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COMPARATIVE EFFECTIVENESS OF GYPSUM AND FORAGE PLANT SPECIES IN RECLAMATION OF A CALCAREOUS SALINE-SODIC SOIL

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Biotic and chemical methods for the reclamation of a calcareous saline-sodic soil were compared under field conditions. Five Treatments viz. cóntrol, gypsum @100% GR-15 cm, Sesbania (*Sesbania aculeata*), sordan (*Sorghum bicolor* X *Sorghum Sudanese*), and Kallar grass (*Leptochola fusca*) were employed on a permanent layout for a period of two years..Canal water was used for irrigation and leaching. Sesbania and kallar grass were found to be potential biotic materials for soil reclamation. These plant species produced substantial biomass and also improved the soil conditions by lowering ECe and SAR of the soil. Efficiency of Sordan was relatively less due to its sensitivity to high temperature and sodicity during germination and early seedling stages .

INTRODUCTION

A large section of sodic and saline-sodic soils of Pakistan contains lime in different ratios at varying depths. Calcium present in this form remains ineffective in soil exchange reactions due to its negligible solubility . To supply soluble calcium for the replacement of sodium adsorbed on the clay complex , there are several amendments available in the market. These either supply soluble calcium directly or indirectly by solubilizing the already existing insoluble fraction of calcium. However, the initial cost of these amendments restricts their potential utilization especially from poor farmer's point of view. The other possibility of utilizing these land resources may be the cultivation of certain forage plant species which are considered more tolerant to salinity/sodicity then most field crops. Their growth may also cause a continuous decrease in soil salinity/sodicity with time (Abrol *et al.*,1988) and their roots can act as potential tillage tools to improve soil permeability (Elkins,1985). This may be done at relatively low initial cost with dual benefit of forage off take as well as of soil reclamation. The potential biotic materials found suitable for such conditions are sesbania (Salim *et al.*,1978; Evans and Rotar,1987), sordan (Robbins,1986a and1986b) and Kallar grass (Malik *et al.*,1986 ; Sandhu and Qureshi, 1986).

We have tried to evaluate the relative effectiveness of chemical and biotic means for the reclamation of a calcareous saline-sodic soil under field conditions.

MATERIALS AND METHODS

The experiment was conducted on a calcareaous, saline-sodic sandy clay loam soil at Postgraduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad. There were five treatments i.e., control, gypsum @ 100% GR-15 cm (13 t ha^{-1}), sesbania (*Sesbania aculeata*), sordan (*Sorghum bicolor* x *Sorghum sudanese*), and kallar grass (*Leptochloa fusca*). These treatments were arranged in a Randomized Complete Block Design with four replications having a plot size of 7.5 m x 3.3 m.

Soil samples were collected from each plot from 0-15 and 15-30 cm depths after layout of the experiment and were analysed for gypsum requirment (0–15 cm), pH, ECe and SAR. Agricultural grade gypsum powder (passed through a 70 mesh sieve and having 90 % purity) was broadcast on the soil surface in the plots under gypsum treatment and was mixed by means of a cultivator with the surface soil to a depth of 15 cm. During first season (1988), sesbania and sordan were sown in rows 30 cm apart with the help of a seed drill. Kallar grass was transplanted from cuttings of the plants. In the second season (1989), Sesbania and sordan were sown by broadcast method. No fertilization was done to the plant species. All the plants were irrigated every seven days with approximately equal quantities of canal water (EC=0.27 dS m^{-1}) through out the growing season of the crops. Two cuttings of each crop were taken during 1988 and three cuttings during 1989. Weighing of the harvested material was done just after harvest of the plant species. Soil samples were collected from each plot from 0–15 cm and 15–30 cm depths by means of an auger after the final cutting of plant species during both years. These were analysed for the same parameters as mentioned above according to the methods of U.S. Salinity Laboratory Staff (1954).

RESULTS AND DISCUSSION

Electrical Conductivity of Saturation Extract (ECe)

The analysis of soil samples, taken at different intervals, indicates a decrease in salinity/ sodicity hazard in all the treatments. The maximum decrease in ECe of the original soil was observed in Sesbania followed by kallar grass (Table 1). The efficiency of treatments in lowering ECe of the original soil was in the order: Sesbania > kallar grass > gypsum = sordan > control. The reduction in ECe in the cropped treatments may obviously associated with the improved soil permeability (see Elkins, 1985) which helped the soluble salts to leach out of the root zone. In the gypsum treatment, increase in solute concentration in soil solution at initial stages was due to dissolution of calcium (Oster, 1982).

Sodium Adsorption Ratio (SAR)

Gypsum was the leading treatment for lowering down SAR of the soil from its original level (Table 2). The decrease in SAR with respect to the efficiency of treatments was in the order: gypsum > sesbania = kallar grass > sordan > control. The decrease in SAR in the gypsum treated soil was due to the availability of solube calcium while in the cropped treatments this was due to valence dilution (Reeve and Bower, 1960), calcium supplied in the irrigation water and possibly due to dissolution of soil lime under the action of plant roots and soil microbes.

pH of Saturated Soil Paste (pHs)

As regards soil pH, an inconsistent response to the reclamation treatments was observed (Table 1). There was a slight decrease in pH of the soil in all the treatments except control at the end of the first season. However, in the second year of the experiment, there was no change in soil pH in sesbania and Kallar grass while in case of the control and sordan there was slight increase over the original level. The treatment receiving gypsum was the only one which showed some decrease in pH. However, the differences among the treatments were statistically nonsignificant.

Biomass Production of Plant Species

During the first season (1988), sowing of Sesbania and sordan and transplanting of Kallar grass was done in the last week of June (hot, dry and windy). Sordan completely failed to germinate in the first attempt. However, after two more attempts, the crop was established in patches except for one plot where its germination and growth was adequate. Establishment of Kallar grass and germination of Sesbania were not affected to a great extent. However, in the next season (1989), sowing of the crops was

Table 1. Effect of reclamation treatments on ECe (dS m^{-1}) and pHs of the soil

Treatments	Soil Depth						Percent increase(+) / decrease (–) Over original level	
	0–15 cm		15–30 cm		0–30 cm			
	ECe	pHs	ECe	pHs	ECe	pHs	ECe	pHs
Original soil								
Control	9.0	8.5	8.6	8.4	8.8	8.5		
Gypsum	9.0	8.6	8.9	8.6	9.0	8.6		
Sesbania	7.8	8.3	7.2	8.1	7.5	8.2		
Sordan	7.9	8.2	7.8	8.3	7.8	8.3		
Kallar grass	7.8	8.5	7.0	8.2	7.4	8.4		
A. H.* (1988)								
Control	7.5	8.6	8.5	8.4	8.0 a	8.5 a	–9.1	–
Gypsum	7.0	8.1	7.4	8.1	7.2ab	8.1 b	–20.0	–5.8
Sesbania	5.7	8.1	5.3	8.1	5.5c	8.1 b	–2.7	–1.2
Sordan	6.2	8.2	6.6	8.3	6.4bc	8.2 b	–17.9	–1.2
Kallar grass	5.2	8.2	5.4	8.3	5.3c	8.2 b	–28.4	–2.4
A.H. (1989)								
Control	7.4	8.5	8.2	8.6	7.8 a	8.6 N.S.	–11.4	+1.2
Gypsum	6.7	8.3	7.0	8.2	6.8 b	8.2	–24.4	–4.6
Sesbania	4.1	8.3	4.8	8.2	4.4 c	8.2	–41.3	–
Sordan	5.8	8.4	6.1	8.3	6.0 b	8.4	–23.1	+1.2
Kallar grass	4.8	8.4	5.0	8.3	4.9 c	8.4	–33.8	–

*After harvest of the plant species
Means with different letters in the same column differ significantly according to Duncan's Multiple Range Test (P = 0.05)
NS = Non–significant

Table 2. Effect of reclamation treatments on SAR of the soil

Treatments	SAR $(mol\ L^{-1})^{\frac{1}{2}}$			Percent decrease over original level
	0–15 cm	15–30 cm	0–30 cm	
		Original Soil		
Control	67.3	64.9	66.1	
Gypsum	76.1	69.9	73.0	
Sesbanie	61.7	49.5	55.6	
Sordan	66.7	58.2	62.3	
Kallar grass	64.6	51.2	57.9	
		A. H.* (1988)		
Control	61.7	63.9	62.8 a	5.0
Gypsum	49.6	57.0	53.3 ab	27.0
Sesbania	39.4	47.6	43.5 b	21.8
Sordan	52.8	57.4	55.1 ab	11.8
Kallar grass	44.6	44.8	44.7 b	22.8
		A. H. (1989)		
Control	57.4	57.0	57.2 a	13.5
Gypsum	23.6	25.8	24.7 c	66.2
Sesbania	28.1	32.1	30.1 c	45.9
Sordan	42.0	38.0	40.0 b	35.8
Kallar grass	32.8	32.2	32.5 bc	43.9

* = After harvest of the plant species
Means with different letters in the same column differ significantly according to Duncan's Multiple Range Test (P = 0.05).

done during the second week of April and germination and growth of sordan was improved.

As regards performance of the plant species for biomass production, Sesbania emerged as a better species than Sordan and kallar grass during both years (Table 3). Kallar grass produced almost equal amounts of biomass during both seasons while the performance of sordan in this respect was improved during 1989. The poor response of sordan during first season may be attributed to its sensitivity to high temperature, salinity and sodicity during germination and seedling stages.

Table 3. Performance of plant species for biomass production (fresh weight)

Plant species	First Cutting	Second Cutting	Third Cutting	Total biomas production
	($t\ ha^{-1}$)			
		1988		
Sesbania	21.8	12.1	–	33.9 a*
sordan	6.9	2.8	–	9.7 b
Kallar grass	13.3	16.2	–	29.5 a
		1989		
Sesbania	25.4	20.6	1.6	47.6 a
Sordan	14.1	17.8	7.7	39.6 b
Kallar grass	16.6	12.1	0.8	29.1 c

* = Means with different letters in this column differ significantly according to Duncan's Multiple Range Test (P = 0.05)

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