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Implications of Organic Amendments and Tillage of A Sandy Soil on its Physical Properties and C-Sequestration as well as Its Productivity of Wheat and Maize Grown Thereon

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S OIL organic matter is an essential component of fertility of soils, especially the sandy ones. It also accounts for increasing the emission of the greenhouse gases (GHG). Efficient managements of applied organic amendments to soil are required to reduce GHG emission. The current research aimed at investigating the effects of farm yard manure and compost applied at two different rates, *i.e.,* 24 and 48 Mg ha^{-1} using shallow (0-10 cm) or deep (0-20 cm) tillage operations on improving the physical properties of the studied soil, carbon sequestration in soil and its relation to the wheat and maize yields. Increases in aggregate stability, available water content and the grain yields of wheat, as well as maize were obtained with the application of the organic amendments . Increasing the application rate resulted in more positive effects. The second degree equation seemed to be the best fitting model for predicting wheat and maize yields as affected by the rate of the applied organic C. Shallow tillage led to higher trapping of soil CO_2 and more residual organic carbon in soil after harvest than the deep tillage did.

Keywords: Wheat, Maize, Farmyard manure, Compost, Soil tillage, CO_2 trapping, Soil physical properties.

Wheat is an strategic commodity in Egypt and is mainly consumed in the Egyptian diet as bread (Kheralla *et al.,* 2000). The Egyptian government is subsiding flour and bread (Gutner, 2002 and Ramadan & Thomas, 2011), in spite of the national production of wheat accounts only for 56% self-sufficiency (Shehata and Mohammad, 2010). The Egyptian government fills the gap between the consumption and production by importing wheat from other countries (Seleiman *et al.,* 2010). Maize is another important crop for human food as well as animal feed (Shiferaw *et al.,* 2011 and Wu and Guclu, 2013). It is used in the production of bread in Egypt by mixing its flour with wheat flour (Ghoneim, 2012). Maize consumption in Egypt was estimated at 9.0 million mega grams during 2012/13 and the imports of maize were estimated at 5.0

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million mega grams during 2011/12 (USDA, 2012). Accordingly, raising the production of wheat and maize became a national target in Egypt especially in the new reclaimed soils (mostly sandy desert soil) to meet the overgrowing demands on one hand and to decrease imports of these crops on the other hand.

Soil organic matter is essential for improving soil fertility under sustainable agricultural systems (Johnston *et al.,* 2009), especially in sandy soils which suffer mainly from low fertility and poor plant productivity (Jaiarree *et al.,* 2011). Increasing N or P content in soil could accelerate the decomposition of the organic matter in soil and thus increase crop production (Cleveland and Townsend, 2006). Organic amendments decrease soil bulk density and increase available water content in soil (Ozores-Hampton *et al.,* 2011). On the other hand, application of organic residues might also account for increasing the emissions of the greenhouse gases (GHG). Thus, efficient managements of organic applications to soil is necessary to decrease such emissions (Burney *et al.,* 2010).

The recent increases in global temperature indicates a future new phase of climate in which the enhanced greenhouse effect has the most influence on the atmosphere (Woodwell *et al.,* 1998). Although, some gases, principally methane, nitrous oxide and chlorofluorocarbons are more important per molecule on climate than carbon dioxide emission, yet carbon dioxide emissions still account for 80% of the current greenhouse gas emissions (Lashof and Ahuja, 1990). Soil carbon sequestration is the process of increasing in the soil content of organic carbon due to the change in soil management (Powlson *et al.,* 2011) and, to some extent, is affected by soil water conservation and soil fertility regulations (Lal, 2004 and Lal & Kimble, 1997). The rate of soil C sequestration varies between 100 to 1000 kg ha^{-1} yr^{-1} depending on land use, soil properties, landscape position, climate, and cropping/farming systems (Lal, 2009).

The current research aims at investigating the effects of amending sandy soil with two sources of organic amendments, *i.e.,* farm yard manure and compost at two different rates, *i.e.,* 24 and 48 Mg ha^{-1} on soil physical properties and grain yield of wheat and maize. This study also considers the effects of the depth of tillage (shallow vs. deep tillage) on carbon sequestration in soil, and its relation with wheat and maize yields.

Material and Methods

Material of study

A representative surface soil sample (0-30 cm) of the area of study was collected prior to the winter and summer seasons, air dried and sieved to pass through a 2-mm sieve then analyzed for physical and chemical properties according to the standard methods outlined by Klute (1986) and Page *et al.* (1982). Physical and chemical properties of the studied soil are presented in Table 1.

TABLE 1. Physical and chemical properties of the studied soil .

Coarse sand, %	Fine sand, %	Silt, %	Clay, %	Texture	Bulk Density Mg m^{-3}	CaCO$_3$ g kg^{-1}	Organic matter g kg^{-1}	Moisture at 10 kPa, %	Moisture at 1.5 MPa %	pH*	EC*, dS m^{-1}
42.26	43.28	13.28	1.18	Sand	1.67	6.15	3.25	14.99	5.56	8.25	3.65

*pH in 1:2.5 soil water suspension; EC: in soil paste extract.

Two organic amendments, the first one was farmyard manure obtained from Balouza Experimental Station of Desert Research Center (DRC), while the other one was compost supplied by Maryut Experimental Station of the DRS. Physical and chemical characteristics of the organic amendments used in the study are shown in Table 2. Seeds of wheat (*Triticum aesitivum* L. c.v Giza 93) and maize (*Zea mays* c.v. Giza 310) one way cross hybrid were supplied by the Crops Research Institute, Giza.

TABLE 2. Physico-chemical properties of the different amendments used in study.

	pH *	EC* dS m^{-1}	Bulk density Mg m^{-3}	Organic C g kg^{-1}	Total N g kg^{-1}	Total P g kg^{-1}	Total K g kg^{-1}
Farmyard manure	6.90	2.10	0.57	280	17.0	14.0	19.0
compost	6.95	2.18	0.65	230	13.6	14.3	12.3

*pH and EC: 1:5 w/w water extract.

The field experiment

A field experiment was conducted at El-Fardows valley, Southern East of El Qantra – North Sinai, for two successive seasons, *i.e.,* winter season of 2009/2010 where the soil was under wheat and summer season of 2010 where the soil was under maize. The experimental design was a split plot design with three replicates, a plot area of 12 m^2. Main plots were assigned to the depth of tillage by which the organic amendment was applied, *i.e.*, surface tillage from 0-10 and deep tillage from 10-20 cm and the sub-plots were assigned to the organic amendments, *i.e.,* farmyard manure (FYM) and compost (CMPT), each applied at two rates, *i.e.,* 24 and 48 Mg ha^{-1}. A non amended treatment was also carried out. The applied organic amendments were thoroughly mixed throughout with soil before plowing.

1. The wheat experiment

Wheat seeds were sown on the 22nd of November 2009 at the rate of 145 kg ha^{-1}. Ammonium nitrate fertilizer (335 g N kg^{-1}) was added to all the experimental plots at a rate of 240 kg N ha^{-1} at three equal doses, *i.e.,* during planting, 30 days

after planting and 60 days after planting. Superphosphate fertilizer (68.9 g P kg^{-1}) was applied at a rate of 49 kg P ha^{-1} during soil preparation. Potassium sulphate fertilizer (400 g K kg^{-1}) was applied at a rate of 50 kg K ha^{-1} at 30 days after planting. Plants were irrigated every 6 days interval using sprinkler irrigation system and all the cultivation practices were followed as recommended by the Ministry of Agriculture and Land Reclamation. Wheat was then harvested from all plots on the 22nd of April and the grain yields were recorded.

2. *The maize experiment*

Maize seeds were sown was on 5th of May 2010 at a rate of 48 kg ha^{-1}. Ammonium nitrate fertilizer (335 g N kg^{-1}) was applied to all experimental plots at three equal doses, *i.e.,* during planting, 30 days after planting and 60 days after planting at a rate of 360 kg N ha^{-1}. Super phosphate fertilizer (68.9 g P kg^{-1}) was applied at a rate of 50 kg P ha^{-1} during soil preparation. Potassium sulphate (400 g K kg^{-1}) was added at a rate of 33 kg K ha^{-1} at 30 days after planting. Plants were irrigated every 3 days interval using sprinkler irrigation system and all the cultivation practices were followed as recommended by the Ministry of Agriculture and Land Reclamation. Maize was harvested on the 26th of August and the grain yields were recorded.

Soil analysis

Surface soil samples were collected from the rhizosphere of the grown plants in each experimental plot immediately after harvest, placed in plastic bags which were tightly closed to minimize the loss of soil CO_2. Soil moisture tension was determined at 10 kPa and 1.5 MPa using the pressure membrane method as outlined by Stakman and van de Harst (1962). Available water content was calculated as the difference between soil moisture determined at 1.5MPa (considered as welting point) subtracted from the moisture content in soil measured at 10 kPa (considered as field capacity for sandy soils). The organic matter content was determined in soil samples after cropping according to the modified Walkley and Black method (Page *et al.,* 1982). The mean weight diameter (MWD) of the soil aggregates was determined according to Fonte *et al.* (2010). Measuring CO_2 trapping in soil was taken as an indication of the metabolic activities of the soil microorganisms according to Pramer and Schmidt (1964) modified by Shehata (1972). Twenty five gram soil portions were placed in cylindrical polyethylene bags and brought to 60% of water holding capacity. The bag was hooked to a wire in the lower surface of a rubber plug fitted closely into neck of one liter Pyrex glass flask containing 30 mL of NaOH 0.05 *N* for trapping CO_2. All flasks were incubated at 28±2 °C for 24hr. Afterwards, 2-3 drops of phenolphthalein were added to the entrapped CO_2 solution in the flask followed by titration against HCl 0.05 *N*. Calculations of CO_2 were carried out according to the following equation:

$$\mu g\, CO_2\,/g.\, dry\, soil/h = (B-T) \times \frac{N_{HCl} \times Eq.Wt._{CO_2} \times 1000}{sample\, weight \times incubation\, period}$$

Where: B= volume of HCl used in blank titration; T=volume of HCl used in the sample titration; N = normality of HCl; Eq.Wt.$_{CO_2}$= molecular weight of CO_2; sample weight =weight of the used soil sample, 25g; incubation period = the incubation period in hours, 24hr.

Data analysis

The relations between soil C and either of the wheat or maize yields were plotted graphically for each depth of soil application. The soil C was calculated during the winter season through the summation of initial C in soil plus the C of the applied organic amendments; whereas, soil C was calculated during the summer season through the summation of the residual C in soil after wheat cropping plus organic carbon of the organic amendment at its applied rate. The obtained relations were fitted to four mathematical models. The equations used in this study according to number Wallace (2010) were (1) the linear first degree equation $y = a + bx$ where a and b are constants (2) the quadratic second degree equation $y = a + bx + cx^2$ where the coefficients a, b and c are real numbers ≠ zero (3) the exponential equation $y = e^{ax}$ where the coefficient e is the approximately 2.72 and "a" is a constant (4) fractional power $y = x^a$ where "a" is a negative. The standard error of estimate (S.E.) for the mathematical models were calculated according to Shariatmadari *et al.* (2006) and Abbas and Salem (2011) as follows:

$$SE = [\sum (Q_t - Q_t^{'})^2 /(n-2)]^{1/2}$$

Q_t and $Q_t^{'}$ are the obtained and predicted grain yields of wheat and maize, respectively, and n is the number of measurements.

Results

Effect of type and rate of the applied amendments and the tillage depth on the yield of wheat grain and straw

Data presented in Table 3 reveal that the grain yields of wheat and maize increased significantly with the application of either of the farmyard manure (FYM) or the compost (CMPT) amendment. In this concern, FYM applications recorded significantly higher increases in the grain yields than those attained owing to application of CMPT. The average increases in the grain yield due to FYM and CMPT at a rate of 24 Mg ha^{-1} were 54 and 45%, respectively for wheat and 31 and 26%, respectively for maize. In spite of doubling the rate of the applied FYM and CMPT from 24 to 48 Mg ha^{-1} , the obtained increases did not exceed 17 and 21%, respectively for wheat grain yield and 15 to 12 %, respectively for maize grain yield. Considering effect of tillage depth, shallow tillage caused more significant increases in grain yields of wheat and maize than deep tillage (about 6% increase in the grain yield of wheat and maize).

TABLE 3. Yields of wheat and maize grain (Mg ha⁻¹) as affected by type and rate of the applied organic amendment and depth of tillage .

Amendment (A)	Rate of application (R), Mg ha⁻¹	Depth of tillage (T)					
		Winter Season (Wheat)			Summer season (Maize)		
		Shallow	Deep	Mean	Shallow	Deep	Mean
Farmyard manure	24	6.79	6.36	6.58	7.24	6.88	7.06
	48	7.81	7.62	7.72	8.17	7.88	8.03
	mean	7.30	6.99	7.15	7.71	7.38	7.55
Compost	24	6.36	6.02	6.19	6.95	6.69	6.82
	48	7.64	7.38	7.51	7.74	7.50	7.62
	Mean	7.00	6.70	6.85	7.35	7.10	7.23
Non-amended		4.49	4.14	5.32	5.55	5.24	5.40
Grand mean		6.60	6.30	6.45	7.13	6.84	6.99
Means of the rate of application							
Rate of application		Winter season		Summer season			
Non-amended		4.32		5.40			
	24	6.38		6.94			
	48	7.61		7.83			

LSD (0.05)	T	A	R	T×A	T× R	A×R	T×A×R
Winter	0.010	0.006	0.009	0.015	0.009	0.012	0.017
Summer	0.007	0.007	0.006	0.009	0.007	0.009	0.013

Effect of type and rate of the applied amendments and the tillage depth on the available water in soil

Table 4 shows that application of the soil amendments at the low rate increased significantly available water content of soil by an average of 19% during the winter and 17% during the summer seasons. The higher rate of application of the organic amendments caused more increases in the available water content (averaging 35% in winter and 26% in summer). Concerning the effects of the tillage depth on soil available water, it was found that the shallow tillage caused significant increases in the available water content than did the deep tillage (averaging about 4% in both seasons).

Effect of type and rate of the applied amendments and the depth of tillage on mean weight diameter (MWD) of soil aggregates

Data shown in Table 5 reveal that values of the mean weight diameter (MWD) of soil aggregates increased significantly with the application of FYM as well as compost. The average increases in MWD due to application of FYM and CMPT at a rate of 24 Mg ha⁻¹ were about 1.24 fold during the winter season and 1.25 fold during the summer one. Increasing the rate of application from 24 to 48 Mg ha⁻¹ caused significant increases in MWD; however such increases were very low (2-7% increase in MWD). On the other hand, the shallow tillage caused significant higher increases in values of MWD than the deep tillage did (about 10% increase in MWD during both the winter and the summer seasons).

TABLE 4 . Soil available water content as affected by the type and rate of the applied organic amendment and the depth of tillage.

Amendment (A)	Rate of application (R), Mg ha⁻¹	Depth of tillage (T)					
		Winter Season (Wheat)			Summer season (Maize)		
		Shallow	Deep	Mean	Shallow	Deep	Mean
Farmyard manure	24	14.56	14.07	14.32	16.04	15.55	15.80
	48	16.62	15.81	16.22	17.46	16.68	17.07
	Mean	15.59	14.94	15.27	16.75	16.12	16.44
Compost	24	14.41	13.79	14.10	15.78	15.18	15.48
	48	16.28	15.55	15.92	17.14	16.41	16.78
	Mean	15.35	14.67	15.01	16.46	15.80	16.13
Non-amended		12.00	11.81	11.91	13.32	13.43	13.43
Grand mean		14.77	14.21	14.49	15.99	15.43	15.71

Means of the rate of application				
Rate of application		Winter season	Summer season	
Non-amended		11.91	13.38	
24		14.21	15.64	
48		16.07	16.92	

LSD (0.05)	T	A	R	T×A	T× R	A×R	T×A×R
Winter	0.0004	0.010	0.008	0.015	0.009	0.012	0.017
Summer	0.008	0.005	0.007	0.007	0.009	0.011	0.015

TABLE 5. Soil aggregate mean weight diameter as affected by type and rate of the applied organic amendment and the depth of tillage .

Amendment (A)	Rate of application (R), Mg ha⁻¹	Depth of tillage (T)					
		Winter Season (Wheat)			Summer season (Maize)		
		Shallow	Deep	Mean	Shallow	Deep	Mean
Farmyard manure	24	1.00	0.95	0.98	1.01	0.99	1.00
	48	1.10	0.99	1.05	1.05	1.01	1.03
	Mean	1.05	0.97	1.01	1.03	1.00	1.02
Compost	24	0.98	0.93	0.96	1.02	0.98	0.98
	48	1.06	0.96	1.01	1.04	1.01	1.01
	Mean	1.02	0.95	0.99	1.03	1.00	1.00
Non-amended		0.82	0.74	0.78	0.84	0.76	0.76
Grand mean		0.99	0.91	0.95	0.99	0.95	0.95

Means of the rate of application				
Rate of application		Winter season	Summer season	
Non-amended		0.78	0.81	
24		0.97	1.00	
48		1.03	1.03	

LSD (0.05)	T	A	R	T×A	T× R	A×R	T×A×R
Winter	0.032	0.021	0.028	0.030	0.032	0.040	0.056
Summer	0.0005	0.001	0.0007	0.001	0.001	0.001	0.001

Effect of type and rate of the applied amendments and the depth of tillage on the residual organic carbon in soil after cropping

Data presented in Table 6 show that application of either of FYM or CMPT markedly increased the organic carbon content (OC) in soil at the end of each growing season by 70 and 54 %, respectively during the winter season corresponding to 70 and 61%, respectively during the summer season. Increasing the rate of application of either FYM or compost from 24 to 48 Mg ha^{-1} showed further significant increases in the OC; however such increases were only 15% during winter and 12 % during summer. On the other hand, significant increases were found in OC due to shallow tillage vs. deep tillage (about 13% during winter and 8% during summer).

TABLE 6. Organic carbon in soil (g kg^{-1}) at end of the growing seasons as affected by type and rate of the applied organic amendment and the depth of tillage.

Amendment (A)	Rate of application (R), Mg ha^{-1}	Depth of tillage (T)					
		Winter Season (Wheat)			Summer season (Maize)		
		Shallow	Deep	Mean	Shallow	Deep	Mean
Farmyard manure	24	6.05	5.35	5.70	4.55	3.50	4.03
	48	6.90	6.20	6.55	7.15	6.55	6.85
	Mean	6.48	5.78	6.13	5.85	5.03	5.44
Compost	24	5.45	4.85	5.15	7.90	7.40	7.65
	48	6.30	5.65	5.98	6.55	6.45	6.50
	Mean	5.88	5.25	5.57	7.23	6.93	7.08
Non-amended		3.80	2.90	3.35	4.55	3.50	4.02
Grand mean		5.70	4.99	5.25	6.14	5.48	5.81

Means of the rate of application

Rate of application		Winter season	Summer season
	Non-amended	3.35	4.03
	24	5.43	5.84
	48	6.26	6.68

LSD $_{(0.05)}$	T	A	R	T×A	T× R	A×R	T×A×R
Winter	0.010	0.005	0.009	0.007	0.010	0.013	0.019
Summer	0.018	0.005	0.006	0.008	0.007	0.009	0.013

Effect of type and rate of the applied amendments and the depth of tillage on CO$_2$- trapped in soil

Table 7 reveals that trapped CO$_2$ in soil increased with the application of either of FYM or CMPT amendment. The average increases in trapped CO$_2$ due to the application of FYM and CMPT at rates of 24 Mg ha^{-1} were 292 and 264%, respectively during the winter season corresponding to 285 and 260%, respectively during the summer season. Such increases seemed to be associated

with the rate of the applied organic amendment with significant increases of about 20% for increasing the rate of application from 24 to 48 Mg ha^{-1}for both amendments. Trapped CO_2 increased in soil under all treatments with shallow tillage to higher values than those attained due to the deep tillage. Although the increases in CO_2-trapping per hour were around 10% for shallow tillage vs. deep tillage during the winter and summer seasons; yet, such increases seemed to be more pronounced in determining the yields of wheat or maize.

TABLE 7. Trapped soil CO_2 (µg CO_2/g.dry soil/h) as affected by type and rate of the applied organic amendment and the depth of tillage.

Amendment (A)	Rate of application (R), Mg ha^{-1}	Depth of tillage (T)					
		Winter Season (Wheat)			Summer season (Maize)		
		Shallow	Deep	Mean	Shallow	Deep	Mean
Farmyard manure	24	24.75	22.24	23.50	27.99	24.53	26.26
	48	29.67	27.35	28.51	31.65	28.89	30.27
	Mean	27.21	24.80	26.01	29.82	26.71	28.27
Compost	24	22.51	20.02	21.27	25.75	22.19	23.97
	48	27.38	25.06	26.22	29.38	26.75	28.07
	Mean	24.95	22.54	23.75	27.57	24.47	26.02
Non-amended		8.75	7.35	8.05	9.90	8.55	9.23
Grand mean		22.61	20.40	21.51	24.93	22.18	23.56
Means of the rate of application							
Rate of application		Winter season			Summer season		
Non-amended		8.05			9.23		
24		22.38			24.63		
48		27.37			28.94		

LSD $_{(0.05)}$	T	A	R	T×A	T× R	A×R	T×A×R
Winter	0.018	0.004	0.006	0.006	0.007	0.009	0.012
Summer	0.116	0.070	0.063	0.008	0.010	0.013	0.018

The relation between wheat and maize grain yields as affected by C content in soil and the depth of tillage

The relations between the obtained yields of either wheat or maize and the rate of soil C were plotted graphically for each type of soil tillage, *i.e.,* shallow vs. deep tillage (Fig. 1).

Four mathematical models were fitted to these relations to find out the best fitting model to explain such relations and the calculated correlation coefficients r^2 and standard error of estimates (S.E.) of these fitting models are shown in Table 8. Based on the highest r^2 values and the lowest values of standard error of estimates (S.E.), the second degree function seemed to be the best fitting model for describing the relation between the obtained wheat grain yield in relation with the rate of soil C under the shallow and deep tillage.
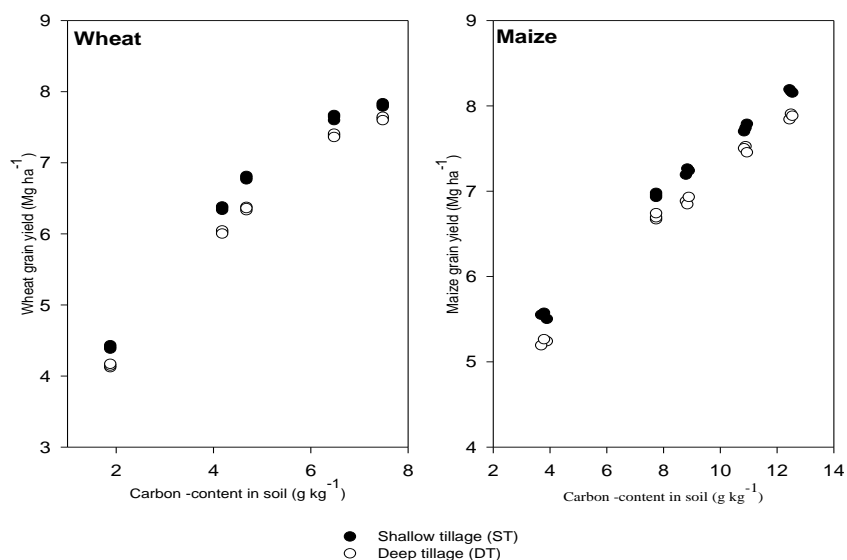
Fig. 1. Wheat (A) and maize (B) grain yields as affected by type and rate of the applied organic amendment and the depth of tillage .

TABLE 8. Correlation coefficients of the wheat and maize grain yields as affected by type and rate of the applied organic amendment and the depth of tillage.

	Wheat				Maize			
	Deep tillage		Shallow tillage		Deep tillage		Shallow tillage	
	r^2	S.E.	r^2	S.E.	r^2	S.E.	r^2	S.E.
First degree	0.970	0.232	0.946	0.305	0.987	0.110	0.989	0.101
Second degree	0.999	0.049	0.999	0.051	0.996	0.061	0.998	0.048
The exponential	0.000	2.100	0.000	2.338	0.000	2.278	0.000	2.456
The fractional power	0.995	0.095	0.986	0.155	0.997	0.058	0.997	0.049

The calculated quadratic second order relations were:

$$y = 2.084 + 1.202x - 0.06x^2 \qquad \text{Eq. 1 (Deep tillage)}$$

$$y = 2.093 + 1.373x - 0.09x^2 \qquad \text{Eq. 2 (Shallow tillage)}$$

By differentiating equations 1 and 2, we can obtain the following equations

$$\frac{dy}{dx} = 1.202 - 0.12x \qquad \text{Eq. 3 (Deep tillage)}$$

$$\frac{dy}{dx} = 1.373 - 0.18x \qquad \text{Eq. 4 (Shallow tillage)}$$

Thus, the ultimate outcomes of the organic amendments (in the term of organic C) on the wheat grain yield can be obtained when value of the calculated

$\dfrac{dy}{dx}$ exceeds one, afterwards the yield decreases. The calculated x values for these turning points were 10.02 and 7.63 g C kg^{-1} under deep and shallow tillage, respectively. After considering the initial content of soil C (1.89 g kg^{-1}), the required amounts become 8.14 and 5.785 g kg^{-1} for deep and shallow tillage, respectively. These amounts could be considered on basis of the organic amendments rather than organic C as 84 and 69 kg ha^{-1} of CMPT and FYM, respectively required under deep tillage; whereas, only 60 and 49 kg ha^{-1} of the respective amendments are required under shallow tillage. In case of maize, both the second degree equations seemed to be the most fitting models for describing the obtained grain yields of maize as affected by the C content of soil. Probably, the fraction power could be the most appropriate model for describing maize grain under continuous organic farming. Anyhow, the maximum amounts of the organic amendments required for obtaining the highest possible grain yield seemed to be far higher than the normal application rates, accordingly, the calculations of these amounts were neglected in the current research.

Discussion

Application of the organic amendments, *i.e.,* FYM and CMPT improved significantly the investigated soil physical properties, especially at the higher application rate of these organic amendments. Organic amendments increased the mean weight diameter (MWD) of the soil aggregates and also available water content. "MWD" is considered a reliable indicator for the stability of aggregates in soil, *i.e.,* high MWD value indicates high aggregate stability. The diffusion of the organic substances within the soil aggregates would increase the inter-particular cohesion force besides the large labile organic pool of these amendments would stimulate the microbial activity in soil which leads to increased water repellency (Annabi *et al.,* 2007). Marked effect of applied organic amendments on increasing available water content in soil was reported by Mylavarapu and Zinati (2009) and Weber *et al.* (2007), especially in sandy soil which suffers from low water retention (Andry *et al.,* 2009). The increases in yields of wheat and maize noticed in the current study owing to the application of the organic amendments agree with findings reported by Cherif *et al.* (2009), Alemazadeh and Kazemeini (2010) and Blaser *et al.* (2012). Rasool *et al.* (2008), Anyanzwa *et al.* (2010) and Chivenge *et al.* (2011) reported significant increases in maize productivity due to application of the organic amendments. Treatments receiving the organic amendments, especially at the higher application rates showed significant higher organic carbon after cropping. This finding agrees with that of Majumder *et al.* (2008) and Zhao *et al.* (2009) who reported significant increases in organic carbon upon FYM applications and Steiner *et al.* (2007) who found increases in organic carbon with compost application. Another component of the soil C in soil is the CO_2. This fraction results from the respiration of plant roots and soil microorganisms (Ivo and Salcedo, 2012) and its emission is considered the main route of C loss from soil to the atmosphere (Parkin and Kaspar, 2003). Thus, determining the CO_2 trapped in

soil might give estimates of the impacts of the different soil management practices on soil organic C (Fortin *et al.,* 1996).

Application of large amounts of organic matter to soil requires better management to attain the premier effects of these amendments on the physical properties of the sandy soils to achieve highest possible grain yield and, avoid more emissions of the green house gases. In this concern, sequestration of carbon in soil might be affected by soil surface managements (Lal, 2004 and Lal & Kimble, 1997). Increases in the sequestered CO_2 were noticed due to the change from conventional tillage to no-tillage (Ghimire *et al*., 2011, McCarl and Schneider, 2001 and West & Post, 2002). The two soil tillage methods, *i.e.,* shallow and deep tillage would reflect the effects on C-sequestration in soil. The shallow tillage increased the mean weight diameter of soil aggregates, available water content in soil and CO_2 trapped in soil. Also, higher grain yields of wheat and maize together with increasing the content of reserved organic carbon in soil after cropping were obtained in this study with shallow tillage rather than deep tillage. Kihara *et al.* (2011) reported also significant higher increases in the mean weight diameter of the aggregates and maize productivity with shallow tillage rather than deep tillage. However, Blaser *et al.* (2012) found no significant effect for the intensive tillage, moderate tillage or no tillage on the wheat yield. Concerning the residual organic carbon after cropping. Sainju *et al.* (2011) found that it increased in soil under reduced tillage. Also, Sommer *et al.* (2011) reported that the application of organic amendments can build-up soil organic matter under shallow tillage rather than the conventional moldboard plowing. Potentiality of C sequestration in soil depends on its affinity to store and accumulate humic substances in soil (Swift, 2001). Probably, the deep tillage accelerated the losses of organic matter from soil than the shallow tillage (Melero *et al.,* 2012).

Conclusion

Amending soil with organic materials is of high importance for increasing aggregate stability in sandy soil and increasing available water content. Such amendments increased the grain yields of wheat and maize under the efficient irrigation system (sprinkler irrigation). Increasing the application rate of the organic amendments from 24 to 48 Mg ha^{-1} resulted in further improvements in the studied physical properties of the soil and recorded higher grains yields of wheat and maize. Efficient management and appropriate rates of amendment application would be of vital importance for maximizing the outcomes of these amendments and, at the same time, reducing the emissions of the green house gases. Accordingly, the relations between the obtained yields of either wheat or maize and the C-content in soil were plotted graphically for each application depth, *i.e.,* surface shallow vs. deep tillage and four mathematical models were fitted to these relations. The results showed that the second degree equation was the best fitting model for wheat cropping; whereas, two models, *i.e.,* second degree and the fractional power seemed to be the best fitting models for maize

cropping. In general, the applied amounts of the organic amendments were still lower than the calculated amounts of organic amendments required for maximum yield. On the other hand, the shallow tillage seemed to be more effective than deep tillage in increasing the benefits of soil carbon, at least under the used application rates of the soil amendments. The shallow tillage led to higher reservation of organic carbon in soil and trapped more soil CO_2 than did the deep tillage, consequently the obtained grain yields of wheat and maize caused by shallow tillage were higher than those attained with deep tillage.

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تداعيــات إضافــة المحسنات عضويــة و الحراثــة على الخواص الفيزيائية لتربة رملية و احتجاز الكربون بها و كذلك إنتاجيتها من القمح و الذرة النامية عليها

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تلعب المادة العضوية دورا هاما في تحسين خصوبة التربة ، خصوصا الرملية كما تسهم في زيادة معدلات انبعاث غازات الصوبة الزجاجية ، الأمر الذي يتطلب إدارة جيدة لمثل هذه المخلفات للحد من انبعاث مزيد من غازات الصوبة الزجاجية ومن هنا تأتي أهمية الدراسة الحالية والتي تهدف إلي التحقق من الآثار المترتبة على إضافة سماد المزرعة والكمبوست بمعدلين هما 24 و 48 ميجا جرام هكتار $^{-1}$ مع عمق الحراثة (حرث سطحية ، 0-10 سم مقابل الحرث العميق ، 0-20 سم) على خواص الأرض الطبيعة و احتجاز الكربون في التربة وعلاقة ذلك بمحصول كل من القمح والذرة ، وقد أوضحت النتائج أن إضافة محسنات التربة كان لها تأثيراً كبيراً في زيادة ثبات المجمعات الأرضية بالإضافة إلي رفع محتوى الماء الميسر في الأرض ، وانعكس ذلك علي زيادة إنتاجية محاصيل الحبوب من القمح و الذرة وظهرت تلك التأثيرات بصورة أوضح مع زيادة معدل الإضافة. ويبدو أن المعادلة من الدرجة الثانية كانت أفضل النماذج رياضية والتي يمكن استخدامها للتنبؤ بمحصولي القمح و الذرة كدالة لكميات الكربون العضوي المضاف إلي التربة أما بالنسبة للحراثة السطحية فقد أدت إلي احتجاز اكبر لـ CO_2 في التربة وزيادة في نسبة الكربون العضوي المتبقي بعد الزراعة مقارنة بالحرث العميقة.