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SOIL MANAGEMENT AND IMPROVEMENT OF SALT AFFECTED SOILS

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ABSTRACT

A field experiment was conducted in clay saline –sodic soils, located in the north east of Egypt, Sahl El-Hossinia Research station, Agriculture Research Center, El-Sharkia Governorate, Egypt, during summer season 2011 and winter season2011/ 2012 to evaluate the effect of some soil management practices i.e., mole drain filled back with sand at two diameter 7.5 cm and 10 cm under three distances 4, 6 and 8 m individually or combined with some soil amendments application;(gypsum, sand and aluminum sulfate) on improving some physical and chemical soil properties. Also, use of the continuous leaching processes for salt removal after each rotation of leachate 25, 75, 125 and ٢75 days. The soil samples were taken to determine EC, pH and ESP as well as at the end of experiment. Also, the hydraulic conductivity, bulk density and total porosity were determined. The results indicated that the construction of mole drain filled back with sand individually after four rotations of leachate processes led to significant decrease in the values of EC, pH and ESP compared with the initial values. These decreases were more effective with application of soil amendments i.e. (gypsum, sand and aluminum sulfate) combined with the mole drain compared with the empty mole drain . It was observed that at the end of the experiment after four rotations leachate processes, the mole drain at different spacing which filled back with sand combined with soil amendments application significantly decrease the values of bulk density and increase the values of hydraulic conductivity and total porosity compared with the initial values. The superiority in improving physical properties (hydraulic conductivity, bulk density and porosity of the studied soil was recorded with mole drain filled back with sand combined with the soil amendment as aluminum sulfate or gypsum compared with sand after fourth rotations of leachate.

INTRODUCTION

Saline - sodic soils having low permeability, excess soluble salts and contain excess of exchangeable sodium and such soils are mostly found in arid zones in Egypt especially in the north and north east. Improving such soil needs some soil management practices include the following: sub soiling, with inversion, auger hole piercing in the impermeable layer, addition of amendments , and irrigation practices. (Gupta and Gupta,1987). Reclamation of saline-sodic and sodic soils, however, cannot be achieved by simple leaching, also reclamation of these soils is difficult, time consuming and more expensive than that of saline soils due to replacement of exchangeable sodium with calcium. Hence, it requires the addition of chemical amendments along with leaching. Ghafoor and Muhammed (1981) and Ahmed et al., (1986) reported that the native insoluble Ca^{+2} can be solubilized by addition of H_2SO_4, HCl, S, FeS_2 and $Fe_2SO_4.7H_2O$ and $Al_2(SO_4)_3.18H_2O$. Gypsum is the most common amendment and its application for ameliorative sodic soils. The effectiveness of gypsum depends upon (i) the degree of fineness (ii) the way in which it is incorporated in the soil and (iii) the efficiency of the drainage system. Gypsum has a calcium content of 23% and sulfur content of 19%. It is usually used for treating sodium affected soils on farm. The calcium in the applied gypsum enables sodium displacement on the cation exchange capacity of the soil. **Qureshi and Barrett-Lennard (1998)** found that application of gypsum to sodic soils improves the infiltration rate and helps in leaching the salts into the lower layers. Gypsum is widely used to improve soil porosity. In packed soils columns, increase in hydraulic conductivity was observed with gypsum. From scanning electron microscope observation, it was concluded that the increase in HC was closely associated with an increase in visible pores and reduction in clay dispersion. Similarly, a three-fold increase in HC was observed in the case of gypsum-applied to sodic soil as compared to distilled water application. A marked decrease in soil bulk density was observed when treated with surface applied phosphogypsum. Adequate infiltration rate in sodic soils was achieved due to increase in electrolyte concentration of soil water after gypsum application (Frenkel et al., 1989; Ghafoor et al., 1990). Sodic soils when clayey in nature have very compact mass, addition of sand improved the percent of pore space, hydraulic conductivity and degree of clay dispersion, except the bulk density (Hussain et al.,1990).

Sand and alkalization desertification of soil play a dominant role in the landscape’s geochemical property in the area, in situations where sand is easy to obtain and is cheap and salinity and alkalinity is a problem, questions and concerns exist over the selection and use of soil amendments. (Wang et al. 2008).

Mole drains are unlined channels formed in clay subsoil (40−60cm depth) with a ripper blade with a cylindrical foot, often with an expander which helps compact the channel wall. Mole drain is widely used in heavy soils to improve productivity of pastures and crops (David,2002). Moukhtar et al., (2003b) and Antar et al., (2008) found that, mole drains perpendicular to open drains accelerated downward water movement to the depth of mole plow. Mole drains are generally considered to be the result of the physical shattering of the hardpan, which allows increasing water penetration into the subsoil. This may also accelerate the leaching of sodium from the subsoil thereby further reducing the possibility of reformation of the hardpan. Said (2002) revealed that soil compaction influenced soil strength, bulk density, distribution and continuity of pores with consequent an adverse effect on drainage, root penetration, aeration, biological processes and nutrient uptake; all of which could have a direct bearing on crop production.

The objective of this study is to investigate the effect of the mole drain construction in combination with some soil amendments i.e., (gypsum, sand and aluminum sulfate) on the reclamation of saline –sodic soils.

MATERIALS AND METHODS

To achieve the aim of this investigation a field trail selected at Sahl El-Hossinia located in the north east Delta, Sharkia Governorate, Egypt was carried out. The field trail was divided into 72 plots, with an area 15 m^2 for each one.

Experimental layout and treatments:

Experimental treatments were conducted in split, split plot design with three replicates. The soil amendments were assigned to main plots; control, Gypsum, sand and aluminum sulfate. While, subplot treatments include the mole drain,(1) distance of mole drain at 4, 6 and 8 m and (2)different two diameters of mole drain 7.5 and 10 cm, respectively.Were allocated in sub-sub plot

Soil samples were collected at soil depth (0-30 cm) before and at the end of the experiment, continuous leaching method is used in surface irrigated fields. It depends on flooding the field plot, with water and allowing the water level to rise up to several centimeters (20 cm) above the ground surface. Also, soil samples of each plot were collected after 25, 75, 125 and ٢75 days at depth of 0-30 cm and chemically analyzed according to method described by Page (1982) in order to follow up the soil salinity, pH and ESP changes through the leaching process and soil amendments application.

Some soil physical parameters such as, hydraulic conductivity, bulk density, total porosity, for a depth of 0-30 cm were determined according to (Klute, 1986), and represented in Tables (1 &2)

Statistical analysis:

Data were statistically analyzed using analysis of variance for split split plot design according to Snedecor and Cochran (1982)

Table (1): Some chemical properties of studied soil in saturated soil paste extract

Soil depth, Cm	pH	EC dSm^{-1}	Anions ($mmol_cL^{-1}$)			Cations($mmol_cL^{-1}$)				ESP (%)
			HCO_3^-	Cl^-	So_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+	
0 - 30	8.90	183.5	3.05	3444	804.6	336	717	3136	63.15	68.4

Table (2) A- Physical properties of studied soil

Soil depth, Cm	Hydraulic Conductivity (Cm/h)	Bulk density (g/cm^3)	Total porosity (%)	CEC ($cmol_c\ kg^{-1}$)	Soil moisture content		
					F.C	W.P	A.W
0 - 30	1.14	1.٥٥	٤١.٥١	51.7	47.63	25.58	25.97

Table (2) B-

Soil depth, (cm)	$CaCo_3$ %	O.M%	Particle size distribution%				Texture class
			Coarse sand	Fine sand	Silt	Clay	
0 - 30	7.6	0.33	13.55	4.55	8.35	73.35	Clay
30 - 60	6.2	0.15	12.7	5.3	8.1	73.9	Clay

RESULTS AND DISCUSSION

Some soil chemical properties:

Soil salinity:

Data of soil salinity as affected by different treatments are shown in .table (3) and expressed as electrical conductivity in dS/m. In general, the data of soil salinity for the studied area before starting leaching process is very high (183.5 dS m^{-1}). Data of soil salinity for first rotation leachate after 25 days from beginning of leaching are shown in Table (3). Results indicated that decreasing of soil salinity with leaching due to construction the mole drain at different spacing and diameters where, the average decreasing percentage were 51.44, 46.04 and 44.63 % for 4, 6 and 8 mole drain distances at diameter 7.5 cm, respectively, compared with the initial soil salinity. However the corresponding values for 4,6 and 8 mole drain distances at 10 cm diameter were, 52.37, 49.26 and 48.61%, respectively, in the absence of any soil amendments. Mole drain is effective way for removal of soluble salts, large amounts of water was added to field and dissolved salt removed from field through nearby drain system (Li and Keren., 2009).

The decreases in soil salinity due to the combination between mole drain and soil amendments are shown in Table (3) The data revealed that a highly decrease in soil salinity due to application of soil amendments (gypsum, sand and aluminum sulfate) combined with mole drain compared to mole drain alone, while at the distance4m of mole drain combined with amendments was more effective on decreasing soil salinity compared to the other distances. Also, it is worthy to mention that there is no significant effect due to mole drain diameter on decreasing of soil salinity. The percentages of decreasing were (41.41, 29.19 and 25.19) , (20.98, 27.67 and 27.75) and (50.28, 48.08 and 52.06%) for the mole drain distance 4, 6 and 8 at 7.5 cm diameter combined with gypsum, sand and aluminum sulfate respectively, and compared with mole alone.

Data of soil salinity for the second rotation (after 75 days) from leaching are shown in Table (3). Results indicated that application of all treatments led to decrease of the soil salinity where the average decreasing percentages were, (60.05, 60.03 and 57.11) & (58.85, 60.03 and 60.81) for mole drain at distance 4,6 and 8 at diameters 7.5 and 10 cm, respectively compared to the initial state soil salinity. Data also depicted that with application of soil amendments combined with mole drain was more pronounced in the reduction of soil salinity and the average decreasing percentages were, (66.43, 49.65 and 49.94) & (66.43, 49.65 and 49.93) for mole drain at distance 4, 6 and 8 m and having diameter 7.5 and 10 cm combined with gypsum, respectively compared to the mole drain individually. While the mole drain combined with sand, the average decreasing percentages were (39.56, 47.31 and 56.54) & (47.81, 66.49 and 59.12). With regard to mole drain combined with aluminum sulfate, the values were (46.64, 48.28 and 47.01) & (42.64, 56.86 and 51.04). These results attributed to the application of soil amendments greatly enhanced the leaching of salts from saline sodic soil. Ritzema (1994) reported that heavy soils of low hydraulic conductivity (less than 0.01 m/day) often require very closely spaced drainage systems (2-4 m spacing) for satisfactory water control. With conventional pipes, the cost of such systems is usually uneconomic and hence alternative techniques are required. Surface drainage is one possibility, while the other is mole drainage. The success of a mole drainage system is dependent upon satisfactory water entry into the mole channel and upon the mole channels itself remaining stable and opens for an acceptable period.

Table (3) Effect of different treatments on ECe, pH and ESP after 25 days for leaching of salt affected soil

Chemical properties	Treatments	Soil samples after 25 days of leaching						L.S.D at 0.05
		Mole drain diameter (7.5cm)			Mole drain diameter(10cm)			
		Distance of mole drain(m)						
		4	6	8	4	6	8	
EC dS/m	Control	89.1	99.00	101.6	87.4	93.1	94.3	A: 0.40 A x B :0.406 B:0.03 A x C:0.507 C:0.04 B x C:0.091 A x B x C : 0.303
	Gypsum	52.00	70.10	76.00	48.8	63.00	71.9	
	Sand	70.4	71.6	73.4	66.5	68.2	70.1	
	Aluminum sulphate	44.3	51.4	48.7	39.1	47.7	40.5	
pH	Control	7.95	8.3	8.42	7.91	8.21	8.56	A: 0 ٠٠٥ A x B :0.٠٠٥ B:0.٠٠٠٩ A x C:0.٠٠٨ C:0.٠٠٢ B x C:0.٠٠٤ A x B x C : 0.٠٠٥
	Gypsum	7.7	7.8	7.9	7.7	7.6	7.8	
	Sand	7.91	8.10	8.17	7.80	7.90	7.98	
	Aluminum sulphate	7.35	7.65	7.83	7.4	7.61	7.54	
ESP %	Control	54.2	56,10	60.11	50.11	52.31	56.21	A: 0 ٠٩ A x B :0.٠٩٩ B:0.٠٢ A x C:0.١٢١ C:0.٠١ B x C:0.٠٣٠ A x B x C : 0.٠٧٤
	Gypsum	46.21	47.88	49.11	45.00	46.89	47.01	
	Sand	51.21	52.78	54.89	50.21	50.52	52.12	
	Aluminum sulphate	43.46	44.90	46.90	42.90	44.11	45.01	

A: Treatments B: Mole drain diameter C: Distance of mole drain

Table (4) Effect of different treatments on ECe, pH and ESP after 75 days for leaching of salt affected soil

Chemical properties	Treatments	Soil samples after 75 days of leaching						L.S.D at 0.05
		Mole drain diameter (7.5cm)			Mole drain diameter (10cm)			
		Distance of mole(m)						
		4	6	8	4	6	8	
EC dS/m	Control	73.3	72.7	78.7	75.5	72.8	71.9	A: 0 .٣٦ A x B :0.٣٧٣ B:0.٠٤ A x C:0.٤٧٢ C:0.٠٥ B x C:0.١٢٤ A x B x C : 0.٢٩٢
	Gypsum	61.0	36.6	39.4	57.4	25.96	24.69	
	Sand	44.30	38.3	34.2	39.4	24.39	29.39	
	Aluminum sulphate	49.8	37.6	41.7	43.3	31.4	35.2	
pH	Control	7.8	7.85	7.95	7.7	7.8	7.9	A: ٠.٠٠٦ A x B :0.008 B:0.٠٠٢ A x C:0.009 C:0.٠٠١ B x C:0.004 A x B x C : 0.006
	Gypsum	7.6	7.7	7.8	7.5	7.8	7.8	
	Sand	7.60	7.75	7.78	7.61	7.69	7.75	
	Aluminum sulphate	7.15	7.35	7.26	7.45	7.64	7.76	
ESP %	Control	46.21	48.14	50.34	45.08	46.24	48.98	A:٠.07 A x B :0.068 B:0.007 A x C:0.089 C:0.٠١ B x C:0.025 A x B x C : 0.056
	Gypsum	41.21	44.43	45.22	40.21	44.21	44.21	
	Sand	44.89	46.21	47.90	43.89	45.90	46.03	
	Aluminum sulphate	38.11	40.11	42.75	37.87	38.12	41.76	

A: Treatments B: Mole drain diameter C: Distance of mole drain

Table (5) Effect of different treatments on ECe, pH and ESP after 125 days for leaching of salt affected soil

Chemical properties	Treatments	Soil samples after 125 days of leaching						L.S.D at 0.05
		Mole drain diameter (7.5cm)			Mole drain diameter (10cm)			
		Distance of mole(m)						
		4	6	8	4	6	8	
EC dS/m	Control	37.5	37.5	39.1	35.2	38.4	38.12	A:0.10 A x B :0.1 B:0.01 A x C:0.136 C:0.02 B x C:0.091 A x B x C : 0.108
	Gypsum	24.5	25.1	27.35	24.2	24.4	26.8	
	Sand	32	32.3	34.9	28.6	30	31.7	
	Aluminum sulphate	22.5	29.8	31.5	24.2	34.6	31	
pH	Control	7.87	8.21	8.33	7.83	8.13	8.47	A:٠.007 A x B :0.008 B:0009 A x C:0.009 C:0.002 B x C:0.002 A x B x C : 0.006
	Gypsum	7.62	7.72	7.82	7.62	7.53	7.72	
	Sand	7.83	8.01	8.08	7.75	7.83	7.90	
	Aluminum sulphate	7.20	7.49	7.67	7.25	7.55	7.48	
ESP %	Control	36.3	38.11	40.01	35.26	36.00	38.76	A:٠.015 A x B :0.121 B:006 A x C:0.153 C:0.014 B x C:0.030 A x B x C : 0.083
	Gypsum	22.4	26.88	27.43	22.00	25.56	27.11	
	Sand	27.2	29.94	33.67	27.01	29.00	33.32	
	Aluminum sulphate	22.90	24.05	27.23	21.88	23.89	25.37	

A: Treatments B: Mole drain diameter C: Distance of mole drain

Data of soil salinity for third rotation after 125 days and fourth rotation after 175 days from leaching are shown in Table (4). In the third rotation, results indicated that there was also more decreasing for soil salinity with leaching for all treatments. For third rotation, the average decreasing percentages were (79.50, 79.56 and 78.69%) & (80.86, 79.07 and 79.22%) for mole drain at distances 4, 6 and 8 m at different diameters 7.5 and 10 cm, compared to the initial soil salinity, respectively. While the corresponding values of decreasing percentage were, (82.29, 81.16 and 80.80%) & (83.46, 82.23 and 81.84%) for fourth rotation.

The effect of mole drain combined with gypsum was more effective in reducing soil salinity, the average decreasing percentages were (34.66, 33.06 and 30.05) & (31.25, 36.45 and 29.69) and (28.22, 27.66 and 31.28) & (33.68, 29.18 and25.59) for third and fourth rotation leachate, respectively. Concerning the mole drain combined with sand the soil salinity was slightly decreased but the values were still more than mole drain alone. The average decreasing percentages were (14.66, 13.86 and 10.74) & (18.75, 21.87 and 16.84) and (9.98,10.44 and8.51) & (3.25, 8.50 and 8.25) for third and fourth rotation of leachate, however the corresponding values for mole drain combined with aluminum sulfate compared with mole drain alone, the decreasing percentages, were (40.00, 20.50 and 19.33) & (31.25, 9.80 and 18.67) and (49.82, 42.40 and 43.54) & (46.17, 44.74 and 42.96), for third and fourth rotation leachate, respectively. The decrease in EC with gypsum treatment might be due to quick action of gypsum in dissolving insoluble salts and flushing them with frequent leachates. Also, data showed gradual decrease with increasing leachates numbers; it might be due to the gypsum has steady reaction with sodium of soil to replace it.

The original soil was saline sodic in nature and very compacted addition of sand loosed the soil and increased its porosity in the upper layers. The effectiveness of the applied aluminum sulfate is further higher than that gypsum and sand. Prapagar et al. (2012) found that gypsum application in combination with organic amendments improved the soil chemical properties by reducing the EC, SAR and pH, than the applying gypsum alone. Niazi et al. (2001) found that application of sand helped in improvement leaching ions then the concentration of the salts was reduced.

Table (6) Effect of different treatments on ECe, pH and ESP after ٢75 days for leaching of salt affected soil

Chemical properties	Treatments	Samples of soils after 175 days of leaching						L.S.D at 0.05
		Mole drain diameter (7.5cm)			Mole drain diameter (10cm)			
		Distance of mole(m)						
		4	6	8	4	6	8	
EC dS/m	Control	31.21	33.62	35.23	30.34	32.34	33.31	A:٠.١٣A x B :0.١٣١
	Gypsum	22.40	24.32	24.21	20,12	22.90	24.8	B:٠.٠٠A x C:٠.١٦٢
	Sand	28.25	30.11	32.23	29.36	30.33	30.56	C:0.٠١B x C:٠.٠٢٢
	Aluminum sulphate	17.22	19.46	19.89	16.33	17.87	19.00	A x B x C : 0.0٩١
pH	Control	7.81	7.87	7.87	7.62	7.73	7.82	A:٠.٠٠A x B :0.٠٠٨
	Gypsum	7.72	7.63	7.72	7.43	7.72	7.74	B:٠.٠٠٢A x C:٠.٠١١
	Sand	7.52	7.67	7.70	7.53	7.61	7.67	C:0.٠٠٢Bx C:٠.٠٠٤
	Aluminum sulphate	7.01	7.21	7.15	7.40	7.49	7.61	A x B x C : 0.0٠٥
ESP %	Control	34.20	36.10	38.21	32.90	35.00	36.87	A:٠.١٨A x B :0.١٨٥
	Gypsum	18.02	20.11	24.80	17.32	19.23	20.00	B:٠.٠١١A x C:٠.٢٢٨
	Sand	26.13	27.34	31.34	26.16	28.23	31.22	C:0.٠١٣Bx :.٠.٠٢٩
	Aluminum sulphate	15.21	15.90	16.11	13.01	13.90	14.45	A x B x C : 0.١٣٠

A: Treatments B: Mole drain diameter C: Distance of mole drain

Soil pH: Effect of mole drain individually or combined with soil amendments on soil pH after four leachates process i.e. after 25, 75, 125 and 275 days are shown in Tables(3) and(4). The data showed that the pH values of soil after every leachate decreased than the (initial value). Mole drain decreased the pH values for first, second, third and fourth leachate. These average decrements were 7.64%, 12.00%, 8.5% and 12.50%, relative to the initial pH value, respectively. Data also, indicated that the decrease in the pH values of soil after first, second, third and fourth leachate and these average decrements were (12.92, 13.48, 13.82 and 13.93) for mole drain+gypsum, (10.44, 13.59, 11.23 and 14.49%) for mole drain+sand and (15.05, 16.51, 16.40 and 17.86%) for mole drain +aluminum sulfate relative to the initial pH value, respectively. The decrease in soil pH may be due to decrease in sodium concentration as a fraction of the cations. This decreasing may be due to removal of exchangeable sodium from the soil. Moreover, gypsum solubility is also enhanced because of the increased activity coefficient of calcium and sulfate as a result of increased ionic strength of solution and the formation of the sodium sulfate ion pair. Besides, large quantities of CO_2 must have been evolved during leaching process, some of which would become soluble in soil solution giving carbonic acids. Sabir et al. (2007) found that gypsum application as amendment for treating sodic soils improved soil properties by reducing pH and SAR; also they showed that ameliorative effect of gypsum is expected when more number of irrigations are applied with the provision of good drainage allowing the salts to flush out the soil profile. Niazi et al (2001) found that reduction in pH of the soil was observed due to application of 0.1 % sand at the end of second year of cropping. Junbo et al. (2010) found that sand application can improve the physical properties of saline sodic soil. Three test levels, heavily, middle, and light, were designed for experiment of amelioration saline sodic soil using sand application. The sand applications for heavy level, middle level, and light level were1050, 900, and 750m^3 ha^{-1}, respectively. After 3 years of continuous sand application, the soil pH decreased from 9.08 to 7.21. it is also noticed that the pH values due to application of aluminum sulfate was more effective than the other soil amendments. This result may be attributed to aluminum sulfate which decrease pH because the dissociated into aluminum and sulfuric acid the aluminum binds to the clay or precipitates out of the soil solution leaving the sulfuric acid behind. When the salts added to moist soils they hydrolyze rapidly, producing H_2SO_4 as shown by the following equation:

$$Al_2(SO_4)_2 + 6\ H_2O \rightarrow Al(OH)_3 + 3H_2SO_4$$

Exchangeable sodium percentage (ESP):

The changes in exchangeable sodium percent due to mole drain buck filled with sand individually and combined with soil amendments (gypsum, sand and aluminum sulfate under four rotation leachate are presented in Tables (3 and 4). The data indicated that the ESP values were decreased due to construction of drain filled with sand at different distances and diameters after each process of leachate. The mean average decreasing percentages were 16.90% for mole drain filled with sand at diameter 7.5 cm and 22.69% for 10 cm, respectively for first leachate compared to the initial value. The corresponding values for second, third and fourth leachate were (14.86 % and 31.62), (44.33 % and 46.38 %) and (47.11% and 48.94%), respectively. Concerning the impact of mole drain filled with sand at different distances and different diameters combined with soil amendments (gypsum, sand and aluminum sulfate) Data revealed that the values of average decreasing percentage of ESP were 30.21% and 32.30% for mole drain filled with sand at diameter ٧.٥ and ١0cm +gypsum for first leachate. However, the corresponding values of decreasing percentage at second, third and fourth leachates were 36.22 and 37.31, 57.74% and 63.61, 69.33% and 81.21%, respectively. For mole drain filled with sand at diameter 7.5 and 10 cm +sand for first leachate, second, third and fourth leachate the mean values percentages decreasing in ESP were 22.57% and 25.51, 32.69 and 33.81, 55.74 and 29.77% and 58.66 and 58.27%, respectively compared with the initial value. While the combined between mole drain at different both space and diameters with aluminum sulfate the mean decreasing percentage in ESP for first, second, third and fourth leachate were 34.08% and 35.66%, 41.04% and 42.61%, 63.84% and 65.33% and 76.98% and 79.84%, respectively compared with the initial value. It worthy to mention that mole drain filled with sand technique combined with soil amendments was more effective in reducing exchangeable sodium percentage. **Hussain et al. (2001)** reported that simple leaching can reclaim saline soils whereas black alkali soils need proper amount of gypsum, sulfur, Iron sulfate and aluminum sulfate along with leaching.

Table (7) Effect of different treatments on hydraulic conductivity, bulk density and total porosity at the end of experiment of salt affected soil

Physical properties	Treatments	Samples of soils after ٢75 days of leaching						L.S.D at 0.05
		Mole drain diameter (7.5cm)			Mole drain diameter (10cm)			
		Distance of mole(m)						
		4	6	8	4	6	8	
Hydraulic conductivity (cm/h)	Control	1.79	1.70	1.670	1.97	1.69	1.59	A:٠.٠٠٣ A x B :0.٠٠٤
	Gypsum	2.62	2.47	2.41	2.69	2.49	2.46	B:٠.٠٠١ A x C:٠.٠٠٧
	Sand	1.96	1.88	1.85	1.98	1.83	1.74	C:0.٠٠٢ B x C:٠.٠٠٤
	Aluminum sulphate	2.32	2.12	1.91	2.52	2.51	1.93	A x B x C : 0.0٠٥
Bulk density ($g.cm^{-3}$)	Control	١.٥١	١.٥٣	١.٥٤	١.٥٠	١.٥١	١.٥٢	A:٠.٠٠٧ A x B :0.٠٠٩
	Gypsum	١.٢٦	١.٣٣	١.٣٧	١.٢٤	١.٢٦	١.٢٨	B:٠.٠٠٢ A x C:٠.٠١١
	Sand	١.٤٧	١.٤٩	١.٥٠	١.٤١	١.٤٤	١.٤٦	C:0.٠٠٢ B x C:٠.٠٠٥
	Aluminum sulphate	١.٢٩	١.٣١	١.٣٣	١.٢٦	١.٣٠	١.٣١	A x B x C : 0.0٠٧
Total porosity (%)	Control	٤٣.٠٠	٤٢.٢٦	٤١.٨٩	٤٣.٤٠	٤٣.٠٢	٤٢.٦٤	A:٠.٠٨٣ A x B :0.٠٨٧
	Gypsum	٥٢.٥٠	٤٩.٨١	٤٨.٣٠	٥٣.٢١	٥٢.٥٠	٥١.٧٠	B:٠.٠١٢ A x C:٠.١٠٤
	Sand	٤٤.٥٢	٤٣.٧٧	٤٣.٤٠	٤٦.٧٩	٤٥.٦٦	٤٤.٩١	C:0.٠٠٦ B x C:٠.٠١٨
	Aluminum sulphate	٥١.٣٢	٥٠.٥٧	٤٩.٨١	٥٢.٤٥	٥٠.٩٤	٥٠.٥٧	A x B x C : 0.0٦٢

A: Treatments **B: Mole drain diameter** **C: Distance of mole drain**

Soil hydraulic conductivity (HC): The effects of different treatments at the end of experiments after 4 process rotation leachate on values of hydraulic conductivity of salin-sodic soil are presented in Table (5). Results indicated that hydraulic conductivity in the initial soil was low (1.14cm/hr). The mean increasing percentages in hydraulic conductivity were 50% and 114% due to mole drain filled with sand at different diameters, respectively compared with the initial value.

While the combined between mole drain and soil amendments the data reveal that values of the soil hydraulic conductivity were more higher than the mole drain alone.

Data in Table (5) show that mole drain combined with gypsum application markedly increased soil hydraulic conductivity of soil being 1.14 cm/hr in the initial soil to 2.26, 2.47 and 2.41 cm/hr for mole drain at distance 4, 6 and 8 m under 7.5 cm diameters combined with gypsum. In the mole drain at distance 4, 6 and 8 m at 10 cm diameters combined with gypsum, the corresponding HC values were 2.69, 2.49 and 2.46 cm/hr, respectively. However, mole drain when combined with sand the increase in soil hydraulic conductivity was slightly higher than these of the mole drain alone. The relative percentages increases of HC values were (71.00, 64.91 and 62.28%) & (73.68, 60.52 and 52.63%) compared with the initial value of HC for sand as amendment combined with mole drain refilled with sand at distance 4, 6 and 8 m at ٧.٥ cm and ١0 cm diameters, respectively. The corresponding HC values for mole drain refilled with sand combined with aluminum sulfate were (191.22, 85.96 and 67.54%) & (121.05, 120.17 and 69.29 %) in the same order. As regards the reclamation efficiency in terms of improving hydraulic conductivity, various amendments proved useful but their combinations with mole drain may be regarded the best.

Bulk density:

Data presented in Table (5) show the effect of mole drain filled with sand individually or combination with soil amendment i.e. gypsum, sand and aluminum sulfate on bulk density values of soil saline sodic under study. The values of bulk density were decreased due to implement of mole drain filled with sand individually when compared with the initial value. Whereas, the bulk density of initial soil was 1.٥5 and decreased up to (1.٥1, 1.٥3 and 1.٥4) & (1.٥0, 1.٥1 and 1.٥2 g/cm^3) for mole drain filled with sand at distance 4, 6 and 8 m at diameters 7.5 and 10 cm, respectively. Addition of soil amendments combined with mole drain the bulk density values were decreased. The relative decrease percentage of bulk density values for mole drain refilled with sand at 4, 6 and 8 distance at both ٧.٥ and ١0 diameters combined with gypsum were (١٨.٧٠, ١٤.١٩ and ١١.٦١%) & (٢٠.٠٠, ١٨.٧١ and ١٧.٤١%) compared with the initial value of bulk density, respectively. The corresponding values of decrease bulk density were (٥.١٦, ٣.٨٧ and ٣.٢٣%) and (٩.٠١, ٧.١٠ and ٥.٨%) for mole drain combined with sand as amendment. Also, when mole drain combined with aluminum sulfate the percentage of relative decrease were (١٦.٧٧, ١٥.٤٨ and ١٤.١٩) & (١٨.٧٠, ١٦.٣٠ and ١٥.٤٨) in the same order.

Total porosity

Data presented in Table (5) show the effect of mole drain refilled with sand individually or combined with soil amendments i.e. gypsum, sand and aluminum sulfate on total porosity values of saline-sodic soil under investigation. The values of total porosity in the soil were increased due to the application of mole drain individually or combination with soil amendments compared with initial value. The total porosity of the initial soil was ٤١.٥١ and the mean values increased to ٤٢.٤٣ and ٤٣.١٦ for mole drain at different distance at ٧.٥and ١0 cm diameters, respectively. It worth to mentioned that the increase in the total porosity was slightly increase attributed to the application of mole drain individually. While, when the soil treated with amendment combined with the mole drain the total porosity values were increase more positively. The mean of relative percentages increased of total porosity were, ٢١.٠٣ and ٢٦.٤٠% for gypsum+ mole drain at both diameters (٧.٥ and ١0 cm), respectively. In the corresponding values for both sand + mole drain and aluminum sulfate + mole drain the mean relative percentages increased values were, (٥.٤٢ and ٨.٦٩%) and (٢١.٨٣ and ٢٣.٦٣%), respectively compared with initial value of total porosity. Odes (1984) found that the addition of 20ml Al or 60 ml Fe per gram of clay was needed to flocculate Na-exchanged montmorillonite.

CONCLUSION

Results showed that a combination of physical and chemical methods can accelerate the reclamation process. Mole drain filled with sand at narrow spacing and diameters 7.5 or 10cm was an adequate auxiliary treatment in heavy clayey saline – sodic soil of low permeability which encouraged the reduction of soil salinity. Soil amendments such as gypsum, sand and aluminum sulfate application can be used as an effective practice for the reclamation of saline-sodic soils and improve reclamation efficiency.

REFERENCES

Ahmed, M., B.H. Niazi, Rahmatullah and G.R. Sandhu. (1986). Reclamation of calcareous saline sodic soils by gypsum and HCl under rice cultivation. Trop. Agric. (Trinidad) 63: 271-272.

Antar, S. A.; A. S. El-Henawy and A. A. E. Atwa (2008). Improving some properties of heavy clay salt affected soil as a result of different subsurface tillage. J. Agric. Sci. Mansoura Univ., 33 (10): 7675- 7687.

David Hopkins, Colac (2002). Managing wet soils: mole drainage. WWW.dse. Vic. Gov.

Frenkel, H., J.O. Gerstle and N. Alperovitch.(1989). Exchanged induced dissolution of gypsum and the reclamation of sodic soils. J. Soil Sci. 40: 599-611

Ghafoor, A. and S. Muhammed. (1981). Comparison of H2SO4, HCl, HNO3 and gypsum for reclaiming calcareous saline-sodic soil and for plant growth, In Bull. (J)

Irrigation, Drain. Flood Control Res. Council of Pakistan, 11: 69-75

Ghafoor, A., S. Muhammed, N. Ahmad and M.A. Mian. (1990). Making salt-affected soils and waters productive. I. Gypsum for the reclamation of sodic and saline-sodic soils. Pak. J. Sci. 41-42: 23-37.

Gupta, S.K., and I.C. Gupta. (1987). Land development and leaching. Pp. 136-152 in Management of Saline Soils and Waters. New Dehli, Mohan Primlani.

Hussain, G. Hassan, M. Arshadullah and F. Mujeeb (2001). Evaluation of amendments for the improvement of physical properties of sodic soil. International Journal of agriculture & Biology 3: 319-322.

Junbo, Y., Z.Wang, F.X. Meixner, F. Yanf, H. Wu and X. Chen (2010). Biogeochemical characterizations and reclamation strategies of saline sodic soil northeastern China. Clean-Soil, Air, Water 38 (11) :1010-1016.

Klute, A. (Ed.) (1986). Methods of Soil Analysis. No. 9 Part 1, Amer. Soc. Agron., Inc. Madison, Wisconsin, USA.

Li, F.H. and R. Keren. (2009). Native CaCO3 mineral dissolution and its contribution to sodic calcareous soil reclamation under laboratory conditions. Arid Land Res. Manage. 22: 1-15.

Moukhtar M. M., Madiha H. El-Hakim, A, S.A. AbdelMawgoud, A. I. N. Abdel-Aal M. B. El Shewikh and M.I.I. Abdel-Khalik (2003b). Drainage and role of mole drains for heavy clay soils under saline water table, Egypt. Paper No 078. Presented at the 9th International Drainage Workshop, September 10 – 13, 2003, Utrecht, The Netherlands.

Niazi, B.H., M. Ahmed, N. Hussain and M. Salim (2001). Comparison of sand, gypsum and sulphuric acid to reclaim a dense saline sodic soil. International Journal of Agriculture & Biology. 3: 316-318.

Oades, J. M. (1984).Interactions of polycations of Al and Fe with clays. Clays & Clay Minerals 32. 49-57.

Page, RH. (Ed.) (1982). Chemical and Microbiological Analysis. Part II: Methods of Soil Analysis. Agron. Ho. 9, Madison, U.S.A.

Prapagar, K., S.P. Indaratne and P. Premanandharajah (2012). Effect of soil amendment on reclamation of saline-sodic soil. Trpical Agricultural Research Vol.23 (2): 168-176.

Ritzema, H.P. (1994). Drainage Principles and Applications. ILRI Publication 16. International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.

Qureshi, R.H. and E.G. Barrett-Lennard (1998). *Saline Agriculture for Irrigated Land in Pakistan: A handbook.* Australian Centre for International Agriculture Research, Canberra, Australia.

Sabir, G.K., I. Haq, A. Malik, M. J. Khattak and N.Naveedullah (2007). Effect of various levels of gypsum application on the reclamation of salt affected soil grown under rice followed by wheat crop. Sarhad J. Agric. Vo;. 23, No.3: 675 – 680.

Said H. M. (2002). Effect of deep ploughing on some physical properties and corn yield in calcareous sandy clay loam soil. Egypt. J. Soil Sci. 42: 57-70.

Snedecor, G.W. and W.G. Cochran (1982). Statistical Methods. 7 Edition. Iowa state Univ. th Press., Ames.,IA. U.S.A.

Wang, G. P., Z. L. Zhai, J. S. Liu, and J. D. Wang (2008). Forms and profile distribution of soil phosphorus in four wetlands across gradients of sand desertification in Northeast China. Geoderma 145(1-2):50-59.

ادارة وتحسين الأراضى المتأثرة بالأملاح

فكرى عبد المنعم فرج ، محمد أحمد السيد الشاذلى ، أحمد حماده عبد الرحمن و محمد سعيد عواد
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أجريت هذه التجربة الحقلية في ارض ذات قوام طينى متاثره بالاملاح ، وتقع هذه التربه في الشمال الشرقي، لمصربمنطقة سهل الحسينيه ، محطة البحوث الزراعيه، مركز البحوث الزراعية، محافظة الشرقية ، خلال موسمين متتاليين صيف ٢٠١١ و شتاء 2011/2012 لتقييم تأثير بعض الممارسات الزراعيه مثل أنفاق الصرف المولى و تعبئتها بالرمل باقطار ٧.٥ سم و ١٠ سم و بمعدل ثلاثة مسافات وهى ٤ ، ٦ ، ٨ متر منفرده او بمصاحبة اضافة بعض المحسنات مثل الجبس والرمل وكبريتات الألومنيوم على تحسين بعض خواص التربة الفيزيائية والكيميائية و أيضا تم اجراء عمليات الغسيل المستمر لمده اربع دورات متتاليه حيث أخذت عينات تربه فى نهايه كل دوره غسيل بعد ٢٥، ٧٥، ١٢٥، ٢٧٥ يوم على التوالى و ذلك لتقدير التوصيل الكهربائى ودرجه الحموضه و نسبه الصوديوم المتبادل و ايضا فى نهايه التجربه تم تقد ير التوصيل الهيدروليكي و الكثافة الظاهريه و المساميه الكلية.

أشارت النتائج إلى أن اقامة مصرف المول المعبء بالرمل بشكل فردي بعد أربعة دورات من عمليه الغسيل قد احدث انخفاض ملحوظ في قيم التوصيل الكهربائى (EC)، ودرجة الحموضة و نسبه الصوديوم المتبادل بالمقارنة مع القيم الأولية و ذلك بعد كل دوره غسيل وكانت هذه القيم اكثر انخفاضا فى الغسله الرابعه مقارنه بالاولى.

أدى اقامه مصرف المول و اضافة المحسنات (الجبس والرمل وكبريتات الألومنيوم) الى انخفاض فى القيم السابقه مقارنه بمصرف المول منفردا.

ولوحظ أنه في نهاية التجربة بعد دورات الغسيل الاربعه فان تطبيق مصرف المول المعبء بالرمل مع اضافة المحسنات السابقه قد ادى الى انخفاض قيم الكثافة الظاهرية وزيادة قيم التوصيل الهيدروليكي والمسامية الكلية بالمقارنة مع القيم الأولية. وأوضحت النتائج ايضا ان عمل مصرف المول المعبء بالرمل بمصاحبه سلفات الألومنيوم او الجبس قد تفوق فى تحسين بعض خواص الارض الكيميائيه و الفيزيائيه مقارنه بمعاملة الرمل منفردا.

قام بتحكيم البحث

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