

DESALINIZATION AND FORTIFICATION OF SOIL USING POTASSIUM CHLORIDE

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ABSTRACT

This study was conducted on saline soil collected from Biosaline Research Station (BSRS) of Nuclear Institute for Agriculture and Biology (NIAB) Faisalabad, Pakistan to determine the effect of potassium fertilizer (KCl) on growth performance of *Eucalyptus camaldulensis*. Potassium was applied at 100 and 200 kg K₂O ha⁻¹ as KCl. Results showed that most agronomic parameters like number of branches, leaves per plant, fresh and dry weight and ionic uptake of potassium and chloride increased in *Eucalyptus camaldulensis* due to soil applied KCl. However, 200 kg K₂O ha⁻¹ (as KCl) was more effective in producing higher biomass than 100 kg ha⁻¹ in salt-affected wastelands. It was concluded that application of KCl (muriate of potash) could increase the growth and nutrients uptake of *Eucalyptus camaldulensis* in salt-affected soil.

Key-words: K-Fertilizer, growth parameters, *Eucalyptus*, saline soil.

INTRODUCTION

Land deterioration and lack of its utilization for food, timber, fodder and industrial raw materials is being observed all over the world but it is more acute in the developing and under developed countries. In many low rain fed areas, good soils are scanty with their on the whole output declining (Barungi *et al.*, 2013) because of soil dilapidation and lack of appropriate soil and water management practices. Salt-affected soils, which are prevalent in low rain-fed and coastal counties of sub-humid areas, have low crop yield. There are 380 million hectares of salt-affected soils on earth's land surface, and of these 140 million hectares are extremely saline (IAEA, 1995) and have higher electrical conductivity (EC). In many region of the world, foodstuff, firewood and trade raw material production is harshly affected by high salt contents in soils. In many part of the southern Asia and the Near East, several million hectares of agricultural land are exaggerated by salinity (e.g. 6.3 million ha in Pakistan and 2.5 in India) causing significant losses in plant production. It is expected that nearly 10 % of the total land of the world used for agricultural production is badly affected by soil salinity (IAEA, 1995). Literature is well documented on various aspects of chemical reclamation of saline sodic soils (Vance *et al.*, 2008; Sutter and Cihacek, 2009) and on efficiency and cost effectiveness of biological and chemical methods of reclamation (Ahmad and Chaudhry, 1990; Qadir *et al.*, 1996a, 1996b). The recovery of salt-affected soils by chemical amendments is a well-known technology, while, traditional reclamation methods have been proved to be hard (Rafiq, 1990), derisory (Qureshi, *et al.*, 1992), costly (Qureshi, 1993), and too costly on highly impervious dense saline-sodic soils in Pakistan. Further, under the on hand situations, not only the extent of this approach is limited, its sustainability is also uncertain (Qureshi, 1993; Qureshi and Barrett-Lenard, 1998). Siddiqui, (1994) stresses the need for plantation of halophytes that can produce timber, forage and fuel wood on saline land. The other approach is based on growing salt tolerant plant species and use of saline waters to utilize salt-affected soils which has been explored to a lesser extent (Qureshi and Barrett-Lenard, 1998). It appears that there is a great scope to grow salt tolerant trees for reforestation on waste land both under dry and waterlogged condition. *Eucalyptus camaldulensis* Dehnh. has been identified as a tolerant tree species to salinity and has more than 85% survival rate under saline soil conditions (Qureshi *et al.*, 2000). Hence, it is the most successful tree species under a variety of saline conditions (Qureshi, 1993). *Eucalyptus* has been planted successfully under a variety of ecological conditions of Pakistan (Siddiqui, 1994) and its survival in nutrient solution up to 50 dS m⁻¹ in aerobic conditions (Marcar, 1989) and up to 42 dS m⁻¹ in both aerobic and waterlogged conditions (Moezel *et al.*, 1988) has been reported. Studies on the separate effect of salinity on growth of some *Eucalyptus* species are well documented (Sun and Yadav., 1985; Marcar, 1989; Pearce- Pinto *et al.*, 1990; Marcar, 1993; Clemen and Pearson, 1997; Qureshi *et al.*, 2007). Most studies showed that nutrients are involved in basic physiological processes related to photosynthesis and leaves growth (Suar *et al.*, 2000) and low fertility resulted in reduced growth and poor performance (Harwood *et al.*, 1993). Application of nitrogen fertilizer has been shown to enhance growth of *Eucalyptus nitens* (Williams *et al.*, 2003) and phosphorus fertilizer induces early vegetative phase in some *Eucalyptus* trees. K fertilization has been used for a long time to increase leaf growth (Teixeira *et al.*, 2006). Despite the huge influence of K fertilization on *Eucalyptus* growth, little information is available on the consequences of K addition for growth and efficiency (Binkley *et al.*, 2004). Keeping in view the

importance of K application in saline soils for sustainability of the stands, the present study is designed to investigate whether *Eucalyptus* growth could enhance by applying muriate of potash under salt-affected soils.

MATERIAL AND METHODS

Saline soil was collected from Biosaline Research Station (BSRS) of Nuclear Institute for Agriculture and Biology (NIAB) Faisalabad, Pakistan and the samples were then analyzed for chemical properties according to the standard methods described in U.S. Salinity Laboratory Staff Hand Book-60 (1954). The seeds of unpedigreed *Eucalyptus camaldulensis* Dehnh. were sown in the plastic pots (15 x 30 cm) containing sand for raising the nursery and at the age of 22 days, the seedlings were shifted in polyethylene bags (23 x 10 cm) containing sandy loam soil and were allowed to grow for further three months to develop healthy saplings of *Eucalyptus*. There after, these saplings were planted in pots containing 20kg soil collected from site at BSRS which were irrigated with tap water. Soil characteristics are summarized in table 1. The transplanted saplings were allowed to grow for about 8 weeks on this salt-affected soil. There after, the plants were harvested and their height and diameter were recorded. At harvesting time, the soils samples were also collected to estimate the changes in chemical properties of soil. Then the soil was dried, ground and analyzed for EC, pH, SAR, soluble anions and cations according to the methods described by U.S. Salinity Laboratory Staff, Hand Book-60 (1954). The plant height (inches) was measured with the help of meter rod from the base to the tip of the tree. The number of leaves and green branches per plant were also counted. Fresh weights of whole aerial plants were noted at the time of harvest and dry weight after oven drying the plant material at 70 ° for 48 hours.

Plant analysis

The well ground plant samples (0.2 gram) in triplicate were kept over night for digestion after adding 2ml of concentrated HNO₃ and then after addition of 6 ml of distilled water the material was boiled for 15 minutes. The supernatant liquid was transferred in a 50 ml volumetric flask following by 3 more washing with hard distilled water and volume was made up to 50 ml (Hand book 60 USDA). Potassium in the plant extract was determined by Flame Photometer (Jenway PFP-7). Chloride in the plant extract was determined by using titration method in which 2 gram ground sample with 20ml distilled water was titrated against AgNO₃ by using potassium chromate as indicator with brick red end point.

Soil analysis

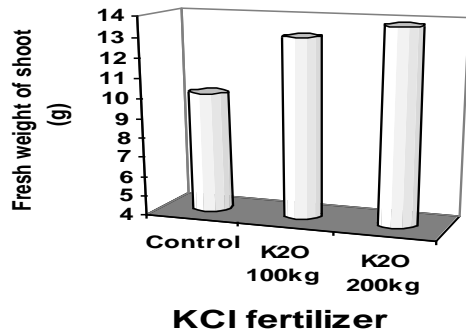
The pH of saturated paste of soil samples with two replicates was recorded by using HANNA digital pH meter 8520. The saturated soil paste was transferred to Buckner's funnel with a filter paper in place then vacuum was applied and extract was collected in tube. Electrical conductivity E_{Ce} was measured by using digital conductivity meter (WTW L 538). Soluble sodium (Na) was measured by using Jenway PFP-7 flame photometer. Calcium + magnesium was determined by titration with 0.01 N EDTA solution using Eriochrome Black-T as an indicator. Sodium adsorption ratio (SAR) was calculated by the following formula $SAR = Na / (Ca + Mg/2)^{1/2}$. The data obtained were subjected to analysis using Duncan's New Multiple Range Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

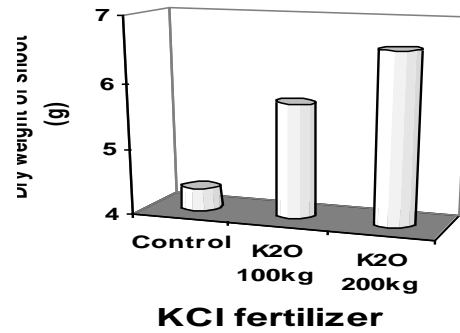
Influence of KCl fertilization on plant growth parameters

Fresh and dry weights of shoot, number of branches and leaves, enhanced by application of K₂O @ 100 and 200 kg as KCl in Fig. 1(a, b, c & d). The difference in mean plant height between the two treatments was not marked. Potassium fertilization enhanced the fresh weight of the shoot by 23% and 26%, respectively (Fig. 1, a) and it was the lowest in control treatment. However, shoot dry mass (Fig. 1, b) was enhanced by 24% and 34%, respectively. Basile *et al.* (2003) showed a significance increase in photosynthetic biomass on addition of K-fertilizer in deciduous species. In contrast, a large response of KCl fertilization was observed. Potassium chloride addition led to an increase (20 %) in number of branches in both the treatments as compared to control (no K₂O) (Fig. 1, c) however, response of plant height to 100 kg K₂O was limited and somewhat negative at 200 kg K₂O as compared to control (Fig. 1, e). Many scientists have discussed similar results for *Eucalyptus* growth on potassium fertilization. Laclau *et al.* (2008) observed an improvement in growth while Whitehead and Beadle (2004) reported broad leaf growth and physiological regulation in *Eucalyptus*. A positive effect of K addition on *Eucalyptus grandis* was observed by Basile *et al.* (2003). Binkley *et al.*, (2004) recommended addition of potassium and Almedia *et al.*, (2010) nitrogen+potassium for commercial plantation of *Eucalyptus grandis*. Leaf production was significantly enhanced by KCl addition in both the treatments (Fig. 1, d) however; the increase in number of leaves was higher @

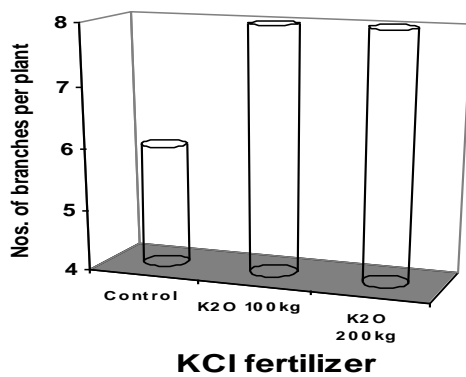
200 kg than 100 kg of K_2O and increased by 40% and 42%, respectively. Fife *et al.* (2008) reported substantial internal re-translocation of K in Eucalyptus leaves. Growth of *Eucalyptus* and soil fertility enhanced in Brazil with K fertilization (Goncalves *et al.*, 2008). Kitajima *et al.* (2002); Escudero and Mediavilla (2003) also discussed the increase in photosynthesis rate with K availability. Oikawa *et al.*, (2006) showed increase in leaf production by addition of potassium fertilizer.



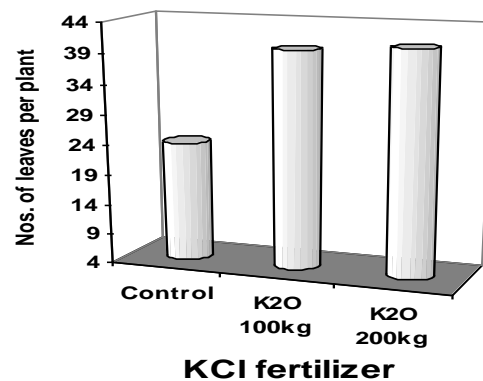
(a)



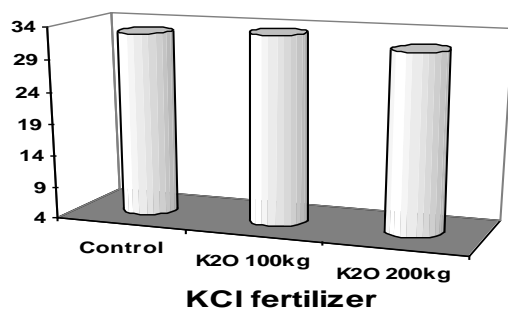
(b)



(c)



(d)



(e)

- a) Fresh weight of shoot
- b) Dry weight of shoot
- c) Nos. of branches per plant
- d) Nos. of leaves per plant
- e) Plant height

Fig. 1. Agronomic data of *Eucalyptus camaldulensis* after eight weeks of growth in saline-sodic soil fertilized with 100 and 200kg K_2O as KCl.

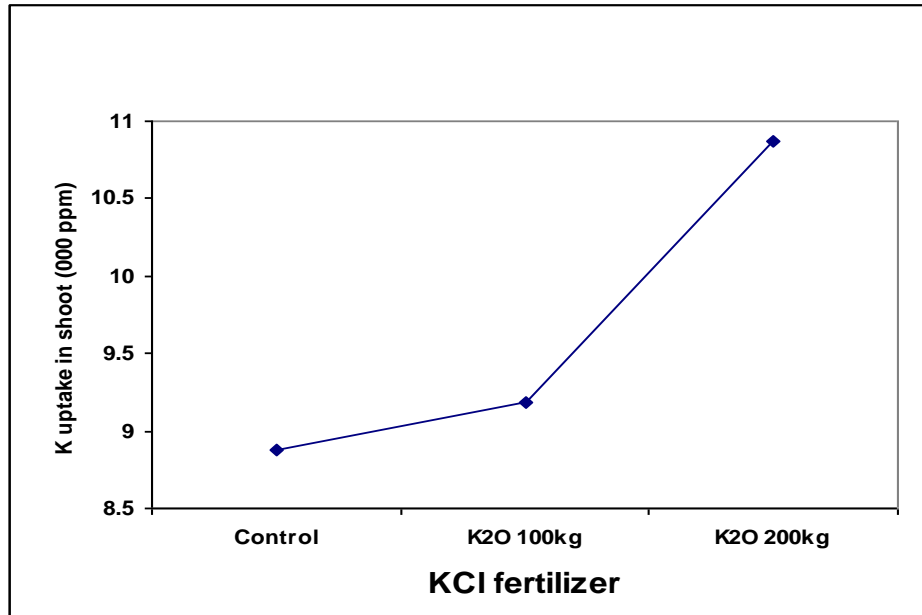


Fig. 2. Potassium uptake in *Eucalyptus camaldulensis* after eight weeks of growth in saline-sodic soil fertilized with 100 and 200kg K₂O as KCl.

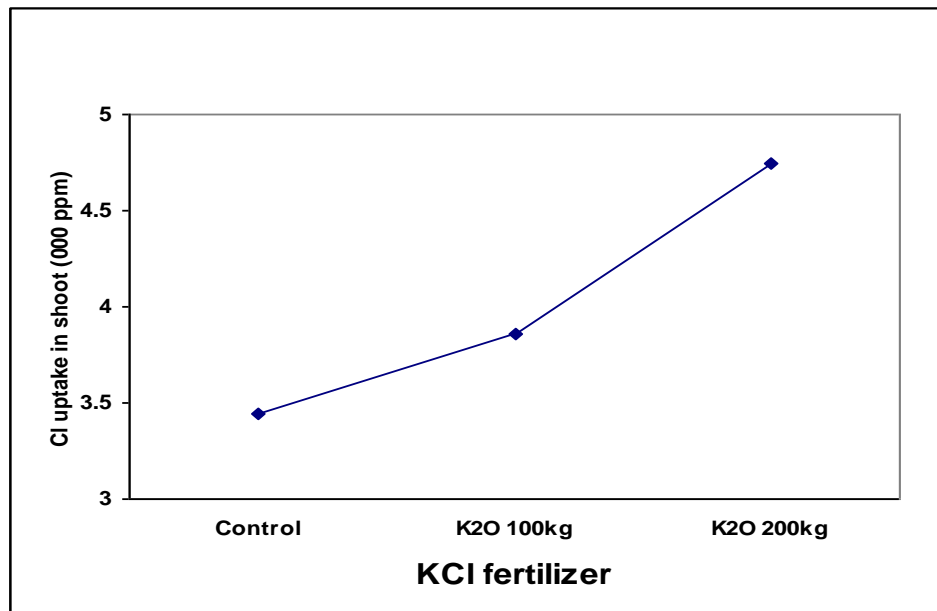


Fig. 3. Chloride uptake in *Eucalyptus camaldulensis* after eight weeks of growth in saline-sodic soil fertilized with 100 and 200kg K₂O as KCl.

Potassium and chloride uptake in Eucalyptus

Potassium controls plant functions including photosynthesis, respiration, assimilate translocation and many enzymatic systems which results in great influences on growth and quality of plant and fruit. The effect of K can also be indirect as a result of its positive interaction with different plant nutrients and production practices (Stewart *et al.*, 2005, Wang *et al.*, 2013). The present study showed positive effect of K addition in shoot content of Eucalyptus. Potassium uptake in shoot increased gradually in both the treatments, however, it was maximum in the treatment applied @ 200 kg (18%) followed by 100 kg (3%) of K₂O ha⁻¹ as compared to control (Fig. 2). Potassium dynamics in the leaves were consistent in all the plots where K fertilizer was applied (Laclau *et al.*, 2008). The increase in K content in plant could be due to luxury consumption (Qureshi *et al.*, 2007). Potassium concentration and its uptake were increased significantly with its increasing application rates (Chahabra, 1985). Chloride

concentration varies widely between plant species and cultivars. Chlorides of plants generally accumulate in vegetative parts, mainly in the leaves. Generally, woody plant is susceptible to Cl toxicity. The present investigation showed chloride concentration in shoot were increased with the increasing levels of KCl application i.e. more uptake was observed at 200 Kg followed by 100 Kg of K₂O as compared to control and its concentration in Eucalyptus enhanced by 27% and 11.7% respectively. (Figure3). Yang and Blanchar, (1993) observed KCl increased the Cl concentration in soybean plant. Christensen *et al.*, (1981) reported increase in Cl content of plant when applied 355 kg Cl ha⁻¹ of soil. The chloride content of grain, fruit and seeds were very low and hardly affected by the Cl concentration of the soil solution and its concentration in sugar beet leaves increased from 9.8 to 54.1 g kg⁻¹ (Zhou and Zhang, 1992). Schumacher and Fixen, (1989) also described residual effect of Cl on wheat and corn crops.

Table1. Changes in soil characteristics with soil applied KCl

Soil properties	Treatments											
	Control				KCl @ 100 kg K ₂ O				KCl @ 200 kg K ₂ O			
	Min	Max	Av	SD	Min	Max	Av	SD	Min	Max	Av	SD
pHs	8.52	8.69	8.6	0.08	8.52	8.85	8.6	0.1	8.5	8.7	8.6	0.1
EC _e (dSm ⁻¹)	6.48	9.61	7.7	1.35	6.48	8.27	7.5	0.7	6.62	9.63	7.7	1.3
Na (meqL ⁻¹)	110	181	142.3	30.58	108	133	124.3	10.5	108	142	123.2	14
Avail. K (ppm)	165	176	170	4.65	168	184	178	6.6	177	201	181	11
Ca + Mg (meqL ⁻¹)	36	50	43.5	5.8	36	41	36.9	2.6	26.2	53	36.9	11
Cl (meqL ⁻¹)	18	26	21	3.56	30	52	48	10	41	56	52	6.3
SAR (cmol L ⁻¹) ^{1/2}	29.3	30.5	30.2	1.1	28.3	30.1	28.9	0.9	24.6	30.6	27.6	2.6

Post harvest changes in soil characteristics

Results indicated marked changes in soil physico-chemical properties with *Eucalyptus* plantation when K₂O applied @ 200 and 100 kg ha⁻¹. Sodium decreased from 142.3 meq L⁻¹(control) to 123.2 and 124.3 meq L⁻¹ in both the treatments respectively. Available K increased with the increase in rate of applied K₂O with having concentration 181 and 178 ppm (when K₂O applied @ 200 and 100 kg) as compared to 170 ppm (control). Chloride concentration showed similar trend like K and the Cl concentration was also increased with increase in K-fertilization and was 52, 48 as compared to 21 meq L⁻¹(control) respectively. The reduction in Ca⁺⁺ + Mg⁺⁺ content was same in both the treatments (36.9 meq L⁻¹) as compared to control (43.5 meq L⁻¹). However, the present study showed no marked changes in soil pH, EC_e and SAR with addition of K-fertilizer. Plantation of *Eucalyptus* is beneficial for soil because it absorbs more Na⁺ and other soluble toxic ions from soil which were retained in root and limited amount of those were transferred to leaves which is typical character of salt tolerant plants (Qureshi *et al.*, 2000). On the other hand increase in Ca+Mg in soil is also a good sign to suppress the Na⁺ ion toxicity as sulfates or chlorides of Ca⁺⁺ and Mg⁺⁺ react with Na⁺ to form chlorides/sulphates of Na and leach down, resulting in improvement of infiltration, porosity, aeration and structure of soil (Gadallah, 1996).

Conclusion

Most growth parameters like number of branches, leaves per plant, fresh and dry weight and ionic uptake (potassium and chloride) increased in *Eucalyptus camaldulensis* due to the application of potassium fertilizer (KCl). The KCl @ 200kg K₂O ha⁻¹ produced maximum biomass, K and Cl ion uptake in salt-affected wastelands. It was concluded that KCl (muriate of potash) could be used profitably for better growth of *Eucalyptus camaldulensis* as a source of potassium in salt-affected soils of Pakistan.

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(Accepted for publication March 2014)