

The Effect of Tillage on Fertile Sodic and Saline Micro-textured Soil Rehabilitation Process of Southern Khuzestan Lands

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Abstract: Soil rehabilitation is one of the concerns of those involved in the agricultural sector for sustainable development and it is one of the quantitative developments. This study was conducted in Darkhoein region located in Shadegan city in 35 km north of Abadan. To evaluate the soil, the specimens were collected by digging deep profiles at the depths of 0-20, 20-40, 40-60 and 80-100 cm and after its analysis in the laboratory and calculating EC_e, SAR ESP, CEC and... values, the physical and chemical characteristics were studied. The study was conducted as completely randomized block design with 2 treatments (control, tillage) and 3 replications in 1*1 metal plots. The amount of water required for leaching was determined at a rate of 100 cm and at 5 levels. After each step specimens were taken from four depths of soil and the experiments were conducted. Study of the results and statistical analysis showed that tillage process has no desired effect on leaching and it is proposed to use tillage process after leaching to prevent a secondary salinity.

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1. Introduction

The existence of soil soluble salts in the root zone can cause problems such as decreased absorption of water by plants due to reduced osmotic potential of the soil solution and the soil structure degradation due to excessive exchangeable sodium and poisoning against the plant, thus the rehabilitation of saline and alkaline soils is important. On the other hand lack of germination at the beginning of cultivation for various reasons including salt accumulation, especially in the root zone at different depths necessitates leaching process. Leaching of land in areas with saline soils through the necessary measures to increase efficiency is necessary. In some areas with respect to the relatively low alkaline soils' permeability, deep tillage can be useful in accelerating the process of leaching. In this study leaching process in saline and sodic lands is studied by variables such as electrical conductivity, exchangeable sodium percentage, absorbable sodium, soil acidity, calcium and magnesium divalent cations and anions including carbonates and bicarbonates before and after leaching.

As it was expected, tillage enhances the permeability and speeds up the leaching process, thus, in this study the intermittent leaching was used in two treatments. In the first treatment leaching with irrigation and in the second treatment tillage process were used to study the effect of tillage on leaching process. Providing suggested strategies to reduce the

time and used water and to enhance the leaching efficiency were also examined in this research.

Akinori (2006) in Japan studied the effect of tillage on salt movement in rehabilitated soils. He added a large amount of gypsum to the clay soil and performed leaching for a few months to improve the soil physical properties. He studied the soil physical properties and salinity in the surface layer of the tilled soil. His results showed no accumulation of salts in the soil surface layer due to broken capillary tubes through tilling.

Karimi (2008) studied the effect of tillage on the efficiency of leaching saline soils and heavy textured soil in Tabriz plain and concluded that 25 to 30 cm tillage has not been effective in improving the results of soil salinity, it has leached half of the salts at a depth of 45 to 50 cm and at a depth of 75 to 80 cm soil salinity has reached a point that it has no adverse effect on plant growth.

2. Materials and methods:

This research was conducted in Darkhoein region in Shadegan city. The lands are located in the western end of Shadegan plain, eastern part of Karun River, west of Ahvaz – Abadan road and within 35 km north-west of Abadan city.

Experiments were conducted in 2 treatments (with and without tillage) and each treatment was conducted with 3 replications. The required sampling was conducted to study the physical and chemical

properties of soil and water and their changes in different stages of leaching. During the implementation of the experiment after each stage of leaching, four specimens were collected at four depths from each replication and sent to the laboratory. Auger was used to collect the specimens. Soils related to each depth were mixed at each replication and located in a nylon bag on which the soil properties (treatment number and replication) were listed. In the laboratory after preparing the saturated extraction of each soil specimen, the levels of cations and anions and measuring lime and gypsum, the levels of acidity, electrical conductivity, calcium, magnesium and sodium were determined.

The applied water was prepared from Karun River. The depth of water for leaching in these treatments was 100 cm and used in five 20cm replications. Considering the advantages and disadvantages of leaching methods, the available water resources and weather conditions the intermittent leaching method is the best and most practical method of leaching in this study. Moreover, deep tilling process was conducted due to heavy texture and increasing soil permeability. The water level for leaching was estimated as 1 meter water to leach 1 meter soil depth according to preliminary estimates using the Richards model and considering 80% reduction in final salinity compared to the initial state. In this study, the leaching of saline and sodic soils was conducted as completely randomized block design. In the implementation of intermittent leaching method two treatments were considered for 5 different depths of water application including 20, 40, 60, 80 and 100 cm. The considered period in all treatments including the time required for water permeability and achieving the field capacity was 8 days. The depth of leaching the salts from the soil was considered as one meter. Accordingly the soil sampling was conducted up to the depth of one meter at 0-25, 25-50, 50-75 and 75-100 cm.

Dimensions of plots were considered as 1 square meter (1×1) and the distance between them was 4m so

that the interaction between the plots was eliminated. To prevent the lateral permeability of water and its effect on test results a protective 9 m² (3×3m) plot was established around each plot. During the leaching period adequate water was added to the protective plots and it was attempted to keep the water level the same in the model and protective plots. Also to prevent water evaporation, the plots were covered with nylon sheets. Given the size of the plots and the water depth at each leaching the amount of water needed for each plot was estimated as 200 liters. In the first treatment the intermittent leaching along with irrigation was used and in the second treatment it was attempted to perform deep tillage process by ripper. Then the metal and protective plots were installed in the determined locations and leaching began.

3. Results

Before starting the project the specimens were taken at three points and for depths to a depth of one meter. Table 1 shows the results of soil chemical decomposition and Table 2 presents the physical characteristics of the different layers of soil testing and water depth needed to provide soil moisture deficits in each layer to a depth of one meter.

Results of Table 1 show that soil is saline and sodic to a depth of one meter. The level of salinity and sodium is reduced by increasing depth. The average electric conductivity of soil saturated extract was about 83 ds/m to a depth of one meter, moreover the exchangeable sodium percentage values indicate a lack of uniformity in the various layers and the reducing trend from the surface to the sub layers such that it is more than 62% at 0-25 cm layer.

According to the USA Salinity Laboratory classification the tested soil is among the saline and sodic soils. Also based on saline and sodic soils' classification in Iran, the soil under study is located in class S_4 (very high salinity problem) and A_4 (very high sodium problem) in terms of salinity and sodification.

Table 1. Results of chemical analysis of soil samples before leaching

Soil depth (cm)	EC (ds/m)	PH	Gypsum (%)	Na ⁺ (meq/lit)	Ca ²⁺	Mg ²⁺	Total cations	So ₄ ²⁻	Cl ⁻	Hco ₃ ⁻	Total anions	SAR	%ESP
0-25	98.6	8.2	5.3	1328	147	131	1606	204	1408	7	1619	112.64	62.25
25-50	87.1	8.1	5.3	1012	127	117	1256	150	1082	8	1240	91.62	57.24
50-75	76.3	8.1	5.4	721	130	103	954	129	805	8	942	66.8	49.31
75-100	69.7	8.1	5.5	684	100	87	871	118	731	7	856	77.74	50.76

According to figures presented in Table 2 it is observed that moisture deficit has reached a total of 13.17cm to a depth of one meter. Thus, 86.83 cm (100-13.17=86.83) out of 100 cm has been able to exist as depth and gravity permeability from the one

meter profile of the soil and it has led to leaching the salts of the layers.

The results of chemical decomposition of water applied in the leaching are presented in Table 3. The qualitative classification of this water has a very high risk of salinity and moderate sodium risk for irrigation

based on Wilcox chart. The process of desalination in two treatments.

Table 2. The results of physical layer analysis in different soils and water depths required to provide the lack of moisture each layer

Soil depth	Mechanical analysis of soil				Thickness (cm)	Wt% of initial soil moisture content	Bulk density gr/cm ³	Weight % of soil moisture at field capacity (%FC)	Lack of soil moisture to field capacity (cm)
	% Sand	% Silt	% Clay	Soil texture					
0-25	24	43	33	C.L	25	21.36	1.46	37.14	5.76
25-50	28	45	27	C.L	25	21.86	1.49	35.26	4.99
50-75	22	65	13	Si.L	25	22.6	1.62	26.42	1.55
75-100	24	63	13	Si.L	25	23.2	1.65	25.32	0.87

Table 3. The results of chemical decomposition of water applied in the leaching experiments

Classified according to Wilcox chart	SAR	meq/lit									T.D.S)mg/lit (EC)ds/m (PH
		Anions	Hco ₃ ⁻	Cl ⁻	So ₄ ²⁻	Cations	Mg ²⁺	Ca ⁺	Na ⁺				
C4-S2	4.6	27.5	2.5	16	9	29	7	9	13	972	2.37	7.3	

Table 4. Percentage of leached and residual salinity changes in the soil saturated extract in the control treatment

Depth of leaching (cm)	Different depths of soil profile (cm)				Percentage of leached and residual salinity in the soil saturated extract
	0-25	0-50	0-75	0-100	
20	43/81	29/24	17/06	11/03	Leached
	56/19	70/76	82/94	88/97	Residual
40	80/41	64/61	44/08	31/98	Leached
	19/59	35/39	55/92	68/02	Residual
60	90/26	86/81	70/80	57/46	Leached
	9/74	13/19	29/20	42/54	Residual
80	92/98	89/63	81/27	73/87	Leached
	7/02	10/37	18/73	26/13	Residual
100	94/73	92/84	89/82	86/66	Leached
	5/27	7/16	10/18	13/34	Residual
Mean	80.44	72.62	60.61	52.20	Leached
	19.56	27.38	39.39	47.80	Residual

Table 5. Percentage of leached and residual salinity changes in the soil saturated extract in the tillage treatment

Depth of leaching (cm)	Different depths of soil profile (cm)				Percentage of leached and residual salinity in the soil saturated extract
	0-25	0-50		0-100	
20	33/98	22/08	20	4/07	Leached
	66/02	77/92		95/93	Residual
40	48/17	39/90	40	11/98	Leached
	51/83	60/10		88/02	Residual
60	60/85	52/91	60	28/55	Leached
	39/15	47/09		71/45	Residual
80	69/52	63/61	80	42/30	Leached
	30/48	36/39		57/70	Residual
100	81/35	75/90	100	58/20	Leached
	18/65	24/10		41/80	Residual
Mean	58/77	50/88	Mean	29/02	Leached
	41/23	49/12	60/72	70/98	Residual

Process of desodification for both control and tillage treatments and different soil depth for different amounts of leaching.

Table 6. Percentage of leached and residual exchangeable sodium in the soil saturated extract in the control treatment

Depth of leaching (cm)	Different depths of soil profile (cm)				Percentage of leached and residual salinity in the soil saturated extract
	0-25	0-50		0-100	
20	33/91	18/17	20	4/15	Leached
	66/09	81/83		95/85	Residual
40	49/67	34/25	40	12/63	Leached
	50/33	65/75		87/37	Residual
60	71/02	65/76	60	39/74	Leached
	28/98	34/24		60/26	Residual
80	84/26	80/96	80	57/49	Leached
	15/74	19/04		42/51	Residual
100	89/43	88/03	100	69/02	Leached
	10/57	11/97		30/98	Residual
Mean	65/66	57/44	Mean	36/61	Leached
	34/34	42/56	55/23	63/39	Residual

Table 7. Percentage of leached and residual exchangeable sodium in the soil saturated extract in the tillage treatment

Depth of leaching (cm)	Different depths of soil profile (cm)				Percentage of leached and residual salinity in the soil saturated extract
	0-25	0-50		0-100	
20	15/40	10.84	20	0.88	Leached
	84/60	14/89		92.12	Residual
40	38/24	26/27	40	5/19	Leached
	61/76	73/73		94/81	Residual
60	51/13	43/75	60	20/88	Leached
	48/87	56/25		79/12	Residual
80	65/01	54/74	80	34/80	Leached
	34/99	45/26		65/20	Residual
100	80/35	68/95	100	49/74	Leached
	19/65	31/05		50/26	Residual
Mean	50/02	40.92	Mean	22.30	Leached
	49/98	59.08	70.05	77.7	Residual

Comparing the difference between mean results of desalination and desodification of the two treatments and calculating the statistical indices by

SPSS showed a significant difference between the two treatments. The results are provided in Table 8.

Table 8: Comparing the difference between mean results of the two treatments by salinity and exchangeable sodium percentage test at a depth of one meter per different amounts of leaching

The dependent variable	Treatment	Mean	SD	T value	Probability
EC	Control	39.6350	29.41808	-8.192	*00000
	Tillage	58.8590	22.52900		
ESP	Control	35.4705	17.95590	-5.786	* 0.000
	Tillage	42.9640	13.97550		

Significance at 5%

Based on the results presented in the table (8) there is a significant difference at 5% probability between the control and tillage treatments by applying 100 cm of leaching up to 1m soil profile in desalinization and desodification.

Changes in reducing salinity and content of exchangeable sodium at a depth of 1m for different quantities of water applied in the control and tillage treatments are presented in Table 9 and Figure 1.

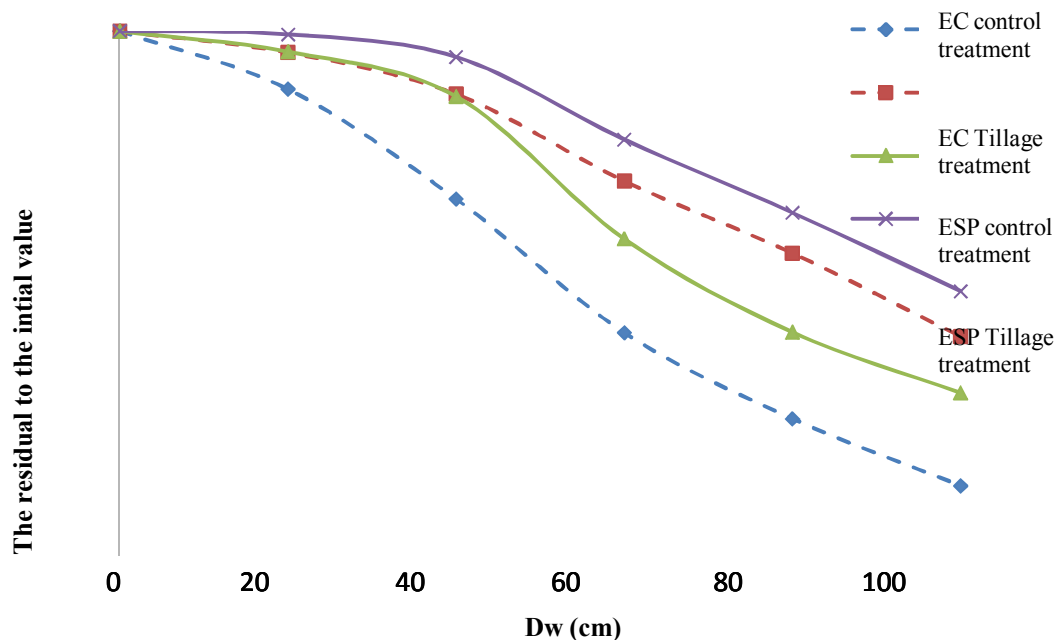


Figure 1. Comparing changes in residual salinity and exchangeable sodium percentage to the initial level at a depth of 1m for different quantities of leaching (20 to 100 cm) in the control and tillage treatments

Table (9): Changes in salinity and exchangeable sodium percentage ratio at a depth of 1m for different quantities of leaching (in percentage)

Comparison criterion	Treatment	Depth of leaching (cm)				
		20	40	60	80	100
EC	Control	95.93	88.02	71.45	57.70	41.80
	Tillage	88.97	68.02	42.54	26.13	13.34
ESP	Control	99.12	94.81	79.12	65.20	50.26
	Tillage	95.85	87.37	60.26	42.51	30.98

Assessment of changes in salinity and exchangeable sodium percentage in Table 9 shows that the control treatment presents better results than the tillage treatment at all stages of leaching that is more evident in the early stages of leaching. Comparing the desodification process of the two methods also suggests that the control treatment's leaching was more effective in soils desodification. The downward desodification trend in both treatments illustrates that it is not necessary to till before leaching in order to improve saline and sodic soils.

Difference in leaching efficiency between the control and tillage treatments is because the tillage treatment has been subject to the soil pore blockage by rapid entry of water and clay particles' inflation and on the other hand the rate of water infiltration into the soil is reduced in the later rounds by the demolition of soil structure. Therefore leaching in tillage condition has caused disorder in leaching and the control treatment demonstrated better results.

4. Conclusions

Figures derived from tests showed high levels of soil salinity and sodification of the region especially in the surface layers of soil before leaching which is often caused by intense evaporation from the soil surface and low quality shallow subsurface water rise into the upper layer. Also the presence of chloride ion in this region's soil in addition to increase the salinity potential causes the sodium properties and sodium ion accumulation in the soils.

Although deep tillage operation increases soil porosity and permeability in the early leaching stages, later by reducing the permeability it has made the results of residual leaching less satisfactory. This process can be attributed to reasons such as low soil moisture as a result of tillage, the rapid in depth entry of water (20 cm), aggregate inflation and reduced water channels in the soil. Moreover reduced salinity in sodic soils can destroy the aggregates' structure and severely reduce hydraulic conductivity and cause leaching to face with problem. Thus performing tillage before leaching is not recommended.

As anticipated, the use of intermittent leaching reduced soil salinity and sodium exchange with a favorable trend. This leaching process in the intermittent leaching was associated with water movement in the soil unsaturated zones. Since the accumulation of salts in the fine pores and the outer surfaces of soil particles and movement occur in the saturated state through the large pores, intermittent leaching has led to better desalination.

The process of soil desalination and desodification indicates the right choice of an 8-day period. This time was based on measuring the amount of final soil permeability before the start of leaching operations.

Although the results of field tests of leaching are more reliable than the results obtained from computer models and laboratory methods because of the complex relationships between water and soil, for the purpose of time and cost effectiveness, it is proposed to review and analyze valid computer models and laboratory methods using the results of field tests conducted in each region.

Due to the high salinity in the southern arid lands of Khuzestan province, the reduced quality of surface waters in recent years and the volume of drainage water left in the area it is recommended to study the initial leaching of the lands using agricultural wastewater or mixing it with flowing waters scientifically.

In rehabilitating the arid lands with high initial salinity, it is proposed to continue soil rehabilitation after reducing soil salinity to a certain level (about 10 dS/m) by the cultivation of plants resistant to salinity such as paddy and barley in several seasons. This

leads to simultaneous implementation of leaching and cultivation and better use of water resources because during the latter stages of leaching as the level of soil salinity approaches the balanced salinity, less salt is washed out by a certain amount of water. Also plants' cultivation grows soil structure and leads to biological activity in the soil that is useful to correct the arid lands.

It is recommended to perform tillage process after leaching to prevent secondary salinization in agricultural fields.

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