Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
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Asian Journal of Plant Sciences 6 (1): 56-60, 2007
ISSN 1682-3974

Physiological Changes in Seedlings of *Talinum triangulare* (Water Leaf) Grown in Saline Conditions

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Abstract: The present study was conducted in the University of Benin to investigate the effects of salinity on the growth and development of the seedlings of Water leaf (*Talinium triangulare)*. The parameters considered included plant height, leaf number, leaf area, succulence, fresh and dry weight and shoot/root ratio, respectively. All the different rates of salinity used (0 mM NaCl- 560 mM) NaCl affected the normal function of the crop. There was a significant decrease in growth rate in all the parameters evaluated, except in leaf succulence. The highest leaf succulence was recorded at 70 mM NaCl while the lowest value was obtained at 560 mM NaCl. Information emanating from this study indicated that water leaf (*Talinium triangulare*) is a miohalophyte as it performed best in non-saline conditions.

Key words: *Talinum triangulare*, salt stress, physiological changes, saline conditions, seedlings

INTRODUCTION

Salinity has been described as a critical environmental problem especially when it adversely affects plant growth, Salinity has been observed by Madenovo (1990) to be capable of restricting growth of plants in large areas of the earth than other inhibitory substances encountered by plants in natural environment. In fact, salinity has been described by Rowell (1994) and Ghafoor *et al.* (2004) to affect plant growth directly through Osmotic stress and ionic toxicity caused by NaCl and SO_4 which may result in imbalance in plant nutrient metabolism.

Salinity has been explained by Sprent (1984) as the salt content of sea water and it is the weight of total salts (g) dissolved in 1 kg of sea water usually expressed as parts per thousand (ppt). An environment is said to be saline if the salt content of the soil is higher than that of any normal soil. It was documented by Llanes *et al.* (2005) that the majority of salt studies have used NaCl as the experimental salt. Few research work have recently reported results on the effects of Na_2SO_4 on germination and plant growth.

Bradbury and Ahmad (1990) estimated that about 1/3 of the world's land surface is arid or semi-arid (4.8×10^9 ha) of which half is affected by salinity. Also Vincente *et al.* (2004) stressed that as salinity affects 20% of the world's cultivated, land, breeding of salt resistant, crop varieties will require the understanding of salt stress tolerance which is still lacking in the past decade, Ungar (1995) observed that in saline environments adaptation of plants to salinity during germination and early seedling stages is crucial for the establishment of species. The morphology, structure and anatomy of plant species have been reported by Solomon *et al.* (1986) and Kulper *et al.* (1998) to be affected by saline stress.

Saline environments affect plants in a variety of ways such as injury to leaves manifested as marginal chlorosis of leaves followed by extensive scorching of the leaf blades. Also leaf mottling and necrotic patches or tip burns have been revealed by Schaffer *et al.* (1999) as saline injury to plants. Salinity has also been found by Ungar (1982) to reduce the total number of seed germination and postpone the initiation of the germination process. This he said is done by lowering the osmotic potential of the soil sufficiently to retard water absorption by seeds but also by toxicity to the embryo. Salinity has been confirmed by Kozlowski and Paltardy (1997) to also have adverse effects on reproductive growth such as flowering, fruit development and seed production as well as suppression of leaf initiation and expansion during vegetative growth.

According to Gates (1972), soil salinity often alters the morphology and anatomy of plants such as thicker and more succulent leaves produced in saline areas than those growing on salt free soils. Inhibition of enzymatic activity, photosynthesis, mineral absorption, protein metabolism and respiration have all been documented by Shannon *et al.* (1994) as effects of soil salinity on plant growth.

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An urgent global problem is how to find enough water and land to support the world's food needs since approximately 46.5% of the total land area of the earth is affected. There is the need to reclaim salt affected soils for agricultural use by breeding salt-tolerant crop species. The objective of this study is to assess *Talinium triangulare* for its tolerance to salinity and its potential for use in breeding programmes. Also such results may assist in improving the salt to tolerance of crops for marginal agriculture.

MATERIALS AND METHODS

Stem cuttings of *Talinium triangulare* were obtained from a garden within the University of Benin environment and planted in loamy soil. The seeds were raised in prenursery chamber before being transplanted into plastic bowls of 8×14 cm after 3 weeks.

The salt (NaCl) was obtained from the Department of Botany Laboratory, dissolved in water to obtain the various NaCl concentrations as stipulated below:-

Distilled Water	(0.0 mM NaCl)
1/8 Strength Sea water	(70 mM NaCl)
1/4 Strength Sea water	(140 mM NaCl)
1/2 Strength Sea water	(280 mM NaCl)
Full strength sea water	(560 mM NaCl)

The seedlings were watered at first with distilled water for two weeks so plants can adjust to their new environment. They were then subjected to NaCl concentrations of 0, 70, 140, 280 and 560 mM, respectively. There were three replicates per treatment. Six weeks after treatment, the following growth parameters were taken; plant height, leaf number and leaf area. Fresh and dry weights were determined at harvest when the plants were separated into root, stem and leaves.

These were weighed fresh and later dried. The ISTA (1996) rules of drying at low constant oven temperature for 90°C for 24 h until constant weights were obtained was used. The values obtained were subjected to analysis of variance. The succulence (%water content) was determined using the method of Handley and Jennings (1977) which interpret as

$$\text{Succulence (\%)} = \frac{\text{Fresh weight-dry weight}}{\text{Dry weight}} \times 100$$

RESULTS

Various morphological changes resulted in the growth of *Talinium triangulare* 6 weeks after treating the plants with saline water, as abnormal symptoms were observed. These included small sized and chlorotic leaves at 280 and 560 mM NaCl, while leaves also began to drop prematurely. The stems grew thinner and turned purplish pink in colour compared to green stems of lower salinity levels of 70 and 140 mM NaCl, respectively. Flowering also commenced earlier in plants at 0 mM NaCl than those of higher salinity levels of 280 and 560 mM NaCl and this showed that the effect of salinity on *Talinum triangulare* was concentration dependent.

Leaf number: Table 1 revealed that the effect of external salinity on leaf number showed the highest number of leaf was recorded for the control plants (0 mM NaCl) while the lowest of 72% reduction was observed for the 560 mM NaCl plants as against the control.

Leaf area: With increase in salinity levels, the leaf area of *T. triangulare* decreased significantly as the highest level (560 mM NaCl) was observed to have very low leaf area parameters. The effect of salinity on leaf area *T. triangulare* is shown in Fig. 1.

Plant height: There was significant decrease ($p<0.05$) in plant height of *Talinum* with increasing salinization. Plant height was highest at (0 mM NaCl) but lowest when exposed to 560 mM NaCl. The effect of salinity on plant height of *T. triangulare* is shown in Fig. 2.

Fresh weight: Significant decrease in fresh weight of *Talinum* was obtained under non-saline condition (0 mM NaCl) compared with other treatments. as presented in Table 2. There was therefore a significant reduction in fresh weight as salinity levels increased.

Table 1: Effects of salinity (mM NaCl) on leaf number of *Talinium triangulate*

Salinity level (mM NaCl)	Leaf No.
0	37±4.91
70	15±0.67
140	31±4.58
280	14±3.21
560	10±2.40

Results are mean of 3 replicates±SEM

Table 2: Effects of salinity (mM NaCl) on fresh weight partitioning of *Talinium triangulate*

Salinity level (mM NaCl)	Fresh weights (g) Leaf	Stem	Root
0	9.49±1.19	5.75±0.69	4.81±1.13
70	7.07±1.12	4.49±1.23	1.98±0.29
140	6.74±0.67	4.42±1.05	1.28±0.15
280	1.97±0.36	1.68±0.10	0.55±0.24
560	0.76±0.04	1.42±0.37	0.28±0.07

Results are mean of 3 replicates±SEM

Table 3: Effect of salinity on leaf succulence of *Talinum triangulare*

Salinity level (mM NaCl)	Succulence (% water content)
0	1594.6±120.9
70	2109.4±290.6
140	1673.6±136.3
280	1541.7±118.4
560	985.7±100.6

Results are mean of 3 replicates±SEM

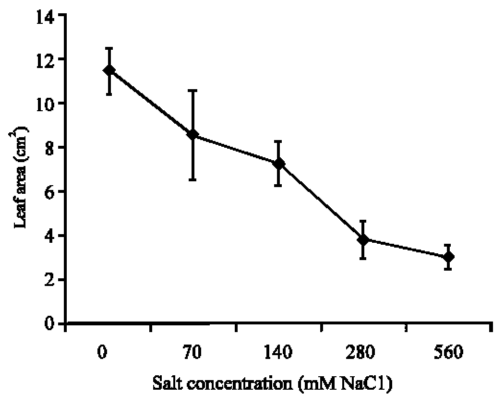

Fig. 1: Effect of salinity on leaf area of *Talinum triangulare*. Vertical bars represent SEM of 3 replicates

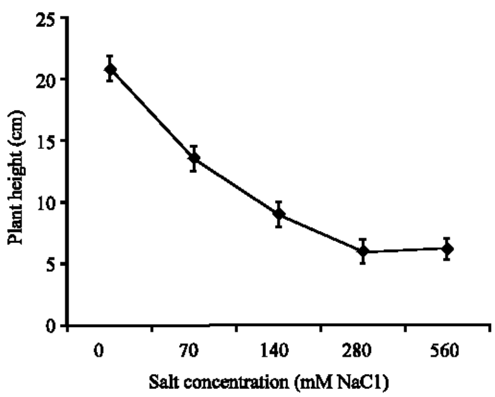

Fig. 2: Effect of salinity on plant height of *Talinum triangulare*. Vertical bars represent SEM of 3 replicates

Total dry weight: Figure 3, shows mean total dry weight of *T. triangulare* as affected by various salinity levels. The highest dry weight was obtained for the control plants (non-saline condition). At 140 mM NaCl, mean total dry weight recorded was 1.05±0.21

Leaf succulence: An increase in succulence at low salinity level was observed in this study (Table 3).

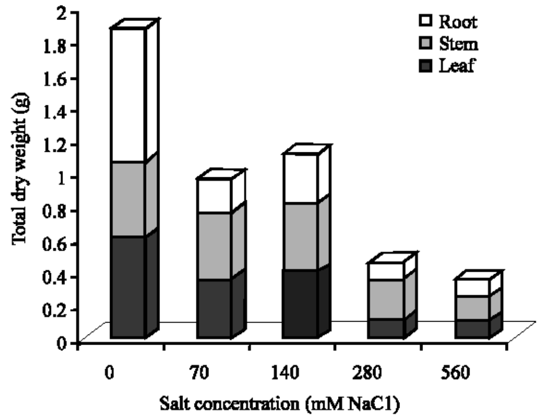

Fig. 3: Total dry weight partitioning in *Talinum triangulare* seedlings in response to various salinity regimes

DISCUSSION

Increasing salinity progressively decreased plant growth which included plant height, stem diameter, leaf number, leaf area and fresh and dry weights, respectively. These results are in consonance with the investigations of Rajpar *et al.* (2006). The adverse effect of NaCl salinity was obtained at higher concentration of NaCl.

However, the growth of some halophytes have been observed to be stimulated by sea water and others by compromise level of added salt. This fact was corroborated by Bamidele and Ikanone (1998) on *Mariscus ligularis*. In this study, *Talinum triangulare* seedlings were observed to tolerate all prevailing levels of salinity utilized (0 to 560 mM NaCl) but salinity had a significant influence on plant growth. This finding is similar to that reported by Morris and Grant (2001) in *Bolboschoenus medianus*.

Leaf number and leaf area: The reduction in number of leaf and leaf area in this investigation (Table 1 and Fig. 1) may be as a result of accumulation of ions especially sodium and chloride, which may have been toxic to the leaves turning them chlorotic and leading to loss of leaves and reduced growth. Munns (1993) also discovered that leaf death was obvious under high saline conditions, as a result of a rapid rise in salt concentrations in the cell walls or cytoplasm when the vacuoles can no longer compartmentalize the salts. This fact resulted in reduced photosynthesis as well as leaf abscission as reported by Kozlowski and Pallardy (1997). Ahmed and Ali (1990) also revealed that there was reduction in photosynthesis with high salinity levels in their work on *Hyoscyamus muticus* and *Datura stramomium*. Sprent (1984) also observed that salinity reduces shoot growth by suppressing leaf initiation and expansion as well as internode growth of leaves leading to reduced plant growth.

Plant height: Plants grew taller in non-saline soil condition as in control than in the other saline treatments. Increasing saline levels was reported by Gupta and Sharma (1990) to progressively decrease plant height and yield compared to the control. The adverse effects of NaCl, according to them were associated with significantly ($p<0.05$) higher concentration of Na^+ and lower concentration of K^+ determined in the seedling sap.

Leaf succulence: An increase in leaf succulence at low salinity level (70 mM NaCl) was obtained when compared with the control. However, the highest salinity of 560 mM NaCl were observed to decrease leaf succulence. Increased succulence has been considered beneficial to plants growing in saline conditions because the higher water content at high salinity level will assist in diluting and reducing the effects of salt content in the cells. Waisel (1997) reported that plants grown in saline soils produced thicker and more succulent leaves than those growing on salt free soils. It was revealed by Shannon *et al.* (1994) that leaf succulence may increase CO_2 absorption per unit of leaf area.

Dry weight: This is considered to be a reliable measure of productivity. Dry matter accumulation was best under non-saline conditions. This fact was corroborated by Olusola and Okusanya (1990) who reported a gradual decrease in dry weight, culm length and tiller number in *Paspalum orbiculare* as salinity level increased.

These results show that the presence of NaCl is not an absolute requirement for the growth of *Talinum triangulare*. *Talinum* is therefore a good example of a miohalophyle having the best growth under non saline conditions. In addition *T. triangulare* which is a nutrient rich vegetable can be grown successfully in areas of low salinity level. It may also assist in stabilizing moderately saline and nutrient rich beaches,. The fact that *T. triangulare* is a useful crop with good tolerance to low salinity level makes it As a useful crop with good tolerance to low salinity level, makes it of agronomic interest.

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