5

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Soil Characteristics after Growing Compost-Amended Vegetable Crops

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TWO FIELD experiments were carried out in the Experimental Farm of Agriculture Faculty, Kafrelsheikh University, Kafr El Sheikh Governorate during the successive summer and winter seasons of 2004/2005. Two vegetable crops, green bean (*Phaseolus vulgaris* L. cvs. Bronco) as a summer crop and pea (*Pisum sativum* cvs. Master B) as a winter crop, were grown to evaluate the potential effects of application of rice straw compost (RSC) and municipal solid waste compost (MSWC). Different application rates of the two types of compost (10, 15 and 20 tones fed^{-1}) as well as mineral fertilizers treatment with recommended dose of NPK were applied. The seeds of the two crops were inoculated before sowing with each selective rhizobia, *Rhizobium leguminosarum* cv *phasoli* and *Rhizobium leguminosarum* cv *vicia* respectively and also with mycorrhizal inoculum contains mycorrhiza spores and corn infected roots. The experimental plots, those received compost, were enriched with some beneficial microorganisms (*Azotobacter chroococcum*, *Bacillus megatherium* and *Azospirillum lipoferum*). Four replicates were done for each treatment in complete randomized block design. All agricultural practices were followed as recommended order. Composite soil samples were taken before and after cultivation of both crops for soil chemical and microbiological analyses. A third soil sample was taken at flowering stage to perform the complete analyses of microorganisms population.

All compost treatments (different types and doses) increased soil microbial population over NPK treatment under both bean and peas crops at different growth stages. The biomass including bacteria, fungi, actinomycetes, phosphate-dissolving microorganisms, *Azotobacter*, *Azospirillium* and *Rhizobium* reached its maximum peak at the flowering stage of plants. As a general trend, increasing compost application rate increased the soil microbial community as well as the mycorrhiza infection percentage of plant roots. The microbial numbers gradually decreased with tendency of plant to maturity stage but its numbers still over than those scored at sowing stage.

In general, all fertilization treatments increased soil EC, CEC, OC % and OM %, but little decreases in soil pH were observed. The differences in these parameters were parallel to the increase in organic fertilization rate under the two vegetable crops. The data also exhibited that using RSC resulted in high values of tested parameters compared to MSWC.

Organic fertilization generally increased macro-, micro-nutrients and heavy metals content in soil, these increases were more pronounced with increasing fertilization rate. It was also observed that the increases in available macronutrients were more pronounced in case of fertilization with RSC compared to MSWC at all rates of application under the two crops. In contrary to that, MSWC provided the highest concentration of micronutrients and heavy metal at different rates of application in both bean and pea experiments compared to RSC.

Keywords: Soil characteristics, Compost amendments, Vegetable crops.

Soil organic matter is considered as a major component of soil quality because it contributes directly or indirectly to many physical, chemical and biological properties. Thus, soil amendment with composts is an agricultural practice commonly used to improve soil quality and also to manage organic wastes (Ana *et al.*, 2006). The beneficial effects of compost on crop production and soil properties are directly related to the application rate of manure compost (Wong *et al.*, 1999).

Studies of the impact of composts on soil have mainly evaluated physical and chemical factors, potentially involved in plant productivity parameters. Evaluations through field experiments showed that organic amendments not only act by improving soil structure and as a source of nutrients, they can also strongly influence the soil microflora (Crecchio *et al.*, 2001).

It has been shown that microbial activity and biomass was higher in fields with organic amendments than those with conventional fertilizers (Gunapala & Scow, 1998).

Integrating compost into commercial vegetable production for disease suppression represents a long-term approach to enhance soil microbial activity and system resilience to disease pressure. It was found that, increasing compost addition rate increased N, P, K and Mn content in plant tissues, as well as soil EC and pH (Gaber, 2000 and Rangarajan *et al.*, 2000) demonstrated through a filed study that organic fertilizers significantly increased N and K uptake and yield of legume crops.

Compost amendments can modify the microbial community composition and as a result, enhance the competition and/or antagonism among microbes, leading to a decrease in plant pathogens activity (Hoitink & Boehm, 1999 and Steinberg *et al.*, 2004). Abdelhamid *et al.* (2004) stated that compost addition increased soil pH, EC, OM, TC, CEC and TN and decreased particle density with increasing rate. Even at the highest rate, EC was suitable for all types of plants. They added that, application of compost increased soil respiration indicating increase the microbial activity rate.

Soils with alternative fertility (compost) amendments initially had a lower soil pH than soils with synthetic fertilizers, but over time soil pH increased in soils with alternative amendments to higher levels than pH in soils with synthetic fertilizers. Levels of other soil nutrients (zinc, iron and aluminum) were not affected by soils amendment, sample time, production history or interactions of these components. However, copper and phosphorus levels were higher in soils with alternative than synthetic soil fertility amendments. Mean soil organic matter, total C, and CEC were higher and bulk density was lower in plots with the alternative soil amendments compared to synthetic fertilizers after 2 years. Continuous annual applications of compost are typically required to cause significant enhancements in soil properties (Shiralipour *et al.*, 1992 and Bulluck *et al.*, 2002).

The sorption behavior of Cd, Cu, Ni, and Zn in soils varies from soil to soil and is influenced by soil properties, such as pH, organic matter, cation exchange capacity (CEC) and clay contents (McBride, 1989). It was also found that the lowering of pH in peat-amended soil decreased the sorption of Cd, Cu, Zn and Ni in the soil.

This study is concerned with determination of the impact of compost amendments on soil fertility after growing vegetable crops.

Material and Methods

Two field experiments were carried out in the Experimental Farm of Faculty of Agriculture, KafrelSheikh University, Kafr El-Sheikh Governorate during the successive summer and winter seasons of 2004/2005. Two vegetable crops, green bean (*Phaseolus vulgaris* L. cvs. Bronco) as a summer crop and Pea (*Pisum sativum* cvs. Master B) as a winter crop, were grown. Soil plot area was 7 m^2 manured with rice straw (RS) compost and/or municipal solid waste compost (MSW) at 3 different rates (10, 15 and 20 ton fed^{-1}) compost with the above mentioned rates. The control plots received the recommended dose of mineral fertilizers nitrogen, phosphorous and potassium (NPK) with a total dose of 200 kg ammonium sulphate, 200 kg superphosphate and 100 kg potassium sulphate / fed^{-1} divided to three portions. The commercial bio-pesticide (Bio-Fly) was used in pest control with the compost treatments while the "Malathion" was used with NPK treatment. Completely randomized block design with four replicates was used in the experiments.

Forty kg of bean seeds[**] and thirty five kg of pea seeds fed^{-1} were sown on September 18th and December 2nd, 2004, respectively, in hills containing 3- 4 seed with 10 cm spacing. All the agricultural practices were followed as recommended instructions.

Chemical analyses of soil and compost

Surface composite soil samples (0-30 Cm) from each experimental plot were taken before and after the cultivation of both crops for chemical and microbiological analyses. A third soil sample (rhizosphere) was taken at the flowering stage to perform the soil microbiological analysis.

Surface composite soil samples were air dried, crushed, passed through a 2 mm sieve and used for the following assessments: Soil mechanical analysis according to Piper (1950), pH, organic carbon, organic matter, soluble cations and anions (Na^{+}, K^{+}, Ca^{++}, Mg^{++}, CO_3^{--}, HCO_3^{-}, Cl^{-} and SO_4^{--}), cation exchange capacity (CEC), total and available nitrogen content as reported by Page *et al.*, (1982), electric conductivity (EC) (dsm^{-1}) Chen *et al.* (1988), total carbonate (Richards, 1954), Available and total phosphorous were determined by the method of Schouwenbury Van & Walinge (1967), Available potassium, available micro-elements and heavy metals were determined according to the methods described by Cottenie *et al.* (1982) (Table 1).

Microbiological analyses

Microbiological analyses of rhizosphere soil and compost samples, the technique described by Louw & Webley (1959) was followed. The serial dilution pipette method was used for the microbial count on different selective media as following:

- Total bacteria on nutrient agar medium (Difco, 1976);
- Total fungi on Martin's medium (Allen, 1953);
- Actinomycetes on Yeast extract-malt extract agar medium (Szabo,1974);
- Phosphate-dissolving bacteria on Bunt & Rovira medium (1955) modified by Louw & Webley (1959);
- *Azotobacter* on modified Ashby's medium (Abd-El-Malek & Ishac, 1968);
- *Rhizobium* on yeast extract mannitol agar medium (Allen, 1953);
- *Azospirillum* grown on N-deficient semi-solid medium (Dobereiner *et al.*, 1976);
- Spore-formers counted on nutrient agar medium (Difco, 1976) after heating the dilution tubes for 10 minutes at 80-90°C;
- Cellulose-decomposing microorganisms were counted by MPN technique using Dubo's cellulose medium (Allen, 1953).

Mycorrhiza colonization was determined by the grid intersect method (Giovannetti & Mosse, 1980).

Results and Discussion

Microbial population in soil under bean and peas crops

Changes in soil biomass of soil amended with different doses of two types of compost, RSC and MSWC under green bean and peas are shown in Table 2. The data exhibited that organic matter amendment to soil at different doses 10, 15 and

20 ton fed^{-1} animated all the bacterial groups throughout the three stages of plant growth irrespective to the type of compost material. This flourished effect greatly exceeded that obtained by the application of NPK treatments. This is why organic matter is considered as a major component of soil quality because it contributes directly or indirectly to many physical, chemical and biological properties. This soil amendment with compost is an agricultural practice commonly used to improve soil quality and also to manage organic wastes (Ana *et al.*, 2006 and Saison *et al.*, 2006).

TABLE 1. Phisco-chemical characteristics of the initial soil.

Parameter	Value
pH (1:2.5 soil water susp.)	8.32
EC dSm^{-1} (soil paste extract) at 25°C	4.83
TSS (Total soluble salts) %	0.26
SP % (saturation percent)	85.05
Total nitrogen %	0.08
Total organic carbon %	0.68
Organic matter %	1.17
Total carbonate %	2.97
CEC (meq/100 g soil)	32.86
Available N mg kg^{-1}	38.00
Available P mg kg^{-1}	10.30
Available K mg kg^{-1}	417.20
Soluble cations meq L^{-1}	
Ca^{++}	17.30
Mg^{++}	4.25
Na^{+}	23.92
K^{+}	0.86
Soluble anions meq L^{-1}	
CO^{--}_3	-
HCO^{-}_3	4.81
Cl^{-}	24.60
SO^{--}_4	16.92
Micronutrient mg kg^{-1}*	
Available Cu	0.98
Available Fe	3.26
Available Mn	4.37
Available Zn	1.23
Heavy metal mg kg^{-1}*	
Available Cd	0.012
Available Ni	0.019
Available Pb	0.49
Texture	**Clay**
Sand %	22.86
Silt %	28.65
Clay %	48.49

*Ammonium acetate-EDTA extraction method.

Total bacterial count

The total bacterial count occurred with high density in the rhizosphere of bean and peas plants after the application of compost materials (Table 2). This density reached its maximum at flowering stage of plant growth irrespective to the plant type or the dose of application. The highest densities of total bacteria were detected after use the medium rate of RSC application for bean and the highest dose of MSWC for peas. These distinguished increases through flowering stage indicated that the bacterial numbers positively influenced by the plant root exudates and surplus of nutrients. Afterwards, the population turned to decrease sharply to reach maturity stage. These data are in agreement with those found by Badr El-Din *et al.* (2000) who demonstrated that bacterial count was higher in rhizoshere of tomato treated with different manures than that treated with NPK. Also, Zayed & Heba Abdel Motaal (2005) established that the biological mass in rhizosphere soil samples of unfertilized cowpea was higher than that of non-rhizosphere soil indicating that the root exudates of the growing plants enhanced the bacterial growth. They added that any compost greatly increased the total bacterial numbers. Similar trend was also obtained by Ana *et al.* (2006), since they mentioned that the impact of organic amendments on soil characteristics differed up to the nature of compost and soil type.

Total fungi

As regards to the total fungi, the data exhibited that incorporation of the two types of compost RSC and MSWC to soil as organic manures greatly increased the numbers of fungi (Table 2). These increases reached their maximum at the flowering stage, the most active period in plant growth, at all rates of amendment. A little differences was observed between the two types of compost, since the peak number was detected at application rate of 10 ton fed-1 in case of RSC, but it was at 15 ton fed-1 in case of MSWC for both crops. In general, these increases could be deduced to the different available nutrients and the suitable moisture content in this stage of plant growth in addition to plant root exudates. The same trend was observed through the application of NPK but the rate of increases was much little compared to those obtained due to the manuring with the two composts.

However, under the two systems of fertilization, the fungi numbers greatly decreased by the tendency of plant to maturity but they still higher than the count at the initial stage of plant growth. This may be due to the depletion in available nutrients and to soil dryness at the end of plant growth, these soil constituents that play a determinant factor in microbial propagation. In this respect Sivapalan *et al.* (1993) demonstrated that greater increases in fungal population were detected under organic cultivation than those recorded under conventional one. Similar statements were stated by Guerrero *et al.* (2000), they indicated that capability of MSWC to accelerate bacteria and fungi as well as to re-establish physical properties of a burnt soil. They also found that the number of viable fungal propagules increased in all the compost amended soil. This positive effect lasted until the end of the experiment.

TABLE 2. Microbial changes in soil during bean and pea experiments.

Compost ton fed^{-1}	Growth stage	NPK	RSC 10	RSC 15	RSC 20	MSWC 10	MSWC 15	MSWC 20
				Bean crop				
Total bacteria 10^6/g	Sowing	2.1	6.7	6.8	7.0	5.7	6.6	7.1
	Flowering	23.8	141.0	163.2	154.8	93.2	139.6	155.1
	Maturity	9.7	41.7	47.2	45.5	39.9	38.3	49.8
Total fungi 10^4 /g	Sowing	1.2	2.3	2.3	2.6	1.9	2.4	2.3
	Flowering	9.2	27.2	21.1	22.3	21.4	27.2	25.0
	Maturity	2.2	5.8	5.2	6.0	4.8	5.4	4.9
Total actinomycetes 10^5/g	Sowing	1.2	6.8	7.5	7.2	6.0	6.6	7.0
	Flowering	10.2	40.3	52.1	47.2	39.7	41.4	49.2
	Maturity	2.4	8.7	8.8	9.3	7.9	8.1	7.8
Phosphate - dissolving bacteria 10^5 /g	Sowing	0.5	3.3	3.6	3.2	2.7	3.6	3.3
	Flowering	1.1	18.3	20.2	19.5	19.9	27.2	25.9
	Maturity	0.7	7.4	6.7	6.8	7.2	6.1	5.4
Azotobacter 10^4/g	Sowing	1.1	10.8	9.9	11.2	9.4	10.6	10.8
	Flowering	7.3	43.6	48.2	59.1	36.6	45.2	37.8
	Maturity	1.8	19.2	18.7	22.1	16.5	17.8	18.1
Azospirillium 10^4/g	Sowing	1.0	1.5	1.6	1.4	1.8	2.1	2.1
	Flowering	10.5	126.0	101.5	160.0	92.0	101.5	94.0
	Maturity	2.1	10.5	9.4	10.3	6.4	11.5	5.1
Rhizobium 10^4/g	Sowing	0.4	8.2	9.4	8.9	9.1	8.7	9.6
	Flowering	13.2	72.3	72.3	81.2	75.4	79.1	88.3
	Maturity	1.3	16.1	19.2	12.8	17.2	18.3	14.6
Mycorrhiza infection %	Flowering	23.0	53.0	58.0	69.0	54.0	60.0	67.0
				Peas crop				
Total bacteria 10^6/g	Sowing	1.0	3.8	4.1	4.1	3.6	4.9	5.0
	Flowering	19.2	129.0	112.0	133.0	136.0	98.0	203.0
	Maturity	2.3	19.3	35.1	47.6	18.2	33.0	36.5
Total fungi 10^4 /g	Sowing	1.8	3.1	3.6	3.2	2.2	2.8	3.3
	Flowering	3.9	20.2	16.5	15.0	17.1	19.8	16.1
	Maturity	1.2	5.4	6.2	6.7	3.2	4.3	3.8
Total actinomycetes 10^5/g	Sowing	1.3	5.6	6.4	9.2	6.6	5.3	7.1
	Flowering	18.3	29.8	32.5	43.6	22.9	29.7	39.1
	Maturity	2.2	6.7	8.8	7.3	5.4	4.4	6.8
Phosphate - dissolving bacteria 10^5 /g	Sowing	1.2	5.0	4.9	5.4	4.3	4.9	5.0
	Flowering	5.3	18.0	11.1	15.3	12.2	14.7	13.7
	Maturity	1.9	6.0	7.2	7.6	5.1	5.9	6.7
Azotobacter 10^4/g	Sowing	0.73	12.7	11.3	13.1	10.3	10.8	9.9
	Flowering	8.8	23.1	25.7	26.8	21.9	23.3	22.8
	Maturity	1.1	10.4	10.8	10.2	9.8	9.5	9.4
Azospirillium 10^4/g	Sowing	0.2	1.0	1.0	1.1	1.0	1.3	1.3
	Flowering	6.4	44.5	56.5	48.5	50.0	43.0	53.5
	Maturity	1.4	2.1	2.3	2.6	1.9	1.8	2.4
Rhizobium 10^4/g	Sowing	0.6	7.2	5.4	7.4	5.7	5.9	5.3
	Flowering	10.2	32.0	41.0	48.0	36.0	39.0	32.0
	Maturity	2.6	9.3	9.9	10.3	8.4	9.5	10.1
Mycorrhiza infection %	Flowering	21.0	51.0	57.0	66.0	50.0	57.0	64.0

Total actinomycetes

Data in Table 2 showed that, there were no variations between the two types of compost dealing with the general trend of increases. Both RSC and MSWC positively affected the actinomycetes population at the different rates of amendment, particularly at flowering stage of plants further than these obtained with mineral fertilization. It was also observed that, at the larger rates of compost application (15 and 20 ton fed^{-1}) their numbers tended to increase more particularly under bean. These data are in accordance with those obtained by Badr El-Din *et al.* (2000) who found a significant increase in total streptomyces count as a result of fertilization with compost or FYM.

Phosphate-dissolving bacteria

As well known phosphate-dissolving bacteria "PDB" have the capability to bring insoluble P in soil into soluble form by producing organic acids. Different bacterial groups can play such role as bacteria, fungi and actinomycetes. The total count of PDB illustrated in Table 2. As obviously seen the incorporation of the two types of compost RSC and MSWC at different rates resulted in sensible variations in the numbers of PDB. Since the increases reached to 17.6 and 24.1-folds the NPK fertilization of bean crop for RSC and MSWC at the flowering stage by the application of 15 ton fed^{-1} of both composts, but in case of peas their population was less developed. This may be not only due to the vital role of organic materials in enriching microbial communities but also to the preinoculation of all plots received compost with *Bacillus megatherium* as PDB. No remarkable differences in PDB numbers between the three rates of both types of compost under both crops. As shown in all bacterial groups, the PDB numbers at sowing and maturity stages were lower than those at flowering stage of plant growth. Similar findings obtained by Zayed & Heba Abdel Motaal (2005) indicated that the highest PDB numbers were found in rhizosphere soils of cowpea plants fertilized with compost + FYM, since the latter is a good source of PDB.

Azotobacter numbers

It was observed that, the larger increment of *Azotobacter* numbers was obtained due to RSC compared to MSWC (Table 2). However, both materials proved to be the best compared to the NPK treatment. As expected, the highest numbers were detected at plant flowering stage for all types of fertilization, mineral and organic. This increase at flowering stage was followed by sharp decline in numbers in all treatments at plant maturity stage.

It has been reported that *Azotobacter* not only provides nitrogen, but also produces a variety of growth-promoting substances (Hegde *et al.,* 1999). These substances stimulate at least to some degree, the production of root exudates which in turn affect their numbers. Wu *et al.* (2005) reported that the application of any organic manure may enhance the benefit of *Azotobacter*. This may be due to the fact that the N_2 fixation reaction needs a lot of energy from available organic carbon to break the bonds between nitrogen atoms.

Azospirillium numbers

Azospirillium followed the same trend of the previous different bacterial groups, since the manured soil had have the higher numbers compared to that received NPK (Table 2). their numbers tended to increase through the plant growth period to reach their maximum peak at flowering stage. Afterwards, the numbers declined until the maturity stage. The rate of 20 ton fed^{-1} RSC under bean crop was the highest rate-developing numbers through all treatments. These data are in agreement with those obtained by Saini *et al.* (2004) who indicated that the application of farmyard manure increase the *Azospirillium* population in soil.

Rhizobia population in soil

It is well known that the available N and salt stress negatively acts on the nodulation process in legumes and there is an international problem dealing with the nodulation of bean plant (Obbard & Jones, 2001). On the other hand, the high organic matter inputs from manure amendments could improve survival and persistence of rhizobia that live as saprophytic organisms in the soil until the next legume crop is planted by utilizing available organic materials as a source of C and energy. Dependent on the knowledge, the population size of rhizobia increased as a result of growing legume plants through the different growth stages of plant growth. These increases were more appreciable especially at flowering stage for the three different rates of organic matter amendment. These increases were in parallel to the increase in rate of OM application in most treatments. This could be attributed to the high organic carbon content of amended organic materials (35.74% for RSC and 24.75% for MSWC) which acted as a nutritional source for rhizobia. By the end of plant growth the population tends to decrease. The present data are in harmony with those obtained by Zengeni *et al.* (2006) who demonstrated that, manure application significantly influence rhizobial population with numbers increased with increasing manure rate.

Mycorrhizal colonization

It is obviously seen (Table 2) that organic matter amendments greatly influenced the mycorrhizal colonization percentage than did the mineral fertilizers. Arbuscular mycorrhiza "AM" infection percentage increased constantly with the increase in compost application rate for both RSC and MSWC and they were more predicted at the highest rate of both compost applications with no much variations between the two crops. These increases in number of AM infection percentage could be due to the mycorrhizal inoculation which had been done for soil plots received composts in addition to the containing of compost material on heavy load of different beneficial microbial groups including mycorrhiza. These microorganisms play a vital role in enhancing number and bioaction of AM fungi. In accordance with the present data Baby & Manibhushanrao (1996) concluded that selective organic amendment could be used to enhance development of native AM fungi and reduce the incidence of plant diseases. Saini *et al.* (2004) stated that AM infection percentage were also improved due to combination of inoculant with FYM. Wu *et al.* (2005) reported that the inoculation with beneficial bacteria increased root colonization by AM at low fertilization level.

It can be also concluded that the soil microflora play a vital role in plant nutrition. Since, strong positive correlations have been found between the amount of nutrient held in the microbial biomass and amount of mineralizable nutrients in the soil. Saini *et al.* (2004) indicated that nutrient cycling in organic resources is tightly linked to the turnover of microbial biomass.

Some chemical characteristics of the experimental soil after harvesting of bean and peas crops

Soil electrical conductivity

Soil chemical characteristics of experimental soil as influenced by incorporation of two types of compost RSC and MSWC through growing bean and pea crops are illustrated in Table 3. The present data showed that amendment of fertilizers, chemical or organic, to soil generally increased its "EC". These increases were more pronounced in case of organic fertilization and developed gradually with increasing rate of application irrespective to the type of compost. Fluctuated values were detected at the different rates of compost amendments varied with the two growing vegetable crops. These increases could be deduced to the large content of these organic materials on plenty of cations and anions which continuously release during plant growth by chemical and biological action in soil. Some reports mentioned that, when used in sufficient amount, compost has long-term positive impact on soil properties and provides a more stabilized form of organic matter than raw waste and can improve physical, chemical and biological properties of soil. Even at the high rates, EC was suitable for all types of plants (Wong *et al.*, 1999 and Abdelhamid *et al.*, 2004). Similar data were obtained by Walker *et al.* (2004) who stated that the increase in EC following the addition of compost may have been caused by the relative high EC of that compost and also to the formation of a lot of soluble salts as a result of continuous mineralization process in soil.

Soil reaction (pH)

Soil acidity affects the availability and absorption of nutrients by plants, particularly micronutrients. Most composted materials have a near neutral or slightly alkaline pH with a high buffering capacity. Elevation of pH by compost application can bring about strong absorption of heavy metals such as Cd, Pb and Zn in soil particles resulting in lower accumulation of these elements in plant tissues (Baran *et al.*, 2001and Walker *et al.*, 2003).

TABLE 3. Some chemical characteristics of the experimental soil after harvesting of bean and pea crops.

Treatment	EC 1:5	pH 1:2.5	CEC Cmol kg^{-1}	SOC %	SOM %	Available macronutrients mg kg^{-1}		
						N	P	K
Initial soil	0.81	8.32	32.86	0.68	1.17	38	10.30	395.3
				Bean crop				
NPK	0.92	8.15	33.00	0.73	1.26	37.53	9.80	353.66
RSC10	2.17	7.98	34.90	0.97	1.67	69.42	15.98	368.53
RSC15	2.40	7.91	37.13	1.12	1.93	86.15	17.42	346.5
RSC 20	2.51	7.80	39.22	1.26	2.17	102.57	19.91	341.44
MSWC10	2.31	8.00	34.71	0.88	1.53	59.82	15.46	364.50
MSWC15	2.53	7.98	36.69	0.98	1.69	77.69	17.25	341.12
MSWC 20	2.60	7.88	38.97	1.07	1.84	93.11	19.38	371.99
				Peas crop				
NPK	0.83	8.16	33.17	0.74	1.27	34.11	10.12	367.25
RSC10	2.11	8.00	35.25	0.98	1.68	52.17	15.90	383.35
RSC15	2.36	7.95	37.40	1.14	1.97	65.35	17.31	390.00
RSC 20	2.48	7.89	38.67	1.31	2.26	78.86	19.83	359.10
MSWC10	2.20	8.03	34.92	0.87	1.50	42.37	15.33	375.63
MSWC15	2.41	7.96	37.00	0.99	1.70	50.78	17.07	385.98
MSWC 20	2.48	7.91	38.13	1.10	1.90	59.99	19.20	386.66

Although the above mentioned statements the data over here exhibited different decreases in soil pH values after harvesting the two vegetable crops bean and peas compared to the initial soil. The decreases in soil pH values due to the mineral fertilization NPK were little slight than those occurred under the organic fertilization and these decreases were continued by increasing rate of application. It should also be mentioned that the decreases in case of bean crop were relatively higher than those detected under peas crop in most treatments. This result could be owing to the more stability of compost as a result of storage of compost until the time of peas cultivation which comes after bean cultivation date. Generally, these decreases happened in soil pH values due to the application of compost materials could be because of the soil sampled from the rhizosphere area since this area subjected to the active biological role of enriched microorganisms existed in this area in continuous decomposition of organic materials and release of CO_2 and different organic acids in addition the flow acidic root exudates. In agreement with the present data, Talha (2003) stated that addition of different organic materials reduced soil pH values. On the other hand, Wong *et al.* (1999) and Ouédraogo *et al.* (2001) demonstrated that in all the compost plots, an increase of soil pH was noted compared to the non compost plots, thus may be due to the differences in soil types since the soil was acidic (pH 5.31) in these experiments and between 6.00 and 6.80, respectively.

Cation exchange capacity

The data showed that, the fertilization with NPK treatments or organic manure resulted in different increases in CEC. These increases were lower in case of NPK treatment compared to those receiving organic materials since they appeared positive response increased with the increase in application rate of the two types of compost under the two cultivated crops (Table 3). The increases in CEC due to NPK fertilization were low, ranged between 0.42 % and 0.94 %, whereas these increases were more remarkable due to the fertilization with compost, reached to 19.35 % and 17.68 % for bean and peas at RSC20 treatment, respectively. Similar findings were obtained by McConnell *et al.* (1993) who mentioned that a compost application rate of 15 ton /acre increased CEC by about 10 %, while low rates (less than 10 ton/acre) did not change or had minimal effect on CEC of most mineral soils. Almost the same conclusion was obtained by Ouédraogo *et al.* (2001) and Bulluck *et al.* (2002) who mentioned that CEC was higher in soil with organic manuring compared to that received chemical fertilizers. Walker *et al.* (2004) also indicated that the OM act as nutrient pool, improves nutrient cycling, increased CEC and buffering capacity of treated soil. Recently, Weber *et al.* (2007) stated that soil CEC indicated a vital increase with increasing amount of compost.

Soil organic carbon (SOC)

As that expected the application of the two types of compost markedly increased the SOC and consequently total content of SOM (Table 3). These increases in both soil constituents were in parallel to the increase in rate of organic manure application under the two crops whereas the increases up to the NPK fertilization were not appreciable and could deduced to existence of plant root residues after harvesting both crops. However, these large increases in soil SOC and SOM could be attributed to the high content of both determinants in the two types of compost (35.74 % and 61.47 in RSC and 24.75 and 42.19 % in MSWC). These data are in accordance with those obtained by Bulluck & Ristiano (2002) and Abdelhamid *et al.* (2004) who demonstrated that the use of recycled organic wastes as alternative soil amendments increased soil SOC and SOM content.

Available macronutrients

The application of the two types of compost RSC and MSWC enriched soil with large quantities of organic forms of macronutrients which slowly released in the mineral forms by the act of the soil microorganisms through mineralization process. Under both vegetable crops, it was observed that different increases were detected in soil available N and P (Table 3). These increases were magnified by increasing the compost application rates. It was also observed that the increases in available N were more pronounced in case of fertilization with RSC compared to the MSWC at all rates of application under the two crops. Whereas the mineral fertilization with NPK resulted in slight decreases in the available forms of the elements compared to the initial soil. On the other hand, K was the only element decreased through the experiment may be due to the consumption of K through plant uptake. The data are in agreement with those obtained by Wong *et al.* (1999) who indicated that soluble NH_4^+, NO_3^- and PO_4^{3-} in amended loamy soil increased significantly according to compost application rates due to the abundant of macronutrients in the compost. Also Ouédraogo *et al.* (2001) mentioned that, at harvest the nutrient content increased in all plots amended with compost particularly those received the large rate of compost application. Bulluck *et al.* (2002) and Odongo *et al.* (2006) suggested that compost increased P availability and had a positive effect on plant growth. Ultimately, Weber *et al.* (2007) reported that mineralization of SOM in added compost leads to stepwise release in nutrient elements especially N.

Generally, it is worthy to state that, although compost contains a considerable quantity of macro- and micro-elements, the nutrient available content is lower than commonly used chemical fertilizers. And although N and P content of compost are higher than most agricultural soils, the availability of these nutrients is often slow process. The rate of microbial mineralization and release of available N from the structural forms in the compost depend on the local climate and soil type. In warm climate, mineralization process is very high; therefore, plant response to compost nitrogen is much faster than in cold climate.

Soil available micronutrients and heavy metals

The present data revealed that fertilization with the two types of compost (RSC and MSWC) at different rates as well as mineral fertilization positively affected soil available micronutrients (Cu, Fe, Mn and Zn) after cultivation of both bean and peas crops compared to its concentration in the initial soil. The data also showed that the increase in soil available content of micronutrients differed influenced by the fertilization type (mineral or organic). Since the organic fertilization with both RSC and MSWC gave a higher micronutrients content in soil compared to NPK treatment in bean and peas experiments (Table 4). Similar results were found by Wei & Liu (2005) who reported that NPK application produce little effect on the accumulation of Cu and Zn in soil compared to untreated control, whereas the application of compost at rate of 150 ton ha^{-1} resulted in a significant increase of Cu and Zn in the surface soil (0-20 cm). They added that, heavy metal accumulation in soil depends on the original content of heavy metals in compost, so more attention should by paid to the fact that the compost application enhanced the heavy metals accumulation.

Data also shown that, the soil available content of micronutrients increased with the increase in the compost application rate for both RSC and MSWC after harvesting of bean and peas crops. In general, MSWC provided the highest concentration of micronutrients at different rates of application in both bean and peas experiments compared to RSC except Mn which its content was higher in RSC than MSWC. The higher values of Cu, Fe and Zn occurred with MSWC could be owing to its higher content than RSC. There were little differences between the three rates of application with both compost types. In general, the highest available micronutrient content occurred with the highest rate of compost application under bean and peas crops. Similar results were cited by many authors. Wong *et al.* (1999) indicated that, DTPA-extracted Cu, Mn and Zn showed increased trend in concentration as the amendment rate increased (10, 25, 50,75 ton ha^{-1}). Baldwin & Shelton (1999) reported that, Zn and Cu linearly related to the application rate of both municipal solid waste and waste water biosolids compost. The same results were reported by Karaca (2004); Wei & Liu (2005) and Weber *et al.* (2007) who indicated that, Zn and Cu increased with increasing application rate of different composted materials.

TABLE 4. Soil available micronutrients and heavy metals "mg kg^{-1}" after harvesting of bean and pea crops.

Treatments	mg kg^{-1}						
	Micronutrient				Heavy metals		
	Cu	Fe	Mn	Zn	Cd	Ni	Pb
Initial soil	0.98	3.26	4.37	1.23	0.012	0.019	0.49
Bean crop							
NPK	2.96	5.91	8.73	1.49	0.010	0.33	0.92
RSC10	5.08	8.53	25.60	2.17	0.016	0.83	2.53
RSC15	5.23	9.31	26.12	3.34	0.021	0.92	3.03
RSC 20	5.92	10.06	27.31	4.66	0.022	0.99	3.42
MSWC10	5.73	13.72	23.86	2.58	0.070	1.12	4.76
MSWC15	6.14	14.95	24.91	4.01	0.110	1.19	4.83
MSWC 20	6.87	16.08	25.42	5.93	0.120	1.20	4.99
Peas crop							
NPK	2.81	5.62	8.31	1.41	0.011	0.32	0.93
RSC10	3.72	8.23	24.70	2.01	0.014	0.69	2.31
RSC15	4.01	9.15	25.34	3.21	0.017	0.81	2.78
RSC 20	4.60	9.98	26.12	4.56	0.020	0.89	3.11
MSWC10	5.46	13.34	23.10	2.35	0.070	1.00	4.62
MSWC15	5.91	14.72	24.23	3.83	0.080	1.09	4.71
MSWC 20	6.52	15.30	24.90	5.77	0.100	1.13	4.80
Critical limits	0.20	2.80	2.00	0.80	*0.01-0.7	*2.0-50	*0.1-20

* The normal values in soil (Gray, 1992).

The data revealed a slight graduated increase in Cd concentration due to the application of the three successive rates of RSC (10, 15 and 20 ton fed^{-1}) in both bean and pea crops compared to the initial soil content. On the other hand, the addition of MSWC gradually increased Cd content which reached 10.0 and 8.3 folds, respectively for bean and pea crops at the highest rate of application compared to the initial soil. These results are in agreement with those obtained by Weber *et al.* (2007) who demonstrated that, Cd concentration increased from 1.0 to 1.3 mg kg^{-1} with increasing compost application rate from 30 to 120 ton ha^{-1}.

The data exhibited also that, continuous increase in Ni and Pb concentration in soil was detected after cultivation of bean and pea crops with the increase in the application rates irrespective to the compost type. On the other hand, NPK fertilization revealed a mild increase in Ni and Pb soil available content after harvesting of both bean and pea crops because of containing of the commercial mineral fertilizers on such these elements as contaminants.

It should be mentioned that, these increases in the heavy metals in case of NPK fertilization were always lower than those obtained with organic manuring even if compared to the lowest rate of composting. As a general trend, the application of the two types of compost increased heavy metals content in soil. These findings are in accordance with those found by Karaca (2004) who indicated that, compost application increased soil available Ni. Also, Weber *et al.* (2007) demonstrated that, increasing compost application rate increased Ni and Pb in soil compared to the control (untreated) and NPK treatment.

With respect to heavy metals content of soil and because of organic manuring adopted farmers are concerning about heavy metals availability, particularly after using MSWC, this investigation is also took in consideration the accumulation of these elements in soil after compost amendments. It is worthy to mention that, the high pH values in most Egyptian soils renders these heavy metals to unavailable form and reduce too much extent its absorption by plant roots (Walker *et al.*, 2003).

It is worthy to mention that, the beneficial effects of compost on crop production and soil properties are directly related to the application rate of manure compost. Therefore, it is desirable to provide data and guidelines on the agronomic utilization of manure compost generated in Egypt.

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خصائص الأرض بعد زراعة محاصيل الخضر المعاملة بالكمبوست

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أجريت تجربتين حقليتين فى مزرعة كلية الزراعة، جامعة كفر الشيخ خلال موسمى ٢٠٠٤ و٢٠٠٥ لزراعة محصولى خضار (فاصوليا فى الموسم الصيفى لعام ٢٠٠٤ و البسلة فى الموسم الشتوى لعام ٢٠٠٥).

تم استخدام نوعى السماد العضوى الناتجين من معالجة المخلفات (كمبوست قش الأرزRSC وقمامة المدن MSWC) بثلاثة معدلات مختلفة لكل منهما (١٠، ١٥ و ٢٠ طن / فدان) بالإضافة إلى معاملة التسميد المعدنى بالمعدلات الموصى بها. والقطع التجريبية التى تم معاملتها بالأسمدة العضوية تم تلقيحها ببعض الميكروبات التى تلعب دوراً هاماً فى عملية التسميد الحيوى *Azotobacter chroococcum* (*Azospirillum lipoferum* و *Bacillus, megatheriu*) وكذلك تم تلقيح البذور قبل الزراعة بالريزوبيا الخاصة بكل محصول بالإضافة إلى التلقيح بلقاح من فطريات الميكوريزا.

أتبع تصميم القطع التجريبية كاملة العشوائية فى توزيع المعاملات فى أربعة مكررات لكل معاملة. وأجريت العمليات الزراعية حسب التوصيات الخاصة بكل محصول. وتم اخذ عينات تربة ممثلة لكل قطعة تجريبية قبل وبعد الزراعة لكل محصول لإجراء التحاليل الكيماوية والميكروبيولوجية وتم اخذ عينة تربة ثالثة من كل معاملة عند الإزهار لإجراء التحاليل الميكروبيولوجية.

الخواص الميكروبيولوجية والكيماوية للأرض بعد زراعة محصولى الفاصوليا والبسلة

أ- المحتوي الميكروبي

١. أدى التسميد العضوى بمعدلات مختلفة إلى زيادة أعداد الميكروبات فى التربة مقارنة بالتسميد المعدنى عند مراحل النمو المختلفة لكلا المحصولين وتناسبت هذه الزيادات مع زيادة معدل التسميد العضوى كما أدت إلى زيادة نسبة إصابة جذور الفاصوليا والبسلة بفطريات الميكوريزا.

٢. الكتلة الحية والتى شملت أعداد البكتريا، الفطريات، الاكتينوميسيتات، الميكروبات المذيبة للفسفور، الازوتوبكتر، الازوسبيرلم و الريزوبيا، وصلت أقصى معدلاتها فى مرحلة الإزهار لكلا المحصولين.

٣. اتجهت أعداد الميكروبات إلى الانخفاض بعد نضج المحصولين ولكن أعدادها ظلت أعلى منها قبل الزراعة.

ب- الخواص الكيميائية والمحتوي من العناصر

١. أدت جميع المعاملات إلى زيادة فى OM%،OC%، CEC%، EC% مع انخفاض بسيط فى قيم pH فى عينات الأرض بعد كلا المحصولين و كانت الزيادة السابقة متوازية مع الزيادة فى معدل إضافة نوعى السماد العضوى.

٢. أدى التسميد العضوى إلى زيادة التركيزات الميسرة من العناصر الكبرى والصغرى والعناصر الثقيلة بالأرض بعد كلا المحصولين وكانت تركيزات هذه العناصر فى التربة تزيد بزيادة معدل الإضافة لكل من RSC وMSWC. وكانت الزيادة فى محتوى الأرض من العناصر الكبرى أوضح مع سماد قش الأرز عنها مع سماد قمامة المدن والعكس بالنسبة للعناصر الصغرى والثقيلة.