EFFECT OF COMPOST ON POLLUTION PROBABILITY AND RATIONALIZATION OF IRRIGATION WATER

E. I. Gaber
Dept. of Natural Resources, Inst. of African Research and Studies, Cairo Univ. Giza, Egypt.

(Received: Mar. 23 , 2008)

ABSTRACT: **Filed experiment was carried out in 2005 at El Nubaria Agricultural research station in El Behera Governorate, to study the effect of banana compost and their combination with mineral fertilizers on sandy calcareous soil content of Ni, Cd and Pb as well as its hydro-physical properties and reducing pollution of corn plants. In the same plots, bean was planted to evaluate the residual effect of treatments. The experiment included three main plots [60% (I_3), 80%(I_2) and 100% (I_1) of full water requirement] and six fertilization treatments [150% compost (F_1), 100% compost (F_2), 75% compost + 25% NPK (F_3), 50% compost + 50% NPK (F_4), full recommended NPK (F_5) and control (F_0)]. Results indicated that, about 20% of irrigation water can be saved if farmers applied 80% of full water requirement to corn plants. Also, corn grain yield increased with increasing mineral fertilizer rate in contrast of bean yield which increase with raising compost level. Under low amount of water, application of (75% compost + 25% NPK) increased water use efficiency (WUE) of corn yield than (50% compost + 50% NPK). Cadmium and nickel concentrations in green leaves, ear leaf, corn grains and bean seeds increased with decreasing water doses. No clear relationship was observed between Pb concentration in responsive plant parts and irrigation treatments. In general, replacing compost instead of mineral fertilizers reduce concentration of Ni, Cd and Pb in corn and bean tissues. All plots treated with lower water dose produced higher available heavy metals. There are positive increase in extractable Cd, Ni and Pb due to application of mineral fertilizers in comparison with those obtained when compost was added. Application of compost decreased soil bulk density (BD) and increased total porosity, water holding pores, total soil aggregates and aggregation index, subsequently increased field capacity and available water.**

Key Words: **Compost – Pollution – Irrigation.**

INTRODUCTION

Sustainable production of safe food for human consumption is of great importance. Use of organic fertilizers serve in this context. Banana residues are available in abundance and it is difficult to dispose. Egypt produce 216000 of banana dry matter residues. Our attention directed to the sustainable use of these renewable residues beneficially as a compost and

promising alternative for nutrient recycling. So, use of organic by products as soil amendments in agricultural production exemplifies a strategy for converting wastes to resources.

Although intensive crop cultivation requires the use of chemical fertilizers, but they may be expensive and have some harmful effects on the environment (Abdel Moez 2001; Nesme *et al*., 2004; Fan *et al*., 2005 and Abdul Khaliq *et al.,* 2006). Both farmyard and chicken manures have been traditionally applied as a fertilizer of slowly released nutrients, for some crops (Khalil *et al*., 2004) and to improve the physico-chemical soil properties (Abdel-Sabour *et al*., 1999). Applying organic matter (OM) amendments to cropland reduces requirements for synthetic fertilizer (Singer *et al*., 2004 and Noufal *et al*., 2005).

Amending soil with composted swine manure can increase corn and soybean yields, but no difference was observed after only one compost application (Singer *et al*., 2004). The compost treatments produced comparable above ground biomasses (green pepper) more than mineral fertilizers and control (Lobo *et al*., 2006). Plant growth and yield were reduced in all treatments in the absence of inorganic fertilizer. However, all coapplication treatments resulted in similar yields to NPK fertilizer alone in both field and glasshouse experiments (Roberts *et al*., 2007). Organic matter, the biomass and height of test plants pointed distinctly to better and faster degradation within the plots treated with compost compared to the untreated ones (Illmer *et al*., 2007).

El-Naggar (1996) mentioned that although organic residues is beneficial to crops as a source of essential nutrients, they are also considered serious sources of non-essential metals i.e Cd, Pb and Ni. So application of organic residues represent a limiting factor because of the excessive accumulation of heavy metals in soils resulting in metal uptake and phytotoxicity for plants. Cox *et al*., (2001) reported that barley grain trace element uptake, barley yield, and pea yield were uninfluenced by amendments (compost, coal ash, wheat straw, three rates of inorganic N and a control) although plots receiving N fertilizer yielded significantly higher than plots not receiving N. Murakami *et al*., (2005) concluded that rice plants absorbed not only exchangeable Cd, but also organic matter–bound Cd. On contrast, maize plants could absorb exchangeable Cd, but not OM-bound Cd. Chiu *et al*., (2006) revealed that plant tissue analysis showed that application of manure compost and sewage sludge could significantly reduce Pb uptake and accumulation.

Eghball, *et al*., (2002) reported that residual effects of manure or compost application can maintain crop yield level for several years after application. Only a fraction of the N and other nutrients in manure or compost become plant available in the first year after application. Eghball, *et al*., (2004) reported that residual effects of N- or P-based manure and compost application increased corn yield and N uptake for one year and influenced

soil properties for several years. Ginting *et al*., (2003) found that the residual effects of organic materials on soil properties can contribute to improvement in soil quality for several years after application ceases.

Joshi and Luthra (2000) noticed that sewage sludge composted with poultry manure at 1 : 3 ratio minimized the heavy metals enrichment and their availability in soil. Chiu *et al*., (2006) revealed that, applications of manure compost or sewage sludge decreased DTPA-extractable Pb. Xial *et al*., (2007) reported that the concentrations of Cd, and Pb in all the compost amended media were below the limit of the drinking water standards.

Negm *et al*., (2004) compared between compost (4 and 8 ton/fed.) and farmyard manure (FYM). There were real increases in soil-water relationships with manuring such as total porosity (TP), water holding capacity (WHC), field capacity (FC) and available water (AW) and decreasing in bulk density (BD) and quickly drainable pores (QDP).The rate of 8 ton/fed. of compost was as the same effect as FYM on TP, WHC and BD. Medina *et al*., (2004) concluded that the application of organic amendments to the soil increased aggregate stability. Noufal *et al*., (2005) summarized that soil water content at FC, WP as well as AW contents were increased due to addition of organic materials.

Fan *et al*., (2005) suggested that long-term additions of organic materials could increase WHC that, in return, improves water availability to plants and arrests grain yield declines, and sustains productivity.

Newman *et al*., (2005) indicated that either total carbon (TC) or particulate organic matter carbon (POM-C) explained greater than 50% of the variation in AW in years 2 through 4, indicating the functional similarities between the two carbon pools.

Lobo *et al*., (2006) found that no differences were found between the two irrigation doses (100 and 80% of FC) under all compost treatments. The compost treatments were also most efficient with regard to amount of water needed to produce one unit of biomass. Liu and Zhang (2007) summarized that, as water supply increased, WUE reached its maximum before yield did. Yield response to water and fertilizer inputs followed a quadratic function with a positive interactive term.

The aim of this research is to study the effect of banana compost as a bio-organic fertilizer on soil properties, yield of corn and bean in combination with inorganic fertilizers and irrigation doses. Residual effect of compost on bean production was also evaluated.

MATERIALS AND METHODS

Field experiments were conducted at El Nubaria Agricultural Research Station in El Behera Governorate, National Research Center, during two successive seasons started in 2005/2006 and lasted in 2006/2007. Corn grains and bean seeds were drilled on May 15^{th} and November 23, but the crops were harvested on 12 September and 22 March, respectively. This

investigation was conducted to study the possibility of composting banana plants residues and evaluate the effect of compost and their combined with mineral fertilizers applied to sandy calcareous soil on soil chemical and physical properties as well as the growth, yield and yield components and some chemical characteristics of corn plants. Under the same treatments of organic and chemical fertilizers additions, bean was planted to evaluate the residual effect of the previous additions. Maize cultivar Single cross 129 (white) and bean cultivar Nubaria 1 were obtained from Ministry of Agriculture, Giza, Egypt. The experiment included the following treatments:

A) water supply treatments

Irrigation treatments	Corn (m^3/fed.)	Bean (m^3/fed.)
I_1 (100% of WR)	3300.4	960.9
I_2 (80% of WR)	2640.3	768.8
I_3 (60% of WR)	1980.2	573.5

WR= water requirement based on Penman Monteith (Allen *et al*., 1998).

B) fertilizer treatments involved

1) F_0 (control)
2) F_1 (150% compost)
3) F_2 (100% compost = 9.76 and 10.90 ton/fed. for first and second season, respectively)
4) F_3 (75% compost + 25% NPK)
5) F_4 (50% compost + 50% NPK)
6) F_5 (full recommended NPK)

Three main plots representing irrigation treatments were separated by 2m. Each main plot contain 18 subplot (3 replicates x 6 fertilizers treatments). The subplot area was 10.5m^2. Plots replicated three times in 2-Way Randomized Block design.

Organic amendments application rates were based on the total N content of the materials and followed the recommendations for fertilization of corn plants in Egyptian new reclaimed soils. Recommended doses of chemical fertilizers (120 kg N/fed. as ammonium sulfate + 30 kg P_2O_5/fed. as super phosphate + 24 kg K_2O/fed.) are considered as 100% chemical fertilizers. Chemical composition of the used fertilizers are given in Table (1). Prepared banana compost, phosphorus, Potassium fertilizers were added before sowing. Nitrogen fertilizer was added in three equal doses: before cultivation, after two weeks and five weeks from cultivation. Drip irrigation system with 50cm spaced emitters and a flow rate of 4 L h^{-1} was used with three days irrigation interval.

Water use efficiency was calculated for each treatment using the following formula:

$$\text{WUE}= \frac{\text{Grain yield (ears or pods as kg/fed.)}}{\text{Total water applied } (m^3/\text{fed.})} = \text{kg}(m^3)^{-1}$$

Table (1): The chemical composition of used fertilizers.

Chemical fertilizer	N (%)	P_2O_5 (%)	K_2O (%)	Ni (μgg^{-1})	Cd (μgg^{-1})	Pb (μgg^{-1})
Ammonium sulfate	20.6	-	-	22.32	14.8	39.44
Super phosphate	-	15.0	-	24.20	17.6	12.35
Potassium sulfate	-	-	48	13.02	11.6	113.39

Compost preparation

Residues of banana were grinded in a pile and mixed with rabbit manure at a rate of 3:1 to obtain a compost rich in nutrients content and narrow in C/N ratio. Each layer of the pile was slightly moistened to reach about 60% of its water holding capacity. The pile was turned every week to enhance aeration.

Effective microorganisms (EM) was applied to compost during preparation. A mixed culture of beneficial microorganisms including a predominant population of (*Bacillus subtilis* F.50, F.30), (*B. Theremogensid* F.64), (*Trichoderma reesei* F.418) and yeast (*Sacchromyces cerevisiae* F N.10) was used. EM was brought from Biotechnology Unit, Microbial Chemistry Dept., National Research Center. Some properties of prepared compost are given in Table (2).

Soil samples:

Soil samples were collected from the surface layer (0-15 cm) for all plots at different times

1- after harvest corn in first season (first sample)
2- after harvest bean in first season (second sample)
3- after harvest corn in second season (third sample)
4- after harvest bean in second season (fourth sample)

These soil samples and those of initial soil were air-dried, crushed, sieved through 2mm sieve and analyzed for physical and chemical characteristics as follows: 1) Particle size distribution, according to (Klute 1986). 2) Total carbonates, following Page *et al*., (1982). 3) Soil pH, organic matter and EC were measured according to Page *et al*., (1982). 4) Soluble cations and anions were determined according to Page *et al*., (1982). 5) Available phosphorus was estimated colourmetrically, according to Watanabe and Olsen (1965). 6) Available K and extracted heavy metals (Ni, Cd, Pb) were extracted with "NH_4HCO_3-DTPA" according to Soltanpour (1985) and determined by using atomic absorption spectrophotometer apparatus Perkin Elemer, Model 2308. 7) Soil bulk density (P_b) and particles density (P_p) were determined according to Klute (1986). 8) Soil moisture retention curves were determined by using pressure membrane (Stakman and Hast, 1962). 9) The pore spaces are classified by Deleenher and De Boodt (1965). 10) Dry sieving

Table 2

stability was determined according to Klute (1986). 11) Wet sieving stability was determined by using the wet sieving technique described by Klute (1986). Some physical and chemical properties of the used initial soil are given in Table (3).

Table (3): Some physical and chemical properties of the studied soils.

Characteristics	Value
pH (1 : 2.5 soil : water ratio)	8.11
EC (Soil paste extraction) dSm^{-1}	1.32
<u>Soluble cations (m.e./L):</u>	
Calcium	4.8
Magnesium	1.2
Potassium	6.9
Sodium	0.6
<u>Soluble anions (m.e./L):</u>	
Bicarbonate	2.2
Chloride	7.7
Sulphate	3.6
<u>Available nutrients (mg/kg):</u>	
Phosphorus	7.90
Potassium	186.63
<u>Extracted elements (mg/kg):</u>	
Nickel	0.37
Cadmium	0.156
Lead	0.592
<u>Physical properties (%):</u>	
Organic matter	0.47
Calcium carbonate	24.9
Sand	68.91
Silt	16.57
Clay	14.52
Textural class	Sandy loam

Plant analysis:

The crops were harvested at physiological maturity and yields recorded. Corn grains and bean seeds were dried in an oven at 70 ^0C, ground and wet-digested with di-acid mixtures as described by Chapman and Pratt (1978). The digested aliquot was analyzed for macronutrients (N, P and K) and heavy metals (Ni, Cd and Pb) content as described by Cottenie *et al*., (1982).

Statistical analysis:

All obtained data from this study were statistically analyzed through analysis of variance (ANOVA) and least significant difference (LSD) at 0.05 probability level to make comparisons among treatment means according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Corn grain and bean seeds yield (ton/fed.)

Concerning of corn grain yield, it is clear from the results in Table (4) that I_2 treatment (80% of full water requirement) is considered the best water treatment. It gave 1.368 and 2.029 ton/fed. in first and second season, respectively. Furthermore, about 20% of irrigation water can be saved if farmers follow this practice. The enhanced grain yield with I_2 may be interpreted by 1) the more efficiency of nutrients in soil treated with I_2 compared with the others. 2) this amount of water more suitable to exporting the dry matter content to grains resulting more grain filling and weight as well as grain yield. 3) improving soil chemical and biological properties. 4) decreasing nutrient losses by leaching. 5) good aeration associated with moderate application of irrigation water. The low amount of nutrients mineralized in the compost plots may explain the low grain yield in spite of improved soil physical properties and increased availability of micronutrients. These results are consistent with the findings of Cox *et al*., (2001), Rizk (1997), Verma and Singh (1997), Badran (2001), Abou El Magd *et al*., (2004), Yang *et al*., (2005) and Fan *et al*., (2005). Generally, grain yield in the second season is greater than that in first season by 1.5 time. It is also clear that the increase in corn grain yield as an average of the two seasons reached 2.45, 1.98, 2.97, 3.34 and 4.23 times that of control (F_0) for F_1, F_2, F_3, F_4 and F_5, respectively.

As for seeds yield of bean plants, data revealed that, reducing water application rate from 100% Etc (I_1 = 960.9 m^3/fed.) to 80% Etc (I_2=768.8 m^3/fed.), seed yield reduced by 54.74%, while the yield reduced by 28.38% when reducing water application rate from 80% Etc to 60% Etc (I_3=573.5 m^3/fed.). Seeds yield was significantly increased by using compost as compared with control in the two seasons. The lowest values were obtained with control followed by full recommended dose of mineral fertilizer. But the highest yield in the first and second seasons was recorded by applying 150% compost (F_1). Khalil *et al*., (2000) found that addition of compost increased dry matter yield of corn plants in sandy soil. Earlier studies of Badran (2001), Eghball *et al*., (2002) and Eghball *et al*., (2004) also showed that residual effect of compost application can maintain crop yield level for several years after application.

Table (4): Corn and bean yield (ton/fed.) in two growing seasons as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	Corn grains				Bean seeds			
	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
First season								
F_0	0.472	0.580	0.279	0.444	0.545	0.318	0.219	0.361
F_1	1.017	1.167	1.025	1.070	4.270	2.869	2.132	3.090
F_2	0.714	1.002	0.695	0.803	2.642	1.753	1.218	1.871
F_3	1.203	1.414	1.405	1.340	2.378	1.229	1.041	1.549
F_4	1.507	1.908	1.247	1.554	1.413	1.030	0.879	1.107
F_5	1.872	2.136	1.622	1.877	1.183	0.835	0.769	0.929
Mean	1.131	1.368	1.045		2.072	1.339	1.043	
$LSD_{0.05}$	I=0.099	F=0.140	IxF=0.242		I=0.08	F=0.11	IxF=0.19	
Second season								
F_0	0.809	0.853	0.325	0.662	0.699	0.526	0.239	0.488
F_1	1.805	1.990	1.170	1.655	4.270	3.411	2.956	3.546
F_2	1.619	1.659	0.981	1.420	3.136	2.985	1.388	2.503
F_3	2.130	2.221	1.452	1.934	2.687	2.679	1.123	2.164
F_4	2.371	2.512	1.448	2.110	1.828	1.809	0.924	1.520
F_5	3.094	2.936	2.366	2.799	0.904	1.393	0.806	1.034
Mean	1.971	2.029	1.290		2.254	2.134	1.240	
$LSD_{0.05}$	I=0.165	F=0.233	IxF=ns		I=0.12	F=0.17	IxF=0.29	

Water use efficiency (WUE) of corn and bean yields as affected by fertilization treatments and their interaction under different irrigation levels.

Water use efficiency presented in Table (5) defined as biomass accumulation over water consumed. Values of WUE were greater at lower than at higher water rates for corn and bean yields in the two growing seasons. These results emphasized that low yields due to water stress didn’t concomitant to low WUE values, and the increase in WUE didn’t refer to suitable or high amount of water. This may be due to 1) Mathematically, WUE calculated as yield (kg/fed.)/total water applied (m^3/fed.), hence increasing water amount tend to raise the denominator, subsequently decrease the net result. 2) As for viewpoint of plant nutrition the plant response to first application unit (water or fertilizer) higher than that after adding second unit. These finding are consistent with the results of Zhang and Yang (2005). Concerning the effect of fertilization treatments irrespective of irrigation levels, data revealed that WUE of corn and bean followed the same order of corn and bean yield whereas increased gradually with increasing mineral fertilizers amount. Treating sandy soil with examined compost led to an increase in WUE by bean plants. With respect to adding I_1 or I_2 doses to corn yield in the two seasons, WUE values increased gradually in the order: F_5> F_4> F_3> F_1> F_2> F_0, but with adding I_3 level arranged in the order F_5> F_3> F_4> F_1> F_2> F_0. This mean that under low amount of water, application of (75% compost + 25% NPK) was higher than applied (50% compost + 50% NPK). These results are in close agreement with Fan *et al*., (2005) who hypothesized that perhaps the WUE of manure + NP treatment would increase with time as soil organic matter increased.

Table (5): Water use efficiency (WUE) for corn and bean yield in two growing seasons as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	Corn				Bean			
	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
First season								
F_0	0.318	0.398	0.318	0.345	2.51	2.86	2.29	2.55
F_1	0.594	0.795	1.025	0.805	12.94	13.49	12.98	13.14
F_2	0.509	0.716	0.707	0.644	8.99	12.24	11.75	10.99
F_3	0.806	1.113	1.414	1.111	7.68	8.06	9.57	8.43
F_4	0.848	1.299	1.096	1.081	6.26	7.00	9.56	7.61
F_5	1.018	1.299	1.591	1.303	6.04	6.85	8.18	7.02
Mean	0.682	0.937	1.025		7.802	8.418	9.055	
$LSD_{0.05}$	I=0.062	F=0.088	IxF=0.152		I=0.754	F=1.067	IxF=ns	
Second season								
F_0	0.472	0.594	0.636	0.657	2.14	2.34	2.11	2.20
F_1	0.891	1.379	1.166	1.145	12.83	14.01	17.93	14.92
F_2	0.870	1.310	0.884	1.021	11.58	13.11	14.46	13.05
F_3	0.993	1.426	1.555	1.325	9.44	10.05	11.36	10.28
F_4	1.294	1.511	1.343	1.383	8.76	7.09	9.80	8.55
F_5	1.561	2.185	2.510	2.085	2.87	5.44	7.06	5.12
Mean	1.058	1.401	1.349		7.94	8.67	10.45	
$LSD_{0.05}$	I=0.106	F=0.150	IxF=0.259		I=0.664	F=0.940	IxF=1.627	

Water use efficiency values were relatively higher in the second year than those in the first one for the two crops corn and bean. Values ranged from 0.318 to 1.591 and from 0.472 to 2.51 kg/m^3 for corn in the first and second season, respectively. For bean, WUE values ranged from 2.51 to 13.49 kg/m^3 and from 2.11 to 17.93 kg/m^3 in the two seasons, respectively.

Heavy metals concentrations and uptake by corn and bean plants during two seasons.

Determination of trace and heavy metals concentrations in yield is one step towards evaluating its potential health or ecological hazard.

Cadmium

Data in Table (6) focused on cadmium concentration (µgg^{-1}) in responsive corn and bean parts as affected by irrigation and fertilization treatments in the two growing seasons. Generally, in second year the amount of Cd in plant tissues could not be sufficient to detect. This may contributed to that cadmium occurs naturally in all soils but with very small amount. Most of Cd removed from cultivated soil by crop uptake and harvest at first time. Also, this could be attributed the dilution effect because the growth of growing plants in the second season was higher than those obtained in the first one, or due to that, corn and bean plants could absorb exchangeable Cd but not OM-bound Cd as concluded by Murakami *et al*., (2005). Cadmium concentration of green leaves affected significantly with increasing water amount. Although I_3 gave the same average concentration as I_2 (1.052 µgg^{-1}), but Cd concentration in both I_3 and I_2 increased than I_1 by 85.87%. As for ear leaf, also I_3 was the highest one with significant difference, but no significant difference between I_1 and I_2. Corn grains took the same line of ear leaf, while Cd concentration in bean seeds as affected by irrigation levels follow the order $I_3 > I_2 > I_1$. This may also explained by dilution effect, whereas the bean yield follow the order $I_1 > I_2 > I_3$ as mentioned before. With regard to fertilization doses and their effect on Cd concentrations in all samples, it can be noted that, Cd concentration of green leaves, ear leaf, corn and bean yields increased with increasing mineral fertilizer. This is logic trend because total Cd content in compost material not detected as shown in Table (2) but mineral fertilizer contain substantial amount of Cd element, especially super phosphate. Also this refers to Cd ions may associated with humified and less soluble organic materials such as humic and fulvic acids which possess strongest Cd-binding groups as reported by Kaschl *et al*., (2002). Cadmium concentration in green leaves and ear leaf samples was higher than those in corn grain. Although Cd accumulated to high concentration in leaves, it is slowly transported to grains. In this respect, El-Naggar (1996) and De Pieri et al., (1996) reported that high accumulation of heavy metals are in leaves than edible parts of plants. As evidenced in these results, residual effect of

Table 6

applied 150 and 100% of compost under I_1 irrigation dose not detect in bean seeds. The reasons for that, 1) Cd under these conditions was low because this amount of water may dissolve some of $CaCO_3$ which precipitate Cd ions. Hammer and Keller (2002) summarized that in calcareous soil whereas only a small amount of Cd was taken up by *T. caerulescens* (Phytoremediation plant) and this came mainly from the carbonate-bound fraction, 2) Bean growth and yield were high. 3) Rather it is likely that, compost burning during the seasons of cultivation increased the amount of effective groups which blocked with Cd ion, similar trend was obtained by Joshi and Luthra (2000).

It is obvious from the data that the lowest Cd concentration was obtained with 150% or 100% compost and 80% of water treatments. While the highest values obtained by using 100% NPK and 60% of water requirement.

Nickel

Irrigation level (I_3) recorded significant increase in Ni concentration than I_1 and I_2 in all cases, except ear leaf and corn grain in the second season, where the differences among all irrigation treatments were not significant (Table 7). The middle irrigation dose (I_2) set between I_1 and I_3. Fertilization treatment exert a significant effect on Ni concentration in all parts of plants during the two growing seasons. Adding mineral fertilizers alone increased Ni concentration in plant tissue, while the reverse was true for compost. Organic application had a promising effect on reducing Ni concentration. This advantage could be based on, firstly organic compost has a high capacity to adsorbs and binds heavy metals subsequently keeping them out of the soil solution and not easy to be taken up by plants and secondly addition of compost increase biological activity and encourage bacteria multiplication. Some of this bacteria able to dissolve and adsorb toxic heavy metals, finally the bacteria were added during compost preparation especially *Bacillus suptilies* possess the ability to absorb heavy metals and fixed them in their bodies. Generally, these results are in harmony with those obtained by many investigators: El-Kassas (1999), Sauve *et al*., (2000), Cooperband (2002) and Somasundaran *et al*., (1998). Although Ni accumulation in leaves was high but it is much slowly translocated to corn grains or bean seeds.

Lead

Water irrigation doses significantly increased Pb concentration in green leaves at first season with no significant differences in the second season (Table 8). Leaf ear and corn grains took in the second year the same trend of green leaves whereas I_1 treatment plays an important role in dissolving soil lead, which much readily transported to the top of plants. But the lowest concentration of Pb was observed in I_3 treatment. Different trend found in ear leaf at first season whereas I_2 gave the highest concentration with

Table 7

Table 8

insignificant difference between I_2 and I_3. A contradict line was appear in corn grain at first season, I_3 and I_2 were higher than I_1. This direction related to available Pb in soil as shown in Table (11). Lead concentration in bean seeds increased as water amount decreased during the two years. The opposite of this trend occurred in yield of bean, subsequently Pb concentrated in the lowest yield. From this discussion, no clear relationship was observed between Pb concentration in responsive plant parts and irrigation treatments, and there is no data available to support this conjecture, whereas Pb behavior under various soil moisture content are not yet full known. With regard to effect of fertilization treatments, Pb concentrations in various plant tissues increased with increasing mineral fertilization dose. This could arise due to 1) mineral fertilizers can be an important source of pollution especially heavy metals. Joshi and Luthara (2000) reported that, one of prominent sources contributing to contamination of soil with heavy metal is using of fertilizer, 2) the precipitation of Pb was primarily through the fixation by compost. Sauve *et al*., (2000) showed that organic matter has a high capacity to adsorb Pb and concomitantly maintain a low free Pb^{+2} activity in solution. It is therefore, important to assess the adsorption capacity of natural materials and evaluate their potential to reduce toxicity. In contrast El-Naggar (1996) noted that organic residues is considered a serious sources of nonessential metals i.e. Ni, Cd and Pb. The present discrepancy among the investigators may be refer to 1) the type of organic materials and their chemical composition, 2) the application rate, 3) kind of plant and whether the edible part is the root, leaves or grains, some plants can change metal availability directly by uptake. Murakami *et al*., (2005) detected that, Milyang 23 (*Oryza sative L*, cultivar) assess the ability to absorb Cd from polluted soils. Other plants change metal availability indirectly by different mechanisms (e.g. exudation of complexing agents, respiration of roots etc.) as reported by Hammer and Keller (2002). 4) the region which were planted and it's physical and chemical properties, especially percentage of OM and $CaCO_3$.

Extracted heavy metals in soil after harvest corn and bean in the two growing seasons.

Cadmium

Statistical analysis of available Cd (mg/kg) listed in Table (9) revealed that, various irrigation levels did not affect significantly soil extracted Cd concentration after corn nor after bean at first season. All plots treated with lower water dose produced higher soil Cd. This trend is also true after corn and after bean at second season. The reason of that, low amount of water (I_3) sufficient to dissolve heavy metal but not competent to leach or remove this concentration from surface layer, while the reverse was true, for I_1

subsequently increased adsorption energy of Cd as showed by Murakami *et al*., (2005) who declared that, thermodynamically speaking, adsorption energy of Cd to soil surface increases exponentially with decreasing Cd concentration in soil solution. Irrespective of irrigation treatments, fertilizer applications affected significantly soil Cd in all samples. There are significant positive increase in extractable Cd due to application of mineral fertilizer in comparison with those obtained when compost was added. Several studies have shown that compost application decrease extracted heavy metals such as Zhang *et al*, (2004) who reported that incorporation of compost into the peat based media significantly decreased the proportions of extracted Cd, Ni and Pb.

Table (9): Extracted cadmium (mg/kg) in soil after harvest corn and bean plants in first and second season as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	After corn				After bean			
	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
First season								
F_0	0.084	0.075	0.152	0.104	0.100	0.112	0.120	0.111
F_1	0.112	0.112	0.045	0.090	0.112	0.096	0.088	0.099
F_2	0.112	0.079	0.067	0.086	0.084	0.084	0.072	0.080
F_3	0.147	0.119	0.072	0.112	0.112	0.124	0.088	0.108
F_4	0.159	0.207	0.147	0.171	0.112	0.136	0.135	0.128
F_5	0.168	0.236	0.187	0.197	0.191	0.200	0.224	0.205
Mean	0.130	0.138	0.112		0.118	0.125	0.121	
$LSD_{0.05}$	I=ns	F=0.04	IxF=0.06		I=ns	F=0.04	IxF=ns	
Second season								
F_0	0.040	0.044	0.064	0.049	0.037	0.040	0.060	0.046
F_1	0.084	0.080	0.064	0.076	0.064	0.078	0.064	0.069
F_2	0.092	0.090	0.096	0.093	0.084	0.083	0.088	0.085
F_3	0.098	0.109	0.132	0.113	0.096	0.088	0.121	0.102
F_4	0.120	0.150	0.148	0.139	0.096	0.136	0.139	0.124
F_5	0.136	0.167	0.178	0.160	0.112	0.152	0.160	0.141
Mean	0.095	0.107	0.114		0.082	0.096	0.105	
$LSD_{0.05}$	I=0.01	F=0.01	IxF=ns		I=0.01	F=0.01	IxF=0.02	

Extracted nickel

The results presented in Table (10) showed that with higher irrigation amounts extracted Ni values tended to be fall and any reduction in water dose result in significant increase in extractable Ni. In the first year, 20% and 40% reduction in irrigation water requirement resulted in 15.73 and 41.57% increase in extracted Ni for samples after first corn, respectively. As for residual effect of first compost application, insignificant difference was observed between I_1 and I_2 but I_3 raised extractable Ni by 48.53% compared with I_1 dose. Also, similar trend was observed after second corn, whereas no significant difference between I_1 and I_2, but I_3 raised Ni concentration by 27.62% compared with I_1 treatment. At the end of two years there were significant difference among the three irrigation levels, whereas I_3 and I_2 increased extracted Ni by 3.18 and 2.15 times compared with I_1 level. Generally, application of compost without chemical fertilizer led to significant decrease in extracted Ni in all samples except after bean at first year, whereas F_1 and F_2 treatments did not induce any significant effect in comparison with control treatment. The extractable Ni was increased as mineral fertilizer rate increased. These results are consistent with the findings of Zhang *et al*., (2004).

Table (10): Extractable nickel (mg/kg) in soil after harvest corn and bean plants in first and second season as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	After corn				After bean			
	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
First season								
F_0	0.317	0.167	0.335	0.273	0.204	0.205	0.168	0.192
F_1	0.260	0.112	0.298	0.223	0.112	0.152	0.354	0.206
F_2	0.112	0.100	0.260	0.157	0.094	0.149	0.335	0.193
F_3	0.298	0.223	0.446	0.322	0.260	0.186	0.410	0.285
F_4	0.242	0.526	0.447	0.405	0.353	0.260	0.420	0.344
F_5	0.372	0.726	0.484	0.527	0.409	0.409	0.446	0.421
Mean	0.267	0.309	0.378		0.239	0.227	0.355	
$LSD_{0.05}$	I=0.04	F=0.06	IxF=0.11		I=0.05	F=0.07	IxF=0.13	
Second season								
F_0	0.207	0.230	0.197	0.211	0.130	0.130	0.220	0.160
F_1	0.140	0.150	0.167	0.152	0.020	0.100	0.140	0.087
F_2	0.130	0.140	0.180	0.150	0.030	0.100	0.130	0.087
F_3	0.180	0.140	0.230	0.183	0.050	0.130	0.230	0.137
F_4	0.200	0.150	0.280	0.210	0.067	0.160	0.250	0.159
F_5	0.230	0.210	0.330	0.257	0.100	0.230	0.290	0.207
Mean	0.181	0.170	0.231		0.066	0.142	0.210	
$LSD_{0.05}$	I=0.04	F=0.06	IxF=ns		I=0.03	F=0.04	IxF=ns	

Extracted lead

Data in Table (11) showed that, all plots treated with high amount of irrigation water produced lower soil Pb and any reduction in water quantity resulted in significant increase in extracted Pb by the order $I_3>I_2>I_1$. This trend was found after harvest of four yields. Fertilization mixtures application affected significantly extracted lead in first, second and fourth samples, but insignificant difference obtained with third sample. After the first year all values of extracted Pb increased than those in initial sample (0.592 ppm). This may be refer to 1) In beginning of organic decomposition, organic acids dissolved and released Pb from unavailable pool to available pool. 2) In first year, the stable component like humic and fulvic acids haven't been created yet, but in the second year Pb may be tightly bound by large humic molecules and humin, thereby increasing the capacity of the soil to adsorb Pb, as detected for Cd by Kaschl *et al*., (2002). Also Cooperband (2002) showed that, well-decomposed organic matter buffers the soil from rapid changes in soil pH, it also reduces the negative environmental effects of heavy metals by binding contaminants. 3) Plant growth in the second year was more than that in the first year, subsequently increment root growth and penetration to greater uptake of water and nutrients as discussed by Sharma and Acharya (1997).

Table (11): Extractable lead (mg/kg) in soil after harvest corn and bean plants in first and second season as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	After corn				After bean			
	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
First season								
F_0	0.589	0.589	0.685	0.621	0.493	0.641	0.592	0.575
F_1	0.690	0.895	1.233	0.939	0.401	0.690	0.887	0.659
F_2	0.493	0.682	1.233	0.803	0.394	0.592	0.676	0.554
F_3	0.822	1.331	1.392	1.182	0.496	0.740	1.233	0.823
F_4	1.000	1.529	1.479	1.336	0.641	1.282	1.292	1.072
F_5	1.380	1.691	1.676	1.582	1.134	1.282	1.380	1.265
Mean	0.829	1.119	1.283		0.593	0.871	1.010	
$LSD_{0.05}$	I=0.13	F=0.19	IxF=ns		I=0.08	F=0.11	IxF=0.19	
Second season								
F_0	0.199	0.448	0.497	0.381	0.198	0.099	0.197	0.165
F_1	0.299	0.398	0.497	0.398	0.149	0.149	0.199	0.166
F_2	0.348	0.398	0.497	0.414	0.199	0.149	0.298	0.215
F_3	0.348	0.398	0.596	0.447	0.199	0.249	0.298	0.249
F_4	0.398	0.447	0.597	0.481	0.249	0.398	0.497	0.381
F_5	0.398	0.597	0.646	0.547	0.298	0.398	0.548	0.415
Mean	0.332	0.447	0.555		0.215	0.240	0.339	
$LSD_{0.05}$	I=0.09	F=ns	IxF=ns		I=0.07	F=0.10	IxF=ns	

4.7. Effect of irrigation and fertilization treatments and their interaction on soil hydro-physical properties.

Soil bulk density

Data presented in Table (12) show insignificant effect of irrigation treatments on bulk density values in the two growing seasons. Addition of organic compost decrease soil bulk density relative to those of untreated soil. The decrease in soil bulk density as related to mineral or/and compost fertilizers and their interaction compared with control or bulk density value of initial soil interpreted by 1) Mechanical disturbance of surface soil resulted from cultivation practices. 2) The cumulative effects of high volume and low mass of applied compost subsequently lowering bulk density of compost. 3) The particle densities of organic particles is lower than those of mineral fertilizers. 4) The aggregation effect and increment porosity resulted from compost application may cause a decrease in bulk density. Generally, similar results were reported by Cox *et al*., (2001) and Ogunwole and Ogunleye (2004) who concluded that soils under treatments involving sole cowdung, cowdung + phosphorus fertilizer and cowdung + NPK fertilizers recorded lower soil bulk density.

Total porosity, water holding pores, field capacity, available water, total stable aggregates and aggregation index:

Data in Table (13) show total porosity (T.P), water holding pores (W.H.P), field capacity (F.C), available water (A.W), total stable aggregates (T.S.A) and aggregation index (A.I) at the end of two seasons as affected by irrigation and fertilization treatments. Total porosity decrease with decreasing in water amount, this may be attributed to under low amount of water soil tend to be more compacted and rate of OM decomposition decreased so that the role of organic compost in enhancing total

porosity was limited. Generally, application of compost improve total porosity. The increase percentages in total porosity were 19.26, 15.44, 10.83, 7.04 and 2.04% for F_1, F_2, F_3, F_4 and F_5 compared with F_0. The maximum increase percentage was obtained when compared F_4 (50% compost + 50% NPK) with F_5 (100% NPK). This may revealed the important role of compost in increment total porosity. The minimum increase percentage was recorded by comparing 100% NPK with control. This may be due to the few differences observed in absence or presence of mineral fertilizers.

Concerning values of water holding pores (W.H.P) which have a diameter 8.62-0.19µ, data show that W.H.P values increase with adding full amount of water requirement (I_1) and no significant difference found between I_2 and I_3. In general, W.H.P values increased gradually with increasing rate of compost application, presumably from the presence of humified organic materials which improve soil aggregation subsequently enhance W.H.P.

Field capacity (F.C) in all plots increased with amount of water toward the high rate. The increases were 10.42 and 5.17% for I_1 and I_2 compared with I_3, respectively. Also, values of field capacity increased with increasing rate of applied compost irrespective of irrigation levels. The increase percentages were 46.68, 35.71, 27.92 and 17.09% for F_1, F_2, F_3 and F_4 compared with control (F_0), respectively while the decrease percentage was 2.37 for F_5 compared with control (F_0). Insignificant difference was observed between F_5 and F_0.

Irrigation doses, fertilization mixtures and the interaction between them affected significantly available water. The magnitudes of increase resulted from I_1 and I_2 treatments were 14.21 and 7.28% compared with I_3,

respectively and 54.59, 41.49, 32.5 and 20.68% for F_1, F_2, F_3 and F_4 compared with F_0, respectively. No significant different could be established between F_5 (100% NPK) and F_0 (control).

Use of compost alone or mixed with mineral fertilizers enhanced soil aggregation. This effect was less pronounced in control plots followed by 100% NPK. The influence of organic compost in encourage soil aggregation could be refer to that decomposition of soil organic matter produce several materials which play as adhesion agent and withholding soil particles hence, soil organic matter implicate stabilization of soil aggregation. Data of aggregation index confirm the results concerning T.S.A. This may be due mathematically to A.I values are calculated using records of water stable aggregates. Aggregation index increased gradually in the order: $F_1>F_2>F_3>F_4>F_5> F_0$.

Conclusions:

From all above results, it can concluded that 1) Application of recycled plant materials especially banana residues in the compost form is important to reducing the problem of increasing agricultural residues. 2) Organic materials must be decomposed firstly to release the nutrient elements. So that compost must be applied early with enough time to decomposition. 3) Adding compost to sandy soils under arid and semi arid conditions reduce water stress on the crop and this consider one of the most striking results. 4) About 20% of irrigation water can be saved if all farmers applied 80% only of water requirement to corn plants. 5) Banana compost is a serious source of balanced essential elements. 6) Compost application had a promising effect on reducing pollution of heavy metals in plant tissues compared with chemical fertilizers.

Table (12): Effect of irrigation and fertilization treatments on bulk density (g cm^{-3}) in soil samples after bean harvesting in two growing seasons.

Fertilization treatments	First season				Second season			
	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3	
F_0	1.49	1.49	1.51	1.50	1.46	1.45	1.46	1.46
F_1	1.29	1.35	1.38	1.34	1.22	1.26	1.28	1.26
F_2	1.32	1.39	1.40	1.37	1.35	1.29	1.36	1.33
F_3	1.38	1.43	1.42	1.41	1.36	1.30	1.39	1.35
F_4	1.42	1.44	1.46	1.44	1.39	1.36	1.37	1.38
F_5	1.48	1.48	1.48	1.48	1.44	1.45	1.44	1.44
Mean	1.40	1.43	1.44		1.37	1.35	1.39	
$LSD_{0.05}$	I=0.02	F=0.03	IxF=ns		I=ns	F=0.06	IxF=ns	

REFERENCES

Abdel Moez, M.R. (2001). Effect of some organic composts and elemental sulphur application under two tillage methods on growth, yield and nutrients uptake by corn plants. Annals. Agric. Sci. Moshtohor 39(2):1341-1354.

Abdel-Sabour, M.F.; Abo-El-Seoud, M.A. and Rizk, M. (1999). Physiological and chemical response of sunflower to previous organic waste compost application to sandy soil. Egypt. J. Soil Sci. 39:407-420.

Abdul Khaliq; Abbasi, M.K. and Hussain, T. (2006). Effects of integrated use of organic and inorganic nutrient sources with effective microorganisms (EM) on seed cotton yield in Pakistan. Bioresource Tech. 97: 967-972.

Abou El-Magd, M.M.; Hoda, A.M. and Abd El-Baky, M.M.H. (2004). Organic and mineral fertilization of onion crop in relation to its vegetative growth, yield and bulb quality. Egypt. J. Appl. Sci. 19(7A):265-278.

Allen, R.G., L.S., Pereira, D., Raes, and M., Smith (1998). Crop evapotranspiration. Guidelines for computing crop water requirements. Irrig. And Drain. Paper, No. 56, FAO, Rome, Italy. P. 300.

Badran, N.M. (2001). Residual effect of nutrients-enriched organic residues on growth and nutrients utilization by corn plants growth on a sandy soil. Annals. Agric. Sci. Moshtohor 39(1): 611-630.

Chapman, H.D. and Pratt, P.F. (1978). Methods of analysis for soils, plants and waters. 50, California Univ. Div. Agric. Sci. Priced Publication 4034.

Chiu, K.K.; Ye, Z.H. and Wong, M.H. (2006). Growth of *Vetiveria zizanioides* and *Phragmities australis* on Pb/Zn and Cu mine tailings amended with manure compost and sewage sludge: A greenhouse study. Bioresource Technol. 97: 158-170.

Cooperband, L. (2002). Building soil organic matter with organic amendments. Center for integrated Agricultural system. Univ. Wisconsin. Madison.

Cottenie, A.; Verlo, M.; Kiekeus, L.; Velghe, G. and Camerlynck, R. (1982). "Chemical Analysis of plants and soils". Laboratory of Analytical and Agrochemistry State Univ., Ghent-Belgium.

Cox, D.; Bezdicek, D. and Fauci, M (2001). Effect of compost, coal ash, and straw amendments on restoring the quality of eroded Palouse soil. Biol. Fertil. Soils 33:365-372.

De Pieri, L.A.; Buckley, W.T. and Kowalenko, C.G. (1996). Cadmium and lead concentrations in commercially grown vegetables and soils in the Lower Fraser Valley of British Columbia. Can. J. Soil Sci. 77:51-57.

Deleenher, L. and De Boodt, M. (1965). "Soil physics" International Training Center for Post Graduate soil scientists (ITC-Ghent), Belgium.

Eghball, B., Wienhold, B.J.; Gilley, J.E. and Eigenberg, R.A. (2002). Mineralization of manure nutrients. J. Soil Water Conserv. 57: 470–473.

Eghball, B.; Ginting, D.; Gilley, J.E. (2004). Residual effects of manure and compost applications on corn production and soil properties. Agron. J. 96:442-447.

El-Kassas, H. I. (1999). Lead, Cadmium and Nickel release from different fertilizers and their implication on Fennel plants grown in sandy soils. Egypt. J. Soil Sci. 39(3):337-349.

El-Naggar, E.M.A (1996). Effect of applying some organic residues to sandy and calcareous soils on growth and composition of some plants. M.Sc. Thesis Fac. Agric. Mansoura Univ. Mansoura.

Fan, T.; Stewart, B.A.; Payne, W.A.; Yong, W.; Luo, J. and Gao, Y. (2005). Long-term fertilizer and water availability effects on cereal yield and soil chemical properties in Northwest China. Soil Sci. Soc. Am. J. 69:842-855.

Ginting, D., Kessavalou, A.; Eghball, B. and Doran, J.W. (2003). Greenhouse gas emissions and soil indicators four years after manure and compost applications. J. Environ. Qual. 32:23-32.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for agricultural research. Second ed. Jon Willey and Sons Inc. New York, U.S.A.

Hammer, D. and Keller, C. (2002). Changes in the rhizosphere of metal-accumulating plants evidenced by chemical extractants. J. Environ. Qual. 31:1561–1569.

Illmer, P.; Wagner, A.O.; Mair, J.; Malin, C. and Farbmacher, S. (2007). Chemical and biochemical parameters during composting of lawn clippings with special regard to the efficiency of a compost starter kit. Compost Science & Utilization 15(1): 40-46.

Joshi, U.N. and Luthra, Y.P. (2000). An overview of heavy metals: Impact and remediation. Current Sci. 78(7):2-4.

Kaschl, A.; Romheld, V. and Chen, Y. (2002). Cadmium binding by fractions of dissolved organic matter and humic substances from municipal solid waste compost. J. Environ. Qual. 31:1885-1892.

Khalil, A.A.; Nasef, M.A.; Ghazal, F.M. and Emam, M.A. (2004). Effect of integrated organic manuring and biofertilizer on growth and nutrient uptake of wheat plants grown in diverse textured soils. Egypt. J. Agric. Res. 82(2):221-234.

Khalil, M.E.A.; Badran, M. and EL-Emam, M.A.A. (2000). Effect of different organic manures on growth and nutrition status of corn. Egypt. J. Soil Sci. 40 (1-2): 245-263.

Klute, A. (1986). Methods of Soil Analysis: Part I: Physical and mineralogical Methods. (2nd Ed), Amer. Soc. Agron. Monograph No. 9, Madison, Wisconsin. U.S.A.

Liu, W.; Zhang, X.J. (2007). Optimizing water and fertilizer input using an elasticity index: a case study with maize in the Loess Plateau of China. Field Crops Research 302-310.

Lobo, D.; Torres, D.;Gabriels, D.; Rodriguez, N. And Rivero, D. (2006). Effect of organic waste compost and a water absorbent polymeric soil conditioner (hydrogel) on the water use efficiency in a Capsicum annum (green pepper) cultivation. Proceedings of Agro. Environ. 453-459.

Medina, A.; Vassilev, N.; Alguacil, M.M.; Roldan, A. and Azcon, R. (2004). Increased plant growth, nutrient uptake and soil enzymatic in a desertified Mediterranean soil amended with treated residues and inoculation with native mycorrhizal fungi and plant growth promoting yeast. Soil Sci. 169 (4): 260-270.

Murakami, M.; Ae, N.; Ishikawa, S. and Arao, T. (2005). Uptake of cadmium tightly bound to the soil solid phases by rice. C.J. Li *et al*., (Eds), Plant nutrition for food security, human health and environmental protection 712-713.

Negm, M.A.; Zaki, R.N.; Mohammedain, A.A. and Elmeniesi, A.I.A. (2004). Comparative study on saw-dust and farmyard manure with combination of N sources in relation to calcareous soil properties and production of sugar beet and maize. Egypt. Soil Sci. Soc. (ESSS) 7th Nat. Conf. Dec., 27-28, Cairo Egypt.

Nesme, T.; Bellon, S.; Lescourret, F.; Senoussi, R. and Habib, R. (2004). Are agronomic models useful for studying farmers' fertilization practices?. Agric. Systems 83:297-314.

Newman, C.M.; Rotenberg, D. and Cooperband, L.R. (2005). Paper mill residuals and compost effects on particulate organic matter and related soil functions in a sandy soil. Soil Sci. 170(10): 788-801.

Noufal, E.H.A.; Habib, F.M.; Khalil, M.G.and Abd El-Ha M.S.S. (2005). Effect of nutral organic conditioners addition on some properties of a calcareous soil, its available content of some nutrients and their uptake by barley plant grown thereon. 1- Physical and chemical properties. Egypt. J. Agric. Res. 2(1):35-58.

Ogunwole, J.O. and Ogunleye, P.O. (2004). Surface soil aggregation, trace and heavy metal enrichment under long-term application of farm yard manure and mineral fertilizers. Communications in soil Sci. plant Anal. 35(11-12):1505-1516.

Page, A.L.; Miller, R.H. and Keeny, D.R. (1982). Methods of Soil Analysis, Part II Chemical and Microbiological Properties. (2nd Ed), Amer. Soc. Agron. Monograph No. 9, Madison, Wisconsin. U.S.A.

Rizk, F.A. (1997). Productivity of onion plant (*Allium cepa* L.) as affected by method of planting and NPK application. Egypt. J. Hort. 24(2):219-238.

Roberts, P.; Jones, G.E. and Jones, D.L. (2007). Yield responses of wheat (Triticum aestivum) to vermicompost applications. Compost Science & Utilization 15(1): 29-33.

Sauve, S.; Martinez, C.E.; McBride, M. And Hendershot, W. (2000). Adsorption of free lead (Pb^{2+}) by pedogenic oxides, Ferrihydrite, and leaf compost. Soil Sci. Soc. Am. J. 64:595-599.

Sharma, J.C. and Acharya, C.L. (1997). Response of wheat grown on an acidic Alfisol to nitrogen and tillage. Indian J. Agron. 42(4):622-625.

Singer, J.W.; Kohler, K.A.; Liebman, M.; Richard, T.L.; Cambardella, C.A. and Buhler, D.D. (2004). Tillage and compost affect yield of corn, soybean and wheat and soil fertility. Agro. J. 96: 531-537.

Soltanpour, P.N. (1985). Use of ammonium bicarbonate DTPA soil test to evaluate elemental availability and toxicity. Common. Soil Sci. Plant Anal. 16: 323-318.

Stakman, W.P. and Hast, G.G.V. (1962). The use of the pressure membrane apparatus to determine soil moisture contents at pF 3 to 4.2 inclusive. Institute for Land and Water Management Research, Note No. 159.

Somasundaran, P.; Ren, Y. and Rao, M.Y. (1998). Applications of biological processes in mineral processing. Colloids Surf., A. Physico. Chem. Eng. Asp. 133(1-2): 13-23.

Verma, S.K. and Singh, T. (1997). Effect of weed control measures and fertilizers on growth and productivity of rainy season onion (*Allium cepa* L.). Indian J. Agron. 42(3):540-543.

Watanabe, F.S. and Olsen, S.R. (1965). Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. Soil Sci. Soc. Am. Proc. 29: 677-678.

Xial, Y.P.; Stoffella, P.J.; He, Z.L.; Zhang, M.K.; Calvert, D.V.; Yang, X.E. and Wilson, S.B. (2007). Leaching potential of heavy metals, nitrogen, and phosphate from compost-amended media. Compost Science & Utilization 15(1): 6-15.

Yang, S.M.; Song, J.R.; Yue, W.Y.; Wang, J.G.; Guo, T.W. and Malhi, S.S. (2005). Effect of fertilizers and manure on yields of wheat and oilseed: results from a 22-yr fertilization trial in rain fed region of China. C.J. Li *et al*., (Eds), Plant nutrition for food security, human health and environmental protection 1170-1171.

Zhang, J. and Yang, J. (2005). Improve crop water-use efficiency through enhancing harvest index in cereals. C.J. Li *et al*., (Eds), Plant nutrition for food security, human health and environmental protection 560-561.

Zhang, M.K.; He, Z.L.; Stoffella, P.J.; Calvert, D.V.; Yang, X.E.; Xia, Y.P. and Wilson, S.B. (2004). Solubility of phosphorus and heavy metals in potting media amended with yard waste–biosolids compost. J. Environ. Qual. 33:373–379.

أثر التسميد العضوي على تقليل التلوث و ترشيد استخدام ماء الرى

د. السيد إبراهيم جابر

قسم الموارد الطبيعية – معهد البحوث و الدراسات الإفريقية – جامعة القاهرة

أجريت تجربة حقلية بمحطة البحوث و التجارب التابعة للمركز القومى للبحوث بالنوبارية بهدف دراسة تأثير إضافة الكمبوست المصنع من مخلفات الموز أو مخاليطها مع الأسمدة المعدنية على محتوى الأرض الرملية الجيرية من العناصر الثقيلة و كذلك خواصها الهيدروفيزيائية و أيضاً تقليل التلوث الناجم عن إضافة الأسمدة المعدنية. ثم تم زراعة نبات الفول فى نفس القطع التجريبية لدراسة الأثر المتبقى للمعاملات و ذلك لمدة موسمين متتاليين. اشتملت التجربة على ٣ معدلات رى مختلفة (٦٠و ٨٠ و ١٠٠% من الاحتياجات المائية الكلية للمحصول) و ٦ معاملات تسميد (١٥٠% كمبوست، ١٠٠% كمبوست، ٧٥% كمبوست+٢٥% تسميد معدني، ٥٠% كمبوست+٥٠% تسميد معدنى، ١٠٠% تسميد معدني و كنترول) حيث أظهرت النتائج ما يلى:-

من الممكن توفير ٢٠% من مياه الرى المضافة للذرة عند إضافة ٨٠% فقط من الاحتياجات المائية لها. كما لوحظ زيادة محصول حبوب الذرة بزيادة معدل التسميد المعدنى على عكس محصول بذور الفول الذى زاد بزيادة معدل إضافة الكمبوست.

عند إضافة أقل معدل رى وجد أن معاملة (٧٥% كمبوست+٢٥% تسميد معدني) أدت إلى زيادة كفاءة استخدام المياه WUE بواسطة محصول الذرة أكثر من معاملة (٥٠% كمبوست+٥٠% تسميد معدنى).

زاد تركيز كل من الكادميوم و النيكل فى أوراق الذرة الخضراء و ورقة إبط الكوز و حبوب الذرة و بذور الفول مع انخفاض معدل الرى لكن لا توجد علاقة واضحة بين تركيز الرصاص فى الأجزاء النباتية محل الدراسة و معدلات الرى المختلفة.

و عموماً فان إحلال الكمبوست محل التسميد المعدنى يعمل على تقليل تركيز الكادميوم و النيكل و الرصاص فى كل من الذرة و الفول.

زاد تيسر العناصر الثقيلة فى التربة تحت معاملة ٦٠% من الاحتياجات المائية مقارنة بالمعدلات الاخرى و كذلك مع زيادة معدل التسميد المعدنى على حساب التسميد العضوى.

أدت إضافة الكمبوست إلى انخفاض الكثافة الظاهرية و زيادة المسامية الكلية ، مسام حفظ الماء ، التجمعات الثابتة الكلية و دليل التجمعات و بالتالى زيادة السعة الحقلية و الماء الميسر للنبات.

(الكلمات الدالة: كمبوست – تلوث – الرى)

Table (2): Some physical and chemical properties of the compost in two seasons.

Season	Total nutrients						OM%	C/N ratio	EC dS/m 1:5	pH 1:2.5	BD g cm^{-3}	WHC %
	N%	P%	K%	Ni ppm	Cd ppm	Pb ppm						
First season	1.23	0.79	2.042	2.975	-	2.65	25.21	11.9	5.63	7.47	0.35	110
Second season	1.10	0.82	2.201	13.9	-	3.65	37.69	17.8	5.50	7.44	0.34	160

Table (6): Cadmium concentration ($\mu g g^{-1}$) in green leaves, ear leaf, corn grain and bean seeds in two growing seasons as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	Green leaves				Ear leaf				Corn grains				Bean seeds			
	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3	
	First season															
F_0	0.334	1.280	1.391	1.002	0.668	0.519	1.113	0.766	0.742	0.742	1.113	0.865	0.074	0.148	0.816	0.346
F_1	0.390	0.631	0.577	0.532	0.816	0.816	1.113	0.915	0.593	0.464	0.808	0.622	N.D	0.148	0.519	0.222
F_2	0.613	1.058	0.874	0.848	0.593	0.779	1.113	0.828	0.556	0.223	0.742	0.507	N.D	0.111	0.445	0.185
F_3	0.613	1.058	0.909	0.860	0.890	0.816	1.113	0.939	0.742	0.557	1.030	0.776	0.074	0.223	0.593	0.297
F_4	0.613	1.115	1.058	0.928	0.890	0.816	1.187	0.964	0.835	0.667	1.187	0.896	0.223	0.297	1.001	0.507
F_5	0.835	1.169	1.503	1.169	0.890	0.890	1.632	1.137	0.890	0.890	1.335	1.038	0.371	0.371	1.335	0.692
Mean	0.566	1.052	1.052		0.791	0.773	1.211		0.726	0.590	1.036		0.124	0.216	0.785	
$LSD_{0.05}$	I=0.26	F=0.37	IxF=ns		I=0.31	F=ns	IxF=ns		I=0.26	F=ns	IxF=0.64		I=0.16	F=0.23	IxF=ns	
	Second season															
F_0	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
F_1	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
F_2	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
F_3	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
F_4	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
F_5	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D

N.D = not detected

Table (7): Nickel concentration ($\mu g g^{-1}$) in green leaves, ear leaf, corn grain and bean seeds in two growing seasons as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	Green leaves				Ear leaf				Corn grains				Bean seeds			
	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3	
	First season															
F_0	0.519	0.345	0.838	0.567	0.389	0.433	0.432	0.418	0.317	0.403	0.403	0.374	0.000	0.115	0.029	0.048
F_1	0.302	0.201	0.548	0.350	0.172	0.302	0.345	0.273	0.086	0.151	0.258	0.165	0.029	0.029	0.029	0.029
F_2	0.345	0.345	0.634	0.441	0.207	0.345	0.316	0.289	0.086	0.115	0.201	0.134	0.029	0.086	0.115	0.077
F_3	0.432	0.520	0.896	0.616	0.245	0.345	0.475	0.355	0.129	0.172	0.404	0.235	0.129	0.115	0.143	0.129
F_4	0.475	0.665	0.925	0.688	0.274	0.374	0.489	0.379	0.230	0.201	0.374	0.268	0.144	0.172	0.201	0.172
F_5	0.547	0.665	1.042	0.751	0.287	0.547	0.518	0.451	0.259	0.230	0.432	0.307	0.201	0.230	0.259	0.230
Mean	0.436	0.457	0.814		0.262	0.391	0.429		0.184	0.212	0.345		0.089	0.124	0.129	
$LSD_{0.05}$	I=0.13	F=0.18	IxF=ns		I=0.07	F=0.10	IxF=ns		I=0.06	F=0.09	IxF=ns		I=0.03	F=0.04	IxF=ns	
	Second season															
F_0	0.114	0.214	0.228	0.185	0.043	0.014	0.028	0.028	0.028	N.D	0.021	0.017	N.D	0.028	0.071	0.033
F_1	0.114	0.185	0.185	0.161	0.028	0.057	0.071	0.052	N.D	N.D	0.028	0.009	N.D	N.D	N.D	N.D
F_2	0.071	0.157	0.171	0.133	0.028	0.038	0.000	0.022	N.D	N.D	0.014	0.005	N.D	0.043	0.028	0.024
F_3	0.142	0.243	0.199	0.195	0.085	0.064	0.100	0.083	N.D	0.014	0.028	0.014	N.D	0.043	0.042	0.028
F_4	0.156	0.257	0.272	0.228	0.085	0.085	0.128	0.100	0.028	0.057	0.057	0.047	0.021	0.057	0.085	0.054
F_5	0.200	0.286	0.199	0.228	0.106	0.106	0.142	0.118	0.042	0.057	0.071	0.057	0.028	0.099	0.128	0.085
Mean	0.133	0.224	0.209		0.063	0.061	0.078		0.017	0.021	0.037		0.008	0.045	0.059	
$LSD_{0.05}$	I=0.04	F=0.05	IxF=ns		I=ns	F=0.05	IxF=ns		I=ns	F=0.03	IxF=ns		I=0.02	F=0.03	IxF=ns	

Table (8): Lead concentration (μgg^{-1}) in green leaves, ear leaf, corn grain and bean seeds in two growing seasons as affected by irrigation, fertilization treatments and their interaction.

Fertilization treatments	Green leaves				Ear leaf				Corn grains				Bean seeds			
	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean
	I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3	
	First season															
F_0	3.560	0.673	1.251	1.828	0.770	1.347	0.866	0.994	0.381	1.432	0.954	0.922	0.289	0.481	0.962	0.577
F_1	1.443	1.058	0.962	1.154	0.577	0.866	0.577	0.673	0.570	0.999	0.758	0.775	0.192	0.289	0.866	0.449
F_2	2.309	1.731	1.154	1.731	0.866	0.989	0.866	0.907	0.473	0.854	0.854	0.727	0.192	0.577	1.154	0.641
F_3	2.598	1.731	1.346	1.892	0.866	1.154	1.010	1.010	0.858	1.047	0.854	0.920	0.962	0.866	1.250	1.026
F_4	2.602	1.962	1.443	2.002	0.962	1.250	1.154	1.122	0.854	1.143	1.720	1.239	1.154	0.962	1.635	1.250
F_5	2.886	2.117	1.443	2.149	1.250	1.539	1.347	1.379	1.287	1.332	1.720	1.446	1.154	1.058	2.116	1.443
Mean	2.566	1.545	1.266	1.154	0.882	1.191	0.970	0.673	0.737	1.134	1.143		0.657	0.705	1.331	
$LSD_{0.05}$	I=0.26	F=0.37	IxF=0.64		I=0.24	F=0.34	IxF=ns		I=0.34	F=0.47	IxF=ns		I=0.37	F=0.52	IxF=ns	
	Second season															
F_0	2.573	2.375	2.672	2.540	0.891	1.088	0.792	0.924	0.495	0.297	N.D	0.264	0.495	1.089	N.D	0.528
F_1	2.177	2.178	2.276	2.210	0.594	0.891	0.149	0.544	0.198	0.396	0.099	0.231	0.099	1.287	N.D	0.462
F_2	2.276	2.178	2.573	2.342	1.188	1.085	0.495	0.923	0.495	0.396	0.099	0.330	0.396	1.633	N.D	0.676
F_3	2.573	2.375	2.474	2.474	1.485	1.188	0.594	1.089	0.495	0.494	0.099	0.363	0.495	1.683	0.099	0.759
F_4	2.771	2.375	2.672	2.606	1.683	1.485	0.594	1.254	0.594	0.594	0.297	0.495	0.693	1.782	0.099	0.858
F_5	2.672	2.771	2.672	2.705	1.988	1.485	1.188	1.554	0.792	0.792	0.297	0.627	0.891	1.782	0.198	0.957
Mean	2.507	2.375	2.557		1.305	1.204	0.635		0.511	0.495	0.148		0.511	1.542	0.066	
$LSD_{0.05}$	I=ns	F=ns	IxF=ns		I=0.30	F=0.43	IxF=ns		I=0.16	F=0.23	IxF=ns		I=0.27	F=ns	IxF=ns	

Table (13): Total porosity (T.P), water holding pores (W.H.P), Field capacity (F.C), available water (A.W), Total stable aggregates (T.S.A) and aggregation index (A.I) in soil at the end of two seasons as affected by irrigation fertilization treatments and their interaction.

Fertilization treatments	T.P				W.H.P				F.C				A.W				T.S.A	A.I
	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean	Irrigation treatments			Mean		
	I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3		I_1	I_2	I_3			
F_0	35.69	35.55	34.83	35.36	13.23	11.63	11.40	12.09	22.03	21.27	19.87	21.06	6.33	6.17	6.27	6.26	9.2	0.048
F_1	44.33	41.74	40.44	42.17	22.47	20.82	18.40	20.56	33.03	31.27	28.37	30.89	8.13	7.95	7.93	8.01	17.0	0.171
F_2	42.89	40.01	39.58	40.82	19.43	16.73	17.97	18.04	29.90	28.20	27.63	28.58	7.67	7.60	7.63	7.63	16.2	0.139
F_3	40.58	38.28	38.71	39.19	17.17	15.37	16.23	16.26	27.97	26.87	26.00	26.94	7.47	7.10	7.43	7.33	15.6	0.122
F_4	38.71	37.85	36.99	37.85	14.63	13.50	15.60	14.58	25.33	24.53	24.10	24.66	6.77	6.93	6.70	6.80	13.7	0.086
F_5	36.12	35.98	36.12	36.08	12.93	12.15	11.00	12.03	21.97	20.50	19.20	20.56	6.23	6.35	6.20	6.26	12.7	0.076
Mean	39.72	38.23	37.78		16.64	15.03	15.10		26.71	25.44	24.19		7.10	7.02	7.03			
$LSD_{0.05}$	I= 0.95	F= 1.34	IxF= ns		I= 0.62	F= 0.87	IxF= 1.51		I= 0.51	F= 0.72	IxF= ns		I= ns	F= 0.24	IxF= ns			

T.S.A=Total stable aggregates = Aggregate state = weight of soil sample after wet sieving without dispersion- weight of soil sample after wet sieving with dispersion.

A.I = Aggregation index = (total of dispersion – total of undispersion) x 0.02

T.S.A and A.I were determined only under (I_1) and different fertilization treatments.