ASI and yield in maize. Similar differences among hybrids were also reported in maize (Zaidi *et al.,* 2002).

Conclusion:

From the above results, it can be concluded that the waterlogging stress significantly affected maize yield and its components. Kernel yield decreased by 48.3 per cent under waterlogging condition. Among the hybrids, Lakshmi-2277 recorded higher yield and yield components followed by Bharati-99 and SY-280 where as CN-117 recorded lower yield and yield components

Table 1. Effect of waterlogging on Yield and yield components in maize.

Name of the Hybrid	Cob length (cm)			Cob girth (cm)			Cob weight (g)			Test weight (g)		
	Control	Waterlogging	Mean	Control	Waterlogging	Mean	Control	Waterlogging	Mean	Control	Waterlogging	Mean
33A96	18.22	13.00	15.61	15.21	13.71	14.46	173.2	106.17	139.67	30.82	29.20	30.01
King-3063	17.57	12.95	15.27	15.33	13.47	14.40	172.01	109.67	140.84	30.81	29.17	29.99
Bharati-99	18.49	14.49	16.49	15.12	13.89	14.50	186.97	124.27	155.62	30.71	29.59	30.15
Sandya-666	18.21	13.07	15.64	14.97	13.38	14.18	176.31	101.84	139.07	29.86	29.36	29.61
Lakshmi-2277	18.44	14.73	16.58	15.61	13.99	14.80	190.15	122.13	156.14	30.75	29.81	30.28
CN-117	17.30	12.52	14.91	14.75	13.05	13.90	174.77	97.63	136.20	30.05	28.94	29.50
JKMH-4545	17.21	13.78	15.50	15.78	13.52	14.66	175.58	113.02	144.30	30.64	29.55	30.09
SY-280	18.27	14.47	16.36	15.13	14.18	14.66	189.65	117.58	153.61	30.39	29.88	30.14
Mean	17.97	13.62 (-24.2%)*		15.23	13.65 (-10.4%)*		179.83	111.53 (-38.%)*		30.50	29.44 (-3.5%)*	
	Main	Hybrids	Interaction	Main	Hybrids	Interaction	Main	Hybrids	Interaction	Main	Hybrids	Interaction
SEm	0.17	0.35	0.13	0.18	0.37	0.14	3.43	3.94	2.14	0.06	0.15	0.05
CD (5%)	0.60	1.01	NS	0.64	NS	NS	11.87	11.49	NS	0.21	0.45	NS
CV	5.33	5.36		6.26	6.19		11.54	6.62		1.00	1.27	

* The figures in parenthesis indicate the percent reduction over control.

Table 2. Effect of waterlogging on Yield and yield components in maize.

Name of the	Number of kernel rows per cob			Number of kernels per row			Cob yield (Kg ha^{-1})			Kernel yield (Kg ha^{-1})		
	Control	Waterlogging	Mean	Control	Waterlogging	Mean	Control	Waterlogging	Mean	Control	Waterlogging	Mean
33A96	14.47	13.33	13.90	35.67	21.93	28.80	9656.94	3877.50	6767.22	4640.28	2011.94	3326.11
King-3063	14.4	13.07	13.73	35.53	21.47	28.50	9224.28	3744.17	6484.22	4873.61	1841.11	3357.36
Bharati-99	14.93	13.30	14.12	34.87	27.33	31.10	10138.61	4385.56	7262.08	4848.61	2875.56	3862.08
Sandya-666	14.67	13.20	13.93	36.80	22.87	29.83	9064.72	3797.50	6431.11	4192.78	1727.78	2960.28
Lakshmi-2277	14.33	13.93	14.13	34.67	27.67	31.17	9539.72	5063.89	7301.81	4741.39	3018.89	3880.14
CN-117	14.67	12.27	13.47	31.33	20.53	25.93	8859.72	3516.94	6188.33	4076.11	1795.83	2935.97
JKMH-4545	14.53	13.60	14.07	34.47	26.13	30.3	9278.75	4444.17	6861.46	4566.67	2548.33	3557.50
SY-280	14.33	13.87	14.10	35.13	27.00	31.07	9553.33	4862.50	7207.92	4560.83	3065.00	3812.92
Mean	15.24	13.65 (-10.4%)*		34.81	24.37 (-30%)*		9414.51	4211.53 (-55.3%)*		4562.53	2360.56 (-48.3%)*	
	Main	Hybrids	Interaction	Main	Hybrids	Interaction	Main	Hybrids	Interaction	Main	Hybrids	Interaction
SEm	0.25	0.29	0.16	0.36	0.67	0.27	177.12	210.66	111.29	68.66	165.50	58.07
CD (5%)	0.90	NS	NS	1.26	1.97	0.81	612.94	614.92	NS	237.61	483.09	NS
CV	9.12	5.14		6.05	5.60		12.74	7.57		9.72	11.71	

* The figures in parenthesis indicate the percent reduction over control.

under waterlogging condition. Lakshmi-2277 is a superior hybrid in producing higher dry matter, better assimilate transfer from source to sink and higher yields under waterlogged conditions due to its quick recovery after waterlogging stress followed by Bharati-99 and SY-280. Hence, the maize hybrid Lakshmi-2277 is recommended to Agro-Climatic Zone -III (Guntur and Prakasam) of Andhra Pradesh because of its inbuilt tolerance to waterlogging stress.

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