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# Influence of Organic and Inorganic Manures on Macro-Nutrients, Micro-Nutrients and Anti-Nutrients in two *Amaranth* spp in Kiambu Couny, Kenya

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author KT designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TW and PGOJ managed the analyses of the study. Author PGOJ managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

An experiment was carried out to investigate the influence of organic and inorganic manure on macronutrients, micronutients and antinutrients in two Amaranth spp. The experimental design was Randomized Complete Block Design (RCBD) in a factorial arrangement with three replicates, consisting of three factors which are *A. tricolar* and *A. cruentus Amaranth spps*, three rates of NPK Compound fertilizer 17-17-17 at 0, 250 kg ha$^{-1}$ and 500 kg ha$^{-1}$.Three rates of quail organic manure at 8.45 t ha$^{-1}$,16.9 t ha$^{-1}$ and control (no fertilizer applied). Secondary metabolites were also investigated in the two amaranth species. The experiment was carried for two seasons. The result showed that, Nitrogen increased from 1.87% at control to 2.27% when 16.9 t ha$^{-1}$+250kg ha$^{-1}$ was applied in *A. cruentus* variety and at the same rate, *A. tricolor* had 1.79%, 2.93% at control and16.9 t ha$^{-1}$+250 kg ha$^{-1}$ respectively. In season one, at 16.9 t ha$^{-1}$+250 kg ha$^{-1}$ Nitrogen in *A. cruentus* increased from 2.27% to 2.73% but in *A. tricolor* the nitrogen content increased to 2.98% in the second season. The highest potassium was 1.03% in *A. cruentus* and the same variety recorded the

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highest potassium of 1.04% in the second season at 8.45 t $ha^{-1}$ +500 kg $ha^{-1}$.Iron increased from 69.58% at 16.9 t $ha^{-1}$+250 kg $ha^{-1}$ to 191.2% when 8.45 t $ha^{-1}$+500 kg $ha^{-1}$ of NPK was applied in *A. cruentus*. *A. cruentus* in season one at 8.45 t $ha^{-1}$ +500 kg $ha^{-1}$ had 40.33GAE/kgDM total phenolic content whereas *A. tricolar* at the same application had 40.67gGAEkg/DM, in season two *A. cruentus* had the highest total phenolic compound of 42.33 g GAE/kgDM. *A. tricolor* had 4.04 mg/100 gfw of oxalate in season one, in season two, *A. cruentus* had 3.25 mg/100 gfw whereas *A. tricolor* had 3.15mg/100gfw in season two.

*Keywords: Amaranth spp; secondary metabolites; soil chemical properties.*

## 1. INTRODUCTION

Amaranth is a popular leafy crop grown and consumed in many parts of the world. It is a highly nutritious food rich in protein, vitamins, carbohydrates and mineral salts [1]. The leaves, shoots and tender stems are eaten as a potherb in sauces or soups, cooked with other vegetables, with a main dish or by itself. The seed or grain is also edible [2]. Chopped plants have been used as forage for livestock. It was reported through the ECHO network that goats fed with amaranth forage, consistently bore twins and, the flowers make nice ornamentals while fresh or dried. Amaranth leaves and stems, or entire plants may be eaten raw or cooked as spinach or greens. The results study act as a basis for advising farmers on use of the orphaned vegetable that is highly yielding, highly nutritive and matures within a short time. it is a source of scientific facts on the effects of organic and inorganic manure on overall crop production. The research identified and recommended the proper rate of quail manure per hectare. This also will also assist government and extension policymakers on efficient production of amaranth using organic quail manure. There are some disagreement over the value of animal manures in crop production [3]. They observed that organic matter content of the soil offers the best index of the productivity and value of agricultural land. In an Alabama study measuring the separate and combined effects of irrigation, organic materials, and fertilizer rates, there was an increase in the average yield of 11 vegetable crops by 2,752 pounds per acre by irrigation, organic material by 4,987 pounds, and higher fertilizer rates by 3,127 pounds. Animal manures have been used for plant production effectively for centuries. Chicken manure has long been recognized as perhaps the most desirable of these natural fertilizers because of its high nitrogen content [4]. In addition, manures supply other nutrients that serve as soil amendments by adding organic matter [5]. Organic matter persistence in soil will vary with temperature, drainage, rainfall and other environmental factors. Arisha and Bradisi [6] argued that organics matter in soil improves moisture and nutrient retention and soil physical properties. The utilization of manure is an integral part of sustainable agriculture. Poultry manure is often produced in areas where it is needed for pastures and crop fertilization. The increased poultry operations make poultry manure available in sufficient quantities and on timely basis to supply most fertilizer needs [4]. When properly applied, poultry manure can be a valuable resource for grass, small grains and other crop production. The economics of using poultry manure varies considerably. Poultry litter is made out of raw poultry manure and bedding materials such as sawdust, wood shavings, grass cuttings, banana leaves or rice husks. These combinations provide an excellent source of nitrogen (N), phosphorus (P), potassium (K) and sulphur (S).

## 2. QUALITATIVE INFLUENCE OF POULTRY MANURE ON PLANT NUTRIENTS

Poultry manure contains nitrogen that is very essential for the growth of leaves, as it enhances vegetative growth which is very crucial, especially in plants where leaves are the source of food, for instance in case of amaranth, cabbages and kales. Nitrogen is a nutrient essential in the formation of the chlorophyll molecule, giving the leaf its deep green colour. As chlorophyll increases, the rate of photosynthesis increases, hence the food is available to plants making it to have a high growth rate that consequently increases the leaf size of the plant [7]. Poultry manure also contains potassium that is an essential element in the formation of chlorophyll. Potassium is essential for carbohydrates formation that occurs in the leaves of plant through photosynthesis; consequently increasing the leaf size [8]. Magnesium is also an essential element required in the formation of the chlorophyll molecule that is critical for the growth of leaves as well as the whole plant since it is responsible for carbohydrate metabolism [8]. Sulphur is essential to the plant it influences the physiological process of plants for instance chlorophyll formation as well as carbohydrate metabolism that are critical for increasing the leaf size of the plant [8]. Calcium is responsible for strengthening cell wall in the plant cells with calcium acetate. It is also required for the formation of the middle lamellae of the leaf as well as for increasing the protein content in the mitochondria to enhance metabolic processes. Therefore, calcium is responsible for the development of the leaf that translates to increase in the leaf size [8]. Carbon, hydrogen as well as oxygen are the raw materials for photosynthesis where the leaves of plant are able to manufacture carbohydrates in the process of chlorophyll as well as sunlight this consequently leads to growth hence increase in the leaf size of plants [8]. Micronutrients such as copper, molybdenum and iron are crucial in enzymatic systems responsible for oxidation as well as reduction chemical reactions in plants. Copper is a nutrient element that is crucial the respiration process in addition, it aids in the utilization of iron. Iron on the other hand is responsible for synthesis of chloroplast that is an essential in the leaves of plants. Molybdenum as well as manganese is critical for specific nitrogen transformation in plants. In addition, molybdenum an element that is required for nitrogen fixation, it required to metabolize amino acids as well as proteins from nitrates [9]. All these micronutrients are critical in ensuring increase of the leaf size [10]. Poultry manure is crucial to the root of a plant especially in regards to its size.

Poultry manure contains phosphorus that is critical for the development of roots, as phosphorus increases the length of the root consequently increases. Root elongation is due to enhanced cell division as phosphorus is an essential constituent of the nucleoproteins responsible for cell division [11].

Magnesium ensures that carbohydrates are metabolised after which these foods undergo translocation to roots where they are stored increasing the diameter of the root. Potassium in poultry manure is critical as it aids in translocation of carbohydrates from the leaves to the various parts of the plant as required by the plant this consequently leads to increase in the length of the root. Magnesium plays a significant role in the metabolism of carbohydrates that enhance growth consequently expanding the root length of plants [8]. Sulphur is available to plant in the form of sulphate ion that enables uptake of this element by the roots. It plays a major role in the formation of plant proteins as well as plant hormones. It is also responsible for the activation of coenzymes, which are critical in the undertaking of growth and development of a plant that leads to increase in root length [8]. Calcium is a very important nutrient element as it stabilises the soil pH making nutrient such as nitrogen, potassium and phosphorus available to plants. Calcium is a crucial element in cell division that leads to increasing in root length [8].

Zinc is a micronutrient that is responsible for the formation of particular growth hormones of the plant, this growth hormone responsible for bringing about increase in the root length as the plant undergoes growth and development [10]. The macronutrients found in poultry manure affect the diameter of the roots of a plant. For instance, phosphorus increases root diameter of a plant due to the increase in dry matter when metabolic activities increase. Phosphorus enhances metabolic process such as respiration, synthesis of carbohydrates, protein as well as fat formation, brings about increase in the root's dry matter [11]. Potassium is also an important element as it aids in translocation of carbohydrates to the root area ensuring that the diameter of the root increases. Growth and development brought about by the various physiological processes that sulphur elements influence consequently leads to increase in the girth of the root, of the plant. Calcium is an element that encourages the increase in the diameter of the root as it a critical requirement in the cell division process [11]. Poultry manure also contains micronutrient responsible for the increase in the root diameter, boron is a nutrient involved in water absorption as well as translocation of sugar in plants consequently increasing the root diameter [10].

### 2.1 Anti-nutrients in Amaranths

Vegetables contain anti-nutritional factors that can affect the availability of nutrients to the human body. These anti-nutritional factors interfere with metabolic processes and reduce the bioavailability of nutrients from plants or plant products used as human foods [12,13]. Plants generally contain chemical compounds (such as saponins, tannins, oxalates, phytates, trypsin inhibitors and nitrates) which are known as secondary metabolites and are biologically active

[14]. most of the reported anti-nutritional factors in amaranth are phenolics, saponins, tannins, phytic acid, oxalates, protease inhibitors, nitrates and polyphenols. Of these, oxalates, phytates and nitrates are of more concern.

## 2.2 Oxalates

Amaranth is one of the vegetables that have been documented to accumulate high amounts of oxalic acid [15]. The amount of oxalic acid is almost the same as that found in spinach (*Spinacia oleracea*). Excessive amounts of oxalic acid may reduce the availability of certain minerals in the body, most notably calcium. This could be a concern especially if calcium intake levels are low to begin with, or if foods high in oxalic acid are consumed on a regular basis over long periods of time. Oxalates occur in many plants where it is synthesized through incomplete oxidation of carbohydrates.

In the body, oxalic acid combines with divalent metallic cations such as calcium ($Ca^{2+)}$ and iron (II) ($Fe^{2+)}$ to form crystals of the corresponding oxalates which are then excreted in urine as minute crystals. These oxalates are known to form insoluble calcium oxalate with calcium thereby preventing the absorption and utilization of calcium by the body hence causing diseases such as rickets and osteomalacia [16,17].

Accumulation of this insoluble compound over a long period in the renal glomeruli leads to the formation of renal calculi and kidney damages [18,19]. Accumulation of oxalates appear to be related to nitrate assimilation and cation-anion imbalance [20] Oxalates have a possible role in pest resistance, Calcium oxalate, an important constituent in leaf extract of elephant foot yam (*Amorphophalus campanulata*) has been reported to block growth and aflatoxin biosynthesis in *Aspergillus flavus*. [21].

## 2.3 Metabolism and Absorption of Oxalates

Oxalate combine with calcium to form calcium oxalate in the lumen; making calcium unavailable for absorption. The calcium oxalate is later excreted in feaces. Free or soluble oxalate is absorbed by passive diffusion in the colon in humans [22,23]. Other studies also suggest that the small intestine is the major absorption site rather than the colon [24]. It has been estimated that about 2-5% of the total oxalates administered is absorbed in the body; while its absorption is higher at lower doses [25].

## 2.4 Toxic Effects of Oxalates

Minimum doses that can lead to death are 4-5 g of oxalate [20]; whereas other studies show that 10-15 g is the usual dose that causes fatalities. Ingestion of oxalic acid results in corrosion of the mouth and the gastrointestinal tract; gastric haemorrhage; renal failure and haematuria [26]. High oxalate levels may interfere with carbohydrate metabolism.

Oxalate content has been reported to increase as plant ages [27], sometimes, it can accumulate up to 15% of the total dry weight. Other studies suggest that the accumulation of oxalates in plant tissues could be attributed to a shift in equilibrium towards biosynthesis rather than to degradation [28]. Accumulation of oxalate also appears to be related to nitrate assimilation and cation- anion imbalance [20].

## 2.5 Effects of Oxalates on Bioavailability of Minerals

Oxalates inhibit calcium absorption by binding it to form calcium oxalate [29]. Adverse effects are considered in terms of oxalate: calcium ratio, [20]. Oxalates also cause mineral imbalances in the body. Intake of oxalates plus fibre causes negative balance of calcium, magnesium, zinc, and copper [30]. Decreased mineral balance may be due to the combined effects of high fibre intake and oxalic acid, but this may be only a transient response [31].

# 3. MATERIALS AND METHODS

The study was carried out at Kiambu county, the county has an altitude of 1520-1760.m above sea level. The area had minimum temperatures of 12°C and maximum of 24.6°C. The rainfall range was aggregate 1100mm and the distribution pattern is bimodal. The long rains were experienced between March to May and the short rains between Octobers to December. The area had dark reddish brown to dark brown loam.

## 3.1 Analyses of Micro and Micro Nutrients

At 45 days after planting, amaranths plant were uprooted. The shoot and root parts of each sampled plant was washed with clean water, bagged in brown envelope and labeled. The samples were dried in the oven at 75°C until constant weight was recorded. The dried plant samples were ground with a Willey mill to pass through 0.5 mm sieve. The ground samples were digested with 25: 5:5 ml nitricperchloric– acid mixtures with exception of total N [32]. Total N was determined by Microckjedahl procedure. Phosphorus was determined colormetrically by the vanadomolybdate method. Potassium and Ca were determined on flame photometer while Mg was determined using atomic absorption spectrophotometer. For micronutrients ($Fe^{2+,}$ $Cu^{2+,}$ $Zn^{2+}$ and $Mn^{2+)}$ were read on AAS.

## 3.2 Analyses of Anti-nutrients

The total phenolics were determined by an assay described by Shetty *et al*, [33]. Briefly, one milliliter of ethanoic extract was transferred into a test tube and mixed with 5ml of distilled water. To each sample 0.5ml of 0.2N (v/v) Folin-Ciocalteu reagent was added and mixed. After 5min, 1.5ml of 5% $Na^2CO^3$ was added to the reaction mixture and allowed to stand for 60 min. The absorbance was read at 765nm. The absorbance values were converted to total phenolics and were expressed in milligrams equivalents of garlic acid per grams dry weight (DW) of the sample. Standard curves were established using various concentrations of garlic acid in 95% ethanol.

## 3.3 Analyses of Oxalates

This was done by HPLC analysis method [34]. Aliquots of 0.2–0.5g sample was homogenized in 1–4 ml of 0.5 N HCl. The homogenate was heated at 80 °C for 10 min with intermittent shaking. To the homogenate distilled water was added up to a volume of 5–25 ml. About 2–3 ml of the solution was withdrawn and centrifuged at 12 000 rpm for 10 min. About 1 ml of supernatant was passed through a filter (0.45 μm) before HPLC analysis. Standards were prepared at varying concentrations for quantification. Hypsil C18 column (5 μM, 4.6 mmx250 mm) equipped Waters 550 was used as the static phase and the mobile phase was a solution containing 0.5% $KH_2PO_4$ and 0.5 mM TBA (tetrabutylammonium hydrogen sulphate) buffered at pH 2.0 with orthophosphoric acid. Flow rate was 1 ml min–1 and detection wavelength was at 220 nm.

# 4. RESULTS AND DISCUSSION

## 4.1 Effect of Organic and NPK(17-17-17) on the Micronutrients, macronutrients and Anti-nutrients of two Amaranth Species

Application rates significantly (P≤0.05) influenced the content of some chemical properties of the two varieties. A study by Akanini and Ojenini 2007 observed that poultry manure increased uptake of macro and micro nutrient due to increased organic matter. The effect of combination of quail manure and NPK fertilizer on nutrient concentration in amaranth in the two seasons. The macro and microelements increased above the control treatment at control calcium recorded 2.05%,3.08% at 16.9t $ha^{-1}$ +500kg $ha^{-1}$ for *A. cruentus* and *A. tricolar* recorded 2.23% at control and 2.57% at 16.9 t $ha^{-1}$ + 500 kg $ha^{-1}$ in season one (Table 4) in season two the amount of the highest Calcium was 2.25 in *A. cruentus* at 16.9t/h +500 kg $ha^{-1}$.The study of Ayeni et al., [35] showed that poultry manure increased uptake of N, P, CA, Mg, Zn, Fe and Cu, in maize. This is consistent with the current study that poultry manure enhanced nutrient status in amaranth. Potassium level increased from 1.03% when 8.45 t $ha^{-1}$+500 kg $ha^{-1}$ was applied for *A. cruentus* to 1.85% when 16 t ha-$^{1}$+500 kg $ha^{-1}$ was applied in *A. cruentus* level increased in season one (Table 5). Ojenini et al. (2009) observed that poultry manure increased tissue Nitrogen, Potassium and Phosphorous in tomatoes, they also observed that it also increased intake of Nitrogen, Phosphorous, Calcium and Magnesium in the tomato plant. Quail manure have cation exchange sites (Okanine et al., 2007), so micronutrient organic matter is known to form chelate with micro-nutrients, increasing availability of micronutrients like Fe, Cu, Zn and Mn and are mostly available when there is reduced soil pH, micro nutrients cations are soluble and available under acidic conditions [36]. Zinc was 28.5 mg/kg in *A. cruentus*, 28.5 mg/kg in *A. tricolor* at 16 t $ha^{-1}$ +500 kg $ha^{-1}$ recording the highest in season one, it increased to 34.5 mg/kg in *A. tricolor* in season two.

A combined integration of organic and inorganic ensured availability of essential nutrients, the trend in the data shows that to maximize nutrient status in the plant tissue NPK fertilizer should be combined with poultry manure. The higher macro and micro elements in season two could be due to higher nutrients dissipated from the organic fertilizer over the two seasons, also due to improvement of soil physio-chemical properties like increased water infiltration rate, and retention soil aggregate and nutrients stabilizers [36]. Organic fertilizer application rate significantly influenced the phosphorus, sulphur, calcium, magnesium and manganese content of the two *Amaranth* spp.

**Table 1. Chemical composition of quail manure used**

| Total N % | Total O. Carbon % | Phosphorus ppm % | Potassium me% | pH | Calcium me% | Magnesium me % | Manganese me% | Copper ppm% | Iron ppm% | Zinc ppm % | Sodium me% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4.5 | 5.3 | 9.748 | 1.3 | 6.4 | 3.2 | 0.29 | 0.089 | 20 | 460 | 900 | 0.08 |

**Table 2. Chemical properties of soil at the experimental site before the experiment**

| Total N % | Total O. Carbon % | Phosphorus ppm % | Potassium me% | pH | Calcium me% | Magnesium me % | Manganese me% | Copper ppm% | Iron ppm% | Zinc ppm% | Sodium me% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.07 | 0.74 | 6 | 0.9 | 5.2 | 1.7 | 0.73 | 0.16 | 15.98 | 59.3 | 9.02 | 0.16 |

**Table 3. Symbols for Treatment Combinations**

| Treatment number | Variety | Quail manure | NPK (17-17-17) rate | Symbol |
|---|---|---|---|---|
| 1 | V1 | 0 | 500 | V1Q0N2 |
| 2 | V1 | 8.45 | 500 | V1Q1N2 |
| 3 | V1 | 16.9 | 500 | V1Q2N2 |
| 4 | V1 | 0 | 250 | V1Q0N1 |
| 5 | V1 | 8.45 | 250 | V1Q1N1 |
| 6 | V1 | 16.9 | 250 | V1Q2N1 |
| 7 | V1 | 0 | 0 | V1Q0N0 |
| 8 | V1 | 8.45 | 0 | VIQ1N0 |
| 9 | V1 | 16.9 | 0 | V1Q2N0 |
| 10 | V2 | 0 | 500 | V2Q0N2 |
| 11 | V2 | 8.45 | 500 | V2Q1N2 |
| 12 | V2 | 16.9 | 500 | V2Q2N2 |
| 13 | V2 | 0 | 250 | V2Q0N1 |
| 14 | V2 | 8.45 | 250 | V2Q1N1 |
| 15 | V2 | 16.9 | 250 | V2Q2N1 |
| 16 | V2 | 0 | 0 | V2Q0N0 |
| 17 | V2 | 8.45 | 0 | V2Q1N0 |
| 18 | V2 | 16.9 | 0 | V2Q2N0 |

*KEY: V1 =Variety A. cruentus, V2= Variety A. tricolor, Q0=0 t/ha, Q1=8.45 t/ha, Q2=16.9t/ha, N0=0 kgha$^{-1}$ , N1= 250 kgha$^{-1}$ , N2=500 kgha$^{-1}$*

## 4.2 Nitrogen

The highest quail manure rate and the 250 kg $ha^{-1}$ NPK rate showed significantly (P≤0.05) the highest nitrogen content in the amaranth plant tissues with 2.93% on the *A.tricolor* variety during the first season and 2.98% during the second season. For both seasons, the lowest nitrogen content in the plant tissues was observed in the controls with as low as 1.21% on the *A. cruentus* variety and 1.82% on the A. tricolor variety. The nitrogen content of amaranth increased with quail manure applications in season two while the NPK fertilizer only marginally increased the nitrogen content. In season one the nitrogen content increased with increase in NPK rate, this is because quail manure dissipate nutrients very fast unlike the inorganic that dissipate nutrients slowly over a long period [36]. *A. cruentus* that received 8.45t $ha^{-1}$ of quail manure compost contained significantly more nitrogen than the other organic treatments including *A. cruentus* that did not receive any organic fertilizer. In a study conducted by Warman and Havard [37] where chicken manure (170 kg N $ha^{-1}$) was applied over a period of 3 years, the nitrogen content of spinach significantly increased compared to Spinach grown in inorganic fertilized soil. The NPK increased the nitrogen content in season one above the control, the highest being 2.199%, the amount was increased at a decreasing rate in the second season, the lowest being 2.009% of *A. tricolar*.

## 4.3 Phosphorous

It is the second important nutrient required by plants its important component of nucleic acid, lipid and proteins which control plants life processes, Lampkin [38]. The amount of phosphorus in the plant tissue was significantly influenced by organic and NPK treatments. The highest phosphorus content was at 0.466% in *A. cruentus* in season two while treated with 16.9t/ha. The highest application rates (16.9 t ha-1). (Table 5) of poultry manure significantly increased the phosphorus content (0.449% and 0.466%) in season two of *A. cruentus* and *A. tricolar* respectively. According to Lairon et al., [39] the phosphorus content of potatoes and carrots treated with organic fertilizer for two seasons was higher than those treated with NPK. In season two phosphorus content of amaranth was significant increased by the organic fertilizer, *A. cruentus* had 0.466% and *A. tricolor* had 0.449% at 16.9 t $ha^{-1}$at 8.45 t ha-$^{1}$whereas *A. tricolar* had 0.364% but *A. cruentus* had 0.364% due to application of NPK + 500 $kgha^{-1}$ (Table 5).

## 4.4 Calcium

A maximum of 3.08% calcium was recorded under the highest rate of quail manure and NPK on the *A. cruentus* variety with the lowest being observed on the control of *A. cruentus* variety. Both organic fertilizer and application rates significantly (P≤0.05) influenced the calcium content of the two amaranth spp. As the organic fertilizer rate increased the calcium content of the two species increased compared to the amaranth that did not receive any organic treatment *A. cruentus* had 2.591% at 16.9t ha-1 and *A. tricolar* had 2.474% in season one (Table 4) in season two *A. tricolar* had a higher calcium content of 2.279% in comparison with *A. cruentus* which had 2.266% at the same treatment (Table 5). Calcium significantly decreased irrespective of the application rate when the amount of NPK was increased from 250 kg $ha^{-1}$ to 500 $kgha^{-1}$ the two seasons. Although the unfertilized soil still had the lowest amount of calcium, 0.231% in *A. cruentus* and 0.228%. *A. tricolar*. The amount of calcium was further decreased in the second season in the soils that were treated with organic quail manure, Lampkin [38] found high calcium levels in organic grown products than inorganic grown ones. Increase in acidity decrease calcium uptake, the absorbed calcium combine with oxalate forming calcium oxalate making the calcium unavailable to the plant [40].

## 4.5 Iron

Iron content of *A. cruentus* was significantly (P≤0.05) lower in the two seasons that received both quail and NPK fertilizers in comparison with *A. tricolor* that was fertilized with the two different types of fertilizer in the two seasons, but where the soil was unfertilized in the two seasons the iron content was much lower. *A. cruentus* had the highest iron of 68.52% while treated with 250 kg $ha^{-1}$ of NPK whereas the highest in *A. tricolor* was 173% while treated at the same rate of NPK. It was observed that the iron content in the amaranth that received organic fertilizer increased with increase in addition of the manure but at a very low margin, the conventionally grown amaranth had higher iron content in season one than *A. tricolor* variety of amaranth grown at 250 kg $ha^{-1}$ of NPK had 172% in the first season followed by 173.7% fertilized with 500 kg ha-$^{1}$ in the second season which is contrary to Smith [41] and Worthington (1998) who reported a higher iron content in organic grown vegetables in comparison with inorganic NPK grown vegetables.

### 4.6 Sodium, Potassium, Copper and Zinc

In season one the amount of sodium was not significantly affected (P≤0.05) due to the treatment of quail and NPK fertilizers. The highest amounts of sodium was at the unfertilized soil with 0.063 mg/kg followed by quail manure at 8.45t $ha^{-1}$ and the least of the sodium was 0.004 mg/kg in *A. tricolor* at 16.9 t/ha in season two. The highest amount of copper and zinc in season one were recorded at 250 kg $ha^{-1}$ of inorganic manure, in *A. cruentus* variety. In season two the highest amount of copper was recorded at 500 kg $ha-^{1}$ and the highest amount of zinc which was 33.9 mg/kg was recorded at 500 kg $ha^{-1}$.

The initial properties of the plant were significantly (P≤0.05) influenced during the second season and it was clear that organic fertilizer rate influenced most of the chemical properties. inorganic manure rates 250kg $ha^{-1}$ and 500 kg $ha^{-1}$ significantly increased the, copper and zinc content of the tissue especially in the second season. Quail manure significantly increased the phosphorus content of the plant tissue when compared to NPK fertilizer though in the first season NPK fertilized crops had higher phosphorous content. inorganic manure significantly increased copper and zinc content of the plant tissue more than the quail. The chemical properties of amaranth were mainly influenced by inorganic fertilizer application rates. The copper and zinc content of the two amaranth species that receive the two highest application rates (250 kg $ha-^{1}$ and 500 kg $ha^{-1}$) were significantly higher than those that did not received any inorganic fertilizer sodium content was significantly lower at the two rates application rates compared to the control. Organic fertilizer application rate 3 significantly (P≤0.05) increased the content of zinc in *A. cruentus* in comparison to the same application in *A.tricolor* in the two seasons, while the phosphorous content of amaranth that received organic fertilizer at 8.45 t/ha was significantly lower than those that did not receive any organic fertilizer.

### 4.7 Oxalates as a Result of Application of Organic and NPK

Amaranth beside providing nutrients also accumulate high levels of anti-nutritional factors e.g. oxalate [42]. Oxalates play an important role in plants like calcium regulation, plant protection and detoxification of certain metals [43], like Lead oxide and also accumulate oxalate in vivo to cope with aluminium and lead toxicity [44]. Calcium oxalate crystals act as an effective defence against chewing insects [45]. Despite their protection roles in plants Nakata in 2005 noted that high levels could be toxic to human by forming kidney stones. The number of oxalates increased with increase in treatment rates. The plants fertilised with NPK had significantly (P≤0.05) higher levels of oxalates in relation to the plants treated with the organic fertilizer in the two season, the highest oxalate amount was found in *A. tricolor* treated with NPK at 500kg $ha^{-1}$ it recorded 10.47 mg/100 gFW in season one, and the same variety had the highest amount with 11.34 mg/100gFW at the same application in season two the amount of oxalates was highly reduced in the two seasons where the was integration (Fig. 1). Anti-nutrients in amaranth like oxalic acid, nitrates and Saponins, oxalic acid reduce the availability of calcium in human beings. Oxalate in leaf were significantly affected by the different levels of the fertilizers in the two seasons, in season one mean values of data showed that NPK applied at 500 kg $ha^{-1}$ in season one had the highest amount of oxalate of 10.93 mg/100 gFW, The lowest oxalate was shown at the control, followed by quail manure that was applied at 16.9 t $ha-^{1}$ + 500 kg $ha^{-1}$ of NPK that recorded 3.13 mg/100 gFW for *A. cruentus.*

### 4.8 Phenolic Compounds

The phenolic compound was significantly (P≤0.05) influenced by the organic and NPK treatments in both seasons. The highest phenolic compound was shown on the NPK fertilized plants, and where no fertilizer was applied. The lowest phenolic compound concentration was exhibited at the highest quail manure rate (16.9 t $ha-^{1}$) with a low of 20.21 g GAE/kg on the A. tricolor variety. Phenolic are examples of secondary metabolites. Different plants produce different types of secondary metabolites. They are usually secreted when the plant is in stress full condition, due to disease and pest attack .They are not involved in plant growth.

Phenolic in amaranth is also useful in human body, Ferry et al. [46] shown that phenolic have got anticancer activities and inhibit cancer cell growth. Ryan et al. [47] noted that different plants have different reservoir for phenolic in different parts like in the roots, shoot and leaves. Faller et al. [48] total phenolic were higher in convectional onions than organic onions, NPK reduce antioxidant levels but organic fertilizers increase its levels contrary to this study, [49] all shown that phenolic had anticancer activities that are able to inhibit cancer cell growth. Total phenolic contents in the leaves were significantly affected (P≤0.05) by the different levels of the fertilizers, highest mean values showed maximum leaf total phenolic compound on plants with 8.45t $ha^{-1}$+500kg $ha^{-1}$ in season one and at 8.45 t $ha^{-1}$ +500 kg $ha^{-1}$ in season two. *A. cruentus* in season one at 8.45 t $ha^{-1}$ +500kg $ha^{-1}$ had 40.33GAE/kgDM in season one whereas *A. tricolar* at the same application had 40.67gGAEkg/DM.The minimum phenolic in season one was at 0 t $ha^{-1}$ 0f the organic + 0 kg $ha^{-1}$ of NPK, 25.67gGAE/kg/DM for *A. cruentus* and 24.67 gGAE/kgDM for *A. tricolor*, in season two the highest amount was recorded *A. cruentus* variety which had 43.33gGAE/kg/DM in season one and in season two it had 42.78gGAE/kg/DM (Table 9).

**Table 4. The interaction effect of variety, NPK rates and quail manure rates in the two amaranth species on plant tissue macro and micronutrients properties during the first season**

| Variety | NPK | Manure | N % | P % | Ca % | K % | Fe (mg/k |
|---|---|---|---|---|---|---|---|
| A. cruentus | 0 t/h | 0 kg/ha | 1.87c | 0.37b | 2.05c | 0.6c | 50.73c |
| | | 250 kg/ha | 1.87c | 0.36b | 2.09c | 0.88ab | 63.40b |
| | | 500 kg/ha | 2.58a | 0.40a | 2.59a | 0.89ab | 66.06ab |
| | 8.45 t/ha | 0 kg/ha | 2.00b | 0.37b | 2.07b | 0.87ab | 65.51ab |
| | | 250 kg/ha | 2.13a | 0.36b | 2.23ab | 0.87ab | 65.77ab |
| | | 500 kg/ha | 2.16a | 0.39a | 2.38ab | 1.03a | 64.10ab |
| | 16.9 t/ha | 0 kg/ha | 2.03b | 0.38b | 2.35ab | 0.84ab | 64.86ab |
| | | 250 kg/ha | 2.2a | 0.47a | 2.80a | 1.85a | 69.58a |
| | | 500 kg/ha | 2.03b | 0.30b | 3.08a | 0.96ab | 62.00b |
| A. tricolor | 0 t/ha | 0 kg/ha | 1.82c | 0.25c | 2.23b | 0.67c | 53.50c |
| | | 250 kg/ha | 1.97b | 0.34b | 2.61a | 0.87ab | 64.07ab |
| | | 500 kg/ha | 2.21a | 0.41a | 2.16b | 0.79ab | 61.60b |
| | 8.45 t/ha | 0 kg/ha | 1.85b | 0.34b | 2.09b | 0.90ab | 64.13ab |
| | | 250 kg/ha | 2.17a | 0.36b | 2.23b | 0.92ab | 66.83a |
| | | 500 kg/ha | 2.14a | 0.39a | 2.05b | 0.88ab | 67.57a |
| | 16.9 t/ha | 0 kg/ha | 2.11a | 0.36b | 2.67a | 0.87ab | 66.07ab |
| | | 250 kg/ha | 2.93a | 0.39a | 2.48ab | 0.92ab | 65.30ab |
| | | 500 kg/ha | 2.24a | 0.41a | 2.57ab | 1.01a | 65.97ab |
| | | LSD | 0.155 | 0.054 | 0.774 | 0.186 | 4.212 |

*Means in a same column followed by different letter (s) are significantly different at P≤0.05*

**Table 5. The interaction effect of variety, NPK rates and quail manure rates on the plants tissue macro and micronutrients properties during the second season**

| Variety | Nitrogen | Manure | N % | P % | Ca % | K % | Fe (mg/kg) |
|---|---|---|---|---|---|---|---|
| A. cruentus | 0 t/ha | 0 kg/ha | 1.21c | 0.33c | 0.13c | 2.77c | 120.9g |
| | | 250 kg/ha | 1.89b | 0.34c | 0.16ab | 2.87b | 118.6g |
| | | 500 kg/ha | 2.13a | 0.39b | 0.15ab | 2.89b | 159.8e |
| | 8.45 t/ha | 0 kg/ha | 1.93b | 0.36b | 0.14ab | 2.89b | 164.3d |
| | | 250 kg/ha | 2.20a | 0.34c | 0.15ab | 2.80b | 138.2f |
| | | 500 kg/ha | 2.21a | 0.38b | 0.15ab | 2.04a | 162.7d |
| | 16.9 t/ha | 0 kg/ha | 1.96b | 0.36b | 0.15ab | 2.87ab | 168.9c |
| | | 250 kg/ha | 2.73a | 0.46a | 0.15ab | 2.90ab | 69.58i |
| | | 500 kg/ha | 2.33a | 0.30c | 0.25a | 2.98a | 191.2a |
| A. tricolor | 0 t/ha | 0 kg/ha | 1.79c | 0.35b | 0.16ab | 2.72c | 181.1b |
| | | 250 kg/ha | 1.98bc | 0.36b | 0.14ab | 2.87ab | 91.6h |
| | | 500 kg/ha | 2.20b | 0.40a | 0.15ab | 2.87ab | 129.0g |
| | 8.45 t/ha | 0 kg/ha | 1.85b | 0.34b | 0.15ab | 2.79c | 120.9g |
| | | 250 kg/ha | 2.23a | 0.36b | 0.17ab | 2.90ab | 118.4g |
| | | 500 kg/ha | 2.13a | 0.36b | 0.17ab | 2.92ab | 170.0c |
| | 16.9 t/ha | 0 kg/ha | 2.07ab | 0.37b | 0.17ab | 2.88b | 169.2c |
| | | 250 kg/ha | 2.98a | 0.37b | 0.16ab | 2.91ab | 149.9e |
| | | 500 kg/ha | 2.34a | 0.40a | 0.16ab | 2.99a | 166.3d |
| LSD | | | 0.385 | 0.058 | 0.034 | 0.223 | 7.85 |

*Means in a same column followed by different letter (s) are significantly different at $P \leq 0.05$*

**Table 6. The interaction effect of variety, NPK and quail manure rates on sodium, copper and zinc in the plant tissues during the first season**

| Variety | Treatments | Sodium | Copper | Zinc |
|---|---|---|---|---|
| A. tricolor | 0 t/ha+0 kg/ha | 0.063b | 5.253a | 27.57a |
| | 0 t/ha+250 kg/ha | 0.63a | 4.75a | 29.5a |
| | 0 t/ha+500 kg/ha | 0.7a | 5.063a | 30.1a |
| | 8.45 t/ha+0 kg/ha | 0.056b | 4.22a | 25.4b |
| | 8.45 t/ha+250 kg/ha | 0.7a | 4.7a | 26.2b |
| | 8.45 t/ha+500 kg/ha | 0.61a | 4.653a | 28.27b |
| | 16.9 t/ha+0 kg/ha | 0.004bc | 4.5a | 25.2b |
| | 16.9 t/ha+250 kg/ha | 0.3b | 3.9b | 26.1b |
| | 16.9 t/ha+500 kg/ha | 0.35b | 3.3b | 27.5a |
| A. cruentus | | | | |
| | 0 t/ha+0 kg/ha | 0.06b | 4.67a | 28.97ab |
| | 0 t/ha+250 kg/ha | 0.66a | 5.903a | 30.3a |
| | 0 t/ha+500 kg/ha | 0.76a | 5.473a | 33.9a |
| | 8.45 t/ha+0 kg/ha | 0.7a | 4.6a | 26.3b |
| | 8.45t/ha+250 kg/ha | 0.65a | 4.75a | 25b |
| | 8.45 t/ha+500 kg/ha | 0.04b | 5.83a | 26.4b |
| | 16.9 t/ha+0 kg/ha | 0.015bc | 4.45a | 24b |
| | 16.9 t/ha+250 kg/ha | 0.35b | 3.59b | 26b |
| | 16.9 t/ha+500 kg/ha | 0.32b | 3.4b | 28.5a |
| | LSD | 0.51 | 1.06 | 4.56 |

*Means in a same column followed by different letter (s) are significantly different at P≤0.05*

**Table 7. The interaction effect of variety, NPK and quail manure rates on sodium, copper and zinc in the plant tissues during the second season**

| Variety | Treatments | Sodium | Copper | Zinc |
|---|---|---|---|---|
| A. tricolor | 0 t/ha+0 kg/ha | 0.06a | 4.253ab | 27.57 a |
| | 0 t/ha+250 kg/ha | 0.07a | 4.765ab | 29.5 a |
| | 0 t/ha+500 kg/ha | 0.07a | 5.063a | 29.1 a |
| | 8.45 t/ha+0 kg/ha | 0.01a | 4.12a | 31.4 a |
| | 8.45 t/ha+250 kg/ha | 0.17 | 4.5ab | 26.2b |
| | 8.45 t/ha+500 kg/ha | 0.161 | 4.73ab | 32.27a |
| | 16.9 t/ha+0 kg/ha | 0.004 | 4.57ab | 24.9b |
| | 16.9 t/ha+250 kg/ha | 0.13 | 3.86abc | 26.2b |
| | 16.9 t/ha+500 kg/ha | 0.3 | 3.2acb | 27.39a |
| A. cruentus | 0 t/ha+0 kg/ha | 0.05a | 4.77ab | 28.97a |
| | 0 t/ha+250 kg/ha | 0.06a | 5.913a | 30.3ab |
| | 0 t/ha+500 kg/ha | 0.06a | 5.973a | 33.9ab |
| | 8.45 t/ha+0 kg/ha | 0.01a | 5.23a | 30.4ab |
| | 8.45 t/ha+250 kg/ha | 0.17 | 4.5ab | 25.1b |
| | 8.45 t/ha+500 kg/ha | 0.04 | 5.85a | 26.45b |
| | 16.9 t/ha+0 kg/ha | 0.15 | 4.45ab | 23.9b |
| | 16.9 t/ha+250 kg/ha | 0.21 | 3.5abc | 26.3b |
| | 16.9 t/ha+500 kg/ha | 0.01a | 4.6ab | 34.5a |
| LSD | | 0.45 | 0.99 | 6.37 |

*Means in a same column followed by different letter (s) are significantly different at P≤0.05*

**Table 8. The interaction influence of variety and quail manure rates on the total oxalate compound content in amaranth during the first season and second season**

| Variety | Quail Rate | Oxalate (season 1) | Oxalate (season 2) |
|---|---|---|---|
| *A. cruentus* | 0 t/ha | 6.28c | 6.2c |
| | 8.45 t/ha | 6.9b | 6.78b |
| | 16.9 t/ha | 7.85a | 7.23a |
| *A. tricolor* | 0 t/ha | 6.69b | 6.3c |
| | 8.45 t/ha | 7.16a | 7.2a |
| | 16.9 t/ha | 6.11c | 7a |
| | LSD | 0.48 | 0.39 |
| V×Q | | * | * |

*Means in a same column followed by different letter (s) are significantly different at P≤0.05,NS = Not significant. * Significant at α=0.05** Significant at α=0.01*

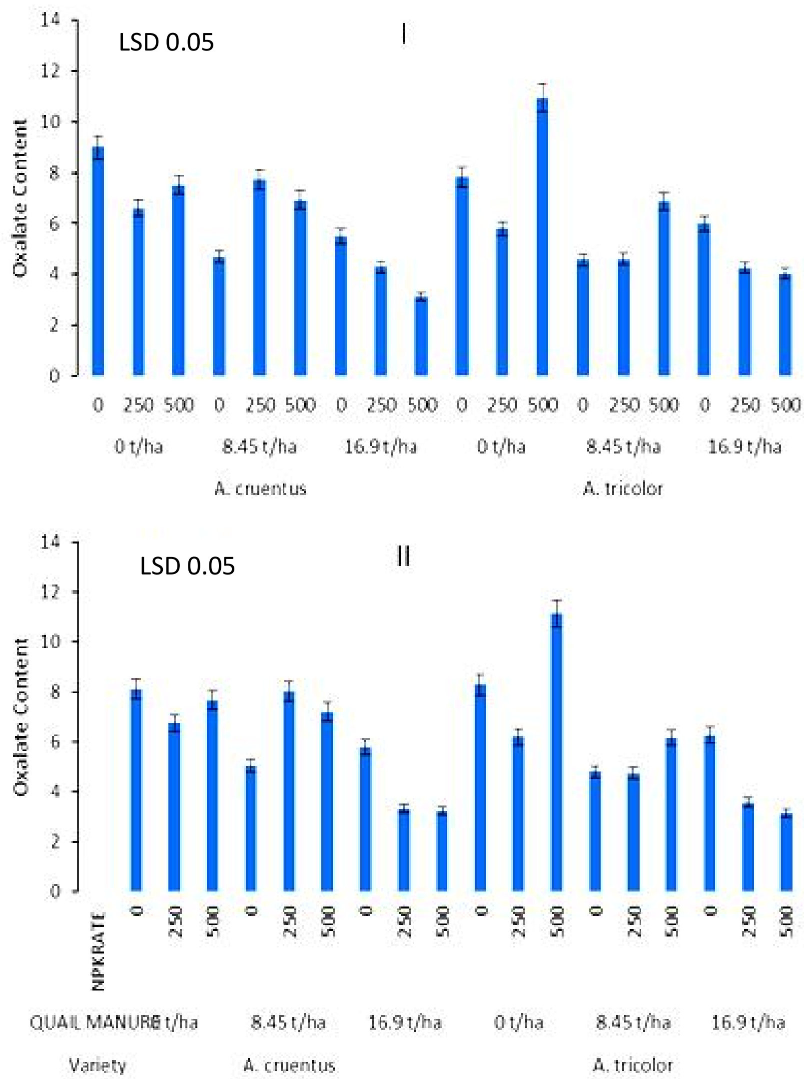


**Fig. 1. The interaction effect between the variety, NPK and quail manure rates on the oxalate content during the first (I) and second (II) seasons**

**Table 9. The interaction influence of variety and NPK fertilizer rates on the total phenolic compound content in the two amaranth species during the first and second season**

| Variety | NPK Rate | Phenolic Compounds (season 1) | PhenolicCompounds (season 2) |
|---|---|---|---|
| *A. cruentus* | 0 kg/ha | 26.9a | 25.4c |
| | 250 kg/ha | 23.4b | 38b |
| | 500 kg/ha | 22.5c | 44.3a |
| *A. tricolor* | 0 kg/ha | 26.2a | 26.5c |
| | 250 kg/ha | 24b | 39.1b |
| | 500 kg/ha | 20.21d | 44.4a |
| | LSD | 0.96 | 3.52 |
| V×N | | * | ** |

*Means in a same column followed by different letter (s) are significantly different at P≤0.05*
*NS = Not significant. * Significant at α=0.05** Significant at α=0.01*

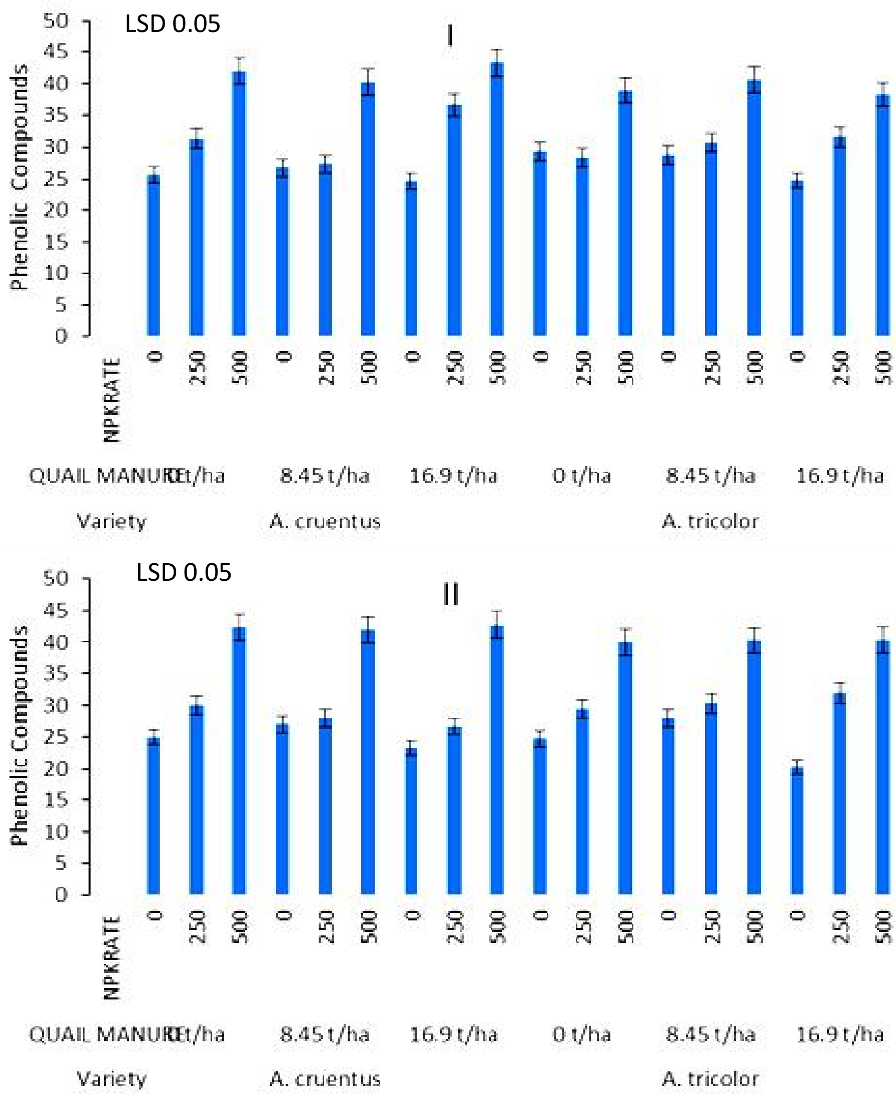


**Fig. 2. The interaction effect between the variety, NPK and quail manure rates on the total phenolic compound content during the first (I) and second (II) seasons**

## 5. CONCLUSION

This study on comparative effect of organic and inorganic fertilizers on revealed that organic fertilizer produced higher effects on most of nutrients investigated when compared with inorganic fertilizer. The results are in agreement with previous researchers who have reported increases with organic fertilizers on some proximate, mineral contents [6,50]. Nutrients in organic material are less easily available since the materials have to be decomposed and organic nutrients mineralized [50]. Organic manures activate many species of living organisms which release phytohormones and may stimulate the plant growth and nutrients [6]) and such organisms need nitrogen for multiplication [51]. Results of this study are also in results by Katherine [52] who reported that organic food is more nutritious than non organic food and increase peoples lives. She also found that they contain higher levels of antioxidants and flavonoids which help fight heart disease and cancer. The high amounts of phytochemicals, minerals and antioxidants in this study gives preference to the use of organic than inorganic fertilizer for better nutritional quality.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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