FEASIBILITY OF SILVO-PASTORAL MODEL FOR SALINE - SODIC SOILS IN ARID CLIMATE

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ABSTRACT

A study was conducted at Arid Zone Research Station (P ARC), Bahawalpur, during 1991-92 on saline-sodic soils, in order to bring these areas under economic productivity and to overcome the deticiency of forage and fuelwood. Eighteen strips, each measuring 8mx 25m, were planted with Kallar grass *(Leptochloa fusca).* Grass seedlings were planted at 0.5-m spacing. One-year old nursery-raised seedlings of six species of saltbush *(Atriplex lentiformis, A. halimus, A. amnicola,. A. nummularia., A. canescens. and A. stocksii)* were planted on raised beds (0.5 m high) in rows, along strips containing Kallar grass. The saltbush seedlings were planted in linear fashion at a spacing of 2.5 m. There were 10 seedlings of each saltbush species in a row, forming a replication. The study was replicated three times. Thus, there were 18 strips of Kallar grass having 30 seedlings of each of the six *Artiplex* species. Data on green biomass of Kallar Grass, survival percentage, crown diameter and height of the seedlings of each species of saltbush were recorded on six-monthly basis.

The results revealed that Atriplex halimus outperfomrd all the six species, in terms of survival, followed by A. conescens, A. amnicola, A. nummularia and A. lentiformis. Atriplex stocksii exhibited the lowest (4%) survival in this study. Maximum crown diameter was observed in case of A. canescens, followd by A. amnicola, A. nummularia and A. A. halimus. The seedlings of A. lentiformis and A. stocksii did nto survive in two replications. Kallar grass, on the average provided 20-tons/ha fresh matter yield on six-monthly basis. The study revealed that this type of landuse is highly suitable for areas infested with salinity/sodicity and where cereal crops cannot be grown. Moreover, this study also exhibited that forage and fueldwood demand can successfully be met by bringing such problem-areas under suitable silvo-pastoral system.

INTRODUCTION

About 20 million hectare (m. ha) of the total area of Pakistan is under cultivation. Almost 16.2 m ha of the cultivated area is irrigated, of which canals irrigate 11.4 m. ha and the rest is irrigated either by tubewellsor other means. Salt-affected area is about 6.3 m. ha, which is mainly confined to the irrigated parts of the Indus plain (Qureshi *et at.* 1996). These areas have serious socio- economic implications and mostly concerns subsistence farmers. Although occurring in patches. These soils have combined salinity, sodicity problems (Aslam et al. 1991; Qureshi and Barrett-Lennard. 1998). Saline sodic soils are generally regarded as wastelands and such areas play no significant role in the national economy. These soils could be reclaimed,either by use of gypsum or through raising salt-tolerant plants. Biological approaches improve soil-structure by adding organic matter and acidifying the soil that makes soluble calcium available. Continuous raising of kallar grass *(Leptochloa fusca)* on such soils is widely practiced by the farmers (Qureshi and Barrett-Lennard, 1998).

Livestock is an integral part of the agriculture in Pakistan and hence fodder-shortage is a common problem when we try to raise good-quality animals. Apart from fodder-shortage, household energy requirements in the rural setup are met mainly from the trees grown on agricultural lands. Having this scenario in mind, a study was underaken to evaluate the potential of salt-tolerant shrubs and grass species under saline sodic conditions, to meet the forage and fuelwood needs from the areas regarded as waste-lands. The ultimate aim of this study was to explore the possibilities of bringing saline sodic soils under productive use.

STUDY SITE

The study was conducted at Arid Zone Research Station of Pakistan Agricultural Research .Council at Bahawalpur. Bahawalpur lies in the southern part of Punjab province, at about 29^{o} 24' N latitude and longitude 710 47' E,at an elevation of about 116 m above mean sea level (FAO 1993). The soils are generally clay loam (clay 43%, silt 36% and sand 21%). Irrigation to the study-area was provided through tubewell, whose water, like 70% of the tubewells in

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Indus basin (Qureshi and Barret-Lennard 1998), is marginally fit for cultivation (1300 mmohs) (AZRI 1996). Other chemical characteristics of the study-soil include pH 8.9, ECe 10.8 dS/m-l, and SAR 28.

Bahawalpur, being on the immediate verge of Cholistan desert, experiences hot tropical climate (Table 1). Maximum temperature during summer may reach up to 50 °C, while the minimum temperature seldom drops below zero. Most of the precipitation is received during monsoon period, extending from July through mid-September (FAO, 1993). Evaporation exceeds precipitation in each month considerably. Climate data, based on 30 years average (FAO, 1993), is presented in Table 1.

MATERIALS AND METHODS

During the month of August, 1991, eighteen strips, each measuring 8m x 25m, were planted with Kallar grass (*Leptochloa fusca*). Grass seedlings were planted at 0.5-m spacing. One-year old nursery-raised seedlings of six species of saltbushes (*Atriplex lentiformis, A. halimus, A. ammnicola, A. mammularia., A. canescens and A. stocksii*) were planted on raised beds (0.5 m high) in rows, along stirps containing Kallar grass. The saltbush seedlings were planted in linear fashion ata spacing of 2.5-m. There were 10 seedlings of each saltubsuh species in a row, forming a replication. The study was replicated three times. Thus, there were 18 strips of Kallar grass having 30 seedlings of each of the six Atriplex species. Data on green biomass of Kallar grass. survival percentage, crown diameter and height of the seedlings of each saltbush species, were recorded on six-monthly bases. Samples of green biomass fo kallar grass were oven-dried for 48 hours at 60 ^{o}C and dry-matter yeild (DMY) was worked out. Irrigation was provided to the study area, except for rainy days, on weekly basis during summer (April - September) and on monthly basis during winter (October - March). The data were analyzed using Randomized Complete Block Design and means were separated using Duncan's multiple range test (Gomez and Gomez 1984).

RESULTS

Saltbush Species: Final measurements, as in September 1994, regarding growth-rate (height and crown diameter) and survival of all the saltbush species are presented in Table 2 and Figure 1 below.

The results (Table 2) indicate that, in case of plant height, A. amnicola outperformed numerically all the saltbush species tested in this study; however, its height was significantly ($p<0.05$) greater than A. canescens and A. stocksii. Both the latter species did not differ significantly ($p<0.05$) from Atriplex lentiformis, A. nummulari and A. halimus. The crown diameter among all the species did not differ significantly *($p<0.05$).* Numerically, *Atriplex canescens* attained more crown-spread), followed by *A. amnicola, A. nummularia, A. halimus, A, lentiformis* and finally A. stocksii. Crown diameters of all the saltbush species raised in this study were higher, compared to their respective vertical growth.

The plants of *A, halimus* exhibited 100% survival-rate followed by *A. canescens, A. amnicola, A. mummularia, A. lentiformis and A, stocks ii,* Thus, the results revealed that *A, stocksii* is poor performer in terms of growth-rate as well as plant-survival among all the six saltbush species planted in this study. All other species did well in hot climatic and saline sodic conditions of Bahawalpur.

Kallar Grass: Dry matter yield (DMY) of kallar grass increased progressively with the time from initial establishment (Fig. 2). The lowest DMY was recorded six mmonths after the initiation of the study (April 1992) that did not differ significantly ($p<0.05$) from that one year after planting (September 1992), but it differed significantly ($p<0.05$) as the time increased from one year after planting onward. However, the DMY was not significantly different ($p<0.05$) among the last two cuttings (April and September 1994) of the study, showing that the grass had increased potential of adding biomass with the passage of time, This also provided the evidence that soil-conditions had also improved over time. The earlier reduction in the yield was probably the initial growth-development of the plants and their adjustment with the soil conditions.

DISCUSSION

The study-site of Bahawalpur is a representative hot area of the Indus plain, where salinity-sodicity is a wide-spread problem. Accompanied to this, fuel wood and forage are also immediate requirements of the

Table – 1: Meteorological Data of Bahawalpur (30 Years Average) (1961 – 1990)

Month	Mean Monthly Temp		Rainfall	Mean R.H.	PE (Max)	Wind
	Min	Max	mm	(%)	(mm)	(Knots)
	°C					
Jan.	2.0	26.0	5.9	68	65.3	2.9
Feb.	3.5	29.5	11.1	64	77.8	3.4
Mar.	8.1	36.6	9.2	60	103.2	3.8
April	14.1	42.4	7.1	47	133.4	3.8
May	19.1	45.1	6.1	40	156.5	4.8
June	23.5	45.8	16.4	48	169.4	5.7
July	24.0	43.5	51.3	61	163.2	4.5
Aug.	24.6	41.2	42.1	65	159.9	4.7
Sept.	21.2	39.7	11.6	64	145.9	4.1
Oct.	13.6	38.3	0.6	60	127.7	3.3
Nov.	7.2	34.0	4.2	65	98.4	2.0
Dec.	3.0	28.2	3.0	69	71.5	2.2
Year (Mean)	13.7	37.4	168.6 (Total)	59	147.2	3.6

R.H.=Relative Humidity, PE = Potential Evaporjation

Table – 2: Height and crown diameter of different *Atriplex* species grown in saline-sodic soil (cm)

S.No.		Height	Crown diameter
1.	*A. lentiformis*	66ab	80a
2.	*A. conescens*	41b	239a
3.	*A. amnicola*	145a	225a
4.	*A. nummularia*	125ab	219a
5.	*A. stocksii*	32b	67a
6.	*A. halimus*	119ab	193a

Figures with the same superscripts in the same column do not differ significantly (p<0.05), LSD=94 & 182 for height and dia., respectively

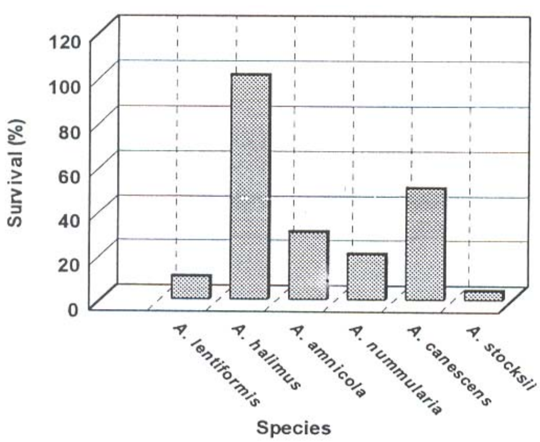
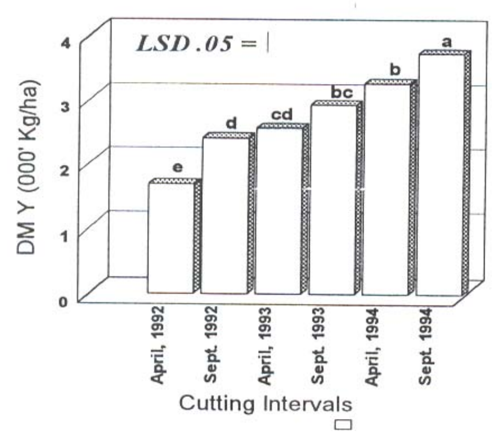


Figure - 1: Survival performance of Saltbush species in saline sodic soil



Note: Bars carrying similar alphabets do not differ significantly at P≤0.05

Figure - 2: Dry matter yield of Kallar grass at different cutting intervals

subsistence farmers. The Artip*lex* species that are commonly known as salt bushes, perform well in such *hot* places and are highly suited in agroforestly land-use for saline areas. These species provide nutritious forage *to* the livestock, particularly small ruminants year round, in areas where availability of good-quality forage is a serious problem, since livestock in general meets half of its feed-requirements from crop-residues and one-third from grazing (Sandhu 1988; Hanjra and Rasool 1991; Barrett-Lennard and Galloway, 1996).

Saltbushes comprise almost 200 species, thus exhibiting high genetic diversity (Hanjra and Rasool 1991) These species adapt well, not only to the dry areas, but also irrigated areas where salinity is a serious problem. Thus, saltbushes have enormous potential to foster plant, soil and livestock productivity. Hanjra and Rasool (1991) reported that saltbushes have been regarded as nutritious forage-plants (organic matter 73%, crude protein 19%, crude fiber 24% and digestibility of crude protein 79%). In feeding trials, sheep not only increased its intake but also gained slight weight when fed solely on saltbush (A. *canescens)* (Rehman *et al.* 1988; 1991).

The potential of using halophytes like saltbushes on salt-affected soils can bridge the gap of forage-supply during critical periods. Apart from meeting forage and fuel-wood requirements of the small farmers, saltbushes provide a less expensive option for biological amelioration of problem-soils. Such land-use practices increase the income of subsistence farmers from areas lying unproductive otherwise. Saltbushes are capable of growing under various soil and climatic conditions and have the characteristic of drought-resistance and can tolerate salinity, both in soil and water.

Ahmad (1989) reported the results of study conducted at sandy coast. Eleven saltbush species were initially sown in this study, but only eight species germinated under prevailing condicitons while the remaining three (*viz.*, *A. bunburyana, A. semibaccata and A. canescens*) failed to do so. These eight species were studed under field conditions. the plants were irrigated with undergorund saline water (EC. varying from 10-17 dS/m^{-1}; SAR varying from 25-30). Data on biomass-production of thse species revelaed that A. amnicola outperfomred in yeild of biomass, followed by A. *isatidea, A. cinerea, A. lentiformis, A. halimus, A. nummularia, A. paludosa and A. undulata*. However, the author mentioned that A. halimus was found to be the most drought-tolerant our of all the Atriplex species tested in the study. Abdullah et al. (1991) ranked the saltbush species in descending order, based on survival, height, volume and biomass as A. lentiformis. A. bunburyana, A. halimus, A. undulata, A. amnicola and A. cinerera. The authors, while reporting the results of a study conducted in Dingarh (Cholistan desert, Bahawalpur) concluded that *A. lentiformis, A. bunburyana, A. halimus and A. amnicola 949* are the most prominent species that could be raised by using saline water. Similarly, *A. lentiformis, A. ammnicola, and A. halimus* have exhibited the best growth in saline sodic soils of Peshawar valley (Rashid et al. 1991).

Aslam et al. (1991) mentioned that salt-affected soils could be effectively used for the production fo Kallar grass during summer, provided sufficient irrigation-water is available. The autors mentioned that by raising Kallar grass, soil-properties are also improved beside a net income to the farmer at Rs. 1400/- per acre. Kallar grass is widely planted by the irrigated farmers in areas having problems of salinity and it is primarily used as a potential forage for cattle and buffaloes. The biomass produced by this grass can also be used as a substratum for mushroom and enerlgy production (Aslam et al., 1991).

Malik et al (1986) reported that ,among many plants collected in the country (by Nuclear Institute for Agriculture and Biology (NIAB)) for testing them for the levels of their salt-tolerance, the Kallar grass was found to be the most salt-tolerant. The grass can survive at very high salinities (40 ds m^{-1}). However, it remains economical upto a salinity-level of 22 ds mol, which is quite a high salinity indeed. The grass was also grown in fields and it was noticed that it grew, year after year ,without any fertilizer but there was no loss of yield. It was also found that grass fixes biological nitrogen through free living nitrogen-fixing bacteria in the soil. The authors mentioned that the grass is perennial and can be propagated vegetatively through its cuttings. It can grow to a height of 4-5 feet and can provide four cuttings, to give 40 tons of biomass per ha) per year. The grass has been used as fodder for the buffaloes, without any apparent adverse eftects. It has also been used as green manure and as feed-stock for a pilot biogas plant. It has successfully been used for making pulp and as substrata for raising mushrooms and even for saccharification of celluosic materials and their one-stage conversion into alcohol.

Singh et al. (1988) discussed the forage production, chemical composition and nutrient cycling fo karnal grass (*Leptochloa fusca*) planted with mesquite (*Prosopis juliflora*) in a unified agroforestry system, on an extrely sodic soil lying barren in Karnal district of India. Karnal grass gave 25.3 t/ha green-forage yield in 8 cuts, in a period of 26 months proving its great potential as a fodder crop. The mean N, P, K, Ca, Mg, S and Na contents in the whole plant was 1.36, 0.20,0.65,0.19, 1.54 and 1.52 percent in first cut, and 0.92,0.18,0.74,0.34,0.68,0.14 and 0.64 percent in the last cut, respectively. Increased content of the Ca and K decreased the Na concentration with subsequent cuttings and made this grass a valuable fodder under sodic soil conditions. Total nutrient removed was 567 kg/ha, within a period of little more than two years. It was interesting to note that this grass biologically pumped out 114-kg/ha sodium through the aerial biomass, thus acting as a trigger for the start of a plant-succession for the reclamation of sodic soils lying unproductive.

CONCLUSION

Silvo-pastoral land-use model discussed above needs to be established in the arid hot climate of the country, where salinity and sodicity are serious problems. However, the present study did not fully determine the extent of soil-improvement with this model and the economics of such land-use, if adopted by a small farmer. These questions need to be carefully addressed in future in investigations.

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