J.Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 9(11): 601 – 613, 2018

Amelioration some Physical and Hydrophysical Properties of Clay Loam Soil Using Compost at Different Depths and Nitrogen Fertilizer rates.

El-Sodany, M. E.; E. I. El-Maddah and Y. A. M. Abd-Allah
Soil, Water and Environment Research Inst. Agric. Res. Center, Giza, Egypt.

ABSTRACT

Field experiments were conducted on clay loam soil during two successive seasons. Summer season 2017 using maize plants and winter season 2017/2018 using barley plants at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, to evaluate the effect and residual effects of compost rates placed in moles 30 cm depth, arranged in parallel orientation with respect to one another and spaced at 3 m apart or placed on the surface soil layers besides the nitrogen fertilizer rates on improving soil physical and hydrophysical properties. Furthermore, economical analysis was done by calculating the net income for every treatment to determine the economical value. The rates of compost were 0.0, 2.5, 5.0 and 7.5 t fed.$^{-1}$, while the nitrogen rates were 0.0, 50, 75 and 100 % of the recommended dose for every growing crop. The experiments were conducted in split-split plot arranged in a randomized complete block design (RCBD) with three replicates. Results can be summarized as follows:- 1- Soil penetration resistance significantly decreased with increasing the addition rates of compost and depths. 2- The soil bulk density (Db) significantly decreased under different compost rates and depths, while total soil porosity (E) and void ratio (e) took the opposite trend. 3- The settling percentage of the soil was significantly decreased with increasing of compost rates and depths, indicating a higher degree of structural stability. 4- The values of pore size distribution (large, medium and micro pores as a percent of total porosity) were significantly increased in the two growing seasons. 5- Soil hydraulic conductivity (Kh) and soil moisture content, i.e., saturation percent (SP), water field capacity (FC), wilting point (WP), available water (AW) and soil moisture content just before harvesting (θw) were significantly increased for the two seasons, with increasing the rates of compost. 6- Water consumption (Cu) was decreased and water use efficiency (WUE) was increased in all treatments of the two seasons. 7- Cost benefit analysis revealed that the most valuable treatment was adding compost (5.0 t fed.$^{-1}$) in 30 cm mole depth with 100 % of the recommended dose of nitrogen fertilizer for each crop, since it gave the highest net income. 8- From the above results, it is more useful to use of compost filled moles with different rates and nitrogen fertilizers to markedly improve both physical and hydro physical properties under clay loam soil.

Keywords: Moles, Maize, Barley, Fertilization.

INTRODUCTION

There are about 2 million feddans of heavy textured soils in Nile Delta, Egypt, which suffer from the presence of a dense layers and clay pan (El-Mowelhi *et al*., 1982). These soils are heavy clay or clayey soils which contain 40 to 65 % clay and have poor physical properties which reflected on their productivity, (El-Hadidi *et al*., 2004). Thus, at El-Gemmeiza Agricultural Research Station in the Middle Delta, the reduction in crop yields could possibly be ascribed to the soil compaction that can be induced by adapting the heavier vehicles and agro mechanical operations for long periods (El-Maddah and El-Sodany, 2003).

Improving the heavy clay soils can be achieved by drainage and sub-soiling technique. Mole drains are conveniently used in heavy soils. Abo El-Soud *et al.* (1996) reported that in the majority of cases of their study, decreasing the mole spacing to 2 m doubled basic infiltration rate and obviously promoted salt leaching from soil profile under different crops. The mean values of the data obtained in all seasons under this study showed that installation of moles at 2, 4 and 6 m spacing clearly magnified basic infiltration rate in soil comparing to the control. Shetawy (2001) evaluated the drain depth and the drain space on moisture distribution, the soil strength and the crop yields. He reported that following the moisture content distribution showed that the soil between 150 cm drain space exhibited the higher drain factor values, as well as exhibited more homogeneously moisture distribution throw the soil profile.

El-Sabry *et al.* (1992) found that the superiorty of treatment was 3 m spacing comparing with the other treatments (6, 8 and 12 m spacing). El-Maddah and El-Sodany (2003) reported that the mean values of the data obtained in all seasons under study showed that the moles at 2, 4 and 6 m spacing clearly decrease bulk density, settling percentage, soil moisture content and water consumption and increase total soil porosity, hydraulic conductivity and water use efficiency. El-Maddah and Badr (2005) showed that soil penetration resistance decreased by increasing mole depth and by decreasing mole space. Also, the soil bulk density, settling percentage and water consumption decreased, while total soil porosity, void ratio, hydraulic conductivity and water use efficiency were increased by the same treatments.

Application of compost to the soil support plant growth and enhance plant yield as well as improve the physical, chemical and biological properties of soils (Convertini *et al.*, 2004). Saraiya *et al*., (2005) showed that the application of compost prepared from rice residue to wheat decreased the soil bulk density and penetration resistance and increased the hydraulic conductivity, infiltration rate, organic carbon content, available nitrogen, and grain and straw yield of wheat.

El-Hady and Abo-Sedera (2006) reported that the applied conditioners (organic compost) positively affect hydrophysical properties of the soil. These include, decreasing soil bulk density as well as macro porosity (drainage pores) on the expense of micro ones. Therefore, water holding pores were increased. Increasing retained moisture in the soil at all suctions under study (from 0 - 15 atmo), because the increase in water retained in the soil at field capacity is far beyond that at wilting percentage, available water was highly increased. Decreasing mean diameter of soil pores and turn its water transmitting properties namely, infiltration rate, hydraulic conductivity and transmissivity for vertical flow of water through soil profile. El-Sodany *et al.* (2009) showed that farmyard manure resulted in a decrease in soil bulk density, settling percentage and consumptive water use, while total soil porosity, void ratio, pore size distribution (large, medium and micro pores), soil hydraulic conductivity, soil moisture constants, i.e., saturation percent, field capacity, wilting point, available water and soil moisture content just before harvesting and water use efficiency were increased. Diana *et* *al*. (2008) reported positive effects of organic wastes on soil physical properties (viz. water retention and hydraulic conductivity). Aguilera *et al*. (2012) showed that lower soil bulk density was observed after organic fertilizers were applied with or without inorganic fertilizers and this residual effect persisted for the quinoa crop. El-Sodany *et al*., (2015) showed that soil penetration resistance, soil bulk density, settling percentage and water consumption decreased with all natural soil conditioners while total soil porosity, void ratio, values of pore size distribution (large, medium and micro pores as a percent of total porosity), soil hydraulic conductivity, soil moisture content, i.e., saturation percent, field capacity, wilting point, available water and soil moisture content just before harvesting and water use efficiency were increased.

Amer (2016) referred that soil infiltration rate, hydraulic conductivity and soil porosity were highly significant increased due to individual application of biochar, compost tea and recorded the highest values by combination of treatments after harvesting of plant. While, bulk density values were decreased with individual and combination of them. Also, he added that water use efficiency was highly significant increased, Total income, net income, economical of all treatments and recorded the highest values by combination of them.

Cercioglu (2017) showed that all organic amendments (chicken manure, bio-humic and composted tobacoo wast) increased porosity, structure stability index, field capacity, wilting point, and available water amount and decreased bulk density and particle density of soil when compared to the control.

Guo *et al*., (2014) referred that mineral fertilizer applications combined with (wheat straw and farmyard manure) improved soil physical properties such as the soil bulk density, which decreased more than 10%. While, the air porosity and field water content increased more than 90% and 15%, respectively compared with the values at the start of the experiment. Guo *et al.,* (2016) demonstrated that organic matter, water content from topsoil were significantly and positively related to cattle manure compost (CMC) input. Applying chemical fertilizers alone led to the lower soil organic matter, water content.

Tadesse *et al.* (2013) showed that application of 15 t· FYM· ha^{-1} significantly increased soil organic matter and available water holding capacity but decreased the soil bulk density, creating a good soil condition for enhanced growth of the rice crop. Also, the combined application of FYM and inorganic N and P fertilizers improved the chemical and physical properties, which may lead to enhanced and sustainable production of rice in the study area.

Abd-Allah (2014) reported that the natural soil amendments such as water hyacinth compost, rice straw compost and farmyard manure have improving some soil physical and hydrophysical properties where soil bulk density, settling percentage, water consumption decreased, while total soil porosity, void ratio, values of pore size distribution (large, medium and micro pores as a percent of total porosity), structure factor, soil hydraulic conductivity and soil moisture content, i.e. (saturation percent, water field capacity, wilting point, available water and soil moisture content just before harvesting) and water use efficiency were significantly increased with the addition of these amendments.

This work aims to study the effect and residual effects of compost rates filled moles at 30 cm depth, arranged in parallel orientation with respect to one another's at 3 m spacing or placed on the surface soil layer on improving some soil physical and hydro-physical properties of clay loam soils at the Middle Delta. Furthermore, the whole improvements of such soils are economically determined by calculating the net income from maize and barley crops for all treatments.

MATERIALS AND METHODS

The experiments were done in the experimental farm of El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate, during two consecutive growing seasons of 2017 and 2018. The experiment was initiated in summer season 2017 using maize plants (*Zea mays*) and lasted for winter season 2017/2018 using barley plants (*Hordum vulgare*) to study the effect and residual effects of compost rates placed in moles 30 cm depth arranged in parallel orientation with respect to one another and spaced at 3 m aparts or placed on surface soil layer (10 cm depth) and different rates of nitrogen fertilizers on improving the physical and hydro-physical properties of clay loam soil which in turn affect on yield production and net income. The soil properties of the two soil layers (0-10 and 10-30 cm) of the experimental site are shown in Table (1-a) and the used compost analysis are shown in Table (1-b).

In summer season 2017, seeds of maize (*Zea mays L.*) single cross 10 maize hybrid were planted at the rate of 10 kg fed^{-1} during the first week of June 2017, while in winter season 2017/2018, seeds of barley (*Hordum vulgare L.*) cultivar Giza 126 were planted at the rate of 50 kg $fed.^{-1}$ during the third week of December 2017. All other necessary operations except those under study were kept normal and uniform for all the treatments according to the recommendations of El-Gemmeiza Research Station.

The moles were constructed at 30 cm depth by special ditcher, then the compost were placed on the soil surface or filled moles manual. The addition of compost rates were done before maize planting in the first season only and the residual effects of these compost were studied on barley crop in the second one, where the same experimental plots were left without application of compost to study the residual effects of applied compost in the first season.

During the two seasons, the basal doses of P in the form of mono supper phosphate, 15.5 % P_2O_5 and K in the form of potassium sulphate, 48 % K_2O were applied according to the recommendations for each crop, 31 Kg P_2O_5 fed^{-1} and 48 Kg K_2O fed^{-1}, for maize and 15.5 Kg P_2O_5 fed^{-1} and 24 Kg K_2O fed^{-1} for barley. While, the recommended dose of N fertilizer, 120 Kg N fed^{-1} for maize and 45 Kg N fed^{-1} for barley, were applied in the form of ammonium nitrate, 33.5 % N.

The compost was placed and mixed with surface soil layer by chisel plow (9 shares) two passes at an average depth of 10 cm and underground moles 3 m spacing at 30 cm depth, with rate of 0.0, 2.5, 5.0 and 7.5 ton fed^{-1} before sowing.

Table 1-a. Some soil properties of the experimental site.

Soil depth, cm		0-10	10-30	Soil depth, cm		0-10	10-30
Physical properties							
	Coarse sand	5.17	4.65	Settling, %		31.06	31.41
Particle size	Fine sand	19.77	19.81		> 9 μ	21.88	22.42
distribution, %	Silt	36.96	35.93	Pore size distribution, %	9 - 0.2 μ	11.89	12.19
	Clay	38.10	39.61		< 0.2 μ	14.16	12.19
Texture class		Clay loam	Clay loam	Structure Factor (S.F),%		60.02	59.21
$CaCO_3$, %		3.44	3.32	Hydraulic conductivity (Kh, cm hr^{-1})		0.47	0.44
Penetration resistance (Mpa)		2.85	2.86	Saturation percentage (SP, %)		74.13	73.62
Bulk density (Db, g cm^{-3})		1.38	1.41	Field capacity (FC, %)		40.29	40.01
Total porosity (E, %)		47.92	46.79	Wilting point (WP, %)		21.90	18.27
Void ratio (e)		0.92	0.88	Available water (AW, %)		18.39	18.27
Chemical properties							
EC, dSm^{-1}		1.80	2.00	Organic carbon (O.C, %)		1.467	1.304
pH, 1:2.5 (susp.)		7.80	8.06	Total nitrogen (T.N, %)		0.138	0.127
Organic matter (O.M, %)		2.53	2.25	C/N ratio		10.63	10.27
Soluble cations, meq l^{-1}				Soluble anions, meq l^{-1}			
Ca^{2+}		5.28	4.93	CO_3^{2-}		0.00	0.00
Mg^{2+}		3.77	3.42	HCO^{3-}		2.65	2.81
Na^+		8.84	11.57	Cl^-		8.30	8.83
K^+		0.11	0.08	SO_4^{2-}		7.05	8.36

The experimental fields consisted of 32 plots for each replicate, where the plot area was 24 m^2 (4.0 m × 6.0 m) organized as split-split plots in a randomized complete block design (RCBD) with three replications.

Table 1-b. Some chemical characteristics of the investigated compost.

Properties	Compost	Properties	Compost
pH (1:10 manure: water)	7.39	Bulk density, g/cm^3	0.57
EC, dS m^{-1}(1:10 manure:water)	3.19	Moisture content, %	18.00
Ca, %	0.84	Ash, %	66.33
Mg, %	0.29	Organic matter, %	33.67
Na, %	0.27	Organic carbon, %	19.53
Cl, %	0.14	Total N, %	1.57
Fe, ppm	1215.00	C/N ratio	12.44
Zn, ppm	83.15	Total P, %	0.95
Mn, ppm	72.80	Total K, %	1.6
Cu, ppm	31.25		

The main plots were for compost application at two depths as follows:
D1 = Surface depth, ≈ 10 cm
D2 = 30 cm mole depth
The sub-plots were for nitrogen fertilizer applying rates from the recommended dose for each crop as follows:
N1 = 0.0 % (without) N2 = 50 %
N3 = 75 % N4 = 100 %
The sub-sub plots consisted of compost rates (ton/fed) as follows:
C1 = 0.0 (ton fed^{-1}) (without) C2 = 2.5 (ton fed^{-1})
C3 = 5.0 (ton fed^{-1}) C4 = 7.5 (ton fed^{-1})

Japanese cone penetrometer, modle SR-2Dik 5500 was used to measure the penetration resistance of soil. This measurement was done 4 times. The first 3 times, each was done 10 days after the primary three irrigation, while the last was done direct before harvesting in the two growing seasons.

After harvesting of each growing season, soil samples (10 and 30 cm depths) were taken from each plot to determine the following soil physical and hydrophysical properties: soil bulk density was determined using the core methods (Vomocil, 1986), total porosity (E,%) and void ratio (e) were calculated using the following equations:-

$$E, \% = (1 - \frac{Db}{Dr}) \times 100$$

and $$e = \frac{Dr}{Db} - 1$$

Where: **Db = soil bulk density, g cm^{-3}**
Dr = soil real density, taken as 2.65 g cm^{-3}

Settling percentage of the soil aggregates was determined in soil aggregates of 2 – 5 mm size, as the method described by Williams and Cooke (1961) and Hartge (1969).

Structure factor (SF, %), was calculated by the Bouyoucos hydrometer method using Calgon solution as a dispersing agent to determine the clay fraction (<2μ) and without dispersion by transferring soil samples to chaking bottles (1.0 liter capacity), left for 12 hours in distilled water, and were mildly agitated in an end-over-end shaking machine with 50 r.p.m, for two hours. The equation modified by Fathi (1958) was applied as follows:

$$SF = \frac{[\%clay\ after\ dispersion - \%clay\ without\ dispersion]}{[\%clay\ after\ dispersion]} \times 100$$

Hydraulic conductivity (cm hr^{-1}) was determined using undisturbed soil cores using a constant water head according to Richards (1954). Soil moisture characteristics and soil moisture content were determined using the method outlined by Stakman (1969). Pore size distribution was calculated according to De Leenher and De Boodt (1965).

Water consumption was determined by collecting soil samples from each plot before and after 48 hours of every irrigation and computed according to the Israelsen and Hansen (1962)

$$Water\ consumption,\ cm = \frac{\theta_2 - \theta_1}{100} \times Db \times D$$

Where: **θ_2 = Soil moisture percentage on weight basis after 48 hours from irrigation.**
θ_1 = Soil moisture percentage before irrigation.
Db = Bulk density, g cm^{-3}
D = Soil depth, cm

Water use efficiency was calculated by dividing the grain yield of maize and barley (kg fed^{-1}) by water consumptive use according to Jensen (1983):

$$WUE\text{, kg fed}^{-1}\text{ cm}^{-1} = \frac{Grain\ yield,\ (kg\ fed^{-1})}{Water\ consumptio\ n\ (cm)}$$

The collected data were statistically analyzed according to procedure out lined by Sendecor and Cochran (1981). Economic evaluation was done to compare between different treatments to state which one was recorded the highest net income.

RESULTS AND DISCUSSION

Effect of different treatments on some soil physical properties.

1- Soil penetration resistance.

The results in Table (2) indicate that the penetration resistance values significantly decreased with the addition of compost rates at different depths in the two growing seasons as compared with the initial soil, Table (1-a). The best treatment was found by the addition of 7.5 ton compost fed^{-1} in 30 cm depth, since it recorded the lowest values that decreased to 2.28, 2.26, 2.25 and 2.26 Mpa in the first season and 2.26, 2.23, 2.21 and 2.22 Mpa in the second one for the primary three irrigation and just before harvesting, respectively. Similar results were confirmed with El-Maddah and Badr (2005).

Data in Table (2) declare that soil penetration resistance was significantly decreased with increasing the application depth, where the decrease in soil penetration resistance can be arranged in the descending order: D2 (30 cm) > D1 (10 cm surface depth). The lowest values were recorded by 30 cm depth at 10 days after 1st, 2nd, 3rd and just before harvesting, where the decreases reached to 2.52, 2.49, 2.47 and 2.49 Mpa and were 2.42, 2.40, 2.38 and 2.39 Mpa compared to the values at surface depth (D1) in the first and second seasons, respectively. Similar results were obtained by El-Maddah and Badr (2005), they found that soil penetration resistance (PR) was significantly decreased by increasing mole depth.

Table 2. Effect of different treatments on penetration resistance (Mpa) at sequence measuring time.

Application depth cm	Nitrogen fertilizer	Compost rates (ton fed^{-1})	First season (Zea mays)				Second season (Barley)			
			10 days after 1st irri.	10 days after 2nd irri.	10 days after 3rd irri.	Just before harvesting	10 days after 1st irri.	10 days after 2nd irri.	10 days after 3rd irri.	Just before harvesting
D1	N1	C1	2.85	2.83	2.82	2.83	2.75	2.72	2.70	2.71
		C2	2.65	2.63	2.60	2.62	2.55	2.53	2.50	2.51
		C3	2.59	2.55	2.51	2.53	2.50	2.47	2.45	2.46
		C4	2.55	2.50	2.47	2.49	2.45	2.44	2.41	2.43
	N2	C1	2.84	2.81	2.78	2.80	2.73	2.71	2.68	2.70
		C2	2.63	2.61	2.47	2.58	2.52	2.51	2.48	2.49
		C3	2.56	2.53	2.49	2.51	2.48	2.46	2.43	2.45
		C4	2.51	2.48	2.45	2.47	2.43	2.42	2.40	2.41
	N3	C1	2.82	2.80	2.77	2.79	2.70	2.68	2.66	2.67
		C2	2.62	2.60	2.54	2.55	2.51	2.49	2.47	2.48
		C3	2.54	2.52	2.47	2.49	2.46	2.45	2.42	2.43
		C4	2.52	2.47	2.44	2.46	2.41	2.40	2.37	2.39
	N4	C1	2.81	2.79	2.76	2.78	2.68	2.65	2.64	2.65
		C2	2.61	2.55	2.53	2.54	2.49	2.47	2.46	2.47
		C3	2.53	2.50	2.46	2.48	2.44	2.43	2.41	2.42
		C4	2.49	2.44	2.42	2.45	2.40	2.39	2.35	2.37
D2	N1	C1	2.72	2.70	2.68	2.69	2.67	2.65	2.63	2.64
		C2	2.58	2.54	2.52	2.55	2.42	2.40	2.39	2.40
		C3	2.50	2.48	2.47	2.49	2.40	2.37	2.35	2.36
		C4	2.44	2.40	2.38	2.39	2.30	2.28	2.26	2.27
	N2	C1	2.69	2.67	2.65	2.66	2.64	2.61	2.58	2.60
		C2	2.56	2.51	2.49	2.53	2.40	2.38	2.37	2.38
		C3	2.48	2.46	2.44	2.47	2.38	2.35	2.34	2.35
		C4	2.38	2.35	2.34	2.34	2.28	2.26	2.24	2.25
	N3	C1	2.68	2.65	2.63	2.64	2.63	2.60	2.57	2.58
		C2	2.54	2.50	2.48	2.52	2.39	2.37	2.35	2.36
		C3	2.46	2.45	2.42	2.44	2.37	2.34	2.32	2.33
		C4	2.31	2.29	2.28	2.29	2.27	2.25	2.22	2.23
	N4	C1	2.66	2.64	2.61	2.63	2.62	2.59	2.56	2.57
		C2	2.53	2.49	2.46	2.50	2.38	2.36	2.34	2.35
		C3	2.44	2.43	2.41	2.43	2.35	2.33	2.31	2.32
		C4	2.28	2.26	2.25	2.26	2.26	2.23	2.21	2.22
A Application depth cm		D1	2.63	2.60	2.56	2.59	2.53	2.51	2.49	2.50
		D2	2.52	2.49	2.47	2.49	2.42	2.40	2.38	2.39
		F - test	**	**	**	**	*	*	*	*
B Nitrogen fertilizer		N1	2.61	2.58	2.56	2.57	2.51	2.48	2.46	2.47
		N2	2.58	2.55	2.51	2.55	2.48	2.46	2.44	2.45
		N3	2.56	2.54	2.50	2.52	2.47	2.45	2.42	2.43
		N4	2.54	2.51	2.49	2.51	2.45	2.43	2.41	2.42
		F - test	NS	NS	NS	NS	NS	NS	NS	NS
C Compost rates (ton)		C1	2.76	2.74	2.71	2.73	2.68	2.65	2.63	2.64
		C2	2.59	2.55	2.51	2.55	2.46	2.44	2.42	2.43
		C3	2.51	2.49	2.46	2.48	2.42	2.40	2.38	2.39
		C4	2.44	2.40	2.38	2.39	2.35	2.33	2.31	2.32
		F - test	**	**	**	**	**	**	**	**

The results reveal that nitrogen fertilization rates non-significantly decreased soil penetration resistance, where the application of 100 % N fertilizer of the recommended dose led to the lowest values as compared with the other rates of N fertilizer, with non-significant difference between them.

Also, data reveal that the compost rates addition under different depths significantly affected on soil penetration resistance which could be decreased by increasing compost rates, where the addition of 7.5 ton compost/fed causes low values as compared with the other rates of compost during the two growing seasons. The decreases were reached to 2.44, 2.40, 2.38 and 2.39 Mpa and were 2.35, 2.33, 2.31 and 2.32 Mpa in the first and second seasons, respectively. These decreases may be related to the products of compost decomposition during growth seasons, microbial gums and promoting root growth enhanced soil aggregation processes, subsequently soil penetrability resistance decreases. The results agree with that obtained by Saraiya *et al.,* (2005) and El-Sodany *et al.*, (2015)

Also, it can be noticed that soil penetration resistance just before harvesting was decreased in the second season than in the first one and in both they have the lowest values. This may be due to the natural dries of soil during the growing period. These results are in line with El-Maddah and Badr (2005).

2- Soil bulk density, total soil porosity and void ratio.

Data in Tables (3 and 4) show that the addition of compost rates at different depths with nitrogen fertilizer rates led to decreases in soil bulk density and increases in total soil porosity and void ratio for the two sequence soil depths (10 and 30 cm) at the end of the two seasons as compared with the initial soil, Table (1-a).

Table 3. Effect of different treatments on some soil physical properties in the first season (summer 2017).

Application depth cm	Nitrogen fertilizer	Compost rates (ton fed^{-1})	Bulk density (Db, g cm^{-3})	Total porosity (E, %)	Void ratio (e)	Settling, %	Pore size distribution, %			Structure Factor (S.F),%
							> 9 µ	9 - 0.2 µ	< 0.2 µ	
D1	N1	C1	1.38	47.92	0.92	31.06	21.88	11.89	14.16	60.02
		C2	1.33	49.81	0.99	28.34	22.74	12.36	14.71	72.92
		C3	1.32	50.19	1.01	27.69	22.91	12.45	14.82	73.21
		C4	1.31	50.57	1.02	27.21	23.08	12.55	14.94	73.27
	N2	C1	1.37	48.30	0.93	30.87	22.05	11.98	14.27	60.25
		C2	1.32	50.19	1.01	28.25	22.91	12.45	14.82	73.15
		C3	1.32	50.19	1.01	27.61	22.91	12.45	14.82	73.35
		C4	1.31	50.57	1.02	27.16	23.08	12.55	14.94	73.39
	N3	C1	1.36	48.68	0.95	30.75	22.22	12.08	14.38	60.43
		C2	1.32	50.19	1.01	28.14	22.91	12.45	14.82	73.52
		C3	1.32	50.19	1.01	27.58	22.91	12.45	14.82	73.47
		C4	1.30	50.94	1.04	27.12	23.26	12.64	15.05	73.51
	N4	C1	1.35	49.06	0.96	30.70	22.40	12.17	14.49	60.52
		C2	1.31	50.57	1.02	28.07	23.08	12.55	14.94	73.05
		C3	1.32	50.19	1.01	27.49	22.91	12.45	14.82	73.18
		C4	1.30	50.94	1.04	27.07	23.26	12.64	15.05	71.29
D2	N1	C1	1.36	48.68	0.95	30.49	22.22	12.08	14.38	71.37
		C2	1.30	50.94	1.04	26.31	23.26	12.64	15.05	73.74
		C3	1.29	51.32	1.05	25.44	23.43	12.73	15.16	73.97
		C4	1.28	51.70	1.07	25.00	23.60	12.83	15.27	74.11
	N2	C1	1.35	49.06	0.96	30.42	22.40	12.17	14.49	71.37
		C2	1.30	50.94	1.04	26.25	23.26	12.64	15.05	73.90
		C3	1.29	51.32	1.05	25.40	23.43	12.73	15.16	74.18
		C4	1.27	52.08	1.09	24.71	23.77	12.92	15.38	74.32
	N3	C1	1.35	49.06	0.96	30.37	22.40	12.17	14.49	71.60
		C2	1.29	51.32	1.05	26.19	23.43	12.73	15.16	74.10
		C3	1.29	51.32	1.05	25.34	23.43	12.73	15.16	74.32
		C4	1.27	52.08	1.09	24.68	23.77	12.92	15.38	74.54
	N4	C1	1.34	49.43	0.98	30.31	22.57	12.27	14.60	71.69
		C2	1.29	51.32	1.05	26.14	23.43	12.73	15.16	74.27
		C3	1.28	51.70	1.07	25.30	23.60	12.83	15.27	74.45
		C4	1.27	52.08	1.09	24.60	23.77	12.92	15.38	74.67
A Application depth cm	D1		1.33	49.91	1.00	28.44	22.78	12.38	14.74	69.91
	D2		1.30	50.90	1.04	26.68	23.24	12.63	15.03	73.54
	F - test		*	*	*	**	*	*	*	**
B Nitrogen fertilizer	N1		1.32	50.14	1.01	27.69	22.89	12.44	14.81	71.58
	N2		1.32	50.33	1.01	27.58	22.98	12.49	14.87	71.74
	N3		1.31	50.47	1.02	27.52	23.04	12.52	14.91	71.94
	N4		1.31	50.66	1.03	27.46	23.13	12.57	14.96	71.64
	F - test		NS	NS	NS	NS	NS	NS	NS	NS
C Compost rates (ton)	C1		1.36	48.77	0.95	30.62	22.27	12.10	14.41	65.91
	C2		1.31	50.66	1.03	27.21	23.13	12.57	14.96	73.58
	C3		1.30	50.80	1.03	26.48	23.19	12.60	15.01	73.77
	C4		1.29	51.37	1.06	25.94	23.45	12.75	15.17	73.64
	F - test		**	**	**	**	**	**	**	**

Table 4. Effect of different treatments on some soil physical properties in the second season (winter 2017/2018).

Application depth cm	Nitrogen fertilizer	Compost rates (ton fed^{-1})	Bulk density (Db, g cm^{-3})	Total porosity (E, %)	Void ratio (e)	Settling, %	Pore size distribution, % > 9 μ	Pore size distribution, % 9 - 0.2 μ	Pore size distribution, % < 0.2 μ	Structure Factor (S.F),%
D1	N1	C1	1.37	48.30	0.93	29.38	22.05	11.98	14.27	60.75
		C2	1.30	50.94	1.04	26.80	23.26	12.64	15.05	74.03
		C3	1.30	50.94	1.04	26.21	23.26	12.64	15.05	74.23
		C4	1.29	51.32	1.05	25.81	23.43	12.73	15.16	74.29
	N2	C1	1.36	48.68	0.95	29.31	22.22	12.08	14.38	60.93
		C2	1.30	50.94	1.04	26.72	23.26	12.64	15.05	74.21
		C3	1.30	50.94	1.04	26.15	23.26	12.64	15.05	74.38
		C4	1.29	51.32	1.05	25.76	23.43	12.73	15.16	74.42
	N3	C1	1.35	49.06	0.96	29.27	22.40	12.17	14.49	61.17
		C2	1.30	50.94	1.04	26.69	23.26	12.64	15.05	74.38
		C3	1.30	50.94	1.04	26.00	23.26	12.64	15.05	74.50
		C4	1.29	51.32	1.05	25.71	23.43	12.73	15.16	74.57
	N4	C1	1.34	49.43	0.98	29.21	22.57	12.27	14.60	61.35
		C2	1.30	50.94	1.04	26.63	23.26	12.64	15.05	74.49
		C3	1.29	51.32	1.05	25.97	23.43	12.73	15.16	74.64
		C4	1.28	51.70	1.07	25.66	23.60	12.83	15.27	74.69
D2	N1	C1	1.35	49.06	0.96	28.72	22.40	12.17	14.49	73.04
		C2	1.27	52.08	1.09	24.81	23.77	12.92	15.38	75.18
		C3	1.26	52.45	1.10	24.05	23.95	13.01	15.49	75.61
		C4	1.25	52.83	1.12	23.75	24.12	13.11	15.60	75.71
	N2	C1	1.34	49.43	0.98	28.68	22.57	12.27	14.60	73.21
		C2	1.27	52.08	1.09	24.78	23.77	12.92	15.38	75.32
		C3	1.26	52.45	1.10	23.95	23.95	13.01	15.49	75.78
		C4	1.25	52.83	1.12	23.69	24.12	13.11	15.60	75.89
	N3	C1	1.34	49.43	0.98	28.62	22.57	12.27	14.60	74.38
		C2	1.26	52.45	1.10	24.72	23.95	13.01	15.49	75.49
		C3	1.26	52.45	1.10	23.89	23.95	13.01	15.49	75.87
		C4	1.25	52.83	1.12	23.60	24.12	13.11	15.60	76.09
	N4	C1	1.33	49.81	0.99	28.58	22.74	12.36	14.71	74.52
		C2	1.26	52.45	1.10	24.68	23.95	13.01	15.49	75.58
		C3	1.25	52.83	1.12	23.81	24.12	13.11	15.60	75.96
		C4	1.24	53.21	1.14	23.55	24.29	13.20	15.72	76.25
A Application depth cm	D1		1.31	50.57	1.02	26.96	23.08	12.55	14.94	71.06
	D2		1.28	51.79	1.08	25.24	23.65	12.85	15.30	75.24
	F - test		*	*	*	**	*	*	*	**
B Nitrogen fertilizer	N1		1.30	50.99	1.04	26.19	23.28	12.65	15.06	72.86
	N2		1.30	51.08	1.05	26.13	23.32	12.67	15.09	73.02
	N3		1.29	51.18	1.05	26.06	23.36	12.70	15.12	73.31
	N4		1.29	51.46	1.06	26.01	23.50	12.77	15.20	73.44
	F - test		NS	NS	NS	NS	NS	NS	NS	NS
C Compost rates (ton)	C1		1.35	49.15	0.97	28.97	22.44	12.19	14.52	67.42
	C2		1.28	51.60	1.07	25.73	23.56	12.80	15.24	74.84
	C3		1.28	51.79	1.07	25.00	23.64	12.85	15.30	75.12
	C4		1.27	52.17	1.09	24.69	23.82	12.94	15.41	75.24
	F - test		**	**	**	**	**	**	**	**

The lowest values of soil bulk density and the highest values of total soil porosity and void ratio were recorded by the addition of 7.5 ton compost fed^{-1} in 30 cm depth, where the lowest values of soil bulk density were reached to 1.27 and 1.24 g cm^{-3}, respectively in the first and second seasons. While, the values of total soil porosity and void ratio take the opposite trend, where increases to 52.08 and 53.21 % for (E), and 1.09 and 1.14 for (e) at the end of the two seasons, respectively. Similar results were obtained by El-Maddah and El-Sodany (2003), El-Maddah and Badr (2005) and Cercioglu (2017).

The results in Tables (3 and 4) show that soil bulk density decreased and total soil porosity and void ratio increased as a result of increasing application depth. The decreases in (Db) were ranged from 1.33 to 1.30 and 1.31 to 1.28 g cm^{-3} for the two soil depths (10 and 30 cm) in the first and second seasons, respectively. While, the increases in (E) and (e) were ranged from 49.91 to 50.90 and 50.56 to 51.79 % for (E) and from 1.00 to 1.04 and 1.02 to 1.08 for (e) at the same depths in the two seasons, respectively. Similar conclusion were obtained by El-Maddah and Badr (2005).

Also, the results indicate that nitrogen fertilizer rates addition non-significantly decreased soil bulk density or increased (E) and (e). These results agree with that obtained by Guo *et al.,* (2014).

Concerning the addition of compost rates, the data in Fig. (1) reveal that soil bulk density was significantly decreased by increasing the addition rates of compost. The addition of 7.5 ton compost fed^{-1} gave the lowest values of soil bulk density, where decreased to 1.29 and 1.27 g cm^{-3} in the two seasons, respectively. On the other hand, the values of (E) and (e) take the opposite trend, where the increases of (E) were reached to 51.37 and 52.17 %, while, the increases of (e) were reached to 1.06 and 1.09 in the two seasons, respectively. The decrease of soil bulk density may be due to the high content of organic matter in compost which refers to formation of soil aggregates and may be indicated by the improvement in soil structure (Table 1-b). The results agree with that obtained by Aguilera *et al*. (2012), El-Sodany *et al.* (2015) and Cercioglu (2017). Also, it can notice the high bulk density of the treated soil with compost at the end of the first season compared with the second one, which may be due to the slight decomposition of these materials after the first season. The results agree with that of Abd-Allah (2014). In general also, increasing total soil porosity and void ratio may be related to seasonal variation of bulk density, but this usually requires addition of compost for longer periods.

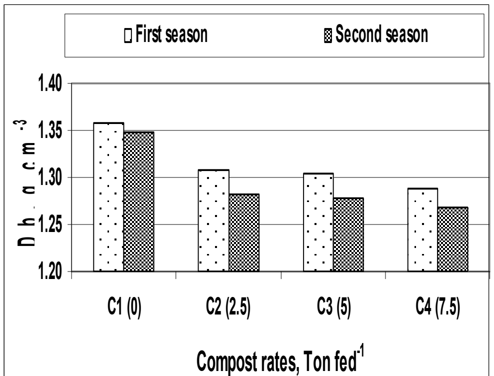

Fig (1): Effect of compost rates on soil bulk density in the two seasons

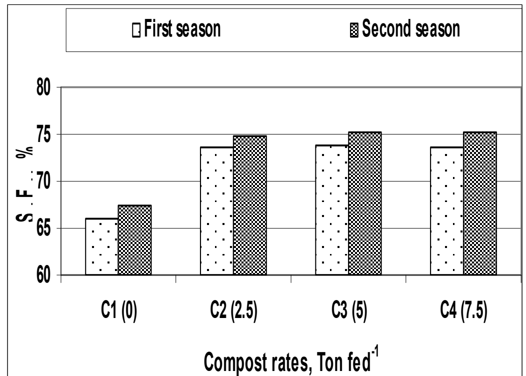

Fig. (2): Effect of compost rates on structure factor in the two seasons

3- Structural stability (Settling percentage).

Data presented in Tables (3 and 4) declare that the addition of compost rates at 30 cm mole depth with nitrogen fertilizer rates led to decreases in settling % in the two growing seasons as compared with the initial soil, Table (1-a), where the lowest values were resulted by the addition of 7.5 ton compost fed^{-1} in 30 cm mole depth with 100 % N fertilizer of the recommended dose, which decreased to 24.60 and 23.55 % compared to the initial soil at the end of the two seasons, respectively.

Data show that the increasing of application depth led to significant decreases in settling %, where 30 cm depth gave the lowest values of settling %, which was more effective than the surface application. The values of settling % were ranged from 28.44 to 26.68 % and 26.96 to 25.24 % in the first and second seasons, respectively. The results declare that the application of nitrogen fertilizer rates led to non-significant decrease in settling %. The higher rates of N fertilizer resulted in the lowest values of settling %, which means higher degree of soil structure stability.

Concerning the compost rates, the results in Tables (3 and 4) reveal that settling % were significant decreased with increasing the application of compost rates. The application of 7.5 ton compost fed^{-1} resulted in the lowest values, where the values of settling % decreased to 25.94 and 24.69 % at the end of the two seasons, respectively. These results are confirmed with those of Abd-Allah (2014) and El-Sodany *et al.,* (2015). The improvement effect of these treatments may be attributed to the formation of water stable aggregates as a result of root exudates, root growth and decay besides the decomposition of the added compost.

4- Pore size distribution.

Pore size distribution as a percent of total porosity were presented in Tables (3 and 4). The results show that increasing the addition of compost rates with increasing mole depth to 30 cm and nitrogen fertilizer rates led to increases in the large, medium and micro pores in the two seasons. The highest values of large, medium and micro pores were recorded by the addition of 7.5 ton compost fed^{-1} in 30 cm mole depth with 100 % N fertilizer of the recommended dose, where its increased to 23.77, 12.92 and 15.38 % in the first season and 24.29, 13.20 and 15.72 % in the second one for >9µ, 9-0.2 µ and <0.2 µ pores, respectively. Similar conclusions were obtained by El-Hady and Abo-Sedera (2006) and El-Sodany *et al.* (2009).

The results indicate that large, medium and micro pores values were significantly increased by increasing the application depth. The highest values of large, medium and micro pores were obtained by 30 cm mole depth, where the values increased from 22.78 to 23.24 and 23.09 to 23.65 % for >9µ pores, 12.38 to 12.63 and 12.55 to 12.85 % % for 9-0.2 µ pores and 14.74 to 15.03 and 14.94 to15.30 % for <0.2 µ pores in the first and second seasons, respectively. These results agree with that obtained by El-Sodany *et al.*, (2015), they reported that the values of pore size distribution (large, medium and micro pores as a percent of total porosity) were significantly increased with addition of compost rates filled moles at different depths.

The results clarify that the application of nitrogen fertilizer rates led to non-significant increase the pores values >9µ, 9-0.2 µ and <0.2 µ, where the application of 100 % N fertilizer of the recommended dose recorded the highest values. Concerning the application of compost rates, the results indicate that the pores values of >9µ, 9-0.2 µ and <0.2 µ were significantly increased by increasing compost rates. The highest values of >9µ, 9-0.2 µ and <0.2 µ were obtained by the application of 7.5 ton compost fed^{-1}, where its increased to 23.45, 12.75 and 15.17 % in the first season and 23.82, 12.94 and 15.41 % in the second one, respectively.

5- Structure factor

Data in Tables (3 and 4) indicate that the addition of compost rates at different depths with nitrogen fertilizer rates led to increases in soil structure factor (S.F, %) at the end of the two seasons compared with the initial soil, Table (1-a). It can be noticed that the highest value of (S.F) was obtained by the addition of 7.5 ton compost fed^{-1} in 30 cm mole depth with 100 % N fertilizer rate of the recommended dose, where the highest values were increased to 74.67 and 76.25 % at the end of the first and second seasons, respectively.

Concerning the application depth, the results show that increasing the application depth significantly increased (S.F) values. The highest values were recorded by 30 cm mole depth where 30 cm depth was more effective than surface depth on increasing the (S.F) values. The values of (S.F) were increased from 69.91 to 73.54 and 71.06 to 75.24 % in the first and second seasons, respectively.

Also, date show that the application of nitrogen fertilizer rates led to insignificant increases in (S.F) values, where the application of 100 % N fertilizer of the recommended dose resulted the highest values.

The results in Fig. (2) indicate that the application of compost rates led to significantly increased in (S.F) values. The application of 7.5 ton compost fed^{-1} gave the highest values, where the increased of (S.F) reached to 73.64 and 75.24 % for the first and second seasons, respectively. These results agree with that obtained by Abd-Allah (2014) and Cercioglu (2017), who indicate that all organic amendments increased structure stability index of soil when compared to the control.

Effect of different treatments on some soil hydrophysical properties.

1-Soil hydraulic conductivity.

Data in Tables (5 and 6) show that the addition of compost rates at different depths with nitrogen fertilizer rates led to progressive increases in soil hydraulic conductivity (Kh) of the two soil depths (0-10 and 10-30 cm) at the end of the two seasons compared with the initial soil, Table (1-a). It can be noticed that the highest value of (Kh) was obtained by the addition of 7.5 ton compost fed^{-1} in 30 cm mole depth, where increased to 0.65 and 0.69 cm hr^{-1} at the end of the first and second seasons, respectively. These results agree with that obtained by Amer (2016).

Table 5. Effect of different treatments on some soil hydrophysical properties in the first season (summer 2017).

Application depth cm	Nitrogen fertilizer	Compost rates (ton fed^{-1})	Hydraulic conductivity (Kh, cm hr^{-1})	Soil moisture characters %				Soil moisture content (Θw, %) Just before harvesting	Water consumption (CU, cm)	Water use efficiency (WUE, Kg fed^{-1}cm^{-1})
				Saturation percentage (SP, %)	Field capacity (FC, %)	Wilting point (WP, %)	Available water (AW, %)			
D1	N1	C1	0.47	74.13	40.29	21.90	18.39	15.39	67.89	23.77
		C2	0.54	77.45	42.09	22.88	19.22	18.65	65.73	26.83
		C3	0.55	81.62	44.36	24.11	20.25	19.20	64.99	27.56
		C4	0.57	83.17	45.20	24.57	20.64	19.67	64.67	27.95
	N2	C1	0.48	74.32	40.39	21.95	18.44	15.82	66.42	26.24
		C2	0.55	77.59	42.17	22.92	19.25	18.76	60.36	37.26
		C3	0.55	81.76	44.43	24.15	20.29	19.38	60.17	37.66
		C4	0.57	83.29	45.27	24.60	20.67	19.76	59.71	38.33
	N3	C1	0.48	74.51	40.49	22.01	18.49	15.96	61.67	34.84
		C2	0.56	77.68	42.22	22.94	19.27	18.92	56.59	52.32
		C3	0.56	81.89	44.51	24.19	20.32	19.49	56.19	53.69
		C4	0.58	83.41	45.33	24.64	20.69	19.85	55.15	55.14
	N4	C1	0.49	74.70	40.60	22.06	18.53	16.13	57.76	49.38
		C2	0.56	77.79	42.28	22.98	19.30	19.05	52.19	61.69
		C3	0.56	81.99	44.56	24.22	20.34	19.53	51.27	62.86
		C4	0.58	83.64	45.46	24.70	20.75	19.92	50.69	65.34
D2	N1	C1	0.48	76.62	41.64	22.63	19.01	16.75	67.26	25.29
		C2	0.58	79.15	43.02	23.38	19.64	20.22	63.75	29.06
		C3	0.59	84.14	45.73	24.85	20.88	20.91	63.53	29.41
		C4	0.63	85.86	46.66	25.36	21.30	20.98	63.29	29.87
	N2	C1	0.49	76.81	41.74	22.69	19.06	16.91	64.17	28.60
		C2	0.58	79.35	43.13	23.44	19.69	20.41	59.55	39.30
		C3	0.59	84.28	45.80	24.89	20.91	21.12	59.33	39.82
		C4	0.63	85.94	46.71	25.38	21.32	21.21	59.11	40.20
	N3	C1	0.49	76.94	41.82	22.73	19.09	16.99	60.98	35.70
		C2	0.58	79.55	43.23	23.50	19.74	20.52	54.74	55.91
		C3	0.59	84.42	45.88	24.94	20.95	21.35	54.47	56.75
		C4	0.64	86.12	46.80	25.44	21.37	21.39	54.13	58.73
	N4	C1	0.50	77.10	41.90	22.77	19.13	17.24	57.19	50.32
		C2	0.58	79.69	43.31	23.54	19.77	20.64	49.76	65.24
		C3	0.59	84.63	45.99	25.00	21.00	21.57	48.80	68.29
		C4	0.65	86.29	46.90	25.49	21.41	21.64	47.82	70.65
A Application depth cm	D1		0.54	79.31	43.10	23.43	19.68	18.47	59.47	42.55
	D2		0.57	81.68	44.39	24.13	20.27	19.99	57.99	45.20
	F - test		*	**	**	**	**	*	NS	**
B Nitrogen fertilizer	N1		0.55	80.27	43.62	23.71	19.92	18.97	65.14	27.47
	N2		0.56	80.42	43.71	23.75	19.95	19.17	61.10	35.93
	N3		0.56	80.57	43.79	23.80	19.99	19.31	56.74	50.39
	N4		0.56	80.73	43.88	23.85	20.03	19.47	51.94	61.72
	F - test		NS	NS	NS	NS	NS	NS	**	**
C Compost rates (ton)	C1		0.49	75.64	41.11	22.34	18.77	16.40	62.92	34.27
	C2		0.57	78.53	42.68	23.20	19.49	19.65	57.83	45.95
	C3		0.57	83.09	45.16	24.54	20.62	20.32	57.34	47.01
	C4		0.61	84.72	46.04	25.02	21.02	20.55	56.82	48.28
	F - test		**	**	**	**	**	**	**	**

Table 6. Effect of different treatments on some soil hydrophysical properties in the second season (winter 2017/2018).

Application depth cm	Nitrogen fertilizer	Compost rates (ton fed^{-1})	Hydraulic conductivity (Kh, cm hr^{-1})	Soil moisture characters % Saturation percentage (SP, %)	Field capacity (FC, %)	Wilting point (WP, %)	Available water (AW, %)	Soil moisture content (Θw, %) Just before harvesting	Water consumption (CU, cm)	Water use efficiency (WUE, Kg fed^{-1}cm^{-1})
D1	N1	C1	0.50	75.82	41.21	22.39	18.81	14.95	39.33	42.43
		C2	0.59	78.84	42.85	23.29	19.56	16.69	37.78	49.66
		C3	0.60	82.47	44.82	24.36	20.46	17.10	37.56	50.04
		C4	0.61	84.64	46.00	25.00	21.00	17.65	37.35	50.55
	N2	C1	0.51	75.94	41.27	22.43	18.84	15.15	38.04	46.61
		C2	0.60	78.96	42.91	23.32	19.59	16.72	34.98	61.47
		C3	0.60	82.61	44.90	24.40	20.50	17.21	34.73	62.61
		C4	0.62	84.76	46.07	25.04	21.03	17.76	34.46	63.47
	N3	C1	0.51	76.11	41.36	22.48	18.88	15.24	35.66	57.62
		C2	0.61	79.14	43.01	23.38	19.64	16.83	32.42	76.02
		C3	0.60	82.74	44.97	24.44	20.53	17.30	32.08	77.22
		C4	0.62	84.85	46.11	25.06	21.05	17.84	31.73	80.86
	N4	C1	0.52	76.28	41.46	22.53	18.93	15.33	32.92	72.72
		C2	0.61	79.33	43.11	23.43	19.68	16.94	30.31	87.85
		C3	0.60	82.89	45.05	24.48	20.57	17.39	29.41	93.19
		C4	0.63	84.97	46.18	25.10	21.08	17.93	28.89	99.61
D2	N1	C1	0.53	77.44	42.09	22.87	19.21	15.50	38.55	44.98
		C2	0.63	80.23	43.60	23.70	19.91	17.42	36.83	53.33
		C3	0.65	85.41	46.42	25.23	21.19	17.85	36.72	53.99
		C4	0.67	86.92	47.24	25.67	21.57	18.41	36.52	54.43
	N2	C1	0.53	77.62	42.18	22.93	19.26	15.68	37.22	52.37
		C2	0.63	80.40	43.70	23.75	19.95	17.54	34.18	64.55
		C3	0.65	85.52	46.48	25.26	21.22	17.92	33.83	66.96
		C4	0.68	87.18	47.38	25.75	21.63	18.49	33.71	68.21
	N3	C1	0.54	77.77	42.27	22.97	19.30	15.76	35.33	59.09
		C2	0.64	80.57	43.79	23.80	19.99	17.68	31.41	82.57
		C3	0.66	85.68	46.57	25.31	21.26	18.14	31.25	83.41
		C4	0.68	87.32	47.46	25.79	21.66	18.58	31.11	90.06
	N4	C1	0.54	77.89	42.33	23.01	19.33	15.87	32.80	74.85
		C2	0.64	80.70	43.86	23.84	20.02	17.78	28.37	95.20
		C3	0.66	85.75	46.60	25.33	21.28	18.25	27.99	102.59
		C4	0.69	87.51	47.56	25.85	21.71	18.69	27.25	107.63
A Application depth cm	D1		0.58	80.65	43.83	23.82	20.01	16.75	34.23	67.00
	D2		0.63	82.74	44.97	24.44	20.53	17.47	33.32	72.14
	F - test		*	*	*	*	*	*	NS	*
B Nitrogen fertilizer	N1		0.60	81.47	44.28	24.06	20.21	16.95	37.58	49.93
	N2		0.60	81.62	44.36	24.11	20.25	17.06	35.14	60.78
	N3		0.61	81.77	44.44	24.15	20.29	17.17	32.62	75.86
	N4		0.61	81.92	44.52	24.20	20.33	17.27	29.74	91.71
	F - test		NS	NS	NS	NS	NS	NS	**	**
C Compost rates (ton)	C1		0.52	76.86	41.77	22.70	19.07	15.44	36.23	56.33
	C2		0.62	79.77	43.35	23.56	19.79	17.20	33.29	71.33
	C3		0.63	84.13	45.73	24.85	20.88	17.65	32.95	73.75
	C4		0.65	86.02	46.75	25.41	21.34	18.17	32.63	76.85
	F - test		**	**	**	**	**	**	**	**

The results indicate that the (Kh) values were significantly increased with increasing the application depth, where 30 cm mole depth was more effective than surface depth on increasing the (Kh) values, which take the order: D2 (30 cm) > D1 (10 cm surface depth). Also, the increases of (Kh) values were ranged from 0.54 to 0.57 and 0.58 to 0.63 cm hr^{-1} in the first and second seasons, respectively. Similar conclusions were obtained by El-Maddah and Badr (2005).

Data in Tables (5 and 6) indicate that the increasing of nitrogen fertilizer rates led to insignificantly increases in (Kh) values. The application of 100 % N fertilizer of the recommended dose gave the highest values.

Concerning the application of compost rates, data in Fig. (3) indicate that the increasing of compost rates induced significantly increased in (Kh) values. The application of 7.5 ton compost fed^{-1} gave the highest values, where the values of (Kh) increased from 0.49 to 0.61 and 0.52 to 0.65 cm hr^{-1} for the first and second seasons, respectively. These increases may be due to modification in pore size distribution, and total porosity as mentioned before. These results agree with that of Diana *et al*. (2008), Abd-Allah (2014) and El-Sodany *et al*., (2015).

2- Soil moisture characteristics.

Data in Tables (5 and 6) indicate that soil moisture content retained at saturation percentage (SP), water field capacity (WFC), wilting point (WP), available water (AW) and moisture content just before harvesting (Θw,%) were increased at the end of the two seasons compared with the initial soil, Table (1-a), with increasing the application depth to 30 cm and increasing the addition of compost and nitrogen fertilizer rates. It could be observed that the addition of 7.5 ton compost fed^{-1} in 30 cm mole depth gave the highest values of these characteristics, where the highest values increased to 86.29, 46.90, 25.49 21.41 and 21.64 %, in the first season, and increased to 87.51, 47.56, 25.85, 21.71 and 18.69 %, in the second one, for SP, WFC, WP, AW and ϴw, respectively. These results agree with that of El-Sodany *et al.,* (2015).

The results indicate that the increase of application depth gave significantly increased in soil moisture content retained at SP, WFC, WP, AW and ϴw. The highest values were recorded at 30 cm mole depth, where the SP, WFC, WP, AW and ϴw values increased from 79.31 to 81.68, 43.10 to 44.39, 23.43 to 24.13, 19.68 to 20.27 and 18.47 to 19.99 % in the first season. While, in the second season, the values increased from 80.65 to 82.74, 43.83 to 44.97, 23.82 to 24.44, 20.01 to 20.53 and 16.75 to 17.47 % for the same characteristics, respectively. Similar conclusions were obtained by Abo El-Soud *et al.* (1996) and Shetawy (2001).

Also, nitrogen fertilizer rates addition led to insignificant increases of soil moisture characteristics values. The application of 100 % N fertilizer of the recommended dose for each crop led to the highest values.

Data reveal that the compost rates addition led to significantly increased of soil moisture characteristics values. It can be noticed that the application of 7.5 ton compost fed^{-1} gave the highest values of SP, WFC, WP, AW and ϴw (Fig. 4). The increased values were reached to 84.72, 46.04, 25.02, 21.02 and 20.55 % in the first season, and 86.02, 46.75, 25.41, 21.34 and 18.17 % in the second one for SP, WFC, WP, AW and ϴw, respectively. The increases may be due to the application of organic matter which markedly improve soil permeability and the increases of soil total porosity. These results agree with that of El-Hady and Abo-Sedera (2006), they reported that the applied conditioners (organic compost) increase retained moisture in the soil at all suctions under study (from 0 - 15 atmo.), because the increase in water retained in the soil at field capacity is far beyond that at wilting percentage, available water was highly increased. Similar conclusions also were obtained by Tadesse *et al.* (2013) and Cercioglu (2017)

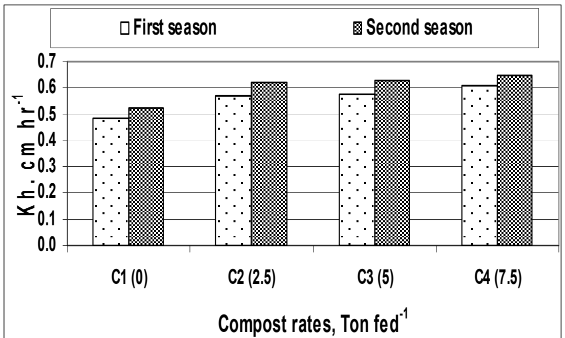

Fig.(3): Effect of compost rates on hydraulic conductivity in the two seasons

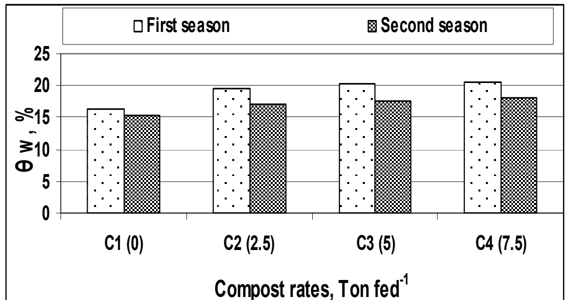

Fig. (4): Effect of compost rates on soil moisture content (ϴw, %) just before harvesting in the two seasons

3- Water consumption (CU) and water use efficiency (WUE).

The results in Tables (5 and 6) indicate that increasing the application depth to 30 cm and increasing the addition of compost and nitrogen fertilizer rates led to a decrease in CU values and increase in WUE for maize and barley plants. The results reveal that the lowest values of CU and the highest values of WUE were recorded by the addition of 7.5 ton compost fed^{-1} at 30 cm mole depth with 100 % N fertilizer of the recommended dose for each crop, where the recorded values of CU and WUE were 47.82 cm and 70.65 Kg fed^{-1} cm^{-1}, for maize plants and 27.25 cm and 107.63 Kg fed^{-1} cm^{-1}, for barley plants, respectively. Similar conclusions were obtained by El-Sodany *et al.,* (2015).

The results reveal that the CU values were insignificant decreased and WUE values significantly increased with increasing the application depth, where 30 cm mole depth was more effective than the surface depth on decreasing CU values and increasing WUE values. The decreased of CU values were ranged from 59.47 to 57.99 and 34.23 to 33.32 cm and the increased of WUE values were ranged from 42.55 to 45.20 and 67.00 to 72.14 Kg fed^{-1} cm^{-1}, for maize and barley plants, respectively. These decreases in CU values may be due to the moisture of soil under surface layer is more subject to transpiration and evaporation from the soil than 30 cm mole depth. Thus it is clear that WUE tended to decrease with the increase of moisture in root zone.

Also, it can be noticed from Figs. (5 and 6) that the addition of nitrogen fertilizer rates significantly decreased the CU values and significantly increased the WUE values. The application of 100 % N fertilizer of the recommended dose gave the lowest CU values and the highest WUE values. Where the lowest values of CU decreased to 51.94 and 29.74 cm, while, the lowest values of WUE increased to 61.72 and 91.71 Kg fed^{-1} cm^{-1} for maize and barley plants at the end of the two seasons, respectively. The most probable explanation for above mentioned results is that increasing N rates lead to increase in plant growth and plant healthy (such as plant height, number of branches/plant and other growing characters) which means decreasing the surface evaporation from the surface soil.

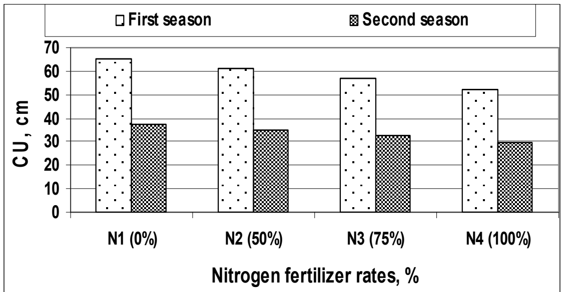

Fig. (5): Effect of nitrogen fertilizer rates on water consumption in the two seasons

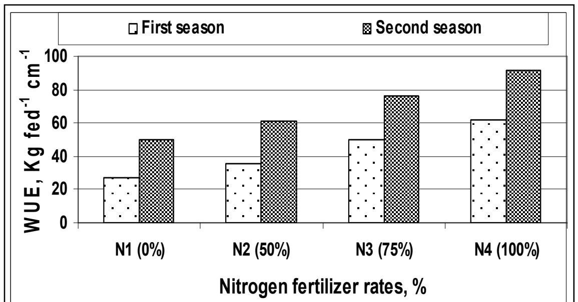

Fig. (6): Effect of nitrogen fertilizer rates on water use efficiency in the two seasons

Concerning the application of compost rates, data in Figs. (7 and 8) indicate that CU values were significantly decreased and WUE values were significantly increased with increasing the compost rates. The lowest CU values and the highest WUE values were recorded by the application of 7.5 ton compost fed^{-1}, where the lowest CU values decreased to 56.82 and 32.63 cm and the highest WUE values increased to 48.28 and 76.85 Kg fed^{-1} cm^{-1} for maize and barley plants, respectively. These results agree with that of Amer (2016). The decreases in CU values may be due to the moisture retained of the soil as a result of compost (organic matter) and N rates application which is less subjected to evaporation from the soil due to dense growth of plants. On the other hand, it is clear that WUE tended to increase by increasing organic matter and N rates. These increases in WUE may be due to increase in maize and barley grain yield (Table 7)

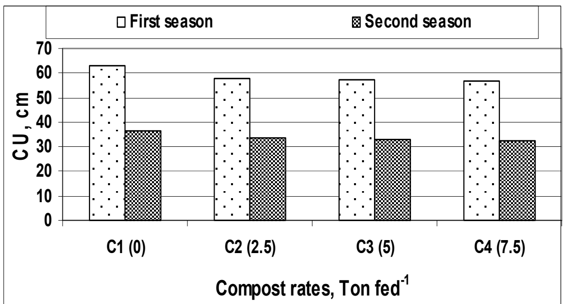

Fig. (7): Effect of compost rates on water consumotion in the two seasons

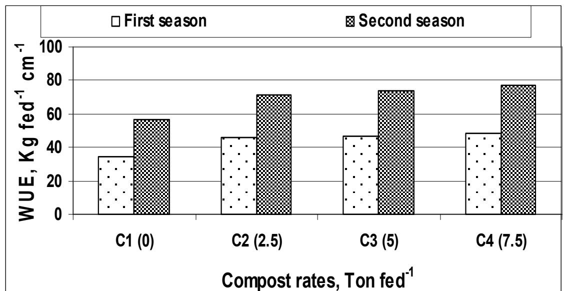

Fig. (8): Effect of compost rates on water use efficiency in the two seasons

Economic evaluation.

The total inputs costs, outputs, net income and the investment ratio for the tested treatments were presented in Tables (7 and 8), where the test was executed according to the price of the yield maize grain in the first season and barley grain and straw in the second season, as well as the cost of different treatments were calculated considering conventional method of both fixed and variable costs (Table 7). Total cost per fed was calculated by multiplying the hourly cost by the actual time required by the machine to cover one feddan.

The results in Table (8) show that the highest net income value (16809.80 LE fed^{-1}) was incorporated by the addition of 5.0 ton compost fed^{-1} in 30 cm mole depth and 100 % of the recommended dose N fertilizer for each crop, which was the best treatment and should be recommended due to relative high net income comparing to the other treatments. This may be due to this treatment was recorded the highest values of yield in the first and second seasons, consequently high net income. On the other hand, the highest values of investment ratio (4.26) was recorded by the addition of 2.5 ton compost fed^{-1} in 30 cm mole depth and 100 % of the recommended dose N fertilizer for each crop.

Table 7. Input production items and output of the experiments through the two growing seasons under study (summer season 2017 and winter season 2017/2018).

Items	Treatment	Unit	Unit price (LE)
Input			
Mineral fertilizer			
Nitrogen fertilizer	0,50,75,100% from recommended dose	Kg N	5.67
Phosphorus fertilizer	Recommended dose	Kg P_2O_5	7.74
Potassium fertilizer		Kg K_2O	13.13
Compost		Ton	180
Land preparation			
Surface tillage 10 cm		per fed	150
30 cm mole depth		per fed	180
Seeds of maize	10 kg fed-1	Kg	17
Seeds of barley	50 kg fed-1	Kg	4.66
labor		per fed	550
pesticides		per fed	500
Other costs		per fed	200
Output			
Maize grain		Ton	2000
Barley grain		Ton	4000
Barley straw		Ton	1000

The results indicate that the increase depth of compost application obtained increasing in the mean value of net income and investment ratio. The highest mean value of net income and investment ratio were recorded at 30 cm mole depth (D2), where increased to 12739.30 LE fed^{-1} and 3.62 as compared with the surface depth (D1) which was 12020.83 LE fed^{-1} and 3.49, respectively.

Table 8. Economical assessment of the tested variables for the two growing seasons under study (summer season 2017 and winter season 2017/2018).

Application depth cm	Nitrogen fertilizer	Compost rates (ton fed^{-1})	Total yield, Ton fed^{-1} Maize grain	Barley grain	Barley straw	Yields income, LE fed^{-1} Maize grain	Barley grain	Barley straw	Total income of two seasons, LE fed^{-1}	Total cost of two seasons, LE fed^{-1}	Net income, LE fed^{-1}	Investment ratio
D1	N1	C1	1.6135	1.6689	1.5962	3227.00	6675.60	1596.20	11498.80	3599.65	7899.15	3.19
		C2	1.7635	1.8763	2.1347	3527.00	7505.20	2134.70	13166.90	4049.65	9117.25	3.25
		C3	1.7911	1.8797	2.1874	3582.20	7518.80	2187.40	13288.40	4499.65	8788.75	2.95
		C4	1.8072	1.8881	2.4190	3614.40	7552.40	2419.00	13585.80	4949.65	8636.15	2.74
	N2	C1	1.7430	1.7730	2.0006	3486.00	7092.00	2000.60	12578.60	4067.43	8511.17	3.09
		C2	2.2493	2.1501	2.8850	4498.60	8600.40	2885.00	15984.00	4517.43	11466.57	3.54
		C3	2.2658	2.1741	2.9388	4531.60	8696.40	2938.80	16166.80	4967.43	11199.37	3.25
		C4	2.2890	2.1873	2.9498	4578.00	8749.20	2949.80	16277.00	5417.43	10859.57	3.00
	N3	C1	2.1487	2.0547	2.7261	4297.40	8218.80	2726.10	15242.30	4301.31	10940.99	3.54
		C2	2.9610	2.4644	3.3101	5922.00	9857.60	3310.10	19089.70	4751.31	14338.39	4.02
		C3	3.0168	2.4773	3.3501	6033.60	9909.20	3350.10	19292.90	5201.31	14091.59	3.71
		C4	3.0411	2.5654	3.3758	6082.20	10261.60	3375.80	19719.60	5651.31	14068.29	3.49
	N4	C1	2.8520	2.3940	3.1750	5704.00	9576.00	3175.00	18455.00	4535.20	13919.80	4.07
		C2	3.2197	2.6630	4.0370	6439.40	10652.00	4037.00	21128.40	4985.20	16143.20	4.24
		C3	3.2232	2.7410	4.0488	6446.40	10964.00	4048.80	21459.20	5435.20	16024.00	3.95
		C4	3.3118	2.8777	4.0798	6623.60	11510.80	4079.80	22214.20	5885.20	16329.00	3.77
D2	N1	C1	1.7007	1.7340	1.9811	3401.40	6936.00	1981.10	12318.50	3629.65	8688.85	3.39
		C2	1.8527	1.9644	2.4462	3705.40	7857.60	2446.20	14009.20	4079.65	9929.55	3.43
		C3	1.8684	1.9822	2.4510	3736.80	7928.80	2451.00	14116.60	4529.65	9586.95	3.12
		C4	1.8904	1.9880	2.5147	3780.80	7952.00	2514.70	14247.50	4979.65	9267.85	2.86
	N2	C1	1.8354	1.9493	2.4376	3670.80	7797.20	2437.60	13905.60	4097.43	9808.17	3.39
		C2	2.3407	2.2060	3.0249	4681.40	8824.00	3024.90	16530.30	4547.43	11982.87	3.64
		C3	2.3622	2.2654	3.1030	4724.40	9061.60	3103.00	16889.00	4997.43	11891.57	3.38
		C4	2.3759	2.2997	3.1289	4751.80	9198.80	3128.90	17079.50	5447.43	11632.07	3.14
	N3	C1	2.1772	2.0874	2.7826	4354.40	8349.60	2782.60	15486.60	4331.31	11155.29	3.58
		C2	3.0604	2.5934	3.3958	6120.80	10373.60	3395.80	19890.20	4781.31	15108.89	4.16
		C3	3.0915	2.6064	3.4213	6183.00	10425.60	3421.30	20029.90	5231.31	14798.59	3.83
		C4	3.1789	2.8021	3.9469	6357.80	11208.40	3946.90	21513.10	5681.31	15831.79	3.79
	N4	C1	2.8777	2.4547	3.2087	5755.40	9818.80	3208.70	18782.90	4565.20	14217.70	4.11
		C2	3.2464	2.7010	4.0630	6492.80	10804.00	4063.00	21359.80	5015.20	16344.60	4.26
		C3	3.3325	2.8710	4.1260	6665.00	11484.00	4126.00	22275.00	5465.20	16809.80	4.08
		C4	3.3787	2.9327	4.2013	6757.40	11730.80	4201.30	22689.50	5915.20	16774.30	3.84
A Application depth cm	D1		2.4560	2.2397	2.9509	4912.09	8958.75	2950.89	16821.73	4800.90	12020.83	3.49
	D2		2.5356	2.3399	3.1396	5071.21	9359.43	3139.56	17570.20	4830.90	12739.30	3.62
B Nitrogen fertilizer	N1		1.7859	1.8727	2.2163	3571.88	7490.80	2216.29	13278.96	4289.65	8989.31	3.12
	N2		2.1827	2.1256	2.8086	4365.33	8502.45	2808.58	15676.35	4757.43	10918.92	3.30
	N3		2.8345	2.4564	3.2886	5668.90	9825.55	3288.59	18783.04	4991.31	13791.73	3.76
	N4		3.1803	2.7044	3.8675	6360.50	10817.55	3867.45	21045.50	5225.20	15820.30	4.04
C Compost rates (ton)	C1		2.1185	2.0145	2.4885	4237.05	8058.00	2488.49	14783.54	4140.90	10642.64	3.55
	C2		2.5867	2.3273	3.1621	5173.43	9309.30	3162.09	17644.81	4590.90	13053.92	3.82
	C3		2.6189	2.3746	3.2033	5237.88	9498.55	3203.30	17939.73	5040.90	12898.83	3.53
	C4		2.6591	2.4426	3.3270	5318.25	9770.50	3327.03	18415.78	5490.90	12924.88	3.33

The price of yield and the costs of different treatments were calculated as subsidized price of 2017 and 2018.

The results reveal that nitrogen fertilization rates increased the mean value of net income and investment ratio, where the application of 100 % of the recommended dose N fertilizer led to the highest values as compared with the other rates of N fertilizer.

It can be noticed that (Table, 8), the net income values were increased by increasing the addition rates of compost. The mean values of net income were differed between 10642.64 (C1) and 12924.88 (C4) LE fed^{-1}.

Thus it can be concluded that it is better from the economical point of view to add 5.0 ton fed^{-1} of compost in 30 cm mole depth. Also, it can be noticed that the net income values were increased by using all different treatments comparing with the treatment of surface depth without any addition. These results are in line with those reported by Amer (2016)

Thus, it is more useful to use compost filled moles at 30 cm depth with the different rates of compost and N fertilizer at the rate of 100 % of recommended dose for each crop to markedly improve both physical and hydro-physical properties and the net income under clay loam soils.

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تحسين بعض الخصائص الطبيعية والهيدروفيزيائية للتربة الطميية الطينية بإضافة معدلات من الكمبوست علي أعماق مختلفة مع معدلات من التسميد النتروجيني

منصور الدسوقي السوداني، الحسيني إبراهيم المداح و يسري احمد محمود عبد الله
معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية – الجيزة – مصر.

أجريت تجارب حقلية علي أرض طميية طينية خلال موسمين متعاقبين، الموسم الصيفي 2017 باستخدام محصول الذرة الشامية والموسم الشتوي 2018/2017 باستخدام محصول الشعير في محطة البحوث الزراعية بالجميزة، محافظة الغربية لتقييم تأثير إضافة معدلات من الكمبوست علي سطح التربة، وفي أنفاق متوازية علي عمق 30 سم والمسافة بين هذه الأنفاق 3 متر مع معدلات من الأسمدة النتروجينية علي تحسين بعض الخواص الطبيعية والهيدروفيزيائية للتربة مع دراسة الأثر المتبقي لهذه المعاملات علي نفس الخصائص السابقة، بالإضافة إلي إجراء الدراسة الاقتصادية بهدف تحديد أفضل معاملة لتحقيق اعلي صافي دخل مزرعي .وكانت معدلات إضافة الكمبوست هي صفر ، 2,5 ، 5,0 ، 7,5 طن/ف ، ومعدلات إضافة النتروجين هي صفر ، 50 ، 75 ، 100 % من الكمية الموصي بها لكل محصول. وكان تصميم التجربة قطاعات كاملة العشوائية منشقة مرتين في ثلاث مكررات. ويمكن تلخيص النتائج المتحصل عليها كالتالي:- 1- انخفضت مقاومة الأرض للاختراق معنويا بزيادة معدلات الكمبوست والعمق. 2- انخفضت الكثافة الظاهرية معنويا تحت مختلف معدلات الكمبوست والأعماق المعاملات بينما المسامية الكلية ونسبة المسام فقد أخذت الاتجاه المضاد. 3- انخفضت نسبة التحبب في التربة معنويا بزيادة معدلات الكمبوست والأعماق مما يدل علي وجود درجة عالية من ثبات البناء. 4- قيم التوزيع ألحجمي للمسام (المسام الكبيرة والمتوسطة والصغيرة كنسبة مئوية من المسامية الكلية) زادت معنويا في موسمي النمو. 5- التوصيل الهيدروليكي للتربة والمحتوي الرطوبي للتربة (سواء قيم الثوابت الرطوبية أو المحتوي الرطوبي قبل الحصاد) زادت معنويا بزيادة معدلات الكمبوست في موسمي النمو. 6- انخفض الاستهلاك المائي وزادت كفاءة استخدام المياه في كل المعاملات في موسمي النمو. 7- يؤكد التحليل الاقتصادي أن إضافة 5,0 طن/ ف كمبوست في أنفاق علي عمق 30 سم مع 100 % من الموصي بة تسميد نتروجيني أعطت اكبر عائد اقتصادي. 8- من النتائج السابقة يتبين أنه من المفيد استعمال معدلات مختلفة من الكمبوست في أنفاق مع التسميد النتروجيني للحصول علي تحسن واضح في الخواص الطبيعية والهيدروفيزيائية في الأراضي الطميية الطينية.