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Chemical Properties of Compost in Relation to Calcareous Soil Properties and Its Productivity of Wheat

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TWO FIELD experiments were conducted during two successive growing winter seasonsin at a private farm at Abu El-Matamir (El-Beheira Governorate,Egypt). It was carried on wheat plant to study the effect of three types of composts prepared from three plant residues, *i.e.,* maize (CMR), tomato (CTR) and vine (CVR). This study also included the chemical properties of sandy calcareous soil, *i.e.,* pH, EC, OM, CEC, $CaCO_3$and available content of some macro- and micro-nutrients as well as its productivity of wheat yield and its components. These composts were analyzed for their chemical composition and content of available macro- and micronutrients. Each compost was added at rates of 0, 5, 10 and 20 ton fed^{-1}. The prepared composts had wide variations in their chemical composition. For example, CTR had a highest content of organic matter, total nitrogen and available macro- and micronutrients, while the lowest values were found in CMR. Soil pH, EC and $CaCO_3$ decreased as a result of compost applications, while soil CEC, OM and available macro- (N, P, K, S, Ca and Mg) and micronutrients (Fe, Mn, Zn and Cu) increased. The high relative changes of the determined soil chemical properties and its content of available nutrients were found in the soil treated with CTR followed by those resulted from CVR treatments. Increasing application rates of the used composts were associated with an increase of both straw and grain yields of wheat and their relative changes (%), where the highest yield was found with the treatment of CTR followed by that of CVR. Also, CTR gave the highest value of agronomical efficiency of wheat plants compared with the other two composts. Finally, the application of CTR (20 ton fed $^{-1}$) was superior in greatly improving soil chemical properties of the studied soil and reflected on wheat productivity and nutrients uptake.

Keyword: Calcareous soil, Nutrient availability, Plant residues, Compost, Wheat, Agronomic efficiency and Relative change.

Introduction

The cultivation of newly reclaimed sandy and calcareous soil has become an unavoidable necessity for increasing our agricultural production to meet the over-growing demand for food. Desert covers about 96% of the total area of Egypt; most of which are scattered in the eastern and western banks of the Nile Valley and Delta. Conversion of desert lands to agriculturally productive ones takes the first priority of the government vision. Occurrence of calcareous soils is wide in the desert areas of Egypt. Most of newly reclaimed calcareous soils are mainly located in the Western Desert. Calcareous soils are those with high content of $CaCO_3$, especially the active fraction with high specific surface area causing some physical problems that affect water use and crop production in these soils. One of the most important physical problems of calcareous soil is crust formation in newly cultivated areas. Surface crusting impedes young seedlings emergence even when other factors such as moisture availability, oxygen, soil temperature and planting depth are not limiting (Awadhwal & Thierstein ,1985 and Imas, 2000).

Many challenges are encountered during cultivation of calcareous soils, such as low water retention, high infiltration rate, poor structure, low

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clay and humus content, low CEC, nutrients loss via leaching or deep percolation. These are side problems caused by high $CaCO_3$ content such as, surface crusting, high pH and low nitrogen (N) use efficiency, low availability of macronutrients particularly phosphorous (P) and micronutrients, and imbalance between nutritional elements such as magnesium (Mg), potassium (K), and calcium (Ca) (El-Hady and Abo-Sedera, 2006). Under such severe conditions, it is difficult to attain desired yield levels. However, economic yields can be attained through adoption of proper soil management practices.

The application of organic wastes, rich organic matter, such as fresh and composted urban wastes, municipal landscape composted plant materials (Tejadaet al., 2006) to semi-arid soils has become a common environmental practice for supplying plant nutrients, reclaiming degraded soils, maintaining soil and organic matter soil restoration. Organic matter plays an important role in soil by improving soil aggregates formation and stability and enhancing soil physical and chemical properties (Ahmed, 2007). In varying extents, application of composts to soils have been reported to improve soil physical properties (Helmi, 2018), enhance soil nutrients availability, microbial population and its activity, reduce presence of soil nematodes and pathogens (El-Tahlawy, 2018), increase crop yields (Helmi, 2018) and sustain soil fertility and productivity(Zinatiet al., 2001).

Wheat plant (*Triticum aestivum* L.) is considered one of the most important cereal crops in the world. The mass production of wheat in Egypt (8 million ton) is about 50% lower than the consumption (14.5 million ton / year at 2010). Therefore, more than six million tons must be imported annually. One or more of various manners should be followed. The first is by increasing the cultivated area of wheat in both old and newly reclaimed soils. The second is by growing resistant cultivars (plant certified must-free seed) which is considered the most economical and effective way of controlling diseases. The third is by improving agriculture practices among which are the time, irrigation and amount of chemical fertilization (Elbaalawy, 2010).

Therefore, the aim of the present investigation was to study the effect of used different plant residues types (maize, tomato and vine) on the chemical composition of the produced compost. Also, the effect of produced compost from different plant residues at different rates (0, 5, 10 and 20 ton fed^{-1}) on the chemical properties of sandy calcareous soil, the content of available macro- and micronutrients and its productivity of wheat yield were studied.

Materials And Methods

Two field experiments were conducted during the two successive growing winter seasons, *i.e.,* 2016 / 2017 and 2017 / 2018 in a private Farm at Village 6, Abu El-Matamir, El-Beheira Governorate, (Latitude, 30.908411^{o} N and longitude, 30.148487º E) Egypt, on wheat plant (*Triticum aestivum* L.) variety Misr 1, to study the effect of three types of composts varies in their chemical composition on chemical properties of sandy calcareous soil (*i.e.,* pH, EC, OM, CEC, $CaCO_3$and available content of some macro- and micronutrients) and its productivity of wheat yield and its components as well as macro- and micronutrients (N, P, K, Mg, S, Fe, Mn, Zn and Cu) uptake.

Soil sampling

Representative surface soil samples (0 - 20 cm) were taken from the used soil before performance of the experiment. Soil samples were air - dried, ground, mixed well, sieved through a 2 mm sieve. The samples then were analyzed for determination of some physical and chemical properties, also, the content of some available macro- and micronutrients according to the methods described by Cottenie et al. (1982); Page et al. (1982) and Klute (1986). The obtained data were recorded in Table 1.

Organic Materials and Compost Preparation

In this study, three plants residues varied in their planting origins are used in compost preparation. These plant residues were maize "MR" (as field crop), tomato "TR" (as vegetable crop) and vine "VR" (as fruit crop).All plant residues were collected from the study region. Plant residues were separated in open air for dryness, then chopped into 2-4 cm segments using crushing machine. Farmyard manure (FYM) was collected from a private animal breeding farm which was used as a natural activator for composting process.

Each chopped plant residues were mixed with air-dried FYM at mixed ratio of 65:35 (plant residues: FYM) by weight. Three piles were made from mixtures of chopped plant residues and FYM. An activating mixture containing about 16.0 g $Ca(H_2PO_4)_2$, 50 g $CaCO_3$, 1.5 g urea and 500 ml of fresh fertile soil water suspension(1:5) was added for each 100 kg of the composted organic materials. Each pile was moistened up to about 50-60% of its water holding capacity and left for decomposition until mature compost obtained (about 60 days). (Aiad, 2010 and Abou Hussien et al., 2016).The piles were turned upside down every 15 days starting from top and sides into the corners to enhance the aerobic decomposition process. Additional water was supplied during the composting process to keep moisture content of each pile about 60% of water holding capacity.

Representative sample of each pile was taken at the end of composting period (60 days), air-dried, ground and analyzed for its chemical composition according to the methods described by Cottenie et al. (1982) and Page et al. (1982). The obtained data are recorded in Table 2.

TABLE 1. Some physical and chemical properties of the experimental soil

Soil properties and units			Values
Particle size distribution (%)		Sand	79.10
		Silt	9.80
		Clay	11.10
Texture grade			Sandy
pH (1:2.5 soil : water suspension)			8.92
EC(dS m^{-1}) 1 : 5, soil paste extract			1.50
Organic matter “OM” (%)			0.50
Calcium carbonate “$CaCO_3$” (%)			15.12
Cation exchange capacity “CEC” ($cmol_c$ kg^{-1})			11.11
Soluble ions ($meql^{-1}$)	Soluble cations	Ca^{2+}	4.80
		Mg^{2+}	1.35
		K^+	0.20
		Na^+	8.65
	Soluble anions	CO_3^{2-}	0.00
		HCO_3^-	2.30
		Cl^-	7.15
		SO_4^{2-}	5.55
Available macronutrients ($mgkg^{-1}$)		N	41.15
		P	3.91
		K	910.11
		S	7.10
		Ca	15.05
		Mg	8.14
Available micronutrients ($mgkg^{-1}$)		Fe	4.50
		Mn	6.61
		Zn	1.50
		Cu	0.70

TABLE 2, Some chemical properties of used composts

Properties and units		Values		
		CMR	CTR	CVR
pH (1:10 compost: water suspension)		7.15	6.85	6.96
EC (dSm^{-1})1:20,compost : water extract		2.20	2.42	2.34
Organic carbon (%)		25.28	26.28	25.37
Organic matter (%)		44.35	46.11	44.50
Total N (%)		1.55	1.78	1.68
C/N ratio		16.3	14.8	15.1
Available macronutrients	N	860	925	905
(mg kg^{-1})	P	695	778	755
	K	1980	2092	2060
	Ca	590	614	605
	Mg	530	567	542
	S	201	322	288
Available micronutrients	Fe	405	442	430
(mg kg^{-1})	Mn	450	547	505
	Zn	70	78	73
	Cu	28	36	31

CMR, CTR and CVR= compost from maize, tomato and vine residues, respectively.

Plan of work and experimental treatments

The experimental plots were 36 unit including 3 treatments of composts × 4 rates of each type × 3 replicates. The area of each plot was 21 m^2 (7 m length × 3 m width).The used three composts prepared from three plant residues, *i.e.,* maize (CMR), tomato (CTR) and vine (CVR),were analyzed for their chemical composition and content of available macro- and micronutrient. Each compost was added at rates of 0, 5, 10 and 20 ton fed^{-1}. The studied treatments were arranged in randomized complete block design with three replicates.

Before sowing, all compost treatments were carried out during the final soil preparation. At the same time, all experimental units were fertilized by ordinary super phosphate "15.5% P_2O_5" at rate of 150 kg fed.$^{-1}$ (0.75 kg plot^{-1}). Applications of compost and super phosphate were well mixed with the surface layers (0-20 cm) of the experimental units. Wheat grains (Misr 1, cv.) were sown at 10th and 15th November during the first and second season, respectively. Potassium fertilizer (K_2SO_4) "50 % K_2O" was applied at rate of 200 kg fed.$^{-1}$ (1 kg plot^{-1}) in two equal doses after 21 and 42 days of sowing. At the same time of N-fertilization, ammonium nitrate (NH_4NO_3)"33 %N" was added at rate of 150 kg fed^{-1} (0.75 kg plot^{-1}) intwo equal doses. All agricultural practices beginning from sowing to harvesting were performed as recommended by Egyptian Ministry of Agriculture and Land Reclamation. At maturity stage (last week of April of the two growing seasons), the plants of each experimental unit were harvested separately. The harvested plants of each unit were separated into straw and grains, weighed and recorded to obtain grain and straw yields as ton per feddan. Biological yield (ton /fed.), harvest index (%), relative change of wheat yield (grains and straw) and agronomical efficiency were calculated. Grain and straw samples were air-dried then, oven-dried at 70 °C for 48 hrs., weighed , ground and digested for chemical determination according to the method described by Chapman and Pratt (1961). Nitrogen, P , K, Mg and S contents in the digests were determined according to the methods described by Cottenie et al. (1982). Crude protein percentage was estimated in the different parts by multiplying N % values by 5.75 as described by A.O.A.C. (1990). The atomic absorption spectrophotometer was used to determine Fe, Zn, Mn and Cu concentrations in the prior parts according to the methods recommended by A. O. A. C. (1990).

The relative change (RC) of wheat yield (grains and straw) was calculated according to Khalil et al. (2015) as follows:

RC = {(dry matter yield of treated plants)-(dry matter yield of untreated plants) / (dry matter yield of untreated plants)} × 100.

The agronomical efficiency (AE) was calculated according to Sisworo et al. (1990) as follows:

AE = {(dry matter yield of treated plants)-(dry matter yield of untreated plants)}/added compost (ton fed.$^{-1}$).

The harvest index (%) of wheat yield was calculated according to Khalil et al. (2015) as follows:

Harvest index(%)={grains yield (ton fed.$^{-1}$) / biological yield (ton fed.$^{-1}$)} × 100

After plant harvesting, surface (0-20 cm) soil samples were taken separately from each experimental unit, air-dried, ground sieved through 2 mm sieve and analyzed for soil pH, EC (dSm^{-1}), CEC (cmol$_c$ kg^{-1}) and content of OM (%), $CaCO_3$ (%) and some available macro- and micronutrients according to the methods described by Cottenie et al. (1982).

The obtained data of both soil and plant were statistically analyzed according to Snedecor and Cochran (1980).The significant differences among means were tested using the least significant differences (L.S.D.) at 5 % level of significant error.

Results and Discussions

Compost properties

The presented data in Table 2 showed that, the chemical composition of the three composts used in this study. These data showed wide variations in the chemical composition of three composts. For example, pH value of CTR decreased by 0.30 and 0.19 units than CMR and CVR, respectively, but CTR have a high EC (dSm^{-1}) compared to CMR and CVR. Also, the high contents (%) of OC, OM and total N were found in CTR and the lowest values were found in CMR. So, the three composts may be arranged based on their C/N ration as follows: CMR (16.3:1) >CVR (15.1:1)> CTR (14.8:1). Sullivan and Miller (2001) found that, the final pH of the compost is highly dependent on feedstock, composting process and addition of any amendments or activators. In addition, Gohar (2011) and Abou Hussien et al. (2012) found similar variation within chemical properties, *i.e.,* pH, EC and content of OM and total N of the composts prepared from plant residues (rice, clover and potato). These variations were related to the chemical composition of the used organic resides and its decomposition rate.

Regarding the data of the composts content of available macro- and micronutrients as presented in Table 2, the highest values of available macro- and micronutrients content were found in the composts of CTR followed by those found in CVR. According to the contents of determined macro-nutrients in the produced three composts takes the order: K > N > P >Ca > Mg > S, but the order of the micro-nutrients was Mn> Fe > Zn >Cu. Alexander (2001) and Nada (2011) pointed out that compost products contain considerable amounts of plant nutrients. So, such these composts are considered as a good source for essential macro and micronutrients. As compost contains relatively stable organic matter sources, plant nutrients are released in a slow-rate. Application rate of compost is usually higher than inorganic fertilizer; thus it can have a significant effect on nutrient content and availability. He et al. (1995) revealed that phosphorus concentrations in composts generally ranged from 2.0 to 6.6 g kg^{-1} depending on used sources.

Effect of adding different sources and levels of compost

Chemical properties of investigation soil

Soil reaction (pH), EC and content of $CaCO_3$

Data in Table 3 showed the chemical properties of sandy calcareous soil as affected by application of the different types of composts, after harvesting wheat. Results showed that with increasing rate of added composts, soil pH, EC, and $CaCO_3$content were decreased. The found decrease of soil pH was attributed to H^+ ions released during composting process of the used composts (Stevenson, 1994) and also to produced organic and inorganic acidic compounds. El-Meselawe (2014) attributed the decline in soil pH in the soil treated by compost and farmyard manure to the increase in chemical and biological activities and resulted acidic compounds.

In addition, the decrease in soil pH varied according to the type, rate of used compost and its chemical composition. For example, soil pH decreased from 8.88 to 8.65, 8.48 and 8.55 with the application 20 ton fed^{-1} of CMR, CTR and CVR, respectively (Table 3). This means that CTR applications were associated with a high decline in soil pH compared with CMR and CVR. This order may be shown from negative RC (%) values of pH which become more negative at high rates of added composts. Also, these results may be attributed to the higher content of sulphur in CTR, which may have played a major role in soil pH decrease. In this respect, El-Meselawe (2014); Elgezery (2016) and Abou Hussien et al. (2017) obtained similar results.

With respect to soil EC, data in Table 3 clearly showed that, with all applications of the used three composts, soil EC decreased with increasing rate of added compost. There are wide variations among the effect of the composts in decline soil EC, where the highest declines resulted from CMR treatments followed by those resulted from CVR applications. These variations related with the chemical compositions of the added compost. So, all RC (%) values of EC were negative. The decline of soil EC as a result of composts applications may be attributed to the improvement of physical soil properties especially the increase in its hydraulic conductivity and total porosity (El-Gamal, 2015). Ashour (2003) revealed that the application of different organic manures (sheep manure, town refuse and camel manure) to calcareous soil resulted in decline of soil EC value. Also, Mohamed et al. (2007) observed that application of different organic manures decreased soil pH, EC, SAR and soluble Na^+, Cl^- and HCO_3^- while CEC and soluble Ca^{2+} and Mg^{2+} increased. They attributed the slight change in values of Ca^{2+} to increased solubility of $CaCO_3$ as a result of applied manures.Moreover, El-Shouny and Behiry (2011) reported that, at different application rates of soil amendments (compost and sulphur) to calcareous soil, decreased soil pH, SAR, EC, ESP and soluble Na^+, HCO_3^- and Cl^-, but increased soluble Ca^{2+}, Mg^{2+}, K^+ and SO_4^{2-}.

Regarding the sandy calcareous soil content of $CaCO_3$ as affected by application of different compost types, after harvesting wheat, data in Table 3 indicated that, increasing the rate of added composts resulted in a decrease in soil content of $CaCO_3$ which varied widely from compost to another depending on their chemical composition especially the content of OM and S (Table 2). The highest decline in soil $CaCO_3$ was found in the soil treated with CTR and the lowest one was associated with the treatment of CMR. Decline rate of soil $CaCO_3$ may be cleared from RC (%) values of soil content of $CaCO_3$ listed in Table 3. All RC values were negative and increased with the increase in the application rate of the composts. In this respect, Sweed (2012); El-Gamal (2015) and Abou Hussien et al. (2017) obtained similar results with calcareous soils of Egypt treated with different sources of organic amendments.

Soil organic matter (OM) and CEC

Data presented in Table 3 revealed that, sandy calcareous soil content of OM and its CEC values varied widely from added compost type to another and their application rates. All applications of the composts were associated with increases in soil OM and CEC. At the same application rates of the composts, the highest content of OM and CEC values were found in the soil treated with CTR, where the lowest values were associated with the treatments of CMR. This order may be obvious from the calculated RC (%) values for both soil OM and CEC, where all RC values were positive. According to found RC values for both OM and CEC, at different application rates of the used three composts, these composts take the order: CTR> CVR > CMR. This order is in harmony with these composts chemical composition especially the content of OM (Table 2). In this connections, El-Gamal (2015); Mahmoud (2017) and Abou Hussien et al. (2017) obtained similar results with many types of composts varied in their chemical properties under different soil conditions of Egypt.

Soil content of available macronutrients

Concerning the residual effect of different treatments on available macronutrients in soil after harvesting of wheat, data in Table 4 showed that the content of available N, P, K, Ca, Mg and S in relation to both type and application rates of the composts varied in their chemical composition. The soil content of the determined macronutrients was increased with increasing rate of added composts. This increase effect of composts applications on soil content of available N, P, K, S, Ca and Mg may be obvious from the calculated RC (%) for these nutrients, where these values were positive and increased with the increasing rate of added compost. Also, the found increases in the soil content of available macronutrients clearly related with the chemical composition of added compost and its effect on soil chemical properties and its content of available macronutrients. Also, RC (%) values of soil content of available macronutrients show the high increase of CTR applications followed by the additives of CVR on calcareous soil content of available macronutrients. Similar results were obtained by Gohar (2011), El-Meselawe (2014) and Elgezery (2016).

In addition, data in Table 4 showed that, with the treatments of composts, the rate of increase in the soil content of available macronutrients varied widely from nutrient to another as shown from calculated RC (%) values of these nutrients content. These changes are depending on added composts content of the determined macronutrients and also its effect on organic and inorganic soil compounds degradation and solubilization. Based on thecalculated RC (%) values of the determined macronutrients,the rate of increase caused by different composts application may take the order: N> P > K > S > Ca > Mg. In this respect, Abou Hussien et al. (2012), El-Gamal (2015), El-Meselawe (2015) and Elgezery (2016) obtained similar results. Similarly, Bullucket al. (2002) noted a two-fold increase in soil Ca content over two years following compost application of 9 and 20 Mg ha^{-1} to two typicHapludult loams.

Soil content of available micronutrients

Data in Table 5 depictsthe soil content of available micronutrients (Fe, Mn, Zn and Cu) and its relative changes (RC" (%) as affected by different compost types (CMR, CTR and CVR) and its application rate. These data showed that, increasing rates of composts resulted in an increase of sandy calcareous soil content of the determined available micronutrients. So, all RC (%) values of the content of available micronutrients in relation with composts at different rates were positive and become more positive at higher application rates. The found increases in the soil content of available micronutrientsfollowed by composts applications may be due to the chemical composition of the used composts especially its content of the tested micronutrients and also to solubilization effect of added compost on some organic and inorganic compounds. Sweed (2012) and Abou Hussien et al. (2017) found a decrease in $CaCO_3$ content in calcareous soil treated by organic acids and compost. In addition, the increase of the tested micronutrients varied from compost to another, where the highest content resulted from CTR and the lowest one was associated with the treatments of CMR.At the same application rate of the composts, Mn followed by Fe recorded the highest content, where the lowest was found with Cu. This order mainly related to the initial content of the tested available micronutrients. In this respect, partially similar results were obtained by El-Gamal (2015); Elgezery (2016) and Abou Hussien et al. (2017).

Yield and yield component of wheat

Straw and grain yields

The data in Table 6 revealed that the yields of straw and grains of wheat plants and its relative changes "RC" (%), biological yield and harvest index were affected by adding different sources and levels of compost, under calcareous soil conditions.

TABLE 3. Mean values (2016/2017 and 2017/2018) of some chemical properties and their relative changes "RC (%)" in the experimental soil as affected by the studiedtreatments, after wheat harvested

Compost treatments		pH		EC (dSm^{-1})		OM %		CEC ($cmol_c\ kg^{-1}$)		$CaCO_3$ %	
Type (A)	Rate (B) (ton $fed.^{-1}$)	value	RC (%)	value	RC (%)	value	RC (%)	value	RC (%)	value	RC (%)
Control	0	8.88	---	1.48	---	0.50	---	11.13	---	15.10	---
CMR	5	8.80	-0.90	1.39	-6.08	0.52	4.00	11.25	1.08	14.95	-0.99
	10	8.74	-1.58	1.20	-18.92	0.60	20.00	11.50	3.32	14.70	-2.65
	20	8.65	-2.59	1.16	-21.62	0.70	40.00	11.85	6.47	14.50	-3.97
	Mean	---	---	**1.25**	**-15.54**	**0.61**	**21.33**	**11.53**	**3.62**	**14.72**	**-2.54**
CTR	5	8.70	-2.03	1.44	-2.70	0.56	12.00	11.50	3.32	14.48	-4.11
	10	8.60	-3.15	1.33	-10.14	0.70	40.00	12.50	12.31	14.10	-6.62
	20	8.48	-4.50	1.22	-17.57	0.82	64.00	13.10	17.70	13.65	-9.60
	Mean	---	---	**1.33**	**-10.14**	**0.69**	**38.67**	**12.37**	**11.11**	**14.08**	**-6.78**
CVR	5	8.76	-1.35	1.41	-4.73	0.53	6.00	11.37	2.16	14.87	-1.52
	10	8.63	-2.82	1.25	-15.54	0.66	32.00	11.80	6.02	14.50	-3.97
	20	8.55	-3.72	1.20	-18.92	0.73	46.00	12.45	11.86	14.05	-6.95
	Mean	---	---	**1.29**	**-13.06**	**0.64**	**28.00**	**11.87**	**6.68**	**14.47**	**-4.15**
L.S.D. at 0.05	A	0.014		0.009		0.011		0.045		0.020	
	B	0.033		0.020		0.021		0.071		0.022	
	AB	0.057		0.035		0.036		0.122		0.038	

CMR, CTR and CVR= compost from maize, tomato and vine residues, respectively.

TABLE 4. Mean values (2016/2017 and 2017/2018) of some available macronutrients(mg kg^{-1}) and their relative changes (RC %)in the experimental soil as affected by the studiedtreatments, after wheat harvested

Compost treatments		N		P		K		S		Ca		Mg	
Type (A)	Rate (B) (Mg fed.$^{-1}$)	value	RC (%)	value	RC (%)	value	RC (%)	value	RC (%)	value	RC (%)	value	RC (%)
Control	0	40.25	----	3.85	----	905.00	----	6.98	----	15.01	----	8.10	----
CMR	5	43.12	7.13	3.89	1.04	920.00	1.66	7.05	1.00	15.10	0.60	8.15	0.62
	10	44.11	9.59	4.12	7.01	932.00	2.98	7.10	1.72	15.28	1.80	8.23	1.60
	20	56.15	39.50	4.25	10.39	951.00	5.08	7.28	4.30	15.50	3.26	8.38	3.46
	Mean	**47.79**	**18.74**	**4.09**	**6.15**	**934.33**	**3.24**	**7.14**	**2.34**	**15.29**	**1.89**	**8.25**	**1.89**
CTR	5	52.20	29.69	4.30	11.69	940.00	3.87	7.20	3.15	15.38	2.47	8.28	2.22
	10	59.42	47.63	4.50	16.88	956.00	5.64	7.37	5.59	15.63	4.13	8.45	4.32
	20	66.80	65.96	4.75	23.38	975.00	7.73	7.60	8.88	16.10	7.26	8.67	7.04
	Mean	**59.47**	**47.76**	**4.52**	**17.32**	**957.00**	**5.75**	**7.39**	**5.87**	**15.70**	**4.62**	**8.47**	**4.53**
CVR	5	47.10	17.02	4.15	7.79	935.00	3.31	7.10	1.72	15.22	1.40	8.20	1.23
	10	55.20	37.14	4.33	12.47	940.00	3.87	7.22	3.44	15.45	2.93	8.32	2.72
	20	60.60	50.56	4.50	16.88	968.00	6.96	7.45	6.73	15.80	5.26	8.50	4.94
	Mean	**54.30**	**34.91**	**4.33**	**12.38**	**947.67**	**4.71**	**7.26**	**3.96**	**15.49**	**3.20**	**8.34**	**2.96**
L.S.D. at 0.05	A	0.092		0.037		2.49		0.044		0.019		0.024	
	B	0.165		0.032		8.46		0.061		0.038		0.013	
	AB	0.286		0.055		14.65		0.105		0.066		0.023	

CMR, CTR and CVR= compost from maize, tomato and vine residues, respectively.

The improvement of properties of the studied soil as a result of using different sources and levels of compost induced an enhancements in the yield of wheat.All treatments caused an increase in yield (straw and grain), biological yield and harvest index of wheat compared to control treatments. All composts applications were associated by increase of straw and grains yields with wide variations in these increases. At the same rate of added composts, the highest yields of wheat (straw and grains), biological yield and harvest index were found with application of CTR followed by those produced from soil treated by CVR. Also, data showed that grain, straw, biological yields and harvest index were significantly increased due to application of composts as compared to control where the high rate was better.This trend may be shown from RC (%) values of both straw and grains for the data of each compost type. According to the increases of straw and grains yields and its relative changes, the composts take the order: CTR > CVR > CMR. This trends are in consistent with chemical composition and nutrients content of the composts and also with their improving effect on calcareous soil properties and its content of available macro- and micronutrients (El-Gamal, 2015 and Elgezery, 2016). Also, this might be attributed to high decomposition of the organic matter and its effect on soil biological conditions, nutrient mineralization and release of essential nutrients in available forms, root development and thus higher yields (Mirlohi et al., 2008 and Frøseth et al., 2014).

TABLE 5. Mean values (2016/2017 and 2017/2018) of some available micronutrients (mg kg^{-1}) and their relative changes(RC %) in the experimental soil as affected by the studiedtreatments, after wheat harvested

Compost treatments		Fe		Mn		Zn		Cu	
Type (A)	Rate (B) (Mg fed.$^{-1}$)	value	RC (%)	value	RC (%)	value	RC (%)	value	RC (%)
Control	0	4.42	----	6.30	----	1.30	----	0.68	----
CMR	5	4.53	2.49	6.65	5.56	1.54	18.46	0.70	2.94
	10	4.65	5.20	6.78	7.62	1.63	25.38	0.76	11.76
	20	4.78	8.14	6.90	9.52	1.72	32.31	0.85	25.00
	Mean	**4.65**	**5.28**	**6.78**	**7.57**	**1.63**	**25.38**	**0.77**	**13.24**
CTR	5	4.60	4.07	6.80	7.94	1.62	24.62	0.80	17.65
	10	4.81	8.82	6.95	10.32	1.78	36.92	0.90	32.35
	20	5.05	14.25	7.30	15.87	1.90	46.15	0.98	44.12
	Mean	**4.82**	**9.05**	**7.02**	**11.38**	**1.77**	**35.90**	**0.89**	**31.37**
CVR	5	4.98	12.67	6.70	6.35	1.60	23.08	0.74	8.82
	10	4.72	6.79	6.80	7.94	1.70	30.77	0.82	20.59
	20	4.92	11.31	7.05	11.90	1.85	42.31	0.92	35.29
	Mean	**4.87**	**10.26**	**6.85**	**8.73**	**1.72**	**32.05**	**0.83**	**21.57**
L.S.D. at 0.05	A	0.027		0.444		0.025		0.013	
	B	0.021		0.565		0.036		0.026	
	AB	0.036		0.979		0.062		0.045	

CMR, CTR and CVR= compost from maize, tomato and vine residues, respectively.

TABLE 6. Mean values (2016/2017 and 2017/2018) of wheat yield (straw, grains and biological, ton fed.$^{-1}$) and its relative changes "RC" (%), agronomical efficiency (AE, ton ton^{-1}) and harvest index (%) as affected by the studied treatments

Compost treatments		Straw(Mg fed^{-1})			Grains(Mg fed^{-1})			Biological yield (Mg fed^{-1})	Harvest index (%)
Type (A)	Rate (B) (Mg fed^{-1})	value	RC (%)	AE (ton ton^{-1})	Value	RC (%)	AE (ton ton^{-1})		
Control	0	3.087	----	----	2.650	----	----	5.737	46.19
CMR	5	3.180	3.013	0.019	2.750	3.774	0.020	5.930	46.37
	10	3.280	6.252	0.019	2.950	11.321	0.030	6.230	47.35
	20	3.395	9.977	0.015	3.220	21.509	0.029	6.615	48.68
	Mean	**3.285**	**6.414**	**0.018**	**2.973**	**12.201**	**0.026**	**6.258**	**47.47**
CTR	5	3.220	4.308	0.027	2.980	12.453	0.066	6.200	48.06
	10	3.410	10.463	0.032	3.180	20.000	0.053	6.590	48.25
	20	3.710	20.181	0.031	3.450	30.189	0.040	7.160	48.18
	Mean	**3.447**	**11.651**	**0.030**	**3.203**	**20.881**	**0.053**	**6.650**	**48.16**
CVR	5	3.140	1.717	0.011	2.810	6.038	0.032	5.950	47.23
	10	3.335	8.034	0.025	3.050	15.094	0.040	6.405	47.62
	20	3.520	14.027	0.022	3.300	24.528	0.033	6.820	48.39
	Mean	**3.332**	**7.926**	**0.019**	**3.053**	**15.220**	**0.035**	**6.392**	**47.75**
L.S.D. at 0.05	A	0.143			0.601			0.176	1.510
	B	0.186			0.774			0.223	1.999
	AB	0.322			1.340			0.386	3.462

CMR, CTR and CVR= compost from maize, tomato and vine residues, respectively.

In addition, the agronomical efficiency "AE" of the composts, showed that, at the same application rate of the three composts, the treatment of CTR recorded the highest AE values and the lowest values were associated with the treatment of CMR (Table, 6). These findings are in harmony with the chemical composition of the used composts and their effect on both soil chemical properties and its content of available macro- and micronutrients. The positive relationship between compost chemical composition and its effect on chemical properties of calcareous soil and compost agronomical efficiency were reported earlier by Elgezery (2016) and Abou Hussien et al. (2017). The trend of the agronomical efficiency of the three composts was similar with both straw and grains.

Grains content of macronutrients and crude protein

The results presented in Table 7 showed significant increase in N, P, K, Mg and S content (concentration, % and uptake kg fed.$^{-1}$) by grains of wheat plants due to the effect of added different sources and levels ofcomposts.With three compost types, increasing rate application resulted in a significant increase of grains concentration and uptake of the determined macronutrients. These increases resulted from high content of essential macronutrients (Table, 2) of the used composts as well as their improve effect on chemical, physical and biological properties which resulted in more availability of the determined macronutrients. Gohar (2011) pointed out that, compost applications to new reclaimed soils of Egypt reduced soil pH and its content of $CaCO_3$ and increased soil CEC and its content of both OM and essential nutrients. Elgezery (2016) found that barley plants content of N, P, K, Mg and S increased with added compost content of these nutrients.

The efficiency of the studied different treatments on wheat grains content of macronutrients under studied values could be arranged in the following order: CTR > CVR > CMR.This order is in harmony with the chemical composition of the used composts especially with their content of S. The positive relationship between compost content of S and barley plants concentration of N, P, K, Mg and S under calcareous soil condition were reported earlier by Elgezery (2016) and Abou Hussien et al. (2017). Also, they pointed out that, increasing rate of S to calcareous soil either individually or combined with un-sulphured compost and as sulphur compost resulted in an increase of barely plants content of N, P, K, Mg and S under calcareous soil conditions. They attributed these increase to the improve effect of S on calcareous soil properties such as decrease in soil pH and its content of $CaCO_3$ followed by increase in soil content of essential macro and micronutrients.

With the same treatment of each added compost, grain content of the determined macronutrients varied widely from nutrient to another, where the highest content (and uptake) (% and kgfed.$^{-1}$) were recorded with N followed by K but the lowest was found with S followed by Mg (Table 7). The increase rate of nutrient uptake resulted from the used composts varied from nutrient to another. For example, at 20 ton fed.$^{-1}$ application rate of CMR, the increase rate (%) of N, P, K, Mg and S uptake by grains of wheat plants were74.77, 264.5, 46.88, 73.58and 94.30%, respectively. Similar results were reported earlier by Mahmoud (2017).

On the other hand, data in Fig. 1 revealed that, grains content of crude protein takes the same trend with that obtained in N concentration, where it was obtained by multiplying the content of N (%) by 5.75 (A.O.A.C., 1990). Generally, the amount of protein was significantly affected by application of compost, the treatments of CTR especially at rate of 20 ton fed.$^{-1}$ resulted in highest increases of protein content.

TABLE 7. Mean values (2016/2017 and 2017/2018) of macronutrients concentration (%) and uptake (kg fed.$^{-1}$) by grains of wheat as affected by the studied treatments

Compost treatments		**N**		**P**		**K**		**Mg**		**S**	
Type (A)	Rate (B) (Mg fed^{-1})	Conc. (%)	Uptake (kg fed^{-1})	Conc. (%)	Uptake (kg fed^{-1})	Conc. (%)	Uptake (kg fed^{-1})	Conc. (%)	Uptake (kg fed^{-1})	Conc. (%)	Uptake (kg fed^{-1})
Control	0	1.62	42.93	0.30	7.95	1.58	41.87	0.42	11.13	0.45	11.93
CMR	5	1.78	48.95	0.60	16.50	1.70	46.75	0.45	12.38	0.52	14.30
	10	2.10	61.95	0.73	21.54	1.81	53.40	0.48	14.16	0.60	17.70
	20	2.33	75.03	0.90	28.98	1.91	61.50	0.60	19.32	0.72	23.18
	Mean	**2.07**	**61.98**	**0.74**	**22.34**	**1.81**	**53.88**	**0.51**	**15.29**	**0.61**	**18.39**
CTR	5	1.95	58.11	0.73	21.76	1.76	52.45	0.50	14.90	0.61	18.18
	10	2.42	76.96	0.87	27.67	1.97	62.65	0.60	19.08	0.70	22.26
	20	2.91	100.40	1.05	36.23	2.15	74.18	0.75	25.88	0.87	30.02
	Mean	**2.43**	**78.49**	**0.88**	**28.55**	**1.96**	**63.09**	**0.62**	**19.95**	**0.73**	**23.48**
CVR	5	1.85	51.99	0.71	19.95	1.73	48.61	0.47	13.21	0.55	15.46
	10	2.30	70.15	0.80	26.54	1.88	57.34	0.54	16.47	0.66	20.13
	20	2.68	88.44	0.98	32.34	1.96	64.68	0.66	21.78	0.80	26.40
	Mean	**2.28**	**70.19**	**0.83**	**26.28**	**1.86**	**56.88**	**0.56**	**17.15**	**0.67**	**20.66**
L.S.D at 0.05	A	0.016	12.40	0.015	4.67	0.017	10.89	0.023	2.78	0.010	4.66
	B	0.016	15.81	0.044	5.46	0.027	14.54	0.017	3.29	0.021	5.45
	AB	0.028	21.477	0.076	9.457	0.047	25.184	0.029	5.698	0.036	9.440

CMR, CTR and CVR= compost from maize, tomato and vine residues, respectively.

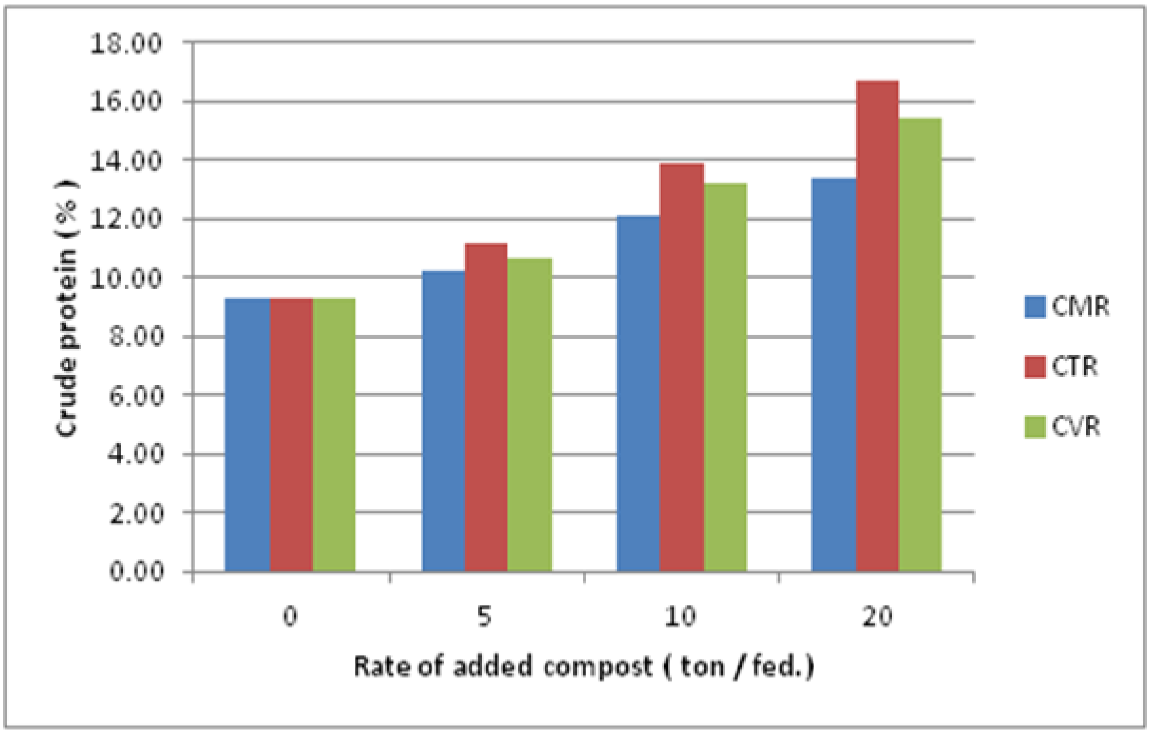

Fig. 1. Mean values (2016/2017 and 2017/2018) of protein content (%) of grains as affected by the studied treatments
L.S.D. at level 0.05 (Type compost =0.093, rate =0.093 and interaction=0.160).

TABLE 8. Mean values (2016/2017 and 2017/2018) of micronutrients concentration (%) and uptake (kgfed.-1) by grains of wheat as affected by the studied treatments

Compost type		Fe		Mn		Zn		Cu	
Type (A)	Rate (B) (Mg fed^{-1})	Conc. (mg kg^{-1})	Uptake (kg fed^{-1})	Conc. (mg kg^{-1})	Uptake (kg fed^{-1})	Conc. (mg kg^{-1})	Uptake (kg fed^{-1})	Conc. (mg kg^{-1})	Uptake (kg fed^{-1})
Control	0	103.5	0.274	48.7	0.129	0.83	0.0022	0.33	0.0009
CMR	5	118.3	0.325	52.2	0.144	0.90	0.0025	0.36	0.0010
	10	128.4	0.379	58.3	0.172	0.96	0.0028	0.41	0.0012
	20	144.4	0.465	68.8	0.222	1.03	0.0033	0.52	0.0017
	Mean	**130.4**	**0.390**	**59.8**	**0.179**	**0.96**	**0.0029**	**0.43**	**0.0013**
CTR	5	135.5	0.404	60.1	0.179	0.98	0.0029	0.40	0.0012
	10	147.7	0.470	70.1	0.223	1.12	0.0036	0.50	0.0016
	20	171.4	0.591	76.8	0.265	1.21	0.0042	0.63	0.0022
	Mean	**151.5**	**0.488**	**69.0**	**0.222**	**1.10**	**0.0036**	**0.51**	**0.0017**
CVR	5	125.4	0.352	55.4	0.156	0.95	0.0027	0.38	0.0011
	10	140.8	0.429	63.6	0.194	1.03	0.0031	0.43	0.0013
	20	158.5	0.523	70.9	0.234	1.14	0.0038	0.60	0.0020
	Mean	**141.6**	**0.435**	**63.3**	**0.195**	**1.04**	**0.0032**	**0.47**	**0.0015**
L.S.D.	A	0.710	0.077	2.250	0.033	0.017	0.006	0.016	2.000
at	B	0.820	0.097	3.410	0.041	0.025	0.008	0.022	2.830
0.05	AB	1.420	0.168	5.906	0.071	0.043	0.001	0.038	4.902

CMR, CTR and CVR= compost from maize, tomato and vine residues, respectively.

Grains content of micronutrients

Data in Table 8 showed that, micronutrients (Fe, Mn, Zn and Cu) concentrationand uptakeof grains under sandy calcareous soil condition after manured by three types of compost. There are wide variations in grains content of the determined micronutrients based on the compost and its application rate. Generally, increasing rate of added composts were associated by a significant increase of Fe, Mn, Zn, and Cu content, where the highest content were found in the grains of wheat plants grown on the soil manure by CTR followed by those recorded with the plants manure by CVR. The increase in the grains content of the determined micronutrients and their variation resulted from the effect of added compost type on sandy calcareous soil properties such as decreasing pH and its content of $CaCO_3$ resulted in an increase in the availability of micronutrients as suggested before by Gohar (2011) and Hashem and Abd-Elrahman (2016).The variation effects of composts on soil chemical properties and the content of available micronutrients is in agreement with these composts content of S, where increasing added S led to more decrease in the soil content of $CaCO_3$ as mentioned by Abou Hussein et al. (2017). So the obtained data shows the high improve effect of compost with high content of S and organic matteron soil properties and plant growth and its content of macro and micronutrients. Under the same treatment of each compost, grain content of the determined micronutrients varied widely from nutrient to another, where the highest content was recorded with Fe followed by Mn but the lowest was found with Cu followed by Zn (Table, 8).

With the same treatments of composts, the increase rate "RC" (%) of grains uptake of the determined micronutrients varied from nutrient to another depending on the initial content of available micronutrient in the used soil (Table,1) and found changes as a result of composts application. For example, Fe, Mn, Zn and Cu uptake by grains of wheat plants grown in the soil treated by CVR increased by 90.9, 81.4, 72.7 and 122.2% with the increase of added rates from 0 to 20 tonfed.$^{-1}$, respectively.

Conclusion

From the above mentioned results it could be concluded that, compost as soil amendment enhanced the soil chemical properties and may be the bedding materials of root zone area as well as, to some extent, the availability of nutrients in soil which positively reflected on the productivity of wheat. The best treatment with regard to improving soil properties as well as increasing wheat yield and nutrients uptake was the treatment of CTR (compost tomato residue), especially at rate of 20 ton fed.$^{-1}$,under calcareous soil conditions.

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الخواص الكيميائية للكمبوست وعلاقتها بخواص الأرض الجيرية وإنتاجيتها للقمح

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أجريت تجربتان حقليتان خلال موسمى نمو شتاء متتاليين (٢٠١٦/٢٠١٧-٢٠١٧/٢٠١٨) بإحدى المزارع بأبوالمطامير –محافظة البحيرة. وذلك لدراسة تأثير ثلاثة أنواع من الكمبوست المختلفة فى تركيبها الكيميائى على الخواص الكيميائية للأرض الجيرية وكذلك إنتاجيتها من محصول القمح و مكوناته و أيضاً محتواه من بعض المغذيات الكبري و الصغري (النيتروجين، الفوسفور ، البوتاسيوم ، المغنسيوم ، الكبريت ، الحديد ، المنجنيز ، الزنك و النحاس) . ولقد تم إعداد الثلاثة أنواع المستخدمة من الكمبوست من ثلاث بقايا نباتية مختلفة وهى مخلفات حطب الذرة والطماطم والعنب. كذلك تم تحليل التركيب الكيميائي وكذلك المحتوى من المغذيات الكبرى والصغرى الميسرة فى أنواع الكمبوست تحت الدراسة. و قد تم إضافة كل نوع من الكمبوست علي حدة بمعدلات إضافة صفر ، ٥، ١٠ و ٢٠ طن/فدان. و أُجريت التجربة في تصميم قطاع تام العشوائية ، بثلاث مكررات. ويمكن تلخيص بعض النتائج المُتحصل عليها كالآتي:-

- أظهرت الأنواع الثلاث المحضرة من الكمبوست إختلافات كبيرة فى تركيبها الكيميائى , فعلى سبيل المثال كان أعلى محتوى من المادة العضوية والنيتروجين الكلى وكذلك المحتوى من المغذيات الكبرى و الصغرى موجودا فى الكمبوست المحضر من بقايا الطماطم بينما أظهر محتوى كمبوست حطب الذرة المحتويات الأقل من هذه القياسات.

- إنخفض كل من رقم الحموضة وقيمة التوصيل الكهربى وكربونات الكالسيوم للتربة مع الإضافات المختلفة من الكمبوست والتى أدت بدورها إلى زيادة السعة التبادلية الكاتيونية للأرض كما ازداد محتوى الأرض من المادة العضوية وكذلك المحتوى من المغذيات الكبرى (النيتروجين, الفوسفور, البوتاسيوم, الكبريت, الكالسيوم والمغنسيوم) والصغرى (الحديد, المنجنيز, الزنك والنحاس) وكانت أعلى قيم التغيرات النسبية للخواص الكيميائية للأرض وكذلك محتواها من المغذيات موجودا فى الأرض المعاملة بكمبوست بقايا الطماطم تلاها فى ذلك معاملات كمبوست مخلفات العنب.

- إزداد محصول كل من الحبوب والقش لنبات القمح وكذلك التغيرات النسبية لها مع زيادة معدلات الإضافة من الثلاث أنواع المستخدمة من الكمبوست وكانت أعلى القيم المتحصل عليها من معاملات كمبوست مخلفات الطماطم تلاه فى ذلك معاملات كمبوست مخلفات العنب. كما أعطت معاملات كمبوست مخلفات الطماطم أعلى كفاءة محصولية مقارنة بالنوعين الأخريين من الكمبوست.

- وأخيراً ، فإن إضافة كمبوست مخلفات الطماطم عند معدل إضافة ٢٠ طن / فدان حققت أفضل النتائج المتُحصل عليها لكلٍ من الأرض و النبات مقارنة بباقي المعاملات.