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Full Length Research Paper

Short-term studies on use of organic amendments for amelioration of a sandy soil

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The increase in world population has posed more pressure in existing arable lands. The nutrients poor sandy soils could be productive if their content of organic matter can be increased. Agricultural and animal wastes instead of being dumped, could offer a cheap alternative source of organic matter to increase soil fertility. Three glasshouse short-term experiments were carried out to evaluate the effects of incorporation of: (1) agricultural residues (trashes of *Cajanus cajan* and sugarcane factory by-product (baggase); (2) recycling of various vegetable market wastes and; (3) application of animal wastes (hoof and wool) on soil properties and performance of fodder sorghum (*Sorghum bicolor* L.) or maize (*Zea mays* L.). Results showed that almost all sources of organic materials had resulted in significant positive effects on accumulation of plant dry matter and soil physical and chemical characteristics. Organic amendments are necessary for the sustainable use of nutrient-poor Sudanese sandy soils.

Key words: Organic amendments, sandy soil, amelioration, fodder crops.

INTRODUCTION

More than 60% of Sudan area lies in the arid and semi-arid region which is characterized by low and erratic rainfall. Salih (2007) stated that the desert extends from north to south at an alarming rate and he also mentioned that about 13 states out of the 26 states of the Sudan are affected by desertification. Aeolian sandy soils have weakly developed profiles and a loose consistency (Henry, 2005). They are largely barren ecosystems characterized by frequent drifting of sand, poor plant substrates, and low biological activity.

In many of the arid and semi-arid regions of the world (including Sudan), water is likely to become the most critical resource and the most limiting factor in the production of food (Elquosy, 1998).There is more interest in utilizing soils of low or marginal productivity (for example, sandy soils) for crop production to match the demand for agricultural products (Cecil, 1990). The major constraints of these soils are their water retention, high water transmission and low nutrient content.

Organic amendments have been proposed as an effective method to improve physical properties of soils. Earlier Kunar et al. (1985) and recent study by Diana et al. (2008) reported positive effects of organic wastes on soil physical properties (viz. water retention and hydraulic conductivity). Amelioration of these properties is largely based on increasing organic carbon in the soils (Garcia et al., 1992). El-Asswad et al. (1993) indicated that olive oil cake significantly increased the ability of two sandy soils to retain water.

A study carried out by Mtambanengwe and Mapfumo (2006) on sandy soils in Zimbabwe to investigate the effect of organic resource quality on maize yield showed that maize yield increased linearly with total N added in these resources in combination with N fertilizer. They documented improvements in soil physical properties and in maize yield and showed significant correlations between soil organic matter and porosity, water holding capacity and yield. Gioacchini et al. (2006) reported that mixing of hoof and horn with fur and farm yard manure can be a slow release fertilizer. Organic amendments like straw can greatly decrease the intensity of sand flux by as much as 95.5% due to increase in soil roughness (Yu Qui et

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Table 1. Chemical and physical properties of the soil.

Soil parameter	Value
pH $_{(paste)}$	7.6 - 8.5
TN (g kg^{-1})	0.125 - 0.93
OC (g kg^{-1})	0.12 - 0.37
ECe (dSm^{-1})	0.5 - 0.8
CEC $cmol_c$ (+) kg^{-1}	0.25 - 11.27
WHC (g kg^{-1})	5.29 - 21
Sand (g kg^{-1})	750 - 780
Silt (g kg^{-1})	82 - 140
Clay (g kg^{-1})	80 - 168
Texture	Sandy loam
Sub-order	Orthid

TN: Total nitrogen, OC: organic carbon, ECe: electrical conductivity of the saturation extract, CEC: cation exchange capacity, WHC: water holding capacity.

al., 2004; Zhang et al., 2004).

In Sudan, the quantity of hoof and wool produced from livestock in the capital (Khartoum) was estimated to be 400 - 600 t y^{-1}. Recently, hoofs are powdered, sieved and exported. The 0 -1 mm particle size is to be waste and constituted about 7 - 8% of the total product (30 - 45 t $year^{-1}$) and may reach up to 100 t $year^{-1}$. Content of wool was estimated to be 50 - 80 t $year^{-1}$. All of this by-product is located in the west of the capital which is heavily populated and with degraded soils. Similarly, Sudan produced about 200 t $year^{-1}$ of baggase from four main sugarcane factories which may cause disposal problems (Ali, 2005) and might be of value if recycled to the soil. There are also tremendous agricultural wastes (mainly vegetables) left in open markets and causing laborious work of cleaning and dumping with other non-classified household wastes. Taking all these into consideration, together with the fact that Khartoum State (8 million) is surrounded by displaced people occupying fragile soils around the State thereby, increasing demand for agricultural products. It is necessary to utilize the marginal soils around the capital by improving their productive capacity using low input systems. Therefore, the study aimed at conducting short-term experiments utilizing an array of organic wastes for the improvement of nutrient poor sandy soils.

MATERIALS AND METHODS

Three experiments were conducted in the glasshouse of the Department of Botany, Faculty of Agriculture, University of Khartoum, Shambat, Sudan (15° 37' N 32° 33' E, altitude 382 m abs) to study: (1) the effects of different organic sources on establishment of either fodder sorghum (*Sorghum bicolor*) or fodder maize (*Zea mays*) and; (2) effects on properties of a nutrient poor soils with high sand content. The soil used in all experiments was collected from the top 0 - 30 cm depth of highly populated areas around the capital (Khartoum). The soil was passed through a 2 mm sieve to exclude non soil particles and analyzed for pH $_{(paste)}$ using pH-meter, total carbon (Walkley and Black, 1934), total N (Bremner and Mulvaney, 1982), cation exchange capacity, electrical conductivity and soluble Ca, Mg and K (Chapman and Pratt, 1961), water holding capacity (Dane, 2002) and particle size distribution (Gee and Bauder, 1986). Table 1 shows initial selected chemical and physical properties of the soil used in the experiments. Manures and vegetable residues were collected from the Experimental Farm of the University of Khartoum and local vegetable markets. The hoof and wool were collected from animal spots waiting for slaughtering and slaughtering places. Sugarcane baggase was obtained from Gunaid Sugar Company, Sennar State. All organic sources were dried at 60 - 70℃ and a sub-sample was used for the determination of TN (Bremner and Mulvaney, 1982), OC (modified Walkley and Black, 1934), cations (Chapman and Pratt, 1961), lignin and cellulose (Van Soest, 1963). Chemical properties of the organic sources are presented in Table 2.

Experiment 1

This study was conducted to determine the effects of some vegetable residues and manure on performance of fodder maize and overall effects on soil properties. Treatments included:

1) Control, C (no organic source) or unmanured
2) Recommended inorganic fertilizer (F)
3) Farm yard manure (FYM)
4) Chicken manure (CM)
5) Carrot residues (CR)
6) Onion residues (OR)
7) FYM + CR (1:1) weight/weight (FYM+CR)
8) FYM + OR (1:1) weight/weight (FYM+OR)
9) CM + CR (1:1) weight/weight (CM+CR)
10) CM + OR (1:1) weight/weight (CM+OR)

About 3 kg air-dried soil was added to 30 (10 treatments x 3 replication) plastic pots (0.03629 m^2 surface area). Materials were added at constant rate of 10 t ha^{-1} (36. 29 g pot^{-1}) and incorporated in the top 5 cm soil depth. The inorganic treatment included application of 72 kg N ha^{-1} in the form of urea (46%N) which was equivalent to 1.36 g urea pot^{-1} and 40 kg of P_2O_5 in the form of Triplesuperphosphate (TSP, (48%) which was also equivalent to 0.873 g TSP pot^{-1}. The pots were arranged in the glasshouse in a completely randomized block design. The pots were irrigated (twice a week) with tap water to 70% of the water field capacity. After 10 days, five seeds of fodder maize were sown in each pot, thinned to 2 after 7 days. At harvest (12 weeks), plants were removed (5 cm above the surface) with a blade and dry matter weight (DMW) measured in g $plant^{-1}$ was determined. The soil in each pot was dried and analyzed for pH $_{(paste)}$, TN, OC, ECe, soluble cations and water retention capacity as earlier described.

Experiment 2

This experiment was conducted to study effects of incorporation of residues from pigeon pea (*Cajanus cajan*) and baggase wastes on yield of fodder sorghum and soil properties. Treatments were as follows:

1) Control, C (no crop residues)
2) Inorganic fertilizer (F)
3) Dried leaves of pigeon pea (DP)
4) Fresh leaves of pigeon pea (FP)
5) Baggase waste (B)
6) Baggaes combined with Fresh leaves of pigeon pea (B+FP)
7) Combined dried leaves of pigeon pea and fresh leaves of pigeon pea (DP+FP)

Table 2. Chemical composition of the organic amendments.

Organic material	TN (gkg^{-1})	OC (gkg^{-1})	Lignin (gkg^{-1})	Ca (gkg^{-1})	Mg (gkg^{-1})	C/N ratio
Farm yard manure (FYM)	1.82	54.3	73.9	10	2.4	29.8
Chicken manure (CM)	5.48	104.4	66.7	21	6.6	19.1
Carrot residues (CR)	6.44	97.2	11.5	11	9.0	12.3
Onion residues (OR)	6.30	95.8	14.7	13	3.9	15.2
Baggase (B)	3.35	439.9	220	Nd	Nd	131.3
Dried Pigeon pea (DP)	14	400	157	Nd	Nd	2.8
Fresh Pigeon pea (FP	30	450	128	Nd	Nd	3.2
Hoof (H)	175.7	484	57.5	200	100	15
Wool (W)	155	500	120	100	50	28.6

Nd: not determined, TN: total nitrogen, OC: organic carbon, C/N: carbon to N ratio.

Plastic bags (surface area of 0.0134 m^2) with 4 small openings at the bottom were used for this experiment. About 8 kg of the sandy soil was added to 28 bags (replicated four times). Crop residues were added at the rate of 31.4 g bag^{-1} (10 t ha^{-1}) and incorporated in the entire bag content. The inorganic treatment involved an application of the recommended fertilizer (applied as urea or TSP) dose of fodder sorghum or maize as described in experiment 1 (0.096 g N /bag, 0.094 P_2O_5/bag). The treatments and replicates were arranged in a completely randomized block design, placed in the glasshouse and irrigated (up to 70% field capacity) for two weeks before sowing. Then after, about four seeds of fodder sorghum were placed in each bag, thinned to 2 stands a week later. Irrigation continued until harvest (after 12 weeks) where plants were removed (5 cm above soil surface) using a sharp blade. Plant and soil samples were treated as earlier described in experiment 1.

Experiment 3

This experiment was conducted to study the effects of incorporation of wool and hoof powder on establishments of fodder maize and effects on properties of a sandy soil. Treatments were:

1) Control, C (no organic source and no inorganic fertilizer)
2) Inorganic fertilizer (F)
3) Hoof (H) at the rate of 10 t ha^{-1}
4) Wool (W) at the rate of 10 t ha^{-1}

About 7 kg of the sandy soil was added to each pot with a surface area of 0.0462 m^2. Hoof and wool (4.26 g each pot^{-1}) were incorporated in the whole soil inside the pot. The rate of inorganic fertilizer treatment was similar to the previous experiments (0.33 g N, 0.22 g P_2O_5) where N and P were added as urea and TSP, respectively. A control treatment was also included where no fertilizer or organic materials were added. The treatments were arranged in a complete randomized design with four replicates (total of 16 experimental units). A similar set up of the experiment, but without plants, were used for monitoring changes in pH of the soil. Pots were irrigated with water to 70% of the field capacity and irrigation continued for two weeks before sowing. Then after, about 5 seeds of fodder sorghum were sown and thinned to 2 a week later. After 8 weeks, plants were harvested in the same procedure as earlier described in experiment 1 and 2. Dry matter weight (DMW) measured in gram per plant was determined and the soil was analyzed for some chemical and physical characters as also described earlier.

Statistical analysis

In all experiments, variation between treatments were determined using SAS (1985) with Least Significant Difference (LSD) to separate means at a probability of $P \leq 0.05$ level.

RESULTS

Effects of vegetable residues and manure on performance of fodder maize and soil properties

The effects of incorporation of vegetable residues on plant dry matter weight and soil chemical properties are presented in Table 3. With the exception of OR, incorporation of individual vegetable residues, combined or along with manures had resulted in significantly ($P \leq 0.01$) higher (by about 41 - 70%) DMW compared to the control treatment. Application of FYM or OR, though significantly higher (20 - 23%) than the control and the inorganic fertilizer, were found to be inferior to other organic sources or combinations.

Soil pH, EC_e soluble Na and WHC were not significantly different between treatments. However, soil OC, TN, CEC, soluble cations (K, Ca and Mg) and HC were significantly ($P \leq 0.01$ - $P \leq 0.05$) different among treatments. The content of soil OC was significantly increased (44 - 72%) over the control and the fertilizer treatments. The content of TN in the soil was only significantly increased (more than 3 folds) by application of CM. All organic sources had almost similar and significant increase in CEC (ranged from 1.89 - 3.53 $cmole_c$ + kg^{-1}), soluble K (ranged from 0.15 - 0.34 meq L^{-1}) and soluble Ca (ranged from 0.98 - 1.65 meq L^{-1}) as compared to the average of the control and fertilizer treatments whereas effects on Mg were erratic. Application of organic residues had significantly decreased hydraulic conductivity (HC) from 9.47 - 10.17 cm h^{-1} (in the control and fertilizer) to an average of 7.59 (23% reduction).

Table 3. Effects of incorporation of some vegetable residues on soil properties and plant DMW (average ± standard deviation).

		Soil chemical properties									Soil physical properties	
	DMW	pH	OC	TN	CEC	ECe	Soluble cations meq L^{-1}				HC	WHC
Treatment	(g $plant^{-1}$)	(paste)	(g kg^{-1})	(g kg^{-1})	($cmole_c$/kg)	(dSm^{-1})	K	Ca	Mg	Na	($cmhr^{-1}$)	(%)
C	13.7c±1.2	8.5a±0.4	0.36b±0.01	1.76b±0.02	11.17b±1.1	0.50a±0.01	0.22b±0.01	3.03b±0.1	1.0c±0.02	0.65a±0.1	9.47a±0.7	24.33a±1.2
F	12.7c±0.9	8.4a±0.2	0.36b±0.02	1.99b±0.01	11.17b±1.0	0.65a±0.02	0.24b±0.02	3.67b±0.2	2.0ab±0.03	0.51a±0.2	10.17a±0.5	24.33a±1.6
FYM	16.3b±0.8	8.2a±0.1	0.55a±0.03	1.76b±0.01	14.67a±1.3	0.70a±0.03	0.38a±0.01	4.67a±0.2	1.33bc±0.03	0.55a±0.3	7.52b±0.4	24.33a±1.3
CM	20.3a±1.7	8.4a±0.3	0.52a±0.01	6.16a±0.02	14.30a±0.9	0.73a±0.01	0.47a±0.02	5.00a±0.2	1.33bc±0.02	0.68a±0.2	7.84b±0.5	24.33a±1.5
CR	23.3a±1.4	8.5a±0.2	0.54a±0.02	1.80b±0.01	13.97a±0.9	0.63a±0.03	0.47a±0.02	4.60a±0.1	1.70abc±0.01	0.61a±0.1	7.56b±0.4	24.33a±1.6
OR	16.8b±0.9	8.4a±0.1	0.60a±0.01	1.73b±0.02	13.56a±1.2	0.67a±0.02	0.57a±0.02	4.60a±0.5	1.60abc±0.02	0.45a±0.1	7.39b±0.2	23.67a±1.1
FYM+CR	21.3a±1.1	8.4a±0.4	0.49a±0.02	1.63b±0.01	14.37a±0.8	0.57a±0.02	0.38a±0.01	4.90a±0.4	1.60abc±0.01	0.70a±0.2	7.73b±0.4	23.67a±1.4
FYM+OR	22.0a±0.6	8.4a±0.3	0.57a±0.01	1.63b±0.01	14.60a±0.9	0.57a±0.01	0.38a±0.01	4.33a±0.3	1.82abc±0.01	0.74a±0.2	7.47b±0.4	23.67a±1.8
CM+CR	19.3a±0.4	8.4a±0.1	0.62a±o.o1	1.70b±0.02	14.03a±1.1	0.70a±0.02	0.43a±0.03	4.36a±0.2	2.26a±0.03	0.54a±0.1	7.47b±0.2	25.00a±1.3
CM+OR	20.3a±1.3	8.4a±0.2	0.57a0.03	1.76b±0.03	14.70a±1.5	0.70a±0.03	0.34a±0.01	4.47a±0.3	2.20a±0.04	0.58a±0.1	7.73b±0.4	23.67a±1.4

Values in columns followed by similar letter(s) are not significantly different at P ≤ 0.05 using least significant difference (LSD). DMW: dry matter weight, OC: organic carbon, TN: total nitrogen, CEC: cation exchange capacity, ECe: electrical conductivity of the saturation extract, HC: hydraulic conductivity, WHC: water holding capacity.

Effects of incorporation of pigeon pea (*C. cajan*) residues and baggase wastes on fodder maize

Incorporation of residues from pigeon pea (dried or fresh) and baggase had no significant effects on soil pH, ECe, soluble cations (Ca, Mg and Na) and WHC (Table 4). However, With the exception of baggase residues, dried pigeon pea, fresh or combined with other sources had significantly (P ≤ 0.05) increased DMW by 9 - 26%. On the other hand, baggase residues had resulted in similar DMW to the control, though the latter seemed to be higher. Our results showed that application of all organic residue had significantly (P ≤ 0.02) increased OC over the control by almost 61%. However, the DP resulted in significantly (P ≤ 0.01) higher soluble K as compared to other treatments. Soil moisture content determined after harvest was significantly (P ≤ 0.03) higher in pots treated with DP as compared to other treatments.

Effects of incorporation of wool and hoof powder on establishments of fodder maize and soil properties

Our results showed that application of hoof (H) and wool (W) had various significant effects on plant dry matter weight (DMW) and soil properties (Table 5). Dry matter weight of plants was significantly (P ≤ 0.0008) similar to fertilizer application and showed an increased of 22 - 28% over the control. The soil pH values monitored during the 8 weeks showed no consistent effects of either H or W application and showed some periods where there was an increase in pH (Figure 1). Compared to the control, treatments with H and W contained significantly (P ≤ 0.0001) 5 - 6 folds more soil OC whereas application of W had resulted in the highest (P ≤ 0.0001) TN. Opposite to TN, application of H had resulted in significantly (P ≤ 0.01) the highest soluble K. The content of soil P in treatments with both W and H was significantly (P ≤ 0.05) similar to fertilizer application. Soil Ca and Mg were significantly (P ≤ 0.02) increased with application of H and W over the control and fertilizer treatments. However, W was superior to H in the case of Ca whereas H resulted in the highest Mg content. Although application of W had increased the EC_e values of the soil, statistical analysis showed that it was not significant whereas, application of H had significantly (P ≤ 0.0001) raised the EC_e by 50% over the control. The contribution of W to CEC was significantly (P ≤ 0.0001) higher compared to H, though the latter resulted in a small increment. The soil moisture content after harvest was significantly (P ≤ 0.0001) different among treatments. It was found that, application of W and H had resulted in higher soil moisture content (3 - 4 folds) compared to the control or the fertilizer treatments.

Table 4. Effects of incorporation of pigeon pea and baggase residues on soil properties and plant DMW (average ± standard deviation).

Treatment	DMW (g plant^{-1})	pH (paste)	OC (g kg^{-1})	ECe (dSm^{-1})	Soluble cations (meq L^{-1})				WHC (%)	MC (%)
					K	Na	Ca	Mg		
C	55.5b±3.9	7.9a±0.1	0.27b±0.1	0.68a±0.1	0.34c±0.02	3.91a±0.9	2.1a±0.2	1.2a±0.7	23.8a±1.0	11.6b±1.3
F	69.9a±2.2	8.2a±0.2	0.29b±0.1	0.70a±0.1	0.45bc±0.01	4.38a±0.8	2.4a±0.5	1.1a±0.4	23.8a±0.3	9.5b±1.0
FP	67.5a±6.9	8.1a±0.1	0.41a±0.1	0.73a±0.1	0.60b±0.02	4.53a±0.9	2.0a±0.7	1.0a±0.6	23.3a±0.7	11.0b±1.1
DP	60.6a±4.4	8.3a±0.1	0.40a±0.1	0.83a±0.1	1.22a±0.01	5.20a±0.9	2.2a±0.4	1.3a±0.3	24.3a±0.5	13.2a±0.7
B	53.4b±4.4	8.1a±0.3	0.48a±0.1	0.68a±0.1	0.60b±0.01	4.68a±0.5	2.4a±0.5	1.3a±0.4	24.6a±0.9	9.8b±1.5
B+FP	64.1a±0.8	7.6a±0.4	0.45a±0.1	0.78a±0.1	0.55b±0.01	4.88a±1.3	2.2a±0.5	1.1a±0.3	22.9a±1.3	10.1b±2.0
DP+FP	65.9a±1.3	8.0a±0.2	0.44a±0.1	0.89a±0.1	0.72b±0.03	4.68a±0.9	2.2a±0.2	1.0a±0.4	23.4a±0.8	9.5b±1.9

Values in columns followed by similar letter(s) are not significantly different at P ≤ 0.05 using least significant difference (LSD). DMW: dry matter weight, OC: organic carbon, ECe: electrical conductivity of the saturation extract, WHC: water holding capacity, MC: moisture content.

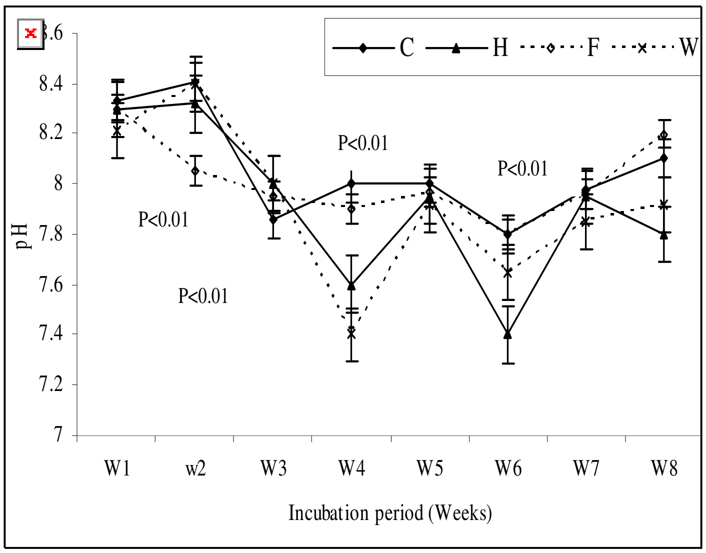

Figure 1. Effects of incorporation of wool and hoof on changes of pH in the soil.

DISCUSSION

With the exception of onion residues, baggase and to a less extent application of FYM, our results clearly showed that incorporation of organic wastes had similar results to fertilizer application. The above mentioned organic materials contained the lowest N (low quality) content that may possibly result in the shortage of mineral N, though the latter was not determined (Singh et al., 2006). These results support earlier findings studying the role of recycling of either crop residues or manure in amelioration of nutrients poor sandy soil or soils with high content of sand (Mubarak et al., 2003a; Kiani et al., 2005; Mtambanengwe and Mapfumo, 2006). In this study, all crop residues had no effects on soil pH, ECe and WHC. Low content of cations, especially in the initial materials might be the reason for that (Mubarak et al., 2003a). Shaw and Mask (2003) reported that crop residues from wheat, corn and soybean had minimal effects on a sandy loam soil pH. We did not find an increase in soil pH in manure treatments. This contradicts Naramabuye and Haynes (2006) who reported that manure application caused increase in soil pH. They attributed this increase to the high Ca and Mg contents in the manure whereas their contents in this study were low. The relatively high initial content of hoof and wool Ca and Mg may justify the periods where we found significant, but not consistent, increase in soil pH. Incorporation of crop residues was earlier reported not to affect soil pH level (Mubarak et al., 2003b; Govaerts et al., 2006). The increase in soil OC content in manure treatments (44 – 72%) reported in this study is consistent to that (63.5%) found by Hati et al. (2006). Positive effects of incorporation of crop residues on soil OC was also earlier reported (Mubarak et al., 2003b; Thomsen and Christensen, 2004). The increase in cations (K, Ca and Mg) in soil amended with wool and vegetable residues might possibly be the reason for increase in CEC. However, absence of significant variations between vegetable residues in CEC indicates that their performance is quite similar. Mubarak et al. (2003b) reported a slight but significant increase in CEC of the sandy loam soils in Malaysia. Application of hoof and wool seems to have greater imbibitions for water since soil moisture content at harvest reported in this study was greater than without amendments. However, greater plant dry matter in pots treated with vegetable residues might cause depletion of water, hence, moisture content at harvest showed levels similar to the control. Absence of effects on WHC might possibly be due to low amount used (less than 10 t ha^{-1}). Jiao et al. (2006) reported that application of cattle manure at rate of 30 t ha^{-1} or greater significantly increased water soluble aggregates of a sandy soil and that means an improvement of the soil structure which might have positive effects on water retention capacity. In this study we observed that there was a decrease in water movement in sandy soils amended with organic residues. This offers a better chance for crops to absorb water and nutrients instead of being leached down rapidly. Zaongo et al. (1994) reported that rapid hydraulic conductivity of the Sahelian sandy soils is among the constraints that may limit sustainable production of cereals. Wanas and Omran (2006) stated that the application of

Table 5. Effects of hoof and wool on soil properties and DMW (average ± standard deviation).

Treatments	DMW (g plant^{-1})	TN (g kg $^{-1}$)	OC (g kg $^{-1}$)	Soluble cations (meq L^{-1}) K	Ca	Mg	P (mg kg^{-1})	ECe (dSm^{-1})	CEC (cmol$_c$(+) kg^{-1})	MC (%)
F	42a ± 0.5	0.41b ± 0.02	1.0b ± 0.01	0.25c ±0.01	2.5c ± 0.08	1.2b ± 0.02	0.88a ± 0.03	0.40b ± 0.01	1.22b ± 0.02	7c ± 0.2
H	39a ± 0.7	0.45b± 0.02	4.9a ± 0.01	0.65a ±0.03	5.5b ± 0.07	2.5a ± 0.03	1.1a ± 0.01	0.82a ± 0.02	1.73b ± 0.03	22b ± 0.1
W	41a ± 0.9	0.70a ± 0.04	5.9a ± 0.03	0.42b ±0.02	7.5a ± 0.09	1.5b ± 0.02	0.72a ± 0.02	0.62a ± 0.02	2.25a ± 0.03	27a ± 0.9
C	23b ± 0.8	0.15c ± 0.01	1.5b ± 0.02	0.15c ± 0.01	2.3c ± 0.05	1.5b ± 0.04	0.5b ± 0.02	0.55b ± 0.01	0.21c ± 0.01	7c ± 0.2

Values in columns with similar letter (s) are not significantly different at P ≤ 0.05 using least significant difference (LSD). DMW: dry matter weight, TN: total nitrogen, OC: organic carbon, ECe: electrical conductivity of the saturation extract, CEC: cation exchange capacity, MC: moisture content.

of banana and cotton composts to sandy soil in Egypt had resulted in a direct decrease in drainable pores (responsible for water loss under gravity) and consequently, in reduction of hydraulic conductivity (main problem) of the soil. It could be concluded that for the improvement of nutrients poor sandy soils, it is necessary to recycle organic wastes which in this study proved to have various positive effects on soil attributes and accumulation of plant dry matter weight.

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