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EFFECTS OF SALT STRESS ON SOME GROWTH PARAMETERS AND BIOCHEMICAL CHANGES IN BEAN (*Phaseolus vulgaris* L.)

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ABSTRACT

Salinity is one of the most important abiotic stresses that affect plant cell metabolism and reduce plant productivity. In the study, some growth and biochemical characteristics of two different types of dwarf and lantern beans were investigated. The study was carried out in an aeroponic environment in a fully controlled climate room with 6 repetitions according to a completely randomized experimental design. In the experiment where two bean types (dwarf and pole types) were used as material, four different salt doses (0, 25, 50, 100 mM NaCl) were used for the salt stress conditions desired to be created. In the study, root length, seedling length, seedling fresh and dry weight, root fresh and dry weights, and leaf area were measured as some growth parameters, while MDA, APX, CAT, SOD activities, and proline and chlorophyll content were observed as biochemical parameters.For both genotypes, salinity induced a marked reduction in growth parameters. In parallel with the aggravation of salinity stress conditions, an increase in MDA, SOD, and proline content occurred. In the other investigated biochemical enzyme activities (APX and CAT), there was an increase up to a certain dose compared to the control and a decrease in the subsequent doses. Additionally, it has been determined that chlorophyll content is stable until the third dose but a significant decrease started after the fourth salt application. These results show that there has been a significant increase in enzymatic defense systems to reduce the effects of salt-induced stress in beans, and it has been observed that dwarf and pole bean types show close responses to salt stress.

Key words: *Phaseolus vulgaris* L., enzymes, salt stress, proline

INTRODUCTION

Phaseolus vulgaris L. is an important and popular worldwide *Phaseolus* species belonging to the Leguminosae family. It is a common bean that is the most widely distributed, grown on all continents except Antarctica, and occupies more than ~90% of production areas sown to *Phaseolus* species in the world.

Among the edible legumes, bean ranks first in the world in terms of cultivation areas and production amount. The world green bean cultivation area is 1,649,711 ha, and its production is 29,981,784 t. China, Indonesia, and after India Turkey ranks fourth in the world with 596,074 tons of fresh bean production. The world haricot bean cultivation area is 33,066,183 ha, and its production is 28,902,672 t. Myanmar, India, Brazil, and China are in the top four in the world [FAO 2019].

Soil salinization hazardously presents a global problem that threatens land productivity and recent estimates show that 50% of all arable land will be powerfully affected by salinity by 2050. It is scientifically, therefore, significant to possess precisely a global look at the fertile soil's salinity response to minimize economic losses and maximize food security [Beinsan et al. 2018]

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With a rapidly increasing world population, this considerable amount, which was 7,631.1 million in 2017, is ordinarily expected to reach 12 billion by 2050. In this considerable sense, considering the potential destruction caused by salinity and other stress (abiotic and biotic) factors, it is concluded that agricultural products, which have an important place in human nutrition, will not meet the need. Salinity seriously disrupts the chloroplast structure in plants, changes the photosynthetic pigment structure, carbohydrate and protein content, as well as negatively affects the specific processes of photosynthesis and biosynthesis, which are the main functions of osmolytes and antioxidant enzymes. After the ions are taken into the plant with roots with water and scarcely carried to the leaves, destruction occurs inevitably in cellular membranes and cytoplasmic structures [Çulha and Çakırlar 2011]. Salinity, which is at every stage of the life cycle of plants, is the most critical environmental and agricultural abiotic factor that limits plant existence and causes product loss in this sense. Scholarly estimates typically show that 20% of all cultivated crops and 33% of irrigated farmland are adversely affected by high salinity. In addition, salted areas grow remarkably at an annual rate of 10% for various key reasons, including low precipitation, high surface evaporation, natural rock effect, saltwater irrigation, and improper farming practices [Akhtar et al. 2015].

There are three main causes of salinity occurring in the rhizosphere depending on the amount of NaCl increase and therefore salt stress acting on the plants preventing the plant development. The first of these is the water stress (osmotic effect) that occurs due to the difficulty of water intake in the soils with negative water potential. The second is poisonings caused by Na^+ and/or Cl^- ions. The third is the energy used differently from its purpose [Salisbury et al. 1992].

Antioxidant enzyme amounts, and activities, which convert high levels of reactive oxygen (ROS) into harmless compounds, formed as a result of salt stress, function as the most important and effective resistance mechanisms against oxidative stress in plants. Enzymes like superoxide dismutase (SOD), ascorbate peroxidase (APX), glutathione reductase (GR), and catalase (CAT) are among the effective antioxidative enzymes. In addition, plants under stress accumulate various organic substances synthesized in the cell, and which are also soluble in the cytoplasm and organelles in the cell. These substances play an important role in the structure of osmotic balance by ensuring membrane integrity besides creating a positive effect on enzymes. Proline and glycine betaine, which are among these substances, are osmotic regulators that have an important effect on ensuring tolerance to stress [Ashraf and Foolad 2007, Deivanai et al. 2011, Bayat et al. 2014].

In this study, it was aimed to investigate how salinity, which is the most important stress factor that prevents or limits bean production, affects the development of dwarf and pole bean varieties. In this context, lipid peroxidase (MDA), ascorbate peroxidase (APX), catalase (CAT), superoxide dismutase activity (SOD), and prolin analyzes were performed.

MATERIAL AND METHOD

In the study, two bean varieties, one dwarf (Mina) and one pole (Beyza) were used. The variations of malondialdehyde (MDA), ascorbate peroxidase (APX), superoxide dismutase (SOD), catalase (CAT), proline, and chlorophyll were investigated in bean varieties exposed to salt stress.

Germination and early seedling development stage

Seeds with the same morphology and the same size from the seeds of both bean varieties and whose cotyledon was not damaged were carefully selected and subjected to shell sterilization.

In order to provide shell sterilization, after keeping the seeds in 95% ethanol for 5 min they were treated with 3% hydrogen peroxide for 5 min and washed 6 times with distilled water. The study was conducted in an aerophonic fully controlled climatic chamber with 6 repetitions according to the Completely Randomized Experimental Design (CRD). In the experiments, the aerophonic containers were filled with the prepared Hoagland solution. While only water containing Hoagland solution was added to control applications, in other applications, salt solutions with different concentrations (containing 25, 50, 100, mM NaCl) were added along with water containing Hoagland solution. The seeds were left to germinate at 23°C for 96 h (4 days) and after the 4th day, the seedlings were allowed to grow until the 6th true leaf at 23°C under 40–50% humidity conditions at 16 h light/8 h dark photoperiod and 250 μmol m^{-2} s^{-1} light intensity.

Physical, chemical, and biochemical analysis

Morphological measurements. The length of the seedling (cm) by measuring the length from the root of the seedling to the root tip, the length of the seedling (cm) by measuring the length from the root of the seedling to the shoot tip, the diameter of the root collar (mm) by measuring the diameter of the root collar and leaf area (cm^2) by measuring with the easy leaf area software, were carried out.

Determination of fresh and dry weight. The stem and roots of the seedlings will be weighed during harvest and their fresh weights (gr stem/root) will be determined. The parts of the plant whose fresh weight was determined were dried in a 70°C oven until they reached a constant weight for 24 h, and their weights were weighed and their dry weights (gr stem/root) were determined.

Chlorophyll amount. Chlorophyll content was made with leaf samples taken from 3 plants with the portable chlorophyll meter (Minolta SPAD-502, Osaka, Japan), which indirectly measures the amount of chlorophyll in the leaf. The wavelengths of infrared and red areas (650 nm and 940 nm, respectively) were measured in the leaf tissue as relative chlorophyll density [Madeira et al. 2000].

Lipid peroxidation (MDA) activity. Lipid peroxidation in plants is expressed as malondialdehyde (MDA) content. After the 0.5 g leaf sample taken was homogenized with 10 ml 0.1% trichloroacetic acid (TCA), the homogenate was centrifuged at 15 000 rpm for 5 min. 1 ml was carefully taken from the clear part of the centrifuged sample, was dissolved in 4 ml of 20% TCA and was added 0.5% thiobarbituric acid (TBA). After the mixture was kept at 95°C for 30 min, it was rapidly cooled in an ice bath and centrifuged for 10 min at 10 000 rpm, and the absorbance at the clear part was determined at 532 and 600 nm wavelength and the content of malondialdehyde (MDA) was calculated [Sairam et al. 2005].

Catalase (CAT) activity. Catalase activity was determined by monitoring the loss of H_2O_2 at 240 nm wavelength. 0.05 M phosphate buffer (KH_2PO_4), 1.5 mM H_2O_2 mixture was used as the reaction solution (pH: 7.0). Mixing 2.5 ml reaction solution and 0.2 ml plant extract, the spectrophotometric readings of 0 and 60 th seconds of 240 nm wavelength were recorded. The reaction was initiated by the addition of 0.1 ml enzyme extract and the evaluation was made within 1 min considering the change in absorbance [Jebara et al. 2005].

Ascorbate peroxidase activity (APX). It was accurately measured with the reduction of H_2O_2 due to ascorbic acid at 290 nm wavelength. 50 mM phosphate buffer (KH_2PO_4), 0.5 mM ascorbic acid, 0.1 mM EDTA, 1.5 mM H_2O_2 mixture were used as the reaction solution (pH: 7.0). By mixing 3 ml of the reaction solution and 0.1 ml of plant extract, the Spectrophotometer was read at 0 and 60 seconds at a wavelength of 290 nm. The reaction was initiated by the addition of 0.1 ml enzyme extract and evaluation was made within 1 minute taking into account the change in absorbance [Sairam et al. 2005]

Superoxide dismutase (SOD) activity. Determined by inhibition of nitro blue tetrazolium (NBT) at 560 nm wavelength. 50 mM Na-phosphate buffer ($Na_2HPO_4 \times 2H_2O$), 0.1 mM Na-EDTA, 33 µM NBT, 5 µM riboflavin, 13 mM methionine mixture were used as the reaction solution (pH: 7.0). 25 ml of the reaction solution and 0.1 ml of plant extract were mixed and the reaction was held at 25°C for 10 min under 75 µmol $m^{-2}s^{-1}$ (40 W) light. The control solution was kept in the dark for the same time without enzyme and 560 nm wave readings were made. SOD activity was determined as the unit that reduces 50% of NBT [Rahnama and Ebrahimzadeh 2005].

Proline. 0.5 g of fresh plant sample was instantly taken and then broken down with 3% sulfosalicylic acid and then centrifuged. 2 ml of the centrifuged sample was taken, and 2 ml of acetic acid and 2 ml of ninhydrin reagent (ninhydrin, acetic acid, and orthophosphoric acid) were carefully added. Then, the samples placed in the tubes were kept in a water bath at 100°C for one hour, and the specific reaction was terminated in ice. It was vortexed by quaintly adding 4 ml of toluene on the cooled samples and read accurately on the spectrophotometer set at 520 nm wavelength. Then, necessary calculations were ideally made with proline standards [Bates 1973].

Statistical analysis

The raw data obtained as a result of the experiment were subjected to analysis of variance using the Costat V.6.0 package program according to the Completely Randomized Experimental Design (CRD).

Phot. 1. Mina (dwarf type) variety

Phot. 2. Beyza (pole type) variety

The averages of the applications were grouped by comparing them with Duncan (5%) multiple comparison test.

RESULTS AND DISCUSSION

Genetic diversity in a species provides a valuable opportunity for salinity resistance studies. Beans are one of the most important crops grown all over the world and it is very sensitive to salinity [Brugnoli and Lauteri 1991]. As it is known, the reactions of different plant forms of the same species to salinity may be different, as in different plant species. In this study, it was determined that dwarf and pole bean types (Phot. 1 and 2) showed very different tolerance to increased salinity.

Effect of NaCl on some properties of growth traits of the dwarf and pole bean types

Root length (RL). As seen in Table 1, the dwarf (Mina) cultivar RL was significantly higher than that of the pole (Beyza) cultivar (52.68 cm, 44.17 cm). This shows that varieties react differently to salt doses in terms of root length. The treatments of salt significantly negatively affected RL at all applied doses. The highest RL (60.17 cm) was obtained from the dwarf type at control, while the shortest value (37.33 cm) was measured from the pole variety at the highest salt dose (100 mM). The results obtained from the study are in harmony with the results of some previous studies [Ashagre et al. 2014, Mena et al. 2015].

Seedling length (SL). The results of the seedling length (SL) are shown in Table 1. The highest SL (74.50 cm) was observed from the pole variety, which was higher than the dwarf variety (38.69 cm). This shows that pole variety is more sensitive to salt doses in terms of seedling length. It was observed that SL was affected significantly and differently from salt doses. Thus, the shortest SL (47.58 cm) was measured at the fourth salt dose (100 mM). Unlike RL, the longest SL (83.17 cm) was measured from the pole cultivar at the 25 mM salt dose, while the shortest value (33.50 cm) was determined from the dwarf cultivar at the fourth salt application (100 mM). The results ob-

Table 1. The means and the LSD groups of some physical properties of *Phaseolus vulgaris*

Variation sources	Variety	Salt dose	Root length (cm)	Seedling length (cm)	Root fresh weight (g)	Root dry weight (g)	Seedling fresh weight (g)	Seedling dry weight (g)	Leaf area (cm^2)
Varieties (V) × salt doses (SD)	Beyza*	0 (mM)	48.84 c	80.00b	8.13 bcd	0.48	14.97 ab	1.36 ab	6.19 a
		25 (mM)	48.50 c	83.17 a	6.63 cd	0.57	13.87 ab	1.43 ab	4.88 c
		50 (mM)	42.00 e	73.17 c	8.07 bcd	0.59	14.23 ab	1.99 ab	5.49 b
		100 (mM)	37.33 f	61.67 d	8.40 bcd	0.45	8.63 b	1.09 b	4.10 e
	Mina*	0 (mM)	60.17 a	40.17 e	16.57 a	0.71	19.43 a	2.22 ab	5.66 ab
		25 (mM)	47.33 cd	41.27 e	12.60 ab	0.72	21.40 a	2.29 a	4.68 c
		50 (mM)	57.17 b	39.83 e	9.93 bc	0.63	7.47 b	0.80 b	4.55 cd
		100 (mM)	46.07 d	33.50 f	5.23 d	0.45	10.23 b	1.54 ab	4.28 de
Beyza**		Average	44.17 B	74.50 A	7.81 B	0.52	12.93	1.47	5.16 A
Mina**		Average	52.68 A	38.69 B	11.08 A	0.63	14.63	1.71	4.79 B
Salt doses' averages***		0 (mM)	54.50 a	60.08 b	12.35 a	0.59	17.20 a	1.79	5.92 a
		25 (mM)	47.92 c	62.22 a	9.62 ab	0.65	17.63 a	1.86	4.78 b
		50 (mM)	49.58 b	56.50 c	9.17 ab	0.61	10.85 b	1.39	5.02 b
		100 (mM)	41.70 d	47.58 d	6.65 b	0.45	9.43 b	1.31	4.19 c
LSD (5%) for V			1.009	0.858	2.171	0.145	3.290	0.550	1.727
LSD (5%) for SD			1.427	1.213	3.070	0.204	4.652	0.779	2.442
LSD (5%) for V × SD			3.496	2.972	7.520	0.501	11.396	1.907	5.982

* The means in the same column, expressed in lowercase and indicated with different letters, is statistically different from each other within the $P \leq 0.05$ error limits according to LSD (least significant difference) test.
** The means in the same column, expressed in capital and indicated with different letters, is statistically different from each other within the $P \leq 0.05$ error limits according to LSD (east significant difference) test.
*** The mean in the same sub-column, expressed in lowercase and indicated with different letters, is statistically different from each other within the $P \leq 0.05$ error limits according to LSD (least significant difference) test.

tained from the study are parallel to the results reported by [Ashagre et al. 2014, Mena et al. 2015].

Root fresh weight (RFW). Both varieties were significantly affected by salt doses in terms of the root fresh weight (RFW). In direct proportion to RL, the root fresh weight (RFW) of dwarf (11.08 g) cultivar was significantly higher than that of pole cultivar (7.81 g). It was observed that the salt doses had significant effects on the RFW of both cultivars. So, the fourth salt dose produced the lightest RFW as 6.65 g (Tab. 1). As seen in the table, the highest RFW value (16.57 g) was determined from the dwarf variety at 0 mM salt treatment, while the lowest value (5.23 g) was weighed at the fourth salt dose-treated to the same variety. The results are in accordance with the study results of [Ashagre et al. 2014] As the means can be observed from Table 1, In the study, it was determined that the bean types and salt doses, which were considered as factors, had no significant effect on root dry weight (RDW). Although there was a partial difference between the values obtained after weighing, it was found that this difference was not statistically significant at the level of 5%.

Seedling fresh weight (SFW). When Table 1 is examined in terms of SFW, the tolerances of the bean types to the salinity were the same on seedling

fresh weight, therefore, there wasn't any significant difference between bean types. The salt doses significantly affected the SFW, thus the shortest SFW values (9.43 and 10.85 g) were measured at the third and fourth salt dose (100 mM), which had no significant differences between themselves. The interactions effect of both factors on SFW was found to be statistically significant at the 5% level. The highest SFW (19.43 g) was obtained from the dwarf type at control, while the lowest value (7.47 g) was weighed from the same type at the highest salt dose (100 mM). Similar salinity effects were reported by Ashagre et al. [2014] on seedling fresh weight.

Seedling dry weight (SDW). As can be seen from Table 1, while the effects of both factors on SDW were statistically insignificant at the level of 5%, it was determined that the two bean types formed significant differences in seedling dry weight values. Therefore, the heaviest SDW (2.29 g) was determined in the dwarf variety in 25 mM salt application, while the lightest (0.80 and 1.09 g) was observed in the third salt dose in the dwarf variety and the fourth salt application in the pole variety. Similar results were reported by Jebara et al. [2005] who stated that the SDW was significantly affected by the salt treatments and results reported by [Ashagre et al. 2014].

Leaf area LA. When the results presented in Table 1 were examined, it was seen that the LA showed significant variation in both salt-treated bean types. The highest LA value (5.16 cm^2) was observed from the pole variety, while it was higher than that of the dwarf variety (4.79 cm^2). In Table 1, it was determined that LA was affected significantly and differently from salt treatments. Thus, the minimum LA value (4.19 cm^2) was measured at the fourth salt application (100 mM). The highest LA mean (6.19 cm^2) was measured from the pole cultivar at the control, while the lowest value (4.10 cm^2) was determined from the same pole cultivar at the fourth salt application (100 mM). The results are in harmony with that of Kaymakanova and Stoeva's study [2008]. Additionally, results similar to the results of the study were reported by Hernandez and Almansa [2002] and Mena et al. [2015] who emphasized that increased salt levels caused decrease in the leaf area.

Effect of NaCl on some properties of biochemical properties of dwarf and pole beans types. he biochemical properties such as MDA, APX, CAT, SOD, proline, and chlorophyll, which allowed a more accurate understanding of the physiological properties examined in the study, were also examined and the results were given in Table 2. Enzymes such as ascorbate peroxidase (APX), catalase (CAT), and superoxide dismutase (SOD) are among the effective antioxidative enzymes.

Lipid peroxidation (MDA) activity. As seen in Table 2 and Figure 1, as a result of the MDA analysis, there were no statistically significant differences between the cultivars, while significant differences were detected between the salt doses on the MDA activity. The lowest MDA value (1.05) was observed from the control, while there were no differences were determined among the other treatments. It was monitored that the reactions of both varieties to the salt doses were the same, therefore, there wasn't found any statistical variation among V × SD interactions.

In a similar study, which supported these results, it was reported that the MDA content increased up to a certain dose and then decreased again, but after this decrease, the MDA content was observed higher than the control application [Kaymakanova et al. 2008].

Catalase (CAT) enzyme activity. The results of CAT enzyme activity are shown in Table 2 and Figure 3. There was no difference in CAT enzyme activity between both cultivars and it was found that their reactions to salt doses were the same. However, significant statistical ($P < 0.05$) differences were found between the applied salt doses. The highest CAT enzyme activity (0.077) was determined from the second salt dose (25 mM) while the lowest value (0.026) was determined from the control (0 mM). Similar to the study results, Rahnama and Ebrahimzadeh [2005] reported that salt levels significantly increased catalase enzyme compared to control.

In a previous study, which supported the study results, it was reported that the CAT content increased up to a certain dose and then decreased again differently in the species, but after this decrease, the CAT content was observed higher than the control application [Yasar et al. 2008].

The superoxide dismutase activity (SOD). The SOD measures showed higher total SOD activity in dwarf bean type than in pole type, although the salt treatment generated a higher activation as 657.91 at the fourth salt dose treatment, contrasting with the

Table 2. The means and the LSD groups of some biochemical properties of *Phaseolus vulgaris* L. dwarf and pole type varieties

Variation sources	Variety	Salt dose	MDA	APX	CAT	SOD	Proline	Chlorophyll
Varieties (V) × salt doses (SD)	Beyza*	0 (mM)	1.20	0.65 d	0.026	314.03 f	0.32 de	37.11
		25 (mM)	1.99	1.61 bc	0.068	435.93 c	0.66 bc	36.87
		50 (mM)	1.55	1.89 b	0.049	398.93 d	1.00 a	33.02
		100 (mM)	1.55	0.85 d	0.038	652.82 a	0.98 a	27.22
	Mina*	0 (mM)	0.90	1.02 cd	0.027	309.25 f	0.25 e	34.04
		25 (mM)	1.81	1.30 cd	0.086	334.26 e	0.52 cd	39.24
		50 (mM)	1.55	3.21 a	0.030	656.80 ab	0.45 de	35.63
		100 (mM)	1.68	3.57 a	0.048	662.99 a	0.74 b	25.56
	Beyza**	Average	1.57	1.25 B	0.045	450.43 B	0.74 A	33.56
	Mina**	Average	1.48	2.27 A	0.048	490.83 A	0.49 B	33.62
Salt doses' averages***		0 (mM)	1.05 b	0.83 d	0.026 c	311.64 d	0.28 d	35.58 a
		25 (mM)	1.90 a	1.45 c	0.077 a	385.10 c	0.59 c	38.05 a
		50 (mM)	1.55 a	2.55 a	0.040 bc	527.87 b	0.72 b	34.33 a
		100 (mM)	1.61 a	2.21 b	0.043 b	657.91 a	0.86 a	26.39 b
LSD (5%) for V			0.312	0.232	0.010	4.504	0.075	4.056
LSD (5%) for SD			0.441	0.327	0.013	6.369	0.106	5.736
LSD (5%) for V x SD			1.080	0.802	3.296	15.601	0.260	14.050

* The mean in the same column, expressed in lowercase and indicated with different letters, is statistically different from each other within the $P \leq 0.05$ error limits according to LSD (least significant difference) test.
** The mean in the same column, expressed in capital and indicated with different letters, is statistically different from each other within the $P \leq 0.05$ error limits according to LSD (least significant difference) test.
*** The mean in the same sub-column, expressed in lowercase and indicated with different letters, is statistically different from each other within the $P \leq 0.05$ error limits according to LSD (least significant difference) test.

value (311.64) of SOD activity at control treatment (Tab. 2). Significant differences were detected between the interaction effects of both factors on SOD enzyme activity. The lowest SOD values (309.25 and 314.03) were obtained from the dwarf and pole varieties from the control application, while the highest values (652.82 and 662.99) were obtained from the fourth salt dose application from the pole and dwarf varieties (Tab. 2, Fig. 4). Similar to the result of the experiment, in a study carried out under salt stress in the pumpkin plants, the increase in SOD was found to be parallel to the increase in proline [Hernandez and Almansa 2002, Bayat et al. 2014].

Proline biosynthesis. In terms of proline biosynthesis, the reactions of the varieties to salt stress were not the same, thus the highest (0.74) proline content was obtained from the pole cultivar. An increase was significantly elevated at a progressive level of salt in both the cultivars and becomes the highest (0.86) at the fourth salt dose treatment while the lowest (0.28) was observed at the control application. As the cultivars reacted differently to increasing salt levels, significant differences were observed between the varieties of salt dose interactions. For this reason, the highest proline contents (0.98 and 1.00) were obtained from the third and fourth applications of the pole variety, while the lowest value (0.25) was obtained from the control application of the dwarf variety (Tab. 2, Fig. 5). In many plant species, accumulation of proline under abiotic stress conditions has been associated with stress toler-

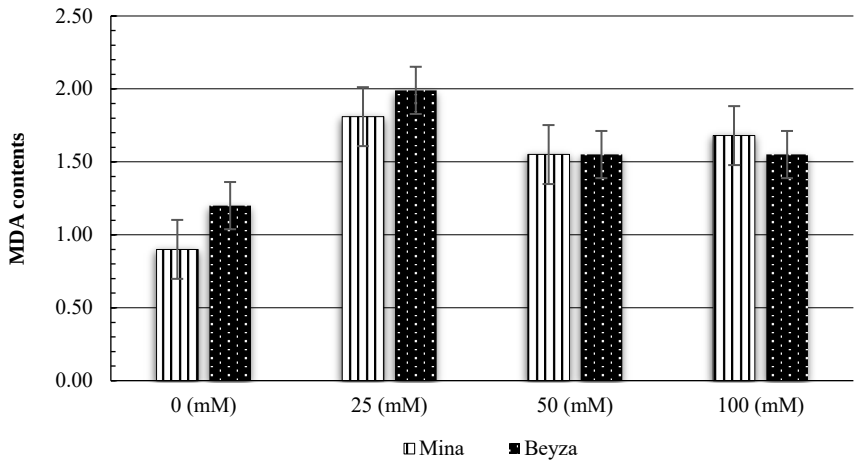

Fig. 1. Effect of salinity stress on MDA enzyme activities of bean types

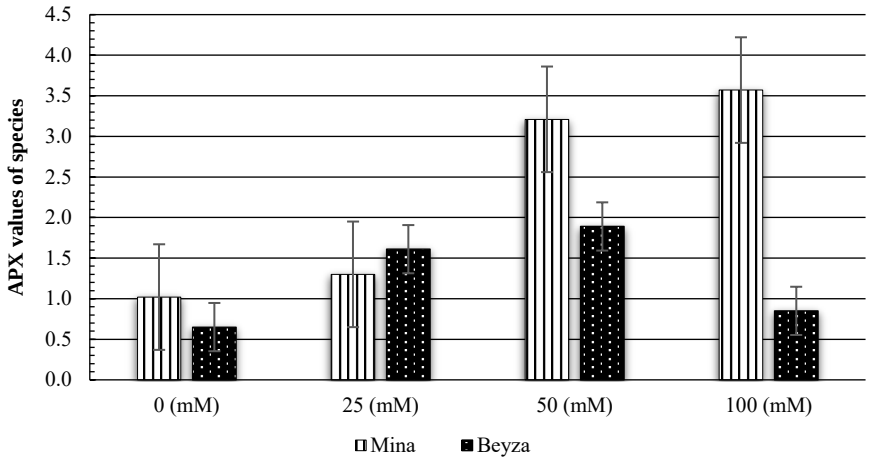

Fig. 2. Effect of salinity stress on APX enzyme activities of bean types

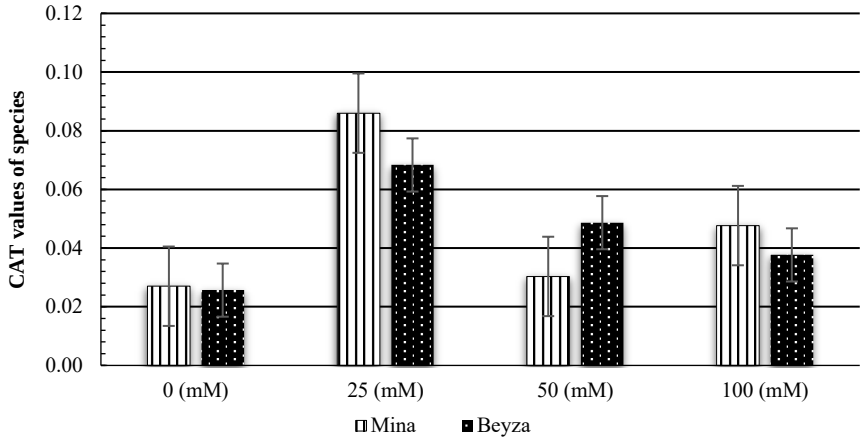

Fig. 3. Effect of salinity stress on CAT enzyme activities of bean types

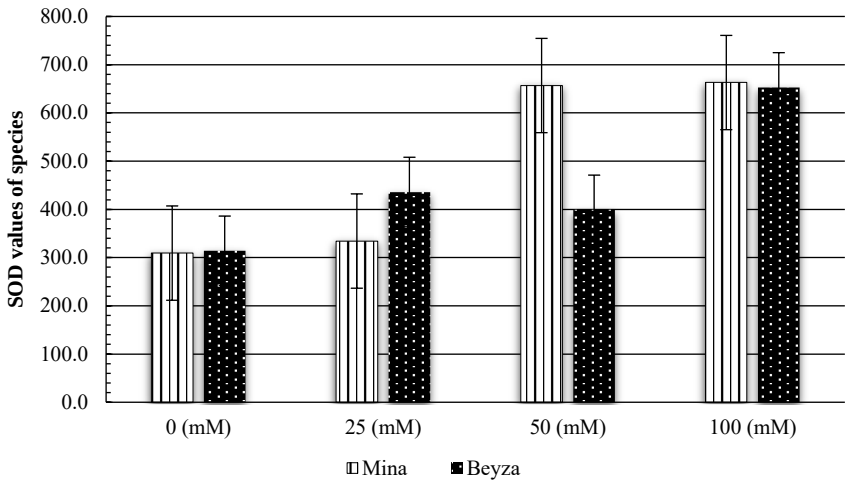

Fig. 4. Effect of salinity stress on SOD activities of bean types

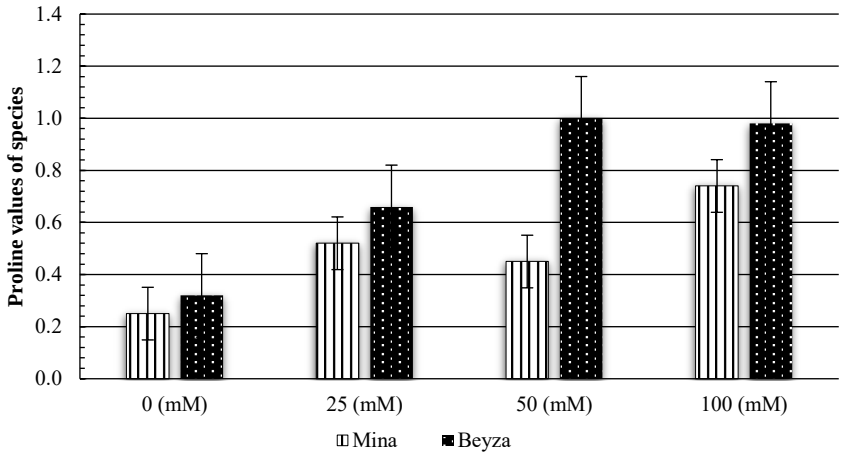

Fig. 5. Effect of salinity stress on proline contents of bean types

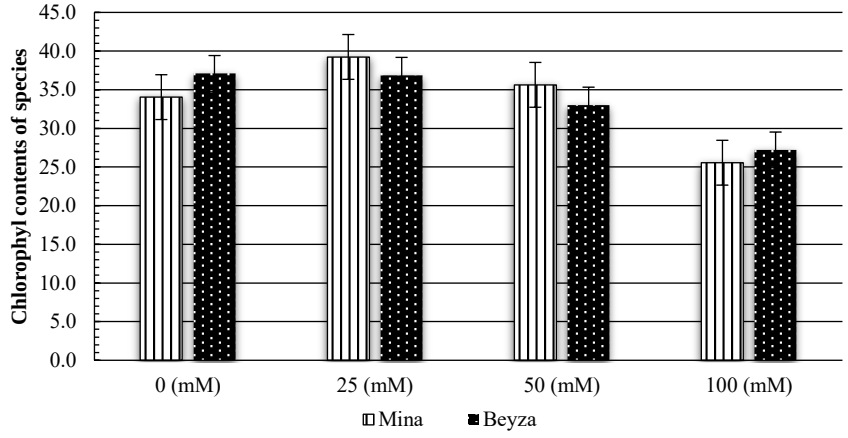

Fig. 6. Effect of salinity stress on chlorophyll contents of bean types

ance. Generally, the accumulation of proline has been reported to be higher in stress tolerant plants than in stress sensitive plants [Kishor et al. 2005, Ashraf and Foolad 2007, Stoeva and Kaymakanova 2008, Bayat et al. 2014].

Chlorophyll content. The results of chlorophyll contents are shown in Table 2 and Figure 6. There was no statistical significant ($P > 0.05$) difference in chlorophyll content between both bean types and it was determined that the dwarf and pole bean species had the same response to salt doses. However, statistically significant ($P < 0.05$) differences were found among the applied salt doses. It was found that the chlorophyll content (26.39) obtained in the fourth salt dose was lower than the other three salt doses that had no statistical difference between each other. At the same time, as the cultivars showed the same reaction to the salt levels, it was seen that the interaction between the cultivar and the salt dose was also insignificant ($P > 0.05$). It was observed that the chlorophyll amount decreased in direct proportion with the leaf area, which was affected by salt stress. It has been determined that opinions close to the results of the experiment were reported in previous studies [Akhtar et al. 2015, Darkwa et al. 2016].

CONCLUSION

In the study, where some growth and biochemical properties of dwarf and pole bean varieties were examined, significant differences were detected between dwarf and pole varieties in terms of many features. It has been found that increased salt doses significantly affect the germination and growth parameters examined, except for root dry weight. When the MDA, APX, SOD, and CAT activities of bean genotypes were examined, it was observed that there was an increase in the amount of these features in varying rates in both dwarf and pole bean types in the later doses of salt stress. The salt stress conditions have been shown to cause a reduction in chlorophyll in both bean species. Additionally, it was observed that there was an increase in the amount of proline in the leaves of the bean in parallel with increasing salt doses and increased salinity tolerance in order to encourage photosynthesis against the negative effects of increased salt levels, and to protect the enzyme activities.

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