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FIELD TRIAL OF *AZADIRACHTA INDICA* (L.) A. JUSS. UNDER HIGHLY SALINE WATER IRRIGATION AT ARID SANDY COASTAL REGION OF PAKISTAN

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Abstract

In a field trial at sandy arid coastal land of Bhawani (Gaddani Coast, Baluchistan) *Azadirachta indica* (L.) A. Juss., plants irrigated with highly saline (EC_{iw}:10.0-15.3 $dS.m^{-1}$) and sodic (irrigation quality: C_4S_2; SAR: c. 28) undergrcund water exhibited relative inhibition of growth in height during winter months. Such inhibition was more conspicuous in stem diameter of the treated plants which was overcome after rainfall (100mm) in April with no difference in height or stem diameter after one year of post-transplantation growth. Saline water irrigation induced no significant change in foliar concentration of moisture, chlorophyll, protein, proline and cations such as Na^+, K^+, and Mg^{++}. Ca^{++} content declined by 41.78% in leaf. Saline irrigation substantially increased salt content in the upper profile of soil with SAR just on and beyond the critical value, whereas, rainfall (c. 100mm) during April washed down the salts thus reducing the salt content to the same level as that in the virgin soil.

Introduction

Azadirachta indica (L.) A. Juss., commonly known as neem tree or Indian Lilac, a native of mid-southwest Asia is known for providing good quality energy-wood, low quality timber, raw chemicals to pharmaceutical industry and for its soil ameliorative property (NAS, 1980). Some indications to its salt tolerance are given by Tomar & Yadav (1980) and Ahmad *et al.*, (1985) at both the germination stage and the early growth of the seedling. Considering the demand for afforestation at coastal sandy desert of Pakistan, a field trial was carried out to cultivate this species using highly saline sub-soil water for irrigation. The results of this trial are presented in this paper.

Materials and Methods

The experiment was conducted in the premises of Grasshopper and Locust Research Center, Bhawani (off Gaddani Coast, Baluchistan), c.40 Km from Karachi on main RCD Highway. The area is arid with erratic and irregular low precipitation below 200 mm. It is bimodel; occurring to a greater extent during monsoon season but also in winter (Snead, 1968). Soil is predominantly sandy and deficient in phosphorus and nitrogen (Champion *et al.*, 1965). Mean data of the comprehensive soil analysis of Bhawani experimental field is presented in Table 1. The brackish water used in the experiment was obtained from a well (c.70 feet deep) dug in the experimental field. On the basis of its EC and SAR, it may be classified as highly saline and medium alkali water (Table 2).

Table 1. Analysis of soil sample of Bhawani station (Baluchistan).*

1. Particle size distribution (%)			Potassium	0.67
Sand	89.38		Calcium	2.63
Silt	6.48		Magnesium	0.56
Clay	4.14	16.	Anions (meq/1)	
2. Bulk Density (gm. cm^{-3})	1.10		Carbonates	1.40
3. Porosity (%)	57.50		Bicarbonates	0.60
4. Osmotic Pressure (atms.)	0.18		Sulphates	2.51
5. Moisture Content (%)	3.77		Chlorides	0.25
6. Saturation Percentage (%)	23.07	17.	Sodium Adsorption Ratio	
7. Water Holding Capacity (%)	30.38		(SAR)	1.39
8. Field Capacity (%)	8.10	18.	Exchangeable Sodium	
9. Wilting Coeffecient (%)	6.15		Percentage (ESP)	0.79
10. Calcium Carbonate (%)	3.13	19.	Potassium Adsorption Ratio	
11. Organic Matter (%)	1.46		(PAR)	0.53
12. Total Soluble Salts		20.	Exchangeable Potassium	
(mg/10g soil)	3.09		Percentage (EPP)	4.78
13. pH	8.35	21.	Exchangeable Cations (meq/100g)	
14. Electrical Conductivity			Sodium	1.09
[EC_e] (dS/m)	0.50		Potassium	0.26
15. Cations (meq/1)			Calcium	24.31
Sodium	1.76		Magnesium	2.61

*Following references were made for determination of various soil parameters: Parameter 1 and 11 (USDA, 1951); Parameter 2, 4-6 and 13-20 (USDA, 1954); Parameter 7 (Keen, 1920); Parameter 8 (Mayer and Anderson, 1965); Parameter 3 and 9 (Wilde *et al.*, 1972); Parameter 10 (Qadir *et al.*, 1966) and Parameter 21 (Bower *et al.*, 1952).

Cultivation Practice: The experiment was started in July, 1984 and terminated in June, 1985. Saplings of *A. indica* were pre-conditioned for building salt tolerance by irrigating them with increasing concentration of the brackish water reaching with time up to its full salt concentration. Nine pre-conditioned seedlings (c. 40cm in height) were transplanted in a 50 m^2 plot in 930 cm^2 pits with an inter-plant distance of 3m. Prior to transplantation the soil was treated with Dieldrin-20 @ 1 ml/m^2 of irrigation water for termite control.

The saplings were treated with sub-soil saline water weekly during initial 2 months and later fortnightly. Chemical additives like Urea, Di-Ammonium Phosphate, Sulphate of Potash having N:P:K ratio of 125:100:100 were applied at monthly interval. The N:P:K ratio was increased keeping in view the high sodium concentration in irrigation medium and their deficiency in the coastal soil. Control plots were prepared at a distance of c. 20m and irrigated with non-saline water with corresponding amount of N:P:K. Each plant received c. 20 l. of water at every irrigation. Chemical analysis of non-saline water is given in Table 3.

Table 2. Variation in chemical composition of underground saline water of Bhawani station.

Analysis Period	EC_{iw}	pH	Na^+	K^+	Ca^{++}	Mg^{++}	SAR
			(meq/l)				
July, 84	15.3	8.00	90.05	10.03	4.99	10.71	32.14
Aug, 84	15.3	8.00	89.81	9.70	4.86	10.66	32.24
Sept, 84	15.3	8.10	86.95	9.51	4.99	10.69	31.05
Oct, 84	14.0	8.00	84.78	8.37	4.86	8.96	32.25
Nov, 84	10.5	8.60	80.43	7.67	5.24	9.78	29.35
Dec, 84	10.0	8.50	76.08	9.59	4.49	9.90	28.36
Jan, 85	9.5	8.60	71.74	7.67	4.86	9.45	26.82
Feb, 85	9.5	8.50	61.95	8.95	4.49	8.71	24.11
Mar, 85	10.5	8.65	76.08	9.59	3.74	9.90	29.13
Apr, 85	9.8	8.65	71.74	7.67	3.86	8.96	28.33
May, 85	10.0	8.50	76.08	9.59	3.74	9.13	29.99
June, 85	10.5	8.50	81.52	7.67	5.24	10.73	28.84
July, 85	10.0	8.00	69.56	8.31	5.24	9.78	25.38
Aug, 85	10.0	8.00	74.32	8.52	5.37	10.21	26.63

Quality of irrigation water*: C_4-S_2 (cf. USDA, 1954).

*C_4 *Very High salinity Water*: It is not suitable for irrigation under ordinary conditions, but may be used occasionally under special circumstances. The soils must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt tolerant crops must be selected.

S_4 *Medium Sodium water*: It will present an appreciable sodium hazard at fine textured soils (having high cation exchange capacities) especially under low leaching conditions in absence of gypsum. This water may be used on coarse textured soils with good permeability.

The relative growth rate (RGR) of plants was calculated following Hunt (1982) in terms of monthly increment in height and stem diameter. Water content of the leaves was determined by relative difference between fresh and oven-dry weight. Chlorophyll (Maclachlam & Zalik, 1963), total sugars (Yemm & Willis, 1956), protein (Lowry *et al.*, 1951) and proline (Bates, *et al.*, 1973) contents of leaf were also estimated with replicates for each analysis. Cations were extracted by acid digestion method and estimated using JARREL ASH-782-A atomic absorption spectrophotometer.

To determine the extent of leaching and accumulation of salts in the root zone due to saline water irrigation, soil samples were collected from various depths and analysed at regular interval with respect to their salinity and sodicity status. Soil samples were also analysed after a rainless period (September 1984 – March 1985) when the plants were irrigated with saline water and after 100 mm rainfall which occurred in April, 1985.

Table 3. Analysis of non-saline water used in irrigation of *Azadirachta indica* plants at Bhawani Station.

1.	pH	8.25
2.	Electrical Conductivity [EC_{iw}] (dS/m)	1.60
3.	Cations (meq/1)	
	Sodium	5.21
	Potassium	0.05
	Calcium	2.60
	Magnesium	4.80
4.	Sodium Adsorption Ratio (SAR)	2.71
5.	Total Dissolved Solids (gm/1)	1.02
6.	Classification of Irrigation Water Type	C_1-S_1*

*, C_1 *Low Salinity Water*: Can be used for irrigation with most crops on most soils with little likelihood that soil salinity will develop. Some leaching is required but this occurs under normal irrigation practices except in soils of extremely low permeability.

S_1 *Low Sodium Water*: Can be used for irrigation on almost all soils with little danger of development of harmful levels of exchangeable sodium.

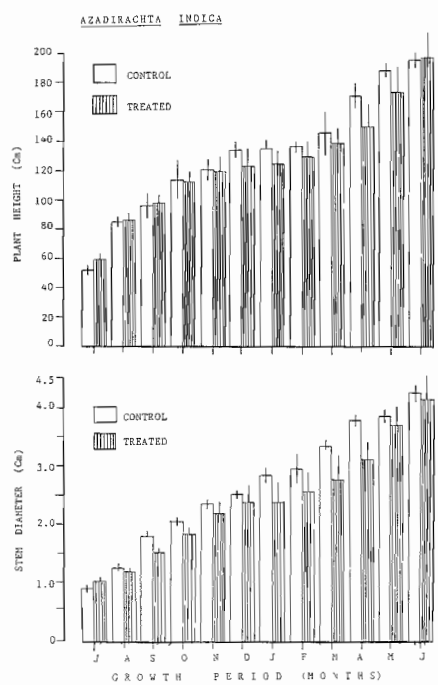

Fig. 1. Variation in plant height and stem diameter of *Azadirachta indica* grown under saline water irrigation at coastal field conditions of Bhawani.

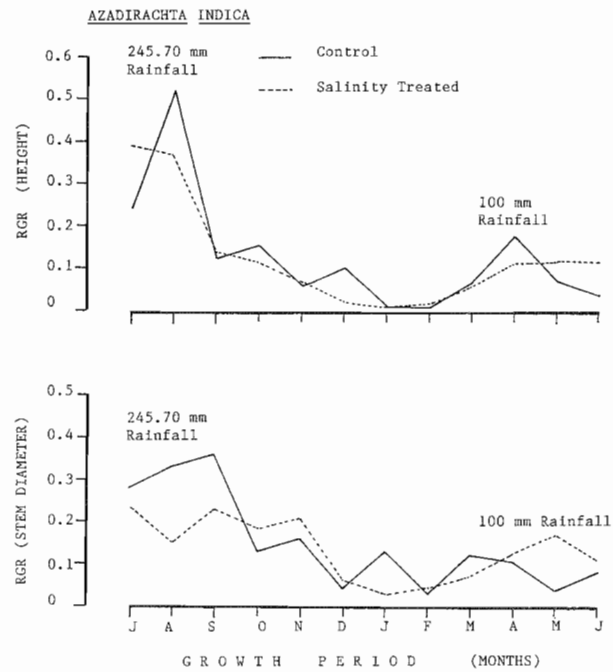

Fig. 2. Relative growth rate (RGR) in terms of height and stem diameter increment of *Azadirachta indica* under saline water irrigation at coastal field conditions of Bhawani.

Results

Height of *A. indica* plants after irrigation with highly saline water exhibited no significant difference from that of the control plant (Fig. 1). All the treated and control plants, exhibited relative inhibition of growth in height during winter months, with greater inhibition in stem diameter in the treated plants only. This inhibition was overcome after rainfall in April (=100mm) showing no difference in growth between control (1.95 ± 0.05m) and treated plants (1.96 ± 0.16m) after one year of post-transplantation period. The relative growth rate (RGR) exhibited similar trend (Fig. 2). The growth rate remained slow showing variations from October to February with peaks of rapid growth rate during August, 1984 and April, 1985. The early peak was correlated with 245.7mm rainfall and the later peak with 100mm rainfall. These peaks were comparatively less evident for increment of stem diameter.

Irrigation of plants with saline water induced no significant difference in moisture, total chlorophyll, total sugars, proline and protein contents in treated as compared to control plants (Fig. 3). Concentration of Na^+, K^+ and Mg^{++} in leaf of treated plants also behaved similarly. Significant decrease in foliar concentration of Ca^{++} was observed in plants irrigated with saline water.

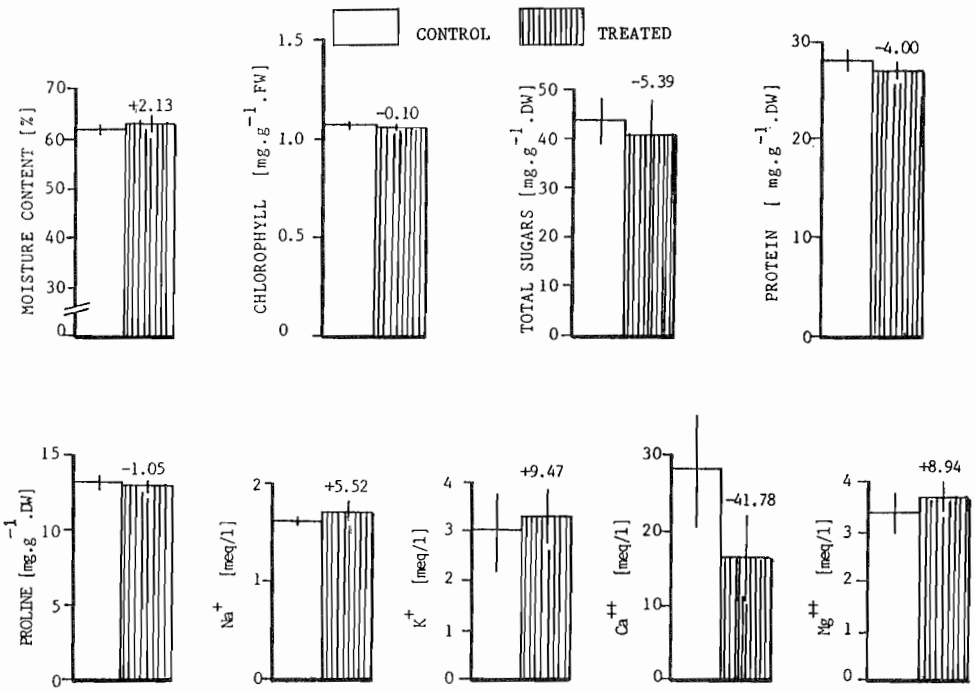

Fig. 3. Effect of saline water irrigation on moisture content, some biochemical and ionic constitutents of *Azadirachta indica*. Figures above the bars indicates percent increase (+) or decrease (-) over control.

Table 4. Annual changes in soil chemistry of Bhawani field before and after rainfall.

Analysis Period	Soil Depth (cm.)	EC_e: ($dS.m^{-1}$)	pH	Na^+	K^+	Ca^{++}	Mg^{++}	SAR	ESP
				---- (meq/l) ----------					
Pre-Rainfall									
Irrigation with	0	9.0	7.85	43.47	3.19	17.21	13.65	11.06	13.09
saline water	30	4.5	8.25	31.52	1.91	9.98	3.18	12.28	14.43
(Sept 1984 –	60	4.6	8.25	35.32	2.55	5.86	3.39	16.42	18.67
March 1985)									
Post-Rainfall									
No saline water	0	0.86	7.85	4.56	0.96	2.56	5.06	2.35	2.15
irrigation.	30	0.15	8.45	3.91	0.84	2.12	1.48	2.91	2.95
May (1985)	60	0.24	8.45	3.48	0.96	2.49	2.08	2.30	2.09

Rainfall (100mm) washed down the accumulated salts to greater depths of the soil profile reducing the salt content in the root zone almost to the same level as that in the virgin soil before saline irrigation (Table 4). Irrigation with saline water increased the salt content in the upper profile with SAR value just on and beyond the critical level. This increase of salts does not appear to be due to soil texture but due to high evapo-transpiration rate because of high temperature during summer that helped in accumulation of salts near the surface.

Discussion

Irrigation with brackish water of EC: 10.0–15.3 $dS.m^{-1}$ and average SAR of 28.90 did not affect the growth of *A. indica* in the sandy stratum where the rate of growth was fairly rapid. Mean net increment in height as a result of one year post-transplantation growth of saplings (initially of 40cm height) in control as well as in the treated plants was around 1.56m so that the plant attained a mean height of c.2m. The net annual girth increment was around 3.16 cm in treated plants which was only 5.67% less than that of the control (3.35 cm). This rate of girth increment is comparable to that given by NAS (1980). The net increment in height was, however, comparatively lower than that of one year old *A. indica* shelter belt at Mudia State Farm, P.D.R. Yemen (2.66 ± 0.20 m) (Costin, 1976). *A. indica* has been graded as salt tolerant plant (Tsing *et al.*, 1956; Yadav & Singh, 1970; Tomar & Yadav, 1980). The experimental results indicate a good feasibility of growing neem under saline irrigation at sandy coastal area. It is potentially one of the most v duable of all arid zone trees since it is deep rooted, broad-leaved, evergreen wide spreading species native to the dry forests of mid-southwest Asia and has shown good plantations in Sudan and Sahelian zone of African as well as in Sierra Leone, Malavi, Zimbabwe, Tanzania, Zangibar and non-Sahelian areas of Guinea, Nigeria and Ghana (Sanger, 1977; NAS, 1980). *A. indica* has also been used for shelterbelt in many mediterranean countries (Costin, 1976).

In physiological respose of plant to salinity, no significant difference between control and treated plants was observed with respect to any physiological parameters. Foliar concentration of Na^+, K^+ and Mg^{++} remained unaffected with salinity and sodicity in the root zone. The only significant decrease observed was in foliar concentration of calcium ion (decrease being 41.78% over the control). This may probably be due to suppressing effect of Na^+ on calcium uptake (Lessani & Marschner, 1978) or due to more preferential accumulation of calcium in the roots than the shoots (Lazaroff & Pitman, 1966). Foliar concentration of K^+, inspite of very high Na^+ concentration in the irrigation medium, was quite high. Foliar K^+/Na^+ ratio in control plants was around 1.85 and 1.99 in the treated plants. This indicates that *A. indica* is potassiophillic in nature, and probably there occurs rapid translocation of K^+ from the roots to the shoots. Almost similar concentration of sodium in control and the treated plants indicate that *A. indica* is a sodium excluding plant

which checks the entry of sodium in the leaves. This potassium-sodium regulation is similar to that observed in *Prosopis juliflora* (Khan, *et al.*, 1986; 1987). The results indicate that rainfall as low as 100 mm washes down the salts to deep stratum of the soil thus avoiding salt accumulation. Rainfall received once in a year may not only supplement the irrigation but also create conditions more conducive to growth of the plant. Frequent and even excess irrigation with saline water in order to avoid moisture depletion during dry and hot season at sandy soil may result in salt accumulation in the rhizosphere up to certain extent which could prove lethal to the plant if it is continued for a longer period.

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