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Short Communication

Characteristics of coastal saline soils inhabiting halophytes and salt tolerant plants

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ABSTRACT

The present investigation has shown 8 plant species as dominant halophytes and salt tolerant that occurs in Bara tract salt affected region of Gujarat. Soil samples from the rhizosphere of different halophytes and salt tolerant plant species were collected for physico-chemical analysis. Almost all the soils were alkaline in reaction, because all the soils were of pH values above 8 with high EC values (0.55 to 82 dS/m), indicating prevalence of moderate to high salinity conditions in the root zone region of the selected plant species. The organic carbon content was low in rhizospheric soil of *Leucaena leucophala* and high in *Suadea nudiflora*. The water holding capacity of soils from the rhizosphere of different halophytes and salt tolerant plant species was observed to be high. The ionic content in the soils collected from the rhizosphere of various halophytes and salt tolerant plant species was very high. From the fertility status of the various rhizospheric soil samples, it was found that the highest value of available nitrogen was found in the rhizospheric soil sample of *Acacia nilotica* and the lowest value was found in the rhizospheric soil sample of *Suadea nudiflora.* The highest value of available P content of soil was found in the rhizospheric sample of *Prosopis cineraria.*

Key words: Halophytes, Salt tolerant plants, Rhizosphere soil, Coastal, *Suadea nudiflora*

Saline soils are prevalent in coastal and inland saline areas in the Gujarat. The salt affected soil in the state accounts for 2.22 Mha. The problem being dynamic in nature, keeps on changing. These degraded salt affected lands needs to delineated and ameliorated for the problem. Economic utilization of salt-affected Vertisols by using biosaline agriculture technique by growing halophytes and other commercially important plants as alternate for the traditional crop plants in salt-affected and coastal lands under saline irrigation develops practical solutions to problems associated with the salinity management aspects (Arora *et al*., 2013). The domestication of halophyte plants and other salt tolerant plant species has been proposed as a strategy to expand cultivation on salt affected degraded soils (Rao *et al*., 2013). The study was conducted to assess the saline soil and the halophyte plants inhabiting different localities. Rhizosphere bio-chemical activities improve the uptake of nutrients by plants and /or produce plant growth promoting compounds and regenerate the quality of soil.

The Study site

The Bara Tract covers three talukas *viz.* Vagra, Jambusar and Amod of Bharuch district and falls in the Agro-climatic region IV of Gujarat State. It lies between 21º40′ to 22º13′N latitude and 72º 32′ to 72º 55′ E longitude between the reduced level of 5-9 m above mean sea level in Gulf of Khambhat. The productivity of these soils even at low salinity is poor because of the typical physico-chemical characteristics. This area is bounded by the River Narmada in the south and the River Mahi in the north and forms a part of Mahi-Narmada Doab. The landscape is nearly flat with slope gradient of 1:2800-4500 or more. This region is also characterized by poor out fall and out flow conditions. Soils of this region are classified as Vertisols and associated soils and are generally very deep (150-200 cm), fine textured with clay content ranging from 45-68 per cent with montomorillonite as the dominant clay mineral.

Collection and preparation of soil sample

The rhizospheric (0-50 cm) soil samples from dominant halophyte and salt tolerant plant species were collected from the Bara Tract of Gujarat, representing coastal and inland salt affected lands. For each plant species, two rhizospheric soil samples were collected from different regions of the tract. The soil samples were stored in polythene

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bags so that they could be used for determining various physical and chemical parameters.

Soil reaction of the soil samples was determined in 1:2 soil: water ratio (w/v) with the help of glass electrode pH meter. Electrical conductivity was estimated in 1:2 soil:water suspension (w/v) with solubridge EC meter. Maximum WHC of the disturbed soil sample was determined using Keens-Razknwski box (Forster, 1995). Soil bulk density was determined by oven drying soil in cores. Soil moisture content was estimated gravimetrically. For available potassium content in soil, the soil was extracted by shaking the soil with 1*N* Ammonium acetate (pH 7.0) in soil solution ratio of 1:5. K and Na content of the soil were determined from the soil extract using the Flame photometer (Systronics Model 128) after calibration with suitable standards. The Ca and Mg content was determined through EDTA titration methods. The carbonate, bi-carbonate and chloride contents in soil samples were determined as per standard tritration methods. Soil organic carbon was estimated by rapid titration method (Walkley and Black, 1934). Available N was determined using alkaline permanganate as per the modified Kjeldahl distillation method proposed by Subbiah and Asija (1956). For determining available P content in soils, Olsens' method was used, where 0.5M $NaHCO_3$ (pH 8.5) was used as an extractant.

Soil properties

The soil samples collected from the rhizosphere soils of the different dominant halophyte and salt tolerant plant species from the Bara Tract region of Gujarat were analysed for different soil properties to ascertain the salinity levels and nutrient status. The results of the soil analysis are presented under each property as sub-heads.

It has been found that the pH values of the different soil samples from the rhizosphere of the halophytes and salt tolerant plants range from 8.33 to 9.50 (Table 1). All the soil samples were in the alkaline pH range. Highest pH value (9.50) has been obtained in the soil sample from the rhizosphere of *Leucaena leucophala*. Soil samples from the rhizosphere of *Suadea maritima, Acacia nilotica* and *Salvadora persica* also showed comparatively high pH values (i.e. 9.38, 9.40 and 8.84, respectively). Rao *et al*. (2001, 2009) also reported that being coastal region, soils are predominantly saline due to ingress of salty waters. The soils have high amounts of soluble salts (EC >4 dS/m) and the pH is seldom higher than 8.5. Soil electrical conductivity (EC) of soil samples showed wide variation as the EC values ranged from 0.55 dS/m to 82 dS/m (Table 1). Highest EC (82 dS/m) was found in the soil sample of *Leucaena leucophala,* while the lowest EC (0.55 dS/m) was found in the soil sample of *Cressa cretica.* Soil sample from the rhizosphere of *Atriplex nummularia, Suaeda nudiflora* and *Prosopis cineraria* also showed comparatively high EC (i.e. 15.5, 30.0 and 35.5 dS/m, respectively).

The organic carbon content of the different soil samples was found to be in the range of 0.13% to 0.74% (Table 1), with the highest organic carbon content of 0.48% in the rhizospheric soil of *Suaeda nudiflora.* Rhizosphere soil of the *Prosopis cineraria* and *Suaeda maritima* also contained comparatively high organic carbon content with average values of 0.41 and 0.38%, respectively. Soil organic carbon (SOC) is a soil property considered one of the most important indicators of soil quality; it has positive effects on soil physical properties and promotes water infiltration, storage and drainage (Magdoff and Weil, 2004; Kowaljow, 2007).

The water holding capacity (WHC) of the collected rhizospheric soil samples were found to be in the range of 39.51% to 64.97%, with the highest value WHC (64.97%) in the soil from the rhizosphere of *Cressa cretica.* Rhizospheric soil sample of *Atriplex nummularia* showed the lowest WHC (39.51%) (Table 1). The water holding

Table 1. Properties of rhizospheric soil of halophytes and salt tolerant plant species

Rhizosphere of plant species	pH	EC (dS/m)	OC (%)	WHC (%)	BD (Mg/m^3)	Moisture content (%)
Cressa cretica	8.43	0.55	0.24	64.97	1.20	3.88
Suadea maritima	9.38	3.66	0.38	58.55	1.21	8.69
Suadea nudiflora	8.35	30.00	0.48	61.79	1.25	20.33
Salvadora persica	8.84	9.41	0.37	54.10	1.27	11.84
Atriplex nummularia	8.65	15.50	0.31	39.51	1.30	9.76
Prosopis cineraria	8.33	35.50	0.41	57.22	1.21	12.89
Leucaena leucophala	9.50	82.00	0.18	58.72	1.13	16.14
Acacia nilotica	9.40	2.00	0.31	51.34	1.27	5.82

Note: the values are the average of the two samples for each plant spp.

capacity of soils from the rhizosphere of different halophytes and salt tolerant plant species was observed to be high. This might be due to more organic matter as well as high clay contents that contribute towards water absorption. High clay content in the coastal salt affected soils of Gujarat has been reported (Chinchmalatpure *et al*., 2011).

Bulk densities of different rhizospheric soil samples from halophytes and salt tolerant plant species did not showed much variation. It ranges from 1.13 Mg/m^3 to 1.30 Mg/m^3 (Table 1). The highest bulk density (1.30 Mg/m^3) was observed in the soil samples of *Atriplex nummularia* while soil sample of *Leucaena leucophala* showed the lowest bulk density (1.13 Mg/m^3).

There is a great variation in the moisture content of different soil samples. It was observed to vary between 3.88% and 20.33%. The highest moisture content (20.33%) was found in the rhizospheric soil of *Suadea nudiflora,* while the lowest soil moisture content (3.88%) was in the rhizospheric soil sample of *Cressa cretica* (Table 1). Soil samples from the other salt tolerant plants like *Prosopis cineraria* and *Leucaena leucophala* also have comparatively high moisture content (12.89% and 16.14%, respectively). From agricultural soils of the region, similar results were reported by Kumar *et al*. (2016).

Ionic composition of soils

Calcium content of the various soil samples from the rhizosphere of halophytes and salt tolerant plant species was found to be in the range of 3400 ppm and 7000 ppm (Table 2), in which the highest Ca (7000 ppm) was found in the soil sample from the rhizoshpere of *Salvadora persica* while in the soil sample from the rhizoshpere of *Sphaeranthus indicus* its content was observed to be lowest Ca (3400 ppm). Soil samples of *Cressa cretica* and *Capparis decidua* also show comparatively high Ca values (i.e. 6800 ppm and 5800 ppm, respectively).

Differences have been found in magnesium of the various soil samples (Table 2). It ranges from 420 ppm to 3060 ppm, in which the lowest value (420 ppm) was found in *Leucaena leucophala* and the highest value (3060 ppm) was found in soils under *Prosopis cineraria.* Soil sample from *Suadea nudiflora* showed comparatively high Mg content (2160 ppm).

It has been found that the potassium content of different soil samples from the rhizosphere of the various halophytes and salt tolerant plant species varies from 325 ppm to 4550 ppm. The highest value of potassium (4550 ppm) was found in the soil sample of *Prosopis cineraria* and the lowest value of 325 ppm was observed in the soil sample of *Leucaena leucophala.* Different soil samples from the different halophytic and salt tolerant plants showed the great level of variation in K content (Table 2).

The soil sample from the rhizoshpere of *Cressa cretica* contains the lowest Na (968.75 ppm) and the soil sample from the rhizoshpere of *Prosopis cineraria* contains the highest Na (16312.5 ppm) (Table 2). All the soil samples showed the Na content in the range of 968.75 ppm to 16312.5 ppm.

Carbonate content (CO_3^-) was found only in two soil samples of *Cressa cretica* and *Salvadora persica* and that was 2 meq/l. All other soil samples did not show CO_3^- content (Table 2).

All the soil samples contain HCO_3^- and it was found in the range of 6 meq/l to 23 meq/l (Table 2), in which the highest value (23 meq/l) was found in the rhizoshperic soil sample of *Suadea maritima* and the lowest value (6 meq/l) was found in the rhizospheric soil sample of *Prosopis cineraria.* Soil samples from the *Leucaena leucophala* and *Acacia*

Table 2. Ionic composition and nutrient status of rhizosphere soil of halophyte and salt tolerant plant species

Rhizosphere of plant species	Ca (ppm)	Mg (ppm)	K (ppm)	Na (ppm)	CO_3^- (meq/l)	HCO_3^- (meq/l)	Cl^- (meq/l)	Av N (mg/kg)	Av P (mg/kg)
Cressa cretica	6800	1020	425	968.7	2	14	25.25	78.40	1.68
Suadea maritime	4500	480	437.5	4537.5	A	23	57.25	53.20	2.21
Suadea nudiflora	4000	2160	1775	13875	A	10	575	50.40	2.17
Salvadora persica	7000	750	1025	5171.8	2	9.75	155.5	64.40	2.19
Atriplex nummularia	3800	840	675	8500	A	9	300	72.80	2.40
Prosopis cineraria	5300	3060	4550	16312.5	A	6	1930	89.60	2.67
Leucaena leucophala	4400	420	325	1580	A	16	35	61.60	1.41
Acacia nilotica	4400	720	450	1730	A	17	21	106.40	2.66

A-absent

nilotica also show comparatively high HCO_3^- (i.e. 16 meq/l and 17 meq/l, respectively).

Perusal of data from the Table 2, it is found that the Cl^- content of the different soil samples shows the variation from 21 meq/l to 1930 meq/l. The highest Cl^- (1930 meq/l) was found in the rhizospheric soil sample of *Prosopis cineraria* and the lowest Cl^- (21 meq/l) was found in the rhizoshperic soil of *Acacia nilotica* (Table 2). The rhizospheric soil sample of *Suadea nudiflora* also shows comparatively high Cl^- value (i.e. 575 meq/l).

The high amounts of Ca, Mg, K and Na was mainly due to salinity effect where the salt gets accumulated in the root zone. Most of the soils do not contain carbonate ions, while meager amounts of bicarbonate and chloride was present in all soils. It has been found that soil from the rhizosphere of *Salvadora persica* contains all the ions (i.e. Ca^{2+}, Mg^+, K^+, Na^+, CO_3^-, HCO_3^- and Cl^-) indicating high salt accumulation. This may also be attributed to the coastal site where ground waters were also saline. Chinchmalatpure *et al.* (2005) also showed that in coastal regions soils have high soluble salts of chloride and sulphate of sodium, calcium and magnesium. As long as excess soluble salts are present, these soils exhibit the properties of saline soils.

Soil nutrient status

Soil available nitrogen of the various rhizospheric soil samples from halophytes and salt tolerant plant species was found in the range of 50.40 mg/kg to 106.40 mg/kg (Table 2). The highest value of available nitrogen (106.40 mg/kg) was found in the rhizospheric soil sample of *Acacia nilotica* and the lowest value (50.40 mg/kg) was found in the rhizospheric soil sample of *Suaeda nudiflora.* Rhizospheric soil samples of *Prosopis cineraria* and *Cressa cretica* also showed the high values of available nitrogen (i.e. 89.60 mg/kg and 78.40 mg/kg, respectively) compared to others.

From the table, it has been found that the values of available phosphorous content of rhizospheric soils varied from 1.41 mg/kg to 2.67 mg/kg. Many samples show the similar values of the available phosphorous, but the highest value (2.67 mg/kg) was found in the rhizospheric soil sample of *Prosopis cineraria* and the lowest value (1.41 mg/kg) was found in the rhizospheric soil sample of *Leucaena leucophala* (Table 2).

REFERENCES

Arora, Sanjay, Bhuva, C., Solanki, R.B. and Rao, G.G. 2013. Halophytes for bio-saline agro-forestry and phyto-remediation of coastal saline lands. *Journal of Soil and Water Conservation* **12**(3): 252-259.

Chinchmalatpure, Anil R., Nayak, A.K. and Rao, G.G. 2011. Saline vertisols – characteristics, distribution and management. *Bulletin Indian Soc. Soil Sci.* **28**: 67-82.

Forster, J. C. 1995. Determination of the gravimetric water content and soil dry mass. In: *Methods in Applied Soil Microbiology and Biochemistry* (eds. Alef, K. and Nannipieri, P.), Academic Press, London, pp. 105.

Kowaljow, E. M. J. 2007. Soil restoration in semiarid Patagonia: Chemical and biological response to different compost quality. *Soil Biology and Biochemistry* **39**: 1580-1588.

Kumar, S., Das, A. and Chinchmalatpure, A. R. 2016. Soil properties and available sulphur variability under irrigated and rainfed cotton in Bara tract of Bharuch, Gujarat. *J. Soil and Water Conservation* **15**(4): 296-301.

Magdoff, F. and Weil, R. 2004. Soil Organic Matter Management Strategies. In: Magdoff F, Weil, R, editor. *Soil Organic Matter in Sustainable Agriculture*. Boca Raton, Fl: CRC Press LLC p. 59-84.

Rao, G.G., Arora, Sanjay, Nikam, V.R. and Sharma, D.K. 2015. Prospects and impact of cultivating salt tolerant varieties of cotton and wheat in coastal saline soils of Gujarat. *Indian J. Soil Conservation* **44**(3): 308-131.

Rao, G.G., Chinchmalatpure, A.R., Khandelwal, M.K., Arora, Sanjay and Singh, G. 2009. Management of salt affected black soils – impact of technological interventions. *J Soil Salinity and Water Qual*. **1**(1&2): 55–62.

Rao, G. G., Ravindra Babu, V., Abhay Nath and Rajkumar 2001. Salt tolerance in *Salvadora persica*: 2.Osmotic constituents and growth during immature phase. *Indian Journal of Plant Physiology* **6**: 131-135.

Subbiah, G.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soil. *Curr. Sci*. **25**: 258-260.

Walkley, A. and Black, I.A. 1934. An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci*. **37**:29-38.