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EFFECT OF *ATRIPLEX LENTIFORMIS* ON SOIL PROPERTIES AND VICE VERSA

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ABSTRACT

A growing experimental plot of *Atriplex lentiformis* was selected at the research area of University of Agriculture, Faisalabad. The *Atriplex lentiformis* plants (240 number) growing at the spacing of 3 x 3 meter were available in an area of one acre. 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. Mean ECe, of the soil was decreased in second cutting as compared to first one, thus indicating a decrease with plant growth. Mean soil pHs, 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 (m. 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 lentiformis* was positive and generally significant. However, all other correlations like between soil pHs and plant parameters, SAR and plant parameters.

Key-words: Soil profile, organic matter, *Atriplex* sp. , plant biomass, growth

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). 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 and Hoofman, 1977). Of the current 230 m. ha of irrigated land; 45 m.s ha are salt-affected soils (19.5%) and of the almost 1500 m. ha of dry land agriculture, 32 m. 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 and 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 and 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 lentiformis* 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 lentiformis* was selected at the research area of University of Agriculture, Faisalabad. *Atriplex lentiformis* plants were growing at the spacing of 3 x 3 meter and 240 plants were available in an area of one acre. 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 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, pHs, and SAR.

Canopy volume of *Atriplex lentiformis:* Canopy volume of living plants was estimated by measuring plant height, diameter-1 (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, pHs 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 growth parameters and soil characteristics and their correlations are presented under different titles as under:

Plant Canopy Volume: Canopy volume of different plants of *A. lentiformis* has been indicated in Table 1. The canopy volume of this plant in the first cutting ranged from 0.4 to 11.9 m^3 P^{-1} with a mean value of 4.0 m^3 P^{-1} and Standard Error (SE) ± 1.6. The range of values for last cutting was found to be 0.4 to 10.5 m^3 P^{-1}. with a mean value of 3.3 m^3 P^{-1} and standard error (SE) $\underline{+}$ 1.3 which was clearly lower than first cutting. 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 0.08 – 3.99 kg $plant^{-1}$ with a mean value of 1.1 and SE + 0.6. The mean values for the last cutting were 0.4 with SE ± 0.2 (Table 1). The range of dry matter yield in this cutting was 0.05 - 0.58 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 and furthermore, branches, leaf number and leaf expansion reduced which contributed towards reduced dry weight (Reihl and Ungar, 1983).

Electrical Conductivity (ECe): The ECe of the soil at first and last cutting is given in Table 2. These results indicate that mean ECe at the time of first cutting was 6.5, 4.1, 3.8, 3.2 and 2.0 dSm^{-1} for all the depths respectively. Thus, this parameter was decreasing from the surface to the lower profile gradually. Up to 2^{nd} depth (30-60cm), ECe was above the limit of 4.0 dSm^{-1} while in lower depths, it was below the level of 4.0 dSm^{-1}. The respective values for these depths at last cutting were 6.8, 3.9, 2.8, 2.3 and 2.0 dSm^{-1}. The SE values were more in surface ECe. There was a little increase in the ECe at surface, decrease in depths 2 (30-60cm), 3 (60-90cm) and 4 (90-120cm)with no change in the last depth (120-150cm). The increase in surface ECe may be due to leaf litter effect (Sharma and Tongway, 1973). In the study of Rashid et al., 1993 *A. amnicola* performed better than *A. lentiformis* with increasing salinity.

Soil pH: The data presented in Table 3 indicate that soil pHs was 8.4, 8.6, 8.6, 8.5 and 8.6 at the depth of 1,2,3,4 and 5 respectively when the first cutting of *A. lentiformis* was obtained (Table 3). At the time of last cutting, the values of this soil property increased to 8.7, 8.7, 8.7 and 8.8 for the respective depths. Wider differences were not observed in the mean soil pHs of various depths. The cause for higher pHs 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 being drought tolerant and the net movement of salts was upward.

Table 1. Plant canopy volume and dry matter yield of *Atriplex lentiformis.*

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	7.5	2.60	4.6	0.52
P2	11.9	3.99	10.5	1.17
P3	3.4	1.24	2.9	0.25
P4	0.4	0.08	0.4	0.05
P5	0.4	0.16	0.5	0.05
P6	0.4	0.19	1.0	0.10
P7	3.9	0.38	1.8	0.06
P8	4.7	0.60	1.7	0.10
P9	4.1	0.43	4.6	0.31
P10	5.3	1.72	3.0	0.38
P11	2.4	0.77	4.7	0.71
P12	4.0	1.53	4.0	0.58
Mean	4.0	1.1	3.3	0.4
SE	± 1.6	± 0.6	± 1.3	± 0.2

Table 2. Soil ECe (dSm^{-1}) measured at various depths of *Atriplex lentiformis.*

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	2.7	1.2	1.7	3.0	1.6	22.5	12.0	7.6	5.6	3.5
P2	30.5	8.8	8.5	4.8	1.8	17.4	6.1	3.2	3.8	5.0
P3	12.6	8.9	4.2	3.3	1.9	16.7	13.0	4.9	3.2	3.6
P4	6.7	3.9	3.2	5.1	2.5	4.1	1.4	1.2	2.0	1.3
P5	3.9	3.3	3.9	3.8	3.3	4.4	2.9	3.1	2.9	2.0
P6	10.9	2.6	3.2	1.6	1.8	10.0	3.6	2.1	1.4	1.0
P7	1.8	3.7	7.6	9.9	4.6	1.4	2.3	0.9	0.9	1.2
P8	1.5	6.2	1.8	1.9	1.2	0.8	0.7	0.7	1.1	2.3
P9	1.6	1.3	2.2	2.0	1.6	1.1	0.8	1.0	1.0	13
P10	1.7	2.3	1.9	1.2	1.9	1.2	1.3	3.2	3.2	1.1
P11	2.2	3.9	6.3	0.9	0.8	0.8	1.5	4.6	1.6	0.7
P12	1.9	2.5	1.5	1.2	0.9	1.4	1.2	1.3	0.5	0.6
Mean	6.5	4.1	3.8	3.2	2.0	6.8	3.9	2.8	2.3	2.0
SE	± 4.1	±1.3	± 1.2	± 1.2	± 0.5	± 3.8	± 2.1	± 1.0	± 0.7	± 0.7

Sodium Adsorption Ratio (SAR): Soil SAR decreased in the lower profile with the increasing depths in both cuttings (Table 4). The recorded mean values at the first cutting were 15.8, 10.4, 8.3, 7.7 and 6.7 (in mol $L^{-1})^{1/2}$ at depths 1 (0-30cm), 2 (30-60cm), 3 (60-90cm), 4 (90-120cm) and 5 (120-150cm) respectively, whereas the respective values at the last cutting were 24.1, 16.5, 12.8, 11.9 and 10.1 (m mol $L^{-1})^{1/2}$. Thus, there was a noticeable increase at all the depths in case of *A. lentiformis*. The reason for this increase may be the movement of Na salts from the underneath horizons into upper 150 cm soil in the absence of artificial irrigations as well as rainfall. The leaf litter effect may also be present in the surface soil. 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 *A. lentiformis* as well as *A. amnicola* indicated better survival at three different sites.

Correlation between ECe and various plant parameters of *Atriplex lentiformis*: Correlation between ECe of different soil depths and volume canopy of *A. lentiformis* is given in Table 5. It was observed that correlation between volume of *A. lentiformis* and EC_e of all the depths in the first and last cutting was non-significant except at depth 5 (120-150 cm) in the last cutting which was found to be significant. This correlation was found to be positive. All the values for lower soil depths were well below the critical limit of 4.0 dSm^{-1}. Even surface EC_e 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 of 26.65for ECe of all the soil depths and both cuttings of *A. lentiformis*. 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 *A. lentiformis*. 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 species 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 3. Soil pH_s measured at various depths of *Atriplex lentiformis.*

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	8.3	8.5	8.9	8.3	8.6	8.9	8.6	8.7	8.5	8.5
P2	8.6	8.6	8.5	8.5	8.6	8.9	9.1	9.2	8.8	8.9
P3	8.7	8.8	9.0	8.8	8.9	8.8	8.9	8.8	8.7	8.8
P4	8.0	8.7	9.2	8.4	8.5	8.8	9.0	9.4	9.0	8.9
P5	8.5	8.6	8.6	8.4	8.3	8.7	8.8	8.9	8.7	8.9
P6	8.6	9.0	8.5	8.7	8.8	8.6	8.8	8.9	8.8	9.1
P7	8.1	8.1	8.3	8.1	8.2	8.2	8.6	8.4	8.5	8.8
P8	8.0	8.2	8.4	8.5	8.5	8.1	8.1	8.7	8.9	8.8
P9	8.2	8.4	8.5	8.7	8.6	8.5	8.5	8.7	8.8	8.6
P10	8.6	9.1	8.4	8.7	8.4	9.1	8.8	9.1	8.8	8.9
P11	8.6	8.5	8.5	8.5	8.8	8.7	9.0	8.5	8.7	8.8
P12	8.7	8.6	8.7	8.7	8.5	8.6	8.6	8.6	8.6	8.9
Mean	8.4	8.6	8.6	8.5	8.6	8.7	8.7	8.8	8.7	8.8
SE	$\pm$0.1	$\pm$0.1	$\pm$0.1	$\pm$0.1	$\pm$0.1	$\pm$0.1	$\pm$0.1	$\pm$0.1	$\pm$0.1	$\pm$0.1

Table 4. Soil SAR measured at various depths of *Atriplex lentiformis.*

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	7.8	5.8	7.3	5.0	6.8	93.8	24.9	11.4	10.3	5.1
P2	50.8	12.4	10.1	7.3	6.3	42.3	13.2	14.4	13.0	15.9
P3	33.4	21.1	10.1	15.6	10.9	38.4	53.7	16.4	15.2	16.1
P4	10.9	10.7	7.7	6.5	6.9	22.0	13.4	28.0	27.7	7.6
P5	10.6	12.5	9.1	9.2	6.1	17.1	19.7	12.2	13.3	10.6
P6	30.7	11.6	5.7	3.9	5.0	44.0	14.7	15.1	15.4	7.5
P7	6.4	12.4	11.7	10.9	9.8	8.3	10.2	9.5	9.4	18.2
P8	2.4	10.1	8.0	9.4	7.0	2.9	3.8	12.2	10.0	7.6
P9	5.6	8.2	5.3	6.8	6.9	3.4	3.4	5.7	3.4	17.3
P10	16.3	3.8	5.9	5.8	5.7	6.8	24.2	15.4	12.7	5.6
P11	10.1	9.0	13.5	3.3	3.9	5.8	10.2	5.9	6.8	4.7
P12	4.9	7.0	4.9	8.1	5.1	4.9	6.5	7.2	6.1	4.4
Mean	15.8	10.4	8.3	7.7	6.7	24.1	16.5	12.8	11.9	10.1
SE	$\pm$7.1	$\pm$ 2.1	$\pm$ 1.3	$\pm$ 1.6	$\pm$ 0.9	$\pm$12.9	$\pm$ 6.6	$\pm$ 2.9	$\pm$ 3.0	$\pm$ 2.6

A positive correlation was found between fresh biomass of *Atriplex lentiformis* and ECe, of upper three soil depths of first cutting and all the soil depths after last cutting (Table 5). However, correlation for ECe of third (60-90 cm), fourth (90-120 cm)and fifth depth (120-150 cm) recorded after first cutting was assessed to be negative. Fresh biomass of *Atriplex lentiformis* did not correlate significantly with ECe of any soil depth determined after both the cuttings. 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 *A. 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 5). The only exception was that ECe of first depth (0-30 cm) was assessed as significant. 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.

Table 5. Correlation between Electrical Conductivity (ECe) and various plant growth parameters of *Atriplex lentiformis.*

Depth (cm)	**First Cutting**	**Last Cutting**
	Canopy Volume	
0-30	+ 0.534 NS	+ 0.417 NS
30-60	+ 0.343 NS	+ 0.244 NS
60-90	+ 0.293 NS	+ 0.299 NS
90-120	+ 0.086 NS	+ 0.351 NS
120-150	- 0.191 NS	+ 0.583*
	Fresh Biomass Yield	
0-30	+ 0.549 NS	+ 0.409 NS
30-60	+ 0.303 NS	+ 0.229 NS
60-90	+ 0.184 NS	+ 0.395 NS
90-120	- 0.118 NS	+ 0.391 NS
120-150	- 0.339 NS	+ 0.500 NS
	Dry Matter Yield	
0-30	+ 0.623*	+ 0.369 NS
30-60	+ 0.341 NS	+ 0.197 NS
60-90	+ 0.253 NS	+0.382 NS
90-120	- 0.052 NS	+ 0.354 NS
120-150	- 0.295 NS	+ 0.456 NS

Table 6. Correlation between p_{Hs} and various plant parameters of *Atriplex lentiformis.*

Depth (cm)	**First Cutting**	**Last Cutting**
	Canopy Volume	
0-30	+ 0.139 NS	+ 0.315 NS
30-60	- 0.166 NS	+ 0.250 NS
60-90	- 0.209 NS	+ 0.033 NS
90-120	- 0.102 NS	-0.012 NS
120-150	- 0.028 NS	- 0.205 NS
	Fresh Biomass Yield	
0-30	+ 0.454 NS	+ 0.439 NS
30-60	+ 0.161 NS	+ 0.368 NS
60-90	+ 0.034 NS	+ 0.075 NS
90-120	+ 0.076 NS	+ 0.019 NS
120-150	+ 0.160 NS	- 0.128 NS
	Dry Matter Yield	
0-30	+ 0.399 NS	+ 0.429 NS
30-60	+ 0.099 NS	+ 0.369 NS
60-90	+ 0.010 NS	+ 0.051 NS
90-120	+ 0.019 NS	+ 0.031 NS
120-150	+ 0.125 NS	- 0.118 NS

Correlation between pH_s and various plant parameters of *Atriplex lentiformis*: The correlation between soil pH_s and plant volume was evaluated as non significant for both the cuttings at all the soil depths (Table 6). The non-significant correlation was positive for first depth at first cutting while other four depths correlated negatively. At the last cutting pHs of the upper three depths remained positively correlated while the lower two depths were negative in this regard. All the correlations between pH and fresh biomass yield were non-significant except the lowest depth (120-150 cm) at last cutting which was found to be significant (Table 6). The relationship of *A. lentiformis* with pH of all depths at both the cuttings were positive except the lowest depth (120-150cm) at last cutting which remained negative. Similarly, when considered the correlation between pH_s and dry matter yield of *A. lentiformis*, it was exactly similar as reported under fresh biomass yield i.e. positive but non-significant. 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 *A. lentiformis*.

Table 7. Correlation between (Sodium Adsorption Ratio) SAR and various plant parameters of *Atriplex lentiformis.*

Depth (cm)	**First Cutting**	**Last Cutting**
	Canopy Volume	
0-30	+ 0.415 NS	+ 0.232 NS
30-60	- 0.164 NS	- 0.072 NS
60-90	+ 0.063 NS	- 0.307 NS
90-120	+ 0.010 NS	- 0.363 NS
120-150	+ 0.078 NS	+ 0.221 NS
	Fresh Biomass Yield	
0-30	+ 0.514 NS	+ 0.261 NS
30-60	- 0.175 NS	- 0.052 NS
60-90	+ 0.014 NS	- 0.265 NS
90-120	- 0.065 NS	- 0.295 NS
120-150	- 0.059 NS	- 0.020 NS
	Dry Matter Yield	
0-30	+ 0.552 NS	+ 0.222 NS
30-60	- 0.143 NS	- 0.069 NS
60-90	+ 0.034 NS	- 0.291 NS
90-120	- 0.070 NS	- 0.319 NS
120-150	- 0.059 NS	- 0.044 NS

Where + = Positive Correlation; - = Negative Correlation; ** = Highly Significant ($P<0.05$); * = Significant ($P<0.01$);
NS = Non-Significant.

Correlation between SAR and various plant parameters of *Atriplex lentiformis*: All correlations between volume of *A. lentiformis* and SAR of cutting were recorded non-significant (Table 7). All correlations of first cutting were found positive except second depth (30-60cm) which was negative. In case of last cutting, only positive correlations were for first and last cutting while other three remained negative. All correlation between fresh biomass and dry matter yield were also assessed as non-significant. The only positive correlation between SAR and fresh biomass were first and third depth of first cutting and first depth of last cutting. 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.

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