

Original Research Article

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Effect of Peg-6000 Induced Drought on Physiological Indices and Correlation of Seedling Stage Traits in Maize (*Zea mays* L.) Hybrids

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ABSTRACT

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Maize is an economically important crop and also a major shareholder in the global food bowl. The queen of cereals is widely cultivated across varied topography. Climate change and its related water stress are on the increase, reducing the yield potential of maize. The experiment with PEG-6000 was carried out in a completely randomized block design with two replications for twenty maize hybrids. The concentrations of PEG-6000 taken for study were 0%, 10% and 20%. The osmotic stress inducer had a drastic reducing effect on the six physiological characters and their related indices except for root length which showed an increased *per se* performance under moderate osmotic stress. Germination percentage was the most affected character under water stress. Association analysis between characters identified three effective parameters for indirect selection under drought *viz.*, germination percentage, root length and promptness index. These characters are utmost suitable for selecting tolerant hybrids at seedling stage.

Introduction

Maize is an interesting crop in terms of its wide area of cultivation and hybrid yield potential however; various abiotic stresses limit the magnitude of yield. Water stress due to drought is one such stress that plays a significant role in crop growth and development (Hartman *et al.*, 2005).

The never ending demand for maize crop and growing monsoon failure has tilted the objectives of plant breeding towards the identification of hybrids tolerant to water stress (Avramova *et al.*, 2015). The screening

for water stress is facilitated by a high molecular weight chemical called PEG-6000 and this induces varying osmotic pressure at different concentrations (Hardegree and Emmerich, 1990).

It is a better agent than mannitol as the latter could induce certain toxic effects to the growth of a plant (Hohl and Schopfer, 1991) and is an able laboratory screening method.

Hence, an attempt was made to understand the effects PEG-6000 on seedling vigour indices and the association between traits under drought.

Materials and Methods

The experiment was conducted at Abiotic stress laboratory, Annamalai University using twenty one maize hybrids and the design laid out was completely randomized design. Seeds of homogenous size were selected and placed in petridishes with germination papers. Ten seeds of each hybrid were placed in petridishes which was treated with corresponding PEG treatments diluted in distilled water (control, 10% and 20%). The osmotic pressure exerted by these concentrations was estimated using Michel’s formulae and the estimates were 0 bar, -3 bars and -6 bars respectively at 32°C.

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

Where, Ψ_s = Osmotic potential (bar)
 C = Concentration (g L⁻¹ PEG-6000 in water)
 T = Temperature (°C)

Seven physiological traits were recorded viz., germination percentage (%), shoot length (cm), root length (cm), seminal root length (cm), fresh weight (g), dry weight (g) and seed vigour index. The duration of experiment spanned for seven days and the data recorded

were subjected to mean performance analysis and character correlation assessment.

Results and Discussion

Combined analysis of variance was carried out which showed significant variation among hybrids and significant effect of PEG-6000 treatments on all the seven morphological traits (Table 1), hence an assessment of the effect of PEG solution on the observed indices were possible (Partheeban *et al.*, 2017).

Main effects of drought stress levels on the physiological indices were analyzed by comparing the *per se* performance which revealed high limiting effects on all the characters (Table 2). The most limited traits due to water stress were germination percentage followed by seedling vigour index. The rapid reduction in germination percentage is due to inefficient cell division and plant growth metabolism (Ayaz *et al.*, 2001). Root length increased under osmotic potential of -3 bars but under severe osmotic pressure the length decreased, emphasizing the role of vigorous root growth at seedling stage which would result in better root structure at maturity (Nejad, 2011).

Table.1 Analysis of variance of observed traits in maize hybrids under drought stress

Source	df	EP (%)	SL (cm)	RL (cm)	SRL (cm)	FW (g)	DW (g)	SV I (%)
Genotype	20	462.14**	1.43**	6.32**	4.11**	0.03**	0.01**	90366.88**
Treatment	2	36144.05**	60.29**	59.84**	82.43**	0.42**	0.08**	2552009.00**
G × T	40	120.30**	0.41**	1.31**	0.79**	0.02**	0.01**	18480.88**
Error	60	5.99	0.00	0.00	0.00	0.00	0.00	376.51

*: Significant at 5% level; **: Significant at 1% level
 EP- Emergence percentage SL- Shoot length, SLSI- Shoot length stress index, RL- Root length, SRL- Seminal root length, FW- Fresh weight, DW- Dry weight, SV I- Seed vigour I.

Table.2 Mean comparison of main effects of drought stress levels

Drought Stress	EP (%)	SL (cm)	RL (cm)	SRL (cm)	FW (gm)	DW (gm)	SV I (%)
Control	96.67	3.58	4.26	4.39	0.48	0.24	758.52
T ₁ (10%)	46.90	1.66	5.19	3.71	0.43	0.22	353.97
T ₂ (20%)	14.29	0.20	1.91	0.67	0.22	0.12	64.49

Table.3 Genotypic and phenotypic correlation among physiological indices (Control)

Characters		EP	SL	RL	SRL	FW	DW	SV I
EP	G	1.000	-0.107	0.204	0.456*	-0.131	-0.193	0.244
	P	1.000	-0.107	0.204	0.454*	-0.131	-0.192	0.244
SL	G		1.000	0.508*	0.155	0.037	-0.143	0.790**
	P		1.000	0.508*	0.154	0.037	-0.142	0.790**
RL	G			1.000	0.487*	0.240	0.229	0.910**
	P			1.000	0.485*	0.240	0.228	0.910**
SRL	G				1.000	-0.077	-0.137	0.475*
	P				1.000	-0.074	-0.131	0.473*
FW	G					1.000	0.877**	0.146
	P					1.000	0.877**	0.146
DW	G						1.000	0.032
	P						1.000	0.033
SV I	G							1.000
	P							1.000

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

Table.4 Genotypic and phenotypic correlation among physiological indices under drought

Characters		EP	SL	RL	SRL	FW	DW	SV I
EP	G	1.000	0.981**	0.888**	0.927**	0.720**	0.751**	0.956**
	P	1.000	0.959**	0.869**	0.907**	0.709**	0.743**	0.955**
SL	G		1.000	0.912**	0.937**	0.777**	0.788**	0.917**
	P		1.000	0.910**	0.935**	0.775**	0.785**	0.905**
RL	G			1.000	0.903**	0.900**	0.903**	0.818**
	P			1.000	0.902**	0.900**	0.901**	0.808**
SRL	G				1.000	0.714**	0.708**	0.881**
	P				1.000	0.714**	0.707**	0.870**
FW	G					1.000	0.972**	0.563**
	P					1.000	0.971**	0.560**
DW	G						1.000	0.607**
	P						1.000	0.605**
SV I	G							1.000
	P							1.000

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

Correlation between traits was analyzed under both normal and severe drought conditions (Table 3 and 4). Under normal condition both shoot and root length showed high positive association towards seed vigour index, whereas under severe osmotic stress all the six characters were positively correlated to seed vigour index of which germination percentage was of highest magnitude followed by shoot length and seminal root length. Similar findings were reported by Khan *et al.*, (2004) in maize hybrids.

Considering the above findings, the physiological traits *viz.*, germination percentage, shoot length and root length are able factors aiding indirect selection for drought tolerant hybrids. Germination percentage is the candidate trait that determines seed vigour index under stress conditions.

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