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EFFECT OF SALICYLIC ACID PRETREATMENT ON SEEDLING GROWTH AND ANTİOXIDANT ENZYME ACTIVITIES OF SUNFLOWER (*Helianthus annuus* L.) AND LINSEED (*Linum usitatissimum* L.) PLANTS IN SALINITY CONDITIONS

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ABSTRACT

Salinity has become a problem all over the world in agricultural areas. Plants develop a defense mechanism to increase various antioxidant enzyme activities to resist salt stress. In addition, the effects of stress are tried to be reduced with various applications. One of these applications is the application of salicylic acid (SA). However, the effects of SA application vary depending on the plant species and cultivar. In this study, the seeds of sunflower and linseed plants were primed for 4 hours with different concentrations of SA doses 0 (control) (SA1), 0.25 mM (SA2), 0.50 mM (SA3), 1.00 mM (SA4) priming. In the laboratory, the seeds were permitted to develop in petri dishes with different salt 0 (control) (S1), 50 mM (S2), 100 mM (S3), 150m M(S4) concentrations for 14 days. As a result of the study, it was determined that SA had a positive effect on both morphological and chemical properties in both plant species grown under salt stress.

Keywords: salt stress, sunflower, linseed, antioxidant enzymes, chlorophyll.

INTRODUCTION

Salinity is one of the important environmental stress factors that cause great damage to plant production and biodiversity (Yamaguchi and Blumwald, 2005; Jafari and Garmdareh, 2019; Jamalian et al., 2019). In addition, salinity is one of the most important factors causing a decrease in crop production in agricultural areas (Forghani et al., 2018; Razzaq et al., 2020). Salt stress affects plants in two ways. The first one causes the water in the soil to decrease by osmotic stress. In this way, the water intake of the plant is restricted. The second is reported to cause excessive ion uptake, especially the increase of Na^+ and Cl^- ions (Abogadallah, 2010). In parallel, salt soil conditions also negatively affect the growth of plants, this is because the high concentration of salt decreases water absorption, leading to ion imbalance and toxicity in the plant (Roussos et al., 2013).

Seed germination and seedling development are very important and critical stages in terms of crop production (Almansouri et al., 2001). However, when plants are exposed to adverse environmental conditions such as salinity during these initial development periods, seedling development is prevented (Albuquerque and Carvalho, 2003). Generally, plants are very sensitive to salinity during germination and seedling (Jafari and Garmdareh, 2019). In plants, salt tolerance can be increased with some environmental applications as well as genetic mechanisms (Razzaq et al., 2020).

Salicylic acid (SA) is an endogenic plant hormone that plays an antioxidant role in reducing the various effects of biotic and abiotic stresses on plants (Rehman et al., 2019) as well as promoting plant growth and development, ripening and flowering (Miura and Tada, 2014). It is reported by researchers that SA plays an important role in the defense mechanism against various pathogen infections in plants (Salarizdah et al., 2012). Idrees et al. (2010) reported that SA's effects on species have an important role in inducing abiotic stress in each plant, but large differences between cultivars were reported.

Sunflower (*Helianthus annuus* L.) is one of the most widely grown oilseed plants in

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the world (Monazzah et al., 2017). The seeds of the sunflower plant contain high levels of fat (40-47%) and protein (Saleem et al., 2003). Sunflower oil is a good quality vegetable oil due to its high level of unsaturated and low levels of saturated fatty acids (Gürsoy, 2019; Rehman et al., 2019). Linseed (*Linum usitatissimum* L.) is a plant that has been grown for thousands of years for both oil and fiber (Zhang et al., 2020). In addition to its quality fiber, linseed oil is also a very valuable oil. Linseed seed is rich in omega-3 fatty acids (Gogus and Smith, 2010).

SA is reported to be a synthetic plant growth regulator (Khan et al., 2018). Triggering multiple stress tolerance has an important role in agriculture, gardening and forest areas due to external application of SA and its derivatives (Senaratna et al., 2000). Researchers have reported that SA's foliar application in wheat increases salt and water stress in plants and increases seedling development and improves growth processes (Sakhabutdinova et al., 2003). It has been reported that antioxidant potential is stimulated due to the increase in peroxidase activity in the leaves of SA sunflower (Noreen and Ashraf, 2008). It has been determined that the application of SA as spraying under salt stress in canola plants plays an effective role as a potential plant growth regulator (Hussein et al., 2015).

In this study, sunflower and linseed seeds were primed with different doses of SA and they were grown in salty environment and the effects of SA in two different varieties were investigated.

MATERIAL AND METHODS

Plant material and growth conditions

Sunflower seeds (Sanbro MR) was provided by Ankara University Faculty of Agriculture/ Ankara/ Turkey and the linseed seeds (local population) from Zeytinburnu Medicinal Plant Garden Zeytinburnu/ Istanbul/ Turkey. The research was carried out at the Aksaray University Scientific and Technological Research Laboratory (ASÜBTAM). Seeds of both cultivars were kept in 5% sodium hypochlorite solution for 5 minutes for surface sterilization. Then washed with pure water and subjected to 4 hours priming with different concentrations of SA [0 (control) (SA1)], 0.25 mM (SA2), 0.50 mM (SA3), 1.00 mM (SA4). For each SA dose, 50 seeds were placed in sterile petri dishes on Whatman No: 1 blotting papers. For each dose of SA 10 mL of solutions at different concentrations [0 (control) (S1)], 50 mM (S2), 100mM (S3), 150 mM (S4) were added. Only water was added to the control petri dishes. In order to prevent evaporation, the petri dishes are wrapped with parafilm. The same procedures were carried out for both varieties. The petri dishes were left to germinate at 24±1°C. The research randomized plots experimental design was made with 3 replications according to the trial pattern. Measurements and observations were made on the 14^{th} day after treatments.

Germination percentage (%)

Germination percentage was calculated using the formula below (Siddiqi et al., 2007).

Germination % = (number of germinated seeds / total number of seeds) × 100

Chlorophyll (mg/g)

The young leaf samples (0.25 g) from each cultivar were filtered after homogenizing in 80% acetone and the extracts were filtered with 25 ml with acetone. These samples were read at 663 nm and 645 nm wavelength (Beckman-Coulter DU 730 Life Sciences UV/VIS Spectrophotometer) followed by calculation of chlorophyll using the formula given below (Lichtenthaler and Wellburn, 1983; Kabay and Şensoy, 2016; Amira and Qados, 2011). Before each reading, the device was reset using blind reading.

Chlorophyll a (mg/g) = (12.7 * 663 nm) - (2.69 * 645 nm) * V / W * 10000

Chlorophyll b (mg/g) = (22.91 * 645 nm) - (4.68 * 663 nm) * V / W * 10000

Total Chlorophyll = Chlorophyll a + Chlorophyll b

Carotenoid (mg/g)

The carotenoid amount was determined according to the Jaspars formula by reading the extract used in determining the chlorophyll amount at 450 nm wavelength (Beckman-Coulter DU 730 Life Sciences UV / VIS Spectrophotometer) (Turfan, 2017).

Carotenoid mg/g = (4.07 × A450) - (0.0435 × Chlorophyll a + 0.367 × Chlorophyll b)

β-Carotene

100 mg sample was homogenized for 1 minute in a mixture of 10 ml acetone-hexane (4:6) and filtered. The absorbance of the filtrate at 453, 505 and 663 nm was recorded. It is preferred in the calculation of β-carotene amount (Nagata and Yamashita, 1992).

mg β-Carotene/100 ml = 0.216 x A663 - 1.22 x A645 - 0.304 x A505 + 0.452 x A453

Lycopene

100 mg sample was homogenized for 1 minute in a mixture of 10 ml acetone-hexane (4:6) and filtered. The absorbance at 453, 505 and 663 nm was recorded in the filtered extract. The following formula was used to determine the amount of lycopene (Nagata and Yamashita, 1992).

mg Lycopene/100 ml = -0.0458 x A663 + 0.204 x A645 + 0.372 x A505 - 0.0806 x A453

Statistical analysis

The experimental data obtained at the end of the research, was subjected to analysis of variance using MSTAT-C computer software. Duncan test was applied to determine the significance levels of the differences between means of applications.

RESULTS AND DISCUSSION

It has been determined that the interaction of Salt doses × SA doses is significant at the level of 1% in terms of all the characteristics examined in sunflower. In linseed, on the other hand, significant results were obtained at the level of 1% in all parameters examined, except for root wet weight and lycopene properties. No statistical difference could be determined in root wet weight, and significant results were obtained at the level of 1% between SA doses in lycopene property.

Morphological characteristics

In terms of seedling length feature, the longest seedling length (10.78 cm) in sunflower was determined in S3 application and in the 3rd dose (SA3) of SA (Table 1). However, the shortest seedling length was obtained from S4 application. In parallel with the increase in salt doses, the length of sunflower seedlings shortened. In SA doses, the longest seedling length was obtained from SA3 dose. It is observed that SA increases the length of the seedling by inhibiting the effects of salt stress with increasing salt doses. This effect appears to occur especially in S3 and S4 doses. The seedling length, which was 9.67 cm at the S2 dose, was 10.78 cm at S3. Similarly, the seedling length of 6.00 cm in SA1, which is the control dose of SA in S4, was determined as 10.18 cm in SA3. It was determined that SA applications had a positive effect on seedling length. The interaction of salt doses × SA doses in sunflower has made a statistically significant difference at the level of 0.01. In linseed (Table 2), salt doses × SA doses interaction were found statistically significant at the level of 0.01. The third dose of salicylic acid in S3, which is the 3rd dose of salt, that is, the longer seedling length in SA3 than S2. Similarly, in S2 salt application in SA2, longer seedlings were determined than S1 and S2. However, the longest seedling length in linseed was detected in control. SA had different effects on both types depending on the salt doses. The longest seedling in sunflower was obtained from S3 and SA3 application, while linseed was obtained from S1 and SA1 application. In this study, the effect of SA was different in both plant species. When the Table 1 and Table 2 were examined in both plant varieties in terms of root length, a statistically significant difference was found at the level of 0.01 in

terms of salt doses × SA doses interaction. The longest root length (4.26 cm) in sunflower was obtained from S2 salt dose and SA2 salicylic acid application. It is seen that SA shows different effects in increasing salt doses. The root length, which was gradually shortened at S2 and S3 at SA3, has been extended at S4 to 3.95 cm. In linseed, the longest root length was determined in S1 and SA3 applications. There is 1.19 cm difference between the longest seedling length and the shortest seedling length, the longest root was obtained in S1 SA3 application and the shortest was obtained from S4 SA1 application. SA applications had a positive effect on root length. When the average results of sunflower are examined in terms of seedling wet weight feature, the maximum seedling wet weight was determined as 0.91 g in S3 SA3 application. The minimum seedling wet weight was determined at the doses of S1 SA1 (Table 1). In linseed, the most seedling wet weight was determined at S2 SA2 and S2 SA3 doses, and the minimum seedling wet weight was determined in S1 SA1 application and S4 SA4 applications (Table 2). The effect of salt and SA doses was different in terms of seedling wet weights of two different plant species. Seedlings of SA3 in sunflower seeds had the highest seedling wet weight, and SA1 and SA4 were included in the same statistical group. In linseed, the highest wet weight was obtained from SA2 and a statistical difference was determined among all SA doses. In terms of root wet weight, there was a statistically significant difference at 0.01 level in terms of the interaction of salt doses × SA doses in sunflower, and this interaction could not be determined in linseed. In terms of averages, the maximum root wet weight in sunflower is 0.41 g realized as. The minimum root wet weight is 0.25 g S3 SA3 and S4 were determined at SA3 doses, S3 and S4 salt doses were ineffective in terms of root wet weight. In linseed, the application of SA4 at the dose of S3 caused the most root wet weight to appear. The lowest root wet weight was determined in S1 SA1. The two different plant species used in the study were affected at different levels by salt and salicylic acid applications in terms of root wet weight. The S3 dose was effective in determining the root wet weight in one species and the least in the other. In terms of germination rate, there was a statistically significant difference at 0.05 level in terms of salt doses × SA doses interaction. 100% germination rate of sunflower has been determined in S1, SA2 and SA3. The germination rate decreased as the salt doses increased. In linseed, the most germination was determined in S1 SA1 application and it was determined that germination also increased in SA3 and SA4 despite the increase in salt doses.

Biochemical characteristics

In terms of total chlorophyll content, the maximum chlorophyll content in sunflower is 4.51 mg/g in S1 and in SA1 and the least chlorophyll is 2.47 mg/g was realized in S4 and SA4. It is expected that the chlorophyll content will decrease with increasing salt doses. However, despite the increase of salt in salt doses of S1 and S2, chlorophyll content has been increased, and even in S4 dose in SA4, chlorophyll is higher than S1. The same is also true in linseed, although the total chlorophyll S1 was determined in SA1, but decreased gradually with the increase in chlorophyll salt doses in the control dose of SA. However, even if the salt doses increased in SA3, the amount of chlorophyll increased. In SA4, chlorophyll content higher than S1 was detected at S2 and S3 doses. In terms of carotenoid content, the lowest carotenoid S1 was detected in SA1. The highest was determined in S2 SA3, and when Table 1 was examined, it was determined that the amount of carotenoid increased as the salt stress increased. The lowest carotenoid S1 and SA1 application in linseed was determined. Of the SA doses, the SA2 dose was more effective in increasing the carotenoid due to increased stress doses in linseed. The most ß-carotene content in terms of ß-carotene is 0.80 mg/g it was determined in S4 SA3 application. If it is the lowest, 0.32 mg/g. It was determined in S1 and SA1 applications. With the increase of salt stress, the amount of ß-carotene increased in sunflower and was realized as a

result of the antioxidant defense system. In linseed, similar to sunflower, the highest ß-carotene was detected in S4 and SA3 application, while the lowest was found in S1 and SA1 application. The amount of ß-carotene increased as the dose of stress increased in both species. In terms of lycopene content, there was a statistical difference of 0.01 in terms of salt doses × SA doses interaction in sunflower, which is not the case in linseed. There was a significant difference between 0.01 and SA doses only in linseed. The lowest lycopene sunflower was determined as 0.40 mg/100 ml in S1 SA1 and in linseed, S1 in SA2. Different plant species were affected at different levels from salt doses and SA doses in terms of lycopene. Lycopene increased as the dose of stress increased in sunflower. However, this increase in linseed was only in SA3 application.

Morphological characteristics

In this study, in which different doses of salicylic acid and salt are applied to the seeds of sunflower and linseed plants, there is a decrease in some morphological features due to salt doses, and it has been identified a increase in seedling length, root length, root wet weight, seedling wet weight, germination rate with SA application. The findings obtained in this study are consistent with the findings of a study (Sakhabutdinova et al., 2003) reporting that the application of SA from the leaf against salt and water stress in wheat increased the development of seedling development and growth parameters. Arfan et al. (2007) reported that SA is an effective growth regulator in plants' resistance to various abiotic stresses. Duggoi et al. (2012) applied 2 doses of SA (35 and 70 mg) to (*Brassica juncea* L.) of Indian mustard by spraying. As a result of the study, they determined a significant increase in plant characteristics such as plant height, number of branch branches and leaf area. In addition, they reported that in the application of 70 mg/l, there were increases in all parameters of the plant compared to 35 mg/l dose. Miura and Tada (2014) reported that SA is known as a regulator of physiological processes in plants, for example, growth, development, photosynthesis, root development and germination. Similarly, Hasanah and Sembiring (2018) applied chitosan and salicylic acid from leaves to soybean varieties. As a result of the study, they reported that chitosan application increased plant height, seedling, and root dry weight. Khan et al. (2018) reported that SA and plant growth promoting rhizobacteria (PGPR) applications have positive stimulating effects on increasing root and seedling development, as well as increasing root biomass and increasing root length and root weight and desired seedling development with strong root system. Rehman et al. (2019) reported that applying 10 mM SA from leaf under saline conditions to plant height, diameter of the stem and chlorophyll content. Chavoushi et al. (2020) applied SA to safflower plant under drought stress. As a result of the study, they reported that the seedling length was increased compared to the SA applications compared to the control.

Biochemical characteristics

Our results evidentiated, increases in biochemical parameters because of the defense system of the plants used in the study increase under salt stress. Salt stress affects chlorophyll metabolism and causes a significant decrease in chlorophyll production (Qin et al., 2019). However, it is reported by SA that it contributes to the increase of pigments and the development of photosynthesis processes by stimulating some enzymes (Khodary, 2004). In this study, it is seen that SA has a positive effect and especially SA3 dose is more effective in this increase. Stahl and Sies (2003) reported that carotenoids are pigments that play a very important role in the protection of plants against photooxidative processes in plants and are antioxidants that play an extremely active role in eliminating the harmful effects of free oxygen radicals.

In plants under stress, the amount of photosynthetic pigment consisting of

chlorophyll a, chlorophyll b, total chlorophyll and carotenoid varies depending on factors such as species, type of stress, duration of stress, the period of the plant in the life cycle, and the intensity of stress (Turfan, 2017). Abd El-Rheem et al. (2018) applied ascorbic acid to sunflower under saline soil conditions. As a result of the study, they reported that the applications caused increases in chlorophyll and carotenoid content. He et al. (2020) applied $CaCl_2$ and NaCl to the corn plant. As a result of the study, they reported that the combination of both applications played an effective role in the increase of carotenoids. ß-carotene is an organic red-orange colored pigment that is abundant in plants (Pop et al., 2019). Sadi et al. (2017) in their study to determine the biochemical characterization of 4 (Avangard, Bony Doon, Linda and Linton) linseed varieties (phenolics, flavonoids, β-carotene, lycopene, DPPH radical capture activity, MDA, proline, SOD, CAT, APx, and GR) reported that they determined to be high. Linić et al. (2019) suggested that carotenoids, which are specific metabolites, can play a positive role as natural ingredients in stress management in tolerant species. Gürsoy (2020) applied chitosan under salt stress in safflower cultivars. As a result of the study, chitosan application increased carotenoid content compared to salt application.

Table 1. Average values of the effect of SA doses applied to sunflower on saline conditions on morphological and biochemical characteristics

SA doses	**Salt doses**				**Mean**
	Seedling Lenght (cm)				
	S1	S2	S3	S4	
SA1	9.31 cd	6.85 ef	6.98ef	6.00 f	**7.29 C**
SA2	10.47 ab	9.81 abc	8.66 d	6.74 ef	**8.92 B**
SA3	9.74 bc	9.67 bc	10.78 a	10.18 abc	**10.09 A**
SA4	7.22 e	6.48 ef	6.01 f	4.67 g	**6.10 D**
Mean	**9.18 A**	**8.20 B**	**8.11 B**	**6.90 C**	
LSD%1	0.9354				
	Root Lenght (cm)				
SA1	3.61 abc	3.13 bc	3.15 bc	2.87 cd	**3.19 A**
SA2	4.17 a	4.26 a	3.21 bc	2.71 cd	**3.59 A**
SA3	3.58 abc	2.96 cd	2.72 cd	3.95 ab	**3.30 A**
SA4	3.11 bc	2.89 cd	2.18 de	1.72 e	**2.48 B**
Mean	**3.62 A**	**3.31 A**	**2.82 B**	**2.81 B**	
LSD%1	0.8246				
	Seedling Wet Weight (g)				
SA1	0.58 g	0.83 abc	0.70def	0.59fg	**0.68 C**
SA2	0.74 cde	0.85 abc	0.79 bcd	0.70 def	**0.77 B**
SA3	0.81 abc	0.74 cde	0.91 a	0.89 ab	**0.84 A**
SA4	0.74 cde	0.66 efg	0.64 efg	0.65 efg	**0.67 C**
Mean	**0.72 B**	**0.77 A**	**0.76 A**	**0.71 B**	
LSD%1	0.1000				
	Root Wet Weight (g)				
SA1	0.29 bcd	0.31 bcd	0.41 a	0.33 bcd	**0.33 A**
SA2	0.35 ab	0.34 abc	0.32 bcd	0.34 abc	**0.34 A**
SA3	0.32 bcd	0.35 ab	0.25 d	0.25 d	**0.29 B**
SA4	0.26 cd	0.31 bcd	0.30 bcd	0.33 bcd	**0.30 AB**
Mean	**0.30**	**0.33**	**0.32**	**0.31**	
LSD%1	0.07071				
	Germination rate (%)				
SA1	99.90 a	98.83 abc	96.77 ef	97.47 de	**98.24 AB**
SA2	100.00 a	99.40 ab	98.27 bcd	96.27 fg	**98.48 AB**
SA3	100.00 a	99.20 ab	98.40 bcd	97.87 cde	**98.87 A**
SA4	99.47 ab	98.77 abc	97.80 cde	95.47 g	**97.88 B**
Mean	**99.84 A**	**99.05 B**	**97.81 C**	**96.77 D**	
LSD%1	1.070				

	Total chlorophyll (mg/g)				
SA1	4.51 a	3.96 ab	3.35 cd	3.17 cdef	**3.75 A**
SA2	2.99 cdefg	3.51 bc	3.36 cd	2.84 defg	**3.18 B**
SA3	3.45 bcd	4.00 ab	3.26 cde	2.56 fg	**3.32 B**
SA4	2.71 efg	3.29 cde	2.81 defg	2.47 g	**2.82 C**
Mean	**3.41 AB**	**3.69 A**	**3.20 B**	**2.76 C**	
LSD%1	0.5612				
	Carotenoid (mg/g)				
SA1	1.83 b	2.88 ab	3.55 ab	4.2 a	**3.12 B**
SA2	3.71 ab	3.86 a	4.14 a	4.00 a	**3.93 AB**
SA3	4.09 a	4.25 a	3.92 a	4.03 a	**4.07 A**
SA4	3.23 ab	3.62 ab	3.07 ab	2.73 ab	**3.17 B**
Mean	**3.22 B**	**3.65 A**	**3.67 A**	**3.75 A**	
LSD%1	1.717				
	ß-Carotene (mg/100 ml)				
SA1	0.33 j	0.34 j	0.41 ı	0.53 h	**0.40 B**
SA2	0.63 def	0.58 efgh	0.73 ab	0.71 bc	**0.66 A**
SA3	0.64 cde	0.55 gh	0.68 bcd	0.80 a	**0.67 A**
SA4	0.74 ab	0.67 bcd	0.61 defg	0.56 fgh	**0.64 A**
Mean	**0.58 B**	**0.53C**	**0.61 B**	**0.65 A**	
LSD%1	0.0707				
	Lycopene (mg/100 ml)				
SA1	0.40 e	0.41 e	0.48 de	0.48 de	**0.44 C**
SA2	0.51 cd	0.53 cd	0.57 bc	0.58 bc	**0.55 B**
SA3	0.59 bc	0.58 bc	0.74 a	0.75 a	**0.66 A**
SA4	0.72 a	0.57 bc	0.71 a	0.62 b	**0.66 A***
Mean	**0.56 B**	**0.52 B**	**0.62 A**	**0.61 A**	
LSD%1	0.07071				

* Dissimilar letters in the column show different groups

Table 2. Average values of the effect of SA doses applied to linseed on saline conditions on morphological and biochemical characteristics

SA doses	**Salt doses**				**Mean**
	Seedling Length (cm)				
	S1	S2	S3	S4	
SA1	9.36 a	8.68 ab	8.23 bc	7.81 cdef	**8.52 A**
SA2	6.82gh	6.88 gh	7.27 efg	7.06 fg	**7.01 C**
SA3	8.09 bcd	7.52 cdefg	8.04 bcde	8.09 bcd	**7.94 B**
SA4	7.92 bcde	7.36 defg	6.95 gh	6.22 h	**7.11 C**
Mean	**8.05 A**	**7.61 B**	**7.62 B**	**7.30 B**	
LSD%1	0.7071				
	Root Length (cm)				
SA1	3.08 bcdef	3.04 bcdef	2.92 def	2.51 f	**2.89 C**
SA2	2.94def	3.55 abc	2.96 cdef	2.58 ef	**3.01 BC**
SA3	3.70 a	3.26 abcd	3.17 abcde	3.58 ab	**3.43 A**
SA4	3.16 abcde	3.37 abcd	3.32 abcd	2.90 def	**3.19 AB**
Mean	**3.22 A**	**3.30 A**	**3.09 AB**	**2.89 B**	
LSD%1	0.5244				
	Seedling Wet Weight (g)				
SA1	0.07 ef	0.09 def	0.10 cdef	0.077 def	**0.08 C**
SA2	0.11 abcde	0.14 a	0.13 abc	0.10bcdef	**0.12 A**
SA3	0.08 def	0.11 a	0.11 abcd	0.10 abcdef	**0.11 AB**
SA4	0.13 ab	0.10 abcdef	0.08 def	0.07 f	**0.09 BC**
Mean	**0.10 B**	**0.12 A**	**0.10 AB**	**0.09 B**	
LSD%1	0.03162				

	Root Wet Weight (g)				
SA1	0.02	0.03	0.03	0.04	0.03
SA2	0.03	0.05	0.08	0.08	0.06
SA3	0.07	0.07	0.06	0.08	0.07
SA4	0.08	0.08	0.09	0.07	0.08
Mean	**0.05**	**0.06**	**0.06**	**0.07**	
LSD%1	0.02				
	Germination rate (%)				
SA1	100.00 a	97.17 abc	99.53 a	99.07 ab	**98.94 A**
SA2	97.87 abc	96.37 bc	96.47 bc	95.60 c	**96.57 C**
SA3	98.37 abc	99.03 ab	98.13 abc	96.07 c	**97.90 AB**
SA4	97.27 abc	97.37 abc	97.87 abc	97.53 abc	**97.51 BC**
Mean	**98.38 A**	**97.48 AB**	**98.00 AB**	**97.07 B**	
LSD%1	2.439				
	Total chlorophyll (mg/g)				
SA1	4.24 a	3.67 b	2.96 def	2.56 fg	**3.36 A**
SA2	2.66 ef	2.53 fg	2.21 g	1.77 h	**2.30 B**
SA3	2.80 ef	3.03 de	3.56 b	3.58 b	**3.24 A**
SA4	3.07 cde	3.47 bc	3.28 bcd	2.92 def	**3.19 A**
Mean	**3.19 A**	**3.18 A**	**3.00 A**	**2.71 B**	
LSD%1	0.4000				
	Carotenoid (mg/g)				
SA1	1.39 f	1.96 e	2.21 e	3.11 bc	**2.17 D**
SA2	2.60 d	2.09 e	3.13 bc	2.64 d	**2.62 C**
SA3	3.67 a	3.59 a	3.53 a	3.65 a	**3.61 A**
SA4	3.63 a	3.43 ab	3.07 bc	2.95 cd	**3.27 B**
Mean	**2.82 BC**	**2.77 C**	**2.98 AB**	**3.09 A**	
LSD%1	0.3674				
	ß-Carotene (mg/100 ml)				
SA1	0.34 f	0.36 f	0.36 f	0.61 cde	**0.42 C**
SA2	0.57 e	0.64 bcde	0.66 bcde	0.69 bcd	**0.64 B**
SA3	0.59 de	0.67 bcde	0.77 bc	0.81 a	**0.70 A**
SA4	0.74 ab	0.67 bcde	0.63 bcde	0.60 cde	**0.66 AB**
Mean	**0.56 B**	**0.59 B**	**0.59 B**	**0.67 A**	
LSD%1	0.1000				
	Lycopene (mg/100 ml)				
SA1	0.64	0.58	0.61	0.58	**0.60 B**
SA2	0.60	0.65	0.66	0.65	**0.64 B**
SA3	0.73	0.65	0.75	0.79	**0.73 A**
SA4	0.67	0.61	0.63	0.55	**0.61 B***
Mean	**0.66**	**0.62**	**0.66**	**0.64**	
LSD%1	0.07071				

* Dissimilar letters in the column show different groups

CONCLUSIONS

In this study, plant species were affected at different levels by the negative effects of salt doses and positive effects of SA applications. The most advantageous results in terms of morphological (seedling length, root length, seedling wet weight, germination) and biochemical (carotenoid, ß-carotene, lycopene) parameters were obtained by SA3 dose in sunflower. In linseed, the root length, root wet weight, and biochemical properties are among the morphological features; total chlorophyll, carotenoid, ß-carotene, lycopene parameters have played a role in SA3 application in making the plant growth and stress defense system most effective. The morphological properties of sunflower and biochemical properties of linseed grown under salt stress were affected by the positive effects of salicylic acid application.

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