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**Research Article****Foliar application of salicylic acid and ascorbic acid mitigates salinity stress in hot pepper through enhanced antioxidants activity****Muhammad Iqbal<sup>1</sup>, Hassan Raza<sup>2</sup>, Muneeb Munawar<sup>1</sup>, Wajeaha Khan<sup>1</sup>, Zarghona Siddique<sup>2</sup>, Muhammad Irfan Ashraf<sup>2</sup>**<sup>1</sup> Vegetable Research Institute, Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan.<sup>2</sup> Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan.**ABSTRACT**

Three genotypes of hot pepper were subjected to three different levels of salinity in a pot experiment to study the effect of salt stress on vegetative and reproductive growth of hot pepper along with efficacy of exogenous application of salicylic acid (SA) and ascorbic acid (AsA) in enabling plant to withstand salinity. Two concentrations (1 and 2 mM) of SA and AsA, both individually and in combination were applied through foliar spray. Salinity stress significantly reduced growth of hot pepper with plant height, root length, and biomass decreasing by up to 73.28%, 74.09%, and 82.57%, respectively as compared to control. Likewise, fruit yield per plant was reduced by 76.44%. The activity of superoxide dismutase (SOD) and peroxidase (POD) were also affected in response to salinity. Among the treatments, the application of 2 mM SA and 2 mM AsA led to greatest improvements in growth and yield, especially in the genotype SV5232-HY. This study will be helpful for selecting salinity-tolerant genotypes for cultivation in saline-prone areas and demonstrates the potential of using exogenous compounds to enhance plant resilience against salinity stress.

**Keywords:** *Capsicum annuum*; abiotic stress; chilli; growth parameters, proline.**INTRODUCTION**

Salinity stress has emerged as a serious threat to agricultural productivity worldwide. Approximately, 20% of the world's cropped area and 30% of its irrigated area are affected by salinity (Amer et al., 2020; Moneim, 2023). Hot pepper (*Capsicum annuum* L.), which is an important vegetable worldwide due to its nutritional value and profitability (Mweta & Nnungu, 2023), is prone to salt stress (Purnama et al., 2022). Salinity levels exceeding 1.5 dSm<sup>-1</sup> can initiate yield reductions in hot pepper (Shams et al., 2023), with losses from 20-50% depending on the cultivar and environment (Moneim, 2023). Salt stress has negative effect on hot pepper productivity by reducing plant's ability to uptake nutrients from soil, photosynthesis and vegetative growth (Rahil et al., 2019). Sarwar et al. (2022) has reported that salinity significantly reduces stem and root length and overall plant biomass. This is due to reduced uptake of potassium ions, which play important role in many metabolic processes, by plant roots in response of high concentration of sodium ions in salinity conditions (Qiu et al., 2018). Salinity stress triggers antioxidant defense mechanism of plant due to oxidative stress. Many studies has reported elevated activity of different antioxidant enzymes in response to oxidative damage caused by salinity stress (Abdelkhalik et al., 2023; Shams & Yıldırım, 2021). Mahmood et al. (2021) has reported increase in proline, under abiotic stresses, which is an osmoprotectant and help plant in to withstand physiological drought (Mahmood et al., 2021).

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Use of various exogenous chemicals like salicylic acid and ascorbic acid has gained attention in agricultural research during recent years to improve plant's ability to withstand salinity and other abiotic stresses. These chemicals enable plant to withstand stress conditions by increasing many antioxidant enzymes activity and other physiological changes (Fatah & Sadek, 2020; Youssef et al., 2023). Salicylic acid improves vegetative growth and increase antioxidants activity under abiotic stress conditions in plants (Abdelaal et al., 2019; Kaur & Gupta, 2017; Mohammadi, 2023). Ascorbic acid, an important antioxidant, plays role in redox reactions and help plant to fight against reactive oxygen species (ROS) at cellular level (Jung et al., 2020; Wang et al., 2018). This experiment was designed to study the effect of salinity on vegetative and reproductive growth of different hot pepper genotypes and efficacy of foliar application of SA and AsA in enabling hot pepper genotypes to withstand salinity stress through modification of antioxidant enzymes activity.

## MATERIALS AND METHODS

The experiment utilized a three-factor (genotype, salinity stress and foliar application) factorial design (Table 1) with three replications. Three hot pepper genotypes were sown in peat moss-filled plastic seedling trays on December 1, 2020, under a plastic tunnel. Germination occurred within 10-15 days. Seedlings were transplanted into pots filled with soil and peat moss, in equal ratio, at the four-leaf stage on January 28, 2021. Each pot received one liter of water and was left overnight before transplanting two seedlings per pot in moist soil. Daily irrigation continued until seedling establishment, after which one plant per pot was retained.

Salt stress was applied one week after transplantation using sodium chloride (NaCl) to achieve the desired salinity levels, using following formula (Hussain et al., 1989)

$$\text{Amount of Salt (NaCl) required } \left( \frac{g}{kg} \right) = \frac{(EC2 - EC1) \times TSS \times \text{Mol. weight of NaCl} \times \text{Saturation \% of Soil}}{100 \times 1000}$$

Whereas, EC2 is final electrical conductivity, EC1 is initial electrical conductivity and TSS is total suspended solids and saturation percentage of soil is ratio of water needed to saturate fully dried soil to weight of dry soil (Aali et al., 2009).

Three levels of salinity were used i.e. control, designated as S<sub>0</sub> (EC = 3.2 dSm<sup>-1</sup>), salinity level one, designated as S<sub>1</sub> (EC = 6 dSm<sup>-1</sup>), and salinity level two, designated as S<sub>2</sub> (EC = 10 dSm<sup>-1</sup>).

Fifteen days after initiating salinity stress, plants were sprayed every two weeks for a total of three applications using salicylic acid and ascorbic acid. Two concentrations of each chemical (1 mM and 2 mM) were applied, along with four combinations of both chemicals (Table 1). Growth and yield parameters were measured at crop maturity.

### Estimation of Enzymatic Antioxidants Activity

After ten days of final foliar application, fresh leaves were harvested from plants for estimation of antioxidants activity.

#### Superoxide Dismutase (U/mg)

Superoxide dismutase (SOD) activity was estimated following Shahid et al. (2014) with minor modifications. Reaction mixture was prepared using 250 µl of phosphate buffer (pH 7.5), 50 µl riboflavin, 100 µl methionine, and 50 µl nitro-blue tetrazolium. This reaction mixture was put under fluorescent light for 15 minutes. The change in absorbance was measured at 560 nm using UV-Vis spectrophotometer (UV-2550, Shimadzu, Kyoto, Japan). Superoxide dismutase (SOD) activity was calculated and expressed as enzyme units per milligram of protein (U/mg).

#### Peroxidase (U/mg)

Peroxidase (POD) activity was determined using a reaction mixture freshly prepared with 75 ml of 100 mM sodium phosphate buffer (pH 6), 28.5 µl 30% hydrogen peroxide, and 42 µl of guaiacol. 1 ml of enzyme extract was added to 3 ml of the reaction mixture. The change in absorbance at 470 nm was monitored at 30-second intervals for 2 minutes. The specific activity of the enzyme was calculated as the increase in absorbance at 470 nm per minute per gram of fresh weight.

#### Catalase (U/mg)

For catalase (CAT) activity estimation, reaction mixture consisted of 1.5 ml 0.05 M sodium phosphate buffer (pH 7.8), 1 ml deionized water, and 0.3 ml 0.1 M hydrogen peroxide. To this 3 ml mixture, 0.2 ml of enzyme extract was added. The decrease in absorbance at 240 nm was measured using a spectrophotometer. Enzyme activity was expressed as the change in absorbance at 240 nm per minute per gram of fresh weight.

#### Estimation of Proline (µmoles/g)

Proline contents were measured following Ünyayar et al. (2004). 100 mg of plant material was grounded in 5 ml of 5-sulfosalicylic acid (3%) solution. The resulting extract was mixed with 2 ml of glacial acetic acid and 2 ml of ninhydrin solution and heated at 100°C for 1 hour. The reaction was then stopped by cooling in an ice bath. Subsequently, 1 ml of toluene was added, and the optical density of the solution was recorded at 250 nm.

## Statistical Analysis

Analysis of variance (Steel et al., 1997) and Least Significant Difference test of replicated data was performed using Statistix® 8.1. Factoextra (Kassambara & Mundt, 2020) and patchwork (Pedersen, 2024) packages of R software were used for graphical presentation of mean values.

## RESULTS AND DISCUSSIONS

The analysis of variance (Table 2) showed significant variations in treatment means and their interactions for vegetative growth parameters, fruit characteristics, and antioxidant enzymes activities and proline content. Salinity adversely affected growth, yield, and biochemical parameters in all genotypes. Plant height decreased by up to 73.28%, plant spread by up to 72.11% (Figure 1) and root length by up to 74.09% (Figure 2). The root-to-shoot ratio declined significantly, and biomass reductions ranged from 36.49% to 82.57% across the genotypes under salinity stress (Figure 3). Salinity stress significantly affected fruit characteristics and yield across all genotypes (Figure 4-5). Fruit weight decreased by 21.9%-66.02% in SV5232-HY, 31.85%-63.97% in SV8233-HD, and 35.51%-70.14% in SV8883-HA. Fruit length reductions ranged from 37.04%-67.86% in SV5232-HY to 36.81%-66.31% in SV8883-HA. Yield was reduced by 14.25%-76.44% in SV5232-HY, 46.31%-75.6% in SV8233-HD, and 35.35%-69.17% in SV8883-HA (Figure 5). The least reduction in plant height at 6 dSm<sup>-1</sup> was observed with water (control), showing a decrease of 22.47% in SV5232-HY. At 10 dSm<sup>-1</sup>, the minimum reduction in plant height was achieved with ascorbic acid (2 mM), showing a decrease of 51.78% in SV8883-HA. At 6 dSm<sup>-1</sup>, the combined application of SA and AsA (2 mM each) increased root length by 15.56% in SV5232-HY but reduced it by 71.89% in SV8233-HD. At 10 dSm<sup>-1</sup>, the same treatment minimized root length reduction (51.39%) in SV5232-HY, while the maximum reduction (87.83%) occurred in SV8233-HD. At a salinity level of 6 dSm<sup>-1</sup>, the smallest reduction in plant spread was observed in SV5232-HY with 2 mM AsA, showing a 22.81% decrease, while the largest reduction (57.58%) was noted in SV8233-HD. At 10 dSm<sup>-1</sup>, the combination of 2 mM SA and 1 mM AsA minimized plant spread reduction in SV5232-HY by 52.42%, but the greatest reduction (85.63%) occurred with 2 mM SA alone. The root-to-shoot ratio increased by 154.84% with the combined application of SA and AsA at 6 dSm<sup>-1</sup> in SV5232-HY, whereas the largest reduction (55.65%) was seen in SV8233-HD at 10 dSm<sup>-1</sup>. Biomass exhibited a 7.65% increase with SA (1 mM) at 6 dSm<sup>-1</sup> in SV5232-HY, but reductions reached 96.34% with SA (2 mM) at 10 dSm<sup>-1</sup>.

Table 1. Description of treatments and levels used in three factor factorial experiment.

Genotypes		Salinity level				Foliar spray			
Cod e	Genotyp e	Cod e	EC	Code	Concentratio n	Code	Concentratio n	Code	Concentratio n
G <sub>1</sub>	SV8233-HD	S <sub>0</sub>	Contro l	Contro l	Water	AsA1	Ascorbic Acid (1 mM)	SA1AsA 2	Salicylic Acid (1 mM) + Ascorbic Acid (2 mM)
G <sub>2</sub>	SV5232-HY	S <sub>1</sub>	6 dSm <sup>-1</sup>	SA1	Salicylic Acid (1 mM)	AsA2	Ascorbic Acid (2 mM)	SA2AsA 1	Salicylic Acid (2 mM) + Ascorbic Acid (1 mM)
G <sub>3</sub>	SV8883-HA	S <sub>2</sub>	10 dSm <sup>-1</sup>	SA2	Salicylic Acid (2 mM)	SA1AsA 1	Salicylic Acid (1 mM) + Ascorbic Acid (1 mM)	SA2AsA 2	Salicylic Acid (2 mM) + Ascorbic Acid (2 mM)

Fruit weight saw a maximum increase (15.23%) with AsA (1 mM) at 6 dSm<sup>-1</sup> in SV5232-HY, while the greatest reduction (86.64%) occurred in SV8233-HD at 10 dSm<sup>-1</sup>. Fruit length and width showed no increases at 10 dSm<sup>-1</sup>, but minimal reductions were noted with SA (2 mM) at 6 dSm<sup>-1</sup>. The number of fruits per plant increased by 41.03% at 6 dSm<sup>-1</sup> with combined application of SA and AsA in SV5232-HY, while reductions peaked at 96.43% in SV8233-HD at 10 dSm<sup>-1</sup>. Yield increased by 97% with combined SA and AsA at 6 dSm<sup>-1</sup> in SV5232-HY but saw a maximum reduction of 96.85% in SV8233-HD at 10 dSm<sup>-1</sup>. Antioxidant enzyme activities revealed diverse responses under salinity stress in response to exogenous application of SA and AsA (Figure 6). Overall, salt stress reduced SOD activity significantly as compared

Table 2. Combined analysis of variance of various growth traits, yield components and biochemical parameters of hot pepper genotypes under different salinity levels and foliar sprays.

Source	DF	PH	RL	RSR	PS	BM	FW	FL	FD	F/P	Y/P	SOD	POD	CAT	Proline
R	2	10	9.1	0.001	15.2	1040	3.7	1.6	1.1	17.4	0.002	37.5	20.4	11.1	15.7
F	8	24**	84.5**	0.1**	311.7**	1500**	9.9**	1**	8.3**	187.4**	0.02**	8076.8**	99.4**	0.6	25.9**
G	2	1342.2**	0.8	0.2**	240.2**	14016**	291.9**	55.9**	424.5**	3227.4**	0.08**	4560**	13.5**	4.2	518.7**
S	2	20443.9**	5990.8**	0.1**	61460.2**	191817**	588.2**	496.1**	3003.5**	8417.9**	0.6**	3212.4**	180.9**	0.8	99.3**
F × G	16	106.8**	29.9**	0.03**	90.4**	1668**	7.6**	1.4**	8.9**	103.9**	0.01**	10699.3**	208.1**	1	56.9**
F × S	16	63**	44.9**	0.06**	172.4**	1418**	6.7**	0.7**	3.4**	45.2**	0.006**	5771.9**	178.5**	1.3	53.9**
G × S	4	344.5**	58.9**	0.12**	335.9**	3368**	18.2**	3.9**	31.4**	172.1**	0.03**	3739.9**	131.6**	1.3	73.4**
F × G × S	32	33.4**	55.4**	0.07**	131.2**	1500**	5.1**	0.8**	9.28**	122.7**	0.01**	7752.3**	178.6**	1.1	45.5**
Error	160	0.3	0.41	0.0005	0.4	6	0.02	0.01	0.01	0.4	5E-05	1.4	0.4	11.1	0.3

\* Significant at 5%, \*\* Significant at 1%, R: Replication, F: Foliar spray, G: Genotype, S: Salinity level, PH: Plant height (cm), RL: Root length (cm), RSR: Root shoot ratio, PS: Plant spread (cm), BM: Biomass(g), FW: Fruit weight (g), FL: Fruit length (cm), FD: Fruit diameter (mm), F/P: Number of fruits per plant, Y/P: Yield per plant (Kg), SOD: Superoxide dismutase (U/mg), POD: Peroxidase (U/mg), CAT: Catalase (U/mg), Proline ( $\mu$ moles/g)

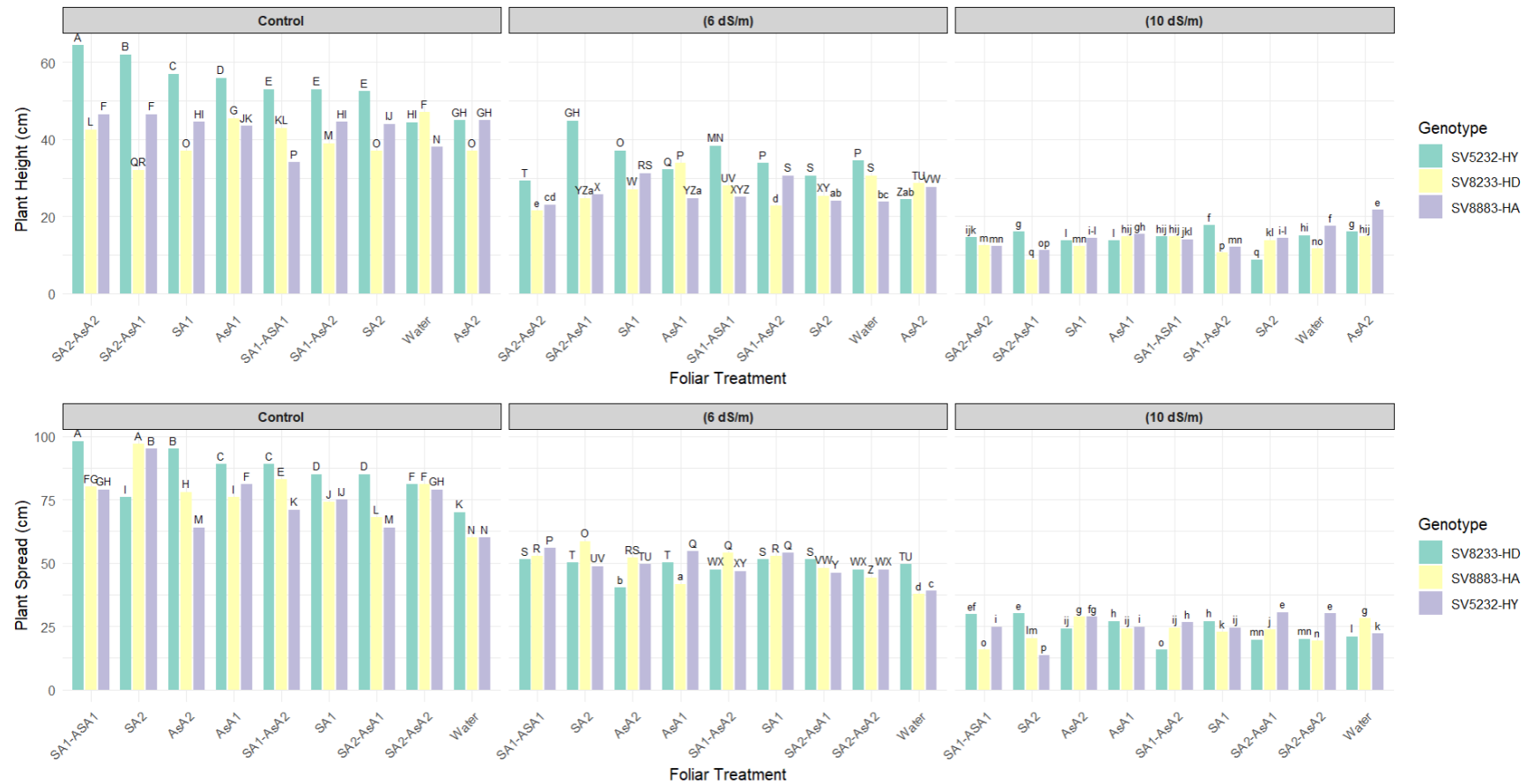


Figure 1. Response of hot pepper genotypes to foliar spray of Salicylic acid (SA) and Ascorbic acid (AsA) under salinity stress for plant height, and plant spread. SA1: Salicylic Acid 1mM solution, SA2: Salicylic Acid 2mM solution, AsA1: Ascorbic Acid 1mM solution, AsA2: Ascorbic Acid 2mM solution

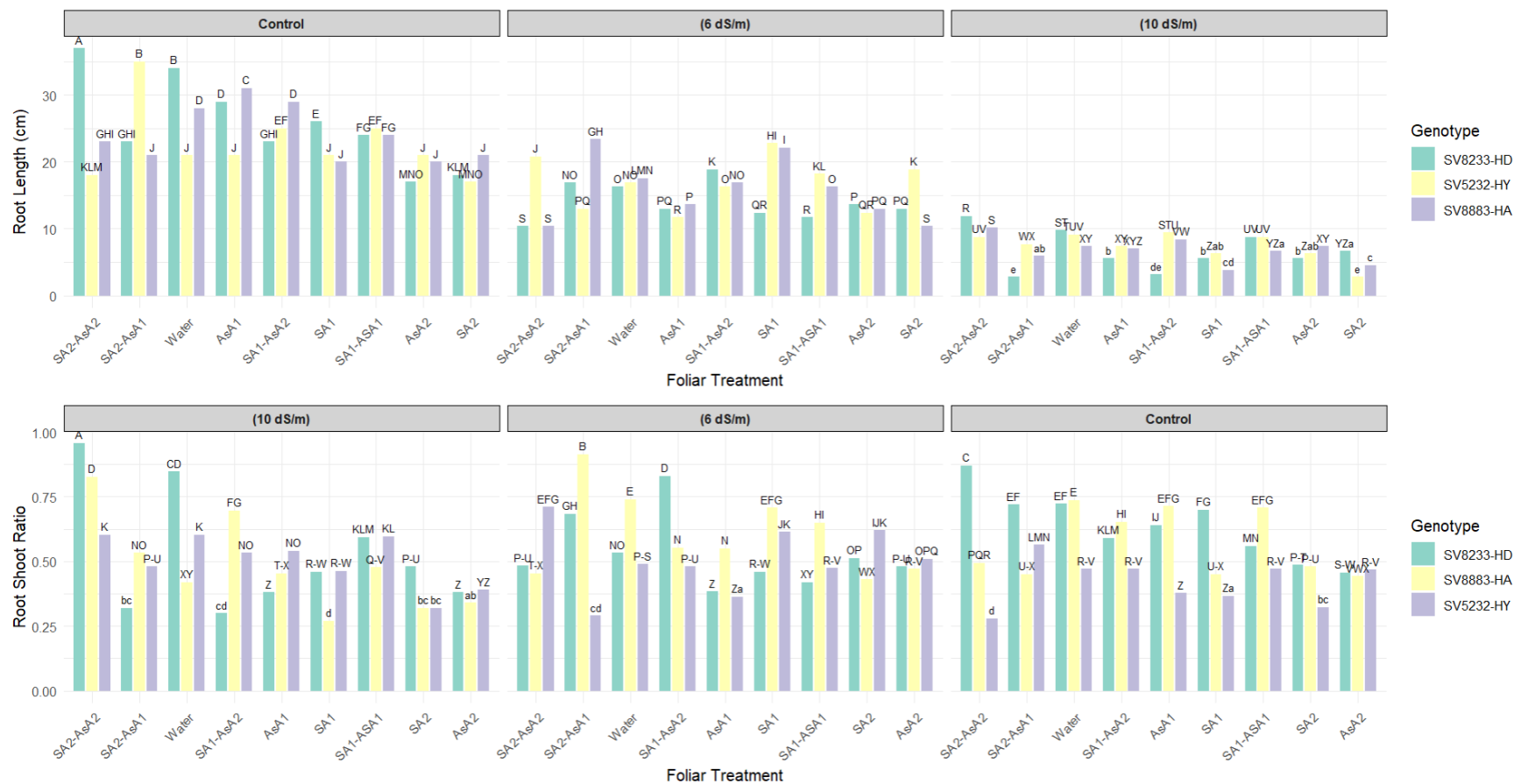


Figure 2. Response of hot pepper genotypes to foliar spray of Salicylic acid (SA) and Ascorbic acid (AsA) under salinity stress for root length and root shoot ratio. SA1: Salicylic Acid 1mM solution, SA2: Salicylic Acid 2mM solution, AsA1: Ascorbic Acid 1mM solution, AsA2: Ascorbic Acid 2mM solution.

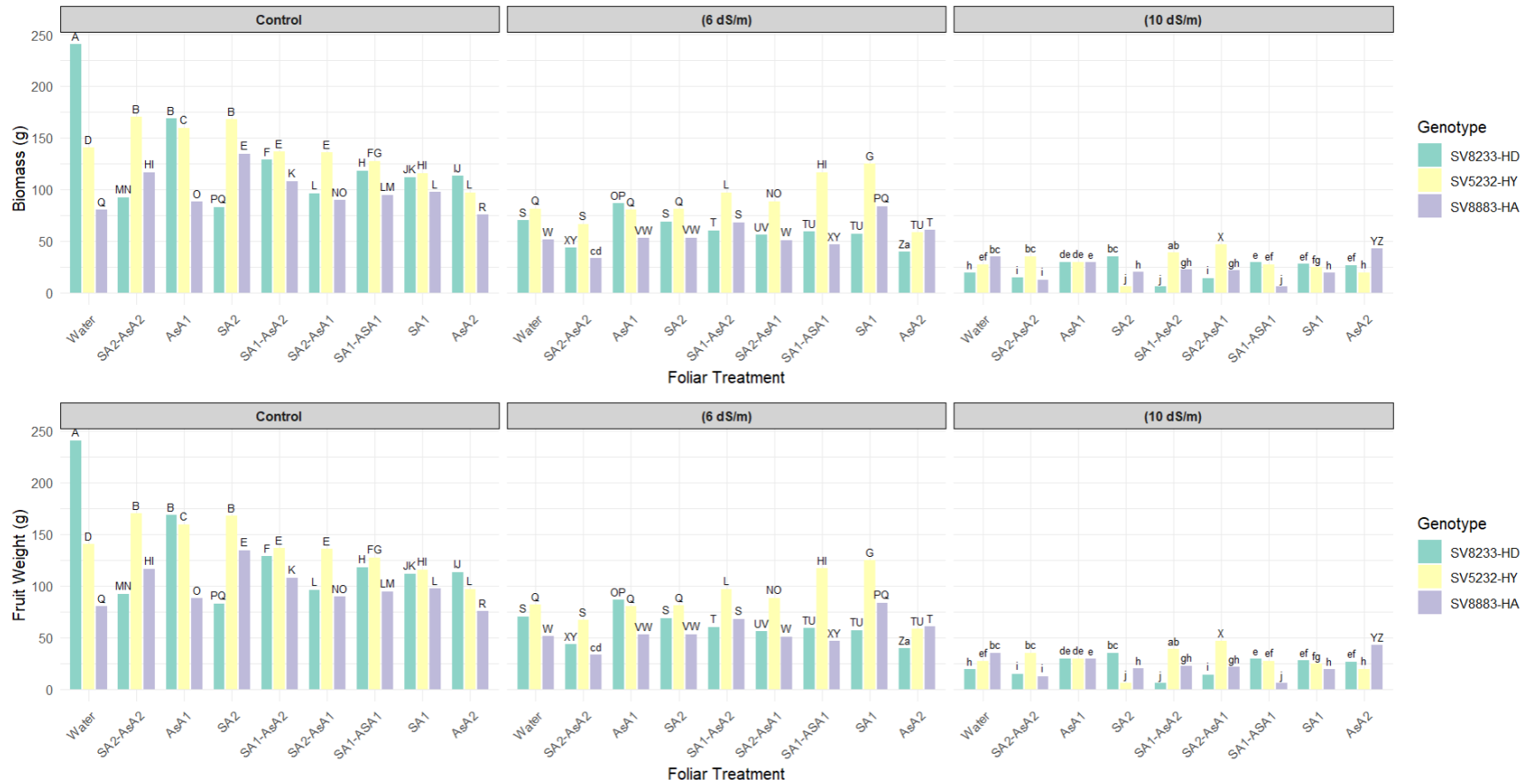


Figure 3. Response of hot pepper genotypes to foliar spray of Salicylic acid (SA) and Ascorbic acid (AsA) under salinity stress for fruit weight and plant biomass. SA1: Salicylic Acid 1mM solution, SA2: Salicylic Acid 2mM solution, AsA1: Ascorbic Acid 1mM solution, AsA2: Ascorbic Acid 2mM solution.

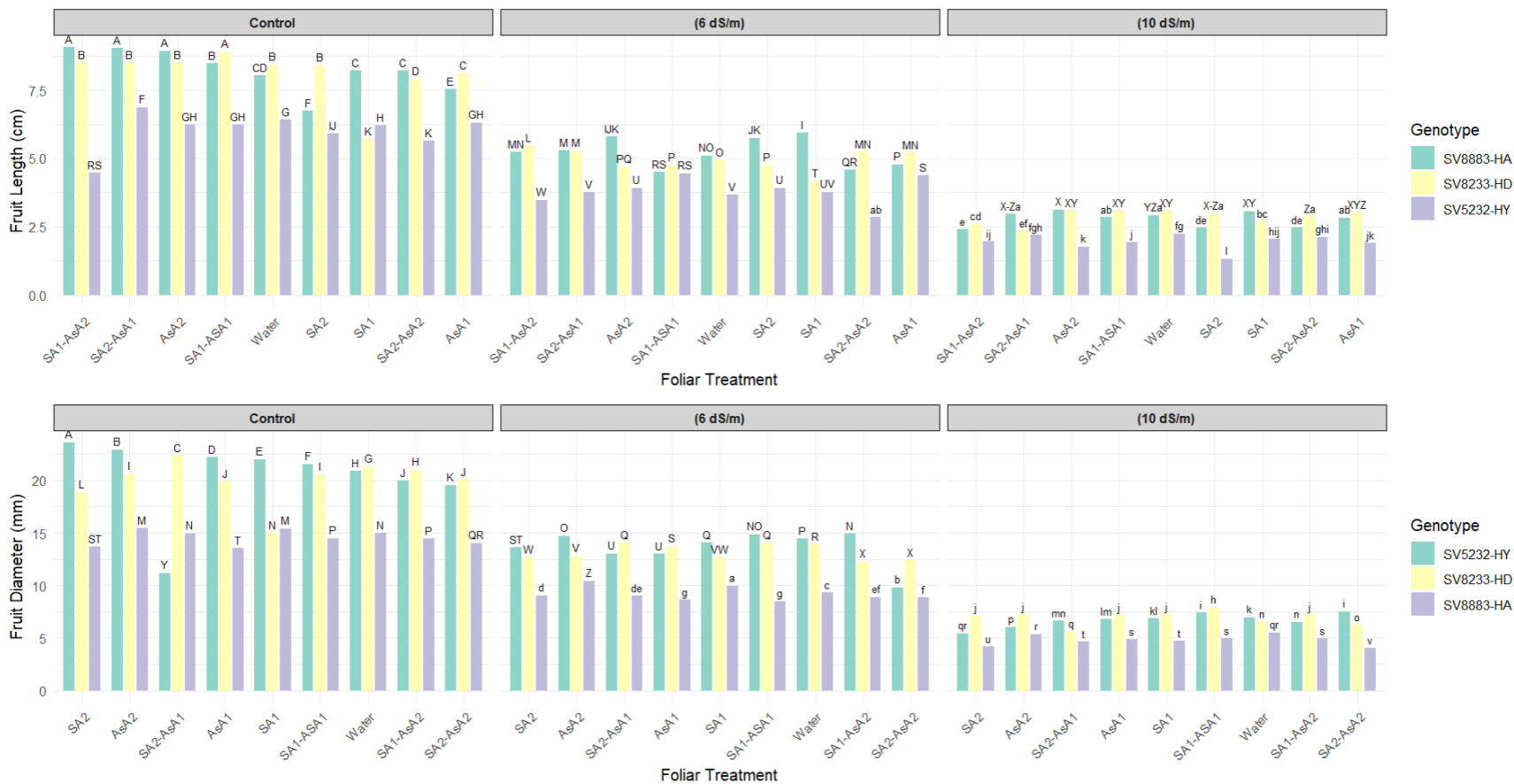


Figure 4. Response of hot pepper genotypes to foliar spray of Salicylic acid (SA) and Ascorbic acid (AsA) under salinity stress for fruit length and fruit diameter. SA1: Salicylic Acid 1mM solution, SA2: Salicylic Acid 2mM solution, AsA1: Ascorbic Acid 1mM solution, AsA2: Ascorbic Acid 2mM solution.

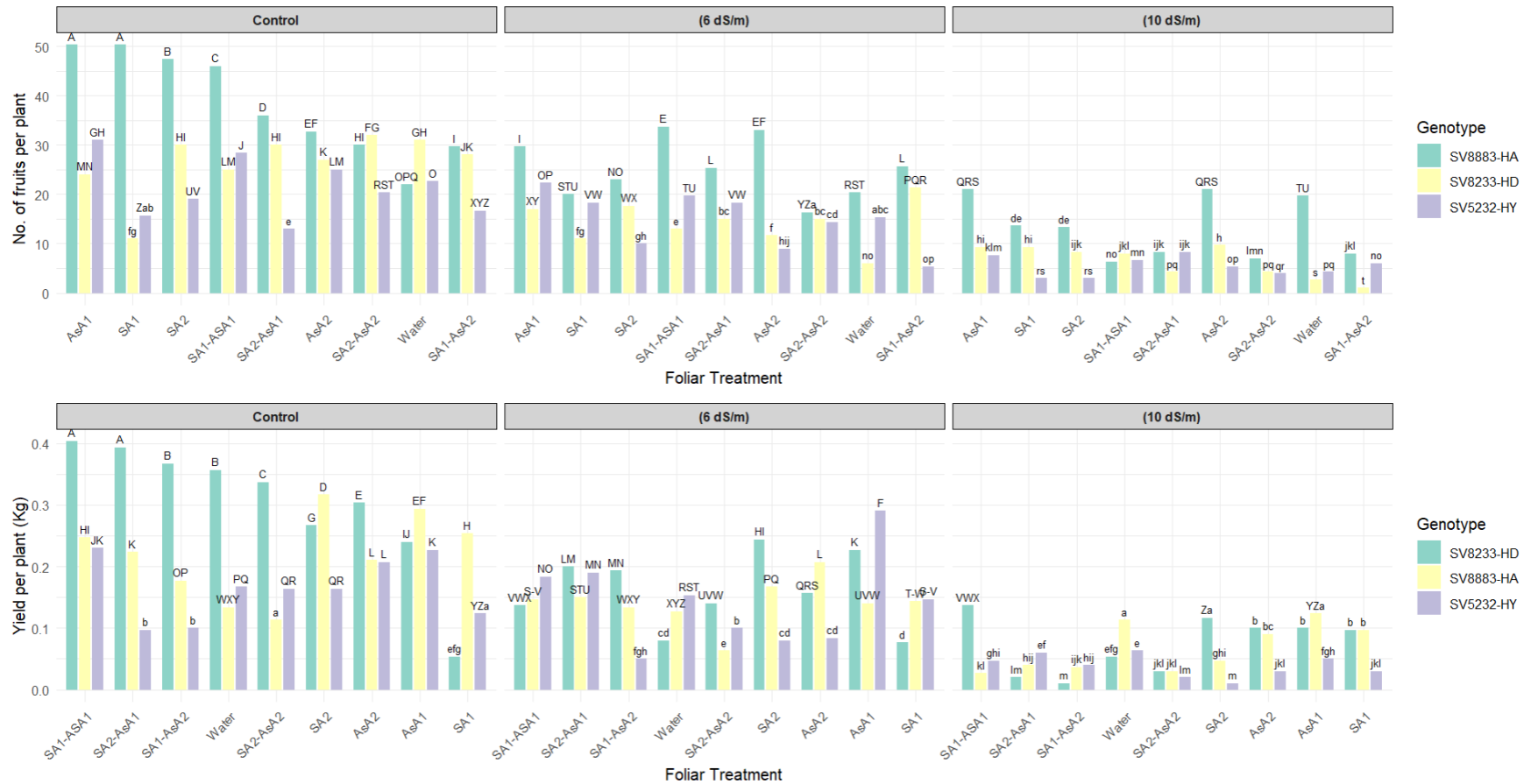


Figure 5. Response of hot pepper genotypes to foliar spray of Salicylic acid (SA) and Ascorbic acid (AsA) under salinity stress for number of fruits per plant and yield per plant. SA1: Salicylic Acid 1mM solution, SA2: Salicylic Acid 2mM solution, AsA1: Ascorbic Acid 1mM solution, AsA2: Ascorbic Acid 2mM solution.

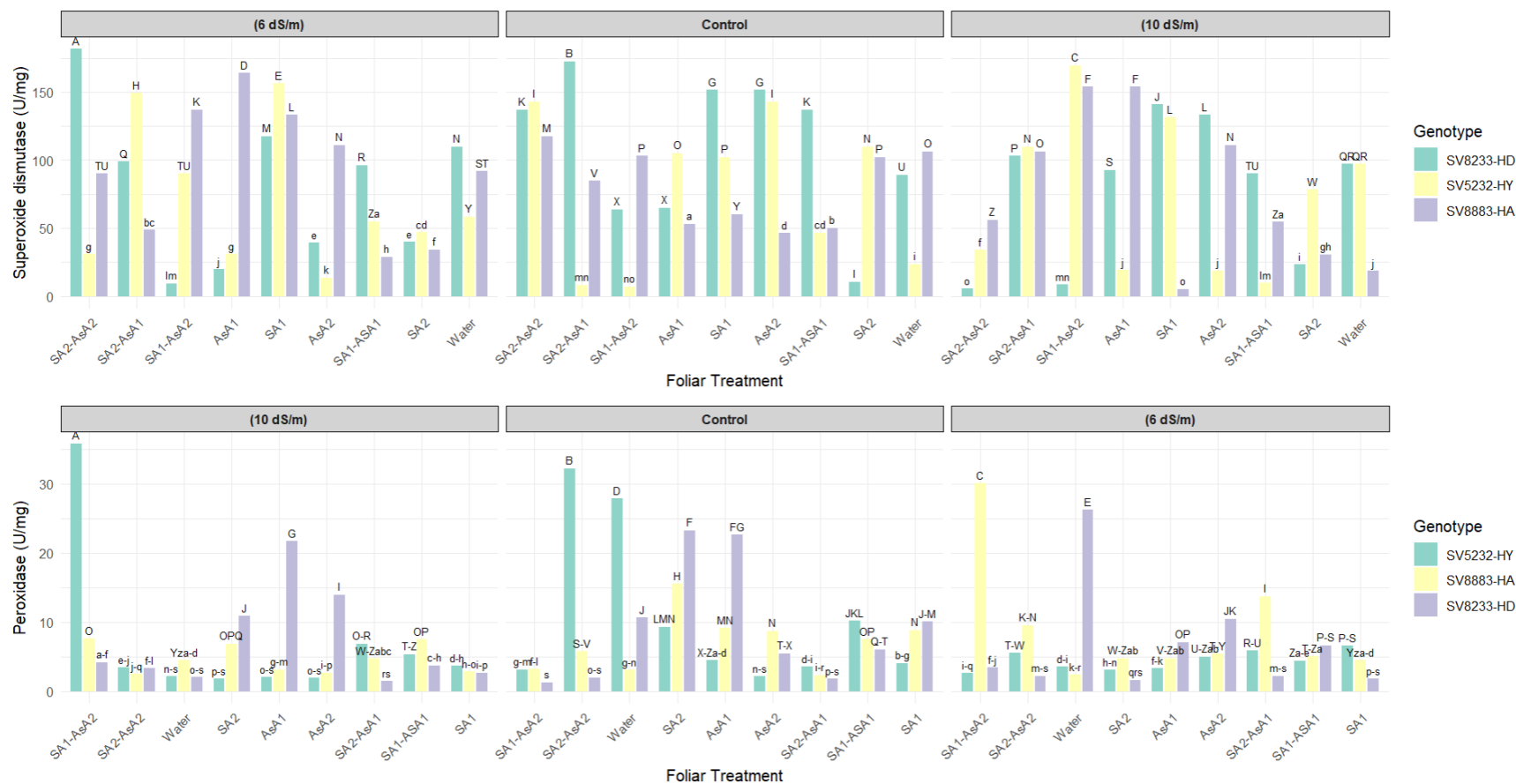


Figure 6. Response of hot pepper genotypes to foliar spray of Salicylic acid (SA) and Ascorbic acid (AsA) under salinity stress for superoxide dismutase and peroxidase activity. SA1: Salicylic Acid 1mM solution, SA2: Salicylic Acid 2mM solution, AsA1: Ascorbic Acid 1mM solution, AsA2: Ascorbic Acid 2mM solution.

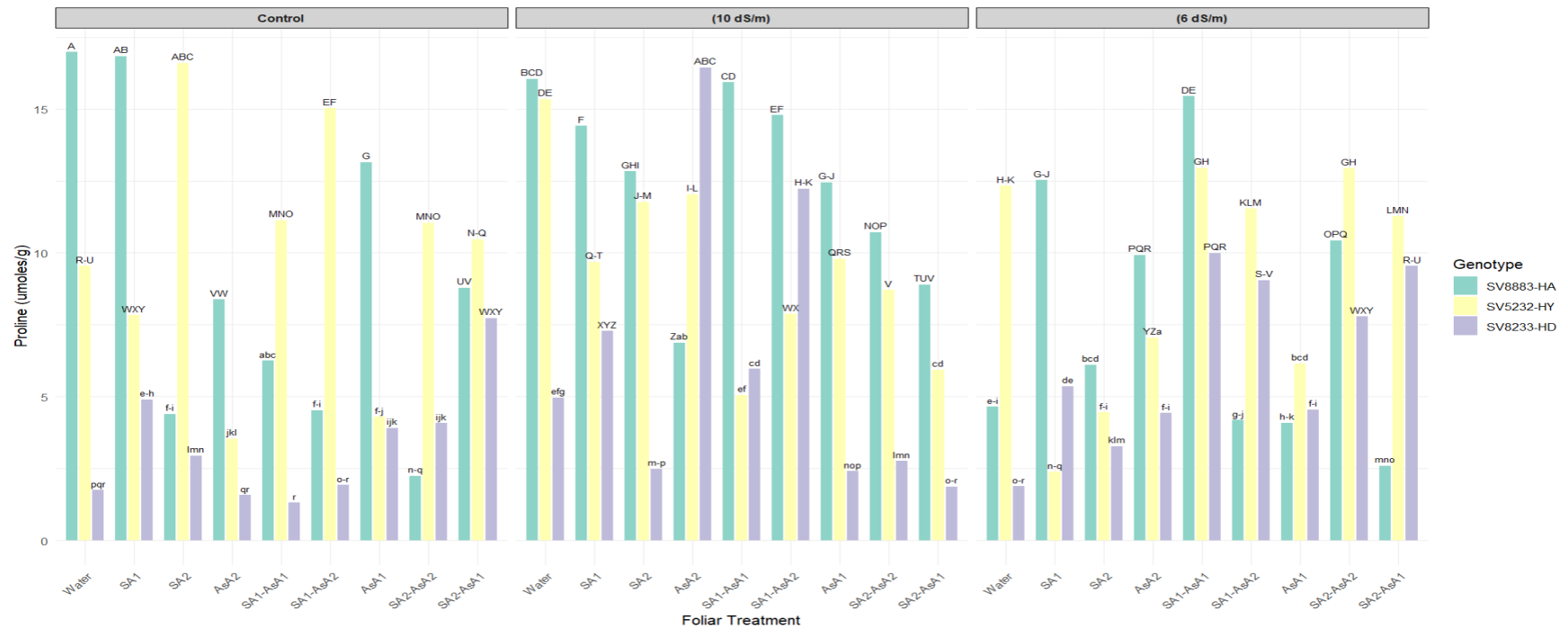


Figure 7. Response of hot pepper genotypes to foliar spray of Salicylic acid (SA) and Ascorbic acid (AsA) under salinity stress for proline. SA1: Salicylic Acid 1mM solution, SA2: Salicylic Acid 2mM solution, AsA1: Ascorbic Acid 1mM solution, AsA2: Ascorbic Acid 2mM solution.

to control. Genotype SV8233-HD exhibited maximum SOD activity at 6 dSm<sup>-1</sup> under combined application of SA and AsA at 2mM. Whereas maximum SOD activity at 10 dSm<sup>-1</sup> was exhibited by SV5232-HY under combined application of SA and AsA at 1 mM and 2 mM concentration respectively. Notably, SOD activity of SV8233-HD was statistically at par under no spray (control) to SA<sub>1</sub>-AsA<sub>2</sub> application. SV8883-HA showed peak SOD activity at 10 dSm<sup>-1</sup> salt stress under foliar spray of AsA (1 mM). On average, foliar application of AsA at 1 mM concentration showed maximum SOD activity. On average, POD activity was reduced significantly from 9.02 U/mg under control condition to 6.02 U/mg at 10 dSm<sup>-1</sup>. SV5232-HY exhibited maximum POD activity at 10 dSm<sup>-1</sup> under combined foliar spray of SA and AsA at 1 and 2 mM concentration respectively. Whereas, at 6 dSm<sup>-1</sup>, SV8883-HA had maximum POD activity under same foliar spray. CAT activity showed no significant change under any salinity stress level. Under control, SV8883-HA had maximum level of proline. Under 10 dSm<sup>-1</sup> salinity stress, SV8233-HD exhibited maximum proline contents under foliar spray of AsA (2mM). Likewise, at 6 dSm<sup>-1</sup>, SV8883-HA had maximum proline contents under combined foliar spray of SA and AsA at 1 mM concentration (Figure 7).

Salinity has become a serious issue in hot pepper growing regions (Bouras et al., 2024). Furthermore, recent trends in climate change are further worsening the salinity problem in cultivated lands (Khamidov et al., 2022). In present study, plant height decreased by up to 73.28%, while root length was reduced by as much as 74.09% under high salinity conditions (6 dSm<sup>-1</sup> and 10 dSm<sup>-1</sup>) as compared to control (Afifi et al., 2017; Baath et al., 2017). Detrimental effects of salt stress on growth parameters of hot pepper may be attributed to salinity induced drought stress and nutrients imbalance (Abdelkhalik et al., 2023; Lima et al., 2017). A healthy root system is necessary for proper nutrients and water uptake from soil especially under saline conditions (Ibrahim et al., 2016). In present study, root length was reduced significantly which directly affected plant growth and productivity. These results confirm that salinity is a serious challenge to hot pepper productivity, highlighting need for effective and sustainable approaches to mitigate its effects (Pascale et al., 2003).

The negative effect of salinity on vegetative growth of hot pepper genotypes also resulted in detrimental effects on fruit quality and yield parameters. For instance, fruit weight decreased by 66.02% in SV5232-HY at 10 dSm<sup>-1</sup> as compared to control. Similarly, fruit yield per plant was reduced by 76.44% at 10 dSm<sup>-1</sup>. Many other studies have also reported significant reductions in hot pepper fruit quality and yield due to salinity stress (Aragão et al., 2023; Qiu et al., 2017; Veloso et al., 2021). Hamed and Ahmed (2013) has stated that salt stress reduces chlorophyll contents in leaves and hence rate of photosynthesis. This effects CO<sub>2</sub> assimilation and food production in plant which ultimately affects fruit development and yield (Lima et al., 2017).

Under salinity stress, the superoxide dismutase (SOD) activity showed a decrease of 8.28% and 2.99% in the genotype SV5232-HY, and a more pronounced decrease of 27.14% and 28.98% in SV8233-HD at salinity levels of 6 dSm<sup>-1</sup> and 10 dSm<sup>-1</sup>, respectively. Conversely, in the genotype SV8883-HA, SOD activity increased by 15.93% at 6 dSm<sup>-1</sup> but then decreased by 4.59% at 10 dSm<sup>-1</sup> compared to control conditions. Similarly, peroxidase (POD) activities decreased by 59.07% and 35.16% in SV5232-HY and by 26.07% and 23.3% in SV8233-HD under the same salinity levels (Aslam, 2018; Gupta & Mandal, 2022; Singh et al., 2012).

Proline content was notably increased in SV8233-HD, with increases of 85.24% and 87.05% at 6 dSm<sup>-1</sup> and 10 dSm<sup>-1</sup>, indicating a strong osmotic adjustment mechanism in this genotype (Khalid et al., 2022; Sadak, 2019). However, SV5232-HY exhibited a decrease in proline content by 9.38% and 3.65% at same salinity levels. Genotypes differ in their ability to withstand oxidative damage under salinity stress due to difference in production of antioxidant enzymes and proline (Alsamadany et al., 2024). Proline help plant to maintain its cellular structures and also play role in redox homeostasis (Zheng et al., 2015). Elevated levels of proline in response to abiotic stress is an important physiological mechanism which tolerant genotypes employ to withstand environmental stresses (López-Serrano et al., 2021).

Exogenous application of SA and AsA increases vegetative growth of different crops under salinity stress (El-Beltagi et al., 2022; Ilyas et al., 2024; Kanwal et al., 2024). Specifically, the combined application of SA and AsA resulted in 97% increase in yield at 6 dSm<sup>-1</sup> salinity stress in genotype SV5232-HY. Additionally, fruit parameters also showed positive responses; for instance, fruit weight improved by 15.23% under the same salinity conditions with the application of AsA at 1 mM.

The application of SA and AsA resulted in 44% increase in activity of SOD under salt stress. Specifically, the cultivar SV8233-HD exhibited a 66% increase in SOD activity at 6 dSm<sup>-1</sup>, while SV5232-HY showed a 75% increase in SOD activity at 10 dSm<sup>-1</sup> under the combined application of SA and AsA. Loutfy et al. (2020) has reported a 31-35% increase in SOD activity in maize seedlings through SA and AsA treatment under drought stress. Similarly, peroxidase (POD) activity showed a notable increase of 11% in response to the foliar application of SA and AsA. Abedini and Hassani

(2015) has reported a 38-68% increase in POD activity in wheat through SA treatment. These compounds enable plant to withstand salt stress by regulating physiological processes, enhancing enzymatic antioxidants activity, and facilitating osmotic homeostasis. (Ahmad et al., 2017; Chan et al., 2008; Loutfy et al., 2020). Research has shown that SA can activate stress tolerance genes (Kang et al., 2012; Rao et al., 2019). Likewise, AsA is essential for maintaining redox balance and eliminating ROS, which are critical for plant survival under stressful conditions. (Chen et al., 2024; Jung et al., 2020).

The differences in response of hot pepper genotypes to varying levels of salinity stress highlight the importance of selecting tolerant genotypes for cultivation in saline areas (López-Serrano et al., 2021). Other researchers have also reported that genetic variability exists among pepper genotypes for salinity tolerance in terms of growth, yield and biochemical adaptation (Niu et al., 2012; Zamljen et al., 2022). Breeding programs should focus on screening and selection of those genotypes which exhibit elevated activity of antioxidant enzymes under stress conditions (Erken & Çolak Levent, 2023).

## CONCLUSION

Hot pepper growth parameters and fruit traits were significantly reduced with 76.44% reduction in yield under salinity. Moreover, genotypes varied in their response of antioxidants production and osmo-protectants accumulation under salinity. The combined application of SA and AsA (2 mM each) was found to be highly effective in mitigating the adverse effects of salinity on growth and yield of pepper plants. This is achieved by elevated enzymatic activity of antioxidants, as well as increasing proline accumulation. Genotype SV5232-HY performed better under salt stress among tested genotypes and exhibited least reduction in growth and yield parameters with enhanced antioxidant enzymes activities.

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