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Influence of salinity levels on vegetative development of landrace dwarf common bean (*Phaseolus vulgaris* L.) Genotypes

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ABSTRACT

In this study, plant growth parameters of 16 landrace dwarf common bean genotypes collected from Western Mediterranean region of Turkey at different salinity levels were investigated. The salt concentrations were applied 0.5 (regular irrigation water), 2, 4 and 6 dSm^{-1}. The study continued until the first flowering was observed in the plants. The results of analysis of the variance revealed significant variations among different salinity levels, genotypes and interaction effects of salinity levels × genotypes for morphological characters. According to statistical analysis results, there was no correlation between stem diameter and other morphological characters. It was determined that there was a statistically significant positive strong correlation between plant height and plant dry weight (r=0.703). There was a moderately statistically significant positive correlation between all other characters. The increased salinity level negatively affected the vegetative growth of the common bean genotypes. However, low doses of salt have promoted development in some genotypes (AGB10, AGUN25, BY4, BY24, IYOZ10). However, a slight increase in salt level caused a sudden drop in development. These genotypes are thought to be suitable for soils with low salinity. The genotypes gave different responses to salt stress and ISGA1 and ISGA10 genotypes gave the best results. Besides them, prominent genotypes were detected as AGUN6, BKARA2, AGB10 and IYOZ10.

Contribution/ Originality

Since pre-screening allows for the separation of genotypes at the early stage of plant development, it will provide labour and financial savings for a large-scale breeding programme. Authors decelerated that the manuscript has never been published before or currently submitted anywhere.

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1. INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is an important plant for sustainable agriculture that can be grown in all continents except Antarctica. Being sensitive to biotic and abiotic stress conditions is one of the reasons why average the yield still does not reach the desired level. Salinity is one of the most important abiotic stresses that limits agricultural production in the world. It is estimated that over 6% of all agricultural land and about 20% of the world's irrigated land is impacted by salinity and sodicity (Chemura *et al.*, 2014). Loss of yield of common bean occurs after the value of 1 dSm^{-1} salinity. The yield for unit salinity increase is reduced by 19% (Hoffman *et al.*, 1992). In this case, 50% yield loss occurs in common beans at 4 dSm^{-1} soil salinity levels. It is possible to improve the soil salinity, which causes significant losses in agricultural production, by some methods. Hydraulic practices, physical/mechanical management, chemical practices and biological practices are methods that can be used to control salinity. The difficulty of implementing measures that can be taken against soil salinity, the long time required to see the effect and the expense limit the use of these practices. Along with these measures, the introduction of genotypes resistant to salt stress and their breeding offer more permanent and effective solutions. In this context, the abundance of salt-resistant gene sources offers great opportunities for the development of salt-resistant varieties. Having a large number of salt-tolerant gene sources is only possible by examining much more genotypes (Epstein *et al.*, 1980; Foolad, 1996; Moud and Maghsoudi, 2008; FAO, 2017).

Landrace genotypes, one of the important genetic resources, are crucial in terms of food security, breeding studies and sustainable genetic diversity. They are important sources for stress studies, which have been well adapted to the soil and climatic conditions of the region where they grow. Observations on common bean-cultivated fields show that there are significant differences in plant growth, pod and grain yields of different bean genotypes under salt stress conditions. This difference in the same species seems to be related to the differences in genotypes' adaptation mechanisms to saltiness (Costa *et al.*, 2000). For this reason, the collection of landrace common bean genotypes adapted to specific regions and the determination of salt tolerance are great importance both for the prevention of genetic erosion and for the economic evaluation of these genotypes.

In this study, it was aimed to determine the salinity levels of landrace common bean genotypes during early development period by examining the plant development criteria. Since pre-screening allows for the separation of genotypes at the early stage of plant development, it will provide labour and financial savings for a large-scale breeding programme.

2. MATERIALS AND METHODS

In this study, plant growth parameters of 16 landrace dwarf bean genotypes collected from Western Mediterranean region of Turkey at different salinity levels were investigated. This study was carried out Batı Akdeniz Agricultural Research Institute (BATEM), in Antalya, Turkey. The geographical coordinates of the study area was located at a latitude of 36 56' N and a longitude of 30 53' E, and an altitude of 28 m.

Sixteen landrace dwarf bean genotypes were irrigated with tap water (EC: 0.50 dSm^{-1} and pH: 6.5) for 2 weeks and then salt application began. Plants were irrigated every 2 days with 5 different saline water treatments. The saline waters were arranged by adding NaCl, $CaCl_2$ and $MgCl_2$ salts into tap water. Irrigation water sodium adsorption ratio (SAR) values were maintained less than 5 in order to eliminate the adverse effect of SAR. Salinity levels having different concentrations of 2, 4, and 6 dSm^{-1}, as measured by electrical conductivity, were prepared using salt source of NaCl, $MgCl_2$ and $CaCl_2$. Tap water is used for control treatment. Quality parameters of irrigation water used in the study were given in Table 1.

The study continued until the first flowering was observed in the plants. In the plants harvested after the first flowering; plant height (cm), root length (cm), plant fresh and dry weight (g), leaf width and length (cm) and stem diameter (cm). Statistical analyses of obtained data were held in accordance with Variance Analysis (ANOVA), Least Significant Difference and correlation analysis. SAS-9.1 computer programs were used in analysis.

Table 1: Quality parameters of irrigation water

EC	pH	Anions (me l^{-1})				Cations (me l^{-1})				SAR
dS m^{-1}		Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4	
0.5	6.5	0.60	0.05	3.33	1.40	-	4.01	1.26	0.10	0.39
2.0	7.6	8.00	0.07	8.64	7.52	-	3.66	14.50	6.07	2.82
4.0	7.5	15.70	0.08	15.15	15.52	-	4.51	23.00	18.94	4.00
6.0	7.6	26.82	0.09	33.84	28.00	-	5.02	51.45	32.28	4.82

3. RESULTS AND DISCUSSION

In order to determine the salt tolerance levels of the landrace dwarf common bean genotypes, 4 different salinity levels were applied and primarily the changes that occurred in the plants' growth as a result of these applications were evaluated. The effects of different salinity levels plant dry weight of landrace dwarf common bean genotypes are presented in Table 2. Statistical analysis of the data indicated that salinity levels and genotypes had a significant ($p \leq 0.05$) effect on plant dry weight.

Table 2: Effects of salinity levels on plant dry weight (g) of landrace dwarf common bean genotypes

Genotypes	Salinity Levels (dS m^{-1})				Genotypes average
	0.5	2.0	4.0	6.0	
ADY4	7.94 EF	6.59 HJ	4.65 TU	1.67 D	5.21 fgh
% Difference	0.0	-17	-41,4	-79	
AGB1	12.29 A	8.61 D	7.49 FG	2.97 bc	7.84 b
% Difference	0.0	-30	-39	-75,8	
AGB5	6.22 IN	7.51 FG	5.75 MQ	5.28 PS	6.19 de
% Difference	0.0	-20,6	-7,7	-15,1	
AGB10	5.48 OS	5.25 QT	5.11 RT	3.09 Zab	4.73 j
% Difference	0.0	-4,1	-6,8	-43,6	
AGUN6	6.45 IL	17.39 FG	5.97 JO	5.55 OR	6.34 d
% Difference	0.0	14,6	-7,4	-13,9	
AGUN19	5.83 LQ	6.66 HI	4.36 UW	3.05 ac	4.97 hıj
% Difference	0.0	14,4	-25,2	-47,7	
AGUN25	6.64 HI	6.76 HI	4.63 TV	2.42 c	5.12 ghı
% Difference	0.0	1,8	-30,3	-63,5	
BKARA1A	6.36 IM	9.59 B	4.01 VX	1.53 d	5.37 fg
% Difference	0.0	50,7	-37	-76	
BKARA2	4.46 UV	4.38 UW	4.40 UW	3.69 XZ	4.23 k
% Difference	0.0	-1,7	-1,3	-17,1	
BY4	6.46 IK	6.50 HK	5.20 NR	3.19 Yb	5.44 f
% Difference	0.0	0,7	-13	-50,6	
BY24	5.29 PS	7.59 FG	3.63 Xa	3.07 ab	4.90 ıj
% Difference	0.0	43,4	-31,5	-42,1	
ISGA1	9.51 BC	11.81 A	8.89 CD	6.74 HI	9.23 a
% Difference	0.0	24,2	-6,5	-29,1	
ISGA7	8.55 DE	3.71 XZ	2.77 bc	1.17 d	4.05 k

% Difference	0.0	-56,6	-67,7	-86,4	
ISGA10	6.31 IM	7.11 GH	5.35 OS	4.85 SU	5.91 e
% Difference	0.0	12,8	-15,2	-23	
IYOZ10	5.25 QT	7.96 EF	3.78 WY	3.37 Yb	5.09 ghı
% Difference	0.0	51,6	-28,1	-35,8	
IYOZ14	8.55 DE	9.87 B	5.87 KP	4.90 SU	7.30 c
% Difference	0.0	15,4	-31,2	-42,7	
Salinity average	6.97 b	7.33 a	5.14 c	3.53 d	
LSD%5genotype: 0.1559 LSD%5salinity: 0.3117		LSD%5genotypexsalinity: 0.6234			
Genotype (G): * Salt concentration (S): * GXS: *					

Means with different letters in the same lines are significantly different at P≤ 0.05 by LSD test
*Statistically significant at 5% level

Landrace common bean genotypes were found to give different responses to applied salinity levels. Plant dry weight of some genotypes were not affected by 2 dSm^{-1} salinity level, furthermore this level of salt has increased plant dry weights of them. The lowest decrease in plant dry weight was observed in the genotypes of BKARA2 (1.7%) and AGB10 (4.1%) and the highest decrease was in ISGA7 (56.6%) genotype in 2 dSm^{-1} application. At the same salinity level, the highest dry weight increment was detected in IYOZ10 (51.6%), BKARA1A (50.7%) and BY24 (43.4%) genotypes. When the salt level was increased to 4 dSm^{-1}, the dry weight of all genotypes decreased. The most affected genotypes were ADY4 (41.4%) and ISGA7 (67.7%) while the least affected genotypes were BKARA2 (1.3%), ISGA1 (6.5%), AGB10 (6.8%), AGUN6 (7.4%) and AGB5 (7.7%) respectively. The rate of influence of dry weights at 6 dSm^{-1} salinity level increased as expected and this ratio reached to 86.4% in ISGA7 genotype. AGUN6 (13.9%), AGB5 (15.1%) and BKARA2 (17.1%) genotypes were least affected genotypes.

Common bean is a salt sensitive species and the dry weight values (both plant and root) of the landrace common beans genotypes varied according to the genetic structure of them. When the genotypes showing dry weight increase at 2 dsm^{-1} salinity were examined among themselves, it was determined that, unlike the findings of Bayuelo-Jim'enez *et al.* (2012), the tolerance of low dose salinity levels was not compatible with the high dose applications. Bayuelo-Jim'enez *et al.* (2012) reported that the best growing genotypes in control practice also gave the best results in salt applications. In this study, dry weights of AGUN6 and BKARA2 genotypes were gradually decreased and it was determined that these genotypes were least affected genotypes in terms of plant dry weight. Taïbi *et al.* (2016) reported that the two bean genotypes they worked with were severely reduced in root and shoot dry weights at high salinity levels. However, they found that the low-yielding variety was more affected by salt stress. Bayuelo-Jim'enez *et al.* (2012) reported that the final biomass production was reduced by 47 to 72% for salt-sensitive genotypes and by 58 to 61% for salt-tolerant genotype.

The effects of different salinity levels on plant fresh weight of landrace dwarf common bean genotypes are given in Table 3. It was determined that genotypes, salinity levels, and interaction of genotypes-salinity levels are significant at 0.5 % confidence level.

Table 3: Effects of salinity levels on plant fresh weight (g) of landrace dwarf common bean genotypes

Genotypes	Salinity Levels (dS m^{-1}) 0.5	2.0	4.0	6.0	Genotypes average
ADY4	83.00 E	59.68 IL	49.00 PR	46.33 QS	59.50 c
% Difference	0.0	-28	-41	-44	
AGB1	76.00 F	53.00 MP	45.00 RS	15.00 Z	47.25 f
% Difference	0.0	-30	-41	-80	
AGB5	49.67 OR	49.67 OR	36.33 T	29.00 VX	41.17 h
% Difference	0.0	0.00	-27	-42	
AGB10	36.33 T	42.33 S	34.67 TU	27.00 WX	35.08 ı
% Difference	0.0	17	-5	-26	
AGUN6	87.67 CE	56.33 KM	53.00 MP	26.33 WX	55.83 d
% Difference	0.0	-36	-40	-70	
AGUN19	69.00 GH	62.33 IJ	61.00 IK	33.33 TV	56.42 d
% Difference	0.0	-10	-12	-52	
AGUN25	35.33 T	35.33 T	21.33 Y	14.67 Z	26.68 k
% Difference	0.0	0.00	-40	-58	
BKARA1A	83.68 DE	72.67 GF	34.00 TU	14.33 Z	51.17 e
% Difference	0.0	-13	-59	-83	
BKARA2	33.33 TV	32.33 TV	30.33 UW	27.00 WX	30.75 j
% Difference	0.0	-3	-9	-19	
BY4	51.33 NP	35.67 T	32.33 TV	26.33 WX	36.42 ı
% Difference	0.0	-31	-37	-49	
BY24	64.33 HI	53.33 MP	32.67 TV	29.00 VX	44.83 g
% Difference	0.0	-17	-49	-55	
ISGA1	76.00 F	112.00 A	71.00 G	54.00 MO	78.25 a
% Difference	0.0	47	-7	-29	
ISGA7	102.68 B	55.00 LN	33.00 TV	26.00 WY	54.17 d
% Difference	0.0	-46	-68	-75	
ISGA10	57.67 JM	59.00 JL	45.33 RS	35.67 T	49.48 ef
% Difference	0.0	2	-21	-38	
IYOZ10	92.00 C	88.33 CD	42.33 S	27.00 WX	62.42 b
% Difference	0.0	-4	-54	-71	
IYOZ14	73.00 FG	51.00 MP	43.00 S	24.67 XY	47.92 f
% Difference	0.0	-30	-41	-66	
Salinity average	66.94 a	57.38 b	41.52 c	28.48 d	
LSD%5genotype: 2.4008 LSD%5salinity: 1.2004		LSD%5genotypex salinity: 4.8016			
Genotype (G): * Salt concentration (S): * GXS: *					

Means with different letters in the same lines are significantly different at P≤ 0.05 by LSD test
*Statistically significant at 5% level

The change in plant fresh weights was observed after a concentration of salt of 4 dSm^{-1}, similar to that of the plant dry weight. At 2 dSm^{-1} salt level, it was determined that there were genotypes that showed no change (AGB5, AGUN25) or elevation (ISGA1, ISGA10) in plant fresh weight (Table 3). The highest weight loss occurred in ISGA7 (68%), IYOZ10 (54%) and BY24 (49%) genotypes at 4 dSm^{-1} salt level. It was determined that BKARA1A (83%), AGB1 (80%), ISGA7 (75%), IYOZ10 (71%) and AGUN6 (70%) were the most affected genotypes in 6 dSm^{-1} salinity level. At the end of the experiment, the genotypes that occur at least a decrease in the plant fresh weight; BKARA2 (19%), AGB10 (26%) and ISGA1 (29%).

The analysis of variance results for plant height and root length of genotypes were presented in Table 4 and 5. Data showed differing responses of the genotypes to increasing salinity levels and it was also showed that the genotypes responded differently to increasing salinity levels than control.

Table 4: Effects of salinity levels on plant height (cm) of landrace dwarf common bean genotypes

Genotypes	Saliniy Levels (dS m^{-1}) 0.5	2.0	4.0	6.0	Genotypes average
ADY4	176.00 E	190.00 C	156.67 FG	115.66 RT	159.58 a
% Difference	0.0	8	-11	-34	
AGB1	103.33 WY	107.00 UW	84.33 de	77.68 fg	93.08 h
% Difference	0.0	4	-18	-25	
AGB5	183.00 D	211.67 A	110.667 TV	105.00 VX	152.58 b
% Difference	0.0	16	-40	-43	
AGB10	141.00 IJ	154.00 GH	123.00 OQ	87.00 cde	126.25 e
% Difference	0.0	9	-13	-38	
AGUN6	158.00 FG	154.67 FH	142.66 I	102.33 WY	139.42 c
% Difference	0.0	-2	-10	-35	
AGUN19	200.67 B	160.00 F	153.33 GH	91.00 ac	151.25 b
% Difference	0.0	-20	-24	-55	
AGUN25	97.67 YZ	131.33 LM	47.58 l	33.00 m	77.42 ı
% Difference	0.0	34	-51	-66	
BKARA1A	140.67 IK	149.33 H	124.0 NP	122.00 OQ	134 d
% Difference	0.0	6	-12	-13	
BKARA2	98.00 YZ	93.68 ab	59.67 k	34.33 m	71.42 j
% Difference	0.0	-4	-39	-65	
BY4	98.00 YZ	120.66 OR	88.00 bcd	62.00 jk	92.17 h
% Difference	0.0	23	-10	-37	
BY24	84.00 de	74.00 gh	71.67 ghı	67.67 ıj	74.33 ıj
% Difference	0.0	-12	-15	-19	
ISGA1	134.66 KL	133.67 L	130.00 LN	117.66 QS	129 e
% Difference	0.0	-1	-3	-13	
ISGA7	98.00 YZ	81.33 ef	70.68 hı	35.00 m	71.25 j
% Difference	0.0	-17	-28	-64	
ISGA10	104.66 VX	119.00 PR	94.68 Za	75.00 gh	98.33 g
% Difference	0.0	14	-10	-28	
IYOZ10	99.70 XZ	112.33 TU	89.00 ad	87.68 bd	97.18 g
% Difference	0.0	13	-11	-12	
IYOZ14	135.67 JL	126.66 NO	102.33 WY	77.00 fg	110.42 f
% Difference	0.0	-7	-25	-43	
Salinity average	128.31 b	132.46 a	103.02 c	80.63 d	
$LSD_{\%5}$genotype: 3.1221		$LSD_{\%5}$genotypex salinity: 6.2442			
$LSD_{\%5}$salinity: 1.561					
Genotype (G): * Salt concentration (S): * GXS: *					

Means with different letters in the same lines are significantly different at P≤ 0.05 by LSD test
*Statistically significant at 5% level

Statistical analysis of the data indicated that salinity levels and genotypes had a significant ($p \leq 0.01$) effect on plant height. As shown in Table 4, the highest plant height value was obtained from 2 dSm^{-1} level of the AGB5 genotype with 211.67 cm and the lowest value was obtained from 33.00 cm from 6.0 dSm^{-1} level of the AGUN25 genotype. As in the case of plant fresh and dry weight, 2 dSm-

1 administration has stimulating effect on some plants, and about 10-20% height increase has occurred. Similarly, increasing the applied level to 4 dSm^{-1} caused plant height to decrease by inserting stress. The highest decrease in plant height at 4 dSm^{-1} salinity level occurred in AGUN25 (51%) and AGB5 (40%) genotypes. At 6 dSm^{-1} level; AGUN25 (66%), BKARA2 (65%), ISGA7 (64%) and AGUN19 (55%) were found to be the genotypes most exposed to decrease in plant height.

Table 5: Effects of salinity levels on root length (cm) of landrace dwarf common bean genotypes

Genotypes	Salinity Levels (dS m^{-1}) 0.5	2.0	4.0	6.0	Genotypes average
ADY4	155.73 D	151.43 D	146.10 E	135.03 G	147.08 a
% Difference	0.0	-3	-6	-13	
AGB1	58.60 W	30.40 ab	29.66 ab	26.46 bc	36.28 k
% Difference	0.0	-48	-49	-55	
AGB5	103.83 L	119.97 I	81.03 PQ	31.90 Za	84.18 f
% Difference	0.0	16	-22	-69	
AGB10	56.57 W	83.43 OP	40.70 Y	33.87 Za	53.64 j
% Difference	0.0	47	-28	-40	
AGUN6	153.07 D	105.87 KL	75.36 RT	65.20 V	99.88 e
% Difference	0.0	-31	-51	-57	
AGUN19	94.57 N	75.87 RS	71.73 SU	70.90 TU	78.27 g
% Difference	0.0	-20	-24	-25	
AGUN25	127.17 H	145.43 EF	120.17 I	70.63 TU	115.85 d
% Difference	0.0	14	-6	-44	
BKARA1A	145.90 E	140.60 F	110.47 JK	76.03 RS	118.25 d
% Difference	0.0	-4	-24	-48	
BKARA2	75.07 RT	81.33 PQ	31.30 Zb	22.27 c	52.49 j
% Difference	0.0	8	-58	-70	
BY4	84.50 OP	55.66 W	47.53 X	38.97 Y	56.67 ı
% Difference	0.0	-34	-44	-54	
BY24	161.07 C	155.83 D	114.90 J	101.33 LM	133.28 c
% Difference	0.0	-3	-29	-37	
ISGA1	174.03 B	102.87 LM	98.40 MN	95.07 N	117.59 d
% Difference	0.0	-41	-43	-45	
ISGA7	121.20 I	73.13 RU	68.90 UV	36.00 Y	74.81 h
% Difference	0.0	-40	-43	-70	
ISGA10	122.90 HI	87.37 O	76.70 QR	55.16 W	85.53 f
% Difference	0.0	-29	-38	-55	
IYOZ10	180.70 A	151.30 D	123.43 HI	112.47 J	141.98 b
% Difference	0.0	-16	-32	-38	
IYOZ14	154.03 D	87.40 O	81.23 PQ	77.77 QR	100.11 e
% Difference	0.0	-43	-47	-50	
Salinity average	123.06 a	102.99 b	82.35 c	65.57 d	
LSD%5genotype: 2.4489		LSD%5genotypex salinity: 4.8977			
LSD%5salinity: 1.2244					
Genotype (G): * Salt concentration (S): * GXS: *					

Means with different letters in the same lines are significantly different at P≤ 0.05 by LSD test
*Statistically significant at 5% level

The effects of different salinity levels on the root length of the landrace dwarf common bean genotypes were given in Table 5. As seen in the table, the root lengths of AGB10, AGB5, AGUN25 and BKARA2 genotypes at 2 dSm^{-1} levels increased. However, the root lengths of all genotypes decreased after salinity level rise. In particular, a very serious decrease in the BKARA2 genotype (%58) has occurred. On the other hand, it appears that the root length of the ADY4 genotype declined slightly, and the genotype was the least recorded with a decrease of 13%. AGUN19 (25%) was the other genotype with a minimum root length reduction at 6 dSm^{-1} level. ADY4 (6%) and AGUN25 (6%) genotypes came into prominence at 4 dSm-1 level.

When the plant height and root length were examined together, it was observed that the root length was more affected by the stress conditions. It was noteworthy that genotypes gave the best results in terms of plant height were not affected too much decreasing root length of them. Similar to the results of the study, negative effects of salt stress on many plant height have been reported such as pumpkin (Yetişir and Uygur, 2009), rapeseed (Rameeh and Gerami, 2015), faba bean (Abdul, 2011), tomato (Oztekin and Tuzel, 2011) and canola (Bybordi, 2010).

The impact of different salinity levels on leaf width, leaf length and stem diameter of landrace dwarf common bean genotypes were significant at 0.5% confidence levels (Table 6, 7, 8).

Table 6: Effects of salinity levels on leaf width (cm) of landrace dwarf common bean genotypes

Genotypes	Salinity Levels ($dS\ m^{-1}$)				Genotypes average
	0.5	2.0	4.0	6.0	
ADY4	87.00 FGH	99.03 AB	88.00 EH	58.67 SU	83.18 a
% Difference	0.0	14	1	-33	
AGB1	71.07 OP	68.20 PQ	47.83 XY	32.07 c	54.79 g
% Difference	0.0	-4	-33	-55	
AGB5	95.80 AC	81.47 IK	77.97 KM	54.70 UW	77.48 b
% Difference	0.0	-15	-19	-43	
AGB10	61.63 RS	64.83 QR	44.93 YZ	40.73 Za	53.03 g
% Difference	0.0	5	-27	-34	
AGUN6	61.77 RS	69.10 PQ	57.57 SV	42.43 Za	57.72 f
% Difference	0.0	12	-7	-31	
AGUN19	57.57 SV	52.73 VW	51.80 WX	10.03 d	43.03 h
% Difference	0.0	-8	-10	-83	
AGUN25	79.83 IL	80.90 IK	74.83 MO	53.53 VW	72.28 c
% Difference	0.0	1	-6	-33	
BKARA1A	74.87 MO	72.10 OP	59.53 SU	44.30 Ya	62.70 e
% Difference	0.0	-4	-20	-41	
BKARA2	92.10 CE	70.77 OP	39.87 ab	35.87 bc	59.65 f
% Difference	0.0	-23	-57	-61	
BY4	77.00 KN	88.20 DG	60.77 RT	41.53 Za	66.88 d
% Difference	0.0	15	-21	-46	
BY24	100.00 A	83.93 GI	56.20 TW	52.97 VW	73.43 c
% Difference	0.0	-17	-44	-47	
ISGA1	83.30 HJ	78.77 JM	74.80 MO	67.70 PQ	76.14 b
% Difference	0.0	-5	-10	-19	
ISGA7	67.60 PQ	72.27 NP	56.97 SV	53.56 VW	62.60 e
% Difference	0.0	7	-16	-21	
ISGA10	93.00 CD	89.47 DF	75.43 LO	69.20 PQ	81.76 a
% Difference	0.0	-4	-19	-26	
IYOZ10	80.53 IK	95.07 BC	60.97 RT	14.60 d	62.79 e
% Difference	0.0	18	-24	-82	
IYOZ14	80.27 IL	78.50 JM	56.70 TV	47.43 XY	65.73 d
% Difference	0.0	-2	-29	-41	

Salinity average	78.99 a	77.83 a	61.51 b	44.96 c	
$LSD_{\%5}$genotype: 2.4256 $LSD_{\%5}$salinity: 1.561		$LSD_{\%5}$genotypex salinity: 4.8512			
Genotype (G): * Salt concentration (S): * GXS: *					

Means with different letters in the same lines are significantly different at P≤ 0.05 by LSD test
*Statistically significant at 5% level

In Table 6, the effects of different salinity levels on leaf width of common bean genotypes were given. As seen in the table, the leaf width of the genotypes is not affected much by the 2 dSm^{-1} salinity level. The most affected genotype at this level was the BKARA2 genotype with a 23% reduction. In 4 dSm^{-1} salinity level, the reduction in leaf widths of the genotypes became more pronounced. In particular, the effects of salt stress were more pronounced in BKARA2 (57%) and BY24 (44%) genotypes. On the other hand, the ADY4 genotype was not affected until the salinity level was increased to 6 dSm^{-1} level. The decrease in AGUN6, AGUN25 and ISGA1 genotypes remained at around 10% in 4 dSm^{-1}. The genotypes that exhibited the least decrease in the leaf width; ISGA1 (19%), ISGA7 (21%) and ISGA10 (26%) at 6 dSm^{-1}. The greatest reduction in leaf width occurred in AGUN19 genotype (83%).

Table 7: Effects of salinity levels on leaf length (cm) of landrace dwarf common bean genotypes

Genotypes	Salt Concentrations (dS m^{-1}) 0.5	2.0	4.0	6.0	Genotypes average
ADY4	80.67 QT	125.87 FG	81.53 PS	78.73 RT	91.70 ef
% Difference	0.0	56	1	-2	
AGB1	83.53 PR	70.87 UV	73.83 TU	39.00 Za	66.81 ı
% Difference	0.0	-15	-12	-53	
AGB5	120.80 GH	135.16 CE	102.40 KL	81.23 PS	109.90 b
% Difference	0.0	-12	-15	-33	
AGB10	108.03 JK	12.36 EF	92.27 NO	79.56 RT	103.06 d
% Difference	0.0	23	-15	-26	
AGUN6	80.50 QT	105.36 JL	74.43 SU	70.60 UV	82.73 g
% Difference	0.0	31	-8	-12	
AGUN19	92.47 NO	92.16 NO	75.57 SU	42.87 Z	75.77 h
% Difference	0.0	0.0	-18	-54	
AGUN25	65.00 VW	70.83 UV	51.93 Y	32.23 ab	55.00 k
% Difference	0.0	9	-20	-50	
BKARA1A	121.10 GH	122.03 GH	100.80 LM	75.63 SU	104.89 cd
% Difference	0.0	1	-17	-38	
BKARA2	78.40 RT	76.80 RU	59.60 WX	27.20 b	60.50 j
% Difference	0.0	-2	-24	-65	
BY4	107.63 JL	94.50 MN	73.80 TU	54.87 XY	82.70 g
% Difference	0.0	-12	-31	-49	
BY24	170.10 A	150.27 B	116.26 HI	94.53 MN	132.79 a
% Difference	0.0	-12	-32	-44	
ISGA1	149.87 B	140.50 C	139.60 CD	111.16 IJ	135.28 a
% Difference	0.0	-6	-7	-26	
ISGA7	132.47 DF	110.43 IJ	94.07 MO	79.27 RT	104.06 d
% Difference	0.0	-17	-29	-40	
ISGA10	135.23 CE	92.10 NO	78.57 SR	57.37 XY	90.82 f
% Difference	0.0	-32	-42	-58	
IYOZ10	94.77 MN	120.30 GH	87.23 OQ	76.43 RU	94.68 e
% Difference	0.0	27	-8	-19	

IYOZ14 % Difference	122.03 GH 0.0	116.10 HI -5	106.20 JL -13	88.37 NP -28	108.18 bc
Salinity average	108.91 a	109.73 a	88.01 b	68.07 c	
LSD%5genotype: 3.6145 LSD%5salinity: 1.8072		LSD%5genotypex salinity: 7.229			
Genotype (G): ** Salt concentration (S): ** GXS: **					

Means with different letters in the same lines are significantly different at P≤ 0.05 by LSD test
*Statistically significant at 5% level

As shown in Table 7, the effect of different salinity levels on leaf length was statistically significant at 5% level. Depend on the increase in the salinity level of the irrigation water, a decrease in leaf length occurred. The highest leaf length was obtained from the control application of the BY24 genotype and the lowest leaf length was obtained from the BKARA2 genotype with 27.20 cm at 6.0 dS m^{-1} application. Genotypes that occur the least decrease in leaf length were determined as ADY4 (2%), AGUN6 (12%), IYOZ10 (19%), AGB10 (26%) and ISGA1 (26%).

Table 8: Effects of salinity levels on stem diameter (cm) of landrace dwarf common bean genotypes

Genotypes	Salinity levels (dS m^{-1}) 0.5	2.0	4.0	6.0	Genotypes average
ADY4 % Difference	4.03 NO 0.0	3.17 U -21	4.33 KL 7	3.53 R -12	3.77 j
AGB1 % Difference	5.83 B 0.0	2.63 V -55	4.63 HI -21	3.73 Q -36	4.21 g
AGB5 % Difference	4.33 KL 0.0	4.43 JK 2	3.93 OP -9	3.33 ST -23	4.01 h
AGB10 % Difference	4.23 LM 0.0	4.33 KL 2	4.23 LM 0.00	4.33 KL 2	4.28 f
AGUN6 % Difference	4.23 LM 0.0	3.13 U -26	3.73 Q -12	4.63 HI 9	3.93 i
AGUN19 % Difference	4.73 H 0.0	4.93 G 4	4.70 H -1	4.03 NO -15	4.60 d
AGUN25 % Difference	4.43 JK 0.0	4.43 JK 0.00	5.13 EF 16	5.43 D 23	4.86 c
BKARA1A % Difference	4.13 MN 0.0	3.43 RS -17	3.93 OP -5	3.23 TU -22	3.68 k
BKARA2 % Difference	3.23 TU 0.0	4.03 NO 25	3.23 TU 0.00	4.53 IJ 40	3.76 j
BY4 % Difference	3.83 PQ 0.0	4.43 JK 16	4.53 IJ 18	4.13 MN 8	4.23 fg
BY24 % Difference	4.23 LM 0.0	4.43 JK 5	5.53 CD 31	5.63 C 33	4.96 b
ISGA1 % Difference	5.23 E 0.0	4.43 JK -15	5.83 B 11	3.83 PQ -27	4.83 c
ISGA7 % Difference	6.23 A 0.0	5.03 FG -19	3.43 RS -45	3.53 R -43	4.56 d
ISGA10 % Difference	4.53 IJ 0.0	4.13 MN -9	4.63 HI 2	4.23 LM -7	4.38 e
IYOZ10 % Difference	4.73 H 0.0	5.63 C 19	5.43 D 15	4.53 IJ -4	5.08 a
IYOZ14	4.03 NO	3.93 OP	3.97 O	3.97 O	3.98 hi

% Difference	0.0	-2	-2	-2
Salinity average	4.50 a	4.16 c	4.45 b	4.16 c
LSD%5genotype: 0.0553	LSD%5genotypex salinity: 0.1106		LSD%5salinity: 0.0277	
Genotype (G): * Salt concentration (S): * GXS: *				

Means with different letters in the same lines are significantly different at P≤ 0.05 by LSD test
*Statistically significant at 5% level

The stem diameter measurements obtained in salinity levels of different common bean genotypes used in the study are given in Table 8. It was found that in all genotypes there was not a decrease in the stem diameters despite increased salinity levels, but in some genotypes, the stem diameters of them increased even in 6.0 dS m^{-1} application. It is thought that this situation is related to the genetic structure of the genotypes and that the dwarfing that occurs in the salt stress conditions in some genotypes also affects the stem diameter. At the end of the research, it was determined that the genotypes with the largest decrease in stem diameter were ISGA7 (43%) and AGB1 (36%).

Table 9: Correlation of plant growth characteristics of landrace dwarf common bean genotypes applied to salt stress

	Plant dry weight	Plant fresh weight	Plant height	Leaf width	Leaf length	Root length	Stem diameter
Plant dry weight	1.00000	0.70322 <.0001	0.44819 <.0001	0.50589 <.0001	0.49937 <.0001	0.29880 <.0001	0.17442 0.0155
Plant fresh weight	0.70322 <.0001	1.00000 <.0001	0.49280 <.0001	0.49730 <.0001	0.57807 <.0001	0.56963 <.0001	0.25651 0.0003
Plant height	0.44819 <.0001	0.49280 <.0001	1.00000	0.37907 <.0001	0.42562 <.0001	0.39499 <.0001	-0.13452 0.0628
Leaf width	0.50589 <.0001	0.49730 <.0001	0.37907 <.0001	1.00000	0.58453 <.0001	0.56721 <.0001	0.05250 0.4695
Leaf length	0.49937 <.0001	0.57807 <.0001	0.42562 <.0001	0.58453 <.0001	1.00000	0.54629 <.0001	0.14984 0.0380
Root length	0.29880 <.0001	0.56963 <.0001	0.39499 <.0001	0.56721 <.0001	0.54629 <.0001	1.00000	0.21398 <.0001
Stem diameter	0.17442 0.0155	0.25651 0.0003	-0.13452 0.0628	0.05250 0.4695	0.14984 0.0380	0.21398 0.0029	1.00000

The correlation between plant growth characteristics of landrace dwarf common bean genotypes applied with salt stress was given in Table 9. As seen from Tables 9, there are statistically positive correlations between some of the plant morphological characteristics ($p < 0.05$). According to statistical analysis results, there was no correlation between stem diameter and other morphological characters. It was determined that there was a statistically significant positive strong correlation between plant height and plant dry weight (r=.703). There was a moderately statistically significant positive correlation between all the other characters. However, it was determined that the characters were highest correlation value among them; between plant dry weight and leaf width (r=.506), between plant fresh weight and leaf length (r= .578), root length (r= .569); between leaf width and leaf length (r= .584), root length (r= .567); between leaf length and root length (r= .546). A statistically significant correlation between all characters except for the stem diameter is important as it indicates that salt stress adversely affects the development of the plant. All results showed that different vegetative parameters of landrace dwarf common bean genotypes were significantly affected by salinity levels. The results obtained in present study are in agreement with previous studies reporting increase on salinity level negatively affects root length, plant height, plant fresh weight, plant dry weight, leaf width, leaf length and stem diameter (Jan *et al.*, 1995; Dash and Panda, 2001; Munns, 2002; Delgado and Sanchez-Raya, 2007; Aydinsakir *et al.*, 2013; Kurum *et al.*, 2013).

As a result, positive results were obtained from AGUN6, BKARA2, AGB10, ISGA1, ISGA10 and IYOZ10 genotypes. In addition, ISGA1 and ISGA10 genotypes gave the best results under the salt stress condition, and these genotypes are thought to be promising genotypes for salt stress tolerance studies.

4. CONCLUSION

This study was conducted to determine the effects of different salt levels on the vegetative growth parameters of the landrace dwarf common bean genotypes collected from the Western Mediterranean region of Turkey. It was determined that the plant growth of the landrace genotypes was adversely affected at varying rates depending on the increased salinity levels. It is concluded that some landrace genotypes can be used for breeding studies against to salinity stress in the end of the study.

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