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Full Length Article

Effect of Salinity and Municipal Wastewater on Growth Performance and Nutrient Composition of *Acacia nilotica*

HASNAIN FAROOQ, NADIA BATOOL†, JAVAID IQBAL[1] AND WASIF NOUMAN‡
College of Agriculture, Dera Ghazi Khan, Punjab, Pakistan
†*Government College, Dera Ghazi Khan, Punjab, Pakistan*
‡*Department of Forestry, Range Management and Wildlife, University of Agriculture, Faisalabad, Pakistan*
[1]Corresponding author's e-mail: javaidleghari@hotmail.com

ABSTRACT

Re-vegetation of plant species using industrial and municipal wastewater and alternate bio-saline approach to grow salt tolerant plant species on salt affected soils may help to lessen the burden on fresh water source being used for irrigation. In this study, response of *Acacia nilotica* to combined stress of municipal wastewater and salinity was evaluated in pots conducted during 2007. Treatments comprised of four salinity levels i.e., control, electrical conductivity (EC) 6, 9 and 12 dS m^{-1} and three water types i.e., wastewater, tap water and mixed water (Waste & Tap water with ratio of 1:1). Mixing of wastewater with tap water was found the best for the better growth of *A. nilotica* at control salinity level. Shoot and root length, fresh and dry weights were reduced with increasing salinity. Maximum reduction of these parameters was recorded at highest salinity level (EC 12 dS m^{-1}). Highest Nitrogen and Phosphorus contents were observed in plant samples under mixed water at control level of salinity and were similar to plant samples under mixed water at highest level of salinity (EC 12 dS m^{-1}). Potassium contents were found maximum in plant samples under mixed water with EC 6 dS m^{-1}. By increasing salinity the NPK contents in plant samples decreased gradually. The general order of reduction of different growth parameters of *A. nilotica* by salinity (dS m^{-1}) was (highest inhibition) EC 12 > EC 9 > EC 6 > Control. The general order of best fit water was mixed water > wastewater > tap water. However, the salinity inhibited the growth of *A. nilotica,* but by mixing the municipal wastewater (an important source of nutrients) the problem of salinity can be alleviated. © 2010 Friends Science Publishers

Key Words: Salinity; *Acacia nilotica*; Water types; Salt tolerance

INTRODUCTION

Salinity and water scarcity are mutually affecting the farmlands of the Pakistan and devastating the production capacity up to an alarming mark. Saboora *et al.* (2006) warned that there was a dangerous trend of a 10% per year increase in saline area throughout the world. Salinity and sodicity are most talked soil ailments in Pakistan (Aslam, 2006; Khan, 2006). Khan (2006) stated that saline soils cover 5.3 million hectares in Pakistan. Out of 20 million hectares of agriculture land 6.67 million hectares are salt affected (Ansari *et al.*, 1998). This loss would increase over the next twenty years by making the world food supplies vulnerable (Akhtar *et al.*, 2008).

Soil salinity is a major problem in both arid and semiarid regions of the world for agriculture production (Epstein *et al*., 1980). The shortage of water and hot, dry climates often result in high concentrations of salts in soils, which limit crop production. Salinity is a complex environmental constraint that presents 2 main components: an osmotic component due to the decrease in the external osmotic potential of the soil solution and an ionic component linked to the accumulation of ions that become toxic at high concentrations (mainly Na^+, Cl^-, SO_4^{2+}, CO_3^{2-} & HCO_3^-) and a stress-induced decrease in the content of essential ions, such as K^+ and Ca^{2+}. The effect of salinity on the nutrient composition of plant tissues, especially concentrations of K^+ and Ca^{2+}, has been extensively investigated and several researchers have proposed that the detrimental effects of salinity on plant growth may occur through an ionic imbalance, particularly of K^+ and Ca^{2+} (Cerda *et al*., 1995). Plant species differ in their sensitivity or tolerance to salts (Ramoliya & Pandey, 2006; Masilamani *et al*., 2009). Tewari *et al*. (2006) observed the decrease in the growth and dry weight of one-year old seedlings of *Dalbergia sissoo* than in *Acacia nilotica* as the level of sodicity and salinity increased in both species. They found *A. nilotica* more sensitive against sodicity and salinity as compared to *D. sissoo.*

The safe disposal of wastewater is also a major issue in developing and developed countries due to rapidly increasing population, urbanization and industrialization (Ensink *et al*., 2005). In modern ages, various techniques have been developed to dispose of the wastewater safely,

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but the threat to the environment yet has not been catered. The sewage and effluent water has been the serious factor contributing to soil and water contamination (Rahmani, 2007). The best possible approach for safe disposal of wastewater is to use it for irrigation for the production of vegetables, grasses and trees being an important source of nutrients and reclamation of the un-productive soil (Dwivedi, 2000; Lait *et al*., 2001; Bozkurt & Yarilga, 2003; Rahmani, 2007). It has been estimated that 5 irrigations of 7.5 cm each, raw sewage water provides the essential nutrient in sufficient amount as 181 kg of N ha^{-1}, 29 kg P ha^{-1}, 270 kg K ha^{-1} and 130 kg S ha^{-1} along with micro nutrients i.e., 1.28 kg Zn, 0.75 kg Cu, 41.86 kg Fe and 1.37 kg Mn, which are very useful for good crop growth (Dwivedi, 2000). Rahmani (2007) observed organic matter content, total nitrogen, available phosphorous and potassium and selected heavy metals higher with municipal wastewater as compared to well water in soil. He also found the higher concentration of Mn, Zn, Cd and Cu in industrial wastewater application.

Reclamation technology for salt affected soil is well established, but traditional reclamation methods are difficult, inadequate, expensive and non-sustainable. A number of attempts have been made to increase the utilization of industrial and municipal wastewater as irrigation source by researchers and some research institutes (Asha & Katewa, 1999; Paramathma *et al*., 2003), but a very few research studies have been undertaken to evaluate the individual and combined response of wastewater and salinity on the plants especially tree species in order to utilize the un-cultivable land to generate income, combat food shortage and minimize the water pollution effects in the country. Hence, this bio-saline approach is considered as the most useful technique for the reclamation of saline soils (Maos, 1990), which will also help to minimize the use of fresh water as an irrigation source (Singh & Bhati, 2004) and save precious foreign exchange in terms of importing wood and wood based products. Many tree species take up the large amounts of water and minerals by controlling biologically the adverse effects of wastewater on the soil and the plants (Hopmans *et al*., 1990; Nelson, 1995) and increasing the minerals in the photosynthetic parts (leaves) of the plants (Brister & Schultz, 1981; Neilsen *et al*., 1989). *A. nilotica* was selected in this experiment because of its importance for wood quality with multiple uses. Therefore, the present study was designed to appraise and determine the individual and combined effects of wastewater and salinity on the growth of trees.

MATERIALS AND METHODS

General procedures: Three months pot experiment was conducted at the experimental area department of botany, Government College, Dera Ghazi Khan during, 2007. The Pots (15 cm diameter, 20 cm depth) were filled with 5 kg sandy clay loam soil each taken from the upper 10 cm layer from Shoria distributry. One month old uniform sized seedlings of *Acacia nilotica* were obtained from the college of Agriculture, Dera Ghazi Khan. Five seedlings were transplanted in each pot during July, 2007. Wastewater was collected from sewage disposal point located at Model Town, Dera Ghazi Khan. Treatments comprised of four salinity levels i.e., control, EC 6, 9 and 12 dS m^{-1} and three water types i.e., wastewater, tap water and mixed water. After transplanting the seedlings of *A. nilotica,* the pots were irrigated with these water types as twice a day for 1st two weeks, once a day for the next two weeks and on alternate days till the end of experimental period. The experiment was laid out in completely randomized design with four replicates. Data on shoot and root length, shoot and root fresh weight, shoot and root dry weight and number of leaves per plant were recorded at the end of September following the standard sampling procedures.

NPK analysis: The plant samples were oven dried at 85ºC to a constant weight and ground to pass 2 mm sieve. These samples were digested in concentrated nitric acid and then diluted 10 times with distilled water and filtered through Whatman's filter paper No. 1.

Nitrogen was determined by "Gunning and Hibbards'' method of sulpher acid digestion and distillation was made with micro Kjeldhal's apparatus (Jackson, 1962). Estimation of Phosphorus was done calorimetrically on the perchloric acid digest. Color was developed with molybdate-vandate solutions (Jackson, 1962). Jenway PEP-7 flame photometer was used to determine K in diluted extracts of plant material by using potassium filter (Jackson, 1962).

Statistical analysis: Statistical software package" MSTAT-C" was used to analyze the data (Anonymous, 1986). Least significance difference (LSD) test was applied at 5% level of significance to compare treatment means.

RESULTS

Shoot length, fresh and dry weights: Salinity levels and water types significantly affected the shoot length of *A. nilotica* (Fig. 1). Tallest shoots were recorded with wastewater at control salinity level and was on equivalence with mixed water at control. Smallest shoot length was observed at EC 12 dS m^{-1} with all water types. However, wastewater and mixed water countered the problem of salinity up to a certain level (EC 9 dS m^{-1}) as compared to tap water. The general order of shoot length as affected by salinity levels (dS m^{-1}) was EC 12 >EC 9 >EC 6 >control. Wastewater was found fit for the growth of *A. nilotica* followed by mixed water.

The interaction between water types and salinity level was found non-significant for shoot fresh weight (Fig. 1). However, water types and salinity levels individually affected the shoot fresh weight. Heaviest shoots (46-72%) were recorded for mixed water and were similar to wastewater treatment. Tap water was found the least effective in promoting the shoot fresh weight. The

Table I: ANOVA for different growth and quality parameters of *Acacia nilotica*

Parameters		D.F	SS	MS	F value	Sig.
	Water types (W)	2	64.44	32.22	8.02	**
Shoot length	Salinity levels (S)	3	533.68	177.89	44.29	**
	Interaction (W x S)	6	102.32	17.05	4.24	**
	Water types (W)	2	64.32	32.16	3.96	**
Root length	Salinity levels (S)	3	484.06	161.35	19.88	**
	Interaction (W x S)	6	104.64	17.44	2.14	ns
	Water types (W)	2	4.85	2.42	3.20	ns
Shoot fresh weight	Salinity levels (S)	3	54.29	18.09	23.90	**
	Interaction (W x S)	6	9.16	1.50	2.01	ns
	Water types (W)	2	0.50	0.25	1.63	ns
Root fresh weight	Salinity levels (S)	3	8.38	2.79	18.10	**
	Interaction (W x S)	6	4.06	0.67	4.39	**
	Water types (W)	2	0.79	0.39	4.43	**
Shoot dry weight	Salinity levels (S)	3	8.59	2.86	31.91	**
	Interaction (W x S)	6	0.57	0.09	1.06	ns
	Water types (W)	2	0.85	0.42	14.32	**
Root dry weight	Salinity levels (S)	3	2.60	0.86	28.95	**
	Interaction (W x S)	6	0.51	0.86	28.86	*
	Water types (W)	2	86.26	43.13	9.40	**
No. of leaves	Salinity levels (S)	3	287.18	95.72	21.07	**
	Interaction (W x S)	6	71.11	11.85	2.60	*
	Water types (W)	2	736.05	368.03	6.46	**
N	Salinity levels (S)	3	254.75	84.92	1.49	ns
	Interaction (W x S)	6	2964.86	494.14	8.68	**
	Water types (W)	2	110.72	55.36	9.86	**
P	Salinity levels (S)	3	64.30	21.43	3.82	*
	Interaction (W x S)	6	299.27	49.87	8.89	**
	Water types (W)	2	2012.66	1006.33	28.34	**
K	Salinity levels (S)	3	1274.97	424.99	11.97	**
	Interaction (W x S)	6	3823.11	637.18	17.94	**

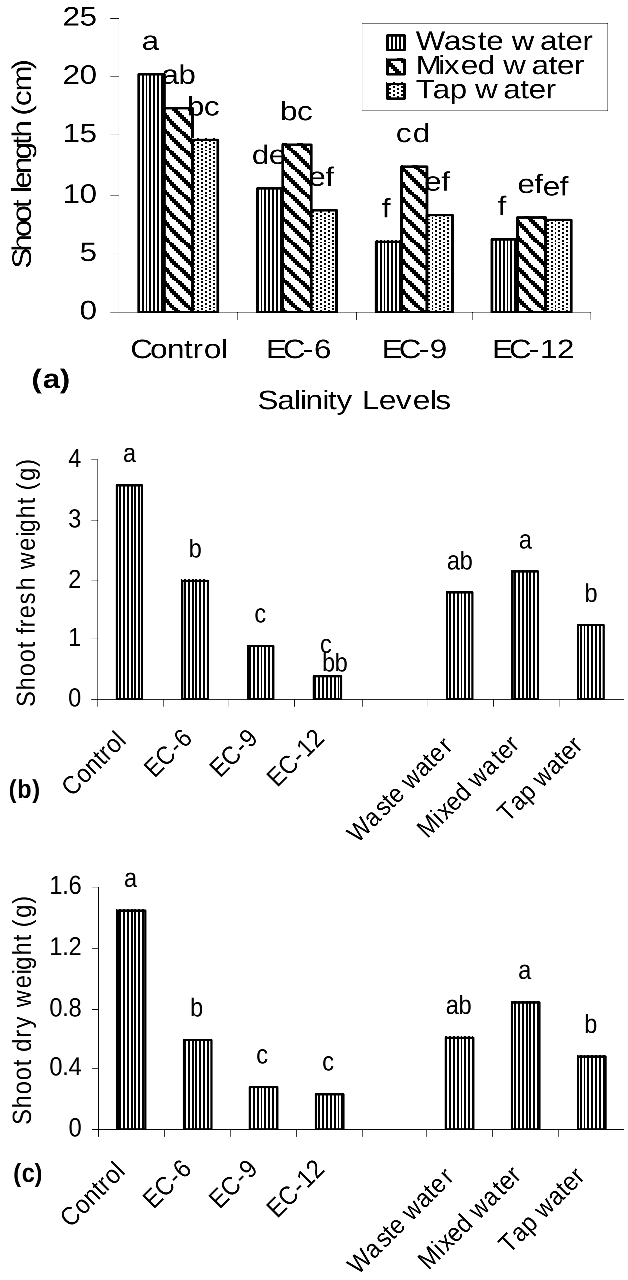
*= Significant at 0.05 P; **= significant at 0.01 P, ns = Non-significant

maximum fresh weight was recorded at control salinity level followed by EC 6 dS m^{-1}. Fresh weight was adversely suppressed by highest salinity levels (EC 9 & 12 dS m^{-1}; 75-90%). Almost similar results were observed for shoot dry weight (Fig. 1).

Root length, fresh and dry weights: The interaction between water types and salinity levels was found non-significant for root length (Fig. 2). However, water types and salinity levels individually affected the root length. Mixed water was observed the best fit with longer roots followed by wastewater and tape water. The maximum root length was recorded with control level of salinity. Root length was badly affected by higher salinity level (EC 9 & 12 dS m^{-1}; 42-51%).

Root fresh weight was drastically affected by water types and salinity levels (Fig. 2). Heavier roots were observed for wastewater at control. Minimum fresh weight was recorded for wastewater at highest level of salinity (EC 12 dS m^{-1}) and was similar to EC 9 dS m^{-1} and tap water at EC 6, 9 and 12 dS m^{-1} and mixed water at EC 12 dS m^{-1}. Mixed water compensated the adverse effect of salinity followed by wastewater. In the individual treatment comparisons, water types showed non-significant effect of root fresh weight, on the other hand, salinity affected it. Lowest fresh weight of roots was observed at EC 12 dS m^{-1} and was on same level with EC 9 dS m^{-1}. Control produced heavier roots. Dry weight of roots showed different response

Fig. 1: Effect of water types and salinity levels on shoot characteristics of *Acacia nilotica,* in case of b and c the interaction was non-significant and individual water types and salinity effects are given



as compared to fresh weight. Maximum dry weight was recorded for all water types at control and water at par with mixed water at EC 6 dS m^{-1}. Statistically similar effects were observed at all salinity levels for wastewater and tap water; however, mixed water treatments compensated the adverse effects of salinity. The effect of water types and salinity also affected independently. Mixed water treatment was found the best fit for root dry weight. The increased salinity negatively affected the root dry weight.

Fig. 2: Effect of water types and salinity levels on root characteristics of *Acacia nilotica*, in Fig. (a) the interaction was non-significant, therefore, individual water types and salinity effects are given

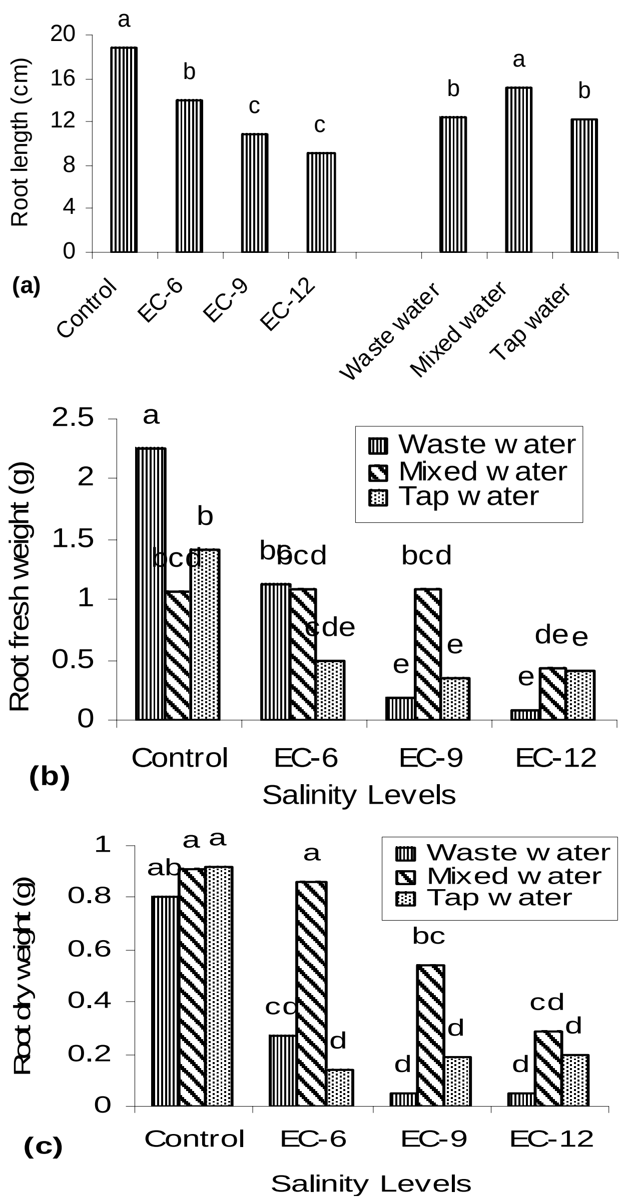
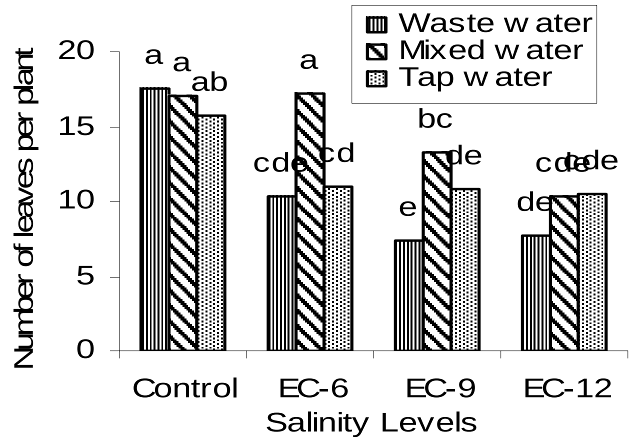


Fig. 3: Effect of water types and salinity levels on leaf count plant^{-1} of *Acacia nilotica*



Leaf count plant^{-1}: Water types and salinity significantly affected the leaves count of *A. nilotica* (Fig. 3). More leaves were recorded for wastewater at control and was at par with mixed water at control and EC 6 dS m^{-1} and Tap water at control level. Increased salinity with both types of water (waste & Tap water) decreased number of leaves, on the other hand, mixed water treatments compensated the bad effect of salinity up to a certain level. The individual treatment comparisons proved the mixed water as best mixture for leaf count. Increased salinity un-favorably affected the leaf number

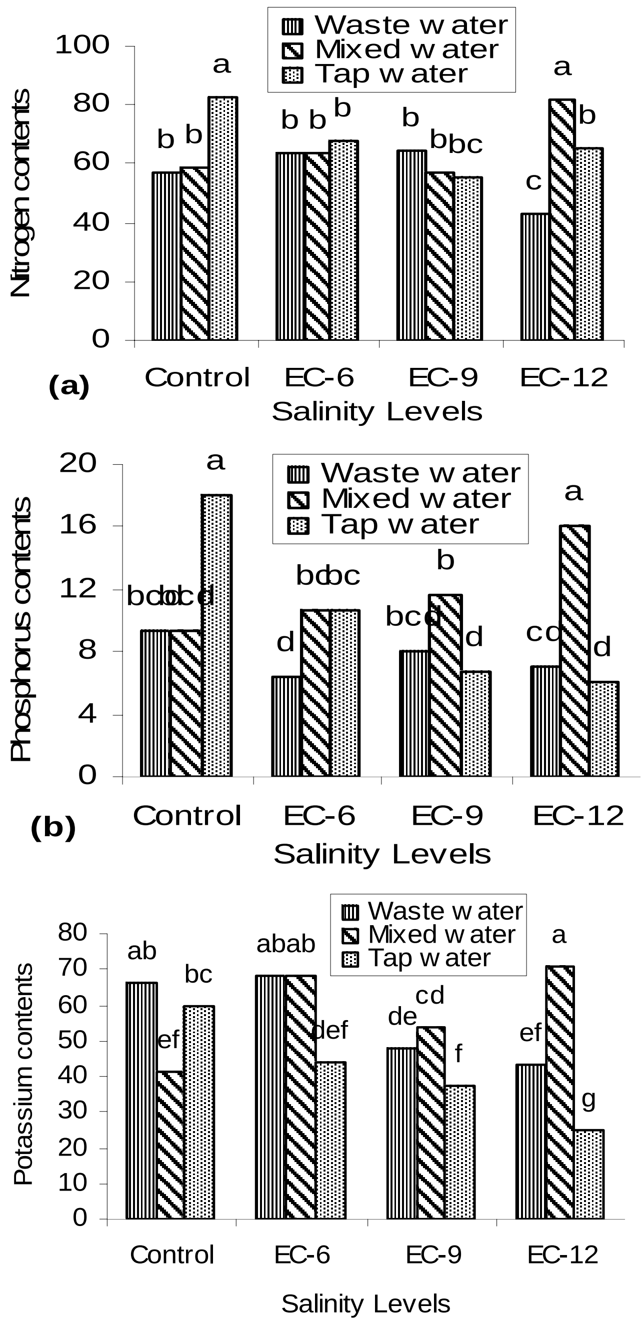
NPK Contents in plant matter: Water types and salinity levels significantly affected the Nitrogen, Phosphorus and potassium concentration in plant material (Fig. 4). Highest accumulation of nitrogen was recorded in tape water at control salinity level and was at par with mixed water at highest level of salinity (EC 12 dS m^{-1}). All water types and salinity level treatments were comparable in their effect on nitrogen accumulation except highest level of salinity with wastewater in which lowest contents were recorded. In individual treatment comparisons, salinity levels did not affect nitrogen content in the plant matter of *A. nilotica*. However, maximum Nitrogen contents were observed for wastewater treatment.

Phosphorus contents were also observed highest similar to nitrogen content in plant matter. Lowest phosphorus contents were recorded for tap water at highest level of salinity (EC 12 dS m^{-1}) and were statistically similar to wastewater at all salinity levels, tap water at EC 9 and 12 dS m^{-1} and mixed water at control level of salinity. Individual treatments comparison showed highest phosphorous contents for mixed water which was similar to tap water. In control level of salinity highest phosphorus contents were observed; however, similar phosphorus contents were observed at EC 6, 9 and 12 dS m^{-1}. In case of K mixed water at EC 12 dS m^{-1} proved better in absorption and were on par with mixed water at EC 6 dS m^{-1}, wastewater at control and EC 6 dS m^{-1}. The lowest potassium contents were recorded in tap water with EC 12 dS m^{-1}. Increased level of salinity decreased potassium concentration. Mixing of wastewater and tap water better improved the potassium concentration as compared to tap water.

DISCUSSION

Many research studies and projects have been accomplished on the usage and effects of wastewater as irrigation source on different crops (Dighton & Jones, 1991; Rahmani, 2007) by increasing the amount of minerals in the foliage of the plants (Nielsen *et al.*, 1989; Bozkurt &

Fig. 4: Effect of water types and salinity levels on Nitrogen, Phosphorus and Potassium contents in *Acacia nilotica* plant matter



Yarilga, 2003), but a very few studies are available on the response of tree species against the wastewater application on saline soils. This study was conducted to evaluate the growth performance of *A. nilotica* in reference to wastewater application under saline stress conditions. The responses of different parameters were checked out and manifested to find the optimum response level of the selected tree species under different water types and increasing salinity levels.

The individual effects of wastewater at different salinity levels are very tricky. Both factors bounce and reduced the biomass production and NPK ions' concentration at different levels but the mixed water treatment enhanced the growth performance of *A. nilotica*; however, the growth was reduced at increasing salinity levels. The mixture of wastewater and tap water was found to be the best approach to grow tree on saline soil, as reported by Karpiscak and Gottfried (2000) for cottonwood and willow, which survived under mixture of effluent and potable water.

The wastewater individually increased the biomass and NPK resulting in taller and leafier plants as compared to tap water (Farooq *et al.*, 2006) under control salinity level. These results support the findings of Mirghan *et al.* (2002), who compared the potential of normal and sewage water on plants belonging to family Poaceae. They also found taller plants by irrigating with sewage water in contrast to normal. In contrast Bozkurt and Yarilga (2003) found no significant increase in tree trunk girth and P, K, Ca, Ni, Cr and Cd concentrations in leaf samples of apple trees with sewage sludge applications. They further stated that leaf Fe, Mn and Zn concentrations increased at the highest sludge rate from 88.0 to 105.3, from 44.2 to 75.5 and from 9.2 to 10.4 mg kg^{-1}, respectively. The increasing salinity levels retarded the growth performance, biomass production and NPK composition under all water types. The decrease in biomass production due to increase in salinity levels has also been reported by many researchers (Awan *et al.*, 2002; Tewari *et al*., 2006; Tabatabaie & Nazari, 2007; Ahmad, 2009 & Khan *et al.*, 2009), but Hebbra *et al.* (2004) found that *A. nilotica* showed best performance at all salinity levels as compared to other species.

The interaction of the both factors demonstrated the significant growth performance and increase in biomass production of *A. nilotica* as illustrated in Fig. 1-3. Hence the wastewater can be utilized in saline areas to bring about the non-cultivable land under cultivation by growing leguminous trees like *A. nilotica*. The wastewater adds nutrients in the soil and increases the fertility that sustains the plants' growth (Rehmani, 2007).

In conclusion, though salinity retarded the growth of *A. nilotica*, but by mixing the municipal wastewater in soil the problem of salinity can be countered and non-cultivable land can be cultivated with trees like *A. nilotica*.

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