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Screening of Pigeonpea Genotypes for Waterlogging Tolerance

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ABSTRACT

Seventeen diverse pigeonpea accessions were evaluated for seed level water submergence tolerance under different time periods viz., 12 hours, 24 hours, 48 hours, 96 hours and 144 hours. All genotypes exhibited good germination percentage up to 48 hours of submergence (43 to 100 %). A few genotypes (LRG 30, MRG 66 and ICPL 85063) showed higher germination percentage and seedling vigour index even after 144 hours of submergence. No germination was observed in ICPL 8863(Maruti), LRG 41, PRG-158, WRG 53, WRG 27, WRG 65, TRG 33 and UPAS 120 after 144 hours of submergence. Electrical conductivity (E.C) as a measure of cellular membrane stability of seeds after submergence was calculated. There was a only a slight change observed in E.C after 48 hours of submergence in majority of the genotypes .A greater change in E.C was observed after 96 and 144 hours of submergence. Based on the changes in E.C the genotypes were grouped in to high E.C (PRG 176, PRG 100 and TRG 33), moderate E.C (ICPL 85063, ICPL 332, UPAS 120, PRG 158, ICPL 8863, LRG 41, ICPL 87119, TRG 38, LRG 30 and MRG 66) and low E.C (WRG 27, WRG 65 and WRG 53) genotypes. There was a significant negative correlation observed between seedling vigour index and E.C values at 96 hours after submergence. Those genotypes performed better at seed level submergence with less E.C values were proved to have high seedling viguor index and tolerance to waterlogging stress. E.C values could be used as a surrogate for screening of genotypes for waterlogging tolerance.

Key words: *Genotypes, Genotypes, Germination, Seed.*

INTRODUCTION

The productivity of pigeon pea is low in India (686.5 kg ha^{-1}) and Andhra Pradesh (652.27 kg ha^{-1}). The main reason for the low productivity of redgram is due to its susceptibility to many biotic and abiotic stresses. Waterlogging is one such abiotic stress in heavy soils of delta region. Pigeonpea is highly sensitive to waterlogging[7]. Since it is generally grown under rainfed conditions in rainy season it is often exposed to drought as well as extended episodes of transient waterlogging during the peak rainy days, leading to a heavy loss of individuals in the plant stand. In the recent times, no much change was observed in total rainfall availability, but its occurrence in a comparatively shorter span of time became an alarming issue it causes flooding and waterlogging in standing crops.

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Anaerobic respiration does not completely oxidize glucose to CO_2 and water. Hence, toxic organic end products like ethanol increases. Lack of oxygen rapidly results in less ATP and increased NAD (P)H as well as decreased cytosolic pH. Waterlogging is known to retard growth at vegetative and flowering stages[3] and inhibits yield[2] of several plant species. This is accompanied by poor uptake of water and minerals from the soil[9], epinasty, senescence and abscission of leaves[5] and derangement in the hormonal metabolism of the plant[1,8]. Besides, waterlogging also predisposes Pigeonpea plants to *Fusarium* wilt and *Phytopthora* blight infections which are common fungal diseases of rainy season resulting in up to a 100 per cent yield losses.

In Andhra Pradesh Pigeonpea is mainly cultivated in heavy soils of Krishna and Guntur districts. The problem of transient waterlogging has caused for a decrease in yield of pulse crops in general and redgram in particular in this locality. A very few concerted efforts were made to address this important issue[4].

MATERIAL AND METHODS

A laboratory experiment was carried out at P.G Laboratory, Department of Crop Physiology, S.V. Agricultural College, Tirupati during *Kharif*, 2013-2014. In order to screen the genotypes of pigeonpea for waterlogging tolerance seventeen popular pigeonpea varieties were procured from various research stations of Andhra Pradesh *viz*., ICRISAT (Hyderabad), Agricultural Research Station (Madhira) and Regional Agricultural Research Stations located at LAM (Guntur), Palem (Mahaboob nagar) and Tirupati.Pigeonpea seeds were initially washed under running tap water to remove the chemicals used for seed treatment. In each beaker (150 ml) 10 seeds were put for soaking in 100 ml of double distilled water according to treatment duration (12hrs, 24 hrs, 48 hrs 96 hrs and 144 hrs). After completion of soaking period all the 10 seeds were taken out and put for germination on crepe craft paper. The crepe paper was carefully rolled and both ends were closed with twine thread. All these units were placed in a slant position on a wide plastic tub where a continuous thin film of water (1 cm depth) was maintained to supply moisture for proper germination.The experiment was conducted in a Completely Randomized design with 17 redgram genotypes *viz*,. ICPL 332 (Abhaya), ICPL 8863 (Maruti), ICPL 87119 (Asha), ICPL 85063 (Lakshmi), LRG 30 (Palanadu), LRG 41, PRG 158 (Palem Kandi), PRG 100, PRG 176, WRG 53 (Warangal Kandi), WRG 27, WRG 65, MRG 66, TRG 38, TRG 22, TRG 33, UPAS 120). There were five treatments with four replications. Germination percentage, seedling vigour index and electric conductivity were calculated using the following formulae.

Germination Percentage: Germination percentage was calculated (after seven days) with the following formula

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds kept for germination}} \times 100$$

Vigour Index:

Vigor Index = Mean germination percentage × mean dry weight per seedling (mg).

Seeds were considered germinated when the emergent radicle was 3mm or greater in length. The seedlings were then dried in an oven at 60° C and the dry weight was recorded after 72 hours[4].

Electrical Conductivity:

When the seeds were subjected to anoxic condition the susceptible genotypes lose their membrane integrity and causes leakage of important electrolytes like sugars, amino acids etc. Electric conductivity of the double distilled water in which the seeds were soaked was tested with E.C meter (Systronics model

no.304). The reading was expressed as µ mhos/cm/g of seed.

RESULTS AND DISCUSSION

Mean values of germination percentage, vigor index and electrical conductivity varied significantly across genotypes. Seeds subjected to 12 hours, 24 and 48 hours of submerged condition did not show wide variation in germination percentage among the genotypes. However when seeds were subjected to 96 hours and 144 hours of submergence (6 days) certain genotypes *viz*., ICPL 8863(Maruit), WRG 53, WRG 65, WRG 27, LRG 41, PRG 158, TRG 33 and UPAS 120 recorded zero percent germination. LRG 30, MRG 60 and ICPL-85063 showed a significantly higher percentage of germination (76.25, 75 and 60 percent) (Table 1) even after prolonged submergence. Genotypes *viz*., MRG 66, ICPL 332 and PRG 176 were found to be moderate in germination percentage. Whereas, ICPL 87119 (Asha) recorded low germination percentage (35%). Similar genotypic variation for submergence tolerance in Pigeonpea was also reported by Meena *et al*[6]., and Sultana *et al*[10].Vigor index is synonymous to robustness of seed metabolism. It is often considered as a reliable measure to estimate the field emergence of seedlings under stress situation. The results of 12 hours, 24 and 48 hours treatments showed increased vigor index except in few genotypes. High vigor index (165.92) was observed in 24 hours treatment because of more germination percentage compared to other treatments. The results after 96 and 144 hours of seed submergence revealed that MRG 66 which showed a moderate germination percentage recorded significantly higher vigor index (72.4) followed by ICPL 85063 (62.5). LRG 30 also recorded a reasonably higher vigor index (60.81). As there was no germination in ICPL 8863(Maruti), LRG 41, PRG 158, WRG 53, WRG 27, WRG 65, TRG 33 and UPAS 120 their vigor index was considered zero (Table 2).Electric conductivity is generally considered as a measure of membrane stability and integrity. If the membrane is damaged it allows leakage of important electrolytes of the cells. Seeds submerged to 12 hours, 24 and 48 hours showed low electric conductivity (0.25) compared to 96 and 144 hours treatments. After 96 and 144 hours of submergence WRG 65 and WRG 53 recorded a lower electric conductivity (1.05 and 1.00 respectively). LRG 30 recorded moderate electric conductivity values (1.75). Significantly higher E.C was recorded in PRG 176 (2.67) followed by PRG 100. A higher electric conductivity was also observed in Maruti (2.15) and Asha (2.02) (Table 3). 12 hours and 24 hours treatments promoted the germination compared to other treatments. High germination percentage was observed in 12 hours submergence treatment in WRG 65 (100%) followed by LRG-30 (96.25%), MRG-66 (91.25%), ICPL-85063 (75%). A higher vigor index was observed at 12, 24 and 48 hours treatments compared to 96 hours and 144 hours treatments. Good vigor index was maintained in genotypes MRG-66, ICPL-85063 and LRG-30 at all treatments. Some genotypes maintained high vigor index at 12, 24 and 48 hours (LRG 41, PRG 158, WRG 65 and TRG 33). However, at 144 hours after of submergence vigor index was zero. At 144 hours treatment Warangal genotypes (WRG-53, WRG-27 and WRG 65) and Tirupati genotypes (TRG-38, TRG 22 and TRG-33) showed very low vigor index. Very low electric conductivity was observed at 12, 24 and 48 hours of submergence compared to other treatments. More electric conductivity was observed in 144 hours treatment. After 144 hours of submergence ICRISAT genotypes (ICPL-332, ICPL-8863, ICPL-87119, ICPL-85063) and Palem genotypes (PRG-158, PRG-100, PRG-176) showed more electric conductivity. Those genotypes which showed good germination percentage and low electric conductivity values after prolonged period of submergence (96 hours) showed good seedling vigour index (Table 4 & Table 5). Relationship between electrical conductivity and seedling vigour index showed as a negative correlation (Figure 1). Thus it was concluded that E.C values after prolonged submergence period could serve as good surrogate to screen the genotypes for waterlogging tolerance.

Table 1: Effect of different periods of submergence on germination percentage of pigeonpea genotypes

S.No	GENOTYPE	12 Hrs	24 Hrs	48 Hrs	96 Hrs	144 Hrs
1	**ICPL 332 (Abhaya)**	57.50	87.50	83.75	32.50	40.00
2	**ICPL 8863 (Maruti)**	52.50	57.50	48.75	5.00	0.00
3	**ICPL 87119 (Asha)**	81.25	75.00	75.00	57.50	35.00
4	**ICPL 85063 (Lakshmi)**	75.00	90.00	80.00	80.00	60.00
5	**LRG 30 (Planadu)**	96.25	85.00	90.00	80.00	76.25
6	**LRG 41**	80.00	88.75	73.75	23.75	0.00
7	**PRG 158 (Plem kandi)**	76.25	75.00	90.00	68.75	0.00
8	**PRG 100**	65.00	88.75	92.50	40.00	52.50
9	**PRG 176**	62.50	88.75	87.50	7.50	40.00
10	**WRG 53 (Warangal kandi)**	87.50	67.50	77.50	27.50	0.00
11	**WRG 27**	80.00	78.75	67.50	0.00	0.00
12	**WRG 65**	100.00	88.75	93.75	68.75	0.00
13	**MRG 66**	91.25	82.50	93.75	71.25	75.00
14	**TRG 38**	78.75	88.75	80.00	0.00	7.50
15	**TRG 22**	95.00	91.25	86.25	77.50	17.50
16	**TRG 33**	90.00	85.00	90.00	0.00	0.00
17	**UPAS 120**	65.00	43.75	62.50	22.50	0.00
	SEm±	**4.02**	**4.83**	**4.61**	**3.82**	**3.35**
	CD (P=0.05)	**11.44**	**13.74**	**13.13**	**10.87**	**9.55**

Table 2: Effect of different periods of submergence on Vigor index of pigeonpea genotypes

S.No	GENOTYPE	12 Hrs	24 Hrs	48 Hrs	96 Hrs	144 Hrs
1	**ICPL 332 (Abhaya)**	26.80	125.95	143.93	20.77	25.90
2	**ICPL 8863 (Maruti)**	32.40	48.11	43.93	0.60	0.00
3	**ICPL 87119 (Asha)**	71.26	104.68	106.37	57.92	16.50
4	**ICPL 85063 (Lakshmi)**	60.57	155.92	139.05	120.56	62.50
5	**LRG 30 (Planadu)**	70.22	85.12	96.90	77.65	60.81
6	**LRG 41**	70.82	153.42	104.36	11.26	0.00
7	**PRG 158 (Plem kandi)**	69.52	115.25	163.63	92.62	0.00
8	**PRG 100**	65.17	157.31	159.95	26.76	40.23
9	**PRG 176**	37.75	142.85	128.20	1.22	21.50
10	**WRG 53 (Warangal kandi)**	78.03	64.80	87.25	12.07	0.00
11	**WRG 27**	64.50	82.95	59.32	0.00	0.00
12	**WRG 65**	75.50	119.31	118.55	76.06	0.00
13	**MRG 66**	103.42	132.57	154.80	95.82	72.47
14	**TRG 38**	81.86	165.92	135.10	0.00	1.17
15	**TRG 22**	115.87	156.38	139.23	104.97	5.61
16	**TRG 33**	116.77	165.82	151.17	0.00	0.00
17	**UPAS 120**	44.55	48.51	70.66	11.83	0.00
	SEm±	**9.02**	**12.12**	**12.64**	**6.60**	**6.88**
	CD (P=0.05)	**25.69**	**34.52**	**36.00**	**18.79**	**19.59**

Table 3: Effect of different periods of submergence on Electrical conductivity of pigeonpea genotypes

S.No	GENOTYPE	12 Hrs	24 Hrs	48 Hrs	96 Hrs	144 Hrs
1	**ICPL 332 (Abhaya)**	1.00	0.35	0.75	1.83	2.38
2	**ICPL 8863 (Maruti)**	1.28	0.55	0.85	1.73	2.15
3	**ICPL 87119 (Asha)**	0.98	0.45	0.40	1.03	2.03
4	**ICPL 85063 (Lakshmi)**	0.90	0.40	0.78	1.25	2.53
5	**LRG 30 (Planadu)**	0.65	0.25	0.30	0.80	1.75
6	**LRG 41**	0.88	0.45	0.85	1.75	2.08
7	**PRG 158 (Plem kandi)**	1.00	0.48	0.73	1.60	2.18
8	**PRG 100**	0.98	0.50	0.68	1.80	2.58
9	**PRG 176**	1.08	0.53	0.93	2.00	2.68
10	**WRG 53 (Warangal kandi)**	0.65	0.35	0.48	0.90	1.00
11	**WRG 27**	0.70	0.43	0.60	1.20	1.33
12	**WRG 65**	0.48	0.30	0.33	0.83	1.05
13	**MRG 66**	0.88	0.38	0.55	0.88	1.65
14	**TRG 38**	0.58	0.50	0.75	1.70	2.00
15	**TRG 22**	0.48	0.38	0.38	0.98	1.50
16	**TRG 33**	0.88	0.38	0.45	1.60	2.58
17	**UPAS 120**	0.90	0.55	0.75	1.58	2.38
	SEm±	**0.05**	**0.04**	**0.05**	**0.10**	**0.10**
	CD (P=0.05)	**0.14**	**0.10**	**0.14**	**0.28**	**0.29**

Table 4: Tukey's grouping of genotypes based on Electrical conductivity (submergence at 96 hours)

Tukey's Grouping			Mean	Variety No.	Group combination	Variety
	A		2.00	9	A	**PRG 176**
	A		1.82	1	A	**ICPL 332 (Abhaya)**
	A		1.80	8	A	**PRG 100**
B	A		1.75	6	AB	**LRG 41**
B	A		1.72	2	AB	**ICPL 8863 (Maruti)**
B	A	C	1.70	14	ABC	**TRG 38**
B	A	C	1.60	7	ABC	**PRG 158 (Plem kandi)**
B	A	C	1.60	16	ABC	**TRG 33**
B	A	C	1.57	17	ABC	**UPAS 120**
B	D	C	1.25	4	BCD	**ICPL 85063 (Lakshmi)**
	D	C	1.20	11	DC	**WRG 27**
	D		1.02	3	D	**ICPL 87119 (Asha)**
	D		0.97	15	D	**TRG 22**
	D		0.90	10	D	**WRG 53 (Warangal kandi)**
	D		0.87	13	D	**MRG 66**
	D		0.82	12	D	**WRG 65**
	D		0.80	5	D	**LRG 30 (Planadu)**

Table 5: Tukey's grouping of genotypes based on Seedling vigour index (submergence at 96 hours)

Tukey's Grouping		Mean	variety	Group Combination	Variety
	A	120.56	4	A	**ICPL 85063 (Lakshmi)**
B	A	104.97	15	AB	**TRG 22**
B	A	95.82	13	AB	**MRG 66**
B	A	92.62	7	AB	**PRG 158 (Plem kandi)**
B	C	77.65	5	BC	**LRG 30 (Planadu)**
B	C	76.06	12	BC	**WRG 65**
D	C	57.92	3	CD	**ICPL 87119 (Asha)**
D	E	26.76	8	DE	**PRG 100**
	E	20.77	1	E	**ICPL 332 (Abhaya)**
	E	12.07	10	E	**WRG 53 (Warangal kandi)**
	E	11.83	17	E	**UPAS 120**
	E	11.26	6	E	**LRG 41**
	E	1.22	9	E	**PRG 176**
	E	0.60	2	E	**ICPL 8863 (Maruti)**
	E	0.00	14	E	**TRG 38**
	E	0.00	16	E	**TRG 33**
	E	0.00	11	E	**WRG 53 (Warangal kandi)**

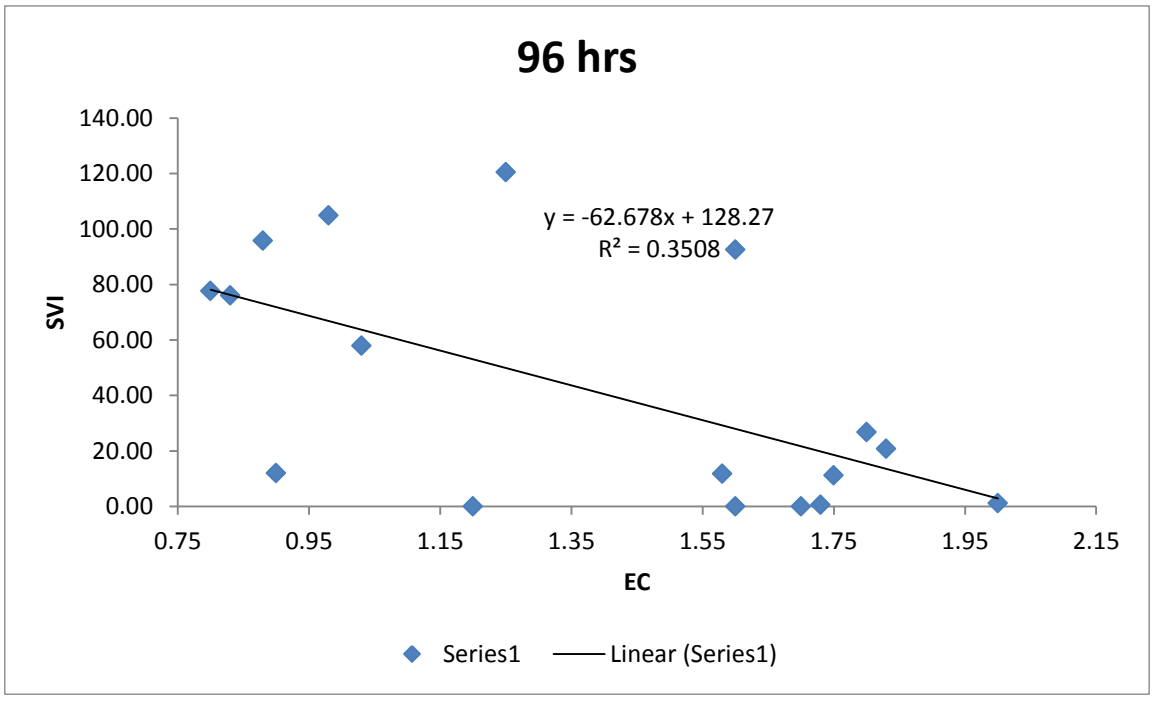

Fig. 1: Correlation between Electric conductivity and Seedling vigour index at 96 hours of submergence

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