

EFFECT OF APPLICATION RATES OF POULTRY DROPPINGS ON THE GROWTH OF AMARANTHUS (AMARANTHUS HYBRIDUS) GROWN ON CONTAMINATED SOIL IN ANYIGBA, KOGI STATE

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ABSTRACT

A pot experiment was carried out at the Greenhouse, Faculty of Agriculture complex, Kogi State University, Anyigba to investigate the effect of poultry droppings (100g, 200g, 300g, 400g and control) on the growth of Amaranthus on a contaminated soil. A completely randomized block design (RCBD) with five treatments (four rates of poultry manure and control) was replicated four times. Treatment means were separated using Least Significant Difference (LSD) where necessary. Poultry manure had a significant influence on growth parameters such as number of leaves, stem girth, height and leaf area of amaranth. The poultry manure increased the level of nutrient concentration and heavy metals in the soil, but had no positive influence on the number of heavy metals found in the amaranth (biomass), as the heavy metals increased with increase in the rates of poultry manure. The application of 200g of organic manure (poultry droppings) gave the optimum result on the growth of Amaranthus on a contaminated soil.

Keywords: Organic manure; Contaminated soil, Heavy metals; Amaranthus; Faculty of Agriculture, Kogi State University, Anyigba.

INTRODUCTION

Historically, human beings live in harmony with their natural environment, however, the current rapid rate of industrialization, urbanization and economic activities like mining, agriculture and transportation, lead to contamination of environmental resources due to huge amount of waste they generate (Jaradat et al., 2013; David and Sunday 2012). For instance, automobiles' used oil, used batteries, organic and inorganic chemicals used in oil additives, release heavy metals such as Cadmium, Zinc, Copper, Nickel, Lead, Mercury, Cobalt, Manganese, and Chromium (EEA 2007) and these heavy metals enter the human body and environment through bio magnifications in food chains,

ingestion, skin absorption, inhalation of volatile heavy metals, leaching, runoff, deposition of atmospheric particulate, disposal of metal enriched sewage sludges and effluents (Bradl 2005)

Organic manures such as Poultry, have long been used to help recycle nutrients and improve soil tilts on agricultural fields (Edwards and Daniel 1992). Poultry manure is an excellent source of nutrients such as Nitrogen, Phosphorus, Potassium, Calcium and Magnesium, and has a high content of organic Carbon (Zhu et al., 1998). Nutrients contained in poultry manure, especially nitrogen are easily taken up by plants for fast growth (Ewulo, 2005 and Awodun, 2007).

Amaranthus is the common name for the domesticated species of the genus Amaranthus (family Amaranthaceae). It has been considerably high in minerals, such as Calcium, Iron, Phosphorus, and Carotenoids than most vegetables (Alegbejo, 2013).

Materials and Methods

Description of the Study Location

The experiment was carried out at the Green House, Faculty of Agriculture Complex, Kogi State University, Anyigba. Anyigba is located on latitude 7°6'N and longitude 6°4'E and it lies between the southeastern Guinea savanna agro-ecological zone of Nigeria. Kogi has a total land area of 25,948 square kilometers. Kogi State has a bimodal rainfall with the peak occurring in July and September. The mean annual rainfall ranges from 1,560mm at Kabba in West to 1,808mm at Anyigba in the East. Farther North, the rains are shorter with rainfall maximum occurring in August. Local variation of this pattern could occur as a result of hilly mountainous terrains (Kowal and Knabe, 1972). The dry season generally extends from November to March. During this period. Rainfall drops drastically to less than 12.00mm in any of the months. The temperature shows some variations throughout the years. Average monthly temperature varies from 17°C to 36.2°C. Relative humidity is moderately high and varies from an average of 65- 85% throughout the year. The state enjoys an average of between 4.00 and 8.2 hours of sunshine daily (Kowal and Knabe, 1972).

Experimental Treatments and Design

Top soil (0-15cm) was collected from an automobile mechanic work shop (Ojonimi Mechanic Workshop, along upper chide road,

Anyigba, Kogi State), with a spade, air dried, crushed and sieved with 2mm sieve. The soil was measured 5kg each, and treated with a given quantity of poultry manure per pot (100g, 200g, 300g and 400g) and control (without poultry manure) and, the treatments were replicated four times. The five (5) treatments were randomized, using the Completely Randomized Design (CRD). Amaranth seedlings were transferred from the nursery into each pot at one plant per pot. Details of Experimental treatment for pot are as follows;

Cultural Practices

The Amaranthus seedlings were transplanted one plant per pot and they were transplanted three to five centimeters deep. Weeding was carried out frequently to ensure that weeds do not compete with the Amaranthus plant for nutrient, space, sunlight and water. Watering: Each pot was watered daily, (early morning). Water logging was avoided because Amaranthus plant cannot cope or survive in water logged soil.

Soil Analysis.

Soil sample was obtained from the ploughed layer (0-15cm) with the aid of soil auger. Soil samples were taken before planting (pre planting analysis) and after the experiment was done (post planting analysis) from the pots.

For the post analysis, different samples were taken from each pot. soil samples (post planting and pre planting) were analyzed for physical and chemical properties in the Soil Science Laboratory of Kogi State University and, the heavy metal content of the soil

samples was analyzed in Federal University of Agriculture, Makurdi, Benue State, Nigeria, using the following methods;

Particle Size Analysis

This was carried out using hydrometer method. Fifty grams (50g) of the soil sample was weighed into a beaker and 100ml of calgon. Ten milligrams of deionized water were added in the beaker and stirred carefully. It was then allowed to stand for 30minutes and transferred into a 1liter measuring cylinder and deionized water was added to make up to 1liter. The soil suspension was mixed with a plunger and hydrometer was gently inserted immediately in the suspension, while taking the temperature (T1). The reading of the hydrometer (H1) was taken after 40seconds and after 2hours with the corresponding temperature T3. The percentage sand, silt and clay were determined according to Gee and Bauder (1985). The textural class of the soil was determined using a textural triangle (Bouyoucos, 1962).

Determination of Total Available Phosphorus.

Bray-1 method was used for the analysis. Five grams (5g) of the airdried composite sample was weighed into 250ml volumetric flask and then, 35ml of phosphorus extraction solution was added and shaken for 1minute and filtered. 8ml of the filtrate was pipetted into 50ml volumetric flask, and 8ml of ascorbic acid solution was added and then made up to mark with distilled water. This was allowed to stand undisturbed for about 30 minutes for the colour to develop. The extracted phosphorus was read calorimetrically at a wavelength of

660nm after the development of molybdenum blue colour (Bray and Kurtz, 1945)

Determination of Organic Carbon

This was done using the potassium dichromate and ferrous ammonium sulphate as reagents. The residual dichromate was titrated against ferrous sulphate (Walkey and Black method, 1934). The percentage organic matter (%OM) was then obtained by multiplying organic carbon (OC) by 1.724 Van Bemmelen factor (Bray and Kurtz, 1945)

Determination of Total Nitrogen

This was determined using the standard macro, Kjeldahl method in which the soil sample was digested with tetraoxosulphate (vi) acid (H_2SO_4). Excess caustic soda was added and the absorbed H_2SO_4 was released and ammonia was distilled and reabsorbed in boric acid for titration with hydrochloric acid (HCl) (Bremner and Mulvaney, 1982)

Soil pH Determination.

The pH of the soil was determined in distilled water at soil to water ratio of 1:1, using electrometric method and measured by pH meter (McLean, 1982).

Determination of Cation Exchange Capacity (Na, Ca, Mg, K).

This was determined by extracting exchangeable base with NH_4OAc (pH 7.0) using 1:10 soil solution ratio. Potassium and sodium in the extract was determined with flame photometer while, Ca and Mg were determined by atomic absorption spectrophotometer (Thomas, 1982).

Analysis of Poultry Droppings

The poultry droppings were collected and subjected to laboratory analysis to determine the nutrient content. Following the procedures outlined in the soil analysis section, the following nutrient content were determined: Sodium (Na), Phosphorus(P), Potassium(K), Calcium (Ca), Magnesium (Mg), Nitrogen (N) and Organic Carbon(C) content.

Heavy Metal Analysis.

Soil sample of 5kg was weighed into a beaker. Ten (10ml) of an acid -mixtures (Nitric/chloric acid in ratio 2:1 was added to the content. The beaker was then placed in a hot plate for about 30 minutes until the colour changes from brown to colourless. The digest was allowed to cool and this was read on Bulk Scientific Absorption Spectrophotometer (AAS) to analyse Cadmium (Cd) and Lead (Pb) (Novotry et al., 2000) at the Federal University of Agriculture, Makurdi, Benue State.

Crop Data (Growth Parameter).

The following growth parameters were measured; Number of leaves, plant height, leave area and stem girth. The measurement began at 1 week after transplanting. Biomass analysis was carried out for the heavy metal (Cadmium and Lead) content of the plant.

Number of leaves,

The number of leaves produced by the plant in each pot was counted manually at 1-week interval. **Plant height,**

the apical height of each of the plant (i.e., the height from the soil to the apical tip of the plant) was measured using a meter rule. This was obtained by measuring the height at 1 week interval. **Stem girth,** the stem girth was measured using vernier caliper. **Leaf area,** the leaf area of each plant was measured using meter rule.

Statistical (Data) Analysis. Data collected was subjected to Analysis of Variance (ANOVA), Significant mean effect was separated using Least Significant Difference LSD, where necessary.

Results and Discussions

Table 1: Physical and chemical properties of the soil (pre planting analysis)

Properties	Values
pH in water (Ratio)	7.5
Organic carbon (%)	1.062
Total Nitrogen (%)	0.053
Available phosphorus (mg/kg)	8.98
Exchangeable Cations (cmol/kg)	
Sodium	0.16
Potassium	1.56
Magnesium	2.83
Calcium	4.60
CEC (cmol/kg)	10.74
Exchangeable acidity (cmol/kg)	1.59
Clay (%)	17.20

Silt (%)	1.28
Sand (%)	81.52
Textural class	Sandy loam

Table 2: Pre-planting Analysis for Heavy Metals

Heavy Metals	Values (mg/kg)
Lead (Pb)	0.28
Cadmium (Cd)	0.25

Table 3: Result of Analysis of poultry droppings

Nutrient	Value (%)
Organic Carbon	20.60
Nitrogen	2.86
Carbon/Nitrogen Ratio	7.20
Phosphorus	2.43
Potassium	1.41
Sodium	0.24
Magnesium	0.83

Poultry Droppings Analysis

From the results of the poultry droppings analysis (Table 3), it was found that the poultry droppings contained Nitrogen (N) (2.86%), Organic Carbon (C) (20.6%), C/N ratio (7.20), Phosphorus(P) (2.43%), Potassium(K) (1.14%), Sodium (Na) (0.24%), and Magnesium (Mg) (0.83%).

Table 4: Effect of Poultry Droppings on Height of amaranthus

TREATMENT	1 WAT	2 WAT	3 WAT	4 WAT
T0	11.92 ^{ab}	12.82 ^{ab}	13.43 ^b	14.75 ^{ab}
T1	12.50 ^a	12.95 ^{ab}	14.35 ^{ab}	15.15 ^{ab}
T2	9.60 ^{ab}	15.10 ^a	18.72 ^a	22.47 ^a
T3	7.85 ^b	8.00 ^b	6.90 ^c	7.85 ^b
T4	11.90 ^{ab}	8.95 ^b	10.67 ^b	10.50 ^b
	*	*	*	*

KEY *: Significant WAT: Weeks After Transplanting.

Effect of Poultry Droppings on The Height of Amaranthus

At one week after transplanting (1WAT), pot treated with 100g of poultry manure (T1) produced the highest mean value (12.50cm) of amaranth height. However, it was similarly significant ($p < 0.05$) to pot treated with 200g, 400g and control (T2, T4 and T0 respectively). Pot treated with 300g of poultry manure (T3)

gave the least significant mean value (7.85cm) at 5% level of probability. At two weeks after transplanting (2WAT), pot treated with 200g of poultry manure (T2) produced the highest mean value (15.10cm) compared to pot treated with 300g of poultry manure (T3) had the least mean value (8.00cm) at 5% level of probability. At three weeks after transplanting (3WAT), pot treated with 200g of poultry

manure (T2) produced the highest mean value (18.72cm) compare to pot treated with 300g of poultry manure (T3) had the least mean value (6.9cm) at 5% level of probability. However, there was a decline in average mean value of amaranth height due to plant death (in one of the replications). At four weeks after transplanting (4WAT), the pot treated with 200g of poultry manure (T2) produced the highest mean value (22.47) compared to pot treated with 300g of poultry manure (T3) gave the least mean value (7.8cm) of amaranthus height at 5% level of probability. There was also a decrease in the average mean value of amaranth height due to plant death in some of the replications.

The statistical analysis of variance (ANOVA) showed that there was a significant difference in plant height at 5% level of probability from the first week after transplanting till 4weeks after transplanting. It was deduced that the 200g of poultry droppings (T2) produced the

highest mean values (9.6cm, 15.10cm, 18.72cm, and 22.47cm) at 1, 2, 3, and 4 weeks after transplanting respectively. Although, at 3 weeks after transplanting, pot treated with 300g of poultry manure produced the least mean value (6.9) in general.

Results showed that the height of *Amaranthus* increased up to two weeks after transplanting (2WAT) but, started reducing at three to four weeks after transplanting for pots treated with 300g and 400g of poultry manure. This was because at three to four weeks after transplanting, some plants in pots treated with 300g and 400g of poultry manure died. This is due to the application of excess poultry manure on the amaranth. The reduced yield that is found in crop with excess or over application of poultry manure may be due to the toxic substances like NH_3 , NO_3^- N and some soluble salts produced in the soil by the manure (Edwards and Daniel, 1992).

Table 5: Effect of Poultry Droppings on Number of Leaves of Amaranth

TREATMENT	1 WAT	2 WAT	3 WAT	4 WAT
T0	5.50 ^{ab}	8.25 ^{ab}	9.00 ^b	14.00 ^a
T1	7.00 ^a	6.50 ^{ab}	9.50 ^b	12.75 ^a
T2	5.00 ^{ab}	10.75 ^a	23.50 ^a	36.00 ^a
T3	5.00 ^{ab}	5.25 ^b	6.25 ^b	8.00 ^b
T4	4.00 ^b	5.50 ^b	10.75 ^b	19.25 ^a
	*	*	*	*

KEY *: Significant WAT: Weeks After Transplanting.

Effect of Poultry Droppings on the Number of Leaves of Amaranthus

At one week after transplanting, pot treated with 100g of poultry manure (T1), had the highest number of leaves with an average mean value (7.00) compared to pot treated with 400g of poultry manure (T4) had least

mean value (4.00) at 5% level of probability. At two weeks after transplanting (2WAT), pot treated with 200g, 400g of poultry manure (T1, T2) and control (T0) with average mean (6.5, 10.75, and 8.25 respectively) where similarly significant at 5% level of probability. At three weeks after transplanting (3WAT),

pot treated with 200g of poultry manure (T2) produced the highest mean value (23.5). However, it was significantly different to all other treatments (100g, 300g, 400g) with mean value 9.50, 6.25 and 10.75 respectively and control (pot without poultry manure) at 5% level of probability. At four weeks after transplanting (4WAT), pot treated with 200g of poultry manure (T2) produced the highest mean value (36.00) compared to pot treated with 300g of poultry manure (T3) with least mean value (8.00) at 5% level of probability. From the result obtained, there was an increasingly significant difference ($P > 0.05$) in the average mean value of number of leaves throughout the experiment. Pot treated with 200g of poultry manure (T2) showed the highest number of leaves with an average mean (36.00) at four weeks after

transplanting (4WAT) compared to pot treated with 400g of poultry manure had the lowest number of leaves with an average mean value (4.00) at one week after transplanting (1WAT).

Increase of amaranth growth by Poultry Manure in this study was also attributed to poultry manure having low C: N ratio (7.20) which is expected to hasten faster decomposition and nutrient release for amaranth uptake and hence growth. The improved growth as the rates of poultry manure increases can be adduced to better soil nutrient (Agbede, 2009) and Adekiya et al. (2016) especially Nitrogen that is needed by leafy vegetable like amaranth. Nitrogen is known to promote rapid growth, increasing above ground vegetative growth etc.

Table 6: Effect of Poultry Droppings on the Stem Girth of Amaranthus

TREATMENT	1 WAT	2 WAT	3 WAT	4 WAT
T0	0.625	0.85 ^{ab}	0.80 ^b	0.92 ^{ab}
T1	0.675	0.72 ^b	0.92 ^{ab}	1.02 ^{ab}
T2	0.575	1.25 ^a	1.55 ^a	1.95 ^a
T3	0.400	0.65 ^b	0.57 ^b	0.65 ^b
T4	0.675	0.60 ^b	0.72 ^b	0.92 ^{ab}
	N.S	*	*	*

KEY N.S: Not Significant *: Significant WAT: Weeks After Transplanting.

Effect of Poultry Manure on the Stem Girth of Amaranth

The stem girth showed no significant difference at one week after transplanting (1WAT). Although, there was significant difference from two weeks to four weeks after transplanting. At two weeks after transplanting (2WAT), pot treated with 200g of poultry manure (T2) produced the highest average mean value (1.25) compared to pot

treated with 400g of poultry manure (T4) had the least mean value (0.60) at 5% level of probability. Pot treated with 200g of poultry manure was significantly different to all treatment except the control (pot without poultry manure). However, pot treated with 400g of poultry manure (T4) gave least average mean value (0.60) at 5% level of probability. At three weeks after transplanting (3WAT), pot treated with 200g of poultry

manure (T2) produced the highest mean value (1.55) compared to pot treated with 300g of poultry manure (T3) had the least mean value (0.57) at 5% level of probability. At four weeks after transplanting, Pots treated with 100g, 200g, 400g of poultry manure with mean value (1.02, 1.95, 0.92 respectively) and control (0.92) were similarly significant but highly significant ($p.005$) to pot treated with 300g of poultry manure(T₃).

From the result obtained, there was an increasingly significant difference ($P>0.05$) in

the average mean value of stem girth from two weeks after transplanting (2WAT) to four weeks after transplanting (4WAT). Pot treated with 200g of poultry manure (T2) had the highest mean value (1.95) at 4 weeks after transplanting compared to pot treated with 300g of poultry manure had the least mean value (0.4) at 1 week after transplanting. Increase in the stem girth of Amaranth plant in this study was due to the availability of nutrients in the soil as a result of mineralization of the poultry manure applied (Adekiya et al., 2016)

Table 7: Effect of Poultry Droppings on the Leaf Area of Amaranthus

TREATMENT	1 WAT	2 WAT	3 WAT	4 WAT
T0	5.09 ^a	5.18 ^b	5.08 ^b	6.25 ^b
T1	3.64 ^{ab}	4.62 ^b	5.50 ^b	5.81 ^b
T2	5.40 ^a	10.77 ^a	22.63 ^a	25.85 ^a
T3	1.98 ^b	3.09 ^b	2.98 ^b	3.37 ^b
T4	2.89 ^{ab}	4.45 ^b	9.48 ^b	13.04 ^{ab}
	*	*	*	*

KEY *: Significant WAT: Weeks After Transplanting.

Effect of Poultry Manure on The Leaf Area of Amaranthus

At one week after transplanting (1WAT), pot treated with 200g of poultry manure (T2) had the highest mean value (5.40) compared to pot treated with 300g of poultry manure (T3) had the least mean value (1.98). At two weeks after transplanting (2WAT), pot treated with 200g of poultry manure (T2) had the highest mean value (10.77) compared to the pot treated with 300g poultry manure (T3) had least mean value (3.09) at 5% level of probability. At three weeks after transplanting (3WAT), pot treated with 200g of poultry

manure (T2), had the highest value (22.63) compared to pot treated with 300g of poultry

manure (T3) gave the least mean value (2.98) at 5% level of probability. At four weeks after transplanting (4WAT), pot treated with 200g of poultry manure (T2) gave the highest mean value (25.85) compared to pot treated with 300g of poultry manure (T3) gave the least average mean value (3.37) at 5% level of probability.

The result obtained from the analysis of variance showed that the effect of poultry manure on the leaf area of amaranth was significantly different at 5% level of probability. Pot treated with 200g of poultry manure (T2) had the highest average mean value (25.85) at 4 weeks after transplanting compared to pot treated with 300g of poultry manure (T3) had the least average mean value

(1.98) at 1 week after transplanting, throughout the experiment. The improvement in the leaf area of the amaranth from the first week after transplanting to the fourth week after transplanting was attributed to improved nutrient availability in the soil resulting to

increase nutrient (especially Nitrogen) uptake by amaranth plant (Agbede, 2009)). Nitrogen is needed by leafy vegetables to promote rapid growth, increasing leaf sizes and above ground vegetative growth.

Table 8: Post harvest soil analysis result

TRT	PH	OC (%)	TN (%)	Av. P (mg/kg)	Ca	Mg	Na	K	EA	CEC
(cmol/kg)										
T0	5.40	0.74	0.037	7.39	3.68	1.97	0.41	1.74	1.81	9.61
T1	6.80	1.55	0.078	12.35	4.06	2.39	0.38	2.14	1.23	10.20
T2	7.00	1.76	0.088	14.55	4.44	4.01	0.27	3.63	1.18	13.53
T3	7.1	2.72	0.136	20.17	5.11	4.28	0.25	3.84	0.98	14.46
T4	7.2	2.77	0.139	18.86	6.74	4.51	0.29	4.03	0.87	16.44

Table 9: Post harvest soil analysis for heavy metals

Treatment	Lead (mg/kg)	Cadmium (mg/kg)
T0	0.19	0.021
T1	0.39	0.039
T2	0.26	0.028
T3	0.25	0.022
T4	0.41	0.025

Table 10: Plant Dry Matter (Biomass) Analysis for Heavy Metals

SAMPLE	Cadmium (Mg/l)	Lead (Mg/l)
P0	1.350	2.84
P1	1.710	3.59
P2	1.150	2.42
P3	0.650	1.37
P4	0.480	1.29

Chemical and Physical Properties of the Post-Harvest Soil and Plant (Post Analysis)

The chemical properties of the soil were influenced by different rates of organic manure (poultry droppings) application. The result shows that: pH values after harvest were

as follows (pH: 5.40, 6.80, 7.00, 7.10, 7.20 respectively), was less than pH of pre-planting soil (pH 7.5). Also, there was a progressive increase in the organic carbon, total nitrogen, available phosphorus, potassium, magnesium, and calcium content of the soil with increase in the amount of poultry manure present, this is in line with the findings of Adekiya et al., (2016) that, application of Poultry manure to soils can increase concentrations of organic carbon and other nutrients (Adekiya et al., 2016). There was a decrease in the sodium content as the amount of poultry manure increased, this could be due to nutrient imbalance, preventing the availability of other nutrients (Agbede, 2009). There was a fluctuation in the concentration of heavy metals in both the soil and plant with increase in rate of poultry manure applied as shown in Tables 8 and 9.

For the soil, the Cadmium concentration in the soil sample analyses ranged from 0.021 mg/kg to 0.076 mg/kg and, the lead concentration ranged from 0.19mg/kg to 0.41mg/kg. Pot without poultry manure (control), showed the lowest concentration of both the cadmium and lead content in the soil.

Biomass analysis showed cadmium concentration 0.480mg/kg to 1.710mg/kg and lead concentration 1.29mg/kg to 3.59mg/kg respectively. The level of cadmium and lead as affected by different rate of poultry manure exceeded FAO/WHO permissible limits of 0.20mg/kg and 0.43mg/kg for cadmium and lead respectively for edible plants (WHO/FAO, 2007; FAO/WHO 1984).

CONCLUSION

Poultry manure improved soil nutrients, plant height, stem girth, number of leaves, and leaf area of Amaranth compared to pot without poultry manure (control). Soil pH, organic carbon, Nitrogen and phosphorus content of the soil were increased with increase in poultry manure. There was a progressive

(increase) deposition of heavy metals (cadmium and lead) in pots treated with different rates of poultry manure in contaminated soil compared to pot without poultry manure (control). However, there was a decrease in heavy metals (cadmium and lead) uptake in Amaranth biomass, although, the level of cadmium and lead in the Amaranthus exceeded the maximum limit of 0.2mg/kg and 0.43 mg/kg for cadmium and lead respectively as set by (FAO/WHO, 2007; FAO/WHO, 1984) for edible plants.

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