Original Research Article

Evaluating the Impact of Fertilisers and Elicitors on *Amaranthus cruentus* (L): Sustainable Fertilization and Elicitation Strategies for Enhanced Nutrition and Productivity

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ABSTRACT

Amaranthus cruentus plants were grown in the screen house of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria in 2016 to determine the effects of fertilizers and elicitors on the growth, yield, and micronutrient content of the plants. The experiment comprised compost manure applied at the rates of 5, 10, and 15 t/ha (CP_5, CP_{10}, and CP_{15}), poultry manure applied at the same rates (PM_5, PM_{10}, and PM_{15}), and NPK 15:15:15 fertilizer applied at the rates of 50, 100, and 150 kg/ha (NPK_{50}, NPK_{100}, and NPK_{150}), Methyl jasmonate and Salicylic acids applied each at 125, 250, 500 µmol/L ($MejA_{125}$, $MejA_{250}$, $MejA_{500}$; SA_{125}, SA_{250}, SA_{500}, respectively) with a control group receiving no treatment. The study used a completely randomized design with three replicates. Data were collected on plant height, number of leaves, leaf area, and stem girth. Harvesting was done six weeks after sowing, and fresh weight, dry matter were determined. Folate, iron and zinc, moisture contents, crude fiber, and ash contents were determined. Data were analysed with analysis of variance (ANOVA). Means were separated with Duncan Multiple Range Test (P=0.05).

The highest plant height, leaf area, and chlorophyll content of *A. cruentus* were obtained in plants treated with NPK_{100}. The highest marketable0 yield (52.29 g/plant) was obtained in plants treated with PM_{10}. NPK_{100} and PM_{10} resulted in significantly higher folate content (190.05, 185.06 µg/100 g, respectively) compared to the control. Higher iron content (22.00

mg/100g) was obtained in plants treated with CP_{10} compared to control. NPK_{100} treated *Amaranthus* had the highest iron concentration (17.30 mg/100g). A higher zinc concentration (3.86 mg/100g) in *A. cruentus* was obtained in plants treated with CP_{10}, which was comparable to 3.40 mg/100g in NPK_{100} treated plants. Compost and poultry manure fertilizers at a rate of 10 t/ha can be used to improve the nutritional quality of *A. cruentus.*

Keywords: [Amaranthus cruentus, growth, fertilizers, yield, micronutrients}

1. INTRODUCTION

The worldwide health emergency brought about by the Corona Pandemic coupled with the menace of hidden hunger on public health has shifted the attention of people globally to the nutritional value of their diet, particularly the micronutrients that are essential in boosting the body's immune system (1, 2). Therefore, the significance of agriculture, particularly in the production of high-quality food crops, has increased (3, 4). The agricultural farming system is now much more than just producing food; it is essential to supply food that promotes human health (5). This is because many people in developing countries continue to suffer from hidden hunger, despite increased crop yields (6). For example, there is a high prevalence of hidden hunger in Nigeria, as shown by the Global Hunger Index, which measures undernourishment, child underweight, and child mortality. Approximately 20% of African children are stunted, and 45% of deaths in under-fives are related to undernutrition (7). This affects cognitive development and negatively impacts future potential.

Hidden hunger results from insufficient intake of essential micronutrients, such as vitamins and minerals, owing to a lack of diversity in the diet, poor soil quality, and low micronutrient content in staple foods consumed in Africa (8, 6). People who rely mainly on staple foods, such as cereals, roots, and tubers, and consume few fruits and vegetables are at risk of hidden hunger because plants are the primary source of food and micronutrients for humans (9). The deficiency of certain nutrients in the soil may affect the quality of crops grown on such soil, which in turn could affect the health and well-being of people who consume such food crops (10).

Although several biofortification strategies, including breeding, metabolic engineering, and agronomic biofortification, have been adopted to enhance micronutrients in plants (11, 12), the choice of biofortification approach mostly depends on micronutrient deficiencies. Agronomic biofortification, which is a process of increasing micronutrient content in food crops through agronomic approaches, such as the use of fertilizers, has the potential to improve crop productivity and nutritional quality by addressing micronutrient deficiencies because they are easily adopted by farmers without the necessary technical skills required to carry out breeding and metabolic engineering (13, 14). In addition to the positive influence of fertilizer application on yield, it also affects other aspects of human nutrition such as the quantity of vitamins and minerals in plants.

Furthermore, fertilizer application has been shown to enhance the nutritional quality of food crops in addition to increasing yield (15). However, more emphasis has been placed on optimum yields than on food quality (16). Thus, fertilizer usage should be directed towards promoting human health to achieve the goal of food security and healthy diets, leading to healthy lives in the face of an ever-increasing world population (17, 18). Although fertilizer use in agriculture is high because it has been shown to improve soil quality and crop productivity, the extent to which fertilizers can enhance changes in crop nutritional quality, particularly micronutrients such as zinc (Zn), iron (Fe) and folate in *Amaranthus cruentus*, has rarely been studied in Nigeria.

Moreover, over the past two decades, there has been increased interest in the promotion of African leafy vegetables as sources of micronutrients and bioactive compounds (19, 20). *Amaranth l*eaves are rich in proteins and micronutrients, including iron, calcium, zinc, vitamin C, and vitamin A (21). However, research avenues continue to explore ways to increase yield. Although the yield has increased, micronutrients such as folate, iron, and zinc are still low. This trend might be linked to the adoption of high-yielding varieties and potential fertilizer misuse. Thus, leveraging agronomic approaches in terms of fertilizer usage would contribute to climate-smart agriculture, enhance the sustainability of agricultural systems, and improve human health. This study was designed to determine the effects of elicitors and inorganic and organic fertilizers on the growth and folate and mineral contents of Amaranthus *cruentus*.

2. MATERIAL AND METHODS

A screen house trial was conducted at the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria, in 2016.The experiment comprised the following treatments: organic manure (poultry manure and compost); compost manure applied at three rates (5 t/ha-CP_5, 10 t/ha-$CP_{10,}$ and 15 t/ha- CP_{15}); poultry manure applied at three rates (5 t/ha-PM_5, 10 t/ha-$PM_{10,}$ and 15 t/ha- PM_{15}); NPK 15:15:15 (inorganic fertilizer) applied at 50 kgN/ha- NPK_{50}, 100 kgN/ha -NPK_{100}, and 150 kgN/ha -NPK_{150} and a control (no treatment), Methyl jasmonate(MejA) and Salicylic acid (SA) applied each at 125, 250, 500 µmol/L

(MejA_{125}, MejA_{250}, MejA_{500}; SA_{125}, SA_{250}, SA_{500}, respectively). The experiment was conducted in a completely randomized design (CRD) with three replicates.

List 1 : Treatment composition

Treatments	**Composition**
NPK_{50}	50 kg Nha-1 NPK
NPK_{100}	100 kg Nha-1 NPK
NPK_{150}	150 kg Nha-1 NPK
CP_5	5 t-ha-1 Compost
CP_{10}	10 t-ha-1 Compost
CP_{15}	10 t-ha-1 Compost
PM_5	5 t-ha-1 Poultry manure
PM_{10}	10 t-ha-1 Poultry manure
PM_{15}	15 t-ha-1 Poultry manure
MejA125	Methyl jasmonate applied at 125 µmol/L
MejA250	Methyl jasmonate applied at 250 µmol/L
MejA500	Methyl jasmonate applied at 500 µmol/L
SA125	Salicylic acid applied at 125 µmol/L
SA250	Salicylic acid applied at 250 µmol/L
SA500	Salicylic acid applied at 500 µmol/L
Control	No treatment

Amaranthus cruentus seeds were obtained from the National Institute of Horticultural Research (NIHORT) Ibadan. Cured Poultry manure was obtained from the Teaching and Research Farm of the University of Ibadan, Nigeria. NPK (15:15:15) was obtained from the Department of Agronomy at the University of Ibadan, Nigeria. Composting was performed from the shoots of *Tithonia diversifolia* (L) and fresh poultry manure, which were mixed in a ratio of 3:1 on a layer basis. The heap was left to decompose for three months with continuous turning and watering every week. The matured compost was air-dried and ground to ensure uniformity (22).

Thirty, 5 litre capacity polythene planting bags were filled with five-kilogram (5 kg) dry top soil. Compost (5, 10, and 15 t/ha) and poultry manure (5, 10, and 15 t/ha) were applied to the soil in polythene bags one week before sowing, and two weeks after sowing, NPK was administered at 50, 100, and 150 kg N/ha two weeks after sowing. *Amaranthus cruentus* seeds were sown directly into each of the designated 30 planting bags, thinning was done to two plants per pot at 2 weeks after planting, and watering was done regularly to field capacity.

Data were collected starting two weeks after sowing at two weeks interval on the following growth parameters of *Amaranthus cruentus*: plant height, number of leaves, leaf area, and stem diameter. Shoot harvesting was performed six weeks after sowing, and yield parameters, such as shoot fresh weight and shoot dry matter, were determined. Folate (23, 24, 25), iron and zinc (26, 27), percentage moisture content, crude fiber, and ash content were determined in shoot dry matter using standard procedures (27). All data were analyzed by analysis of variance (ANOVA) using SAS software. Means were separated using Duncan's multiple range test (P =.05).

3. RESULTS AND DISCUSSION

In this study, both organic and inorganic fertilizers improved *Amaranthus cruentus* performance. Fertilizer application (organic and inorganic) has been shown to improve plant performance, which reconfirms the assertion that fertilizers are necessary for optimal plant performance (28, 29). Several researchers have affirmed the beneficial effects of fertilizers on the performance of *Amaranthus cruentus* (30)

3.1. Vegetative Parameters

3.1.1 Plant height (cm)

The height of *Amaranthus cruentus* was significantly affected by fertilizer application (Table 1). The highest plant height (52.70 cm) was recorded in NPK_{100} and was similar to the plant height of *Amaranthus cruentus* treated with PM_{10}, PM_{15}, $CP_{10,}$ and CP_{15}, whereas SA_{250} gave a higher plant height (49.80 cm) when compared among elicitor treatments, and was similar to plant heights obtained in plant foliar sprayed with $MejA_{500}$, and in plant foliar sprayed $SA_{500,}$ whereas the lowest plant height was obtained in the control (37.62 cm). The effect observed in *Amaranthus cruentus* treated with NPK_{100} might be due to the early nutrient release by mineral fertilizers for plant absorption. In addition, plant height in organic manure (poultry manure and compost) also compared favorably with inorganic amendments, which implies that although organic manure might slow the release of nutrients to plants, the effect is negligible and overall plant growth is ensured (31, 32). Salicylic acid plays important role in plant defense against environmental stress which in turn leads to healthy plants and better allocation of nutrients plant growth (33)

3.1.2 Number of leaves

PM_{10} produced the highest number of leaves (22.70), which was similar to the number of leaves obtained under PM_{15}, CP_{10}, CP_5, NPK_{100}, and $MejA_{500}$. SA_{500} produced more leaves than the control (16.00), whereas plants sprayed with SA_{125} and SA_{500} produced leaves that were not more than those of the control. The increase in the number of leaves might be because fertilizers provide the necessary nutrients for leaf development, especially nitrogen, which is essential for leaf development (34,37). This indicates that the NPK, compost, and poultry manure used in this study contained adequate Nitrogen to enhance leaf growth. Methyl jasmonate Salicylic acid enhance plant ability to withstand external stress which in turn leads to healthy plants and better allocation of nutrients leaf production (33)

3.1.3 Stem girth (cm)

Similarly, the highest stem girth (3.05 cm) was obtained in *Amaranthus cruentus* treated with PM_{15}, which was superior to the control (2.01 cm), but not more than the values obtained in CP_{10}, CP_{15}, PM_{10}, and PM_5, and was closely followed by *Amaranthus cruentus* that received NPK_{100} when compared to the control. Since N, P and K is essential for plant growth, the availability of these nutrients for plant use might have influenced stem girth (34) In elicitor treatments, the highest stem girth (2.60 cm) obtained in plants sprayed SA_{250} which was similar to all the rates of either SA or MejA applied (33)

3.1.4 Leaf area (cm^2)

All fertilizer treatments produced leaf area values that were significantly higher than the control, with the highest leaf area (65.05 cm^2) obtained in *Amaranthus cruentus* amended with NPK_{100}, and it was not more than the leaf area obtained in PM_{15}, PM_{10}, PM_5, CP_{10} and $NPK_{150,}$ respectively (Table 1). In elicitor treatments, *Amaranthus cruenthus* sprayed with SA_{250} had the highest leaf area (58.35 cm^2) and was similar to leaf area obtained in plants sprayed with SA_{500}, $SA_{125,}$ and $MejA_{500}$ (Table 1). The enhanced leaf area observed with poultry manure application might be linked to favorable soil conditions created by the organic matter components of poultry manure (36). MejA and SA interacts with other hormones such as Auxin and cytokinin in the plant, this balance interaction enhance leaf initiation and growth (35)

Table 1: Effects of fertilisers and elicitors on the vegetative parameters of *Amaranthus cruentus* in the screen house at 6 weeks after sowing

Treatments	Plant height (cm)	Number of leaves	Stem girth (cm)	Leaf area(cm^2)
CP_5	44.40c	20.60ab	2.42bcd	56.45bc
CP_{10}	50.76ab	20.75ab	3.00a	60.67a
CP_{15}	51.55a	19.00bc	2.70abc	55.75bc
PM_5	47.20bc	18.00cd	2.50abc	61.80a
PM_{10}	50.40ab	22.70a	2.73abc	64.93a
PM_{15}	51.89a	20.90ab	3.05a	60.75a
NPK_{50}	49.60ab	17.00cd	2.20bcd	52.18c
NPK_{100}	52.70a	19.50bc	2.54abc	65.05a
NPK_{150}	50.00ab	20.00bc	2.45abc	62.39a
$MejA_{125}$	39.55fg	19.30bc	2.20bcd	47.49e
$MejA_{250}$	44.30de	18.75bcd	2.33bcd	50.81cde
$MejA_{500}$	48.65abc	21.60abc	2.59abc	54.45c
SA_{125}	44.90bcd	18.00bcd	2.40bcd	52.20d
SA_{250}	49.80ab	20.10abc	2.60abc	58.35bc
SA_{500}	45.25cd	17.50bcde	2.45abc	57.99bc
Control	37.62d	16.00d	2.01d	47.35d

Means with identical letters in each column are statistically significant (P =.05).

3.2 Yield Parameters

3.2.1 Fresh weight (g/plant)

The marketable yield (fresh weight) of *Amaranthus cruentus* was significantly affected by all fertilizer treatments (Table 2); poultry manure showed higher effects, with a higher increase (67%) when compared to the control, whereas in plants treated with PM_{10}, 53% was obtained in plants treated with CP_{15} when compared to the control and 58% obtained in plants treated with NPK_{150} when compared to the control, and SA_{250} showed an increase that was comparable to PM_{10}. These yield increases might be attributed to the rich nutrient profile of poultry manure, which provides essential elements necessary for plant growth and development, whereas the ability of SA to improve solubility and nutrient absorption might have enhanced yield (33,38).

3.2.2 Dry weight (g/plant)

A similar trend was observed in the dry matter yield, with plants treated with PM_{10} showing the highest dry matter yield (Table 2). The highest dry matter (3.85 g) of Amaranthus cruentus in the elicitor treatments was obtained in plants treated with $MejA_{500}$, which was not more than the values obtained for all salicylic acids applied (Table 2). (40) also observed an increased yield and quality with NPK application in Amaranthus *spp*. In this study, the effects were similar to those observed in organic application, while the fresh weight and dry matter yield showed the highest effects in plants fertilized with either poultry manure or compost than in NPK-fertilized plants. This indicates that organic manure supports plant productivity and is beneficial for the overall plant performance. Poultry manure also provides essential nutrients, such as nitrogen, phosphorus, and potassium, which are crucial for plant growth and development, ultimately improving dry matter accumulation. The effects of MejA and Salicylic acid on dry matter accumulation may be due to their ability to influence nutrient uptake (33,38).

Table 2: Effects of inorganic and organic fertilizers on chlorophyll contents, shoot fresh and dry weights of *Amaranthus cruentus* at 6 weeks after sowing

Treatments	**Chlorophyll (SPAD)**	**Fresh weight (g/plant)**	**Dry matter (g)**
CP_5	34.60bcd	40.00d	3.10bc
CP_{10}	35.70abc	45.00cd	3.32ab
CP_{15}	36.20abc	48.00abc	2.17e
PM_5	34.00cde	51.35a	3.24ab
PM_{10}	35.20abc	52.29a	4.50a
PM_{15}	30.50de	48.70abc	3.90ab
NPK_{50}	35.00bcd	45.00cd	2.90c
NPK_{100}	36.90abc	47.30bc	3.20bc
NPK_{150}	40.00ab	49.48ab	3.22bc
$MejA_{125}$	34.60bcd	35.44ef	2.48cde
$MejA_{250}$	30.50de	34.00ef	2.71cde
$MejA_{500}$	34.70cde	40.00de	3.85a
SA_{125}	37.50abc	41.00d	3.35ab
SA_{250}	40.20a	49.00ab	3.76ab

SA_{500}	35.50bcd	48.62b	3 .80a
Control	32.40de	31.30e	1.60d

Means with identical letters in each column are statistically significant (P =.05).

3.3 Quality Parameters

3.3.1 Chlorophyll (SPAD)

Chlorophyll content was slightly enhanced with the application of fertilizers, especially inorganic fertilizers, which showed an approximately 23% increase in plants treated with NPK_{150} when compared to the control, and compost, which showed only a 12% increase in plants treated with CP_{15} when compared to the control (Table 2). The elicitors significantly influenced the chlorophyll content of *Amaranthus cruentus* with the highest chlorophyll content (40.20 SPAD) when compared to the control (32.40 SPAD) in plants treated with SA_{250} (Table 2). NPK application enhanced the chlorophyll content of *Amaranthus cruentus* compared to that of the control. This assertion was also observed (32), who showed that plants that received inorganic fertilizers had a higher chlorophyll content than those that received organic fertilizers. (41) also showed that NPK fertilizers improve the chlorophyll content and yield of *Amaranthus hybridus*. This assertion was corroborated by (42), who observed improved growth and chlorophyll content in *Amaranthus tricolor*. The increased chlorophyl content observed might be due to ability of SA and MejA to improve photosynthetic efficiency of plant (43)

3.3.2 Folate concentration (µg/100 g)

The effects of fertilizers on folate concentrations in *Amaranthus cruentus* varied across the treatments. Although NPK_{100} and PM_{10} resulted in significantly higher folate contents (190.05, 185.06 µg/100 g, respectively) than the control (140.10 µg/100 g), all other fertilizer rates did not enhance folate concentration in *Amaranthus cruentus*; in elicitor treatments, the highest folate concentration (250.20 µg/100 g) in plant tissue was higher in plants sprayed with SA_{250} µM, whereas $MejA_{500}$ gave the highest folate concentration (186.10 µg/100 g). However, methyl jasmonate treatment resulted in lower folate concentrations than SA treatments. The higher folate concentration obtained in plants treated with NPK might be due to the presence of nitrogen, which is a precursor for the glutamate link necessary for folate synthesis in plants (37,39). Moreover, the synthesis of most vitamins is determined by the presence of an amino acid precursor that has been linked to nitrogen metabolism in plants.

As Salicylic acid enhances the absorption of nutrients from the soil, nitrogen absorption from the soil might have been enhanced as well (37)

3.3.3 Zinc concentration (mg/100g

A higher zinc concentration (3.86 mg/100 g) in *Amaranthus cruentus* was obtained under compost applied at 10 t/ha when compared to the control and was comparable to 3.40 mg/100 g obtained under NPK_{100}. Zinc concentration (3.70 mg/100 g) was higher in plants sprayed with SA_{250} than in those sprayed with SA_{500} (3.69 mg/kg) (Table 2). This might be due to the ability of compost to improve the structure of the soil and increase the availability of nutrients to plants, which enhances plant nutrient signaling (33,40) while SA effects might be due to influence nutrient transporters and uptake processes of nutrients, this suggests that SA can enhance the plant's ability to regulate the uptake and distribution of micronutrients, thereby improving plant health and stress tolerance (37)

3.3.4 Iron concentration (mg/100g)

The highest iron concentration (22.00 mg/100 g) was obtained in plants treated with CP_{10}, which was significantly higher than that in the control (14. and was similar to that obtained in plants treated with CP_5 and PM_5 (Table 3). Studies have also shown that organic fertilizers can increase the nutrient content of leafy vegetables by enhancing the soil organic matter, pH, cation exchange capacity, and microbial activity, which can improve the solubility and mobility of these micronutrients in the soil (44). Foliar application of elicitors significantly increased iron concentration in Amaranthus cruentus when compared to the control (Table 4.). The highest value of iron (218.60 mg/kg) was obtained in SA_{125} and was not significantly different from that in SA_{250}, $MejA_{500}$, and $MejA_{250}$. MejA and SA enhance the absorption of micronutrients in plants (45). This suggests that SA can enhance the ability of plants to regulate micronutrient uptake and distribution, thereby improving plant health and stress tolerance (37,43).

Table 3: Effects of different rates of fertilisers on folate, mineral of *Amaranthus cruentus* grown in the screen house at 6 weeks after sowing

Treatments	**Folate (µg/100g)**	**Zinc (mg/100g)**	**Iron (mg/100g)**
CP$_{5}$	148.32bcd	3.39ab	20.50a
CP$_{10}$	150.54bcd	3.86a	22.00a
CP$_{15}$	135.12d	2.91ef	18.00bcd
PM$_{5}$	144.61d	2.55fgh	19.00abcd
PM$_{10}$	185.06ab	3.14def	16.65def
PM$_{15}$	160.00bcd	2.83f	13.90ef
NPK$_{50}$	158.40bcd	2.94defg	16.94def
NPK$_{100}$	190.05a	3.40abcd	17.30cde
NPK$_{150}$	181.00ab	3.28bcde	15.10e
MejA$_{125}$	151.28de	3.00def	16.72de
MejA$_{250}$	175.60cde	2.98efg	18.00bcd
MejA$_{500}$	186.10cde	3.23cde	20.00ab
SA$_{125}$	245.15ab	3.00def	21.86ab
SA$_{250}$	250.20a	3.70abc	19.50abc
SA$_{500}$	239.40ab	3.69abc	15.20de
Control	140.10d	2.250h	14.34fg

Means with identical letters in each column are statistically significant (P =.05).

3.4 Correlation

The SPAD chlorophyll values of *Amaranthus cruentus* had a low correlation with its fresh weight (28%), whereas folate was 45%, zinc was 53%, and iron was 22% (Table 4). Fresh weight was positively correlated with folate (38%), and dry matter was positively correlated with folate (63%) (Table 4). Low iron and zinc levels can impair the synthesis of chlorophyll; thus, high iron levels enhance chlorophyll levels and are essential for chlorophyll synthesis.

Thus, a positive correlation between high folate levels in plants with high chlorophyll levels and the overall health of plants is ensured, which might lead to higher folate synthesis. Dry matter accumulation represents the total biomass of the plant. Chlorophyll is crucial for photosynthesis, and contributes to biomass production. Chlorophyll content has been positively correlated with iron and zinc levels in plants. are important for chlorophyll synthesis. Thus, a positive correlation indicates efficient photosynthesis, which leads to better plant development. A high chlorophyll content contributes to efficient photosynthesis, leading to increased fresh weight and overall plant vigor. Elevated chlorophyll levels enhance photosynthetic efficiency, resulting in greater dry matter accumulation and biomass (46, 47)

3.5 Percentage Contribution

Table 5 shows the percentage contribution of the micronutrients obtained in this study with their corresponding RDA values. *Amaranthus cruentus* treated with NPK_{100} had the highest percentage (31.68%) contribution to the recommended daily folate intake, followed by $PM_{10,}$ whereas *A. cruentus* treated with CP_{10} had the highest percent contribution of iron and zinc. *Amaranthus cruentus* treated with NPK_{100} had the highest percentage (31.68%) contribution to the recommended daily folate intake of 600 µg/100 g for pregnant women, followed by PM_{10}, *and Amaranthus cruentus* treated with CP_{10} had the highest percentage contribution of iron and zinc to the daily intake of 15 mg/day for both minerals. These results suggest that organic and inorganic fertilizers are effective for enhancing human nutrition and health. Furthermore, as folate, iron, and zinc levels in all samples exceeded 20% of the daily intake, *Amaranthus cruentus* can be considered a rich source of micronutrients and a potential crop for alleviating hidden hunger in Africa.

3.6 Proximate concentration % (Crude fibre, Ash and moisture content)

The proximate concentration of *Amaranthus cruentus* also improved with fertilizer application (Table 6). The highest crude fiber content (12.55%) was obtained under PM_{15} and was similar to the crude fiber obtained at all fertilizer rates applied. The ash content was only slightly affected by fertilizer treatments with NPK_{100}, giving the highest ash content (10.91%) and was not significantly better than the values obtained in *Amaranthus cruentus* (AC) under PM_{10}, CP_{10}, $CP_{15,}$ $PM_{10,}$ and PM_{15}. A higher moisture content (13.60%) in *Amaranthus cruentus* was obtained under PM_{15} than in the control and was comparable to the moisture content obtained under PM_5, PM_{10}, and CP_{10}. The application of compost and poultry manure increased the content of crude fiber and moisture in *Amaranthus cruentus*, which may be attributed to the ability of organic fertilizers to improve soil properties. However, the application of NPK fertilizer enhanced the crude ash content of *Amaranthus cruentus*, although this effect was comparable to the effects of poultry manure and compost on crude ash. The results obtained for crude fiber, moisture, and ash were similar to those reported by (48, 49), who found higher crude fiber and ash contents in organic fertilizer treatments. However, (50) observed differing effects where poultry-grown *Amaranthus cruentus*, *Amaranthus hybridus*, and *Amaranthus deflexus* had higher ash content, while higher crude fiber was obtained in poultry-grown *Amaranthus cruentus* while NPK_{100} enhanced higher crude fiber in *Amaranthus hybridus* and *Amaranthus deflexus*. SA_{250} and $MejA_{500}$ improved crude fiber content and were comparable to PM_{15} effects on crude fiber, while SA_{125} showed higher effects on ash; the effects were comparable to the effects on ash observed in NPK_{100}, and higher moisture content was obtained in $MejA_{500,}$ which was lower than the moisture content obtained in PM_{15}. This suggests that SA can enhance the uptake and distribution of essential nutrients, thereby improving performance and leading to improved crude fiber, ash, and moisture content in the plant (33).

Table 4. Correlation matrix between SPAD chlorophyl, fresh shoot weight, dry shoot weight, folate, zinc and iron values in *Amaranthus cruentus*

	Chlorophyll (SPAD)	Fresh weight (g/plant)	Dry matter (g)	Folate (µg/100g)	Zinc (mg/100g)	Iron (mg/100g)
Chlorophyll (SPAD)	1.000					
Fresh weight (g/plant)	0.426	1.000				
Dry matter (g)	0.223	0.611	1.000			
Folate (µg/100g)	0.405	0.168	0.470	1.000		
Zinc (mg/kg)	0.532	0.325	0.428	0.471	1.000	
Iron (mg/kg)	0.283	-0.057	0.068	0.222	0.384	1.000

Table 5. Comparison of effects of the treatments on folate, zinc and iron contents of *Amaranthus cruentus* RDA of 600 µg/100g of folate, and 15.0 mg/day of iron and zinc

Treatments	**Folate µ/100g**	**Zinc (mg/100g)**	**Iron (mg/100g)**		**Contribution to RDA value (%)**	
					Zinc (mg/100g)	Iron (mg/100g)
CP_5	148.32	3.39	20.50	24.72	22.59	136.67
CP_{10}	150.54	3.86	22.00	25.09	25.71	146.67
CP_{15}	135.12	2.92	18.00	22.52	19.45	120.01
PM_5	144.61	2.55	19.00	24.10	17.00	126.67
PM_{10}	185.06	3.14	16.65	30.84	20.93	111.00
PM_{15}	160.00	2.83	13.90	26.67	18.89	92.67
NPK_{50}	158.40	2.94	16.94	26.40	19.63	112.93
NPK_{100}	190.05	3.40	17.30	31.68	22.69	115.33
NPK_{150}	149.00	3.28	15.10	24.83	21.85	100.67
$MejA_{125}$	151.28	3.00	16.72	25.21	20.00	111.47
$MejA_{250}$	175.6	2.98	18.00	29.27	19.87	120.00
$MejA_{500}$	186.1	3.23	20.00	31.02	21.52	133.33
SA_{125}	245.15	3.00	21.86	40.86	20.00	145.73
SA_{250}	250.2	3.70	19.50	41.70	24.67	130.00
SA_{500}	239.4	3.70	15.21	39.90	24.63	101.40
Control	140.1	2.25	14.34	23.35	15.00	95.60

***Percent contribution calculated with RDA of 600 µg/100g of folate, and 15.0 mg/day of iron and zinc*

Table 6: Effects of fertilisers on crude fibre, ash and moisture composition of *Amaranthus cruentus* at 6weeks after sowing in the screen house

Treatments	**Crude Fibers (%)**	**Crude Ash (%)**	**Moisture content (%)**
CP_5	11.35a	9.32cde	11.15bcd
CP_{10}	11.88ab	10.01abc	13.34a
CP_{15}	10.96abc	10.50ab	11.04bcd
PM_5	8.01d	9.00de	13.35a
PM_{10}	11.92a	10.62ab	12.51ab
PM_{15}	12.55a	10.15ab	13.60a
NPK_{50}	10.98abc	8.60e	11.65bc
NPK_{100}	11.01ab	10.91a	12.00b
NPK_{150}	11.25ab	9.48bcd	11.37bc

MejA$_{125}$	10.41bcd	10.26a	11.01bc
MejA$_{250}$	10.18bcd	10.01bc	10.95cde
MejA$_{500}$	11.00ab	9.45bcde	11.20bc
SA$_{125}$	10.30bcd	10.77a	10.90cdef
SA$_{250}$	11.15ab	9.14cde	11.13bc
SA$_{500}$	9.40cde	9.85bc	9.84def
Control	8.00d	9.01de	10.13d

Means with identical letters in each column are statistically significant (P =.05).

4. CONCLUSION

This study found that both organic and inorganic fertilizers significantly increased the yield of *Amaranthus cruentus*; however, organic fertilizer had a more positive effect on the micronutrient content of the plant, particularly iron and zinc. This study suggests that organic fertilizers may be a better option for improving the nutritional quality of *Amaranthus cruentus* and reducing micronutrient deficiencies in Africa. These findings have implications for reducing micronutrient deficiencies, and promoting healthy diets.

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