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Effect of Salt Stress on Germination in Some Snap Bean (Phaseolus vulgaris L.) Genotypes Collected from Erzurum Region

Araştırma Makalesi

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Salinity, Genotype, Tolerance, Snap bean, Germination

Anahtar Kelimeler

Tuzluluk, Genotip, Tolerans, Taze fasulye, Çimlenme

Abstract

This study was carried out in laboratory conditions at the Atatürk University, Faculty of Agriculture, Department of Horticulture. In the research, 5 local snap bean genotypes (1:ERZ-TO-48, 2:ERZ-HN-78, 3:ERZ-TO-64, 4:ERZ-P5-117, 5:ERZ-OL-99) collected from the Erzurum region and 1 commercial variety (ALMAN AYŞE-6) were used as experimental material. The experiment was conducted with a completely randomized design comprising three replicates in three concentration levels (0, 75, and 150 mM) of sodium chloride (NaCl). Twenty-five seeds from each genotype were placed between filter paper in petri dishes (120 mm in diameter). Petri dishes added 10 ml of irrigation water were observed for 9 days at 25 °C and germinated seeds were recorded. The results of the study showed that the increase in salinity concentration caused a statistically significant decrease in seeds germination percentages, germination index, stem lengths, stem diameter, root lengths, seedling fresh and dry weights, except mean germination time. When the results were analyzed, it was determined that the local genotypes collected were more tolerant than the selected commercial cultivar. As a result, all parameters examined were decreased with increasing NaCl concentration.

Erzurum Yöresinden Toplanan Bazı Taze Fasulye (Phaseolus vulgaris L.) Genotiplerinde Çimlenme Üzerine Tuz Stresinin Etkisi

Özet

Bu çalışma, Atatürk Üniversitesi Ziraat Fakültesi Bahçe Bitkileri Bölümü'nde laboratuvar koşullarında gerçekleştirilmiştir. Araştırmada Erzurum yöresinden toplanan 5 yerel taze fasulye genotipi (1: ERZ-TO-48, 2: ERZ-HN-78, 3: ERZ-TO-64, 4: ERZ-P5-117, 5: ERZ-OL-99) ve 1 ticari çeşit (ALMAN AYŞE-6) deney materyali olarak kullanılmıştır. Çalışma, üç farlı tuz (0, 75 ve 150 mM NaCl) konsantrasyon seviyesinde üç tekerrürlü olarak tam şansa bağlı deneme planında gerçekleştirilmiştir. Her genotipten yirmi beş tohum, petri kaplarındaki (120 mm çapında) filtre kağıdı arasına yerleştirilmiş ve 10 ml sulama suyu ilave edilen petri kapları, 25 °C'de 9 gün boyunca gözlemlenerek, çimlenen tohumlar kaydedilmiştir. Çalışma sonuçları incelendiğinde, tuzluluk konsantrasyonundaki artışın ortalama çimlenme süresi dışında tohum çimlenme yüzdesi, çimlenme indeksi, gövde uzunluğu, gövde çapı, kök uzunluğu, fide taze ve kuru ağırlıklarında istatistiksel olarak anlamlı bir azalmaya neden olduğunu belirlenmiştir. Sonuçlar analiz edildiğinde, toplanan yerel genotiplerin kullanılan ticari çeşitten daha toleranslı olduğu tespit edildi. Sonuç olarak, incelenen tüm parametrelerin artan NaCl konsantrasyonu ile azaldığı tespit edilmiştir.

1. INTRODUCTION

The germination of seed is a complex process depending on the genetic and environmental factors, such as temperature, light, and salinity (Barbour, 1968). Salinity is one of the most environmental problems in arid and semi-arid regions. Salty soils contain soluble salts that prevent plant growth in different growth periods and play a restrictive role in the productivity of plants, their development in different periods, and some biochemical and physiological events occurring within plant (Güngör et al. 2017). Salinity as an abiotic stress factor adversely affects the plant growth and development, hindering seed germination (Dash and Panda, 2001).

There are significant differences in terms of physiological and metabolic changes between plant species and varieties and even organs in terms of salt response (Awank et al. 1993). The genetic diversity within a species presents a valuable opportunity for salinity tolerance studies. Bean (Phaseolus vulgaris L.) is one of the most important crops grown worldwide. Although it is not the primary gene center, Turkey is one of the most important countries in terms of genetic richness of bean (Ekincialp and Sensoy 2013; Kabay and Şensoy 2016). Many previous studies have carried that bean genotypes show a wide variation in terms of consumption characteristics and morphology (Sözen 2006; Fidan and Ekincialp 2017; Kıpçak et al., 2019). When compared to other plant species, legumes are among the most sensitive group to salinity and beans are reported to be one of the most sensitive species (Ashraf and Wu 1994; Fidan and Ekincialp 2017; Kıpçak et al., 2019). High salt level negatively affects the germination of the beans (Demir and Demir 1996; Fidan and Ekincialp 2017).

One of the applications that can be done to eliminate the negative effects of salinity in plants is to wash away the salts accumulated in the soil. However, this method is not preferred due to its high cost. Salt tolerance may vary according to the development period of the plant, the density and duration of the salt, climate and soil properties. There are differences between family, genus and species in terms of salt tolerance, and even differences are encountered between genotypes belonging to the same species (Greenway and Munns, 1980; Doğan et al. 2008). This indicates that genetic factors are the main source of salt tolerance as well as environmental factors and physiological effects (Koç 2005; Fidan and Ekincialp 2017). For this reason, another way to eliminate the negative effects of salinity is to grow salt-resistant plant species and varieties (Doğan et al. 2008; Fidan and Ekincialp 2017). The aim of the study is to determine the germination tolerance of local snap bean genotypes collected from Erzurum region at different salt levels. Genotype identified as tolerant towards to the salt levels can be recommended for direct cultivation.

2. MATERIALS AND METHODS

2.1. Material

This study was carried out in laboratory conditions at the Atatürk University, Faculty of Agriculture, Department of Horticulture. In the research, 5 local snap bean genotypes (1:ERZ-TO-48, 2:ERZ-HN-78, 3:ERZ-TO-64, 4:ERZ-PS-117, 5:ERZ-OL-99) collected from Erzurum region and 1 commercial variety (CV: ALMAN AYŞE-6) were used as plant material (Table 1).

Table 1. Geographical origins and genotype codes of snap bean landraces

G-No	G-code	District	Altitude (meters)	Coordinates	
				North	East
1	ERZ-TO-48	TORTUM	1524	40º 19',114"	41º 30',235"
2	ERZ-HN-78	HINIS	1591	39º 19',512"	41º 48',851"
3	ERZ-TO-64	TORTUM	1569	40º 18',036"	41º 71',719"
4	ERZ-PS-117	PASİNLER	1718	40º 1',136"	41º 45',511"
5	ERZ-OL-99	OLUR	1313	40º 45',917"	42º 10',528"

G:Genotype

2.2. Method

Germination experiments were carried out in petri dishes to determine the responses of genotypes to salt stress during germination. Twenty-five seeds from each genotype were placed between filter paper, according to the paper method, in petri dishes (120 mm in diameter). The experiment was conducted with a completely randomized design comprising three replicates in three concentration levels (0, 75, and 150 mM) of sodium chloride (NaCl). Petri dishes added 10 ml of corresponding NaCl concentrations were observed during 9 days (final germination) at 25 °C in the dark and germinated seeds were recorded. The germinated seeds were counted daily according to the seedling evaluation procedure described in the ISTA (International Seed Testing Association).

During the germination test, the mean germination time was determined by counting the seeds that germinated every 24 hours (if the rootlets were elongated by 2 mm, the seed was counted as germinated) (Ellis and Roberts, 1980). At the end of the 9th day, germination percentages were measured and then root length (mm), root diameter (mm), stem length (mm) and stem fresh weights (g) were determined in 10 samples randomly selected from each petri dish (Bilgili et al. 2018). Stem dry weights (g) were recorded by drying and weighing at 70 ° C for 48 hours of the samples fresh weighed. Germination indexes calculated according to the formula below by dividing the number of seeds that germinated every day by the count days (Maguire, 1962).

GI= n1/t1+n2/t2+ n3/t3….n/t

GI: Germination index;
n1; Number of seeds germinated on day 1;
t1: 1st day,
nt; number of seeds germinated in the last day,
nt; last day of germination.
All data in the present study were processed by SPSS and the means were separated by Duncan's multiple range tests.

3. RESULTS AND DISCUSSION

When the effects of NaCl applied in increasing concentrations on the germination properties of local snap bean genotype seeds collected from the Erzurum region were examined, it was observed that the germination rate and germination index of the seeds started to decrease significantly in the 75 mM NaCl concentration and these decreases were more pronounced in the 150 mM NaCl concentration. At the control application, the germination percentage and the germination index were recorded 90.56% and 4.40, respectively; whereas under 150 mM application 76.11% and 3.38 were recorded, respectively. All bean genotypes used in the study were obtained with a germination rate of 80% and above at the 75 mM salt concentration. And it has been determined that all genotypes and commercial bean variety (CV) can tolerate this concentration. Statistically, the effect of genotypes on germination rate and germination index was observed to be significant (($P < 0.001$). These findings were in line with the findings of Güngör et al. (2017). The highest germination rate with 98.22% and the highest germination index with 4.84 were determined in the genotype 5, (ERZ-OL-99). At the 150 mM salt concentration, the highest germination rate and germination index were determined in genotype 5 (90.67% and 4.32, respectively) (Table 2, Table 3). Our results verified with the study of Doğan et al. (2008) who stated that the highest germination percentage of tomato genotypes under control conditions. Similar results are obtained by many researchers who reported that germination percentages decreased with increasing salt doses (Atış, 2011; Uyanık et al. 2014; Doğan and Çarpıcı, 2016; Güngör et al. 2017).

In the study, it was determined that the effect of genotypes on mean germination time was statistically significant ($p < 0.001$), whereas the effects of applications on mean germination time were not statistically significant ($p > 0.05$) (Table 4). The highest average germination time with 5.09 days, was determined in the genotype 5, ERZ-OL-99, and it was statistically included in the same statistical group with the genotype 1, 2, 3 and 4. The lowest germination time with 4.65 days was determined in CV (Table 4). Rush et al. (2000) emphasized that the most harmful effect of salty conditions is seen in the germination period and that high salt concentrations significantly inhibit germination.

As a result of the evaluation of root and shoot length parameters, it was determined that there were statistically significant differences between both in applications and in genotypes (Table 5, Table 6). Application of 150 mM salt negatively affected the root and shoot lengths of all genotypes according to the percentage change rates in the control group (Table 5, Table 6). In addition, according to the findings of the study conducted by Güngör et al. (2017), root length is significantly shortened as a result of increasing salt concentrations. Increased salt concentrations degraded germination, and germination was severely affected at high concentrations (Sönmez and Kaplan 1997; Cuartero and Fernandez-Munoz (1999). Negative effects of shoot length have been reported in many plant species such as beans (Kaya 2011; Fidan and Ekincialp., 2017), melon (Kuşvuran 2010), and many plant species grown under salt application, with increasingthe salt application and increased salt dose.It has been determined that there were statistically significant differences in stem diameter both in applications and between genotypes. It was observed that genotype 1 and 2 were the most affected and CV was the least affected. In the application of 150 mM salt, reductions were observed in shoot diameter of all genotypes and genotype 1 was the most affected (Table 7). Takagi et al. (2009) reported that salt stress in tomatoes causes negative effects on plant development and causes a decrease in stem diameter. Atak (2014) reported that increasing salt doses have more negative effects on shoot development. Our study results were found to be consistent with these findings.

Among the genotypes, the highest stem fresh weight (1.159 g) and stem dry weight (0.127 g) were obtained from genotype number 3. Genotype number 3 and 4 were in the same statistical group. Increased salt concentrations had negative effects on stem fresh and dry weights; furthermore and as salt concentration increased, fresh and dry weights decreased with increasing salt concentration (Table 8, Table 9). Atak (2014) and Güngör et al. (2017) reported that increasing salt doses had more negative effects on shoot development. Seemann and Critchley (1985) stated that there is a decrease in the fresh and dry weights of the plant as a result of the application of 150 Mm salt on the beans. Our study results were found to be parallelin line with these findings.4. Conclusion

As a result of the research, it was determined that the increase in salt concentrations significantly decreased the germination percentage of the local snap bean genotypes collected from the Erzurum region. However, germination losses that occurred with the increase in salt

Table 2. Germination percentage (%) of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	91.33a***	92.00 a*	84.67a***	92.00 ns	100.00ns	83.33ns	**90.56A*** **
75 mM	81.33 b	90.00 a	80.00 a	86.67	100.00	80.67	**86.44 B**
150 mM	76.00 c	81.67 b	62.33 b	81.33	94.67	60.67	**76.11 C**
Mean	**82.89C*** **	**87.89 B**	**75.67 D**	**86.67 B**	**98.22 A**	**74.89 D**	**84.37**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6.
Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

Table 3. Germination index of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	4.41a***	4.97 a*	4.16 a**	4.59 a**	5.22a***	3.03 ns	**4.40A*** **
75 mM	3.72 b	4.53 a	3.85 a	4.36 a	4.99 b	2.82	**4.04 B**
150 mM	3.02 c	3.70 b	2.84b	3.75 b	4.32 c	2.66	**3.38 C**
Mean	**3.72C*** **	**4.40 B**	**3.62 C**	**4.23 B**	**4.84 A**	**2.84 D**	**3.94**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6. Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

Table 4. Mean germination time (day) of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	5.12^{ns}	4.70^{ns}	4.90 ^{ns}	4.83 ^{ns}	4.84 b**	4.78 ^{ns}	**4.86^{ns}**
75 mM	5.01	5.20	4.53	5.17	5.03 b	4.41	**4.89**
150 mM	4.84	5.01	4.80	4.92	5.41 a	4.77	**4.96**
Mean	**4.99AB*****	**4.97 AB**	**4.74 AB**	**4.97 AB**	**5.09 A**	**4.65 B**	**4.90**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6. Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

Table 5. Root lengths (mm) of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	46.53a***	42.22 a*	34.07 a*	70.17a***	64.36a***	63.57a***	**53.49A*****
75 mM	28.54 b	40.11 a	34.70 a	48.33 b	60.92 a	40.00 b	**42.10 B**
150 mM	15.58 c	23.72 b	21.08 b	25.82 c	19.46 b	21.27 c	**21.16 C**
Mean	**30.22D*****	**35.35 C**	**29.95 D**	**48.11 A**	**48.24 A**	**41.61 B**	**38.91**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6. Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

Table 6. Stem length (mm) of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	13.41 a*	13.31^{ns}	12.94a***	13.08 a**	12.31a***	34.06a***	**16.52A*****
75 mM	12.44 a	12.25	11.57 b	11.67 a	9.22 b	27.77 b	**14.15 B**
150 mM	9.62 b	11.76	10.32 c	9.40 b	8.71 b	21.99 c	**11.97 C**
Mean	**11.82B*****	**12.44 B**	**11.61 B**	**11.38 B**	**10.08 C**	**27.94 A**	**14.21**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6. Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

Table 7. Stem diameter (mm) of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	3.04 a***	2.82^{ns}	2.71 ab*	3.08 a***	3.13 a*	2.99^{ns}	**2.96 A*****
75 mM	2.75 b	2.66	2.96 a	2.61 b	2.65 b	2.99	**2.77 B**
150 mM	2.26 c	2.58	2.53 c	2.65 b	2.53 b	2.76	**2.55C**
Mean	**2.68 C***	**2.69 C**	**2.73 AB**	**2.78 AB**	**2.77 AB**	**2.91 A**	**2.76**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6. Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

Table 8. Seedling fresh weight (mm) of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	1.124^{ns}	1.085 a*	1.116^{ns}	1.114^{ns}	1.035^{ns}	1.134 a**	**1.102A*****
75 mM	0.984	0.969 b	1.186	1.130	1.013	1.025 a	**1.051 B**
150 mM	0.983	0.934 b	1.174	1.062	0.963	0.841 b	**0.993 C**
Mean	**1.030B*****	**0.996 B**	**1.159 A**	**1.102 A**	**1.004 B**	**1.000 B**	**1.048**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6. Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

Table 9. Seedling dry weight (mm) of five snap bean genotypes germinated under different NaCl treatments

Treatment	1	2	3	4	5	CV	Mean
0 Mm	0.124 a**	0.115 a*	0.123 ns	0.123 ns	0.114 ns	0.114 a *	**0.119A** ***
75 mM	0.108 b	0.107 ab	0.130	0.124	0.112	0.113 a	**0.116 A**
150 mM	0.102 b	0.103 b	0.129	0.117	0.106	0.092 b	**0.108 B**
Mean	**0.111B*** **	**0.108 B**	**0.127 A**	**0.121 A**	**0.110 B**	**0.106 B**	**0.114**

1: ERZ-TO-48; 2: ERZ-HN-78; 3:ERZ-TO-64; 4: ERZ-PS-117; 5: ERZ-OL-99; CV: ALMAN AYŞE-6. Values with same letter (A,B,C or a,b,c) are not significantly different (P<0.05), between samples.

dose differed according to the genotypes. The genotype 5, which shows high germination ability at 150 mM concentration, draws attention. It can be recommended to use genotype no. 5 with such high germination performance in medium saline soils, as it would be more advantageous. In this context, the results obtained from our study can contribute to the breeding studies on this subject in terms of material.

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