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Effects of Salinity Stress on Growth and Yield of *Aloe vera* L.

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ABSTRACT: The excess of soil salinity is one of the major factors that limit the survival of plants in their natural habitats. It is a major threat to crop yield, especially in countries where irrigation is an important aid to agriculture. Salinity affects plant growth and metabolism and cause modifications in gene expression of plants. *Aloe* plants irrigated with nutrient solution containing different levels of NaCl on December. Results revealed that salinity affected plant height, root length, number of sprout, root weight and plant weight. All measured characteristics were highest in control.

Key words: Salt stress, *Aloe vera*, stress tolerance, morphological characters.

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INTRODUCTION

Aloe vera L. is the perennial liliaceous plant with succulent green leaves joined at stem in whorled pattern. It is has a short growth period and economically important among all *Aloe* species. It is also 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 serious problem in the world (Episteine, *et al* 1980). Salinity is the process of accumulation of soluble salts by which saline soils are produced (Chen *et al*., 2001). The composition of salts in large amounts mostly is Ca, Na, $MgCl_2$, SO_4 ions and relatively small amounts are potassium carbonates, bicarbonates, borates and lithium salts (Zhu, 2001).

Aloe belongs to the family Aloceae consisting of perennial tropical plants of African origin. About 360 species are present in parts of Africa, Europe, Asia and the Americas. Among all the species, *A. vera* is more popular all over the world because it propagates faster than any other known species of *Aloe* (Anselm, 2004). It is characterized by stemless, large, thick and fleshy leaves showing lance shaped a sharp apex and a spiny margin. The fleshy, sword shaped leaves are grey-green and grow to 80-90cm long. Younger leaves have pale spots. The plant slowly offsets to form a clump. Only large plants, flower in November-December. The unbranched flower spike carries tubular yellow flowers (Chaudhari and Chaudhari, 2012). Salt stress is known to be a limiting factor in plant growth and yield and is presently impairing at least 20% of crop productivity worldwide (Yan *et al* 2005; Debnath *et al* 2011). Salinity can cause many different responses in plants, including readjustment of transport and metabolic processes that can affect growth inhibition.

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 negative effects of salinity on plant growth are associated with low osmotic potential, nutritional imbalance, specific ion effect or a combination of these factors in the soil (Parida and Das 2005; Luo *et al* 2005). Gumi *et al* (2013) reported that salinity stress affects growth, biochemical parameters and ion homeostasis in Solanum lycopersicum. Nabizadeh *et al* (2015) investigated the effect of different levels of NaCl salinity on antioxidant enzyme's activity in seedling of different wheat cultivars.

Studies of the plant tolerance to salt stress cover many aspects of the influences of salinity on plant behavior, including alternations at the morphological, physiological and molecular levels. In light of this, the present research aims to study the effect of salt stress, using different concentrations of NaCl, on the growth of *A. vera*.

MATERIALS AND METHODS

A. Plant material

The experiments were carried out in greenhouse, at Jaipur using *Aloe vera*; the plants were obtained from the local nursery. The plants were uniform in size, health and colour with height of 30-40cm.

B. Souring of plantlets

The plantlets were transplanted and circulated in small field area during the month of December.

C. Treatments

Different concentrations of sodium chloride (0, 100, 200, 300, 400 mM) were used. Plant irrigated every three days, alternatively with filtered water and nutrient solution, until they were 6 weeks old. After that, homogenous plants comprising one of concentration of sodium chloride. The control plants only received nutrient solution.

Plants were irrigated with nutrient solution every three days (250ml per day) with the addition of sodium chloride to the nutrient solution every two weeks. A total of two replicates were chosen for each morphological measurement.

D. Growth Measurements

Specimens were collected after 1 month from the start of treatment, and when 40% of fourth group of plants on the highest concentration had died. The total age of plants at that time was 90 days.

Growth measurements, for the plants exposed to saline treatments, were taken at times mentioned previously, namely after 1 month of treatment and at the death of 40% of plants at the highest concentration. The replicates taken for each treatment were used to calculate mean of each measurements. The measurements taken were the following:

(i) Plant height
(ii) Root length
(iii) Number of sprouts
(iv) Plant fresh weight
(v) Root fresh weight

RESULT AND DISCUSSION

By following the length of the plants under salt stress during the treatment period 30 days, 60 days, 90 days (Table 1, 2, 3), it appears there is a general trend for the decrease in the length of the plants and root length using the above concentrations.

Length of the plants and length of the roots decreases in all periods. It was lowest after 90 days in 400mM concentration. In general statistical analysis demonstrated significant differences during all periods and in all concentrations. Some plants in 400mM concentration were died.

Misra *et al* (1997), Dantus *et al* (2005) and Memon *et al* (2010) reported in their studies that low concentrations of NaCl support the increase in plant length whereas higher concentrations caused decrease in plant lengths. In our experiments there was a clear decline in the lengths of the plants due to the increase in concentrations of NaCl. Mazher *et al*, 2007 reported that the elongation of the stem when treated with low concentrations of salts may induce osmotic adjustment activity in the plants which may improve growth. On the other hand, the noticed decrease in the length of the stem, also due to treatment with NaCl solution, could be due to negative effect of this salt on the rate of photosynthesis, the change in enzyme activity and also the decrease in the level of carbohydrates and growth hormones; both of which can lead to inhibition of the growth.

Table 1: Growth parameters after 30 days.

S. No.	Parameters	Control	100mM	200mM	300mM	400mM
1.	Plant Height (cm)	39.33±0.5	34.33±1.7	36.5±0	34±1	30.5±0.5
2.	Root Length (cm)	8.6±0.8	7.03±1.13	8.5±1.32	7.3±0.6	6±1.5
3.	Number of Sprouts	8±0	8.5±0.5	8±1.00	8.23±0.68	5.66±1.52
4.	Plant Weight (gm)	160±6.4	158.33±1.7	138±1.67	96.66±7.8	73.33±1.52
5.	Root Weight (gm)	20±0	10.23±0.25	15.0±0.23	14.33±1.5	10.00±0

Table 2: Growth parameters after 60 days.

S. No.	Parameters	Control	100mM	200mM	300mM	400mM
1.	Plant Height (cm)	43±3.6	31.9±1.53	29.63±1.58	30.1±1.52	26.2±1.32
2.	Root Length (cm)	10.83±1.04	6.80±0.6	6.7±0.6	6.7±0	5.8±1.52
3.	Number of Sprouts	9.2±0.50	5.66±0.57	6±0	7.28±0.23	4.5±0
4.	Plant Weight (gm)	165±2.51	140±0	122±1.55	90±1.07	65.00±2.65
5.	Root Weight (gm)	22.0±1.20	9.6±1.51	12.33±2.64	13.00±1.65	7.8±1.15

Table 3: Growth parameters after 90 days.

S. No.	Parameters	Control	100mM	200mM	300mM	400mM
1.	Plant Height (cm)	48±1.45	27.0±1.84	24±4.8	25±0.3	18.5±3.9
2.	Root Length (cm)	12.01±3.3	5.6±0.69	5.16±1.75	4.26±0.25	4.13±1.20
3.	Number of Sprouts	10.0±1.15	5.03±0.05	5.33±1.52	6.6±0.52	3.0±0.66
4.	Plant Weight (gm)	174±0.57	136±2.56	101±3.32	47.66±2.04	38.33±1.04
5.	Root Weight (gm)	28.0±0.69	7.33±6.33	8.20±4.16	8.12±1.52	5.36±1.15

High salinity may inhibit the root and shoot elongation due to the slowing down the water uptake by the plant. Neumann (1997) indicated that salinity can rapidly inhibit the root growth and its capacity to water uptake and essential mineral nutrition from soil.

The reduction in shoot dry weight could also be associated with reduced rate of leaf production, hence low number of leaves leading to reduced photosynthesis and accumulation of dry matter.

Salinity reduces shoot and root growth due to the reduction in turgor in expanding tissues resulting from lowered water potential in root growth medium (Alam *et al*, 2004). A disturbance in mineral supply, either on excess or deficiency, induced by changes in concentrations of specific ions the growth medium might have directly affected growth (Lazof and Bernstein, 1998).

Results presented in the Table 1,2,3 showed that the higher levels of salinity decrease number of sprouts. It was found that the general trend of the treatment reflects a gradual decrease in the number of sprouts with the increase of NaCl concentrations. Karen *et al* (2002) and Raul *et al* (2003) reported that, the treatment of NaCl reduced the number of leaves compared to the control plants. Accumulation of sodium chloride in the cell walls and cytoplasm of the older leaves occurs due to which, number of leaves are decreased. At the same time, their vacuole sap cannot accumulate more salt and the concentration of salt inside the cells decreases, which results in their quick death and cut down (Munns, 2002). Data presented in the Table (1, 2, 3), showed that there is a negative effect for salt stress on the fresh weight of the *Aloe*. Jamil *et al* (2007a), Ha *et al* (2008) and Rui *et al* (2009) also reported the negative effect of salt stress on fresh weight. Rani and Rose (2012), reported that salt stress is an important factor affecting crop productivity. Productivity decreases when crops are subjected to salt stress. Akbari *et al* (2015) also reported that high levels of salinity caused significant reduction in growth parameters in corn. Morphological changes do indicate the fact that the plant is suffering in its metabolic activities which clearly make a guess towards the disturbance.

In conclusion plants showed high reduction in growth parameters in response to salt stress. Salt stress reduced the plants height, root length and number of sprouts during the growth period of these plants. Salinity also caused a reduction in plant and root weight of the plants.

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