Plants in Relation to Salinity and their Interaction with Soil Water Stress

Dhupper.R

Amity Institute of Environmental Science, Amity University (Noida)

Abstract- The growth response of *Acacia nilotica*, *Albizzia lebbeck* and *Prosopis cineraria* seedlings in relation to salinity and water stress levels under green house conditions were studied. The response to salinity with water stress by three species possessing different reproductive strategies were investigated to determine the implication of using combined levels of salinity with water stress availability to manipulate plant growth and increased the yield. Three species were compared in terms of growth parameters and response breadth. The suppression of growth parameters caused by the interaction of salinity with water stress was greater in *Prosopis cineraria* than in *Acacia nilotica.* The response breadth for both height growth and dry weight along combined gradient of interaction of salinity and water stress was narrower in all the species. The broadest was in *A. nilotica* (0.495, 0.516) and narrower in *P. cineraria,* indicating that all the species can grow along a limited gradient of combined salt and water stress. These results suggest the growth of *Acacia nilotica* seedlings was greatly promoted under the stress conditions of salinity with water stress and resulting in a much more balanced growth in terms of response breadth, which is vital for plants growing in the harsh arid environments where concentration of salts is much more and competition for water is usually intense.

Index Terms- Growth, Harsh, Intense, Response, Strategies

I. Introduction

On a world scale, there is an area of about 380 million hectares that is potentially usable for agriculture, but where production is severely restricted by salinity (Flowers, 1977). A large area in the world (952 million ha) is affected with salinity or alkalinity or both (Gupta and Gupta, 1984). In India nearly 9.38 million ha area is occupied by salt-affected soils out of which 5.5 million ha are saline soils (including coastal) and 3.88 million ha alkaline soils (IAB 2000). In India, the deterioration of agricultural productive lands in the arid and semi arid zones can be directly attributed to the evolution of salinity (Pieri *et al*., 1996).

In India ground water is major source of irrigation to supplement the water requirement of plants in arid and semiarid regions but the quality of majority ground water encountered in these regions is invariably poor (Yadav, 1980). Application of such poor quality water makes the soil saline in nature which affects the plant growth adversely. The main reason of soil getting affected by salt is the application of ground water that is often saline thereby resulting in enhancement of salt loads in soils. Poor infiltration and drainage practices and expansion of irrigated agriculture lands in arid zones with huge evaporation rates are other reasons of accumulation of salinity. Increased salinity requires plants to use more energy to get water from the soil, which leaves the plant with less energy available for the growth. Visual symptoms (leaf burn, necrosis and defoliation), sometimes occur particularly in woody species. High levels of salinity can cause plant cell dehydration, reduced plants growth and possibly death in less tolerant plants. The threefold problems of salinity are low soil water potential leading to symptoms of water stress, specific ions (Na, Cl) may be toxic, there by leading to ion imbalance (mainly calcium), leading to deficiency symptoms (Lambers et al., 1998). Saline soils, predominantly have chlorides and sulfates of Na, Ca and Mg, a saturation paste pH of <8.2 and the electrical conductivity of saturation extracts of saline soil is generally more than 4 dsm-1 at 25OC.

Although considerable attention has been given to the toxic limits of salt concentration but investigations on the utilization of saline water by developing different cultural practices are lacking. To reclaim such degraded land of arid areas investigations on methodology and monitoring of salt affected soils is required. Afforestation under such situations can be the most remunerative proposition to improve local economy by using multipurpose tree species and establishing them with the available saline water, because forest species are know to tolerate more salt stress in comparison to the agricultural field crops and are found to grow even naturally on the salt affected soils. It is of vital importance to know precisely the composition of ground water, its effects on soil properties and plant growth, the tolerance limits of important trees and to develop suitable management practices for using salt water for irrigation without much adverse effects on soil, for deciding the suitability of species for plantation on such sites. These tree species are not only tolerant to salt and drought stresses but also is well adapted to the local agro climate. This has immense significance in the present situation, when there is a burgeoning demand for protection of natural resources (land, soil and water). Keeping these facts in view, the present investigations have been undertaken. The objective was to determine the effect of the interaction of salts and water stress on growth performance of these seedlings and determine whether water reduces the negative impact of salinity on seedlings and to what extent.

II. MATERIALS AND METHODS

Soil used in the experiment was sandy loam with sand 89.6% silt 7.4% and clay 3%. The physio-chemical analysis of soil was done before sowing the seeds in pots which had pH of 8, ECe 1.03 dsm-1; Na 15.3 m.e.l-1; K 0.2 m.e.l-1; Ca 1.1 m.e.l-1; Mg

1.23 m.e.l-1; Zn 0.40 ppm; Fe 4.72 ppm; Cu 0.24 ppm; Mn 5.74 ppm and the available N, P and K were 169 Kg ha-1, 12 kg ha-1 and 275 kg ha-1 respectively, ESP was 17.2 and organic carbon content was 2.5g kg-1.

Healthy seeds of three multipurpose tree species of *Albizzia lebbeck*, *Acacia nilotica* and *Prosopis cineraria* soaked in distilled water overnight, were sown directly in 90 experimental earthen glazed pots at the rate of 10 seed per pot. Potting medium consisted of 10 kg normal well pulverized sandy loam soil.

To determine the effect of interaction of salts with water stress, the experiment was conducted for these three species. Three levels of salinity were used i.e $S_{O,}$ (control) S_1 (4EC) and S_2 (8EC) and each level was subjected to three levels of different watering frequency i.e. M_0 (control), M_1 (5D) or low water stress, M_2 (10D) or medium water stress and M_3 (15D) or high water stress. Water holding capacity of soil after watering on 5th, 10th and 15th day was 33.6%, 28.6% and 20% respectively whereas the day before watering at these intervals it declined to 25%, 20% and 10% respectively. These values for control (i.e. with daily watering and highest soil water level) were 60% after and 40% just before watering. Thus, there were in all seven interaction levels each comprising of possible combinations of two levels of salinity with three levels of water stress (S_0M_0 to S_2M_3) and one control of best available water (S_0M_0 /BAW) was synthesized. The experiments were initiated in the month of August and the duration of the experiments were twelve months. The experiments were laid out in randomized block design with three replications.

Effect of saline water irrigation with water stress

Germination and Survival: The germination and survival percentage of all the species decreased with increase in the salinity and water stress levels (Table 21). At lowest salinity level with lowest water stress, the maximum germination was found in *A .nilotica* (81%) and least in *A.lebbcek* (70%). On comparison with other possible interaction of salinity with water stress level, highest germination was observed at S_1M_1 level as compared to other levels, maximum being in *A.nilotica* (65%) and least in *A.lebbeck* (59%). The maximum reduction in germination percentage was observed at S_2M_3 level in all the species (Table 23). Highest values for survival percentage were also observed at lowest salinity level with lowest water stress level (S_0M_0). But in comparison to other levels, better survival percentage was observed at S_1M_1 level, highest being in *P.cineraria* (53%) and lowest in *A. lebbeck* (49 %). The maximum reduction relative to control for survival percentage was observed in *P.cineraria* (78%) at S_2M_2 level and minimum in *A.lebbeck* (74.6%) at S_2M_3 (Table 23).

Growth parameters : All the growth parameters showed the maximum value at low salinity level (BAW) with no water stress level (S_0M0) and declined thereafter at high level of salinity with high water stress S_2M_3. The values of height, stem diameter and number of leaves of one year old seedlings decreased with increase in salinity and water stress levels (Table 21). At S_0M_0 level *A. nilotica* attained comparatively greater height (80 cm) and number of leaves (1800) than the others species, however stem diameter was higher in *A. lebbeck* (12.8 mm), Table 21. At S_0M_0 and S_1M_1 levels the rate of height growth from May to August was maximum in *A. nilotica* and minimum in *P. cineraria* (Fig 7). In all the species, shedding of leaves was observed during February to May at all levels of interactions of salts and moisture stress (Fig 8). Height growth of all the species reduced drastically (20-81%) with increasing stress level. At low salinity level ($S_1M_{1-}S_1M_3$) as well as with marked high salinity, reduction in height growth was observed in *P. cineraria* (74% - 81%) and least in *A. nilotica* (20% - 60%), Table 23. Leaf area decreased with increasing salinity and water stress. Within the two salinity stress levels at three different water stress levels, the S_1M_1 level showed the better performance than the other levels, highest leaf area being in *A. lebbeck* (1.11 cm2). Both root length and spread differed in response to combined effect of salinity and water stress (Table 21). Root length was maximum for *P. cineraria* at S_0M_0 level (79 cm) and minimum in *A. lebbeck* (17cm) at S_2M_3 level, whereas spread was maximum in *A. lebbeck* (6.9) under S_0M_0 and minimum *in A. nilotica* (3.0) at S_2M_3 level.

Total seedling dry mass and ratios : In all the species, dry mass values decreased with increasing levels of interaction of salinity and water stress (Table 22) and exhibited the same trend as that of germination and survival at S_1M_1 level, the maximum dry weight being in *A. nilotica* (43 g) and minimum in *P. cineraria* (31 g). At low salinity level, water stress did not affect the biomass much (S_1M_1 - S_1M_3), whereas at higher salinity levels S_2M_1-S_2M_3 water stress lead to reduction in biomass from 10 to 50% in *A. lebbeck*, 30 to 60% in *A. nilotica* and 40 to 70% in *P. cineraria*. Thus higher water stress did not have much affect at low salinity level (Table 23). Multiple correlation analysis was done between the growth parameters with salinity and water stress levels. In *A.lebbeck* the correlation was significant for all the parameters except biomass and in *A.nilotica* correlation was significant only for height and biomass, whereas in *P.cineraria* germination, height and biomass was significantly correlated to salinity and water stress levels (Table 24). The proportional allocation of biomass into different component of the three species at different interaction levels is depicted in Fig 9. At higher stress levels proportional allocation to root component was maximum in P. cineraria and allocation to stem increased in *A.nilotica*. Not much difference in proportional allocation to different component with change in stress was observed for *A. lebbeck*.

Table 21: Growth parameters of the species at varying levels of saline water with water stress

Tree species	**Levels**	**Germination (%)**	**Survival (%)**	**Height (cm)**	**Stem diameter (mm)**	**Leaf area (cm^2)**	**Root length (cm)**	**Root spread (cm)**
A. lebbeck	S_0 M_0	70	59	66	12.81	1.30 ±0.059	61 ±1.019	6.9 ±0.567
	S_1 M_1	59	49	50	7.11	1.11 ±0.067	58 ±3.578	6.2 ±0.102
	S_2 M_1	52	32	40	5.98	1.01 ±0.006	54 ±1.765	6.0 ±0.059
	S_1 M_2	53	30	40	7.91	1.00 ±0.059	38 ±1.176	5.5 ±0.256
	S_2 M_2	39	18	20	7.09	0.98 ±0.031	25 ±1.176	5.0 ±0.059
	S_1 M_3	40	21	19	5.11	0.96 ±0.056	24 ±1.656	4.1 ±0.059
	S_2 M_3	30	15	14	4.00	0.94 ±0.067	17 ±2.121	3.5 ±0.256
A. nilotica	S_0 M_0	81	68	80	8.09	0.21 ±0.006	70 ±0.588	4.5 ±0.269
	S_1 M_1	65	52	60	8.11	0.19 ±0.016	72 ±3.113	3.7 ±0.306
	S_2 M_1	55	29	43	7.09	0.18 ±0.049	48 ±2.121	3.4 ±0.311
	S_1 M_2	41	21	40	7.07	0.17 ±0.031	45 ±1.556	3.3 ±0.102
	S_2 M_2	33	18	33	7.04	0.16 ±0.020	29 ±1.019	3.1 ±0.059
	S_1 M_3	40	20	23	5.04	0.15 ±0.004	25 ±1.176	3.0 ±0.059
	S_2 M_3	30	17	18	5.01	0.11 ±0.010	19 ±1.556	3.0 ±0.059
P. cineraria	S_0 M_0	80	69	78	6.90	0.23 ±0.006	79 ±2.121	4.9 ±0.156
	S_1 M_1	60	53	35	4.11	0.20 ±0.006	76 ±3.275	3.9 ±0.102
	S_2 M_1	51	40	30	3.09	0.19 ±0.016	49 ±1.556	3.5 ±0.256
	S_1 M_2	48	26	25	3.03	0.18 ±0.020	30 ±2.037	3.4 ±0.311
	S_2 M_2	40	15	18	3.01	0.17 ±0.031	29 ±1.019	3.3 ±0.102
	S_1 M_3	45	25	20	3.00	0.16 ±0.020	27 ±3.056	3.0 ±0.059
	S_2 M_3	33	19	15	3.00	0.13 ±0.006	21 ±1.019	3.0 ±0.059
SEm±		2.5	1.6	2.7	0.07			

Table 22: Effect of saline water with water stress on other growth parameters of the species

Species	Levels	Root wt (g)	Shoot wt (g)	Total biomass (g)	Root : Shoot ratio	Leaf : Stem ratio	Specific leaf area ($cm^2 g^{-1}$)	Height: Diameter ratio
A. .lebbeck	$S_0 M_0$	19	22	41	0.864	0.833	0.130	5.16
	$S_1 M_1$	17	22	39	0.773	0.692	0.123	7.03
	$S_2 M_1$	16	20	36	0.800	0.818	0.112	6.69
	$S_1 M_2$	14	16	30	0.875	0.778	0.143	4.68
	$S_2 M_2$	11	13	24	0.846	0.875	0.163	5.92
	$S_1 M_3$	13	15	28	0.867	0.875	0.137	3.72
	$S_2 M_3$	9	11	20	0.818	0.833	0.188	4.50
A .nilotica	$S_0 M_0$	21	25	46	0.840	0.786	0.019	12.36
	$S_1 M_1$	20	23	43	0.869	0.769	0.019	8.88
	$S_2 M_1$	14	18	33	0.737	0.727	0.023	8.74
	$S_1 M_2$	15	17	32	0.882	0.700	0.017	5.66
	$S_2 M_2$	14	15	29	0.933	0.875	0.023	9.19
	$S_1 M_3$	12	14	26	0.857	0.750	0.025	4.56
	$S_2 M_3$	9	12	19	0.750	0.833	0.026	3.59
P. cineraria	$S_0 M_0$	23	20	43	1.150	0.818	0.026	11.59
	$S_1 M_1$	18	13	31	1.385	0.857	0.033	8.52
	$S_2 M_1$	10	9	19	1.111	0.800	0.048	9.71
	$S_1 M_2$	15	14	29	1.222	0.875	0.026	8.25
	$S_2 M_2$	10	9	19	1.111	0.800	0.034	10.56
	$S_1 M_3$	11	8	19	1.375	0.600	0.053	6.67
	$S_2 M_3$	7	5	12	1.400	0.667	0.065	5.00

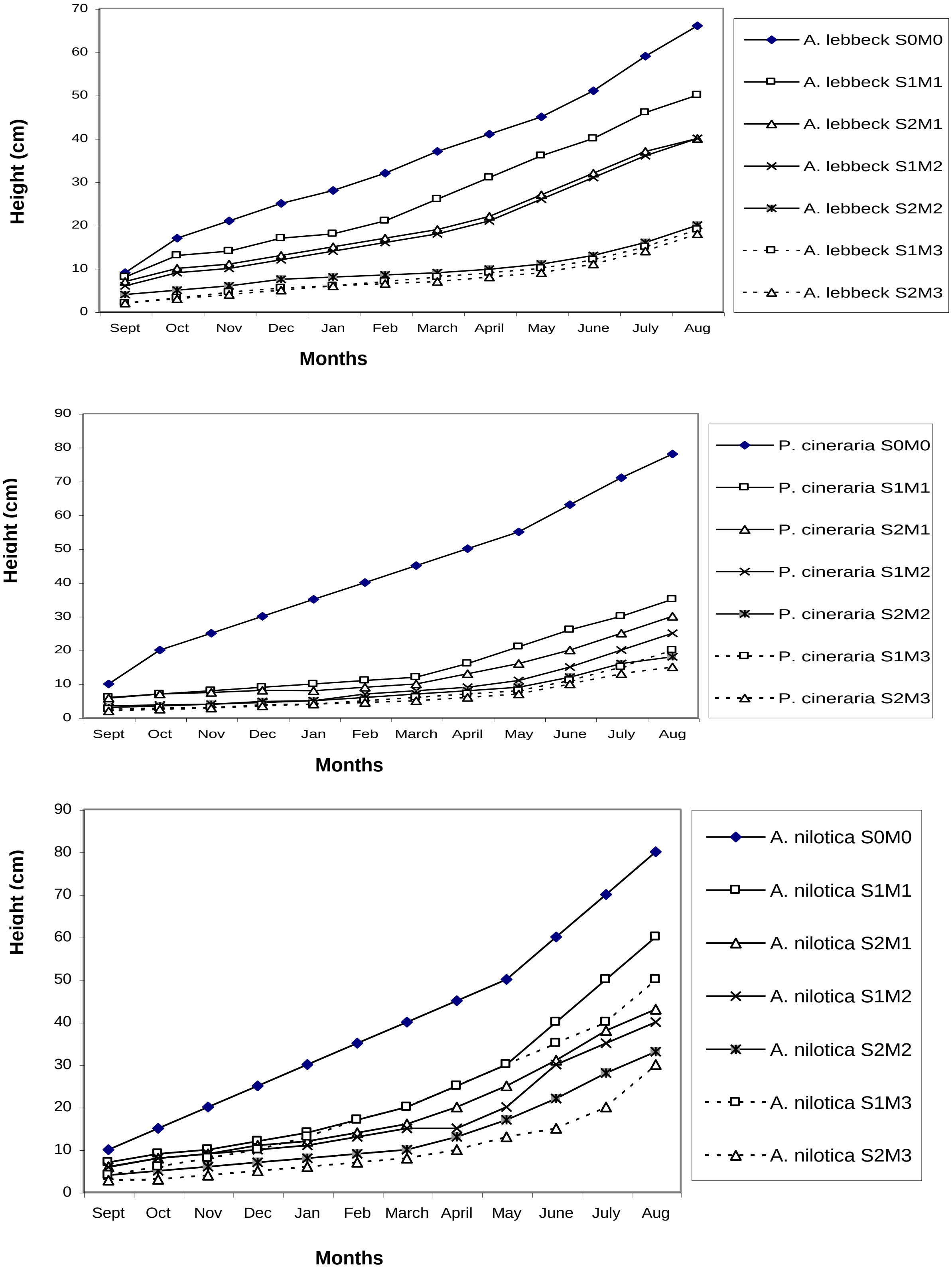

Figure 7: Monthly height growth of the spices under different saline water and water stress levels

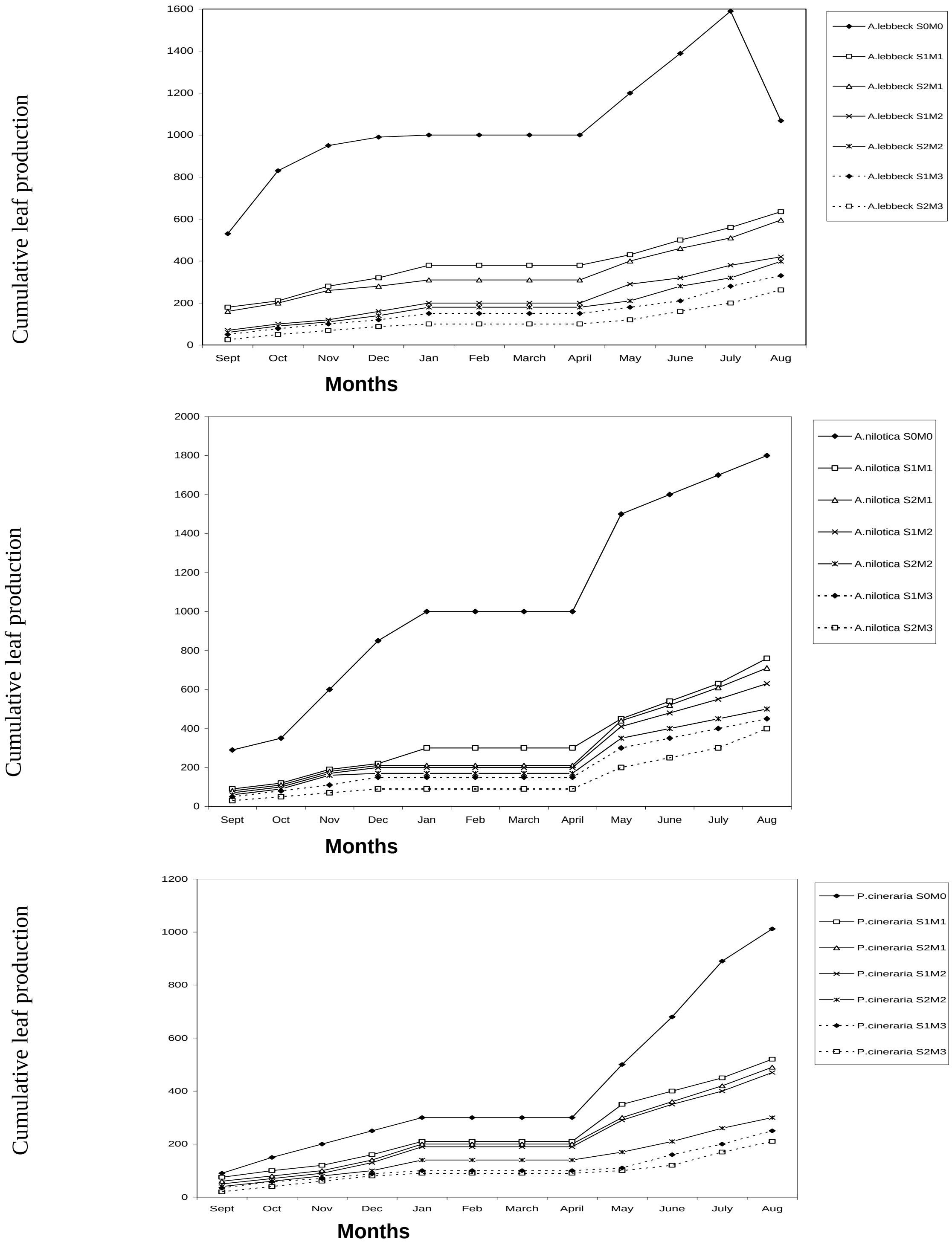

Figure 8: Cumulative leaf production under different saline water and after stress levels for one year study period

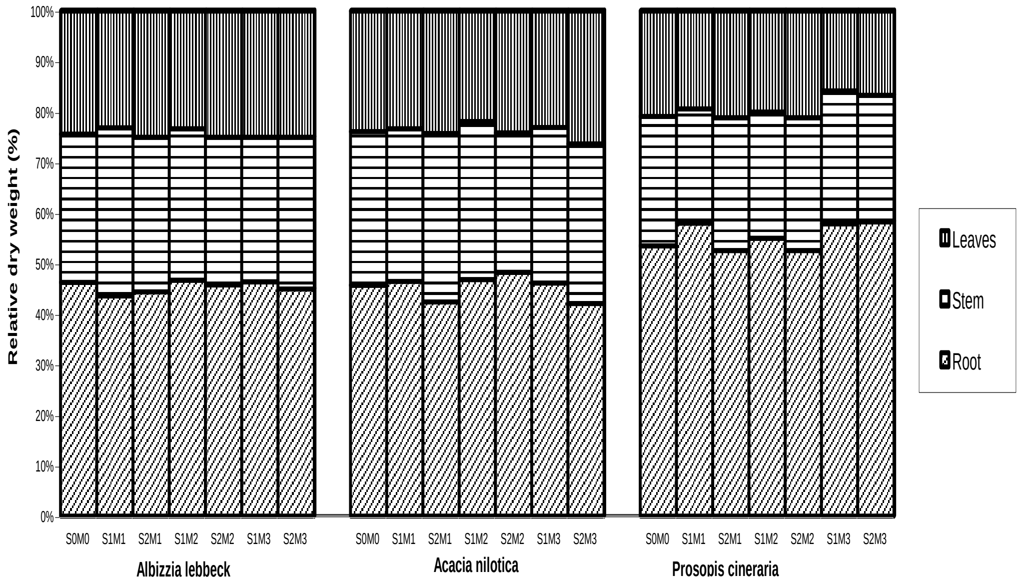

Figure 9 : Proportional allocation of biomass of three species into different components under different salinity and water stress levels.

At (S_2M_3) level *P. cineraria* attained the maximum root : shoot ratio (1.4). This ratio was least in *A. lebbeck* (0.77) at S_1M_1 level. The leaf : stem ratio was maximum in *P. cineraria* at S_1M_2 (0.875) in *A. nilotica* at M_2S_2 (0.875) and in *A. lebbeck* at S_1M_3 levels (0.875), Table 22. The SLA was highest in *A. lebbeck* (1.88 cm2/g) under S_2M_3 level and least at S_2M_3 level in *A. nilotica* (0.026 cm2/g), Table 22. In terms of height attained per unit diameter, *A. nilotica* attained the maximum values at low stress levels (12.4). Though these value decreased up to S_1M_3 levels. Only in case of *A. lebbeck* sturdiness increased with increasing levels of salinity and water stress up to S_2M_1 level and declined thereafter up to highest level (Table 22).

Response breadth: Compared to salinity stress gradient alone, the response breadth for both height growth and dry weight along combined gradient of interaction of salinity and water stress was narrower in all the species.The broadest was in *A. nilotica* (0.495, 0.516) and narrower in *P. cineraria*, indicating that all the species can grow along a limited gradient of combined salt and water stress (Table 25).

Table 23: Percent reduction or increase in different growth parameters of the species relative to control (S_0Mo, with no salinity and moisture stress)

Species	**Levels**	**Germination (%)**	**Survival (%)**	**Height (cm)**	**Total biomass (g)**
A.lebbeck	S_1 M_1	-20.0	-16.9	-20.0	-10.0
	S_2 M_1	-30.0	-45.8	-40.0	-10.0
	S_1 M_2	-20.0	-49.1	-40.0	-30.0
	S_2 M_2	-40.0	-69.5	-70.0	-40.0
	S_1 M_3	-40.0	-6404	-71.2	-30.0
	S_2 M_3	-60.0	-74.6	-78.8	50.0
A.nilotica	S_1 M_1	-20.0	-23.5	-20.0	-10.0
	S_2 M_1	-30.0	-57.4	-50.0	-30.0
	S_1 M_2	-50.0	-69.1	-50.0	-30.0
	S_2 M_2	-60.0	-73.5	-60.0	-40.0
	S_1 M_3	-50.0	-58.8	-60.0	-30.0
	S_2 M_3	-60.0	-75.0	-62.5	-60.0
P.cineraria	S_1 M_1	-20.0	-23.2	-60.0	-30.0
	S_2 M_1	-40.0	-42.1	-60.0	-40.0
	S_1 M_2	-60.0	-62.3	-67.9	-30.0
	S_2 M_2	-50.0	-78.3	-80.0	-40.0
	S_1 M_3	-30.0	-63.8	-74.4	-40.0
	S_2 M_3	-60.0	-72.5	-80.8	-70.0

Table 24 : Multiple correlation equations of growth parameter of the species with salinity and water levels

Tree Species	Germination (%)	Survival (%)	Height (cm)	Stem diameter (mm)	Total biomass (g)
A. lebbeck	$Y=36.7-1.7X_1 + 1.0X_2$ $R^2 = 0.925$* F= 12.84	$Y=19.9-2.3X_1 + 1.1X_2$ $R^2 = 0.897$* F= 9.20	$Y=40.02-3.4X_1 + 0.8X_2$ $R^2 = 0.898$* F= 9.26	$Y=4.9-0.4X_1 + 0.2X_2$ $R^2 = 0..905$* F= 10.0	$Y=23.09-0.7X_1 + 0.6X_2$ $R^2 = 0.757$* F= 3.56
A. nilotica	$Y=31.3-2.1X_1 + 1.4X_2$ $R^2 = 0.863$* F= 6.78	$Y=17.3-2.6X_1 + 1.3X_2$ $R^2 = 0.842$* F= 5.79	$Y=59.9-4.6X_1 + 0.01X_2$ $R^2 = 0.977$* F= 43.4	$Y=3.8-0.04X_1 + 0.12X_2$ $R^2 = 0.808$* F= 4.7	$Y=22.02-0.9X_1 + 0.7X_2$ $R^2 = 0.884$* F= 8.1
P. cineraria	$Y=42.1-2.5X_1 + 1.02X_2$ $R^2 = 0.964$* F= 27.5	$Y=19.4-2.4X_1 + 1.3X_2$ $R^2 = 0.819$* F= 4.9	$Y=28.8-3.7X_1 + 1.2X_2$ $R^2 = 0.899$* F= 9.4	$Y=3.1-0.3X_1 + 0.08X_2$ $R^2 = 0.834$* F= 5.5	$Y=23.8-2.1X_1 + 0.6X_2$ $R^2 = 0.972$* F= 34.7

* significant at 5% level of probability

Table 25 : Response breadth pattern of different tree species as affected by saline water and water stress levels

Tree species	Response breadth	
	Height	**Total biomass**
A.lebbeck	0.463	0.516
A.nilotica	0.495	0.516
P.cineraria	0.411	0.473

III. DISCUSSION

For the rehabilitation of soils rendered barren owing to salinity problems adaption to site conditions and their multiple uses, form important criteria for tree selection. Establishing salt tolerant tree plantations utilizing the saline ground water may provide for an economic use of abandoned arid lands. The initial establishment of transplanted tree saplings is critical for raising tree plantation in salt affected soils, which provide stressful conditions of both salt and water stress. In fact, for arid areas not just physical measurements of tree size and quantities of useful productivity, but also the impact of trees on its surroundings and improvement in microclimate need to be monitored. It is difficult to make an objective assessment of salt tolerance of the tree species raised in this experiment but overall plant growth and survival do indicate this response.

In the absence of clear and unambiguous procedure for assessment of tree species for suitability to site condition, an effort was made to rank the tree species on the basis of three criteria. The first was the germination and survival percentage on the basis of which the salt tolerance is often described (Marcar et al., 1993). As the second criterion, the tree species were simply ranked on the basis of their height growth, leaf production and biomass produced by these tree species. The third ranking was based on response breadth (in terms of dry weight and height growth) and the salt tolerance of these tree species.

Increase in salinity delayed the initiation of seed germination and decreased survival rate in all species. Salt tolerance during germination and early seedling growth is critical for plants survival in saline soils. The tolerance of forest tree species greatly varies at germination and seedlings stage (Tomar and Yadav, 1980). In case of germination and survival A. nilotica showed the tolerance up to medium level of salinity. Initial seed germination was significantly affected by salinity levels. Paliwal (1972) has reported that the emergence time was delayed and percent germination decreased as the degree of salinity increased. Similar results have been reported by Tomar and Yadav (1980). This reduction could be attributed to the osmotic effect of NaCl limiting seed hydration and to the toxic effect of NaCl on seed embryo or endosperm cell membranes (Bliss et al., 1986).

All the growth parameters showed the maximum value at low salinity and water stress and the value declined thereafter at high levels of stress but only in case of A. nilotica growth parameters increased up to medium level of salinity and decreased thereafter. Shalhevet and Hsiao (1986) showed a clear distinction between the responses of plants to water stress and salt stress in terms of incomplete osmotic adjustment under water stress. There were additive effects of water stress and salt stress in depressing the growth parameters at higher levels. The effect of highest tested level of combined effect of salts and water stress was most pronounced in A. lebbeck but least in A.nilotica thereby indicating the good tolerance of A. nilotica to high salt and water stress. Similar findings on some forest species were also reported by Singh et al., (1991). In all the three species leaf area decreased with increase of salts and water stress. Under chronic stress, plant often can adjust osmotically and maintain turgor, but leaf area production, photosynthesis and yield are often considerably reduced in spite of this adjustment .Both root length and spread differed in response to salt levels. In A. nilotica and P. cineraria the value for root length was maximum but spread was minimum but in A. lebbeck root length was minimum whereas root spread was maximum at lowest level of combined effect of salts and water stress level. Roots are directly in contact with the salts and are potentially the first line of defense. In A. nilotica and P. cineraria the deep vertical roots penetrating up to 75 cm depth, reach lower water levels and enhance the chances of survival in dry habitat, since salts are known to be concentrated on upper crusts of soil. However, in A. lebbeck the horizontal growth was more and root length was minimum, resulting in decline in tolerance to combined stress of salts and water. Root elongation can be rapidly inhibited by alkalinity depending upon the type and concentration of salt. The crust formed by the alkalinity reduces the infiltration rate causing over saturation and aeration problem and retards the root penetration.

Total seedling mass values decreased with increasing salts and water stress levels in all the species. The most likely factor causing these differences in salt tolerance may be the rate of salt transport to the shoots adversely affecting the leaf expansion, reducing the photosynthetic efficiency of plant, further reducing the dry matter production. Inherently slow growth is associated with species characteristic of saline environments (Ball and Pidsley, 1995 and Ball, 1998). The maximum root: shoot ratio at all the salt treatments were observed in P. cineraria, whereas leaf : stem ratio was observed maximum at all the salts treatments in A. nilotica. Along the combined stress gradient of salinity and water stress all the species showed relatively very narrow response breadth, the broadest for height growth being in A.nilotica but for biomass, A.lebbeck showed wider values. This indicated that the distribution of all the species is restricted by the interaction of salts with water stress. With the use of saline waters, a depression in soil pH in the treatment of high EC irrigation water can be attributed to the high electrolyte concentrations. The ECe of the soil increased with the increase in salinity. The increase in soil salinization in the case of irrigation water of 8 mmhos/cm EC was of lesser magnitude as compared to that with water of 4 mmhos/cm EC

Three important growth criterions produced different rankings and these criterions were later combined to give a final ranking. Following this procedure the tree species in order of preferred choice for arid areas with both salts and water stress should be A. nilotica, A. lebbeck and P. cineraria. During the past few decades, a number of well-designed species evaluation trails were established on saline water logged soils (Ahmad and Ismail, 1992; Marcar et al., 1993; Tomar et al., 1994; Marcar and Khanna, 1997). Our evaluation trail has shown that A. nilotica at arid land is suitable for higher wood production at medium level of salinity. It has been reported that favored species of foresters (e.g. Dalbergia sissoo) should not be recommended for saline soils because of its sensitivity to the presence of salts during initial establishment stages (Singh et al., 1991) whereas A. nilotica should be recommended for saline soils at medium level of salinity because of its tolerance to the presence of salts and A.lebbeck may be recommended for its moderate tolerance to medium and high levels of alkaline water irrigation.

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AUTHORS

First Author – Dhupper.R, Amity Institute of Environmental Science, Amity University (Noida), Email: renu.dhupper@rediffmail.com, Mob: 9910705193