EFFECTS OF IRRIGATION WITH DIFFERENT LEVELS OF NaCl AND VITAMIN C SUPPLEMENTATION ON GROWTH AND MORPHOLOGICAL CHARACTERISTICS OF *ALOE VERA* L PLANT

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Salt stress is a limiting factor of plant growth and yield, and becoming a serious problem in the world. The aim of this study was to investigate the effects of irrigation with different levels of NaCl on the growth of *Aloe vera* L plant. Plants were irrigated with nutrient solutions containing different levels of NaCl (0, 3, 5, 7 and 9 ds.m) at the end of December and harvesting took place four times with one month interval in February, March and April 2016. Results showed that the salinity stress affected leaf number, plant height, sprout number, root weight, plant weight, leaf weight, total gel weight, root dry weight, Vitamin C and total soluble solids. Data analysis also showed that sampling time relieves significant effect on number of leaf, plant height, root length, number of sprout, root weight, plant weight, leaf weight and total gel weight. All measured characteristics were highest for control. The interaction effects between salinity and sampling time on plant height, plant weight, leaf weight and total gel weight showed that these traits decreased in all salinity levels when sampling happened 50 days after transplanting and the lowest value was related to the highest salinity.

Keywords: aloe vera, salt stress, morphological characteristics, nutrient solution, Vitamin C.

INTRODUCTION

Aloe vera L. is a perennial liliaceous plant with succulent green leaves joined at the stem in a whorled pattern. It is highly appreciated due to its short growth period and high economic value among all the aloe species, and is used in pharmaceuticals, folk medicine, healthcare, cosmetic products and food products (Reynolds and Dweck, 1999). Salt stress is a limiting factor of plant growth and yield and becoming a serious problem in the world (Epsteine, 1980). Studies of plant tolerance to salt stress cover many aspects of the influences of salinity on plant behavior, including alterations at the morphological, physiological and molecular levels. Recently, investigations are focusing more on: biotechnology, transgenic plants, improvement of breeding and screening methodologies and modification of

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the genetic structure of existing crops aiming at enhanced adaptation to salinity conditions (Mahdava et al., 2006). Mustafa (1995) suggested that in *A. vera*, 0.1% salinity has resulted in an increase in growth parameters while 0.4% salinity reduced growth parameters. Additionally he demonstrated that the highest amounts of compound carbohydrates were obtained with 0.4% salinity while the highest amount of crude aloin and barb loin were obtained with 0.2% salinity. The aim of this study was to investigate the effects of irrigation with different levels of NaCl on the growth of *Aloe vera* L plant.

MATERIAL AND METHODS

EXPERIMENTAL PLAN

The experiment was conducted in a greenhouse in 2016 in the Agricultural Faculty, Esfahan, Iran. This experiment was conducted in bi-factorial design in completely randomized design with 4 replications which each replication containing 4 pots and Sprouts of A. vera with 16 cm length obtained in in vitro culture used in this work. Aloe sprouts were cultured in greenhouse in pots with 30 cm diameter containing cocopeat and perlite (50:50 v.v) and were irrigated with nutrient solutions (Tables 1), containing different levels of NaCl (0, 3, 5, 7 and 9 ds.m) in December and harvesting took place four times with one month interval in February, March and April 2016.

Table 1

Macronutrients and Micronutrients used in nutrient solutions ($mg \cdot L^{-1}$)

KNO3	101.2
KH2PO4	61.02
NaCl	5.88
Ca(NO3)2	108.9
MgSO4	92.30
NH4NO3	4.10
(NH4)6Mo7O2/4H2O	0.06
H3BO3	1.7
MnSO4/4H2O	2.1
CuSO4/5H2O	0.26
ZnSO4/7H2O	1.1
Sequesteren Fe136	10.2

Salinity effects were studied on the number of leaf, plant height, number of sprout, root weight, plant weight, leaf weight, total gel weight, and root dry weight. The dry matter content of the samples was determined by drying a known fresh weight of homogenized samples at 75 °C until there were no further changes in the weight under this temperature. After cooling to room temperature, the samples were reweighed, and the dry matter content was calculated. Total soluble solid content was determined by extracting and mixing one drop of juice from each sample. Vitamin C was quantitatively determined according to 2, 6-dichlorophenolindophenol dye method (Ranganna, 1997). The ascorbic acid of fresh samples 10 g was extracted by grinding in a suitable medium with a small amount of sand and using 3% meta phosphoric acid (v.v) as a protective agent. The extract was made up to a volume of 100 ml mixed and centrifuged at 3,000 g for 15 min at room temperature. Ten milliliters were titrated against standard 2, 6- dichlorophenolindophenol dye, which was already standardized against standard ascorbic acid.

STATISTICAL ANALYSIS

Statistical analysis was made by one way analysis of variance and significant differences between treatments means were determined by Duncan (1995) test using the SAS (2001) software.

RESULT AND DISCUSSION

Salinity affected the leaf number, plant height, sprout number, root weight, plant weight, leaf weight, total gel weight, and root dry weight. Variance analysis also showed that sampling time relieves significant effect on the leaf number, plant height, and root length, sprout number, root weight, plant weight, leaf weight and total gel weight (Table 2).

Table 2

Effects of salinity stress on morphological characteristics in *Aloe vera*

Treatments	Leaf number	Sprout number	Root weight (g)	Root dry weight (g)
Control	11.71^{a**}	22.76^{a}	51.50^{a}	5.36^{a}
3 ds.m	11.52^{a}	30.10^{b}	46.92^{b}	3.98^{b}
5 ds.m	11.41^{a}	1.90^{bc}	46.40^{b}	3.65^{b}
7 ds.m	9.30^{b}	1.20^{c}	33.86^{c}	2.01^{c}
9 ds.m	7.25	31.80^{c}	32.11^{c}	2.55^{c}
P value	**	**	**	**

*abc: Means within columns with differing letters are different ($p \leq 0.05$)

Salinity decreased the growth of plant leaves and roots and their dry matter all measured characteristics showed differences between control and 3, 5, 7 and 9 ds.m salinity (Table 2). Fuentes and Rodriguez (1988) reported similar report and revealed that the height of leaves and sprouts reduced with increasing salinity in different Aloe spp. The same results were obtained by Kock (1980), Upchurch (1981) and Nobel and Berry (1985) on Agave spp. By increasing interval between transplanting and harvesting time leaf number, sprout number and root weight increased (Table 3) that is common phenomena due to plant growth but the root dry weight did not change in different sampling times.

Table 3

Effect of salinity on Vitamin C and total soluble solids content in *Aloe vera* leaves

Treatments	Vitamin C (mg.100 g)	Total soluble solids (%)
Control	0.90[a**]	0.42[a]
3 ds.m	0.71[a]	0.39[b]
5 ds.m	0.45[b]	0.33[c]
7 ds.m	0.31[c]	0.28[d]
9 ds.m	0.30[c]	0.21[e]
P value	**	**

*abc: Means within columns with differing letters are different ($p \leq 0.05$)

In fact different sampling times show differences after 95 days from transplanting while 65 days after transplanting there are no differences between plants as regards leaf and sprout number. Interaction between salinity and sampling time on plant height, plant weight, leaf weight and total gel weight showed that these traits decreased in all salinity levels when sampled 35 days after transplanting and the lowest value was related to the highest salinity. Mustafa (1995) suggested that in *A. vera*, 0.1% salinity has resulted in an increase in growth parameters while 0.4% salinity reduced growth parameters. However, all salinity levels decreased root length 90 days after transplanting (Table 4).

Table 4

Effect of sampling time on measured characteristics

Treatments	Leaf number	Sprout number	Root fresh weight (g)
35 days after transplanting	9.35b	74.11b	40.11c
65 days after transplanting	10.10b	3.20b	43.26b
95 days after transplanting	11.24a	4.36a	46.14a
P value	**	**	**

*abc: Means within columns with differing letters are different ($p \leq 0.05$)

By increasing salinity stress the plant response changed negatively, while in short period (less than 65 days) plant respond positively to salinity stress. In other word short period stress is suitable but by increasing stress duration plants loss their tolerance and their growth will be reduced. Results indicated that aloe plants are not able to tolerate long time salinity stress while in short time they show some positive responses such as root length.

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