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Trace-elements evaluation of composted municipal solid wastes used in dry season production of tomato (*Lycorpersicum esculentus*) in an inland valley soils of Delta State, Nigeria

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Abstract

Field experiments were carried out in the inland valley soil to evaluate the trace-elements concentration of composted municipal solid wastes used as a soil amendment in dry season cultivation of Tomato (*Lycorpersicum esculentus*). The experiments were laid out in a Randomized Complete Block Design in three replicates. Each experimental plot measured 2.5 m × 2.5 m with an alley of 1m between blocks and 0.5 m between plots. The initial physico-chemical properties of the soil, concentration of trace-elements in the municipal solid wastes and total extractable trace-elements in tomato plants after harvest were all routinely analyzed. The treatment was incorporated during the harrowing of the experimental site at the rate of 20 t/ha. Nursery-raised tomato seedlings (Var. Roma VF) were transplanted to the field 4 weeks after treatment application. Data were collected on plant height, number of leaves/plant, number of branches/plant, number of fruits/plant, fresh fruit weight and total fresh fruit yield at 2 weeks interval after transplanting and at 12 and 14 WAT for yield variables. Results showed that the soil of the experimental site was acidic, sandy loam and loam in texture with variable nutrient concentrations. Composted municipal solid wastes significantly ($P < 0.05$) increased plant height, number of leaves/plant, number of branches/plant and total yield of Tomato over the control plots. The content of trace-elements evaluated in the study at harvest showed that they were below the threshold of toxicity and above optimal growth levels. Thus, they do not pose any threat to human health and the environment.

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Introduction

In the Sub-saharan regions, the ever-increasing use of composted municipal solid waste in agricultural crop production cannot be overlooked. It has been recognized by many vegetable crops farmers as a cheap and rich source of nutrients needed by plants/crops for enhanced yield, good crop quality, thus, increased financial returns. Although municipal solid wastes have being identified as a good and cheap source of soil fertility maintenance, Nriagu (1998) however reported that the continuous use as a soil amendment might increase the level of potentially harmful trace-elements and organic toxins. According to Ezeaku *et al.* (2003) long-term accumulation of composted municipal solid wastes in the soil can lead to adverse and detrimental changes in the soil's physical, biological and chemical characteristics due to increased toxicity. According to Silveiral *et al.* (2003), Okoronkwo *et al.* (2005), the public health implication of using composted municipal solid wastes is that crops grown on soils amended with biosolids such as municipal solid wastes, can immobilize heavy metals which could find their ways in human being through food chain processes and constituted numerous health hazards and spread of various infectious diseases (USEPA, 1994; Deportes *et al.*, 1995). Although the general mindset among farmers in using composted municipal solid wastes was to obtain maximum yield from marginal land through increased soil productivity, the practice is prone to the dangers of accumulation of phytotoxic metals in the wastes that were anaerobically degraded. This could possibly cause soil/water pollution by toxic chemicals such as Cd, Cr, Fe, Pb and Cu which could leached into the underground water (Agunwamba, 1998).

Trace-elements are generally micronutrients that plants in minimal quantities require. They become heavy metals when their concentrations are more significant than 5 gm/rn2 (Brady and Weil, 2007). Now that many vegetable farmers have resorted to the use of composited municipal solid wastes as a cheap source of soil fertility improvement to produce a good yield that can attract reasonable prices. The million naira question is how safe are food crops cultivated with municipal solid wastes? One way to achieve this is to assess the chemical constituents of the composted municipal solid wastes and determine their levels of tolerance to human use for crop production. Against this background, the objective of this study was to assess the trace-elements concentrations of composted municipal solid wastes commonly used in tomato cultivation and their uptake by the cultivated crops.

Materials and methods

Description of the study area

The study was conducted in the inland valley soils of Anwai-Delta State, Nigeria. The topography was flat-floored with little or no mound or gilgal formation and liable to flooding annually for about three months, between September to November. It is located at longitude 06° 49`E and longitude 06° 14`N of the equator and characterized by a bimodal rainfall pattern with peaks in July and September and a short dry spell in August traditionally called “August break”. The annual rainfall is between 1,500 mm-1,850 mm, with a relative humidity of between 65 - 85% depending on the time of the year. The yearly temperature ranged from 27 °C-32 °C. The vegetation is typical of rainforest types; commonly seen vegetation includes trees, grasses and shrubs. The land use is mainly crop farming based on rainfed agriculture. Crops widely grown include root and tuber crops, cereals, pulses and vegetables of different kinds.

Field study

Field experiments were conducted during the 2017/2018 dry season cropping seasons on a land area measuring 30 x 30 m^2. The experimental site was cleared manually, ploughed and harrowed twice and marked out with pegs into six plot sizes, each measuring 2.5 m ' 2.5 m and separated by 0.5 m.

Initial pre-planting soil samples were collected from each of the plots, bulked and composited. The samples were air-dried at room temperature of 27°C for 3 days, then ground, and sieved to pass through a

2 mm sieve mesh for laboratory analysis of the initial physico-chemical properties of the soil.

Laboratory analysis

Three different laboratory analyses were carried out. The first was the initial physicochemical properties of the soil, the second was the trace2elements contents of the municipal solid wastes before applying to the soil and the third was the total extractable trace-elements at harvest from the test crop.

Methods

The initial physico-chemical properties evaluated include the particle size distribution of the soils determined by the standard hydrometer method as described by Gee and Bauder, (1986). The soil pH measured in 1:2.5 soil:water suspension ratio using a glass electrode pH meter. Organic carbon was determined by Dichrornate Wet Oxidation method of Nelson and Sommers, (1986). Total nitrogen was determined by Micro-Kjeldahl distillation method as described by Agbenin (1996). Available phosphorous was determined by the Molybdate Blue method of Lowry and Lopez using ascorbic acid as a reductant (Van Reeuwijik, 1993). Exchangeable bases (Ca, Mg, K and Na) were extracted with 1N NH4OAC and Na and K in the extract determined by Flame photometer, while Ca and Mg were determined colorimetrically by titration with 0.01 N EDTA. The second and third determinations were the trace-elements content of the composted municipal solid wastes fore and after harvest to determine uptake. The procedure involved extracting the treatment with 0.005 M DTPA and 0.01 M CaC12. After shaking for 30 minutes and filtered, the elements were determined using Atomic Absorption Spectrophotometer.

Treatment application

Composted municipal solid wastes treatment was incorporated during the second harrowing of the experimental site at the rate of 20 t/ha.

Tomato seedlings (Roma UF Cv) were raised in a make-shift nursery for a period of 4 weeks after which, they were transplanted to the field a week later. The seedlings were watered at two days, interval and regularly weeded. Growth and yield characters measured include plant height, number of leaves and branches per plant and total fresh fruit yield (t/ha).

Data collection and analysis

Data on growth characters were collected at 2, 4, 6 and 8 WAT (Weeks after treatment), while the number of fruits, fresh trust weight and total fresh fruit yield were collected at 10 and l2WAT. All the data collected were subjected to Analysis of Variance (ANOVA) and means separated using Least Significant Difference (LSD).

Results and discussion

Table 1 showed the particle size distribution of the experimental land area. With relatively higher and clay (15.0%), the soils were generally sandy loam and loam in texture. The dominance of sand fraction could be attributed to the sandstone origin of the parent material (Brady and Weil, 2008). The soil reaction was strong to moderately acidic (5.42-6.10). The acid nature could be attributed to the acid sand parent material and high rainfall characteristics of the study area, usually greater than 1,500 mm/annum, which could possibly induce the leaching of metallic cations. The organic carbon content (19.84 — 22.14 gkg^{-1}) was rated medium in content (FMANR, 2012). The medium content could be attributed to the deposition of all forms of residues during the flooding regime. Total nitrogen content (1.52 gkg^{-1} -1.75 gkg^{-1}) could be rated medium (FMANR, 2012). This could be attributed to the organic matter content of the soil. According to Agboola (1978)) organic matter supplies about 75 — 85% of soil organic nitrogen. The mean value of available phosphorous of10.13 $mgkg^{-1}$ was rated medium (FMANR, 2012). This value is also attributed to the organic matter content of the soil which is a pool of soil total nitrogen and phosphorus of a soil (Brady and Weil, 2007). The content of exchangeable bases varied from low to medium. Particularly low was the exchangeable Na, which ranged from 0.02 to 0.03 $cmolkg^{-1}$ depicting the soils are not saline (Holland *et al*., 1989).

Table 1. Some Physico-chemical properties of ferralitic soils in Delta State, Nigeria.

	Particle size distribution %				pH	O.C	T. N	Avail P	Exchangeable cations cmolkg⁻¹				CEC
Sample location	Sand	Silt	Clay	Texture	H_2O	gkg⁻¹	gkg⁻¹	mgkg⁻¹	Ca	Mg	K	Na	cmolkg⁻¹
1	64	21	15	SL	5.42	21.52	1.52	9.34	5.20	1.24	0.12	0.03	10.75
2	70	21	9	SL	5.64	20.34	1.58	9.52	5.38	1.34	0.12	0.03	10.56
3	68	20	12	SL	5.62	19.84	1.61	9.75	5.45	1.20	0.09	0.03	10.42
4	48	32	20	L	5.83	21.35	1.65	10.22	8.20	1.63	0.12	0.82	12.45
5	43	38	19	L	5.82	22.10	1.72	12.14	8.42	1.68	0.13	0.02	12.38
6	44	41	15	L	6.10	22.14	1.75	12.38	8.62	1.70	0.98	0.02	12.52
X	56.17	26.40	15		5.67	21.03	1.55	10.13	6.53	1.51	0.09	0.03	11.31
Sd	12.50	8.14	4.61		0.17	0.92	0.20	1.19	1.63	0.23	0.04	0.05	1.01
Cv%	22.25	30.83	30.73		3.00	4.31	12.90	11.75	24.96	15.23	44.44	10.67	8.93

Note: O.C. = Organic carbon, T.N = Total nitrogen, Avail P = Available phosphorus, CEC = Cation exchange capacity.

Table 2. Initial Concentration of Trace-elements in the Municipal Solid Waste used as treatments in the experiment.

Sample Location	Trace-elements (ppm)					
	Fe	Cu	Zn	Mn	Mo	B
1	54.74	0.84	1.12	4.25	2.10	0.21
2	53.25	0.10	1.08	4.28	2.14	0.13
3	61.20	0.92	1.24	5.12	2.22	0.14
4	58.42	0.84	1.09	4.81	1.76	0.20
5	53.14	0.86	1.20	5.20	0.98	0.18
6	52.46	0.90	1.18	6.42	1.24	0.88
x	56.15	0.71	1.15	4.73	1.84	0.17
Sd	3.54	0.34	0.07	0.15	0.51	0.04
Cv%	63.05	47.89	6.09	9.51	27.72	23.53

The mean cation exchange capacity (CEC) of 11.31 cmolkg⁻¹ showed that they were medium in content. This could be attributed to the organic matter content of the soil and the moderate exchangeable base status of the soil.

Trace-elements content

The Initial content of trace-elements evaluated (Fe, Cu, Zn, Mn, Mo and B) of the composted municipal solid wastes (Table 2) showed that Fe content with a mean value of 56.15 ppm was low. Cu with a mean value of 0.71 ppm was low and below 2-100 ppm established as a critical level. Zn was low with a mean value of 1.15 ppm below the critical level of 10-1,000 ppm, Mn was low. All the contents of trace-elements eva1uatd in the composted municipal solid waste were generally low and below the established by Agarwala and Sharma 1979 and Adeoye (1986).

Table 3. Total extractable Trace-elements content in Tomato plant (Roma Vs Cv) at 12 WAT (Weeks after treatment applications).

Sample Location	Trace-elements (ppm)					
	Fe	Cu	Zn	Mn	Mo	B
Control	42.35^{a}	0.18^{a}	0.15^{a}	2.18^{b}	0.12^{a}	0.03^{ab}
1	42.00^{a}	0.12^{a}	0.10^{a}	1.76^{c}	0.08^{a}	0.02^{ab}
2	43.15^{a}	0.98^{a}	0.10^{a}	1.66^{d}	0.08^{a}	0.02^{ab}
3	40.72^{b}	0.10^{a}	0.09^{a}	1.24^{a}	0.10^{a}	0.02^{ab}
4	44.12^{c}	0.12^{a}	0.12^{a}	1.21^{a}	0.09^{a}	0.02^{ab}
5	40.14^{b}	0.09^{a}	0.12^{a}	1.10^{a}	0.10^{ab}	0.03^{ab}
6	39.76^{b}	0.09^{a}	0.12^{a}	1.12^{ab}	0.13^{a}	0.04^{ab}

Means with the same alphabet on the same row are not significantly different at 0.05 level of probability.

Total extractable trace-elements

Table 3 showed the total extractable trace-elements after harvest of 12 Weeks after treatment application.

The results showed that Fe, which is one of the most essential micro-elements needed by growing plants as a compound of many enzymes and a catalyst in the synthesis of chlorophyll, was the most abundant in the soil and most absorbed. About 74.94 % was extracted. This was followed by Cu 38.01%, Mn 32.35%, B 11.76%, Mo 4.49% and Zn 0.70%. all the extractable trace-elements were below the threshold of toxicity and above the optimal level for plant growth. The implication of the result was that their contents were low and could not pose any threat to cultivated crops as they are eaten.

Table 4. Effect of treatment (composted municipal solid wastes) 20t/ha on growth characters of Tomato in an inland valley soil of Anwai-Delta State, Nigeria.

Sample location	Plant height (cm)	No of leaves/plant	No of branches/plant
Control	43.7	18.17	4.3
1	52.6	22.4	6.2
2	54.3	23.2	6.1
3	48.4	24.3	5.8
4	52.4	26.4	5.8
5	58.3	26.6	6.2
6	60.1	25.2	6.3
Mean	54.35	23.6	5.73
F-L&D(0.05)	34.03	NS	NS

Table 5. Effect of treatment (composted municipal solid wastes 20 t/ha on the yield characters of Tomato in an inland valley soil of Anwai-Delta State, Nigeria.

Sample location	No. of fruits/plant	Fresh fruit wt. (kg/ha)	Total fresh fruit yield (t/ha)
Control	4.2	3.5	0.52
1	6.3	5.4	1.25
2	6.4	5.6	1.45
3	5.6	5.2	1.78
4	6.2	4.2	1.64
5	6.4	3.6	1.72
6	6.3	4.3	1.84
Mean	5.85	5.85	1.39
F-L&D(0.05)	NS	NS	NS

Analysis of data presented no significant difference of the treatment means with respect to plants growth and yield parameters measured (Tables 4 and 5) respectively.

Conclusion

The evaluation of trace-elements contents of composted municipal solid wastes used in dry season tomato cultivation for soil fertility maintenance, higher crop yield and better financial pay-back showed that the trace-elements were in very low concentration and that crop requirements presently and on a short-term basis can be met. Since trace-elements are generally required by plants in very small amounts, their concentrations in the analysed composted municipal solid wastes were within optimal growth level and below the toxicity threshold as observed in the study. Even when composted municipal solid wastes have variously been reported as a chief source of plant nutrients that can boost yield, the public health concern is of paramount importance. Crops grown on soils amended with composted municipal solid wastes over time, can immobilize heavy metals, which could have their ways into human beings through food chain processes. This could manifest a lot of health challenges (health risk). Against this backdrop, there is every need to routinely evaluate trace-element content of municipal solid wastes presently used by a larger farming population as a cheap source of soil amendment in growing vegetable crops.

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