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INFLUENCE OF TWO SEWAGE SLUDGE SOURCE ON PLANT GROWTH AND NUTRIENTS UPTAKE

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The effect of dried sewage sludge from two sources (Suez and Giza governorates) on faba bean growing on sandy soil followed by sorghum to test the residual effect of the sludge on it's growth and mineral content was studied in a pot experiment. The results showed that, for faba bean, the number of nodules/plant, plant height and leaf area increased significantly due to application of either Suez or Giza sludge up to 5%. The former sludge increased the yield not up to 5% while the latter gave only 2.5% increase. Data also revealed that shoot and root dry weights of sorghum plants significantly increased by Suez and Giza sludge by 7.5 and 5% respectively. The higher rate (10%) of Giza sludge inhibited root growth. Nitrogen and P contents increased by either sludge application. Zn and Cu contents of roots and shoots increased by increasing the rate of Suez sludge, while Fe, Mn, Ni and Cr contents of roots were slightly affected and they remained unchanged in the shoots. Giza sludge applications caused progressive increase in most of heavy metals in sorghum plants specially Cr. According to the Zn equivalent, the maximum rate of dried sludge to be added to the soil is 78.13 tons/fed for Giza sludge and 160.25 tons/fed for Suez sludge before the safe limits are exceeded. The addition may be divided over long period.

Key words: Sewage sludge, Plant growth, Nutrients.

Introduction

The response of crops to sludge application varied with the source of sludge, rate of addition, plant species, soil type, weather condition and management practices. Numerous studies have shown the value of sewage wastes as a plant nutritive amendment for agricultural soils in Egypt [1-5]. El-Keiy [1] found that fresh weights of wheat and faba bean increased with increasing the amount of added sludge till 50 g/kg soil. Rabie [3] and Eid [2] found that sewage sludge (up to 15 tons/fed) increased the dry weight of faba bean plants. Mays *et al.* [6] showed positive yield response to the annual appliction of sewage sludge and municipal refuse at rates up to 143 tons/ha for forage sorghum and 112 tons/ha for corn.

Experiments of Kelling *et al.* [7] showed reductions in forage yields of sorghum following sludge applications at the rates of 30 and 60 tons/ha.

In pot experiment Bolten [8] found that addition of sludge (up to 8%) to acid soil increased rye grass yields, probably as a result of N released by mineralization; 12% sludge rate decreased yields. Also, he reported that more than 350 ppm Zn, 160 ppm Ni and 40 ppm Cu in the grass dry matter were associated with lowered yields. On the other hand, the treatments had no effect on Cr and Pb concentrations in the grass. Chaney *et al.* [9] demonstrated that concentration of Zn, Cd, Cu and Mn in soybean leaves increased as rates of sludge increased while Pb decreased and Ni remained unchanged. Assuming that Cu is twice toxic and Ni is eight times toxic as Zn (Chumbley [10]), the amounts of these metals added to soil (pH 6.5) should not exceed 250 ppm Zn equivalent in a 30 years period.

The present work is trial to evaluate influence of different rates processed sewage sludge produced in municipal sewage stations in Giza (Abu Rawash) and Suez governorate, on the growth of faba bean and sorghum grown on sandy soil and sorghum content of some macro and micro-elements in order to evaluate any toxic or hazardous effects of the accumulating elements in the test plants particularly those absorbed from the sludge & thus recommending the optimum levels of sludge manuring.

Materials and Methods

A pot experiment was set up under greenhouse conditions using sandy soil collected from Ismailia Agricultural Research Station Farm. Erthen ware pots of 8 kg capacity were filled with the soil with 4 replicates for each sewage sludge level in order to have 10-12 replicate plants for each treatment which represent the least number of replicates for appropriate statistical analysis. Municipal sewage sludge from Giza (Abu-Rawash station) and Suez, were mixed thoroughly with the sample soil at the rate of 0, 25, 50, 75 or 100 g/kg soil. Chemical analysis of the tested sewage sludge are given in Table 1. Each pot received 15 g Ca-superphosphate, 1.5 g ammonium sulphate and 2 g K-sulphate before sowing. Faba

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TABLE 1. CHEMICAL ANALYSIS OF SEWAGE SLUDGE UNDER INVESTIGATION.

Fractions		Sludge location	
		Suez	Giza
Ec(1:5) mmhos/cm/25C		4.8	3.7
pH (1:2.5)		6.8	6.7
Moisture	(%)	6.0	5.5
Organic matter	(%)	35.6	52.6
Total element (in digested sludge)			
N	(%)	1.2	1.8
P	(%)	0.082	0.090
K	(%)	0.157	0.172
Na	(%)	0.343	0.111
Fe	(%)	5.1	2.2
Mn	(ppm)	165.0	325.0
Zn	(ppm)	1000.0	1300.0
Cu	(ppm)	290.0	390.0
Ni	(ppm)	110.0	140.0
Cr	(ppm)	50.0	2000.0
Available elements (DTPA) extractable, ppm			
N	-	464	104
P	-	106	114
Fe	-	170	110
Mn	-	14	38
Zn	-	280	320
Cu	-	35	40
Ni	-	5	10
Cr	-	0.50	1.50
Zn - equivalent (µg/g)		1560	3200
Sludge added (ton/fed)		160.26	78.13

bean seeds (Giza 2) were sown and thinned to 3 seedlings per pot after 15 days of sowing. After 40 days from sowing the number of nodules and branches/plant, leaf area and plant height were recorded. Grain yield/pot also recorded at maturity.

To study the residual effect of the sewage sludge, sorghum seeds (Giza 114) were sown in the same pots, receiving 5g urea, 2g Ca-superphosphat and 2g K-sulphate per pot and thinned to 10 seedlings/pot after 15 days of sowing. The plants were harvested after 50 days from sowing and divided into shoots and roots which were dried at 70°C and weighed. Dry matter of shoots and roots were ground and prepared for chemical analysis to determine their content of Fe, Mn, Zn, Cu, Ni and Cr by wet digestion methods using the atomic absorption spectrophotometer. N and P contents were determined as described by Jackson [11].

Results and Discussion

Influence of sewage sludge application on faba bean growth. Table 2 shows that the mean values of number of branches/plant, leaf area, plant height and number of nod-

TABLE 2. YIELD AND SOME GROWTH CHARACTERS OF FABA BEAN AS AFFECTED BY SOURCES AND RATES OF SEWAGE SLUDGE.

Treatment	No. of branches/ plant	Leaf area (cm^2)	Plant height (cm)	No. of nodules/ plant	Seed yield (g/pot)
Control	2.57	6.70	41.3	105.0	5.5
Suez sludge (%)					
2.5	2.90	9.7	52.0	142.7	6.8
5.0	2.97	8.4	54.0	160.3	7.6*
7.5	2,67	8.2	50.0	103.3	6.2
10.0	2.67	6.9	46.6	92.3	6.0
Giza sludge (%)					
2.5	2.67	8.5	46.3	118.3	6.2*
5.0	2.90	8.2	54.0	108.3	5.3
7.5	2.40	7.2	46.1	36.7	5.2
10.0	2.03	6.1	35.0	30.0	4.3
LSD at 5%	Ns	Ns	Ns	Ns	0.98

Ns = non significant

ules/plant increased by Suez and Giza sludge application to 5% level, then slightly decreased or even declined by raising the sludge level to 10%. It was also noticed that seed yield significantly increased by 5% Suez sludge and 2.5 of Giza sludge application. Further increase in sludge level decreased on faba bean yield, compared with the control treatment. The inhibited growth of faba bean caused by the higher rates of Giza sludge may be due to its higher content of heavy metals especially Cr, Ni and Cu. Similar results were also obtained by other authors [1-3].

Dry weight and elemental composition of sorghum plants. Table 3 shows that shoot dry weight of sorghum plants significantly increased by both sludge at the tested rates compared with control probably as a result of N and p released by mineralization, but it decreased by increasing both sludge more than 7.5%.

The same trend was also observed on root dry weight and the higher rate of Giza sludge (10%) inhibited root growth compared with control. The inhibition of root growth may be attributed to the excess of Zn, Cu, Ni and Cr concentrations in tissue roots as as a result of addition of higher rates of Giza sludge. In general, application of sewage sludge, till 5% increased significantly the N contents of shoots then declined by further rise of Giza sludge. Nitrogen content of roots also increased by increasing the sludge rate up to 5% Suez sludge and upto 7.5% for Giza sludge then declined. Similarly P content of plants (organs) increased with increasing the rate of either sludge up to 5%. The increase of shoot or root N and P could be attributed to the increase of their availability in soil following sludge applications.

Table 3 further shows that Zn and Cu contents of shoots and roots significantly increased by increasing the rate of

TABLE 3. SHOOT DRY WEIGHT AND MINERAL CONTENT OF SORGHUM AS AFFECTED BY SEWAGE SLUDGE.

Treatment	Dry weight (g/pot)	N	P	Fe	Mn	Zn	Cu	Ni	Cr
		%		ppm					
				Shoots					
Control	13.8	1.18	698	350	33.3	28.3	6.7	4.5	0.5
Suez sludge (%)									
2.5	21.1	1.45	886	366	31.7	41.0	6.7	4.5	0.5
5.0	20.8	1.65	922	400	35.0	71.7	23.3	4.0	0.5
7.5	22.2	1.65	720	350	33.3	95.0	13.3	4.2	0.5
10.0	19.7	1.75	662	216	35.0	83.3	15.0	5.2	0.5
Giza sludge (%)									
2.5	15.5	1.72	762	366	25.0	50.0	15.0	4.5	0.5
5.0	19.8	1.87	1064	516	25.0	103.3	18.3	11.7	0.5
7.5	19.5	1.75	815	550	23.3	106.7	15.0	23.3	0.5
10.0	17.3	1.57	648	333	25.0	103.3	15.0	36.7	0.6
LSD at 5%	1.8	0.16	82	95	7.0	16.5	5.0	4.7	NS
				Roots					
Control	15.5	0.50	392	2533	86.7	55	25.0	3.7	22
Suez sludge (%)									
2.5	31.7	0.52	472	3000	93.3	131	50.0	18.3	23
5.0	33.9	0.93	711	2866	93.3	200	68.3	46.7	25
7.5	18.7	0.80	356	2833	101.7	256	81.7	8.3	25
10.0	16.0	0.73	258	2733	101.7	333	140.0	6.7	22
Giza sludge (%)									
2.5	16.2	0.72	705	2733	96.7	223	95.0	21.7	653
5.0	19.1	0.93	843	3100	100.0	310	115.0	18.3	713
7.5	17.9	1.00	461	3366	110.0	400	151.7	6.7	776
10.0	13.2	0.60	444	3566	105.0	413	161.7	36.7	856
LSD at 5%	2.6	0.23	77	456	13.2	31	16.2	8.5	58

sludge. It could be concluded that the root is an accumulator of these metals since higher concentrations of both metals were detected in roots than shoots specially at higher rates. On the other hand Fe, Mn and Cr contents of the roots were slightly affected while they remained unchanged in the shoots, but Ni was significantly increased in roots at higher rates of sludge and remained unchanged in shoots. These results are in agreement with those obtained by other authors [3,5,9].

As well as Zn, Cu and Ni concentrations in sorghum shoots and roots progressively and consistently increased by increasing the rate of Giza sludge application and the roots record more accumulation than shoots. On the other hand, Mn and Cr content of shoots remained unchanged by Giza sludge rates while roots contents of Mn and Cr were greatly increased by increasing the sludge rate specially Cr which accumulated progressively in the roots than any other element. also there was a significant increase in Fe content in the roots and in some treatments of shoots, there was significant decrease in Mn content in shoots. This can be explained by the activity of microorganisms in the rhizosphere which can use iron and manganese oxides as electron acceptors for their metabolic activity (synthesis of ATP). The high content of heavy metals in the roots, specially the higher rates of Giza sludge, was associated with visual symptoms of phytotoxicity such as yellow leaves and blackening of buttress roots.

Table 4 and 5 show the relative amount between mineral uptake by shoots and roots of Sorghum and soluble or insoluble elements in sludge. The amounts of elements uptake increased with increasing of these elements in soil.

It is clear from these results that the plants are most affected by Zn, Cu, Ni and Cr, It could be concluded that using sludge collected from Giza (Abu-Rawash) had some disadvantages. The primary disadvantage is high level of heavy metals (i.e Zn, Cu, Ni and Cr) and other toxic inorganic compounds in sludges. Since the sludge is often produced under anaerobic conditions, reduced forms of these elements may be present in the soil and become readily available to plants.

With respect to the phytotoxicity as a result of sludge application, a general statement about the relative toxicity of three metals was observed, that Zn was the least toxic [10], while Cu was twice and Ni was eight times as toxic as Zn. Zinc equivalent has been calculated according to their relative toxicity in sludge, thus: Zn-equivalent = (1 x Zn) + (2 x Cu) + (8 x Ni) μg/g dry matter of sludge. It has been recommended that a total of 250 μg Zn-equivalent /g soil is the

TABLE 4. RELATIVE AMOUNT BETWEEN MINERAL UPTAKE IN *SORGHUM* AND SOLUBLE ELEMENTS IN SLUDGE.

Treatment	N	P	Fe	Mn	Zn	Cu	Ni	Cr
Suez sludge (%)				Shoots				
2.5	31.25	8.36	2.15	2.26	0.14	0.19	0.90	1.0
5.0	35.56	8.70	2.35	2.50	0.25	0.66	0.80	1.0
7.5	35.56	6.79	2.06	2.38	0.33	0.38	0.84	1.0
10.0	37.72	6.25	1.27	2.50	0.29	0.42	1.04	1.0
Giza sludge (%)								
2.5	165.38	6.68	3.33	0.65	0.15	0.37	0.45	0.33
5.0	179.81	9.33	4.69	0.65	0.32	0.45	1.17	0.33
7.5	168.23	7.15	5.00	0.61	0.33	0.37	2.33	0.33
10.0	150.96	5.68	3.03	0.65	0.32	0.37	3.67	0.40
Suez sludge (%)				Roots				
2.5	11.21	4.45	17.65	6.66	0.46	1.42	3.66	46
5.0	20.04	6.71	16.86	6.66	0.71	1.95	9.34	50
7.5	17.24	3.36	16.66	7.21	0.91	2.33	1.66	50
10.0	15.73	2.43	16.08	7.21	1.18	4.00	1.34	44
Giza sludge (%)								
2.5	69.23	6.18	24.85	2.55	0.69	2.37	2.17	435.3
5.0	89.42	7.40	28.18	2.63	0.96	2.87	1.83	475.3
7.5	96.15	4.04	30.60	2.90	1.25	3.79	0.67	517.3
10.0	57.69	3.90	32.42	2.76	1.29	4.04	3.67	570.7

TABLE 5. RELATIVE AMOUNT BETWEEN MINERAL UPTAKE IN *SORGHUM* AND INSOLUBLE ELEMENTS IN SLUDGE.

Treatment	N	P	Fe	Mn	Zn	Cu	Ni	Cr
Suez sludge (%)				Shoots				
2.5	1.25	1.24	0.07	0.21	0.05	.02	0.04	0.01
5.0	1.43	1.29	0.07	0.23	0.01	.09	0.03	0.01
7.5	1.43	1.00	0.06	0.22	0.13	.05	0.04	0.01
10.0	1.51	0.92	0.04	0.23	0.11	.05	0.05	0.01
Giza sludge (%)								
2.5	0.96	0.96	0.16	0.08	0.05	0.04	0.03	0.00
5.0	1.05	1.35	0.23	0.08	0.10	0.05	0.09	0.00
7.5	0.98	1.03	0.25	0.08	0.10	0.04	0.17	0.00
10.0	0.88	0.82	0.15	0.08	0.10	0.04	0.28	0.00
Suez sludge (%)				Roots				
2.5	0.45	0.66	0.59	0.61	0.18	0.19	0.17	0.46
5.0	0.80	0.99	0.56	0.61	0.27	0.26	0.44	0.50
7.5	0.69	0.49	0.55	0.67	0.35	0.32	0.07	0.50
10.0	0.63	0.36	0.53	0.67	0.46	0.54	0.06	0.44
Giza sludge (%)								
2.5	0.40	0.89	1.24	0.33	0.22	0.27	0.16	0.32
5.0	0.52	1.07	1.41	0.34	0.31	0.32	0.14	0.35
7.5	0.56	0.58	1.53	0.38	0.40	0.43	0.05	0.38
10.0	0.33	0.56	1.62	0.36	0.42	0.46	0.28	0.42

maximum range which can be safely added to the soil over a period of 30 years. On this basis, the maximum rate of sludge to be added to the tested sandy soil is 160.26 tons of Suez sludge/feddan and 78.125 tons Giza sludge/feddan before the safe limits are exceeded. In this connection, the maximum rate of Abu-Rawash (Giza) sludge to be added to the soil is 88.7 tons/fed [4]. The addition may be divided in small portions over long period.

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