J. Agric. Sci. Mansoura Univ., 33 (10): 7675 - 7687, 2008

IMPROVING SOME PROPERTIES OF HEAVY CLAY SALT AFFECTED SOIL AS A RESULT OF DIFFERENT SUBSURFACE TILLAGE.

Antar, S. A. *; A. S. El-Henawy. ** and A. A. E. Atwa *

*** Soils, Water and Environment Res. Inst., Agric. Res. Center, Egypt.**

**** Soils dept., Fac. of Agric., Kafrelsheikh Univ., Egypt.**

ABSTRACT

A field experiment was conducted at North Nile Delta, Egypt (Islah-Perempal Region, Motobus District, Kafer El-Shiek Governorate), to evaluate the effect of subsoiling and mole drains with open drainage on improving some soil properties and yields of rice and sugar beet crops as well as raising the efficiency of the open drainage system.

Results indicate that, subsurface tillage operations with open surface drainage lowered the water table level, after all growing seasons. The mean values of water table levels are 59.5, 59.5 and 62.3 cm with subsoiling, mole drain and subsoiling +mole, respectively while, it is 44.3 cm with the control (open drainage). Water table level is lower after sugar beet than after rice.

Soil salinity and sodcity in the topsoil, were reduced after subsoiling and moling installation. The reductions of salinity, after three years from experiment installation were 86.71, 96.81 and 98.76% for subsoiling, moling and subsoiling +moling, respectively over the control. The corresponding values of ESP decreaces were 83.93, 83.20 and 119.40%, respectively. Ratio of Ca^{++}/TSS in the topsoil (0-60cm) was increased in the treated soils.

Subsoiling and/or moling seemed to be more effective on reducing soil bulk density especially in the surface layer (0-30cm). Subsoiling and/or moling treatments were superior in enhancing soil porosity. Basic infiltration rate (BIR) was increased with subsoiling and/or moling (from 0.9 to 1.66 cm/h) while, it was ranged from 0.39 to 0.59 cm/h with the control (open drainage). Data also cleared that, BIR after rice crop season was lower than that after sugar beet crop season.

The saturation percent, field capacity and wilting point values are lower in the treated soils than untreated soils. Subsoiling and/or moling realized increases in quickly and slowly drainable pores (QDP and SDP) and higher decrease in fine capillary pores (FCP) than open drains. Mean values of QDP, SDP and FCP% in the soil depth of 0-60cm, are 8.71, 12.93 and 32.35%, respectively with open drainage. The corresponding values are 10.66, 16.57 and 23.80%, respectively with subsoiling and 11.56, 16.35 and 23.52%, respectively with moling and 12.52, 18.84 and 20.87%, respectively with subsoiling+moling.

Rice and sugar beet yields are related to the salinity contents in soil. The yields increased when the EC decreased as affected by subsoiling and/or moling. Rice and sugar beet yields are higher under subsoiling and/or moling than with open drains in all growing seasons. Rice grain yield is higher under subsoiling tillage, moling and subsoiling +moling by 37.19, 38.43, and 34.30 %, respectively, than the control. The corresponding values of sugar beet yield are 5.31, 4.65 and 7.65 ton/fed., respectively.

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

INTRODUCTION

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. These soils are always threatened by a shallow saline groundwater. In the irrigated area, saline groundwater is a permanent source of soil salinization that causes poor productivity (Moukhtar et al., 2003b).

A secondary drainage treatment of moling seeks to be an inexpensive "drain" at close spacing, intercepted by permanent laterals at wider spacing. Moling is the best suited to clay soils with a minimum clay content of about 30%. During installation the moisture content at mole depth is near to the lower plastic limit. Mole drainage, on the suitable soil type and done properly can reduce waterlogging problems. Mole drainage is widely used on heavy soils to improve productivity of pastures and crops (David, 2002). 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). Moling or 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 (Moukhtar *et al.*, 2002a &b and Moukhtar *et al.*, 2003a & b).

Moukhtar *et al.* (2002a and 2003b**)** found that, mole drains perpendicular to open drains accelerated downward water movement to the depth of mole plow. Soil salinity and alkalinity in the root zone was maintained under the permissible level to sustain a convenient production.

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). 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. Said (2003) 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 mole drains and subsoiling with open drainage on improving some soil physical and chemical properties as will as yields of rice and sugar beet crops.

MATERIALS AND METHODS

A field experiment was conducted at North Nile Delta (Islah-Perempal Region, Motobus District, Kafer El-Shiek Governorate, Egypt), to evaluate the effect of mole drains and subsoiling with open drainage on improving some soil physio-chemical properties and yields of rice and sugar beet crops. The soil has a clayey texture; the average textural analysis for this soil is 12.9% sand, 32.5% silt and 54.6 % clay (Table 1). The initial of some soil properties for the experimental field are presented in Table (1).

The experiment was installed before summer season (2005) as follows:

1: Open drainage with 30 m spacing between drains and 90 cm depth.

2: Subsoiling with 2 m distances between the ploughed lines and 60 cm depth perpendicular to the open drainage. "subsoiling are unlined channels formed in a clay subsoil with a ripper blade."

3: Mole drains with 2 m distances between the ploughed lines and 60 cm depth perpendicular to the open drainage. "Mole drains are unlined channels formed in a clay subsoil with a ripper blade with a cylindrical foot, often with an expander which helps compact the channel wall."

4: Combined between mole drains with 2 m distances between the ploughed lines at 60 cm depth and subsoiling with 2 m distances between the ploughed lines at 45 cm depth perpendicular to the open drainage.

Open drain was used to collect the drainage water brought by mole drain channels. Like most of the northern lands, the field lies on the tail of the main canal, irrigation water is frequently insufficient. The main source of irrigation water is El-Nor branch canal which, was included of mixed water. The salinity of irrigation water ranges between 1.12 - 1.26 dS/m with an average of 1.19 dS/m.

In the summer seasons (2005, 2006 and 2007) rice (*Oryza sativa* L.) was planted. 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. In the winter season (2005/2006, 2006/2007 and 2007/2008) sugar beet (*pleno variety*) was planted. All plots received 100 kg/fed. of Ca-superphosphate (15.5% P_2O_5) before cultivation and 120 kg N/fed (as urea) in three doses before the first, the second and the third irrigations. The different agricultural practices were done as recommended for all crops under study. Productivities for all crops with different treatments were determined.

Soil samples (0-15, 15-30, 30-60 and 60-90cm depth) were collected after first, second and third years 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). A set of observation wells were installed in the plots to measure the water table depth at the end of seasons in all treatments. Infiltration rate was determined using double cylinder infiltrometer as described by Garcia (1978). Soil bulk density and total porosity of the different layers of soil profile were measured after first, second and third years from treatments instillation for all treatments using the core sampling technique as described by Campbell (1994).

Soil moisture characteristics curves, field capacity and wilting point were determined by using the pressure plate extractor with regulated air pressure (Garcia, 1978). Pore size distribution was calculated from soil moisture retention curves according to Deleenher and De Boodt (1965). Soil pores are classified according to their size and ability to retain water at different head pressures, to quickly drainable pores (QDP) that can hold water between 0.00 and 100cm head, slowly drainable pores (SDP) difference between 100 and 330cm head. Water holding pores (WHP) or medium pores which retain soil moisture between field capacity (330cm head) and wilting point (15000cm head) and fine capillary pores (FCP) which retained soil moisture at suction head of 15.0 atm.

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)	K (cm/day)
	Sand%	Sand%	Sand%						
0-15	12.17	32.81	55.02	Clayey	6.74	17.37	1.36	0.55	10.09
15-30	12.46	32.46	55.08	Clayey	8.43	21.01	1.44		
30-60	13.74	31.41	54.85	Clayey	9.27	20.7	1.47		
60-90	13.22	33.32	53.46	Clayey	10.29	23.58	1.55		
Mean	12.9	32.5	54.6	Clayey	8.68	20.67	1.45		

RESULTS AND DISCUSSION

Water table depths:

Results of water table measurements in Fig (1) indicate that different tillage practices had lowered the water table level after all seasons as compared to open drains. The mean values of water table levels after subsoil tillage installation are 58.0 and 63.1cm while, they are 40.3 and 48.3cm with the open drainage for rice and sugar beet, respectively. Subsoiling and/or moling in conjunction with open drains realize a high rate of water table drawdown in almost all the irrigations. This demonstrates show the beneficial effect of subsoiling and/or moling combined with open drains to prevent waterlogging in the rootzone (Moukhtar *et al*., 2003b and Abdel-Mawgoud *et al*., 2006**)**.

Results also show that moling combined with subsoiling perpendicular to open drains are superior to subsoiling or moling in lowering the water table level. Subsoiling loweres the water table level down that with the open drains by 18, 16 and 17cm after rice and 14, 13 and 13cm after sugar beet for the first, second and third seasons, respectively. The corresponding values with mole drains are 16, 15 and 18cm after rice and 13, 15 and 14cm after sugar beet, respectively. The combined between moling and subsoiling lowered water table level by 21, 18 and 20 cm after rice and 17, 17 and 17cm after sugar beet for the first, second and third seasons, respectively. The beneficial effect of subsoiling and moling are to avoid the harmful stagnation of irrigation water and dissolved salts around the rootzone. The downward water movement is enhanced through cracks and fissures developed by the mole plough blade and water is evacuated partly through the mole drains. Similar results were obtained by Moukhtar *et al*. 2003a & b**,** and Abdel-Mawgoud *et al.* 2006. Generally, average of water table levels from soil surface, after rice cultivation are lower (varied from 40 to 61cm) than after sugar beet cultivation (varied from 48 to 66cm).

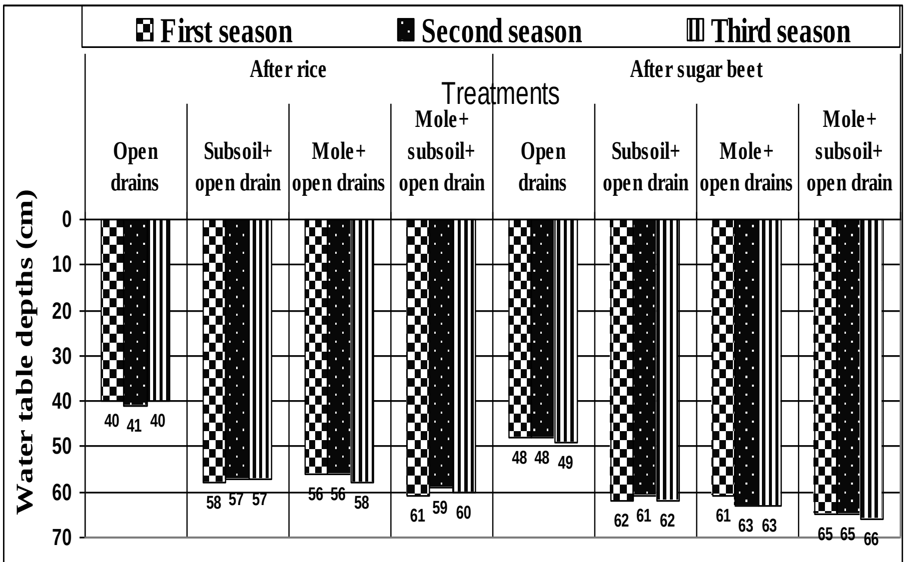

Fig (1): Water table depths as affected by different tillage practices.

Soil salinity and sodcity:

Data presented in Table (2) show that, application of subsoiling and/or moling seeme to be more effective in decreasing of soil salinity and sodcity. The salinity and sodcity of the soil increased markedly with the increasing of soil depth. Soil salinity and sodcity in the topsoil up to 60cm, under open drainage are relatively high (EC_e varied from 6.55 to 9.61dS/m and ESP from 16.90 to 21.29) comparing with subsoiling and/or moling in conjunction with open drains (varied from 3.44 to 6.21dS/m for EC_e and 6.64 to 15.94 for ESP). The decreases of soil salinity and sodcity after three years of treatment installation are more pronounced compared to after one and two years (Table, 2). The reduction of salinity, after three years with subsoiling, moling and subsoiling + moling are 86.71, 96.81 and 98.76 %, respectively, over than open drains. The corresponding values of ESP are 83.93, 83.20 and 119.40 %, respectively. It is clear that moling+ Subsoiling with open drains is superior to subsoiling or moling in reducing soil salinity and sodcity. After three years from treatments installation, EC_e decrease is realized in the topsoil up to 60cm, especially in the surface layer (0-30cm). The EC values are decreased to be less than 4 dS/m in the top layer (0-60) in all treatments while, no decrease is shown in subsurface layer 60-90cm. These results might be explained by the effect of subsurface tillage on water table recession, which occurred only through mole 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 and/or moling are 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 Spoor et al., (1990); Moukhtar *et al.* (2003b) and Abdel-Mawgoud *et al*. (2003).

The effect of the treatments on improving soil desalinization, desodification is clarified in Table (2). It should be mention that the greatest desalinization occurs after subsurface tillage. Results could be attributed mainly to that subsoil or mole forms many lines with big crack extent from soil surface to subsoil or mole depth (50- 60cm 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*., 2002a). Moukhtar *et al*. (2003b) 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. The percolating water will constitute a temporary front preventing the saline groundwater in subsurface soil layers from linking with the upper ones.

Table (2): Average of soil salinity (EC, dS/m) and sodcity (ESP) after first, second and third years from treatments instillation.

Year	Depths (cm)	Open drains		Subsoil+ open drain		Mole+ open drains		Mole+ subsoil+ open drain	
		EC (dS/m)	ESP %	EC (dS/m)	ESP %	EC (dS/m)	ESP %	EC (dS/m)	ESP %
First	0-15	6.85	17.79	5.64	14.41	5.25	14.64	4.86	12.88
	15-30	9.43	23.78	5.98	14.84	5.42	15.11	5.12	13.33
	30-60	9.01	21.29	5.74	15.94	5.73	15.12	5.58	13.99
	60-90	10.24	23.33	10.32	22.98	10.05	21.49	9.47	22.80
Mean (0-60cm)		8.43	20.95	5.79	15.06	5.47	14.96	5.19	13.40
Second	0-15	6.55	17.43	5.31	13.19	4.88	11.59	3.78	8.70
	15-30	8.28	20.79	5.13	13.77	5.44	12.83	4.12	9.47
	30-60	9.19	20.88	6.21	15.15	5.55	12.63	4.77	10.83
	60-90	10.49	23.98	10.20	22.63	10.01	21.98	9.22	24.11
Mean (0-60cm		8.01	19.70	5.55	14.04	5.29	12.35	4.22	9.67
Third	0-15	6.83	16.90	3.78	8.04	3.55	8.20	3.44	6.94
	15-30	7.58	18.44	3.97	9.21	3.85	10.14	3.88	8.09
	30-60	9.61	19.94	5.11	12.82	4.82	11.83	4.77	10.18
	60-90	10.14	23.43	9.87	22.90	9.16	23.21	9.08	21.95
Mean (0-60cm		8.01	18.43	4.29	10.02	4.07	10.06	4.03	8.40

Ratio of Ca^{++}/TSS:

Results in Fig (2) show that, subsoiling and/or moling seemed to be more effective on increasing (Ca^{++}/TSS) ratio in the topsoil up to 60cm, than open drainage. The increases of (Ca^{++}/TSS) ratio after three years from treatments installation are more pronounced compared to after one and two years. This may be due to the leachability of Na^{+} is higher than that of Ca^{++} and Mg^{++} with subsoiling and/or moling. Also, Na^{+} and Cl^{-} are leached more readily than SO^4, Ca^{++} and Mg^{++}. Change in (Ca^{++}/TSS) ratio was not shown in deeper layer (60-90cm). Whereas, subsoiling and/or moling are effective in removing salts especially Na^+ from the topsoil up to 60cm. Subsoiling+ moling with open drains are superior to subsoiling or moling with open drains in increasing (Ca^{++}/TSS) ratio. This may be due to the good effectiveness of Subsoiling+ moling with open drains. Also, the results of (Ca^{++}/TSS) ratio are nearly the same in both treatments of subsoiling or moling with open drains.

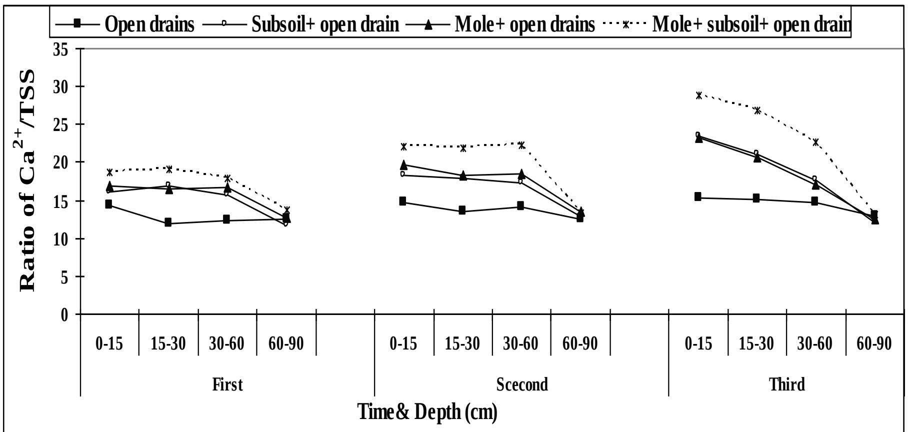

Fig (2): Ratio of Ca^{2+}/TSS in the soil as affected by different tillage practices.

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 Fig (3) 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/or moling reduce soil bulk density in the topsoil up to 60cm, especially in the layer (0-30cm). The decreases of soil bulk density after three years from treatments installation are more pronounced compared to after one and two years. Soil bulk density did not change in deeper layer (60-90cm) with different tillage practices. These results might be explained by the effect of subsoiling and/or moling on bulk density, which occurred only around and above subsoiling and mole depths. It could be attributed to the effects of subsoiling and/or moling 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).

Soil porosity values (Fig 3) 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 (Fig, 3). Subsoiling and/or moling treatments are superior in enhancing soil porosity. Jodi DeJong (2004) 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.

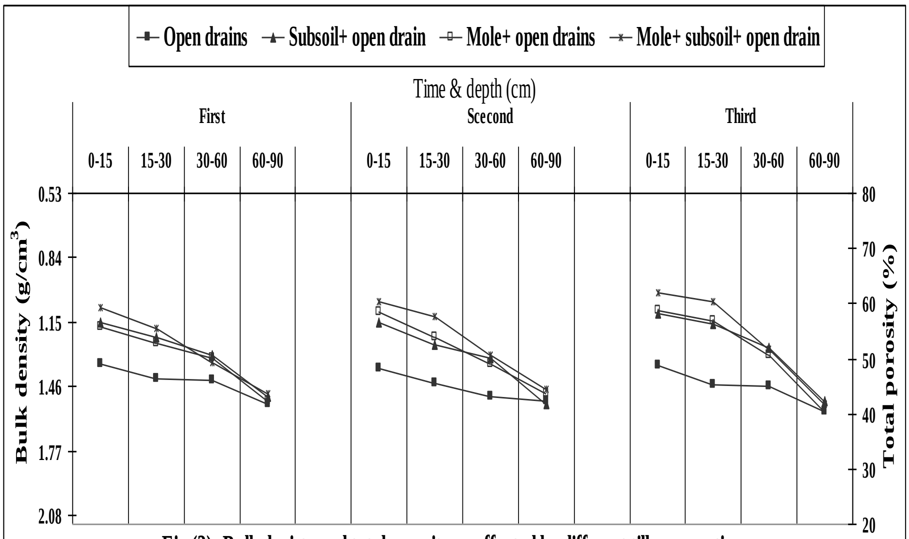

Fig (3): Bulk denisty and total porosity as affected by different tillage practices.

Infiltration rate (IR)

The values of basic infiltration rate (IR) of soil as affected by different treatments are presented in Table (3). Data show that, basic infiltration rate values after each season are increased in the treated soils, where as, the values of basic IR under subsoiling and/or moling varied from 0.9 to 1.66 cm/h while, under open drainage they ranged from 0.39 to 0.59 cm/h. 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 mole or subsoil line. Similar results were obtained by Abdel-Mawgoud et al., (2003 and 2006). Basic IR in all seasons is in somewhat higher with subsoil+mole than that with subsoil or mole treatment. Also, no obvious different between basic IR values under both subsoil and mole treatments. Data also clear that, mean values of basic IR are lower after rice crop than after sugar beet crop by 41.81, 35.13, 46.31 and 38.42 % for open drainage, subsoil+open drainage, mole+open drainage and subsoil+mole+open drains, respectively. Basic IR after first season is superior to after the third season from treatments installation.

Table (3): Basic infiltration rate (cm/h) after the first, second and third seasons from treatments executed.

Treatments	First season		second season		third season		Means	
	Rice	Sugar beet	Rice	Sugar beet	Rice	Sugar beet	Rice	Sugar beet
Open drainage	0.39	0.52	0.39	0.59	0.41	0.58	0.397	0.563
Subsoil+ open drains	1.21	1.56	1.05	1.48	1.02	1.39	1.093	1.477
Mole + open drains	1.11	1.59	1.08	1.51	0.9	1.42	1.030	1.507
Subsoil+mole+open drains	1.22	1.66	1.11	1.55	1.05	1.47	1.127	1.56

Soil moisture characteristics and pore size distribution:

The effect of subsoiling and moling treatments on soil moisture contents at different applied pressure heads and pore size distribution, after three year, are realized in the topsoil up to 60cm while, no different was shown in deeper layer (60-90cm). Whereas, subsoiling and moling are effective in the upper layers only (0-60cm) while, in the deeper layers (60-90cm) soil moisture content depends on the efficiency of drainage.

Data in Table (4) show that, the saturation percent (SP), field capacity (FC) and wilting point (WP) with subsurface tillage are lower than that with the open drains. The mean values of SP, FC and WP in the topsoil (0- 60cm) under open drainage are 75.28, 53.65 and 32.35%, respectively. The corresponding values, respectively are 73.65, 46.42 and 23.80%, with subsoiling and 73.78, 45.86 and 23.52%, with moling and 74.54, 43.18 and 20.87%, with subsoiling+moling. This increase in soil moisture parameters (SP, FC and WP) in case of open drainage soil may be due to the high salt contents and high values of ESP throughout the soil profiles (Table, 2). Also, the low soil moisture content at SP, FC and WP in treated soils can be attributed to their higher values of total drainable pores (quickly + slowly drainable pores) compared to open drainage soil. These results suggest that as soil aeration and soil structure improved, soil SP, FC and WP decreaseds because more water can be removed by gravitational force.

Pore size distribution (quickly drainable pores, QDP, slowly drainable pores, SDP, water holding pores, WHP and fine capillary pores, FCP)) of the studied soil are presented in (Fig, 4). Results show that, the low percent of QDP and SDP and high percent of FCP are found with open drains soils. These high values of FCP which are often filled with water and cause water logging, while plants grown in these soils suffer from drought. Results indicate that subsoiling and/or moling in conjunction with open drains realize increases of QDP% and SDP% and decrease of FCP% as compared to open drains. Mean values of QDP, SDP and FCP in the topsoil (0-60cm), are 8.71, 12.93 and 32.35%, respectively with open drainage. The corresponding values, respectively are 10.66, 16.57 and 23.80%, with subsoiling, 11.56, 16.35 and 23.52%, with moling and 12.52, 18.84 and 20.87%, with subsoiling+moling. These results might be explained by the effect of subsoiling and/or moling on pore size distribution, which occurred only around and above subsoiling and mole depths. It could be attributed to the effects of subsoiling and/or moling on breaking soil cods and bigger granular into smaller crumbs as well as breaking and cracking the compacted 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. Results showed that, subsoiling and/or moling tend to enhancing of WHP% compared to open drains. Results indicate that, subsoiling+ moling with open drains are superior to subsoiling or moling with open drains in enhancing of moisture contents and pore size distribution in soil.

Table (4): Soil moisture contents (SP, FC, WP %) at different applied pressure heads (cm) and pore size distribution (QDP, SDP, WHP, FCP %) with soil depths under different tillage practices.

Treatments	Depth (cm)	Applied pressure "h" cm				QDP %	SDP %	WHP %	FCP %
		0.00	100	330	15000				
Open drains	0-15	75.79	66.36	52.94	31.33	9.42	13.42	21.61	31.33
	15-30	74.85	66.18	53.19	32.45	8.67	12.99	20.74	32.45
	30-60	75.21	67.17	54.81	33.27	8.04	12.36	21.54	33.27
	60-90	73.15	65.87	53.89	33.05	7.28	11.98	20.83	33.05
Mean (0-60cm)		75.28	66.57	53.65	32.35	8.71	12.93	21.30	32.35
Subsoil+ open drain	0-15	73.45	62.41	45.45	23.40	11.04	16.95	22.05	23.40
	15-30	73.88	63.27	46.85	24.18	10.61	16.43	22.66	24.18
	30-60	73.61	63.28	46.95	23.82	10.34	16.33	23.13	23.82
	60-90	72.26	64.12	50.93	29.97	8.14	13.19	20.96	29.97
Mean (0-60cm)		73.65	62.99	46.42	23.80	10.66	16.57	22.62	23.80
Mole+ open	0-15	74.20	62.25	45.42	22.66	11.95	16.83	22.76	22.66
	15-30	73.27	61.52	45.41	22.53	11.74	16.11	22.88	22.53
	30-60	73.86	62.87	46.76	25.36	10.99	16.11	21.40	25.36
	60-90	72.86	63.95	51.54	30.37	8.90	12.41	21.17	30.37
Mean (0-60cm)		73.78	62.21	45.86	23.52	11.56	16.35	22.34	23.52
Mole+ subsoil+ open drain	0-15	73.95	61.05	42.15	19.99	12.90	18.90	22.15	19.99
	15-30	74.70	62.40	43.12	20.47	12.30	19.28	22.65	20.47
	30-60	74.98	62.62	44.27	22.15	12.36	18.35	22.12	22.15
	60-90	73.70	65.06	50.28	27.90	8.64	14.78	22.38	27.90
Mean (0-60cm)		74.54	62.02	43.18	20.87	12.52	18.84	22.31	20.87

QDP: quickly drainable pores SDP: slowly drainable pores WHP: water holding pores FCP: fine capillary pores

Yields:

Data in Table (5) indicate clearly that rice and sugar beet yields are related to soil salinity contents. The yields are increased when the EC decreases as affected by subsoiling and/or moling. It can be concluded that heavy clay salt affected soils could have good productivity with the execution of subsoiling and/or moling. For subsoiling and/or moling, rice and sugar beet yields are higher than that with open drains in all seasons (Table 5). Rice grain yield is higher under treatment of subsoiling, moling and subsoiling +moling by 37.19, 38.43, and 34.30 %, respectively than the control. It can be concluded that under such conditions the subsoiling and/or moling are the most effective treatments that ameliorate saline sodic clay soil. Similar results were obtained by Lickacz (1993), Said (2002) and Moukhtar et al, (2003b).

In relation to sugar beet crop, the average roots yield under subsoiling, moling and subsoiling +moling are higher than the open drains by 5.31, 4.65 and 7.65 ton/fed., respectively. Such findings may be attributed to the effect of subsoiling and/or moling 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 to gypsum application in enhancing the sugar beet yield.

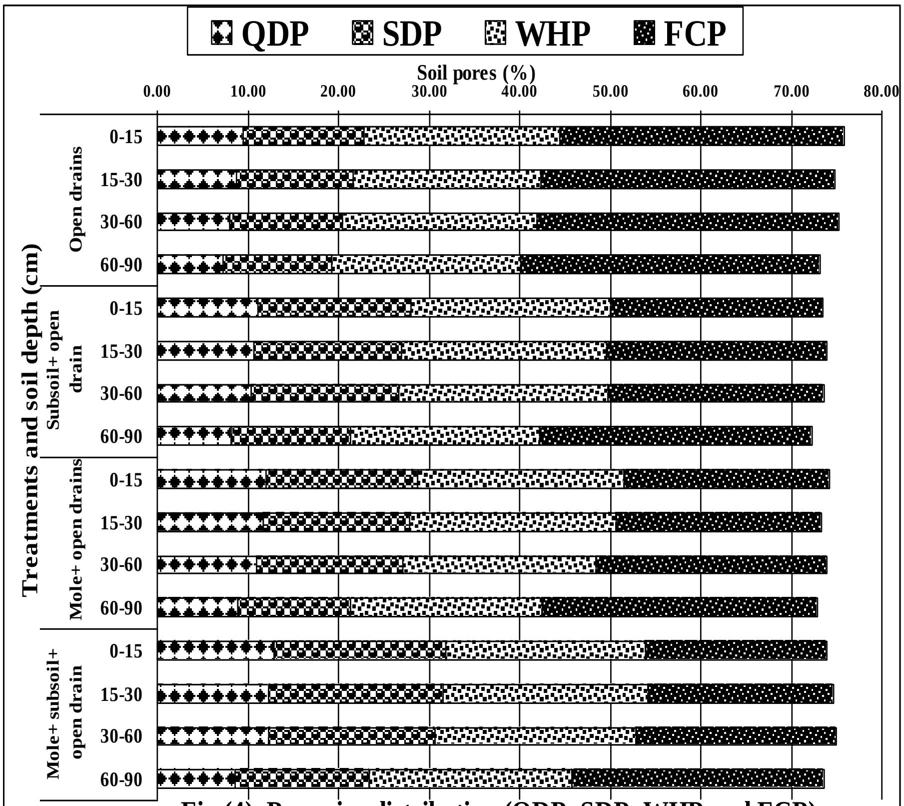

Fig (4): Pore size distribution (QDP, SDP, WHP and FCP) as affected by different tillage practices.

Table (5): Rice and sugar beet yields (ton/fed.) with different studied treatments for three successive growing seasons.

Crop	Treatments	First season	Second season	third season	mean
Rice (Ton/fed.)	Open drains	2.43	2.39	2.45	2.42
	Subsoil+ open drains	3.11	3.35	3.50	3.32
	Mole + open drains	3.17	3.32	3.55	3.35
	Subsoil+mole+open drains	3.05	3.25	3.45	3.25
Beet (Ton/fed.)	Open drains	18.85	18.22	19.02	18.70
	Subsoil+ open drains	24.55	23.94	23.56	24.01
	Mole + open drains	23.54	22.98	23.54	23.35
	Subsoil+mole+open drains	26.87	26.54	25.65	26.35

Conclusion

*Moling and/or subsoiling are good two ways to raise the efficiency of open drainage and adequate auxiliary drainage treatments in clay soils of shollow level with a saline water table to reserve the root zone from water logging and salinity.

*Moling and/or subsoiling tend to improve soil physio-chemical characteristics and increase crop production.

REFERENCES

Abdel-Mawgoud A.S.A (2004). Sobsoiling to conserve rootzone stratum of heavy clay soil. Minufiya J. Agric. Res. Vol. 29 No. 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.

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.

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.

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

De Leenher, L. and M. De Boodt (1965). Soil physics. Intre. Training Center for Post Graduate Soil Scientists, Gent., pp. 126-135.

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.

Moukhtar M. M., Madiha H. El-Hakim, A, S.A. Abdel-Mawgoud, 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 watertable, Egypt. Paper No 078. Presented at the 9th International Drainage Workshop, September 10 – 13, 2003, Utrecht, The Netherlands.

Moukhtar M. M., Aly I.N.Abdel-Aal, M.A.B.El-Sheikh and M.I.I. Abdel-Khalik (2002a). The Role of Mole Drainage in Degradation Soils Under Saline Ground water Table, Egypt The Second International Conference on Sustainable Agriculture for Food, Energy and Industry September 8-13, Beijing, China.

Moukhtar, M. M., E. M. El-Hadidy, M.Y.S. El-Arquan And M.A.B. El-Shewikh (2002b). 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 (2003a). 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.

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.

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

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

Said H. M. (2003). Effect of tillage implements on the state of compaction in different soils. Egyp. J. Soil Sci. 43: 91-107.

Spoor, G., C. J. Cronion and P. B. Leeds-Harrison (1990). Mole drain installation for leaching purposes. Proc. Symp. On Land Drainage for Salinity Control in Arid and Semi-Arid Regions. 3:47-45, Cairo, Egypt.

تحسين بعض صفات الأرض الطينية المتأثرة بالأملاح نتيجة الخدمة المختلفة لتحت التربة

عنتر شعبان عنتر*، أحمد سعد الحناوى و عادل أحمد إبراهيم عطوة***

*** معهد بحوث الأراضي والمياه والبيئة- مركز البحوث الزراعية- الجيزة – مصر**

**** قسم الاراضى- كلية الزراعة- جامعة كفر الشيخ-مصر**

أجريت التجربة الحقلية في شمال الدلتا بمصر(منطقة إصلاح برنبال- مركز مطوبس- محافظة كفر الشيخ) وذلك لمعرفة تأثير الحرث تحت التربة، أنفاق المول، تفاعلهما معا على مدى تحسين بعض صفات الأرض الطينية المتأثرة بالأملاح والإنتاجية لمحصولي الأرز وبنجر السكر وأيضا رفع كفائة الصرف المكشوف.

وتوضح النتائج أن خدمة تحت التربة مع الصرف المكشوف أدت إلى تخفيض مستوى الماء الأرضي بعد كل المواسم. وكان متوسط قيم مستوى الماء الأرضى 59.5، 59.5، 62.3 سم للحرث تحت التربة، أنفاق المول، تفاعلهما معا على التوالي بينما كانت تلك القيمة 44.3 سم مع الصرف الكشوف.

وتوضح النتائج انخفاض لملوحة وصودية الأرض حتى عمق 60سم نتيجة الحرث تحت التربة، أنفاق المول، تفاعلهما معا. حيث كان نقص الملوحة بعد ثلاث سنوات من إنشاء التجربة 87.71، 96.81، 98.76 ٪ لكل من الحرث تحت التربة، أنفاق المول ، الحرث تحت التربة+ أنفاق المول على التوالي مقارنة بالصرف المكشوف. وكانت القيم المماثلة لخفض الصودية هي83.93, 83.20, 119.40 ٪ على التوالي. وأيضا تطبيق المعاملات أدى إلى زيادة نسبة Ca^{++}/TSS للأرض حتى عمق 60سم من سطح التربة .

البيانات توضح أن الحرث تحت التربة، أنفاق المول، تفاعلهما معا كانت فعاله في خفض الكثافة الظاهرية وبالتالي زيادة المسامية للأرض حتى عمق 60سم من سطح التربة. وعن معدل الرشح الأساسي فان الحرث تحت التربة، أنفاق المول، تفاعلهما معا حققت قيم عالية مقارنة بالصرف المكشوف. وتراوحت قيم معدل الرشح الأساسي للأرض المعاملة من 0.9 إلى 1.66 سم/الساعة، بينما في أراضى الصرف المكشوف تراوحت من 0.39 إلى 0.59 سم/الساعة . وقلت قيم معدل الرشح الأساسي بعد زراعة الأرز عنها بعد زراعة بنجر السكر.

أظهرت النتائج انخفاض نسبة التشبع والسعه الحقلية ونقطة الذبول للأرض بعد إنشاء معاملات الحرث وأنفاق المول مقارنه بالصرف المكشوف. وأيضا معاملات الحرث وأنفاق المول حققت زيادة في مسام الصرف السريعة والمتوسطة وانخفاض كبير للمسام الشعرية الدقيقة مقارنه بالصرف المكشوف. فكان متوسط قيم مسام الصرف السريعة، المتوسطة ، الشعرية الدقيقة حتى عمق 60سم هى 8.71، 12.93، 32.35٪ على التوالي في أراضى الصرف المكشوف. والقيم المماثلة على التوالي 10.66، 16.57، 23.80٪ في أراضى الحرث تحت التربة و 11.56، 16.35، 23.52٪ مع أنفاق المول وأيضا كانت 12.52، 18.84، 20.87٪ مع تفاعل الحرث و أنفاق المول معا.

إنتاجية الأرز وبنجر السكر تبعت درجة الملوحة حيث لوحظ زيادة الإنتاج مع نقص الملوحة. فالحرث تحت التربة أو أنفاق المول أو تفاعلهما معا حققت زيادة عالية في إنتاج محصولي الأرز وبنجر السكر مقارنة بالصرف المكشوف. حيث زاد إنتاج الأرز بمقدار 37.19, 38.43, 34.30٪ لكل من الحرث تحت التربة, أنفاق المول, الحرث تحت التربة + أنفاق المول على التوالي مقارنة بالصرف المكشوف. وذاد إنتاج بنجر السكر بمقدار5.31, 4.65, 7.65 طن للفدان لنفس المعاملات على التوالي.