J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 5 (12): 1717 -1730 , 2014

IMPROVING HEAVY CLAY SALT AFFECTED SOIL AND ITS PRODUCTION USING SOME AMENDMENTS APPLICATION IN NORTH DELTA

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ABSTRACT

A field experiment was conducted through winter season 2013/2014 and summer season 2014 at North Delta, Egypt (Al-Hamool District, Kafr El-Shiekh Governorate), to evaluate the effect of subsoiling types (one and two directions) and gypsum application rates (1.5 and 3 ton fed.$^{-1}$) on improving some soil physical and chemical properties and yields of sugar beet and rice crops.

Subsoiling and gypsum application were reduced salinity and sodcity of the soil. The reduction of salinity, after two seasons from application are 38.58, 41.06, 42.50 and 43.58 %, for subsoiling one direction + 1.5 ton G.fed.$^{-1}$, two directions + 1.5 ton G.fed.$^{-1}$, one direction + 3 ton G.fed.$^{-1}$ and two directions + 3 tonG.fed.$^{-1}$, respectively than before treatments application. The corresponding values of ESP are 29.40, 33.44, 34.26 and 38.77 %, respectively. Subsoiling two directions and high gypsum rate are superior to one direction and low gypsum rate in reducing soil salinity and sodcity. Subsoiling and gypsum application caused increasing Ca^{++}/TSS and decreasing Na^{+}/TSS ratios in the topsoil up to 45cm especially under high rate of gypsum.

Subsoiling and gypsum application were reduced moisture content, bulk density and penetration resistance of the soil than before, especially subsoiling two directions. Basic infiltration rates before treatments application was low (0.66 cm/hr) and higher after application (varied from 0.81 to 1.89 cm/hr).

Data indicate that subsoiling and gypsum application caused significant increases for sugar beet and rice yields compared to control. Sugar beet roots yield are higher after application of subsoiling and gypsum than that control by 3.48, 3.80, 3.80 and 3.31 ton fed.$^{-1}$ for subsoiling one direction + 1.5 ton G.fed.$^{-1}$, two directions + 1.5 ton G.fed.$^{-1}$, one direction + 3 ton G.fed.$^{-1}$ and two directions + 3 ton G.fed.$^{-1}$, respectively. The corresponding values of gross sugar yield were 0.550, 0.650, 0.650 and 0.580 ton fed.$^{-1}$, respectively. Also, rice grain yield are higher after application of subsoiling and gypsum than that control by 0.590, 0.610, 0.610 and 0.580 ton fed.$^{-1}$ for the above mentioned treatments, respectively. Subsoiling and gypsum are good ways in clay soils to reserve the root zone from salinity and sodcity as well as tend to improve soil physio-chemical characteristics and increase crops production.

Keywords: Drainage, Subsoiling, Clay soil, Rice, sugar beet.

INTRODUCTION

The global extent of salt affected lands is considerable. Whereas the world's population continues to rise, the total land area under irrigation appears to have leveled off. Moreover, the expanded salinity area is expected to be more because climate change and water shortage, particularly in Egypt. At least 20% of all irrigated lands are salt-affected, with some estimates being as high as 50%. In Egypt, northern part of the Nile Delta represents a large area of heavy clay soils with shallow open drainage which are low permeability that might have a low productivity. Most of these areas suffers from the major soil twin problems i.e., salinity/sodicity and water logging. The nature and properties of these soils are diverse and require specific approaches for their reclamation and management to maintain their long term productivity (Mc Williams, 2003 and Moukhtar *et al.,* 2003). Soil salinity and sodicity are one of the main agricultural problems limiting plant growth and development in the world especially in arid and semiarid regions (Pessarakli, 2010). Osmotic effect, ionic imbalance, and specific ion toxicity are the main harmful salinity effects that can be inhibited plant growth and development (Chen et al, 2010). Alkali soils which are characterized by their adverse physical properties, their dispersed condition and impermeability to water, are to be directly connected with sodium as the dominant exchangeable base and the presence of magnesium silicate precipitated during the process of soil alkalinization. Gypsum applications followed by leaching, and biological methods such as growing salt-tolerant crops, were found successful in reclamation of a number of sodic and saline-sodic soils having good drainage conditions (Ahmad *et al.,* 1990; Oster *et al.,* 1996 and Reda 2006).

Subsoiling in the drainage mode seeks to lift and shatter the soil peds to induce improved structure and so improve the water movement to the permanent pipe system (Abdel-Mawgoud *et al.,* 2006). Subsoiling will enhance downward movement of irrigation water carrying off excess salts from surface layers. After wards, regular subsequent irrigations will gradually reduce the salt content in groundwater at least when close to soil surface. The percolating water will constitute a temporary front preventing the saline groundwater in subsurface soil layers from linking with the upper ones. Subsoiling, on the suitable soil type and done properly can reduce water logging problems (Moukhtar *et al.,* 2002, Moukhtar *et al.,* 2003) and Antar, *et al.,* (2012).

Improved crop growth following subsoiling and mole drains are generally considered to be the result of the physical shattering of the hardpan, which allows to increase 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 (Lickacz, 1993). Aiad *et al.,* (2012) revealed that soil compaction influenced soil strength, bulk density, root penetration, aeration and nutrient uptake; all of which could have a direct bearing on crop production. Said (2003) and Antar, *et al.,* (2008) concluded that the cumulative and basic infiltration rate of the treated soil by subsoiling markedly increased relative to the untreated one. He also, found that the treated soil resulted in a sharp decrease in the bulk density and penetration resistance in coincidence with a sharp increase in total porosity and macro pores relative to the untreated one.

The current study aims to evaluate the effect of subsoiling types (one and two directions) and gypsum application rates (1.5 and 3 ton/fed.) on improving some soil physio-chemical properties and yields of sugar beet and rice crops.

MATERIALS AND METHODS

A field experiment was conducted through winter season 2013/2014 and summer season 2014 at North Nile Delta (Al-Hamool District, Kafer El-Shiek Governorate, Egypt), to evaluate the effect of subsoiling types (one direction and two directions) and gypsum application rates (1.5 and 3 ton/fed.) on improving some soil physio-chemical properties and yields of sugar beet and rice crops. The soil has a clayey texture; the average textural analysis for this soil is 14.19% sand, 30.50% silt and 55.31 % clay (Table 1). The location is situated at 31° 18′ 12″ 8 N latitude and 31° 03′ 30″ 8 E longitude. The initial of some soil properties for the experimental field are presented in Table (1).

The experiment was installed before winter season (2013/2014) as follows:

1: Open drainage with 20 m spacing and 75 cm depth (control).
2: Subsoiling one direction with gypsum application at rate of 1.5 ton/fed.
3: Subsoiling two directions with gypsum application at rate of 1.5 ton/fed.
4: Subsoiling one direction with gypsum application at rate of 3 ton/fed.
5: Subsoiling two directions with gypsum application at rate of 3 ton/fed.

Before winter season (2013/2014, gypsum was application as well as subsoiling installed at 45 cm depth and 1.5 m distances between the ploughed lines "subsoiling are unlined channels formed in a clay subsoil with a ripper blade."

Open drain was used to collect the drainage water brought by subsoiling unlined channels. The salinity of irrigation water ranges between 0.8 – 0.6 dSm-1 with an average of 0.73 dSm^{-1}.

In the winter season (2013/2014) Seeds of sugar beet (*pleno variety*) were sown on 5th of October in 2013. The hills were thinned to one plant before the first irrigation. All plots received 100 Kg Ca-superphosphate/fed, and 50 Kg K-sulfate/fed, during tillage operation. Nitrogen fertilizer in the form of urea was side dressed at a rate of 100 Kg N/fed, in three doses before the first, the second and the third irrigations. In the summer season (2014) rice (*Oryza sativa* L.) was transplanting on 7th of Jun in 2014. All plots received 50 kg/fed. of Ca-superphosphate (15.5% P_2O_5) before cultivation and 75kg N/fed (as urea) in two doses after 15 and 35 days from transplanting. The different agricultural practices were done as recommended for two crops under study.

Soil samples (0-15, 15-30, 30-45 and 45-75cm depth) were collected before experiment and after first and second seasons from treatments instillation for all treatments and monitored for some physical and chemical analysis. Salinity was determined in saturated soil best extract according to Page et al. (1982). Exchangeable sodium was determined using ammonium chloride and measured by using flame photometer according to Page et al. (1982). Soil bulk density and total porosity of the different layers of soil profile were measured before experiment and after first and second seasons from treatments instillation for all treatments using the core sampling technique as described by Campbell (1994). Soil penetration resistance (SPR) was determined by hand penetrometer apparatus (Read by Newten/cm2) and, convert the Newten into Mega Pascal (MPa) values (100 Newten/cm^2 = 1 Mega Pascal). Infiltration rate was determined using double cylinder infiltrometer as described by Garcia (1978). At the end of second season, soil moisture content (%) was determined by drying the soil samples at 105°C to constant weight and the moisture content was calculated according to Singh, (1980). Productivities for two crops with different treatments were determined.

Statistical analysis: Data obtained are subjected to statistical analysis according to Snedecor and Cochran (1980).

Table (1): The initial of some soil properties for the experimental field

Soil depth (cm)	Particle size distribution			Texture grade	EC (dS/m)	ESP %	Bulk density g/cm^3	IR (cm/h)
	Sand%	Silt%	Clay%					
0-15	13.29	30.28	56.43	Clayey	7.88	16.84	1.34	0.66
15-30	13.71	30.65	55.64	Clayey	8.23	17.54	1.35	
30-45	14.88	29.84	55.28	Clayey	9.68	19.56	1.40	
45-75	14.87	31.24	53.89	Clayey	10.26	21.27	1.45	
Mean	14.19	30.50	55.31	Clayey	9.01	18.80	1.39	

RESULTS AND DISCUSSION

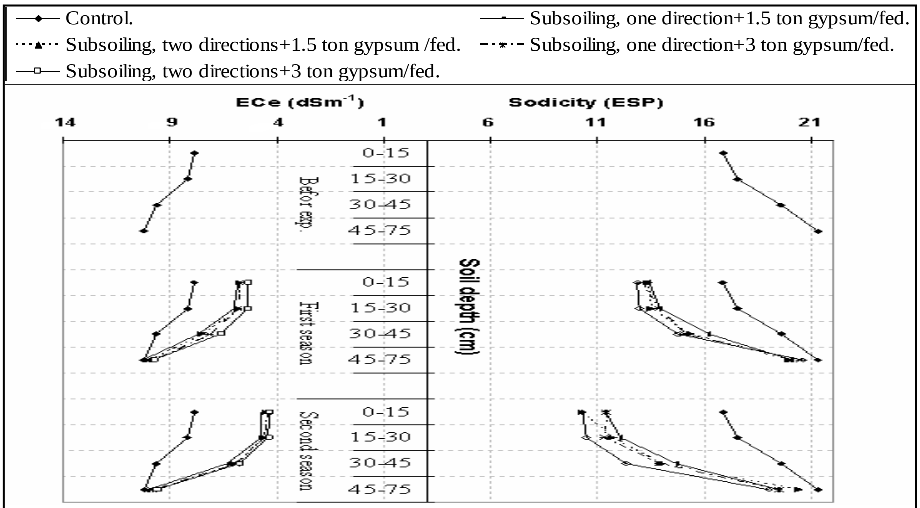
Soil salinity and sodcity:

Data presented in Table (2) and Fig (1) show that, application of subsoiling and gypsum seem to be more effective in decreasing soil salinity and sodcity. The salinity and sodcity of the soil increased markedly with the increasing of soil depth (Fig 1). Soil salinity and sodcity in the topsoil up to 45cm, before treatments application are relatively high (EC_e varied from 7.88 to 9.68 dSm^{-1} and ESP from 16.84 to 19.56) comparing with after the first and second seasons from treatments application (varied from 4.35 to 7.68 dSm^{-1} for EC_e and 10.26 to 16.21 for ESP). The decreases of soil salinity and sodcity in the topsoil up to 45cm, after the second season of treatment installation are more pronounced compared to after one season (Table, 2). The reduction of salinity, after two seasons from treatments application are 38.58, 41.06, 42.50 and 43.58 %, for subsoiling one direction + 1.5 ton gypsum $fed.^{-1}$, subsoiling two directions + 1.5 ton gypsum $fed.^{-1}$, subsoiling one direction + 3 ton gypsum $fed.^{-1}$ and subsoiling two directions + 3 ton gypsum $fed.^{-1}$, respectively comparing with before treatments application. The corresponding values of ESP are 29.40, 33.44, 34.26 and 38.77 %, respectively. Salinity and sodcity of the soil are decreased in the top layer (0-45) in all treatments while, no decrease is shown in subsurface layer 45-75cm. These results might be explained by the effect of subsurface tillage on water table recession, which occurred only through subsoil depth and thus contributed to an active salt transfer during the falling of water table. It could be concluded that in heavy textured soils, the ponding conditions under open drains, realizes desalinization of the surface soil layers and partly of the subsurface layers. Whereas, subsoiling is effective in removing salts from the upper layers only. Salt leaching from deeper layers depends on the efficiency of drainage system. Similar results were obtained by Moukhtar *et al.,* (2003), Abdel-Mawgoud et al. (2003) and Antar, *et al.,* (2012).

It is clear that subsoiling two directions (Net) is superior to subsoiling one direction under two rates of gypsum in reducing soil salinity and sodcity after the first season. While, the high rate of gypsum is superior to the low rate under both subsoiling types in reducing soil salinity and sodcity after the second season. The average values of soil salinity (0--45cm) were 6.51, 6.11, 6.27 and 5.83 dSm^{-1} after the first season and 5.28, 5.07, 4.94 and 4.85 dSm^{-1} after the second season for subsoiling one direction + 1.5 ton gypsum $fed.^{-1}$, subsoiling two directions + 1.5 ton gypsum fed.$^{-1}$, subsoiling one direction + 3 ton gypsum fed.$^{-1}$ and subsoiling two directions + 3 ton gypsum fed.$^{-1}$, respectively. The corresponding values of soil sodcity were 14.51, 13.98, 14.15 and 13.50 after the first season and 12.69, 11.97, 11.82 and 11.01 after the second season respectively. The effect of the treatments on improving soil desalinization, desodification is clarified in Table (2) and Fig (1). It should be mention that the greatest desalinization occurs after subsurface tillage. Results could be attributed mainly to that subsoil forms many lines with big crack extent from soil surface to subsoil depth (45cm deep) and also numerous effective capillary cracks is formed. All these cracks together break the soil matrix and encourage downward of water as well as solute movement. The soil cracks life may be several months or years (Moukhtar *et al.,* 2002). Moukhtar et al, (2003) reported that, moling or subsoiling enhance downward movement of irrigation water carrying off excess salts from surface layers. After wards, regular subsequent irrigations will gradually reduce the salt content in groundwater at least when it is close to soil surface. Similar results were obtained by Aiad *et al.,* (2012) and Antar, *et al.,* (2012)

Table (2): Salinity and sodcity of the soil as affected by the different studied treatments.

Treatments	Soil depth (cm)	First season		Second season	
		EC dSm^{-1}	ESP	EC dSm^{-1}	ESP
Before ex (Control).	0-15	7.88	16.84	7.88	16.84
	15-30	8.23	17.54	8.23	17.54
	30-45	9.68	19.56	9.68	19.56
	45-75	10.26	21.27	10.26	21.27
Average (0-45)		8.60	17.98	8.60	17.98
Subsoiling (one direction) with 1.5 ton gypsum/fed.	0-15	5.84	13.42	4.74	11.35
	15-30	6.01	13.89	4.75	12.08
	30-45	7.68	16.21	6.35	14.65
	45-75	10.32	20.12	10.03	19.45
Average (0-45)		6.51	14.51	5.28	12.69
Net subsoiling (two directions) with 1.5 ton gypsum /fed.	0-15	5.61	13.33	4.53	10.27
	15-30	5.66	13.28	4.61	11.65
	30-45	7.06	15.34	6.06	13.98
	45-75	10.06	19.96	9.68	20.42
Average (0-45)		6.11	13.98	5.07	11.97
Subsoiling (one direction) with 3 ton gypsum/fed.	0-15	5.78	13.05	4.53	11.35
	15-30	5.83	13.85	4.62	11.27
	30-45	7.21	15.55	5.68	12.84
	45-75	9.86	20.49	9.89	19.47
Average (0-45)		6.27	14.15	4.94	11.82
Net subsoiling (two directions) with 3 ton gypsum/fed.	0-15	5.41	12.85	4.35	10.26
	15-30	5.43	12.93	4.44	10.48
	30-45	6.65	14.73	5.76	12.29
	45-75	9.78	20.62	9.68	19.01
Average (0-45)		5.83	13.50	4.85	11.01



Fig(1): Average of soil salinity (ECe, dSm^{-1}) and sodicity (ESP) before exp., after first and second seasons from treatments installation of study.

Ratio of Ca^{++}/TSS and Na^{+}/TSS:

Results in Table (3) show that, application of subsoiling and gypsum seemed to be more effective on increasing Ca^{++}/TSS and decreasing Na^{+}/TSS ratios in the topsoil up to 45cm, than before treatments application. The increases of Ca^{++}/TSS and decreases Na^{+}/TSS ratios after the second season from treatments application are more pronounced compared to after the first season. This may be due to the leachability of Na^{+} is higher than that of Ca^{++} and Mg^{++} with subsoiling. Also, Na^{+} and Cl^{-} are leached more readily than SO_4^{+}, Ca^{++} and Mg^{++}. In this concern, Ali and Kahlown (2001) mentioned that reclamation of saline – sodic and sodic soils, however, can not be achieved by simple leaching. 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 such as gypsum along with leaching. They also added that, the effectiveness of gypsum depends upon: i. Degree of fineness, ii. Way in which it is incorporated on the soil and iii. Efficiency of drainage system. Change in Ca^{++}/TSS and Na^{+}/TSS ratios were not shown in deeper layer (45-75cm). Whereas, subsoiling is effective in removing salts especially Na^{+} from the topsoil up to 45cm. It is clear that, no obvious differences for both Ca^{++}/TSS or Na^{+}/TSS ratios in all treatments after the first season whereas, the results are nearly the same (Table, 3). After the second season, high rate of gypsum is superior to the low rate under both subsoiling types in increasing Ca^{++}/TSS and decreasing Na^{+}/TSS ratios in the topsoil up to 45cm. After the second season, the average of Ca^{++}/TSS rate were 24.29, 25.45, 27.06 and 29.05 for subsoiling one direction + 1.5 ton gypsum $fed.^{-1}$, subsoiling two directions + 1.5 ton gypsum $fed.^{-1}$, subsoiling one direction + 3 ton gypsum $fed.^{-1}$ and subsoiling two directions + 3 ton gypsum $fed.^{-1}$, respectively. The corresponding values of Na^{+}/TSS ratio were 63.73, 64.55, 59.74 and 58.71, respectively. This may be due to the good effectiveness of high rate (3 tonfed^{-1}) of gypsum with subsoiling. Similar results were obtained by Aiad *et al.,* (2012).

Table (3): Ratio of Ca^{++}/TSS and Na^{+}/TSS of the soil as affected by the different studied treatments.

Treatments	Soil depth (cm)	First season		Second season	
		Ca^{++}/TSS	Na^{+}/TSS	Ca^{++}/TSS	Na^{+}/TSS
Before ex (Control).	0-15	16.22	74.06	16.22	74.06
	15-30	15.46	73.40	15.46	73.40
	30-45	13.50	72.91	13.50	72.91
	45-75	13.23	73.73	13.23	73.73
Average (0-45)		15.06	73.46	15.06	73.46
Subsoiling (one direction) with 1.5 ton gypsum/fed.	0-15	24.73	66.93	26.75	59.93
	15-30	24.66	68.15	26.59	60.74
	30-45	19.10	70.49	20.44	70.53
	45-75	15.80	77.37	15.39	77.31
Average (0-45)		22.83	68.52	24.59	63.73
Net subsoiling (two directions) with 1.5 ton gypsum /fed.	0-15	25.13	67.04	27.68	61.09
	15-30	24.56	67.32	27.51	62.62
	30-45	19.67	70.05	21.15	69.93
	45-75	15.71	79.06	15.49	77.27
Average (0-45)		23.12	68.14	25.45	64.55
Subsoiling (one direction) with 3 ton gypsum/fed.	0-15	26.02	64.86	28.74	57.26
	15-30	25.04	67.65	28.57	57.41
	30-45	20.18	73.44	23.88	64.56
	45-75	15.44	78.08	15.53	70.03
Average (0-45)		23.75	68.65	27.06	59.74
Net subsoiling (two directions) with 3 ton gypsum/fed.	0-15	25.53	65.51	31.86	56.07
	15-30	24.13	66.10	31.40	56.60
	30-45	20.21	72.57	23.89	63.45
	45-75	15.47	79.85	16.55	76.51
Average (0-45)		23.29	68.06	29.05	58.71

Soil moisture contents:

Soil moisture redistribution as affected by subsoiling and gypsum treatments are presented in Figure 2. Results show that, soil moisture content was lower in the topsoil layers and increase with increasing soil depth. Results show that soil moisture content was higher before subsoiling application (varied from 31.6 to 41.6 %) and reduced after the second season from subsoiling application (varied from 22.4 to 40.7%). Results could be attributed mainly to that subsoil forms many lines with big crack extent from soil surface to subsoil depth (45cm deep) and also numerous effective capillary cracks is formed. All these cracks together break the soil matrix and encourage downward of water. Moukhtar et al, (2003) reported that, moling or subsoiling enhance downward movement of irrigation water from surface layers. In this concern, Abdel-Mawgoud (2004) found that subsoiling resulted in a noticeable increase in macro-pores with a consequent decrease in micro-pores compared with the control treatment.

The effect of subsoiling treatments on soil moisture content after the second season, are realized in the topsoil up to 45cm (Fig 2) while, no difference was shown in deeper layer (45-75cm). Whereas, subsoiling is effective in the upper layers only (0-45cm) while, in the deeper layers (45-75cm) soil moisture content depends on the efficiency of drainage. This may be due to improve the aeration conditions in the area adjacent and above subsoiling lines. Whereas, cycles of drying and wetting of soil decrease soil compaction and improves soil properties which leads to increase of soil aeration in the root zone and consequently reduce of soil moisture content. Results show that, subsoiling two directions (Net subsoiling) is superior to subsoiling one direction in reducing soil moisture content. This may be due to the good effectiveness of net subsoiling with open drains than subsoiling one direction. While, no obvious different between soil moisture contents under both gypsum rates treatments (1.5 and 3 ton fed.$^{-1}$). The average values of soil moisture contents (0-45cm) were 28.3 and 26.9% for one direction and two directions of subsoiling under 1.5 ton gypsum fed.$^{-1}$ and were 28.7 and 26.6 % for one direction and two directions of subsoiling under 3 ton gypsum fed.$^{-1}$, respectively.

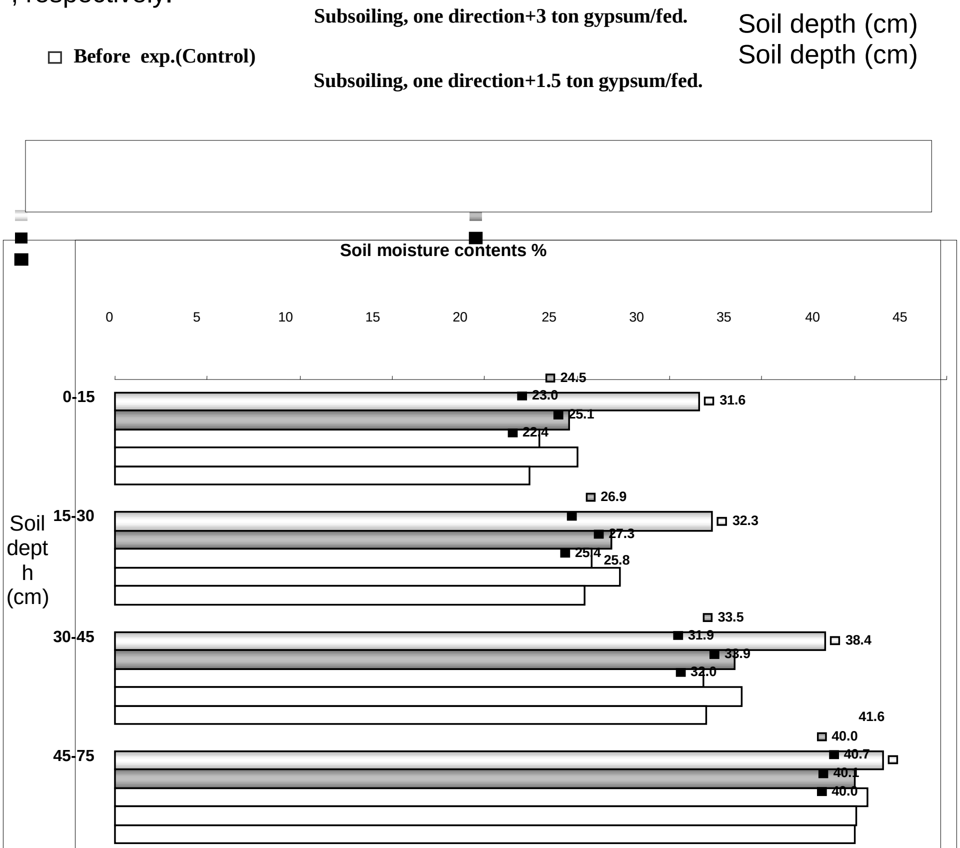


Fig (2): Avarege of soil moisture contents (%) before exp. and after the second season from treatments installation of

Soil bulk density and Soil porosity

Soil bulk density is considered as one of the parameters which indicate the status of soil structure and consequently, soil water, air and heat regimes

(Richards, 1954). Results in Table (4) show that, soil bulk density is increased with increasing soil depth for all tested profiles. This increase may be resulted from increasing soil compaction due to layers weight. Subsoiling and gypsum application were reduced soil bulk density, especially in the topsoil up to 45cm. The decreases of soil bulk density after two seasons from treatments installation are more pronounced compared to before treatments application. Soil bulk density did not change in deeper layer (45-75cm) with different treatments. These results might be explained by the effect of subsoiling on bulk density, which occurred only around and above subsoiling depth. It could be attributed to the effects of subsoiling on breaking soil cods and bigger granular into smaller crumbs as well as breaking and cracking the compacted layers (Amer, 1999 and Abdel-Mawgoud *et al.,* 2006). Results show that, subsoiling two directions is superior to one direction in reducing soil bulk density. This may be due to the good effectiveness of subsoiling two directions than one direction. While, no obvious different between soil bulk density values under both gypsum rates treatments. The average values of soil bulk density (0-45cm) were 1.26 and 1.25 Mgm^{-3} for one direction and two directions of subsoiling under 1.5 ton gypsum $fed.^{-1}$ and were 1.26 and 1.24 Mgm^{-3} for one direction and two directions of subsoiling under 3 ton gypsum $fed.^{-1}$, respectively.

Soil porosity values (Table 4) take almost the opposite trend to that encountered with bulk density. The results indicate that the values of bulk density were increased and values of total porosity were decreased with the depth for all treatments (Table 4). Subsoiling especially two directions are superior in enhancing soil porosity. Jodi DeJong (2004) and Antar, *et al.,* (2012) stated that the theory behind subsoiling is to shatter a deep compacted layer in the soil to increase water movement, increase total porosity, create better aeration for the root and increase the availability of nutrients for plant growth.

Table (4): Bulk density and total porosity of the soil as affected by the different studied treatments.

Soil depth (cm)	Before exp. (Control)	Subsoiling, one direction +1.5 ton gypsum/fed.	Subsoiling, two directions +1.5 ton gypsum/fed.	Subsoiling, one direction +3 ton gypsum/fed.	Subsoiling, two directions +3 ton gypsum/fed.
Soil bulk density (Mgm^{-3})					
0-15	1.34	1.18	1.19	1.19	1.16
15-30	1.35	1.23	1.21	1.21	1.22
30-45	1.40	1.38	1.35	1.37	1.33
45-75	1.45	1.43	1.43	1.44	1.43
Average (0-45)	1.36	1.26	1.25	1.26	1.24
Soil porosity (%)					
0-15	49.45	55.55	55.00	54.92	56.22
15-30	49.23	53.72	54.22	54.23	53.85
30-45	47.34	47.85	49.05	48.44	49.66
45-75	45.46	45.93	45.94	45.48	45.86
Average (0-45)	48.67	52.37	52.76	52.53	53.24

Infiltration rate (IR)

Basic infiltration rates (BIR) of soil as affected by different treatments are presented in Table (5). Data show that, subsoiling and gypsum application were increased basic infiltration rate than before treatments application. Basic infiltration rates before treatments application was 0.66 cm/hr while, after treatments application varied from 0.81 to 1.89 cm/hr. The increases of basic infiltration rate after first season from treatments installation are more pronounced (varied from 1.57 to 1.89 cm/hr) compared to after second seasons(varied from 0.81 to 1.06 cm/hr). This may be due to the good effectiveness of subsoiling after first season than after second one as well as the compaction resulted from rice cultivation in the second season. Results show that, subsoiling two directions (Net subsoiling) is superior to subsoiling one direction in increasing basic infiltration rate. This may be due to the good effectiveness of two directions subsoiling than one direction. The high rate of gypsum caused somewhat higher of basic infiltration rate than low rate. The overall average values of basic infiltration rate were 1.19 and 1.44 cm/hr for one direction and two directions of subsoiling under 1.5 ton gypsum $fed.^{-1}$ and were 1.25 and 1.48 cm/hr for one direction and two directions of subsoiling under 3 ton gypsum $fed.^{-1}$, respectively. This may be due to the subsurface tillage gave the top soil layer a chance to dry and permitted for shrinkage and formation of water passage ways which allowed a rather easier movement of water into subsoil line. Similar results were obtained by Abdel-Mawgoud *et al.,* (2003 and 2006) and Antar *et al.,* (2012).

Soil penetration resistance:

Soil penetration resistance (SPR) as affected by different treatments for the studied soil profile (0-45cm depth) is presented in Table (5). Data showed that, the high values of SPR (varied from 1.21 to 1.34 MPa) were found before treatments application, and the low values (varied from 0.72 to 1.08 MPa) were found after treatments application. The reduction of SPR after first season from treatments installation are more pronounced compared to after second season. This may be due to the good effectiveness of subsoiling after first season than after second seasons as well as the compaction resulted from rice cultivation in the second season. Also, subsoiling two directions is superior to one direction in decreasing SPR. This may be due to the good effectiveness of two directions subsoiling than one direction. Results show that, no obvious trend with soil penetration resistance values under gypsum treatments. The values of SPR were varied from 0.83 to 1.08 and 0.72 to 1.02 MPa for one and two directions of subsoiling under 1.5 ton gypsum $fed.^{-1}$ and from 0.82 to 1.08 and 0.75 to 0.95 MPa for one and two directions of subsoiling under 3 ton gypsum $fed.^{-1}$, respectively. This means that subsoiling effect was more superiority on reducing soil penetration resistance. It could be attributed to the effects of subsoiling on breaking soil clods and bigger granular into smaller crumbs as well as breaking and cracking the compacted layers (Amer, 1999, Abdel-Mawgoud *et al.,* 2006 and Aiad *et al.,* (2012).

Table (5): Penetration resistance (SPR) and Basic Infiltration rate (BIR) of the soil as affected by the different studied treatments.

Treatments	Soil depth (cm)	Soil penetration resistance (MPa)	Basic infiltration rate (cm/hr)	Soil penetration resistance (MPa)	Basic infiltration rate (cm/hr)
		Before experiment			
Control	0-15	1.21	0.66	1.21	0.66
	15-30	1.28		1.28	
	30-45	1.34		1.34	
		First season		Second season	
Subsoiling, one direction+1.5 ton gypsum/fed.	0-15	0.83	1.57	0.98	0.81
	15-30	0.91		1.08	
	30-45	1.01		1.08	
Subsoiling, two directions+1.5 ton gypsum/fed.	0-15	0.73	1.85	0.84	1.02
	15-30	0.72		1.02	
	30-45	0.87		1.01	
Subsoiling, one direction+3 ton gypsum/fed.	0-15	0.82	1.62	1.04	0.87
	15-30	0.93		0.95	
	30-45	1.01		1.08	
Subsoiling, two directions+3 ton gypsum/fed.	0-15	0.75	1.89	0.95	1.06
	15-30	0.76		0.91	
	30-45	0.88		0.86	

Yields:

Data in Table (6) indicate clearly that subsoiling and gypsum application caused significant increases for sugar beet and rice yields compared to cantor. The yields are increased when the EC decreases as affected by subsoiling and gypsum. It can be concluded that heavy clay salt affected soils could have good productivity with the execution of subsoiling and gypsum. While, there were insignificant differences within treatments after application. Data in Table (6) show that, there were no obvious differences between shoots yield (ton fed^{-1}) as well as sugar percentages of sugar beet with all treatments. Sugar beet roots yield are higher after application of subsoiling and gypsum than that control by 3.48, 3.80, 3.80 and 3.31Tonfed.$^{-1}$ for subsoiling one direction + 1.5 ton gypsum fed.$^{-1}$, subsoiling two directions + 1.5 ton gypsum fed.$^{-1}$, subsoiling one direction + 3 ton gypsum fed.$^{-1}$ and subsoiling two directions + 3 ton gypsum fed.$^{-1}$, respectively. The corresponding values of gross sugar yield were 0.550, 0.650, 0.650 and 0.580, respectively. Such findings may be attributed to the effect of subsoiling and gypsum on improving soil properties which affects water-air relationships in the root zone and increase the root penetration. In this regard, Abdel-Mawgoud *et al.,* (2006) mentioned that the subsoiling was superior in enhancing the sugar beet yield. Also, rice grain yield are higher after application of subsoiling and gypsum than that control by 0.590, 0.610, 0.610 and 0.580 Tonfed.$^{-1}$ for the above mentioned treatments, respectively. It can be concluded that under such conditions the subsoiling and gypsum are the most effective treatments that ameliorate saline sodic clay soil. Similar results were obtained by Lickacz (1993), Aiad *et al.,* (2012) and El-Sanat *et al.,* (2012).

Table (6): Rice and sugar beet yields (ton/fed.) with different studied treatments.

Treatments	Sugar beet yield (Ton fed^{-1})		Sugar %	Gross sugar yield (Ton fed^{-1})	Rice yield (Ton fed^{-1})
	Roots	Shoots			
Control	19.74 b	3.12	17.06	3.37	2.05 b
Subsoiling (one direction) with 1.5 ton gypsum/fed.	23.22 a	3.12	16.87	3.92	2.64 a
subsoiling (two directions) with 1.5 ton gypsum /fed.	23.54 a	3.18	17.06	4.02	2.66 a
Subsoiling (one direction) with 3 ton gypsum/fed.	23.11 a	3.17	16.94	3.91	2.71 a
subsoiling (two directions) with 3 ton gypsum/fed.	23.05 a	3.21	17.14	3.95	2.63 a

CONCLUSION

*Subsoiling and gypsum are good ways in clay soils to reserve the root zone from water logging and salinity.

* Subsoiling and gypsum tend to improve soil physio-chemical characteristics and increase crop production.

REFERENCES

Abdel-Mawgoud A.S.A (2004). Subsoiling to conserve rootzone stratum of heavy clay soil. Minufiya J. Agric. Res. (29), 6: 1456-1478.

Abdel-Mawgoud A.S.A, , M. B. El Shewikh, A. N. Abdel-Aal and M.I.I. Abdel-Khalik (2003). Open drainage and moiling for desalinization of salty clay soils of Northeastern Egypt. Presented at the 9th International Drainage Workshop, September 10 – 13, 2003, Utrecht, The Netherlands.

Abdel-Mawgoud A.S.A, A.A.S. Gendy and S.A. Ramadan (2006). Improving root zone environment and production of a salty clay soil using subsoiling and gypsum application. Assiut J. of Agri. Sci., 37, 2: 147-164.

Ahmad, N., Qureshi, R.H. and M. Qadir, (1990). Amelioration of a calcareous saline-sodic soil by gypsum and forage plants. Land Degradation and Rehabilitation, 2, 277–284.

Aiad M.A.F., M.A. Abd El-Aziz, B.A.A. Zamil and A.S. Antar (2012). Combating of soil deterioration at north delta, Egypt. J. Agric. Res. Kafr El-Sheikh Univ., 38 (2), 322-341.

Ali, T. and M.A. Kahlown (2001). Role of gypsum in amelioration of saline-sodic and sodic soil. International Journal of Agriculture and Biology. 3(3): 326-332.

Amer, M. H. (1999). Effect of tillage operations on some soil physical properties and water relations of corn. Egypt, J. Appl. Sci., 14 (6):354-365.

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.

Antar, S. A.; Mohamedin, A.A.M. and El-Meligy, A.M. (2012). Improving root zone and production of clay salt affected soil as a result of different subsurface tillage. 11th ICID International Drainage Workshop on Agricultural Drainage Needs and Future Priorities. Cairo, Egypt September 23 – 27, 2012.

Campbell, D.J. (1994). Determination and use of bulk density in relation to soil compaction. In Soane and Ouwerk (Eds). Soil compaction in crop production. Elsever, London and Amsterdam.

Chen, W., Z. Hou, L. Wu, Y. Liangand C. Wei, (2010). Effects of salinity and nitrogen on cotton growth in arid environment. Plant soil, 32 (6): 61 – 73.

El-Sanat G. M. A., M.A. Aiad, A. S._Antar, and B.A. Zamil (2012). Effect of tillage methods and depths on sugar beet and rice yields, salt distribution and water use efficiency in salt affected soils at North Delta. Minufiya J. Agric. Res. Vol. 37, No. 5(2):1307-1323.

Garcia, G. (1978). Soil water Engineering Laboratory Manual. Colorado State Univ. Dept. of Agric. and Chemical Engineering. Fortcollins, Colorado.

Jodi DeJong, H. (2004). Can subsoiling increase crop yields in Minnesota? Agric. World Wide Correspondent. Meredith Coporation.

Lickacz, J. (1993). Management of solonetzic soils. Agdex 518-8. Revised, Edmonton, Alberta, Canada.

Mc Williams, D. (2003). Soil salinity and sodicity limits efficient plant growth and water use. Cooperative Extension Service, Collage of Agriculture and Home Economics, Guide A-140. New Mexico State University, USA.

Moukhtar, M. M., E. M. El-Hadidy, M.Y.S. El-Arquan And M.A.B. El-Shewikh (2002). Soil amelioration technique of cover drainage combined subsoiling for saline-sodic clay in North Egypt. XVth World Congress of the International Commission of Agricultural Engineering (CIGR) on July 28-31 - 2002, Chicago, USA.

Moukhtar, M.M., M.Y.S. El-Arquan, E.M. El-Hadidy and M.A.B. El-Shewikh (2003). Amelioration of salt affected soils in north Dakhlia Governorate through application of tile drainage and subsoiling. J. Agric. Sci. Mansoura Univ., Special Issue, Sci. Symp. On Problems of soils and waters in Dakhlia and Damietta Governorate. March 18.

Oster, J.D., I. Shainberg and I.P. Abrol, (1996). Reclamation of salt affected soils. In: Soil erosion, conservation and rehabilitation (ed.M. Agassi), pp. 315-352. Marcel Dekker, New York.

Page, A.L.; R.H. Miller and D.R. Keeney (1982). Methods of Soil Analysis. Part Π: Chemical and microbiological properties, 2nd ed. Soil Sci. Soc. Am. Inc., Madison, USA.

Pessarakli, M., (2010). Handbook of plant and crop stress. Third Edition. CRc press.

Reda, M.M.A., (2006). Amelioration techniques for saline sodic soils in north Nile delta and its impact on sunflower productivity. Egypt. J. Appl. Sci. 21:213-228.

Richards, L.A. (1954). Diagnosis and Improvement of Saline and Alkali Soils U.S.D.A. Hand Book No. 60.

Said H. M. (2003). Effect of tillage implements on the state of compaction in different soils. Egyp. J. Soil Sci. 43: 91-107.
Sendecor, G.W. and W.G. Cochran (1980). "Statistical Methods" 7th ed., 225-330. Iowa state Univ., Press., Ames., Iowa, USA.
Singh, R. A. (1980). Soil Physical Analysis Published by Kalyans publishers, New Delhi. P.: 81-82.

تحسين الأرض الطينية الثقيلة المتأثرة بالأملاح وإنتاجيتها بإضافة بعض المحسنات في شمال الدلتا

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أجريت التجربة الحقلية خلال الموسم الشتوي 2014/2013 والموسم الصيفي 2014 في منطقة الحامول - محافظة كفر الشيخ - شمال الدلتا وذلك لمعرفة تأثير الحرث تحت التربة (اتجاه واحد، اتجاهين) مع إضافة الجبس الزراعي (1.5طن للفدان، 3طن للفدان) على تحسين بعض صفات الأرض الطينية الثقيلة المتأثرة بالأملاح والإنتاجية لمحصولي بنجر السكر والأرز وتوضح النتائج أن:-

انخفاض ملوحة وصودية الأرض نتيجة خدمة تحت التربة مع إضافة الجبس الزراعي حيث كانت نسبة النقص بعد موسمين من عمل الخدمة 38.58، 41.06، 42.50، 43.58 % للمعاملات تحت التربة اتجاه واحد +1.5طن جبس، تحت التربة اتجاهين +1.5طن جبس، تحت التربة اتجاه واحد +3طن جبس، تحت التربة اتجاهين +3طن جبس على التوالي. وكانت القيم المماثلة لخفض الصودية هي29.40, 33.44, 34.26، 38.77٪ على التوالي. وخدمة تحت التربة اتجاهين والمعدل الأعلى من الجبس أفضل من اتجاه واحد والمعدل الأقل من الجبس في خفض ملوحة وصودية الأرض. وأيضا خدمة تحت التربة مع إضافة الجبس أدت إلى زيادة نسبة Ca^{++}/TSS ونقص في نسبة Na+/TSS في قطاع التربة حتى عمق 45سم من سطح التربة خصوصا مع المعدل الأعلى من الجبس.

البيانات توضح أن قيم الكثافة الظاهرية ومحتوي التربة من الرطوبة ومقاومة التربة للاختراق تناقصت نتيجة خدمة تحت التربة مع إضافة الجبس الزراعي خصوصا مع اتجاهين لتحت التربة. وأيضا لوحظ زيادة في معدل الرشح الأساسي نتيجة خدمة تحت التربة مع إضافة الجبس، فكان 0.66 سم/الساعة قبل التطبيق وزاد بعد التطبيق فتراوح من 0.81 الي 1.89 سم/الساعة.

إنتاجية بنجر السكر والأرز تبعت درجة الملوحة، حيث لوحظت زيادة معنوية في إنتاج جذور بنجر السكر وحبوب الأرز نتيجة خدمة تحت التربة مع إضافة الجبس الزراعي مقارنة بالكنترول. حيث زاد إنتاج بنجر السكر من الجذور بمقدار 3.48, 3.80, 3.80، 3.31 طن للفدان للمعاملات تحت التربة اتجاه واحد +1.5طن جبس، تحت التربة اتجاهين +1.5طن جبس، تحت التربة اتجاه واحد +3طن جبس، تحت التربة اتجاهين +3طن جبس على التوالي عن الكنترول. وكانت القيم المماثلة لإنتاج البنجر من السكر الخام هي0.55, 0.65, 0.65، 0.58 طن للفدان على التوالي. وأيضا زاد إنتاج الأرز من الحبوب بمقدار 0.59, 0.61, 0.61، 0.58 طن للفدان للمعاملات الموضحة بعالية علي التوالي. وعموما يمكن القول أن خدمة تحت التربة مع إضافة الجبس الزراعي هي وسائل جيدة في التربة الطينية لخفض الملوحة والصودية من منطقة الجذور وحفظها وتؤدي إلي تحسين خواص الأرض وزيادة إنتاج المحاصيل.