Journal of Medicinal Plants Research Vol. 6(16), pp. 3272-3277, 30 April, 2012
Available online at http://www.academicjournals.org/JMPR
DOI: 10.5897/JMPR11.1698
ISSN 1996-0875 ©2012 Academic Journals

Full Length Research Paper

Effects of salinity stress on growth and yield of *Aloe vera* L.

Ecehagh Moghbeli[1], Samaneh Fathollahi[2], Hadi Salari[3], Golale Ahmadi[2], Fagheh Saliqehdar[2], Aliraza Safari[4] and Mohammad Sadat Hosseini Grouh[1]*

[1]Department of Plant Science, Faculty of Agriculture, University of Jiroft, Jiroft, Iran.
[2]Department of Horticulture, Faculty of Agriculture, University of Guilan, Rasht, Iran.
[3]Department of Soil Science. University of Islamic Azad, Jiroft Branch, Jiroft, Iran.
[4]Department of Soil Science. University of Islamic Azad, Lahijan Branch, Lahijan, Iran.

Accepted 26 January, 2012

Salt stress is a limiting factor of plant growth and yield, and becoming a serious problem in the world. In this research the effect of salinity stress on Aloe plant was studied. Aloe plants were irrigated with nutrient solutions containing different levels of NaCl (0, 2, 4, 6 and 8 ds/m) in December and harvesting took place three times with one month interval in January, February and March. Results revealed that the salinity stress affected number of leaf, plant height, number of sprout, root weight, plant weight, leaf weight, total gel weight, root dry weight, Vitamin C and total soluble solids (TSS). Variance 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. 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 sampling was 30 days after transplanting and the lowest value was related to highest salinity.

Keywords: Salt stress, nutrient solution, vitamin c, stress tolerant.

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).

According to a survey, more than 800 million hectares of land throughout the world are salt affected (Anonymous, 2008). The impact of salt stress has been correlated with some morphological and physiological traits like reduction in fresh and dry weight (Chartzoulakis and Klapaki, 2000). In fact, salinity affects plant metabolism by disturbing physiological and biochemical processes of plants due to ionic and osmotic imbalances which results in the reduction of plant growth and productivity (Munns, 2005). The deleterious effects of salinity on plant growth are associated with low osmotic potential of soil solution, nutritional imbalance, specific ion effect, or a combination of these factors (Ashraf and Harris, 2004). 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 the genetic structure of existing crops aiming at enhanced adaptation to salinity conditions (Mahdava et al., 2006). Zan et al. (2007), studying the physiological and ecological characters on *A. vera* under seawater irrigation (EC= 23.4 ds m^{-1}) reported that salinity stress caused a decrease in tissue water, total soluble sugars and glucose.

Mustafa (1995) suggested that in *A. vera*, 0.1% salinity

*Corresponding author. E-mail: msadat.1983@gmail.com. Tel: +98-348-3260062. Fax: +98-348-3260065.

Table 1. Macronutrients used in nutrient solutions 1.

mg·L^{-1}					
KNO_3	KH_2PO_4	NaCl	$Ca(NO_3)_2$	$MgSO_4$	NH_4NO_3
101	60.9	5.85	108.7	92.25	4

Table 2. Micronutrients used in nutrient solutions.

mg·L^{-1}					
$(NH_4)_6Mo_7O_2/4H_2O$	H_3BO_3	$MnSO_4/4H_2O$	$CuSO_4/5H_2O$	$ZnSO_4/7H_2O$	SequesterenFe 136
0.05	1.5	2	0.25	1	10

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 barbaloin were obtained with 0.2% salinity.

The aim of this study was to investigation the effect of salinity stress on some traits related to growth and yield of *A. vera* L. plant.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse in 2010 in the Agricultural Faculty, University of Guilan, Rasht, Iran (37°16′N). This experiment was conducted in bi-factorial design in completely randomized design with three replications which each replication containing three pots.

Plant material

Sprouts of *A. vera* with 13 cm length obtained in *in vitro* culture used in this work.

Culture conditions and treatments

Aloe sprouts were cultured in greenhouse in pots with 29 cm diameter containing cocopeat and perlite (50:50 v/v) and were irrigated with nutrient solutions (Tables 1 and 2) containing different levels of NaCl (0, 2, 4, 6 and 8 ds/m) in December and harvesting took place three times with one month interval in January, February and March.

Morphological observations and statistical analysis

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 solids (TSS)

Total soluble solid content was determined by extracting and mixing one drop of juice from each sample into a refractometer (JENWAY – 6405 UV/V).

Determination of Vitamin C

Ascorbic acid was quantitatively determined according to 2, 6-dichlorophenolindophenol dye method (Ranganna, 1997). The ascorbic acid of fresh samples 10g was extracted by grinding in a suitable medium with a small amount of sand and using 3% metaphosphoric acid (v/v) as a protective agent. The extract was made up to a volume of 100 ml mixed and centrifuged at 3000 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. Results were expressed as mg 100 g^{-1} on fresh weight (FW) basis.

Statistical analysis

Statistical analysis were made by oneway analysis of variance (ANOVA) and significant differences between treatments means were determined by Tukey's test using the SAS software package (9.2).

RESULTS AND DISCUSSION

Salinity affected the number of leaf, plant height, number of sprout, root weight, plant weight, leaf weight, total gel weight, and root dry weight (Table 3). Variance analysis also showed that sampling time relieves significant effect on the number of leaf, plant height, and root length, number of sprout, root weight, plant weight, leaf weight and total gel weight (Table 3). Salinity decreased plant leaves and roots growth and their dry matter all measured characteristics showed differences between control and 2,4,6 and 8 ds/m salinity (Table 4). The results showed that salinity led to a decrease in TSS and Vitamin C (Table 5). Zan et al. (2007) indicated that salt stress led to decreasing TSS in both cultivars of *Aloe* and it is a limiting factor of plant growth and yield. Salinity

Table 3. ANOVA table of the effects of salinity stress on morphological characteristics in *Aloe vera.*

Salinity of variation	df	Mean of Square								
		Number	Plant height	Root length	Number of sprout	root weight	Plant weight	Leaf weight	Total gel weight (g)	Root dry weight
Salinity	4	30.9**	274.98**	16.14^{ns}	17.81**	696.74**	67941.16**	55613.58**	23808.45**	15.87**
Sampling time	2	12.23**	117.02**	459.8**	4.62**	99.03**	42364**	38368.81**	20343.45**	0.27^{ns}
Salt*time	8	0.842^{ns}	11.24**	25.24*	0.17^{ns}	5.58^{ns}	4379.84**	4129.7**	3276.08**	0.23^{ns}
Error	30	0.65	3.14	10.42	0.24	3.08	705.04	746.15	557.42	0.14
C.V (%)		6.3	8.31	10.55	9.63	4.19	10.65	13.16	7.44	11.81

ns, *, **: non significant, significant at P ≤ 0.05 or P ≤ 0.01 respectively.

Table 4. Effect of salinity on morphological traits.

Salinity treatment	Number of Leaf	Number of sprout	Root weight (g)	Root dry weight (g)
Control	11.62a	22.67a	51.41a	5.27a
2 ds/m	10.55a	3.00b	46.57b	3.37b
4 ds/m	10.39a	1.78bc	46.25b	3.27b
6 ds/m	9.00b	1.11c	33.15c	1.75d
8 ds/m	6.81c	0.56c	31.80c	2.4c

Table 5. Effect of salinity on Vitamin C and total soluble solids (TSS) content in *Aloe vera* leaves.

Treatment	Vitamin c (mg·100g-1 FM)	TSS (%)
Control	0.81^{a}	0.40^{a}
2 ds/m	0.6^{ab}	0.37^{b}
4 ds/m	0.42^{bc}	0.33c
6 ds/m	0.26^{c}	0.28d
8 ds/m	0.21^{c}	0.25e

affects strongly the number of sprout and reduces sprout production to less than 30 percent of control while other characteristics decreasing were smaller. Pasternak et al. (1986), Fuentes et al. (1988) and 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 number of leaf, number of sprout and root weight increased (Table 6) that is common phenomena due to plant growth but the root dry weight did not change in different sampling times. At first, root growth begins then number of leaf and sprout increases. In fact different sampling times show differences after 90 days from transplanting while 60 days after transplanting there are no differences between plants for the number of leaf and sprout. 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 30 days after transplanting and the lowest value was related to highest salinity. This result was similar 60 and 90 days after transplanting (Table 6). Plant weight, leaf weight and total gel weight increasing ratio in different sampling time decreased where the salinity level increased (Figures 1-3). Interaction

Table 6. Effect of sampling time on measured characteristics.

Sampling time	Mean square		
	Number of leaf	**Number of sprout**	**Root fresh weight (g)**
30 days after transplanting	8.87 b	72.2 b	39.35c
60 days after transplanting	9.5b	2.53b	41.68b
90 days after transplanting	10.65a	3.33a	44.48a

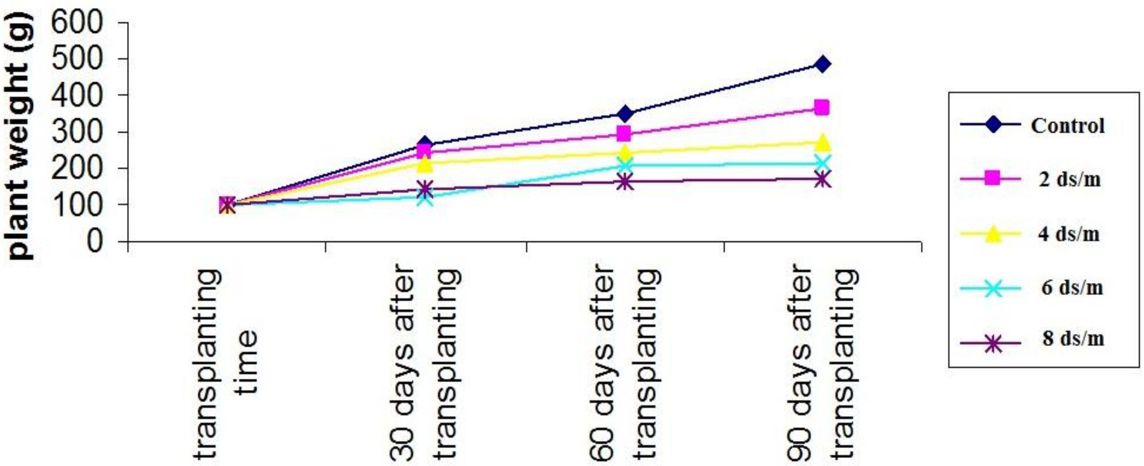

Figure 1. Aloe response to salinity for plant weight in different sampling times.

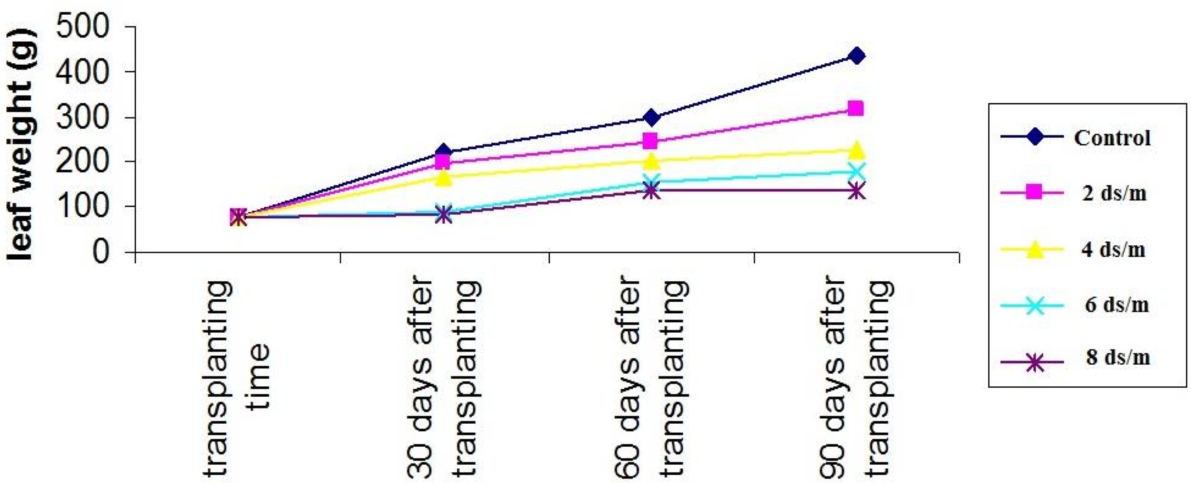

Figure 2. Aloe response to salinity for leaf weight in different sampling times.

between salinity and sampling time on root length showed that the highest root length was obtained in 2 and 4 ds/m salinity levels when sampled 30 days after transplanting while the highest value was related to 2 ds/m salinity level when sampled 60 days after transplanting. Mustafa (1995) suggested that in *Aloe vera*, 0.1% salinity result in an increase in growth parameters while 0.4% salinity reduces growth parameters. However all salinity levels decreased root length 90 days after transplanting (Table 7). By increasing salinity stress the plant response changed negatively, while in short period (less than 60 days) plant

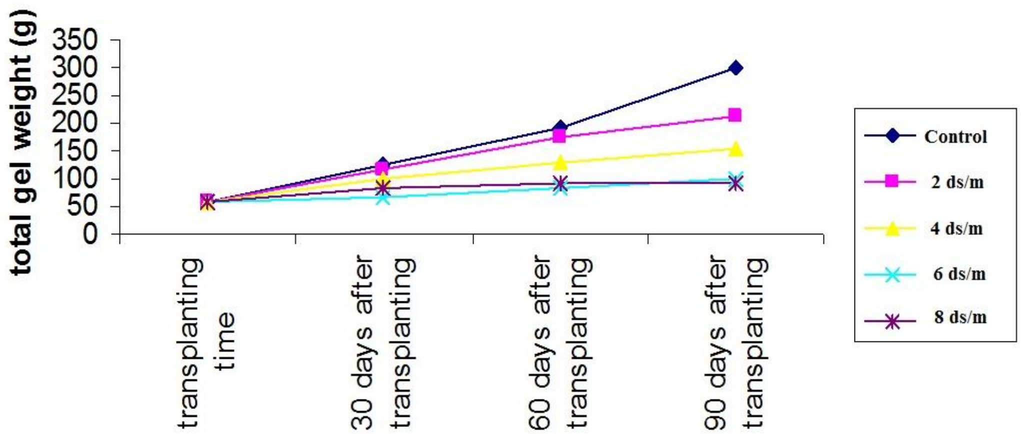

Figure 3. Aloe response to salinity for total gel weight in different sampling times.

Table 7. Effect of sampling time and salinity interaction on morphological characteristics.

Sampling time	Salinity	Plant height	Plant weight	Leaf weight	Total gel weight	Root length
30 days after transplanting	Control	29.83±0.76	267.81±24.98	220.46±24.23	123.58±12.06	21.33± 2.31
30 days after transplanting	2 ds/m	28.17±.6	241.67±10.76	198.35±11.88	115.71±21.29	28±7
30 days after transplanting	4 ds/m	24.66±.29	211.16±21.15	167.36±23.2	98.89± 8.66	29.67±1.53
30 days after transplanting	6 ds/m	22±1.73	120.52± 4.96	89.12±6.59	67.64±11.19	23.67±3.51
30 days after transplanting	8 ds/m	21.5±1.73	142.7±10.87	81.11±10.08	82.76±4	21±1
60 days after transplanting	Control	36±3.6	347.6±33.46	296.64± 34.13	189.79± 21.52	31.67±0.58
60 days after transplanting	2 ds/m	32.27±1.1	293.36±115.17	246.52±16.33	173.23± 33.79	33.33±2.31
60 days after transplanting	4 ds/m	26.67±1.76	245.89± 9.12	200.41±11.88	130.2±8.77	31.67±1.15
60 days after transplanting	6 ds/m	24±.86	207±82.57	153.78± 27.72	82.57±12.45	29.67± 4.73
60 days after transplanting	8 ds/m	23.16±1.76	167.03±13.12	135.36±14.29	90.36± 5.22	30.33±2.08
90 days after transplanting	Control	41±3.6	488.86± 59.56	432.93±61.28	298.44±68.28	39±5.2
90 days after transplanting	2 ds/m	36±1	364.69±18.54	315.13± 18.83	211.18±19.23	35.33± 3.79
90 days after transplanting	4 ds/m	27.67±1.15	274.45±1.14	224.98± 9.41	153.08±15.86	33±1
90 days after transplanting	6 ds/m	26±1	215.1±51.74	180.51±52.71	100.76±16.8	36.33± 2.51
90 days after transplanting	8 ds/m	23.33±1.53	172.09± 16	139.23±16.05	93.32±10.85	35±2

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 like root length.

ACKNOWLEDGMENT

Thank the University of Jiroft for financial supports and University of Guilan for providing the plant materials.

REFERENCES

Anonymous (2008). FAO. http://www.fao.org/ag/agl/agll/spush.

Ashraf M, Harris PJC (2004). Potential biochemical indicators of salinity tolerance in., 166: 3-16

Chartzoulakis K, Klapaki G (2000). Response of two greenhouse pepper hybrids to NaCl salinity during different growth stages. Sci. Hort., 86: 247-260.

Epsteine E (1980). Saline culture of crops: a genetic approach. Science, 210: 399-404.

Fuentes V, Rodriguez N, Rodriguez C, Ramos R (1988). Salinity tolerance including Aloe arborescens and other species. Agrotecnia Cuba, 20: 1-6.

Kock GC (1980). Drought resistant fodder shrub crops (*Agave americana*) in South Africa. Herbage Abst. G-55, No. 1068.

Mahdava KV, Raghavendra AS, Janardhan R (2006). Physiology and Molecular Biology of Stress Tolerance in Plants. Springer. Printed Netherlands, 1-16.

Munns R (2005). Genes and salt tolerance: bringing them together. New Phytol., 167: 645-663.

Mustafa M (1995). Physiological Studies on Growth and Active Constituents of *Aloe vera* L. Ph.D., Floriculture. Zagazig Univ., Fac. Agric., 176: 45-89.

Nobel PS, Berry WL (1985). Element and salinity responses of Agaves species. California Univ., Los Angelos. U.S.A., Am. J. Bot., 72: 686-694.

Pasternak D, Aronson JA, Dov JB (1986). Development of new arid zone crops (*Aloe* sp.) for the Negev desert of Israel. J. Arid Environ. (Abst. Trop. Agric.), 12: 58967.

Upchurch RP (1981). New Crops for Arid Lands. Advances in food producing systems for arid and semi-arid lands. Part B. USA, New York, Academic Press.

Reynolds T, Dweck AC (1999). *Aloe vera* leaf gel: a review update. J. Ethnopharmacol., 68: 3–37.

Zan MJ, Chang HW, Zhao PL, Wei JG (2007). Physiological and ecological characters studies on *Aloe vera* under soil salinity and seawater irrigation. Process Biochem., 42: 710–714.