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Effects of Different Types of Organic Fertilizers on the Nutrients and Anti Nutrients Composition of *Amaranthus caudatus* and *Amaranthus cruentus*

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Authors' contributions

This work was carried out in collaboration between both authors. Author KJC designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KJC and UCC managed the analyses of the study. Author KJC managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate the effect of different types of organic fertilizers on the nutrients and anti nutrients composition of *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452).

Study Design: A randomized complete block design (RCBD) was used for the experiment.

Place and Duration of Study: The experiment was carried out in the nursery of a homestead garden at No 20, Isaiah Balat Street, Sabo GRA, Kaduna State, Nigeria.

Methodology: The study consists of seven treatments which includes control (no fertilizer), 5 t ha^{-1} and 10 t ha^{-1} poultry manure, 5 t ha^{-1} and 10 t ha^{-1} sewage sludge, 35 kg ha^{-1} and 70 kg ha^{-1} NPK compound fertilizer and also with two varieties; *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452) with factorial arrangement in a randomized complete block design (RCBD) and replicated three times. At maturity, the leaves were harvested and prepared for laboratory analysis for both nutrients and anti-nutrient composition. Proximate composition was determined according to A.O.A.C protocol. Water soluble vitamins were analyzed using High

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Performance Liquid Chromatography (HPLC) while the metals were analyzed using Atomic Absorption Spectroscopy (AAS).

Results: The ash, moisture, fat, protein, fibre, carbohydrate and energy of the two varieties were found in the range of 2.58 - 3.06%, 78.78 - 80.69%, 1.04 - 1.49%, 7.49 - 9.67%, 2.41 - 3.29%, 3.02 - 6.46% and 54.72 - 61.52 Kcal/100 g respectively. The micronutrients including β-carotene, vitamin C, niacin, riboflavin, iron and zinc were found in the range of 4.79 - 6.68, 14.37 - 40.36, 5.97 - 22.15, 8.37 - 27.99, 10.03 - 13.40 and 5.11 – 941 mg/100 g respectively. The anti-nutrients; tannins, phytate, saponins and oxalate were in the range of 0.33 - 0.69, 0.40 - 0.94, 1.29 - 2.30 and 0.53 - 1.01% respectively

Conclusion: Poultry manure provided higher nutrients on the two varieties of Amaranth when compared with sewage sludge and NPK compound fertilizer. While sewage sludge resulted in the plants having higher anti-nutrients. The application of poultry manures at 10 tons/ha is therefore recommended for farmers to use to obtain more nutritious amaranth.

Keywords: NPK; poultry manure; sewage sludge; Amaranth; soil.

1. INTRODUCTION

Vegetables are grown worldwide and make up a major portion of the diet of humans in many parts of the world. Vegetables play a significant role in human nutrition, especially as sources of vitamins, minerals, fibre and phytochemicals [1,2] Vegetables in the daily diet have been strongly associated with improvement of gastrointestinal health, good vision and reduced risk of heart disease, stroke, chronic diseases such as diabetes, and some forms of cancer [3].

Amaranthus species are a highly popular group of vegetables that belong to different species [4,5,6]. Amaranth has been naturalized in central parts of Asia and possibly Iran [7] and has cultivation history of more than 2000 years [8]. Cultivation of the various *Amaranthus* species is acquiring increasing importance in Nigeria and other parts of African continent where the available species are grown for their leaves [9].

Growth of Amaranth can be enhanced by use of organic and inorganic fertilizers as they supply plants with the nutrients needed for optimum performance. Organic fertilizer has been used for many centuries whereas chemically synthesized inorganic fertilizers were only widely developed during the industrial revolution. Inorganic fertilizers have significantly supported global population growth, as it has been estimated that almost half the people on the earth are currently fed as a result of artificial nitrogen fertilizer use [10]. Commercial and subsistence farming has been and is still relying on the use of inorganic fertilizers for growing crops because they are easily absorbed and utilized; prices of food have skyrocket due the continual use of inorganic fertilizers as they are expensive to purchase [11].

Fertilizer application rates in intensive agricultural systems have increased drastically during recent years in Nigeria. Farmers depend largely on locally sourced organic fertilizers [12]. Huge amount of organic wastes such as poultry waste, animal excreta, sewage sludge, refuse soil and palm oil mill effluent are generated and heaped on dump sites, posing potential environmental hazard. Incorporating these waste materials into the soil for crop production is expected to be beneficial to the buildup of organic matter layer that is needed for a steady supply of nutrients by tropical soils [13].

Oyedeji et al. [14] reported that NPK and poultry manure improved the growth and yield of three different species of amaranth (*Amaranthus hybridus*, *Amaranthus deflexus* and *Amaranthus cruentus*) but influenced proximate composition differently. However, use of NPK provided plants with the highest crude fibre, protein and fat while plants cultivated using poultry manure presented the highest fat content. Makinde et al. [12] reported that organic material alone or in combination with NPK significantly increased protein and ash content of vegetables while fibre was reduced; NPK gave least values of protein, fibre and ash compared with organic material. Funda et al. [15] studied the effect of organic and inorganic fertilizers on yield and mineral content of onion for two years and reported that the treatments influenced K content, but did not influence N, P, Ca, Na, Mg, Fe, Zn, Cu and Mn contents of the onion bulb. Still in research with onion, Coolong et al. [16] reported that N, P, Mn, Fe and Zn content of bulb were increased by N treatments but the content of N was decreased by N doses but K, Cu and Mo contents were not affected by the treatments. Abdelrazzag [17] found that increasing the rate of sheep and chicken manure increased N content of onion significantly, while P and K contents had low level. Mixture of chicken manure and biofertilizer increases the yield of onion and enriched nutrient content in tuber [17].

In order to enhance nutrient content of vegetables and further alleviate the risk of diet related health problems, there is a need to evaluate the effect of different types of organic fertilizers on nutrients and anti-nutrients composition of *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452).

2. MATERIALS AND METHODS

2.1 Study Area

The field experiment was carried out in the nursery of a homestead garden at No 20, Isaiah Balat Street, Sabo GRA, Sabo Tasha, Kaduna State, Nigeria. Garden space was prepared by digging up existing vegetation with a shovel, the sandy clay loamy soil was tilled and raised- bed frame was created, with 12 inches between rows. Rows were made straight to make weeding easier. Kaduna metropolis has a tropical savanna climate with dry winters characterized by maritime air and rainfall is between April and October with annual raining days ranging from 81 to 103 mm. During the reference period, the annual mean rainfall values range from 145.37 mm to 318.67 mm. From the figures above, ample rains are available for the production of many agricultural crops. During harmattan, dry desert wind blows between December and mid February while night temperature is very low. The geographical location of Kaduna metropolis is Latitude 9° 03^{1}N and 11° 32^{1}N north of the equator and Longitudes 6° 05^1 E and 8° 38^1 E East of the Greenwich meridian. Kaduna metropolis has a sub-humid semi arid tropical climate with maximum annual mean temperature ranging from 25.30°C to 36.20°C while the minimum annual mean temperature range of 28.45°C to 34.38°C [18].

2.2 Seeds

The seeds of *Amaranthus caudatus* (Samaru local variety) were obtained from local farmers in Samaru, Zaria, Nigeria while the seeds of *Amaranthus cruentus* (NH84/452) were obtained from National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. *Amaranthus caudatus* samples collected were authenticated at the herbarium unit of Biological Sciences Department, Ahmadu Bello University Zaria, Nigeria and voucher specimens were deposited.

2.3 Soil Sampling and Analysis

Surface soil sample was taken from the experimental site at a depth of 0 – 15 cm at land preparation (after ploughing and harrowing) using the zigzag method. The sample was collected from twenty points and homogenized to form a composite sample. The composite sample was air-dried, crushed and sieved through a 2 mm mesh sieve and stored for chemical analysis [19].

The sampled soil was analyzed at the Soil Science Department of the Institute of Agricultural Research, Ahmadu Bello University Zaria, Nigeria. The following parameters were analyzed in the sampled soil; particle size, pH (in water), organic carbon, available phosphorus, total nitrogen, cation exchange capacity (CEC) and exchangeable bases [19].

2.4 Fertilizer Collection and Treatment

Poultry manure was collected at Ishaya's poultry farm in Sabo GRA, Sabo Tasha Kaduna State, Nigeria. The dried sewage sludge was collected at the sewage site of Ahmadu Bello University Zaria, Nigeria. NPK compound fertilizer (15:15:15) was bought at Kawo market Kaduna State, Nigeria. Two 20-litre containers were washed thoroughly with deionised water and 0.1 m sodium hypochlorite, allowed to dry properly for 2 days, before the organic fertilizers; poultry manure and sewage sludge were separately packaged in each container, properly sealed and kept in a clean store room prior to use.

2.5 Experimental Design and Fertilizer Treatment

The experiment included seven fertilizer treatments for each of the two varieties of Amaranth which are in factorial arrangement fitted into a randomized complete block design (RCBD) and replicated three times. Hence, the experiment had a total of 42 experimental plots. The treatments were: Control (no fertilizer), 5 t ha^{-1} poultry manure, 10 t ha^{-1} poultry manure, 5 t ha^{-1} sewage sludge, 10 t ha^{-1} sewage sludge, 35kg ha^{-1} NPK compound fertilizer, 70kg ha^{-1} NPK compound fertilizer [20].

2.6 Planting and Nursery Management

Before planting, the amaranth seeds were soaked in water for about 24 hours in order to enhance germination. The soaked seeds were firstly sown in the nursery at 1.9 cm depth and were watered twice daily. Appropriate nursery management practices were carried out as at when needed to obtain healthy and uniform seedlings. The experimental site was ploughed, harrowed and prepared into slightly raised beds (plots) of 25 cm width × 80 cm length dimension preparatory to transplanting the crop seedlings. Poultry manure and sewage sludge were incorporated according to treatment level to specific plots during land preparation, thoroughly mixed with the soil and then left for two weeks to allow for mineralization. Half of the NPK Compound fertilizer was applied at day of transplanting while the remaining was applied one week later. After two weeks in the nursery, randomly picked seedlings were transplanted to the well prepare beds (plots). The seedlings were watered twice daily using watering can and the surrounding areas were weeded regularly. The experimental area and the surroundings were kept clean to prevent harbouring of pests. Insects were controlled by using "Dime Force Insecticide" with concentration of 1.5 L ha^{-1} [21].

2.7 Harvesting

The samples were harvested 2 months after sowing when their stems and leaves were fully developed, but before flowering, and also have attained the maturity height of 35-40 cm [22]. They were manually harvested using sharp knives.

2.8 Preparation of Plant for Chemical Analysis

Upon arrival at the laboratory, the fresh and healthy vegetable were immediately washed under tap water and excessive water dripped off. Edible portions of the vegetables were cut into small pieces and homogenized using a Commercial Blender for two minutes. The homogenized sample was used for analysis immediately, but otherwise were transferred into an air-tight container and kept at -20°C before analysis [23,24].

2.9 Estimation of Proximate Composition

The macronutrient compositions of each treatment were determined using the procedures of A.O.A.C. (1999). The macronutrient composition consist of ash content, moisture content, crude protein, total fat, crude fibre, available carbohydrate and total energy [25].

2.10 Estimation of Micronutrients

Water soluble vitamins (Vitamin C, Vitamin B2, and Vitamin B3) were estimated using High Performance Liquid Chromatography (HPLC) according to A.O.A.C protocol [25]. B-carotene content was determined by ethanol and petroleum ether extraction method [25]. Iron (Fe) and Zinc (Zn) were determined using a Perkin Elmer AAnalyst 400 AAS according to A.O.A.C protocol [25].

2.11 Estimation of Anti-nutrients

The analysis of tannins content was performed according to the International Pharmacopoeia [26] and AOAC [27] method, after some modifications [28]. Saponins were determined according to methods by Hudson and El-Difrawi [29]. Phytic acid was determined by the procedure of Lucas and Markakas [30]. Oxalate was determined by using the method of Sanchez-Alonso and Lachica [31].

2.12 Statistical Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS) version 21.0 computer package. Descriptive statistics was used to determine the measures of central tendency. Means were separated using Duncan Multiple Range test. Values with different superscripts down the column are significantly different at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1 Soil Analysis Results

Results of analyses of the soil used for this experiment are shown in Table 1. The texture class of the soil is sandy clay loam in which sand was highest with value of 66 ± 2.0%, followed by clay with 24 ± 3.0% and silt was the lowest with value of 10 ± 1.0%. The soil organic carbon, total nitrogen and available phosphorus were 0.46 ± 0.02%, 0.32 ± 0.01% and 7.4 ± 0.30 ppm respectively. The exchangeable bases of Sodium, magnesium, calcium, potassium and cation exchange capacity (CEC) contents were 0.34 ± 0.02 cmol kg^{-1}, 0.84 ± 0.02 cmol kg^{-1}, 3.26 ± 0.05 cmol kg^{-1}, 0.65 ± 0.03 cmol kg^{-1} and 5.7 ± 0.20 cmol kg^{-1} respectively. Soil pH value was 7.7 ± 0.2.

3.2 Organic Fertilizer Analysis Results

Results of analyses of the organic fertilizers used for this experiment are shown in Table 2. Poultry manure showed a pH of 7.62 ± 0.04, while the concentrations for total nitrogen, available phosphorus and potassium were found to be 3.53 ± 0.02%, 0.71 ± 0.05% and 1.61 ± 0.03% respectively. Sewage sludge pH was found to be 8.25 ± 0.09; the concentrations of total nitrogen, available nitrogen and potassium were gotten as 2.44 ± 0.03%, 0.97 ± 0.02% and 1.33 ± 0.05% respectively.

3.3 Proximate Composition of *Amaranthus caudatus* (Samaru Local Variety) and *Amaranthus cruentus* (NH84/452)

Amaranthus caudatus (Samaru local variety) in poultry manure at 10 t ha^{-1} showed highest values in Ash, fat and crude fibre. Plants treated with N.P.K. compound fertilizer at 70 kg ha^{-1} had highest protein while the control plants had highest values for carbohydrate and energy as shown in Fig. 1.

For *Amaranthus cruentus* (NH84/452), plants treated with10 t ha^{-1} of poultry manure had highest values for ash, moisture, fat and crude fibre. Plants that were introduced N.P.K compound fertilizer had the higher values of protein and energy while the control was highest in carbohydrate as shown in Fig. 2.

Amaranthus caudatus (Samaru local variety) recorded higher levels of ash, fat, protein, available carbohydrate and energy than *Amaranthus cruentus* (NH84/452). The ash content observed in the *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452) respectively were not significantly ($p<0.05$) different among the treatments but is in agreement with the findings of Oyedeji et al. [14] who reported similar results for *Amaranthus hybridus*, *Amaranthus deflexus* and *Amaranthus cruentus*. The ash content in the organic fertilizers were significantly higher and may be due to the balanced nutrients in the manures which contains a lot of minerals and trace elements unlike the NPK compound fertilizer with only proportionate content of nitrogen, phosphorus and potassium. Plants derived from plots treated with 10 t ha^{-1} poultry manure recorded the highest amount of fat for both varieties but there was no significant ($p<0.05$) difference among the treatments. This finding does not agree with previous work of Aluko et al. [32] who reported that NPK fertilizer gave higher values of fat for amaranth and Jute mallow respectively. But Mofunanya et al. [33] had similar findings with this study, the author verified that plants grown with organic fertilizer gave the highest value for fat. The reason for having higher fat for plants grown with organic fertilizers was attributed to the high organic content of the poultry manure and sewage sludge, thereby having high level of carbon containing compounds which are attacked by bacteria, actinomycetes and fungi under aerobic conditions and the carbon is primarily mineralized into CO_2 and some lost as methane. The CO_2 is absorbed by the plants and used to produce fatty acids [34].

Table 1. Physical and chemical properties of soil from study area

Physical and chemical properties of soil used in experiment	
Particle size	
• Clay	24 ± 3.0 %
• Silt	10 ± 1.0 %
• Sand	66 ± 2.0 %
Texture Class	Sandy Clay Loam
pH (in H_20)	7.70 ± 0.20
Organic Carbon (C)	0.46 ± 0.02 %
Available Phosphorus (P)	7.40 ± 0.30 ppm
Total Nitrogen (N)	0.32 ± 0.01 %
Exchangeable bases	
• Calcium (Ca)	3.26 ± 0.05 cmol kg^{-1}
• Magnesium (Mg)	0.84 ± 0.02 cmol kg^{-1}
• Potassium (K)	0.65 ± 0.03 cmol kg^{-1}
• Sodium (Na)	0.34 ± 0.02 cmol kg^{-1}
• Cation Exchange Capacity (CEC)	5.70 ±0.20 cmol kg^{-1}

Values are mean ± standard deviation of triplicate analysis

Table 2. Chemical properties of organic fertilizers used in this experiment

Chemical properties of the organic fertilizers used in the experiment				
	pH (in H_2O)	Total Nitrogen (N) (%)	Available Phosphorus (P) (%)	Potassium (K) (%)
Poultry manure	7.62± 0.04	3.53 ± 0.02	0.71 ± 0.05	1.61± 0.03
Sewage sludge	8.25± 0.09	2.44 ± 0.03	0.97 ± 0.02	1.33 ± 0.05

Moisture and crude fibre were higher in *Amaranthus cruentus* (NH84/452) than *Amaranthus caudatus* (Samaru local variety) as shown in Figs. 1 and 2. Similar result was reported by Mofunanya et al. [33] on the effect of organic and inorganic fertilizers on the nutritional composition of *Amaranthus spinosus* L. The reason for a higher moisture content in both poultry manure and sewage sludge was attributed to the dense organic matter in the organic fertilizers which improves the water holding capacity of the soil. Hence, the plants will be able to absorb more water for use and in turn the amount of moisture on the leaves might be higher [33]. NPK compound fertilizer applied at 70 kg ha^{-1} gave the highest level of crude protein for both varieties and was significantly ($p<0.05$) different among the treatments. This work was similar with works of Oyedeji et al. [14] on *Amarnthus hybridus*, *Amaranthus cruentus* and *Amaranthus deflexus*. NPK fertilizer contains very high amount of nitrogen, so when applied to the soil the nitrogen is converted into ammonia by the process of nitrogen fixation by some bacteria such as azotobacter, clostridium, rhizobium and azospirillum. Also, the ammonia can be further converted to nitrate by nitrifying bacteria, the ammonia in the form of ammonium and nitrate are taken by the plants and used for synthesis of nucleotides and protein. The lower level of protein in poultry manure and sewage sludge treated plants as compared to plants from NPK compound fertilizer may be due to the presence of sawdust or other bedding or large amount of residue deposited in the soil surface, thereby making the available nitrogen in the soil or manure to be immobilized by bacteria decomposing the carbonaceous material leaving plants with less nitrogen than they need for protein synthesis. Crude fibre was found to be highest for the 10 t ha^{-1} poultry manure for both varieties but there was no significant ($p<0.05$) difference among treatments. Mofunanya et al. [33] reported similar results for *Amaranthus spinosus* L and suggested that high crude fibre may be due to the high levels of carbon containing compounds in the poultry manure which are easily converted to CO_2 and absorbed by the plants which readily synthesize fibre.

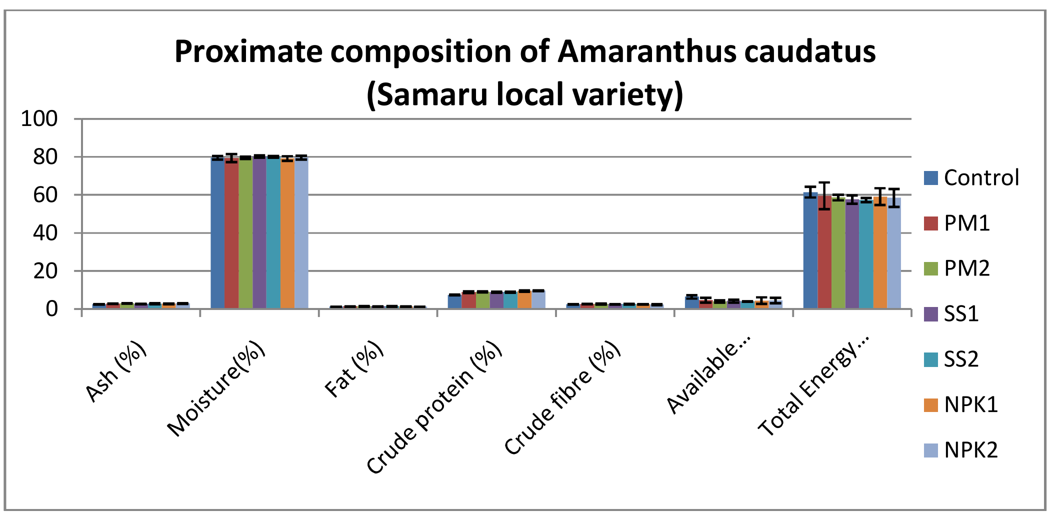

Fig. 1. Effect of organic fertilizers on proximate composition of *Amaranthus caudatus* (Samaru local variety)

Control = No fertilizer, PM1 = Poultry manure at 5 t ha^{-1}, PM2 = Poultry manure at 10 t ha^{-1}, SS1 = Sewage sludge at 5 t ha^{-1}, SS2 = Sewage sludge at 10 t ha^{-1}, NPK1 = NPK compound fertilizer at 35 kg ha^{-1}, NPK2 = NPK compound fertilizer at 70 kg ha^{-1}. Chart represents mean and standard deviation of triplicate analysis

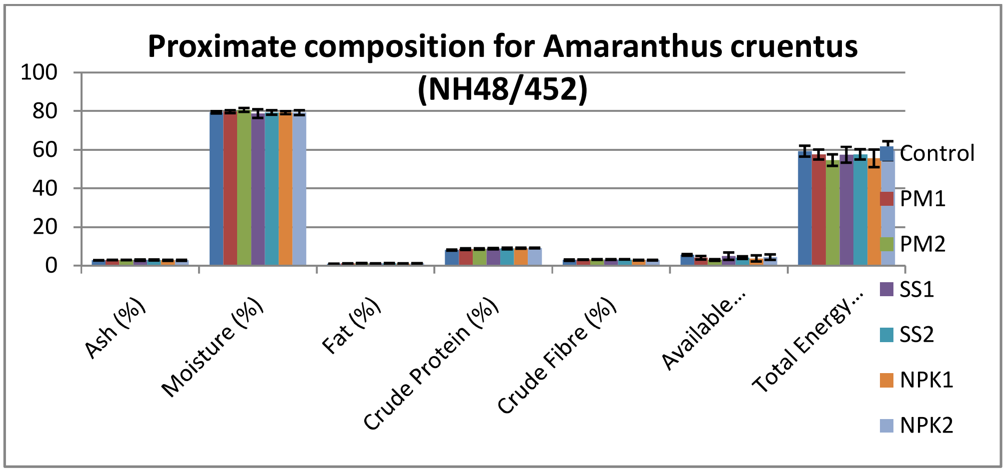

Fig. 2. Effect of organic fertilizers on proximate composition of *Amaranthus cruentus* (NH84/452)

Control = No fertilizer, PM1 = Poultry manure at 5 t ha^{-1}, PM2 = Poultry manure at 10 t ha^{-1}, SS1 = Sewage sludge at 5 t ha^{-1}, SS2 = Sewage sludge at 10 t ha^{-1}, NPK1 = NPK compound fertilizer at 35 kg ha^{-1}, NPK2 = NPK compound fertilizer at 70 kg ha^{-1}. Chart represents mean and standard deviation of triplicate analysis

The control treatment recorded the highest available carbohydrate result for both varieties but there was no significant ($p<0.05$) difference among the treatments. The untreated plants contained high carbohydrate because the plants harvested from the treated plots had more available nutrients like mineral elements, fat and protein, thereby having less carbohydrate than the untreated plants which doesn't contain many nutrients. Energy was highest for the control for both varieties but was not significantly ($p<0.05$) different. This may be due to the fact the control plants have high levels of carbohydrate coupled with a bit elevated levels of fat and protein which are sources of energy [14].

3.4 Micronutrient Composition of *Amaranthus caudatus* (Samaru Local Variety) and *Amaranthus cruentus* (NH84/452)

For *Amaranthus caudatus* (Samaru local variety), Plants treated with poultry manure at 10 t ha^{-1} gave highest values for vitamin C, iron and zinc. The plants treated with sewage sludge at 10 t ha^{-1} had the highest beta-carotene while plants treated with 70 kg ha^{-1} N.P.K compound fertilizers had higher niacin and riboflavin as shown in Fig. 3.

For *Amaranthus cruentus* (NH84/452), plants treated with 10 t ha^{-1} of sewage sludge had highest values for beta-carotene, riboflavin and iron while plants in 10 t ha^{-1} of poultry manure had higher zinc and in N.P.K, the plants had higher vitamin C and niacin as shown in Fig. 4.

Amaranthus caudatus (Samaru local variety) gave higher levels of beta-carotene, vitamin C, niacin and iron than *Amaranthus cruentus* (NH84/452). Riboflavin and zinc were higher in *Amaranthus cruentus* (NH84/452) than *Amaranthus caudatus* (Samaru local variety) as shown in Figs. 3 and 4. The 10 t ha^{-1} of poultry manure gave the highest level of vitamin C for *Amaranthus caudatus* (Samaru local variety) which was significantly ($p<0.05$) different among the treatments while plants submitted to 70 kg ha^{-1} of NPK was found to be highest for the *Amaranthus cruentus* (NH84/452) but there was no significant difference among the treatments. Similar findings were reported by Mofunanya et al. [33] on *Amaranthus spinosus* L. and Adekayode and Ogunloya [35] on amaranth in southwest Nigeria. Virtually, vitamin C was high in plants treated with organic matter content which leads to an increase in soil microbial population, while high microbial population had been reported to improve the antioxidant capacity of the soil which could lead to availability of the substrates for vitamin C biosynthesis. The high levels of vitamin C for NPK in *Amaranthus cruentus* (NH84/452) may be due to genetic variation. Beta-Carotene was observed to be highest in plants derived from 10 t ha^{-1} sewage sludge treatments for both varieties and was significantly different from the other treatments. The results of this study are in agreement with Arisha et al. [36] on pepper cultivars, Abdelrazzag [17] on onion and Mofunanya et al. [35] on *Amaranthus spinosus* L. Niacin was highest for plants treated with 70 k ha^{-1} NPK compound fertilizer for both varieties and was significantly different among the treatments. This may be attributed to high amounts of nitrogen in NPK fertilizer compared to the organic fertilizers. The high level of beta-carotene on plants treated with sewage sludge over the poultry manure may be attributed to the higher phosphorus (P) content in the sewage sludge than the poultry since the precursor of carotenoids is phytoene which is synthesized from small precursor molecules called Geranylgeranyl pyrophosphate, indicating that the phosphorus is used to synthesize Geranylgeranyl pyrophosphate [37].

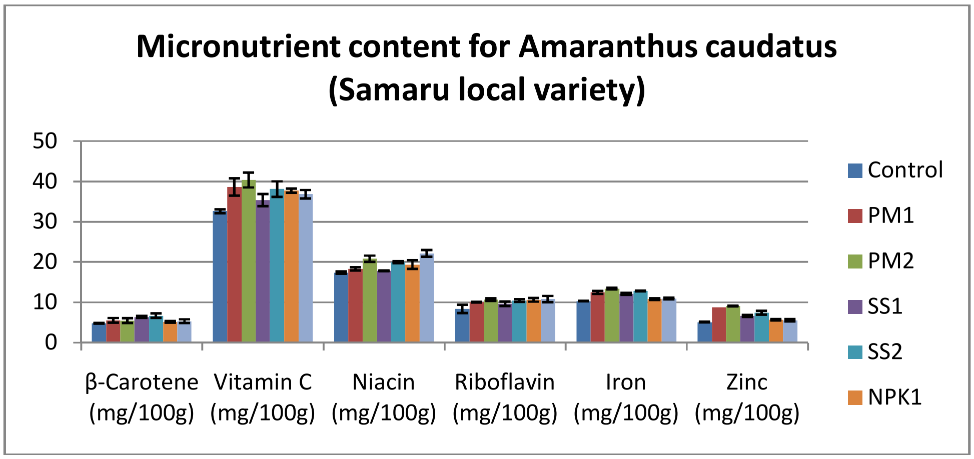

Fig. 3. Effect of organic fertilizers on micronutrient composition of *Amaranthus caudatus* (Samaru local variety)

Control = No fertilizer, PM1 = Poultry manure at 5 t ha^{-1}, PM2 = Poultry manure at 10 t ha^{-1}, SS1 = Sewage sludge at 5 t ha^{-1}, SS2 = Sewage sludge at 10 t ha^{-1}, NPK1 = NPK compound fertilizer at 35 kg ha^{-1}, NPK2 = NPK compound fertilizer at 70 kg ha^{-1}. Chart represents mean and standard deviation of triplicate analysis

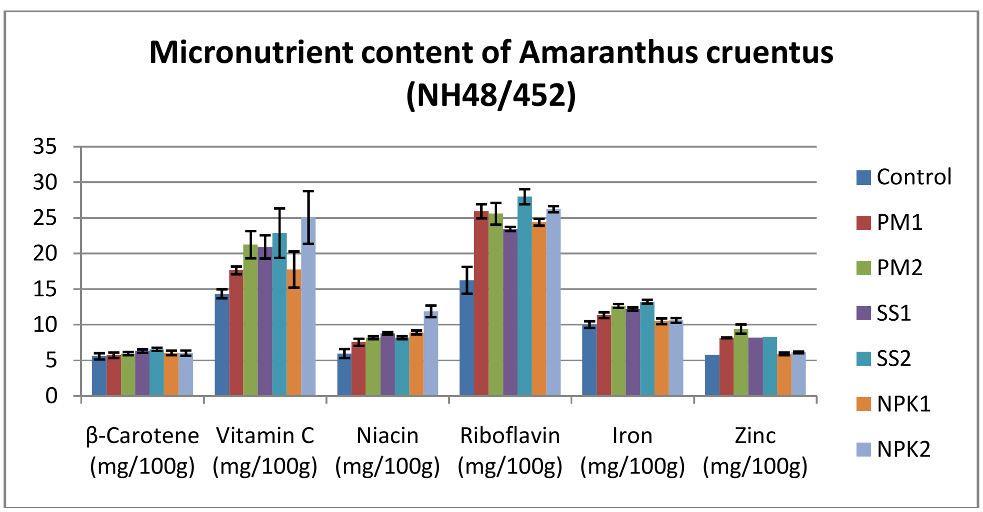

Fig. 4. Effect of organic fertilizers on micronutrient composition of *Amaranthus cruentus* (NH84/452)

Control = No fertilizer, PM1 = Poultry manure at 5 t ha^{-1}, PM2 = Poultry manure at 10 t ha^{-1}, SS1 = Sewage sludge at 5 t ha^{-1}, SS2 = Sewage sludge at 10 t ha^{-1}, NPK1 = NPK compound fertilizer at 35 kg ha^{-1}, NPK2 = NPK compound fertilizer at 70 kg ha^{-1}. Chart represents mean and standard deviation of triplicate analysis

Nitrogen is required in the synthesis of tryptophan which is an amino acid having an indole side chain containing N, tryptophan serves as the precursor of niacin. Riboflavin content was found to be highest for plants treated with 70 kg ha^{-1} of NPK compound fertilizer and 10 t ha^{-1} of sewage sludge for *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452) respectively but there were no significant difference among the treatments. The reason behind the high riboflavin content in plants from NPK compound fertilizer and sewage sludge over poultry manure may be due to the higher amounts of phosphorus in NPK and sewage sludge over poultry manure. Since riboflavin is synthesized from one molecule of guanosine triphosphate and two molecules of ribulose-5-phosphate, both substrates containing phosphate backbone produced from phosphorus [38].

In all treatments, fertilization resulted in significant effects in mineral composition of the leaves of *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452). There were relatively higher Zn and Fe contents in plants produced from poultry manure and sewage sludge, there were significantly ($p<0.05$) different from the plants treated with NPK compound fertilizer. Similar results were reported by Masarirambi et al. [11] on effect of organic fertilizers on growth, yield, quality and sensory evaluation of red lettuce (*Lactica sativa* L.) "Veneza Roxa". The higher level of Zn and Fe from the organic fertilizers compared to the NPK fertilizer can be attributed to the balance quantity of nutrients in the poultry manure and sewage sludge. Magkos et al. [39] reported that although a small number of studies have been published, slightly higher contents of minerals such as Fe and Zn have been obtained in organic vegetables.

3.5 Anti-nutrients Composition of *Amaranthus caudatus* (Samaru Local Variety) and *Amaranthus cruentus* (NH84/452)

For *Amaranthus caudatus* (Samaru local variety), 10 t ha^{-1} of poultry manure treatment had the highest level of tannins at 0.64 ± 0.08% and the control treatment had the lowest tannins content at 0.33 ± 0.08% while the phytate level was significantly ($p < 0.05$) different from the control. With the 70 kg ha^{-1} of NPK compound fertilizer having the highest level at 0.94 ± 0.05% and the lowest level at 0.40 ± 0.07 for the control treatment as shown in Table 3.

Saponins level was significantly highest in the treatment with 10 t ha^{-1} of sewage sludge with value of 2.30 ± 0.18% and the control treatment had the lowest level at 1.36 ± 0.11%. The 10 t ha^{-1} of poultry manure and 5 t ha^{-1} of sewage sludge treatments had the highest level of oxalate at 0.96 ± 0.11% and 0.96 ± 0.05% respectively while the control treatment had the lowest level at 0.61 ± 0.06% as shown in Table 3.

For *Amaranthus cruentus* (NH84/452), plants derived from 10 t ha^{-1} of poultry manure had the highest level of tannins with value of 0.69 ± 0.14% but there was no significant ($p<0.05$) difference among the treatments. Phytate level was significantly different from the control in plants from the 35 kg ha^{-1} and 70 kg ha^{-1} NPK compound fertilizer having the highest levels at 0.90 ± 0.04% each. The 10 t ha^{-1} of sewage sludge treatment had the highest levels of saponins and oxalate with values of 2.09 ± 0.23% and 1.01 ± 0.06% respectively, which was significantly ($p<0.05$) different from the control treatment as shown in Table 4.

Table 3. Effect of organic fertilizers on anti-nutrient composition of *Amaranthus caudatus* (Samaru local variety)

Anti-nutrients content on *Amaranthus caudatus* (Samaru local variety)				
Treatments	**Tannins (%)**	**Phytate (%)**	**Saponins (%)**	**Oxalate (%)**
Control	0.33 ± 0.08^{a}	0.40 ± 0.07^{a}	1.36 ± 0.11^{a}	0.61 ± 0.06^{a}
PM1	0.60 ± 0.16^{ab}	0.58 ± 0.05^{b}	1.71 ± 0.13^{ab}	0.81 ± 0.05^{b}
PM2	0.64 ± 0.08^{b}	0.66 ± 0.06^{bc}	2.04 ± 0.26^{bc}	0.96 ± 0.11^{c}
SS1	0.51 ± 0.16^{ab}	0.63 ± 0.04^{bc}	2.06 ± 0.36^{bc}	0.96 ± 0.05^{c}
SS2	0.60 ± 0.08^{ab}	0.68 ± 0.02^{c}	2.30 ± 0.18^{c}	0.92 ± 0.05^{c}
NPK1	0.51 ± 0.29^{ab}	0.82 ± 0.06^{d}	1.35 ± 0.07^{a}	0.70 ± 0.03^{ab}
NPK2	0.60 ± 0.16^{ab}	0.94 ± 0.05^{e}	1.55 ± 0.47^{a}	0.72 ± 0.06^{ab}

Control = No fertilizer, PM1 = Poultry manure at 5 t ha^{-1}, PM2 = Poultry manure at 10 t ha^{-1}, SS1 = Sewage sludge at 5 t ha^{-1}, SS2 = Sewage sludge at 10 t ha^{-1}, NPK1 = NPK compound fertilizer at 35 kg ha^{-1}, NPK2 = NPK compound fertilizer at 70 kg ha^{-1}. Values are mean ± standard deviation of triplicate analysis

Table 4. Effect of organic fertilizers on anti-nutrient composition of *Amaranthus cruentus* (NH84/452)

Anti-nutrients content on *Amaranthus cruentus* (NH84/452)				
Treatments	**Tannins (%)**	**Phytate (%)**	**Saponins (%)**	**Oxalate (%)**
Control	0.37 ± 0.16[a]	0.43 ± 0.03[a]	1.29 ± 0.09[a]	0.53 ± 0.04[a]
PM1	0.60 ± 0.08[a]	0.58 ± 0.08[b]	1.67 ± 0.24[bc]	0.85 ± 0.05[bc]
PM2	0.69 ± 0.14[a]	0.60 ± 0.12[bc]	1.46 ± 0.30[ab]	0.95 ± 0.07[cd]
SS1	0.64 ± 0.21[a]	0.70 ± 0.03[cd]	1.89 ± 0.16[cd]	1.00 ± 0.04[d]
SS2	0.64 ± 0.21[a]	0.72 ± 0.06[d]	2.09 ± 0.23[d]	1.01 ± 0.06[d]
NPK1	0.55 ± 0.28[a]	0.90 ± 0.04[e]	1.52 ± 0.11[ab]	0.75 ± 0.08[b]
NPK2	0.65 ± 0.21[a]	0.90 ± 0.04[e]	1.47 ± 0.05[ab]	0.76 ± 0.13[b]

Control = No fertilizer, PM1 = Poultry manure at 5 t ha^{-1}, PM2 = Poultry manure at 10 t ha^{-1}, SS1 = Sewage sludge at 5 t ha^{-1}, SS2 = Sewage sludge at 10 t ha^{-1}, NPK1 = NPK compound fertilizer at 35 kg ha^{-1}, NPK2 = NPK compound fertilizer at 70 kg ha^{-1}. Values are mean ± standard deviation of triplicate analysis

The observed high level of tannins with poultry manure that showed no significant (p<0.05) difference among the treatments for both varieties except for the control is in agreement with the findings of Mofunanya et al. [33] on *Amaranthus spinosus* L. Tannins are synthesized from gallic acid with a carbohydrate usually glucose, It is found in a number of plants and stem bark [40] And could be found present in poulty manure due to constant use of saw dust as bedding. whereas gallic acid is derived from 3-dehydoshikimic acid which comes from glyceraldehydes-3-phospahte via the Calvin cycle. The insignificant difference observed for tannins among the fertilizers may be due to moderate contribution of phosphorus to its synthesis including other biomolecules like carbohydrate [41].

The plants from plots treated with 70 kg ha^{-1} NPK compound fertilizer showed the highest values for phytate for both varieties and were significantly (p<0.05) different among the treatments. This may be due to higher amount of phosphorus in the NPK compound fertilizers which are soluble and readily available to the plants. Phosphorus is a key component of phytate which is also known as inositol hexakisphosphate. Phytate was observed to be higher in plants treated with sewage sludge than poultry manure; this is evident in the higher phosphorus content of sewage sludge over poultry manure during fertilizer analysis. Saponins and oxalate contents were higher in plants derived from plots treated with sewage sludge compared to the other fertilizers. This may be as a result of presence of considerable high levels of glycosides, triterpene and some other sugar units in the sewage sludge which are responsible for the synthesis of saponins and oxalate [42].

4. CONCLUSION

The result of this present study justifies the use of some organic fertilizers over chemical fertilizer due to increased level of nutrients. In *Amaranthus caudatus*, it could be seen that the use of poultry manure resulted in the highest content of Ash, fat, crude fibre, vitamin C, iron and zinc with sewage sludge giving the highest value for B-carotene, while the NPK only produced highest values for protein, niacin and riboflavin, also in *Amaranthus cruentus*, poutry manure produced the highest values for Ash, moisture, fat, crude fibre and zinc. Sewage sludge produced highest values of B-carotene, riboflavin and iron while NPK gave highest values for protein, energy, niacin and vitamin C. Organic and chemical fertilizers increased the nutrients composition of both *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452) with organic fertilizers showing the highest values. However, the result of this present study fails to justify the elevated level of anti-nutrients and heavy metals seen in the organic fertilizer treatments. Sewage sludge had higher effect on the elevated level of anti-nutrients composition on *Amaranthus caudatus* (Samaru local variety) and *Amaranthus cruentus* (NH84/452).

5. RECOMMENDATION

Beyond the common application of organic manures as fertilizers, this research has demonstrated the efficacy of 10 t ha^{-1} poultry manure to improve the levels of many nutrients in

Amaranth. Hence it's recommended for farmers to use to obtain relatively higher yields.

Since both the organic and chemical fertilizers showed improved growth and nutrient content, it is recommended that further research should be made by mixing these fertilizers in varying rates so as to further reveal their effects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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