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The effect of salinity on growth of Elephant grass (*Pennisetum purpureum*)

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ABSTRACT. Elephant grass (*Pennisetum purpureum*) is a fast-growing forage crop. Salinity arising from irrigation represents a major problem for its growth in AL-Madinah AL-Munawwarh in the Western part of Saudi Arabia. The objective of this study was to evaluate salt tolerance of elephant grass subjected to four different NaCl concentrations (0, 100, 200, 400 mM). Leaf extension, leaf area, number of leaves, plant height, fresh and dry weights of shoots and roots, and the chlorophyll contents were measured to determine the effect of salinity on growth of elephant grass. Results obtained indicated that the leaf extension was significantly reduced when highest level of NaCl was used. Plant height, number of leaves and the area of leaf were reduced with increasing salinity but chlorophyll content was increased. Dry weights of shoot and root were reduced with the increase of salinity. Compared to control (with 0 mM NaCl), about 66% dry weight reduction occurred when NaCl increased from 200 to 400 mM. This study showed that elephant grass was sensitive to high salinity stress (400 mM NaCl), and relatively low to moderate salinity must be maintained to achieve a high growth rate.

Introduction

Salinity is one of the major problems that influence plant growth (Misra *et al.*, 1997; Bernsten *et al.*, 2001; Gibberd *et al.*, 2002; Munns, 2002; Rivelli *et al.*, 2002). It is responsible for the loss of 10 million hectares/annum of agricultural land (Quispe & Jacobsen, 1999). In the arid environmental habitats, such as that in Saudi Arabia, the salt stress provides an extreme environment to plant growth which must be overcome by a tolerant species in order to establish itself successfully in such environment.

Elephant grass (*Pennisetum purpureum*) is a fast-growing C_4 grass (Wang *et al.*, 2002) that is cultivated in AL-Madinah AL-Munawwarah in the Western part of Saudi Arabia. It is used for feeding cattle. Salinity arising from the irrigation presents a major problem for its growth in AL-Madinah AL-Munawwarah.

Since there is a lack of information concerning the salt tolerance of elephant grass, this work was carried out to investigate the growth response of the elephant grass to different salinity treatments.

Materials and Methods

Rhizomes of *Pennisetum purpureum* originally derived from Africa were planted in 12-litres pots filled with coarse sand and grown in high-light, 600 μmol $m^{-2}s^{-1}$, controlled environment chamber (Fitotron SGC066. CHX, Sanyo Gallenkamp PLC, Leicester, UK.), at day/night temperatures of about 25°C/20°C. The VPD was kept below 1 kPa. Photon flux density at leaf height was 600 μmol $m^{-2}s^{-1}$ and the photo period was 14 hours.

Three NaCl concentrations, 100, 200 and 400 mM, in full strength Hoagland nutrient solution were used (Arnon & Hoagland, 1940). The control was Hoagland nutrient solution with no NaCl added. All pots were irrigated every other day for 7 days with full strength Hoagland nutrient solution. NaCl treatments were begun 9 days after the start of the experiment. The NaCl concentration was increased in steps of 100 mM on alternate days until the appropriate salt treatments were reached.

Leaf extension was measured every day. Growth parameters included shoot length, number of leaves, leaf area and fresh weights of shoots and roots were determined 30 days after planting. Shoot and root samples were oven-dried at 70 °C for 48 h in order to determine dry weight. Chlorophyll of leaves was extracted with 80% acetone and determined as described by Arnon (1949), thereby spectrum absorption was measured at 645 and 663 nm.

The data obtained from various analyses and measurements were statistically analysed using one-way analysis of variance (Systat, Inc., Evanston, Illinois. U.S.A).

Results

The effects of four salinity treatments on leaf extension are illustrated in Figure 1. The rate of leaf extension was only significantly reduced at the highest level of salinity (400 mM NaCl). Increasing salinity from 200 to 400 mM reduced leaf extension rate to about 54% compared to control. On the other hand, leaf extension was not significantly affected by the 100 and 200 mM NaCl compared to the control.

Plant height, number of leaves and leaf area were significantly reduced by increasing salinity level from 200 to 400 mM (Table 1). A comparison of the responses of the three growth parameters indicated that leaf area was the most sensitive to the highest level of salinity at the concentration of 400 mM NaCl. The leaf area reduction was amounted to 72% compared to the control, while the reduction in plant height and number of leaves were 48% and 45%, respectively. In contrast, all growth parameters were not significantly affected by the 100 and 200 mM NaCl compared to the control (Table 1).

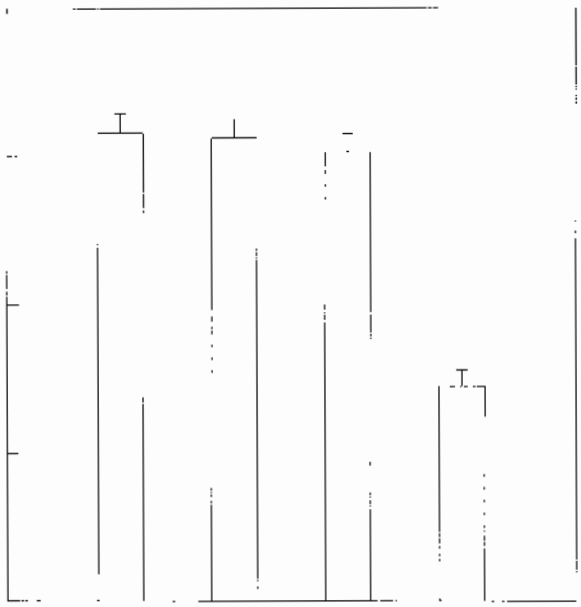

Fig. (1). The effect of salinity on leaf extension of elephant grass.
Values shown are the mean of n=3 replicate plots (+SE).
Different letters show significant differences between NaCl treatments (P>0.05).

Table 1. Effect of salinity on the shoot growth and leaf area of elephant grass.

Treatment NaCl (mM)	No. of leaves per plant	Plant height (cm)	Leaf area per plant (cm^2)
Control	6.67 ± 0.33^{a}	42.00 ± 1.22^{a}	135.9 ± 1.73^{a}
100	6.45 ± 0.30^{a}	41.76 ± 1.04^{a}	134.2 ± 1.54^{a}
200	6.33 ± 0.35^{a}	41.53 ± 0.93^{a}	132.1 ± 1.46^{a}
400	3.67 ± 0.28^{b}	22.00 ± 1.03^{b}	38.4 ± 0.87^{b}

Means, within a column followed by the same letter do not differ significantly at 5% level of probability according to Scheffe's Test. Values shown are the mean of n=3 replicate plots (+ SE).

Fresh and dry weights of shoots and roots signifieantly decreased at the 400 mM NaCl concentration eompared to other salinity treatments which showed non significant decrease (Table 2). The results also showed that shoot was more sensitive to the salinity than root. Moreover, fresh weights of shoots and roots were more affected than their dry weights.

Tahle (2). Effect of salinity on fresh and dry weights of shoots and roots of elephant grass.

Treatment NaCl (mM)	Fresh weight of shoot ($g\ plant^{-1}$)	Dry weight of shoot ($g\ plant^{-1}$)	Fresh weight of root ($g\ plant^{-1}$)	Dry weight of root ($g\ plant^{-1}$)
Control	6.04 ± 0.23^{a}	1.41 ± 0.04^{a}	4.85 ± 0.24^{a}	0.23 ± 0.01^{a}
100	5.96 ± 0.20^{a}	1.39 ± 0.03^{a}	4.66 ± 0.21^{a}	0.22 ± 0.02^{a}
200	5.87 ± 0.14^{a}	1.37 ± 0.03^{a}	4.22 ± 0.17^{a}	0.21 ± 0.02^{a}
400	1.56 ± 0.08^{b}	0.42 ± 0.01^{b}	2.89 ± 0.15^{b}	0.17 ± 0.01^{b}

Means, within a column followed by the same letter do not differ significantly at 5% level of probability according to Scheffe's Test. Values shown are the mean of n=3 replicate plots (+ SE).

Figure 2 shows that the control plants had a lower concentration of chlorophyll compared to the other salinity treatments. The highest chlorophyll concentration in leaves at 400 mM NaCl was about 59% higher as compared to the control. However, the chlorophyll concentrations at the 100 and 200 mM NaCl were not significantly affected by salinity compared to control.

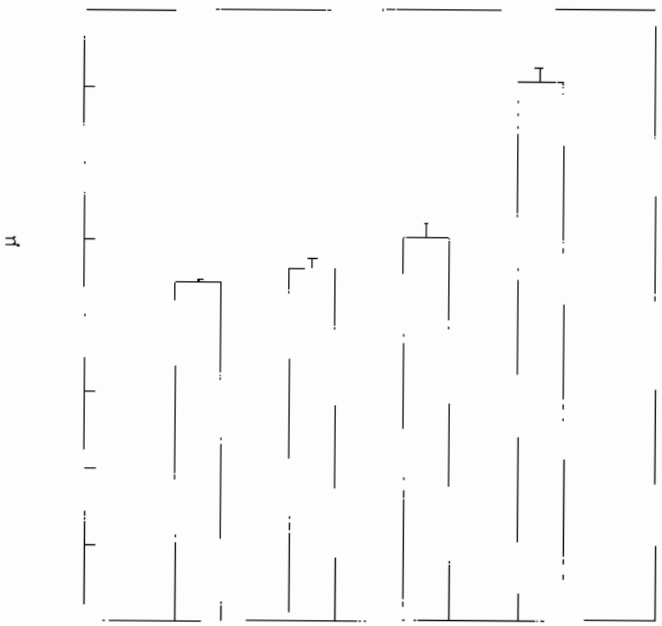

Fig. (2). The effect of salinity on chlorophyll content of elephant grass.
Values shown are the mean of n=3 replicate plots (−SE).
Different letters show significant differences between NaCl treatments (P>0.05).

Discussion

Concerning the effect of salinity on growth of elephant grass, the results reported in Figure 1 showed that leaf extension was reduced significantly at the highest level of salinity in contrast to a marginal change at the 100 and 200 mM NaCl levels compared to control. High salinity level significantly reduced the number of leaves, plant height, leaf area and fresh as well as dry weights of shoots and roots, the results reported here are in agreement with those reported by Misra *et al.*, (1997), Gasim (1998), Esaa & Al-Ani (2001) and Essa (2002).

Cordovilla *et al.*, (1995) and Essa (2002) reported that roots are more resistant to salinity than shoots. The present results confirmed the earlier observations of higher roots resistant to salinity compared to shoots (Table 2). At the 400 mM NaCl, shoots fresh and dry weights showed about 34% greater reduction than roots compared to control.

A decrease in chlorophyll contents was reported in many crops that had different responses to salinity (Misra *et al.*, 1996; Gasim, 1998; Sayed & Gadallah, 2001). On the other hand, an increase in the chlorophyll contents was reported in some crops like wheat, broad bean and rice (Abd El-Samad, 1993; Aldesuquy & Gaber, 1993; Misra *et al.*, 1997).

Moreover, Rao & Rao (1981) found that salinity enhances chlorophyllase activity. The results in Figure 2 showed that chlorophyll contents increased with increasing salinity levels. This increase could be due to an increase in the number of chloroplasts in stressed leaves (Aldesuquy & Gaber, 1993). Another possibility is that, this increase in chlorophyll contents could be a result of leaf area reduction.

It can be concluded that elephant grass is sensitive to high salinity stress (400 mM NaCl), and relatively low to moderate salinity must be maintained to achieve a high growth rate.

Acknowledgement

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تأثير الملوحة على نمو نبات عشبة الفيل

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المستخلص. تعتبر عشبة الفيل من المحاصيل ذات النمو السريع. وفى منطقة المدينة المنورة يعاق نمو هذه العشبة بالملوحة الناتجة من مياه الري.

تهدف هذه الدراسة إلى معرفة تأثير تركيزات مختلفة من كلوريد الصوديوم (٠، ١٠٠، ٢٠٠، ٤٠٠ مل مول) على نمو هذه العشبة. ولمعرفة تأثير التركيزات المختلفة لكلوريد الصوديوم على نمو هذه العشبة تمت دراسة الدلالات التالية: نمو الورقة، مساحة الورقة، عدد الأوراق، ارتفاع النبات، الوزن الرطب والوزن الجاف للمجموعين الخضري والجذري وكذلك كمية الكلوروفيل.

أوضحت النتائج أن نمو الورقة انخفض انخفاضاً شديداً عند استخدام التركيز العالي لكلوريد الصوديوم، بينما انخفض كل من عدد الأوراق وارتفاع النبات ونمو المجموعين الخضري والجذري بزيادة تركيز الملوحة، في حين ازدادت كمية الكلوروفيل بزيادة تركيز الملوحة.

وخلصت الدراسة إلى أن عشبة الفيل أظهرت حساسية للملوحة المرتفعة (٤٠٠ مل مول كلوريد الصوديوم)، وأن الحصول على إنتاجية عالية لهذه العشبة يستوجب نموها تحت تركيزات منخفضة أو متوسطة من الملوحة.