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Evaluating Salinity Tolerance of Sheesham (Dalbargia sisso L.) Tree Seedlings

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Abstract
In order to assess the influence of different salinity (0 (control), 2, 4, 8 and 12 (dS m^{-1})) levels on the growth and development of sheesham tree seedlings, an open field pot experiment was conducted during 2013 at the Centre for Bio-saline Agriculture, Department of Soil Science, SAU, Tandojam. The results on height, stem girth, number of branches plant^{-1} and fresh and dry leaf weights plant^{-1} were recorded. Analysis of Na^+ and K^+ was done in the ash obtained from the leaves. The data showed that increasing salinity levels significantly decreased all the growth and development traits of seedlings. Compared to control, seedlings stressed with 2, 4, 8 and 12 EC (dS m^{-1}) salt solution showed 7, 14, 34 and 39% reduction in height; 10, 30, 89 and 95% reduction in weight of fresh leaves; 2, 25, 92 and 95% reduction in weight of dry leaves; 10, 41, 51 and 72% reduction in number of branches and 8, 10, 16 and 35% reduction in stem girth, respectively. The poor performance of seedlings under salt-stress condition was associated with more Na^+ and less K^+ contents of leaves. Compared to control, seedlings, grown in 2, 4, 8 and 12 EC (dS m^{-1}) treatments had 0.98, 30, 79 and 89% more Na^+ and 21, 32, 37 and 51% lower K^+ in leaves, hence they displayed lower K^+/Na^+ ratio. It is concluded from this study that *Dalbargiasisso* L. is a salt-sensitive trees species at initial growth stage, it should not be grown under saline conditions.
Keywords: Salinity, Seedlings, Stress, Growth and Ratio

Introduction

Among the major abiotic environmental stresses (Grewal, 2010) salinity is becoming serious global issue (Zhu, 2001; Cha-um *et al*., 2006; Qadir *et al*., 2007) more than 3% of the world's total land mass is affected by salinity and half of the world countries are having at least same quantity of salt-affected land. Globally, there are over 4,000,000 sq kilometers affected by salinity (Anon, 1995). Soil salinity becomes cause of degradation and reduction of crop yield and plant nutrition (Metternicht and Zinck, 2003). Soil salinity is a serious problem for plant growth in most countries having arid and semi-arid climate in the world. In such soils because of high dissolved salts (mostly NaCl) plant growth decreases (Ali *et al.,* 2011; Azeem and Ahmed, 2011; Saqib *et al*., 2012). This problem is particularly more serious in Asia, where major portion of the land is affected by salinity (Aslam *et al*., 1993). Due to climatic conditions, soil origin, land use, irrigation practices, etc, about 6.3 million hectares of land seem to be salt-affected in Pakistan, of which around 1.89m ha is saline, 1.85 million ha is permeable saline-sodic, 1.02 million ha is impermeable saline-sodic and 0.028 million ha is sodic in nature (Qureshi, 1993). It is estimated that out of 1.89 million ha saline patches, 0.5 million ha are found in Punjab, 0.94 million ha in Sindh and 0.5 million ha in KPK (Rafiq, 1990). It has long been reported that salinity is adversely affecting growth, development and yield of agricultural crops, including forest trees (Jampeetong and Brix, 2009; Gorai *et al*., 2010). Qadir *et al*. (2007) have also reported that plant growth and development processes viz. seed germination, seedling growth, flowering and fruiting are adversely affected by salinity, resulting in reduced yield and quality.

Among the forest tree species sheesham has its own importance and economic value (Tewari, 1994). Sheesham is an indigenous multipurpose tree species, widely planted under various agro forestry systems (Tewari, 1994). Sheesham tree is native to Haryana and various parts of India and other countries including, Pakistan and Nepal. It has high economic value, because of its multiple uses particularly, in furniture, buildings, plywood, fuel, etc. It is medium to large sized deciduous tree with a light crown, planted by seed and suckers (Hassan, 2005). Now a days this tree is under serious threat due to various diseases (die-back or mortality of seed and seedlings), salinity, water-logging, and poor drainage problems in Pakistan (Zakaullah, 1999; Khan and Khan, 2000; Yousaf, 2002; Sah *et al*., 2003). Particularly, in Sindh province this tree is no more growing along water channels, canals, river, banks, borders of agricultural fields, etc. This suggests that future research should be planned to restore this tree again by overcoming the various problems, including salinity as well. Although, there are several reports which indicate that this sheesham tree can grow on poor soils (Yadav and Singh, 1970; Grewal and Abrol, 1986). The detailed information regarding its tolerance to salinity at an early growth stage is lacking, thus the purpose of this study was to test the salinity tolerance of sheesham tree seedlings.

Materials and methods

In present study a pot experiment was conducted to evaluate the salinity tolerance of sheesham tree seedling at the Centre for Bio-saline Agriculture, Department of Soil Science, Sindh Agriculture University, Tando jam, Pakistan in a Randomized Complete Block Design (RCBD) during 2013. Five large cemented pots with capacity of 60 kg soil pot^{-1} were used in the experiment. Under present study soil was used fertile clay loam by weight 60 kg soil pot^{-1}, twenty five 30-days-old sheesham tree seedlings were obtained from forest nursery. Five seedlings were planted into each large cemented pot at equal distance from plant to plant. Five salinity levels were used in this experiment vis: T_1: Control: (only canal water), T_2: 02 EC (dS m^{-1}), T_3: 04 EC (dS m^{-1}), T_4: 08 EC (dS m^{-1}) and T_5: 12 EC (dS m^{-1}) salt solution. Prepare salt solution for each salt stress treatment through NaCl and $CaCl_2$ were used 20:1 ratio. All salt solutions were applied to plants continuously.

Observations recorded

After 90 days of planting, plants were used to recorded data, Seedling height (cm), Number of branches (plant^{-1}), Stem thickness (cm), Fresh weight of leaves (plant^{-1}), Dry weight of leaves (plant^{-1}) and Leaf analysis for Na^+ and K^+ concentrations and K^+/Na^+ ratio calculated. Leaf samplings was done to determine the Na^+ and K^+ through dry-ash method of Ryan *et al.* (2001) using flame photometer and calculate K^+/Na^+ ratio was value obtained by determination.

Soil analysis:

Before placing in pots, the soil was analyzed for physico-chemical properties, Soil texture by hydrometer method of Bouyoucos (1962), Organic matter using Walkley-Black method (Walkley, A. 1947), pH (H_2O), and EC (dS m^{-1}) were determined at 1:2 ratio using digital electrodes. Lime content was determined by Acid neutralization method of Ryan *et al.*, (2001). Concentration of Na^+ Ca^+ and Mg^+ were determined in soil samples. Exchangeable Sodium percentage was determine using the formula of Rewell (1994).

Data analysis

The plant data obtained from the study were processed and analyzed statistically using analysis of variance (ANOVA) Least Significant Difference (LSD) method was used to test the differences between treatment at <0.05 level of probability by computer software package "Statistix (SXW), version 8.1" (copyright 2005 Analytical Software, USA).

RESULTS

The data related to the physico-chemical properties of the soil used in the pots are given in the (Table-1). The results showed that the soil selected for the experiment was clay loam in texture, calcareous in nature, low in organic matter content, salt-free, normal in reaction and had no salinity problem.

Table 1. Physico-chemical properties of the experimental soil

Properties	Values
Mechanical analysis	
a. Sand%	33.7
b. Silt%	28.3
c. Clay%	38.0
Textural class	Clay loam
pH (H_2O)	7.7
Electrical conductivity (EC dS m^{-1})	0.6
Lime content ($CaCO_3$)%	8.7
Soil organic matter (S.O.M)%	0.71
Exchangeable Sodium Percentage (ESP)	6.8

Plant height

The data given in Figure 1 indicate the effect of salinity on the height of sheesham tree seedlings. It is evident from the results that increasing EC of salt solution significantly ($P<0.05$) decreased the height of sheesham tree seedlings. Compared to control (without salt), the seedlings stressed with 02, 04, 08 and 12 EC (dS m^{-1}) salt solution showed 7, 14, 34 and 39 % reduction in height, respectively.

Number of branches

The effect of salinity on the number of branches developed on sheesham tree seedlings is shown in the Figure 2. It is evident from the data that the sheesham tree seedlings stressed with salt had fewer branches. Increasing salinity significantly decreased numbers of branches per plant. As compared to freshwater, the seedlings stressed with 2, 4, 8 and 12 EC (dS m^{-1}) solution had 10, 41, 51, and 72 % fewer branches, respectively.

Stem girth
The results related to the effect of salinity on stem girth of sheesham tree seedlings are presented in the Figure 3. The data indicate that the sheesham tree seedlings stressed with 02, 04, 08 and 12 EC (dS m^{-1}) salinity were not able to develop their stem girth well enough as compared to control seedlings. Increasing EC of solution resulted in a continuous decrease in stem girth. Generally, compared to control, the seedlings receiving solution of 02, 04, 08 and 12 EC (dS m^{-1}) showed reduction of 8, 10, 16, and 35% in stem girth, respectively.

Fresh leaf weight
The fresh weight of leaves developed on sheesham tree seedlings was significantly ($P<0.05$) affected by salinity (Fig 4). Compared to control seedlings stressed with 02, 4, 8, 12 EC solution showed 1, 30, 89, and 92% reduction in leaf fresh weight per plant, respectively.

Leaf dry weight
Similarly, there was significant reduction in dry weight of leaves produced by sheesham tree seedlings under saline conditions (Fig. 5). Compared to control, the seedlings stressed with 2, 4, 8, and 12 Ec (dS m^{-1}) salt solution showed 2, 25, 92 and 95% lower leaf dry matter, respectively.

Fig-1: Effect of salinity on height (cm) of sheesham tree seedlings	**Fig-2:** Effect of salinity on number of branches developed on sheesham tree seedlings
Fig-3: Effect of salinity on stem girth (cm) of sheesham tree seedlings	**Fig-4:** Effect of salinity on fresh leaf weight of Shesham tree seedlings
Fig-5: Effect of salinity on dry leaf weight of sheesham tree seedlings	**Fig. 6:** Effect of salinity on Na^+ content of sheesham tree seedlings
Fig-7: Effect of salinity on K^+ content of Sheesham tree leaf tissue	**Fig-8:** Effect of salinity on $K^{+/}Na^+$ determined in the leaves of sheesham tree seedlings

Effect of salinity anion contents of leaves
Na^+ content
The data related to the effect of salinity on Na^+ content of leaf tissue are shown in the Fig. 6. It is evident from the data that stressing seedlings with salt solution increased the sodium content of leaf tissue, compared to control, increasing salinity from 0, to 02, 04, 08 and 12 EC (dS m^{-l}) raised the Na^+ content of leaf tissues from 0.98 to 30.03, 78.75 and 89 %, respectively.

K^+ content
The data related to the effect of salinity on K^+ content of leaf tissue is given in the Fig. 7. There seems to be significant effect of salinity on the accumulation of K^+ in leaves. Compared to non-saline treatment, the seedlings receiving 02, 04, 08 and 12 EC (d Sm^{-l}) salt solution accumulated 11, 19, 45, and 54% less K^+ in leaf tissue, respectively.

K^+/Na^+ ratio
As increasing salinity increased Na^+ and decreased K^+ in leaf tissue, there was significant decrease in K^+/Na^+ ratio (Fi. 8). Compared to control, the sheesham tree seedlings receiving salt solutions of 02, 04, 08, and 12 EC (dS m^{-1}) displayed 44, 65, 82, and 88% lower K^+/Na^+ ratio in their leaf tissue.

Discussion
In the Sindh and Baluchistan provinces, shortage of irrigation water is a major issue, groundwater is salty and poor in quality, temperature seems to be very high particularly in summer, cyclones and seawater intrusion are common in coastline. Hence the productive land of these areas is being converted into salt-affected waste land with high speed. This suggests that these problems must be minimized and/or managed to sop conversion of productive land into salt-affected areas. Among the management practices, introduction of salt-tolerant plant species seems to be getting much importance now a days. Majority of the scientists are screening salt-tolerant plant species including, tree species. More than 1500 species has been introduced as salt-tolerant plants (Qureshi, 1998). In this study an economically important tree sheesham was evaluated for its tolerance to salinity at an initial stage; particularly, effect of salinity on some important parameters was investigated during the study. The study indicated that salinity has negative effect on sheesham tree seedlings. Salinity with 4, 8 and 12 EC (dS m^{-1}) decreased shoot height (Figure-1), number of leaves per plant (Figure-2), number of branches per plant (Figure-3) and stem girth (Figure-4) Around 100 percent reduction in majority of the traits was observed at 12 EC (dS m^{-1}) level.

Generally, the effect of high (12 EC dS m^{-1}) salinity was larger on the number of leaves, branches and stem girth. Similar effect of salinity on branches, leaves and stem girth has also been observed by some other workers on various tree species including, Yaron *et al.* (1996); Qadir *et al.* (1997); Ashraf and Sarwar (2002). It is interesting to know that sheesham plant survived upto 2 and 4 EC levels. This suggests that sheesham has ability to survive well under saline condition with EC (dS m^{-1}) up to 2 and 4 (dS m^{-1}), where it showed slight reduction in growth and development traits. This also suggests that care must be taken that this tree should not be grown on salt-affected soils with EC above 4(dS m^{-1}) because, a significant reduction in their growth characteristics is expected to occur if the salinity level is increased above a critical level. There are several evidences which indicate that unlike crops, some woody plants or trees are much more tolerant to salt-stress. Although, they show sharp decline in growth under saline condition, they still survive and give respond positively under salt stress environment. But that is not true for this tree species as evident from the results. Salinity also adversely affected Na^+ and K^+ contents of leaves. Compared to other treatments, the seedlings stressed with 12 EC (dS m^{-1}) solution had much more Na^+ and less K^+. This indicates the toxic effect of Na^+ and deficiency of K^+ created possibly by salinity. There are several evidences (Saqib *et al.,* 2004), which indicate the antagonistic effect of Na^+ to K^+ under saline environment. High concentration of sodium is cytotoxic for growth and development of plants under saline condition (Iqbal and Ashraf, 2007). Reduction in K^+ concentration under saline environment decreases the enzymes activity, as K^+ is largely required for the activation of several beneficial enzymes required for plant growth (Netondo *et al*., 2004; Shirazi *et al.,* 2005; Willadino and Camara, 2005). In addition to the excess salts in root zone not only decreases availability of water to plants, but their uptake causes problem of ion toxicity in the cytoplasm.

Conclusion

Finally, this study suggests that sheesham plant has no ability to survive and grow well under saline condition with EC above 4 (dS m^{-1}). However, further future studies must be planned and conducted under field conditions.

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