Effect of different salinity levels on Morphological and Yield-related traits of tomato (*Solanum lycopersicum* L.)

ABSTRACT

Salinity stress arises from the accumulation of elevated salt levels in the soil, leading to the hindrance of plant growth and eventual crop loss. Compounds that induce stress tolerance exhibit a remarkable capacity to enhance growth and mitigate the impacts of salinity stress, all while maintaining a positive environmental impact by regulating plant activities. to investigate how varying levels of salinity in the irrigation water impact the morphological characteristics and yield of tomato plants. The experiment employed a complete randomized design with one plant per pot and three replicates per treatment, spanning from October 2021 to April 2022 and October 2022 to April 2023 at SVPUAT, Meerut. The objective was to investigate the impact of four NaCl levels (0, 50, 100, and 150 mM) on the Morphological traits of ten tomato cultivars (Arka Rakshak, Punjab Ratta, H-88-78-5, VRT-16-1, Pusa Ruby, Pant T-3, Arka Samrat, Kashi Aman, Kashi Anupam, Pusa Rohini) during the mature stage. Various genotypes displayed distinct reactions concerning plant growth, with a focus on factors such as plant height, the quantity of branches per plant, the number of flower trusses per plant, and the number of flowers per truss being examined. Parameters such as average fruit weight, fruit diameter, fruit length, and TSS were also measured. The findings revealed that increasing NaCl salinity adversely affected the morphological properties of all examined tomato plants compared to the control group (tap water). Salinity was found to decrease morpho and yield related parameters, except for TSS in tomato fruit. Nevertheless, there was a variation in the response to salt stress among the studied varieties. "Pusa Ruby" and "Pusa Rohini" demonstrated greater performance and stability under salinity stress, followed by Arka Rakshak and Kashi Aman, while Punjab Ratta, followed by Pant T-3, inferior performance under salinity. Water salinity significantly impacts the growth and production of crops, and the insights from this study can aid in the selection of better varieties in saline-affected areas. However, it is essential to further evaluate the potential of these genotypes under saline conditions and assess the variability in various biochemical parameters.

Keywords: Salinity stress, Plant Growth, Crop loss, NaCl levels, Tomato

1. INTRODUCTION

Tomato (*Solanum lycopersicum*) is a member of the Solanaceae family and a crucial nutritional source for the global population. It ranks as the fourth most widely grown vegetable worldwide and stands as a nutrient-dense plant serving as a model for the development of flavourful fruits. It follows closely behind potatoes and sweet potatoes in global vegetable production [1]. It is an annual crop predominantly undergoing self-pollination, with a chromosome number of 2n = 2x = 24. Believed to have originated in the New World, specifically the Andean region (now spanning parts of Bolivia, Chile, Colombia, Ecuador, and Peru), the diversity observed in cultivated tomatoes strongly suggests their domestication in Mexico. Following the discovery of the New World, tomatoes were introduced to Europe and gradually disseminated globally [2]. However, tomatoes have faced considerable damage in recent years, not only due to abiotic factors like drought or salinity stress but also due to different infections and pests such as fungi, insects, and nematodes [3]. Salt-affected soils span around 1.5 million hectares or roughly 10% of the country's total area. Many crops undergo morphological, physiological, and biochemical alterations as a result of salt, according to several studies. Different species, variations, and even ecotypes have different

levels of stress tolerance [4]. Salt stress represents a significant abiotic challenge impacting every aspect of a plant's physiology and biochemistry, ultimately leading to diminished yields. This poses a critical threat to agricultural productivity, particularly in arid and semi-arid regions. Soil salinity is categorized based on the pH of saturated soil paste, electrical conductivity of saturated paste extract (ECe), and exchangeable sodium percentage (ESP) [5].Plants cultivated in saline conditions experience stress through three primary mechanisms: (1) a decrease in water potential within the root zone, leading to water deficit; (2) phytotoxic effects of ions, including Na+ and Cl-; and (3) disruption of nutrient balance due to reduced uptake and/or impaired shoot transport [6]. Salt stress induces hyperosmotic stress and disrupts ion equilibrium, causing impairment to essential cellular functions in plants. Consequences include decreased water availability, heightened respiration rates, altered mineral distribution, membrane instability, and the inability to maintain turgor pressure. In response to these challenges, plants employ strategies such as tolerance mechanisms or transitioning into a dormant stage to cope with the adverse effects of salt stress [7]. The influx of sodium and chloride ions from the soil into plant cells disrupts ion balance in both the plant and the soil. This excessive uptake of these ions by the plant gives rise to various physiological issues affecting different tissues of the plant, including the roots, leaves, grains, fruits, or fibers [8]. Soil salinization imposes severe constraints on land utilization and has a considerable impact on crop yields [9]. Consequently, salt stress has emerged as a prominent abiotic factor posing a significant threat to global food security. While technologies for improving saline-alkali lands contribute to expanding arable areas, the associated costs limit widespread implementation. Exploring the cultivation of salt-tolerant crops presents a viable avenue for addressing this challenging issue. A comprehensive comprehension of the mechanisms underlying salt tolerance is crucial for expediting the development of new crop varieties with heightened resilience to salt stress.

The objective of this research was to investigate the influence of varying NaCl treatments on the agro-morphological parameters of ten tomato varieties. This study aimed to deepen our understanding of the differences in salt stress tolerance among these varieties by assessing the percent reduction in various parameters and yield-related traits. The ultimate goal was to identify and select varieties suitable for cultivation in arid, semi-arid, and coastal saline soils. Therefore, comprehending the impact of salinity on both tomato plants and fruits is crucial for selecting and implementing appropriate crop practices to meet the demands of the tomato market. This study specifically focuses on evaluating the responses of tomatoes to salinity stress, emphasizing the effects on morphology and fruit quality under varying levels of soil salinity.

2. MATERIAL AND METHODS

2.1 EXPERIMENTAL DESIGN AND LAYOUT

The design used for this was Completely Randomized Design (CRD) with three replications. The tomato genotypes were grown in plastic pots and then they were exposed to four simulated soil salinity levels (0, 50, 100 and 150mM of NaCl) after attaining stability after transplantation (fig 1). The diameter of each plastic pot was 18 × 20 cm^2, containing soil, compost and Manure in a 3:1:1 ratio.

2.2 Experimental site

The experiment was conducted at the Field Laboratory and Experiment Station within the Department of Agricultural Biotechnology at the College of Biotechnology, SVPUA&T, Meerut, India. This location resides in the semi-arid environment and agro-climatic plain zone of Uttar Pradesh state, situated in the North West Plain Zone of India, at 28.99°N latitude and 77.7°E longitude, with an altitude of 220 meters above sea level.

2.3 Nursery Raising and Seedlings Transplantation

All ten accessions were evaluated during *Rabi* season 2021-22 and 2022-23 at the Field Laboratory and Experiment Station within the Department of Agricultural Biotechnology at the College of Biotechnology, SVPUA&T, Meerut, India. Seedlings were raised in pro-trays having 50 cavities with coco peat, vermicompost, and soil (2:1:1) under intensive care and with a high survival percentage under shade net house during September and transplanted in the second week of October. The pots were filled with soil and seedling having a reasonable size of 3–4 leaves were transplanted in the pots. The pots were arranged randomly and repeated three times. One seedling per pot was planted. After the plant's establishment, they were subjected to salinity stress.

2.4 Salt treatment

Salinity conditions were established as follows: Control (no NaCl), T1 (50 mM NaCl), T2 (100 mM NaCl) and T3 (150 mM NaCl). So, the sodium chloride (NaCl) was weighed by an electric balance as 2.92, 5.84 and 8.6 g/L, respectively. The weighed salt was mixed properly with water and irrigation was done with the help of a 100ml watering in each pot. Plants were stressed with water containing respective concentration of NaCl at late vegetative stage (25 days after transplanting) and salinity stress was carried at 7 days interval until the harvesting. The plants were not watered for 2 days after being stressed so that they could absorb the salts properly. Rest of the time, water was supplied to the plants as per requirement. For control the plants were treated with tap water.

2.5 Meterological data

Line graph (Fig 2) illustrates the meteorological data variables recorded from October 2021 to April 2022 and October 2022 to April 2023, the duration of the experimental period.

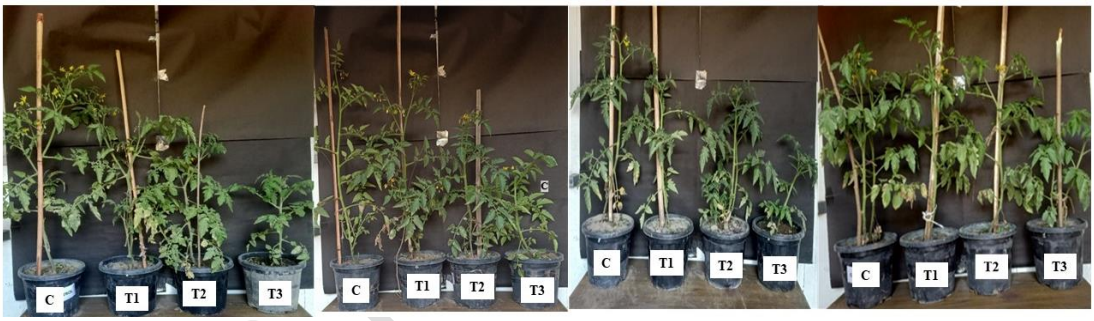


Figure 1. Assessment of Tomato genotypes under different levels of salinity (C-0mM, T1-50mM, T2-100mM, T3-150mM)

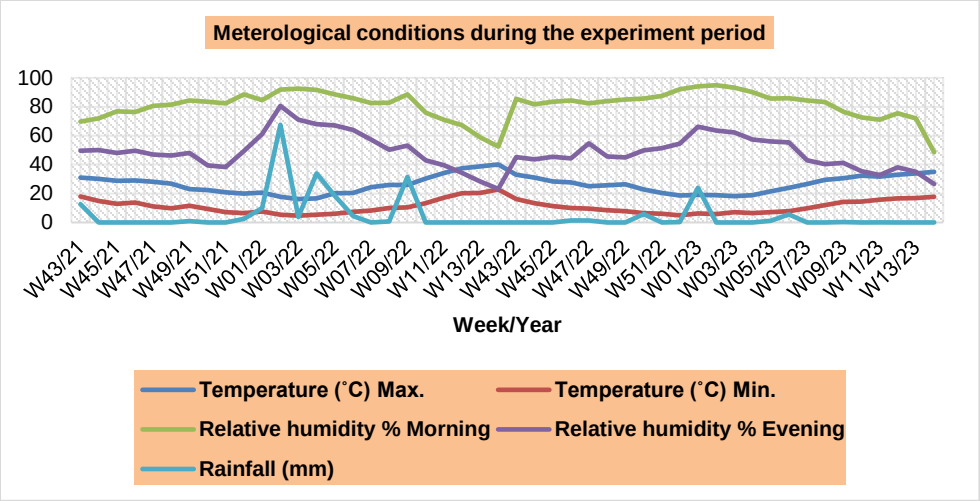


Figure 2: Line graph showing the meterological conditions of the experimental period.

2.4 Morphological parameters measurement

2.4.1 Plant height (PH)

The height of three replicates for each treatment was determined with the help of a meter scale and recorded plant height in cm after one month of treatment and at maturity. The average plant height was calculated.

2.4.2 Number of branches per plant (NBP)

The number of branches arising on the main shoot was counted for each plant at the time of maturity and recorded as the number of branches per plant.

2.4.3 Number of flower trusses per plant

Recordings of all the flower trusses of a plant were taken at the time of flowering and regular intervals till fruit setting took place. The total number of flower trusses was recorded for all the treatments.

2.4.4 Number of flowers per truss

Recordings of the number of flowers per truss were taken for three flower trusses of each plant at the time of flowering.

2.4.5 Average fruit weight

The average fruit weight was estimated by weighing three fruits in each treatment, with the help of an electronic balance measuring in grams to the third decimal place and then converting to average fruit weight.

2.4.6 Fruit diameter (cm)

Three fruits per pot were taken and the diameter at the maximum point of fruit was measured by vernier caliper. The average diameter per fruit was calculated.

2.4.7 Fruit length (cm)

For Replication, three fruits of each genotype were selected randomly and the length was measured by vernier caliper and recorded in cm.

2.4.8 Number of fruits per plant

The total number of mature ripe fruits per plant was calculated and recorded.

2.4.9 Total soluble solids (˚ Brix)

Total soluble solids (TSS) were determined on a portable refractometer (NC-1, Atago Co., Japan) standardized with distilled water. A hand refractometer was used for direct determination of total soluble solids (Brix) for fresh Juice. Three ripe fruits were selected at random from each picking of the sample plants and the refractometer reading from the juice of each of the three fruits was recorded separately and the average of these three readings

was calculated. Three such averages were taken from three separate picking and the mean of these three averages was used for statistical analysis.

Statistical analysis

Data are presented in terms of mean (±standard error). All data were subjected to analyses of variance (ANOVA) and then statistically analyzed using Windostat (version 9.3). Statistical differences between treatment means were established using Tukey's HSD test at $p < 0.05$.

3. RESULTS AND DISCUSSION

The variance analysis revealed significant variability among the genotypes in response to salinity stress across various traits, including plant height, number of branches per plant, number of flowers per cluster, number of trusses per plant, number of fruits per plant, diameter, and length of fruit, total soluble solids, average fruit weight, and TSS. To discern the impact of salinity stress at concentrations of 50mM, 100mM, and 150mM, differences in growth parameters were observed by comparing the values obtained in the treatment with the corresponding controls for each parameter and variety. The table presents the mean performance of different genotypes for various traits and the grand mean for these traits under salinity stress.

3.1 Plant height

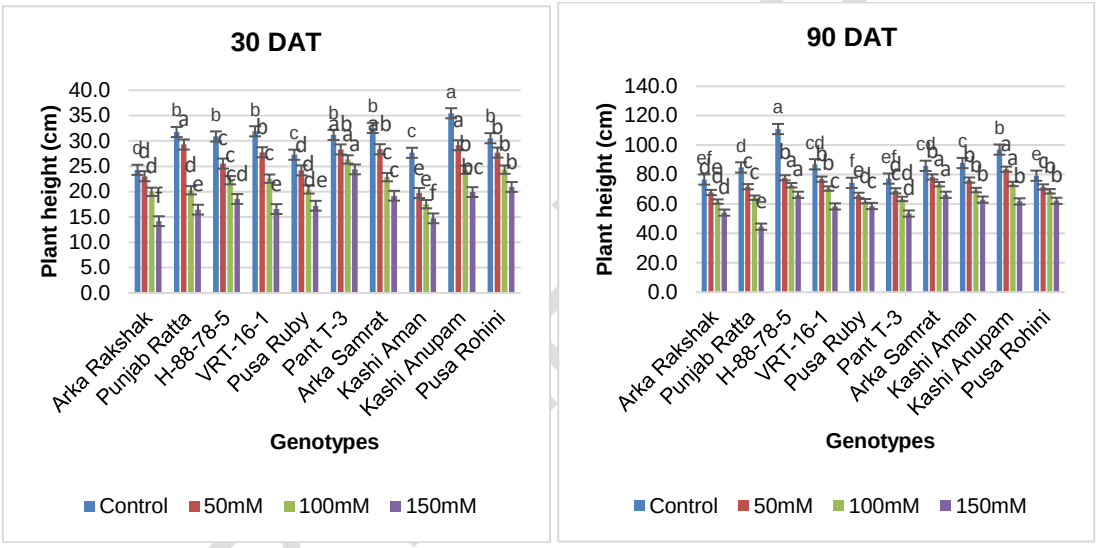
At 30-day after treatment, the data presented in Figure 3 highlights a noteworthy decline in plant height (PLHT) due to salt stress at 50mM, 100mM, and 150mM NaCl concentrations. The most significant reduction in plant height was observed in plants subjected to 150mM concentration, followed by 100mM and 50mM. Comparatively, control plants exhibited greater height than their stressed counterparts. Plant height decreased with the application of elevated salt stress reported by Babu *et al.* (2012); and Ali *et al.* (2014) [7,10]. Taking into account the mean results over both years, the average plant height under control conditions was 30.36 cm, and in stress conditions, the mean plant heights were 26.31 cm, 22.09 cm, and 18.21 cm at NaCl concentrations of 50mM, 100mM, and 150mM, respectively. Plant height ranged from 24.3 ± 0.65 cm (Arka Rakshak) to 35.47 ± 0.75 cm (Kashi Anupam) for control, while stressed plants varied from 14.17 ± 0.6 cm (Arka Rakshak) to 24.39 ± 0.31 cm (Pant T-3) under the highest NaCl concentration (150mM). Among the different germplasms used in the experiment, Kashi Anupam displayed the highest height, with heights of 35.47 ± 0.75 cm, 29.16 ± 0.23 cm, 24.33 ± 0.66 cm, and 19.92 ± 0.36 cm for control and treatments (50mM, 100mM, and 150mM). Conversely, Arka Rakshak exhibited the lowest height, measuring 24.3 ± 0.65 cm, 23.05 ± 0.58 cm, 19.96 ± 0.98 cm, and 14.17 ± 0.6 cm, followed by Pusa Ruby with heights of 27.28 ± 0.71 cm, 24.2 ± 0.63 cm, 20.44 ± 0.79 cm, and 17.22 ± 0.7 cm for control and treatments (50mM, 100mM, and 150mM).

At the 90 days after treatment or maturity, the mean results over both years, the average plant height under control conditions was 86.09 cm and in stress conditions, the mean plant heights were 73.88 cm, 67.94 cm, and 58.84 cm at NaCl concentrations of 50mM, 100mM, and 150mM, respectively. Plant height ranged from 74.33 ± 0.64 cm (Pusa Ruby) to 110.92 ± 1.51 cm (H-88-78-5) for control, while stressed plants varied from 44.56 ± 0.98 cm (Punjab Ratta) to 66.25 ± 0.46 cm (Arka Samrat) under the highest NaCl concentration (150mM). Among the different germplasms used in the experiment, H-88-78-5 displayed the highest height, with heights of 110.92 ± 1.51 cm, 77.76 ± 0.61 cm, 72.73 ± 0.99 cm, and 66.23 ± 0.94 cm for control and treatments (50mM, 100mM, and 150mM) followed by Kashi Anupam with the height of 96.96 ± 1.17 cm, 83.62 ± 0.86 cm, 73.62 ± 0.42 cm and 61.73 ± 0.95 cm. Conversely, Pusa Ruby exhibited the lowest height, measuring 74.33 ± 0.64 cm, 65.87 ± 0.8 cm, 61.87 ± 0.26 cm, and 58.59 ± 0.37 cm for control and treatments (50mM, 100mM, and 150mM), followed

by Arka Rakshak with heights of 76.62 ± 0.42 cm, 67.8 ± 0.79 cm, 61.59 ± 0.55 cm, and 54.11 ± 0.91 cm. observation tells the negative percent reduction for this character as shown in Fig 2. Ismail *et al.* (1994); and Umar *et al*. (2018) [11,12] also reported a comparable outcome, noting that an elevation in salinity is accompanied by a reduction in plant height.

Genotype Punjab Ratta (47.47%) exhibited the highest percentage reduction under stressed conditions, followed by H-88-78-5 (40.29%), while the lowest percentage reduction was observed in Pusa Ruby (21.17%) followed by Pusa Rohini (21.55%). The ANOVA results confirmed the significance of the plant height character outcomes.

Prior research indicates that diminished growth at low salt concentrations results from a decreased availability of nutrients necessary for plant growth. With increasing salt concentration, in addition to nutrient imbalance, hyperosmotic stress, and ion disequilibrium, play a crucial role in disrupting the cellular functions of the plant [13]. Decreasing plant height, leaf area, leaf number, and leaf length in the presence of salt stress might represent an adaptive morphological tactic to restrict water loss through transpiration. Alternatively, these changes could be attributed to the accumulation of Na+ and Cl- ions in cells, impeding the growth of young leaves due to their potential toxicity [14].



Data is represented as mean (±standard error) and the different letters are shown according to the Tukey's HSD test at $p < 0.05$

Figure 3. Effect of tomato genotypes on the plant height at different days after treatment (DAT).

3.2 Number of branches per plant (NBP)

The mean results over both years, the average NBP under control conditions was 11.7 and in stress conditions, the mean was 9.37 cm, 7.90 cm, and 6.00 cm at NaCl concentrations of 50mM, 100mM, and 150mM, respectively (Table 1). Recorded observations show that the number of branches per plant varied from 8.33 ± 0.33 (Pusa Rohini) to 14.67 ± 0.33 (VRT-16-1) in controlled conditions whereas in stressed conditions the number of branches varied from 3.33 ± 0.88 (Kashi Aman) to 8.67 ± 0.33 (Pusa Ruby) under the highest NaCl concentration (150mM) (Table 1). The observations showed a compelling reduction in the number of branches per plant under salinity stress conditions in all ten genotypes. VRT-16-1 displayed the highest NBP i.e 14.67 ± 0.33, 12.33 ± 0.33, 10 ± 0.58 and 7.33 ± 0.33 followed by Pusa Ruby with the number of 12.67 ± 0.33, 10.67 ± 0.33, 9 ± 0.58 and 8.67 ± 0.33 for control and treatments (50mM, 100mM, and 150mM). Conversely, Pusa Rohini exhibited the lowest height, measuring 8.33 ± 0.33, 6.67 ± 0.33, 6.33 ± 0.33 and 5.33 ± 0.33for control and

treatments (50mM, 100mM, and 150mM), followed by Kashi Aman with the number of 8.67 ± 0.67, 6.67 ± 0.33, 5.33 ± 0.33 and 3.33 ± 0.88. Observation tells the negative percent reduction for this character. Similar results were also recorded by Khursheda *et al.* (2015) [15]. Uddin *et al*. (2005) [16] observed a decrease in the number of branches in *Brassica* species with increasing salinity, aligning with a similar finding in rice where salinity led to a reduction in tiller number, as reported by Mortazainezhad *et al.* (2006) [17].

Genotype Kashi Anupam (56.23%) exhibited the highest percentage reduction under stressed conditions, followed by Kashi Aman (61.59%), while the lowest percentage reduction was observed in Pusa Ruby (31.57%). The ANOVA results confirmed the significance of the character outcomes.

Elevated concentrations of NaCl, particularly at 50 and 100 mM, lead to a noteworthy decrease in various vegetative growth parameters, including the number of lateral shoots [18]. The decline in plant height under increased salinity is primarily associated with the shortening of stem internodes rather than a reduction in the number of nodes. The impact of salt stress extends to the morphology, physiology, and fruit weight of tomato plants. Notably, there is a decrease in plant height, leaf number, and the count of branches per plant at salinity levels of 6 and 8 dS m–1. Additionally, there is a reduction in shoot dry weight, leaf area, and fruit weight per plant at 8 dS m–1 [15]. The number of branches is negatively correlated with plant height.

3.3 Number of flower trusses per plant

Salinity stress has been consistently associated with a decrease in the number of flower trusses in tomato plants. This phenomenon can be attributed to the intricate physiological and biochemical changes induced by elevated salt levels in the soil. Salinity stress disrupts various essential processes in plants, including water uptake, nutrient absorption, and hormonal regulation, all of which are crucial for the initiation and development of flowers. Salinity stress adversely affects root development and water uptake by inducing osmotic stress. The resultant water deficit within the plant restricts the normal processes involved in flower initiation and subsequent development of flower trusses. Additionally, the accumulation of sodium and chloride ions, common outcomes of salinity stress, can disrupt the delicate balance of ions within plant cells, leading to ion toxicity and hindering the proper development of reproductive structures [19]. Furthermore, the interference of salinity stress with hormonal regulation in plants, as highlighted by Flowers and Colmer (2008) [20], can impact the initiation of floral buds. Hormones such as auxins and gibberellins, vital for the development of flowers, may be disrupted under salinity stress conditions, leading to a reduced number of flower trusses.

Salinity stress has an adverse effect on crop yield attributes causing a reduction in the number of flower trusses per plant in tomato plants Zhang *et al*. (2017) [21]. The detailed results were recorded and evaluated under control conditions as well as salinity stress conditions and represented. For all tomato genotypes, recorded observations for the number of flower trusses per plant were found to be in the range of 5.33 ± 0.33 to 10.67 ± 0.88 control plants in comparison to salinity stressed plants which showed the range of 1.33 ± 0.33 to 3.67 ± 0.67 when applied the highest concentration of NaCl i.e 150mM (Table 1). The observations showed a compelling reduction in number of flower truss per plant under salinity stress conditions in all ten genotypes. Results further indicated that under controlled conditions genotype Kashi Anupam showed the maximum number of flower trusses per plant i.e 10.67 ± 0.88, 5.67 ± 1.33, 4.67 ± 0.88 and 3.67 ± 0.67 followed by Pusa Ruby i.e 9.33 ± 0.33, 7 ± 1, 6.33 ± 0.33 and 4.67 ± 0.33 for control and treatments (50mM, 100mM, and 150mM) while a minimum number of flower trusses per plant were recorded in Arka Rakshak i.e 5.33 ± 0.33, 4.33 ± 0.33, 3.33 ± 0.33 and 1.67 ± 0.33 followed by Arka Samrat 5.67 ± 0.88, 3.67 ± 0.88, 3 ± 0.58 and 1.67 ± 0.67 for control and treatments (50mM, 100mM, and 150mM). Similar results were recorded by Leiva-Ampuero *et al.* (2020) [22]. One-way ANOVA analyses have shown that the results for the number of flower truss per plant are significant at $p < 0.05$.

Genotype Punjab Ratta (78.98%) exhibited the highest percentage reduction under stressed conditions, followed by Arka Samrat (75.99%), while the lowest percentage reduction was observed in Pusa Ruby (49.94%) followed by Pusa Rohini (59.97%).

3.4 Number of flowers per truss

Several studies state that the capacity of a truss to generate additional flowers beyond this baseline is contingent upon favorable environmental and physiological circumstances. In the presence of salt stress, however, the potential for extra flower production is impeded. The decline in flowering under saline conditions may be attributed to constraints on water availability both before and during the initiation of inflorescence, along with a decrease in the uptake of potassium and phosphorus. In the 'Moneymaker' cultivar, there is a 60% reduction in the number of flowers per truss at a salinity level of 15 dS m^{-1} compared to control plants grown at 2.0 dS m^{-1} [23]. Salinity stress harms crop yield attributes causing a reduction in the number of flowers per truss in tomato plants (Zhang *et al.,* 2017) [21]. The detailed results recorded and evaluated under control as well as salinity stress conditions are represented in Table 1. Recorded observations corresponding to the number of flowers per truss were found to vary from 5.67 ± 0.33 (Pusa Ruby) to 7.83 ± 0.44 (VRT-16-1) in controlled plants while in salinity- stressed plants values varied from 2.17 ± 0.6 (Kashi Anupam) to 3.83 ± 0.44 (H-88-78-5) under the highest NaCl concentration (150mM). The observations showed compelling reduction in number of flowers per truss under salinity stress conditions in all ten genotypes. The tomato plant exhibited the highest floral count in the control condition, while the plant treated with salt showed the lowest counts also reported by Amini *et al.* (2007) [24]. Results also indicated that under controlled conditions genotype VRT-16-1 showed the maximum number of flower per truss i.e 7.83 ± 0.44, 6.43 ± 0.3, 5.6 ± 0.38 and 3.67 ± 0.33 followed by H-88-78-5 i.e 7.77 ± 0.39, 6.19 ± 0.24, 5.53 ± 0.29 and 3.83 ± 0.44 for control and treatments (50mM, 100mM, and 150mM) while a minimum number of flower per truss were recorded in genotype Pusa Ruby i.e. 5.67 ± 0.33, 4.5 ± 0.14, 4.92 ± 0.51 and 3.5 ± 1.89 followed by Pusa Rohini i.e 5.7 ± 0.44, 4.93 ± 0.3, 4.33 ± 0.44 and 2.83 ± 0.6 for control and treatments (50mM, 100mM, and 150mM). Furthermore, salinity negatively impacted flower production, with control plants exhibiting a higher rate compared to those subjected to salinity treatment. Likewise, several studies have observed a reduction in vegetative growth and the number of flowers in tomatoes under salinity [12, 25].

Genotype Punjab Ratta (68.21%) exhibited the highest percentage reduction under stressed conditions, followed by Kashi Anupam (65.71%), while the lowest percentage reduction was observed in Pusa Ruby (38.27%) followed by Pusa Rohini (50.35%). The ANOVA results confirmed the significance of the character outcomes.

Table 1. Effect of different concentrations of salt (50mM, 100mM and 150mM) on Number of branches/plant, Number of trusses/plant and number of flowers/ truss

Cultivar/ Treatment	Number of branches / plant				Number of trusses / plant				Number of flowers / truss			
	Control	50mM	100mM	150mM	Control	50mM	100mM	150mM	Control	50mM	100mM	150mM
Arka Rakshak	12.67 ± 0.33^{bc}	9.33 ± 0.33^{cd}	7.67 ± 0.33^{bc}	6.67 ± 0.33^{bc}	5.33 ± 0.33^{f}	4.33 ± 0.33	3.33 ± 0.33^{bcd}	1.67 ± 0.33^{cd}	6.53 ± 0.29^{cd}	5.2 ± 0.2^{bcd}	4.17 ± 0.17^{c}	2.83 ± 0.17
Punjab Ratta	13.33 ± 0.33^{ab}	10.33 ± 0.33^{bc}	9.33 ± 0.33^{a}	6.33 ± 0.33b^{cd}	6.33 ± 0.33^{def}	4.33 ± 0.67	2.67 ± 0.33^{d}	1.33 ± 0.33^{d}	7.33 ± 0.33^{bc}	6.0 ± 0.29^{abc}	4.5 ± 0.29^{bc}	2.33 ± 0.33
H-88-78-5	11.33 ± 0.33^{cd}	9.00± 0.58^{d}	7.33 ± 0.67^{c}	5.33 ± 0.33^{cde}	7.33 ± 0.33^{cde}	4.33 ± 0.88	3.33 ± 0.33^{bcd}	2.33 ± 0.33^{cd}	7.77 ± 0.39^{ab}	6.19 ± 0.24^{ab}	5.53 ± 0.29^{ab}	3.83 ± 0.44
VRT-16-1	14.67 ± 0.33^{a}	12.33 ± 0.33^{a}	10.00 ± 0.58^{a}	7.33 ± 0.33^{ab}	8.33 ± 0.33^{bc}	5.00 ± 0.58	4.33 ± 0.67^{bc}	2.33 ± 0.33^{cd}	7.83 ± 0.44^{a}	6.43 ± 0.3^{a}	5.6 ± 0.38^{a}	3.67 ± 0.33
Pusa Ruby	12.67 ± 0.33^{bc}	10.67 ± 0.33^{b}	9.00 ± 0.58^{ab}	8.67 ± 0.33^{Aa}	9.33 ± 0.33^{ab}	7.00 ± 1.00	6.33 ± 0.33^{a}	4.67 ± 0.33^{a}	5.67 ± 0.33^{d}	4.5 ± 0.14^{d}	4.92 ± 0.51^{bc}	3.5 ± 1.89
Pant T-3	14.00 ± 0.58^{ab}	11.33 ± 0.33^{ab}	10.33 ± 0.88^{a}	7.33 ± 0.88^{ab}	8.00 ± 0.58^{bcd}	4.67 ± 0.88	4.33 ± 0.33^{bc}	2.67 ± 0.33^{bc}	5.87 ± 0.47^{d}	4.5 ± 0.29^{d}	4.13 ± 0.32^{c}	2.83 ± 0.44
Arka Samrat	10.67 ± 0.88^{d}	8.67 ± 0.33^{d}	7.00 ± 0.58^{c}	5.00 ± 0.58d^{e}	5.67 ± 0.88^{ef}	3.67 ± 0.88	3.00 ± 0.58^{cd}	1.67 ± 0.67^{cd}	6.6 ± 0.4^{cd}	5.27 ± 0.15^{bcd}	4.07 ± 0.56^{c}	2.6 ± 0.31
Kashi Aman	8.67 ± 0.67^{e}	6.67 ± 0.33^{e}	5.33 ± 0.33^{d}	3.33 ± 0.88^{f}	8.33 ± 0.88^{bc}	5.67 ± 0.33	3.67 ± 0.33^{bcd}	2.00 ± 0.58^{cd}	7.4 ± 0.7^{bc}	5.10 ± 0.67^{cd}	4 ± 0.29^{c}	2.73 ± 0.37
Kashi Anupam	10.67 ± 0.33^{d}	8.67 ± 0.33^{d}	6.67 ± 0.33^{cd}	4.67 ± 0.33^{ef}	10.67 ± 0.88^{a}	5.67 ± 1.33	4.67 ± 0.88^{b}	3.67 ± 0.67^{ab}	6.33 ± 0.33^{cd}	5.0 ± 0.58^{cd}	4.83 ± 0.27^{bc}	2.17 ± 0.6
Pusa Rohini	8.33 ± 0.33^{e}	6.67 ± 0.33^{e}	6.33 ± 0.33^{cd}	5.33 ± 0.33^{cde}	6.67 ± 0.33^{cdef}	4.33 ± 0.33	3.67 ± 0.88^{bcd}	2.67 ± 0.33^{bc}	5.7 ± 0.44^{d}	4.93 ± 0.3^{d}	4.33 ± 0.44^{c}	2.83 ± 0.6
Gen. Mean	**11.7**	**9.37**	**7.9**	**6**	**7.6**	**4.9**	**3.93**	**2.5**	**6.7**	**5.31**	**4.61**	**2.93**
F Prob.	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.21**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.78**
S.E.M.	**0.48**	**0.37**	**0.53**	**0.52**	**0.58**	**0.79**	**0.55**	**0.45**	**0.43**	**0.35**	**0.37**	**0.72**
C.D. 5%	**1.42**	**1.08**	**1.55**	**1.52**	**1.7**	**NS**	**1.62**	**1.32**	**1.26**	**1.05**	**1.09**	**NS**
C.V.	**7.15**	**6.75**	**11.56**	**14.91**	**13.16**	**27.88**	**24.12**	**30.98**	**11.05**	**11.57**	**13.88**	**42.48**

Note: Value are means of 3 independent replicates± Standard error, means followed by different letters are significantly different at p ≤ 0.05 according to HSD.

3.5 Average fruit weight

The data presented in Table 3 highlights a noteworthy decline in average fruit weight due to salt stress at 50mM, 100mM, and 150mM NaCl concentrations. Considering the overall mean result of both years the mean average fruit weight at the control condition was 49.15g and at stress 43.89, 40.21 and 35.48g for 50mM, 100mMand 150mM respectively. It ranged between 23.76 ± 0.55 (Punjab Ratta) to 108.73 ± 1.29 g (Kashi Anupam) among control plants whereas, among treatments, it was 18.79 ± 0.45 g (Punjab Ratta) to 78.53 ± 0.71g (Kashi Anupam) under the highest NaCl concentration (150mM). The Highest fruit weight was recorded by Kashi Anupam i.e 108.73 ± 1.29, 97.13 ± 1.03, 91.58 ± 0.47 and 78.53 ± 0.71g followed by Pusa Rohini i.e 54.16 ± 0.85g, 47.72 ± 0.68g, 42.64 ± 0.37 and 35.24 ± 0.34, Arka Rakshak i.e 51.59 ± 1.02, 45.87 ± 0.46, 42.71 ± 0.48 and 39.45 ± 0.56g for control and treatments (50mM, 100mM and 150mM). The Lowest average fruit weight was recorded by Punjab Ratta i.e 23.76 ± 0.55, 22.05 ± 0.3, 20.37 ± 0.2 and 18.79 ± 0.45g for control and treatments (50mM,

100mM and 150mM). Several findings also indicated a notable impact of NaCl on fruit fresh weight, with an observed reduction in plants subjected to NaCl treatment [26,12,10,27].

Genotype Pant T-3 (35.80%) exhibited the highest percentage reduction under stressed conditions, followed by Pusa Rohini (34.93%), while the lowest percentage reduction was observed in Pusa Ruby (19.59%). The ANOVA results confirmed the significance of the Average fruit weight character outcomes.
Salinity stress disrupts both flowering and fruit ripening processes, resulting in reduced fruit quantities, diminished size, and weight. This stress also intensifies fruit sharpness and lowers nutritional values in chili peppers [28]. Similarly, have also documented that the reduction in tomato yield under salinity stress is a result of a decrease in the mean fruit weight [29].

3.6 Fruit diameter (cm)

The fruit diameter is one of the characteristics that helps to measure the size of tomato fruit produced by the plant. The fruit diameter experienced significant alterations under different salinity stress levels (Fig 3). This could be attributed to the detrimental impact of salt stress on water availability and uptake, resulting in a reduction in water content within plant tissues. This, in turn, induces changes in metabolic processes within the cell [30]. The Overall mean of both the years the mean fruit width among control and treatments (50mM, 100mM and 150mM) plants recorded was 4.46, 4.24, 4.01 and 3.71 cm respectively. It ranged from 2.55 ± 0.03 cm (H-88-78-5) to 6.97 ± 0.10 cm (Kashi Anupam) by control and treatments ranged between 1.95 ± 0.02 cm (H-88-78-5) to 4.7 ± 0.02 cm (Pusa Rohini) under the highest NaCl concentration (150mM). The highest fruit diameter recorded by Kashi Anupam was 6.97 ± 0.1, 6.54 ± 0.03, 6.26 ± 0.03 and 5.96 ± 0.03cm followed by Pusa Rohini i.e 5.26 ± 0.02, 5.05 ± 0.04, 4.89 ± 0.04 and 4.7 ± 0.02cm while lowest fruit diameter was shown by H-88-78-5 i.e 2.55 ± 0.03, 2.39 ± 0.03, 2.27 ± 0.03 and 1.95 ± 0.02cm followed by Punjab Ratta 3.7 ± 0.09, 3.54 ± 0.03, 3.22 ± 0.1 and 2.17 ± 0.06cm for control and treatments (50mM, 100mM and 150mM) represented in Table 2. NaCl significantly decreased fruit diameter. Elevated salinity stress, particularly at a concentration of 8.0 dS/m, resulted in a reduction in the radius of tomato fruit and cell size. This effect can be attributed to a decrease in water influx [10, 31]. The findings of this study align with the conclusions of Akladious and Mohamed (2018) [32], who observed a significant reduction in fruit length and diameter of pepper plants when irrigated with high saline water (200mM).
The highest percent Induction for fruit diameter was recorded by Punjab Ratta (41.35%) followed by H-88-78-5 (23.52%). The lowest percent reduction was reported by Pusa Ruby (9.54%) followed by Pusa Rohini (10.64%).
Plants experiencing stress exhibit a slower rate of flower and fruit production, accompanied by the development of smaller-sized fruits in comparison to their non-stressed counterparts [18]. The decrease in tomato (Lycopersicon esculentum L. cv. Momotaro) fruit size under salinity stress is attributed to the inhibition of water uptake by the roots, leading to a reduction in water transport to the fruit [33].

3.7 Fruit length (cm)

Overall results indicated that control plants have bigger-sized fruits as compared to treatment plant fruits, hence, control showed more fruit length than plants under stress in this study (Table 2). This result is reported by Ali *et al.* (2014) [10] in their study. Considering the overall mean result of both years the mean average fruit length at the control condition was 4.34 cm and at salinity treatments (50mM, 100mM and 150mM) was 4.08, 3.76 and 3.43cm respectively. The range shown by control plants was 2.92 ± 0.03cm (Pant-T3) to 6.11 ± 0.07cm (Kashi Aman), and that of treatment plants was 2.04 ± 0.08cm (Pant-T3) to 5.32 ± 0.02 cm

(Kashi Anupam). Among the different germplasms used in the experiment, Kashi Anupam displayed the highest fruit length, with lengths of 6.11 ± 0.07, 5.74 ± 0.04, 5.58 ± 0.03 and 5.32 ± 0.02cm followed by Arka Samrat i.e 5.31 ± 0.05, 4.84 ± 0.02, 4.7 ± 0.01 and 4.51 ± 0.02cm conversely, Pant-T3 exhibited the lowest fruit length, measuring 2.92 ± 0.03, 2.73 ± 0.03, 2.4 ± 0.01 and 2.04 ± 0.08 cm followed by Punjab Ratta i.e 3.46 ± 0.03, 3.27 ± 0.08, 3 ± 0.01 and 2.79 ± 0.03cm for control and treatments (50mM, 100mM, and 150mM).

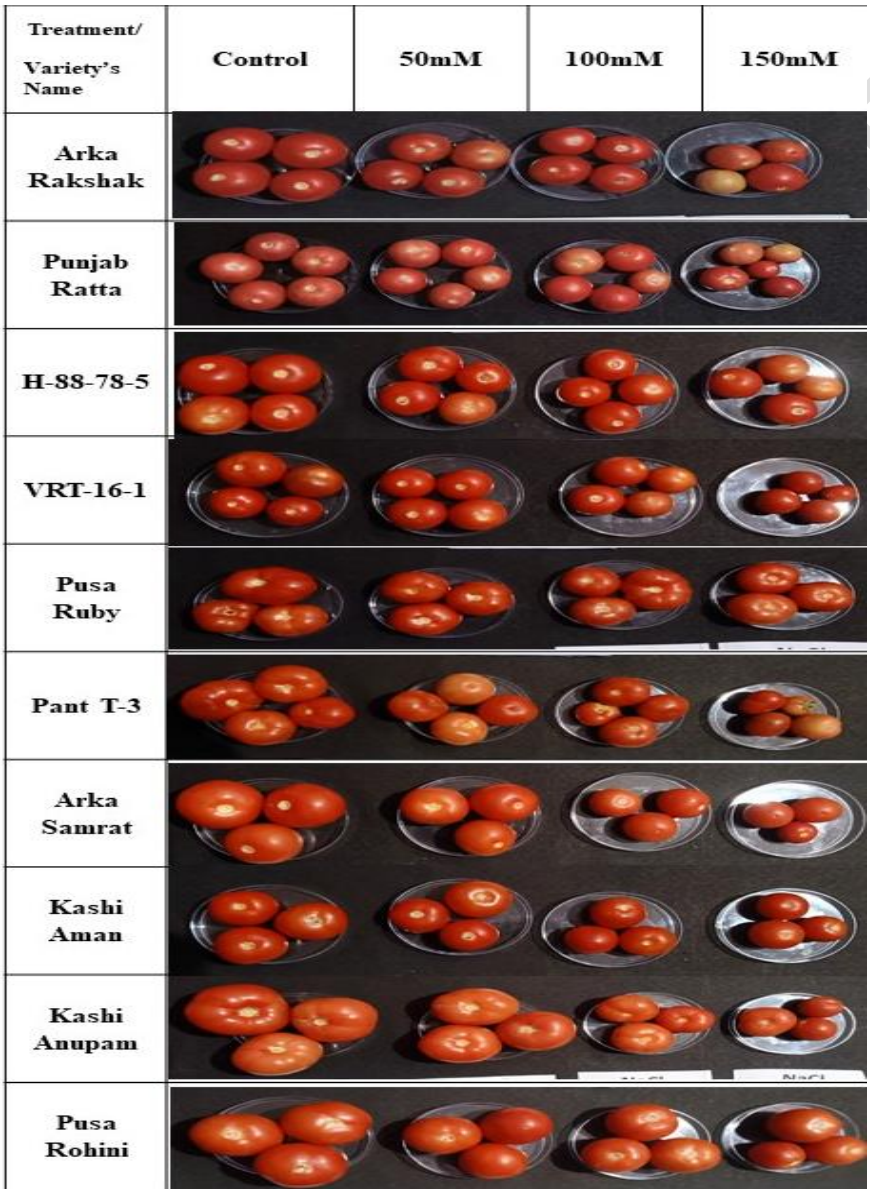


Figure4. Impact of salinity on tomato fruits.

The highest percent Induction for fruit length was recorded by H-88-78-5 (42.29 %). followed by Pant T-3 (30.13%). The lowest percent reduction was reported by Kashi Aman (12.92%) followed by Pusa Rohini (14.37%). Distinct salinity levels led to differences in the length of tomato plant fruits as shown in Fig 4. Notably, substantial fruits were harvested from control plants, while plants subjected to high salinity stress produced smaller fruits. This phenomenon could be attributed to the adverse impact of salinity on cell expansion [34].

Table 2. **Effect of different concentrations of salt (50mM, 100mM and 150mM) on Fruit diameter and length.**

Cultivar/ Treatment	Fruit diameter				Fruit length			
	Control	50mM	100mM	150mM	Control	50mM	100mM	150mM
Arka Rakshak	4.46 ± 0.05^{d}	4.22 ± 0.07^{e}	3.96 ± 0.04^{de}	3.56 ± 0.17^{e}	4.81 ± 0.03^{c}	4.66 ± 0.02^{c}	3.9 ± 0.02^{e}	3.67 ± 0.03^{d}
Punjab Ratta	3.7 ± 0.09^{g}	3.54 ± 0.03^{h}	3.22 ± 0.1^{g}	2.17 ± 0.06^{g}	3.46 ± 0.03^{f}	3.27 ± 0.08^{h}	3 ± 0.01^{h}	2.79 ± 0.03^{f}
H-88-78-5	2.55 ± 0.03^{h}	2.39 ± 0.03^{i}	2.27 ± 0.03^{h}	1.95 ± 0.02^{h}	3.83 ± 0.03^{e}	3.48 ± 0.03^{g}	2.93 ± 0.04^{h}	2.21 ± 0.01^{g}
VRT-16-1	4.12 ± 0.05^{e}	3.94 ± 0.02^{f}	3.76 ± 0.03^{ef}	3.54 ± 0.02^{e}	3.83 ± 0.02^{e}	3.64 ± 0.03^{f}	3.22 ± 0.03^{g}	2.77 ± 0.06^{f}
Pusa Ruby	4.82 ± 0.02^{c}	4.6 ± 0.01^{c}	4.49 ± 0.01^{c}	4.36 ± 0.02^{c}	3.88 ± 0.08^{e}	3.64 ± 0.02^{f}	3.5 ± 0.05^{f}	3.27 ± 0.04^{e}
Pant T-3	4.14 ± 0.02^{e}	3.97 ± 0.03^{f}	3.54 ± 0.01^{f}	3.67 ± 0.02^{e}	2.92 ± 0.03^{g}	2.73 ± 0.03^{i}	2.4 ± 0.01^{i}	2.04 ± 0.08^{h}
Arka Samrat	4.7 ± 0.02^{c}	4.41 ± 0.01^{d}	4.14 ± 0.06^{d}	3.93 ± 0.03^{d}	5.31 ± 0.05^{b}	4.84 ± 0.02^{b}	4.7 ± 0.01^{b}	4.51 ± 0.02^{b}
Kashi Aman	3.94 ± 0.04^{f}	3.7 ± 0.01^{g}	3.53 ± 0.03^{f}	3.31 ± 0.01^{f}	6.11 ± 0.07^{a}	5.74 ± 0.04^{a}	5.58 ± 0.03^{a}	5.32 ± 0.02^{a}
Kashi Anupam	6.97 ± 0.1^{a}	6.54 ± 0.03^{a}	6.26 ± 0.03^{a}	5.96 ± 0.03^{a}	4.52 ± 0.07^{d}	4.31 ± 0.02^{e}	4.1 ± 0.04^{d}	3.71 ± 0.1^{d}
Pusa Rohini	5.26 ± 0.02^{b}	5.05 ± 0.04^{b}	4.89 ± 0.04^{b}	4.7 ± 0.02^{b}	4.73 ± 0.02^{c}	4.46 ± 0.03^{d}	4.23 ± 0.02^{c}	4.05 ± 0.04^{c}
Gen. Mean	**4.46**	**4.24**	**4.01**	**3.71**	**4.34**	**4.08**	**3.76**	**3.43**
F Prob.	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
S.E.M.	**0.05**	**0.03**	**0.1**	**0.06**	**0.05**	**0.04**	**0.03**	**0.05**
C.D. 5%	**0.15**	**0.1**	**0.29**	**0.18**	**0.14**	**0.11**	**0.09**	**0.15**
C.V.	**1.99**	**1.35**	**4.21**	**2.81**	**1.89**	**1.6**	**1.4**	**2.53**

Note: Value are means of 3 independent replicates± Standard error, means followed by different letters are significantly different at $p \leq 0.05$ according to HSD.

3.8 Number of fruits per plant

The results were significant for the important yield contributing character number of fruits per plant for both experiments. Due to abiotic stress, the fruit yield was reduced drastically in treated plants than the control for both the years (Table 3). Several studies reported that number of fruits declined as the salinity increased [12,24,7]. Considering the overall mean of both years the mean number of fruits per plant among control and treatments (50mM, 100mM and 150mM) recorded were 26.47, 20.17, 15.93 and 9.73 respectively. Control plants ranged from 17.33±0.88 (Pusa Rohini) to 35 ± 1.15 (H-88-78-5) and stress applied was from 6 ± 0.58 (VRT-16-1) to 11.67 ± 0.88 (Pusa Ruby) under the highest NaCl concentration (150mM) for number of fruits. Among the different germplasms used in the experiment, H-88-78-5 displayed the highest number of fruits, with the number of 35 ± 1.15, 28.67 ± 0.88, 21 ± 1.15 and 14 ± 1.15 followed by Kashi Aman i.e. 31 ± 1.15, 24.67 ± 0.88, 18.67 ± 0.88 and 9.67 ± 0.88 for control and treatments (50mM, 100mM, and 150mM). Conversely, Pusa Rohini exhibited the lowest number of fruits, measuring 17.33 ± 0.88, 13.33 ± 0.88, 10.67 ± 0.88 and 7.00 ± 1.15, followed by Arka Rakshak with the numbers of 23.33 ± 1.2, 17.67 ± 0.88, 14.67 ± 0.88 and 9 ± 0.58 for control and treatments (50mM, 100mM, and 150mM). The decrease in fruit number could be associated with salt-induced factors leading to a reduction in the number of flowers [35,36]. noted a decrease in tomato plant yield under NaCl stress (Control

= 0.8 dS m−1 and sodium chloride solution with EC = 2.0 dS m−1) when salt stress was applied individually during the vegetative, flowering, and fruiting stages [21].The overall percent reduction signifies the severity of stress and its importance. The highest percent reduction was indicated by genotype Punjab Ratta (74.65 %) followed by Kashi Aman (68.80%). The least affected genotypes were Pusa Ruby (49.97 %) followed by Arka Rakshak (54.11 %). The ANOVA results indicated significant results for this character.

Table 3. Effect of different concentrations of salt (50mM, 100mM and 150mM) on Number of fruits/ plant and Average fruit weight

Cultivar/ Treatment	Number of fruits per plant				Average fruit weight			
	Control	50mM	100mM	150mM	Control	50mM	100mM	150mM
Arka Rakshak	23.33 ± 1.2^{d}	17.67 ± 0.88^{cd}	14.67 ± 0.88^{d}	9.00 ± 0.58^{bc}	51.59 ± 1.02^{c}	45.87 ± 0.46^{c}	42.71 ± 0.48^{b}	39.45 ± 0.56^{b}
Punjab Ratta	23.67 ± 0.88^{d}	15 ± 0.58de	9.33 ± 0.88^{e}	6.00 ± 0.58^{d}	23.76 ± 0.55^{g}	22.05 ± 0.3^{h}	20.37 ± 0.2^{f}	18.79 ± 0.45^{h}
H-88-78-5	35 ± 1.15^{a}	28.67 ± 0.88^{a}	21.00 ± 1.15^{ab}	14.00 ± 1.15^{a}	36.37 ± 0.89^{f}	32.61 ± 0.66^{g}	29.12 ± 0.44^{e}	25.73 ± 0.29^{f}
VRT-16-1	26.67 ± 0.88^{c}	16.67 ± 0.88^{cd}	14.33 ± 0.88^{d}	8.67 ± 0.88^{cd}	34.53 ± 0.66^{f}	31.01 ± 0.19^{g}	28.67 ± 0.52^{e}	24.21 ± 0.38^{g}
Pusa Ruby	23.33 ± 0.88^{d}	18.67 ± 0.88^{c}	15.67 ± 0.88^{cd}	11.67 ± 0.88^{ab}	45.77 ± 0.61^{e}	43.21 ± 0.49^{d}	40.69 ± 0.34^{c}	36.80 ± 0.3^{c}
Pant T-3	28.67 ± 0.88^{bc}	23.67 ± 0.88^{b}	18.33 ± 0.88^{bc}	9.00 ± 1.15^{bc}	48.77 ± 0.73^{d}	40.71 ± 0.58^{e}	35.63 ± 0.46^{d}	31.31 ± 0.34^{e}
Arka Samrat	28.33 ± 0.88^{bc}	25.67 ± 0.88^{b}	21.33 ± 0.88^{a}	13.00 ± 0.58^{a}	43.6 ± 0.49^{e}	39.76 ± 0.46^{ef}	35.43 ± 0.52^{d}	32.45 ± 0.26^{e}
Kashi Aman	31 ± 1.15^{b}	24.67 ± 0.88^{b}	18.67 ± 0.88^{ab}	9.67 ± 0.88^{bc}	44.24 ± 0.42^{e}	38.82 ± 0.32^{f}	35.27 ± 0.26^{d}	32.28 ± 0.36^{e}
Kashi Anupam	27.33 ± 0.88^{c}	17.67 ± 1.45^{cd}	15.33 ± 0.88^{d}	9.33 ± 1.2^{bc}	108.73 ± 1.29^{a}	97.13 ± 1.03^{a}	91.58 ± 0.47^{a}	78.53 ± 0.71^{a}
Pusa Rohini	17.33 ± 0.88^{e}	13.33 ± 0.88^{e}	10.67 ± 0.88^{e}	7.00 ± 1.15^{cd}	54.16 ± 0.85^{b}	47.72 ± 0.68^{b}	42.64 ± 0.37^{b}	35.24 ± 0.34^{d}
Gen. Mean	**26.47**	**20.17**	**15.93**	**9.73**	**49.15**	**43.89**	**40.21**	**35.48**
F Prob.	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
S.E.M.	**0.98**	**0.93**	**0.91**	**0.94**	**0.79**	**0.57**	**0.42**	**0.42**
C.D. 5%	**2.88**	**2.75**	**2.69**	**2.76**	**2.34**	**1.67**	**1.24**	**1.24**
C.V.	**6.4**	**8**	**9.92**	**16.67**	**2.79**	**2.23**	**1.81**	**2.05**

Note: Value are means of 3 independent replicates± Standard error, means followed by different letters are significantly different at p ≤ 0.05 according to HSD.

High salinity levels adversely affect multiple stages of tomato fruit development, leading to a significant reduction in overall fruit yield. Salinity-induced physiological disruptions, such as impaired nutrient uptake, altered water relations, and hormonal imbalances, contribute to poor fruit set and compromised development. Studies, highlight the negative effects of salinity on flowering patterns, pollen viability, and subsequent pollination success [20,19].

3.9 Total soluble solids (˚ Brix)

Total soluble solids (TSS) are mainly composed of a blend of sucrose, hexose, citrate and malate that all together reach 78% of the total content [37]. Total soluble solids (TSS) content is one of the most important quality parameters in tomato fruits, But the most interesting results were the significant TSS increases induced by salinity in ripe fruits of all genotypes. In all genotypes, 50mM and 100mM NaCl treatment caused significant increases in fruit °Brix which is consistent with our results. A significant decrease in fruit Brix under high salinity (150mM) has also been observed (Fig 5). These results are also reported by Habibi *et al*., (2021) [38]. Fruit °Brix ranged from 6.4 ± 0.06 (Arka Rakshak) to 9.13 ± 0.09 (VRT-16-1) for control, while stressed plants varied from 5.1 ± 0.06 (Pant T-3) to 8.43 ± 0.03 (VRT-16-1) under the highest NaCl concentration (150mM). Several findings indicate that moderate salinity (50 mM) can enhance the Brix level of tomato fruit [39]. These findings aligning with our results.

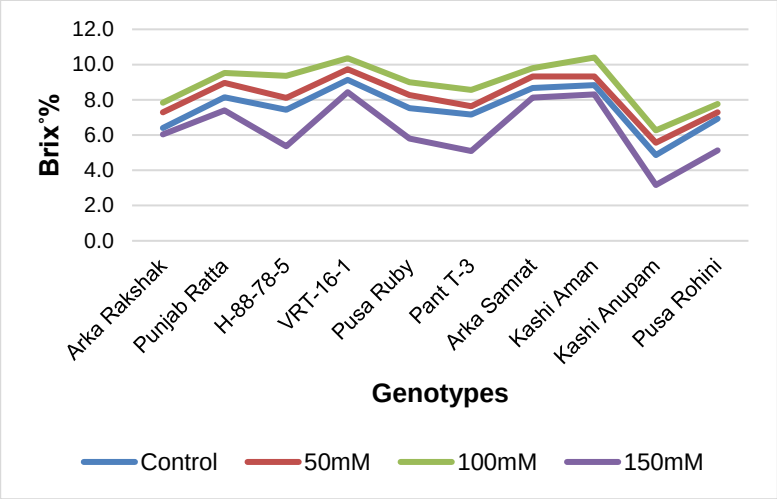


Figure 5. The TSS percent of tomato fruits grown in different salinity levels

The build-up of sugars and Total Soluble Solids (TSS) in fruit can be attributed to a decline in water flow to the fruit when subjected to salt stress, induced by elevated Electrical Conductivity (EC). The TSS level in the fruit serves as a critical indicator of quality for tomato paste processing. The TSS content in ripened fruit rises with heightened salinity. Consequently, employing moderately saline irrigation water (3-6 dS m-1) is advised to enhance fruit quality [36]. Additionally, Studies reported that treatments with 150 mM and 200 mM resulted in a decrease in sucrose [40], while some found that 60 mM NaCl salinity increased sugars in tomato fruits [41], supporting the outcomes of our study.

4. CONCLUSION

Salinity, widespread abiotic stress due to soil salinization and suboptimal irrigation water quality, poses a significant threat to global yields, especially in arid and semiarid regions. This study delves into the complex responses at the plant level that are crucial for enhancing and safeguarding tomato crops against soil salinization. Results reveal varied responses to salinity among different tomato cultivars, with notable reductions in growth, flowering, and fruiting as salinity levels increase. Specific cultivars, such as Pusa Ruby, Pusa Rohini, and Arka Rakshak, demonstrate high tolerance to salt stress, providing valuable insights for in vitro screening of tomatoes under high salinity conditions. The study emphasizes the importance of field trials for validating cultivar performance in real-world conditions. In conclusion, the findings offer valuable information for plant breeders, suggesting the potential inclusion of salt-tolerant cultivars like Pusa Ruby in tomato breeding programs. This approach contributes to sustainable tomato production, especially in coastal areas, addressing the challenges posed by high salinity and guiding future breeding efforts.

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APPENDIX

Table 1A. Effect of different concentrations of salt (50mM, 100mM and 150mM) on Plant height.

Cultivar/ Treatment	Plant Height							
	30DAT				90 DAT			
	Control	50mM	100mM	150mM	Control	50mM	100mM	150mM
Arka Rakshak	24.3 ± 0.65^{d}	23.05 ± 0.58^{d}	19.96 ± 0.98^{d}	14.17 ± 0.6^{f}	76.62 ± 0.42^{ef}	67.8 ± 0.79^{de}	61.59 ± 0.55^{d}	54.11 ± 0.91^{d}
Punjab Ratta	31.77 ± 0.95^{b}	29.3 ± 0.35^{a}	20.27 ± 0.37^{d}	16.44 ± 0.49^{e}	84.84 ± 1.11^{d}	71.74 ± 0.94^{c}	64.24 ± 1.03^{c}	44.56 ± 0.98^{e}
H-88-78-5	30.89 ± 0.95^{b}	25.54 ± 0.33^{c}	22.26 ± 0.66^{c}	18.55 ± 0.9^{cd}	110.92 ± 1.51^{a}	77.76 ± 0.61^{b}	72.73 ± 0.99^{a}	66.23 ± 0.94^{a}
VRT-16-1	31.91 ± 0.96^{b}	27.77 ± 0.4^{b}	22.56 ± 0.3^{c}	16.56 ± 0.29^{e}	87.01 ± 1.04^{cd}	76.86 ± 1.28^{b}	70.48 ± 0.6^{b}	58.35 ± 0.9^{c}
Pusa Ruby	27.28 ± 0.71^{c}	24.2 ± 0.63^{d}	20.44 ± 0.79^{d}	17.22 ± 0.7^{de}	74.33 ± 0.64^{f}	65.87 ± 0.8^{e}	61.87 ± 0.26^{d}	58.59 ± 0.37^{c}
Pant T-3	31.2 ± 0.61^{b}	28.33 ± 0.34^{ab}	26.36 ± 0.38^{a}	24.39 ± 0.31^{a}	77.23 ± 0.99^{ef}	68.93 ± 0.23^{d}	63.42 ± 1.08^{cd}	53.47 ± 0.58^{d}
Arka Samrat	32.58 ± 0.63^{b}	28.37 ± 0.45^{ab}	22.86 ±0.19b^{c}	19.19 ± 0.56^{c}	85.91 ± 0.69^{cd}	78.38 ± 0.48^{b}	73.42 ± 0.49^{a}	66.25 ± 0.46^{a}
Kashi Aman	27.66 ± 0.66^{c}	19.73 ± 0.26^{e}	17.53 ± 0.41^{e}	14.73 ± 0.26^{f}	87.83 ± 0.99^{c}	76.24 ± 1.22^{b}	69.44 ± 0.64^{b}	62.95 ± 0.74^{b}
Kashi Anupam	35.47 ± 0.75^{a}	29.16 ± 0.23^{a}	24.33 ± 0.66^{b}	19.92 ± 0.36^{bc}	96.96 ± 1.17^{b}	83.62 ± 0.86^{a}	73.62 ± 0.42^{a}	61.73 ± 0.95^{b}
Pusa Rohini	30.54 ± 1.07^{b}	27.71 ± 0.36^{b}	24.35 ± 0.39^{b}	20.92 ± 0.51^{b}	79.2 ± 1.05^{e}	71.57 ± 0.4^{c}	68.63 ± 0.59^{b}	62.13 ± 0.74^{b}
Gen. Mean	**30.36**	**26.31**	**22.09**	**18.21**	**86.09**	**73.88**	**67.94**	**58.84**
F Prob.	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
S.E.M.	**0.81**	**0.41**	**0.56**	**0.53**	**1**	**0.83**	**0.71**	**0.78**
C.D. 5%	**2.39**	**1.21**	**1.67**	**1.58**	**2.96**	**2.44**	**2.11**	**2.31**
C.V.	**4.62**	**2.69**	**4.43**	**5.08**	**2.02**	**1.94**	**1.82**	**2.31**

TABLE 2A. Effect of different concentrations of salt (50mM, 100mM and 150mM) on Average fruit weight and Total soluble solid (brix˚).

Cultivar/treatment	Control	50mm	100mm	150mm
Arka rakshak	6.4 ± 0.06^{h}	7.30 ± 0.06^{f}	7.83 ± 0.03^{f}	6.03 ± 0.09^{c}
Punjab ratta	8.15 ± 0.08^{d}	8.97 ± 0.07^{c}	9.53 ± 0.03^{c}	7.40 ± 0.06^{b}
H-88-78-5	7.43 ± 0.03^{e}	8.10 ± 0.06^{d}	9.37 ± 0.03^{c}	5.37 ± 0.03^{d}
Vrt-16-1	9.13 ± 0.09^{a}	9.73 ± 0.12^{a}	10.37 ± 0.09^{a}	8.43 ± 0.03^{a}
Pusa ruby	7.53 ± 0.03^{e}	8.27 ± 0.09^{d}	9.00 ± 0.06^{d}	5.80± 0.40^{c}
Pant t-3	7.17 ± 0.03^{f}	7.63 ± 0.12^{e}	8.57 ± 0.07^{e}	5.10 ± 0.06^{d}
Arka samrat	8.67 ± 0.03^{c}	9.33 ± 0.09^{b}	9.80 ± 0.06^{b}	8.13 ± 0.09^{a}
Kashi aman	8.83 ± 0.03^{b}	9.33 ± 0.07^{b}	10.4 ± 0.15^{a}	8.30 ± 0.06^{a}
Kashi anupam	4.87 ± 0.03^{i}	5.57 ± 0.09^{g}	6.27 ± 0.07^{g}	3.17 ± 0.03^{e}
Pusa rohini	6.93 ± 0.03^{g}	7.30 ± 0.10^{f}	7.77 ± 0.09^{f}	5.13 ± 0.03^{d}
Gen. Mean	**7.51**	**8.15**	**8.89**	**6.29**
F prob.	**<0.001**	**<0.001**	**<0.001**	**<0.001**
S.e.m.	**0.05**	**0.09**	**0.08**	**0.14**
C.d. 5%	**0.15**	**0.26**	**0.22**	**0.41**
C.v.	**1.15**	**1.87**	**1.48**	**3.83**