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GROWTH OF KALLAR GRASS (*Diplachne fusca* (LINN) BEAUV)) AS INFLUENCED BY VARIOUS LEVELS OF GYPSUM APPLICATION*

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Two saline-sodic soils were equilibrated in the laboratory with 0, 1.0, 2.0, 4.0, 8.0, 12.0 me of calcium per 100 g soil and gypsum requirement levels (gypsum requirement for soils I and II was 16.2 and 12.0 me calcium per 100 g soil). The gypsum potential (pNa–1/2 pCa) attained zero value for soils I and II at 7.3 and 6.3 me calcium. The activity ratio of sodium and calcium indicated that at zero gypsum potential, the activity of sodium no long dominated in solution phase. The maximum yield of kallar grass was obtained at 8.0 and 4.0 me calcium per 100 g soil for soils I and II. The minimum yield in soils I and II was obtained at the gypsum requirement levels which revealed that in situations with inadequate drainage, gypsum applied in excessive amount may result in salt concentrations which are detrimental for plant growth. Electrical conductivity, pH and exchangeable sodium in soil media decreased after the harvest of kallar grass compared to that of equilibrated soil before sowing of the crop.

INTRODUCTION

The role of gypsum application in the reclamation of sodic and saline – sodic soils is well recognised. Gypsum applied on the basis of gypsum requirement in certain situations results in excessive salts in soil media. The crop grown on such soils may fail due to osmotic effect, especially in heavy textured soils, where drainage is inadequate to leach excess salts. Since the early years of this century soil scientists have been of the opinion that in reclaiming sodic soils, build up of calcium regime in soil is of prime importance.

Kanwar [4], while working on saline – sodic soils of the Punjab, reported that 30 to 50% of gypsum requirement was an appropriate dose for such soils. Nafady and Lamm [6] used Na (Ca and Mg) exchange isotherm as a simple procedure in soil reclamation studies. They concluded that soil obeyed the ratio law and AR_{Na} – Ca+Mg) were constant over a wide range of (Ca + Mg) concentrations. Hussain [3] equilibrated sodium affected Dandiangas clay with 1.0, 2.0, 4.0, 8.0, 12.0 and 16.0 me of Ca, Mg and Ca + Mg (1-1). He observed maximum yield of rice at 2 me of Ca level and yield decreased at higher treatment levels because of salt concentration increase in soil medium.

Abrol and Bhumbla [1] conducted a field experiment to demonstrate the tolerance of wheat, rice, Dhaincha (*Sesbania aculeata*) and lentil crops to exchangeable sodium percentage (ESP) as regulated by gypsum application to a sodic soil. The gypsum requirement was 60 tons/ha according to standard laboratory tests. They applied gypsum at the rate of 0, 7.5, 15.0, 22.5 and 30.0 tons per hectare. They concluded that under field conditions lower rates than gypsum requirement were effective as far as crop yields and ESP changes in soil medium were concerned. Crop response to sodium varies according to crop species under test and depends upon the physico-chemical properties of soil (US Salinity Laboratory staff, [7]). Although herbaceous and woody plants are sensitive to Cl and Na, yet in general crop yield decrement is a function of osmatic potential of the root medium [5].

The objectives of this study were:

(i) To calculate the minimum amount of the calcium needed for reclamation based on gypsum potential (pNa – 1/2 pCa) and activity ratio ($AR_{Na\text{-}Ca}$),

(ii) To monitor the effect of total salt concentration produced as a result of exchange reaction and that which originally present in soil on growth of kallar grass and

(iii) to observe chemical changes in soil after harvesting the crop.

MATERIALS AND METHODS

The soils under investigation were typical saline – sodic soils of the Indus plain. Soils were collected from Faisalabad District. Some of the important initial physio-chemical characteristics of the soils are given in Table 1.

*The research was conducted by the author at University of Agriculture, Faisalabad as a part of M.Sc. research project.

Table 1. Physico-chemical characteristics of the soils

Soil	pH	EC_e (dsm^{-1})	Soluble anions (me/100 g)				Soluble cations (me / 100 g)			
			CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
I	8.3	35.5	Traces	0.28	6.88	4.81	1.33	0.44	9.87	0.14
II	7.8	43.0	Traces	0.23	11.83	3.88	3.01	1.20	11.50	0.27

Soil	CED (me/100 g soil)	Exchangeable cations (me / 100g Soil)				ESP	Saturation %	Textural class	Gypsum requirement (me calcium/ 100g soil)
		Ca^{++}	Mg^{++}	Na^+	K^+				
I	14.10	4.86	1.05	7.56	0.63	53.60	35.0	Sandy Loam	16.2
II	15.36	7.42	1.37	5.90	0.67	38.40	38.5	Sandy Loam	12.0

The study consisted of two phases, i.e. equilibrium study in the laboratory and greenhouse experiments.

For equilibration study 100 g of each soil were equilibrated with 0, 1.0, 2.0, 4.0, 8.0 and 12.0 me calcium per 100 g soil and gypsum requirement levels of 16.2 and 12.0 me Ca/100 g soil for soils I and II. Calcium as calcium sulphate ($CaSO_4.2H_2O$) was used. The treatments were thrice replicated. Distilled water was added to these soils at the rate of four times of saturation percentage. The air tight flasks were shaken for 24 hr and maintained at a temperature of 32^o for one day. The equilibrated soils were immediately processed for extraction by sunction. Extracts were analysed for sodium and calcium by using a flame photometer and gypsum potential and activity ratios were calculated.

The greenhouse experiment was conducted to find out the possibility of growing a crop on these equilibrated soils, where no leaching facility was provided and salts produced as a result of exchange reaction were allowed to remain in the medium. A fairly salt tolerant kallar grass (*Diplachne fusca* (Linn) Beauv)) was selected as indicator crop. The soils were air dried, pulverized and passed through a 2 mm sieve. The experiment consisted of 7 treatments for each soil and three replications. The experiment was conducted in a completely randomized design. Forty-two plastic pots were required. Each pot was filled with 5.0 kg soil. The calcium as gypsum was added as per treatment mentioned above. Amendment and the soils were thoroughly mixed and allowed to equilibrate for a week. Nitrogen, phosphorus and potassium were applied to these pots at the rate of 100 kg N, 67 kg P_2O_5 and 67 kg K_2O per ha. Nitrogenous and other fertilizers were applied as basal dose to avoid salinity – fertility interactions during the later stages of kallar grass development.

The equilibrated soils were analysed for electrical conductivity, pH and exchangeable sodium. Kallar grass was planted on August 8, 1975 and a constant quantity of water was maintained in each pot. Forty-five days old kallar grass plants were harvested and the dry matter yield was recorded. Representative soil samples were taken after the harvest of crop from each pot. Electrical conductivity, pH and exchangeable sodium were estimated.

RESULTS AND DISCUSSION

Taken as a measure of changes that occurred in equilibrated medium, the values of gypsum potential for two soils are presented in Table 2.

Analogous to the lime potential for acid soils, the term gypsum potential can be used as an index of gypsum requirement and is the negative logarithm of the ratio of sodium ion activity to square root of calcium ion activity in soil solution, i.e. pNa – 1/2 pCa.

The gypsum potential (pNa – 1/2 pCa) data indicate that values for control were 0.168 and 0.083 for soils I and II, respectively. The values decreased with increasing level of gypsum application because of exchange reaction between applied calcium and sodium dominant soil exchange complex. The gypsum potential values became zero at a certain level of calcium and thereafter became negative. The zero gypsum potential (i.e. pNa – 1/2 pCa) was recorded when 7.3 and 6.3 me of calcium were applied in soils I and II respectively. A zero gypsum potential value would mean that no more gypsum is needed for reclamation. The

Table 2. Gypsum Potential (pNa – 1/2 pCa) and Activity Ratio (AR_{Na-Ca})

Treatment	Soil I		Soil II	
(Ca me/100g Soil)	pNa -1/2 pCa	AR_{Na-Ca}	pNa-1/2 pCa	AR_{Na-Ca}
0	0.168	0.679	0.083	0.815
1	0.128	0.744	0.053	0.875
2	0.122	0.756	0.050	0.891
4	0.065	0.861	0.015	0.966
8	–0.015	1.041	–0.004	1.009
12	–0.037	1.089	–0.023	1.056
GR*	–0.052	1.128	–0.017	1.039

* Gypsum requirements in soils I and II were 16.2 and 12.0 me calcium / 100 g soil.

values obtained on the basis of gypsum potential were approximately half of those values obtained on the basis of gypsum requirement.

Activity ratios are also given in Table 2. The activity ratios were 0.679 for soil I and 0.815 for soil II in case of 0 me Ca per 100 g soil treatment. The activity ratios increased as gypsum application increased. The activity ratios attained a unit value when zero gypsum potential values were recorded for both soils under study. A unit activity ratio or AR_{Na} – Ca value of 1.0 indicate equal activity of both Na and Ca ions in soil solution. Such conditions indicate the situation in whcih sodium ion activity no longer dominates in the soil solution. The amount of gypsum applied to bring about such conditions means the minimum amount of amendment necessary for the reclamation of sodic or saline – sodic soils. This indicates that solution phase of equilibrated soil is important parameter with regard to exchange complex of soil under investigation. As early as 1954, U.S Salinity Laboratory staff observed that Sodium Adsorption Ratio $[(Na/(Ca + Mg)^{1/2}]$ $mml^{o}CL^{-1}$ was highly correlated with the proportion of exchangeable sodium adsorbed by the exchange complex.

Dry matter yield of kallar grass for two soils is presented in Fig. 1. It is evident that gypsum application upto the the level of 8 me Ca/100 g soil in soil I and 4 me Ca/100 g soil in soil II, the yield of kallar grass increased with increasing levels. Among all treatments 8 me of calcium level in soil I (a level approximately equal to zero gypsum potential) gave the highest yield of 20.4 g per pot (yield average of three replications). The yield decreased in treatments where calcium was applied at levels higher than that of zero gypsum potential. In the case of soil II the maximum yield of 13.2 g was obtained at 4 me of calcium level and the minimum was recorded at 12 me of calcium level (gypsum requirement for this soil was also 12 me of calcium). The

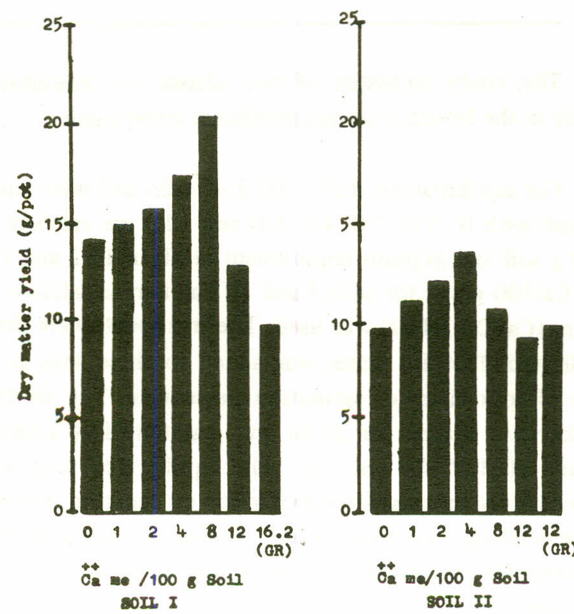

Fig. I. Dry matter yield of "kalllar grass as affected by different levels of gypsum application."

decrease in growth at a higher level of gypsum application than gypsum level at zero gypsum potential may be attributed to excessive salt concentration in soil solution, which was detrimental to plant growth [3,5].

The changes observed in electrical conductivity, pH and exchangeable sodium status of two soils are presented in Table 3. Electrical conductivity estimated after harvest of "Kallar" grass was lower compared to that of equilibrated soils before sowing of the crop. This decrease was attributed to the fact that kallar grass utilized some of the soluble salts. However the salt decrease was not much as the experiment was conducted in lowland conditions. It is possible that substantial decrease in electrical conductivity and other soil properties could have occurred if leaching

Table 3. Chemical changes in soils after the harvest of kallar grass

Treatment Ca me/100 g	Soil I						Soil II					
	pH		EC_e (dsm^{-1})		Exchangeable Na (me / 100 g Soil)		pH		EC_e (dsm^{-1})		Exchangeable Na (me /100 g Soil)	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
0	8.32	8.10	35.06	33.50	7.56	7.18	7.85	7.50	43.00	42.50	5.90	5.66
1	8.17	8.05	38.52	35.60	6.77	6.43	7.68	7.40	45.48	43.60	5.39	5.17
2	8.10	8.00	40.30	37.40	6.12	5.81	7.38	7.30	48.20	46.00	4.92	4.68
4	8.01	7.85	44.80	41.60	5.59	5.33	7.50	7.30	54.72	49.80	4.46	4.25
8	7.95	7.80	56.32	51.37	4.82	4.52	7.47	7.20	68.00	63.50	3.29	3.15
12	7.90	7.75	66.00	62.50	4.19	3.97	7.37	7.10	72.48	68.80	3.27	2.18
GR*	7.90	7.75	68.48	63.50	3.98	3.77	7.37	7.10	71.72	62.00	2.16	2.07

*Gypsum requirement in Soil I and II was 16.2 and 12.0 me Ca / 100g Soil.

facility was provided in the system. A decrease in the pH of both soils was also observed. The exchangeable sodium concentration also decreased at each level of gypsum applied and was lower than that observed in equilibration studies.

The study thus indicates that kallar grass can serve as first plant colonizer in such salt affected soils. To a certain extent, plants remove salts through nutrient uptake. Moreover plants modify physical characteristics of soil [2], should the beneficial effect of cropping on reclamation because of improvement in the physical conditions of the soil.

It is therefore concluded that a higher yield of kallar grass can be attained at calcium level approximately equal to the level of calcium at zero gypsum potential. Further, for the reclamation of saline – sodic and sodic soils, amendment needs to be used in optimum amount, otherwise excessive salt concentration may develop, especially in heavy textured soils with inadequate drainage and may result in decreased plant growth.

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