Assesing the Residual Performance of Cured and Uncured Poultry Dropping on Amaranth (*Amaranthus viridis* L.) Production and Soil Quality

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ABSTRACT

Variation in decomposition status of poultry manure has several residual agronomic implications on the yield and quality of crops and eventually the soil properties. Hence, the need to assess the residual potential of cured and uncured poultry dropping on the yield and quality of *Amaranthus viridis,* as well as the post cropping soil. The experiments were carried out in two successive plantings seasons at the Organic Vegetable Garden, Teaching and Research Farm, University of Ibadan in 2013. The experiment was laid out in 2 x 4 factorial randomized complete block design, replicated four times. Two commonly used poultry droppings stages (cured and uncured) were applied at 0, 50, 100 and 150kg N/ha. Data on fresh and dry biomass yield (t/ha) of *A. viridis*, and some post cropping soil nutrients were observed. Plant yield data were subjected to analysis of variance and means were separated using Duncan Multiple Range Test at 5 % level of significance. The results revealed that cured poultry droppings produced higher yields of *A. viridis* than the uncured poultry dropping in the two planting seasons. The 150kg N ha^{-1} uncured poultry dropping resulted into the significant ($p< 0.05$) value of fresh and dry biomass yield (12.14 t/ha and 1.94 t/ha) in the dry season, while 100kg N ha^{-1} of cured poultry droppings resulted into the highest significant ($p< 0.05$) value of fresh and dry biomass yield (19.6 t/ha and 3.98 t/ha) in wet season. The residual soil analysis revealed that 150kg N ha^{-1} and 100kg N/ha cured poultry dropping by standard deviation resulted in the highest nutrient content (nitrogen, organic carbon, phosphorus, and magnesium) in the dry season. While100kg N ha^{-1} cured poultry dropping resulted in the highest nutrient content (nitrogen, organic carbon, phosphorus, and magnesium) in the wet planting season. Though uncured poultry dropping performed better in terms of yield, cured poultry droppings still left the soil in better condition for subsequent cropping.

Key words: cured and uncured poultry droppings, amaranth, fertilizer, nutrient status, yield

INTRODUCTION

Fertilizers (either organic or inorganic) are known to improve the fertility status of the soil, increase crop growth, and yield performance (Adeniyan and Oyeniyi, 2003; Home and Garden Information Center, 2013). Organic fertilizers are made from plant and animal residue and they are rich sources of essential plant nutrients. Therefore, the low fertility status of the soil necessitated the need of an external fertilizer input which will last beyond a cropping season. The ability of a fertilizer to supply nutrients beyond a cropping season with good crop quality and residual soil fertility is a very important consideration for sustainable crop production. Füleky and Benedek (2012) stated that these considerations could be: improvement of soil structure; increase of cation exchange capacity, allowing better retention of mineral elements; providing the chelation of several micronutrients resulting in better availability; buffering of soil, limiting rapid changes in pH or salt content. Thus, a good organic fertilizer must comply with this.

Organic fertilizers are widely used in both the tropical and temperate environment due to their ecological friendly nature. They have the ability to release their nutrient over an extended period of time due to their slow mineralization process (Hamilton, 2009). Different sources of organic fertilizers have been reported in literature. (Senjobi *et al.,* 2010). Poultry manure which is one of the organic sources of fertilizer is an excellent source of plant nutrients. It is among the few suitable organic fertilizers meant for production in the tropics because of its ability to supply high amount of nutrients especially nitrogen on long term basis (Seiter and Horwath, 2004; Boateng *et al.,* 2006). There are different types of poultry manure, these includes deep litter manure, broiler manure, cage manure and high rise manure, depending on the condition under which it is been processed. According to Dorivar *et al*. (2016), typical poultry manure contains 35 - 60% N, 40 - 60% P, and 20 - 55% K. Studies have estimated that an average of 0.09kg and 0.18kg of manure is been produced by a single broiler and layer hen daily (Tao and Mancl, 2008; Musa *et al*., 2012). Its popular use in Nigeria is due to its availability and the residual effects of its application on subsequent cropping season. It is usually applied to the soil in partly decayed form (uncured) or after further microbial decomposition, resulting from prolongs storage (cured).

The use of poultry manure as soil amendment has been reported by different authors. Amos *et al.* (2013) who worked on the effect of chicken manure on the performance of vegetable maize varieties observed that the growth and yield increased significantly with increase in poultry manure level. Emuh (2013) evaluated the influence of different levels of poultry manure on the growth and yield performance of *Corchorus olitorus.* In the experiment, it was observed that the growth rate and yield performance increased with age and application rates of poultry manure. However, little or no information on the residual effects of the application of this manure on subsequent cropping season has been reported. Thus, evaluation of the residual fertility of cured and uncured poultry droppings applied in previous season on the yield, crop quality and soil quality in the subsequent season becomes paramount. Poultry manure like, other sources of manure is bulky in nature, constant or repeated application particularly on seasonal basis may be laborious. The slow rate of mineralization also lengthens supply of nutrient over a long period of time. Therefore, this calls for better farming practice that could ease the stress of applying poultry droppings more frequently.

Amaranthus (*Amaranthus viridis* L.), is belied to originate from America and Mediterranean region (Mshelia and Degri, 2014; Spetters and Thompson 2007). It is a rapidly growing plant with good leaf sizes, stem and flowers used as nutritional security crop, livestock feed and for medicinal purposes. Its high nitrogen requirement for good vegetative growth makes it a suitable test crop for this experiment. Thus, this report presents an investigation of the residual fertility of cured and uncured poultry droppings on the yield performances of *Amaranthus viridis*, and its residual effects on some soil fertility properties.

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 experiment on the 22nd January, 2013 to 5th march, 2013. 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 plots. 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 involving 2 x 4 factorial 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.

RESULTS

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

Residual fertility of applied treatments on soil nutrient properties

Generally, the soil used is slightly acidic with pH of 6.6 at both wet and dry season. At the end of the experiment, 100kg N/ha of cured poultry droppings had their pH increased at dry season, likewise, 150kg N/ha of cured poultry droppings at wet season. The increase in soil organic carbon, nitrogen, phosphorus, calcium, potassium and exchangeable acidity was also noticed in the treated plots. 150kg N/ha cured poultry droppings plots had the highest organic carbon (43.1gkg-[1]) at dry season, while 100 kg N/ha cured poultry droppings plots had the highest (42.0gkg-[1]) at wet season. Fertility of the residual treatments on other soil essential nutrients also increased alongside.

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	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: 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	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

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. This was contrary to 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 conform to the findings of 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 ($p < 0.05$) 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 Makinde and Ayoola, (2008) who reported that higher application rate of organic fertilizer could result into residual fertility on the growth and yield performance of succeeding crop.
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 decrease 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 Michael *et al.* (2012) 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.

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 Seiter and Horwath, (2004) 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. 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 Michael *et al.* (2012) 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.

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 Abou El – magd *et al.* (2006) who reported that manure provides all necessary macro and micronutrients in their available form, thereby improving the physical and biological properties of the soil.

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.

CONCLUSION

The plots previously treated with uncured poultry droppings at 150kg N/ha in terms of fresh and dry biomass yield showed better residual 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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