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Effect of town waste and fertilizer on growth and heavy metal concentration of tomato plant

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ABSTRACT

The effect of town waste (TW) and inorganic fertilizer on growth and heavy metal concentration of tomato was studied in the green house. The town waste was applied at the rate of 0, 10, 20, 30 and 40 tons ha^{-1} singly or in combination with either ¼ , or ½ fertilizer recommended rate for tomato. Other treatments were full fertilizer recommended rate (110 kgN, 45 kg P_2O_5, 45 kg K_2O) and control – no addition of waste and fertilizer. Results showed that the treatments have significant effect on plant height and dry matter yield (DMY). Plant tissue analysis gave 39.33 – 94.53, 40.60 – 82.20, 68.9 – 213.9 and 0.40 – 0.83 $mgkg^{-1}$ for Pb, Cu, Zn and Cd respectively. Town waste at 40 tons ha^{-1} with or without fertilizer gave high concentrations of Zn and Pb. The concentrations of Pb and Cu are above the permissible level, while that of Zn and Cd are below. The full fertilizer treatment gave the highest plant height and DYM, followed by 40 tons ha^{-1} waste + ¼ fertilizer dose, but there is no statistical difference between the two treatments.

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INTRODUCTION

The soils of the Nigerian savanna are characteristically low in fertility because of continuous cultivation, leading to rapid decline in soil organic matter, leaching of basic cations and high rate of acidification [1]. Farmer have had to rely on the application of mineral and/or organic fertilizers for maintenance of fertility and crop production. The importance of town waste in improving the crop yield and soil properties is well documented [2,3]. Waste is a material that is not needed and it's economically unstable without further processing, and it may be in form of liquid, solid or gas. Waste added to soils increases the percentage organic matter, the concentration of macro and micro-nutrients and the activities of micro organism [3]. Town waste was found to have a high manurial value and improve the growth of crops [4]. The addition of urban waste to soil improves the fertility by acting directly on its biological, physical and chemical properties which in turn activate the microbial biomass, improves soil structure, increase water holding capacity and aggregate stability [5,6].

However, the ever increasing amount of organic waste from different sources (animal and urban wastes) pose a serious environmental and health problems and their possible use of organic matter for agricultural purposes or as amendments in the case of degraded soils have been investigated [6,7,8].

The result of organic waste analysis has shown wide range values of nutrient composition which depended on the source of sampling and type of waste material that constituted the waste [9].

The presence of heavy metals in residues from town waste and sewage sludge as well as some inorganic fertilizers applied to agricultural lands has been found to be the cause of pollution in soils and plants, and their accumulation in soils can result in decrease crop yield [10,11]. Also the heavy metals could be in a concentration necessary to manifest its effect on human health [12].

Direct application of urban waste for sustainable crop production can be particularly attractive in Nigeria as a low cost alternative to conventional inorganic fertilizer and also serves as a means of organic matter utilization for sustainable crop production. The aim of this work was to study the effect of town waste (TW) and inorganic fertilizer on the growth and dry matter yield of tomato and also to determine the heavy metals (Pb, Cu, Zn and Cd) concentrations in tomato plant tissue.

MATERIALS AND METHODS

Soil Sample Collection and Preparation

The soil used for the study was from Institute for Agricultural Research (IAR) farm (horticultural garden, Area 'C'). The soil was collected, dried, crushed and sieved through 2 mm sieve. Some soil samples were used for physico-chemical analysis (Table 1), while the remaining one was used for green house experiment.

Town waste collection and preparation.

The town waste was collected from Mora road, Tudun-wada, near A.B.U. Teaching Hospital, Zaria. Broken bottles, bones, polyethylene nylon bag and pieces, paper and other undecomposed materials were removed. The waste was packed and brought to the laboratory where it was air – dried and sieved. Sub sample of the waste was taken for EDXRF, analysis in the Centre for Energy Research and Training/Ahmadu Bello University, Zaria, Nigeria (CERT).

Green house experiment

Appropriate weight of the waste were taken and added to the soil in the 5 litre pot. Tomato seedlings were raised in nursery for 4 weeks before transplanting. The seedlings were transplanted at the rate of 4 seedlings per pot which were later thinned down to 2 seedlings per pot. Various town waste and fertilizer treatments were weighed and properly incorporated into the soil in the plastic pot before transplanting the tomato seedlings.

Parameters determined included plant height and number of leaves. The plants were harvested at 35 days after transplanting (DAT). The above-ground portion of the plant were cut and washed in distilled water and put in the oven set at 65 ^oC until the dried sampled attained a constant weight. The dried samples were weighed and then ground with a stainless steel mill. The ground samples were stored in polyethylene bags.

Plant tissue analysis

The ground plant materials from the field trials were digested with a mixture of HNO_3, H_2SO_4 and $HClO_4$ acids on a hot plate (13). Heavy metals in the digests were determined by the use of atomic absorption spectrophotometer (AAS), UNICAM 969.

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) and differences between means were evaluated using the least significance difference (LSD). Simple correlation analysis was also carried out to show the relationship between plant height, DMY, heavy metal concentrations and uptake.

RESULTS AND DISCUSSION

Soil and Town Waste Analysis

The pH indicate that the soil is mildly acidic (Table 1) which is a common feature of soils from Samaru, Zaria, which range from 4 – 6.5 (1). The O.C. and total N of the soil are low and falls within the range of low fertility class. The available P is 10 $mgkg^{-1}$which is within the range of medium fertility class (14).

The pH of the waste was 7.03 which is neutral (Table 1) the value of 0 C., total N, available P and exchangeable cations for the waste are high and in fact higher than that of the soil. This reflects the high fertility status of the waste. The heavy metals (Cu, Zn, Pb and Cd) values are high, but are within the range of values obtained by other workers [2,9] from waste analysis. These values are within the permissible values of Dutch standard for total concentration of heavy metal in soils [10].

Plant height and dry matter yield

The effect of town waste and fertilizer on plant height was significant. The values of plant height ranged from 31.00 – 53.33 cm. The highest plant height was obtained with the 40 tons TW + ¼ FR treatment. There is no statistical difference between 40 tons TW, 30 tons TW + ¼ FR, 40 tons TW + ¼ FR and FFR treatments (treatments 5, 9 and 10 and 16 respectively).

Table 1: Physicochemical properties of soil and waste

Characteristics	Soil	Waste
pH (H_2O)	6	7.03
pH ($CaCl_2$)	5	2.01
Organic carbon (g kg^{-1})	1.4	22.90
Total N (mg kg^{-1})	0.6	1.05
Available P (mg kg^{-1})	10	144.38
Exchangeable bases (C mol (+) kg^{-1})	1.00	16.75
Ca	0.12	2.6
Mg	4.40	7.49
Na	0.31	11.54
K		
Micronutrients (mg kg^{-1})	2	42
Cu	2.8	579±18
Zn	-	106±9
Pb	-	8±1
Cd		
Particle-size analysis (g kg^{-1})	500	-
Sand	360	-
Silk	140	-
Clay		

Dry matter yield (DMY) varied from 2.67 – 8.63 g/plot. High values were obtained for 40 tons TW + ¼ FR and FFR treatments (8.21 and 8.63 g/pot respectively). There is no significant difference between the two treatments [10,16], it may therefore be concluded that apart from treatment 16, treatment 10 (40 tons TW + ¼ FR) is superior to other treatments influencing the plant height and DMY of tomato.

Effect of town waste (TW) and fertilizer on heavy metal concentration and uptake

Lead concentration in the tomato plant tissue varied from 39.33 – 94.50 $mgkg^{-1}$ where Pb uptake varied from 105-656.23 mg/pot. The highest Pb concentration was obtained from 40 tons TW + ½ FR. The Pb concentrations obtained in this study is above the sufficiency range of lead in plants. It is also above

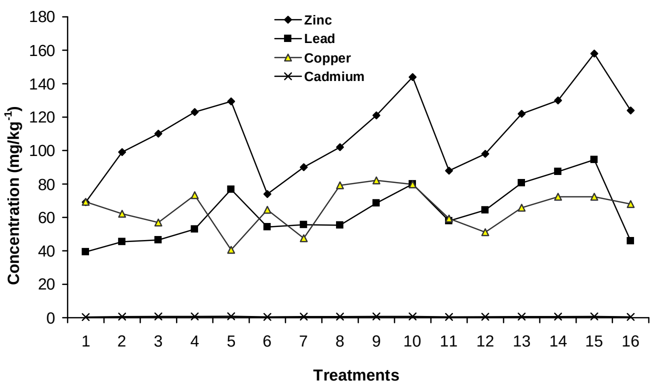

Figure. 1: Effect of town waste and fertilizer on heavy metal (Zn, Cu, Pb, Cd) concentrations

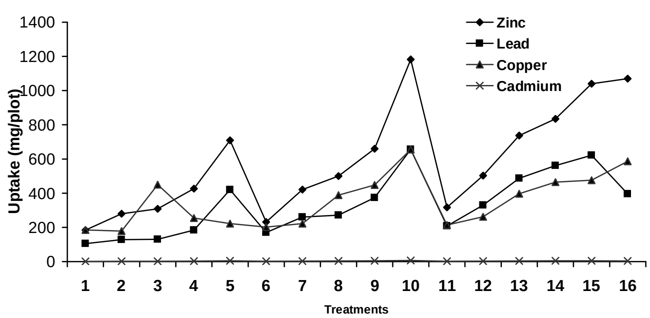

Figure 2: Effect of town waste and fertlizers on heavy metals (Zn, Cu, Pb, Cd) uptake

the lead concentration obtained for fruit type vegetables [15]. This could be due to the high lead concentration (106 $mgkg^{-1}$) in the TW used for the study.

Copper concentration varied from 40.6 to 82.20 $mgkg^{-1}$, whereas copper uptake varied from 178.3 – 655 mg/pot (Figs. 1 and 2). The value of Cu concentrations obtained from this study is higher than the sufficiency range of 5 – 25 mg kg^{-1} reported by Sheldrake (16) for tomato plant.

Zinc concentration in the tomato plant tissue varied from 69.1 – 158 $mgkg^{-1}$, with a mean of 111.36 $mgkg^{-1}$ (Fig. 1). Zinc uptake also varied from 184.5 – 1182.2 mg/pot (Fig. 2). The highest zinc concentration was obtained from 40 tons TW + ½ FR treatment. Although the amount of Zn in the waste was very high (579 $mgkg^{-1}$) it could be that the fertilizer also contained some Zn. However, the concentration of zinc obtained in this study in within the sufficiency range recommended for tomato plants. Roorda van Eysinga and Smilde (17) reported that value above 327 $mgkg^{-1}$ is toxic.

Cadmium (Cd) concentration in the tomato plant tissue varied from 0.40 – 0.83 mgkg-1 (Fig. 1). These values are lower than the values reported by Lin [15] from fruit type vegetables. Cadmium uptake varied from 1.86–4.54 mg/pot (Fig. 2). The highest Cd concentration was obtained from 40 tons TW treatment. The Cd concentrations obtained are above the values quoted by Chen [10].

Correlation studies

Results of the correlation studies conducted showed that plant height correlated with DMY (r = 0.622**), Pb, Zn, Cu and Cd uptake (r = 0.603**, 0.395*, 0.570**, 0.546** respectively) as shown in Table 3. DMY correlated with Cd concentration (r = -0.401**), Pb, Zn, Cu and Cd uptake (r = 0.843**, 0.805**, 0.842**, 0.665** respectively). Also there are strong relationship among heavy metal concentrations and uptake as shown in Table 3.

CONCLUSION

The study revealed the presence of excessive amount of lead and copper in the tomato plant tissue, which are above the permissible level while that of Cd and Cu are below. The presence of the metals indicates that the use of waste should be limited in terms of the amount applied or the frequency of application. Although the addition of waste increased growth and yield (DMY), there is need to know the heavy metal content of waste before applying to agricultural land. The result also revealed that 40 tons TW + ¼ FR proved superior over the other treatments, apart from the full fertilizer dose.

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Table 2: Effect of town waste (TW) and fertilizer on plant height and dry matter yield (DMY) of tomato

Treatment No	Treatment	Plant height (cm)	Dry matter yield (g/pot)
1	0 ton TW	31.00c	2.67f
2	10 tons TW	33.33c	2.82f
3	20 tons TW	43.00abc	2.80f
4	30 tons TW	44.33abc	3.47def
5	40 tons TW	50.67ab	5.48cd
6	0 ton TW + ¼ fertilizer rate (FR)	35.67bc	3.13ef
7	10 tons TW + ¼ FR	38.33abc	4.68cdef
8	20 tons TW + ¼ FR	45.67abc	4.90cde
9	30 tons TW + ¼ FR	51.00ab	5.45cd
10	40 tons TW + ¼ FR	53.33a	8.21ab
11	0 ton TW + ½ FR	35.00bc	3.60def
12	10 tons TW + ½ FR	41.00abc	5.13cd
13	20 tons TW + ½ FR	42.67abc	6.04c
14	30 tons TW + ½ FR	46.00abc	6.42bc
15	40 tons TW + ½ FR	46.67abc	6.58abc
16	Full fertilizer rate (FFR)	52.33a	8.63a
Mean		43.13	5.00
LSD		17.26	2.06

TW – Town waste FR – fertilizer rate FFR – Full fertilizer rate.
Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 3: Simple correlation between plant height DMY, heavy concentrations and uptake

	Plant height	DMY	Concentration				Uptake			
			Pb	Zn	Cu	Cd	Pb	Zn	Cu	Cd
Plant height	-									
DMY	0.622**	-								
Pb conc	0.140	0.193	-							
Zn	-0.177	-0.103	0.739**	-						
Cu	0.186	0.252	0.140	0.290	-					
Cd	-0.174	-0.401*	0.537**	0.705**	0.081	-				
Pb uptake	0.603**	0.843**	0.893**	0.824**	0.269	0.448*	-			
Zn	0.395*	0.805**	0.687**	0.861**	0.325	0.390*	0.928**	-		
Cu	0.570**	0.842**	0.427*	0.718**	0.545**	0.311	0.709**	0.833**	-	
Cd	0.546**	0.665**	0.774**	0.864**	0.280	0.629**	0.936**	0.933**	0.751**	-

* 5% level of significance ** 1% level of significance

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