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APPLICATION OF SOLID ORGANIC WASTES TO IMPROVE SOIL CHARACTERS AND *Sorghum* growth

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ABSTRACT

The main aim of this study is to determine the suitable level of solid organic wastes (SOW) as natural fertilizers to increase productivity and to avoid heavy metal burden in the soil and monitoring the changes in physical and chemical characters of soil due to utilization of solid organic wastes. The present study, the application of solid organic wastes has improved the physical properties of soil such as increasing the fine particles, porosity and water holding capacity. Also the chemical properties increased such as organic carbon, electric conductivity and total soluble salts. The solid organic wastes (SOWs) exhibit several benefits such as: improving of physical and chemical characters of soil ،increasing productivity of *Sorghum virgatum* plants.
On the other hand, SOWs have some harmful effects on: soil environment such as increasing the soil pH. Consequently, further future ecological studies should bring the view to the ideal utilization of these wastes without side effect on the environment
Keywords: *Sorghum*, Sewage sludge, wastes, soil characters

INTRODUCTION

Sorghum virgatum is distributed in Africa (Egypt, Senegal, Mauritania, Niger, Chad, Ethiopia, Sudan) and Asia (Palestine, Jordan, Sinai Peninsula, Saudi Arabia). *S. virgatum* looks distinct enough in damp sandy soils and margins of cultivation in habitats of Egypt, with its scanty, narrow panicle, but there are plants that are less obviously different from S. arundinaceum, (Boulus, 2002).

Sorghum virgatum is certainly the commonest wild sorghum in Egypt but may be no more than a local ecotype. There are numerous synotypes from Egypt (and elsewhere), including from Damietta (Ehrenberg), Alexandria (Wichura), Thebes (Unger) and Suez (Kotschy 882).

Information concerning the genetic diversity of sorghum and the relationships among the infraspecific taxa has come primarily from studies of comparative morphology and biogeography (De wet 1978; Harlan and De wet 1972; Harlan and Stemler 1976).

Sorghum has, therefore, been proposed as a candidate crop for genetic transformation and protocols for Sorghum genetic engineering have recently been optimized and successfully applied for various traits (Casas *et al.,*1997; Girijashankar *et al.,*2005; Zhu *et al.,*1998; Zhao *et al.,*2000; Gao *et al.,*2005; Howe *et al.,* 2006; Ayoo, 2008). In addition, transgenic biofortified sorghum are being developed for sub-Saharan Africa (Zhao, 2008).

The application of organic wastes from different origins (manure, sewage sludge and municipal organic wastes) to degraded soils is a practice globally accepted to recover, replenish and preserve organic matter, fertility and vegetation (Vetterlein and Hüttl, 1999; Civeira and Lavado, 2008). Before application to soils, organic wastes should been stabilized using composting techniques. The use of composted organic wastes produces changes in soil physical, chemical and biological properties and can enhance plant growth after its application. However, the influence of carbon rich materials, like municipal organic wastes compost, on soil physical, chemical and biological properties depends upon several factors: amount and components of added organic materials, soil type and weather conditions (Unsal and Ok, 2001; Drozd, 2003). As pointed out by Giusquiani *et al*. (1995) and Drozd (2003) the use of composts from municipal solid wastes (MSW) improves the restoration of degraded soils and allows an appropriate final disposition of such materials, solving a major environmental and economical problem generated in the cities (Civeira, 2010).

Non-availability of land and need to reuse the dumpsite space, especially in urban areas, call for rehabilitation of these facilities. A variety of options have been tried to achieve the goals of rehabilitation. In the last couple of decades, phytoremediation, collectively referring to all plant-based technologies using green plants to remediate and rehabilitate municipal solid waste landfills and dumpsites, has emerged as a potential candidate. Research and development activities relating to different aspects of phytoremediation are keeping the interest of scientists and engineers alive and enriching the literature.(Nagendran *et al.,*2006).

The aim of the experiment was study the effect of application of different rates of sewage sludge, town refuse and organic manure on the availability index of some heavy metals in the sandy soil as well as sorghum growth and uptake of heavy metals by the plant.

MATERIALS AND METHODS

Soil Analysis:

Soil sampling

The Soil used in the experiments was collected from natural habitat where the sorghum plant was flourished, at 4 km South of Mansoura city, East of Nile Delta, at depth of 0-25 cm according to depth of the roots. Then brought to the laboratory shortly after collection and spread over sheets of paper in air till drying, thoroughly mixed, sieved through a 2 mm sieve to remove gravel and debris to be ready for physical and chemical analysis and for experiment of solid organic wastes treatment (Carter and Gregorich, 2008).

Physical characteristics of soil

Soil texture

For determination of soil texture, drying sieve method (mechanical analysis) was used for the sandy soil. The percentage of sand, silt and clay were calculated according to **Richards(1954) .**

Water-holding capacity (W.H.C.)

Special rectangular shaped box (Hilgard pan box) with internal limensions with 9 **×** 6 cm (long side × short side), 4 cm height and 7 cm feet long at each corner. This is made of brass and has perforated base with numerous holes. These boxes were used for the estimation of water-holding capacity of the soil Klute (1986).

Porosity (soil-space)

The total pore space (in cm^3) is approximately equivalent to weight of distilled water (in gm) in the soil at saturated state. At saturation, water is assumed to occupy all the spaces in the soil. Thus, the principle of the determination of pore space depends on measuring the volume of soil in the saturated condition and its volume in dry condition. The volume of pore-space is expressed as percentage of the original volume of soil sample **Klute (1986).**

Chemical characteristics of soil

Calcium carbonate

Calcium carbonate content was determined using rapid titration method according to Margesin and Sehinner (2005). Five grams of air-dried soil were transferred to a 250 ml beaker. By means of a pipette with enlarged jet, 100 ml of 1N HCI were added and stirred vigorously several times during a period of one hour. Allow settling and pipetting of 20 ml of the suspended liquid, transferred into a conical flask and adding three drops of phenolphthalein indicator and a conical flask and adding three drops of phenolphthalein indicator and titration with 1N NaOH. Carry out a blank titration.

Organic carbon

Oxidizable organic carbon (as indication of the total organic matter) was determined using Walkely and Black rapid titration method as described by **Margesin and Schinner (2005).**

Electrical conductivity (E.C.)

Electrical conductivity was expressed as dS.m-land measured using conductivitimeter (Model Corning, NY 14831 USA) as described by Pansu and Gautheyrous (2006).

Soil reaction (pH value)

Electrical-pH meter (Model Corning, NY 14831 USA) digital analyzer with glass electrode was used to determine the soil reaction (pH value) in 1:5 soil suspension of the collected samples according to Pansu and Gautheyrous (2006).

Extractable anions

The concentration (meq/ 100g dry soil) of the monovalent anions chlorides and bicarbonates and the two divalent anions carbonates and sulphates were evaluated as follows:

Chorides (Cl^-)

Chloride content was determined by Mohar's method as described in American public Health Association (APHA, 1998). The estimation of chlorides was based on the formation of nearly insoluble silver salt. It was carried out by titration method using N/35.5 silver nitrate and potassium chromate solution as indicator. Appearance of reddish brown precipitate of AG_2CRO_4 indicates the end-point of the reaction.

Bicarbonates and carbonates

Soil water-soluble carbonates and bicarbonates were determined in extract (1:5) according to Baruah and Barthakur (1997) by acidimetric titration method, using 0.1N hydrochloric acid in the presence of phenolphthalein as indicator for CO_3^{-2} (pH > 8.5) and methyl orange for HCO_3^- (pH < 6). Phenolphthalein gives a pink color as long as CO_3^{-2} remains. It will be discharged as soon as all CO_3^{-2} is converted into HCO_3^-.

Sulphates ($SO4^{--}$)

Sulphate content was estimated gravimetrically using 5% barium chloride solution according to Jackson (1967). The sulphates were precipitated as barium sulphate, the precipitation washed to remove chloride ions and ignited in a muffle at 600^{o}C for two hours, cool in a desiccator and weight of residue is the weight of barium sulphate.

Organic Wastes Experiment

In Desamber 14, 2014, at laboratory of ecology, Botany Department, Faculty of science Mansoura university, number of 40 equal sized seedling (7days old) of *Sorghum virgtum* were transplanted into thirty pots (4 seedlings in each pot). Three pots were filled with sandy *Sorghum* soil to serve as control. The remainder pots were divided into three sets, 9 pots each. The first set was filled with soil amended with 1, 5 and 10% sewage sludge (SS). The pots were irrigated every 72 hr by tap water . At the end of the experiment (14.12.20114), the plants were harvested and their height, number of leaves, assimilating surface area and dry weight were determined. The dried plants were subjected to elementary analysis to evaluate accumulation of Fe, Cu, Zn, Pb and Co as a result of application of organic wastes. Also, soils amended with the different treatments were analyzed as described by Allen *et al.* (1986).

Estimation of Growth Characteristics

Data of the successive estimation of the assimilating surface area and the biomass were applied to estimate growth characteristics according to the classical growth analysis which were described in detail by Radford (1967), Milner and Hughes (1968),Chapman(1976), Hunt (1978) and Coombs and Hall (1982).The growth parameters measured are:

Relative Growth Rate (RGR) = $\frac{LnW_2 - LnW_1}{t_2 - t_1}\ gg^{-1}d^{-1}$

Relative Assimilating Surface Growth Rate (RASGR) =

$$\frac{LnA_2 - LnA_1}{t_2 - t_1}\quad Cm^2(cm^2)^{-1}d^{-1}$$

Net Assimilation Rate (NAR) = $\frac{W_2 - W_1}{t_2 - t_1} x \frac{LnA_2 - LnA_1}{t_2 - t_1}\ g\,(cm^2)^{-1}d^{-1}$

Where A= Area, t= Sampling period, W= Weight and d = Day.

RESULTS

Effect of application of the different solid organic wastes on soil characteristics

The soil used in the present study was collected from the natural habitat of *Sorghum virgatum*, 4 km south of Mansoura city. The results obtained from the analysis of *sorghum* soil (the control) indicated that, this soil was sandy textured with predominance of fine sand particles (class: 0.211- 0.104 mm diameter). The percentages of coarse and medium sands were generally high with mean value of 31.3 and 25.3%, respectively. Both silt and clay have low occurrence and their mean values were 4.26 and 3.05 %. The percentage of soil pore-spaces was 45.18 %. Water holding capacity attained its mean value of 49.24 %.

The organic carbon is present with appreciable amount (0.6-3.8%). Calcium carbonate content was low and ranged between 2.0 and 4.5%. The electric conductivity which indicates the salinity level was attained mean value was 430.6 mohs /cm. Bicarbonates and chlorides contributed the main anionic content with mean values of 0.080 and 0.025%, respectively. The sulphate content was low (0.009%). The soluble carbonate content was nil. The soil reaction in neutral to slightly alkaline and pH value ranged between 7.0and 7.4 as shown in Tables (1).

With regard to the heavy metals content of *Sorghum* soil at the beginning of the experiment, the given data revealed that Ferric ions content was the highest and attained mean value of 21.76 ppm, followed by Cu, Pb and Zn ions (4.97, 4.07 and 3.45 ppm), respectively. While cobalt ions content was relatively low (1.04ppm). It is worth to note that, mixing organic waste materials with sandy soil improved its physical and chemical characters through increasing the percentages of fine fraction (fine sand, silt and clay). Application of 1, 5 and 10 % sewage sludge (SS) leads to elevation of fine sand content by 11.5, 13.2 and 16.4%, respectively. The silt particles content increased by 0.3 , 20.4 and 25.8% with treating sandy soil by 1, 5 and 10% sewage sludge. The clay particles content increased with increasing the level of addition of organic wastes by 49.3% at the treatment 10 % of SS, respectively. Consequently, soil pore-spaces increased up to 48.04 % at level 10 % of SS. Also, water holding capacity increased with the same trend as porosity and attained the highest mean values ranged between 52.83 and 56.29% at level 10 %. of SS. It is notable that, the organic carbon content of the soil treated with SS was increased up to 1.80%. Also, $CaCO_3$ increased with increasing that rate of organic waste application 2.50 to 4.50% at rate of 10% SS.

1

The soil salinity as indicated by electrical conductivity attained its highest value of 813 M mohs/cm at rate 10%. Total soluble salt as well as chlorides, sulphate and bicarbonate were increased with application of SS to improve sandy soil characteristics .The soluble carbonate content was nill in the treated and untreated soil samples. The soil reaction of pH varied from neutral or slightly alkaline. The mean values of pH attained the highest values of 7.60 in the soil treated by 10% of SS. Data in Table (2) was showed the amount of Fe , Zn , Cu , Co and Pb in the soil treated with different levels of SS. It is obvious that, mixing sandy soil with 10% sewage sludge lead to increasing concentrations up to 61.26 ppm, Zn ions up to 83.90 ppm, Co up to 2.21 ppm and Pb up to 8.36 ppm. Generally all cations concentrations increased with adding SS to the sandy soil by inhabited *Sorghum virgatum*. As apparent from Table 4, soil treated with sewage sludge was highly contained heavy metals.

Effect of application of the different concentration of Sewage Sludge on *Sorghum* growth

This experiment was an attempt to obtain information about the quality of SS treatment on Sorghum growth (Table 3). The periodical changes in total biomass were 10% >5%>1%>control. Also the mean number of leaves and the height of plant were recorded the highest at 10% of SS. Leaves (assimilating surface area), number of branches and nodes per plant were observed the highest at 10% concentration of SS.

2

3

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DISCUSSION

The importance of organic matter for agriculture in Egypt comes next to water. By simple calculation, we find that the 7.5 million fed under cultivation will require 170 million tons farmyard manure. It is worth to mention that the total available organic sources are only 87 million tons of farmyard manure which means that we should make use of any alternative organic resources (Abu ziada 2008 and Ismailetal 1996. On the other hand, the huge amounts of organic wastes accumulating due to the increase in both population and industrial-agricultural activities should be utilized. It is well a known tact, that recycling organic waste materials for increasing agricultural production, reduces environmental pollution. It is promoted due to the use of garbage for increased vegetable production instead of accumulating unsightly heaps around a city for example, is an attractive alternative. However in many countries that have recently been increasingly dependent upon mineral fertilizers, the technical knowledge of organic waste utilization has been lost. It is thus necessary to re-introduce the techniques, to improve them and to develop new practices conforming to modern technology.

Human wastes should not be directly applied to soils as this leads to offensive odors, attraction and multiplication of flies, spread of diseases and, in any case, is inefficient for fertilization purposes. City sewage is usually digested under controlled conditions. It can either be applied directly to soils or composted with more solid materials before use. The use of sewage sludge as a source of supplementary N and P for plant growth will likely continue to increase at a rapid rate in the near future for several reasons. It is the least costly method.

Chu and Wong (1987) investigated the effect of refuse compost and sewage sludge on vegetable crops grown on sandy soil. They found that crop yields followed the descending order of chemical fertilizers, activated sludge, refuse compost and sandy soil alone. Under Egyptian conditions, Abou-Seeda (1987) added sewage sludge at different rates (from 1% to 6% by weight) to sandy soil. He found that the lowest dose increased the growth of barley while the highest one decreased the growth of barley and bean plants. He added that Zn, Cu, and Ni were the most effective elements by a wide range of sludge application. Sheta et al. (1990) found that 35% treatment of sandy soil with sludge tended to a clear desperssion in the dry matter yield of alfalfa.

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المعاملة بالمخلفات العضوية الصلبة لتحسين خصائص التربة ونمو نبات حشيش الفرس

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تهدف الدراسة الى تحديد المستوى المناسب من المخلفات العضوية الصلبة كمخصبات حيوية لزيادة انتاجية نبات حشيش الفرس وتقليل تجميع العناصر الثقيلة بالنباتات مع متابعة التغيرات التي تحدث في الخصائص الفيزيائية والكيميائية للتربة نتيجة المعاملة بالمخلفات العضوية الصلبة.

في هذه الدراسة وجد ان المخلفات العضوية الصلبة تعمل علي تحسين الصفات الفيزيائية للتربة مثل المسامية والسعة المائية للتربة وكذلك الصفات الكيميائية مثل الكربون العضوي والتوصيل الكهربائي والاملاح الكلية الذائبة.

وتظهر المخلفات العضوية الصلبة فوائد عديدة مثل تحسين الصفات الفيزيائية والكيميائية للتربة وزيادة خصوبة نبات حشيش الفرس، ومن ناحية اخري فان المخلفات العضوية الصلبة لها بعض التأثيرات الضارة علي التربة مثل زيادة الاس الهيدروجيني للتربة.

ومن ثم فان الامر يتطلب مزيد من الدراسات البيئية لتقييم الاثر البيئي لأستخدام المخلفات العضوية الصلبة بكافة انواعها باقل آثار ضارة علي البيئة والنباتات المتواجدة ومن ثم الحيوانات المتغذية عليها وذلك نظرا لانها الاقل تكلفة من الانواع الاخري من المخصبات بالاضافة ان استخدمها يعتبر وسيلة لحماية البيئة من المخلفات باعادة تدويرها واستخدامها.

Table (1): The physical and chemical characteristics of cultivated soil treated with sewage sludge before the beginning of the experiment .por.=Porosity ,W.H.C.=water holding capacity ,Org.C.=organic carbon , E.C.=Electric conductivity, and T.S.S=Total soluble salts.

Sample NO	Physical characteristics							Chemical characteristics								
	Mechanical Analysis					Por. %	W.H.C. %	Org.C %	$CaCO_3$ %	Analysis of 1 : 5 water extract						
	Particles Size mm (%)									E.C. µ mohs/ Cm	Cl^- %	SO_4^{--} %	CO_3^- %	HCO_3^- %	T.S.S	pH
	Coarse sand	Medium sand	Fine sand	Silt	Clay											
Sewage sludge 1%																
1	26.31	22.45	40.70	4.39	4.40	47.44	50.80	0.6	4.0	363	0.030	0.008	0.0	0.06	0.20	7.3
2	24.11	25.85	39.97	5.37	4.11	43.96	51.10	1.2	2.5	389	0.025	0.004	0.0	0.09	0.30	7.4
3	25.23	24.97	34.99	4.80	6.29	46.84	48.62	1.2	2.0	405	0.035	0.008	0.0	0.06	0.20	7.3
Mean	25.21	24.42	38.55	4.27	4.93	46.08	50.17	1.0	2.8	385.6	0.03	0.006	0.0	0.07	0.23	7.3
S.E	0.51	0.83	1.46	0.23	1.10	1.07	0.78	0.2	0.6	9.9	0.002	0.001	0.0	0.01	0.033	0.03
sewage sludge 5%																
1	24.18	21.24	42.10	6.60	5.51	47.24	56.15	1.2	2.5	436	0.04	0.008	0.0	0.12	0.40	7.2
2	23.91	21.91	41.69	6.43	5.74	46.64	50.88	0.6	4.5	470	0.04	0.004	0.0	0.09	0.20	7.3
3	25.86	23.93	37.76	5.37	5.75	47.40	50.97	1.8	4.5	529	0.045	0.008	0.0	0.12	0.20	7.6
Mean	24.65	22.36	41.51	5.13	5.65	47.09	52.66	1.2	3.8	478.3	0.041	0.006	0.0	0.11	0.26	7.36
S.E	0.49	0.66	1.12	0.31	0.06	0.23	0.52	0.3	0.6	10.5	0.001	0.001	0.0	0.01	0.06	0.12
sewage sludge 10%																
1	25.91	20.40	40.21	6.81	5.66	46.60	55.26	1.8	4.0	831	0.04	0.012	0.0	0.15	0.30	7.6
2	20.31	19.60	47.11	7.33	5.62	48.04	57.01	1.2	2.5	609	0.045	0.008	0.0	0.15	0.30	7.4
3	20.70	20.04	40.74	10.96	5.07	48.00	56.61	1.8	4.5	724	0.045	0.008	0.0	0.18	0.40	7.4
Mean	24.30	20.01	41.68	5.36	5.45	47.54	56.29	1.6	3.6	721.3	0.043	0.009	0.0	0.16	0.33	7.46
S.E	1.47	0.18	1.81	1.06	0.35	0.47	0.52	0.2	0.6	14.1	0.001	0.001	0.0	0.01	0.03	0.06
Control																
Control	31.25	25.26	35.8	4.26	3.65	45.18	49.24	1.0	3.8	430.6	0.025	0.009	0.0	0.080	0.13	7.0
S.E	0.62	0.62	0.26	0.16	0.19	0.66	4.37	0.2	0.4	36.4	0.002	0.002	0.0	0.009	0.03	0.05

Table (2): Heavy metals concentration in the soil treated with different levels of organic wastes. SS=sewage sludge, FYM=farm yard manure, MSW=municipal solid wastes, at the beginning of the experiment.

Treatments	**Heavy metals content (ppm)**				
	Fe	**Zn**	**Cu**	**Co**	**pb**
Control	21.76	3.45	4.79	1.04	4.07
S.S. 1%	47.98	18.2	7.00	1.43	5.81
S.S. 5%	48.84	28.1	8.0	1.21	5.92
S.S. 10%	61.26	83.9	8.6	2.21	8.36

Table (3):Heavy metals concentration in the Soil treated with different levels of solid organic wastes. SS=sewage sludge, MSW =municipal solid wastes, FYM=farm yard manure , after harvesting.

Treatments	Heavy metals content (ppm)				
	Fe	Zn	Cu	Co	pb
Control	15.76	3.3	4.6	0.88	2.77
S.S. 1%	38.7	8.1	7.2	1.15	5.02
S.S. 5%	18.47	3.3	4.7	1.10	4.15
S.S. 10%	55.3	61.4	11.4	1.5	7.07

Effect of application of the different solid organic wastes on *Sorghum* growth

Table (4): Effect of different levels of sewage sludge on the growth of *Sorghum virgatum* .

Treatment level	Sample NO.	Height (Cm)	Number of Leaves	Biomass (g/plant)				Leaves assimilating Surface area (cm^2)	Number of Branches per plant	Number of Nodes per plant
				Stem Dry wt.(g)	Root Dry wt.(g)	Leaves Dry wt.(g)	Total Dry wt.(g)			
1%	1	81.0	38.0	0.99	0.69	1.05	2.73	29.50	14.0	21.5
	2	110.0	32.5	0.94	0.63	1.14	2.71	35.82	8.6	15.5
	3	90.0	61.0	1.82	0.78	4.95	7.55	33.65	9.6	40.0
	Mean	93.6	43.8	1.25	0.70	2.36	4.33	32.99	10.7	25.6
	S.E	6.9	7.1	0.23	0.03	1.04	1.31	1.51	1.3	6.0
5%	1	94.0	58.5	1.04	0.82	2.18	4.04	37.04	11.5	30.0
	2	92.3	54.6	1.73	0.81	4.06	6.60	35.51	7.5	29.6
	3	97.6	42.3	1.09	0.76	3.79	5.64	38.73	19.0	23.3
	Mean	94.6	51.8	1.28	0.79	3.34	5.42	37.09	12.6	27.6
	S.E	1.2	3.9	0.18	0.01	0.47	0.60	0.75	2.7	1.7
10%	1	91.5	66.0	1.94	0.94	5.12	7.99	36.80	24.0	39.5
	2	111.3	57.3	1.75	1.44	3.50	6.69	40.21	9.3	28.3
	3	92.0	68.5	1.38	1.00	2.05	4.43	38.49	16.0	31.0
	Mean	98.2	63.9	1.69	1.12	3.55	6.37	38.50	16.4	32.9
	S.E	5.3	2.7	0.13	0.12	0.72	0.85	0.80	3.4	2.7
Control	1	60.6	20.0	0.29	0.10	0.47	0.86	20.76	5.0	7.2
	2	54.3	17.0	0.26	0.16	0.64	1.06	16.45	6.3	9.0
	3	66.0	17.3	0.21	0.13	0.77	1.11	23.18	5.6	7.0
	Mean	60.3	18.1	0.25	0.13	0.62	1.01	20.13	5.6	7.7
	S.E	3.2	0.7	0.01	0.01	0.03	0.06	1.60	0.3	0.30