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SCREENING OF TOMATO (*Solanum Lycopersicum* L.) GERMPLASM FOR SALINITY TOLERANCE AT THE GERMINATION STAGE

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ABSTRACT

Salinity is a major constraint to tomato establishment and productivity, highlighting the need to identify germplasm with improved tolerance at the early growth stage. The present study was conducted during December 2025 at the Central Instrumental Laboratory, Post Graduate Institute of Horticultural Sciences (PGIHS), SKLTGHU, Mulugu, Telangana, to screen 35 tomato (*Solanum lycopersicum* L.) germplasm lines for salinity tolerance at the germination stage. The experiment was laid out in a factorial completely randomized design (FCRD) with four NaCl-induced salinity levels (0, 4, 8 and 12 dS m^{-1}) and two replications. Germination percentage, germination index, plumule length and radicle length were evaluated. Salinity significantly reduced all the studied parameters, with mean germination declining from 93.5% under control to 53.5% at 12 dS m^{-1}. At 12 dS m^{-1}, EC690989, EC620360, EC631373, EC620366, EC632944 and EC631477 maintained 100% germination, while IC296468, EC638518, EC520074, EC615040, EC635527 and EC617055 recorded only 0–10% germination. EC631415 and EC620366 recorded comparatively higher germination index values, while EC631415 showed the lowest reduction in radicle length (17.9%). EC690989, EC631415 and EC635529 maintained comparatively greater plumule growth under severe salinity. Based on the overall performance, EC631415, EC690989 and EC620366 emerged as promising germplasm lines for salinity tolerance at the germination stage. These germplasm lines may serve as useful genetic resources for further screening and breeding programmes aimed at developing tomato with improved salinity tolerance.

***Key words*:** Tomato, salinity stress, germplasm, NaCl, seed germination, salinity tolerance.

Introduction

Tomato (*Solanum lycopersicum* L.), a member of the Solanaceae family, is one of the most important and widely cultivated horticultural crops in the world and is particularly important in Mediterranean and tropical production systems. In India, tomato cultivation has increased considerably in terms of both area and production. According to the National Horticulture Board (NHB), tomato production was estimated at 208.19 lakh tonnes during 2023–24, compared with 204.25 lakh tonnes in the previous year. This increase has been associated with the adoption of improved cultivars and crop management practices.

Globally, India is the second-largest producer of tomato after China, followed by the United States and Turkey. Among the Indian states, Madhya Pradesh ranks first in tomato production, contributing nearly 2970 thousand tonnes, which accounts for about 14.63% of the country's total production (Singh *et al*., 2025).

Tomato is an important component of the human diet and is valued for its nutritional and health-promoting properties. The fruit contains considerable amounts of water, minerals and essential vitamins, particularly vitamins A, C and E, which contribute to human nutrition and antioxidant protection (Olaniyi *et al*., 2010). However, tomato production is affected by several abiotic stresses,

among which salinity is an important constraint, particularly in arid and semi-arid regions.

Salinity adversely affects plant growth and productivity through osmotic stress, ion toxicity and nutrient imbalance. Tomato is generally considered moderately sensitive to salinity, with root-zone salinity levels of approximately 2.5–2.9 dS m^{-1} generally considered the threshold beyond which yield reduction may occur, although the response varies with genotype and environmental conditions (Kumar *et al.*, 2017). Salinity can also affect seed germination and early seedling growth, making the germination stage an important phase for identifying contrasting responses among germplasm.

Developing salt-tolerant cultivars and hybrids is an effective approach for improving tomato production under saline conditions. Considerable genetic variation for salinity tolerance exists among tomato genotypes; however, the complex inheritance of the trait and the involvement of multiple physiological mechanisms make the development of salt-tolerant cultivars challenging (Choudhury *et al.*, 2023). Therefore, systematic screening of available germplasm at early growth stages can help identify promising sources of tolerance for further evaluation and breeding.

Materials and Methods

The present study was conducted during December 2025 at the Central Instrumentation Facility (CIF), Post Graduate Institute of Horticultural Sciences (PGIHS), SKLTGHU, Mulugu, Siddipet, Telangana, to screen tomato germplasm lines for salinity tolerance at the germination stage. Thirty-five seeds of each germplasm line were placed in sterile Petri dishes (9 cm diameter) containing two layers of filter paper moistened with 10 mL of the respective treatment solution. Four salinity levels, viz., 0, 4, 8 and 12 dS m^{-1}, were used, with distilled water serving as the control. The volume of treatment solution was selected based on the methodology reported by Mallick *et al.*, (2025). Salinity solutions were prepared by dissolving commercial-grade NaCl in distilled water at 2.5, 5.0 and 7.5 g L^{-1} to obtain 4, 8 and 12 dS m^{-1}, respectively. The electrical conductivity of each solution was measured using an electrical conductivity meter and adjusted to the desired level.

The experiment was laid out in a factorial completely randomized design (FCRD) with germplasm lines and salinity levels as the two factors, with two replications. Each replication consisted of two Petri dishes. The seeds were incubated in a BOD incubator under dark conditions at 25°C. To maintain adequate moisture, 2 mL of the respective treatment solution or distilled water was added at two-day intervals. Observations on germination percentage, germination index, plumule length and radicle length were recorded up to the 14th day after seed placement.

Germination percentage (GP) was calculated as:

Germination percentage (GP %) = (number of germinated seeds/total number of seeds) × 100 (till 14 days).

Germination index (GI) was calculated using the formula:

Germination index (GI) = Σ (Gt / Dt), summation of mean number of germinated seeds per day for t days (AOSA, 1983).

Where Gt is the number of germinated seed on day t, and Dt is the total number of days (14 days in this experiment).

Results and Discussion

Germination percentage

Significant variation was observed among the 35 tomato germplasm lines for germination percentage under different salinity levels (Table 1). Germination percentage decreased progressively with increasing NaCl concentration, with mean germination declining from 93.5% under control to 53.5% at 12 dS m^{-1}. However, considerable variation was observed among the germplasm lines in their response to salinity. EC690989, EC620360, EC631373, EC620366, EC632944 and EC631477 maintained 100% germination even at 12 dS m^{-1}, whereas IC296468, EC638518, EC520074, EC615040, EC635527 and EC617055 were severely affected, recording only 0–10% germination.

The decline in germination with increasing salinity may be due to reduced water availability, restricting seed imbibition and delaying germination. The ability of the superior germplasm lines to maintain high germination at 12 dS m^{-1} indicates better tolerance to salt-induced osmotic stress during germination. Similar reductions in seed germination with increasing salinity have been reported by Ahmed *et al.*, (2022), David *et al.*, (2022), Sivakumar *et al.*, (2023), Mallick *et al.*, (2025) and Zhang *et al.*, (2025).

Germination index

Significant variation was observed among the 35 tomato germplasm lines for germination index under different salinity levels (Table 2). Germination index progressively declined with increasing NaCl concentration, with the overall mean decreasing from 1.80 under control to 1.51, 1.07 and 0.53 at 4, 8 and 12 dS m^{-1}, respectively.

Table 1: Effect of germplasm lines, salinity and their interaction on germination percentage (%).

Germplasm	NaCl (ds m^{-1})				Mean (G)	DC
	0	4	8	12		
EC631415	100.0	100.0	100.0	80.0	95.0	20
EC688516	100.0	100.0	70.0	50.0	80.0	50
EC521070	100.0	100.0	70.0	50.0	80.0	50
IC296468	40.0	20.0	0.0	0.0	15.0	40
EC620397	100.0	100.0	100.0	70.0	92.5	30
EC631325	60.0	60.0	50.0	20.0	47.5	40
IC566014	100.0	100.0	100.0	70.0	92.5	30
EC520074	100.0	70.0	10.0	10.0	47.5	90
Local-1	100.0	100.0	100.0	55.0	88.7	45
EC690982	100.0	80.0	70.0	70.0	80.0	30
EC638518	40.0	20.0	10.0	10.0	20.0	30
EC690989	100.0	100.0	100.0	100.0	100.0	00
EC638521	100.0	100.0	80.0	80.0	90.0	20
EC636877	100.0	80.0	30.0	10.0	55.0	90
EC530074	100.0	100.0	80.0	40.0	80.0	60
EC631406	100.0	100.0	80.0	60.0	85.0	40
Local-2	100.0	100.0	100.0	80.0	95.0	20
EC615040	60.0	30.0	20.0	0.0	27.5	60
EC620360	100.0	100.0	100.0	100.0	100.0	00
EC631373	100.0	100.0	100.0	100.0	100.0	00
EC617060	100.0	90.0	90.0	60.0	85.0	40
EC620366	100.0	100.0	100.0	100.0	100.0	00
EC635527	80.0	50.0	0.0	0.0	32.5	80
EC631369	90.0	60.0	60.0	20.0	57.5	70
Local-3	100.0	100.0	100.0	60.0	90.0	40
EC687604	100.0	100.0	60.0	40.0	75.0	60
EC632944	100.0	100.0	100.0	100.0	100.0	00
EC620482	100.0	100.0	80.0	20.0	75.0	80
EC687423	100.0	100.0	100.0	70.0	92.5	30
EC617055	100.0	40.0	0.0	0.0	35.0	100
EC635529	100.0	100.0	100.0	80.0	95.0	20
EC631455	100.0	100.0	100.0	80.0	95.0	20
EC631477	100.0	100.0	100.0	100.0	100.0	00
EC620388	100.0	80.0	70.0	40.0	72.5	60
Pusa Ruby	100.0	100.0	80.0	50.0	82.5	50
Mean (N)	93.5	85.1	71.7	53.5		
Factors	**SE(m) ±**		**CD@5%**		**CV%**	
Factor (G)	0.42		1.32		**1.7**	
Factor (N)	0.10		0.47			
Factor (G×N)	0.95		2.65			
DC: 12 ds m^{-1} % decrease over control						

Table 2: Effect of germplasm lines, salinity and their interaction on germination index.

Germplasm	NaCl (ds m^{-1})				Mean (G)	DC
	0	4	8	12		
EC631415	2.5	2.5	2.1	1.4	2.1	41.6
EC688516	2.5	2.5	1.2	0.3	1.6	85.6
EC521070	1.9	1.7	0.5	0.3	1.1	81.6
IC296468	0.6	0.3	0.0	0.0	0.3	100.0
EC620397	1.9	1.9	1.4	1.0	1.6	46.9
EC631325	1.3	1.3	0.8	0.1	0.9	89.4
IC566014	2.1	2.1	1.8	0.9	1.8	60.1
EC520074	2.1	0.9	0.0	0.0	0.9	96.7
Local-1	2.1	0.7	0.7	0.4	0.9	81.5
EC690982	2.1	1.8	1.5	1.3	1.7	35.1
EC638518	0.6	0.3	0.2	0.2	0.4	60.9
EC690989	2.3	2.1	1.9	1.2	1.9	44.4
EC638521	2.1	1.9	1.6	1.1	1.7	48.1
EC636877	2.1	1.6	0.5	0.0	1.2	96.7
EC530074	2.3	1.9	1.2	0.2	1.5	87.5
EC631406	2.3	2.1	1.2	0.4	1.6	81.5
Local-2	2.5	2.3	2.1	1.2	2.0	48.4
EC615040	1.1	0.2	0.1	0.0	0.3	100.0
EC620360	2.3	2.1	1.4	1.4	1.8	38.4
EC631373	2.3	2.1	1.4	0.7	1.6	69.4
EC617060	2.1	2.0	1.3	0.9	1.6	55.1
EC620366	2.5	2.3	2.3	1.4	2.1	42.8
EC635527	0.5	0.3	0.0	0.0	0.2	100.0
EC631369	0.6	0.4	0.4	0.1	0.4	78.1
Local-3	2.3	2.0	1.9	0.4	1.7	81.5
EC687604	1.7	0.7	0.4	0.2	0.9	83.8
EC632944	2.3	2.1	1.7	0.7	1.7	69.4
EC620482	1.9	1.7	0.5	0.1	1.2	92.9
EC687423	1.4	1.2	1.0	0.5	1.0	65.0
EC617055	1.4	0.2	0.0	0.0	0.4	100.0
EC635529	2.1	1.9	1.6	0.5	1.5	73.4
EC631455	1.4	1.2	0.7	0.5	0.9	60.1
EC631477	1.0	1.0	0.8	0.7	0.9	33.6
EC620388	1.7	1.4	0.5	0.2	1.0	83.8
Pusa Ruby	2.3	2.1	1.6	0.3	1.7	84.5
Mean (N)	1.8	1.51	1.07	0.53		
Factors	**SE(m) ±**		**CD@5%**		**CV%**	
Factor (G)	0.09		0.02		**4.3**	
Factor (N)	0.06		0.08			
Factor (G×N)	0.07		0.14			
DC: 12 ds m^{-1} % decrease over control						

The percentage reduction at 12 dS m^{-1} compared with the respective control varied considerably among germplasm lines, ranging from 33.6% in EC631477 to 100% in IC296468, EC615040, EC635527 and EC617055. EC631415 and EC620366 recorded the highest germination index (1.4) at 12 dS m^{-1}, followed by EC690989 and Local-2 (1.2), while EC638521 recorded 1.1. In contrast, IC296468, EC520074, EC615040, EC636877, EC635527 and EC617055 recorded very low or zero germination index, indicating greater sensitivity to salinity.

The decline in germination index reflects delayed and less uniform germination under salt stress. The ability of superior germplasm lines to maintain a higher germination

Table 3: Effect of germplasm lines, salinity and their interaction on plumule length of genotypes.

Germplasm	NaCl (ds m^{-1})				Mean (G)	DC
	0	4	8	12		
EC631415	11.5	10.9	10.6	9.8	10.7	14.8
EC688516	13.2	11.7	10.8	6.3	10.4	51.9
EC521070	15.9	14.6	12.6	9.3	13.2	41.2
IC296468	9.9	7.3	0.0	0.0	4.3	100.0
EC620397	21.2	15.4	14.4	12.7	15.8	40.3
EC631325	12.4	11.9	10.3	7.2	10.5	42.6
IC566014	16.7	14.4	13.4	12.6	14.3	23.8
EC520074	13.9	13.4	9.5	5.7	10.6	59.2
Local-1	14.3	12.5	9.4	5.2	10.3	63.4
EC690982	17.1	14.5	10.3	9.0	12.8	47.2
EC638518	11.3	9.3	6.4	5.1	8.0	54.1
EC690989	17.7	16.3	15.5	10.4	14.9	41.7
EC638521	16.8	13.5	10.6	9.5	12.6	42.8
EC636877	18.4	16.3	14.2	9.0	14.6	50.9
EC530074	12.7	11.6	10.6	6.0	10.3	52.0
EC631406	12.5	11.7	9.5	6.4	9.9	48.6
Local-2	16.4	14.6	12.5	6.7	12.6	59.7
EC615040	15.3	12.7	5.1	0.0	8.3	100.0
EC620360	16.4	14.7	9.6	6.8	11.8	58.8
EC631373	17.4	16.4	9.5	5.2	12.1	70.6
EC617060	12.5	10.3	9.6	7.4	9.9	41.4
EC620366	14.5	13.5	12.7	8.3	12.2	42.9
EC635527	12.9	9.4	0.0	0.0	5.6	100.0
EC631369	10.6	9.8	8.1	6.2	8.8	41.9
Local-3	13.7	12.3	8.4	4.2	9.6	69.4
EC687604	12.5	10.6	8.3	6.6	9.5	47.5
EC632944	12.5	11.5	10.6	6.3	10.3	49.5
EC620482	12.8	11.8	10.5	5.3	10.1	58.6
EC687423	11.9	10.5	9.7	8.6	10.1	28.0
EC617055	10.6	9.5	0.0	0.0	5.1	100.0
EC635529	16.4	14.6	12.6	9.7	13.2	41.1
EC631455	9.3	7.4	5.4	4.3	6.5	54.2
EC631477	13.7	11.3	10.5	9.3	11.1	31.6
EC620388	14.4	12.7	10.4	6.3	10.9	56.5
Pusa Ruby	13.4	12.7	11.5	9.7	11.8	28.3
Mean (N)	14.1	12.4	9.6	6.8		
Factors	**SE(m) ±**		**CD@5%**		**CV%**	
Factor (G)	0.05		0.25		**2.5**	
Factor (N)	0.02		0.09			
Factor (G×N)	0.19		0.59			
DC: 12 ds m^{-1} % decrease over control						

index at 12 dS m^{-1} indicates better maintenance of germination rate under salinity. Similar reductions in germination index and germination performance with increasing salinity have been reported by Adilu *et al*., (2021), Raza *et al*., (2017), Saeed *et al*., (2014) and Mustafa *et al*., (2021).

Plumule length

Significant variation was observed among the 35 tomato germplasm lines for plumule length under different salinity levels (Table 3). Plumule length decreased progressively with increasing NaCl concentration, with the overall mean declining from 14.1 cm under control to 12.4, 9.6 and 6.8 cm at 4, 8 and 12 dS m^{-1}, respectively. The percentage reduction in plumule length at 12 dS m^{-1} compared with the respective control varied considerably

Table 4: Effect of germplasm lines, salinity and their interaction on radicle length of genotypes.

Germplasm	NaCl (ds m^{-1})				Mean (G)	DC
	0	4	8	12		
EC631415	5.4	5.1	4.9	4.5	4.9	17.9
EC688516	5.5	4.4	4.1	2.6	4.2	51.3
EC521070	6.8	5.8	4.2	3.3	4.9	50.4
IC296468	2.4	1.6	0.0	0.0	0.9	100.0
EC620397	7.3	6.1	5.2	4.2	5.8	42.5
EC631325	3.7	3.2	2.9	1.4	2.8	62.0
IC566014	4.2	3.8	3.0	2.8	3.5	32.8
EC520074	4.2	3.8	2.2	1.3	2.8	68.7
Local-1	4.4	3.8	2.9	1.1	3.1	75.4
EC690982	5.3	4.3	3.5	2.4	3.8	56.1
EC638518	3.3	2.8	1.7	1.1	2.2	69.5
EC690989	5.2	4.9	4.3	2.4	4.1	55.8
EC638521	4.7	4.5	3.5	2.6	3.9	47.2
EC636877	5.7	4.2	3.6	2.3	3.9	60.7
EC530074	4.3	3.9	2.2	1.0	2.8	75.9
EC631406	4.1	3.7	2.1	1.6	2.9	63.6
Local-2	5.4	4.2	3.9	1.8	3.9	68.2
EC615040	5.8	3.8	1.4	0.0	2.7	100.0
EC620360	5.3	4.8	3.1	2.1	3.9	60.7
EC631373	5.9	4.8	2.6	1.5	3.7	73.7
EC617060	4.7	3.6	2.8	1.5	3.1	67.2
EC620366	4.9	4.2	3.4	2.1	3.7	55.9
EC635527	3.8	2.1	0.0	0.0	1.4	100.0
EC631369	3.2	2.8	1.5	1.1	2.2	65.6
Local-3	4.2	3.7	2.4	0.9	2.8	77.1
EC687604	3.8	2.9	1.9	1.0	2.4	71.1
EC632944	3.8	3.2	2.9	1.9	2.9	50.6
EC620482	4.5	3.6	3.1	1.0	3.0	76.7
EC687423	3.6	3.1	2.6	1.8	2.7	49.7
EC617055	2.6	1.8	0.0	0.0	1.0	100.0
EC635529	4.5	3.8	2.4	2.1	3.3	52.8
EC631455	2.9	1.9	1.6	1.2	1.9	61.9
EC631477	4.6	2.3	2.1	1.5	2.6	67.3
EC620388	4.3	3.3	2.3	1.1	2.8	75.7
Pusa Ruby	4.3	3.9	3.0	2.1	3.3	52.5
Mean (N)	4.5	3.7	2.6	1.6		
Factors	**SE(m) ±**		**CD@5%**		**CV%**	
Factor (G)	0.03		0.17		**5.7**	
Factor (N)	0.01		0.0			
Factor (G×N)	0.16		0.34			
DC: 12 ds m^{-1} % decrease over control						

among germplasm lines. EC690989 recorded the highest plumule length (10.4 cm) at 12 dS m^{-1}, followed by EC631415 (9.8 cm), EC635529 (9.7 cm), EC521070 and EC631477 (9.3 cm each), whereas IC296468, EC615040, EC635527 and EC617055 showed complete inhibition of plumule growth at 12 dS m^{-1}. EC631415 showed comparatively better retention of plumule growth, whereas the highly sensitive lines showed complete inhibition.

The reduction in plumule length under salinity may be associated with inhibited cell division and elongation, resulting in restricted shoot development. The ability of superior germplasm lines to maintain greater plumule growth at 12 dS m^{-1} indicates better tolerance to salt-induced growth inhibition during early seedling development. Similar reductions in plumule length with increasing salinity have been reported by Tahir *et al*., (2018), Sivakumar *et al*., (2020), Ahmed *et al*., (2022), Kumar and Vanitha (2023) and Mallick *et al*., (2025).

Radicle length

Significant variation was observed among the 35 tomato germplasm lines for radicle length under different salinity levels (Table 4). Radicle length decreased progressively with increasing NaCl concentration, with the overall mean declining from 4.5 cm under control to 3.7, 2.6 and 1.6 cm at 4, 8 and 12 dS m^{-1}, respectively. The percentage reduction in radicle length at 12 dS m^{-1} compared with the respective control varied considerably among germplasm lines. EC631415 recorded the highest radicle length (4.5 cm) at 12 dS m^{-1}, followed by EC620397 (4.2 cm), EC521070 (3.3 cm), IC566014 (2.8 cm) and EC688516 (2.6 cm), whereas IC296468, EC615040, EC635527 and EC617055 showed complete inhibition of radicle growth at 12 dS m^{-1}. EC631415 showed the lowest reduction in radicle length (17.9%), while the highly sensitive lines showed 100% reduction.

The reduction in radicle length under salinity may be associated with restricted cell division and elongation in the developing root, limiting radicle extension under osmotic stress. The ability of superior germplasm lines to maintain greater radicle growth at 12 dS m^{-1} indicates better tolerance to salt-induced inhibition of root development during germination. Similar reductions in radicle growth with increasing salinity have been reported by Sivakumar *et al*., (2020), Ahmed *et al*., (2022), David *et al*., (2022) and Mallick *et al*., (2025).

Conclusion

Increasing salinity significantly reduced germination and early seedling growth of tomato germplasm, with the greatest inhibition observed at 12 dS m^{-1}. Considerable variation among the germplasm lines indicated the presence of genetic variability for salinity tolerance at the germination stage. EC631415, EC690989 and EC620366 consistently maintained better germination and seedling growth under higher salinity levels, indicating their potential tolerance to salt stress. In contrast, IC296468, EC615040, EC635527 and EC617055 exhibited severe reductions in germination and seedling growth and were identified as sensitive germplasm. The superior germplasm lines identified in this study could be further evaluated under nursery and field conditions and may serve as useful material for breeding tomato with improved salinity tolerance.

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