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Correlations of *Atriplex amnicola* and Soil Properties

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ABSTRACT

A growing experimental plot of *Atriplex amnicola* was selected at the research area of University of Agriculture, Faisalabad. The *Atriplex amnicola* plants (240 number) growing at the spacing of 3 x 3 meter were available in an area of one acre. The soil of the experimental site was saline sodic, loamy clay {ECe = 8.09 - 39.93 dSm^{-1}, pH, = 8.05 - 8.95 & SAR = 11.23 - 30.22 (m mol $L^{-1})^{1/2}$}. For the present study, 12 approximately uniform plants in age, spread and height were selected. Two cuttings were obtained with an interval of two months. Plant height and crosswise diameters were recorded to calculate the canopy volume. Fresh and oven dried biomass was also determined. Soil profile was sampled up to the depth of 150 cm and representative soil samples were collected and analyzed for ECe, pH and SAR, Plant ash, Na, K and Cl contents in plant materials were determined in the laboratory. Mean ECe, of the soil was decreased in second cutting as compared to first one, thus indicating a decrease with plant growth. Mean soil pH, was found to be 8.6 or less at different depths at the time of first cutting which was raised to 8.8 after last cutting. Mean surface SAR was recorded, as 27.3 (in mol $L^{-1})^{1/2}$ at first cutting and 20.7 (m mol $L^{-1})^{1/2}$ at last cutting. Thus, there was a decrease in SAR at the last cutting. Correlation between soil ECe and volume/fresh yield of *Atriplex amnicola* was positive and generally significant. However, all other correlations like between soil pH_s and plant parameters, SAR and plant parameters and chemical composition (Na: K & Cl content) and plant parameters were found to be non-significant.

Key Words: Correlations; Soil properties

INTRODUCTION

A major constraint for plant growth in arid, semi-arid and seasonal dry coastal areas is of salinity, which imposes a stress on crop growth that results in decreased yield and complete crop failure in extreme cases. This problem is further intensified when marginal land is brought under cultivation by artificial irrigation. It has been estimated that out of 79.61 million hectares of the geographical area of Pakistan, about 6.68 million hectares are salt-affected (Khan, 1998) and crop production is significantly reduced on these soils. The economic importance of salinity is strongly substantiated by the dangerous trend of 10% per year increase of salinized areas all over the world, which is substantial loss of arable land (Ponnamperuma, 1984). One third of the irrigated land in the world is believed to be affected by salinity (Mass & Hoofman, 1977). Of the current 230 ha of irrigated land; 45 in are salt-affected soils (19.5%) and of the almost 1500 in ha of dry land agriculture, 32 ha are salt-affected soils (2.1%) to varying degrees by human-induced process (Oldman *et al*., 1991). It was also estimated that there was a net yearly addition of 0.98 to 2.47 tons salts per hectare, through various sources and each year 0.2 to 0.4% of total arable land was put out of cultivation because of salinity and waterlogging (Sandhu & Qureshi, 1986).

Saline agriculture approach involves the utilization of such lands through the cultivation of salt-tolerant crops, trees and shrubs at the prevailing status. Halophytes have been successfully grown on saline wastelands in many countries. Halophytes accumulate large amount of Na^+ and Cl^- in higher concentration for osmotic adjustment within their tissues to keep the water potential at desired level. *Atriplex* species have tremendous ability to grow in saline conditions by taking up salts from soil and accumulating in their different vegetative parts (Matoh *et al*., 1986). These species have great potential for improving saline rangelands because they are highly tolerant to drought and salinity and thus, have an excellent role to play in biological reclamation. The most promising species for local environment are *Atriplex amnicola*, *Atriplex lentiformis* and *Atriplex canescens* (Ahmad & Ismail, 1993). These shrubs can make a significant contribution to plant and animal productivity in regions considered too dry or too salty for conventional crops.

This study was carried out to see the effect of *Atriplex amnicola* on soil properties. The main objective of this study was to find ways to bring our wastelands under vegetation in order to uplift the living standard of poor farmers of our country.

MATERIALS AND METHODS

An experimental plot of *Atriplex amnicola* was selected at the research area of University of Agriculture, Faisalabad. *Atriplex amnicola* plants were growing at the spacing of 3 x 3 meter and 240 plants were available in an area of one acre. The soil of the experimental site was saline sodic, loamy clay {EC, = 8.09 - 39.93 dSm^{-1}, pH = 8.05 - 8.95 & SAR = 11.23 - 30.22 (m mol $L^{-1})^{12}$}. For the present study, 12 approximately uniform plants in age, spread and height, which were seven-month-old, were selected. Canal water was applied as and when required. Two cuttings were obtained with an interval of two months. Plant height and crosswise diameters were recorded, to calculate the canopy volume. Fresh and oven dry biomass was also determined. From the root vicinity of each of the selected plants, five soil samples up to the depths of 150 cm, at 30 cm interval, were collected before and after the completion of the experiment. These samples were air dried, ground, passed through 2 mm sieve and finally analyzed for ECe, pH, and SAR.

Canopy volume of *Atriplex.* Canopy volume of living plants was estimated by measuring plant height, diameter- I (D1) and diameter- 2 (D2) cross section wise with a measuring tape after four months for last cutting. The following formula was used to measure canopy volume.

C.V. = Dl x D2 x H

Where

C.V. Canopy volume

D1. Diameter of one side

D2. Diameter of other side

H. Height of the plant

Determination of soil EC, pH and SAR as well as plant analysis was achieved according to the methods described by U.S., Salinity Laboratory Staff (1954).

RESULTS AND DISCUSSION

Various results obtained regarding plant parameters and soil characteristics and their correlations are presented under different titles as under:

Plant canopy volume. Canopy volume of different plants of *Atriplex amnicola* has been indicated in Table I. The canopy volume of this plant in the first cutting ranged from 0.1 to 4.5 m^3 P^{-1} with a mean value of 1.4 m^3 P^{-1} and Standard Error (SE) ± 0.7. The range of values for last cutting was found to be 0.3 to 4.5 m^3 P^{-1}. It has been reported that differences in performance are found among the *Atriplex* spp. The promising one among the 29 species was *Atriplex lentiformis* exhibiting excellent forage production and substantial woody component in the studies of Ahmad and Ismail (1993).

Dry matter yield. The range of dry matter yield of first cutting was 0.03 - 2.57 kg $plant^{-1}$ with a mean value of 0.5 and SE + 0.3. The mean values for the last cutting were 0.2 with SE ± 0.2 (Table I). The range of dry matter yield in, this cutting was 0.04 - 0.85 kg $plant^{-1}$. Higher magnitude for the first cutting and lower in the last indicate poor regeneration within the cutting interval. Reihl and Ungar (1983) reported that dry production decreased to 50% on saline habitats. Branches, leaf number and leaf expansion reduced, which contributed towards, reduced dry weight (Khan & Ungar, 1986).

Electrical conductivity (ECe). The ECe of the soil at first and last cutting is given in Table II. These results indicate that mean ECe, at the time of first cutting was 11.1, 5.7, 4.2, 2.6 and 1.9 dSm^{-1} for all the depths, respectively. Thus, this parameter was decreasing from the surface to the lower

Table I. Plant canopy volume and dry matter yield of *Atriplex amnicola*

Plant No.	Canopy volume (m^3 P^{-1})	Dry matter yield (Kg P^{-1})	Canopy volume (m^3 P^{-1})	Dry matter yield (Kg P^{-1})
	First cutting		Last cutting	
P1	4.2	2.57	4.5	0.85
P2	2.1	0.59	1.9	0.47
P3	4.5	1.14	3.4	0.64
P4	0.2	0.07	0.4	0.13
P5	0.1	0.03	0.3	0.08
P6	0.7	0.19	1.0	0.37
P7	0.8	0.06	0.7	0.04
P8	0.3	0.11	0.4	0.09
P9	0.9	0.25	0.3	0.03
P10	1.7	0.45	2.5	0.08
P11	0.4	0.25	0.9	0.09
P12	0.6	0.4	0.3	0.04
Mean	1.4	0.5	1.4	0.2
SE	±0.7	±0.3	±0.7	±0.2

profile gradually. Up to 3rd depth, ECe, was above the limit of 4.0 dSm^{-1}, while in lower depths, it was below the level of 4.0 dSm^{-1} Comparison of ECe at the time of first and last cutting indicated that ECe, decreased from the first depth, while at lower depths, there was very little or low difference. The SE values of ± 6.8, ± 1.8, ± 1.2, ± 0.7 and ± 0.4 for the depths first to fifth at first cutting indicated greater variations from the mean for the surface soil and a little in lower profile. Similar was the trend in the last cutting. The increase in surface ECe, may be due to leaf litter effect (Sharma & Tongway, 1973). In the study of Rashid *et al*. 1993 *Atriplex amnicola* performed better than *Atriplex lentiformis* with increasing salinity.

Soil pH. The data presented in Table III indicated that soil pH was 8.6, 8.6, 8.5, 8.5 and 8.5 at the depth of 1, 2, 3, 4 and 5, respectively when the fast cutting of *Atriplex amnicola* was obtained. At the time of last cutting, the values of this soil property increased to 8.8, 8.8, 8.6, 8.6 and 8.7 for the respective depths. Wider differences were not observed in the mean soil pH, of various depths. The cause for higher pH, at the last cutting may be due to accumulation of Na salt especially $NaHCO_3$ from the lower profile because the plants were not irrigated for a long time beings drought tolerant and the net movement of salts was up-ward.

Sodium adsorption ratio (SAR). Soil SAR decreased in the lower profile with the increasing depths in both cuttings (Table IV). The recorded values at the first cutting were 27.3, 13.9, 9.0, 8.2 and 7.9 (in mol $L^{-1})^{1/2}$ at depths 1, 2, 3, 4 and 5 respectively, whereas the respective values at the last cutting were 20.7, 11.3, 11.5, 9.9 and 9.8 (m mol 1; 1) 112. Thus, a decrement was observed up to 2nd depth but thereafter a slight increase was indicated. Deviations from the mean values were wider in surface soil as the SE for the first and last cutting were ± 20.3 and ± 8.3, respectively. A noticed decrease in the upper two depths may be due to more removal of Na salts by, the plants from these depths. Qureshi *et al*. (1993) also reported that various *Atriplex* spp. could establish on the soil having SAR from 54 to 151(m mol $L^{-1})^{1/2}$ and *Atriplex lentiformis* as well as *Atriplex amnicola* indicated better survival at three different sites.

Table II. Soil ECe (dSm^{-1}) measured at various depths of *Atriplex amnicola*

Plant No.	Depth (cm)									
	0-30	30-60	60-90	90-120	120-150	0-30	30-60	60-90	90-120	120-150
	First cutting					Last cutting				
P1	31.3	10.0	8.0	4.3	2.2	23.0	8.1	6.3	6.6	4.8
P2	44.5	11.6	7.0	4.9	3.2	28.0	12.1	6.0	3.7	2.2
P3	18.3	10.3	4.0	3.0	1.5	16.4	12.0	8.1	6.5	1.9
P4	2.2	6.3	4.5	1.5	1.0	4.2	4.6	4.0	1.7	1.2
P5	5.3	6.6	6.9	3.9	2.2	5.6	5.8	5.1	3.0	1.5
P6	17.0	5.1	5.9	4.4	2.5	10.1	7.4	6.4	4.5	2.5
P7	2.9	1.1	1.4	1.3	1.0	0.6	0.8	0.5	1.1	0.5
P8	1.2	1.5	1.9	1.4	0.9	0.8	0.5	0.5	0.5	1.0
P9	2.5	2.2	2.1	2.2	3.4	1.1	0.6	0.6	0.8	0.7
P10	1.4	1.6	0.8	1.3	1.6	10.2	5.7	3.5	1.8	0.9
P11	4.2	4.2	2.6	1.2	1.0	7.0	5.5	2.1	2.0	1.3
P12	2.1	8.0	5.0	1.7	1.8	6.4	5.3	2.9	2.0	2.5
Mean	11.1	5.7	4.2	2.6	1.9	9.5	5.7	3.8	2.9	1.8
SE	±6.8	±1.8	±1.2	±0.8	±0.4	±4.3	±1.9	±1.3	±1.0	±0.6

Table III. Soil pH measured at various depths of *Atriplex amnicola*

Plant No.	Depth (cm)									
	0-30	30-60	60-90	90-120	120-150	0-30	30-60	60-90	90-120	120-150
	First cutting					Last cutting				
P1	8.7	8.6	8.5	8.4	8.5	8.9	8.8	8.9	8.5	8.5
P2	8.6	8.4	8.5	8.6	8.5	8.8	8.9	8.7	8.8	8.6
P3	8.6	8.7	8.4	8.6	8.6	8.7	8.7	8.6	8.5	8.6
P4	8.9	8.5	8.4	8.5	8.6	9.2	9.0	8.6	8.7	8.8
P5	8.5	8.7	8.3	8.3	8.4	8.4	8.8	8.4	8.4	8.6
P6	8.5	8.5	8.3	8.4	8.5	8.6	8.8	8.3	8.4	8.6
P7	8.3	8.1	8.3	8.2	8.4	8.4	8.3	8.4	8.4	8.5
P8	8.0	8.3	8.3	8.4	8.5	8.5	8.6	8.1	8.5	8.4
P9	8.2	8.3	8.3	8.5	8.3	8.3	8.3	8.7	8.4	8.6
P10	8.9	9.0	8.6	8.6	8.6	9.0	8.7	8.7	8.7	8.9
P11	9.0	9.0	9.0	9.0	8.9	9.3	9.0	8.7	8.9	8.7
P12	9.0	9.1	8.8	8.9	8.7	9.4	9.4	9.2	8.4	9.0
Mean	8.6	8.6	8.5	8.5	8.5	8.8	8.8	8.6	8.6	8.7
SE	±0.2	±0.2	±0.1	±0.1	±0.1	±0.2	±0.1	±0.1	±0.1	±0.1

Table IV. Soil SAR measured at various depths of *Atriplex amnicola*

Plant No.	Depth (cm)									
	0-30	30-60	60-90	90-120	120-150	0-30	30-60	60-90	90-120	120-150
	First cutting					Last cutting				
P1	13.8	1.2	9.0	6.4	11.7	39.7	24.0	12.7	12.9	9.6
P2	135.6	27.5	8.2	11.8	5.6	38.5	19.0	11.4	13.2	9.2
P3	95.4	13.9	14.9	7.7	11.6	4.6	15.4	15.3	7.8	7.7
P4	8.9	7.0	5.4	8.1	6.4	14.6	9.2	12.6	6.7	8.8
P5	9.6	8.9	8.1	5.8	6.2	43.7	12.3	15.1	6.9	11.4
P6	4.7	16.0	8.0	10.7	10.1	17.7	5.7	11.5	14.0	8.5
P7	7.9	4.0	5.0	3.9	4.7	2.2	4.9	2.1	5.1	1.7
P8	4.2	19.1	11.8	5.6	3.4	4.0	1.9	2.9	1.8	4.4
P9	7.0	14.2	9.0	8.1	4.1	4.4	3.1	5.0	7.1	8.1
P10	21.5	11.8	6.5	9.3	7.3	49.8	12.6	13.2	10.1	4.2
P11	10.0	32.1	14.3	15.8	9.2	11.7	12.8	15.1	6.7	9.8
P12	8.8	11.4	7.7	2.7	10.1	17.2	14.3	21.4	27.0	33.7
Mean	27.3	13.9	9.0	8.2	7.5	20.7	11.3	11.5	9.9	9.8
SE	±20.3	±4.3	±1.5	±2.0	±1.4	±8.3	±3.2	±2.7	±3.1	±3.8

Correlation between ECe and various plant parameters of *Atriplex amnicola*. Correlation between ECe, of different soil depths and volume canopy of *Atriplex amnicola* is given in Table V. This correlation was positive for ECe of all the soil depths and both cuttings of *Atriplex amnicola*. All the correlation of this species in last cutting was found to be significant whereas in case of first cutting only first two depths remained significant with respect to plant volume of Atriplex amnicola. This correlation was found to be positive because the mean surface ECe was 13.5 dSm^{-1} at first cutting and 8.5 dSm^{-1} at the last cutting. All the values for lower soil depths were well below the critical limit of 4.0 dSm^{-1}. Even surface ECe, was not too high for growing of *Atriplex* spp. as Qureshi *et al*. (1993) obtained good establishment of different spp. at ECe, of 26.65 dSm^{-1}. The ECe of experimental site caused no harm to plants and its correlation with plant canopy volume was computed as positive.

Table V. Correlation between electrical conductivity (ECe) and various plant parameters of *Atriplex amnicola*

Depth (cm)	First Cutting	Last Cutting
	Canopy Volume	
0-30	+ 0.631*	+0.748**
30-60	+0.592*	+0.615*
60-90	+0.308 NS	+0.611*
90-120	+0.435 NS	+0.798**
120-150	+0.180 NS	+0.623*
	Fresh Biomass Yield	
0-30	+0.606*	+0.862**
30-60	+0.582*	+0.766**
60-90	+0.470 NS	+0.780**
90-120	+0.455 NS	+0.922**
120-150	+0.178 NS	+0.753**
	Dry Matter Yield	
0-30	+0.598*	+0.758**
30-60	+0.571 NS	+0.703*
60-90	+0.480 NS	+0.722**
90-120	+0.447 NS	+0.885**
120-150	+0.180 NS	+0.860**

A positive and significant correlation was found between fresh biomass of *Atriplex amnicola* and ECe, of upper two soil depths of first cutting and all the soil depths after last cutting (Table V). However, ECe of third, fourth and fifth depth recorded after first cutting was assessed to be non-significant. Thus, in general, soil ECe, did not affect negatively the fresh biomass of *Atriplex* within the observed values. Greenway (1968) also did not obtain any negative effect up to salts equivalent 200 mol m^{-1}. Zid and Boukhris (1977) found no loss in germination of *Atriplex halimus* with NaCl up to 10 g L^{-1}.

Almost similar correlation was found between ECe and dry matter yield as in case of fresh biomass yield (Table V). So, dry matter yield increased with increase in ECe in the mean observed range. Rashid *et al*. (1993) had found that the yield of most of the *Atriplex* spp. decreased by 50% at ECe, of 30 dSm^{-1}. However, in present study, ECe, of lower soil depths was much lower than this value and the plant roots were able to penetrate to lower depths for water absorption, thus the effects were positive.

Correlation between pH and various plant parameters of *Atriplex amnicola*. The correlation between soil pH and plant volume was evaluated as non-significant for both the cuttings at all the soil depths (Table VI). Volume of *Atriplex amnicola* was positively correlated with soil pH at first, third and fifth depths in case of first cutting and third and fourth depths in case of last cutting. Other correlations were found to be negative. All the correlations between pH and fresh biomass yield were non-significant except lowest depth (120 - 150 cm) at last cutting, which was found to be significant (Table VI). Hence, pH of various soil depths did not significantly affect the fresh biomass of *Atriplex amnicola*. Similarly, when considered the correlation between pH and dry matter yield of *Atriplex amnicola*, behaviour of *Atriplex amnicola* at last cutting was identical with the fresh biomass. 'However, some change was found at the last cutting. It may be very clearly concluded that pH within the mean range of 8.4 to 8.8 did not affect the dry matter yield of *Atriplex amnicola*. In most of the cases it was rather helpful.

Correlation between SAR and various plant parameters of *Atriplex amnicola.* The only significant correlations between volume of *Atriplex amnicola* and SAR of fifth depth (120 - 150 cm) of first cutting and second depth (30 - 60 cm) of last cutting were recorded (Table VII). All other correlations were assessed as non significant. The positive correlations were first, third and fifth depths at first cutting and the upper two depths in last cutting. Only two correlations between fresh biomass yield and SAR were found to be significant. One was with SAR of fifth depth of first cutting and other was second depth of last cutting. All the other correlations were non-significant. Exactly-similar correlation between dry matter yield and SAR of different soil depths was observed at both the cuttings, as already been reported under fresh biomass yield. Two correlations second and fourth depth at first cutting were negative and all others were positive. Mean SAR of 13.9 (mmol $L^{-1})^{1/2}$ at second depth and 8.2 (mmol $L^{-1})^{1/2}$ at fourth depth affected the dry matter yield negatively.

Table VI. Correlation between p_{Hs} and various plant parameters of *Atriplex amnicola*

Depth (cm)	First Cutting	Last Cutting
	Canopy Volume	
0-30	+ 0.099 NS	-0.032 NS
30-60	-0.007 NS	-0.203 NS
60-90	+0.003 NS	+0.150 NS
90-120	-0.112 NS	+0.069 NS
120-150	+0.069 NS	-0.347 NS
	Fresh Biomass Yield	
0-30	+0.204 NS	-0.141 NS
30-60	+0.069 NS	-0.110 NS
60-90	+0.117 NS	+0.078 NS
90-120	-0.048 NS	-0.033 NS
120-150	+0.081 NS	-0.637 NS
	Dry Matter Yield	
0-30	+0.203 NS	+0.062 NS
30-60	+0.063 NS	+0.181 NS
60-90	+0.135 NS	+0.337 NS
90-120	-0.040 NS	-0.201 NS
120-150	+0.077 NS	-0.379 NS

Table VII. Correlation between (Sodium Adsorption Ratio) SAR and various plant parameters of *Atriplex amnicola*

Depth (cm)	First Cutting	Last Cutting
	Canopy Volume	
0-30	+0.528 NS	+0.311 NS
30-60	-0.202 NS	+0.724**
60-90	+0.345 NS	-0.012 NS
90-120	-0.049 NS	- 0.057 NS
120-150	+0.590*	-0.352 NS
	Fresh Biomass Yield	
0-30	+0.264 NS	+ 0.138 NS
30-60	-0.312 NS	+0.717**
60-90	+0.237 NS	-0.044 NS
90-120	-0.073 NS	+0.019 NS
120-150	+0.641*	-0.237 NS
	Dry Matter Yield	
0-30	+0.232 NS	+0.045 NS
30-60	+0.314 NS	+0.725**
60-90	+0.225 NS	+0.249 NS
90-120	-0.075 NS	+0.388 NS
120-150	+0.626*	+0.156 NS

Where, + = Positive Correlation, - = Negative Correlation, ** = Highly Significant, * = Significant, NS = Non-Significant

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