

RECLAMATION OF TWO SALT-AFFECTED SOILS IN ZULULAND

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Abstract

An alkali soil in Zululand was treated with (a) gypsum and (b) sulphur and the effects followed by regular soil analysis. Cane yield was greater on the sulphur treated plot, but both treatments had similar beneficial effects, pH and ESP being greatly reduced. Possible reasons for the superior growth on the sulphur plot are discussed.

Soil from a saline-alkali site described was used to make up three leaching columns: (a) control, (b) sulphur treated and (c) gypsum treated. Water acceptance and transmission was greatest in (b) followed by (c). In nine months no leachate was collected from (a). Leachate from (b) contained quantities of salts initially, but pH increased from 4.1 to 9.4 over a few months. It is suggested that a reclamation procedure for this soil would be drainage, followed by sulphur and then a gypsum dressing.

Introduction

In arid areas, irrigation is frequently undertaken without proper provision being made for drainage of the additional water and soluble salts. As a result, the water table may rise to the extent that ground waters move upward to the soil surface, where the salts are concentrated by evaporation. The use of poor quality irrigation water, rich in soluble salts, may aggravate this process of salinization. The soil which results is termed *saline* and has the following properties (2): $EC_e^* > 4$ mmhos, ESP (Exchangeable sodium percentage) < 15 , $pH < 8.5$.

Evaporation and water use by plants may concentrate the soil solution to the stage where the solubility limits of the calcium and magnesium salts are exceeded, and these are precipitated with a corresponding increase in the relative proportion of sodium. Sodium will then replace part of the calcium and magnesium on the colloid complex, and this may continue until sodium exceeds 15% of the total exchange capacity. Such a soil is said to be *saline-alkali*, with pH values seldom exceeding 8.5, and $EC_e > 4$ mmhos. If the concentration of salts in the soil solution is now lowered (by leaching and drainage, for example), the Na-colloid complex may tend to hydrolyse, resulting in the formation of NaOH. The soil becomes strongly alkaline, the particles tend to disperse, and water entry and movement in the soil becomes very difficult. Such a soil, having $EC_e < 4$ mmhos, $ESP > 15$, $pH > 8.5$, is termed *alkali*.

The existence and gradual spread of saline and alkali soil conditions in the sugar growing areas of South Africa has been noted previously^{1, 5, 6}. Reclamation studies are being carried out on two such salt-affected soils occurring in the Nkwaleni Valley region of Zululand, and preliminary results of this work are now reported.

1. The alkali site

The alkali soil studied had developed in a low area about 20 x 20 yards in extent in a saline-alkali field which had been drained and planted to cane. Surface irrigation was practised and the more intense leaching over this low area was a possible cause of the alkalization. The soil is described as a brackish, medium sandy loam, Estcourt series, derived from Middle Ecca shale.

The alkali site was divided into two 20 x 10 yard areas, the cane, which was four months old at the time (March, 1968), having a poor appearance overall. Gypsum at five tons per acre (approximate cost: R9 per ton) was broadcast over the one half and sulphur at 1 ton per acre (approximate cost: R55 per ton) over the other, these amendments being hoed into the soil. Duplicate soil samples were taken from the first and second 9 inches in the interrow in both plots before application of the treatments and at approximately monthly intervals thereafter.

Results

Generally poor growth of cane occurred during the first few months, with little difference between the treatments. By the end of June, 1968, however, a marked improvement in cane on the sulphur plot was apparent. Growth on the gypsum treated plot continued to be poor by comparison, the adjacent cane being taller, more dense, and with a healthier dark green appearance. At 14 months the cane was harvested, the yield figures being as follows:

Sulphur treated plot . . . 67.5 tons/acre
Gypsum treated plot . . . 53.5 tons/acre

Details of the soil analyses are shown graphically in Figure 1.

Discussion and conclusions

The gypsum effected an immediate reduction in soil pH, probably by blocking the further hydrolysis of the Na-colloid, while the sulphur achieved a similar end effect, but was slower acting due to the time required for its oxidation. ESP was greatly reduced by both treatments, while EC_e rose slightly, the increase on the gypsum plot being the greater, as expected. Figure 1 illustrates the beneficial effect of both amendments in reclaiming this soil, but does

* EC_e = Electrical conductivity of a saturation extract at 25°C.

not provide any explanation for the improved growth on the sulphur plot. The treatments may, however, have influenced plant growth in other ways, for example by affecting nitrogen mineralisation. Sindhu and Cornfield⁴ found in a laboratory study that mineralisable N was particularly reduced on reclamation of an alkali soil with gypsum, and suggested that this was due to a considerable loss of easily mineralisable organic nitrogen compounds.

As found in the leaching tests discussed later in this paper, sulphur may effect a more rapid improvement in soil physical conditions than gypsum. The better plant growth may thus have resulted from the enhanced soil aeration and drainage. Another possibility is the fungicidal effect of the sulphur which may have suppressed soil pathogens in the rhizosphere³. To establish precise effects and mechanisms, a full scale trial is clearly necessary.

2. The saline-alkali site

The area involved was 2-3 acres of gently sloping boulder-bed derived sandy clay loam which had been salinized by ground waters percolating down-slope from a storage dam. The degree of salinization varied considerably over the area, and the data in Table I refer to a profile in a more highly salinized section. The entire site has been drained and allowed to lie fallow, but regular sampling over the past 18 months has shown little change in the soil conditions. As it was not possible to undertake a full-scale reclamation programme, a laboratory test is being carried out to examine the effects of various amendments on this soil.

Soil from the depth intervals shown in Table I was air dried and crushed to pass a 2mm sieve. Brass cylinders 2 ft. long by 2½ ins. diameter were packed with this soil in the same order and to the same

depths as in the field. The lower ends of the cylinders were covered with nylon gauze and the cylinders clamped vertically, resting in Buchner funnels. Sulphur was applied to the surface of one soil at a rate equivalent to 1 ton per acre and gypsum to another at 5 tons per acre and lightly "dug" into the top few inches of soil. A third cylinder received no amendments and acted as a control. Distilled water (200 ml) was added to each column, additions of 50 ml being made whenever the free water had drained away. The volume of leachate was measured weekly and analysed as soon as a sufficient quantity had been collected.

Results

The rate at which water was added to the columns is illustrated in Figure 2, together with the outflow data. Table II gives analyses of the leachate samples.

Discussion and conclusions

Although initially more rapid on the gypsum treated soil (soil 2), the rate of acceptance of water by the sulphur treated column (soil 1) increased gradually to exceed that of soil 2 after five months. Outflow from column 1 commenced several weeks earlier than from column 2 and continued at a far greater rate. Generally the sulphur appears to have effected a more rapid improvement in the soil physical conditions. It is noteworthy that, during the first nine months of the test, no leachate has been collected from the control column.

The quantity of salts removed from soil 1 was considerable at first, the total sodium leached from this column being equivalent to 7.7 g NaCl (total sodium present in the column initially was equivalent to 22.7 g NaCl). The rate of removal of salts

TABLE I
Analysis of the saline-alkali soil profile at various depths

Depth (inches)	EC _e	pH	ESP	Na (meq.%)	P (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)	Mechanical composition (%)				
									Clay	Silt	F.sand	M.sand	C.sand
0-1	50.0	7.60	100	27.0	21	94	1,100	1,600	21	4	17	20	25
1-2	22.0	8.00	100	20.9	13	137	1,300	1,800	31	8	16	18	22
2-4	9.8	8.40	96	12.6	18	108	900	1,400	29	6	18	20	24
4-6	6.8	8.15	74	11.3	7	115	950	980	31	6	17	19	26
6-9	6.2	7.90	82	13.0	5	108	950	920	35	4	16	16	24
9-12	3.6	8.10	77	13.0	4	115	1,100	900	39	6	18	16	22
12-15	9.2	8.15	78	14.3	9	115	1,150	860	39	6	15	17	22
15-18	4.5	8.20	87	17.4	12	132	1,350	1,020	41	8	14	16	18
18-21	4.6	8.20	64	15.2	16	162	1,550	880	39	17	13	12	13

TABLE II
Analysis of leachate from the saline-alkali soil columns treated with sulphur or gypsum

Treatment	Date	ml collected	Conductivity (mmhos)	pH	Na (ppm)	Ca (ppm)	Mg (ppm)	K (ppm)
Sulphur (1 ton/acre)	27-11-1968	80.5	77,000	4.10	20,000	1,680	4,600	10.2
	8-1-1969	74.0	30,700	7.05	9,000	350	960	21.0
	20-1-1969	90.5	12,490	8.85	4,200	170	205	2.7
	7-2-1969	60.5	5,500	9.35	1,880	54	50	9.4
	21-2-1969	49.5	5,500	9.40	1,600	36	32	8.2
	14-3-1969	59.0	4,700	9.35	1,720	32	22	10.2
Gypsum (5 ton/acre)	12-3-1969	52.7	85,000	6.00	16,000	3,200	4,600	28.0

decreased steadily, however, while the pH of the leachate increased from 4.1 to 9.4 over the three months.

Leachate from the gypsum column was also rich in salts, but this treatment was clearly less effective. Based on results to date, it appears that sulphur should be used to reduce the soil pH and rapidly improve the soil physical condition. Despite its high calcium content, such a soil may develop alkalinity on leaching, and it is suggested that the application of sulphur (1-2 tons per acre) followed by gypsum (4-5 tons per acre) would be the most effective approach in this case. Leaching of a soil so treated should result in the rapid removal of excess sodium and its replacement with calcium, thus bringing about the return of favourable chemical and physical soil conditions.

It is proposed that studies with these leaching columns continue in an effort to forecast responses to various field treatments on similar soils. However, a replicated trial to test the efficacy of the treatment proposed above, and others, would clearly be of greatest value.

References

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Discussion

Dr. Thompson: I am surprised at the rapid plant response to elemental sulphur applied to the soil.

Mr. von der Meden: It is quickly oxidised and immediately thereafter reduces the pH in the soil. Figure I shows that the gypsum had an even quicker effect in reducing pH, however.

Dr. Sumner: Could not the beneficial effect of sulphur, compared to gypsum, on the alkali soil be due to it creating localised areas of very acid soil? Only an average pH is being measured. The localised areas could be making some trace element more available and thus promoting better plant growth than the gypsum.

Mr. von der Meden: I think such a localised effect on trace elements a most likely possibility. There is also a possible effect on nitrogen.

Mr. Meyer: The improvement could be due simply to increased sulphur uptake by the plant.

Mr. von der Meden: It is a possibility but the land had in the past been fertilized with superphosphate.

Mr. Rogers: Was any attempt made to drain the soil?

Mr. von der Meden: In the last two years drains have been dug and although they are working efficiently they do not appear to have resulted in a change in the soil. At present their main purpose is to prevent more water coming into the saline area.

Mr. Tucker: The situation referred to in this paper came about because of water logging and therefore before anything else drainage should be carried out.

Mr. Odendaal: Was not a section that had not been treated at all reaped in order to provide a comparison?

Mr. von der Meden: This was done but not in the alkali site which was only twenty yards square. The surrounding area was saline-alkali and this gave about the same yield as the sulphur treated area.

Dr. Thompson: Another site has been located where it should be possible to put down a statistically designed experiment.

Dr. Dodds: Was the sulphur that was used tested for small quantities of two similar elements — selenium and tellurium?

Mr. von der Meden: No, but it would be interesting to do so.

