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Research Communication

Hydro and aeroponic technique for rapid drought tolerance screening in maize (*Zea mays*)

BHUPENDER KUMAR[1], SHRADDHA SRIVASTAVA[2], HARPREET KAUR[3], PRANJAL YADAVA[4], SHANKAR LAL JAT[5], CHITER MAL PARIHAR[6], ADITYA KUMAR SINGH[7], TANU TIWARI[8], VINOD KUMAR[9], SAVITA SHARMA[10] AND JYOTI KAUL[11]

ICAR-Indian Institute of Maize Research, New Delhi 110 012

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ABSTRACT

Present study was carried out under field and controlled conditions at New Delhi during 2015 and 2016 to standardize a new rapid screening technique to identify drought tolerant maize (*Zea mays* L.)genotypes. The genotypes have shown variable wilting symptoms and recovery during the stress and while reverting back to hydroponic, respectively. Only the tolerant genotypes, viz. hybrid 'PMH 4' and inbreds 'DQL633-1-1', 'DQL 790 PG-2-4', 'CM 125', 'CM 140', and 'LM 14' have shown less wilting and much faster recovery compared to susceptible ones viz., 'IMH 1415', 'CML 327', 'CML 207', 'CML 176', 'CML 266', and 'CML 556(W)'. The new rapid method could able to identify and verified the drought tolerant and susceptible genotypes very effectively at seedling stage and therefore it can be utilized in breeding programme for preliminary identification of drought tolerant and susceptible genotypes.

Key words : Aeroponics and hydroponics, Drought tolerance score, Maize multi-location testing, Yield

Drought stress is the most important production constraint in maize, especially in rainfed agriculture. In India, maize is principally grown as rainfed crop with 80 percent of its area under rainfed ecology. Therefore the development of drought tolerant genotypes may significantly contribute toward the improvement of maize productivity. There are different traits and screening techniques for selection of drought tolerant genotypes, but they have their own merits and demerits. Short anthesis silking interval (ASI) in maize is an important trait for identifying drought tolerant genotypes at flowering stage (Kumar *et al*., 2016), however the possibility of identifying tolerant genotypes at seedling stage may be further exploited.

Root plays an important role in nutrient uptake, anchoring of plant to the soil and to survive under drought stress conditions. But, there is difficulty of measuring root characteristics in a large number of genotypes/plants in field without destruction. Seedlings stage evaluation can fasten/economize the screening technique for drought stress tolerance by screening large numbers of germplasm in minimum time under glass house conditions e.g. by growing plants in pots and hydroponics solution but they have their own demerits (Munns *et al.,* 2010; Nye and Tinker, 1977; Passioura, 2006). Therefore, as an alternative to stress tolerance screening in the field, hydroponics along with aeroponic may allows rapid and low cost screening of large number of genotypes by exposing drought stress at a seedling stage (Singh *et al*., 2013).

The field trials were conducted under managed low moisture stress at New Delhi using 43 and 26 maize hybrids during *khairf* 2015 and *rabi* 2015–16, respectively. Further, a set of 48 hybrids was again evaluated in rainout shelter during *kharif* 2016. Three same set of trials viz., control, stress at flowering and stress at grain filling stage were constituted and evaluated in randomized block design (RBD) with three replications. Low moisture stress was induced at flowering stage by avoiding irrigation at 15 days before initiation of flowering and at grain filling stage by avoiding irrigation after completion of pollination. In grain filling set, the low moisture stress was continued for 20 days after pollination. After additive main effect and multiplicative interaction (AMMI) analysis, two maize hybrids i.e. 'PMH4' and 'DMRH 1306' were iden-

[1]**Corresponding author Email:** bhupender.iari@gmail.com
[1]Scientist, Plant Breeding, [2,3,8,9,10]Senior Research Fellow, Plant Breeding, [4]Scientist, Plant Biotechnology, [5]Scientist, Agronomy, [7]Principal Scientist, Agronomy, ICAR-Indian Institute of Maize Research, New Delhi; [6]Scientist, Agronomy, [11]PrincipalScientist, Plant Breeding, ICAR-Indian Agricultural Research Institute, New Delhi 110 012

tified as winning genotypes under low moisture as well as in normal conditions across the environments (Table 1). Further, three hybrids viz., 'IMH 1415', 'DMRH 1410' and 'HM 5' were identified as low performing genotypes under low moisture stress conditions.

The genotypes identified as drought tolerant and susceptible under field evaluation were verified under control conditions. Two maize hybrids viz. 'PMH 4' and 'IMH 1415' along with 50 inbred lines were used as experimental materials to identify and verify the drought tolerance under glass house. The experiment was carried out in glass house with growing parameters viz., air temperature: 29/25^{o} C day/night; photoperiod 16 h light; and the relative humidity of approximately 60%. Initially, seedlings were raised in moistened germination papers for about one week. After one week, relatively uniform seedlings were selected and transferred to hydroponic solution. Different concentrations of macro and micro nutrients were used for optimization to get better plant growth in hydroponics. A separate replicated set of same genotypes was grown in readymade Hoagland solution.

Drought stress was imposed one week post- transplantation (in 2 weeks old seedling) using aeroponic method, by removing plants from the nutrient solution and exposed to air for 6 hours and 4 hours daily for a period of 5 and 4 consecutive days in hybrid and inbred lines, respectively. In control set, the plants were kept drought free by keeping continuously in nutrient solution for the entire period of development without any interruption. The nutrient solution was regularly aerated by bubbling air using aquarium pumps in trays and solution was replaced after every 3 days. Genotypes identified tolerant and susceptible

Table 1. Relative yield (t/ha) and anthesis silking interval (ASI) of genotypes identified as drought tolerant and susceptible through additive main effect and multiplicative interaction (AMMI) selections under field and rainout shelter evaluation

Hybrids	Under field conditions								Under rainout shelter				Remarks
	Yield t/ha) (Drought-stress)		Yield (t/ha) (Drought-free)		Anthesis silking interval (Drought-stress)		Anthesis silking interval (Drought-free)		Yield (t/ha)		Anthesis silking interval		
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	Drought-stress	Drought-free	Drought-stress	Drought-free	
'PMH 4'	5.8	6.7	6.5	8.3	3.2	2.5	1.8	1.8	4.9	5.4	3.0	1.5	Tolerant
'DMRH 1306'	5.5	6.5	6.7	8.9	3.0	3.2	1.5	1.8	4.7	5.0	2.7	2.0	Tolerant
'DMRH1410'	3.2	4.5	5.8	6.9	4.5	5.3	2.5	2.7	2.4	4.3	5.8	3.2	Susceptible
'IMH1415'	3.6	4.8	5.8	7.4	4.8	5.5	2.2	2.8	3.2	4.5	6.2	2.5	Susceptible
'HM5'	2.5	4.0	5.9	6.5	4.3	5.8	2.8	3.2	2.9	3.7	5.2	3.2	Susceptible
SEm±	0.22	0.23	0.22	0.12	0.27	0.32	0.23	0.30	0.19	0.16	0.33	0.23	
CD (P=0.01)	1.5	1.5	1.4	0.9	1.7	2.1	1.5	2.0	1.3	1.0	2.1	1.5	

Table 2. Performance of tolerant and susceptible genotypes in control and drought stress for various root and shoot parameters observed under hydro and aeroponic conditions

Genotypes	Mean shoot weight (g)				Mean root weight (g)				Mean root length (cm)		Drought tolerance score
	Fresh weight		Dry weight		Fresh weight		Dry weight				
	Stress	Control	Stress	Control	Stress	Control	Stress	Control	Stress	Control	
'PMH 4'	2.14	4.85	0.57	0.87	0.49	0.57	0.11	0.18	33.8	42.9	2.92
'IMH1415'	1.55	6.53	0.29	1.70	0.23	0.62	0.04	0.12	24.4	44.0	8.27
'DQL 633-1'	1.51	1.80	0.34	0.66	0.17	0.26	0.08	0.09	21.3	32.6	3.27
'CM 125'	0.74	1.32	0.27	0.48	0.15	0.17	0.07	0.13	29.6	32.3	3.03
'CM 140'	1.09	1.90	0.26	0.57	0.23	0.26	0.08	0.15	29.4	35.3	3.20
'LM 14'	1.30	2.28	0.36	0.65	0.23	0.32	0.35	0.10	28.0	33.3	3.17
'DQL 790-4'	1.03	2.13	0.25	0.55	0.17	0.31	0.07	0.55	22.1	32.5	2.97
'CML 327'	0.55	2.20	0.13	0.54	0.09	0.29	0.03	0.08	21.3	46.0	8.50
'CML 207'	0.49	1.84	0.07	0.47	0.07	0.22	0.02	0.11	20.3	31.9	8.23
'CML 176'	0.52	1.80	0.07	0.41	0.08	0.29	0.04	0.05	13.3	31.4	8.19
'CML 266'	0.29	1.36	0.06	0.40	0.08	0.34	0.03	0.10	22.7	31.5	8.10
'CML556'	0.46	1.67	0.14	0.59	0.14	0.17	0.04	0.05	21.7	30.3	7.80
SEm±	0.03	0.05	0.01	0.02	0.02	0.01	0.01	0.02	0.16	0.17	0.09
CD (P=0.01)	0.16	0.33	0.10	0.13	0.13	0.08	0.05	0.11	0.98	1.06	0.55

*≤3.0 = tolerant; 3.1 to 5.0 = moderately tolerant; 5.1 to 7.0 = moderately susceptible; 7.1 to 9.0= susceptible.
'PMH4' and 'IMH 1415' are hybrids, rest all are inbred lines.

were again verified in pots by growing seedlings in mixture of coco-peat, vermiculite and sand. The stress was induced at 3 to 5 leaves stage and continued for 20 days in hybrids and 15 days in inbred lines. Again the control set was kept free from drought stress by supplying water in interval of 2 days in both hybrids and inbreds pots. After stress treatment, all the genotypes were rated for drought tolerance on a 1–9 scale: ≤3.0 = green plants with slight wilting (tolerant), 3.1 to 5.0 = green plants with moderate wilting (moderately tolerant), 5.1 to 7.0 = leaves turning yellowish green with moderate to high wilting (moderately susceptible), 7.1 to 9.0 = leaves yellow- brown to completely dried leaves and/ or stems (susceptible). Genotypes with the lowest and highest scores were considered to be the most tolerant and susceptible to drought stress respectively. Plants were harvested and data on shoot weight; root weight (fresh and dry) and root length (fresh) was recorded for all the treatments.

The wilting effect of stress was first observed after 2.0 to 3.0 hours of air exposure on the leaves, on first day of treatment. The inbred lines were found much more sensitive than hybrid lines. Most of the genotypes have shown variable wilting when their plants were exposed to air and afterword only the tolerant genotypes viz. 'Hybrid PMH 4' and inbreds 'DQL633-1-1', 'DQL 790' 'PG-2-4', 'CM 125', 'CM 140' and 'LM 14' (Table 2) showed much faster recovery and less wilting compared to susceptible one [Hybrid, 'IMH 1415' and inbreds 'CML 327', 'CML 207', 'CML 176', 'CML 266', 'CML 556(W)']. Even susceptible genotypes, viz. 'CML 327', 'CML 207', 'CML 176', 'CML 266', 'CML 556(W)' did not show any recovery when returned to the nutrient solution. Differences between tolerant and susceptible genotypes become much prominent as the days past. Almost complete seedling dryness was observed in susceptible genotypes.

Drought stress is a major constraint in enhancing maize productivity worldwide. Therefore identifying of drought tolerant maize genotypes and effective methodology for their screening are the major objectives in maize breeding programme. So far, stress induced by using various stimulants in hydroponic was the one of the normal technique in maize for identify of drought tolerant and susceptible genotypes at seedling stage. However, for the first time in this study in maize, we have tried hydroponic along with aeroponic evaluation for drought stress which could able to identify drought tolerant and susceptible genotypes with minimum time-span. The results are also under validation in pots screening and at genomic level. This technique may be utilized for preliminary identification of drought tolerant and susceptible genotypes under controlled conditions.

REFERENCES

Kumar, B., Guleria, S.K., Khanorkar, S.M., Dubey, R.B., Patel, J.M., Kumar, V., Parihar, C.M., Jat, S.L., Singh, V., Yathish, K.R., Das, A., Sekhar, J.C., Bhati, P., Kaur, H., Kumar, M., Singh, A., Varghese, E. and Yadav, O.P. 2016. Selection indices to identify maize (*Zea mays* L.) hybrids adapted under drought stress and drought-free conditions in a tropical climate. *Crop and Pasture Science* DOI: http://dx.doi.org/10.1071/CP16141.

Munns, R., James, R.A., Sirault, X.R.R., Furbank, R.T. and Jones, H.G. 2010. New phenotyping methods for screening wheat and barley for beneficial responses to water deficit. *Journal of Experimental Botany* **61**(13): 3,499–3,507.

Nye, P.H. and Tinker, P.B. 1977. Solute movement in the soil–root–system. (In) Anderson DJ, Greig-Smith P, Pitelda FA, eds. *Studies in Ecology Vol. 4*. Berkeley, CA: University of California Press. 8–13.

Passioura, J.B. 2006. The perils of pot experiments. *Functional Plant Biology* **33**: 1,075–1,079.

Singh, D., Dikshit, H.K. and Singh, R. 2013. A new phenotyping technique for screening for drought tolerance in lentil (*Lens culinaris* Medik). *Plant Breeding* DOI: 10.1111/pbr.12033.