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Physiological screening for drought tolerance in pearl millet hybrids under polyethylene glycol (PEG) induced water stress

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ABSTRACT

Pearl millet [*Pennisetum glaucum* (L.) R Br. emend. Stuntz] is World's sixth and India's fourth important cereal crop. Pearl millet is grown predominantly in India and Africa. It is generally cultivated in area of arid and semi arid tropics receiving rainfall from 150-700mm. However, among the various abiotic stresses; drought is one of them, which limits its production by preventing from expressing its full genetic potential. Because of its potential for high dry matter production at water deficit and high temperature, it has made a mark in arid and semiarid areas. It is a drought resistant cereal having maximum potentiality of grain production in adverse conditions. In India, water deficit limits the crop production in about 67 % of the net sown area. Hence, the present investigation was undertaken at Department of Agricultural Botany and Biotechnology, B.A. College of Agriculture, Anand Agricultural University, Anand, India to identify the better parental lines and hybrids for drought resistance by inducing differential PEG mediated osmotic stress under *in vitro* condition. Physiological studies suggested that, among female parents, JMSA 101 followed by ICMA 94555 and among the male parents, IPC 1658 followed by J 2340 were found most superior for higher germination percentage, longer roots with better shoot height under PEG induced osmotic stress. The ability of crosses *viz*., ICMA 94555 x IPC 1657, ICMA 94555 x IPC 1658, ICMA 95444 x J 2340 and ICMA 95444 x J 2340 to produce higher grain yield per plant under terminal water stress condition along with longer roots, increased shoot height and greater germination percentage under PEG induced water stress which helped to overcome the simulated drought stress more successfully as compared to other crosses tested. *In vitro* screening showed similar trend for the crosses as it exhibited during field evaluation for the grain yield per plant (kg/plant). Thus, PEG test can also provide a measure of drought sensitivity and gives drought tolerance indices in pearl millet, which could be used for drought resistance screening under *in vitro* conditions.

Key words : Physiological screening, Drought tolerance, PEG induced osmotic stress, Pearl millet and grain yield per plant

INTRODUCTION

In 2004-05, India secured the output of 8.61 million tones from an area of 10.27 million hectares, which accounted for 39 per cent of the total world area under pearl millet with productivity of 927 kg / ha. Pearl millet is not only a quick growing short duration crop, but also well adapted to drought, heat, low fertility and different soil types. In general, water deficit limits the crop production in about 67 % of the net sown area (Srivalli *et al*., 2003). It is generally cultivated in area of arid and semi arid tropics receiving rainfall from 150-700 mm. In the arid zone of world, pearl millet [*Pennisetum glaucum* (L.)] is and will remain a staple cereal crop because no other cereal is as well adapted or as productive under seasonal rainfall as low as 300-250 mm. (Khairwal and Yadav, 2005). Yield in these areas are low and variation in annual production can be extremely high. Under such condition, the prospects for major increase in production based on introduction of purchased inputs into the farming system are limited, as the risks associated with these climatic conditions are very high. Adaptation to expected moisture levels involves both crop duration and the ability to tolerate drought stress during the crop season. (Fussell *et al.*, 1991; Oosterom *et al.*, 2003)

Drought conditions were simulated in the laboratory by using aqueous solutions having osmotic pressures. The Polyethylene glycol (PEG) test can provide a measure of drought sensitivity. Aqueous solutions of polyethylene glycol, especially of 1 and 8 osmotic pressures were beneficial in studying the effects of simulated drought conditions and especially useful in exposing weaknesses of seed (Parmar and Moore, 1966). The osmotic pressure test using polyethylene glycol appears worthy of additional study for possible standardization as a vigor test under water stress conditions.

MATERIALS AND METHODS

The experiment was conducted with 114 seed samples (91 hybrids, 20 parents and 3 standard checks developed through line x tester mating design) was grown in completely randomized design with two replications at the Plant Breeding Farm, B.A. College of Agriculture, Anand Agricultural University, Anand during *Kharif*, 2004-05.

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Effects of PEG 6000 on seed germination at different concentrations were studied. Polyethylene glycol, 6000 (PEG) was dissolved in 100 ml distilled water in concentrations of 11.5 g, 19.6 g, and 23.5 g separately to prepare osmotic solutions of –3.0, -5.0 and -7.5 bars water potential, respectively, following the method of Hadas (1976). Distilled water was used as control. The 25 surface sterilized seeds were placed on moistened and sterilized filter paper in each Petri-plate. Filter papers were moistened at regular intervals with the above-mentioned solutions. The Petri-plates were kept in laboratory under normal light and at room temperature for eight days and observations were recorded (Goswami and Baruah, 1994). The same set of hybrids was grown under terminal water stress condition for computing grain yield per plant which was created by withholding irrigation at flowering stage (Bidinger *et al.*,1987).

RESULTS AND DISCUSSION

The results obtained on the mean performance of parents, hybrids and standard hybrids for different characters under PEG induced osmotic stress conditions and grain yield per plant under terminal drought condition are presented in Table 1.

The variability for all traits was registered among parents and hybrids under different osmotic concentrations. The genotype, treatment and genotype x treatment effects were significant for germination percentage and shoot height. For root length per plant the genotype and treatment effects were significant, while genotype x treatment interactions were non-significant.

The ranges of germination percentage under untreated control, -3.0, -5.0 and -7.5 bars of PEG were 90 to 96, 80 to 86, 70 to 84 and 60 to 72 per cent, respectively, by the same female parents in all treatments. The minimum was recorded by the ICMA 92777 and maximum was recorded by the JMSA 101. Among the females, JMSA 101 followed by ICMA 94555, exhibited least reduction in germination percentage under control as well as in all different concentrations of PEG induced osmotic stress.

In control, the male parent J 2290 exhibited the minimum germination percentage while, IPC 1658 and J 2340 exhibited the maximum germination percentage varying from 88 to 98 per cent, respectively; while under -3.0, -5.0 and -7.5 bars, it ranged from 80 to 92, 70 to 80, and 56 to 74 per cent, respectively by the male parents, J 104 and IPC 1658. Among the male parents, IPC 1658 showed minimum reduction in germination percentage, while J 104 recorded maximum reduction in germination percentage under control as well as in all the three concentrations of PEG.

Reduction in germination at -7.5 bars among female lines was least in JMSA 101 and maximum in ICMA 92777. Similarly, reduction in germination among male parents at -7.5 bars was recorded minimum in IPC 1658 and maximum in J 104 identifying the most desirable as well as most undesirable genotype, respectively as far as PEG induced drought condition is concerned.

The germination percentage progressively decreased with increasing osmotic concentrations of PEG solutions. The similar observation was made for germination percentage by Parmar and More (1966) in maize, Saint-Clair (1976) in sorghum, Singh and Singh (1982) in wheat, Goswami and Baruah (1994) in rice and Vijayalakshmi *et al*. (2000) in pearl millet. However, this decrease was found more pronounced under -5.0 and -7.5 bars of osmotic concentrations. This result was in conformity with the findings of Singh and Singh, (1982) in wheat.

The values of shoot height under control, -3.0, -5.0 and -7.5 bars varied from 16.0 to 19.0, 12.5 to 15.5, 11.0 to 13.5 and 5.5 to 9.5 cm, respectively, among the females. Among the female parents, ICMA 94555 recorded minimum reduction in shoot height followed by JMSA 101, in different concentrations of PEG induced osmotic stress as well as under control. Among the female parents, ICMA 92777 recorded the maximum reduction in shoot height in all the treatments including control.

The shoot height varied from 16.0 (M 46 and IPC 1657) to 20.5 (IPC 1658) under control, 12.5 (J 2454 and J 104) to 15 (IPC 1658) under -3.0 bar, 9.0 (M 46) to 13.0 (IPC 1658) under -5.0 bar, 6.0 (J 104) to 9.5 (IPC 1658) under -7.5 bar. Among all the male parents, IPC 1658 showed minimum reduction in shoot height under all the three concentrations of PEG, followed by J 2340.

Reduction in shoot height at -7.5 bars among female lines was least in ICMA 94555 (L3) and maximum in ICMA 92777 (L2). Similarly, reduction in shoot height among male parents at -7.5 bars was observed with minimum in IPC 1658 (T12) and maximum in J 104 (T7) showing most suitable as well as most unsuitable genotype, respectively, for PEG induced drought condition.

Among the females, JMSA 101 exhibited higher root length, followed by ICMA 94555, under different concentrations of PEG induced osmotic stress including control. The line, ICMA 95222 gave the poorest performance among the female parents for this trait. The lowest and highest root length were recorded by J 2240 and IPC 1658 varying from 11.5 to 15.0 under control, 5.5 to 9.5 under -3.0 bar, 2.5 to 5.5 under -5.0 bar, 1.0 to 3.5 under -7.5 bar. Among all the male parents, IPC 1658

Table 1: Mean performance of parents and hybrids under PEG induced osmotic stress and grain yield per plant

Sr. No.	Parents / crosses	Germination percentage				Shoot height (cm)				Root length (cm)				Grain yield per plant (g)
		Control	-3.0 bars	-5.0 bars	-7.5 bars	Control	-3.0 bars	-5.0 bars	-7.5 bars	Control	-3.0 bars	-5.0 bars	-7.5 bars	
Females (Lines)														
1.	ICMA 89111 (L1)	92	82	72	70	17.5	13.5	11.5	6.5	13.0	7.5	2.5	1.5	65.0
2.	ICMA 92777 (L2)	90	80	72	60	16.0	12.5	11.0	5.5	12.8	6.5	2.0	2.5	86.5
3.	ICMA 94555 (L3)	94	84	84	70	19.0	15.5	13.5	9.5	14.0	7.5	2.5	2.5	87.0
4.	ICMA 95222 (L4)	92	84	74	66	17.0	13.5	12.5	8.0	12.5	5.5	2.0	1.5	84.5
5.	ICMA 95444 (L5)	92	82	76	66	17.5	14.5	12.5	8.5	12.5	7.5	2.5	2.5	83.5
6.	JMSA 101 (L6)	96	86	78	72	18.5	15.0	13.5	9.0	14.8	8.5	3.5	3.0	88.5
7.	JMSA 20005 (L7)	92	84	70	68	17.5	13.0	12.0	7.0	12.0	8.0	2.5	2.0	79.0
Males (Testers)														
8.	J 2290 (T1)	88	84	72	58	19.0	13.5	12.0	7.0	12.0	8.5	4.0	2.0	76.5
9.	J 2240 (T2)	96	84	76	58	18.0	14.5	12.0	7.5	11.5	5.5	2.5	1.0	83.0
10.	J 2405 (T3)	90	88	76	64	19.0	13.5	10.0	7.0	12.5	7.5	3.0	3.0	69.0
11.	J 998 (T4)	90	82	76	58	18.5	14.5	11.5	8.5	12.0	6.5	4.5	3.5	91.0
12.	J 2454 (T5)	96	84	74	68	19.0	12.5	11.5	8.0	13.0	7.5	3.0	3.0	88.5
13.	J 2340 (T6)	98	90	76	70	20.0	14.5	13.5	9.0	14.5	9.0	5.0	3.5	88.0
14.	J 104 (T7)	94	80	70	56	17.5	12.5	11.0	6.0	13.5	9.0	3.5	3.0	69.0
15.	M 46 (T8)	96	84	76	70	16.0	13.5	9.0	7.5	14.3	7.5	5.0	3.0	67.0
16.	PPM 1-85 (T9)	90	84	76	58	16.5	14.5	10.5	7.0	12.5	6.5	4.5	2.0	65.5
17.	PRLT 2/89-33 (T10)	94	84	74	64	17.0	13.5	11.5	7.5	12.0	6.0	3.5	1.5	73.0
18.	IPC 1657 (T11)	96	84	74	66	16.0	13.0	12.5	8.0	13.0	6.5	4.5	1.5	80.0
19.	IPC 1658 (T12)	98	92	80	74	20.5	15.0	13.0	9.5	15.0	9.5	5.5	3.5	79.0
20.	IPC 1664 (T13)	94	84	72	66	18.5	13.0	11.0	8.0	14.3	7.5	5.0	2.5	78.0
Hybrids														
21.	L1 X T1	96	81	73	61	18.5	14.5	11.0	5.5	12.8	7.5	6.5	1.5	54.5
22.	L1 X T2	98	86	72	56	17.5	16.5	11.5	6.5	13.5	8.5	4.5	2.5	87.0
23.	L1 X T3	94	82	76	62	19.0	15.0	12.0	6.0	15.0	7.5	4.0	3.5	76.0
24.	L1 X T4	94	80	72	66	18.0	15.5	10.0	7.5	12.0	8.0	3.0	3.0	69.5
25.	L1 X T5	98	78	72	68	17.5	16.5	10.5	7.0	12.5	8.0	3.5	1.5	73.0
26.	L1 X T6	96	88	76	68	20.0	15.0	10.0	6.0	12.3	8.5	4.5	2.0	91.0
27.	L1 X T7	94	84	80	66	17.5	14.5	9.5	5.5	13.3	7.5	5.5	2.0	75.5
28.	L1 X T8	94	80	78	68	18.5	13.0	9.0	7.5	13.0	9.5	5.0	2.5	75.0
29.	L1 X T9	94	84	80	66	17.5	13.5	9.5	8.0	12.5	7.5	3.5	2.0	93.0
30.	L1 X T10	94	86	72	60	19.0	14.5	10.0	7.5	12.5	8.5	2.5	1.5	65.0
31.	L1 X T11	94	88	76	64	18.5	16.0	9.5	8.5	13.3	8.0	3.0	2.5	88.0
32.	L1 X T12	98	88	78	67	17.5	15.0	10.5	6.5	12.8	9.5	4.0	1.5	92.0
33.	L1 X T13	94	92	78	60	18.0	14.5	10.5	6.0	12.8	9.0	4.5	3.5	97.0
34.	L2 X T1	92	84	78	64	16.5	13.0	11.5	5.5	12.3	10.5	4.5	2.5	67.0
35.	L2 X T2	92	84	74	62	17.5	14.5	12.0	6.5	12.0	8.5	3.5	3.5	92.0
36.	L2 X T3	98	84	74	70	19.5	15.5	10.0	7.5	11.5	8.0	3.5	2.5	76.5
37.	L2 X T4	92	84	78	66	19.0	14.5	9.5	7.0	13.0	9.5	3.5	3.5	70.5
38.	L2 X T5	98	84	76	64	18.0	14.0	10.0	6.5	14.5	8.0	2.5	2.5	70.5
39.	L2 X T6	98	86	76	60	17.5	13.0	10.5	7.0	15.3	9.5	3.5	1.5	87.0
40.	L2 X T7	92	80	74	60	17.0	13.5	11.5	8.5	13.5	8.5	2.5	2.5	60.5
41.	L2 X T8	96	86	72	66	18.5	13.5	9.5	9.5	13.0	8.0	3.5	2.5	87.5
42.	L2 X T9	94	88	76	68	17.0	14.5	8.5	8.5	12.3	8.0	4.5	3.5	94.0
43.	L2 X T10	90	84	76	68	18.0	15.0	9.5	7.5	13.5	10.5	5.0	3.0	64.5

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44.	L2 X T11	88	86	70	70	18.5	14.5	10.0	8.0	13.8	8.5	4.5	2.5	94.0
45.	L2 X T12	92	86	76	68	17.5	14.5	10.5	7.0	14.0	7.5	3.5	3.0	71.5
46.	L2 X T13	90	84	76	66	18.5	15.0	11.0	6.0	12.5	7.0	2.5	2.5	80.0
47.	L3 X T1	94	84	76	70	17.0	14.5	11.5	6.5	13.3	6.5	3.5	2.5	86.0
48.	L3 X T2	94	88	78	68	16.5	13.5	10.5	6.0	14.0	8.0	4.5	3.0	87.5
49.	L3 X T3	98	82	72	64	18.5	14.5	10.5	6.5	13.5	9.5	3.5	3.0	80.0
50.	L3 X T4	90	86	80	60	19.0	14.5	9.5	6.0	13.5	8.5	2.5	1.5	67.0
51.	L3 X T5	94	86	72	60	18.0	14.0	9.0	6.5	12.0	9.5	3.5	1.5	65.0
52.	L3 X T6	98	82	76	54	17.5	13.0	10.0	7.5	11.8	8.5	2.5	2.5	81.0
53.	L3 X T7	94	86	76	54	18.5	13.5	11.0	6.5	12.5	7.5	3.5	2.0	63.5
54.	L3 X T8	94	90	74	58	19.0	14.5	11.5	6.0	12.3	8.0	3.5	3.0	90.0
55.	L3 X T9	94	86	74	62	18.5	13.0	11.5	7.5	13.5	7.0	4.0	3.0	95.5
56.	L3 X T10	92	92	80	64	17.5	13.0	12.5	8.5	14.5	8.5	3.5	2.0	63.0
57.	L3 X T11	98	92	82	70	19.0	14.0	13.0	8.5	15.5	8.0	3.5	3.5	100.0
58.	L3 X T12	96	88	84	74	18.5	13.0	12.0	7.5	15.3	9.0	5.0	4.5	99.5
59.	L3 X T13	92	84	76	64	17.0	14.5	10.0	7.0	13.3	9.0	4.5	2.5	67.5
60	L4 X T1	100	84	76	58	17.5	14.5	10.5	7.0	13.0	9.0	3.0	2.5	68.0
61.	L4 X T2	94	86	76	56	18.0	15.5	9.5	7.5	12.0	8.5	3.5	2.0	60.5
62.	L4 X T3	92	84	78	68	19.0	15.0	13.5	7.0	14.5	7.5	4.0	3.5	97.5
63.	L4 X T4	92	82	70	66	16.5	13.0	9.5	7.5	12.3	8.5	5.0	3.0	76.5
64.	L4 X T5	92	82	76	66	16.0	13.0	10.5	8.0	12.8	7.5	4.5	3.0	94.0
65.	L4 X T6	90	86	80	70	18.5	14.5	13.0	8.5	16.5	8.5	4.0	2.5	94.5
66.	L4 X T7	96	72	68	58	19.5	13.0	11.5	6.5	12.8	8.5	3.5	2.5	69.5
67.	L4 X T8	93	82	72	58	18.0	13.5	10.0	6.0	13.3	7.5	3.0	2.0	79.0
68.	L4 X T9	92	84	76	68	19.0	13.5	12.0	6.5	12.3	6.5	3.5	2.5	69.5
69.	L4 X T10	88	82	78	66	16.0	14.0	11.5	6.5	14.0	9.0	4.5	2.5	70.5
70.	L4 X T11	92	86	76	64	16.5	13.0	11.0	7.5	13.8	6.5	2.5	2.0	72.5
71.	L4 X T12	92	86	78	62	17.5	13.5	9.5	7.0	14.5	9.5	4.5	1.5	74.0
72.	L4 X T13	88	88	82	60	18.5	13.0	8.5	6.5	14.0	7.5	4.0	3.0	94.5
73.	L5 X T1	94	78	76	60	19.5	12.5	11.0	5.5	13.0	8.5	3.5	3.0	71.5
74.	L5 X T2	94	82	74	62	16.5	14.5	8.5	6.5	12.3	8.5	3.5	1.0	65.0
75.	L5 X T3	94	88	70	62	17.5	14.0	8.5	6.5	12.3	8.0	3.0	1.5	65.5
76.	L5 X T4	98	84	74	66	18.5	13.0	9.5	6.5	12.5	8.5	3.5	1.5	93.0
77.	L5 X T5	96	78	72	60	19.5	13.0	11.0	7.5	13.0	6.5	3.5	3.0	60.5
78.	L5 X T6	94	86	78	66	17.5	13.5	9.5	6.0	14.5	7.5	4.5	3.5	98.0
79.	L5 X T7	94	78	76	60	18.0	14.5	9.0	7.5	13.0	7.0	4.0	2.0	65.0
80.	L5 X T8	90	76	70	62	18.5	14.5	10.0	8.5	14.0	9.0	3.0	2.5	65.5
81.	L5 X T9	79	86	74	52	20.0	13.5	10.5	7.5	13.0	7.5	3.5	2.5	57.5
82.	L5 X T10	94	86	80	58	18.5	13.5	11.0	7.0	13.3	8.0	4.5	3.0	65.0
83.	L5 X T11	96	78	70	56	18.5	14.5	11.5	6.5	14.0	7.5	3.5	1.5	88.5
84.	L5 X T12	94	88	76	66	19.0	13.5	10.0	6.0	13.8	8.0	3.0	3.0	93.5
85.	L5 X T13	98	90	72	66	17.5	12.5	10.5	7.5	14.5	7.5	2.5	2.5	66.0
86.	L6 X T1	96	88	74	62	18.5	13.5	10.5	7.0	13.5	9.0	2.0	2.0	67.0
87.	L6 X T2	94	82	76	62	19.5	12.5	11.5	7.0	15.0	9.0	2.5	2.5	68.5
88.	L6 X T3	94	82	74	68	18.5	13.0	9.5	7.5	14.0	9.5	3.5	2.0	88.5
89.	L6 X T4	98	80	74	60	17.5	14.5	10.5	8.0	13.3	8.5	4.5	2.5	73.5
90.	L6 X T5	96	88	76	60	16.5	14.0	11.5	8.5	12.3	7.5	4.0	2.5	65.5
91.	L6 X T6	96	84	78	58	17.5	12.0	10.0	8.0	12.8	8.0	3.0	1.5	72.5
92.	L6 X T7	94	86	72	62	16.5	15.0	11.5	7.5	12.8	6.0	3.5	2.5	86.5
93.	L6 X T8	96	82	78	60	17.5	12.5	11.0	7.0	11.3	7.5	3.5	3.0	63.0

Table 1 contd.........

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94.	L6 X T9	92	84	76	64	18.5	13.5	11.5	7.0	11.5	8.5	3.5	1.5	89.5
95.	L6 X T10	90	82	74	60	19.5	15.5	10.5	7.0	12.8	7.5	4.5	1.0	61.0
96.	L6 X T11	98	76	74	60	16.5	12.5	11.5	8.0	13.8	8.0	4.0	3.5	78.0
97.	L6 X T12	96	80	76	62	17.5	13.5	11.0	7.5	14.3	8.5	4.0	3.0	73.0
98.	L6 X T13	94	80	74	62	18.0	12.5	11.5	8.5	15.0	6.0	4.5	3.5	80.0
99.	L7 X T1	96	88	76	62	17.0	13.5	11.0	7.5	14.5	6.5	4.0	2.5	71.5
100.	L7 X T2	90	80	76	56	17.5	13.5	10.5	7.0	14.0	7.5	4.5	2.5	71.0
101.	L7 X T3	90	80	78	58	18.0	14.5	10.0	8.0	12.8	8.5	4.0	2.0	65.0
102.	L7 X T4	90	80	72	64	17.0	13.5	10.5	7.5	13.5	9.0	4.5	3.0	66.0
103.	L7 X T5	88	82	76	62	18.5	13.5	10.5	6.5	13.0	9.5	4.0	2.5	73.0
104.	L7 X T6	96	84	78	66	19.5	14.5	11.5	6.5	13.0	6.0	3.0	2.5	85.0
105.	L7 X T7	96	76	72	66	19.5	13.0	9.5	7.5	13.8	7.0	3.5	2.5	60.5
106.	L7 X T8	98	86	72	62	18.0	14.0	8.5	7.0	12.8	8.5	3.0	2.5	68.5
107.	L7 X T9	90	84	74	64	18.5	13.5	8.5	8.0	13.8	6.0	3.5	2.0	91.0
108	L7 X T10	97	86	78	64	19.5	12.5	9.0	7.5	13.3	8.5	2.5	1.5	83.0
109.	L7 X T11	90	82	76	64	16.5	13.0	8.5	8.0	12.0	9.5	2.5	1.0	63.5
110.	L7 X T12	97	76	72	64	19.0	13.5	8.5	7.5	12.5	8.5	2.0	1.5	70.5
111.	L7 X T13	90	80	72	72	16.0	12.5	11.5	7.0	12.8	9.5	3.5	2.5	85.5
Standard checks														
112.	GHB-538	98	84	78	66	17.5	12.5	10.0	7.0	13.8	8.5	3.5	2.0	94.5
113.	GHB-577	98	82	80	70	16.0	13.5	11.5	7.5	12.8	7.5	4.0	3.5	90.0
114.	GHB-664	94	84	74	66	17.5	13.0	11.5	7.5	13.5	6.0	4.5	3.0	92.5
General means		93.72	83.86	75.24	63.49	18.00	13.86	10.68	7.22	13.21	8.02	3.65	2.43	77.25
C.D. (P=0.05)	Genotype	4.29**				0.86**				0.85**				7.88
	Treatments	0.81**				0.16*				0.16*				
	Genotypes x Treatments	8.55**				1.73**				NS				
C V %		5.53				7.16				12.87				13.12

N.S.-Non significant

showed greater root length under control as well as in all the three concentrations of PEG, which was followed by J 2340.

Minimum reduction in root length at -7.5 bars, among female lines was observed in JMSA 101 (L6) and maximum in ICMA 95222 (L4). Similarly, reduction in root length among male parents at -7.5 bars was observed with minimum in IPC 1658 (T12) and maximum in J 2240 (T2) showing most suitable as well as most unsuitable genotype, respectively, as far as PEG induced drought condition is concerned. However, this was clearly reflected only in the crosses with their superior parents (lowered reduction in root length), showing a value, 3.5 cm (L6 x T11). This trend was also partially reflected when crosses were made with susceptible genotypes (L4 x T2).

Among the hybrids *viz.*, ICMA 94555 x IPC 1657, ICMA 94555 x IPC 1658, ICMA 95444 x J 2340 and ICMA 95444 x J 2340 were found to produce more grain yield per plant under terminal water stress along with superior for higher germination percentage, longer roots and better shoot height under PEG induced osmotic stress.

The results revealed that, the germination of seed under stimulated drought conditions offers possibilities for revealing inherent seed weaknesses *in vitro* and predicting relative differences among genotypes in laboratory conditions. The germination percentage, shoot height and root length of seedling progressively decreased with increasing osmotic concentrations of solutions. These results are also in conformity with the findings of Parmar and More (1966) in maize, Saint-Clair (1976) in sorghum, Singh and Singh (1982) in wheat, Goswami and Baruah (1994) in rice, Manga (1998) and Vijayalakshmi *et al.* (2000) in pearl millet.

Comparing the data obtained from grain yield per plant and germination studies conducted using PEG in the entire cross combinations suggest that there is similarity in different crossing combinations with regards to field performance under terminal water stress (top ten ranks) which differed only in their ranking, under both the conditions. Vijayalakshmi *et al.* (2000) reported the same trend using different cultivars for same characters under PEG induced osmotic stress in pearl millet.

The highest seed germination in all the genotypes irrespective of treatments was observed on 9th day after soaking. Subsequently, no significant change in seed germination was observed even though a decline in the vigour of shoot was found. Increasing moisture stress resulted in a reduction in shoot height and root length in all the genotypes. Hence, it may be concluded that water stress at -3.0 and -5.0 bars was detrimental for seed germination and seedling growth of all the tested genotypes observed on 9th day. These results are in agreement with the findings of Goswami and Baruah (1994) in rice. Manga (1998) observed that the water stress at –7.5 bars was highly detrimental for evaluating drought tolerance in pearl millet. Similar observations were also made in the present investigation.

Moisture stress effects on the physiological aspects of grain growth and development of crop were analyzed to determine relationships with grain yield and to evaluate possible drought avoidance mechanisms (Murty, 1970). Variation in moisture gradient significantly influenced the grain yield. This might be attributed to the favourable plant water status and better translocation efficiency for maintaining physiological functions favourable to higher yield. Increased in yield under moisture gradient, exhibiting some drought adaptive mechanisms such as better shoot adjustments with an extensive deeper root system (for extracting available water even from the deeper soil profiles). Similar kinds of results were noted by as Premachandra (1988) and Mohandass, *et al.* (1993) by employing various moisture levels through PEG induced moisture gradient in pearl millet.

Among female parents, JMSA 101 followed by ICMA 94555 and among the male parents, IPC 1658 followed by J 2340 were found most superior for higher germination percentage, longer roots with better shoot height under PEG induced osmotic stress. The ability of crosses *viz.*, ICMA 94555 x IPC 1657, ICMA 94555 x IPC 1658, ICMA 95444 x J 2340 and ICMA 95444 x J 2340 to produce higher grain yield per plant under terminal water stress condition along with longer roots, increased shoot height and greater germination percentage which helped to overcome the simulated drought stress more successfully as compared to other crosses tested. Hence, PEG test can also provide a measure of drought sensitivity and gives drought tolerance indices in pearl millet, which could be used for drought resistance screening under *in-vitro* conditions.

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