Effects of organic and inorganic fertilizer on the growth of African spinach 
(*Amaranthus cruentus* L)

Accepted 25th September, 2017

ABSTRACT

Effects of organic and inorganic fertilizer on the growth of *Amaranthus cruentus* L. was studied in the botanical garden of the Department of Biology, Kaduna State University. The experiment was laid out in a Randomized Complete Design (RCD) with 4 replications. Treatment included 2, 4, 6 and 8 ton/ha poultry manure and 25, 50 and 75 kg/ha NPK fertilizer, respectively with a control. Data were collected on plant height, number of leaves, stem girth and seedling vigor and analyzed using analysis of (ANOVA). All the treatments were significantly compared with the control (*P* ≤ 0.05). The result obtained from the study indicated that the highest number of 9 leaves was observed with 25 kg/ha NPK fertilizer. However, the highest plant height of 11.7, stem girth of 1.12 cm and vigor of 1 were observed with 4 ton/ha of poultry manure. Poultry manure is good for soil amendment, since it influences the growth of *A. cruentus* by producing fast growth and higher yield. It is therefore recommended for use in the propagation of the plants.

Keywords: Organic, inorganic fertilizer, growth, African spinach, *Amaranthus cruentus*.

INTRODUCTION

*Amaranthus cruentus* L. belongs to the family Amaranthaceae. It is a leafy vegetable commonly cultivated in Nigeria and other West African countries (Olorode, 1984). *A. cruentus* is a Mexican and Guatemalan species which is useful both as a grain or leaf vegetable type. It is probably the most adaptable of all amaranth species and flowers under a wider range of day length better than the others. *A. cruentus* was most likely introduced to Africa by Europeans.

*A. cruentus* are characteristically very vigorous with broad leaves and protein rich edible seeds. The *A. cruentus* crop is known with broad leaves and protein rich edible seeds. It has a growing period of 5 to 6 weeks, thus, making it an advantage for the rural and peri-urban farmers in Nigeria to keep cultivating it twice or more on the same piece of land in a year (Adewole et al., 2011). The *A. cruentus* crop is known locally as 'tete' (Yoruba), 'green,' (Igbo) or 'aleho' (Hausa); it is a tender herbaceous plant with edible leaves and tender stem. Its importance lies basically in its ease of cultivation, quality of the leaves and tender stem. With other ingredients such as pepper, “egusi”, melon, it is used to make soup. *A. cruentus* leaves contain 3.5% protein and 1.5% carbohydrate as well as, 0.75% minerals and 6.7% vitamins (Saunder et al., 1983). *A. cruentus* is cultivated and consumed all over the country and can be rated among the top five of the most important national vegetables. The average consumption of *A. cruentus* leaves in the tropics is estimated at about 20 to 25 g per head per day which is below the recommended rate of 100 g per head per day (Olufolaji, 1996). Protein from *A. cruentus* leaves provides as much as 25% of the daily protein intake during the harvest season. It is grown all the year round (Denton et al., 2000).

The seeds of *A. cruentus* contain about 16 to 18% protein while maize contained 9 to 10% protein (NCR, 1984). *A. cruentus* leaves are similarly rich in protein content. Higher amino acid lysine content of the seeds makes the seeds even more nutritionally important. The protein has much
lysine mixture as found in milk (Tayo, 1996). On the other hand, the carbohydrate content of the *A. cruentus* leaves and seeds is 30 to 60% with the seed having higher protein-calorie content needed for growth and energy (Tayo, 1996). The nutritional quality of *A. cruentus* is similar to that of leaf vegetables. However, because the dry-matter content is often high, an equivalent amount of fresh *A. cruentus* often provides 2 to 3 times the amount of nutrients found in other vegetables (Saunders et al., 1983).

The low fertility status of the soil necessitated the need for external fertilizer input. The use of fertilizer (organic or inorganic) supplements the soil with nutrients, especially nitrogen for succulent green leafy growth (Olufolaji et al., 1988). Incorporating organic fertilizer into the soil as a cultural practice for crop production is expected to play a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, thereby, improving both the physical and biological properties of the soil (El-Shakweer et al., 2006).

The basic principle of organic fertilizer application is to feed the soil and let the soil feed the plants. This enhanced a balance of air, water, minerals and organic matter. Organic fertilizer makes nutrient to be slowly available and thus provides reservoir of plant food for crops. Synthetic fertilizer increases the nitrate and oxalate content of amaranth (Marderosian et al., 1980) due to its rapid release unlike organic fertilizer with its moderately release is capable of ameliorating this problem. The high organic matter content of the poultry manure serve as food for microbes and enhanced their activities. Considering the scale of poultry rearing in Nigeria, utilizing poultry manure in amaranth production would be a good means of disposing the large amount of wastes often associated with poultry rearing which would have otherwise constituted a nuisance to the community.

It was based on the few highlighted qualities that these three elements are formulated into NPK – fertilizer with different grade ratios. Some of the attendant problems of these elements when applied as fertilizer in a tropical humid environment like Nigeria is the development of soil acidity and fixation of P, making it virtually unavailable for plant uptake, due to the presence of large amount of iron and aluminium – oxides or amorphous alumina silicate clays in tropical soils. Holford (1997) estimated that as much as 90% added fertilizer phosphorous in all its natural forms including organic solution are fixed at any one time, while Bergmann (1992) and Singh et al. (1997) observed that if K is not taken up by plants, it might be lost by leaching as K is mobile and its retention by the negative charges on clay surface is temporal as the application of Ca₅⁺ or Mg₅⁺ containing dolomite or gypsum displaced into the soil solution.

Furthermore, Owen (2008) reported that synthetic fertilizers do not have good characteristics in aggregating soil particles. White (2006) in his study, reported that potassium fertilizers have antagonistic effects on magnesium directly and phosphorus content in some plants, hence, conventional crops would contain toxic heavy metals such as cadmium. Therefore, one of the major ways to reduce this problem is to add organic matter in the form of organic manure to the soil.

Organic manures are excellent fertilizers containing nitrogen, phosphorus, potassium and micro-nutrients for healthy growth of plants. According to Magkos et al. (2003), poultry manure supply macro and trace elements not contained in the organic manure. It is a reservoir of nutrients released during humidification that is eventually made available to the growing plants. Organic manure such as poultry manure can be used to ameliorate the amount of toxic compound produced by chemical fertilizers. Poultry manure increase the organic matter (OM) content of soil and in turn releases the plant nutrients in available form for the use of the plants. Deskissa et al. (2008) emphasized that manure enable the soil to hold more water and improve the drainage, while organic acids help to dissolve soil nutrients and then make it available for the crops. Poultry contains essential nutrient elements associated with high photosynthetic activities and thus, promotes root and vegetable growth (John et al., 2004).

The integration of inorganic fertilizer and organic manure was also reported to be more beneficial than the use of either mineral fertilizer or organic manure alone especially in intensive agricultural production. Nweke et al. (2013, 2015) observed that nutrient use efficiency increased through the combination of organic manure and mineral fertilizer. It was against this backdrop that this work was conceptualized to yield parameters collected on length of fruit (cm), number of fruits, number of marketable fruits and fruit weight (kg).

*A. cruentus* is grown by small scale resource poor farmers who cannot apply recommended rates of nutrients; hence, net negative nutrient balances. This leads to low production and contributes to food insecurity. Nutrients can be supplied from either inorganic or organic sources. The short term benefits from use of inorganic sources include fast release of nutrients to meet crop demand and convenience in application. However, inorganic fertilizers are expensive and out of reach of poor farmers and the nutrients are easily leached leading to pollution of water sources. Slow release fertilizers dissolve gradually, thereby, delaying nutrient release to curb pollution.

Fertilizer pelleting is one of the slow release technologies and has been tried in other crops and further information on its use in grain amaranth is required. Livestock manure which is available in most homesteads can supply crop nutrients. The use of manure has long term benefits that include release of nutrients to plants slowly and for a prolonged period of time in addition to improving the soil physical properties. However, the use of livestock manures alone cannot meet crop nutrient demand due to limited quantities, low nutrient content and the slow release of nutrients during periods of peak crop nutrient demand. To
enhance crop nutrient use efficiency, a fertilizer augmented soil enrichment approach is applied based on making the best use of organic matter and manure with the addition of limited amounts of mineral fertilizer to maintain the supply of essential elements such as phosphorus and nitrogen.

The use of organic and inorganic fertilizers has amassed a great significance in recent years in vegetable production for two reasons. Firstly, the need for enhanced sustainable increase in production and per hectare yields of vegetables which require an increased amount of nutrients. Secondly, the results of a large number of experiments on organic and inorganic fertilizers conducted in several countries revealed that inorganic fertilizer alone cannot sustain productivity of soils under highly intensive cropping system (Khan et al., 2010).

One of the ways of increasing the nutrient content is by boosting the nutrient content with organic materials such as poultry manure, with or without inorganic fertilizers (Dauda et al., 2008). Poultry manure is relatively resistant to microbial degradation (Dauda, 2005). There is also need to determine the independent influence of poultry manure and inorganic fertilizer such as NPK on the growth of fast growing vegetables like Amaranthus species. There is also need to determine a rapid way of propagating Amaranthus species.

The aim of this work is to study the effect of organic and inorganic fertilizer on the growth of African spinach (A. cruentus). The objectives include:

1) To determine the effect of poultry manure on the growth of A. cruentus;
2) To determine the effect of NPK fertilizer on the growth of A. cruentus;
3) To determine the combined effect of poultry manure and NPK fertilizer on the growth of A. cruentus.

MATERIALS AND METHODS

Study area

The experiment was conducted at the botanical garden of the Department of Biology, Kaduna State University, which is located at latitude 10°.31' north and longitude 7°26' and 6.14 m above the sea level.

Source of seed

The seeds for the experiment were locally sourced from Kasuwar Barci Market, Tudun Wada, Kaduna State.

Treatments

Organic manure (Poultry manure)

This was applied in the following rates, 2, 4, 6 and 8 ton/ha respectively and a control.

Inorganic manure (NPK fertilizer)

The inorganic fertilizer was applied in the following rates, 25, 50 and 75 kg/ha with a control.

Planting

The seeds were planted on a nursery bed and germinated after 4 days of planting.

Transplanting

A week after germination, healthy seedlings were selected and transplanted in polythene bags containing loamy soil.

Cultural practices

Fertilization application

Both the poultry manure and NPK fertilizer were applied 1 week after transplanting and continued at a 5 days interval for 6 weeks, the fertilizer were applied 4 cm away from the plant.

Watering

Being a dry season at the initial stages (January to march) the plants were subjected to irrigation for healthy growth.

Weeding

Weeding was done manually using hand in order to allow water infiltration and aeration to the soil and eventually keep the plants from weed competition and make the field always clean.

Observation and data collection

Data were collected on plant height, number of leaves, seedling vigor and stem girth. These data were collected at a 5 days interval starting from one week after fertilizer application.

Experimental design

All experiment was conducted in a completely randomized
Table 1: Effect of poultry manure on the growth of *Amaranthus cruentus*.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>No. of leaves</th>
<th>Stem girth (cm)</th>
<th>Vigor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 ton/ha</td>
<td>8.94&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.98&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.30&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>4 ton/ha</td>
<td>11.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.10&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>6 ton/ha</td>
<td>10.68&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.10&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>8 ton/ha</td>
<td>9.14&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.98&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.59&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Control</td>
<td>5.98&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.96&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.90&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter along columns are not significantly different (p=0.05).

design. There were 8 treatments including a control with 4 replications. The experiment was run for 6 weeks.

**Data analysis**

The data generated from the work was analysed using analysis of variance (ANOVA) SAS (2002) statistical package. Least significant different (LSD) was also used to compare treatment mean (P<0.05).

**RESULTS**

**Effects of poultry manure**

**Plant height**

On the effect of poultry manure, treatment with 4 ton/ha had the highest plant height of 11.7 cm followed by treatment with the level of 6 ton/ha had the average plant height of 10.7 cm; the lowest plant height of 9 to 10 cm was observed with 8 ton/ha and 2 ton/ha compared to the control which had 6 cm (Table 1, Appendix 1 and Figure 1).

**Number of leaves**

Treatment with 6 ton/ha had the highest number of leaves of 9, followed by treatment with the level of 4 ton/ha which had 8 number of leaves; the lowest number of leaves of 6 to 7 was observed in 2 and 8 ton/ha as compared to the control which had 5 number of leaves (Table 1 and Figure 2).

**Seedling vigor**

Treatment with 4 ton/ha had the highest vigour of 1 followed by treatment with 2 ton/ha which had the vigor of 1.30; the lowest vigor of 1.59 was observed with the treatment of 6 ton/ha as compared to the control shows the least significant effect of 2 vigor (Table 1 and Figure 4).

**Effects of NPK fertilizer**

**Plant height**

NPK shows a significant effect on the plant height of *A. cruentus*. Treatment with the level of 25 kg/ha shows the highest average plant of 10 cm, followed by 75 kg/ha which had the plant height of 8.8 cm; the lowest plant height of 7.9 cm was observed in treatment with 50 kg/ha as compared to the control which had 6 cm (Table 2, Appendix 2 and Figure 5).

**Number of leaves**

Treatment with 25 kg/ha had the highest number of leaves of 9, followed by 50 kg/ha which had 8; the lowest number of leaves was observed in the treatment with 75 kg/ha which had 6 leaves as compared to the control which had 5 leaves (Table 2 and Figure 6).

**Seedling vigor**

Treatment with 75 kg/ha had the highest vigor of 1, followed by 50 kg/ha which had the vigor of 1.3; the lowest vigor of 1.4 was observed in the treatment with 25 kg/ha as compared to the control which had 2 vigor (Table 2 and Figure 7).

**Stem girth**

Treatment with 4 ton/ha had the highest stem girth of 1.12 cm followed by treatment with 6 ton/ha which had the stem girth of 1.02 cm; the lowest stem girth 1.00 cm was observed with the treatment of 2 and 8 ton/ha as compared to the control which had 0.76 stem girth (Table 1 and Figure 3).
Figure 1: Plant height in a 3 weeks old *A. cruentus* under poultry manure.

Figure 2: Number of leaves in a 3 weeks old *A. cruentus* under poultry manure.
Figure 3: Stem girth in a 3 weeks old *A. cruentus* under poultry manure.

Figure 4: Plant vigor in a 3 weeks old *A. cruentus* under poultry manure.
### Table 2: Effect of NPK fertilizer on the growth of *Amaranthus cruentus*.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>No. of leaves</th>
<th>Stem girth (cm)</th>
<th>Vigor</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>10.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.84&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.42&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>50</td>
<td>7.90&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>7.76&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.20&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.34&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>75</td>
<td>8.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.36&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.86&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.26&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Control</td>
<td>5.98&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.96&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.09&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Means within a column followed by the same letter along columns are not significantly different (p=0.05).

**Figure 5:** Plant height in a 3 weeks old, *A. cruentus* under NPK fertilizer.

**Figure 6:** Number of leaves in a 3 weeks old, *A. cruentus* under NPK fertilizer.
treatment with the level of 25 kg/ha as compared to the control which had 0.7 cm stem girth (Table 2 and Figure 8).

**Combined effects of poultry manure and NPK fertilizer**

**Plant height**

The combined effect of poultry manure and NPK showed a significant effect on the growth of *A. cruentus* and poultry manure treatment with 4 ton/ha had the highest plant height of 11.7 cm among all the treatment (NPK and poultry manure treatments), followed by poultry manure with 6 ton/ha which had plant height of 10.7 cm; the lowest plant height of 7.9 cm was observed in NPK treatment with the level of 50 kg/ha, compared to the control which had 6 cm (Table 3, Appendix 3 and Figure 9).

**Number of leaves**

NPK fertilizer treatment with 25 kg/ha had the highest number of leaves, 9 among the treatments of the poultry manure and NPK, followed by the poultry manure treatment with 6 ton/ha which had 8 number of leaves; the lowest number of leaves of 6 was observed in NPK treatment with the level of 75 kg/ha, compared to the control which had five leaves (Table 3 and Figure 10).

**Stem girth**

Poultry manure treatment of 4 ton/ha had the highest stem girth of 1.1 cm among the treatment of poultry manure and NPK, followed by poultry manure and NPK treatment with the level of 6 ton/ha and 50 kg/ha which had stem girth of 1.0 cm; the lowest stem girth of 0.8 was observed in NPK treatment with the level of 25 kg/ha as compared to the control which had 0.7 cm stem girth (Table 3 and Figure 11).

**Seedling vigor**

Poultry manure treatment with 4 ton/ha had the highest vigor of 1 among the treatments of poultry manure and NPK, followed by poultry manure treatment with the 6 ton/ha which had the vigor of 1.2; the lowest vigor of 1.6 was observed in NPK fertilizer treatment at 75 kg/ha as compared to the control with had 2 seedling vigor (Table 3 and Figure 4).
DISCUSSION

The highest plant height was observed in poultry manure treatment with the level of 4 ton/ha and the lowest plant height observed in NPK treatment with the level of 50 kg/ha. This is contrary to the work of Makinde et al. (2010) who worked on the effect of organic, organo minerals and NPK fertilizer treatment on the quality of *A. cruentus* on two soil types in Lagos, Nigeria. They found out that the precise requirement of inorganic fertilizer and its possible substitute is yet to be validated for the production of *A. cruentus*.

According to Michel et al. (2012), the quality of application of organic manure has effects on crop yield and nutrient uptake. This is consistent with the work of Xu et al.
Figure 9: Plant height in a 3 weeks old *A. Cruentus* under combined poultry and NPK fertilizer.

Figure 10: Number of leaves in a 3 weeks old *A. Cruentus* under combined poultry and NPK fertilizer.
Figure 11: Stem girth in a 3 weeks old A. Cruentus under combined poultry and NPK fertilizer.

Figure 12: Seedling vigor in a 3 weeks old A. Cruentus under combined poultry and NPK fertilizer.
(2005), who showed that vegetables grown with higher level of organic manure grew better and in a final higher total yield than those grown on lower amount together with those grown using synthetic fertilizer. The highest number of leaves was observed in NPK treatment with the level of 25 kg/ha and lowest number of leaves observed in NPK treatment with the level of 75 kg/ha. This is in agreement with the work of Adeyemi et al. (1987) who studied the effect of poultry manure and cutting height on the performance of A. hybrids and reported that the adequacy of manure increase the number of leaves. Ibude et al. (1998) observed that plant grown on unfertilized plots produced the shortest plant and poor leaves as they have to rely on the native fertility of the soil. According to Al Farhad et al. (2009), herbage yield is the function of growing condition and crop management practice and in this study, it was observed that poultry manure did not significantly affect herbage yield (Aliyu, 2003). Nee et al., (2013) made similar observation on garden egg and okra plant respectively. The highest stem girth was observed in poultry manure treatment with 4 ton/ha and the lowest stem girth observed in NPK treatment at 25 kg/ha. (Okokoh et al., 2011), however, highest stem girth value of A. cruentus was obtained in 4 ton/ha of poultry manure when applied to the soil. The highest treatment with the best vigor was observed in poultry manure treatment at 4 ton/ha and the lowest vigor observed in NPK fertilizer treatment at 8 ton/ha; the result shows that poultry manure had the best seedling vigor than NPK fertilizer; this is consistent with the work of Xu et al. (2005), who showed that vegetables grown with higher level of organic manure grew better and in a final higher total yield than those grown on lower amount together with those grown using synthetic fertilizer.

Conclusion

Both organic and inorganic fertilizer treatments increased the growth of A. cruentus; both plant growths with poultry manure performed better. From the result obtained in this study, it can be concluded that the application of 4 ton/ha of poultry manure resulted to highest growth among the poultry manure and NPK fertilizer because there was a great increase in plant height, stem girth and seedling vigor, however, poultry manure was less effective in increasing the number of leaves of A. cruentus. Therefore, the study demonstrated that the application of poultry manure can enhance the growth of A. cruentus. The following conclusions can be drawn from this study:

- For fast growth and higher yield of A. cruentus, the use of poultry manure is recommended;
- The ideal time for the application of poultry manure to A. cruentus should be determined for a cost effective production and higher yield;
- Further research should be carried out on the effect of applying other varying rates of NPK and poultry manure on the propagation of A. cruentus;
- In places where the manure is in abundance, higher rate of about 4 ton/ha may be applied to maximize the needed good effect.

REFERENCES
