International Scholars Journals

African Journal of Agricultural Economics and Rural Development ISSN 2375-0693 Vol. 2 (6), pp. 001-009, March, 2014. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Variation of salinity tolerance in bean genotypes

Vahdettin Çiftçi[1]*, Önder Türkmen[2], Yusuf Doğan[1], Çeknas Erdinç[3] and Suat ßensoy[3]

[1]Yüzüncü Yıl University, Faculty of Agriculture, Department of Field Crops, 65080, Van, Turkey.
[2]Se1cuk University, Faculty of Agricultural, Department of Horticulture, Konya, Turkey.
[3]Yüzüncü Yıl University, Faculty of Agriculture, Department of Horticulture, 65080, Van, Turkey,

Accepted 18 March, 2014

Bean is among the very sensitive plant species to soil salinity. This study was carried out using the 55 bean genotypes collected from Geva-Van region in Turkey to determine their salinity tolerance. This study aimed to investigate the salt tolerance capacity of this local bean population. 50 mM NaCl was applied to the bean seedlings, and the measurements and observations were done 20 days after the salt application, when the differences among the genotypes appeared. Number of leaves, seedling heights, and root and shoot weights and some nutrients (phosphorous, potassium, iron, calcium, manganese, magnesium, copper, zinc, and sodium) of the seedlings were determined. The wide variation at salt stress tolerance was observed in this population. The overall performances of local genotypes were better than the tried commercial cultivars.

Key words: Bean, nutrients, salinity, seedling, tolerance.

INTRODUCTION

Soil salinity is one of the most serious problems limiting the sustainability of agricultural production especially in arid and semi arid areas (Sharifi et al., 2007; Gama et al., 2007). With the rise of osmotic pressure, due to the toxicity created by Na^+ and Cl^- ion, physiological disturbances and death can be seen (Robison et al., (1997) ; França et al., 2007; Greenway and Munns, 1980; Ekmekçi et al., 2005; Kaynak et al., 2000) and also with the increase in the concentrations of these ions, the rates of Na^+:Ca^{2+}, Na^+:K^+, Ca^{2+}:Mg^{2+} and Cl^-:NO^{-3} increase in soil, thereby ion equilibrium in soil is disturbed (Turkmen et al., (2000) Hu and Schmidhalter, 2005; ensoy et al., 2005). Another adverse effect of salinity is the decrease in water potential in the root zone and consequently reduction in water intake of plant (Gama et al., 2007; Yakıt and Tuna, 2006).

Salinity problem is available if there is a salt accumulation in the plant root zone, causing yield losses. In irrigated areas, the salinity is caused by nearby salty ground water or the applied irrigation water. Yield losses occur when plants cannot take any water from salty soil solution, meanwhile salt is accumulated in the root zone resulting in salt stress at a significant period of time (Ünlükara et al., 2006). Various climatic and environmental factors such as air temperature, atmospheric humidity, and air pollution significantly affect the salt tolerance of crops. Many crops can tolerate more salt stress in cold and humid conditions than in hot and dry conditions. High atmospheric humidity has a tendency to increase salt tolerance of some plant alone; high atmospheric humidity is generally more useful to salt sensitive plants than salt tolerant plants (Ünlükara et al., 2006). While in excess of Na^+ ions, K^+ uptake is blocked and in excess of Cl^- ion, NO^-3 uptake is blocked (Türkmen et al., 2005). Excessive amount of salt compounds in soil reduces the water intake of plant and deteriorate the soil structure (Emekçi et al., 2005).

Bean is among the very sensitive plant species to soil salinity (Mori et al., 2011). Yield loss in bean exceeds 50% above 2 dS/m electrical conductivity (Gama et al., 2007; Ekmekçi et al., 2005). However, it is also known that bean has a wide variation in terms of stress conditions including soil salinity (França et al., 2007).

Turkey has a rich genetic diversity in bean, as well as many other species. Therefore, the selection of salt tolerant genotypes and to utilize them in breeding programs in Turkey using existing genetic diversity will be a more permanent solution in the long term. The Geva - Van region is an area where bean is intensively cultivated and genotypic variation in bean is high. Taking into consideration the importance and essence of using salt

*Corresponding author. E-mail: vahdet2565@yahoo.com. Tel: +90432-2251848. Fax: +904322157510.

tolerant cultivars in production systems, the genetic variation in the region could be very essential. Therefore, this study aimed to investigate the salt tolerance capacity of this local bean population. The objective of this study was to evaluate physiological and morphological responses of fifty-five bean genotypes collected from Geva -Van region in Turkey to salinity stress.

MATERIALS AND METHODS

The study, using the selected 55 bean genotypes from Geva -Van region, was carried out at the growth chamber of the Department of Horticulture, University of Selçuk. The seeds were sown into peat-filled germination trays and were watered with tap water. The germination trays were placed in the growth chamber at a 70% relative humidity and a temperature of 25 ± 1°C with 16 h fluorescent illumination (8000 lx light intensity). The experiment used randomized design with three random replications consisting of ten pots (no drainage), each having one seedling. The emerged seedlings with true leaf were irrigated with ready Hoagland solution (Hoagland and Arnon, 1950). The seedlings with the second true leaf were transferred into 300 cm^3 perlite filled pots and irrigated with ready Hoagland solution for two weeks. Then, 50 mM NaCl was applied to the seedlings for three days at the same time in the mornings. The measurements and observations were done 20 days after the salt application, when the differences among the genotypes appeared. The number of leaves, seedling heights, and root and shoot weights were determined. Moreover, some macro and micro nutrients were determined from the dried (at 65°C for 48 h), and the samples were milled by atomic absorption spectrometry (AOAC, 1990) at the Department of Field Crop, University of Yuzuncu Yil. The nutrient contents of salt and control applications were compared and the relative values of the contents were interpreted. Mean values of the treatments were determined in each plot and analyzed using ANOVA and 1 and 5% levels used for the F-test according to the JMP statistics program: The mean values were compared with each other using the least significant difference (LSD) method at 5% (Anonymous, 2007).

RESULTS

Seedling growth parameters

As can be seen from Table 1, the fresh and dry seedling weights in almost all genotypes significantly decreased compared to control saline condition. While the genotype 42 had the lowest (26.2%) in fresh shoot weight, the genotype 79 had the highest (45.1%) reduction. In saline condition, seven genotypes had higher shoot dry weights compared to their controls. The relative shoot dry weights ranged from 143.1% (the genotype 70) to 40.6% (the genotype 79). The changes in shoot fresh and dry weights may stem from the difference in seedling water intake of various genotypes and drying losses due to salinity.While root fresh weights generally reduced in saline conditions, there were relative increases in root dry weights in two genotypes compared to their controls (Table 1). While the genotype 51 had the lowest (7.2%) reduction in fresh root weight, the genotype 51 had the highest (58.3%) reduction. While the genotype 57 and 74 had 10.7 and 10.1% increases, respectively, in their fresh root weights, the genotype 51 had the highest (83.5%) reduction.

The shoot heights in all genotypes significantly decreased compared to control saline condition (Table 1). While the genotype 49 had the lowest (32.4%) reduction in fresh shoot weight, the genotype 16 had the highest (80.2%) reduction.

The stem diameters were also significantly different in saline condition (Table 1). Eleven genotypes had higher stem diameters in saline condition compared to control condition, and there was no change in one genotype. There were reductions in stem diameter in other genotypes grown under saline condition. While the genotype 81 had the highest increases (31.4%) in stem diameter, the genotype 34 had the highest (36.9%) reduction.

The leaf numbers in all genotypes significantly decreased compared to control saline condition (Table 1). While the genotype 32 had the lowest (7.9%) reduction in leaf number, the genotype 38 had the highest (39.9%) reduction.

Mineral matter contents

While there were significant relative increases in shoot phosphorous contents of 35 genotypes due to salt application, there were significant relative reductions in shoot phosphorous (P) contents of 20 genotypes (Table 2). In shoot P content compared to their controls with salt applications, the genotype 1 had the highest increases (53.5%), but the cultivar ehirali had the highest (47.9%) reduction.

While there were significant relative increases in root phosphorous contents of 41 genotypes due to salt application, there were significant relative reductions in root phosphorous contents of 13 genotypes, and there was no change in one genotype’s (#37) value (Table 2). In root P content compared to their controls with salt applications, the genotype 7 had the highest increases (56.4%), but the genotype 48 had the highest (29.0%) reduction.

The shoot and root iron (Fe) contents in all genotypes significantly varied in saline condition (Table 2). While there were significant relative increases in shoot Fe contents of 33 genotypes due to salt application, there were significant relative reductions in shoot Fe contents of 22 genotypes. In shoot Fe content compared to their controls with salt applications, the genotype 79 had the highest increases (259.8%), but the genotype 61 had the highest (58.4%) reduction. While there were significant relative increases in root Fe contents of 49 genotypes due to salt application, there were significant relative reductions in root Fe contents of 6 genotypes. In root Fe content compared to their controls with salt applications, the genotype 61 had the highest increases (410.0%), but the genotype 8 had the highest (71.7%) reduction.

Table 1. The relative shoot fresh weights (SFW), shoot dry weights (SDW), root fresh weights (RFW), root dry weights (RDW), shoot heights (SH), stem diameters (SD), and leaf numbers (LN) values; (% differences) of the bean genotypes grown under salt condition compared to their normal growing condition.

Genotype number	SFW	SDW	RFW	RDW	SH	SD	LN
1	35.0 e-n	83.4 b-e	67.9 b-j	80.2 a-d	58.4 a-d	92.5 b-k	78.9 a-d
4	25.7 j-n	76.5 c-e	51.3 i-k	61.0 a-e	41.4 c-f	84.2 c-l	66.5 b-d
5	21.8 mn	71.2 de	46.6 jk	58.7 a-e	33.54 fg	73.6 f-l	71.6 a-d
6	51.1 a-h	86.4 b-e	69.1a-j	65.1 a-e	64.0 ab	*	91.8 ab
7	38.8 c-n	80.9 b-e	68.1b-j	64.4 a-e	46.4 b-f	114.0 ab	80.0 a-d
8	66.4 a	84.0 b-e	69.7 a-j	90.6 a-c	41.1 c-f	110.4 a-d	77.3 a-d
10	36.9 c-n	104.5 a-d	73.6 a-i	79.9 a-d	47.4 a-f	100.5 b-h	77.8 a-d
13	21.49 l-n	81.0 b-e	41.7 k	16.5 e	33.7 fg	72.4 g-l	68.8 a-d
14	29.4 h-n	69.8 de	52.3 h-k	37.3 b-e	38.1 d-g	101.3 b-g	73.1a-d
15	46.2 a-k	91.6 b-e	74.9 a-i	60.9 a-e	47.4 a-f	65.3 kl	70.7 a-d
16	39.4 b-n	132.3 ab	77.1 a-g	51.7 a-e	19.8 g	94.9 b-j	65.1cd
17	46.7 a-j	71.6 de	74.4 a-i	65.4 a-e	42.0 c-f	70.7 i-l	73.3 a-d
18	28.61 h-n	99.8 a-d	54.8 g-k	85.3 a-d	48,6 a-f	107.0 a-e	79.5 a-d
19	20.77 mn	62.9 de	66.7 b-j	66.9 a-e	35.9 e-g	73.1 f-l	79.6 a-d
20	37.2 c-n	79.5 b-e	68.6 a-j	58.5 a-e	61.0 a-c	79.2 e-l	79.3 a-d
26	49.1 a-j	64.2 de	69.0 a-j	59.3 a-e	38.1 d-g	100.0 b-h	79.2 a-d
27	48.1 a-j	72.9 c-e	74.1 a-i	56.8 a-e	53.0 a-f	101.6 b-g	76.5 a-d
29	35.2 d-n	127.0 a-c	62.3 d-k	56.1 a-e	36.4 efg	111.4 abc	68.8 a-d
30	59.0 a-d	80.7 b-e	58.6 e-k	60.6 a-e	36.4 efg	82.2 d-l	70.1 a-d
32	32.2 f-n	80.3 b-e	67.0 b-j	55.6 a-e	41.4 c-f	99.3 b-i	92.1 a
34	20.4 mn	76.8 c-e	64.6 c-k	87.4 a-d	42.0 c-f	63.1 l	78.5 a-d
35	44.7 a-l	78.5 b-e	73.5 a-i	79 a-d	40.5 c-g	101.5 b-g	70.3 a-d
36	54.4 a-g	81.5 b-e	71.4 a-i	63 a-e	67.3 a	92.3 b-k	71.5 a-d
37	55.6 a-f	63.9 de	74.5 a-i	62.9 a-e	36.5 efg	90.0 b-l	65.8 cd
38	36.8 c-n	71.0 de	76.5 a-h	77.5 a-d	46.1 b-f	100.6 b-h	60.1 d
39	29.0 h-n	91.8 b-e	88.2 abc	97.3 ab	42.3 c-f	84.8 c-l	68.8 a-d
40	50.9 a-h	102.4 a-d	70.5 a-j	76.8 a-d	38.2 d-g	82.0 d-l	80.1 a-d
41	51.6 a-h	84.4 b-e	69.4 a-j	61.2 a-e	51.8 a-f	78.7 e-l	75.4 a-d
42	64.9 a	73.8 c-e	88.4 abc	59.8 a-e	52.7 a-f	96.2 b-j	69.6 a-d
43	30.8 g-n	79.1 b-e	61.0 d-k	47.2 b-e	58.7 a-d	93.1 b-k	72.5 a-d
44	26.3 i-n	71.1 de	67.4 b-j	59.1 a-e	38,8 d-g	80.1 e-l	63.6 cd
48	28.8 h-n	83.2 b-e	58.0 e-k	78.1 a-d	44.5 b-f	94.5 b-j	85.7 abc
49	53.9 a-g	88.1 b-e	88.6 abc	93.1 abc	67,6 a	97.7 b-j	77.4 a-d
51	62.9 ab	79.4 b-e	92.8 a	78.1 a-d	40.1 c-g	83.8 c-l	75.5 a-d
53	56.3 a-e	82.5 b-e	90.6 ab	88.5 a-d	54.7 a-f	76.4 f-l	86.1 abc
56	43.9 a-m	83.2 b-e	82.4 a-e	93.1 abc	33.4 fg	68.5 jkl	75.1 a-d
57	46.3 a-k	76.6 c-e	78.4 a-g	110.7 a	42.4 c-f	83.6 c-l	62.6 cd
59	35.5 d-n	112.8 a-d	65.1 c-k	63.0 a-e	47.0 a-f	71.6 h-l	71.9 a-d
60	47.2 a-j	70.8 de	65.2 c-k	60.3 a-e	39.5 d-g	102.2 b-f	72.8 a-d
61	22.8 k-n	66.8 de	56.3 f-k	34.1 cde	37.2 d-g	78.7 e-l	65.2 cd
62	60.0 abc	80.4 b-e	76.2 a-h	79.2 a-d	36.2 efg	99.9 b-i	75.1 a-d
64	48.8 a-j	72.4 de	70.9 a-j	56.5 a-e	43.9 b-f	87.2 b-l	78.5 a-d
65	36.8 c-n	105.9 a-d	56.1 f-k	90.0 abc	46.2 b-f	68.9 jkl	75.9 a-d
66	31.0 g-n	84.2 b-e	58.2 e-k	79.3 a-d	42.7 c-f	84.3 c-l	78 a-d
68	28.2 h-n	82.0 b-e	57.3 f-k	34.7 cde	44.2 b-f	94.8 b-j	69.3 a-d
70	56.3 a-e	143.1 a	57.8 e-k	44.2 b-e	42.3 c-f	88.7 b-l	69.5 a-d
72	32.6 e-n	74.1 c-e	64.2 c-k	28.1 de	34.4 efg	77.8 e-l	81.3 a-d
74	49.9 a-i	95.1 a-e	79.2 a-g	110.1 a	47.2 a-f	98.8 b-i	70.0 a-d
76	19.4 n	81.9 b-e	59.8 d-k	64.2 a-e	39.8 c-g	78.1 e-l	67.8 a-d

Table 1. Contd.

78*							
79	18.6 n	40.6 e	68.0 b-j	50.7 a-e	37.7 d-g	68.9 jkl	68.2 a-d
80	46.3 a-k	69.2 de	73.9 a-i	79.3 a-d	39.1 d-g	89.1 b-l	69.9 a-d
81	50.9 a-h	81.4 b-e	83.9 a-d	80.0 a-d	39.7 c-g	131.4 a	71.5 a-d
ehirali	33.3 e-n	71.2 de	79.8 a-f	88.6 a-d	42.1 c-f	96.9 b-j	71.7 a-d
4f-89	34.4 e-n	74.3 c-e	71.0 a-j	65.3 a-e	55.5 a-e	95.0 b-j	69.6 a-d
LSD%5	19.4	43.9	19.7	48.8	17.4	23.7	20.3

* Data not available.

Table 2. The relative shoot and root phosphorous (P), iron (Fe), calcium (Ca), and potassium (K) values; (% differences) of the bean genotypes grown under salt condition compared to their normal growing condition.

Genotype number	P in shoot	P in root	Fe in shoot	Fe in root	Ca in shoot	Ca in root	K in shoot	K in root
1	153.,5 a	108,5 b-l	110.0 cd	40.1 rs	144.7 g-m	104.6 e-j	107.4 ı-k	8.1 j-m
4	146.9 ab	90,3 h-m	70.7 Cd	131.2 m-s	175.5 e-l	121.4 d-j	106.8 ı-k	10.5 j-m
5	144.9 a-c	109,9 b-k	110.3 Cd	106.3 n-s	113.6 lm	145.6 c-h	76.6 jk	3.1 lm
6	141.7 a-d	118,4 b-ı	121.2 Cd	29.7 s	156.6 f-m	84.9 g-j	110.7 ı-k	9.2 j-m
7	137.6 a-e	156,4 a	192.9 cd	44.4 qrs	117.8 k-m	68.4 jk	113.6 ıjk	9.2 j-m
8	129.9 a-f	135,3 ab	77.2 cd	28.3 s	113.2 lm	79.3 hıj	95.8 ı-k	8.4 j-m
10	129.6 a-f	109.5 b-k	95.2 cd	183.0 h-p	136.2 h-m	104.4 e-j	118.7 ı-k	7.0 j-m
13	129.5 a-f	120.6 b-g	90.5 cd	216.2 g-o	81.1 m	124.0 d-j	68.8 k	7.0 j-m
14	128.5 a-f	99,0 d-m	68.7 cd	188.9 h-p	135.9 h-m	158.7 c-f	105.9 ı-k	10.4 ı-m
15	128.0 a-f	129.6 a-e	165.7 cd	112.5 n-s	302.1 bc	144.6 c-ı	248.9 b	44.3 c-l
16	126.9 a-f	119.4 b-h	112.6 cd	351.7 b-f	159.9 f-m	179.5 cd	119.3 ı-k	51.1 c-ı
17	126.9 a-f	115.2 b-k	107.7 cd	229.3 f-n	197.1 d-k	154.1 c-g	106.5 ı-k	10.6 ı-m
18	126.9 a-f	86.6 j-m	94.4 cd	309.7 c-h	117.2 k-m	131.5 c-j	133.5 e-k	18.7 f-m
19	123.8 a-g	90.0 g-m	90.9 cd	140.7 k-s	133.4 h-m	109.6 d-j	167.7 c-ı	141.5 a
20	123.6 a-g	116.7 b-j	126.9 cd	176.0 ı-q	196.5 d-k	112.3 d-j	210.0 b-d	26.7 d-m
26	121.3 a-ı	87.1 I-m	94.5 cd	165.7 j-r	151.1 g-m	90.9 f-j	203.5 b-f	31.4 d-m
27	120.9 a-h	97.9 e-m	150.0 cd	186.5 h-p	184.9 e-l	114.4 d-j	163.1 d-ı	38.4 c-m
29	120.6 a-h	131.1 a-c	92.2 cd	173.8 j-q	137.8 h-m	123.1 d-j	206.9 b-e	38.4 c-m
30	118.5 a-h	116.2 b-j	96.0 cd	145.5 j-s	162.9 e-l	110.2 d-j	196.5 b-h	60.2 b-f
32	116.3 a-ı	111.3 b-k	92.4 cd	84.7 o-s	176.5 e-l	64.8 jk	118.8 ı-k	55.7 c-g
34	115.7 a-ı	135.3 ab	163.1 cd	264.9 e-k	136.4 h-m	135.0 c-j	119.6 ı-k	53.0 c-h
35	114.3 a-j	100.5 c-m	89.7 cd	73.0 p-s	170.7 e-l	74.2 ıj	163.3 d-ı	63.2 b-e
36	112.3 b-k	125.5 a-e	73.2 cd	136.9 k-s	139.4 h-m	109.3 d-j	152.0 d-ı	43.7 c-l
37	110.2 b-l	100.0 c-m	89.7 cd	339.3 c-g	181.7 e-l	127.7 c-j	146.3 d-j	27.3 d-m
38	105.7 c-m	93.6 f-m	118.3 cd	252.6 e-m	147.2 g-m	112.1 d-j	106.9 ı-k	33.8 c-m
39	105.3 d-m	125.2 a-e	171.1 cd	157.3 j-s	273.4 cd	128.7 c-j	341.6 a	74.4 bc
40	104.2 e-m	103.0 c-l	181.0 cd	146.3 j-s	172.4 e-l	118.2 d-j	114.7 ı-k	41.9 c-m
41	103.5 e-m	83.9 k-m	331.9 ab	160.0 j-s	125.7 j-m	106.3 e-j	101.0 ı-k	10.2 ı-m
42	102.8 e-m	78.0 l-m	166.8 cd	436.8 a-c	155.9 f-m	127.5 c-j	97.5 ı-k	4.4 klm
43	102.7 e-m	116.9 b-j	96.0 cd	479.6 ab	135.4 h-m	128.1 c-j	93.3 ı-k	16.1 g-m
44	102.7 e-m	103.1 c-l	116.5 cd	211.4 g-o	171.3 e-l	139.3 c-ı	113.0 ı-k	39.5 c-m
48	101.3 e-m	71.0 m	84.8 cd	278.7 d-j	151.1 g-m	140.2 c-ı	198.0 b-g	11.3 h-m
49	100.8 e-m	93.5 f-m	107.2 cd	126.2 l-s	176.9 e-l	159.9 c-f	105.7 ı-k	98.3 b
51	100.2 e-m	121.9 b-f	119.6 Cd	105.0 n-s	163.6 e-l	119.5 d-j	139.8 d-k	42.7 c-l
53	100.2 e-m	102.8 c-l	65.9 cd	177.4 h-q	130.9 ı-m	121.3 d-j	107.0 ı-k	44.7 c-l
56	97.6 f-m	116.7 b-j	62.2 cd	218.1 g-n	123.7 j-m	152.2 c-g	118.0 ı-k	28.2 d-m
57	97.5 f-m	104.1 b-l	126.3 cd	148.0 j-s	138.3 h-m	104.2 e-j	122.7 h-k	26.4 d-m

Table 1. Contd.

59	96.2 f-m	114.4 b-k	118.3 Cd	258.4 e-l	151.9 g-m	139.6 c-ı	102.7 ı-k	37.2 c-m
60	94.9 f-m	120.2 b-g	109.7 cd	209.3 g-o	163.7 e-l	127.6c-j	133.0 e-k	46.4 c-j
61	94.9 f-m	114.2 b-k	41.6 d	501.0 a	132.3 h-m	139.6 c-ı	102.2 ı-k	22.5 e-m
62	93.9 f-m	135.0 ab	109.4 cd	116.0 n-s	200.5 d-j	124.4 d-j	128.7 f-k	27.5 d-m
64	93.5 f-m	101.6 B-m	137.5 cd	119.1 k-s	194.6 e-l	132.0 c-j	151.8 d-k	25.4 d-m
65	92.3 f-m	107.6 b-l	208.5 bc	188.1 h-p	211.4 d-h	150.2 c-g	110.8 ı-k	33.1 c-m
66	87.6 g-n	117.7 b-j	104.5 cd	381.2 a-e	178.6 e-l	148.4 c-h	127.7 g-k	17.1 g-m
68	85.6 g-n	118.8 b-h	92.1 cd	209.6 g-o	181.2 e-l	105.5 e-j	100.6 ı-k	21.8 e-m
70	84.6 g-n	121.4 b-f	120.8 cd	168.2 j-r	222.2 c-g	3.1 k	94.7 ı-k	0.5 m
72	83.8 h-n	112.7 b-k	136.9 cd	187.2 h-p	159.6 f-m	893.0 a	101.5 ı-k	30.7 d-m
74	82.7 h-n	109.5 b-k	180.1 cd	339.6 c-g	241.9 cde	198.0 c	130.4 f-k	46.4 c-j
76	78.3 ı-n	102.9 c-l	122.9 cd	432.9 abc	184.9 e-l	298.7 b	112.8 ı-k	30.8 d-m
78	75.1 j-n	97.6 e-m	91.1 cd	308.1 c-h	209.5 d-ı	149.7 c-h	133.4 e-k	22.8 e-m
79	73.8 k-n	94.7 e-m	359.8 a	238.0 f-n	446.1 a	161.7 c-e	240.4 bc	17.9 g-m
80	72.5 l-n	134.8 ab	93.4 cd	108.5 n-s	207.9 d-ı	132.5 c-j	118.3 ı-k	55.7 c-g
81	69.0 mn	108.4 b-l	124.2 cd	106.2 n-s	211.8 d-h	105.8 e-j	109.5 ı-k	66.6 bcd
ehirali	52.1 n	130.4 a-c	207.4 bc	126.8 l-s	364.4 b	145.1 c-h	164.2 d-ı	45.1 c-k
4f-89	66.7 mn	119.1 b-h	109.8 cd	402.2 a-d	233.4 c-f	164.5 c-e	118.8 ı-k	34.4 c-m
LSD %5	32.0	31.3	147.5	133.3	80.43	70.48	74.94	41.62

The shoot and root calcium (Ca) contents in all genotypes significantly changed in saline condition (Table 2). There were significant relative increases in shoot Ca contents of all genotypes due to salt application. In shoot Ca content compared to their controls with salt applications, the genotype 79 had the highest increases (346.1%), but the genotype13 had the highest (18.9%) reduction. While there were significant relative increases in root Ca contents of 48 genotypes due to salt application, there were significant relative reductions in root Ca contents of 7 genotypes. In root Ca content compared to their controls with salt applications, the genotype 72 had the highest increases (793.0%), but the genotype 70 had the highest (96.9%) reduction.

The shoot and root potassium (K) contents in all genotypes significantly varied in saline condition (Table 2). While there were significant relative increases in shoot K contents of 49 genotypes due to salt application, there were significant relative reductions in shoot K contents of 6 genotypes. In shoot K content compared to their controls with salt applications, the genotype 39 had the highest increases (241.0%), but the genotype 13 had the highest (31.2%) reduction. While there were significant relative increases in root K content of 1 genotype due to salt application, there were significant relative reductions in root K contents of 54 genotypes. In root K content compared to their controls with salt applications, the genotype 19 had the highest increases (41.5%), but the genotype 70 had the highest (99.5%) reduction.

The shoot and root manganese (Mn) contents in all bean genotypes significantly changed in saline condition (Table 3). While there were significant relative increases in shoot Mn contents of 41 genotypes due to salt application, there were significant relative reductions in shoot Mn contents of 14 genotypes. In shoot Mn content compared to their controls with salt applications, the genotype 81 had the highest increases (260.5%), but the genotype 59 had the highest (28.9%) reduction. While there were significant relative increases in root Mn contents of 46 genotypes due to salt application, there were significant relative reductions in root Mn contents of 9 genotypes. In root Mn content compared to their controls with salt applications, the genotype 59 had the highest increases (1045.8%), but the genotype 7 had the highest (51.1%) reduction.

The shoot and root magnesium (Mg) contents in all bean genotypes significantly varied in saline condition (Table 3). While there were significant relative increases in shoot Mg contents of 54 genotypes due to salt application, there were significant relative reductions in shoot Mg contents of 8 genotypes. In shoot Mg content compared to their controls with salt applications, the genotype 80 had the highest increases (734.8%), but the genotype 8 had the highest (11.8%) reduction. While there were significant relative increases in root Mg contents of 16 genotypes due to salt application, there were significant relative reductions in root Mg contents of 39 genotypes. In root Mg content compared to their controls with salt applications, the genotype 56 had the highest increases (610.0%), but the genotype 70 had the highest (96.2%) reduction.

The shoot and root copper (Cu) contents in all bean genotypes significantly changed in saline condition (Table 3). While there were significant relative increases in shoot Cu contents of 46 genotypes due to salt application, there were significant relative reductions in shoot Cu contents

Table 3. The relative shoot and root manganese (Mn), magnesisum (Mg), cupper (Cu), zinc (Zn), and sodium (Na) values; (% differences) of the bean genotypes grown under salt condition compared to their normal growing condition.

Genotype number	Mn in shoot	Mn in root	Mg in shoot	Mg in root	Cu in shoot	Cu in root	Zn in shoot	Zn in root	Na in shoot	Na in root
1	138.6 b-h	99.6 l-p	154.2 d	71.6 b	87.8 ı-k	4.6 p	245.7 a	17.0 uv	960.5l-u	91.9 st
4	117.7 c-h	170.4 j-p	148.0 d	44.1 b	200.9 d-k	84.0 k-p	109.5 fg	42.0 o-v	850.2q-v	44.7 t
5	110.8 c-h	54.0 op	115.7 d	36.5 b	349.1 a-ı	6.0 op	73.6 g	10.1 v	823.3q-v	40.7 t
6	127.7 c-h	57.2 n-p	175.9 cd	69.7 b	205.4 d-k	6.2 op	103.0 fg	26.4 s-v	1043.2ı-s	165.3 r-t
7	234.0 b	48.9 o	126.0 d	54.0 b	110.6 h-k	8.0 op	99.4 fg	37.6 q-v	770.9s-v	223.6 o-t
8	85.0 gh	58.5 n-p	88.2 d	66.8 b	52.9 jk	7.4 op	83.9 fg	28.2 r-v	891.4p-v	223.8 o-t
10	110.4 c-h	83.0 m-p	164.0 d	53.7 b	250.6 c-k	8.0 op	90.7 fg	22.6 s-v	676.4v	218.3 o-t
13	97.7 d-h	122.8 k-p	106.2 d	39.8 b	126.5 g-k	32.0 n-p	120.0 c-g	19.2 t-v	697.4uv	173.6 q-t
14	85.6 gh	116.8 k-p	128.6 d	69.4 b	612.1 a	111.2 h-p	76.7 fg	59.2 l-u	944.1m-v	153.9 r-t
15	209.5 bc	90.1 l-p	291.3 b-d	115.5b	209.8 d-k	202.5 f-p	120.2 c-g	110.8 c-j	1156.6f-p	865.3 d-ı
16	114.5 c-h	323.7 d-o	139.9 d	101.0b	133.5 g-k	91.1 j-p	241.9 a	108.6 c-k	898.2p-v	698.9 g-l
17	154.7 b-h	349.1 d-m	135.0 d	59.5 b	450.0 a-d	409.6 b-e	102.2 fg	104.8 d-m	903.8p-v	360.2 l-t
18	84.0 gh	205.0 h-p	116.1 d	66.7 b	159.2 f-k	138.1 h-p	152.5 b-f	95.2 e-n	1285.4d-j	536.9 ı-r
19	175.0 b-g	90.9 l-p	147.3 d	207.7 b	79.4 ı-k	459.7 bc	81.0 fg	131.6 c-g	979.4l-t	1201.1b-e
20	136.4 b-h	304.7 e-p	227.1 cd	52.1 b	191.0 d-k	203.2 f-p	110.1 fg	100.9 c-n	917.2o-v	656.9g-m
26	195.1b-e	79.1 m-p	134.0 d	80.3 b	166.4 e-k	58.5 m-p	121.9 c-g	53.8 n-v	778.6r-v	440.1j-s
27	79.0 gh	152.8 j-p	176.7 cd	66.5 b	531.8 ab	399.2 b-f	101.2 fg	104.6 d-m	1008.1k-s	403.7k-t
29	92.7 f-h	221.8 h-p	161.0 d	80.7 b	108.9 h-k	218.1 e-n	137.9 b-g	90.6 f-n	713.3t-v	812.8e-j
30	123.4 c-h	204.9 h-p	220.1 cd	121.4 b	381.2 a-h	138.9 h-p	129.2 c-g	116.2 c-j	708.4t-v	649.6g-n
32	135.8 b-h	198.9 h-p	207.0 cd	78.0 b	136.1 g-k	102.1 ı-p	145.2 b-g	79.0 h-q	837.0q-v	767.5f-k
34	88.6 fgh	231.5 g-p	156.9 d	100.1 b	39.4 k	48.5 m-p	125.7 c-g	90.5 f-n	1019.1j-s	990.6b-h
35	124.9 c-h	100.9 l-p	168.2 cd	101.2 b	139.2 g-k	175.4 g-p	100.0 fg	70.5 ı-s	958.6l-u	904.0c-ı
36	102.1 d-h	183.2 ı-p	177.3 cd	93.3 b	122.5 g-k	74.6 k-p	118.2 d-g	67.6 j-t	1075.9h-q	880.1 c-ı
37	103.3 d-h	306.9 e-p	222.4 cd	66.1 b	187.0 d-k	113.0 h-p	109.2 fg	110.0 c-j	1120.1g-p	670.8g-m
38	95.4 e-h	252.7 f-p	132.8 d	72.2 b	175.7 d-k	169.5 h-p	110.1 fg	223.4 a	1141.4g-p	761.8f-k
39	195.9 b-e	359.6 d-l	231.9 cd	92.5 b	138.3 g-k	206.5 f-o	92.3 fg	139.3 b-f	1475.4b-d	999.9 b-g
40	150.1 b-h	432.1 c-ı	144.5 d	86.9 b	122.3 g-k	158.7 h-p	90.0 fg	142.2 b-e	1019.3j-s	688.8 g-m
41	198.1 bcd	556.8 b-e	227.5 cd	36,8 b	526.7 a-c	423.0 b-d	104.8 fg	123.4 c-h	920.5n-v	264.4 n-t
42	145.0 b-h	501.5 b-g	113.8 d	40.1 b	144.2 g-k	598.6 b	199.7 a-c	185.6 ab	925.5n-v	200.1p-t
43	122.0 c-h	521.5 b-f	173.0 cd	48.3b	177.3 d-k	220.0 e-n	192.1 a-e	156.4 bc	1136.4g-p	300.3m-t
44	126.8 c-h	1045.2 a	161.8 d	76.3 b	193.8 d-k	239.1 d-m	82.7 fg	142.4 b-e	1644.3bc	604.7h-o
48	176.4 b-g	311.5 e-p	234.3 cd	54.7 b	446.3 a-e	845.8 a	82.6 fg	89.2 g-p	1698.7b	878.4c-ı
49	88.4 f-h	183.3 ı-p	111.0 d	135.7 b	107.6 h-k	66.6 l-p	213.3 ab	79.6 h-q	904.5p-v	441.5 j-s
51	106.9 d-h	221.8 h-p	160.8 d	107.1 b	215.8 d-k	77.5 k-p	84.8 fg	82.4 h-q	1183.0e-o	1150.0 b-f
53	87.2 f-h	359.4 d-l	124.1 d	106.9 b	116.2 g-k	192.8 g-p	129.4 c-g	83.9 g-q	1333.2d-h	755.5 g-k

Table 3. Contd.

56	82.8 gh	335.7 d-m	94.8 d	710.0 a	81.4 ı-k	265.2 c-l	75.4 fg	106.7 d-l	1146.0f-p	914.7 b-ı
57	125.1 c-h	242.3 g-p	665.8 ab	80.4 b	113.8 h-k	102.6 ı-p	82.5 fg	41.2 o-v	1416.7c-f	900.2 c-ı
59	71.1 h	1145.8 a	120.4 d	144.0 b	395.6 a-g	88.4 j-p	122.0 c-g	59.9 k-u	1272.2d-k	1262.2 bc
60	123.7 c-h	586.4 b-d	135.1 d	104.9 b	109.4 h-k	282.8 c-j	76.8 fg	97.5 e-n	1086.4g-q	1662.2a
61	111.9 c-h	524.6 b-e	102.8 d	50.5 b	72.2 ı-k	221.8 e-n	99.8 fg	118.3 c-ı	1434.9b-e	853.3d-ı
62	76.4 gh	323.4 d-o	541.8 a-c	78.1 b	437.5 a-f	268.3 c-k	81.1 fg	84.7 g-q	1261.7d-k	1219.5b-d
64	136.3 b-h	359.1 c-n	124.0 cd	66.5 b	78.6 h-k	326.0 c-ı	78.7 fg	90.4 e-q	917.2m-v	1297.7ab
65	115.8 c-h	401.9 c-j	154.7 d	79.3 b	610.2 a	81.0 k-p	110.8 c-g	86.9 g-p	1261.1d-k	710.4g-l
66	125.0 c-h	734.7 b	150.2 d	64.1 b	133.3 g-k	305.5 c-h	89.4 fg	103.6 d-m	1188.3e-o	1012.9b-g
68	116.4 c-h	360.7 c-l	137.6 d	55.7 b	114.7 g-k	144.4 h-p	94.7 fg	100.7 d-n	1205.3d-m	437.3 j-s
70	150.9 b-h	549.6 b-e	92.8 d	3.8 b	322.2 b-j	184.2 g-p	75.8 fg	101.5 d-n	5883.9a	204.5 p-t
72	92.0 f-h	317.5 d-p	104.6 d	70.8 b	197.8 d-k	414.6 b-e	78.2 fg	120.3 c-h	1193.3e-n	534.7ı-r
74	134.5 b-h	440.4 c-ı	161.0 d	108.0 b	113.3 h-k	249.2 d-m	85.1 fg	119.9 c-h	1160.3f-p	677.6g-m
76	176.3 b-g	466.6 b-h	131.7 d	105.2 b	217.0 d-k	375.7 c-g	103.4 fg	70.2 ı-s	1352.4d-g	600.8h-o
78	165.9 b-h	386.3 c-k	148.7 d	62.5 b	54.8 jk	76.9 k-p	117.1 e-g	93.8 e-n	1067.4h-q	640.6g-n
79	198.2 b-d	371.7 c-k	257.7 cd	51.9 b	122.3 g-k	393.9 c-f	127.6 c-g	77.0 h-q	1304.3d-ı	540.3 ı-r
80	189.4 b-f	289.0 e-p	834.8 a	100.2 b	91.1 ı-k	145.3 h-p	197.9 a-d	82.4 h-q	1223.7d-l	577.3ı-p
81	360.5 a	465.5 b-h	131.8 d	73.7 b	186.0 d-k	157.1 h-p	110.7 fg	87.1 g-p	730.4t-v	564.0ı-q
ehirali	133.8 b-h	240.1 g-p	158.6 d	53.3 b	448.5 a-d	132.1 h-p	113.1 e-g	55.9 m-v	1047.6ı-r	703.0g-l
4f-89	172.9 b-h	631.2 bc	146.6 d	125.9 b	150.7 g-k	415.5 c-e	121.2 c-g	147.6 b-d	1044.4ı-s	727.1g-l
LSD%5	102.3	270.7	376.4	232.7	281.1	201.0	80.3	48.9	273.7	391.4

of 9 genotypes. In shoot Cu content compared to their controls with salt applications, the genotype 65 had the highest increases (510.2%), but the genotype 34 had the highest (60.6%) reduction. While there were significant relative increases in root Cu contents of 38 genotypes due to salt application, there were significant relative reductions in root Cu contents of 17 genotypes. In root Cu content compared to their controls with salt applications, the genotype 48 had the highest increases (745.8%), but the genotype 1 had the highest (95.4%) reduction.

The shoot and root zinc (Zn) contents in all bean genotypes significantly varied in saline condition (Table 3). While there were significant relative increases in shoot Zn contents of 31 genotypes due to salt application, there were significant relative reductions in shoot Zn contents of 23 genotypes and there was no change in one genotype's (#35) value. In shoot Zn content compared to their controls with salt applications, the genotype 16 had the highest increases (241.9%), but the genotype 5 had the highest (26.4%) reduction. While there were significant relative increases in root Zn contents of 23 genotypes due to salt application, there were significant relative reductions in root Zn contents of 32 genotypes. In root Zn content compared to their controls with salt applications, the genotype 38 had the highest increases (123.4%), but the genotype 5 had the highest (89.9%) reduction.

The shoot and root sodium (Na) contents in all bean genotypes significantly changed in saline condition (Table 3). There were significant relative increases in shoot Na contents of all genotypes due to salt application. In shoot Na content compared to their controls with salt applications, the genotype 70 had the highest increase (5873.9%), but the genotype 10 had the lowest (576.4%) increase. While there were significant relative increases in root Na contents of 51 genotypes due to salt application, there were significant relative reductions in root Na contents of 3 genotypes. In root Na content compared to their controls with salt applications, the genotype

60 had the highest increases (1652.2%), but the genotype 5 had the highest (59.3%) reduction.

DISCUSSION AND CONCLUSION

Bean is among the very sensitive species to soil salinity, and has a wide variation in terms of stress conditions including soil salinity (França et al., 2007). In a study conducted with 10 bean genotypes and 3 cowpea genotypes, 125 mM NaCl was applied to deep water culture, and the Na, K, and Ca ions concentrations of the genotypes were determined (Dasgan et al., 2006). At the end of the mentioned study, it was determined that cowpea and bean genotypes developed different defense mechanisms against salt stress. Accordingly, cowpea genotypes had Na^+ compartmentation mechanism and were found to be salt tolerant and; one of the bean genotypes had Na^+ extrusion mechanism and salt tolerant; one of the bean genotypes had Na^+ extrusion mechanism and medium salt tolerant; one of the bean genotypes had Na^+ compartmentation mechanism and salt tolerant; three of the bean genotypes had Na^+ compartmentation mechanism and medium salt tolerant; and the rest of the bean genotypes were salt sensitive.

In another study investigating the mechanism of ion regulation and conducted with 64 bean genotypes, 125 mM NaCl was applied to 25-day-old plants and 5, 43, and 16 bean genotypes were found to be salt tolerant, moderately salt tolerant, and salt sensitive, respectively (Da gan and Koç, 2009). These researchers stated that Na: K and Na: Ca ratios were effective in order to make an effective selection in bean genotypes for salinity tolerance during seedling development.

In saline soil conditions, the performance of the seeds during germination is important to measure the response of plants to salt (França et al., 2007). In bean, the periods of seed germinations and seedling emergences and growths are encountered as major problems in salty soil. On this issue, in a study carried out on different NaCl doses, Bayuelo-Jimenez et al. (2002) examined germinations and seedling growth performances of 28 genotypes belonging to five *Phaseolus* species including *P. vulgaris*. Cluster analysis divided these genotypes into three groups. The first group consisted of the salt sensitive genotypes having low seedling growth, high sensitivity index, and low germination rate. The second group consisted of the salt tolerant genotypes having high sensitivity index and fast seedling growth. The third group consisted of moderately salt tolerant cultivars in Mesoamerican and Andean germplasm having medium seedling growth, low sensitivity index, and fast germination. These researchers emphasized that *Phaseolus* species, especially *P. filiformis*, could be an important source of germplasm in salt tolerance.

Gama et al. (2009) examined the plant weight, photosynthesis rate, water relationships, and antioxidant enzyme changes in two bean cultivars grown on different salt concentrations and defined that plant weight and most of the antioxidant enzymes were negatively influenced from salinity. Moreover, these researchers found that leaf osmotic potential was directly related to salt stress. Yasar (2003) and Kaymakanova et al. (2010) stated that some of the antioxidant enzymes were influenced from salinity: an increased GPX activities, as well as decreased GSH content in both root and leaf of salt-treated plants were well expressed.

Local bean population in Gava town of Van province in Turkey, where it has a great potential, has a large genotypic variation. It should be necessary to screen this population for salinity tolerance because it is essential to use tolerant genetic material for salt stress, one of the most important abiotic stresses in agriculture. Therefore, this study was conducted to find better salt tolerant bean genetic resources in this population having large genetic diversity. It was found that one or a few genotypes could not be pronounced as prominent in terms of relative values obtained from the data received saline and normal growing conditions.

The responses of the Geva bean genotypes to salt stress are consistent with the statement of França et al. (2007) highlighting the wide variation at salt stress tolerance in bean. There is an important issue that overall performances of local genotypes were better than the tried commercial cultivars. There will be more striking results if salt stress performances of these genotypes are studied with their other important agricultural traits. The overall performances of local genotypes were better than the tried commercial cultivars; therefore, more detailed studies should be conducted in order to select and breed salt tolerant lines in the future.

ACKNOWLEDGEMENT

This investigation was supported by the Scientific and Technological Research Council of Turkey (TÜBĐTAK).

REFERENCES

Anonymous (1990). AOAC. Official Methods of Analysis of the Association of Official Analytical Chemists. In: Helrich K (ed) Arlington, VA., USA.

Anonymous (2007). JMP7.0. copyright© 2007. SAS Institute Inc.

Bayuelo-Jimenez JS, Craig R, Lynch, PJ (2002). Salinity tolerance of phaseolus species during germination and early seedling growth. Crop Sci., 42: 1584-1594.

Dasgan HY, Koc S (2009). Evaluation of salt tolerance in common bean genotypes by ion regulation and searching for screening parameters. J. Food Agric. Environ., 7(2): 363-372.

Da gan HY, Koç S, Ekici B, Akta H, Abak K (2006). Bazı fasulye ve börülce genotiplerinin tuz stresine tepkileri. Alatarım, 5(1): 23-31 (in Turkish).

Ekmekçi E, Apan M, Kara T (2005). Tuzluluğun bitki geli imine etkisi. OMÜ Zir. Fak. Dergisi, 20(3): 118-125.

França DB, Sa RL, Aragao CA (2007). Germination, initial growth and cotyledon protein content of bean cultivars under salinity stress. Revista Brasileira de Sementes, 29(2): 106-110.

Gama PBS, Inanaga S, Tanaka K, Nakazawa R (2007). Physiological response of common bean (*Phaseolus vulgaris* L.) seedlings to salinity stress. Afr. J. Biotechnol., 6(2): 079-088.

Gama PBS, Tanaka K, Eneji AE, Eltayeb AE, Siddig KE (2009). Salt-induced stress effects on biomass, photosynthetic rate, and reactive oxygen species-scavenging enzyme accumulation in common bean. J. Plant Nutr., 32: 837-854.

Greeenway H, Munns R (1980). Mechanism of salt tolerant nonhalophytes. Ann. Rev. Plant Physiol., 31: 149-190.

Hoagland D, Arnon DI, (1950). The water culture method for growing plants without soil. Calif. Agric. Exp. Stn. Circ., 347: 1-39.

Hu, Y, Schmidhalter U, (2005). Drought and salinity: Acomparison of their effects on mineral nutrition of plants. J. Plant Nutr. Soil Sci., 168: 541-549.

Kaymakanova M, Lyubenova, L, Schröder, P, Stoeva N (2010). Salt stress and glutathione-dependent enzyme activities in bean (*Phaseolus vulgaris* L.). Gen. Appl. Plant Physiol., 36(1-2): 55-59.

Kaynak L, Đmamgiller B, Ersoy N, Yazıcı K (2000). Tarım topraklarında tuzluluk sorunu. 2000 GAP Çevre Kongresi, Ekim 2000, anlıurfa, pp. 16-18 (in Turkish).

Mori M, Di Mola I, Quaglietta CF (2011). Salt stress and transplant time in snap bean: growth and productive behaviour. Int. J. Plant Prod., 5(1): 49-64.

Robinson MF, Very AA, Sanders D, Mansfield TA (1997). How can stomata contribute to salt tolerance. Ann. Bot., 80: 387-393.

Sharifi M, Ghorbanli M, Ebrahimzadeh H (2007). Improved growth of salinity-stressed soybean after inoculation with salt pre-treated mycorrhizal fungi. J. Plant Physiol., 164: 1144-1151.

ensoy S, Türkmen Ö, Kabay T, Erdinç Ç, Turan M, Yıldız M (2005). Determination of salinity tolerance levels of melon genotypes collected from Lake Van Basin. J. Biol. Sci., 5(5): 637-642.

Türkmen Ö, ensoy S, Erdal Đ (2000). Effect of potassium on emergence and seedling growth of cucumber grown in salty conditions. YYÜ ZF, Tarım Bilimleri Dergisi, 10(1): 113-117.

Ünlükara A, Cemek B, Karadavut S (2006). Farklı çevre ko ulları ile sulama suyu tuzluluğu ili kilerinin domatesin büyüme, geli me, verim ve kalitesi üzerindeki etkileri. Gazi Osman Pa a Üniversitesi Ziraat Fakültesi Dergisi, 23(1): 15-23 (in Turkish).

Yakıt S, Tuna AL (2006). Tuz stresi altındaki mısır bitkisinde (*Zea mays* L.) stres parametreleri üzerine Ca, Mg ve K'nın etkileri. Akdeniz Üniversitesi Ziraat Fakültesi Dergisi, pp. 59-67 (in Turkish).

Ya ar F (2003). Tuz stresi altındaki patlıcan genotiplerinde bazı antioksidant enzim aktivitelerinin *in vitro* ve *in vivo* olarak incelenmesi. Yüzüncü Yıl Üniversitesi, Fen Bilimleri Enstitüsü, Bahçe Bitkileri Anabilim Dalı, Doktora Tezi. Van (in Turkish).