SODIUM CHLORIDE STRESS STUDIES ON GROWTH OF SOME LEGUMINOUS FOREST TREE SEEDLINGS

MUHAMMAD ARIF CHAUDHRY, PLANT PHYSIOLOGIST AND *ALTAF HUSSAIN*, ASSISTANT FOREST GENETICIST, PAKISTAN FOREST INSTITUTE, PESHAWAR.

ABSTRACT

An experiment was laid out in split plot design in pot culture to study the effect of sodicity, created through three NaCl stresses: 0.044% to 0.351%, 0.132% to 0.878% and 0.308% to 1.580%, on soil pH, plant height and apical dieback in *Leucaena leucocephala*, *Albizzia lebbek*, *Acacia nilotica* and *A. ampliceps*. The results indicated that the highest salt concentrations (0.878% - 1.580%) produced deleterious changes in soil pH and resulted in dieback injury in *A.nilotica*, *A.lebbek* and *L.leucocephala* in an increasing order. Although the growth of *A.ampliceps* was reduced appreciably but it showed a fair degree of tolerance to the highest concentrations to dieback injury. The higher concentrations (0.308% 0.615%) caused highly significant reductions in plant height in *A.ampliceps*, *A.lebbek*, *L.leucocephala and A.nilotica* in a decreasing order.

INTRODUCTION

The major area of arable lands of Pakistan falls in the arid and semi-arid regions where the land degradation resulting from the excess of different salts and water-logging, is a major impediment to lands utilization. Out of the total (89.96 million ha) land area of Pakistan, only 29.54 million ha are suitable for cultivation. The irrigated area is about 14.97 million ha of which 10.12 million ha are affected by salinity and water-logging or both to varing degree. The area annually damaged by salinity and water-logging is estimated as 0.041 million ha (Gambaly, 1976). This is caused by defective irrigation practices, lack of proper drainage system, evaporation from highly saline ground water table, seepage from the canals and insufficient irrigation water supply during summer months. Such land degradation is responsible for serious decline in the crop production. Various methods have been employed to reclaim these soils depending upon the extent of their degradation. One of these methods is the afforestation.

The afforestation of the saline sodic soils improves their physical and chemical properties, as well as icreases biological activity in the soils. It

brings about the beneficial changes in the soil pH, ECe, organic matter and nitrogen content in the salty soil surface. The beneficial effects of plant growth on the sodic soil could be due to the presence of greater amount of soluble Ca^+ which occurs in the cropped soil owing to an enhanced solubility of $CaCO_3$ in the presence of CO_2 evolved from the plant roots, by improving soil permeability and subsequent leaching by physical action of roots (Goertryen and Bower, 1958).

A large number of plant species have been tried for the reclamation of saline and saline sodic soils throughout the world (Ismail et al. 1990). In this regards, nitrogen fixing leguminous trees can be grown successfully for soil amelioration. The nitrogin fixing halophytes are specially suitable for such soils owing to their nitrogen fixing ability and enrichment of soil through litter fall. These species differ in their ability to tolerate the extent and kind of salinity. Some species absorb and extrude large amount of salts from the soil and thus mitigate to some extent the problem of salinity. The removable of exchangeable sodium from the calcareous alkali soils can be accomplished by growing salt tolerant plants (Mitra and Shanker, 1957). Such plants may have the ability of accumulation of Na^+ in the leaves or salt excreting bands in the roots (Anon. 1991).

Although the survival of different grasses and trees in the sodic soils have been reported by many workers but the exact data on the maximum limit of salt tolerance by halophytes are scanty. The present study was, therefore, started to determine the effect of different levels of sodium chloride tolerance on soil pH and plant growth of *Leucaena leucocephala, Albizzia lebbek, Acacia nilotica* and *Acacia ampliceps*.

MATERIALS AND METHODS

An experiment was set up in pots to study the effect of three stresses each with four NaCl concentrations on four leguminous forest tree seedlings in split plot design with three replications. Seeds of each species were treated with hot water at 90°c for various durations depending upon hardness of testa i.e. *Leucaena Leucocephala* (3 minutes), *Albizzia lebbek* (2 minutes), *Acacia nilotica* (5 minutes) and *Acacia ampliceps* (5 minutes) to hasten the germination. Six hundred and fifty earthen pots (30 x 24 cm size) with closed bottom were filled with 5 kg of nursery soil per pot (farm yard manure, soil and sand in ratio of 1:2:1). At the time of filling the pots the soil moisture content was (18%), pH (7.5) and ECe (1.0 mhos/cm).

Five seeds/pot of each species were sown during the first week of March 1992, which germinated after two weeks of sowing. Seedlings were properly looked after by daily observation and provision of watering twice a week. After two months all except one seedling in each pot were removed and the plants were allowed to grow for four months from May through August. Six hundred pots, 150 of each species each having six months old seedlings of uniform height were selected and arranged according to the experimental design. Thirty seedlings of each species were treated by stock solution of different concentrations of NaCl i.e. 0.044%, 0.88%, 0.176%, 0.351% and control under first stress and then allowed to grow for 90 days to record observations for determining the effect of salt concentrations on them. The potted seedlings were treated to two more stresses of NaCl after an interval of 90 days at the rate of 0.088%, 0.176%, 0.351% and 0.527% (second stress) and 0.176%, 0.351%, 0.521% and 0.702% (third stress). The stock solutions for different doses were prepared in such a way that during salt application each pot got a pre-determined dose with respect to soil weight/pot. Two watering per week were given to the plants over the whole period of 15 months from March, 1992 to May,1993. The treatment schedule was as follows:

Table 1. Details of Treatments (doses g/100g of soil)

Treatment Code No.	Stress-I (grams)	Stress-II (grams)	Total NaCl I + II- stresses (grams)	Stress- III (grams)	Total NaCl I + II + III- stresses (grams)
TO	0.000	0.000	0.000	0.000	0.000
T1	0.044	0.088	0.132	0.176	0.308
T2	0.088	0.176	0.264	0.351	0.615
T3	0.176	0.351	0.527	0.527	1.054
T4	0.351	0.527	0.878	0.702	1.580

Observations on the soil pH, plant height and apical growth as affected by various sodicity levels were recorded at 90 days interval of salt applications. The soil samples were collected from each treatment and species separately at the time of data collection. The pH of soil samples was measured with pH meter using a glass electrode at 25°C in 1:2 soil water ratio. The plant heights were measured with the help of meter rod from the soil surface to the top of the apical bud. Observations on salt injury caused by different levels of NaCl were recorded and percentage dieback of plants caused by different doses was measured by comparing dried stem height with the green stem height in each species. The data were analyzed statistically.

RESULTS AND DISCUSSION

Data of different sodium chloride stresses on soil reaction showed that the application of NaCl progressively increased the pH of the soil over the control. The higher doses of NaCl increased pH from 8.78 to 9.36 in stress-II and -III as shown in Table 2. This rise in pH may be due to the influence of Na^+ which causes more dissociations and hydrolysis in the soil system. The increase in soil pH with increases of exchangeable cations like Ca, Mg, K and Na has been reported in the literature (Paradhan and Mishra, 1982).

Table 2. Effect of sodium chloride on soil pH (at 25°c) after 90 days of NaCl application

Treatment Code No.	Stress-I	Stress-II	Stress-III
T0	8.32	8.34	8.49
T1	8.40	8.49	8.62
T2	8.45	8.56	8.89
T3	8.54	8.78	9.06
T4	8.82	8.98	9.36

The cumulative effect of different salt concentrations on the height of various species was tabulated and is given in Table 3.

Table 3. Effect of different sodium chloride stresses on the plant height (cm) of *L. leucocephala* (sp1), *Albizzia lebbek* (sp2), *A. nilotica* (sp3) and *A. ampliceps*(sp4)

Species Code No.	T0	T1	T2	T3	T4	Mean
			Stress I			
Sp1	116.1	113.6	111.2	106.9	105.8	110.7
Sp2	38.9	37.8	34.6	33.8	32.6	35.5
Sp3	114.1	113.8	108.0	101.3	96.6	106.8
Sp4	60.8	60.2	54.8	51.6	46.3	54.7
Mean	82.5	81.3	77.1	73.4	70.3	-
			Stress II			
Sp1	126.9	121.7	118.6	109.0	71.8	109.5
Sp2	51.6	45.6	37.7	33.2	22.9	38.2
Sp3	130.2	124.3	112.3	103.3	80.9	110.2
Sp4	75.6	67.6	58.7	54.4	45.8	60.4
Mean	96.1	89.8	81.8	75.0	55.3	-
			Stress III			
Sp1	149.8	125.2	118.8	57.9	17.6	93.9
Sp2	62.3	47.7	37.0	16.4	7.2	34.1
Sp3	136.8	127.2	110.0	71.2	23.2	93.7
Sp4	105.8	81.7	61.2	55.7	49.6	70.8
Mean	113.7	95.4	81.8	50.3	24.4	-
Over all mean	97.4	88.9	80.2	66.2	50.0	-

LSD at 5%

In stress-1, application of 0.044% Nacl decreased the plant height non-significantly as compared to control in all the species tested. Higher concentration of 0.088% decreased the height by 4.9 cm and 4.3 cm in *L.leucocephala* and *A.lebbek* while in case of *A.nilotica* and *A.ampliceps* the decrease was 6.1 cm and 6.0 cm respectively as compared to the control. When the concentration of salt was increased to 0.176% the seedlings of *L.leucocephala* and *A.ampliceps* showed an average decrease of 9.2 cm and a decrease of 11.8 cm was observed in *A.nilotica*.

With the increase of salt level to 0.351% the maximum decrease of 17.6 cm was noted in *A.nilotica* and the minimum of 6.3 cm in *A.lebbek*. A height retardance of 10.3 cm and 14.5 cm was recorded in *L.leucocephala* and *A.ampliceps* respectively over the control.

As a result of combined effect of stress-I and stress-II only the highest concentration of 0.878% NaCl produced the apical bud burning in all the tree species except *A.ampliceps*. However, the lowest concentration of 0.132% NaCl caused average decrease of 5.1 cm, 6.0 cm, 5.9 cm and 8.0 cm in plant height of *L.leucocephala*, *A.lebbek*, *A.nilotica* and *A.ampliceps* respectively as compared to control. The next higher concentrations (0.264% and 0.527%) produced the maximum reduction of 17.9 cm and 26.9 cm in *A.nilotica* and the minimum of 8.3 cm and 17.9 cm in *L.leucocephala*. Similar concentrations of NaCl decreased the plant height by 13.9 cm, 18.3 cm and 16.9 cm, 21.1 cm in *A.lebbek* and *A.ampliceps* respectively.

A.ampliceps showed the maximum reduction in average plant height to the combined doses of stress-I,-II and -III, without showing any sign of apical bud burning even with the highest (1.580%) salt concentration. Application of 0.308% NaCl decreased the plant height by 24.6 cm, 14.7 cm and 9.7 cm in *L.leucocephala*, *A.lebbek* and *A.nilotica* seedlings respectively as compared to the control. The does of 0.615% NaCl was found to be the maximum limit of NaCl tolerance of seedlings though it caused an average decrease of 31.0 cm, 25.3 cm and 26.8 cm in plant heights in SP1, SP2 and SP3 respectively over the control. The highest concentrations of 1.054% and 1.580% caused burning of apical buds in *L.leucocephala*, *A.lebbek* and *A.nilotica*.

The apical dieback caused by different salt doses is presented in Table 4 as under.

Table 4. Percent apical dieback caused by NaCl applied under different stresses

Treatment Code No.	Stress-I	Stress-II	Stress-III
	Sp1 Sp2 Sp3 Sp4	Sp1 Sp2 Sp3 Sp4	Sp1 Sp2 Sp3 Sp4
T0	Nil	Nil	Nil
T1	Nil	Nil	Nil
T2	Nil	Nil	Nil
T3	Nil	Nil	52.4 50.5 31.1 Nil
T4	Nil	32.0 28.3 16.2 Nil	75.5 69.1 64.6 Nil

The above table indicates that stress-I produced no injury to the apical bud in all the tree species while stress-II .878% NaCl (T4) caused 32.0%, 28.3% and 16.2% dieback injury of the

total green height of the plant in *L.leucocephala, A.lebbek* and *A.nilotica* respectively. Likewise, the highest concentrations i.e 1.054% (T3) and 1.580% (T4) (stress-III) produced well pronounced dieback in *L. leucocephala, A. lebbek* and *A. nilotica* in the decreasing order.

This study shows that NaCl adversely affects the growth of four tree species which may be due to the accumulation of Na^+ and Cl^- ions in excess (Anon.,1991). The higher level of NaCl severely decreased the plant growth which could be ascribed to Na toxicity as reported by other workers (Shaybany and Kashirad, 1978 Khanduja and Goel, 1968; Luard and El. Lakany, 1984; Prasad et al. 1990 and Hussain and Gull, 1991). Out of the four species tested, *A.ampliceps* showed no sign of injury which could be due to the presence of excretory bands in the root system which help in mitigating the problem of excess salts in the roots zone of plants (Anon., 1991.)

CONCLUSIONS

The following conclusions can be drawn on the basis of the results achieved in the present investigations:

1. *Acacia ampliceps* can be grown in sodic soils containing upto 1.58% NaCl.
2. *Acacia nilotica, Albizzia lebbek* and *Leucaena leucocephala* can tolerate NaCl stress upto 0.61% in the soil. The higher concentrations results in increase of soil pH that adversely affects their root functioning in the plants.

REFERENCES

Anon. 1991. Trees for salty lands. pp.20-23. third progress report ACIAR project 3633, Australian woody species for saline sites in Asia. Gambaly, M.M.EL. 1976. Problems and effects of irrigation in the near east region. In. Irid land irrigation in developing countries; Environmental problems and effects. (Edi.) E.Barton Worthington. Pergamon press. Oxford, England. 239 - 249.

Goertryen.J.O. and C.A.Bower. 1968. Carbon dioxide from plant roots as a factor in the replacement of adsorbed Sodium in calcarious soils. Soil Sci. Soc. Am. Proc. 22:36-37.

Hussain,A. and P. Gul. 1991. Selection of suitable tree species for saline and waterlogged areas.P.J.F. 1 (41): 34-43.

Ismial,S., Malcolm, C.V.and Ahmad, R. 1990. A biblography of forage halophytes and trees for salt-affected land: their use, culture and physiology. Published by Department of Botany, University Karachi, Karachi-75270. Pakistan. PP.258.

Khanduja,S.D. and V.L. Goel. 1986. Pattern of variability in some fuel wood trees grown on sodic soils. Ind. For. 112 (2): 118-123.

Luard,E.J. and M.H. EL-Lakany. 1984. Effect on casuarina and Allocasuarina species of increasing sodium chloride concentrations in solution culture. Aust. J.plant physiology II: 471-481.

Mitra, S.P. and Hari Shanker. 1957. Amelioration of alkali soil by chemicals in combination with organic matter like weeds. Soil Sci.83 (1):471-474.

Pradhan N.K. and C. Mishra. 1982. Effect of liming and organic amendments on crop yield and physio-chemical properties on acid latesite soils. J. Indian. soc. Soil. Sci. 39 (2): 180-184.

Prasad,R; N.G; Totey, Kapoor, K.S. and P.K.Khatri. 1990. Effect of some salts on the soil reaction, growth and dry matter yield of *Leucaena leucocephala* and *Acacia auriculiformis* in pot culture. Ind.For. 116 (3): 227-232.

Shaybany, B. and A.Kashirad. 1978. Effect of Nacl on growth ad mineral composition of *Acacia saligna* in sand culture. Jour. Amer. Soc. Hort. Sci. 103 (6): 823-826.