EFFECT OF FOREST VEGETATION ON SALINITY, SODICITY AND INFILTRATION CAPACITY OF SOIL

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ABSTRACT

Effect of soil salinity and sodicity was investigated on the infiltration capacity of four soil types: normal, saline, sodic and saline-sodic. Bulk density, porosity, moisture holding capacity, and texture of soil samples were also determined in the laboratory. The results showed that the infiltration capacity was highest in normal soil (16.1 cm/hr) and lowest in sodic soil (0.17 cm/hr). The infiltration capacity of saline-sodic soil under different vegetations e.g. tree plantations, grass cover and bare soil differed significantly although other physical characteristics were not significantly different.

INTRODUCTION

Salinity, sodicity, waterlogging and a combination thereof have rendered about 40 million ha of productive agricultural land around the world into marginal land which is unsuitable for farming. The most serious soil degradation has occurred in south and southeast Asian countries e.g. Pakistan, India and Thailand.

In Pakistan alone, about 4.2 million ha or 25% of total irrigated farm area is saline and to some extent, saline-sodic. The salt affected areas are mostly in Punjab, Sind and in some parts of NWFP. About 2.1 million ha and 4.3 million ha area has water table depth of less than 1.5 m in pre-monsoon and post-monsoon seasons respectively and have poor drainage.

The main cause of salinity in the irrigated areas is capillary rise of salts in soil profile due to high water table. The rise of water table in the canal-irrigated areas is due to of seepage from the unlined irrigation channels. Sindhu and Qureshi (1986) are of the opinion that salinity and sodicity in the clayey soil are caused by carbonates and sulphates in irrigation water. A study conducted by Weigand (1966) suggests that salinity is due to differential infiltration of rainfall in the soil which causes differences in leaching in saline and non-saline areas.

There are two major means of controlling water logging and salinity in irrigated areas: mechanical and biological. The mechanical approach consists of sub-soil water drainage through tube wells and surface and sub-surface drains. Ground-water pumping has been widely practiced in Pakistan and recently, sub-surface drainage system is applied in Soil Conservation and Rehabilitation Projects (SCARPs). However, the methods and means adopted by SCARPs are laborious, sophisticated and expensive. Highly saline water is usually disposed of through the main drains into the rivers, evaporation basins or sea. There is of course, limit to the quantity of salts that can be disposed of by such methods. The mechanical methods are effective but are quite expensive.

Secondly amelioration of saline and sodic soils is carried out by biological means. In a number of studies conducted in different ecological zones of Pakistan, it was found that infiltration capacity of soil under forests is almost twice that of the soil under agriculture crops or pastures. These studies indicate that afforestation can help in improving the saline and water-logged soils through leaching of salts from the soil surface and rooting zone by increasing their infiltration capacity.

Afforestation has not yet been used extensively for the rehabilitation of salt affected areas as there are only a few tree species that are salt-tolerant to a significant extent. Besides, not much work has been done on selection of tree species that can tolerate salinity, sodicity and water logging. Therefore, a saline area was selected in Risalpur Military Farm in District Nowshera (NWFP) for testing of different indigenous and exotic tree species under a project of Australian Center for International Agricultural Research (ACIAR) funded by the Australian Government. The present study was undertaken in this area to find out the effect of forest vegetation on salinity, sodicity and infiltration capacity of soil and the role of afforestation on its improvement.

MATERIALS AND METHODS

The test site is situated near Risalpur and lies at 34°-04′ North latitude and 72°-01′ East longitude. The elevation of the site is about 350 m above mean sea level and it receives an average annual rainfall of 560 mm. An area of about 7 hectares has been fenced and testing of different salt- tolerant tree species is in progress in this area since 1986. The soil has been classified, on the basis of soil chemical analysis into normal, saline, sodic and saline-sodic soil. Normal and saline soils were planted with *Populus deltoides* and a test plantation of 35 tree species was started in sodic and saline-sodic soils in 1989.

The infiltration capacity of soil was determined in winter of 1991-92 at three points in each of the four soil types selected by systematic sampling. For this purpose, points were located on the soil map of the study area. At each point, infiltration was measured with the help of double-ring infiltrometer following the procedure used by Hanif and Shah (1989). Soil samples were also taken at each point to study bulk density, porosity, and moisture holding capacity at saturation point, and the texture of the soil. The procedure suggested by these authors for analyzing the soil samples for different physical characteristics was also adopted.

It may be mentioned here that the observation points for normal and saline soils had six years old poplar plantation while in the sodic and saline-sodic soils the observation points were located under both trees planted in and in open area.

To find out the effect of tree plantation on improving the infiltration capacity of soil, a study was conducted in November, 1992 on saline-sodic soil having: i) no vegetation ii) grass cover and iii) three year old plantation of different tree species. Infiltration rates were measured at three points at each site. Soil samples were also analysed for their physical characteristics.

RESULTS AND DISCUSSIONS

The data of infiltration rates is given in Table 1. The results showed that the infiltration capacity was maximum for normal soil (16.11 cm/hr) and minimum for sodic soil (0.17 cm/hr). The infiltration capacity of saline and saline-sodic soil was found to be 7.89 and 0.96 cm/hr. respectively.

Table 1. Mean Infiltration rates (cm/hr) of different soil types at Risalpur experimental area

Soil Types	R1	R2	R3	Mean	Standard Deviation
Normal	16.80	16.06	15.05	16.11	0.67
Saline	6.72	5.78	11.16	7.89	2.87
Sodic	0.06	0.29	0.17	0.17	0.12
Saline-sodic	0.26	0.06	2.56	0.96	1.39

Statistical analysis of the data showed that the infiltration capacities of normal and saline soils were significantly different. But the infiltration capacities of sodic and saline-sodic soils were not significantly different. Physical properties of soil are given below:

Table 2. Physical characteristics of different soil types

	Bulk density gm/cm^3	Porosity (%)	Moisture holding capacity at saturation (%)	Soil texture
Normal	1.44	46	91	Sandy-loam
Saline	1.53	42	93	Sandy-loam
Sodic	1.19	44	91	Silt-loam
Saline-sodic	1.38	48	95	Silt-loam

As seen from the Table 2, porosity, bulk density and water holding capacity of normal, saline, sodic and saline-sodic soils of study area were almost similar. However, the texture of normal and saline soil was sandy loam while that of sodic and saline-sodic soil was silt-loam.

Statistical analysis of the data on bulk density, soil porosity and moisture holding capacity at saturation showed that there was no significant difference in the the physical properties of the soil types tested in this study.

Infiltration is generally believed to be related to physical characteristics of soil. This study, however, showed that irrespective of the physical soil characteristics, the salinity and sodicity did affect the infiltration rates. Although normal and saline soils at the experimental area have the same soil texture (sandy-loam), porosity (46 and 42%), bulk density (1.44, 1.53 gm/cm^3) and both are under poplar plantation, still their infiltration rates were 16.11 and 7.98 cm/hr respectively. Infiltration rates of sodic and saline-sodic soils were much lower; 0.17 and 0.96 cm/hr respectively as compared those of normal and saline soils although their physical characteristics were the same as the latter (Table 2). These results indicate that infiltration rates of the salt affected soil is reduced primarily due to surface sealing by the dispersal of clay particles (Fig. 1).

The infiltration study of saline-sodic soil under different vegetation covers showed that on an average, the infiltration rates of bare soil, soil with grass cover and soil under the 3-year old *Eucalyptus, Acacia, Prosopis,* and *Casuarina* tree species plantation was 0.14, 0.69 and 1.76 cm/hr respectively (Fig. 2). The results indicate that the tree plantation has enhanced the infiltration by 12 times compared to bare soil, and the value in more than double compared to the soil under grass cover. The increase in infiltration capacity can help in reducing the salts concentration by leaching them down during rainy seasons or through irrigation water.

The role of forest vegetation in reducing the soil salinity and sodicity is possible through three processes: i) lowering down the water table through high evapo-transpiration, ii) leaching down the salts from the surface soil by enhancing the infiltration rate and iii) replacing the sodium ions with calcium ions precipitated as calcium sulphate or calcium bicarbonate on the soil surface through root activities.

The research conducted so far in the study area has also shown that after the tree plantation, the salt concentration in the surface soil is reduced while the salt concentration of ground water is increased (Anon, 1992). This is also indicative of leaching of salts through increase in infiltration capacity.

CONCLUSION

It can be concluded from the results of the above study that salinity and sodicity reduce the infiltration capacity of the soil to a great extent and that the tree plantations can be useful in increasing the infiltration capacity of soil and therefore, can be effective in reclamation of salt affected lands.

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Fig. 1 Infiltration Rates of Different Soil Types at Risalpur

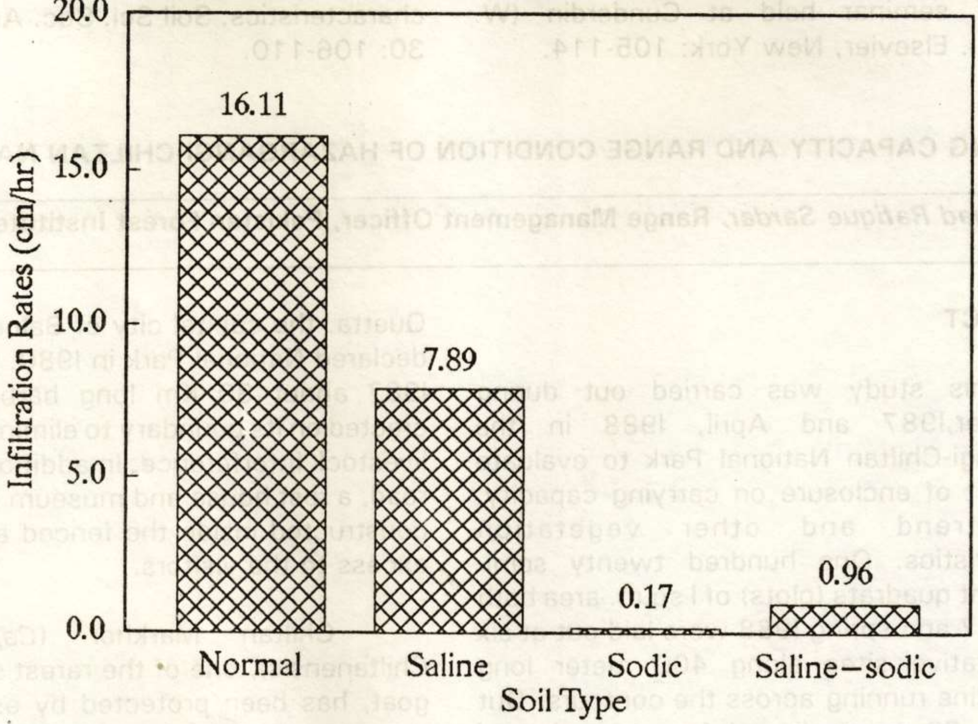
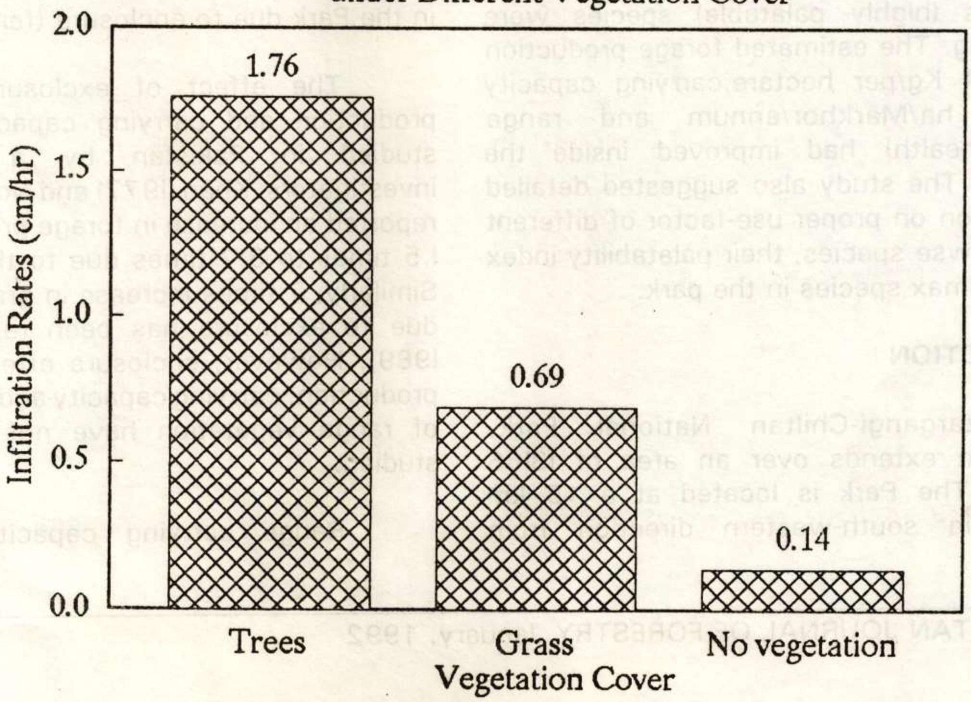


Fig 2. Infiltration of Saline-Sodic Soil under Different Vegetation Cover



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