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RESEARCH ARTICLE

ASSESING THE RESIDUAL PERFORMANCE OF CURED AND UNCURED POULTRY DROPPING ON AMARANTH (*AMARANTHUS VIRIDIS* L.) PRODUCTION AND SOIL QUALITY

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ABSTRACT

Addition of poultry Manure (PM) to a piece of land at a given rate has been speculated to enhance Amaranth yield, increase land-use and improve soil quality. To address this speculation, the residual effects of Cured Poultry Dropping (CPD) and uncured Poultry Dropping (UPD) at different rate of application (0, 50, 100 and 150 kg N/ha) were evaluated on Amaranth (*Amaranthus viridis*) production during two growing seasons at the Teaching and Research Farm, University of Ibadan. The effects of CPD and UPD on the yield of Amaranth and some post cropping soil properties were assessed. 150 kg N ha^{-1} UCP had higher fresh and dry biomass yield (12.14 t/ha and 1.94 t/ha) in dry season, while 100 kg N ha^{-1} CPD gave better yield (19.6 t/ha and 3.98 t/ha) at wet season. The post soil chemical properties showed that 150 kg N ha^{-1} CPD by standard deviation increased the organic carbon (43.1 g/kg), nitrogen (9.4 g/kg), phosphorus (55 mg/kg), and Calcium (9.5 Cmol/kg) content at dry season. While100 kg N ha^{-1} CPD increased the nitrogen (9.6 g/kg), organic carbon (36.1 g/kg), phosphorus (56 mg/kg) content at wet season. Although, there was significant difference amongst the rates of application in terms of yield at dry season, CPD still left the soil in better condition for subsequent cropping.

KEYWORDS

Poultry Droppings; Amaranth; Fertilizer; Nutrient Status; Yield; Soil Quality

1. INTRODUCTION

In Sub Saharan Africa, including Nigeria, soil fertility decline has been a major problem facing farmers. This is evident in the severe poverty and hunger which is currently bedeviling chunk of the population. The low-input nature of agriculture in developing nations, combined with the fact that crops are grown for household food consumption as well as for income, results in multiple connections between soil fertility and poverty (Barrett and Bevis, 2015). Although, the cause of poverty and hunger are numerous, decline in soil fertility and the resultant decrease in crop yield which in turn affect the ability of farmers to labour effectively, grow crops and invest back into the soils for decades is a major contributory factor (Bevis et al., 2019).

In Nigeria, the benefits of using organic fertilizers have been underlined because of the high prices of commercial fertilizers, scarcity during planting season, soil acidity, nutrient imbalance, groundwater contamination, environmental pollution, and human health hazard (Agbede et al., 2019). Only about a third farmers in Nigeria appear to apply inorganic fertilizer, and those that apply this fertilizer do so at much lower levels (Sheahan and Barrett, 2017). The menace associated with the use of inorganic fertilizer could be traced to the much abandoned land of recent past.

On the contrary, organic fertilizers, such as Poultry Manure (PM) has been found useful because of its ability to keeps soil healthy and increase plant resistance to hard environmental conditions, and improve their properties (Al-Taey et al., 2019). The application of poultry manure to the soil increase soil organic matter and other plant nutrients, thereby positively improving soil physical and chemical properties, in turn, crop yields (Agbede and Ojeniyi, 2009; Abd El-Kader et al., 2010; Agbede et al.,2017; Adekiya et al., 2019a, 2020b). a group researchers also reported that PM as organic nutrient source has the potential to enhance crop growth, increase yield and improve soil quality (both physical, chemical and biological) which has made it to be widely accepted by farmers (Chukwu et al., 2012). PM is cheap, readily available at all time, environmentally friendly, last longer in soil and has the ability to improve soil structure compared to chemical fertilizers.

A study stated that PM application increases soil N by more than 53%, while exchangeable cations are also increased significantly upon application and has ability to release its nutrient over an extended period of time due to its slow mineralization process (Boateng et al., 2006). Some researchers reported significant increase in OC, TEB and ECEC in the soil, also increase in concentrations of N, P and K in plant tissue on application of poultry manure and concluded that application of PM increase available nutrients, nutrient uptake and improve dry matter yield in soybean (Soremi et al., 2017). A group researchers also reported that *Amaranthus* spp. in Nigeria grows best with 500 kg ha^{-1} NPK treatment at 4 and 5 WAP and from 250 kg ha^{-1} treatment at 6 and 7 WAP whereas 250 kg ha^{-1} NPK

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application can result in slightly higher values in growth parameters than 125 kg ha^{-1} at 4 and 5 WAP (Alonge et al., 2007).

However, the same equivalent has not being established for Organic manure and its residual effects on sequent cropping season. Although, a lot of studies have been carried out on poultry manure on Amaranth production, however the specific rate of PM application needed to increase the yield of *A. viridis* and at the same time keep the soil in good condition for subsequent cropping season has not been established. *Amaranthus viridis* (L.) a native to East Asia (commonly known as green amaranth or African spinach) is a fast-growing annual herb that can be ready for harvest within 4 to 5 weeks. They are highly branched with edible ovate and long leaves, mostly cultivated on lowlands. It grows best under mesic conditions including soil with good water retention capacity, slightly acidic or alkaline pH and sufficient rainfall or water supply (Ogwu, 2020). However, Amaranth production in Nigeria has of recent suffered setback due to continuous soil fertility decline. Therefore, this research work is aimed at assessing the residual effects of different PM levels (either cured or uncured) on the yield of *A. viridis* and some soil chemical properties.

2. Materials and Methods

The study involved a field experiment to determine the residual response of green amaranth (*A. viridis*) to the application of cured and uncured poultry droppings at different levels of treatments. The fresh and dry biomass yield of vegetable produced from the experimental treatments were evaluated in the laboratory for total yield per hectare as well as the effects of fertilizer on the nutrient status of the experimental soils before and after planting. This investigation was carried out between April and June 2013. The study was carried out at the Organic Vegetable Garden of the Teaching and Research Farm, University of Ibadan, Nigeria. The Teaching and Research Farm is located at latitude 7° 24′ N and longitude 30° 54′ W. The experimental area is characterized by alternating wet and dry seasons which vary markedly in intensity and duration. The predominant soil type in the area is Alfisol (Smyth and Montgomery, 1962). The average rainfall received annually was between 1250mm and 1500mm. The maximum and minimum temperature was 21.3°C and 31.2°C respectively, with relative humidity being 76%.

The experimental materials were based on the past treatment of cured and uncured poultry droppings applied to previous experiments. No fertilizer was applied, except the residual fertility of previously applied treatments that consisted of cured poultry droppings plots and uncured poultry droppings plots, each had four levels of both cured and uncured poultry droppings at the rate of 0, 50, 100, and 150 N kg/ha, where 0 kg N/ha signifies no treatment was applied on that particular plot. The experimental plot size was 24m x 19.8m (456.8m^2), and the size of each vegetable bed was 2m x 1.5m, given a total of thirty two (32) treatments combination replicated four times placed in a randomized complete block design (RCBD). Plant population was at a rate of 1.8 million plant ha^{-1}. The main treatment was the nature of poultry droppings (cured and uncured), while levels of poultry droppings was the sub treatment. The crop was planted at spacing of 3cm inter row and 0.5cm inter bed spacing, exactly where the treatments were previously applied. Planting was done in successions: dry planting was done at dry season and the other at wet season on different plot sizes that had the same treatments previously. Yield parameters were subjected to statistical analysis using significant difference to separate the means.

Soil samples were randomly collected at pre and post – planting operations at a depth of 0 – 15cm and bulked to form a composite sample. Each composite sample was made up of 15 core samples per acre of the experimental site. The sample were air dried, crushed and sieved through 2mm and 0.5mm sieve and preserved in moisture free environment ready for analysis. The soils from the experimental field were analyzed by standard procedures (Page et al., 1982). Particle size analysis was determined using the hydrometer method of Bouyocus (Bouyoucos, 1951). Soil pH in water was determined potentiometrically using glass electrode in a 1:1 soil: water slurry. Organic Matter was determined by the chromic acid oxidative procedure (Walkley and Black, 1934). Total nitrogen was extracted by the (Kjeldahl procedure Jackson, 1962). Available phosphorus was extracted using Bray P1 extractant. P in the extract was determined calorimetrically by molybdenum blue method (Bray and Kurtz, 1945). Exchangeable bases and micronutrients were extracted using Mehlich III method. The Ca, Mn, Fe and Zn were read using Atomic Absorption Spectrophotometer. The K and Na were determined using the flame photometer. Exchangeable acidity of the soil was extracted with 1N KCl solution and determined by titrating with 0.025N NaOH solution.

3. Results

3.1 Response of Amaranth to Residual Fertility of Cured and Uncured Poultry Droppings

The fresh and dry biomass yield of *A. viridis* responded ($p< 0.05$) differently to both treatments at wet and dry season. However, uncured at 150kg N/ha gave the highest (12.14 and 1.94 t/ha) significant fresh and dry biomass yield for dry season, while uncured at 0kg N/ha recorded the least (2.19 and 0.31 t/ha) biomass yield.100 kg N/ha cured poultry droppings had the highest significant ($p < 0.05$) fresh total plant weight of 19.0. While, uncured at 150kg N/ha had the highest significant dry biomass yield at wet season. Cured poultry droppings at 0 kg N/ha recorded the least (9.80 and 1.09) for fresh and dry biomass yields in t/ha respectively at wet season as shown in Table 1. The order of increase effectiveness of cured poultry droppings on the soil which produce fresh biomass yield of *A. viridis* at wet season was 100 > 150 > 50 > 0 kg N/ha, while for uncured poultry droppings was 0 > 150 > 50 > 100 kg N/ha. Whereas, for soil which produced fresh biomass yield at dry season, the effectiveness of the cured poultry droppings increase in the order of 50 > 100 > 150 > 0kg N/ha, while for uncured poultry droppings was 150 > 100 > 50 > 0kg N/ha.

Table 1: Residual effects of poultry droppings, nitrogen rates and their interaction on fresh and dry yields of A. viridis at dry and wet seasons

Treatments	Dry season		Wet season	
	Fresh biomass Yield(t/ha)	Dry biomass Yield(t/ha)	Fresh biomass Yield(t/ha)	Dry biomass Yield(t/ha)
Poultry droppings				
Cured	7.22	1.05	15.2	1.84
Uncured	7.29	1.15	16.5	3.68
LSD (p<0.05)	NS	NS	NS	1.73
Nitrogen rates in poultry droppings (kg N)				
0	2.95	0.38	13.6	2.40
50	7.58	1.11	15.5	3.14
100	8.72	1.39	17.3	2.77
150	9.76	1.52	17.1	2.73
LSD (p<0.05)	4.66	0.74	NS	NS
Cured and uncured poultry droppings interaction with N rates				
Cured*0 kg N/ha	3.72	0.45	9.80	1.09
Cured*50 kg N/ha	9.94	1.41	15.1	2.87
Cured*100 kg N/ha	7.84	1.22	19.0	1.90
Cured*150 kg N/ha	7.38	1.10	16.9	1.49
Uncured*0kg N/ha	2.19	0.31	17.5	3.70
Uncured*50 kg N/ha	5.22	0.80	15.8	3.42
Uncured*100kg N/ha	9.60	1.56	15.6	3.64
Uncured*150 kg N/ha	12.14	1.94	17.3	3.98

LSD- Least Significant Difference ($p < 0.05$), NS = Not significant

3.2 Residual Fertility of Applied Treatments on Soil Nutrient Properties at Both Dry and Wet Season

Table 2 below; shows the residual chemical properties of soils treated with cured and uncured poultry dropping at different level. It was recorded that the soil used was slightly acidic with a pH range of 6.5-6.9 for both samples before and after sowing. The OC content was very high before and after sowing with 150 kg N/ha cured poultry dropping recording the highest OC content of 43.1 g/kg. However, there as an increase (30.5 g/kg) in the OC content for residual plot with 0 kg N/ha of cured poultry dropping compared to the pre sample (19.9 g/kg). There was increase (9.6, 9.2 and 8.9 g/kg) in N content for 0, 50 and 100 kg N/ha of cured poultry dropping, respectively, which is in contrast with that obtained before sowing (0.8, 1.2 and 1.1g/kg). The residual treatments had increase in their available P content except for 150 kg N/ha of uncured poultry dropping which recorded the least (5.0 mg/kg). There was increase in K, Ca, Na, EA, Cu, Fe and Mn content of the residual soil at dry season.

Table 2: Pre and Post – Planting Chemical Properties of Experimental Soil for Dry Season

Treatment	pH (H_2O)	O.C	N	Av. P	Ca	K	Na	Acidity	Cu	Fe	Mn
	←	g/kg →		mg/kg	←	cmol/kg		→	←	mg/kg	→
	Pre-planting chemical properties of the soil before dry season										
Cured*0 kg N/ha	6.9	19.9	0.8	18	2.0	0.2	1.0	0.2	2	1	97
Cured*50 kg N/ ha	6.6	37.1	1.2	66	3.9	0.2	0.8	0.2	1	208	93
Cured*100 kg N/ha	6.5	37.8	1.1	31	3.2	0.2	0.9	0.1	3	219	74
Cured*150 kg N/ha	6.5	31.5	9.6	46	2.5	0.2	0.9	0.1	3	196	34
Uncured*0 kg N/ha	6.5	30.8	7.6	10	2.2	0.2	0.9	0.1	1	213	34
Uncured*50 kg N/ha	6.3	35.0	6.3	9	2.4	0.2	1.0	0.1	1	207	12
Uncured*100kgN/ha	6.5	28.4	6.5	18	2.0	0.3	0.8	0.1	0	187	69
Uncured*150kgN/ha	6.6	26.6	5.8	11	2.4	0.3	0.5	0.1	0	220	105
Mean	6.6	30.9	4.9	26	2.6	0.2	0.8	0.1	1	181	64
SD	0.2	5.6	3.2	19	0.6	0.03	0.2	0.04	1	69	32
	Post-planting chemical properties of the soil after dry season										
Cured*0 kg N/ha	6.5	30.5	9.6	11	2.8	0.2	0.2	0.1	3	183	76
Cured*50 kg N/ha	6.6	38.2	9.2	24	4.5	0.2	0.5	0.1	3	231	77
Cured*100 kg N/ha	6.7	24.9	8.9	23	4.2	0.2	0.6	0.1	2	314	64
Cured*150 kg N/ha	6.6	43.1	9.4	55	9.5	0.3	0.9	0.2	4	272	98
Uncured*0 kg N/ha	6.0	36.8	8.9	26	3.1	0.3	0.7	0.1	1	224	107
Uncured*50 kg N/ha	6.3	34.3	9.0	12	2.6	0.3	0.7	0.2	1	242	80
Uncured*100kgN/ha	6.5	30.5	8.2	22	2.5	0.2	0.7	0.2	1	248	78
Uncured*150kgN/ha	6.4	26.3	7.5	5.0	1.6	0.5	1.0	0.2	1	199	48
Mean	6.5	33.1	8.8	32	3.8	1.0	0.7	0.1	2	242	81
SD	0.2	5.8	0.6	26	2.3	1.9	0.4	0.1	1	48	18

SD – Standard Deviation

Table 3 below; shows the pre and post soil chemical properties for wet season. It was observed that pH of the soil was within the range of 6.6-7.2 for both the pre and post soil sample. Plots treated with cured and uncured poultry dropping had similar OC content for residual and main treatment, except for plots treated with 50, 100 and 150 kg N/ha of uncured poultry dropping which had slightly lower OC of 28.4 and 18.6 g/kg compared to the pre samples having 36.4 and 34.7, respectively. N was at high concentration for both for residual treatments with 100 kg N/ ha recording a higher value of 9.6 g/kg. All the plots recorded high available P content except for plot with no treatment for uncured poultry dropping which had 3 mg/kg for residual treatment against the actual treated plot (13 mg/kg). K, Ca, EA, Cu, Fe and Mn was high for both samples.

Table 3: Pre and Post - Planting Chemical Properties of Experimental Soil for Wet Season

Treatment	pH (H_2O)	O.C	N	Av. P	Ca	K	Na	Acidity	Cu	Fe	Mn
	←	g/kg →		mg/kg	←	cmol/kg		→	←	mg/kg	→
	Pre-planting chemical properties of the soil before wet season										
Cured*0 kg N/ha	6.6	33.9	8.9	22	3.3	0.2	0.8	0.1	3	270	118
Cured*50 kg N/ha	7.0	35.4	8.1	78	4.9	0.4	1.0	0.2	3	298	98
Cured*100 kg N/ha	7.2	37.8	8.3	75	9.6	0.5	0.6	0.2	3	278	81
Cured*150 kg N/ha	7.1	40.9	6.7	83	10.6	0.5	0.9	0.1	4	303	110
Uncured*0 kg N/ha	6.6	35.0	7.5	13	5.2	0.5	0.9	0.1	1	261	86
Uncured*50 kg N/ha	6.6	36.4	8.4	46	5.5	0.3	0.9	0.2	2	280	34
Uncured*100kgN/ha	6.7	34.7	7.8	47	3.8	0.3	0.8	0.2	0	279	74
Uncured*150kgN/ha	6.7	27.3	7.1	51	3.5	0.2	0.7	0.2	1	260	82
Mean	6.8	35.2	7.9	52	5.8	0.4	0.8	0.1	2	279	86
SD	0.2	3.4	0.7	24	2.6	0.1	0.1	0.02	1	15	24
	Post-planting chemical properties of the soil after wet season										
Cured*0 kg N/ha	6.6	33.9	9.4	36	5.8	0.2	0.7	0.2	4	300	92
Cured*50 kg N/ha	6.6	42.0	7.2	42	7.8	0.3	0.8	0.1	2	339	67
Cured*100 kg N/ha	7.0	36.1	9.6	56	10.8	0.2	0.7	0.2	2	345	54
Cured*150 kg N/ha	7.2	33.6	7.8	57	11.6	0.2	0.5	0.2	3	335	69
Uncured*0 kg N/ha	6.8	35.4	7.3	3.0	6.0	0.2	0.9	0.2	1	323	86
Uncured*50 kg N/ha	6.8	28.4	6.8	15	6.7	0.3	0.8	0.1	1	254	87
Uncured*100kgN/ha	6.8	18.6	8.9	21	5.8	0.3	0.7	0.2	1	353	101
Uncured*150kgN/ha	7.0	28.0	7.6	30	7.4	0.5	0.7	0.1	1	365	95
Mean	6.9	32.0	8.1	32	7.7	0.3	0.7	0.1	2	339	82
SD	0.3	6.6	1.0	18	2.1	0.1	0.1	0.02	1	19	15

SD – Standard Deviation

4. Discussion

Amaranthus viridis sown on plot which had been treated with 150kg N/ha of uncured poultry droppings recorded the highest fresh and dry biomass yield of 12.14 and 1.94 t/ha at dry season which was in constrast with the yield effect produced when the treatments were initially applied; where, 100kg N/ha had the highest fresh and dry biomass yield of 22.63 and 4.64t/ha, respectively. However, there was significant difference ($p<0.05$) among the treatments. This result conforms to the findings of who worked on the dry matter and soil quality of *Amaranthus viridis,* their findings showed that 100 kg N/ha poultry manure and its extract had better effects on the dry matter and soil quality than NPK fertilizer treatment (AdeOluwa and Akinyemi, 2014). At wet season *A. viridis* sown on plot previously treated with 100kg N/ha of cured poultry droppings gave the highest fresh and dry biomass yield of 19.6 and 3.98t/ha. Significant difference was observed for all the levels of treatments. Nevertheless, the yield effect agrees with the treatments that were initially applied where the result shows that 100kg N/ha had the highest fresh and dry biomass yield of 25.35 and 6.01t/ha for cured poultry droppings. This result agrees with the findings of who reported that higher application rate of organic fertilizer could result into residual fertility on the growth and yield performance of succeeding crop (Makinde and Ayoola, 2008).

The residual soil pH ranges from 6.5 to 6.7 at dry season which was slightly acidic and a good pH range for the availability of all nutrients for plant growth (Federal Fertilizer Department, 2012; Ewul, 2005). The pH range slightly decreased compared to when the treatments were initially applied, where the pH ranges from 6.3 to 6.9 in some of the plots. At dry season the pH range from 6.6 to 7.2 for both pre-planting and post-planting soil analytical data. The residual organic carbon concentration at dry season in all the plots treated with cured and uncured poultry droppings was between 19.9 – 37.8g/kg for pre-planting soil samples and 24.9 – 38.2 g/kg for post-planting soils, which is above the critical level since the critical level is 15g/kg (Adeoye and Agboola, 1985). However, the soil organic carbon of plot previously treated with cured poultry droppings at 0, 50 and 150kg N/ha was higher at post-planting than pre-planting. The same trend was observed for plots previously treated with uncured poultry droppings at 0 and 100kg N/ha. This result agrees with the report of who stated that the application of poultry droppings to soil increase the organic carbon concentration which in turn leads to increase in the organic matter content (Michael et al., 2012).

The residual N concentration at dry season in all the plots treated with cured and uncured poultry droppings were above critical level since the critical level is 1.5 g/kg (Adeoye and Agboola, 1985). Except for plots which had been treated with 0, 50, and 100kg N/ha of cured poultry droppings before planting which had 0.8, 1.2, and 1.1 g/kg, respectively. However, all the plots previously treated with both cured and uncured poultry droppings showed higher N concentration after harvest. This agrees with the findings of who reported that organic N which is not mineralized becomes integrated into the soil organic matter and is an important residual nutrient source for crops (Seiter and Horwath, 2004). There was exception for plot which had been treated with cured poultry droppings at 100kg N/ha and uncured at 150 kg N/ha which had lower N concentration before planting than after harvest. The same was observed for cured at 0, 100, and 150kg N/ha; uncured at 100 and 150kg N/ha in the wet season.

The residual available P in both pre and post-planting experimental soils were very high since the critical level for available P is < 10mg/kg (Adeoye and Agboola, 1985). However, it was low (6mg/kg) for soil which had 150kg N/ha of uncured poultry droppings after harvest at dry season. Plot previously treated with 150kg N/ha of cured poultry droppings; 0, 50, and 100kg N/ha of uncured poultry droppings recorded increase in available P value after harvest at dry season. The same was observed for plot which had 0 kg N/ha of cured poultry droppings as treatment at wet season. This result agrees with the findings of who reported that the application of organic materials slowly release significant amount of nitrogen and phosphorus which in turn increases the level of organic matter in the soil (Michael et al., 2012).

The residual exchangeable acidity of plot treated with all levels of poultry droppings at dry and wet season was very low (0.1 to 0.2mg/ kg) before and after harvest, since the critical level for exchangeable acidity is 5.0mg/kg (Agboola and Corey, 1973). The residual calcium concentration at post-planting experimental soils were moderate for dry and wet season, except for plot previously treated with 150kg N/ha of uncured poultry droppings at dry season, which had 1.6cmol/kg lesser than the critical level of 2.0 – 2.6cmol/kg (Agboola and Corey, 1973). However, the calcium concentration after harvest for both dry and wet season soil sample was higher than that before planting. This agrees with the findings of who reported that manure provides all necessary macro and micronutrients in their available form, thereby improving the physical and biological properties of the soil (Abou El – magd et al., 2006).

The residual K concentration was high (0.2 – 0.5cmol/kg) for all the plots previously treated with cured and uncured poultry droppings at dry and wet season since the critical level of K is 0.01 – 0.15cmol/kg (Adeoye and Agboola, 1985). The residual Na concentration was moderate (0.2 – 1.0cmol/ha) in the soil which had been treated with cured and uncured poultry droppings at all levels of treatment at dry and wet season, since the critical level of Na is > 1mg/kg. The residual concentration of Fe was very high between 181 – 365mg/kg for all levels of treatment at dry and wet season. Manganese (Mn) concentration is between 34 – 118mg/kg which is high; Cu was also very high in the experimental soil.

5. Conclusion

The above experiment showed that both cured and uncured poultry dropping at the speculated levels as stated above have the potential to increase amaranth production and also improve the soil quality at both dry and wet season. Howbeit, residual treated plot with uncured poultry droppings at 150kg N/ha in terms of fresh and dry biomass yield showed better effects compared to the cured treatments for raising *Amaranthus viridis.* However, the cured poultry droppings had better residual effects on the soil.

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