Pak. J. Bot., 38(5): 1381-1388, 2006.

GROWTH PERFORMANCE AND NUTRIENT CONTENTS OF SOME SALT TOLERANT MULTIPURPOSE TREE SPECIES GROWING UNDER SALINE ENVIRONMENT

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Abstract

A field study was conducted at NIA experimental farm, Tandojam to observe the growth and nutrients (macro and micro) content of some salt tolerant multipurpose tree species (*Acacia ampliceps, Acacia stenophylla, Acacia nilotica, Eucalyptus camaldulensis,* and *Conocarpus lancifolius)* under saline environment. The salinity of the soil was varying from medium saline to very highly saline. The growth performances recorded at 3, 6 and 9 months after transplantation showed that overall survival of all the species tested, was good (70 %). The species *Acacia ampliceps* had maximum survival percentage (98.09%) followed *by Conocarpus lancifolius* (96.82%), *Acacia nilotica* (96.19 %), *Acacia stenophylla* (89.52 %), and *Eucalyptus camaldulensis* (70.47 %). The plant height at 9 months after transplantation was maximum in *Acacia nilotica* (200cm), followed by *Eucalyptus camaldulensis* (190 cm*), Acacia ampliceps* (127.2 cm), *Acacia stenophylla* (125.4 cm), and *Conocarpus lancifolius* (125.1 cm).The leaves samples analyzed for macro & micro-nutrients showed that *Acacia nilotica* had maximum nitrogen content in leaves, whereas maximum values for Potassium were recorded in *Acacia stenophylla.* While, phosphorus content was more or less similar in all species tested. The data for micro nutrients contents in leaves also showed that native acacia have the maximum zinc, copper and iron contents. It was also observed that sodium accumulation in plant was negatively related with nitrogen, phosphorus, copper, zinc, manganese and iron. The high nutritive values in foliage of native a*cacia* indicate that *Acacia nilotica* can play an important role in improving the fertility of the soil and can also give good economic returns from the marginal lands.
Keywords: growth, salt stress, *Acacia*, *Eucalyptus*, mineral nutrition

Introduction

Among the biological measures for the management of salt affected lands, plantation of woody perennials is an important approach. Planting suitable salt tolerant tree species on saline lands not only provide the green coverage to the soil but also give good economical returns to the farmers. In earlier studies, conducted in Pakistan and India, several woody species have been identified as being either highly (*Prosopis juliflora, Prosopis chilensis, Prosopis alba, Tamarix aphylaIa*) or moderately (*Acacia tortilis, Eucalyptus camaldulensis, Casurina equisetifolia, Eucalyptus microtheca, Acacia nilotica)* salt tolerant (Jain *et al.*, 1985; Shaikh, 1987; Singh, 1989; Yadav, 1980). However, there is still need for further research to identify suitable salt tolerant tree species for salt affected lands. More over the successful establishment of tree plantation requires proper monitoring of nutrient status of the stand under saline lands, especially during early establishment. Reliance on visual symptoms of nutrient disorders means that

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some sever nutrient stress situation exist, as a result of which productivity is already adversely affected (Simpson *et al.*, 1998). Foliar chemical analysis is a powerful tool in tree nutrition and fertilizer research developed over the last century (Raupach, 1967). Keeping in view a study was conducted to assess the performance of some salt tolerant tree species and to determine the nutrient status of salt tolerant trees grown under saline environment.

Material and Methods

The study was conducted at newly established plantation of some salt tolerant multipurpose tree species (MPTS) (*Acacia ampliceps, Acacia stenophylla, Acacia nilotica, Eucalyptus camaldulensis,* and *Conocarpus lencifolius)* grown at saline patch of NIA experimental Farm during Feb. 2005. The selected site was evaluated for salinity status. Soil samples from different locations were collected and analyzed for different physio- chemical analysis. The proposed site was medium to heavy in texture and saline - sodic in nature (i.e. ECe (0 -30cm) = 15.5 -61.9, SAR = 14.81-376). The dominant cation in soil was sodium. Soil samples at surface layer (0-30cm), were analyzed for macro (N, P, K, Na) and micro (Cu, Zn, Mn and Fe) nutrients. The detailed results of the soil analysis are presented in (Table: 1 & 2). Total nitrogen in soil and plant was determined by Kjeldahl method (Jackson, 1959). Phosphorus, Potash and Micro nutrients (Cu, Zn, Mn and Fe) were determined after extracting the soil by AB-DTPA solution (Soltanpour & Schwab, 1977). To evaluate the nutrient status of the tree species, plant samples (freshly matured leaves) were collected from the individual tree species and were analyzed for macro and micro nutrients. Phosphorus, Potassium and micronutrients (Cu, Zn, Mn and Fe) in plant tissues were determined after wet digestion, using 2:1 ratio of Nitric acid and Perchloric acid (HNO_3 : $HClO_4$). Phosphorus was determined by UV-Spectrophotometer (Model: Hitachi 150- 20), K and Na by Flame photometer (model: Jenway PFP-7) and micronutrients were determined by Atomic Absorption Spectrophotometer (Model Analytika, novM 400). The data was subjected to analysis of variance (ANOVA) and Duncan multiple range test (DMRT) by MSTATC computer package (USA, version 1.3).

Table 1. Physio-chemical analysis of experimental site

Soil properties	Depth	
	0 – 30cm	30 – 60 cm
Textural class	Silty clay	clay loam
Saturation %	36.85 – 48.0	38.0 – 55.5
ECe (dS/m)	15.5 – 60.9	9.10 – 51.2
pH	7.5 – 8.2	7.3 – 8.0
Na (meq/l)	165.0 – 2890	152.2 – 1695
K (meq/l)	1.41 – 5.00	1.03 – 1.92
Ca + Mg (meq/l)	38.5 – 118	28.75 – 97.5
SAR	14.81 – 376	40.0 – 243.0
Salinity Class	Saline – Sodic	Saline - Sodic

Table 2. Nutritional status of soil under tree plantation at surface layer (0 -30 cm).

Species	Major nutrients (Extractable)			Micro nutrients (ABDTPA- Extractable)			
	Total N	P	K	Cu	Zn	Mn	Fe
	(%)			(mg / L)			
Acacia ampliceps	0.0281	4.019	198.75	3.35	0.095	9.23	19.10
Acacia stenophylla	0.0369	4.748	222.5	3.78	0.119	29.18	15.80
Acacia nilotica	0.0452	6.574	198.5	3.90	0.143	5.52	13.85
Eucalyptus amaldulensis	0.0195	3.113	171.3	3.23	0.093	9.71	17.15
Conocarpus lancifolius	0.0396	4.578	180	4.43	0.105	11.86	22.30

Results

Growth performance: Early growth performances (Survival percentage and plant height), were recorded after three, six and nine months of transplantation. The overall survival of all the species was good after nine months of transplantation (i.e. 70 %). The species *Acacia ampliceps* (98.09%) showed maximum survival percentage (95%) followed *by Acacia nilotica* (96.19 %), *Conocarpus lancifolius* (96.82%), *Acacia stenophylla* (89.52 %), and *Eucalyptus camaldulensis* (70.47 %). Higher survival of *Acacia nilotica* was also observed by Singh *et al.* (1986), who concluded that *Acacia nilotica* can perform well both on saline as well as saline sodic soils. In another study Hussain. *et al.* (1990) also reported the suitability of *Acacia nilotica* under saline sodic soils. According to Macar *et al.* (1990), high salt tolerance in *Acacia* species is associated with maintenance of lower Na and Cl concentration in shoot, particularly in expanding leave.

Table 3. Survival percentage (%) and Plant height (cm) of tree species recorded at 3, 6 and 9 months after transplantation.

Species	Survival percentage (%)				Plant height (cm)		
	After 3 months	After 6 months	After 9 months	Total	After 6 months	After 9 months	Total
A. nilotica	98.09 a	96.19 a	96.19 a	96.82 AB	62.19 c	200.0 a	131.1A
E. camaldulensis	87.6 a	72.38 b	70.47 b	76.82 C	81.47 c	190.0 a	135.8 A
A. ampliceps	99.05 a	98.09 a	98.09 a	98.41 A	65.26 c	127.2 b	96.23 BC
A. stenophylla	89.51 a	89.50 a	89.50 a	89.52 B	80.21 c	125.4 b	102.8 B
C. lencifolius	100.0 a	95.24 a	95.23 a	96.82 AB	30.34 d	125.1 b	77.72 C
Total	**94.85 A**	**90.28 A**	**89.90 A**	----	---	---	----

LSD (0.05%) :	**Germination**	**Plant Height**
Species =	7.373	19.71
Time =	8.729	

The plant height at 9 months after transplantation was maximum in *Acacia nilotica* (200cm), followed by *Eucalyptus camaldulensis* (190 cm), *Acacia ampliceps* (127.2 cm), *Acacia stenophylla* (125.4 cm), and *Conocarpus lancifolius* (125.1 cm). The better growth performance of *Acacia nilotica* and *Eucalyptus camaldulensis* was also reported earlier (Grewal & Abrol, 1986; Gupta *et al.,* 1988; Shirazi, 2001).

Nutrients contents: The data of leaf samples analyzed macro and micro nutrient is presented in table.3. The data showed that among the species tested, all the species are sufficient in nitrogen and phosphorus, except *Acacia ampliceps,* when compared with the possible limits of N (1.75 – 2.5%) and P (< 0.08- 0.12%), as reported by Marcar, 1995. The values for potassium were almost sufficient except *Conocarpus lencifolius*, ranging from (0.56 – 0.96%). The possible limits for potassium in *Acacias* are reported as (0.76 – 0.90%) by Marcar 1995. Sodium contents in plant leaves were ranged between (0.15 – 0.32%). The species *Acacia nilotica* had minimum Na contents, where as the species *C. lencifolius* and *A. stenophylla* had maximum Na contents i.e. 3.2 and 3.0 %, respectively. However all the species were showing bit higher Na contents than the possible limits (0.05 – 0.07%) as reported by Marcar (1995). The lower values of Na in *Acacia nilotica* were also observed in our previous studies (Shirazi, 2001). Similar were the observations of Grewal & Abrol (1986). They observed that *Acacia nilotica* accumulate low Na and had the lowest Na/Ca and Na/K ratio. And hence was found more promising then *Eucalyptus sp.* and *Parkinsonia aculeata* as it experienced low mortality and had better response in alkali soils. Copper content in plant leaves were ranged from 2.05 to 15.77 mg/l, with *Acacia nilotica,* having the maximum values (15.77mg/l). The Cu content in all the tree species were recorded below the critical limits (20 mg/ l), as reported by Reuter and Robinson (1986), Benton (2002). The antagonistic effect of Na on Cu was quite evident as there was a significant negative correlation between Cu and Na (r = - 0.63). The situation in case of Zinc was also alarming with only two species (i.e. *Acacia nilotica* and *E. camaldulensis*), have the Zn contents within the critical limits (> 15.0 mg/l) as reported by Reuter & Robinson 1986, Benton (2002). The correlation between Zn and Na was significantly negative (r = - 0.58). Manganese content in plant leaves was quite satisfactory, ranging from 31.92 to 64.42 mg/l. Maximum values were observed in *E. camaldulensis* (64.45mg/l). Mn content in all the species tested was within the critical limits (20 – 500 mg/l) as reported by Benton (2002). The relationship between Mn and Na was also negative but very week (r = -0.03). All the species had quite normal Fe contents (i.e. 129 – 330 mg/l), except *Acacia nilotica* (760 mg/l), where the Fe contents were ranging towards the toxic limits (i.e. > 200mg/l) as reported by Reuter & Robinson, (1986). The relationship between Fe and Na was also significantly negative (r = 0.55).

Discussion

Salt tolerance in the plant is a complex phenomenon. Various genetical, physiological and environmental factors are involved. The species tested in the present study showed variable response to salinity during early survival and establishment. The three Acacias (*A. nilotica, A. ampliceps,* and *A. stenophylla*) and *Conocarpus lencifolius* showed highest survival. More over the survival become stable after 2 to 3 months after transplanting. On the other hand there was continuous decline in survival percentage in case of *Eucalyptus camaldulensis,* and was become stable after 6 to 7 months of transplantation. This indicates its slower adaptability to saline environments. The salt shock became more sever due to high temperature during hot summer days (i.e. April to July). The survival percentage of *E. camaldulensis* recorded after 9 months was 70.47 percent.

As far as plant height is concerned the growing nature of the trees plays an important role in the growth performance of the tree plant. In spite of lower survival percentage the species *E. camaldulensis* was the main competitor with *Acacia nilotica.* The erectness of these two species had out classed all the other species tested. The bushy nature of the two

Table 3. Macro and micronutrient in leaves of salt tolerant (multipurpose tree species MPTS).

Species	Macro nutrients (%)				Micro nutrients (mg/L)			
	T.N%	P%	K %	Na %	Cu	Zn	Mn	Fe
A. nilotica	3.23 a	0.12	0.76 b	0.15 b	15.77 a	27.07 a	35.15 b	760.83 b
E. camaldulensis	2.17 b	0.10	0.89 a	0.20 ab	6.18 b	16.27 b	64.45 a	330.50 b
A. ampliceps	1.51 b	0.04	0.75 b	0.26 ab	2.05 c	8.76 d	46.02 b	129.47 a
A. stenophylla	2.34 b	0.10	0.96 a	0.32 a	3.13 c	12.92 c	31.92 b	199.83 b
C. lencifolius	2.08 b	0.09	0.56 c	0.30 a	5.65 b	9.52 d	42.65 b	200.60 b
LSD (0.05%)	0.883	N.S	0.103	0.119	1.738	2.63	14.98	9.095

Table 4. Correlation studies between macro and micro nutrients with Sodium (Na) in plant.

Nutrients	Correlation (r) values with Sodium (Na) in plant
Nitrogen (N)	-0.514
Phosphorus (P)	-0.374
Potassium (K)	0.022
Copper (Cu)	-0.631
Zinc (Zn)	-0.580
Manganese (Mn)	-0.033
Iron (Fe)	-0.550

Australian Acacias (i.e. *Acacia ampliceps* and *Acacia stenophylla*) could not compete with the native *Acacia nilotica* as well as *E. camaldulensis.* Similarly the species *Conocarpus lencifolius* though has the single stemic nature but due slow growing habit (personal observations), could not compete with these two species (i.e. *Acacia nilotica* and *E. camaldulensis)*. The better performance of *Acacia nilotica* and *E. camaldulensis* under alkaline conditions were also reported by Gupta *et al.*, (1988). They reported that *Acacia nilotica* and *E. camaldulensis* were alkali resistant tree species. *Acacia nilotica* could be grown up to pH 9.7 on sandy soils, 9.2 in clay soils and 8.8 on loamy soils, while *E. camaldulensis* could be grown at pH values of 11.0 on sandy soils, 9.2 on clay and 8.6 on loamy soils.

The presence of Na salt in the growing medium of the plant also causes nutritional disorder in the tree plants as in other glycophytic herbaceous plants (Akram *et al.*, 2007; Raza *et al.*, 2007). The availability and uptake of nutrients by plants in saline environments are affected by many factors in the soil - plant environment. The concentration and ratios of accompanying elements can influence the uptake and transport of a particular nutrient and indirectly may affect the uptake and translocation of others. These interactions are complicated further by numerous environmental factors such as aeration, temperature, and stresses both biotic and abiotic (Grattan & Grieve, 1999).

In the present study the leaf samples analyzed for macro (NPK) and micro (Cu, Zn, Mn and Fe) were also showing antagonistic effects with Na contents in the leaves except K. However the intensity of this antagonistic effect varies with in the minerals studied. The correlations (r) with sodium content in plant leaves were significantly – ve in case of nitrogen, copper, zinc and iron (i.e. N = -0.514, Cu = 0.63, Zn = -0.58 and Fe = -0.55). In spite of –ve relations of Na with nitrogen all the species are maintaining sufficient nitrogen in leaves except *A. ampliceps*. The possible lower values of N content in *A. ampliceps* may be the more interference of Na content at surface layers, as the species *A. ampliceps* had creeping type of rooting system, mostly dominated at upper surface of the soil, where the Na contents were high as compare to subsurface layers of the soil. Another possible reason for lower values of N content in *A. ampliceps*, might be the dilution effect as it is the only species which had much broader leaf blades. The interaction between salinity and phosphorus (P) nutrition of plants is equally as complex as that between salinity and N. The interaction is highly dependent upon the plant species (or cultivar), plant developmental age, the composition and level of salinity and the concentration of P in the substrate. The values for P content in the leaves of tree species tested was with in the critical limits except *A. ampliceps,* showing P contents below the possible limits (i.e. 0.1 – 0.4 %) as reported by Marcar (1995). The lower values of phosphorus in *A. ampliceps,* in saline soils were also observed in our previous studies (Shirazi, 2001). Grattan & Grieve, (1993), reported that reduction in P availability under salinity occurs, not only because of ionic strength effects, which reduce the activity of phosphate but also because P concentration in soil solution is tightly controlled by sorption processes and by solubility of Ca- P minerals. The Potassium content in the entire tree species tested was almost sufficient. Maintenance of adequate levels of K. is essential for plant survival in saline habitats. According to Marschner (1995), potassium is the most prominent inorganic plant solute, and as such makes a major contribution to the low osmotic potential in the stele of the roots that is a prerequisite for turgor-pressure-driven solute transport in the xylem and the water balance of plants. The sufficient values of K in leaves indicate better tolerance of these species to saline environments (Akram *et al*., 2007). The antagonistic effect of Na was observed more prominent in case of Cu, as none of the species showed Cu values within the critical limits, as reported by Reuter & Robinson (1986), Benton (2002) i.e > 20mg/l. Another possible reason for low Cu contents may be the interaction of Fe with Cu, as presence of sufficient quantity of Fe reduces the Cu absorption from the soil solution (Kitagishi & Yamane, 1981). The situation in case of Zn was quite similar to that of N and P, where *A. ampliceps*, *A. stenophylla* and *Concarpus lencifolius* were showing Zn values blew the critical limits. This might be the competition of sodium with Zn uptake by these species, as *A. ampliceps*, *A. stenophylla* and *Concarpus lencifolius* had comparatively higher Na contents (i.e. 0.26, 0.32 and 0.30%, respectively), in leaves as compared to *Acacia nilotica* (0.15%) and *E. camaldulensis* (0.20%). According to Lindsay (1972) the most important factors contributing to Zn deficiency are low soil Zn, Calcarious in nature, low in organic matter and limited Zn uptake by roots due to restricted root zone and antagonistic effects. Alina & Pendias (2000), had the opinion that the solubility and availability of Zn, is negatively correlated with Ca saturation and P compounds present in soils. This relationship may reflect both adsorption and precipitations processes as well as interaction between these elements**.** The situation in case of Fe contents in tree leaves was quite satisfactory except in case of *Acacia nilotica* and *E. camaldulensis,* where both the species were showing quite higher values of iron in leaves. In spite of antagonistic effects of Na with Fe (r = - 0.5.5), all the species are maintaining normal uptake of iron in leaves. According to Alina & Pandias, (2001), high concentration of Fe in the soil solution is often associated with salinity and low phosphorus or base status of soil. Foy *et al.* (1978), while reviewing the physiology of Fe toxicity and plant resistance stated that plants high in nutrients, especially Ca and SiO_2 can tolerate high internal levels of Fe. This was found true in case of *Acacia nilotica* and *E. camaldulensis*, where both the species were showing higher values of Fe than the other plant species tested. Similarly the Mn contents in all the species tested were also satisfactory. It might be the fact that Mn is not bind to insoluble organic ligands, either in roots or in xylem fluid and is rapidly taken up and translocated with in the plants (Alina & Pandias, 2000). Heenan & Campbell (1980), reported that at a high Mn supply, the leaves accumulate higher concentrations with age, but small amounts of Mn were translocate from old leaves when young expending leaves were Mn deficient.

The results of the present study show that the species *Acacia nilotica* is the good performer under salt affected soils. Due to high nutritive values in foliage, the species can play an important role in improving the fertility of the soil and can also give good economic returns from the marginal lands.

Acknowledgement

The author is highly thankful to Head, Soil Science Division for extending the facilities of micronutrients analysis and Mr. Saqib Ali Memon for composing the manuscript.

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(Received for publication 18 September, 2006)