*International Journal of Food, Agriculture and Veterinary Sciences ISSN: 2277-209X (Online)*
*An Open Access, Online International Journal Available at http://www.cibtech.org/jfav.htm*
*2017 Vol.7 (3) September-December, pp.85-89/Shekhawat and Kumar*
***Research Article***

# BIO-AMELIORATION OF SECONDARY SALINITY USING *SOME* AIZOACEAE HALOPHYTES

***V.P.S. Shekhawat[1] and A. Kumar[2]**

*Department of Botany, R.D. and S.H. National College and S.W.A. Science College, Affiliated to University of Mumbai, Bandra (w), Mumbai India -400050,*
*[2]Department of Botany, University of Rajasthan, Jaipur, India*
**Author for Correspondence: vijendradoc@yahoo.com*

## ABSTRACT

The feasibility of three halophyte plant species *Trianthema triquetra*, *Trianthema portulacastrum* and *Sesuvium sesuviodes* of Aizoaceae were tested for their applicability for bio-reclamation of a secondary salinized soil. Biomass production, Shoot ion content and shoot water content was determined for these plant species. *Trianthema triquetra*, accumulated maximum amount of sodium in the aerial shoot on dry weight basis. Comparatively smaller concentrations were recorded for *Sesuvium sesuvides* and *Trianthema portulacastrum*. On the basis of plant analysis *Trianthema triquetra* was selected for a field experiment for testing the effect of growing this plant on soil salinity. Effects of plantation of this species on soil pH, soil electric conductivity (EC), exchangeable Calcium ($Ca^{2+}$) and exchangeable sodium ($Na^{+}$) was studied. Comparatively higher reduction in soil EC at 5-10 cm depth level was recorded in *Trianthema* grown plots as compared to fallow control plots. Soil pH was also modulated by this plantation treatment. Soil calcium content was also affected by *Trianthema* plantation. Based on the present results we propose the use of these plants as 'primer plants' for the reclamation of salt contaminated soils. Besides biomass production, these three plant species may enhance the process of reclamation of problematic soils.

***Keywords:*** *Soil Salinity, Bio-reclamation, Halophytes, Trianthema sps., Sesuvium sps.*

## INTRODUCTION

Secondary salinization due to saline water irrigation is a common problem in semi-arid and arid parts of world like Rajasthan (India). Prolonged irrigation with saline water causes strong accumulation of salts in the root zone as pure water is passed to the atmosphere through evaporation whereas the salts are left behind and substantial addition of salts in the form of irrigation water give rise to secondary salinity. A case study at our laboratory indicated that only in one crop season of wheat, the quantity of Sodium added to the soil through saline water was as high as 0.576 Mg. ha even when the irrigation water used was only moderately saline. Due to scarcity of water, the leaching and drainage on such contaminated lands is not possible in the area and hence the only preferred method for remediation of this problem is fallowing in which the land is left unsown for one or two year so that the accumulated salt can be washed away by the monsoon rain. However, the rainfall received is very low and generally the onset of monsoon is delayed and besides this there are extended periods of drought in between the season. Therefore a method is urgently required to facilitate effective removal of salts in such low rainfall conditions (Shekhawat *et al.*, 2006).

Plantation of various plant species those can withstands various root zone constrains like salinity has been suggested for reclamation of salt affected lands (Qadir *et al.*, 2006; Shekhawat *et al.*, 2006). Plants used for preparing soil conditions for the benefit of following crop are referred as 'primer plants' (Yunusa and Newton, 2003). The halophytes have been suggested as primer plants for the bio-reclamation of salt affected lands (Chaudhri *et al.*, 1964, Zhao 1991, Qadir *et al.*, 1996). Salt accumulating halophytes can be used to remove excess Sodium and other salts from salt affected soils. Several halophytes including *Suaeda fructicosa* (Chaudhri *et al.*, 1964), *Juncus acutus* and *Juncus rigidus* (Zahran *et al.*, 1982), *Suaeda salsa* (Zhao, 1991), *Mesembryanthemum barklyi* (deVilliers *et al.*, 1995), *Leptochloa fusca* (Qadir *et al.*, 1996), *Echinochloa stagninum* (Helalia *et al.,* 1992) have been suggested for their use in bioremediation of salt affected soils. Besides being useful for bioremediation of salt affected soils, the enormous economic importance of halophytes has been extensively reviewed (Aronson, 1985).

Not many halophyte plant species have been investigated for their Sodium accumulation efficacy and the present investigation was carried out with a primary aim to explore the potential of three Aizoaceae plant species namely *Trienthema triquetra, Trianthema portulacastrum* and *Sesuvium sesuviodes* in bioremediation of secondary salinized soils. In order to examine the feasibility of these plant species in bio-reclamation, the biomass production, shoot water content and ion composition of these Aizoaceae plant species was studied under salinity conditions. A field experiments was also conducted to study the effect of growing *Trianthema triquetra* on soil chemical characteristics.

## MATERIALS AND METHODS

*Plant species*: Following plant species were undertaken in the present investigation. Plants were identified according to Bhandari (1990) and specimens were deposited in Herbarium, Department of Botany, University of Rajasthan, Jaipur.

*Trianthema triquetra* Roeele ex. Willd. (Aizoaceae) is a succulent, prostrate, annual herbaceous plant species, which is generally short lived. This species commonly occurs in saline wastelands. Flowering and fruiting takes place during October- December.

*Trianthema portulacastrum* Linn. (Aizoaceae) is a common weed, mostly found in saline and normal soils. It is succulent, subglaborous, annual herb, stem procumbent or prostrate. Flowering and fruiting takes place during August – December.

*Sesuvium sesuviodes* (Fengl.) verde. (Aizoaceae) is a prostrate, succulent, annual or a short lived plant. It is normally found in saline areas. Flowering and fruiting takes place during October- December.

All these three plant species are widely distributed in Sambhar salt lake area and used as small ruminant forage for livestock.

*Plant cultivation*: Seeds of all the three plant species investigated were collected from Sambhar salt lake area (Rajasthan). The sowing was done by mixing the seeds at 2-3 cm depth in field plots of size 10 $m^2$ for three months.

*Bio-reclamation Experiment*: *Trianthema triquetra* was selected for bio-reclamation experiment on the basis of plant analysis. Sowing of seeds of *T. triquetra* was carried out as described above. Plants of *T. triquetra* were allowed to grow for 3 months. Soil samples from 5-10 cm depth level were collected at the time of sowing and plant harvesting. These soil samples were designated as initial and final soil samples respectively and values for various chemical characteristics of these soil samples were compared to study the effect of growing *T.triquetra*. Data was also compared with soil samples collected from fallow control plots to study the efficiency of fallowing and plantation treatments.

*Experimental Site*: Experiments were conducted at Pachkodia village (District-Jaipur). Geographical data for Pachkodia are latitude 26º 5'N: longitude 75º 28' E; altitude 427m. This area represents the soil and agro-climatic conditions of about two third part of Rajasthan .Chemical composition of irrigation water used at experimental site was of $C_4$-$S_4$ category having pH value of 8.04, EC 8750 $\mu S.cm^{-1}$ and SAR value of 39.3. The climate of this area is semi arid with an average rainfall of about 500 mm, more than 80% of which is received in the months of July and August. Temperature fluctuates widely during the year ranging as high as 45ºC in summer and 2-4ºC in winter. During the study period maximum temperature was in the range of 25º C- 43ºC. Maximum humidity during experimental period ranged from 52% to 100 % on some rainy days. Rainfall during the experimental period ranged between 0.5 mm to 55 mm.

*Soil analysis*: pH and E.C. were determined in 1:2.5 soil water extract where extracts were prepared without using vacuum or pressure. For cation exchange capacity, extracts were prepared using Barium Chloride as exchanger (Mehlich, 1942). Exchangeable sodium, exchangeable Potassium, exchangeable

Calcium and exchangeable Magnesium were determined using Atomic absorption spectrophotometry (Perkin Elmer model 2380). $Na^+$ and $K^+$ were determined by the mean of flame emission spectrophotometry and $Ca^{2+}$ and $Mg^{2+}$ were determined by atomic absorption. SAR value was calculated following Richards (1954).

*Plant analysis*: The total aerial shoot was cut at the soil line and then dried at 105 ºC till the weight became constant. Fresh weight and dry weight were determined. Subsequently, dried aerial shoot was ground in a coffee mill up to 1 mm size. 100 mg plant material was placed in porcelain crucibles and ashing was carried out for approximately 20 h at 550 ºC in a muffle furnace until the complete disappearance of organic matter. Ashes were then digested in 50% v/v Nitric acid and diluted with distilled water for analysis. Potassium and Sodium were determined using flame emission and $Mg^{2+}$ and $Ca^{2+}$ were determined using atomic absorption.

## RESULTS AND DISCUSSION

The rainfall has significant role to play in reclamation of salinized agricultural fields especially in arid and semi-arid areas like Rajasthan. Precipitations for longer duration and with sufficient intensity may flush the salts out of the upper soil layer. But the Sodium adsorbed at soil exchangeable complexes is not much affected by such leaching processes (Bauder and Brock, 1992). Furthermore, the salts leached to the deeper soil horizons during the rainfall, comes upward during the dry periods. The plants likes halophyte may help during low rainfalls in achieving high leaching fractions and consequently in reducing the soil salinity and sodicity. Besides this, effect of plant roots on soil exchangeable complex (Qadir and Oster, 2002) would also help to the rainfall in reducing the problems associated with sodium adsorbed at soil exchangeable complex.

Feasibility of three Aizoaceae plant species *Trianthema triquetra*, *Sesuvium sesuviodes* and *T. portulcastrum* for their utilization in bio-reclamation of salt affected lands was studied. The results indicated that all three species investigated here have got the potential to be utilized for bio-reclamation of saline soils. None of these plant species exhibited any toxicity symptoms. The maximum biomass was produced by *T. triquetra* both on fresh and dry weight basis, this was followed by *S. sesuviodes* and the least biomass was produced by *T. portulacastrum*. Biomass produced and ion accumulation pattern in these three halophytic plant species is depicted in table (1). Sodium ion content in all these species examined was significantly higher than $K^+$, $Mg^{2+}$ and $Ca^{2+}$. The maximum shoot Na+ concentration (82.87 $mg.g^{-1}$dry wt.) was recorded in *T. triquetra* which was followed by *S. sesuviodes* and *T. portulacastrum* whereas maximum $Ca^{2+}$ content was recorded in *S. sesuviodes.*

**Table 1: Biomass production, ion accumulation pattern and sodium removal efficiency of *T. triquetra*, *T. portulacastrum* and *S. sesuviodes***

| Plant species | Ion accumulation $mg.g^{-1}$.dry wt. | | | | Biomass Produced g.dry wt/plant | $Na^+$ accumulated g/ plant |
|---|---|---|---|---|---|---|
| | $K^+$ | $Na^+$ | $Mg^{2+}$ | $Ca^{2+}$ | | |
| *T. triquetra* | 5.67[a] | 82.87[a] | 8.40[a] | 8.94[a] | 109.00 | 9.032 |
| *T. portulacastrum* | 16.97[b] | 65.81[b] | 6.63[b] | 6.71[b] | 31.46 | 2.070 |
| *S. sesuviodes* | 10.35[c] | 62.56[c] | 8.11[a] | 10.32[c] | 84.35 | 5.276 |

*Values represent means. Values in the same column followed by same letter are not significantly different (P>0.05) according to SNK multiple comparison procedure.*

**Table 2: Effect of growing *T. triquetra* on some physical and chemical characters of secondary salinized soil**

| Soil samples | pH | E.C. $\mu S.cm^{-1}$ | K $mg.100\ g^{-1}$ | Na $mg.100\ g^{-1}$ | Mg $mg.100\ g^{-1}$ | Ca $mg.100\ g^{-1}$ | SAR |
|---|---|---|---|---|---|---|---|
| Initial | 8.88 | 4625.00 | $16.00^{a}$±0.35 | $299.70^{a}$ ±10..61 | $26.15^{a}$± 1.40 | $21.00^{a}$ ±2.12 | 14.86 |
| Final F * | 8.67 | 4200.00 | $5.00^{b}$ ± 0.71 | $261.50^{b}$ ±14.85 | $21.25^{b}$±3.18 | $32.75^{b}$±4.60 | 8.774 |
| Final T** | 8.10 | 3370.00 | $8.25^{c}$ ± 1.40 | $158.25^{c}$±12.02 | $14.75^{c}$±3.89 | $60.75^{c}$±3.18 | 4.725 |

*Values in same column with different letter (a, b, c) differ significantly (P< 0.05) according to SNK multiple comparison procedure.*
*Final F** - *Soil samples collected at the time of harvesting, these samples were collected from Control Fallow Plots*
*Final T** - *Soil samples collected at the time of harvesting, these samples were collected from T. triquetra grown field plots*

The variability in various parameters in different soil samples was recorded. Soil pH, Soil EC, Soil exchangeable $Na^{+}$, SAR were all markedly reduced in fallow control and *T. triquetra* grown field plots. This reduction in sodium content was more pronounced in *Trianthema* grown field plots as compared to control fallow plots.

Chemical composition of different soil samples collected before and after growing *T. triquetra* and also the chemical composition of soil sample collected from Control fallow plots has been given in table (2).

Rhizosphere activities like root respiration root exudates, increased microbial activity and organic matter added by vegetation may alter the soil solution movement, which may influence the soil pH (Qadir *et al.*, 2006). Release of acidic root exudates has been reported to decrease the soil pH (Dormaar, 1988). In the present investigation the decrement in soil pH was significantly higher as compared to Fallow control plots. Similar reduction in soil pH by growing *Leptochloa fusca* has been reported by Qadir *et al.*, (1996). Extrusion of $H^{+}$ ion from roots following ionic transport mechanisms which is a general phenomenon in plant roots under saline environment (Gorham *et al.*, 1985) may also contribute significantly to reduction in pH. $NH_4$ uptake by the plants may also reduce the soil pH significantly (Soon & Miller, 1977; Nye, 1981).

Helalia *et al.*, (1992) also reported reduction in soil relative electric conductivity (REC) of saline-sodic soil (mainly in above 45 cm depth) by growing *Echnochloa stagninum.* Similarly positive results for reduction in total soluble solids (TSS) by plantation of ion accumulating species *Juncus acutus* and *Juncus rigidus* have been provided by Zahran *et al.*, (1992). The improvement in soil permeability due to root action may also facilitate leaching, which in turn causes reduction in soil EC. A fraction of soluble salts may also be taken up by these plants. Reduction in soil sodium content at 20-30 cm depth level by growing *Suaeda salsa* plants has been reported by Zhao (1991). The soil physical and chemical properties can be influenced by the plant roots. The amelioration strategy using halophytes may also work through the plant root action that helps dissolve native soil Ca $CO_3$ to supply adequate levels of $Ca^{2+}$ without the application of an amendment. Amelioration of sodic soils involves increase in $Ca^{2+}$on the cation exchange sties at the expense of $Na^{+}$. The replaced $Na^{+}$ together with excess soluble salts if present is removed from the root zone through infiltrating water. In certain investigations the level of $Ca^{2+}$ in calcareous sodic soils grown with certain salt resistant plants was found to be sufficient to cause an effective $Na^{+}$-$Ca^{2+}$exchange at the cation exchange sites resulting in a marked decrease in soil sodicity levels (Qadir *et al.*, 1996). A significant increment in soil exchangeable $Ca^{2+}$ was also recorded in soil samples collected from *T. triquetra* grown field plots. Hence these results demonstrated that growing small halophytic ephemerals like *Trianthema* sps. or *Sesuvium* sps. species can be a better option as compared to only fallowing. Besides being facilitating reclamation process such plants can serve as good forage for livestock.

***Conclusions***

The efficiency of sodium removal in the three species tested was in decreasing order of *T. triquetra* > *S. sesuviodes* > *T. portulacastrum*. Efficiency of these plants in soil calcium concentration modulation needs closer examination. Though the present investigation revealed that all these species can be exploited to recoup the secondary salinized agricultural fields however standardization of duration required for proper bio- reclamation needs intensive experimentation.

**REFERENCES**

**Aronson J (1985)**. Economic halophytes-a global review. p.177-188. In: Wickens G E, JR Goodin J R, Field D V (Eds). *Economic Plants for Arid Lands*. Kew, UK: George Allen and Unwin.

**Bauder JW, Brock TA (1992)**. Crops species, amendment, and water quality effects on selected soil physical properties. *Soil Science Society America Journal* **56** 1292-98.

**Bhandari MM (1990).** *Flora of the Indian desert*. Jodhpur, India: M P S Repros.

**Chaudhri I, Shah BH, Naqvi NI, Mallik IA (1964)**. Investigation on the role of *Suaeda fructicosa* Forsk. in the revegetation of saline and alkali soil in West Pakistan. *Plant Soil* **21** 1-7.

**DeVilliers AJ, VanRooyen MW, Theron GK, Claassens AS (1995)**. Removal of sodium and chloride from a saline soil by *Mesembrayanthemum barklyi*. *Journal of Arid Environment* **29** 325-30.

**Dormaar JF (1988)**. Effect of plant roots on chemical and biochemical properties of surrounding discrete soil zones. *Canadian Journal of Soil Science* **68** 233-42.

**Gorham A, WynJones RG, McDonnel E (1985)**. Some mechanism of salt tolerance in crop plants. *Plant Soil* **89** 15-40.

**Helalia AM, El-Amir S, Abou–Zeid ST and Zaghloul KF. (1992)**. Bio-reclamation of saline sodic soil by Amshot grass in Northern Egypt. *Soil Tillage Research* **22** 109-16.

**Mehlich A (1942)**. Rapid estimation of base-exchange properties of soil. *Soil Science* **53** 8-14.

**Nye PH (1981).** Changes of pH across the rhizosphere induced by roots. *Plant Soil* **61** 7-26.

**Qadir M and Oster JD (2002)**. Vegetative bioremediation of calcareous sodic soils: history mechanisms and evaluation. *Irrigation Science* **21** 91-101.

**Qadir M, Oster JD, Schubert S and Murtaza G (2006)**. Vegetative bioremediation of sodic and saline-sodic soil for productivity enhancement and environment conservation. p.137-146. In: Öztürk M, Waisel Y, Khan M A, Görk G (Eds). *Biosaline Agriculture and Salinity Tolerance in Plants*. Switzerland: Birkhäuser Verlag.

**Qadir M, Qureshi RH and Ahmad N (1996)**. Reclamation of a saline-sodic soil by gypsum and *Leptochloa fusca*. *Geoderma* **74** 207-217.

**Richards LA (1954)**. *Diagnosis and improvement of saline and alkaline soils. Agriculture. USDA agriculture handbook 60.* Washington DC USA: U.S. Govt. Print Office.

**Shekhawat VPS, Kumar A and Neumann KH (2006)** Bio-reclamation of secondary salinized soils using halophytes. In: Biosaline Agriculture and Salinity Tolerance in Plants, edited by Öztürk M., Waisel Y., Khan M.A., Görk G. (Birkhäuser Basel, Switzerland).

**Soon YK, Miller MH (1977).** Changes in the rhizosphere due to $NH_4$ and $NO_3$ fertilization and phosphorus uptake by corn seedlings (*Zea mays* L.). *Soil Science Society America Journal* 41: 77-80.

**Yunusa IAM, Newton PJ 2003**. Plants for amelioration of subsoil constraints and hydrological control: the primer – plant concept. *Plant Soil* **257** 261-81.

**Zahran MA, Abdel W, Amal A. (1982)**. Halophytes and Human Welfare. p. 233-57. In: Sen D N, and Rajpurohit K S (Eds). *Contributions To The Ecology of Halophytes:Tasks for Vegetation Sciences*. Hague, London: Dr. W. Junk Publishers.

**Zhao KF (1991)**. Desalinization of saline soils by *Suaeda salsa*. *Plant Soil* **135** 303-5.