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Evaluation of tomato (*Solanum lycopersicum* L.) genotypes for salinity tolerance

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Abstract
An experiment was conducted at Onattukara Regional Agricultural Research Station (O.R.A.R.S.), Kayamkulam, Kerala (2023-2024) to study the salinity tolerance of ten tomato genotypes under three salinity levels (control, 35 M and 40 mM). The objective was to identify tomato genotypes capable of maintaining growth and yield under saline conditions and to assess variability that could be exploited for future breeding and screening programs. Significant genotype × salinity interactions were observed for the measured traits, including plant height, fruit length, fruit girth, fruits per plant, and yield. Plant height showed considerable variation, with Anagha exhibiting the tolerance under moderate salinity (74.51 cm at 35 mM). Reproductive performance was markedly affected by salinity. The highest fruit count occurred in Anagha under control conditions (29.17), whereas EC-620404 produced the lowest number of fruits per plant at 40 mM (17.53). The mean yield per plant declined progressively with rising salinity, decreasing from 731.89 g (control) to 689.45 g (35 mM) and 645.03 g (40 mM). Among the genotypes, Anagha under control had the highest production of 1103.80 g, whereas EC-638519 under 40 mM had the lowest yield of 396.13 g. Percent yield reduction increased from 5.80% at 35 mM to 11.87% at 40 mM, confirming the intensifying impact of salinity stress. Overall, Anagha and Manulakshmi recorded superior tolerance and productivity under saline conditions, highlighting their potential for cultivation in salt affected regions and for use in future salinity tolerance breeding programs.

Keywords: Tomato, salinity, fruits, yield, effect, variability

Introduction

Tomato (*Solanum lycopersicum* L.) is an important vegetable crop belonging to the Solanaceae family which is widely cultivated across the world. It is one of the most important vegetable crops in the world in terms of both production and area under cultivation. Tomatoes are nutritionally valuable, serving as a major dietary source of essential vitamins and minerals. The versatility of tomato whether consumed raw, cooked or in various processed forms, makes it one of the most indispensable vegetables in cuisines around the world.

Tomato production is adversely affected by a wide range of biotic and abiotic stresses, which reduce the crop yield, productivity and quality. In Kerala, tomato cultivation often faces uncertainties due to climatic aberrations and frequent abiotic challenges. Among the abiotic constraints, soil salinity has emerged as a major limiting factor for vegetable cultivation, especially in the coastal belts where irrigation water quality is poor and saline in nature. Tomato is moderately sensitive to salinity and yield reduction begins when The Electrical Conductivity (EC) of soil or irrigation water exceeds 2.5 dS m^{-1} (Siddiky *et al.*, 2012; Ladewig *et al.*, 2021) [13, 14, 6]. Salt stress leads to adverse biochemical and physiological changes in tomato plants, significantly decreasing growth and yield (Fathima *et al.*, 2022) [5]. In Kerala, salinity issues are particularly severe in the Onattukara region, where several panchayaths experience saltwater intrusion, making vegetable cultivation increasingly challenging (Nizar *et al.*, 2024) [8]. This intrusion raises soil and water salinity to levels unsuitable for sensitive crops like tomato. Besides Onattukara, many other parts of coastal Kerala also face varying degrees of salinity problems, further constraining sustainable vegetable production in the state.

Genetic diversity among the plant species and cultivars within crop species provide a valuable tool for screening and breeding for improved salt tolerance (Arzani, 2008) [2]. Germplasm collection and characterization is the initial stage of salinity breeding works. A comprehensive knowledge of the available variability within the breeding material of a crop species for desired characters enables the breeders to identify most potential genotypes. The development of salt tolerant tomato genotypes is a basic requirement to overcome the challenges of tomato production under salinity in the field. In view of this requirement, the present study was undertaken to assess the genotypic variation for salinity tolerance in tomato for their better adaptability under salinity stress.

Materials and Methods

The present study was conducted at Onattukara Regional Agricultural Research Station, Kayamkulam (O.R.A.R.S.), Kerala from 2023-2024. Ten tomato genotypes collected from various sources of India, were evaluated for salinity tolerance by imposing salt stress using sodium chloride at three levels (control, 35mM and 40 mM), thirty days after transplanting. The experiment was laid out as two factorial completely randomized design with three replications. The results revealed substantial variability in yield traits among the ten tomato genotypes. The performance difference among the different genotypes of tomato for salinity tolerance at varying levels may depend on their differences in salinity tolerance mechanism. This variability among the genotypes for salinity tolerance could be exploited for expanding the area of cultivation of tomato in salt affected areas and thereby increasing the production of tomato.

Results and Discussion

The recorded data were subjected to statistical analysis following the procedures described by Panse and Sukhatme (1985). The analysis of variance (ANOVA) was performed using GRAPES, an online R-based tool.

A significant variation in plant height was observed among the tomato genotypes under different salinity conditions. Plant height ranged from 54.42 cm in EC-638519 at 40 mM to 74.51 cm in Anagha at 35 mM. Anagha had the highest plant height at all the levels of salinity, indicating that Anagha shows superior tolerance under moderate salinity stress, whereas EC-638519 appears to be the most susceptible one to salinity. Reduced growth under salinity is commonly associated with osmotic imbalance, ion toxicity, and inhibited cell elongation, as previously reported in tomato (Cuartero and Muñoz, 1999; Singh *et al*., 2011) [4, 15]. The significant interaction between genotypes and salinity indicates genotypic differences in salt tolerance. Such variability aligns with the findings that genotypic differences strongly influence tomato growth under salinity stress and tolerant varieties can sustain growth at moderate salinity levels. Similar reductions in plant height with increasing salinity levels have also been documented by Nasrin *et al*. (2021) [7] and Zhang *et al*. (2024) [18].

Flowering time was significantly influenced by the genotype x salinity interaction, with genotype LE 19 showing the earliest (34.12 days) at 40 mM which was on par with LE 19 in control (35.16 days) and 35 mM (35.18 days) and LE 20 at high level of salinity (35.51 days). Park *et al.* (2013) reported that, salt stress can also disrupt the flowering timing and diminish the fertility of plants. The results observed in this study were on line with the work of Sun *et al*. (2024) [16] which indicated that salt stress induced early flowering.

Fruit length exhibited a range of 3.02 cm (Manulakshmi) to 4.40 cm (Arka Vikas). The stability of fruit length in certain genotypes across different salt treatments may be attributed to their ability to maintain cellular expansion and osmotic adjustment during fruit development, as previously reported in tomato under salinity stress (Pérez-Alfocea *et al*., 1996; Cuartero and Muñoz, 1999) [11, 4]. Swathi *et al.* (2024) [17] also recorded a similar pattern for fruit length in tomato.

A significant interaction between genotypes and salinity levels was observed for fruit girth. The highest fruit girth was recorded in Anagha at 35 mM (15.00 cm), followed closely by Anagha at control (14.49 cm), reflecting its ability to maintain fruit size even under moderate salinity stress. The minimum fruit girth was noted in EC-638519 at 40 mM (9.17 cm), indicating that, this genotype had high negative interaction with salinity. The variation among genotypes under saline conditions highlights differential adaptability, potentially influenced by genotype-specific osmotic adjustment and cell turgor maintenance mechanisms, as supported by previous findings in tomato under salt stress (Swathi *et al.* 2024; Bigot *et al*. 2024) [17, 3].

Data regarding the fruit weight showed no significant differences among the different salinity levels which ranged from 32.33 g to 29.27 g.

Different salinity levels had a significant effect on the number of fruits per plants. A significant interaction was found between tomato genotypes and salinity levels for fruits per plant. The highest fruit count was recorded in Anagha at control treatment level (29.17) and lowest fruits per plant was observed in EC-620404 at 40 mM (17.53), indicating the negative effect of salinity. The gradual decline in fruit production at elevated salinity levels may be attributed to osmotic stress, ion toxicity and impaired assimilate translocation affecting reproductive growth, corroborating earlier reports in tomato (Ahmed *et al*. 2019; Nasrin *et al*. 2021 and Swathi *et al*. 2024) [1, 7, 17].

A significant interaction between genotypes and salinity levels was observed for yield per plant. The highest yield was recorded in Anagha at non-saline control level (1103.80 g), whereas, the lowest yield was registered in EC-638519 at 40 mM (396.13 g). The mean yield values across salinity levels indicate the overall productivity and adaptability of the genotypes under increasing salt stress. The highest mean yield was recorded in Anagha (968.64 g), followed by Manulakshmi (873.61 g) and Manuprabha (767.40 g), demonstrating their superior performance under salinity. The lowest mean yield was observed in EC-638519 (462.69 g), followed by EC-620404 (483.38 g), indicating their poor adaptability under saline conditions. Based on the mean yield values across salinity treatments, a gradual decline in productivity was evident with increasing salinity levels. The overall mean yield decreased from 731.89 g (control) to 689.45 g (35 mM) and further to 645.03 g (40 mM), confirming a consistent decline with increasing salinity levels. Based on the percent decline in mean yield across salinity levels, a noticeable reduction was observed as salinity intensified. From the control (731.89 g) to 35 mM (689.45 g), the mean yield declined by 5.80%, indicating a moderate impact of mild salinity stress. However, at 40 mM, the reduction became more pronounced, with mean yield decreasing by 11.87% compared to the control. This progressive percentage decline highlights the increasing severity of salinity stress and its strong negative influence on overall yield performance in tomato. The overall percent reduction signifies the severity of stress and its importance as supported by the previous studies of Swathi *et al.* (2024) [17].

Table 1: Interaction effect of genotypes and salinity in tomato

Genotypes	Plant height			Days to first flowering			Fruit length			Fruit girth		
	Control	35 mM	40 mM	Control	35 mM	40 mM	Control	35 mM	40 mM	Control	35 mM	40 mM
Arka Vikas	71.38	68.93	69.01	41.96	39.82	39.05	4.40	4.35	4.18	14.47	14.21	13.96
Arka Ashish	66.12	62.56	64.78	47.05	47.48	47.64	4.23	4.27	4.17	13.51	13.91	13.09
Arka Alok	62.16	63.24	63.41	42.55	43.90	42.65	4.31	4.38	4.31	12.45	12.98	12.31
EC-635526	64.26	66.92	62.27	44.00	46.29	38.01	4.16	4.31	4.16	13.70	13.87	12.65
Manuprabha	64.39	63.54	61.98	39.60	39.75	39.52	4.28	4.29	4.12	11.72	11.45	11.33
EC-620404	57.93	59.27	56.09	41.71	41.98	41.25	4.09	4.29	4.00	10.27	10.40	10.17
Anagha	73.44	74.51	72.57	35.16	35.18	34.12	4.29	4.34	4.03	14.49	15.00	14.18
Manulakshmi	72.03	72.80	70.95	36.01	38.25	35.51	3.02	3.02	3.02	11.14	11.49	10.98
EC-638519	56.26	58.27	54.42	40.71	41.98	39.92	4.03	4.16	3.94	9.27	9.40	9.17
EC-631412	65.17	65.28	64.92	37.02	37.14	36.97	4.38	4.36	4.24	12.27	12.56	12.02
Mean	65.31	65.53	64.04	40.58	41.18	39.46	4.12	4.18	4.02	12.33	12.53	11.99
SE(m)	0.77			0.50			0.04			0.14		
CD (0.05)	2.18			1.41			0.13			0.40		

Table 1: Continued

	Fruit weight			Fruits per plant			Yield per plant		
Genotypes	Control	35 mM	40 mM	Control	35mM	40mM	Control	35 mM	40 mM
Arka Vikas	35.23	33.60	33.43	21.90	21.70	20.97	755.93	736.27	696.77
Arka Ashish	32.20	29.60	35.03	21.20	21.60	19.17	675.57	634.37	675.37
Arka Alok	33.93	29.60	27.33	18.70	19.27	18.83	629.20	567.43	512.03
EC-635526	33.03	28.17	29.77	18.77	19.60	18.00	620.03	540.93	539.57
Manuprabha	33.33	32.60	31.17	23.93	23.33	23.67	804.17	750.67	747.37
EC-620404	27.03	26.97	26.03	18.13	18.53	17.53	491.13	505.50	453.50
Anagha	37.80	31.87	30.83	29.17	28.77	28.53	1103.80	919.20	882.93
Manulakshmi	32.60	30.03	31.57	28.13	29.00	26.17	920.07	872.00	828.77
EC-638519	24.37	18.57	22.90	18.53	29.17	17.53	452.00	539.93	396.13
EC-631412	33.73	31.73	28.57	25.43	25.77	25.07	867.00	828.23	717.83
Mean	32.33	29.27	29.66	23.39	23.67	21.55	731.89	689.45	645.03
SE(m)	3.79			1.00			89.65		
CD (0.05)	Non-significant			1.03			32.75		

Conclusion

The study revealed considerable variations in yield related traits among the different tomato genotypes studied, indicating significant genotypic variability for salinity tolerance. Some genotypes were able to perform better under moderate salt stress, reflecting better osmotic adjustment, ion homeostasis and stress resilience. The study revealed that Anagha and Manulakshmi had superior performance under salinity stress. These genotypes possess substantial potential for utilization in tomato breeding programmes for developing salt tolerant genotypes suited to the salinity prone areas of Kerala.

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