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Changes in Water-soluble and Exchangeable Ions in Saline Sodic Soils Under Reclamation

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ABSTRACT

The change in the concentration of cations, with time, of alkali and saline soils under reclamation was investigated in a pot culture experiment with PVR. 1 and CO. 32 paddy for alkali soils, and SR 26 B and CO. 32 for saline soils. Alkali soils were treated with either 5 tonnes of gypsum or 5 tonnes gypsum plus 5600 kg green manure per hectare. Saline soil was leached with water either alone or with green manure. Gypsum alone was as efficacious as gypsum plus green manure in increasing exchangeable calcium of alkali soils and decreasing exchangeable sodium by about 50 per cent in 10 days. The decrease in exchangeable sodium was still higher at 30th and 45th days. Increase in exchangeable calcium was higher in open textured alkali soil than in close-textured soils. Close relationships between water-soluble and exchangeable calcium and sodium were observed. In the saline soil water-soluble calcium decreased from 0.029 to 0.097 per cent, and water soluble sodium decreased from 0.7 to 0.09 per cent by about 4th day of leaching. Green manure application for the saline soil was not beneficial.

INTRODUCTION

The reclamation of alkali soils chiefly consists of the removal of sodium ions from the exchange complex, and the soluble salts are to be removed to reclaim the saline soil. The presence of soluble calcium salts in the former type of soil aid in its reclamation. Gypsum either alone or combined with green manure was reported to be effective in reducing the exchangeable sodium of alkali soils by several workers (Meenakshisundaram, 1960; Kanwar and Chawla 1963; Taha *et al.*, 1966). However, in the amelioration of these problem soils it would be very useful to have a definite idea as to the pattern of changes in various chemical constituents notably cations in water-soluble and exchangeable forms with time as a result of reclamatory measures. In the present study an attempt was made to obtain such information and the results are presented.

MATERIALS AND METHODS

A pot culture experiment was conducted on alkali soils of Namagiripet, Kaveripatnam and Kallakurichi of

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TABLE 1. Mechanical Analysis (On moisture free basis)

Soil	Moisture %	Coarse sand %	Fine sand %	Silt %	Clay %
Namagiripet	4.0	28.4	16.6	12.4	33.6
Kaveripatnam	1.7	44.5	22.3	11.8	11.5
Kallakurichi	2.9	25.7	25.9	9.5	24.9
Tiruvadanai	0.7	56.6	31.1	2.5	6.2

TABLE 2. Physical constants

Soil	Specific gravity	Pore space %	volume expansion %	Water-holding capacity %
Namagiripet	1.8	67	81.2	92.4
Kaveripatnam	2.8	51	16.9	45.9
Kallakurichi	1.8	62	74.2	71.9
Tiruvadanari	2.4	43	7.9	29.8

Tamil Nadu State with two treatments viz. 1. gypsum at 5 tonnes/ha and 2. gypsum at 5 tonnes/ha and green manure (*Glyricidia* sp) at 5600 kg/ha. Each treatment was replicated twice. Two rice varieties, PVR. 1 and Co.32, were grown as test crops. Seven kg of the respective soil was taken in each pot and P_2O_5 each at 34 kg/ha were applied and the rice seedlings transplanted at 10 seedlings/pot in 5 hills.

Another pot culture study on th saline soil of Tiruvadanai was con ducted with two treatments viz. 1 green manure (*Glyricidia* sp.) at 560 kg/ha combined with leaching o alternate days and 2. leaching alon on alternate days. Each treatment wa replicated twice. SR. 26 B and Co. 3 paddy were grown as test crops Nitrogen and phosphorus fertilizer were applied at the same rates as fo alkali soils and the rice seedlings wer

TABLE 3. Water soluble cations (%)

Treatment	Soil	Variety	Days						
			Untreated	4	10	20	30	45	115
Water-Soluble Calcium									
	Namagiripet		0.010						
T_1		PVR. 1		0.008	0.007	0.006	0.006	0.009	0.005
T_1		Co. 32		0.006	0.010	0.005	0.009	0.007	0.005
T_2		PVR. 1		0.007	0.009	0.011	0.007	0.009	0.005
T_2		Co. 32		0.006	0.010	0.007	0.009	0.011	0.006
	Kaveripatnam		0.012						
T_1		PVR. 1		0.013	0.011	0.009	0.013	0.017	0.019
T_1		Co. 32		0.014	0.012	0.009	0.012	0.019	0.017
T_2		PVR. 1		0 010	0.013	0.009	0.016	0.019	0.017
T_2		Co. 32		0.011	0.013	0.011	0.014	0.016	0.016
	Kallakurichi		0.006						
T_1		PVR. 1		0.007	0.007	0.005	0.008	0.006	0.006
T_1		Co. 32		0.007	0.008	0.006	0.008	0.007	0.006
T_2		PVR. 1		0.005	0.008	0.006	0.009	0.007	0.008
T_2		Co. 32		0.005	0.009	0.007	0.014	0.009	0.010
	Tiruvadani		0.029						
T_3		SR. 26 B		0.010	0 006	0.005	0.008	0.008	0.010
T_3		Co. 32		0.006	0.006	0.006	0.007	0.003	0.010
T_4		SR. 26		0.006	0.006	0.007	0.010	0.007	0.010
T_4		Co. 32		0.007	0.006	0.006	0.009	0.008	0.008

Table 3 (Cntinued)

	Water-soluble Sodium								
	Namagiripet		0.078						
T_1		PVR. 1		0.100	0.101	0.075	0.083	0.096	0.083
T_1		Co. 32		0.112	0.122	0.084	0.091	0.109	0.084
T_2		PVR. 1		0.103	0.119	0.107	0.098	0.111	0.086
T_2		Co. 32		0.112	0.118	0.098	0.091	0.103	0.083
	Kaveripatnam		0.106						
T_1		PVR. 1		0.122	0.006	0.083	0 090	0.084	0.050
T_1		Co. 32		0.104	0.109	0.079	0.085	0.077	0.041
T_2		PVR. 1		0.104	0.112	0.071	0.065	0.074	0.060
T_2		Co. 32		0.121	0.093	0.067	0.055	0.063	0.043
	Kallakurich		0.052						
T_1		PVR. 1		0.076	0.104	0.094	0.006	0.096	0 019
T_1		Co. 32		0.085	0.103	0.086	0.102	0.091	0.094
T_2		PVR. 1		0.068	0.103	0.083	0.112	0.088	0.081
T_2		Co. 32		0.074	0.114	0.088	0.105	0.097	0.076
	Tiruvadanai		0.700						
T_3		SR. 26 B		0.034	0.051	0.055	0.049	0.050	0.025
T_3		Co. 32		0.070	0.043	0.058	0.055	0.055	0.030
T_4		SR. 26 B		0.092	0.082	0.061	0.066	0.057	0.043
T_4		Co. 32		0.091	0.080	0.064	0.076	0.056	0.067

TABLE 4. Exchangeable cations [m. e./100 g.]

Treatment	Soil	Variety	Untreated	Days 4	10	20	30	45	115
			Exchangeable Calcium						
	Namagiripet		10.5						
T_1		PVR. 1		12.7	18.6	15.9	17.9	18.7	13.3
T_1		Co. 32		12.3	18.9	15.3	15.8	17.5	14.3
T_2		PVR. 1		12.5	16.8	17.0	17.8	17.8	16.8
T_2		Co. 32		13.8	17.2	16.1	17.7	16.5	16.4
	Kaveripatnam		10.5						
T_1		PVR. 1		10.4	15.4	17.3	18.3	19.1	14.5
T_1		Co. 32		12.5	16.3	15.8	18.6	17.7	15.4
T_2		PVR. 1		10.8	15.6	17.7	18.2	17.4	15.8
T_2		Co. 32		12.4	16.8	16.3	18.5	18.5	16.2
	Kallakurichi		6.4						
T_1		PVR. 1		8.2	11.9	15.6	12.8	12.4	11.4
T_1		Co. 32		7.6	12.3	11.7	13.9	13.5	11.6
T_2		PVR. 2		8.1	12.2	12.9	14.8	14.0	12.0
T_2		Co. 32		9.4	11.9	13.5	12.4	15.0	13.0
	Tiruvadanai		9.4						
T_3		SR.26B		7.9	9.2	8.1	10.0	10.7	10.2
T_3		Co. 32		9.3	8.5	7.1	9.1	10.4	8.7
T_4		SR.26B		7.6	9.8	8.2	10.1	11.7	10.2
T_4		Co. 32		7.8	8.9	7.1	10.0	10.4	0.6

Table 4 [Continued]

Exchangeable Sodium

Namagiripet		15.00						
T_1	PVR. 1		12.3	6.5	9.6	5.7	5.3	9.5
T_1	Co. 32		12.9	5.8	8.6	6.8	4.9	9.0
T_2	PVR. 1		13.6	7.3	8.1	5.0	6.5	8.6
T_2	Co. 32		11.5	5.8	8.4	3.8	4.8	8.6
Kaveripatnam		8.3						
T_1	PVR. 1		7.8	3.7	3.9	1.6	1.0	5.4
T_1	Co. 32		7.5	2.7	5.7	1.5	1.7	3.2
T_2	PVR. 1		7.8	3.2	3.7	1.7	0.9	3.3
T_2	Co. 32		6.4	3.2	3.5	2.3	0.9	2.9
Kaliakurichi		13.1						
T_1	PVR. 1		12.2	6.8	9.0	3.8	7.4	8.7
T_1	Co. 32		12.1	6.3	7.6	3.0	6.2	6.3
T_2	PVR. 1		10.9	7.3	7.5	2.9	5.0	6.7
T_2	Co. 32		11.1	4.6	6.9	3.7	3.9	5.7
Tiruvandanai		2.4						
T_3	SR. 26B		3.0	2.6	1.8	0.7	0.6	2.0
T_3	Co. 32		3.0	2.5	2.1	1.1	0.7	2.4
T_4	SR. 26B		3.2	1.9	1.5	0.6	0.6	1.7
T_4	Co. 32		3.2	1.9	2.3	1.5	1.5	2.6

T_1 = Gypsum T_2-Gypsum + Green manure T_3-Leaching T_4-Leaching + Green manure transplanted on the 4th day of application of green manure.

Soil samples were drawn from all the pots on the 4th, 10th, 20th, 30th, 40th and 115th days of application of amendments. The samples were analysed for texture by the International Pipette method (Piper, 1966), physical constants by Keen-Raczkowski box measurements, calcium by versenate titration and sodium by flame photometer (Richards, 1954)

RESULTS AND DISCUSSION

The analytical data for mechanical analysis are presented in Table 1, physical constants in Table 2, water-soluble calcium and sodium in Table 3, and exchangeable calcium and sodium in Table 4.

Of the three alkali soils, Namagiripet and Kallakurichi soils could be classified under sandy clay loams, and that of Kaveripatnam soil under sandy loam. Tiruvadanai saline soil was distinctly sandy. High volume expanison of Namagiripet and Kallakurichi soils revealed that these soils contained higher amounts of clay than Kaveripatnam soil.

Water-soluble Calcium

From the data it could be seen that there was a decrease in the water-soluble calcium content of Namagiripet soil from the fourth day of the applic-tion of amendments, while Kallakurichi soil showed no marked difference throughout the crop growth. The decrease in the calcium content of Namagiripet soil may be due to the adsorption of water-soluble calcium on the exchange complex in the process of replacement of exchangeable sodium as this soil had the highest exchangeable sodium followed by Kallakurichi and Kaveripatnam soils. However, an increase in the calcium content was observed in Kaveripatnam soil from the 30th day onwards. This may be due to the favourable texture of this soil which permits good water movement and solubilisation of applied gypsum. A significant correlation ($r = 0.957^{***}$) was observed between the 4th and 115th day values of calcium. This indicates that the calcium content of the soil at 115th day could be predicted even from the initial values. Significant correlation ($r = 0.447^{*}$) was also observed between water-soluble calcium and exchangeable calcium (Periaswamy, 1967). Thus an increase in the water-soluble calcium by the application of gypsum will increase the exchangeable calcium content of the soil which in turn facilitate the removal of exchangeable sodium.

The water-soluble sodium content of Tiruvadani saline soil decreased from 0.029 to 0.007 per cent within four days of leaching. There was not much significant difference between leaching and leaching combined with green manure. This shows that the soluble salts from sandy saline soils could easily be leached out by mere application of water in a very short period.

Water-soluble Sodium

Considerable increase in sodium was observed at 4th and 10th days in Namagiripet and Kallakurichi soils.

The increase was, however, less during the other periods, and the 115th day values were higher than the initial content of the untreated soil. There was not considerable increase in the sodium content of Kaveripatnam soil during the 4th and 10th days. This soil showed a decrease of sodium from the 20th day and the 115th day values were nearly half the initial value of the soil. The increase in the water-soluble sodium content of Namagiripet and Kallakurichi soils may be attributed to the high content of exchangeable sodium in these soils and its removal by calcium through the application of gypsum. The very low content of sodium in Kaveripatnam soil at 115th day may be due to the removal of sodium by percolating waters facilitated by its open texture. Higher sodium content of Namagiripet and Kallakurichi soils at 115th day may be attributed to the high clay content of these soils and poor permeability to percolating waters. Thus open textured soils could easily be reclaimed than close textured soils.

A highly significant correlation was obtained between water-soluble and exchangeable sodium ($r = 0.747$ ***) for alkali and saline soils taken together indicating that an increase in water-soluble sodium may lead to an increase in the exchangeable sodium content of soils.

Water-soluble sodium content of the saline soil decreased from 0.7 to 0.09 per cent by about the fourth day of leaching. There seemed to be remarkable difference in the sodium content between 10th and 45th days. However, a decrease of 11 times of the initial sodium content of the soil was seen at 115th day. Leaching with water alone was as efficient as leaching plus green manure in removing sodium from the soil (Periaswamy, 1967). Thus the sodium salts of saline soils could be removed by mere leaching with water and the application of green manure to these problem soils produce no beneficial effect.

Exchangeable calcium

Application of gypsum alone or gypsum combined with green manure increased the exchangeable calcium of Namagiripet, Kaveripatnam and Kallakurichi alkali soils from 10.5 to 18.9, 10.0 to 16.8 and 6.4 to 12.3 m.e./100 g soil respectively within 10 days. There was an increase in the calcium content of Kaveripatnam soil at 20, 30 and 45th days while the Namagiripet and Kallakurichi soils did not show much increase at the above stages. This may be attributed to the good permeability of Kaveripatnam soil for water which in turn facilitate the solubility of applied gypsum and consequent adsorption of calcium on the exchange complex. There was no significant differences among the treatments gypsum or gypsum plus green manure and the varieties PVR. 1 and CO. 32 in increasing the exchangeable calcium. It would, therefore, be advantageous to apply gypsum alone for the amelioration of alkali soils. This is in accordance with the findings of Puntamkar *et al.* (1972).

The saline soil had an exchangeable calcium of 9.4 m.e./100 g. soil. There was no appreciable change throughout the experiment. Mere leaching alone could not effect any change in the exchangeable calcium content of saline soil.

Exchangeable Sodium.

Alkali soils of Namagiripet, Kaveripatnam and Kallakurichi had an exchangeable sodium content of 15.0, 8 3 and 13.1 m.e/100g soil. Both gypsum plus green manure have decreased the exchangeable sodium content of these soils by about 50 per cent in 10 days. The decrease of exchangeable sodium at 30th and 45th days were still higher. This is partly in accordance with the findings of Kanwar and Chawla (1963). As in the case of exchangeable calcium there was no significant difference among the treatments and the rice varieties in decreasing the exchangeable sodium of these soils. Evidently gypsum application alone would be economical in the reclamation of sodic soils.

A highly significant positive correlation (r = 0.89 ***) obtained between the 4th and 115th day data show that the decrease in exchangeable sodium follows a regular pattern. Guruswamy (1963) obtained such high relationships for the initial and 30th day content of available, ammoniacal and total nitrogen.

Saline soil had an exchangeable sodium of 2.4 m.e./100 g. Leaching alone or combined with green manure application did not cause much decrease of exchangeable sodium due to the sandy nature of the soil.

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REFERENCES

GURUSWAMY, M. 1963. *Study of chemical transformations in paddy soils of Madras State in relation to cropgrowth and yield.* M. Sc. (Ag.) Dissertation, Madras Univ.

KANWAR, J. S. and V. K. CHAWLA. 1963. Comparative study of the effect of gypsum and pressmud on physico-chemical properties of saline alkali soils. *J. Soil Water Conserv. India* 11 : 95–106.

MEENAKSHISUNDARAM, P. C. 1960. *Studies on alkali soil amelioration with amendments.* M. Sc. (Ag.) Dissertation, Madras Univ.

PERIASWAMY, S. P. 1967. *Studies on saline and alkali soils of Madras State.* M. Sc. (Ag.) Dissertation, Madras, Univ.

PIPER, C. S. 1966. *Soil and Plant Analysis.* Hance Publishers, Bombay.

PUNTAMKAR, S. S., P. C. MEHTA and S. P. SETH. 1972. Effect of gypsum and manure on the growth of wheat irrigated with bicarbonate rich water. *J. Indian Soc. Soil Sci.* 20 : 281–5.

RICHARDS, L. A. 1954. Diagnosis and improvement of saline and alkali soils, U. S. D. A. Hand Book No. 60.

TAHA, S. M., S. A. Z. and A. N. IBRAHIM. 1966 Effect of reclamation of alkali soils on some chemical and microbiological properties in U. A. R. *J Microbiol. U. A. R.* 1 : 73-84