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Comparison of Sewage Sludge and Town Refuse as Soil Conditioners for Sandy Soil Reclamation

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Abstract: A pot experiment was carried out to compare the effects of sewage sludge (S) and town refuse(T) additions on plant growth and yield components of wheat (*Triticum sativa* L.), some soil physico - chemical properties and available nutrients in reclaiming sandy soil. The organic residues were applied at rates of 5%, 10%, and in different combinations with N, P, K mineral fertilizers. The addition of sewage sludge, town refuse and their interactions at low rates produced the striking changes in sandy soil. An improvement in soil physical and chemical properties was noticed with increasing addition of organic residues. Town refuse furnished better results than the sewage sludge. A significant increase in grain and straw yield of wheat and plant N, P, K content was found in organic residues treated soils as compared with the control. The treatment of T+NPK was better than the other treatments. A significant decrease in soil bulk density and increase in soil porosity and available NPK contents in soil was observed with organic residues as compared to the control. The investigation exhibited that town refuses were more affective than sewage sludge at different rates. The sewage sludge and town refuse can be used as soil conditioners to improve the soil health and hence the crop yield. At the same time this would help to reduce the environmental contamination.

Key words: Soil conditioning, reclaimation, sandy soil, town refuse, sewage sludge

Introduction

The influences of organic residues such as town refuse, sludge and farmyard manure (FYM) on crop yield has been found to be variable and dependent on its elemental composition and application rate (El-Sokkary and El-Keiy, 1989). Organic residues such as FYM, town refuse (T) and sewage sludge (S) have been applied to the soil in some investigations as soil amendments (Fresquez *et al.*, 1990; Mbagwu and Piccolo, 1990; Khalifa *et al.*, 1994). They studied that these organic residues were rich in their organic matter content and macro and micro nutrients, in addition to their efficiency in improving physical and chemical properties of the soil, thus leading to favorable conditions for better plant growth and greater yields. However, the application of a certain organic amendment is controlled by its ultimate content of plant nutrients and non-nutrients (heavy metals). Parasa (1970) reported that excessive micro nutrients may induce phytotoxicity. Also excessive contents of Cd, Pb, and Ni may produce toxic effects on biological process such as nitrification (Wilson, 1977). Khalifa and Hassan (1993) on squash, found that increasing the rates of S and FYM improved the aggregation parameters of clay soil, mean weight diameter, aggregation index and optimum size of aggregates. Also a positive relationship was observed between application rate of the amendment and concentration of macro and micro nutrients in broad bean seeds and squash fruit, while the concentration of heavy metals obtained in seeds and fruits were increased but remained below the toxic limits. Khaliva *et al.* (1994) reported that the application of FYM and TR to wheat plants in sandy soil increased soil EC and the availability of Fe, Zn and Mn in soil, while the concentration of Fe, Zn, Mn, and Cu in wheat grain were also increased, but remained within the safe limits.

Therefore, the main objective of this work was to compare the effects of T and S application on soil quality, plant growth, yield and at the same time to avoid environmental pollution from chemical fertilizer usage, which leads to adverse effects on potential health hazard to plants, animals and humans.

Materials and Methods

A pot experiment was carried out at Monshaat Abdel-Rahman Village, Dekernes district, Dakahlia Governorate, during winter season of 2000 -01. The experimental soil was sandy in texture with low salinity (0.32 dS m^{-1}), alkaline in reaction (pH 8.2), poor in organic matter content (0.125%) and 1.21% $CaCO_3$. The soil was poor in available macro and micro-nutrients according to their critical limits as recommended by Soil and Water Research Institute for various crops (Hamissa *et al.*, 1993).

Two organic residues used were town refuse (T) and sewage sludge (S). The T was taken from Mansoura Manufactory for Organic Manure, Sandob, Dakahlia Governorate and S from Mansoura Sanitary Drainage Station, El-Mansoura Dakahlia Governorate. Some chemical properties of the organic residues are listed in Table 1 below:

Table 1: Some chemical properties of the organic residues used

Properties		Town Refuse	Sewage Sludge
Total C %		13.3	21.3
Total N %		0.81	0.96
C: N ratio		16.4:1	22.0:1
Total	P	0.36	0.41
macro nutrients (%)	K	0.76	0.52
Available	P	816	700
macro nutrients (ppm)	K	1830	1100
Total micro nutrients	Fe	13452	16321
(ppm)	Mn	280	281
	Zn	69	214
	Cu	204	219
Available	Fe	198	205
micro nutrients (ppm)	Mn	29	31
	Zn	12.3	14.6
	Cu	11.4	12.3

In 5 kg capacity plastic pots (25x16 cm dia.), wheat grain (Sakha 69) were sown in sandy soil and two organic residues (S, T) were applied at two rates (5% and 10%)., The mineral fertilizers N, P, K alone (as ammonium nitrate, single

superphosphate and potassium sulphate) and in combination with organic residues. The treatments used were:
Check (control-no fertilizer or organic residue); NPK alone; ¼ T+ ¾ S+ NPK; ½ T+ ½ S+NPK; ¾ T+ ¼ S+NPK; T+NPK; S+NPK; T and S. All treatments (18) were replicated thrice arranged in a completely randomized design.
Pot which contains (5 kg soil) mixed with 5% and 10% of both organic residues (by weight) was irrigated with water to reach the moisture content at saturation percentage. Then left for a month to elucidate the damage on seedlings and their roots resulted from the heat of decomposition. Wheat plants were fertilized with N, P and K at the rate of 3.5, 1.0 and 2.5 g/pot, respectively. These rates represents the sum of organic residue content plus the calculated and integrated from mineral fertilizers. The sowing and harvesting of wheat was done on 1st November and 15th March, respectively. At harvest stage, in both rates, the grain and straw yields were measured.

Soil mechanical analysis and $CaCO_3$ % was done according to Piper (1974), pH , EC, available P as by Jackson (1967), O.M, available N and K according to Hesse (1971), and available Fe, Mn, Zn, and Cu by the methods of Lindsay and Norvell (1978). Oven dried plant material (grain and straw) was used to determine N, P, K concentrations in the digestive extract of H_2SO_4 + $HClO_4$ (1:1) according to Peterburgski (1968), while Fe, Mn, Zn, and Cu were determined from the digestive extracts of HNO_3 + HCl + H_2SO_4 according to Chapman and Pratt (1961).
The statistical analysis was done according to the methods of CoStat Software, (1991) using L.S.D. to compare the treatment values.

Results and Discussion

Grain and Straw Yield: Data in Tables 2, and 3 show the effects of mineral fertilizers, organic residues and their interaction on grain and straw yield (g/pot) of wheat grown in

Table 2: Effect of organic residues on straw yield and N, P and K uptake in straw

Treatments		With 5% Organic residues addition				With 10% Organic residues addition			
		Straw (g/pot)	N uptake mg/pot	P uptake mg/pot	K uptake mg/pot	Straw (g/pot)	N uptake mg/pot	P uptake mg/pot	K uptake mg/pot
C0		20.40	88.46	14.28	224.60	21.57	88.47	15.32	239.44
C+NPK		34.40	148.07	28.55	412.70	34.33	147.41	28.72	412.03
1/4T+3/4S+NPK		39.23	172.66	32.96	478.68	47.07	211.78	41.42	588.32
1/2T+1/2S+NPK		41.80	188.09	35.11	509.99	49.20	226.34	44.28	615.01
3/4T+1/4S+NPK		42.30	190.31	36.38	524.48	51.07	234.77	46.47	643.30
T +NPK		48.43	232.55	44.56	619.88	57.80	283.17	54.92	751.29
S+NPK		47.03	221.13	42.80	592.55	55.40	267.78	52.08	709.13
T		27.07	116.39	21.65	319.35	31.07	136.59	26.71	372.73
S		25.70	110.56	20.56	300.74	29.87	128.47	25.38	355.32
LSD	1%	1.022	21.56	1.535	24.21	1.943	19.23	2.543	19.91
	5%	0.746	15.74	1.121	17.67	1.418	14.03	1.856	14.54

Co = control T = Town refuse S= Sewage sludge

Table 3: Effect of organic residues on grain yield and N, P and K uptake in grain

Treatments		With 5% Organic residues addition				With 10% Organic residues addition			
		Grain (g/pot)	N uptake mg/pot	P uptake mg/pot	K uptake mg/pot	Grain (g/pot)	N uptake mg/pot	P uptake mg/pot	K uptake mg/pot
C0		6.33	83.61	20.26	19.00	6.00	78.60	18.60	21.00
C+NPK		9.97	142.50	33.90	45.84	10.27	144.17	34.28	46.98
1/4T+3/4S+NPK		11.17	165.25	39.09	52.49	13.80	205.60	49.70	69.05
1/2T+1/2S+NPK		13.03	195.53	45.62	62.57	14.40	216.99	51.83	71.99
3/4T+1/4S+NPK		13.60	209.49	47.61	66.63	15.20	232.60	54.71	77.53
T +NPK		14.87	255.67	56.51	75.80	16.67	288.40	65.02	89.46
S+NPK		14.30	240.28	51.49	71.51	16.10	272.08	61.17	85.31
T		7.00	98.04	23.08	30.12	8.30	117.04	27.38	38.98
S		6.80	93.87	22.44	27.89	7.40	103.63	23.67	33.31
LSD	1%	0.487	11.83	3.863	3.642	0.796	13.41	4.135	7.317
	5%	0.355	8.634	2.819	2.658	0.582	9.784	3.018	5.341

Co = control T = Town refuse S= Sewage sludge

Table 4: Effect of organic residues on micro nutrients in wheat plant

Treatments		With 5% Organic residues addition				With 10% Organic residues addition			
		Fe ppm	Mn ppm	Zn ppm	Cu ppm	Fe ppm	Mn ppm	Zn ppm	Cu ppm
C0		108.3	22.0	55.3	5.0	100.0	23.0	54.0	5.0
C+NPK		161.3	28.0	59.0	6.0	162.3	27.7	60.0	6.0
1/4T+3/4S+NPK		174.0	30.0	65.0	8.0	170.0	35.0	66.0	8.0
1/2T+1/2S+NPK		170.0	31.0	66.0	9.0	174.0	35.0	68.0	9.0
3/4T+1/4S+NPK		175.0	32.0	69.0	10.0	181.0	37.0	70.0	10.0
T +NPK		200.0	35.0	72.0	11.0	211.0	39.0	74.0	12.0
S+NPK		180.0	34.0	70.0	10.0	204.0	38.0	72.0	11.0
T		153.0	29.0	63.0	7.0	158.0	32.0	63.0	7.0
S		152.0	28.0	60.0	7.0	156.0	31.0	62.0	7.0
LSD	1%	9.258	3.994	4.243	1.567	8.040	3.354	5.966	1.919
	5%	6.757	2.915	3.097	1.144	5.868	2.448	4.354	1.401

Co = control T = Town refuse S= Sewage sludge

Table 5: Effect of organic residues on soil physical properties

Treatments	With 5% Organic residues addition			With 10% Organic residues addition		
	Bulk density db gm/cm³	S.P. %	Total Prosity %	Bulk density db gm/cm³	S.P. %	Total Prosity %
CO	1.62	22.5	37.0	1.61	22.5	37.0
C+NPK	1.61	23.0	37.1	1.61	23.0	37.3
1/4T+3/4S+NPK	1.56	24.5	38.4	1.56	25.5	38.5
1/2T+1/2S+NPK	1.57	25.0	38.6	1.54	26.0	38.6
3/4T+1/4S+NPK	1.56	25.0	38.8	1.56	26.0	39.3
T +NPK	1.55	26.0	39.5	1.55	27.0	40.6
S+NPK	1.56	25.5	39.0	1.56	26.5	39.5
T	1.58	24.5	38.0	1.58	25.0	38.5
S	1.57	24.0	37.5	1.56	24.9	37.8
LSD 1%	0.018	1.357	0.344	0.033	1.074	0.378
5%	0.013	0.990	0.251	0.025	0.784	0.276

SP= Saturation percentage CO= Control, T= Town refuse, S= Sewage sludge

Table 6: Effect of organic residues on Available N, P, and K in soil

Treatments	With 5% Organic residues addition			With 10% Organic residues addition		
	Available N%	Available P%	Available K%	Available N%	Available P%	Available K%
CO	5.57	1.40	87.50	5.57	1.50	89.53
C+NPK	7.50	3.03	110.00	7.47	3.13	110.33
1/4T+3/4S+NPK	9.03	3.60	118.00	9.33	5.33	126.33
1/2T+1/2S+NPK	9.17	4.07	116.00	9.47	5.83	139.00
3/4T+1/4S+NPK	9.50	4.20	120.00	9.83	6.03	149.33
T +NPK	10.53	4.57	138.00	11.20	6.53	158.00
S+NPK	10.00	4.43	129.00	10.60	6.20	152.00
T	6.10	3.37	92.60	6.47	5.00	105.00
S	6.03	3.17	90.07	6.27	4.90	101.00
LSD 1%	0.347	0.392	4.448	0.296	0.319	3.858
5%	0.253	0.286	3.247	0.216	0.233	2.816

CO= Control T = Town refuse S= Sewage sludge

a sandy soil . As evident from the Tables, significant increase was recorded in grain and straw yields with incorporation of organic residues as compared to control treatment. The findings of Anton *et al.* (1992), Abdel-Aziz *et al.* (1990) and El-Maghraby (1997) are in good agreement with present results.

Also it is clear that town refuse (T) integrated with N, P, K maintained their superiority over sewage sludge (S) integrated with N, P, K at two rates of organic residues. The mean values obtained are 14.87, 16.67, 14.3 and 16.1 for grain yield (Table 3) and 48.43, 57.8, 47.03 and 55.4 for straw yield, for T and S, respectively, at two different rates (Table 2).

N, P, and K Uptake and micronutrient concentration: The data presented in Tables 2, 3 and 4 revealed the effects of organic residues and their interactions at two rates on uptake of N, P and K (mg/pot) in grain and straw yield and micronutrient concentration of wheat grown in sandy soil.

From Tables 2 and 3 the following striking observations can be cited:

- The uptake of N, P, and K in wheat grain and straw grown in the treated soil with 5% and 10% organic residues and other treatments (NPK mineral fertilizers) were increased significantly as compared to that of control.
- The increase in uptake of N, P and K was proportional to the increase in the application rate of organic residues.
- The most obvious improvement in uptake of these elements in wheat grain and straw was resulted from T + NPK in both rates of organic residues.
- The N uptake (mg/pot) in wheat grain and straw was increased from 83.61 and 88.46 in control to 255.67 and 232.55 in T + NPK treatments, respectively, at 5% level of organic residues. However, at 10 % this improvement was 78.6 to 288.4 in grain and 88.47 to 283.17 in straw in T+ NPK treated soils, as against the control.
- The P uptake (mg/pot) in wheat grain and straw was increased form 20.26 and 14.28 in control to 56.51 and 44.56 in T+NPK treatments, respectively, at 5% level of organic residues. However, at 10% this improvement was 18.6 to 65.02 in grain and 15.32 to 54.92 in straw in T+NPK treated soils as against the control.
- The increase in K uptake (mg/pot) by wheat plant in the first rate (5%) relative to control were 19.0 and 75.80 in grain, 224.6 and 619.88 in straw respectively. However the increase in the second rate (10%) relative to control were 21.0 and 89.46 in grain, 239.44 and 751.29 in straw respectively.
- The increase in micro nutrients (ppm) as (Fe, Mn, Zn, and Cu) concentration in leave wheat plant at booting stage in the first rate (5%) of organic residues, relative to control were 108.3 and 200 ppm in Fe, 22.8 and 35 ppm in Mn, 55.3 and 72.0 ppm in Zn and 5 and 11 ppm in Cu respectively (Table 4). However, the increase in the second rate (10%) of organic residues, relative to control were 100 and 211 ppm in Fe, 23 and 39 ppm in Mn, 54 and 74 ppm in Zn and 5 and 12 ppm in Cu respectively.

Similar results were also reported by Aboulroos *et al.* (1989), El-Sokkary and El-Keiy (1989), Anand (1992) and Morsy and El-Dawwey (1999).

Generally, the increase in nutrients uptake may be due to one or more of the following reasons:

1. The high content of nutrients in the tested organic residues.

2. The improvement in soil structure, which by reflected by water holding capacity and decreasing nutrient losses by leaching and deep percolation.
3. The increase in ion mobility due to the increase in the retained water in the treated sandy soil.
4. The decomposition of organic residues increases the organic acids, hence it reduce P fixation, which in turn, increases available P in soil and P uptake by wheat plants.
5. The decomposition of organic residues in soil liberates the organic nitrogen and increases its availability to plant.
6. The increase in dry weight of plants, grown in the treated soil.

Some Physical Properties of the Studied Soil after Cultivation

Data in Table 5 show the following observations:

- Addition of organic residues to sandy soil slightly decreased the bulk density after cultivation. The slight decrease in the bulk density may be attributed to the affect of increase of aggregates and improvement in soil structure by organic residues (at 5% and 10% levels).
- Application of organic residues to sandy soil slightly increased the saturation percentage (SP) and total porosity (%) after cultivation at both rates (5% and 10%). The increase in SP and total porosity values of treated soil with organic residues may be attributed to its high content of organic matter as well as the effect of organic acids produced from the decomposition of the used material and root residues in the soil for improving soil structure I and aggregates.

The results are in harmony with those of Shehata *et al.* (1985), Fawzi (1986), Mahmoud (1988), Aboulroos *et al.* (1989), Tester (1990), Mohamed (1991), Anand (1992), and Morsy and El-Dawwey (1999).

Content of some macro elements in the studied soil after cultivation: Data given in Table 6 exhibited that the application of organic residues to sandy soil increased the available N, P, K in soil after cultivation, at both rates of organic residues (5% and 10%) application.

The high increase in available N, P and K contents in the treated soil with organic residues as compared to control may be attributed to the decomposition of the used material and producing organic acids, which decreased phosphorus fixation and increased the available phosphorus.

Similar results were obtained by Abulroos *et al.* (1989) and Morsy and El-Dawwey (1999).

Generally, the enhancement in growth parameters, water use efficiency and concentration and uptake of micro- and macro nutrients of the wheat plant could be attributed to the effect of organic residues on the improvement in physical and chemical properties of the sandy soil.

Economically, the most outstanding beneficial effect was obtained from addition of town refuse and sewage sludge as a soil amendments for newly reclaimed sandy soil at the rate of 5% and 10% with integrated NPK fertilizers. Therefore, it is concluded that town refuse and sewage sludge can be considered as a good soil conditioner for improving the physical and chemical properties of coarse textured soils.

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