

Evaluation of poultry manure, cattle dung, water and cattle urine-based composts on soil chemical properties, growth and yield of *Amaranthus cruentus* L.

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ABSTRACT

The inclusion of cattle urine in compost preparation will improve compost quality, particularly with respect to nutrient composition. Field experiments were conducted at the organic farm of the Federal University of Agriculture, Abeokuta, Ogun State in 2014 and 2016 to evaluate the effects of water and cattle urine composts, sole poultry manure and cattle dung on post-harvest soil properties, growth and yield of *Amaranthus cruentus*. Treatments used were: compost derived from poultry manure + rice husk with water as source of moisture at 2.5, 5.0, 6.5 and 7.5 t ha⁻¹, (PRW2.5, PRW5, PRW6.5 and PRW7.5 respectively), compost derived from poultry manure + rice husk with cattle urine as source of moisture at 2.5, 5.0, 5.4 and 7.5 t ha⁻¹ (PRU2.5, PRW5, PRW5.4 and PRW7.5 respectively) and control. Post-harvest soil was analyzed for chemical properties, agronomic parameters and yield of *Amaranthus cruentus* were evaluated. Results showed that the application of PRU5.4 resulted in highest values for most of the agronomic parameters in both years, while the competition for highest values of post-harvest soil parameters was between PRW5 and PRW6.5. The highest values of *Amaranthus cruentus* yield in both years resulted from the application of PRU5.4 and PM3.

Keywords: Cattle urine; compost; poultry manure; cattle dung; rice husk
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Introduction

Tropical soils have been described to be highly weathered, low in nitrogen and organic matter (Obi & Ekperigin, 2001; Ayeni, 2011). This has resulted in nutritionally poor soils leading to reduced productivity and difficulty in both subsistence and commercial agriculture. Kostov (2016) observed that one of the main processes causing soil degradation is soil organic matter depletion. Decline in organic matter content of soil was reported by Ewulo

(2005) to affect not only crop yield, but the physical and chemical properties of the soil. In order to improve the nutritionally poor status of tropical soils, chemical fertilizer application came into the limelight. However, usage of chemical fertilizer was reported to have resulted in poor crop yield, low soil organic matter content and acidity (Milosevic & Milosevic 2009; Ayeni, 2011). In addition to these are non-availability, adulteration, high-cost implication and water pollution (Serpil, 2012;

Chude, 2006). The fertility of the soil can be improved by maintenance of its organic matter content, this is said to be possible through the use of organic-based fertilizer (Olowoake & Ojo 2014). Organic-based fertilizers are amendments derived from plant and animal remains such as poultry manure, cow dung and rice husk.

Management of solid waste has been said to be a serious problem in most developing nations (Wegedie, 2018). Composting is a method that can be used to effectively manage solid waste, Aina & Adewole, (2017) described composting as a simple and environmentally friendly clean-up technology to improve soil properties and crop yield while composting is said to be the reduction of large volumes of organic materials rapidly through biological process (Geisel & Unruh, 2007). Compost is defined by Gurtler *et al.* (2018) as an organic material that has been degraded into a nutrient-stabilized humus-like substance through intense microbial activity, which can provide essential plant nutrients to aid crop growth. Compost has been listed among the available resources and management that can be used for reclamation of degraded soil for nutrient recovery and recycling and increase in crop productivity (McGeehan, 2012). Compost contains high organic carbon content but low nitrogen content (El-Sayed & Khaler, 2015) and the low nitrogen content has been a limitation to the use of compost.

Cattle urine is a liquid waste that is rich in nitrogen, the high N concentration in cattle urine has been linked to nitrate leaching from agricultural soils (Selbie *et al.*, 2015) due to indiscriminate deposition on soil in patches. Averagely, the volume of urine excreted per cattle is 2.1 liters daily (Selbie *et al.*, 2015), while Saxena and Sewak (2016) reported that

India has about 190 million dairy cattle in 2012, and each cattle was reported to excrete about five liters of urine daily. About 13.9 million cattle were reported by Lawal – Adebowale (2012) to be reared in Nigeria.

Adequate availability of cattle urine is evidenced by the large quantity produced in different countries on a daily or annual basis, for example, NPCS Board of Consultants and Engineers (2008) reported that annual production of urine from bovine in India was approximately 370 million tones. In Nigeria, if the population of cattle reared as reported by Adebowale-Lawal (2012) (13.9 million) is multiplied by the average volume of urine excreted per cattle (2.1 million) as reported by Selbie *et al.* (2015), this means that about 29.19 million liters of cattle urine are produced daily. Singh (2017) also reported that over 5,000 liters of cow urine were produced daily in Pantajali. Cow urine has also been reported to be sold in some London shops (Sejal, 2016). All these facts show that cattle urine is abundantly produced in different countries, it is as a result of the abundance of cattle urine that Choudhary *et al.* (2017) described its use in agriculture as low-cost agricultural practice by farmers. Efforts have not been made towards the collection of cow urine because the awareness of its usefulness particularly in agriculture is still very low, as a result of the low awareness of proper utilization of cattle urine, the huge amount excreted in various countries are becoming a waste that is difficult to manage thereby affecting the environment. Therefore, to avoid the negative effect of indiscriminate deposition of cattle urine on our soils, this could be channeled towards composting.

Compost quality and stability are dependent on the composition of the raw material used for the composting process

(Ranalli *et al.*, 2001). Therefore, the quality of composts can be improved by using raw materials with high plant nutrients. According to Lin *et al.* (2008) and Kuwahara *et al.* (2009), moisture content is described as one of the most important factors responsible for biological reactions within a compost pile, moisture content of a compost pile should be about 50% (Liang *et al.*, 2003). Excess moisture will trigger anaerobic conditions while inadequate moisture will limit microbial activity (Das & Keener, 1997). Generally, water has been used as a source of moisture during composting (Aya *et al.*, 2015), however, we hypothesized that if cattle urine which is rich in nitrogen (Choudhary *et al.*, 2017) is used as a source of moisture, this may probably improve the quality of the compost apart from performing moisturizing role.

The objectives of this research work were to evaluate the effect of compost derived from rice husk moistened with water and compost derived from poultry manure and rice husk moistened with cattle urine, sole poultry manure and sole cattle dung on soil chemical properties, growth and yield of *Amaranthus cruentus* L.

Materials and Methods

Description of the Experimental Site

The experiment was conducted at the organic farm of the Federal University of Agriculture, Abeokuta (97.12°N and 7.20°E) Nigeria. The site is located in the transition zone of sub-humid forest and the derived savannah. The area is characterized by distinct wet and dry seasons (bimodal rainfall distribution) with the wet season between April and October and the dry season between November and March. The mean annual rainfall in the area is about 1400 mm and mean annual temperature is about

22.2°C. The soil in the area is described as Oxid Paleustalf (FDALR 1990). The chemical and selected physical properties of the soil used for the experiment are shown in Table 1. Information on temperature and rainfall pattern is shown in Table 2.

TABLE 1
Chemical and physical properties of soil used for the experiment

<i>Property</i>	<i>Value</i>
pH (H ₂ O)	6.8
Avail. P (mg kg ⁻¹)	13.77
TN (g kg ⁻¹)	1.2
OC (g kg ⁻¹)	4.6
Exch. K (cmol kg ⁻¹)	0.68
Exch. Ca (cmol kg ⁻¹)	0.23
Exch. Mg (cmol kg ⁻¹)	0.20
Sand (g kg ⁻¹)	862
Silt (g kg ⁻¹)	120
Clay (g kg ⁻¹)	18
Textural class	Sandy loam

TABLE 2
Mean temperature and rainfall pattern for 2014 and 2016

<i>Month</i>	<i>2014</i>		<i>2016</i>	
	<i>Mean Tem- perature (°C)</i>	<i>Total rainfall (mm)</i>	<i>Mean Tempera- ture (°C)</i>	<i>Total rain- fall (mm)</i>
January	28.9	8.2	28.1	32.0
February	29.3	15.5	30.3	6.0
March	28.8	149.1	29.5	150.3
April	28.2	87.2	29.2	68.2
May	27.8	113.8	29.0	226.2
June	27.5	116.5	26.7	150.3
July	26.6	90.7	26.3	65.2
August	25.6	92.7	25.7	63.6
September	26.3	160.8	26.9	229.0
October	26.3	205.9	27.6	155.4
November	27.5	17.6	28.0	5.9
December	28.5	0.0	22.5	0.0

Source: Department of Water Resources and Agricultural Meteorology, Federal University of Agriculture, Abeokuta Nigeria

Compost preparation

Compost was made using rice husk and poultry manure at ratio 3:1, two heaps of compost materials were prepared, one was moistened with 50 liters of water while the second one was moistened with the same quantity of cattle urine. These were covered with black polythene sheets for heat generation and to prevent excess water from getting into the compost pile. These were allowed to decompose for twelve weeks while each pile was turned at two weeks intervals with the addition of cattle urine or water as the case may be.

Poultry manure, cattle dung and cattle urine

Poultry manure, cattle dung and urine were sourced from the college of animal science and livestock production (COLANIM) farm of the Federal University of Agriculture, Abeokuta, Nigeria. Poultry manure was obtained from layers pen under intensive system while cattle dung and urine were from cattle raised under semi-intensive system. Poultry manure and cattle dung were left for six weeks after collection before application. The chemical properties of the amendments are given in Table 3.

Land clearing and plot demarcation

The experimental area measuring 34 m x 13 m was manually cleared and plots measuring 2 m x 3 m were demarcated. Plots and replicates were spaced by a distance of 1 m. Vegetable beds were manually constructed on the plots.

Pre-planting soil sampling

Soil samples (0-15 cm layer) were collected randomly from six points on the experimental area, these were bulked and sub-sampled for routine analysis.

Treatment application

The optimum nitrogen requirement of 67.5 kg ha⁻¹ for *Amaranthus cruentus* as recommended by Makinde (2013), native soil N and N content of organic materials were used as a guide to determine the rates of organic materials used. The following treatments were applied: compost rates equivalent to 67 kg N ha⁻¹: compost derived from poultry manure + rice husk with water as source of moisture at 6.5 t ha⁻¹ (PRW 6.5), compost derived from poultry manure + rice husk with cattle urine as source of moisture at 5.4 t ha⁻¹ (PRU 5.4), two lower rates of each type of compost (PRW 2.5, PRW 5.0, PRU 2.5, PRU 5) and one higher rate of each type of compost (PRW 7.5 and PRU 7.5), sole poultry manure and cattle manure equivalent to 67.5 kg N ha⁻¹, (PM3 and CD 5.3 respectively) and control. Treatments were applied by broadcasting and incorporated into the top soil on May 22, 2014 and June 1, 2016. Treatments were laid out using randomized complete block design and replicated three times. The experimental site was left without planting any crop at the end of the experiment in 2014 till the commencement of the 2016 trial. The experiment was carried out on the same plot in both years.

TABLE 3
Chemical properties of organic materials used for the experiment

Property	PRW	PRU	PM	CD	RH	CU
pH (H ₂ O)	7.65	8.24	7.30	9.60	6.80	8.0
OC (g kg ⁻¹)	32.2	40.7	64.2	37.6	17.4	6.5
N (g kg ⁻¹)	10.4	12.5	22.4	12.8	5.9	8.2
P (mg kg ⁻¹)	12.68	16.14	7.89	1.78	1.14	1.34
K (g kg ⁻¹)	8.60	10.22	1.61	1.14	4.11	1.02
Na (g kg ⁻¹)	6.02	6.17	3.10	2.25	1.92	2.03
Ca (g kg ⁻¹)	25.10	27.6	4.12	3.47	0.87	2.36
Mg (g kg ⁻¹)	5.60	6.80	7.66	1.36	1.04	1.26
C/N	3.09	3.26	2.87	2.94	2.95	3.23

KEY

PRW – Compost derived from poultry manure + rice husk +water

PRU - Compost derived from poultry manure + rice husk +cattle urine
 PM – Poultry manure
 CD – Cattle dung
 RH – Rice husk
 CU – Cattle urine

Planting and crop management

Amaranthus cruentus L. seeds obtained from the National Horticultural Research Institute, Idi-Ishin, Ibadan Oyo State, Nigeria were planted at 30 cm by 50 cm spacing two weeks after amendment application in 2014. Seedlings were thinned to one plant per stand at 10 days after sowing, making a plant population of 140,000 plants per hectare. Weeds were controlled manually at four weeks after planting.

In 2016, the plots used for the trial in 2014 were cleared manually, treatments were applied by broadcasting method and incorporated in the 0 -15 cm soil layer. The plots were left for two weeks before planting the test crop (*Amaranthus cruentus*). The seeds obtained from the same source as in 2014 were planted at 30 cm by 50 cm spacing two weeks after amendment application. Seedlings were thinned to one plant per stand at ten days after sowing. Weeds were controlled manually at four weeks after planting.

Data collection

Post-harvest soil sampling

At the end of the experiment in each year (2014 and 2016), soil samples (0-15 cm) were collected from four points on each plot, bulked and sub-sampled for analysis.

Soil Preparation and analysis

Soil samples were air-dried for two weeks, crushed with the aid of porcelain mortar and

pestle, sieved with 2 mm and 0.5 mm sieves. Soil sieved with a 2 mm sieve was used for the determination of pH, P, K, Ca and Mg while one sieved with a 0.5 mm sieve was used for the determination of TN and OC.

Soil pH was determined by glass electrode method (McClean, 1982), phosphorus by Bray 1 method (Bray & Kurtz, 1945), potassium by flame photometry while calcium and magnesium were determined by atomic absorption spectrometry. Particle size was by hydrometer method (Bouyoucos, 1962). Nitrogen was determined by Kjeldahl method (Bremner, 1996) and organic carbon by wet oxidation method (Nelson & Sommers, 1996).

Agronomic parameters

Six plants were randomly selected from the middle row of each plot and the following parameters were determined at five weeks after planting: plant height which was determined with the aid of a graduated ruler, number of leaves by physical counting and stem girth using a Vernier caliper.

Fresh yield

Amaranthus cruentus L. was harvested by uprooting at five weeks after sowing, soil particles attached to the roots were carefully removed, after which they were weighed on a scale.

Amendment Analysis

Amendments used for the experiment were analyzed for pH by glass electrode method, nitrogen by Kjeldahl method, phosphorus by vanado-molybdate method (Aduayi & Gatitu, 1973), potassium by flame photometry, calcium and magnesium by atomic absorption method and organic carbon by wet oxidation method.

Statistical analysis

Data were subjected to the analysis of variance using the statistical analysis system (SAS) 2003 package. Significant means were separated using the Least Significant Difference at 5% probability level.

Results and discussion

Post-harvest soil chemical properties

Post-harvest soil pH ranged between 6.45 and 7.40 in 2014. Plots with the application of PRU5.4 had the highest pH value (7.40) followed by PRU2.5 (7.30) while the lowest (6.45) was from the control plot. The pH of all amended plots was significantly ($p < 0.05$) higher than the control. Application of PRU5.4 was also observed to have significantly ($p < 0.05$) increased post-harvest soil pH above PRW2.5, PRW5, PRW6.5, PRW7.5, CD5.3 and PM3. A similar trend was observed in the year 2016 where all the pH of the soil from amended plots were significantly ($p < 0.05$) higher than the control plot. The highest pH (7.53) was however recorded on the plot amended with PRW5 which was followed by PRW7.5 (7.36). The pH values of all amended plots were statistically similar (Table 4).

Amendment application significantly ($p < 0.05$) increased the organic carbon content of post-harvest soil in both years. In year 2014, the order of increase in organic carbon content was: PRU7.5 > PRW6.5, PRW2.5, PRU5.4, PM3 > CD5.3, PRU5, PRU2.5, PRW7.5 > control, while in 2016, the order was: PRW6.5 > CD5.3 > PM3 > PRU5 > PRW7.5, PRU5.4, PRU7.5 > PRW5 > PRW2.5 > C. The organic carbon contents of all the amended plots were not significantly different from each other in both years. Total nitrogen was significantly ($p < 0.05$) increased in comparison with the control by amendment application in both years. The

highest value (0.2 g kg⁻¹) was observed on PRW6.5 and PRU5.4 amended plots in 2014, while the highest value (0.13 g kg⁻¹) was from PRW6.5, CD5.3 and PM3 in 2016. Phosphorus content of post-harvest soil ranged between 12.66 mg kg⁻¹ and 15.62 mg kg⁻¹ in the first year (2014). All amendments with the exception of PRW6.5 gave significantly ($p < 0.05$) higher P content than the control. Percentage increase over the control by the various treatments are: PRW5 (18.95), PRW7.5 (18.64), CD5.3 (17.95), PRU2.5 (15.94), PM3 (15.88), PRU5 (15.54), PRW2.5, PRU7.5, (14.69), PRU5.4 (13.58), PRW6.5 (10.97). P values in 2016 were statistically similar but were significantly ($p < 0.05$) higher in 2016 than in 2014.

TABLE 4
Chemical properties of post-harvest soil as affected by poultry manure, cattle dung, water and cattle - urine based composts in 2014 and 2016

Treatment	Year	pH	OC (g kg ⁻¹)	TN (g kg ⁻¹)	Avail P (mg kg ⁻¹)	K	Ca	Mg
<i>cmol kg⁻¹</i>								
Control	2014	6.45	4.0	1.3	12.66	0.65	0.21	0.22
PM3		7.20	5.7	1.9	15.05	0.80	0.25	0.27
CD5.3		7.20	5.5	1.9	15.43	0.78	0.25	0.27
PRU2.5		7.30	5.5	1.8	15.06	0.79	0.25	0.26
PRU5		7.25	5.5	1.9	14.99	0.79	0.25	0.28
PRU5.4		7.40	5.7	2.0	14.65	0.79	0.26	0.27
PRU7.5		7.25	5.9	1.9	14.84	0.81	0.26	0.28
PRW2.5		7.10	5.8	1.9	14.84	0.73	0.25	0.25
PRW5		7.20	5.6	1.9	15.62	0.82	0.25	0.26
PRW6.5		7.20	5.8	2.0	14.22	0.82	0.25	0.28
PRW7.5		7.20	5.5	1.8	15.56	0.81	0.25	0.27
Control	2016	6.55	5.4	0.5	8.65	0.54	0.17	0.12
PM3		7.24	14.2	1.3	21.70	0.71	0.19	0.19
CD5.3		7.25	14.3	1.3	17.60	0.72	0.22	0.18
PRU2.5		7.15	13.7	1.1	21.50	0.69	0.23	0.17
PRU5		7.14	14.1	1.2	25.05	0.72	0.24	0.20
PRU5.4		7.31	13.2	1.1	21.95	0.70	0.20	0.19
PRU7.5		7.29	13.2	1.1	21.30	0.74	0.29	0.23
PRW2.5		7.20	11.9	1.0	21.85	0.76	0.25	0.19
PRW5		7.53	12.9	1.1	24.40	0.78	0.25	0.21
PRW6.5		7.30	15.0	1.3	24.50	0.77	0.18	0.21

PRW7.5	7.36	13.2	1.1	27.10	0.75	0.30	0.24
LSD ($p < 0.05$)							
2014	0.16	1.2	0.5	1.74	0.04	0.02	2.20
2016	0.47	6.2	0.4	NS	0.19	0.08	0.06
Treatment*Year	NS	0.9	0.1	5.96	0.04	0.02	0.12

PRW – Compost derived from poultry manure + rice husk +water

PRU – Compost derived from poultry manure + rice husk +cattle urine

PM – Poultry manure

CD – Cattle dung

The potassium content of all amended plots was significantly ($p < 0.05$) higher than the control in 2014. The highest value ($0.82 \text{ cmol kg}^{-1}$) was however observed on PRW5 and PRW6.5 treated plots. Potassium content of plots amended with PRW2.5 was significantly ($p < 0.05$) lower than PRW5, PRW6.5 and PRW7.5 while K values of all plots amended with PRU were similar and significantly ($p < 0.05$) higher than PRW2.5. In 2016, all PRW amended plots gave significantly ($p < 0.05$) higher K content over the control while only PRU7.5 treated plot out of all the plots amended with PRU was significantly higher than control. The highest value ($0.78 \text{ cmol kg}^{-1}$) was observed on PRW5 treated plot. Potassium was significantly higher in 2014 than in 2016 (Table 4).

Application of amendment significantly ($p < 0.05$) increased the soil calcium content, the range was between $0.21 \text{ cmol kg}^{-1}$ and $0.26 \text{ cmol kg}^{-1}$, where the highest value was recorded on plots amended with PRU5.4 and PRU7.5 in 2014. Application of PRW2.5, PRW5, PRW7.5 and PRU7.5 significantly ($p < 0.05$) increased the calcium content in 2016. The highest value ($0.30 \text{ cmol kg}^{-1}$) was from PRW7.5 amended plots while the lowest ($0.17 \text{ cmol kg}^{-1}$) was from the control plot. Calcium content was significantly higher in 2014 than in 2016 (Table 4).

Magnesium was significantly ($p < 0.05$) greater than the control by amendment application in 2014. The highest percentage increase over the control (21.43) was observed on plots treated with PRW6.5, PRU5 and PRU7.5. The least Mg content was from an un-amended plot. The magnesium content of PRU7.5 treated plot was significantly ($p < 0.05$) higher than PRW2.5 plot but was similar to other treatments in 2014. Treatment application with the exception of PRU2.5 and CD5.3 significantly ($p < 0.05$) increased the magnesium content over the control in 2016. Highest value ($0.24 \text{ cmol kg}^{-1}$) was observed on plots amended with PRW7.5 followed by PRU7.5 ($0.23 \text{ cmol kg}^{-1}$). Magnesium content of plots amended with PRW7.5 was significantly higher than PRU2.5 and CD5.3. Mg was significantly higher ($p < 0.05$) in 2014 than in 2016.

Post-harvest soil pH was significantly greater than control in both years, this might have resulted from the organic nature of the amendments. Organic amendments were reported to be good sources of CaCO_3 (Eghball, 1999). Application of organic amendment was reported by Han *et al.* (2016) to have increased the pH of soil under yellow poplar. The pH was highest in PRU5.4 and PRW5 in 2014 and 2016 respectively, the composts have higher calcium content than other amendments used for the study. The presence of calcium ion in the soil was reported by Darell (2012) to reduce soil acidity. Application of all amendments resulted in significantly greater OC in both years, the organic nature of the amendments could be the reason for this observation. Organic amendment application was reported by Huag *et al.* (2014) and Ma *et al.* (2011) to have increased the organic carbon content of a paddy field.

Nitrogen was observed in this experiment to be greater in all amended plots, this could be due to low N losses under organic farming as reported by Knudsen *et al.* (2006). This observation is similar to that of Angelova *et al.* (2013) who reported an increase in the N content of soils treated with organic amendments. Potassium was greater than control with PRW application, this could also be due to low leaching of potassium from the soil, compost application was reported by Tong *et al.* (2018) to have resulted in high soil K content. A similar trend was observed for calcium and magnesium which were highest in plots amended with compost in both years, composts used for this study have higher calcium contents than PM and CD. Composts are reported to be rich in calcium and magnesium contents (Suvitha & Remesh, 2017). PRW and PRU have higher C/N ratio than CD and PM used for this study, therefore, high Ca and Mg in soils amended with the composts could have resulted from the gradual release of nutrients by the composts (Gershuny, 2001). Calcium, magnesium and potassium were lower in the soil in the second year of the study (2016) than in 2014, this could be explained by higher rainfall in the month (June) of most active growth of the crop in 2016, thereby reducing evaporation. This observation is similar to the findings of Austin and Vitousek (1998); Quinto-Mosquera and Moreno-Hurtado (2016) who reported significant reductions in exchangeable K, Ca and Mg concentrations in the soil with increase in rainfall.

Agronomic Parameters

The height of *Amaranthus cruentus* increased significantly ($p < 0.05$) than the control with the application of organic amendments irrespective of whether compost, poultry

manure or cattle dung in the first year (2014). The tallest plants (21.43 cm) were the ones amended with PRU5.4, the percentage increase over the control was 54.55%. The height of *Amaranthus cruentus* was significantly ($p < 0.05$) increased above PRW2.5 and PRW7.5 with the application of PRU5.4 (Table 5). However, in 2016, only plants treated with PRU5.4 and PRW7.5 were significantly ($p < 0.05$) taller than the control. Plants amended with PRU5.4 were 51.48% taller while ones with PRW7.5 were 42.15% taller than the control, it could also be observed that plants amended with PRU5.4 grew significantly ($p < 0.05$) taller than ones amended with PM3, PRU5, PRU7.5, PRW2.5, PRW5 and PRW6.5

Number of leaves of *Amaranthus cruentus* ranged from 7.29 to 18.53 in 2014, plants amended with PM3 had the highest number of leaves (18.53) followed by PRU5.4 (15.53), PRU7.5 (14.56), all the above values were significantly ($p < 0.05$) higher than the control which had the lowest value (7.29). Application of PM3 significantly ($p < 0.05$) increased the number of leaves of *Amaranthus cruentus* above CD5.3 but was however similar to those of other treatments. In 2016, only plants amended with CD5.3 and PRU5.4 had significantly ($p < 0.05$) higher number of leaves when compared with the control. The number of leaves of plants amended with CD5.3 were significantly ($p < 0.05$) more than PRW5 and PRW6.5 treated plants. The stem girth of *Amaranthus cruentus* was between 2.53 mm and 4.92 mm in 2014, application of PM3 and PRU5.4 resulted in a significantly ($p < 0.05$) higher stem girth than the control, the percentage increase over the control was 48.58 and 43.27 respectively. In 2016, the application of PRU5.4 was observed to give significantly ($p < 0.05$) higher stem girth than the control. Application of the above

resulted in 48.44% increase in stem girth over the control. Stem girth was significantly higher in 2016 than in 2014 (Table 5).

It was observed that the application of PRU5.4 resulted in significantly taller plants, the number of leaves and stem girth than the control in both years, this could have resulted from higher nitrogen and phosphorus contents in PRU than PRW. Nitrogen and phosphorus were reported to increase the growth of *Acer mono* and garlic (Razaq *et al.*, 2017; Betewulign & Solomon, 2014). Increase in height of *Amaranthus cruentus* in 2014 and stem girth in 2016 by the application of PRU5.4 could be explained by the fact that this treatment supplied the equivalent amount of N (67.5 kg ha⁻¹) recommended for *Amaranthus cruentus* production (Makinde, 2013). The application of nitrogen was reported by Direkvandi *et al.* (2008) to improve the vegetative growth of tomatoes. The number of leaves resulting from the application of PM3 was the highest, this could be due to high N content in PM. Similar findings have been reported by Shormin and Kibria (2018).

Muhammad *et al.* (2004) also observed that nitrogen increased the number of leaves on *Zinnia elegans* Cv. Meteor. The observed significant increase in the number of leaves of *Amaranth* plants amended with PM3 over CD5.3 could be due to higher N content in PM than CD. Dehariya *et al.* (2019) reported an increase in the number of leaves of *Amaranthus tricolor* L. as a result of N application. High phosphorus content in PRU5.4 and PM3 could be responsible for significantly higher stem girth of *Amaranthus cruentus* over the control which resulted from the application of the above. This is similar to the findings of Zhu *et al.* (2017) who reported an increase in stem girth of tomato as a result of P application.

Yield

Application of all amendments resulted in significantly ($p < 0.05$) higher *Amaranthus cruentus* yield than control in both years. In 2014, yield ranged from 0.76 t ha⁻¹ and 3.76 t ha⁻¹, the highest yield which increased by 79.79% more than the control was from plants amended with PM3, followed by this was PRU7.5 which increased by 76.54% more than control. Application of PM3 resulted in significantly ($p < 0.05$) higher yield than PRW2.5, PRW6.5 and PRW7.5. A similar trend was observed in 2016 where the application of all amendments significantly ($p < 0.05$) increased the yield of *Amaranthus cruentus* over the control. The highest percentage increase (87.97) over the control resulted from the application of PRU5.4. The order was: PRU5.4 (87.97%) > PM3 (87.46%) > PRU2.5 (86.99%) > CD5.3 (86.94%) > PRW7.5 (86.48%) > PRW5 (85.82%) > PRW2.5 (85.38%) > PRU5 (85.10%) > PRW6.5 (84.43%) > PRU7.5 (83.97%) > Control (Figure 1). Significant increase in yield by all amendments could be due to the organic nature of the amendments. Organic amendments were reported by Gongwen *et al.* (2018), Wortman *et al.* (2017) and Maltas *et al.* (2018) to increase crop yield. The Highest *Amaranthus* yield observed in PM3 and PRU5.4 in 2014 and 2016 respectively could have resulted from high organic matter contents of the amendments. The stem girth of *Amaranthus cruentus* was significantly ($p < 0.05$) higher in 2016 than 2014, this could be due to lower rainfall during the experimental period in 2014 (Table 2). Increased irrigation was reported by Kwizera *et al.* (2018) to increase the stem girth of *Amaranth*.

TABLE 5
Height, number of leaves and stem girth of
Amaranthus cruentus as affected by poultry manure,
cattle dung, water and cow urine - based composts in
2014 and 2016

Treatment	Year	Height (cm)	Number of leaves	Stem girth (mm)
Control	2014	9.74	7.29	2.53
PM3		19.36	18.53	4.92
CD5.3		18.66	10.90	3.81
PRU2.5		18.14	12.69	3.87
PRU5		16.65	12.70	3.34
PRU5.4		21.43	15.53	4.46
PRU7.5		19.00	14.56	3.35
PRW2.5		15.15	12.69	2.96
PRW5		18.22	14.16	4.12
PRW6.5		16.16	12.76	2.97
PRW7.5		15.75	12.50	3.58
Control	2016	11.02	7.90	3.47
PM3		13.03	10.60	4.69
CD5.3		17.14	15.67	5.11
PRU2.5		16.13	12.47	4.79
PRU5		13.91	10.80	4.10
PRU5.4		22.71	15.00	6.73
PRU7.5		14.57	11.33	3.88
PRW2.5		15.26	12.40	4.07
PRW5		14.75	11.40	4.97
PRW6.5		15.43	9.20	3.91
PRW7.5		19.05	12.40	5.97
L S D				
(p<0.05)				
2014		4.99	6.48	2.09
2015		6.67	6.17	2.94
Treatment* -				
Year		NS	NS	0.62

KEY

PRW – Compost derived from poultry manure + rice husk +water

PRU - Compost derived from poultry manure + rice husk +cattle urine

PM – Poultry manure

CD – Cattle dung

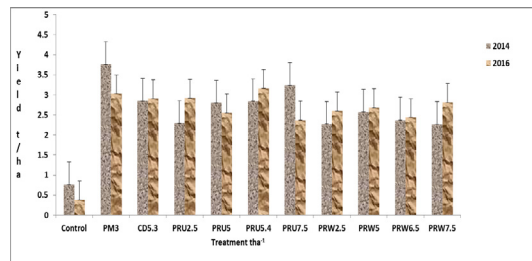


Fig. 1: Yield of *Amaranthus cruentus* as affected by poultry manure, cattle dung, water and cow urine - based composts in 2014 and 2016

KEY

PRW – Compost derived from poultry manure + rice husk +water

PRU - Compost derived from poultry manure + rice husk +cattle urine

PM – Poultry manure

CD – Cattle dung

Conclusion

Results of this experiment showed that the application of PRU5.4 resulted in the highest values for most of the agronomic parameters in both years, while the competition for the highest values of post-harvest soil parameters was between PRW5 and PRW6.5. The highest values of *Amaranthus cruentus* yield in both years resulted from the application of PRU5.4 and PM3. Compost derived from Poultry manure + rice husk and moistened with cattle urine performed better than compost derived from poultry manure+ rice husk and moistened with water, PM and CD in terms of growth and yield of *Amaranthus cruentus*. However, compost derived from poultry manure + rice husk moistened with water is more suitable for improving soil chemical properties under *Amaranthus cruentus*.

Amaranthus cruentus could therefore be planted with compost derived from poultry

manure + rice husk with cattle urine as a source of moisture at 5.4 t ha⁻¹ (PRU5.4) for higher growth and yield while compost derived from poultry manure and rice husk with water as a source of moisture at 5.0 or 6.5 t ha⁻¹ (PRW5 or PRW6.5) is suitable for improved soil chemical properties on similar soils.

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