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Soil Salinity Control through Halophytes in Arid and Semi Arid Area in Mauritania

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Abstract: Soil salinity is one of the most serious agricultural problems. Cultivated area is rapidly decreasing in Mauritania due to consecutive droughts and farmers' migration to the cities. Desertification affects over 80% of the country's lands due to climate change and human activities. The annual precipitation varies from less than 50 mm to more than 300 mm. Low air humidity combined with prevalent winds brings considerable loss of water due to evapotranspiration. Over grazing, improper traditional agricultural methods and deforestation devastate the land resources. Moreover, the soil salinity is considering the most serious problem face agricultural sustainability in Mauritania. In the arid and semi-arid regions of Mauritania, irrigated rice production, using quality water (0.10 – 0.25 dS m^{-1}), has led to rising groundwater levels and increases in soil water salinity (2.20 dS m^{-1}) in the root zone. However, improving soil saline requires two important considerations. First, the use of high efficiency irrigation systems and management options and the second is prevent or minimize the degradation of soil resources through applying bioremediation techniques. There are various kinds of halophytes acceptable to saline soil having specialized and distinguished environmental characteristics. These halophytes plants i.e. *Atriplex* and *Tamarix* extract salt from soil to reclaim the land and produce important bio-mass. This paper attempts to give an account of promising halophytes which can be grown in saline soil and their effectiveness in control of salinity. It also reports recommendations and further research needed for utilization of halophytes in combating salinity.

Key Words: Atriplex, Salt reclamation, Soil salinity

1. Introduction

Soil salinity is the major environmental stress and largely causes yield losses of crops worldwide. This problem is more acute in arid and semi-arid regions (Munns, 2002), where salinity strongly limits crop development. In the Senegal River, irrigation water is mixed to native neutral saline waters inherited from an ancient marine intrusion before the Diama dam constructed (Ceuppens *et al*., 1997). The Diama Dam, located 23 km upstream from the river's mouth, was completed in 1986 and its primary function is to prevent salt-water intrusion from the Atlantic Ocean. The Diama Dam is closed during the dry season from November to June, and is gradually opened during the rainy season, generally around July. Irrigation is usually gravity fed and the water application efficiency is very low. Under dry and hot climatic conditions, irrigation can lead to land salinization.

The main crop grown in Mauritania under irrigation is rice. The potential production of irrigated systems in the Mauritania is large, but actual farmers' yields are very low (less than 3T/ha). Farmers are increasingly abandoning rice fields in Mauritania irrigation schemes which are commonly attributed to salinity problems. Irrigation is often practiced without adequate drainage facilities. Salts may also be brought to the soil surface in the off-season through capillary rise if the water table is close to the soil surface. However, the needs for introduction of new irrigation systems and improvements in existing practices, at least in the intensive vegetable producing regions, have been identified (Ould Ahmed *et al*., 2006). Several workers (Ould Ahmed, *et al*., 2007; Fisher, 1980) have indicated that when land turned saline attention should be given for selection and use of appropriate irrigation systems and practices that will supply just sufficient quantity of water to the root-zone to meet the evaporative demand and minimize salt accumulation in the root-zone (Fisher, 1980; Munns, 2002). The second approach is to select crops/varieties that can tolerate salinity stress to a given degree (Claudivan *et al*., 2005). Therefore, selecting plants tolerant to salinity is an alternative strategy for a sustainable agriculture in these saline soil lands. Meanwhile, soil reclamation could be done using bioremediation method through planting halophyte plant which can absorb salt from soil and utilize these plants as fodder.

Atriplex halimus subsp. *schweinfurthii*, a widely distributed halophyte in the North Mauritania salt steppes, is of interest because of its tolerance to environmental stresses and its possibility to use as a fodder for livestock. The use of halophytic plants in pasture and fodder production on saline soils is the only economically feasible solution available (Khan

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and Duke, 2001). Therefore, this study was carried out to assess the salinity improvement using halophyte plant *Atriplex*.

2. Material and Method

The experiment was conducted at the field located at the Institute of Sciences and Technology (ISET) in Rosso, Mauritania. The soil in the study area is relatively uniform, with clay soil being the most predominant texture clay 45%, silt 40%, and sable 25%). The filed holding capacity is 0.33 cm^3 cm^{-3} and wilting point is 0.18 cm^3 cm^{-3}. The soil is very slow permeability approximately less than 6 mm/day.

Water quality of Senegal River is good and seems consistent. Very low mineral content (18 µS/m electrical conductivity), pH neutral, it has SAR of less than 1. All studies have classified as excellent and safe for irrigation (Boivin *et al*., 1998).

A randomized complete block design with two replications was used in this study and control without plant. The irrigation amount was based on evapotranspiration and leaching water was applied only during rainy season. The amount of water was applied every two weeks. The density of plant was two plants per square meter; each treatment plot was 5 m × 5 m. The shout of plant was harvested every two months and mixed with grass and then gave to livestock (Goats and caws).

The weather data was measured every hour using two meteorological stations at the ISET. The average daily reference evapotranspiration (ETo) was calculated with Penman-Monteith equation. Soil electrical conductivity was measured at depth 20 cm. The soil sample was taken from grid every 1 m. The ECe values were determined in a laboratory. For each sample, approximately 100 g of soil for ECe measurement was dried, and saturated with distilled water for 24 h. The electrical conductivity of saturated paste extract (ECe) was measured using a calibrated conductivity meter (model SypHony SP80PI).

3. Results and Discussion

Atriplex halimus subsp. *schweinfurthii* grows in a brine -contaminated site in southeastern Mauritania (near to Senegal River along 200 Km), where soil specific conductance varied from 8-40 dS m^{-1}. *Atriplex* is valued as livestock forage when herbage availability is low especially in arid environments and salt-affected area (Houerou *et al*., 1995) because they have high content of crude protein, vitamins (A, C and D) and minerals such as chromium (Shani *et al*., 1972; McKell C.M. 1989).

Potential evapotranspiration (ETo) and rainfall during 2009

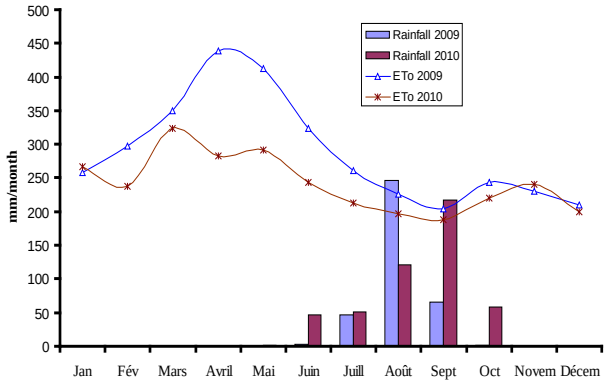

Fig.1 Rainfall and potential evapotranspiraton at the study area.

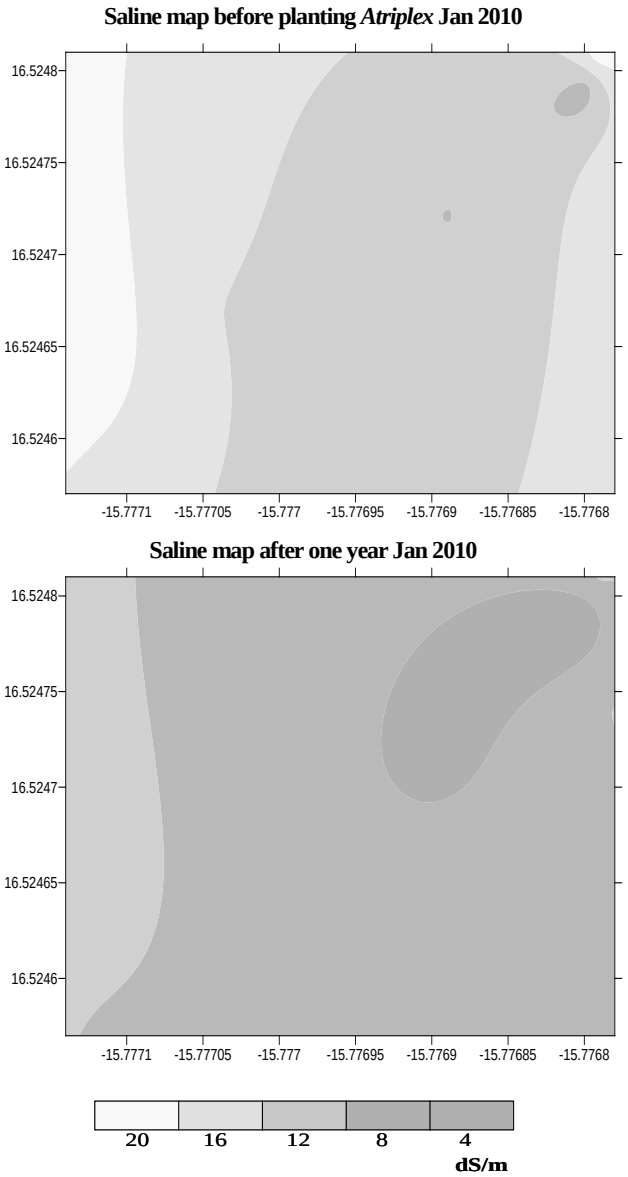

Fig. 2. Electrical conductivity (ECe) profile at *Atriplex* treatment during 2010 and 2011.

and 2010 are shown in **Figure 1** indicated that ETo was very higher compared to rainfall which may directly effect the soil salinization. The higher evaporation may lead to transfer salt

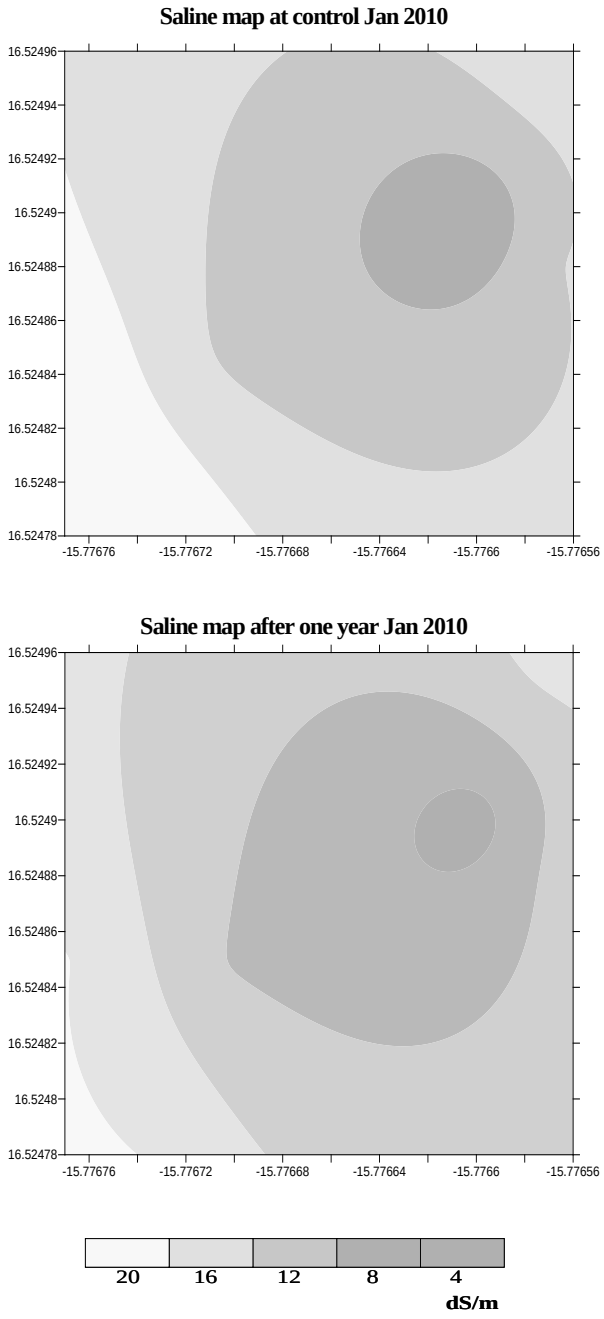

Fig. 3. Electrical conductivity (ECe) profile at control treatment during 2010 and 2011.

in the upper layer. The shallow groundwater approximately less than 3 m in the study area can be bring salt to upper soil layer through capillary phenomena.

To compare the salinity concentration in the soil profile after one year, the average ECe values were plotted in Surfer 8 (Golden Software, Inc.,) (**Fig. 2**).

The elctrical condactivity (ECe) in the soil profile show that salt decrease after one year through planting *Atriplex* and applying leaching during rainy season. Figure 2 shows that higher salt concentration that were present initially were dispresed. Howerever, salt concentartion at the control shows salt was less removed compare to *Atiplex* treatment (**Fig. 3**)

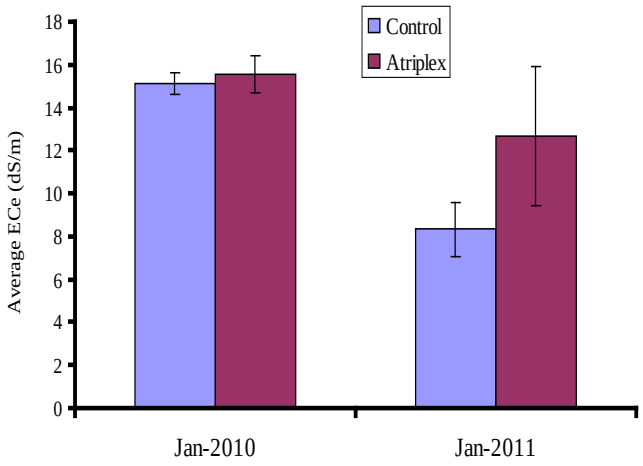

Fig. 4. Average of ECe in 2010 and 2011.

illistrated that with more *Atriplex* plant the amount of salt decrease.

Figure 4 shows the average ECe values during experiment period. Data analysis show significantly remove of salt at *Atrilplex* treatment (40%) compared to control (12%). However, the infiltration rate is generally less than 6 mm/day, due either to poor soil permeability and/or to the rising of the water table. This low infiltration rate may be dangerous for the soils, as it favors salt accumulation, and could eventually lead to soil salinization. More research on soil accumulation impact as results of evapotranspiration and water table change during growing *Atriplex* is needed to derive a better understanding of salt accumulation.

4. Conclusion and Recommendation

This study showed that *Atriplex halimus* subsp. *schweinfurthii* was a highly salt-tolerant species and can growth in very higher soil salinity, therefore, can be used for bioremediation to improve soil salinity. The soil salinity was improved 40% under *Atriplex* treatment during one year experiment. There was no attempt in this experiment to establish whether the *Atriplex* was negatively impacted by the soil salinity but salinity accumulation where improved.

This study suggested further studies:

- Relationship on salt reduction and *Atriplex* density.
- Study of salt reduction depth and leaching with growing *Atriplex*.
- Salt concentration in the shouts weight and dry mater relationship with soil salinity reduction.

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