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RESEARCHARTICLE

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Performance of Tomato Germplas Seedlings (*Lycopersicon esculentum* L.) To Salinity Stress

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Abstract

Tomatoes are a significant vegetable crop due to their high consumption and nutritional value. They have been developed to increase yield, fruit quality, and tolerance to biotic and abiotic stresses like heat, drought, and salinity. A study was conducted in a greenhouse using fifteen genotypes and three salinity levels. The study screened cultivars that adapt well to various saline stress levels and provide higher yields. Three levels of NaCl (OdS/m, 5dS\m, and 10dS/m) were used to assess changes in morphological traits such as germination percentage, shoot length, leaf area, number of leaves per plant, number of branches per plant, shoot dry weight, moisture percentage in shoot, moisture percentage in root, root length, and root dry weight. Data for these traits were collected after 45 days. High NaCl levels negatively affect plant growth, leading to decreased yields and reduced plant health. In this study a positive correlation between plant branch number and various traits like dry shoot weight, fresh root weight, root length, leaf area, shoot length, dry root weight, moisture in shoot and root, number of branches per plant, and root length, but weaker with branches and leaves. High heritability in leaf area, dry root and shoot weight, and fresh shoot weight shows that these traits are less affected by the environment and can be transferred to the next generation.

KEYWORDS
Tomato Seedlings, NaCl levels, Morphological traits, Correlation, Heritability.

1 | INTRODUCTION

Tomatoes are the most produced vegetable, yielding 186 million metric tons annually. However, land scarcity and biotic and abiotic stressors limit production. By 2050, salt stress is expected to reduce yields by 50%, posing a significant concern for Southeast Asian countries (Hernández-Pérez *et al.*,2020).

Plants face various challenges throughout their life cycle, including biotic stressors like infections and abiotic stressors like salt, heat, and drought. These stressors affect the quality, productivity, and production of crops like tomatoes. (Bai *et al.*, 2018). Abiotic stress, such as drought, extreme temperatures, and excessive salt, can result in a 70% reduction in yield, depending on the plant stage and stress duration. (Krishna *et al.*, 2019). Drought and salt are c0dS/mon abiotic stress conditions that negatively impact agricultural production and productivity, particularly in vegetables. (Tahir *et al.*, 2018). Plants adapt to environmental challenges to survive, with crop losses primarily due to drought and salt. Growers are exploring the use of low-quality water resources in agriculture due to drought scarcity. The continuous salinization of irrigated agricultural regions threatens the future of agricultural fields, with high salinity and dryness negatively impacting crops (Ors and Suarez, 2017).

Tomatoes are the most salinity-sensitive crop, affecting various aspects of growth and development, including seed germination, vegetative growth, and reproductive growth. This leads to lower agricultural yields and performance (La Pena and Hughes, 2007). Early stages of saline tolerance development are more important than later stages. (Pailles *et al.*,2020). Tomato seeds are susceptible to saltwater, and even modest levels can reduce germination and vigor. Salinity slows tomato seedling growth during the early growth stage, causing roots to shorten and water and nutrient absorption to diminish. This inhibits photosynthesis in leaves, resulting in a lack of water for transpiration and cooling. Salinity stress also affects germination, osmotic adjustment, stomatal behavior, carbon accumulation and utilization, photosynthesis activity, and cellular metabolite levels, limiting plant growth, development, and overall production (Tavakkoli *et al.*,2011).

Salinity significantly changes tomato production, reducing root elongation, and leaf, shoot, and stem diameter due to decreased photosynthesis, tissue expansion, and cell division suppression. It also lowers leaf chlorophyll levels, stomatal resistance, and photosynthetic activity. The total tomato production is severely reduced at salinity levels equal to or more than 5 dS m-1, with a 7.2% yield drop per unit rise. *(Zhang et al.,* 2016). To improve breeding efficiency, it is crucial to assess available tomato accessions to salinity stress and understand the genetic and metabolic regulation of cellular metabolisms. To develop salt-tolerant tomato varieties, it is essential to discover genes/enzymes whose expression is often changed under salt stress. Salt-tolerant tomato farming is rec0dS/mended to meet the growing demand for this nutritionally essential produce. (Islam et al., 2012).

The genetic makeup of tomato plants varies, and high salt levels decrease production. Understanding salt tolerance is crucial for boosting crop yield and profitability when using saline wastewater for irrigation. However, complexity, lack of information, and ineffective choice restrict salt tolerance breeding programs. To meet the growing demand for nutritionally essential produce, salt-tolerant tomato farming is rec0dS/mended (Singh *et al.*,2012). The study showed new salinity-tolerant tomato genotypes and understood the mechanism of salt tolerance through physiological traits like Na+, K+, proline, ascorbic acid content, and antioxidant enzyme activation. This study helped find linked morphological and physiological indicators for tomato genetic improvement against salt stress.

2 METERIAL AND METHOD

The University of Agriculture Faisalabad experimented on tomatoes, using fifteen genotype lines in plastic pots under a randomized complete block design. The seeds were sown in pre-irrigated sand, with three plants per entry. The experiment involved fifteen genotypes, three replications, and three salt levels. Changes in morphological traits like germination percentage, shoot length, leaf area, number of leaves per plant, number of branches per plant, shoot dry weight, root length, and root dry weight were assessed using three levels of NaCl (OdS/m, 5dS\m, and 10dS/m). Heavy watering was provided to aid in uprooting and reduce root damage. Data was collected from the plants at the seedling stage. The seeds germinated after 7 days of seeding. After 10 days of germination, seedlings were placed into pots. Salt stress begins to occur three weeks after germination. Stress was administered for 2 weeks. To prevent root damage, the experiment's pots were cleaned in a tub of water after completion. Root and shoot lengths, as well as fresh weights, were measured. The roots and shoots were oven-dried at 75°C for 24 hours.

Table 1: Tomato genotypes were evaluated at 0mM, 5dS/m, and 10mM NaCl.

Sr. No	Genotypes	Sr. No	Genotypes
1	Tinto	9	88572
2	Lo-2850	10	Hybrid D
3	M-85	11	Lo-2875
4	M-82	12	Rona
5	Pionee-2761	13	CLN-2413
6	Sandal A	14	Lo-4166
7	CLN-2498	15	88572
8	Veepick		

Statistical Analysis

The data for all traits was analyzed using the analysis of variance technique (Steel et al., 1997) to set up the importance of genotypic responses to salinity. The correlation analysis was performed according to Kwon and Torrie's method (1964). (Falconer, 1985, Johnson et al., 1955) formula was used to calculate broad sense heritability.

Hbs = Vg/Vp,

Where, Vg = genotypic variance, Vp = phenotypic variance, Hbs = heritability broad sense. Genetic advance was computed by the following formula given by Falcon and MacKay (1996):

$G.\ A = K.Sp.H^2$

Where, G.A = genetic advance, K = selection differential at 10% selection intensity, Sp = standard deviation of the phenotypic variance of the population under selection, and H^2 = broad sense heritability.

3 RESULTS

Tomato variability was assessed under salinized and non-salinized environments. We collected data on fifteen tomato genotypes to compare their varied characteristics. The genotypes were compared on an absolute and relative basis.

Analysis of variance revealed significant variations in leaf area among tomato seedling genotypes, with a maximum leaf area of 32.85 cm2 under controlled conditions and minimum under high salt stress, with a statistically significant interaction between salt levels, genotypes, and replication factors. Salt stress dramatically reduced the number of branches per tomato plant, with the highest number (6.3) in normal or no salt circumstances and the lowest (2) in severe salt stress treatments. That high salt application significantly reduced leaf count, with the highest leaf count (25.4) recorded under salt stress leaf number decreases in the genotype. Shoot length significantly decreased under high salt application conditions, with the largest root length of 14 cm under normal conditions or without salt treatment, and a minimum root length of 4.8 cm with high salt application. Fresh and dry shoot weight fell

Table 2: Mean square of values for various traits of fifteen tomato genotypes grown in control, 5dS/m, and 10dS/m NaCl concentration.

	Df	LA	NBPP	NLPP	RL	FSW	FRW	DSW	DRW	SL
Genotypes	14	154.468**	1.48ns	72.69**	23.05**	9.5**	15.9**	0.13**	0.28**	72.6*
Salt levels	2	696.45**	40.27**	917.6**	160.8**	57.5**	89.5**	0.72**	1.16**	734.8*
Genotypes* Salt levels	28	9.128**	1.07*	12.29**	1.226*	1.6**	2.49**	0.02**	0.03**	2.0*
Error	88	6.471	0.8559	3.94	0.663	0.0514	0.1795	0.0009	0.00089	1.694

Abbreviations: DF=Degree of freedom, LA= Leaf area, NBPP= Number of branches per plant, NLPP= Number of leaves per plant, RL= Root length, FSW= Fresh shoot weight, FRW= Fresh root weight, DSW= Dry shoot weight, DRW= Dry root weight, SL= Shoot length.

Table 3: Components of variance and broad sense heritability of NaCl tolerance.

Components	LA	NBPP	NLPP	RL	FSW	FRW	DSW	DRW	SL
Vg	44.5	0.298	2.95	6.51	2.85	4.57	0.04	0.08	19.43
Vp	65.3	1.53	18.1	10.02	4.25	6.82	0.05	0.11	33.8
H2	0.68	0.013	0.16	0.64	0.67	0.67	0.69	0.74	0.57
G.A	11.36	0.05	1.42	4.23	2.85	3.61	0.34	0.52	6.88

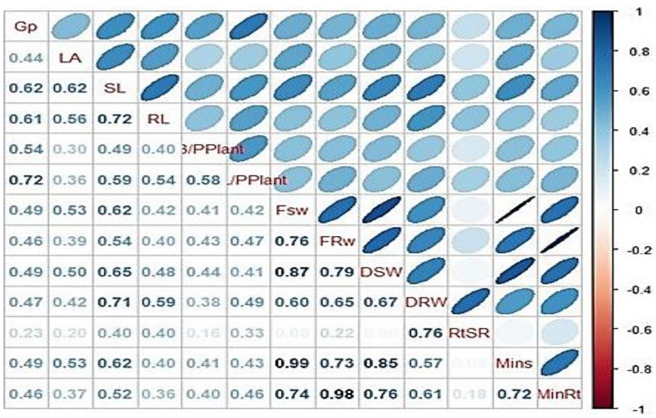

Fig. 1: Correlation matrix for various traits under the effects of different salt levels.
DsW= dry shoot weight, FrW=fresh root weight**,** Fsw= fresh shoot weight**,** RL= root length, LA= leaf area, SL= shoot length, DrW= dry root weight, NBPP= No. of Branches/plant, NLPP= No. of Leaves/plant.

under high salt application circumstances. The largest fresh shoot and dry weight were measured under controlled conditions, while the minimum was discovered under extreme salt stress. When a high salt dose was applied to fresh roots, their weight was reduced dramatically. The highest fresh root weight was measured or without salt application, and it was 6.02g with high salt application. The lowest fresh root weight was recorded under salt stress (1.65g).

The study discovered a positive relationship between the number of branches per plant and a variety of characteristics, including dry shoot weight, fresh root weight, root length, leaf area, shoot length, dry root weight, moisture in shoot and root, number of branches per plant, number of leaves per plant, and root-to-shoot ratio. However, there was a slight correlation between the number of branches and leaves per plant. The association between root length and other features was also weak, with a positive and weak relationship with moisture in the shoot and root but a weak relationship with the number of branches and leaves per plant. The study revealed that dry shoot weight had a positive connection with different attributes, however a weak relationship with root length.

Broad-sense heritability ranged from 81% to 1.3%, while genetic progress ranged from 54.70 to 0.10. The root-to-shoot ratio had the highest heritability (81%), followed by dry root weight (74.0%), dry shoot weight (69.0%), leaf area (60.0%), fresh shoot weight (67.0%), and fresh root weight. These qualities have a lower environmental impact and may be increased by phenotypic choice because of their additive gene effects.

4 | DISCUSSION

Crop plants often face abiotic stress during growth and development. Soil salinity in arid and semiarid regions poses a significant hazard to agricultural productivity. This study assessed genetic variability for salt tolerance in 15 tomato genotypes using morphological and physiological measurements. To improve salt tolerance in crops, it's crucial to discover tolerant genotypes through accurate screening approaches. In the earlier research De Pascale et al. (2012) found that salty water in tomato irrigation reduced leaf number and leaf area by 47.55%. Salinity is crucial for tomato growth, and more research is needed to improve plant resilience to salt stress (Roșca *et al.*,2023).. Increasing salt levels resulted in significant decreases in plant height, number of branches, SPAD reading, fresh weight, and dry weight. However, applying IAA to salinity-stressed tomato plants significantly improved growth and yield (Alam *et al.*, 2020). Leaf osmotic adjustment was proportionate to salinization, and reduced stomatal conductance led to decreased leaf development (Jameel *et al.*, 2024). All tomato genotypes responded differently to varying salt amounts, with Nagina and Naqeeb genotypes increasing salt concentrations to enhance root and shoot length. Rio Grande and Nadir were slightly impacted by NaCl stress, while IQS-7101, Roma, Pakit, and Big Beef were the most susceptible (Chattha *et al.*, 2024). Rising salt levels significantly inhibited growth characteristics across all cultivars, with germination rates, seedling vigor, and root and shoot length reduced. Salt application significantly reduced the fresh shoot weight of all tomato genotypes, while increasing it when no salt was applied (Yildirim *et al.*, 2023). This was due to affecting water relations, cell division, growth, and leaf turgidity. Salt stress also decreases the leaf area of tomato cultivars by promoting cell proliferation, enhancing leaf turgidity, and enhancing water retention. In a related study also found that salt stress significantly reduced the dry root weight of all tomato genotypes. The overall seedling biomass was the same at low and medium salt levels, but at low salt, the roots accounted for a greater proportion of dry weight (Hao *et al.*, 2023). At high salt levels, total biomass decreased. In past study shoot length was reduced under high NaCl stress, with less salt availability resulting in longer shoot production and greater chlorophyll content in plant leaves (Tian *et al.*, 2021). Similar results were documented that high estimates of heritability for root dry weight, shoot dry weight, shoot fresh weight eight, and root fresh weight (Somraj *et al.*, 2017), and leaf area (Ritonga *et al.*, 2018; Behera *et al.*, 2020), and lowest heritability was noticed for number of leaves per plant and number of branches per plant (Meena and Bahadur, 2014).

Conclusion

Tomato (*Solanum lycopersicum*. L) is one of the most significant vegetable crops in the world. Major food crops often experienced abiotic and biotic challenges. Application of different salt especially NaCl reduces the plant growth, and their effect ultimately declines productionA study conducted at the Greenhouse, University of Agriculture, Faisalabad, Pakistan, examined the effects of different sodium chloride (NaCl) applications on tomato genotypes. The experiment used a completely randomized design (CRD) with three replications to examine the role of different NaCl doses on seedlings. Fifteen different tomato genotypes were sown by their seeds, and under controlled conditions, treatments were applied. High NaCl application in tomato can reduce key features that influence plant growth and development. Excess NaCl reduces leaf area, which is crucial for photosynthesis and overall plant vigor. It also affects shoot length, which is another important growth characteristic. In high NaCl conditions, root length decreases, compromising the plant's ability to absorb water and nutrients from the soil. High NaCl treatment also decreases the root/shoot ratio, which measures the balance of above-ground and below-ground development. Moisture in shoot and root tends to decline with high NaCl levels, signaling stress. High heritability with high genetic advance was shown in leaf area, dry root and shoot weight, and fresh shoot and root weight. The study concluded that high NaCl stress has negative impacts on morphological attributes compared to efficient (medium dose) and controlled conditions.

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