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Influence of Sewage Wastes Addition on the Soil Characteristics: III. The Effect on Germination per cent, Drymatter Yield and Macronutrients Uptake by Sorghum Seedlings

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Laboratory experiments were conducted to determine the effect of different levels of sludge (0, 40, 80, 120 and 160 tonnes/ha) and liquid sewage (50 per cent diluted and without dilution) on the germination per cent, dry matter yield of sorghum seedlings and macronutrients uptake by adopting Neubauer technique. The study revealed that the addition of sewage wastes caused reduction in the germination of seeds and in turn affected dry matter yield. Sewage amendments significantly increased the concentration as well as uptake of nutrients like P, K, Ca and Mg by sorghum seedlings compared to control. In the different soil layers studied, the P uptake was more from first (0-5 cm) layer and K, Ca and Mg uptake were more from 3rd layer (15 cm).

Several investigators (Boswell, 1975; Dowdy and Larson, 1975; Sabey and Hart 1975; Cunningham *et. al*. 1975 and Giordano *et. al*. 1975) have demonstrated the plant nutritive value of sewage. Crop yields can be increased with the combined application of sludge and K. Equivalent quantities of N and P from liquid sludge and chemical fertilizer were reported to be equally effective in increasing yields of a grass clover hay. In view of the interest in land disposal of liquid sludge, the present investigation was conducted to determine the effects of this disposal method on soil and plant properties with particular emphasis on germination per cent, drymatter yield and macro nutrient uptake like P, K, Ca and Mg by the sorghum crop.

MATERIAL AND METHODS

Laboratory experiments were conducted to determine the effect of different levels of solid sludge (0, 40, 80 120 and 160 tonnes/ha) and liquid sewage (50 per cent diluted and without dilution) on the germination per cent, dry matter yield of sorghum seedlings with four groups of soils viz. black, red, alluvial and laterite.

One hundred grams of soils from different layers of glass columns were taken in petridish and 50 g of acid washed white sand was added to it and thoroughly mixed. Then 100 sorghum (CSH 5) seeds having 99 per cent germination capacity were sown in each petridish. Germination counts were also made as starting from 3rd

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TABLE I Influence of sewage waste additions on the Germination per cent. dry matter yield and P uptake by sorghum seedlings

Treatment	Black soil			Red soil			Alluvial soil			Laterite soil		
	Germination per cent	Mean dry matter yield in gm	P uptake in mg	Germination per cent	Mean dry matter yield in gm	P uptake in gm	Germination per cent	Mean dry matter yield in gm	P uptake in gm	Germination per cent	Mean dry matter yield in gm	P uptake in gm
T_0	87.70	1.69	1.27	80.30	1.13	0.88	81.30	1.61	1.06	52.30	1.06	0.93
T_1	74.00	0.98	1.31	72.70	1.22	0.90	70.60	1.26	1.10	55.30	1.05	0.95
T_2	70.00	1.59	1.27	73.30	1.13	0.92	61.00	1.03	1.19	78.00	1.24	1.03
T_3	64.70	1.39	1.37	70.70	1.22	1.00	63.70	0.98	1.29	85.30	1.37	1.05
T_4	62.00	1.42	1.49	61.00	1.10	1.04	56.70	1.02	1.36	55.00	1.06	1.10
T_5	86.30	1.26	1.30	76.00	1.28	0.91	58.30	1.12	1.12	59.60	1.13	0.99
T_6	57.30	0.91	1.33	63.70	1.25	0.98	57.30	0.99	1.16	48.30	0.85	1.03

Soil × Treatment	S. E. of mean	C. D. (P=0.05)
1. Germination per cent*	4.82	9.78
2. Drymatter yield in gm*	0.05	0.16
3. P uptake in mg*	0.01	0.03

day till 5th day. After 15 days the plants were removed from the petri dish, dried in the oven after complete washing and dry matter yield was recorded. The plant samples were separately analysed for macronutrients like phosphorus, potassium, calcium and magnesium by the methods described by Jackson (1967). From the nutrient concentrations, uptake values were calculated.

RESULTS AND DISCUSSION

Germination of sorghum seeds

Germination of seeds, expressed as percentage varied from 54 to 94, in black, 48 to 86 in red, 48 to 88 in alluvial and 46 to 89 in laterite soils. There was significant difference in the germination per cent of sorghum seeds sown in different soils. Depths had significant influence on the germination of seeds. Among the treatments T_0 (control) recorded maximum germination (75.4 per cent) than other treatments. Treatment T_4 (160 tons/ha solid sludge) drastically reduced the germination percentage. In the interaction between soil and depth, second depth in all soils recorded maximum germination than other depths. In all depths, except first depth, red soil recorded maximum germination values than other soils, but in the first depth black soil registered maximum values compared to other two subsurface layers. In the first depth (0 - 5 cm) there was greater concentration of micronutrients especially copper and zinc which inturn might have inhibited the germination of sorghum seeds. This is also evident from the negative relationship between available copper and germination per centage viz. ($r = -0{\cdot}53^*$) in alluvial, ($r = -0{\cdot}62^{**}$) in red, ($r = -0{\cdot}47^*$) in black soils. In red soils due to lower pH (6.8) the solubility of micronutrients is likely to be more and this might have reduced the germination percentage especially in the surface layer. Whereas in black soil due to somewhat high pH (8.0), the concentration of micronutrients may be less and also the high base status of the soil would have nullified the bad effects of solid sludge on germination. In the interaction between soil and treatement, in all soils treatment, T_0 (control) registered higher per centage of germination than other treatments. Treatment T_4 (160 tons/ha solid sludge) in red and alluvial soils reduced the germination percentage compared to other treatments. There was slight decrease in the germination percentage of sorghum seeds at the lowest level of sludge addition. As the level was increased to 160 tons ha, there was a drastic reduction in the germination of sorghum seeds. This effect was more pronounced in the case of black, red and alluvial soil than laterite soil. In laterite soil only an initial decrease in germination of sorghum seeds was observed in the present study. It was also observed that as the application rate increased the germination of sorghum seed was

TABLE I (a) Influence of sewage waste additions on the uptake in mg of K, Ca and Mg by sorghum seedlings

Treatments	Black soil			Red soil			Alluvial soil			Laterite soil		
	K uptake	Ca uptake	Mg uptake	K uptake	Ca uptake	Mg uptake	K uptake	Ca uptake	Mg uptake	K uptake	Ca uptake	Mg uptake
T_0	23.15	10.81	6.37	16.70	7.61	3.27	18.57	8.91	4.11	13.84	4.70	2.15
T_1	29.94	11.26	6.18	26.55	7.96	3.46	29.34	9.23	4.34	19.38	4.83	2.28
T_2	35.86	12.15	6.76	31 96	9.02	3.77	31.01	9.63	4.52	19.54	4.91	2.57
T_3	50.94	12.54	6.96	35.12	9.90	4.46	47.45	9.75	4.66	25.19	5.12	2.63
T_4	48.05	13.48	7.08	37.97	10.06	4.61	40.35	10.18	4.94	27.91	5.27	2.89
T_5	23.10	10.72	6.55	18.91	7.60	3.51	22.10	9.13	4.27	15.50	4.78	2.27
T_6	27.14	11.19	6.95	26.11	8.69	3.99	26.34	9.40	4.45	17.69	4.94	2.54

Soil × treatment	S. E. of mean	C.D. (P=0.05)
1. K uptake*	0.81	2.31
2. Ca uptake*	0.08	0.26
3. Mg uptake*	0.08	0.26

also delayed. The principal effect of the sludge was to delay rather than inhibit germination. Soluble salts and pH might have also contributed to some extent for the reduction in the germination of seeds. In the interaction between depth and treatment, in all depths studied, treatment T_4 (160 tons/ha solid sludge) reduced the germination of sorghum seeds. In all the treatments, surface layer (0—5 cm) registered lower germination per centage when compared with other layers. This is in close agreement with the results reported by Lunt (1959) and Hinesly *et al.* (1971).

Drymatter yield

Drymatter yield expressed in g per petridish varied from 0.56 to 1.31 in black, 0.58 to 0.91 in red, 0.53 to 1.14 in alluvial and 0.56 to 1.01 in laterite soils. Soils differed markedly with respect to drymatter yield. Depths had significant influence on the drymatter yield. All treatments recorded lower drymatter yield and were found to be inferior when compared with control. In the interaction between soil and treatment, in all soils except in red and laterite soils, control treatment recorded higher values than other treatments with regard to drymatter yield. The level of sludge addition significantly influenced the drymatter yield of sorghum. Highest sludge rate depressed drymatter yield. It may be that the drymatter yield reduction due to sludge application resulted from subtoxic levels of several elements interacting to reduce growth especially in the surface layer. This type of nutrient interaction has been shown to affect the deficiency level of various elements. Similar to this one were also reported by King and Morris (1972), Bates (1971) and Boswell (1974) elsewhere. The reduction in drymatter yields is more likely to be a result of differences in germination and emergence due to the sewage wastes addition than on subsequent plant growth.

Influence of treatments on the nutrient concentration in the sorghum plants

The concentration of phosphorus, potassium, calcium and magnesium in plants were increased due to sewage amendment compared to control treatment. The different treatments significantly increased the concentration of P, K, Ca and Mg in the plants. Soils significantly influenced the concentration of P, K, Ca and Mg. The K concentration was more in the plants which has been raised from subsurface (> 15 cm) layer compared to other layers. This may be due to the greater mobility of K. This is in close agreement with the results reported by King and Morris (1972).

Influence of treatments on nutrient uptake Phosphorus uptake

Phosphorus uptake expressed in mg varied from 0.84 to 1.04 in black, 0.58 to 0.76 in red, 0.70 to 0.92 in

TABLE II The interaction effect of soil K depth due to the addition of sewage waste on germination and uptake of nutrients.

S / D	Germination per cent			K uptake in mg			Ca uptake in mg		
	0-5 cm	5-15 cm	15 cm	0-5 cm	5-15 cm	15 cm	0-5 cm	5-15 cm	15 cm
Black	66.00	72.14	68.42	33.16	33.52	35.39	11.85	11.41	11.94
Red	65.14	76.00	72.14	23.30	27.66	28.28	8.70	8.58	9.80
Alluvial	65.42	68.42	58.57	29.93	30.66	31.62	9.35	9.35	9.50
Laterite	64.57	62.28	59.14	20.66	18.57	20.36	4.94	4.92	4.94

Soil × depth	S. E. of mean	C. D. (= 0.05)
1. Germination*	2.23	6.39
2. K uptake*	0.52	1.50
3. Ca uptake*	0.05	0.16

alluvial and 0.62 to 0.78 in laterite soils (Table I a). Soils differed significantly with respect to phosphorus uptake. Phosphorus uptake was significantly greater from the surface layer than other layers. This may be due to higher availability of phosphorus from the surface layers compared to subsur faceand bottom most layers. Highest rate of sludge addition significantly increased the phosphorus uptake more than other treatments. Uptake of phosphorus increased significantly with increase in the level of sewage. All treatments recorded higher uptake of P control. The uptake was more in black than soil. This may be due to greater availability of phosphorus in black soil. Similar results were reported by King and Morris (1972) and Milne and Graveland (1972). Phosphorus uptake was closely related to available phosphorus in black ($r = 0.67^{**}$), red ($r=0.59^{**}$), alluvial ($r=0.66^{**}$) and laterite (0.67^{**}), soils. With increase in the available phosphorus, the phosphorus uptake also increased. This result is in close agreement with the results reported by King and Morris. (1972).

Potassium uptake

Potassium uptake expressed in mg varied from 17.85 to 54.56, 15.72 to 38.12, 17.20 to 51.56 and 13.68 to 29.96 in black, red, alluvial and laterite soils respectively. Potassium uptake was found to be high in black followed by alluvial, red and laterite soils. This may be due to the increased availability of potassium in the black soil compared to other soils. The uptake was maximum from soils of third layer (>15 cm) compared to the other two layers. The concentration of available potassium was more in the third layer and this has resulted in greater uptake from that layer. Addition of 160 tons/ha of solid sludge increased the uptake of potassium more than other treatments. All treatments were found to be superior over control in increasing the potassium uptake in sorghum plants. In the interaction between soils and treatments, in all soils the highest rate of sludge significantly increased the potassium uptake than other treatments. In all treatments black soil recorded maximum values than other soils. This is in close agreement with the results reported by King and Morris (1972).

Calcium uptake and magnesium uptake

Calcium uptake expressed in mg ranged from 10.48 to 13.82 in black, 7.36 to 10.24 in red, 8.88 to 10.44 in alluvial and 4.72 to 5.28 in laterite soils. Magnesium uptake expressed in mg ranged from 6.28 to 7.24 in black, 3.16 to 4.96 in red, 4.06 to 5.04 in alluvial and 2.10 to 2.96 in laterite soils. Soils varied markedly with respect to calcium and magnesium uptake. Black soil recorded maximum calcium and magnesium uptake followed by alluvial, red and laterite soils. This is due to higher availability of calcium and magnesium in the black soils compared to other soils. Different layers studied had significant influence on calcium uptake, the uptake being maximum in the third (> 15 cm) layer and least in the surface layer. The same trend was noticed in the magnesium uptake also. The available calcium and magnesium contents were more in the third (> 15 cm) layers and hence this has resulted in significant increase in the uptake of these two nutrients by sorghum seedlings. In the interaction between soil and depth in all depths black soil registered maximum values compared to other soils. In the interaction between soil and treatment, in all soils, treatment T_4 (160 tons/ha of solid sludge) recorded higher values of calcium and magnesium uptake than other treatments. This is because of higher concentrations of these two nutrients added due to the addition of sludge in larger quantities in all the four soils studied. This might be due to the large addition to cations that are present in the sewage waste or it may also be due to large release of exchangeable cations from the reserve pool by the action of sewage on soil chemical constituents. King and Morris (1972) also reported similar findings and revealed that Ca, Mg and Na levels in the plant increased by the sludge treatment. King *et al.* (1974) observed similar results while conducting investigation on the effect of municipal refuse and liquid sewage sludge to agricultural land.

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