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Assessment for Tolerance to Salt Stress during Germination Revealed Variability among the Accessions of the Tomato Association Mapping Panel

***Asif Hadimani*[1], *Mukesh L. Chavan*[2], *Fakrudin, B.*[1*], *Anjanappa, M.*[3], *Halesh G.K.*[1] *and Shivanna, M.*[4]**

[1]*Ph.D. Research Scholar, Department of Biotechnology and Crop Improvement, College of Horticulture, UHS Campus, Bengaluru (Karnataka), India.*
[1]*Professor and Head, Department of Biotechnology and Crop Improvement, College of Horticulture, UHS Campus, Bengaluru (Karnataka), India.*
[2]*Professor and ICAR Nodal Officer UHS Bagalkot (Karnataka), India.*
[3]*Professor and Head, Department of Vegetable Science College of Horticulture, Kolar (Karnataka), India.*
[4]*Professor and Head, Department of SS&AC, College of Horticulture, UHS Campus, Bengaluru (Karnataka), India.*

(Corresponding author: B. Fakrudin)*
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ABSTRACT: Soil salinity is regarded as one of the most serious threats to vegetable production. Genetic variability studies for salt stress during the early seedling stage are useful in the selection and isolation of salt tolerant genotypes from existing germplasm for the development of new salt tolerant tomato varieties and hybridization. A laboratory experiment was carried out to assess the genetic plasticity among 260 minicore collection during germination stage under 100 mm NaCl salt stress. The Analysis of variation revealed that all of the characters studied under salt stress were highly significant, indicating the existence of a wide range of availability for salt tolerance. A wide range of variation along with high heritability and genetic advance suggests the existence of a broad genetic base and less environmental influence which specifies the predominance of additive gene effects. Hence, early generation selection gives a sufficient scope for breeders to select promising genotypes from the existing gene pool for salt tolerance.

Keywords: Tomato, Salt stress, PCV, GCV, Heritability, Genetic advance.

INTRODUCTION

Tomato is one (*Solanum lycopersicum* L.) of the majorly exploited solanaceous vegetables in Indian cuisines and commercially ranks first followed by chilli, potato and eggplant in crop production. Tomatoes are rich in vitamins specially vitamin-C and antioxidants. The colouring pigment of fruits or berries *i.e.*, Lycopene is known to have anti-cancerous, anti-ageing and avoids osteoporosis and cardiac diseases. Abiotic stress is now a days growing challenge for breeders in developing the most prominent variety or hybrid in a crop. Salinity is most disastrous climatic stress factor after drought stress (Faizan *et al.,* 2021) and followed by temperature stress, frost and chilling stress as well as mineral stress. Soil salinity is becoming major problem now a days in arid and semi-arid regions due drastic climatic changes (Ahmed, 2009). Salinity stress is the most serious factors that limits the productivity of agriculture or horticultural crops, with adverse effects on germination, plant vigour and crop yield (Munns and Tester 2008). Crop plants under salinity stress execute three ways *i.e.,* Cause water deficit due to high ionic action at the rhizosphere region; ionic toxicity over plant morphology especially Na^+ and Cl^-; and another nutrient imbalance uptake Basha *et al.* (2015). However, many scientists have revealed the genetics of salinity in tomato. But, due to its complex mechanism there is a need to update the studies. Even though the tomato is exploited by the breeders in order to enhance their yield and quality fruit potential. Besides its adoptability and distribution, the yield of tomato has been restrained by the soil salinity. Hence, developing salt-tolerant tomato varieties is considered most effective strategy for increasing the tomato production in saline areas (Huda *et al.,* 2018). Any plant breeding progromme relay on existing genetic variability and heritability (Yared and Misteru 2016). The existing genetic variability available in the genotypes is the pre-requisite for new varietal development programme (Kumawat and Gothwal 2018). Therefore, analyzing the nature and magnitude of the heritable genetic variation present in the genotypes is necessary (Bhuvaneshwari, 2008). The success of the crop improvement program depends on various genetic variability parameters along with heritability estimates that could provide the better understanding of genetic advances, which provides precise information on selection (Singh *et al.,* 2017; Parmar *et al*., 2013). In order to reveal the present variability for salinity tolerance at high level we aimed this experiment using 260 genotypes. As well as obtained data utilized for further studies.

MATERIAL AND METHODS

A. Planting material and experimental design

Around 260 tomato germplasm seeds were washed and cleanly shade-dried. Without any seed treatment and priming ten seeds per replication were placed in petri-plates layered with sterilized germination paper discs as a substrate media. The experiment was completely randomize designed with three replication per genotypes and carried out inside the growth chamber.

B. Treatment Induction

The saline solution was prepared using NaCl salt of concentration of about 100 mM. The seeds were watered with saline solution on alternated days using filler. The whole *in-vitro* work was carried out in the sterilized condition in order to maintain the specified selection pressure.

C. Record of observations

The observations like germination *per-cent,* Speed of germination, Root length, shoot length, seedling vigour index and dry weight of root to shoot ratio were recorded on the fourteenth day after incubation to understand the salt tolerance ability of the genotypes.

D. Biometric analysis

Statistical analysis like Analysis of Variance, descriptive statistics and genetic parameter estimations were done using online statistical tool *i.e.*, OPSTAT*V.2.0*.

RESULTS AND DISCUSSION

Genetic variability in any crop is required for the choice of superior genotypes over existing cultivars. The analysis of variance for different characters revealed highly significant differences for all six studied characters at the 1% level of significance, implying that each genotype is genetically diverse from each other and that there is ample scope for selecting characters from these diverse sources for yield and its components under saline conditions (Table 1). Such a differential response among the tomato genotypes to salt stress has been reported in different crops including tomato (Dasgan *et al.,* 2002; Kaveh *et al.,* 2011; Devi and Arumugam 2019).

Under salt stress (100 mM NaCl), the mean germination percentage ranged from 0 to 100%. The coefficients of variation for phenotypic (PCV) and genotypic variation (GCV) were 93.80 and 93.19%, respectively. The estimated heritability (in the broad sense) for this character was about 98.71 % with a high genetic advance over the mean of 190.74 % (Table 2). The mean speed of germination under salt stress was in the range of 0 days to 20.5 days with over mean 10.18 days. The PCV & GCV was 65.25 and 63.79 %, respectively. Speed of germination shows high heritability of 95.56 % with a high genetic advance over mean of 128.45 % for this trait (Table 2).

The result of root length under salt stress revealed that it ranged from 0.00 to 5.4 cm with over all mean 0.92 cm. Root length exhibited high heritability of 82.44 % with genetic advance as a percent mean of 190.31 %. The PCV & GCV was 112.05 and 101.74 % was observed for this trait (Table 2). The mean shoot length under salt stress was in the range of 0 to 4.75 cm with an overall mean of 0.98 cm. The phenotypic and genotypic coefficients of variation were 100.25 and 89.73 % respectively. A high heritability of 80.01 % with a high genetic advance over mean of 165.46 % was observed for this trait (Table 2).

The overall mean recorded for seedling vigor index was 106.20 with the range of 0 to 873 at 100 mM NaCl. The PCV & GCV for this character was 138.54 and 132.23 % and also exhibited high heritability of 91.10 %with a high genetic advance over mean of 259.98 % (Table 2). The dry weight root to shoot ratio varied from 0 to 0.294 with an average of 0.067 under salt stress (100 mM NaCl). The PCV & GCV were 138.54 and 132.23 %, respectively. A broad sense heritability of 99.01 % with a high genetic advance 259.98 % was observed for the root-to-shoot ratio (Table 2).

In the current study the parameters like germination percent (%), speed of germination, root length(cm), shoot length (cm), seedling vigor index and dry weight root to shoot ratio has shown high range of phenotypic co-efficient of variation and genotypic co-efficient of variation. And the difference between GCV and PCV is slightly mere. Which indicates the presence of genetic variation for salinity tolerance among the tomato germplasm and the highest contribution is from genetic constitution of germplasm over other environmental factors. The lower impact of other environmental factor is because of experiment was carried under *in-vitro* condition. Similarly, the studies conducted by Farooq *et al.* (2018) in cotton, Huqe *et al.* (2021) in maize, Gobu *et al.* (2017) in brinjal, Huda *et al.* (2017) in rice and Rakshith (2020) in brinjal reported the high PCV and GCV in most of the traits.

The heritability explains about heritability status of a trait into is progeny or further generations and high heritability coupled with high genetic advance over mean is primary criteria for breeders in terms of selection over specified trait. In present study the traits like germination percent (%), speed of germination, root length (cm), shoot length (cm), seedling vigor index and dry weight root to shoot ratio has resulted high broad sense heritability coupled with high genetic advance over mean. Correspondingly, the investigation directed by Farooq *et al.* (2018) in cotton, Huqe *et al.* (2021) in maize, Gobu *et al.* (2017) in brinjal, Huda *et al*. (2017) in rice, Kumawat and Guthwal (2018) in lentil.

Table 1: Analysis of variance for seedling parameters among the accessions of tomato association mapping panel under salt stress *in vitro* condition.

Source	Degrees of freedom	Germination percent (%)	Speed of germination	Root length (cm)	Shoot length (cm)	Seedling vigor index	Dry weight root to shoot ratio
Genotypes	259	1993.27**	81.85**	2.27**	1.98**	48527.0**	0.007**
Error	260	25.71	3.63	0.39	0.39	4320.02	0.000068
Total	519	523,657.6	22,157.99	693.68	621.10	13,702,553.9	1.995
S Em ±		3.772	1.357	0.449	0.452	46.700	0.013
C D @ 1%		10.512	3.780	1.252	1.259	130.126	0.037

Where, * - Significant at 5%; ** - Significant at 1%

Table 2: Estimates of genetic parameters of tomato association mapping panel under salinity stress induced under *in vitro* condition.

Traits	Mean	Range		PCV (%)	GCV (%)	h_{bs}^2(%)	GAM (%)
		Maximum	Minimum				
Germination (%)	33.65	100	0	93.80	93.19	98.71	190.74
Speed of germination (days)	9.80	20.5	0	65.25	63.79	95.56	128.45
Root length (cm)	0.95	5.4	0	112.05	101.74	82.44	190.31
Shoot length (cm)	0.99	4.75	0	100.25	89.73	80.01	165.46
Seedling vigour index	112.43	873	0	138.54	132.23	91.10	259.98
Dry weight root to shoot ratio	0.066	0.294	0	82.12	81.71	99.01	167.48

Where,
PCV–Phenotypic Co-efficient of Variation; GCV–Genotypic Co-efficient of Variation; h_{bs}^2– Broad sense heritability; GAM–Genetic Advance as *per cent* over Mean

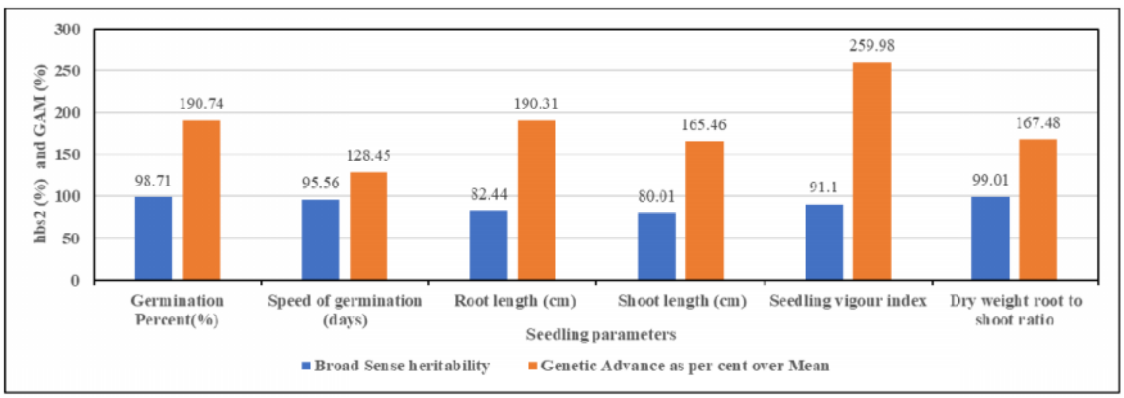

Fig. 1. Comparison between Broad sense heritability (%) and genetic advance over mean (%) for six different seedling parameters of tomato germplasm over salinity stress.

CONCLUSION AND FUTURE SCOPE

Based on ANOVA and genetic parameter estimates we conclude that the presence of genetic variability for salt tolerance in germplasm and the parameters like germination percent (%), speed of germination, root length (cm), shoot length (cm), seedling vigor index and dry weight root to shoot ratio has shown high phenotypic co-efficient of variation and genotypic co-efficient of variation as well as high heritability coupled with high genetic advance over mean. The obtained data results based on genetic variability, heritability and genetic advance would be useful for selection and isolation of tomato genotypes for further crop improvement related to salinity tolerance along with higher yield in tomato.

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Conflict of Interest. None.

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