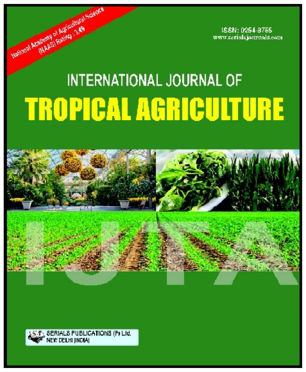

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Comparative Assessment of Genetic parameters in Tomato (*Lycopersicon esculentum L.*) germplasm under Normal moisture and Osmotic Stress in *in vitro* condition

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Abstract: Thirty five tomato genotypes were evaluated to assess the nature and extent of genetic variability, heritability and genetic advance under both normal (0% PEG-6000 as control) and osmotic stress condition (12 % PEG-6000) in germination phases in three replications in a completely randomized design. The observations on germination per cent, root length, shoot length, seedling length, root to shoot ratio and seed vigour were recorded on tenth day after incubation. The results of the analysis of variance for all the characters studied were found to be highly significant in both the conditions indicating the availability of large variability in the study material. A high range of variation and high heritability coupled with high genetic advance was recorded for most of the traits. It indicates the broad genetic base and less environmental influence which specifies the predominance of genetic factor controlling variability. Hence, early generation selection schemes would be effective for improvement. Further, there exists an ample scope for isolation of promising lines from the present gene pool for drought tolerance.

Key words: Tomato, PEG-6000, Moisture stress, Genetic variability and Heritability.

INTRODUCTION

Tomato is a globally important vegetable crop grown in tropical and sub-tropical regions of the world. It is a native of South America where the major domestication of cultivars occurred and is cultivated across various countries in the world like Bangladesh, China, Pakistan, Japan, Philippines, France, Italy, Egypt and United States. The floral structure and floral biology of tomato favors self-pollination and it is reported to have the somatic chromosome number of 2n = 24.

In the era of climate change and receding water resources all over the world, the abiotic stresses like drought and salinity have been considered as major production constraints in crop production of almost all the crops including tomato. The recent trends in abrupt climate change are making the abiotic stresses more common in many crop ecosystems. Screening of tomato cultivars against insect pests and diseases have been attempted by several workers elsewhere in India and abroad. But systematic research efforts for genetic improvement of tomato for abiotic stress tolerance are not well pursued till recent times. Agronomical interventions have their own importance in abiotic stress tolerance, since genetic solutions are unlikely to close more than 30% of the gap between potential and realized yield under water stress as indicated by Edmeades *et al.,* 2004[6]. However, improved genetics can be packed in a seed and easily be adapted than improved agricultural practices that depend more heavily on input availability, infrastructure, access to markets and skill in crop and soil management as cited by Campos *et al.,* 2004 [3]. So, the use of genetics and breeding aspects to improve drought tolerance capacity and provide yield stability is an important part of the solution to this dynamic problem.

However, breeding for water stress requires continuous efforts, primarily through the knowledge of genetic mechanism governing heritable parameters. Systematic improvement of any crop depends mainly on the information on genetic variability and diversity which forms the basis for any crop improvement programme. Further, the success of any crop improvement programme depends on the extent of genetic variability present in the population for the traits for which the improvement is aimed at. So, screening the cultivated varieties and germplasm lines for drought tolerance is the first step in developing varieties with both drought tolerance and high yield.

It is well known that, the drought tolerance screening under field conditions requires lot of resources (land, labour and other resources) and planning of the experiment. Further, it also depends on the environmental influences that affect phenotypic expression of a genotype. The study of the influence of the drought using osmotic solutions in germinal phase is one of the alternative methods for drought tolerance screening. Plants tolerant to both the biotic and the abiotic stresses can be acquired by applying the selective agents such as NaCl, for salt tolerance, polyethylene glycol (PEG) or mannitol, for drought tolerance as per Errabii *et al.*, 2008[7]. Polyethylene glycol is a better choice for imposing low water potential than the often used solute mannitol, because mannitol has been shown to be taken up by plant cells and can cause specific toxic effects on growth as suggested by Hohl and Schopfer, 1991[13] and Verslues *et al.*, 1998 [23]. Several authors reported the use of PEG for *in vitro* drought screening in crop plants since last 3 to 4 decades in plant science research as reported by several workers like Thill *et al.*, 1979 [22], Dragiiska *et al.*, 1996 [5], Hassan *et al.*, 2004 [12], Manoj and Deshpande, 2005 [16], Gopal and Iwama, 2007 [9], Sakthivelu *et al.*, 2008 [20], Harish Babu and Gobu, 2016 [11].

Screening genotypes at seedling stages have several benefits, such as screening large set of germplasm with less effort, more accuracy, low cost, ease of handling, less laborious and getting rid of susceptible genotypes at the early stages. Furthermore, seedling traits have also shown moderate to high heritability with additive type of genetic variance within and over environments as per Rauf *et al.,* 2009 [18]. There are very scanty reports available on the genetics of drought tolerance in tomato. So, the present work was carried out to know the nature and extent of genetic variability, heritability and genetic advance of traits involved in drought tolerance.

MATERIALS AND METHODS

The research materials used in the study consisted of 35 tomato genotypes which were screened under drought stress (induced osmotic stress) and non-stress (normal) conditions. Each of the 35 genotypes was subjected to osmotic stress at germination stage induced by Polyethylene Glycol-6000 (PEG-6000) at 12.0% (equivalent to - 0.7 MPa, as described by Michel and Kaufmann, 1973) in 3 replications in a completely randomized design as reported by for eggplant. Since tomato also belongs to Solanaceous group of vegetables, the same level of osmotic stress (12% PEG-6000) which was reported from our previous study on eggplant was used for screening germplasm for drought tolerance as reported by Gobu and Harish Babu, 2017[8]. For control, sterile distilled water was used instead of PEG-6000 for seed germination and seedling growth. Thirty seeds per genotype were surface sterilized with 70 % ethanol for 1 minute. Later, the seeds were washed thoroughly with sterile distilled water for three times and seeds were kept in petri-plates having moisturized germination paper. Seeds were moisturized with 12% PEG-6000 solution for treatment plates and with sterile distilled water for control plates and were incubated for ten days at room temperature. At daily intervals, 1 ml of PEG-6000 solution or sterile distilled water was added to petri-plates to keep the germination paper sufficiently moistened during the course of incubation. Seed germination was recorded on daily basis. The observations on germination per cent, root length, shoot length, seedling length were recorded on tenth day after incubation. Further, seed vigour and root to shoot ratio were computed to have a better understanding on their drought tolerance ability. Seed vigor was calculated using the following formula given by ISTA, 1985 [14].

$$\text{Seed vigour} = \text{Seedling length (cm)} \times \text{Germination percentage.}$$

The statistical analysis of the data on the individual characters was carried out on the mean values of the seedlings in each genotype and analyzed by using Windostat software package (Version 9.2). The analysis of variance for each character was analyzed by adopting Completely Randomized Design as suggested by Cochran and Cox, 1957 [4]. The mean, range and variance values of each character were calculated for each genotype. The coefficient of variation both at phenotypic (PCV) and genotypic (GCV) levels for all the characters were computed by applying the formula as suggested by Burton and Devane, 1953 [2]. PCV and GCV were classified into low (0 – 10 %), moderate (11 – 20 %) and high (21 % and above) as suggested by Subramanian and Menon, 1973 [21]. Heritability in broad sense for all the characters was computed by the formula suggested by Hanson *et al.,* 1956 [10]. Heritability was classified into low (0 – 30 %), moderate (31 – 60 %) and high (61 % and above) as suggested by Robinson *et al.,* 1949 [19]. The predicted genetic advance was estimated according to the formula given by Johnson and Robinson (1955). The genetic advance as per cent of mean was categorized into low (0– 10 %), moderate (10.1 – 20 %) and high (> 20.1 and above) as suggested by Johnson and Robinson, 1955 [15].

RESULTS AND DISCUSSION

The analysis of variance was done to test the significance of differences among genotypes studied in both moisture stress (12 % PEG-6000) and normal condition (0 % PEG-6000). Analysis of variance revealed that the genotypes under study differed significantly even at one per cent level of probability for all characters studied in both osmotic stress and normal conditions. The mean sum of squares of all the characters is presented in tables 1 and 2 for osmotic stress and normal conditions, respectively.

Table 1
Analysis of variance in tomato genotypes under moisture stress induced by 12 % PEG-6000 in *in vitro*

Source	*d.f*	*Germination per cent*	*Root length (cm)*	*Shoot length (cm)*	*Seedling length (cm)*	*Seed vigour*	*Root to shoot ratio*
Treatment	34	4100.04**	1220.33**	299.41**	38.63**	422568.52**	13.84**
Error	70	5.31	3.96	0.39	0.05	491.51	0.11
S.Em.		0.91	0.08	0.04	0.13	12.71	0.15
C.V. (%)		3.53	3.96	4.22	4.51	6.36	8.65
C.D. 5 %		2.98	0.25	0.11	0.40	35.78	0.43
C.D. 1 %		4.81	0.40	0.14	0.51	47.24	0.72

Where, d.f. - Degrees of freedom; * - Significance @ 5% ; ** - Significance @ 1 %

Table 2
Analysis of variance in tomato genotypes under normal moisture (Dist. water) in *in vitro*

Source	*d.f*	*Germination per cent*	*Root length (cm)*	*Shoot length (cm)*	*Seedling length (cm)*	*Seed vigour*	*Root to shoot ratio*
Treatment	34	1406.00**	13.71**	8.13**	40.11**	463676.12**	1.20**
Error	70	13.34	0.04	0.03	0.14	1536.62	0.02
S.Em.		2.66	0.12	0.11	0.21	23.55	0.04
C.V. (%)		5.14	4.43	4.73	5.11	6.01	5.81
C.D. 5 %		6.01	0.31	0.31	0.63	59.67	0.14
C.D. 1 %		8.13	0.43	0.47	0.88	78.11	0.22

Where, d.f. - Degrees of freedom; * - Significance @ 5% ; ** - Significance @ 1 %

Comparison between mean values of the various traits, range, phenotypic co-efficient of variation, genotypic co-efficient of variation, broad sense heritability estimates and genetic advance for all the characters studied under osmotic stress and normal moisture condition is represented in the table 3.

The mean germination percentage under moisture stress induced by 12% PEG-6000 was in the range of 0 to 100 with an overall mean of 48.97%. While under normal condition (0 % PEG), the mean germination per cent recorded was 82.48% with a range of 21.06 to 100%. Germination per cent in both control and stress condition showed high phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) coupled with a high heritability. The GCV and PCV values recorded have narrow variation which indicates that this trait was less affected by environment. Further, the germination per cent showed high genetic advance over mean (GAM) in both control and stress conditions which clearly depicts that the germination percentage can be used as a reliable parameter for selection of tomato genotypes for drought tolerance. Similar results were reported by Abd El-Lattef *et al.*, 2011 [1] in rice and Gobu and Harish Babu , 2017 [8] in eggplant.

Under moisture stress condition (12% PEG-6000), the mean root length recorded was 3.98 cm with a range of 0.00 to 8.69 cm. However, under

Table 3

Comparative estimates of genetic parameters in tomato genotypes for various traits under osmotic stress (12 % PEG-6000) and normal moisture (Dist. water) in *in vitro* experiment

Sl. No	*Character*	*Mean*		*Range*		*PCV (%)*		*GCV (%)*		*h^2 (%)*		*GAM (%)*	
		Osmotic stress	*Normal moisture*	*Osmotic stress*	*Normal moisture*	*Osmotic stress*	*Normal moisture*	*Osmotic stress*	*Normal moisture*	*Osmotic stress*	*Normal moisture*	*Osmotic stress*	*Normal moisture*
1	Germination percent (%)	48.97	82.48	0.00 - 100.00	21.06 - 100.00	69.81	30.98	68.22	30.13	97.73	97.25	138.32	59.84
2	Root length (cm)	3.98	5.33	0.00-8.69	0.17 - 9.66	71.11	42.26	69.87	41.17	98.26	97.42	130.62	79.36
3	Shoot length (cm)	1.86	4.13	0.00 - 8.17	0.15 - 6.13	89.30	44.16	87.23	43.77	97.70	99.10	175.43	84.39
4	Seedling length (cm)	5.75	9.41	0.00-15.89	0.31 - 15.34	70.08	43.82	69.01	42.56	98.47	97.12	131.61	80.61
5	Seed vigour	411.71	800.21	0.00-1133.69	5.65 - 1534.36	93.86	55.46	92.22	54.13	98.25	97.60	187.21	113.38
6	Root to shoot ratio	2.97	1.66	0.00-11.31	0.56 - 5.33	75.84	44.39	72.89	43.65	96.12	98.33	134.65	90.14

Where,

PCV – Phenotypic Co-efficient of Variation, GCV – Genotypic Co-efficient of Variation,

h^2 – Broad Sense Heritability, GAM – Genetic Advance as percent over Mean normal condition, the root length ranged from 0.17 to 9.66 cm with a mean of 5.33 cm. The phenotypic and genotypic co-efficient of variability for root length in both stressed and normal condition were high which were coupled with high heritability and high genetic advance over mean indicating that the possibility of this trait is under the influence of additive gene action and there exists a scope for selection of genotypes for drought tolerance based on this trait. The mean shoot length under moisture stress was 1.86 cm and ranged from 0.00 to 8.17 cm. But under normal condition, the mean shoot length recorded was 4.13 cm with a range of 0.15 to 6.13 cm. Shoot length showed high level of genotypic and phenotypic co-efficient of variability. It also possess high heritability with high genetic advance over mean in both stressed and control condition indicating very little influence of environment. The mean seedling length under moisture stress was 5.75 cm and was in the range of 0.00 to 15.89 cm. On the contrary, the mean seedling length under normal condition was 9.41 cm with a range of 0.31 to 15.34 cm. For seedling length, coefficient of variability observed at phenotypic and genotypic level was high. It showed high heritability with high genetic advance over mean.

The seed vigour under moisture stress was in the range of 0 to 1133.69 with a mean of 411.71. However, under normal condition, the mean seed vigour was 800.21. The lowest and highest seed vigour recorded was 5.65 and 1534.36, respectively. Seed vigour exhibited high genotypic and phenotypic co-efficient of variation. It also had high heritability indicating that it is less influenced by environmental factors. It had high genetic advance over mean.

The mean root to shoot ratio under moisture stress was 2.97 and it was in the range of 0.00 to 11.31. Under normal condition, the root to shoot ratio was in the range of 0.56 to 5.33 with a mean of 1.66. Root to shoot ratio showed high genotypic and phenotypic co-efficient of variation. This trait exhibited high heritability with high genetic advance over mean and this trait is known to play a pivotal role in drought tolerance, so selection based on this trait will lead to identification of better drought tolerant genotypes.

It can be concluded from the above results that, a vast genetic variability exists among tomato genotypes for drought tolerance or moisture stress tolerance with high heritability. Further, these genotypes can be additionally screened by field evaluation methods to validate drought tolerant genotypes. This would further help in identifying genotypes having better drought tolerance characteristics which may be of great use in breeding for drought tolerance in tomato.

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