Toxicity effect of application of non composted poultry manure on soil and A*maranthus caudatus*

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ABSTRACT

The study was conducted at Adekunle Fajuyi Military Cantonment, Odogbo Barracks, Oojo, Ibadan in May 2010. Soil samples were collected from 6 farmers' fields, growing with *Amaranthus caudatus,* sown at a rate of 10 kg/ha by broadcasting. The fields with an average size of $12m^2$ were selected at random, based on units within the barracks at a distance of about 200m apart. The farmers applied, dry, uncomposted Poultry manure at 1 – 2 weeks before planting at an average rate of 200 t/ha by broadcasting and incorporated into the soil with hoe. Surface soil samples were collected at random from each field, air dried and sieved. They were chemically analysed for pH, particle size distribution, exchangeable bases, ECEC, N, Av. P, Organic Matter, micronutrients (Fe, Mn, Cu and Zn) and heavy metals (Pb, Cd, Ni and Cr). The levels of soil fertility indicators, such as Nitrogen, Phosphorus, Potassium, Effective cation exchange capacity, organic matter and the base saturation were above optimum while that of Mn and Cu were below toxicity level. Levels of Zn and Fe of 22.1 – 203.5 and 44.3 – 86.8 mg/kg respectively are far above toxicity values of 1.0 – 2.0 and 5 – 9 mg/kg respectively thereby causing nutrient imbalance and toxicity, thus resulting in yellowing of Amaranthus crops.
Key words: *Amaranthus caudatus*, composting, Toxicity.

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INTRODUCTION

Eighty percent of the fresh leafy vegetables consumed by about three million people who live in Ibadan city of Nigeria and its environs are produced within and around the city by the farmers in back yards, vacant land, near streams, road sides, barracks and government offices(Olajide-Taiwo *et al*,2011). Virtually any vacant available space is put into leafy vegetable production, including land under high tension wire. These are done, as a sole means of livelihood or to augment meager salaries. The three most important leafy vegetables produced based on land area cultivated are Amaranthus, Celosia and Corchorus. These vegetables are mainly grown for fresh vegetable market. About 89% of the total production of vegetable is taken in fresh, while the remaining 11% are processed (Olujide and Oladele, 2007). In Ibadan, South Western Nigeria, women are mostly involved in this type of urban agriculture, which are faced with a lot of challenges. Some of these challenges include low soil fertility of farmland, which are continuously cultivated on yearly basis, thereby leading to soil degradation and infertility. In order to sustain the fertility status of the soil and economic production of vegetables, these farmers often resort to the use of poultry manure, which most often, was not properly processed before application, without considering the nutrient status of neither the soil nor the quality of the manure.. Furthermore, the campaign, discouraging the use of mineral fertilizers, in favour of organic fertilizer is gaining ground, but caution need to be exercised as to what is being applied as organic fertilizer. Application of organic materials, such as, poultry manure, which has not been properly mineralized, to crops, results into adverse effects, such as, (i) undesirable anaerobic reactions and transformation into ammonia (NH_4), hydrogen sulphide (H_2S) and methane (CH_4) gas, which are toxic to plant growth and produce bad odour; (ii) nitrogen depression (deficiency), characterised by yellowing of plants, is caused by microorganisms that takes up large quantities of nitrogen during cell biomass manufacturing and (iii) potentially toxic waste materials that would have been removed during composting are released into the soil and water(Taylor & Francis Group, 2005).

Presence of high concentrations of heavy metals such as Copper (Cu), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Lead (Pb) and Zinc (Zn) in soils could result in nutrient imbalance, thereby making essential nutrients unavailable to the plants. These heavy metals are at times present in animal waste and would require adequate mineralization before it could be fit for application to the soil. Table 1 contains levels of heavy metals in soil used to guide cleanup and

land use decisions (mg/kg) by United States Environmental Protection Agency (US EPA) and New York State Department of Environmental Conservation(NYS DE). From the table, figures above what is listed under the unrestricted column is considered polluted and toxic to the soil, plant and the environment.

Table 1. Levels of heavy metals in soil used to guide cleanup and land use decisions (mg/kg)

Element	US EPA	NYS DEC	
	(Soil level requiring cleaning-up)	Unrestricted Use	Residential Use
Copper (Cu)	-	270	270
Cadmium (Cd)	70	0.43	0.86
Chromiun (Cr)	230	11	22
Nickel (Ni)	1600	72	140
Lead (Pb)	400	200	400
Zinc (Zn)	23,600	1100	2200

Unrestricted use includes agricultural use

Eventually, after several seasons of this practise, the Amaranthus crops, grown by the farmers, were turning yellow, leading to poor yield and virtually no patronage from consumers. They were about abandoning the land, because they did not know the cause of the yellowing or how to solve it, when this intervention study started. This problem, encountered by the women vegetable farmers, led to the objective of this study, which was to find the cause of yellowing of *Amaranthus caudatus,* as observed by the farmers and proffer solutions.

MATERIALS AND METHODS

The study was carried out on Farmers field at Adekunle Fajuyi Military Cantonment, Odogbo Barracks, Oojo, Ibadan ($3^0$54'E; $7^0$30'N) in May 2010. Ibadan is located in the derived Savannah zone of Southwestern Nigeria with a mean annual rainfall of 1,280mm. The study was conducted on 6 farmers field, of an average size of $12m^2$ already established by the farmers, selected at random, based on units within the barracks at a distance of about 200m apart. Farmers sow Amaranthus seeds at a rate between 8.5 and 12 kg/ha. Dry uncomposted Poultry manure was applied 1 – 2 weeks before planting at an average rate of 200 t/ha by broadcasting and incorporated into the soil with hoe. The poultry manure, which were collected fresh from dump

sites of poultry farmers within reach, were left in the sacks until application time. Surface soil samples at 15 cm depth were collected at random from each field, air dried, sieved and chemically analysed for: pH, particle size distribution, exchangeable bases, effective cation exchange capacity (ECEC), available Phosphorus, total nitrogen, organic carbon, micronutrients (Zn, Cu, Mn and Fe) and heavy metals (Pb, Cd, Cr and Ni).

Soil pH was determined by glass electrode pH meter in distilled water at ratio 1: 1(Bates, 1954) Hydrometer method was used for the particle size distribution determination (Bouyoucus, 1951), while exchangeable bases (Na, Ca, Mg and K) were determined using 1N Ammonium Acetate extraction method (Black, 1965). Ca and Mg were determined by Atomic Absorption Spectrophotometry (AAS) while K and Na were by Flame Photometry. Exchangeable acidity was determined by titration method using 1N KCl extraction (Mclean, 1965). Effective Cation Exchange Capacity (ECEC) was by summation method. Organic carbon was determined by colorimetric method, using the modified Walkley Black method (Hearns, 1984) and the Organic Matter calculated by multiplying with 1.72. Total Nitrogen was by Kjedhal method of digestion and adapted autoanalyzer colorimetric method (Technicon, 1973). Available Phosphorus was extracted, using Bray P 1 extractant (Bray and Kurtz, 1945) and determined colorimetrically. Available Mn was determined from the neutral 1N Ammonium Acetate extract while available Cu, Fe and Zn were extracted by 0.1N HCl and analyzed on Buck Scientific Atomic Absorption Spectrophotometer (AAS). Heavy metals were determined by wet digestion method of Nitric Perchloric acid mixture at ratio 2:1 and the digest read on AAS.

RESULTS AND DISCUSSION

The textural class of the 6 soils is loamy sand, which is what is required for good growth of Amaranthus . Table 2 shows the pH, N, P, K Ca, Mg, ECEC, Base Saturation and the organic matter of analysed soil samples. pH value ranged between 5.4 – 6.2 while the levels of major plant nutrients such as N was from 2.5 – 4.0 g/kg, available P was from 112 – 268 mg/kg and exchangeable K from 0.13 – 0.36 cmol/kg. ECEC values ranged from 6.30 in Garrison to 8.67cmol/kg in Garrison b while the percent Base Saturation values averaged 98% across all the locations. Organic matter of all the locations were high, the value ranged from 6.31 – 11.18 at CODO and Workshop respectively. Micronutrients analysis as shown in Table 3 indicated Mn and Cu values of 0.5 – 2.0 and 1.0 – 1.7 mg/kg respectively while Zn and Fe ranged between

22.1 – 203.5 and 44.3 – 86.8 mg/kg respectively. At the 6 locations, heavy metal levels were below toxicity level except for Ni at CODO (Table 4).

The pH range and levels of N, P, K, ECEC, Base Saturation and organic matter are well above their critical levels and were an indication of very high soil fertility status; any crop grown on it should be profitable. But despite the sufficient levels of the nutrients, the whole crops were yellow and not fit for consumption. This could be attributed to the nutrient imbalance caused by the toxicity of Zn and Fe through application of non properly composted poultry manure. The levels of Zn between 22.1 – 203.5 and Fe with 44.3 – 86.8 mg/kg are far above the toxicity level, which could lead to yellowing of Amaranthus crop due to low absorption of nitrogen by the plant. Zn in soil is reported to be less critical at 1.0 – 2.0 mg/kg by Akinrinde and Obigbesan (2000), while Oluwatosin and Ogunkunle (1991) and Akinrinde and Obigbesan (2000) reported that soil iron value of 5.9mg/kg has no threat to lives. . Proper composting of Poultry Manure before application to the soil would have reduced Zn and Fe content of the manure to tolerable levels.

Table 2. Effect of Application of Non-composted Poultry Manure on Soil Chemical Properties

Location	pH	N	P	K	Ca	Mg	ECEC	Base Saturation	Organic Matter
		g/kg	mg/kg	cmol/kg				%	
Garrison	5.4	2.5	225	0.18	4.96	0.86	6.30	97.62	6.05
Garrison (b)	5.7	3.5	268	0.31	7.58	0.51	8.67	98.62	10.66
CODO	5.8	2.9	159	0.27	5.55	0.93	7.04	98.30	6.31
B.A.D	6.2	3.2	112	0.36	6.71	0.84	8.25	98.79	7.36
Workshop	5.6	4.0	221	0.36	6.22	0.65	7.49	98.40	11.18
Signal	6.2	3.7	118	.013	6.70	0.66	7.72	98.70	7.07

Table 3. Effect of Application of Non-composted Poultry Manure on Soil Micronutrients

Location	Cu	Zn	Fe	Mn
	mg/kg			
Garrison	1.3	40.1	51.7	2.0
Garrison (b)	1.1	203.5	44.3	0.7
CODO	1.0	22.1	80.6	0.5
B.A.D	1.7	24.9	86.8	0.6
Workshop	1.1	37.3	55.3	1.8
Signal	1.2	31.2	71.2	1.7

Table 4. Effect of Application of Non-composted Poultry Manure on Soil Heavy Metals

Location	Pb	Cd	Cr	Ni
		mg/kg		
Garrison	5.5	nd	10.4	15.7
Garrison (b)	5.7	0.38	30.2	114.5
CODO	3.5	nd	73.2	480.0
B.A.D	12.0	nd	7.1	17.2
Workshop	3.7	nd	4.0	51.0
Signal	4.7	nd	nd	2.2

nd – not detected

Furthermore, the yellowing could be as a result of the nitrogen depression (deficiency), caused by microorganisms that takes up large quantities of nitrogen during cell biomass manufacturing, which would have been avoided if the poultry manure had been properly cured, before application to the crop. Curing, which is a stage in composting, allows the compost to be stabilized, as the remaining microorganisms metabolize the remaining nutrients and microbial activity reduces, as available nutrients are depleted.

During composting toxic component are either removed or reduced to tolerable levels. Also, plant nutrients are readily made available for uptake, when applied organic materials, are properly and sufficiently decomposed. Animal and plant wastes should be properly composted before application as fertilizer.

CONCLUSION

The yellowing of *Amaranthus caudatus* crops planted by the farmer were attributed to the toxicity levels of the Zn and Fe and nitrogen depression caused by application of non composted poultry manure. The farmers were advised not to apply poultry manure for the next 2 years, to allow the accumulated manure to be properly mineralized and allow the toxic components to leach away. This will reduce the Zn and Fe toxicity level to tolerable levels and allow the microorganisms causing nitrogen depression to die off during curing and thus lead to a better and acceptable *Amaranthus* crops. Furthermore they were taught the principle and methods of composting to alleviate this problem. Soil tests should be carried out on yearly basis, to determine the levels of nutrients in the soil, so as to ameliorate the effect of yellowing of *Amaranthus caudatus.*

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