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GENETIC VARIABILITY AND DIVERSITY FOR SHOOT/ROOT PARAMETERS UNDER EARLY DROUGHT STRESS CONDITION IN SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH) GENOTYPES

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SUMMARY

Thirty sorghum genotypes were evaluated for their genetic potential to drought tolerance based on shoot/root parameters. The seedling traits as shoot length, root length, fresh root weight and dry root weight were studied under control as well as water stress condition. The traits dry root weight, fresh root weight, shoot length and root length were found most affected due to water stress. Further, the co-efficient of variation, heritability, genetic advance and diversity for shoot/root parameters of sorghum genotypes under moisture stress condition was studied. High estimates of heritability were observed for dry root weight (92.05%), fresh root weight (90.40%), shoot length (83.84%) and root length (61.40%). Genetic advance as per cent of mean were observed for dry root weight (69.89), fresh root weight (64.87), shoot length (43.31) and root length (20.17). The diversity of genotypes was studied based on D2 statistics and grouped into 11 clusters and each cluster revealing considerable amount of genetic diversity. The genotypes in the cluster I (ICSR93001, ICSV95022, AS160, MS8444) and II (DRT1030, B35, CO26) are identified as superior genotypes for early drought tolerance and suggests the possibilities of improvement of these characters through selection for drought tolerance breeding programme.

Keywords : Sorghum, drought, shoot/root, genetic variability, diversity

Sorghum [*Sorghum bicolor* (L.)] is an important food crop in the world and considered to be the fourth most important cereal crop. Sorghum mainly growing in the regions of semi-arid, where sorghum becomes a major stable food crop. Fortunately, water scarcity is the major limiting factor, especially in these areas. It is estimated that the sorghum cultivated area permanently in the world is affected by 28% due to drought stress (Li *et al.* 2009). Water scarcity limits the agriculture production globally and it is estimated that only 16% are arable area because of drought impact (Alexandratos and Bruinsma 2012). Under such circumstances the genotypes have to be evaluated at germination phase and seedling responses to drought stress in order to develop a resistant cultivar. With this background, the aim of this experiment is to select the superior genotypes against drought stress at early stage based on shoot/root parameters.

MATERIALS AND METHODS

The experiment was carried out at Tamil Nadu Agricultural University, Coimbatore during 2017. Thirty sorghum genotypes were used in this study for shoot/root parameters (Table 1). The experiment was laid out under completely randomized block design (CRBD) with two replications. The genotypes and moisture levels were considered as factors *viz*., control and stress. In control seeds were germinated under normal condition and stress were maintained at -0.8 MPa created using a polyethylene glycol solution (PEG-6000) as suggested by Michel and Kaufman (1973). The germination test was conducted by following the procedure prescribed by ISTA (2011) using paper medium at step-in germinator (28 ± 2^0 C and 90 ±3 % RH) for ten days and observations were made on germination percent, shoot and root length. Five plants from each genotype from each replication were evaluated for shoot and root length, fresh root weight and dry root weight. The root and shoot length were measured using measuring scale (cm). Fresh and dry root weight was measured using digital balance (g). Dry root weight was estimated by keeping root on separate paper bag in hot air oven at 70^oC for 24 hrs. (Kaydan and Yagmur, 2008).

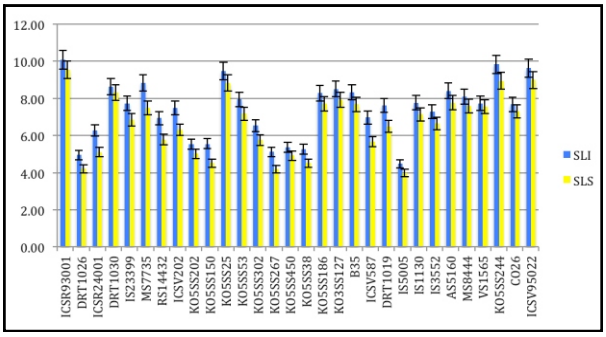
TABLE 1
The list of 30 sorghum genotypes used in this study

S. No.	Genotypes	Source	S.No.	Genotypes	Source
1.	ICSR93001	ICRISAT	16	KO5SS38	IIMR
2.	DRT1026	ICRISAT	17	KO5SS186	IIMR
3.	ICSR24001	ICRISAT	18	KO3SS127	IIMR
4.	DRT1030	ICRISAT	19	B35	ICRISAT
5.	IS23399	ICRISAT	20	ICSV587	ICRISAT
6.	MS7735	Unknown	21	DRT1019	ICRISAT
7.	RS14432	ICRISAT	22	IS5005	ICRISAT
8.	ICSV202	ICRISAT	23	IS1130	ICRISAT
9.	KO5SS202	IIMR	24	IS3552	ICRISAT
10.	KO5SS150	IIMR	25	AS5160	Unknown
11.	KO5SS25	IIMR	26	MS8444	Unknown
12.	KO5SS53	IIMR	27	VS1565	Unknown
13.	KO5SS302	IIMR	28	KO5SS244	IIMR
14.	KO5SS267	IIMR	29	CO26	TNAU
15.	KO5SS450	IIMR	30	ICSV95022	ICRISAT

Differences between genotypes for different characters were tested for significance by using analysis of variance technique (Panse and Sukhatme 1954). Heritability (broad sense) was calculated as the ratio between genotypic variance to total or phenotypic variance and expressed as percentage (Allard 1960). The expected genetic advance was obtained as the difference between the mean of the progeny of selected individuals and base populations, computed with the help of formula suggested by Johnson *et al.* (1955). Phenotypic and genotypic correlation were calculated by the formula suggested by Al-Jibouri *et al*., (1958) using the variance and covariance estimates from the analysis of variance and analysis of covariance tables. The data on four quantitative traits for thirty sorghum genotypes under drought stress condition were subjected to multivariate hierarchical cluster analysis. Cluster analysis was performed using INDOSTAT services Ltd (version 8.5), Hyderabad, India.

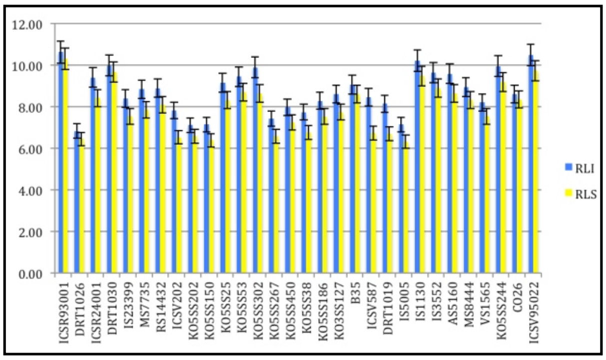
RESULTS AND DISCUSSION

The mean performance of thirty sorghum genotypes for the shoot length (Fig. 1), root length (Fig. 2), fresh root weight and dry root weight traits under both stress and control showed high variation among the genotypes as it was evident from the range of values. Expression of these traits was greatly influenced by osmotic stress built by polyethylene glycol (PEG). Drought stress restricted the traits expressions through affecting cell divisions in the plant tissues and ultimately it affects the various seedling traits physiological and morphological expressions (Bibi *et al.* 2010) such as seed germination shoot length, root length and both fresh weight and dry weight of the plants. Shoot growth is more prone to affect than root growth by drought stress due to restriction in cell division and elongation (Bibi *et al.,* 2010). Though the roots sensitized primarily water stress also the shoots were influenced greatly through decreased water level in the tissues and declined



SLI-Shoot length (control-irrigated), SLS-Shoot length (Drought-stress).

Fig. 1. Mean comparison of thirty sorghum genotypes for shoot length under control (irrigated) and drought (stress).



SLI-Root length (control-irrigated), SLS- Root length (Drought-stress).

Fig. 2. Mean comparison of thirty sorghum genotypes for root length under control (irrigated) and drought (stress).

external osmotic potential (Kaydan and Yagmur, 2008). In the present study also the genotypes shoots had greatly influenced by the drought stress than roots. The traits like dry root weight had greatly influenced based on per cent reduction under drought stress, followed by shoot length, fresh root weight and root length. Influence of these trait expressions were substantiates with finding of (Bibi *et al.*, 2010; Ali *et al.*,2011).

Genetic variability

The analysis of variance showed a significant difference among the 30 genotypes for all traits studied. Broad sense heritability shows the ratio of genetic variance to phenotypic variance. The phenotypic and genotypic coefficient of variation (Table 2) also exhibits were less affected by the environment. The heritability (Table 2) ranges from (61.40% to 92.05 %) indicated that the environment has less affected the studied traits. Further, the genetic advance ranges from (20.17% to 69.89%) for all the traits indicated as high and predicts that additive gene effects and useful in selection (Rajarajan and Ganesamurthy, 2014). The maximum values for *genetic* advance were observed for dry root weight (69.89%) followed fresh root weight (64.87%), shoot length (43.31%) and root length (20.17%). In this study remain the genetic advance was high for the traits studied and further these characters exhibited high heritability, high genetic advance as percentage of mean with high genotypic co-efficient of variation indicating importance of additive genetic variance and that selection may be effective based on these traits (Rajarajan *et al.*,2017).

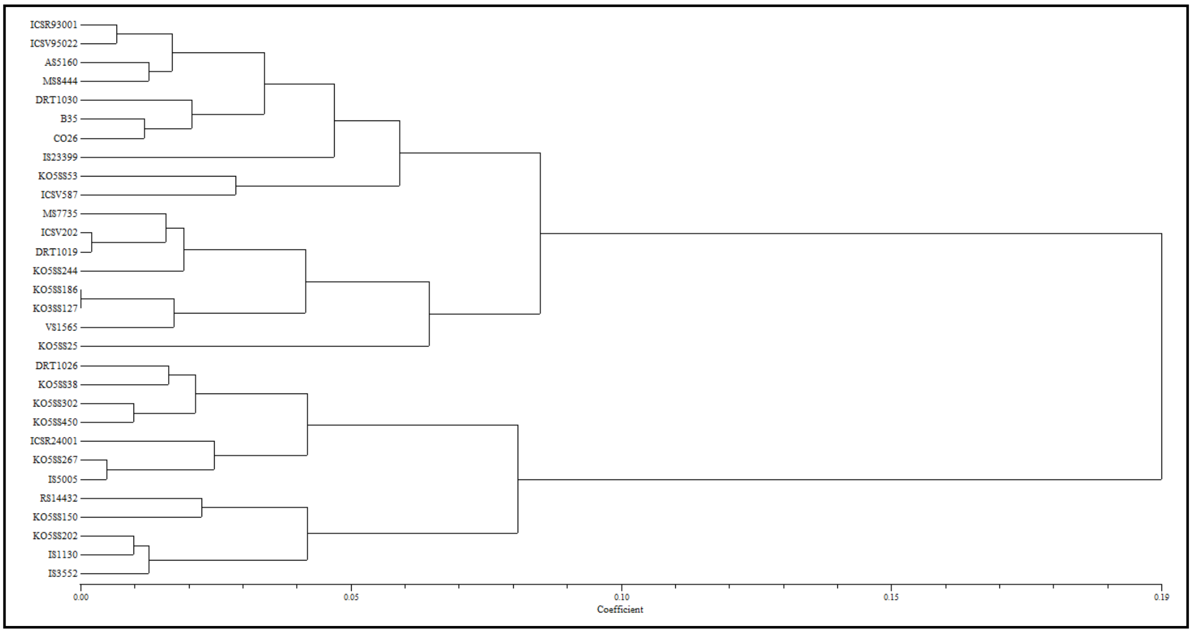


Fig. 3. Dendrogram pattern of 30 sorghum genotypes under PEG induced drought stress.

TABLE 2
Components of variance, heritability and genetic advance for four traits under PEG induced drought stress condition

Characters	PCV (%)	GCV (%)	Heritability (%)	Genetic advance as percentage of mean
Shoot length (cm)	25.07	22.96	83.84	43.31
Root length (cm)	15.94	12.49	61.40	20.17
Fresh root weight (g)	34.83	33.12	90.40	64.87
Dry root weight (g)	36.86	35.36	92.05	69.89

TABLE 3
Clustering composition of 30 sorghum genotypes under PEG induced drought stress

No. of clusters	Name of the genotypes
I	ICSR93001, ICSV95022, AS160, MS8444
II	DRT1030, B35, CO26
III	IS23399
IV	KO5SS53, ICSV587
V	MS7735, ICSV202, DRT1019, KO5SS244
VI	KO5SS186, KO5SS127, VS1565
VII	KO5SS25
VIII	DRT1026, KO5SS38, KO5SS302, KO5SS450
IX	ICSR24001, KO5SS267, IS5005
X	RS14432, KO5SS150
XI	KO5SS202, IS1130, IS3552

Cluster analysis

In this study, diversity among sorghum accessions was estimated using hierarchical cluster analysis for four quantitative traits under PEG induced drought stress conditions (Fig. 3). The genotypes were grouped into 11 different clusters (Table 3). The cluster I and II represents drought tolerant genotypes. Further, cluster IX represents drought susceptible genotypes based shoot/root parameters. The tolerant genotypes possess maximum values for shoot and root length coupled with fresh and dry root weight, which helps in plants to maintain plant water status to combat with water deficit stress conditions. Furthermore, the grouping of genotypes into different clusters gives us an opportunity to identify and select the drought tolerant genotypes at early stages, which can be used in further breeding programme for drought tolerance.

CONCLUSION

The genetic gain of these sorghum genotypes were evaluated based on shoot/root parameters as inherent trait contributing to drought tolerance. The genotypes ICSR93001, ICSV95022, AS160, MS8444, DRT1030, B35 and CO26 identified as superior genotypes at early stages drought tolerance. Initial screening of these genotypes might be productive in subsequent breeding programmes for drought tolerance. Selection can be made possible to screen large populations for drought tolerance. Further it minimizes the time and cost for evaluating the genotypes for drought tolerance.

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