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Determination of the Effects of Different Salt Sources and Doses on Seedling Characteristics of a Local Common Bean (*Phaseolus vulgaris* L.) Variety

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Abstract: Salinity is a major environmental stress that adversely affects plant growth and development, leading to yield loss in agricultural production. Common bean (*Phaseolus vulgaris* L.), widely cultivated in Turkey, is also sensitive to salinity. In this study, the effects of different salt sources (Calcium Chloride, Magnesium Chloride, Magnesium Sulfate, Sodium Sulfate, Sodium Chloride) and concentrations (40, 50, 60, 70 mM) on the seedling characteristics of a local common bean variety were investigated. In the pot experiment conducted using a factorial design in randomized plots, shoot length, leaf length, leaf width, shoot fresh weight, leaf fresh and dry weight, plant water and dry matter content, and chlorophyll content were determined. The results indicate that shoot length ranged between 7.10-11.80 cm (interaction), 9.43-11.06 cm (dose), and 8.80-10.75 cm (sources); leaf length varied between 4.07-6.40 cm (interaction), 5.17-5.90 cm (dose), and 4.95-5.78 cm (sources); leaf width was between 3.67-5.43 cm (interaction), 4.46-4.87 cm (dose), and 4.12-4.91 cm (sources); shoot fresh weight ranged from 0.80-2.07 g (interaction), 1.00-1.43 g (dose), and 1.10-1.46 g (sources); leaf fresh weight varied between 0.22-0.54 g (interaction), 0.30-0.45 g (dose), and 0.29-0.42 g (sources); leaf dry weight was in the range of 0.03-0.86 g (interaction), 0.07-0.33 g (dose), and 0.06-0.31 g (sources); seedling water content ranged between 83-97% (interaction), 85-86% (dose), and 84-88% (sources); dry matter content ranged between 03-18% (interaction), 14-15% (dose), and 12-16% (sources); and chlorophyll content ranged from 37.23-48.17 SPAD (interaction), 41.15-44.15 SPAD (dose), and 40.87-44.66 SPAD (sources). These findings reveal the negative effects of salt stress on plant growth and physiology.

Key words: Dry bean, seedling development, salt concentration, salinity stress

Farklı Tuz Kaynakları ve Dozlarının Yerel Kuru Fasulye (*Phaseolus vulgaris* L.) Çeşidindeki Fide Özelliklerine Etkilerinin Belirlenmesi

Öz: Tuzluluk, bitkilerin büyüme ve gelişimini olumsuz etkileyen önemli bir çevresel strestir ve tarımsal üretimde verim kaybına yol açmaktadır. Türkiye'de yaygın olarak yetiştirilen kuru fasulye (*Phaseolus vulgaris* L.) bitkisi de tuzluluğa karşı hassastır. Bu çalışmada, farklı tuz kaynakları (Kalsiyum Klorür, Magnezyum Klorür, Magnezyum Sülfat, Sodyum Sülfat, Sodyum Klorür) ve konsantrasyonlarının (40, 50, 60, 70 mM) yerel bir kuru fasulye çeşidinin fide özellikleri üzerindeki etkileri incelenmiştir. Tesadüf parsellerinde faktöriyel deneme desenine göre yapılan saksı çalışmasında, sürgün uzunluğu, yaprak uzunluğu, yaprak genişliği, sürgün yaş ağırlığı, yaprak yaş ve kuru ağırlığı, bitki su ve kuru madde oranı ile klorofil miktarı belirlenmiştir. Sonuçlar, sürgün uzunluğunun 7.10-11.80 cm (interaksiyon), 9.43-11.06 cm (doz), 8.80-10.75 cm (tuz kaynağı); yaprak uzunluğunun 4.07-6.40 cm (interaksiyon), 5.17-5.90 cm (doz), 4.95-5.78 cm (tuz kaynağı); yaprak genişliğinin 3.67-5.43 cm (interaksiyon), 4.46-4.87 cm (doz), 4.12-4.91 cm (tuz kaynağı); sürgün taze ağırlığının 0.80-2.07 g (interaksiyon), 1,00-1.43 g (doz), 1.10-1.46 g (tuz kaynağı); yaprak taze ağırlığının 0.22-0.54 g (interaksiyon), 0.30-0.45 g (doz), 0.29-0.42 g (tuz kaynağı); yaprak kuru ağırlığının 0.03-0.86 g (interaksiyon), 0.07-0.33 g (doz), 0.06-0.31 g (tuz kaynağı); fide su içeriğinin %83-97 (interaksiyon), %85-86 (doz), %84-88 (tuz kaynağı); kuru madde içeriğinin %03-18 (interaksiyon), %14-15 (doz), %12-16 (tuz kaynağı); klorofil içeriğinin ise 37.23-48.17 SPAD (interaksiyon), 41.15-44.15 SPAD (doz), 40.87-44.66 SPAD (tuz kaynağı) arasında değiştiğini göstermektedir. Bu bulgular, tuz stresinin bitki büyümesi ve fizyolojisi üzerindeki olumsuz etkilerini ortaya koymaktadır.

Anahtar kelimeler: Fide gelişimi, kuru fasulye, tuz konsantrasyonu, tuz stresi

1. Introduction

Beans (*Phaseolus vulgaris* L.) are one of the most valuable plant species in the legume family and have been used in human nutrition for thousands of years. Bean seeds contain approximately 20-28% protein and around 60% carbohydrates. They are also rich in various vitamins (A, B, and D). These nutritional elements give beans numerous health benefits (Ceyhan et al., 2009; Pekşen and Artık, 2005). Dry bean production ranks first globally, while in our country, it follows chickpeas and lentils (Çiftci et al., 2023). In 2022, dry bean cultivation in our country covered an area of 970,520 decares, with a production volume of 270,000 tons (TÜİK, 2022).

Bean plants are susceptible to abiotic stresses such as salinity and drought. To mitigate the negative effects of these stress factors on bean plants' physiological processes, comprehensive studies on salinity and drought tolerance are being conducted in agricultural research. As a result of these studies, new strategies and varieties are being developed in areas such as genetic breeding, plant nutrition, and irrigation management, aiming to prevent yield and quality losses in bean cultivation.

Globally, over 800 million hectares of land are affected by salinity issues. Approximately one-fifth (32 million hectares) of the 150 million hectares of dry farming land worldwide is at salinity risk. Similarly, 45 million hectares of the 230 million hectares of irrigated agricultural land are affected by salinity stress (Yılmaz et al., 2011; Munns, 2002). This proportion is expected to continue to increase in the coming years. Salt stress inhibits plant growth and development, lowering the osmotic potential of plant cells due to increased salt concentration and decreased water in the soil. Consequently, a series of responses occur in the plant. In plants exposed to salt stress, many physiological processes, such as germination, cell division, photosynthesis, growth, and development, are affected (Bressan, 2008). These effects vary depending on salt stress's type, duration, or intensity. This study focuses on how different salt sources and doses affect the salinity tolerance of dry bean seedlings. For this purpose, some plant characteristics were examined in dry bean seedlings subjected to salt solutions.

2. Materials and Methods

In this study, local dry bean seeds obtained from Karaköy village in Elmalı district of Antalya were used, and the study was conducted as a pot experiment under greenhouse conditions in Rize. The experiment was set up using plastic pots with a diameter of 16 cm and a depth of 13 cm. Sterile peat from a commercial brand was used in the pots. This peat has a high air ratio, is porous and stable in structure, is composed of fine particles, and offers excellent drainage properties. The pH value of the peat was 6.0, and the amount of fertilizer was determined as 1.0 g/l. Fertilizer Sources to the seedlings was carried out using a commercial brand's Liquid Chicken Manure pH Regulator containing 100% organic matter (chicken manure extract) (Güler, 2004; Taban et al., 2013; Tavalı et al., 2014) A 4% fertilizer solution was added to each pot to meet the nutritional needs of the plants. The experiment was established in a factorial experimental design with three replications in randomized plots. Five seeds were sown in each pot, and salt solutions were applied simultaneously with sowing. The salt sources used in the study were Calcium Chloride, Magnesium Chloride, Magnesium Sulfate, Sodium Sulfate, and Sodium Chloride. Each was applied at doses of 0, 40, 50, 60, and 70 mM, as 166 ml of saline solution per pot in a single Sources. Measurements were made using a precision scale and digital caliper, and the dry weight of the plants was determined by drying at 78°C for 48 hours in an oven. After examining seedling characteristics (shoot length, leaf length, leaf width, shoot fresh weight, leaf fresh and dry weight, plant water content, plant dry matter content, and chlorophyll content), statistical analyses were performed using the JMP software, and multiple comparisons were evaluated using the Tukey test (Yıldırım and Yılmaz 2022; Yıldırım and Yılmaz 2023). Chlorophyll measurement was performed with a SPAD-502 Plus chlorophyll meter from Konica Minolta. Shoot length, leaf length, and leaf width were measured with a digital caliper, and their averages were taken. Shoot fresh weight, leaf fresh and dry weight were measured with a precision scale, and their averages were taken.

3. Results and Discussion

This study examined the effects of different salt sources and doses on various development parameters of bean seedlings. The results showed that sources types and doses significantly affected the plants shoot length, leaf length, leaf width, shoot fresh weight, leaf fresh and dry weight, seedling fresh and dry weight, water and dry matter content, and chlorophyll content.

The effects of different salt sources and doses on the shoot length of bean seedlings were investigated. It was found that Sources, dose, and Sources x dose interactions did not create a statistically significant difference in shoot length (Table 1). The most extended shoot length was measured as 11.80 cm with $MgSO_4$ (50 ml/L), followed by Na_2SO_4 (50 ml/L) (11.75 cm), $MgSO_4$ (60 ml/L) (11.75 cm), and Na_2SO_4 (50 ml/L) (11.73 cm). The shortest shoot length was 7.10 cm with $CaCl_2$ (50 ml/L). Similar findings were reported by Çiftçi et al. (2011) and Eroğlu (2007), who found that salt stress reduced considerably shoot length in bean plants. In addition, Uzun Kayıs and Ceyhan (2015) and Cakır and Ceyhan (2021) reported that salt Sources negatively affected root development in lentils, Aldemir and Ceyhan (2015) in chickpeas and Aydın et al. (2019) in cowpeas. These findings align with our study.

When examining the findings related to leaf length, it was determined that Sources and dose factors created statistically significant differences in leaf length, and Sources x dose interactions had an even, more substantial effect ($p \leq 0.001$). The most extended leaf length was recorded as 6.40 cm with $MgCl_2$ (50 ml/L), followed by $CaCl_2$ (60 ml/L) (6.37 cm) and NaCl (60 ml/L) (6.33 cm) (Table 1). The shortest leaf length was measured as 4.07 cm with $CaCl_2$ (70 ml/L). The doses of $MgCl_2$ (50 ml/L), $CaCl_2$ (60 ml/L), and NaCl (50 ml/L) produced the, most extended leaf lengths, with no statistically significant differences among these sources. In the study by Erol et al. (2024), the effect of salt stress on soybeans was examined and it was found that the soybeans were examined, and it was found that the leaf area index decreased as the salt dose increased. These results demonstrate the negative impact of salt stress on leaf development and are consistent with findings in the literature.

Table 1. Effects of Different Salt Sources and Doses on Shoot and Leaf Length of Bean Seedlings
Çizelge 1. *Fasulye Fidelerinde Farklı Tuz Kaynakları ve Dozlarının Sürgün ve Yaprak Uzunluğu Üzerindeki Etkileri*

Factor		Means of Shoot Length (cm)	Factor	Means of Leaf Length (cm)
Sources	Na_2SO_4	10.75	$MgSO_4$	5.78 a
	$MgSO_4$	10.51	NaCl	5.73 ab
	$MgCl_2$	10.23	Na_2SO_4	5.53 ab
	NaCl	10.13	$MgCl_2$	5.30 ab
	$CaCl_2$	8.80	$CaCl_2$	4.95 b
Dose	60 ml/L	11.06	50 ml/L	5.90 a
	50 ml/L	10.00	60 ml/L	5.52 ab
	70 ml/L	9.85	70 ml/L	5.24 ab
	40 ml/L	9.43	40 ml/L	5.17 b
Sources * Dose Interaction	$MgSO_4$, 50 ml/L	11.80	$MgCl_2$,50 ml/L	6.40 a
	$MgSO_4$, 60 ml/L	11.75	$CaCl_2$,60 ml/L	6.37 a
	Na_2SO_4, 50 ml/L	11.73	NaCl,50 ml/L	6.33 a
	Na_2SO_4, 60 ml/L	11.57	$MgSO_4$,60 ml/L	6.15 ab
	Na_2SO_4, 70 ml/L	11.27	Na_2SO_4,50 ml/L	6.13 ab
	$CaCl_2$, 60 ml/L	11.20	NaCl,40 ml/L	5.83 ab
	$MgCl_2$, 40 ml/L	11.17	$MgSO_4$,50 ml/L	5.80 ab
	$MgCl_2$, 60 ml/L	10.73	$MgSO_4$,40 ml/L	5.75 ab
	NaCl, 70 ml/L	10.46	Na_2SO_4,70 ml/L	5.60 ab
	$MgSO_4$, 70 ml/L	10.35	Na_2SO_4,60 ml/L	5.57 ab
	NaCl, 60 ml/L	10.07	$MgCl_2$,70 ml/L	5.57 ab
	NaCl, 40 ml/L	10.04	NaCl,70 ml/L	5.55 ab
	NaCl, 50 ml/L	9.95	$MgSO_4$,70 ml/L	5.43 ab
	$MgCl_2$, 70 ml/L	9.63	NaCl,60 ml/L	5.20 ab
	$MgCl_2$, 50 ml/L	9.40	$MgCl_2$,40 ml/L	4.93 ab
	$CaCl_2$, 40 ml/L	9.37	$CaCl_2$,50 ml/L	4.85 ab
	Na_2SO_4, 40 ml/L	8.43	Na_2SO_4,40 ml/L	4.83 ab
	$MgSO_4$, 40 ml/L	8.15	$CaCl_2$,40 ml/L	4.50 ab
	$CaCl_2$, 70 ml/L	7.55	$MgCl_2$,60 ml/L	4.30 ab
	$CaCl_2$, 50 ml/L	7.10	$CaCl_2$,70 ml/L	4.07 b
General Information	CV (%)	17.83	CV (%)	13.02
	Sources	Ö.D.	Sources	**
	Dose	Ö.D.	Dose	**
	Sources * Dose	Ö.D.	Sources * Dose	***

Na_2SO_4: Sodium Sulfate; $MgSO_4$: Magnesium Sulfate; $MgCl_2$: Magnesium Chloride; NaCl: Sodium Chloride; $CaCl_2$: Calcium Chloride. N.S., Not Significant, $p \leq 0.05$: **, $p \leq 0.001$: *, CV: Coefficient of Variation

The effects of various salt concentrations on the leaf width of bean seedlings were evaluated, and a statistically significant difference was found in terms of the Sources factor ($p \leq 0.05$) (Table 2). The widest leaf length was recorded as 5.43 cm with $MgCl_2$ (50 ml/L), followed by NaCl (50 ml/L) (5.40 cm) and $MgSO_4$ (40 ml/L) (5.35 cm). The lowest leaf width was measured as 3.67 cm with $CaCl_2$ (40 ml/L).

When the effects of different salt sources and doses on the shoot fresh weight of bean seedlings were examined, no statistically significant difference was found in Sources and Sources*dosage interactions (Table 2). However, statistically significant differences were detected regarding dose ($p \leq 0.05$). Na_2SO_4 (1.46 g) provided the highest shoot fresh weight, followed by $MgCl_2$ (1.42 g) and $MgSO_4$ (1.22 g). The lowest shoot fresh weight was obtained with $CaCl_2$ (1.10 g). In studies by Karakullukçu (2008), it was reported that salt stress significantly reduced the fresh weight of plants. Fidan and Ekincialp (2020) obtained similar results and emphasized the effect of salt stress on root fresh weight. These findings are consistent with other studies in literature. Similarly, Aktaş and Kılıç (2013) investigated the effects of salt on soybean sprout (*Glycine max*) production and reported a significant decrease in shoot and root length as well as fresh weights with increasing NaCl concentration. Under 50 mM NaCl application, the shoot fresh weight decreased by 27% and root fresh weight by 60% in sensitive varieties, while these rates were approximately 15% and 6% in tolerant varieties, respectively. These findings align with previous studies, emphasizing the negative impacts of salt stress on plants.

Table 2. Effects of Different Salt Sources and Doses on Leaf Width (cm) and Shoot Fresh Weight (g) of Bean Seedlings

Çizelge 2. *Fasulye Fidelerinde Farklı Tuz Kaynakları ve Dozlarının Yaprak Genişliği (cm) ve Sürgün Yaş Ağırlığı (g) Üzerindeki Etkileri*

Factor		Means of Leaf Width (cm)	Factor	Shoot Fresh Weight
Sources	$MgSO_4$	4.91 a	Na_2SO_4	1.46
	NaCl	4.89 a	$MgCl_2$	1.42
	Na_2SO_4	4.78 ab	$MgSO_4$	1.22
	$MgCl_2$	4.58 ab	NaCl	1.18
	$CaCl_2$	4.12 b	$CaCl_2$	1.10
Dose	50 ml/L	4.87	50 ml/L	1.43 a
	60 ml/L	4.71	70 ml/L	1.42 a
	70 ml/L	4.58	60 ml/L	1.26 ab
	40 ml/L	4.46	40 ml/L	1.00 b
Sources * Dose Interaction	$MgCl_2$,50 ml/L	5.43	Na_2SO_4,70 ml/L	2.07
	NaCl,50 ml/L	5.40	$MgCl_2$,50 ml/L	1.73
	$MgSO_4$,40 ml/L	5.35	$MgCl_2$,70 ml/L	1.69
	Na_2SO_4,70 ml/L	5.23	$CaCl_2$,60 ml/L	1.64
	$MgSO_4$,60 ml/L	5.15	Na_2SO_4,60 ml/L	1.54
	$CaCl_2$,60 ml/L	5.10	$MgSO_4$,50 ml/L	1.53
	Na_2SO_4,50 ml/L	4.87	Na_2SO_4,50 ml/L	1.40
	NaCl,40 ml/L	4.83	NaCl,50 ml/L	1.36
	NaCl,70 ml/L	4.78	$MgCl_2$,40 ml/L	1.29
	Na_2SO_4,60 ml/L	4.77	NaCl,70 ml/L	1.26
	$MgSO_4$,50 ml/L	4.73	$MgSO_4$,70 ml/L	1.24
	$MgCl_2$,70 ml/L	4.67	$MgSO_4$,60 ml/L	1.21
	NaCl,60 ml/L	4.53	NaCl,40 ml/L	1.18
	$MgSO_4$,70 ml/L	4.40	$CaCl_2$,50 ml/L	1.13
	Na_2SO_4,40 ml/L	4.23	$MgCl_2$,60 ml/L	0.99
	$MgCl_2$,40 ml/L	4.20	NaCl,60 ml/L	0.92
	$MgCl_2$,60 ml/L	4.00	$MgSO_4$,40 ml/L	0.90
	$CaCl_2$,50 ml/L	3.90	Na_2SO_4,40 ml/L	0.85
	$CaCl_2$,70 ml/L	3.83	$CaCl_2$,70 ml/L	0.82
	$CaCl_2$,40 ml/L	3.67	$CaCl_2$,40 ml/L	0.80
General Information	CV (%)	12.89	CV (%)	32.12
	Sources	**	Sources	Ö.D.
	Dose	Ö.D.	Dose	**
	Sources * Dose	Ö.D.	Sources * Dose	Ö.D.

Na_2SO_4: Sodium Sulfate; $MgSO_4$: Magnesium Sulfate; $MgCl_2$: Magnesium Chloride; NaCl: Sodium Chloride; $CaCl_2$: Calcium Chloride. N.S., Not Significant, $p \leq 0.05$: **, $p \leq 0.001$: *, CV: Coefficient of Variation

Analyses of seedling water and dry matter content showed that Sources, dose, and Sources x dose interactions created statistically significant differences in these parameters ($p \leq 0.001$) (Table 4). The highest seedling water content was measured as 97% with $MgSO_4$ (40 ml/L), while the lowest was found as 82% with NaCl (60 ml/L). Similarly, the highest seedling dry matter content was measured as 18% with NaCl (60 ml/L), while the lowest was 3% with $MgSO_4$ (40 ml/L). The study by Kibar et al. (2020) also reported that salt stress decreased water content and increased dry matter content. These findings were consistent with the literature.

It was determined that Sources, dose, and Sources x dose interactions created statistically significant differences in leaf dry weight ($p \leq 0.001$) (Table 3). The highest leaf dry weight was obtained with $MgCl_2$ (60 ml/L) (0.86 g), while the lowest was observed with $CaCl_2$ (70 ml/L) (0.03 g). Differences in growth strategies among various genotypes may explain such variations in weight. Erdal et al. (2000) reported developmental regressions and reductions in plant weights in plants grown under salt stress. These findings are similar to those of our study.

When examining the effects of different salt sources and doses on chlorophyll content, it was determined that Sources and Sources x dose interactions created statistically significant differences in chlorophyll content ($p \leq 0.001$). The highest chlorophyll content was measured as 48.17 with $MgSO_4$ (40 ml/L), while the lowest chlorophyll content was found as 37.23 with $MgSO_4$ (70 ml/L) (Table 5). Acar et al. (2011) showed that chlorophyll content decreased in plants under salt stress.

Table 3. Effects of Different Salt Sources and Doses on Leaf Fresh Weight (g) and Leaf Dry Weight of Bean Seedlings

Çizelge 3. *Fasulye Fidelerinde Farklı Tuz Kaynakları ve Dozlarının Yaprak Yaş Ağırlığı (g) ve Yaprak Kuru Ağırlığı Üzerindeki Etkileri*

Factor		Means of Leaf Fresh Weight (g)		Factor	Leaf Dry Weight (g) ortalaması	
Sources	Na_2SO_4	0.42	a	$MgCl_2$	0.31	a
	NaCl	0.40	ab	Na_2SO_4	0.19	b
	$MgCl_2$	0.39	ab	NaCl	0.09	bc
	$MgSO_4$	0.37	ab	$MgSO_4$	0.09	bc
	$CaCl_2$	0.29	b	$CaCl_2$	0.06	c
Dose	50 ml/L	0.45	a	60 ml/L	0.33	a
	70 ml/L	0.39	ab	50 ml/L	0.11	b
	60 ml/L	0.37	ab	40 ml/L	0.07	b
	40 ml/L	0.30	b	70 ml/L	0.07	b
Sources * Dose Interaction	Na_2SO_4,70 ml/L	0.54	a	$MgCl_2$.60 ml/L	0.86	a
	$MgCl_2$,50 ml/L	0.54	ab	Na_2SO_4.60 ml/L	0.51	b
	NaCl,50 ml/L	0.50	ab	$MgCl_2$.50 ml/L	0.22	bc
	Na_2SO_4,50 ml/L	0.48	ab	NaCl.60 ml/L	0.11	c
	$MgCl_2$,70 ml/L	0.47	ab	$MgSO_4$.40 ml/L	0.10	c
	$CaCl_2$,60 ml/L	0.45	ab	$MgSO_4$.50 ml/L	0.10	c
	$MgSO_4$,50 ml/L	0.43	ab	Na_2SO_4.50 ml/L	0.10	c
	Na_2SO_4,60 ml/L	0.40	ab	NaCl.70 ml/L	0.10	c
	NaCl,40 ml/L	0.38	ab	$CaCl_2$.60 ml/L	0.10	c
	$MgSO_4$,60 ml/L	0.37	ab	NaCl.40 ml/L	0.10	c
	NaCl,70 ml/L	0.36	ab	Na_2SO_4.70 ml/L	0.09	c
	NaCl,60 ml/L	0.35	ab	$MgSO_4$.60 ml/L	0.09	c
	$MgSO_4$,40 ml/L	0.35	ab	$MgCl_2$.70 ml/L	0.08	c
	$MgSO_4$,70 ml/L	0.34	ab	Na_2SO_4.40 ml/L	0.06	c
	$MgCl_2$,40 ml/L	0.28	ab	$MgCl_2$.40 ml/L	0.06	c
	$CaCl_2$,50 ml/L	0.28	ab	$MgSO_4$.70 ml/L	0.06	c
	$MgCl_2$,60 ml/L	0.27	ab	$CaCl_2$.50 ml/L	0.05	c
	Na_2SO_4,40 ml/L	0.27	ab	NaCl.50 ml/L	0.05	c
	$CaCl_2$,70 ml/L	0.22	ab	$CaCl_2$.40 ml/L	0.05	c
	$CaCl_2$,40 ml/L	0.22	b	$CaCl_2$.70 ml/L	0.03	c
General Information	CV (%)	27.83		CV (%)	67.28	
	Sources	**		Sources	***	
	Dose	***		Dose	***	
	Sources * Dose	**		Sources * Dose	***	

Na_2SO_4: Sodium Sulfate; $MgSO_4$: Magnesium Sulfate; $MgCl_2$: Magnesium Chloride; NaCl: Sodium Chloride; $CaCl_2$: Calcium Chloride. N.S., Not Significant, $p \leq 0.05$: **, $p \leq 0.001$: *, CV: Coefficient of Variation

This finding aligns with the results of our research. Similarly, Aşcı and Zambi (2020) conducted a study investigating the effects of different salt concentrations (0, 25, 50, 75, 100, 125, and 150 mM) on chlorophyll and mineral content in some forage pea genotypes. The study determined that the genotype x salt dose interaction was statistically significant for many traits, including chlorophyll content. It was reported that salt stress decreased chlorophyll, phosphorus, potassium content, and the K/Na ratio, while calcium and sodium concentrations increased. Notably, the application of 150 mM salt significantly reduced chlorophyll content in the Töre and Ürünlü genotypes, whereas the SPAD values were not statistically affected in the Gölyazı genotype and the Çaybaşı population. Additionally, in the Turnasuyu population, SPAD values were observed to remain within the same group under salt applications up to 100 mM, but a significant decrease occurred when the dose was increased to 125 mM. Acar et al. (2011) reported that salt concentrations between 0-100 mM NaCl did not affect chlorophyll content in peas, while Najafi et al. (2006) found that 100 and 150 mM NaCl applications significantly reduced chlorophyll content compared to the control, with similar effects observed at these doses. Öztürk et al. (2012) stated that chlorophyll content in peas decreased as the salt dose increased. These findings in the literature also support the results of our study.

Table 4. Effects of Different Salt Sources and Doses on Seedling Water Content (%) and Seedling Dry Matter Content (%) of Bean Seedlings
Çizelge 4. *Fasulye Fidelerinde Farklı Tuz Kaynakları ve Dozlarının Fide Su İçeriği (%) ve Fide Kuru Madde İçeriği (%) Üzerindeki Etkileri*

Factor		Seedling Water Content (%) ortalaması		Factor	Means of Dry Matter Content (%)	
Sources	$MgSO_4$	88	a	NaCl	16	a
	$MgCl_2$	86	b	$CaCl_2$	16	a
	Na_2SO_4	85	c	Na_2SO_4	15	b
	$CaCl_2$	85	c	$MgCl_2$	15	b
	NaCl	84	e	$MgSO_4$	12	c
Dose	40 ml/L	86	a	50 ml/L	15	a
	70 ml/L	85	b	60 ml/L	15	a
	50 ml/L	85	b	70 ml/L	15	a
	60 ml/L	85	c	40 ml/L	14	b
Sources * Dose Interaction	$MgSO_4$.40 ml/L	97	a	NaCl.60 ml/L	18	a
	$MgCl_2$.50 ml/L	87	b	$CaCl_2$.40 ml/L	17	b
	$CaCl_2$.60 ml/L	86	c	$CaCl_2$.50 ml/L	17	b
	$CaCl_2$.70 ml/L	86	c	$MgSO_4$.50 ml/L	17	b
	$MgCl_2$.60 ml/L	86	c	$MgCl_2$.40 ml/L	17	b
	$MgCl_2$.70 ml/L	86	c	NaCl.70 ml/L	17	b
	Na_2SO_4.50 ml/L	86	c	Na_2SO_4.40 ml/L	17	b
	Na_2SO_4.70 ml/L	86	c	$MgSO_4$.60 ml/L	15	c
	$MgSO_4$.70 ml/L	86	c	Na_2SO_4.60 ml/L	15	c
	NaCl.40 ml/L	85	d	NaCl.40 ml/L	15	c
	$MgSO_4$.60 ml/L	85	d	NaCl.50 ml/L	15	c
	NaCl.50 ml/L	85	d	Na_2SO_4.70 ml/L	14	d
	Na_2SO_4.60 ml/L	85	d	$CaCl_2$.60 ml/L	14	d
	NaCl.70 ml/L	83	e	$CaCl_2$.70 ml/L	14	d
	$CaCl_2$.40 ml/L	83	e	$MgCl_2$.60 ml/L	14	d
	$CaCl_2$.50 ml/L	83	e	$MgCl_2$.70 ml/L	14	d
	$MgCl_2$.40 ml/L	83	e	$MgSO_4$.70 ml/L	14	d
	$MgSO_4$.50 ml/L	83	e	Na_2SO_4.50 ml/L	14	d
	Na_2SO_4.40 ml/L	83	e	$MgCl_2$.50 ml/L	13	e
	NaCl.60 ml/L	82	f	$MgSO_4$.40 ml/L	03	f
General Information	CV (%)	0.00		CV (%)	0.000001	
	Sources	***		Sources	***	
	Dose	***		Dose	***	
	Sources * Dose	***		Sources * Dose	***	

Na_2SO_4: Sodium Sulfate; $MgSO_4$: Magnesium Sulfate; $MgCl_2$: Magnesium Chloride; NaCl: Sodium Chloride; $CaCl_2$: Calcium Chloride. N.S., Not Significant, $p \leq 0.05$: **, $p \leq 0.001$: *, CV: Coefficient of Variation

4. Conclusion

This study revealed the effects of different salt types and doses applied to bean seedlings on plant growth parameters. Salt types and doses affected several growth parameters, such as shoot length, leaf length, leaf width, and shoot fresh and dry weight. $MgSO_4$ and Na_2SO_4 sources caused less damage to plant growth parameters, while $CaCl_2$ sources negatively affected plant growth. Generally, the 50 ml/L dose yielded the best results on plant growth. This study emphasizes the importance of ensuring optimal conditions when farming in saline soils. Furthermore, using salt-tolerant plant varieties could be an effective strategy to enhance agricultural productivity.

Table 5. Effects of Different Salt Sources and Doses on Chlorophyll Content of Bean Seedlings
Çizelge 5. *Fasulye Fidelerinde Farklı Tuz Kaynakları ve Dozlarının Klorofil İçeriği Üzerindeki Etkileri*

Factor	Chlorophyll Content		
Sources	$MgSO_4$	44.66	a
	$MgCl_2$	44.07	ab
	$CaCl_2$	43.28	ab
	Na_2SO_4	41.27	ab
	NaCl	40.87	b
Dose	60 ml/L	44.15	a
	40 ml/L	43.62	ab
	50 ml/L	42.39	ab
	70 ml/L	41.15	b
Sources * Dose Interaction	$MgSO_4$.40 ml/L	48.17	a
	$MgSO_4$.60 ml/L	47.57	ab
	$CaCl_2$.40 ml/L	46.93	abc
	$MgCl_2$.60 ml/L	46.40	abc
	$MgSO_4$.50 ml/L	45.67	abcd
	$MgCl_2$.40 ml/L	44.87	abcd
	Na_2SO_4.70 ml/L	44.20	abcd
	NaCl.60 ml/L	44.13	abcd
	$MgCl_2$.50 ml/L	43.10	abcd
	Na_2SO_4.50 ml/L	42.87	abcd
	$CaCl_2$.60 ml/L	42.60	abcd
	$CaCl_2$.70 ml/L	42.00	abcd
	$MgCl_2$.70 ml/L	41.90	abcd
	$CaCl_2$.50 ml/L	41.57	abcd
	NaCl.70 ml/L	40.40	abcd
	NaCl.40 ml/L	40.20	abcd
	Na_2SO_4.60 ml/L	40.07	abcd
	NaCl.50 ml/L	38.73	bcd
	Na_2SO_4.40 ml/L	37.93	cd
	$MgSO_4$.70 ml/L	37.23	d
General Information	CV (%)	6.90	
	Sources	***	
	Dose	**	
	Sources * Dose	***	

Na_2SO_4: Sodium Sulfate; $MgSO_4$: Magnesium Sulfate; $MgCl_2$: Magnesium Chloride; NaCl: Sodium Chloride; $CaCl_2$: Calcium Chloride. N.S., Not Significant, $p \leq 0.05$: **, $p \leq 0.001$: *, CV: Coefficient of Variation

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