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IMPACT OF SOME SOIL MANAGEMENT PRACTICES ON SOME PHYSICAL PROPERTIES OF SALT AFFECTED SOILS IN EL-TINA PLAIN AREA

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ABSTRACT

A field experiment was conducted during two successive winter seasons in El Tina plain area, North Sinai, Egypt. It aims to study the effect of drain spacing, ploughing method and gypsum and elemental sulphur as soil amendments application on some soil physical properties. The main plots were devoted to different drain spacing, S (25, 35 and 50 m). The subplots were allocated to ploughing method, P (conventional and cross subsoiling plough). The sub-subplots were assigned for soil amendment application, A (without amendment, gypsum and elemental sulphur application).The results indicated that, for different studied soil depths, the combined treatment of 25 m drain spacing, cross subsoiling ploughing method and gypsum application resulted in the highest effect of decreasing soil bulk density relative to control treatments. Such decreases were 16.80, 16.80, 11.80, 13.50, 14.50 and 11.10 % lower than the control treatment for soil depths 0-10, 10-20, 20-30, 30-40, 40-50 and 50-60, respectively. The interaction effect of 25m drain spacing with cross subsoiling method and gypsum amendment application recorded the highest increase in total soil porosity. Such increments were 19.36, 17.07 and 10.10 % for the three upper studied soil depths, respectively over control treatment. Similar trend was found true for the three studied lower soil depths with different magnitudes. The combined treatment of 25 m drain spacing, cross subsoiling ploughing method and gypsum as soil amendment generally recorded the highest values of soil Ks increments in the studied soil depths . The two values 1.77 and 1.46 m day^{-1} were recorded in 0-10 and 10-20 cm soil depths. The obtained values under corresponding 20-30, 30-40 , 40-50 and 50-60 cm soil depths were 0.81, 0.74, 0.67 and 1.21 m day^{-1}, respectively.

Kew words: Salt affected soils, drain spacing, cross subsoiling, gypsum, sulphur.

INTRODUCTION

El-Tina Plain area is located at the North western part of Sinai Peninsula, Egypt. It was a part of the old Nile Delta, where there is an ancient branch of the Nile. The annual floods of the river shared in the formation of the plain. Due to ignorance of the maintenance requirements, the old branch was gradually blocked and completely diminished, and consequently the agricultural development was stopped. The high salinity of the groundwater table led to the formation of salt crusts and increased the soil sodium content. **Anikwe *et al.* (2016)** found that bulk density was highly influenced by gypsum application, where gypsum can break up compacted soils and decrease penetrometer resistance. **Kanwal *et al.* (2014)** found that gypsum, compost and their combination significantly ($P \leq 0.05$) decreased bulk density in the soils. **Javed *et al.* (2013)** stated that soil physical properties were remarkably affected by

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different tillage practices and organic matter amendment. The lowest bulk density was recorded in deep tillage treatment. **Abdel-Mawgoud *et al.* (2007)** found that soil bulk density increased as tile drain spacing increased. **Gendy (2011)** found that subsoiling combined with application of 1.5 tons gypsum Fed.$^{-1}$ led to decrease soil bulk density compared to other studied treatments. **Salahin *et al.* (2013)** found that bulk density decreased with the increase of tillage depth, which was helpful to the downward growth of crop roots.

Also, **Li and Hang (2013)** found that deep tillage broke plough pan and decreased bulk density values. **Kuldeep *et al.* (2012)** revealed that, the bulk density of the soil decreased with subsoiling plough method. The lower values of bulk density were found in cross subsoiling treatments. **Younesi and Navabzadeh (2007)** found that the bulk density was decreased by a greater percentage with the deep tillage compared with the shallow and semi deep tillage in the 0-30 cm soil depth range. The bulk density decreased by increasing the plowing soil depth. **Moukhtar *et al.* (2003)** stated that the best treatment to loosen soil and lowering bulk density is drain spacing of 15 m combined with net subsoiling ploughing method.

Gendy (2011) revealed that subsoiling plough method was superior to gypsum application in enhancing soil porosity. **Jodi Delong (2004)** found that the subsoiling ploughing a compacted deep layer in the soil increase water movement, increase total porosity, better aeration of the root and excess additional nutrients for plant growth. **Javed *et al.* (2013)** found that higher total soil porosity was recorded in deep tillage treatment followed by conventional and minimum tillage treatments, against the lowest in zero tillage treatment.

When the soil treated with amendment combined with the mole drain, the total porosity values were increased more positively (**Farag *et al.*, 2013**). **Said (2002)** found that at the beginning of growth season, subsoiling had a marked positive effect on soil porosity of the subsurface compacted layers. However, subtiller plow seems to be superior to the subsoiler in increasing porosity down the depth of 70 cm, whereas the improving effect of subsoiler was confined within 50 cm depth.

Nan *et al.* (2015) stated that the beneficial effects of gypsum on saturated hydraulic conductivity of soil which was primarily due to the fact that gypsum can improve soil structural stability through enhancing ionic strength effects and removing exchangeable sodium from the soil colloids. **Ahmed (2013)** found that application of sulphur combined with farmyard manure leaded to an increasing of hydraulic conductivity by about 58% over the control treatment. The combination of mole drain with gypsum application markedly increased soil hydraulic conductivity.

As regards the reclamation efficiency in terms of improving hydraulic conductivity, various amendments proved useful effect but their combinations with mole drain may be regarded the best (**Farag *et al.*, 2013**). The magnitude of hydraulic conductivity increases expected in response to gypsum applications depends on soil properties including clay content, clay mineralogy and bulk density of the soil **(Reading *et al.*, 2012)**. **Jabro *et al.* (2010)** found that soil saturation hydraulic conductivity (Ks) was significantly affected by the depth of tillage and was greater in deep tillage than in shallow one. A significant increase in hydraulic conductivity over the initial values was observed with the application of gypsum and farmyard manure treatments in both soil depths. Gypsum application increased the hydraulic conductivity in both studied soil depths (**Kahlon *et al.*, 2012**). The present study aimed at studying the effect of some soil management practices on some physical properties of El-Tina Plain soil.

MATERIALS AND METHODS

A field experiment was conducted during two successive winter seasons 2012 and 2013, at El Tina plain area, North Sinai, Egypt. The flood irrigation system was applied. The field experiment aims to study the impact of some soil management practices on some physical properties of the soil under investigation. Soil samples representing soil depths 0-10, 10-20, 20-30, 30-40, 40-50 and 50-60 cm were collected and prepared for physical and chemical analysis. The main physical properties of the studied soil samples under investigation are shown in Tables (1& 2). The chemical analysis of the irrigation water is shown in Table (3).The field experiment included the following treatments:

A- Drain spacing:

1- 50 m drain spacing (S1), which represent the common drain distance in the study area.

2- 25 m drain pacing (S2), which represent the unsteady state (transient) flow conditions and calculated using Glover-Dumm′s formula as recommended by **Wesseling (1980).**

3- 35 m drain spacing (S3), which represent the steady state flow conditions and calculated according to **Donnan (1946)** and its modification by **Hooghoudt (1952)**.

B- Ploughing method:

1- Conventional plough.

2- Cross subsoiling plough.

C- Soil amendment:

1- Without soil amendment application (control).

2- Gypsum at rate 10 Mg fed.$^{-1}$

3- Elemental sulphur at rate 0.5 Mg fed.$^{-1}$

The field experiment was carried out in a spilt spilt plot design where, the drain spacing occupied the main plots, the plough method occupied the sub plots and the soil amendment treatments occupied the sub sub plots. The experimental area was cultivated by sugar beet plant (*Beta vulgaris* L.). NPK fertilizers, Leaching requirements and farmyard manure were applied as recommended in the area under investigation. After harvesting, soil samples were collected and prepared for analysis.

Particle size distribution, Bulk density (Db), Total porosity (%), Saturated hydraulic conductivity, The electrical conductivity (EC) in dSm^{-1}and total calcium carbonate ($CaCO_3$) (%), were determined according to **Klute (1986)**. Saturated soil paste was prepared and extracted according to **Richards (1954).** Soil pH in saturation soil paste according to **Richards (1954).** Organic matter content was determined according to Walkley and Black procedure **(Nelson and Sommers, 1982).** Cation exchange capacity (CEC) was determined using ammonium acetate method and exchangeable sodium was determined using ammonum acetate solution as described by **Jackson (1967).** Gypsum requirement (GR) was calculated according to Schoonover′s method **(Richards, 1954).** The obtained Results were statistically analyzed and treatment differences were evaluated using least significant difference ($LSD_{0.05}$) test using SAS software **(SAS, 1994).**

Table (1): Some physical properties of the studied soil under investigation

Soil depth (cm)	Particle size distribution (%)				Textural class	Particle density (Mg m^{-3})	Bulk density (Mg m^{-3})	Porosity (%)	Saturated hydraulic conductivity (K_s) (m day^{-1})
	Coarse sand	Fine sand	Silt	Clay					
0-10	29.40	32.04	21.69	16.87	**Sandy loam**	2.54	1.40	44.88	0.85
10-20	30.50	30.43	23.40	15.67	**Sandy loam**	2.56	1.38	46.09	0.65
20-30	14.87	36.07	32.49	16.57	**Loam**	2.63	1.24	52.85	0.33
30-40	21.91	30.63	27.05	20.42	**Loam**	2.62	1.26	51.91	0.36
40-50	20.08	33.84	29.57	16.52	**Loam**	2.61	1.25	52.11	0.27
50-60	52.17	14.74	17.43	15.66	**sandy loam**	2.57	1.39	45.91	0.92

Table (2): Some chemical properties of the studied soil under investigation

Soil depth (cm)	pH	EC (dSm^{-1})	ESP (%)	$CaCO_3$ (%)	O.M (%)	CEC (cmol$_c$ kg^{-1} soil)
0-10	8.13	16.61	23.31	1.73	1.42	19.35
10-20	8.15	14.65	25.08	1.22	0.78	18.25
20-30	8.06	16.46	28.33	2.05	0.61	22.25
30-40	8.30	18.71	30.14	1.94	0.35	21.16
40-50	8.27	18.08	28.16	2.11	0.26	22.05
50-60	8.14	14.33	22.38	1.31	0.11	17.64

Table (3): Some chemical properties of the irrigation water used in the current study

pH	EC (dSm-1)	Cations meql-1				Anions meq l-1				SAR
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	
7.62	1.43	7.62	2.77	8.40	0.18	-*	5.33	8.61	0.41	4.95

* No carbonate was detected

RESULTS AND DISCUSSION

Effect of Applied Treatments on Soil Bulk Density

Results in Table 4 show the effect of both drain spacings and plough methods as well as soil amendments on bulk density of the soil under investigation.

Obtained results indicated that for all studied soil depths that 25 and 35 m drain spacing treatments significantly decreased soil bulk density comparing to control drain spacing treatment (50 m). The highest and lowest values for reducing soil bulk density were 0.07 and 0.02 Mg m^{-3} which recorded in 0-10 and 50-60 cm soil depths which represents about 5.60% and 1.49%, respectively comparing to control treatments. In general, results also illustrated that for two narrow drain spacing treatments there was a similar trend in decreasing soil bulk density. These results were concomitant with **Behairy (2007)** who reported that the bulk density was slightly decreased with the narrow drain spacing treatments. As regard to plough method treatments, results given in Table 4 point out that, the cross subsoiling plough methods significantly decreased soil bulk density (D_b) comparing to control treatment. In 40-50 cm soil depth the decrease of soil bulk density was 0.08 Mg m^{-3} which represent about 6.61% comparing to control treatment. For different studied soil depths, results in Table 4 also

Table (4): Bulk density (Mg m-3) of the investigated soil as affected by applied treatments

Drain space (m)	Plough (P)	Soil amendments (A)			Mean	Mean of main effects		Soil amendments (A)			Mean	Mean of main effects	
		A_o	A_1	A_2				A_o	A_1	A_2			
		Depth (0-10) cm						**Depth (10-20) cm**					
S_1	P_1	1.39	1.31	1.34	1.35	S_1	1.32	1.39	1.32	1.35	1.35	S_1	1.30
	P_2	1.32	1.26	1.31	1.29	S_2	1.26	1.31	1.17	1.25	1.25	S_2	1.24
Mean		1.35	1.28	1.33	1.32	S_3	1.25	1.35	1.24	1.32	1.30	S_3	1.24
S_2	P_1	1.30	1.26	1.30	1.28	P_1	1.31	1.26	1.22	1.25	1.25	P_1	1.28
	P_2	1.26	1.19	1.24	1.23	P_2	1.25	1.24	1.19	1.22	1.22	P_2	1.24
Mean		1.28	1.22	1.27	1.26	A_o	1.31	1.25	1.20	1.25	1.24	A_o	1.29
S_3	P_1	1.32	1.29	1.31	1.31	A_1	1.25	1.26	1.22	1.25	1.25	A_1	1.22
	P_2	1.28	1.20	1.24	1.24	A_2	1.29	1.26	1.22	1.24	1.24	A_2	1.27
Mean		**1.30**	**1.25**	**1.28**	**1.25**			**1.26**	**1.22**	**1.25**	**1.24**		
		Depth (20-30) cm						**Depth (30-40) cm**					
S_1	P_1	1.30	1.19	1.22	1.21	S_1	1.19	1.26	1.21	1.24	1.24	S_1	1.20
	P_2	1.24	1.13	1.18	1.16	S_2	1.15	1.18	1.14	1.16	1.16	S_2	1.14
Mean		1.21	1.24	1.20	1.19	S_3	1.16	1.22	1.18	1.20	1.20	S_3	1.15
S_2	P_1	1.28	1.14	1.18	1.17	P_1	1.18	1.17	1.14	1.17	1.16	P_1	1.19
	P_2	1.24	1.10	1.15	1.13	P_2	1.14	1.14	1.11	1.12	1.12	P_2	1.14
Mean		1.16	1.29	1.16	1.15	A_o	1.18	1.16	1.12	1.15	1.14	A_o	1.18
S_3	P_1	1.22	1.15	1.19	1.18	A_1	1.14	1.18	1.15	1.17	1.17	A_1	1.15
	P_2	1.27	1.11	1.16	1.14	A_2	1.18	1.14	1.15	1.13	1.14	A_2	1.16
Mean		1.17	1.30	1.17	1.16			1.16	1.15	1.15	1.15		
		Depth (40-50) cm						**Depth (50-60) cm**					
S_1	P_1	1.26	1.22	1.23	1.23	S_1	1.19	1.40	1.38	1.36	1.38	S_1	1.36
	P_2	1.17	1.13	1.15	1.15	S_2	1.16	1.35	1.32	1.35	1.34	S_2	1.32
Mean		1.22	1.17	1.19	1.19	S_3	1.17	1.37	1.35	1.36	1.36	S_3	1.34
S_2	P_1	1.21	1.16	1.22	1.20	P_1	1.21	1.35	1.34	1.35	1.35	P_1	1.36
	P_2	1.13	1.10	1.12	1.12	P_2	1.13	1.31	1.26	1.32	1.30	P_2	1.32
Mean		1.17	1.13	1..17	1.16	A_o	1.19	1.33	1.30	1.33	1.32	A_o	1.35
S_3	P_1	1.23	1.17	1.23	1.21	A_1	1.15	1.37	1.35	1.36	1.36	A_1	1.32
	P_2	1.14	1.11	1.14	1.13	A_2	1.18	1.32	1.31	1.32	1.31	A_2	1.34
Mean		1.19	1.14	1.18	1.17			1.34	1.33	1.34	1.34		

	Depth (cm)	S	P	A	SP	SA	PA	SPA	Depth (cm)	S	P	A	SP	SA	PA	SPA
$L.S.D_{0.05}$	**0-10**	0.01	0.01	0.01	0.03	0.04	0.03	0.02	30-40	0.01	0.01	0.01	0.02	0.04	0.03	0.02
	10-20	0.03	0.02	0.03	0.05	0.06	0.05	0.06	40-50	0.01	0.01	0.01	0.02	0.05	0.02	0.02
	20-30	0.01	0.01	0.01	0.02	0.03	0.02	0.02	50-60	0.01	0.01	0.01	0.03	0.03	0.02	0.02

reveal that the magnitudes of decreasing of soil bulk density were ranged from 0.04 to 0.08 Mg m^{-3} which equivalent to 3.03% to 6.61%, respectively less than control treatments. These results are in the same line with **Zorita (2000)** who concluded that soil bulk density was significantly decreased as tillage intensity was increased. **Jin *et al.* (2007)** also, found that lower bulk density in deep tillage soil comparing to conventional method could be due to loosing the lower layers of soil through deep ploughing method.

Regarding to the influence of addition of gypsum and elemental sulphur as soil amendments on soil bulk density, results in Table 4 show that the application of two studied soil amendments generally resulted in a slightly decreased soil (D_b) of studied soil depths. Apparently, gypsum application was superior to elemental sulphur for decreasing soil bulk density along all soil layers. The high values for reducing soil bulk density were observed in 0-10 cm and 10-20 cm soil depths under gypsum addition treatment. Such decreases represents about 4.58% and 5.43% for the previously mentioned two soil depths, respectively.

In contrast, the lowest value was found in 20-30 cm soil depth under elemental sulphur addition treatment. Generally, gypsum amendment application significantly decreased soil (D_b) in all studied soil depths. These results may be attributed to that addition of Gypsum to the soil under investigation increased the soluble and exchangeable calcium cation, which plays an important role in the formation of a large stable aggregation. These results are in agreement with **El-Gala *et al.* (1998)** and **Awad (1998).**

Results in Table 4 illustrate also that, for different studied soil depths, the combined treatment of 25 m drain spacing, cross subsoiling plough method and gypsum application resulted in the highest effect of decreasing soil bulk density relative to control treatments. Such decreases were 16.80, 16.80, 11.80, 13.50, 14.50 and 11.10% lower than control treatments for soil depths 0-10, 10-20, 20-30, 30-40, 40-50 and 50-60, respectively.

Effect of Applied Treatments on Soil Porosity

With respect to drain spacing treatments and their influences on soil porosity, Results presented in Table 5 reveal that the two narrow drain spacing treatments significantly increased soil porosity. Such effects could be ascribed to narrow drain spacing enhance leached salts *via* water flow and rearrangement soil particles hence, improving soil structure. Increases of porosity were more pronounced under 25 m drain spacing treatment than 35 m drain spacing one. Such effects could be due to effectiveness of salt leashing under such conditions. Results also, elucidate that through all soil depths the increases of soil porosity ranged from (1.35 to 5.56 %) and (0.84 to 2.35%) for 25 and 35 drain spacing treatments, over control treatments, respectively.

Results also show that as percentages the highest percentage of increasing in soil porosity was 5.56% in 10-20 cm soil depths while the lowest one was 1.35 in 40-50 cm soil depth under 25m drain spacing treatment. **Abdel-Mawgoud *et al.* (2007)** found that, total soil porosity increased as tile drain spacing decreased and vice versa.

Considering plough method treatments, results in Table 5 show that cross subsoiling plough method significantly increased soil porosity in the two upper studied soil depths. Such increments were 2.94% and 1.79% at 0-10 and 10-20 cm soil depths, respectively over control treatments. Similar tendency was observed with other soil depths with different magnitudes. In this connection, **Salahin *et al.* (2013)** found that soil porosity was influenced by the tillage practices and the maximum porosity was observed under deep tillage.

Table (5): Total porosity (%) of the investigated soil as affected by applied treatments

Drain space (m)	Plough (P)	Soil amendments (A)			Mean	Mean of main Effects		Soil amendments (A)			Mean	Mean of main effects	
		A_o	A_1	A_2				A_o	A_1	A_2			
		Depth (0-10) cm						**Depth (10-20) cm**					
S_1	P_1	45.31	48.59	46.87	46.92	S_1	47.86	46.08	48.68	47.79	47.52	S_1	49.52
	P_2	47.93	50.22	48.24	48.80	S_2	50.79	49.54	54.54	50.51	51.53	S_2	55.08
Mean		46.62	49.40	47.55	47.86	S_3	50.19	47.81	51.61	49.15	49.52	S_3	51.87
S_2	P_1	48.64	50.09	48.57	49.10	P_1	48.14	51.03	52.78	50.83	51.55	P_1	50.26
	P_2	51.32	54.08	52.03	52.48	P_2	51.08	51.81	53.94	52.07	52.61	P_2	52.05
Mean		49.98	52.08	50.30	50.79	A_o	48.62	51.42	53.36	51.45	55.08	A_o	50.13
S_3	P_1	48.00	49.03	48.18	48.41	A_1	50.92	51.15	52.91	51.09	51.72	A_1	52.63
	P_2	50.55	53.50	51.90	51.98	A_2	49.30	51.16	52.91	52.00	52.02	A_2	50.72
Mean		49.27	51.26	50.04	50.19			51.15	52.91	51.55	51.87		
		Depth (20-30) cm						**Depth (30-40) cm**					
S_1	P_1	52.65	54.19	53.22	53.35	S_1	54.49	51.99	53.65	52.93	52.85	S_1	54.35
	P_2	54.92	56.93	55.02	55.62	S_2	55.97	55.05	56.51	56.00	55.85	S_2	56.54
Mean		53.79	55.56	54.12	54.49	S_3	55.70	53.52	55.08	54.46	54.35	S_3	56.07
S_2	P_1	54.66	56.31	54.50	55.15	P_1	54.47	55.36	56.67	55.32	55.78	P_1	54.71
	P_2	56.37	57.97	56.02	56.78	P_2	56.30	56.69	57.91	57.27	57.29	P_2	56.59
Mean		55.51	57.14	55.26	55.97	A_o	54.84	56.02	57.29	56.29	56.54	A_o	55.14
S_3	P_1	54.42	56.04	54.24	54.90	A_1	56.51	55.23	56.07	55.19	55.50	A_1	56.20
	P_2	56.06	57.64	55.81	56.50	A_2	54.80	56.51	56.38	57.02	56.63	A_2	55.62
Mean		55.24	56.84	55.02	55.70			55.87	56.22	56.10	56.07		
		Depth (40-50) cm						**Depth (50-60) cm**					
S_1	P_1	51.81	53.48	52.90	52.73	S_1	54.21	45.84	46.34	47.14	46.44	S_1	47.22
	P_2	55.03	56.35	55.69	55.69	S_2	55.54	47.66	48.64	47.73	48.01	S_2	48.94
Mean		53.42	54.92	54.29	54.21	S_3	55.05	46.75	47.49	47.44	47.22	S_3	48.33
S_2	P_1	53.67	55.39	53.24	54.10	P_1	53.45	47.46	48.05	48.40	47.97	P_1	47.33
	P_2	56.61	57.47	56.85	56.98	P_2	56.42	48.90	51.62	49.23	49.91	P_2	49.00
Mean		55.14	56.43	55.05	55.54	A_o	54.33	48.18	49.84	48.81	48.94	A_o	47.63
S_3	P_1	52.79	54.85	52.92	53.52	A_1	55.82	46.88	48.13	47.75	47.58	A_1	47.70
	P_2	56.09	57.39	56.28	56.59	A_2	54.65	49.03	49.42	48.77	49.08	A_2	48.17
Mean		54.44	56.12	54.60	55.05			47.96	48.78	48.26	48.33		

	Depth (cm)	S	P	A	SP	SA	PA	SPA	Depth (cm)	S	P	A	SP	SA	PA	SPA
$L.S.D_{0.05}$	**0-10**	0.51	0.41	0.51	1.16	2.11	1.48	2.11	30-40	0.51	0.41	0.51	0.74	1.49	1.19	1.49
	10-20	1.10	0.90	1.10	1.75	2.28	1.97	2.28	40-50	0.42	0.34	0.42	0.81	2.01	0.72	2.01
	20-30	0.35	0.29	0.35	0.94	1.34	0.82	1.34	50-60	0.33	0.27	0.33	0.74	1.30	0.88	1.30

Note: refer to notes under Table (4).

With respect to the effect of soil amendments application on total soil porosity, results in Table 5 show that gypsum addition surpassed elemental sulphur in increasing total porosity of the soil. The magnitude of increasing soil porosity amounted 2.30 and 2.5 % in 0-10 and 10-20 cm soil depths, respectively over control treatments. Similar trend was observed in another studied soil depths with different magnitudes. These findings may be due to the role of gypsum as a source of Ca^{++} in enhancing aggregation process which increase the apparent soil volume and consequently increase soil porosity **(El-Banna, 2007**).

It is worth to mention that, the interaction effect of 25 m drain spacing with cross subsoiling method and gypsum amendments application recorded the highest increase in total soil porosity. Such increments were 19.36, 17.07 and 10.10 % for the three upper studied soil depths, respectively over control treatment. Similar trend was found true for the three studied lower soil depths with different magnitudes**.**

Effect of Applied Treatments on Soil Saturated Hydraulic Conductivity

Obtained results in Table 6 indicates that, the value of saturated soil hydraulic conductivity (Ks) in all studied soil depths ranged from 0.29 to 1.77 m day^{-1}. Most of applied treatments in the current study either individually or in combination are of significant increases of the values of soil Ks with different magnitudes. Obtained results showed that 25 m and 35 m drain spacing treatments significantly increased soil hydraulic conductivity relative to control treatments in different studied soil depths.

Such increases were more pronounced under 25 m drain spacing treatment. The highest value of Ks was 1.77 m day^{-1} which detected in 0-10 cm soil depth under 25 m drain spacing treatment. Similar trend was noticed for all studied subsurface soil depths. These results could be ascribed to the beneficial effect of narrow drain spacing treatment in improvement soil structural properties due to the efficiency of salt leaching. **Wasef (2004)** found that there is an inverse relation between Ks values and drain spacing.

Concerning the effect of ploughing methods treatment on saturated hydraulic conductivity during the course of experimental study, obtained Results in Table 6 show that the cross subsoiling ploughing treatment resulted in a significant increasing in soil Ks. Such effects were found true in all studied soil depths, relative to the control treatments. Such increases were 0.22 and 0.29 m day^{-1} over control treatments at 0-10 and 10-20 cm soil depths, respectively. The corresponding values for 20-30, 30-40, 40-50 and 50-60 cm soil depths were 0.21, 0.17, 0.22 and 0.16 m day^{-1}, respectively. Such effects could be due to that cross subsoiling ploughing method application enhances salt leaching process from both macro and micro pore spaces and consequently improves soil hydraulic conductivity. In this respect, **Said (2002)** and **Jabro *et al.* (2010)** found that soil Ks was significantly affected by depths of tillage which was greater in deep tillage method than shallow one. The increase in Ks with deep tillage is related to soil loosing, greater porosity and better pore continuity in deep tillage than shallow one.

Obtained results in Table 6 show also that generally, addition of gypsum as a soil amendment significantly increased saturated hydraulic conductivity. Exceptional being is the case of 40-50 cm soil depth where soil Ks insignificantly increased under gypsum application treatment relative to control treatment. Also, obtained results in the same Table show that the values of the soil Ks in different studied soil depths ranged from 0.57 to 1.44 m day^{-1} under gypsum addition treatments. Such increments represent about 16.30 and 15.0%, respectively

Table (6): Saturated hydraulic conductivity (m day^{-1}) of the investigated soil as affected by applied treatments

Drain space (m)	Plough (P)	Soil amendments (A) A_o	A_1	A_2	Mean	Mean of main Effects		Soil amendments (A) A_o	A_1	A_2	Mean	Mean of main effects	
		Depth (0-10) cm						**Depth (10-20) cm**					
S_1	P_1	0.88	1.15	1.06	1.03	S_1	1.10	0.70	0.87	0.74	0.77	S_1	0.94
	P_2	1.15	1.25	1.12	1.17	S_2	1.44	1.05	1.23	1.08	1.12	S_2	1.16
Mean		1.02	1.20	1.09	1.10	S_3	1.39	0.87	1.05	0.91	0.94	S_3	1.18
S_2	P_1	1.29	1.37	1.26	1.31	P_1	1.20	0.92	1.18	0.96	1.02	P_1	0.95
	P_2	1.47	1.77	1.47	1.57	P_2	1.42	1.20	1.45	1.26	1.30	P_2	1.24
Mean		1.38	1.57	1.37	1.44	A_o	1.25	1.06	1.32	1.11	1.16	A_o	1.04
S_3	P_1	1.26	1.35	1.21	1.27	A_1	1.44	1.20	1.16	0.86	1.07	A_1	1.22
	P_2	1.43	1.73	1.45	1.51	A_2	1.26	1.17	1.43	1.28	1.29	A_2	1.03
Mean		1.35	1.54	1.33	1.39			1.18	1.29	1.07	1.18		
		Depth (20-30) cm						**Depth (30-40) cm**					
S_1	P_1	0.35	0.49	0.39	0.41	S_1	0.52	0.36	0.44	0.41	0.40	S_1	0.53
	P_2	0.61	0.69	0.61	0.64	S_2	0.63	0.61	0.72	0.63	0.66	S_2	0.60
Mean		0.48	0.59	0.50	0.52	S_3	0.62	0.49	0.58	0.52	0.53	S_3	0.59
S_2	P_1	0.49	0.58	0.52	0.53	P_1	0.49	0.47	0.58	0.53	0.53	P_1	0.49
	P_2	0.71	0.81	0.70	0.74	P_2	0.70	0.64	0.74	0.66	0.68	P_2	0.66
Mean		0.60	0.69	0.61	0.63	A_o	0.56	0.56	0.66	0.60	0.60	A_o	0.53
S_3	P_1	0.49	0.57	0.51	0.52	A_1	0.65	0.48	0.57	0.54	0.53	A_1	0.63
	P_2	0.69	0.77	0.69	0.72	A_2	0.57	0.63	0.71	0.60	0.65	A_2	0.56
Mean		0.59	0.67	0.60	0.62			0.55	0.64	0.57	0.59		
		Depth (40-50) cm						**Depth (50-60) cm**					
S_1	P_1	0.29	0.45	0.33	0.36	S_1	0.47	0.92	0.74	0.95	0.87	S_1	0.96
	P_2	0.54	0.61	0.58	0.58	S_2	0.56	1.04	1.10	1.04	1.06	S_2	1.16
Mean		0.42	0.53	0.46	0.47	S_3	0.55	0.98	0.92	0.99	0.96	S_3	1.15
S_2	P_1	0.48	0.52	0.48	0.50	P_1	0.44	1.06	1.10	1.06	1.07	P_1	1.01
	P_2	0.60	0.67	0.62	0.63	P_2	0.66	1.20	1.30	1.21	1.24	P_2	1.17
Mean		0.54	0.60	0.55	0.56	A_o	0.49	1.13	1.20	1.14	1.16	A_o	1.08
S_3	P_1	0.45	0.50	0.47	0.47	A_1	0.57	1.08	1.11	1.07	1.09	A_1	1.10
	P_2	0.59	0.68	0.61	0.63	A_2	0.52	1.18	1.27	1.21	1.22	A_2	1.09
Mean		0.52	0.59	0.54	0.55			1.13	1.19	1.14	1.15		

	Depth (cm)	S	P	A	SP	SA	PA	SPA	Depth (cm)	S	P	A	SP	SA	PA	SPA
L.S.D$_{0.05}$	**0-10**	0.04	0.03	0.04	0.10	0.16	0.17	0.03	30-40	0.02	0.02	0.02	0.05	0.12	0.05	0.03
	10-20	0.10	0.08	0.09	0.16	0.25	0.17	0.23	40-50	0.09	0.07	0.09	0.04	0.12	0.05	0.02
	20-30	0.01	0.01	0.01	0.05	0.16	0.05	0.03	50-60	0.02	0.02	0.02	0.12	0.18	0.16	0.23

Note: refer to notes under Table (4)

over control treatments. Such obtained increments could be due the beneficial effects of gypsum on saturated hydraulic conductivity were primarily the fact that gypsum as a source of Ca^{++} can improve soil structural stability through enhancing ionic strength effects and removing exchangeable Sodium from the soil colloids. These results are in consistent with **Frenkel *et al.* (1989), Mace and Amrhein (2001) and Rasouli *et al.* (2013)** who demonstrated that the dissolution of gypsum can reduce exchangeable sodium and decrease spontaneous dispersion hazards in salt affected soils.

With respect to elemental sulphur addition, obtained results in Table 6 elucidate that there was no significant differences in soil Ks values under elemental sulphur application related to control treatments, except in 20-30 cm soil depths.

The combined treatment of 25 m drain spacing, cross subsoiling ploughing method and gypsum as soil amendment generally recorded the highest values of soil Ks increments in the studied soil depths. From the presented results in Table 6, the two values 1.77 and 1.46 m day^{-1} were recorded in 0-10 and 10-20 cm soil depths. The obtained values under corresponding 20-30, 30-40, 40-50 and 50-60 cm soil depths were 0.81, 0.74, 0.67 and 1.21 m day^{-1}, respectively.

It is worth to mention that, there was a difference in the initial values of soil Ks along all soil depths. Such differences could be related to the nature of soil texture in the different soil depths, in which the two upper and the lower soil depths are classified as sandy loam in texture whereas the third, fourth and fifths soil layers are classified as loamy texture.

REFERENCES

Abdel-Mawgoud, A.S.A.; El-Sheikh, M.B.A. and Abdel-Khalik, M.I.I. (2007). Impact of agriculture drainage conditions on watertable recession and some soil properties, Nile Delta. J. Agric. Sci. Mansoura Univ., 32 (1): 737-746.

Ahmed, A.R. (2013). Study influence of elemental sulphur compared with foliar spray fertilizers on productivity and maintenance calcareous soil. J. Nat. and Sci., 11 (5): 26-34.

Anikwe, M.A.N.; Eze, J.C. and Ibudialo, A.N. (2016). Influence of lime and gypsum application on soil properties and yield of cassava (*Manihot esculenta* Crantz.) in a degraded Utisol in Agbani, Enugu Southeastern Nigeria. Soil and Tillage Res., 158: 32-38.

Awad, Y.H. (1998). Newly reclaimed soil and wheat tield as affected by FYM and gypsum under different irrigation regimes. Zagazig J. Agric. Res., 25 : 671-677.

Behairy, S.S. (2007). Effect of drain spacing on some soil characteristics and cotton yield in Eastern North Delta, Egypt. J. Agric. Sci. Mansoura Univ., 32 (7): 6067-6075.

Donnan, W.W. (1946). Model tests of a tile-spacing formula. Proc. Soil Sci. Soc., Ame. J., 11: 131-136.

El-Banna, I.M.M. (2007). Some factors controlling the improvement of soil mositure characteristics and pore size distribution in North Nile Delta Soils. J. Agric. Sci. Mansoura Univ., 32 (10): 8767 - 8776.

El-Gala, A.M.; Eid, M.A. and Al-Shandoudy, H.G. (1998). The effect of organic matter, sulphur and Fe application on the availability of certain nutrients in the soils of El-Dhahera area, Sultant of Oman. Arb. Univ. J. Agric. Sci., 6 (2): 607-623.

Farag, F.A.; El Shazely, M.A.E.; Abd Elrahman, A.H. and Awaad, M.S. (2013). Soil management and improvement of salt affected soils. J. Soil Sci. and Agric. Eng., Mansoura Univ., 4 (9): 907-919.

Frenkel, H.; Gerstl, Z. and Alperovitch, N. (1989). Exchange-induced dissolution of gypsum and the reclamation of sodic soils. J. Soil Sci., 40: 599 - 611.

Gendy, A.A.S. (2011). Response of some field crops to proper tillage under salt affected soils in North Nile Delta. J Soil Sci. and Agric. Eng., Mansoura Univ., 2 (5): 441-453.

Hooghoudt, S.B. (1952). Tile drainage and subirrigation. Soil Sci. J., 74: 35-48.

Jabro, J.D.; Stevens, W.B.; Iversen, W.M. and Evans, R.G. (2010). Tillage depth effects on soil physical properties, sugar beet yield and sugar beet quality. Communications in Soil Sci. and Plant Anal., 41: 908-916.

Jackson, M.L. (1967). Soil chemical analysis. Prentic- Hallinc, ebgle wood cliffs, n. S. N. S. Constable and Co. Ltd. London.

Javed, H.M.R.; Zamir, M.S.I.; Tanveer, A. and Yaseen, M. (2013). Soil physical properties and spring maize yield as influenced by different tillage practices and integrated use of poultry manure with synthetic fertilizers. J. Agric. Res., 51 (3): 277-287.

Jin, H.; Honngwen, L.; Xiaoyan, W.; McHugh, A.D.; Wenying, L.; Huanwen, G. and Kuhn, N.J. (2007). The adoption of annual sub-soiling as conservation tillage in dry land maize and wheat cultivation in Northern China. Soil and Tillage Res., 94: 493-502.

Jodi Delong, H. (2004). Can subsoiling increase crop yields in Minnesota? World Wide Corresondent Meredith Corporation.

Kahlon, U.Z.; Murataza, G. and Abdul Ghafoor (2012). Amelioration of Saline-sodic soil with amendments using brackish water, canal water and their combination. Int. J. Agric. and Biol., 14 (1): 38-46.

Kanwal, M.; Abid, M.; Ali, M.A. and Soomro, A.A. (2014). Properties of sodic soils improved when amended with gypsum and municipal waste in an incubation experiment. Pak. J. Agric. Engg., Vet. Sci., 30 (2): 113-125.

Klute, A. (1986). Methods of soil analysis (part I) physical and mineralogical methods. 2nd Ed., Ame. Soc. Agron. Madison Wisconsing, USA.

Kuldeep, S.; Coudhary, O.P. and Singh, H. (2012). Effects of subsoiling on sugarcane productivity and soil properties. J. Sugarcane Res., 2 (1): 32-36.

Li, Y. and Hang, M. (2013). Effects of Tillage managements on the soil Physical Properties and the Water Utilization Efficiency of Winter Wheat. Available at: http://www. seiofbluemou-ntain. com/upload/product/ 201002/ 126-5183792 ra61uon3.pdf.

Mace, J.E. and Amrhein, C. (2001). Leaching reclamation of soil irrigated with moderate SAR waters. Soil Sci. Soc. Ame. J., 65:199-204.

Moukhtar, M.M.; El-Hadidy, E. and El-Shewikh, M.A.B. (2003). Drainage and degrading salty clay soil in Egypt. 9th Int. Drainage Workshop, September 10-13, Utrecht, the Netherlands.

Nan, J.; Xiaomin, C.; Xiaomin, W.; Muhammad, S.L.; Yuanming, W.; Zhichuang, G. and Zhenjie, D. (2015). Effects of applying flue gas desulfurization and humic acid on soil physiochemical properties and rapeseed yield of saline-sodic cropland in the eastern coastal area of China. J. Soil Sediments DOI 10. 1007/s11368-015-1186-3.

Nelson, D.W. and Sommers, L.E. (1982). Total carbon, organic carbon and organic matter. p 539-580. In A. L. Page et al., (ed.) Methods of Soil Analysis .part 2. 2nd Ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI.

Rasouli, F.; Pouya, A.K. and Karimian,. N. (2013). Wheat yield and physic-chemical properties of a sodic soil from semi-aird area of Iran as affected by applied gypsum. Geoderma, 193: 246-255.

Reading, L.P.; Baumgartl, T.; Bristow, K.L. and Lockington, D.A. (2012). Hydraulic conductivity increases in a sodic clay soil in response to gypsum application: impacts of bulk density and cation exchange. Soil Sci., 177 (3): 165-171.

Richards, L.A. (1954). Diagnosis and Improvement of Saline and Alkali Soils U.S. Salinity Laboratory Staff. Agriculture Hand book No. 60. Printing office, Washington, USA.

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 (1): 57-70.

Salahin, N.; Alam, M.K.; Islam, M.M.; Naher, L. and Majid, N.M. (2013). Effects of green manure crops and tillage practice on maize and rice yields and soil properties. Aust. J. Crop Sci., 7 (12): 1901-1911.

SAS (1994). SAS User's Guide, Statistics, Ver. 6.04 4th Ed., SAS Inst. Inc., Carry, NC. USA.

Wasef, M.Z. (2004). Studies on tile drainage in some Egyptian Soils. Ph.D. Thesis, Fac. Agric. Moushtohor, Zagazig Univ., Banha Branch, Egypt.

Wesseling, J. (1980). Subsurface flow into drain c.f. Drainage Principles and Applications. Int. Inst. Land Reclamation and Improv. (ILRI), Pup. 16111 Wageningen, The Nitherlands.

Younesi, M. and Navabzadeh, M. (2007). Investigation of plowing depth effect on some soil physical properties. Pak. J. Biol. Sci., 10 (24): 4510-4514.

Zorita, M.D. (2000). Effect of deep tillage and nitrogen fertilization interactions on dry land corn productivity. Soil and Tillage Res. 54:11-19.

الملخص العربي

تأثير بعض أساليب إدارة التربة على بعض الخواص الفيزيائية للأراضى المتأثرة بالأملاح بمنطقة سهل الطينة

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أجريت تجربة حقلية خلال موسمين شتويين متتاليين ٢٠١٢ و٢٠١٣ بمنطقة سهل الطينة - شمال سيناء - مصر، لدراسة تأثير كلاً من مسافات المصارف الحقلية وطرق الحرث وايضاً إضافة محسنات التربة (الجبس أو الكبريت) على بعض الخواص الفيزيائية للتربة، أستخدم التصميم الإحصائى نظام القطع المنشقة مرتين مع ثلاث مكررات، وضعت مسافات المصارف الحقلية (٢٥، ٣٥ و٥٠ م) فى القطع الرئيسية بينما تم وضع طرق الحرث (حرث تقليدى – حرث تحت التربة متعامد) فى القطع المنشقة الأولى، ووضعت محسنات التربة (جبس أو كبريت عنصرى) فى القطع المنشقة الثانية. ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى: أوضحت النتائج أنه خلال أعماق التربة المختلفة فإن معاملات التفاعل المشترك بين مسافة المصارف الحقلية ٢٥م مع الحرث تحت التربة المتعامد وإضافة الجبس الزراعى قد نتج عنها أعلى إنخفاض فى قيم الكثافة الظاهرية للتربة وذلك مقارنة بمعاملات الكونترول المختلفة، وكانت هذه القيم ١٦,٨٠، ١٦,٨٠، ١١,٨٠، ١٣,٥٠، ١٤,٥٠ و١١,١٠% أقل من معاملات الكونترول وذلك فى أعماق ٠-١٠، ١٠-٢٠، ٢٠-٣٠، ٣٠-٤٠، ٤٠-٥٠ و٥٠-٦٠ سم على الترتيب، وجد أن التفاعل المشترك بين مسافة المصارف الحقلية ٢٥ م والحرث تحت التربة المتعامد مع إضافة الجبس الزراعى قد سجلت أعلى زيادة فى قيم مسامية التربة. وقد كانت قيم الزيادة ١٩,٣٦، ١٧,٠٧ و١٠,١٠% أعلى من معاملات الكونترول فى الثلاثة أعماق العليا للتربة على الترتيب. مثل هذا الإتجاه كان صحيحاً أيضاً خلال الثلاثة أعماق السفلى للتربة، كما تشير النتائج إلى أن أعلى قيم للتوصيل الهيدروليكى المشبع للتربة قد سجلت فى معاملة التفاعل المشترك بين إضافة الجبس الزراعى ومسافة المصارف الحقلية ٢٥م مع الحرث المتعامد تحت التربة وذلك خلال أعماق التربة محل الدراسة. إن أعلى قيمتين للتوصيل الهيدرليكى المشبع للتربة هما ١,٧٧ و١,٤٦م يوم -١ قد سجلتا فى أعماق التربة ٠-١٠ و١٠-٢٠ تحت نفس معاملة التفاعل. وكانت قيم التوصيل الهيدروليكى للتربة خلال أعماق التربة ٢٠-٣٠, ٣٠-٤٠، ٤٠-٥٠ و٥٠-٦٠ سم هى ٠,٨١، ٠,٧٤، ٠,٦٧ و١,٢١ م يوم -١ على الترتيب.

الكلمات الاسترشادية: الأراضي المتأثرة بالأملاح، مسافات المصارف الحقلية، حرث تحت التربة المتعامد، الجبس، الكبريت.

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