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Genetic Diversity of Seedling Traits Conferring Drought Tolerance in Pearl Millet

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As pearl millet is grown principally for food grain in drier areas where rainfall is relatively low and erratic in distribution, breeding for drought tolerance is the integral part in pearl millet breeding programme. In the present study, 63 pearl millet genotypes were evaluated for seedling traits conferring drought tolerance and diverse genotypes were identified. The highest genetic divergence was observed between CO7 and ICMV221 for recorded characters and crossing between these two genotypes would exhibit maximum heterosis for concerned characters. The R/S ratio was positively correlated with fresh root weight (FRW) and dry root weight (DRW), which suggested that simultaneous improvement of root characters is possible in breeding for drought tolerance. Emergence percentage (E%), fresh shoot length (FSL), fresh root length (FRL), fresh shoot weight (FSW), fresh root weight (FRW), dry shoot weight (DSW), dry root weight (DRW) and root shoot (R/S) ratio recorded high heritability estimates along with high genetic advance indicating selection can be possible for improvement of these characters. The pearl millet genotypes namely, ICMV221, PT5541, PT5005, PT5554, PT3764, PT5188(X1), PT4440 and PT5557 were identified as drought tolerant genotypes and they can be used for further analysis.

Key words: D^2 analysis, correlation, variability parameters, drought tolerance, pearl millet

Pearl millet, *Pennisetum glaucum* is the only cereal crop that can be grown in parts of Tropical and Sub tropical Asia and Africa with an annual rainfall below 400mm. So it faces moisture stress very often. Breeding for drought tolerance, therefore, forms an integral part of pearl millet breeding. In crop improvement programme, genetic diversity among breeding material is an essential prerequisite for hybridization. Inclusion of diverse parents in hybridization helps in isolation of superior recombinants. D^2 analysis has been shown to be useful in selecting genetically distant parents for hybridization. Selection for seedling traits conferring drought tolerance such as root length, root weight and root shoot ratio will be useful for identifying genotypes with drought tolerance capacity (Khan *et al*., 2002). Present study was attempted to identify diverse genotypes in terms of seedling traits conferring drought tolerance, to estimate variability parameters and also to identify the correlations between these traits.

Materials and Methods

The experiment was conducted in the Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, India during Summer, 2005. The experimental material consisted of 63 pearl millet genotypes. Twenty five seeds from each genotype were sown in roll towel method and they were evaluated in completely randomized design with two replications. Plant emergence was recorded a day after sowing and 12 days after sowing. Data on emergence percentage (E%), emergence index (EI), emergence rate index (ERI), fresh shoot length (FSL in cm), fresh root length (FRL in cm), fresh shoot weight (FSW in g), fresh root weight (FRW in g), dry shoot weight (DSW in g) and dry root weight (DRW in

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g) were recorded and root/ shoot (R/S) ratio was computed.

Emergence percentage (E%) was calculated according to the formula of Smith and Millet (1964).

$$E\% = \frac{\text{Seedling emerged in 12 DAS}}{\text{Total number of seeds sown}} \times 100$$

Emergence index (EI) is an estimate of emergence rate for pearl millet germplasms in each replication and was calculated according to the formula suggested by Mock and Eberhart (1972).

$$EI = \frac{\text{Plants emerged in a day}}{\text{Plants emerged 12 DAS}} \times 100$$

Emergence rate index (ERI) for each germplasm was calculated as the ratio of EI ratio to emergence percentage.

$$ERI = \frac{EI}{E\%}$$

The root shoot ratio was calculated for each genotype by dividing the dry root weight with the dried shoot weight

$$R/S = \frac{\text{Dried root weight}}{\text{Dried shoot weight}} \times 100$$

D^2 analysis was carried out using computer software, windostat and sixty three pearl millet genotypes were grouped in to various clusters based on D^2 values as per Tocher's method (Rao, 1952). The percent contribution of a character towards genetic divergence was calculated according to Singh and Chaudhary (1977). The genotypic correlations between seedling traits conferring drought tolerance were worked out as per the method suggested by Johnson *et al*. (1955). Genetic components of variance (Burton, 1952), heritability (h^2) in broad sense (Lush, 1940), genetic advance and genetic advance as percentage of mean (Johnson *et al*., 1955) were calculated. Each pearl millet genotype was individually scored as per 1 to 5 scale for eight recorded seedling traits excluding EI and ERI, in such a way that, higher value for each character was given with lower score. The total score for each genotype was

Table 1. Mean square from analysis of variance for seedling traits conferring drought tolerance in pearl millet genotypes

Source	DF	E%	EI	ERI	FSL	FRL	FSW	FRW	DSW	DRW	R/S
Replication	1	6.2222	0.002	0.000007	0.0287	0.0229	0.00001	0.000059	0.000002	0.000001	0.0178
Genotypes	62	238.3574**	0.0069	0.000027	4.3309**	11.9518**	0.000201**	0.000107**	0.000002**	0.000001**	0.0226**
Error	62	12.4158	0.0035	0.000014	0.2211	0.0778	0.000003	0.000003	0.0000001	0.0000001	0.0011
SE		2.4717	0.0414	0.0027	0.3298	0.1956	0.0013	0.0012	0.0002	0.0001	0.0234
CD @ 5%		4.9409	0.0828	0.0053	0.6593	0.3911	0.0026	0.0023	0.0004	0.0001	0.0468
Mean		82.8254	1.0956	0.0139	11.7437	19.3833	0.0609	0.0338	0.0047	0.0021	0.4528

**** Significant at 0.01 probability level**

calculated by adding scores of all eight characters for corresponding genotypes.

Results and Discussion

Analysis of variance (Table 1) indicated that differences among the genotypes were highly significant for all the traits studied except for EI and ERI, indicating presence of genetic diversity among pearl millet genotypes. Since EI and ERI did not show variation among pearl millet genotypes these traits had been excluded for further analysis. In the present study, D^2 analysis was performed to assess the genetic divergence among the genotypes, to identify promising genotypes with more divergence in order to initiate crossing programme and to assess the contribution of different characters towards genetic diversity. By applying clustering technique, all the 63 pearl millet genotypes were grouped into seven clusters with Tocher cut off value of 241.11. Composition of different clusters is given in Table 2.

Table 2. Spread of pearl millet genotypes in different clusters based on seedling traits conferring drought tolerance

Cluster	Number	Genotypes
I	38	PT 4572, PT 4664, PT 5010/2, Thiruvannamalai local, PT 5179, PT 4760, PT 5021, PT 5914, PT 4896, TNBH 8703, PT 3758, PT 4976, PT 5099, PT 5072, PT 5864, PT 5241, PT 4470, PT 4949, PT 5765, PT 5118, PT 4508, PT 5547, PT 4450, PT 4219, PT 5744, PT 5564, Thindivanam local, PT 4619, PT 4060, PT 4551, PT 4266/2, PT 4377, PT 5605, Vellimalai local, PT 4591, PT 5604, PT 5613, PT 5595
II	8	PT 5554, PT 5557, PT 5541, PT 5188(X1), PT 5005, PT 3764, PT 5591, PT 4440
III	11	TNBH 8708, TNBH 8768, CO(cu)9, PT 1890, PT 5913, PT 3987, PT 5077, PT 5722, PT 5608, PT 5552, PT 5843
IV	1	PT 5625
V	3	TNBH 8711, PT 3755, TNBH 8702
VI	1	CO7
VII	1	ICMV 221

Inter and intra cluster distances are presented in Table 3. Cluster III comprised of 11 genotypes and had the highest intra cluster distance (14.27). Considering the inter cluster distance, it was the highest between cluster VI and VII indicates the index of maximum genetic diversity between CO7 and ICMV221 pearl millet genotype. Also, the mean performance for seedling traits conferring drought tolerance such as FRL (21.65cm), FRW (0.0490g), DRW (0.0039g) and R/S (0.7570) were the highest for cluster VII (Table 4), which comprised of ICMV221 genotype. These results were in agreement with Aslam and Tahir (2003). This indicates that ICMV221 is suitable genotype for cultivation in drought prone areas. Cluster II recorded the highest mean value for E% (88.25%), FSL (13.91cm), FSW (0.0756g) and DSW (0.0063g). This suggested that the genotypes PT5541, PT5005, PT5554, PT3764, PT5188(X1), PT4440 and PT5557 belonging to cluster II had good leaf characters along with moderate rooting characters and they can withstand drought to some extend. Keeping this

Table 3. Average intra (diagonal) and inter cluster (above diagonal) distance values

Clusters	I	II	III	IV	V	VI	VII
I	12.35	18.62	23.18	16.25	25.40	35.04	25.55
II		12.87	34.50	23.13	28.54	42.57	22.33
III			14.27	20.66	25.94	23.22	36.87
IV				0.00	28.04	29.63	35.15
V					13.56	25.11	23.37
VI						0.00	42.61
VII							0.00

in view, it appears that crosses between the genotypes with high mean performance belonging to cluster II and VII in all possible combinations would exhibit high heterosis for traits conferring drought tolerance.

The contribution of different characters towards genetic divergence is given in Table 5. It was observed that the maximum contribution to the genetic divergence was recorded by FRL (39.63%) followed by FSW (26.73%) and DRW

Table 4. Cluster mean values of ten characters

Clusters	E%	FSL	FRL	FSW	FRW	DSW	DRW	R/S
I	84.16	11.68	20.28	0.0611	0.0343	0.0039	0.0011	0.4411
II	88.25	13.91	21.53	0.0756	0.0416	0.0063	0.0027	0.4365
III	75.82	10.19	16.27	0.0528	0.0300	0.0047	0.0023	0.4372
IV	82.00	12.80	17.85	0.0610	0.0270	0.0057	0.0014	0.2457
V	84.67	12.30	16.13	0.0660	0.0473	0.0043	0.0028	0.6682
VI	62.00	10.60	11.30	0.0620	0.0250	0.0041	0.0018	0.4274
VII	82.00	12.25	21.65	0.0700	0.0490	0.0051	0.0039	0.7570

Table 5. Character contribution towards genetic divergence

Sl.No.	Characters	Contribution (%)
1	E%	4.86
2	FSL	2.66
3	FRL	39.63
4	FSW	26.73
5	FRW	2.05
6	DSW	7.32
7	DRW	16.28
8	R/S	0.36

(16.28%) suggesting that, selection based on these characters is essential and effective in crop improvement programme. Moreover, other characters namely E%, FSL, FRW, DSW and R/S showed lower contribution to genetic divergence. This lower contribution to genetic divergence by these characters might be due to the fact that selection towards uniformity in these characters could have caused an eroding effect on genetic diversity.

Results on correlation studies are given in Table 6. Among eight characters studied, FRL was highly correlated with FSW (r = 0.5536), FRW (r = 0.4769), DSW (r = 0.5793) and DRW (r = 0.5411) in positive direction. R/S ratio was highly positively correlated with DRW (r = 0.6158) and negatively correlated with DSW (-0.3404) in concurrence with the report of Khan *et al.* (2002). However, R/S ratio was negatively and non significantly correlated with E% and FSW and it had positive non significant correlation with FSL and FRL. The different parameters studied in the present investigation could be proved useful for screening pearl millet genotypes at seedling stage for drought tolerance. High positive correlations between FRW and DRW (r = 0.8800) and between FSW and DSW (r = 0.8105) were recorded which suggested that the selection for these traits will be effective for simultaneous improvement of these traits in breeding programme.

Table 6. Simple correlation coefficients between seedling traits among sixty three pearl millet genotypes

Traits	FSL	FRL	FSW	FRW	DSW	DRW	R/S
E%	0.2782	0.4332**	0.4555**	0.5009**	0.4479**	0.3204**	-0.0508
FSL		0.4688**	0.7518**	0.5672**	0.5909**	0.5542**	0.0606
FRL			0.5536**	0.4769**	0.5793**	0.5411**	0.0506
FSW				0.7682**	0.8105**	0.6978**	-0.0060
FRW					0.5633**	0.8800**	0.4457**
DSW						0.5176**	-0.3404**
DRW							0.6158**

** Significant at 0.01 probability level

Table 7. Estimates on genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense ($h^2_{B.S}$), genetic advance (GA) and genetic advance as percentage of mean (GA %) of seedling traits in sixty three pearl millet genotypes

Characters	GCV %	PCV %	$h^2_{(B.S.)}$ %	GA	GA % of mean
E%	12.83	13.52	90.1	20.783	25.09
FSL	12.21	12.85	90.3	2.806	23.89
FRL	12.57	12.65	98.7	4.987	25.73
FSW	16.32	16.6	96.6	0.02	33.05
FRW	21.36	21.91	95.0	0.015	42.87
DSW	22.48	23.14	94.4	0.002	44.99
DRW	24.99	25.32	97.4	0.002	50.79
R/S	22.87	24.03	90.6	0.203	44.83

Table 8. Scoring for top ten pearl millet genotypes for traits conferring drought tolerance

Sl.No	Genotype	E%	FSL	FRL	FSW	FRW	DSW	DRW	R/S	Total score	Belongs to Cluster
1	ICMV221	2	3	1	2	1	3	1	1	14	VII
2	PT5541	1	2	1	2	1	2	2	3	14	II
3	PT5005	2	3	1	1	1	2	2	3	15	II
4	PT5554	1	3	1	2	1	1	3	4	16	II
5	PT3764	2	3	1	2	2	3	2	2	17	II
6	PT5188(X1)	1	3	1	1	2	2	3	4	17	II
7	PT4440	3	1	1	1	3	2	3	4	18	II
8	PT5557	2	3	2	2	1	1	3	4	18	II
9	PT5605	1	4	1	2	2	2	3	3	18	I
10	PT4219	2	3	1	2	2	3	3	3	19	I

The estimates on genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense ($h^2_{B.S}$), genetic advance (GA) and genetic advance as percentage of mean (GA %) are furnished in Table 7. The magnitude of both genotypic coefficient of variation and phenotypic coefficient of variation for all the characters was more or less equal which indicated that selection for improvement of these characters will be rewarding. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. All the eight characters recorded high heritability estimates, which implied the lesser influence of environmental factors on these characters. In the present study, E%, FSL, FRL, FSW, FRW, DSW, DRW and R/S ratio exhibited high heritability as well as high genetic advance as percentage of mean indicating that selection based on these characters for genetic improvement in pearl millet in order to have drought tolerance capacity will be effective.

Based on present investigation, root length, root weight before and after drying and R/S are useful parameters to be used to screen the genotypes for drought tolerance capacity. Among 63 pearl millet genotypes, ICMV221 belonging to cluster VII recorded the highest mean value for most of the root characters with lower total score (Table 8) and it was identified as highly drought tolerance genotype. The genotypes namely, PT5541, PT5005, PT5554, PT3764, PT5188(X1), PT4440 and PT5557 belonging to cluster II had higher mean for root characters conferring drought tolerance and come within top 10 scores. The above pearl millet genotypes had drought tolerance capacity and these genotypes can be effectively utilized in breeding programme for drought tolerance after evaluation under field condition.

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