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Identification of Drought Tolerant Maize (*Zea mays* L.) Hybrids and Correlation between Characters under PEG-6000 Induced Drought

R. Nirmal Raj[1], C.P. Renuka Devi[2] and J. Gokulakrishnan[3]

[1]PG Scholar, Annamalai University Chidambaram
[2]PG Scholar, Annamalai University, Chidambaram
[3]Assistant Professor, Annamalai University, Chidambaram
E-mail: [1]rnimmu37@gmail.com, [2]renuka7845@gmail.com, [3]gokulayamuna@ gmail.com

Abstract—*Maize is a high yielding crop among cereals which accounts for a major share of global food production. Identifying drought tolerant maize hybrids at seedling stage could be more feasible for commercial recommendations. Twenty one hybrids were taken for PEG induced drought screening and twelve characters were taken for study. A laboratory experiment was laid out under completely randomized design (CRD) with two replications. PEG-6000 treatment was applied in three concentrations which induced osmotic stress levels of 0, -3 and -6 bars respectively. A significant reduction in mean performance of characters viz., germination percentage, shoot length, seminal root length, fresh weight, dry weight, seed vigour index I and seed vigour index II were observed with the increase in concentration of PEG-6000. The mean performance revealed that the hybrids AUK-30 and AUMH-8855 were drought tolerant. The characters showed positive correlation between all the characters under severe drought stress. Germination percentage and germination stress tolerance index were deemed as reliable indicators to screen the drought tolerant hybrids at seedling stage.*

Keywords*: Drought, PEG-6000, Osmotic stress, CRD, Correlation.*

1. INTRODUCTION

Maize (*Zea mays* L.) is a valuable cereal crop which is used as both food and fodder. The global importance of the crop and the changing climate has encouraged identifying drought tolerant maize hybrids [2]. Four tenths of the world's agricultural land lies in arid or semi arid regions and maize is cultivated mainly in dry land (69%) than in irrigated fields (21%) [4]. Drought at a stretch can cause death of livestock, famine and social dislocation. The failure of monsoon results in acute shortage of irrigation water and water stress at critical stages has damaging effects on the growth of plants [7]. Osmotic stress has diminishing effects on seed emergence [9].

2. MATERIALS AND METHODS

The investigation was conducted in Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University. Twenty one hybrids were used to study the effect of drought stress by using PEG-6000 on germination and early seedling growth characters and experiments were laid out in completely randomized design. The study was performed in petriplates having filter paper. The seeds of homogenous size were selected and surface sterilized for 5 min in 1% (v/v) sodium hypochlorite. Ten seeds of each hybrid were placed in the petridishes with corresponding PEG concentration (0, 10 and 20%) and the osmotic stress induced (0, -3 and -6 bar) by each concentration was calculated by using the equation of Michel [8].

$$\Psi s = -(1.18 \times 10^{-2})\, C - (1.18 \times 10^{-4})\, C_2 + (2.67 \times 10^{-4})\, CT + (8.39 \times 10^{-7})\, C_2T$$

Where, Ψs = Osmotic potential (bar)

C = Concentration (g L^{-1} PEG-6000 in water)

T = Temperature (°C)

Six observed characters were recorded up to seven days. After seven days, emergence percentage, shoot length, root length, seminal root length, dry weight, fresh weight and other drought indices are recorded. Stress tolerance indices were calculated following protocol given by International Seed Testing Agency [6].

1. EP (%) = (NGS / TNS) × 100

Where, EP is Emergence percentage, NGS is the number of germinated seeds and TNS is the total number of viable seeds taken for the experiment [12].

2. PI (%) = nd2 (1.00) +nd4 (0.75) +nd6 (0.5) +nd8 (0.25)

Where, PI is promptness index, nd is the number of seeds germinated on the day of observation [5].

3. GSTI (%) = [PI of stressed seeds / PI control seeds] × 100

Where, GSTI is Germination Stress Tolerance Index.

4. SLSI (%) = (Shoot length of stressed plant / Shoot length of control plants) × 100

Where, SLSI is Shoot length stress index

5. RLSI (%) = (Root length stressed plant / Root length of control plants) × 100

Where, RLSI is Root length stress index.

6. Seed vigour I (SVI) = germination percentage × seedling length [1].

7. Seed vigour II (SVII) = germination percentage × dry weight [1].

3. RESULTS AND DISCUSSIONS

Combined analysis of variance showed significance difference among hybrids under drought stress and revealed significant treatment effect on hybrids, hence selection of a drought tolerant hybrid was possible (Table 1).

The mean comparisons (Table 2) recorded highest mean values for control and decreased significantly under the influence of PEG-6000. Desirable mean values were recorded for characters *viz.*, emergence percentage, promptness index, germination stress tolerance index, root length, shoot length and all other tolerance indices by hybrids G_5 (AUK-30) and G_9 (AUMH-8855). Seed emergence was significantly reduced with an increase in PEG concentration. Similar study and reports were given by Partheeban [11] and Zahoor Ahmad [13] in maize. Reduction in seed emergence is attributed to reduced cell division and plant growth metabolism [3]. Root growth is an able indicator for drought tolerance and would result in a better root architecture at maturity [10].

Overall *per se* performace revealed that the hybrid G_5 (AUK-30) had higher significant values for nine characters followed by the hybrid G_9 (AUMH-8855) which showed significant mean values for eight characters. Thereby these two hybrids can be tagged as drought tolerant.

Correlation analysis was done for six observed characters with two vigour indices and revealed significant positive correlation between root length and SV I, whereas for SV II only root length showed positive correlation in control. Emergence percentage, shoot length and root length showed highly significant positive correlation with seed vigour indices under varying drought stress levels and under water stress all the six observed characters were positively correlated to each other and to the vigour indices (Tables 3 & 4). Hence selection for drought tolerance can be made on the basis of characters *viz.*, emergence percentage and root length at early growth stage. These results are in agreement with the findings of Partheeban [11].

The present investigation concluded that the two maize hybrids AUK-30 and AUMH-8855 are drought tolerant (Fig 1 & 2). The study also revealed that variation among genotypes for promptness index and germination stress tolerance index (GSTI) was found to be a reliable indicator of drought tolerance in maize. Seed emergence and root length were found to be in positive correlation with vigour indices under osmotic stress hence, selection can be made on the basis of these characters at seedling stage.

Table 1: Analysis of variance on mean of squares of measured traits in maize hybrids under drought stress

Source	df	EP (%)	PI (%)	GSTI (%)	SL (cm)	SLSI (%)	RL (cm)	RLSI (%)	SRL (cm)	FW (g)	DW (g)	SV I (%)	SV II (%)
Genotype	20	462.14**	4.25**	376.00**	1.43**	176.84**	6.32**	1157.53**	4.11**	0.03**	0.01**	90366.88**	53.33**
Treatment	2	36144.05**	369.09**	40760.11**	60.29**	47126.32**	59.84**	34515.14**	82.43**	0.42**	0.08**	2552009.00**	2173.81**
G × T	40	120.30**	1.04**	110.46**	0.41**	99.92**	1.31**	559.68**	0.79**	0.02**	0.01**	18480.88**	24.10**
Error	60	5.99	0.07	6.72	0.00	0.38	0.00	0.34	0.00	0.00	0.00	376.51	0.68

*: Significant at 5% level; **: Significant at 1% level

EP- Emergence percentage, PI- Promptness index, GSTI- Germination stress tolerance index, SL- Shoot length, SLSI- Shoot length stress index, RL- Root length, RLSI- Root length stress index, SRL- Seminal root length, FW- Fresh weight, DW- Dry weight, SV I- Seed vigour I, SV II- Seed vigour II.

Table 2: Mean comparison of main effects of maize hybrids

Genotypes	EP (%)	PI (%)	GSTI (%)	SL (cm)	SLSI (%)	RL (cm)	RLSI (%)	SRL (cm)	FW (gm)	DW (gm)	SV I (%)	SV II (%)
G_1	45.00	4.08	45.37	2.11	52.73	3.60	74.85	2.39	0.30	0.16	390.35	10.48
G_2	53.33	5.05	58.52	2.92	55.45	3.08	81.63	1.92	0.37	0.19	404.83	10.67
G_3	46.67	4.57	45.70	2.92	53.11	4.38	62.53	3.24	0.32	0.14	541.93	9.83
G_4	58.33	5.61	56.80	1.77	63.15	5.07	88.88	3.43	0.39	0.21	453.03	13.18

G_5	86.67	8.40	84.02	2.77	65.26	6.73	112.15	4.90	0.43	0.25	849.08	21.08
G_6	43.33	4.19	43.25	0.90	37.45	0.94	70.95	1.42	0.19	0.08	141.73	5.22
G_7	43.33	4.17	46.33	1.61	50.08	3.25	69.00	2.88	0.28	0.13	326.12	9.17
G_8	46.67	4.54	45.43	1.24	43.95	3.02	75.12	3.53	0.24	0.11	307.60	7.73
G_9	76.67	7.46	74.63	2.26	57.23	5.51	129.84	4.94	0.44	0.25	618.00	18.93
G_{10}	46.67	4.72	47.73	1.95	47.50	4.70	86.54	2.01	0.50	0.31	390.83	16.00
G_{11}	40.00	4.27	42.72	1.49	38.46	3.31	71.77	1.04	0.33	0.19	313.30	11.90
G_{12}	50.00	5.01	50.05	2.68	47.16	3.69	100.82	2.94	0.47	0.19	394.45	9.70
G_{13}	46.67	4.47	46.35	1.25	37.36	1.83	72.20	1.26	0.20	0.09	240.73	6.53
G_{14}	53.33	5.17	52.36	1.29	52.71	3.43	106.86	2.38	0.48	0.23	289.15	12.90
G_{15}	50.00	4.30	53.68	0.92	51.30	3.48	111.72	3.17	0.44	0.22	240.32	11.60
G_{16}	40.00	3.70	39.15	1.32	46.03	3.06	76.22	2.93	0.42	0.24	271.40	15.27
G_{17}	41.67	3.99	46.13	1.14	49.11	1.74	95.28	2.19	0.41	0.26	155.15	10.42
G_{18}	60.00	5.68	58.08	1.86	53.94	5.16	103.00	4.80	0.39	0.21	472.48	12.05
G_{19}	71.67	6.59	67.54	2.83	56.37	5.65	113.89	3.75	0.48	0.27	675.07	18.67
G_{20}	46.67	4.32	46.02	0.99	40.89	2.57	59.74	2.02	0.44	0.26	277.13	18.03
G_{21}	58.33	5.46	56.62	1.96	52.90	5.33	103.36	4.38	0.38	0.19	486.17	11.58

Table 3: Genotypic and phenotypic correlation among various observed characters and seed vigour indices (Control)

Characters		EP	SL	RL	SRL	FW	DW	SV I	SV II
EP	G	1.000	-0.107	0.204	0.456*	-0.131	-0.193	0.244	-0.021
SL	G		1.000	0.508*	0.155	0.037	-0.143	0.790**	-0.163
RL	G			1.000	0.487*	0.240	0.229	0.910**	0.263
SRL	G				1.000	-0.077	-0.137	0.475*	-0.055
FW	G					1.000	0.877**	0.146	0.879**
DW	G						1.000	0.032	0.984**
SV I	G							1.000	0.073
SV II	G								1.000

*: Significant at 5% level; **: Significant at 1% level

Table 4: Genotypic and phenotypic correlation among various observed characters and seed vigour indices under drought

Characters		EP	SL	RL	SRL	FW	DW	SV I	SV II
EP	G	1.000	0.981**	0.888**	0.927**	0.720**	0.751**	0.956**	0.988**
SL	G		1.000	0.912**	0.937**	0.777**	0.788**	0.917**	0.959**
RL	G			1.000	0.903**	0.900**	0.903**	0.818**	0.874**
SRL	G				1.000	0.714**	0.708**	0.881**	0.915**
FW	G					1.000	0.972**	0.563**	0.672**
DW	G						1.000	0.607**	0.728**
SV I	G							1.000	0.976**
SV II	G								1.000

*: Significant at 5% level; **: Significant at 1% level

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