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Advantages of Applying Various Compost Types to Different Layers of Sandy Soil: 1- Hydro-physical Properties.

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Abstract: To avoid the increasing pollution load in the Egyptian environment as a result of annually huge amounts of agricultural wastes and the miss management of the disposal of these wastes. Therefore, its recycling became a must. The aim of recycling such wastes is to use them in improving the properties of sandy soil which cover about 95% of the total Egyptian area and have unfavorable characteristics necessary for crop production. A pot experiment was conducted to evaluate the effect of applying types of compost (two types prepared from cotton and banana wastes) to sandy soil by three addition treatments (i.e. surface, subsurface and whole mixed) on some soil hydro-physical properties. The concerned properties are water stable aggregates, bulk density, total porosity, pore size distribution, soil available water and hydraulic conductivity. Improving such properties is mandatory for the purpose of reclaiming and increasing productivity of sandy soils. The results and statistical analysis, generally, indicated significant beneficial effects of the application of both two types of compost on all studied soil properties. The surface, subsurface and whole addition treatments (i.e. SA, SbA ; WA) showed significant effects on water stable aggregates, pore size distribution and soil available water. The study recommended using any of the two studied composts to improve hydro-physical properties of sandy soil, in addition to converting agricultural wastes to useful materials in agricultural fields' especially reclaiming and increasing fertility of sandy soil.

Key words: Compost, water stable aggregates, bulk density, pore size distribution, available water, hydraulic conductivity.

INTRODUCTION

Because of the miss management of agricultural wastes, which are usually disposed by burning or discarding the waste at the sides of roads and/or canals, the pollution load in the Egyptian environment has dramatically increased, especially with the huge residuals of plants such as cotton and banana which are left behind after collecting the economic plant component. Consistent with the economic consideration and condensed agriculture followed in Egypt, the farmer needs to dispose of the residual agricultural waste as soon as possible to prepare the soil and cultivate the next crop. Safe disposal of such wastes is fundamentally important but the challenge is the recycling. Francis *et al*[1] mentioned that: there is growing interest in the use of organic amendments for reclamation of degraded soils. In this respect, [2] reported that the addition of organic materials of various origins to soil has been one of the most common rehabilitation practices to improve soil physical properties. Tejada[3] added that compost is of great agricultural interest because of its organic matter content.

FAO[4] reported that with the exception of small scattered areas in the Delta and Nile Valley most of the sandy soils are in the desert which makes up more than 95% of the total area of Egypt. Although sandy soils differ in their origin, formation and properties, yet they can be considered as one group having common problems. The problems we are concerned here are the hydro-physical properties, such as loss structure which associated with low total porosity, rapid hydraulic conductivity and low water retention and soil available water. FAO[4] stated that it is worth mentioning that the reclamation of sandy soils in Egypt was dependent upon the annual addition of Nile mud besides that which was added from clearing irrigation canals and drains as well as the organic material. But the reduction in quantities of clay and silt after the construction of the High Aswan Dam has led research to be directed toward application of different methods such as asphalt emulsions, chemical amendments, whether by direct mixing or in barriers.

Limited research has been done to quantify the beneficial effect of applying compost (which is treated agricultural waste) to Egyptian sandy soils. Applying compost to sandy soil is a good way to recycle the agricultural wastes and increase its organic matter content which may help in solving the sandy soil hydro-physical problems.

The objective of this research is to evaluate the effect of two types of compost applied to different layers (depths) of sandy soil on the soil hydro-physical characteristics.

MATERIALS AND METHODS

A greenhouse experiment was conducted in the National Research Center (NRC), Cairo, Egypt. The experiment was carried out in completely randomized

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Table 1a: Some physical and chemical properties of the experimental soil.

C. sand	F. sand	Silt	Clay	Texture	O.M %	CaCO3	PH	EC (dS /m)
85.79	10.4	2.65	1.16	Sandy	0.09	0.32	7.23	0.3

Table 1b: Some chemical characteristics of the applied composts.

Compost type	PH	EC (dS/m)	C/N ratio	N (%)	P (%)	K (%)	Fe (%)	Mn (%)	Zn (%)	Waxes (%)	Lignin (%)	Hemi-cellulose (%)	Ash (%)
Cotton	7.17	2.0	20.2	1.62	0.89	1.85	106	179	16.1	6.6	15.50	17.20	7.2
Banana	7.64	2.1	18.5	1.82	0.69	3.31	165	207	41.7	10.7	19.07	32.67	12.5

design with three replicates in plastic pots. Each pot received 10Kg of air dried sandy soil. Composts (two types prepared from cotton and banana wastes) used in the experiment were prepared according to the method described by [5] cotton and banana composts were added at the rate of 15g/Kg soil (15tons/feddan; feddan = 4200 m^2).The composts application were as follows:

- Control treatment (CT): No composts were added.
- Surface addition treatment (SA): composts were incorporated with the surface layer (i.e. 0-15cm).
- Subsurface addition treatment (SbA): composts were incorporated with the subsurface layer (i.e. 15-30cm).
- Whole addition treatment (WA): composts were incorporated with the whole soil in the pot (i.e. 0-30cm).

Mineral nutrients additions were 33kg N, 23kg P_2O_5 and 24kg K per feddan. The applied fertilizers for NPK were ammonium nitrate, super phosphate and potassium sulphate, respectively. Spinach (Spinacia Oleracea L.) was chosen as a test plant. It was classified as a short-season shallow root system plant. Lorenz[6] stated that the time required for Spinach to reach market maturity from seedling are 37 and 45 days for early and late variety respectively and between 60 and 70 days for spinach cultivated in Mediterranean area according to [7]. The average root length is ranging between 46-61 cm according to [6] and ranging between 30-50 cm according to [7] So, 30 cm consider a suitable depth under pot experiment and full water requirement compensation condition with short irrigation intervals. Ten seeds per pot were planted, then thinned to five plants selected to grow until the end of the season. The moisture content was maintained at field capacity until the plants were well established (daily irrigation). After that soil moisture depletion was compensated, by irrigation, twice a week. The irrigation requirement was calculated based on the weight difference between pot at field capacity and at the actual moisture content.

After harvest, undisturbed soil samples were taken from each treated layer (e.g. SA, SbA and WA) for the purpose of soil properties determination. Water stable aggregates were determined according to[8]. Soil bulk density was determined by core method and total porosity was calculated using the values of soil bulk density and real density, i.e. 2.65g/cm^3[9].To calculate soil available water, soil moisture content, on dry weight basis, was determined at 0.1 and 15 bars (representing field capacity and permanent welting point respectively) according to[8]. For the purpose of calculating pore size distribution soil moisture content by weight was converted to volumetric moisture content. Pore size distribution was classified into drainable pores (DP), capillary pores (CP), water holding pores (WHP) and fine capillary pores (FCP) as described by [10].Soil hydraulic conductivity (constant head method) was determined after [8].Statistical analysis was done according to [11]. (All tests were performed at the 0.05 significant level. Soil particle size analysis of virgin sandy soil was determined by pipette method[9]. Some physical and chemical analyses of the experimental soil and used composts are presented in Table (1a and b).

RESULTS AND DISCUSSIONS

Water stable aggregates: Water stable aggregates give an indication of soil structure and directly affect pore size distribution. Data in Table (2) indicated the positive effect of the added composts on soil aggregates regardless the type or position of the used composts. It is clear for example that the total aggregates have diameter > 0.25 mm increased when compost applied at the expense of that have diameter < 0.25 mm compared with the control treatment. This means that the used composts were able to create new conditions differ from that predominant in sandy soil.

The aggregate size distribution is presented in fig. (1) The figure generally reveals that the added composts occurred a great modification in the pattern of aggregates distribution either between the two used composts or when compared with the control. The Highest percentage of increase reached 169.77% for the whole addition treatment for the aggregates have diameter 8-2mm under banana compost while it was 44.19% under cotton compost. The same treatment achieved the highest percentage by values 325.88% and 248.88% for the aggregates have diameter 2-1mm under banana and cotton composts, respectively. On the contrary, cotton compost owned the highest percentage for the aggregates have diameter 1-0.425mm which reached 92.23% for the whole addition treatment against 43.78% for the same aggregates and treatment under banana compost. Concerning with the aggregates have diameter 0.425-0.25mm, banana compost had the highest reduction percentage which amounted to 37.87% for the whole treatment addition versus 29.15% for surface addition treatment under cotton compost. The variation in the action of the added composts may be due to the differences in their composition and consequently the products resulting from their decomposition which affect in turn on the pattern of soil aggregates.

Table 2: Water stable aggregates of sandy soil as affected by type and position of composts.

Treatments	Applied level (tons/fed.)	Total aggregates >0.25mm	% of control	Total aggregates <0.25mm	% of control
Control	-	24.78	100.00	75.22	100.00
Cotton compost	15				
SA	"	35.00	141.24	65.00	86.41
SbA	"	35.68	143.99	63.32	84.18
WA	"	37.31	150.56	63.69	84.67
Banana compost	15				
SA	"	33.87	136.68	66.13	87.92
SbA	"	34.66	139.87	65.34	86.87
WA	"	34.87	140.72	65.13	86.59

*SA,SbA;WA = surface, subsurface and whole addition, respectively.

Table 3: Water stable aggregates LSD values of compost type, position and their interaction.

LSD of aggregate	Type	Position	Interaction
8-2 mm	0.10	0.13	0.19
2-1 mm	0.39	0.41	0.67
1-0.425 mm	0.45	N.S.	N.S.
0.425-0.25 mm	0.42	0.44	0.73

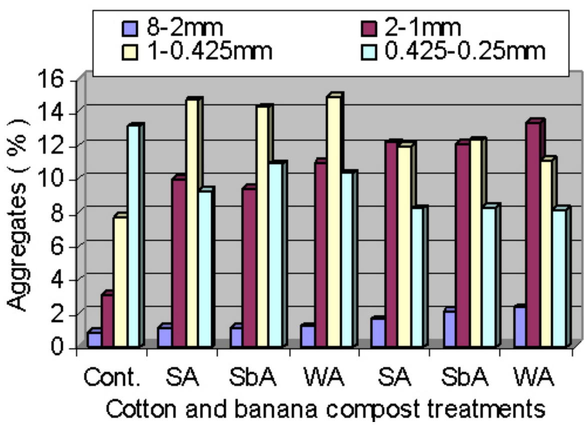

Fig. 1: Wet aggregates size distribution of sandy soil treated with composts at diffrent positions.

Rizzi *et al* [12] reported that compost can help the formation of a larger number of water stable aggregates through links, between smaller particles, strong enough to withstand the dispersing action of water. Similar results were found by [13] who conducted a pot experiment to study the effect of compost on soil physical and chemical properties. He found that compost improved soil aggregation. Also, [14] found that soil structural stability increased 24% with cotton gin crushed compost addition. This is also agree with [15,16] who explained the effect of compost on increasing structural stability and decreasing soil loss by its high content of humic acid and calcium and its low content of monovalent cations, particularly Na+ and fulvic acid.

LSD values, presented in table 3, indicate significant effect of compost type, position and interaction on the stability of all studied aggregates sizes except the size of 1-0.425 mm which showed only significant effect of the compost type.

Table 4: Soil bulk density and total porosity of sandy soil as affected by type and position of composts.

		SBD (Mg/m^3)		TP (%)	
		Soil depth (cm)			
Treatments	Applied level (tons/fed).	0-15	15-30	0-15	15-30
Control	-	1.700	1.700	35.85	35.85
Cotton compost	15				
SA	"	1.351	1.700	49.02	35.85
SbA	"	1.700	1.355	35.85	48.87
WA	"	1.383	1.384	47.81	47.77
Banana compost	15				
SA	"	1.301	1.700	50.91	35.85
SbA	"	1.700	1.303	35.85	50.83
WA	"	1.311	1.320	50.53	50.19

*SBD=soil bulk density; TP=total porosity, The colored numbers= untreated layers.
*SA,SbA;WA=surface, subsurface and whole addition treatments, respectively.

Table 5: Total porosity LSD values of compost type, position and their interaction.

LSD	Type	Position	Interaction
	1.82	N.S.	N.S.

Soil bulk density and Total porosity: From the indicated results in Table (4) concerning with soil bulk density (SBD) and total porosity (TP), it is clear that a pronounced reduction in SBD values was occurred as a result of adding cotton and banana composts relative to the control treatment.The reduction generally was higher under compost of banana than that of cotton, regardless the position of addition (i.e. surface,subsurface ;whole addition).For cotton compost, the highest decrease in SBD values was 20.53% and 20.29% for the layers from 0-15 and 15-30 cm, respectively compared with the control treatment. With regard to banana compost, the highest reduction reached 23.47% and 23.35% for the layers from 0-15 and 15-30cm, respectively.

With respect to TP, the results in the same table showed an increase in the values of TP as a result of applied composts. The values reached its maximum for cotton compost to 49.02% and 50.91% for banana compost for the depth of layer from 0-15 cm while the maximum values were 36.32 and 41.79 for cotton and banana compost, respectively for the depth of layer from 15-30cm relative to the value of control which was 35.85%.

Statistical analysis reveals that compost type treatment results in significant decrease in soil bulk density which reflects in increase in soil total porosity. In this respect, [14] and [15] found that soil bulk density decreased with compost addition. The highest porosity was associated with banana then cotton then control. No significant effect was found for the application position treatments or the interaction between the type and position (calculated LSD values are presented in table 5). This may be due to that the measurements of bulk density were done for the treated layers only.

Such result is very important because low total porosity is considered one of the major problems of sandy

Table 6: Pore size distribution of sandy soil as affected by type and position of composts.

Treatments	Applied level (tons/fed.)	D P (%) 0-15	D P (%) 15-30	C P (%) 0-15	C P (%) 15-30	W H P (%) 0-15	W H P (%) 15-30	F C P (%) 0-15	F C P (%) 15-30
Control	-	11.52	11.52	24.33	24.33	20.52	20.52	3.81	3.81
Cotton compost	15								
SA	"	8.41	11.49	40.61	24.36	30.72	20.69	9.89	3.67
SbA	"	11.52	6.24	24.33	42.63	19.71	32.52	4.62	10.11
WA	"	8.00	7.73	39.81	40.04	31.29	31.78	8.52	8.26
Banana compost	15								
SA	"	7.77	11.51	43.14	24.34	28.96	20.57	14.18	3.77
SbA	"	11.54	6.18	24.31	44.65	20.01	30.50	4.30	14.15
WA	"	10.83	10.38	39.70	39.81	27.27	27.06	12.43	12.43

Soil depth(cm

*DP, CP, WHP; FCP = drainable, capillary, water holding and fine capillary pores, respectively.
*SA,SbA;WA = surface, subsurface and whole addition treatments, respectively.

Table 7: size distribution LSD values of compost type, position and their interaction

LSD of pores	Type	Position	Interaction
DP	0.52	0.55	0.91
CP	1.41	1.48	N.S.
WHP	1.04	1.10	N.S.
FCP	0.40	0.42	0.69

Table 8: Available water of sandy soil treated with composts at different positions.

Treatments	Applied level (tons /fed.)	Available water (%) 0-15cm	% of control	15-30cm	% of control
Control	-	12.07	100.00	12.07	100.00
Cotton compost	15				
SA	"	22.74	188.40	12.17	100.83
SbA	"	11.59	96.02	24.00	198.84
WA	"	22.62	187.41	22.96	190.22
Banana compost	15				
SA	"	22.26	184.42	12.10	100.25
SbA	"	11.77	97.51	23.41	193.95
WA	"	20.80	172.33	20.50	169.84

*SA,SbA;WA= surface, subsurface and whole addition treatments, respectively

soils which in turn involves in some other soil properties such as soil aggregation, pore sizes, water retention and hydraulic conductivity. So to clarify and quantify the beneficial effect of applying compost to sandy soil, measurements, of the parameters specified above, should be done. Wanas[17] reported that compost treatments either alone or in combination with inorganic fertilizers achieved significant impacts on soil bulk density, total porosity, macro and micro pores and soil water retention and soil hydraulic conductivity relative to the control. .

Pore size distribution: Pore size distribution (PSD) is a fundamental soil physical property because it controls soil available water, which is a part of soil water retention and soil hydraulic conductivity. Table (6) shows the effect of compost type and position on pore size distribution. It is clear that the used composts exhibited beneficial effects towards modifying PSD pattern. The changes greatly differed among the different soil pores. The table reveals also that compost addition decreased DP (which is responsible of rapid water losing under gravity force) and increased CP, WHP and FCP (which are responsible of retaining water against gravity force). For DP the maximum reduction was 32.55% under banana compost for surface addition treatment, while it was 30.56% under cotton compost for whole addition treatment. On the other hand, capillary pores (CP) water holding pores (WHP) and fine capillary pores (FCP) achieved a noticeable increase in their values which greatly differed according to the type of compost and the position of treatment. This conceder a great improvement of sandy soil which quickly lose the irrigation water by deep percolation, especially the percent of FCP which increased about three times over control. This result reflected in decreasing soil hydraulic conductivity (discussed later)

Table 7 reveals that both compost type and position, for all pore classes and their interaction (only in case of DP and FCP) significantly affect pore size distribution.

Pagliai *et al*[18] found that both compost and manure improved soil pore system characteristics. The addition position also showed, in general that SbA was the most effective. This may due to that the sub-surface layer is more stable because it is less affected by erosion factors. Pajliai [19] conducted experiments on different types of soils using different types of organic matters (composts and manures). They found that soil pore size distribution significantly changed after treatment with all kinds of organic matter. Also, [17] found that using composts in soil results in a decrease in large pore space.

Soil available water: Table (8) clearly indicates that soil available water was increased for composted soil almost twice over control. This agrees with what was found by[13] who found that compost application increase water

Table 9: Soil available water LSD values of compost type, position and their interaction.

LSD	Type	Position	Interaction
	0.75	0.79	N.S.

Table 10: Soil hydraulic conductivity of sandy soil treated with composts at different positions.

Treatments	Applied level (tons / fed.)	SHC (m/day)	% of decrease
Control	-	1.127	100.00
Cotton compost	15		
SA	"	0.891	20.94
SbA	"	0.907	19.52
WA	"	0.795	29.46
Banana compost	15		
SA	"	0.908	19.43
SbA	"	0.910	19.25
WA	"	0.825	26.8

*SHC = soil hydraulic conductivity.
*SA,SbA;WA = surface,subsurface and whole addition treatments, respectively.

Table 11: Hydraulic conductivity LSD values of compost type, position and their interaction

LSD	Type	Position	Interaction
	0.04	0.04	N.S.

holding capacity. Subsurface addition treatment (SbA) was higher in soil available water than both surface (SA) and whole addition (WA) treatments. This may be due to that the organic matter (compost) is not exposed to open air so lower evaporation is expected. Furthermore, the water capillary rise may fail at the soil surface layer because of braking down of the aggregates much more than the sub-surface layer which considered protected layer. The small difference between the two types of compost may be due to that soil available water is tending to be affected by the rate of application of the organic matter more than type or the source of such organic matter. This is some what agree with the results obtained by [19] who found similar effects of applied manures and composts on soil physical properties. Also, [17] reported that compost treatments increased micro pores of sandy soil which resulted in an increase in soil available water.

Table 9 shows significant effect of both type and position of compost on soil available water and non significant effect of their interaction.

Hydraulic conductivity: Table (10) clearly shows the effect of compost application on decreasing hydraulic conductivity of sandy soil which is the main problem of such kind of soils. It is worthy to notice that the whole addition treatment (WA) exhibited the highest reduction values of hydraulic conductivity where amounted to 29.46% and 26.80% for cotton and banana composts, respectively. This behavior may due to the continuity connection of soil pores from soil surface till the bottom. On the other side, the two other treatments (i.e. SA; SbA) occupied the second order where the percentage of decrease reached 20.94, 19.52, 19.43 and 19.25% for surface and subsurface addition treatments under cotton and banana compost, respectively. This trend may be attributed to the exposure of surface layer directly to the open air specially sunrise which may affect on activity of microorganisms of that layer and consequently affect on the formation of aggregates that related with pore size distribution and lastly hydraulic conductivity. This result may due to the beneficial effect of compost on both soil aggregate stability and pore size distribution. Strictly speaking, the results proved that both of the two types of compost caused reduction of macro pores (DP) and increase of micro pores (CP, WHP and FCP) which should be reflects in hydraulic conductivity reduction.

Lado *et al*[20] found, in experiment on sandy loam soil (close to the soil in this study), significant interaction between the aggregate size and the organic matter content (i.e. compost), in their effects on the saturated hydraulic conductivity.

Table 11 shows calculated LSD of the effect of compost type, position and their interaction on soil hydraulic conductivity. The control treatment showed relatively high hydraulic conductivity (significant changes) comparing with the two specified types of compost (cotton and banana).

The statistical analysis indicates that the two types (no significant differences found between them) significantly decreased hydraulic conductivity. Also there was a significant difference between WA and both SA and SbA (no significant differences found between them). No significant effect was found for the interaction of type and position. This interpretation is supported by the finding [17].

Conclusion: The obtained results indicate that both cotton and banana composts significantly improve sandy soil hydro-physical characteristics studied here and it recommends their use as amendments to such kind of soils. The study also revealed that banana compost which is a source of a huge residual agricultural waste, similar to that of cotton, has given comparable or better effect than cotton compost which is more often studied in the literature. The addition of compost to different layers of soil showed significant effect of some hydro-physical properties, such as aggregation, pore size distribution and soil available water. Another study should be performed to evaluate the effect of compost (type and position addition) on evaporation, transpiration, water use efficiency and yield.

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