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RECLAMATION OF A SALINE-SODIC SOIL IN KHUZESTAN, IRAN[1]

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ABSTRACT

For the reclamation of saline-sodic soils, it is important to have a reliable estimate of the minimum amount of leaching water required to reduce the salinity and sodicity to a desired level. Leaching experiments with 0, 10, 20, 30 and 40 cm of water were conducted at Ramin, Khuzestan to produce the leaching curve and graph and also to estimate the amount of leaching water required for reclamation. Leaching water of more than 20 cm decreased soluble salts and exchangeable sodium percentages (ESP) even at soil depths of 30-50 cm. Due to the high salt content and ESP, none of the treatments changed the soil into a nonsaline-nonsodic condition. The final salinity and ESP values were acceptable for growing salt-and sodium-tolerant crops with no application of chemical treatments. The leaching curve and graph are given for reclamation of Ramin area in Khuzestan, Iran.

INTRODUCTION

Salt-affected soils are distributed mainly in the alluvial area of Iran. Most of the irrigated lands in the plains and low lands are affected by salt to some extent. In Iran, most such soils may be classified as saline-sodic and some as saline (2). Nonsaline-sodic

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soils are rarely found except in some limited areas.

Water is a limiting factor in Iran and is insufficient for use in leaching and irrigation of many salt-affected soils. Exceptions can be found on some saline plains of Khuzestan and a few other places, which have sufficient water to be used for agricultural purposes.

For the reclamation of a saline-sodic area, it is essential to have a reliable estimate of the amount of leaching water required to reduce the salinity and sodicity to a desired level. Empirical approach to this estimation has produced valuable results (4, 5, 6, 8). Hajrasuliha (5) reported that a total of 230 cm of surface ponding water in 25 days lowered the salinity from 14.85 to 2.27 mmhos/cm in the first meter of a soil at Haft Tappeh, Khuzestan. In another site with tile drainage, nearly 410 cm of water was applied in 180 days to lower the salinity of the first 80 cm of soil from 12.8 to 3.8 mmhos/cm. According to Hulsbos and Boumans (6) most of the salt in top 30 cm of Iraqi soils was removed by surface ponding with 20 cm of leaching water.

Objectives of the present investigation were (i) to determine the leaching water requirement for reclamation of saline-sodic soils in Ramin, Khuzestan, (ii) to relate the ratio of drainage water to soil depth and desalinization and (iii) to monitor the changes in ESP as a function of leaching.

MATERIALS AND METHODS

Field leaching trial was conducted at the Agricultural Experiment Station of Jundi Shapur University, located at Ramin 30 km north of Ahwaz, Iran. The experiment was laid out of 10 x 10 m plots, 10 m apart, on a silty loam saline-sodic (2, 3) soil with a tile drainage system of 2m deep and 50 m apart. Leaching treatments were 0, 10, 20, 30 and

40 cm of water in four replicates of a randomized complete block design. Water was applied by ponding the surface. The composition of leaching water is shown in Table 1.

Soil was sampled from four locations of each plot at depths of 0-10, 10-20, 20-35 and 35-50 cm prior to and 24 hours after completion of the leaching process. The electrical conductivity of saturated soil extract (EC_e) was measured by a salt bridge. The exchangeable sodium percentage (ESP) values were determined in samples according to the empirical relationship between sodium absorption ratio (SAR) and ESP as given by the U.S. Salinity Laboratory (9). Some of the soil chemical properties at depth of 0-50 cm are shown in Table 2. More detailed analyses were not available. The free water surface evaporation from class A pan and leaching period were also recorded.

RESULTS AND DISCUSSION

The electrical conductivity of soil samples at different depths after leaching are shown in Table 3.

Leaching with 10 cm of water significantly reduced the EC in 0-10 and 10-20 cm soil layers while the salinity in 20-35 cm was unaffected and that in 35-50 cm increased significantly. Leaching water of 20, 30 and 40 cm significantly reduced the EC in all layers of soil (0-50cm) and indicated a minimum leaching water requirement of 20 cm (Table 3). A similar result was reported by Hulsbos and Boumans (6).

In general, even at the soil surface layer, none of the leaching treatments could lower the soil EC to the non-saline condition (4 mmhos/cm). On the other hand, 20, 30 and 40 cm of leaching water significantly reduced the ESP in all layers of the soil (0-50 cm). The lowest value of ESP (about 15%) occurred in 0-10 cm layer (Table 4). Leaching with 10 cm of water significantly reduced the ESP only in the 0-10 cm soil layer while the

Table 1. Leaching water analysis.

Analysis	Amount
Electrical conductivity	0.9 mmhos/cm
Sodium absorption ratio	2.2
Bicarbonate	5.0 meq./lit
Class	C_3S_1

Table 2. Soil chemical properties at a depth of 0.50 cm.

Analysis	Amount
Carbonate	47%
Gypsum	52.7 meq/100 g
Sulfate in leachate	61.1 meq/lit
Paste pH before leaching	8.4
Paste pH after leaching	7.7
Cation exchange capacity	10.3 meq/100 g
Exchangeable sodium percentage *	33.0

*This figure is the average of the 4 ESP values corresponding to different depths of soil at 0 leaching, taken from Table 4.

Table 3. Electrical conductivity of saturation at various soil depths and leaching treatments.

	Leaching water, cm				
Soil depth	0	10	20	30	40
cm		$EC \times 10^3$	mmhos/cm		
0-10	45.7a*	19.0b	11.7b	7.0b	9.2b
10-20	49.2a	28.3b	12.6c	8.3c	11.7c
20-35	41.6a	37.8a	15.3b	10.6b	17.5b
35-50	25.1b	39.3a	13.5c	11.1c	12.9c

*Means within a row followed by the same letter are not significantly different at 1% level (Duncan's test).

Table 4. Exchangeable sodium percentage (ESP) at various depths and leaching treatments.

	Leaching water, cm				
Soil depth	0	10	20	30	40
cm			Percent		
0.10	32.3a**	22.1b	16.0c	14.8c	14.9c
10-20	36.8a**	34.6a	17.7b	17.9b	21.2b
20-35	34.4a*	40.1a	22.4b	23.3b	27.1b
35-50	29.7b**	44.0a	20.5b	24.2b	28.6b

Means within a row followed by the same letter are not significantly different at 5(*) and 1% (**) levels,respectively (Duncan's test).

ESP values in 10-20 and 20-35 cm layers were unaffected and that in 35-50 cm increased significantly. The increase in ESP in 35-50 cm of soil layer was in accordance with salt accumulation at the same depth of soil under 10 cm of leaching water (Table 3 and 4).

Tables 3 and 4 show that, on a per cm of water basis, 10 cm of applied water was much more effective in leaching salts and reducing ESP in the surface layer of soil than was 40 cm. It is also indicated that 20 cm of water was sufficient to achieve most efficient leaching of salt and ESP reduction. Applications of 30 and 40 cm of water resulted in inefficient use of the water.

The most important tendency was the decrease in ESP with decreasing salinity at a constant pH (Fig. 1). This is the result of soluble calcium salts in soil and leaching water (Table 1 and 2). Similar results have been reported by Boumans and Hulsbos (1). The soils of the experimental site contain high gypsum and calcium carbonate (Table 2). No chemical amendments were required for the reclamation process of this soil. Reduction in sodicity was also reflected in lower pH values after the leaching process (Table 2). The reverse relation is known and explained by hydrolysis provoked formation of sodium hydroxide (1). The practical application of the data in Fig. 1 is that on the basis of only one measurement (EC) with a given pH value the sodicity level of the soil in the experimental region can be predicted.

The average evaporation from the free water surface during the experimental period in April was 7mm/day. The leaching process lasted approximately 10, 25, 48 and 96 hours for 10, 20, 30 and 40 cm water applications, respectively. The soil storage capacity was estimated to be about 0.25 cm of water per cm of soil depth. The ratio of drainage water, D_w, to depth of soil, D_s, (D_w/D_s) for each leaching treatment at different soil depths was calculated. D_w at a specific depth of soil was calculated by subtracting evaporation and soil water storage from the leaching water, applied at the soil surface. Fig. 2 prepared from data of Table 3 (6, 7), shows the values of $(EC_e - EC_{eq})/(EC_o - EC_{eq})$ as a function of

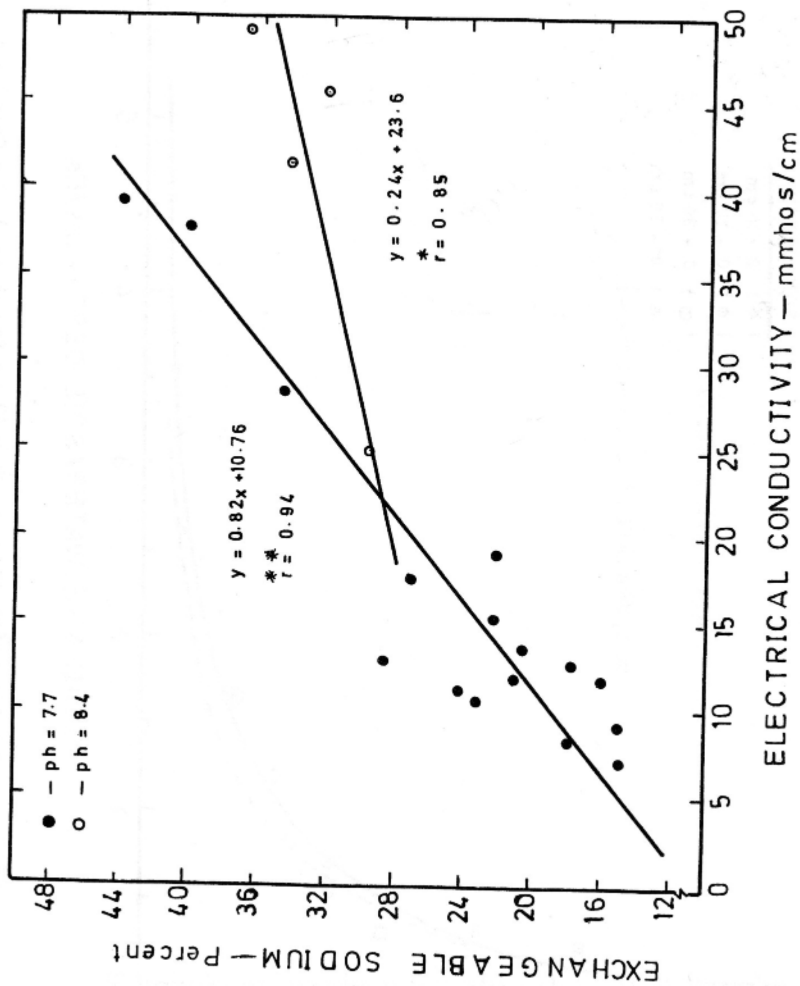

Fig. 1 Relationship between soil salinity and ESP at two constant pH values.

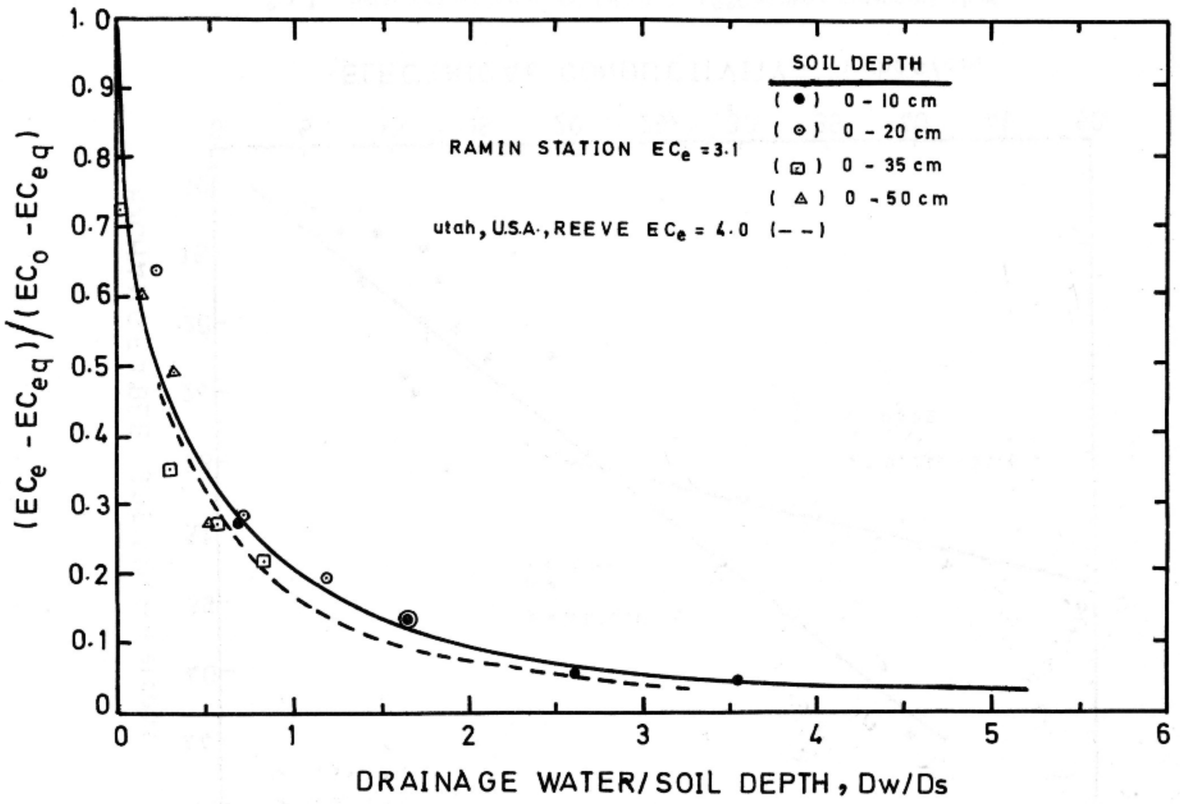

Fig. 2. Leaching curves of the experimental site (Ramin Station) and a soil in Utah, U.S.A.

D_w/D_s. In Fig. 2, EC_o is the EC value of soil before the leaching experiment commenced, EC_{eq} is the equilibrium EC of the soil and EC_e is the EC value of soil after leaching. The value of EC_{eq} represents the final salinity which could be obtained under the actual irrigation practices and complete leaching. In a preliminary trial with more than 40 cm leaching water, EC_{eq} was found to be about 3.1 mmhos/cm. The leaching curve in the ponding condition (Fig. 2) was reported to be dependent upon various soil properties (6). As shown in Fig. 2, Utah soil with silty loam texture (the same as our experimental soil) shows nearly the same leaching curve (7). The result confirmed that soil texture might be one of the important factors in determining the leaching curve (6). The leaching curve, as explained in detail by Hulsbos and Boumans (6), could be used for determining the leaching water requirements to reclaim an area under a particular crop. Using a similar procedure, the leaching graph (Fig. 3) was prepared on the basis of the leaching curve (Fig. 2). This figure shows the ratio of drainage water to soil depth, D_w/D_s, as a function of the salinity before leaching, EC_o, for 5 different levels of salinity tolerance of different crops. For crops less tolerant to saline conditions, more leaching water is required to lower the initial salinity to the desired level (Fig. 3). More leaching water is also required to lower the salinity for a particular crop at higher initial salinity.

The results of this experiment were used in preparation of the leaching curve and graph for Ramin area in Khuzestan, Iran. It was concluded that leaching water of more than 20 cm in the ponding condition, decreased considerably the amount of soluble salt even at soil depth of 30-50 cm. However, due to the high salt content and ESP, none of the treatments could change the soil into a nonsaline-nonsodic condition. But the final salinity and sodicity of 30 and 40 cm leaching treatments were acceptable for growing such salt-tolerant crops as barley, cotton and sugar beet with no chemical amendments (9). The leaching of excess salt might be completed by irrigation practice during the growing season.

For the best results, it is suggested to grow highly salt-tolerant crops or those which can tolerate long periods of leaching without suffering such as barley and rice.

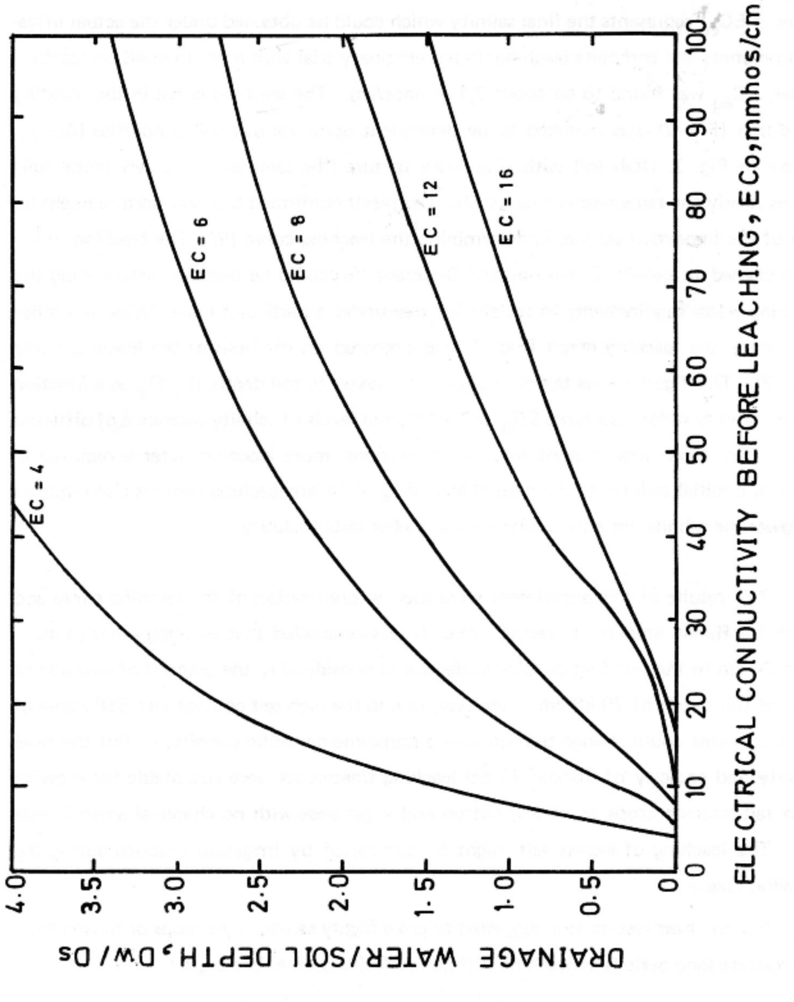

Fig. 3. Leaching graph for Ramin area, Iran.

LITERATURE CITED

1. Boumans, J.H. and W.C. Hulsbos. 1960. The alkali aspect of the reclamation of saline soils in Iraq. Neth. Agr. Sci. 8: 225-235.

2. Dewan, M.L. and J. Famouri. 1954. The soils of Iran,FAO, Rome. p. 234-243.

3. Farazdaghi, H. and A. Kashani. 1974. Effect of irrigation and nitrogen fertilizer on winter sugarbeet at Ramin. Iranian National Committee on Irrigation and Drainage. 13: 7-21 (in Persian).

4. Gardner, W.R. and R.H. Brooks. 1957. A descriptive theory of leaching. Soil Sci. 83: 295-304.

5. Hajrasuliha, S. 1970. Irrigation and drainage practice in Haft Tappeh cane sugar project, Iran. Submitted to Near East-South Asia Regional Irrigation Practices Seminar, Kabul, Afghanistan.

6. Hulsbos, W.C. and J.H. Boumans. 1960. Leaching of saline soils in Iraq. Neth. Agr. Sci. 8: 1-10.

7. Reeve, C.R., L.E. Allison and D.F. Peterson, Jr. 1948. Reclamation of saline-alkali soils by leaching-Delta area, Utah. Utah Agr. Expt. Sta. Bull. 335.

8. Van der Molen, W.H. 1956. Desalination of saline soils as a column process. Soil Sci. 81: 19-27.

9. U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. Agricultural Handbook No. 60.