Comparative effect of pig manure, urea fertilizer and their combinations on the performance of *Amaranthus cruentus* in a Rainforest *Ultisol*, Nigeria

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ABSTRACT: The influence of pig manure, urea and their combinations on the performance of *Amaranthus cruentus* was investigated for two years in a rainforest *Ultisol* of Umudike. The experiment was laid down in a randomized complete block design with four replications. Six treatments consisted of pig manure applied at equivalent rates of 90 kg N/ha as full dose of manure, urea at 60 kg N/ha as full dose of urea. Other treatments were ½ dose of manure (45 kg N/ha) + ½ dose of urea (30 kg N/ha), ¼ dose of manure (22.5 kg N/ha) + ¾ dose of urea (45 kg N/ha), ¾ dose of manure (67.5 kg N/ha) + ¼ dose of urea (15 kg N/ha), and the absolute control. Results indicated that *Amaranthus* plant height was not significantly (*P > 0.05*) affected by the treatments compared to the control. The overall results showed that the combination of ½ manure + ½ urea significantly (*P < 0.05*) increased stem girth (17.42 cm), number of leaves per plant (44.76), fresh yield (41.51 t/ha) and dry matter yield (3.49 t/ha) of *Amaranthus* than sole application of either of them, and is therefore recommended as the best for optimum production of *Amaranthus* in the study area.

**Key words:** *Amaranthus*, growth and development, soil fertility, yield.

INTRODUCTION

The maintenance of soil fertility is essential in achieving and sustaining high crop yields over time. Use of inorganic fertilizers has proven to be more convenient and impactful than the use of organic manures. The resulting soil physical degradation, increased soil acidity, and soil nutrient imbalance have drawn attention of researchers back to the use of manures. Application of organic materials as soil nutrients provides growth-regulating substrates and improves the physical, chemical and microbial properties of the soil (Belay et al., 2001; Iren et al., 2015). Organic residues with high amount of sulphur (S) could reduce soil pH as a result of the addition of sulphate thereby neutralizing the acidity produced by the oxidation of N during decomposition. Sole use of organic manures to sustain high crop production has, however, been reported inadequate, as they are required in rather large quantities to meet crops’ nutrient requirements because of their relatively low nutrient content (Palm et al., 1997).

It has been reported by several researchers (Satyanarayana et al., 2002; Adeniyan and Ojeniyi, 2005; Obasi et al., 2006; Iren et al., 2014) that high and sustainable crop yields are only possible with integrated use of inorganic fertilizers with organic manures. Complementary application of inorganic and organic nutrient sources increases nutrient availability and reduces losses by converting inorganic nitrogen into organic forms (Chand et al., 2006; Chen, 2008). It enhances the efficiency of the fertilizers and also reduces environmental problems that may arise from their use (Zublena et al., 1996; Hoffman et al., 2001).

*Amaranthus* also called African spinach, bush green,
green leaf, *amaranth* in different parts of the world belongs to the family *Amaranthaceae*. *Amaranthus* species are a group of highly popular vegetables, belonging to many different species. They are the most commonly grown leafy vegetable of the lowland tropics in Asia and Africa. The commonly cultivated *amaranth* in Africa include: *Amaranthus cruentus*, *A. dubius*, *A. spinosus*, *A. blitum*, *A. thunbergii*, *A. graecizans* and *A. caudatus*, but only the *A. Cruentus* species is most commonly grown in Africa (Schippers, 2000). *A. cruentus* can be grown all through the year depending on the availability of water. *Amaranthus cruentus* is best recognized by its leaves that are twice or three times as long as wide and often have pointed leaf tip. *Amaranthus* has a high nutritional value because of the high levels of essential micro-nutrients like iron (an important element against anaemia), manganese and zinc (Mkkeni et al., 2007). It contains calcium, Mg, carotene and niacin. Vitamin A and C are also present in significant levels. The protein found in young plants of amaranths can be important for people without access to meat or other sources of protein.

*Amaranthus cruentus* can be sown directly in seed bed with the entire plant harvested some 4 to 5 weeks after sowing (Schippers, 2000), or planted in nursery beds before transplanting them to the main field. According to Schippers (2000), transplanted seedlings are most commonly used for ratoon crops (with successive harvests), whereas direct sowing is the rule for a crop that is harvested by uprooting. The optimal spacing for plants to be harvested by uprooting is 10 x 10 cm, whereas for the one with successive harvests (ratoon crop), the optimum spacing is about 20 x 20 cm (Schippers, 2000; Ayuba et al., 2001).

This study was conducted to determine the effect of sole and combined use of inorganic fertilizer, urea, and organic manure from pig on the performance of *Amaranthus*. It is also designed to establish the best combination of these nutrient sources for *Amaranthus* production in the Rainforest zone of Umudike, Nigeria.

**MATERIALS AND METHODS**

**Description of the Study Area**

This experiment was conducted during the dry season at the Research Farm of Michael Okpara University of Agriculture, Umudike, Abia State in Nigeria. Umudike is located in the humid forest zone of Nigeria and lies within latitude 05° 29’ N and longitude 07° 33’ E, with an altitude of 122 m above sea level. The study area by the virtue of its latitudinal location falls within the humid tropics and hence enjoys humid tropical environment marked by two distinct seasons namely the rainy season and the dry season. Umudike is characterized by tropical wet (March to October) and dry (November to February) seasons. Annual rainfall in Umudike ranges from 1900 mm to 2650 mm, bimodally distributed with peaks in the months of July and September (Iren and Osodeke, 2006). There is usually a short dry spell in August which is referred to as ‘August break’.

The minimum and maximum temperatures ranged from 19 to 24°C and 28 to 34°C respectively. The minimum and maximum monthly relative humidity ranges from 39 to 81% and 52 to 87% respectively in the area. The soil is loamy sand, strongly acidic in reaction with low nutrient reserve (Iren et al., 2012) and classified as an Ultisol (Njoku et al., 2001).

**Treatments and experimental design**

There were six treatments replicated four times (Table 1). The treatments were pig manure applied at an equivalent of 90 kg N/ha as full dose of manure, and urea applied at 60 kg N/ha as full dose of urea. Other treatments were ½ dose of manure (45 kg N/ha) + ½ dose of urea (30 kg N/ha), ¼ dose of manure (22.5 kg N/ha) + ½ dose of urea (45 kg N/ha), ¾ dose of manure (67.5 kg N/ha) + ¼ dose of urea (15 kg N/ha) and absolute control. Pig manure rates were calculated based on its nitrogen (N) content of 2.87% (Table 2).

The experimental design used was a randomized complete block design. Each experimental plot measured 3 m x 1.5 m (4.5 m²) with an alley of 1.2 m left between blocks and spacing of 0.6 m between plots. Pig manure...
Table 3. Effect of pig manure and urea fertilizer on the height of *Amaranthus* plant in the 1st and 2nd cropping seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>3WAP</th>
<th>4WAP</th>
<th>5WAP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>Mean</td>
</tr>
<tr>
<td>Control</td>
<td>12.25</td>
<td>12.3</td>
<td>12.28</td>
</tr>
<tr>
<td>Manure (m)</td>
<td>15.85</td>
<td>14.2</td>
<td>15.03</td>
</tr>
<tr>
<td>Urea (u)</td>
<td>18.1</td>
<td>16.6</td>
<td>17.35</td>
</tr>
<tr>
<td>½ m + ½ u</td>
<td>16.95</td>
<td>17</td>
<td>16.98</td>
</tr>
<tr>
<td>¾ m + ¼ u</td>
<td>17.75</td>
<td>16.4</td>
<td>17.08</td>
</tr>
<tr>
<td>¼ m + ¾ u</td>
<td>19</td>
<td>15.9</td>
<td>17.45</td>
</tr>
</tbody>
</table>

LSD (0.05) NS NS NS NS NS NS NS NS NS

was applied one week before planting (WBP) by broadcast with incorporation method (Iren et al., 2011). Urea fertilizer was applied two weeks after planting (WAP) by band placement method.

*Amaranthus* seeds were mixed with dried river sand before sowing so as to ensure the seeds were not planted too close together for proper management of the seed rate desired. The mixture was 70% sand and 30% *Amaranthus* seeds. These were evenly distributed directly on drills at a distance of 10 cm between each row. The seedlings were later thinned to one plant per stand few days after emergence at a spacing of 10 cm between plants. Therefore, the planting distance was 10 cm × 10 cm giving plant population of 450 plants per bed equivalent to 1,000,000 plants per hectare (10,000 m²).

The plots were kept weed free throughout the crop growing period by hand pulling because of the closeness of the plants. Plots were irrigated manually using watering cans before planting and immediately after planting to ensure germination and enhance sprouting. Watering was done 2 times a day (morning and evening) at the initial stage of development and this was reduced to ones (evening only) every day till the end of the experiment. During this time there was a good canopy development that shaded the ground and reduced soil moisture loss.

**Data Collection**

Agronomic parameters measured included plant height, number of leaves per plant, stem girth, fresh yield and dry matter yield. Plant height was measured with a meter rule as the height from the base of the crop (ground level) to the tip of ten tagged plants, while the number of leaves was taken to be the fully opened leaves per plant. These measurements commenced 3 weeks after planting (WAP) and continued at weekly interval until the end of the experiment. Harvesting was done at 5 WAP by uprooting the entire plant from an area of 100 cm × 100 cm per plot and the fresh yield determined after rinsing the roots free of sand. For dry matter determination, ten tagged plants were uprooted, rinsed, and oven-dried at 65 °C to constant weight (Maerere et al., 2001) and the weight determined using digital balance. Stem girth was measured at harvest using venier caliper. The data on fresh and dry yield were converted into t/ha using the formula below:

\[
\text{Yield (t/ha)} = \frac{\text{WT} \times 10^{-2}}{\text{PA}}
\]

Where WT = weight of *Amaranthus* (g), PA = plot area (m²), 10⁻² = conversion factor because 1 ha = 10⁴ m² and 1 t = 10⁶ g or 10³ kg.

**Data Analysis**

The data collected were subjected to analysis of variance (ANOVA) using the general linear models (GLM) procedures of the Statistical Analysis System Programme (SAS, 1989) to determine treatment effects. Means were separated using Fisher’s Least Significant Difference (FLSD) at 5% level of probability.

**RESULTS**

**Effect of Pig Manures and urea Fertilizer on Growth parameters of *Amaranthus***

The height of *Amaranthus* plants was not significantly (*P* >0.05) affected by the pig manures and urea fertilizers being sole and/or combined (Table 3).

There was no significant (*P* >0.05) difference in the mean number of leaves per plant at 3 WAP from the use of pig manure and urea fertilizer in the first and second cropping seasons (Table 4). However, results indicated that these treatments significantly (*P* <0.05) increased the
**Table 4.** Effect of pig manure and urea on mean number of leaves per *Amaranthus* plant in the 1st and 2nd cropping seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>3WAP (Mean)</th>
<th>4WAP (Mean)</th>
<th>5WAP (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>1st</td>
</tr>
<tr>
<td>Control</td>
<td>13.27</td>
<td>12.05</td>
<td>12.66</td>
</tr>
<tr>
<td>Manure (m)</td>
<td>14.4</td>
<td>14.1</td>
<td>14.25</td>
</tr>
<tr>
<td>Urea (u)</td>
<td>15.95</td>
<td>14.55</td>
<td>15.25</td>
</tr>
<tr>
<td>½ m + ½ u</td>
<td>15.6</td>
<td>14.48</td>
<td>15.04</td>
</tr>
<tr>
<td>¾ m + ¼ u</td>
<td>14.3</td>
<td>14.2</td>
<td>14.25</td>
</tr>
<tr>
<td>¼ m + ¾ u</td>
<td>15.38</td>
<td>14.46</td>
<td>14.92</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>NS</td>
<td>NS</td>
<td>1.06</td>
</tr>
</tbody>
</table>

**Table 5.** Effect of pig manure and urea fertilizer on *Amaranthus* stem girth in the 1st and 2nd cropping seasons.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1st cropping</th>
<th>2nd cropping</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>9.98</td>
<td>9.58</td>
<td>9.77</td>
</tr>
<tr>
<td>Manure</td>
<td>14.20</td>
<td>17.03</td>
<td>13.96</td>
</tr>
<tr>
<td>Urea</td>
<td>16.60</td>
<td>13.83</td>
<td>15.47</td>
</tr>
<tr>
<td>½ m + ½ u</td>
<td>17.83</td>
<td>14.90</td>
<td>15.71</td>
</tr>
<tr>
<td>¾ m + ¼ u</td>
<td>15.25</td>
<td>14.35</td>
<td>15.14</td>
</tr>
<tr>
<td>¼ m + ¾ u</td>
<td>16.53</td>
<td>14.35</td>
<td>15.71</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>2.98</td>
<td>2.57</td>
<td>1.86</td>
</tr>
</tbody>
</table>

number of leaves per plant relative to the absolute control at 4 and 5 WAP. Results also indicated that the highest mean number of leaves per plant (27.65 and 44.77) was obtained from the ½ pig manure + ½ urea fertilizer combinations.

The biggest stem girth of *Amaranthus* was obtained from the ½ manure + ½ urea treatment and the least by the absolute control in both seasons (Table 5), although in the first cropping season, the ½ manure + ½ urea treatment was significantly different from the sole manure treatment but not with the other treatments. In the second cropping season, the ½ manure + ½ urea was significantly different in stem girth from all the treatments except the ¼ m + ¾ u. The results showed that the biggest stem girth (17.42 cm) was obtained from the ½ manure + ½ urea treatment.

**Effect of pig manure and urea fertilizer on fresh and dry matter yield of *Amaranthus***

The highest fresh yield of *Amaranthus* of 42.80 t/ha obtained from application of ¼ manure + ¾ urea in the first cropping season was significant compared to the sole pig manure and the absolute control (Table 6). The highest yield of 41.01 t/ha obtained from application of ½ manure + ½ urea in the second cropping season was significant relative to the absolute control. The mean data for the two years indicated that ½ manure + ½ urea recorded the highest fresh yield of 41.51 t/ha, followed by ¼ manure + ¾ urea (41.40 t/ha) and the absolute control (22.75 t/ha) was the least. The highest dry matter yield (3.49 t/ha) was also obtained from ½ manure + ½ urea combination (Table 6).

**DISCUSSION**

The best result on the performance of *Amaranthus* was obtained from combined use of organic pig manure and inorganic urea fertilizer. This could be attributed to the organic influence of the pig manure on the microbial activities and soil moisture and/or temperature and the easy release of nutrients induced by salt index of urea. These findings are in line with those obtained by Satyanarayana et al. (2002), Adeniyan and Ojeniyi (2005), Adediran et al. (2005), Obasi et al. (2006) Iren et al. (2011 and 2012) and Iren et al. (2014). Most of their findings indicate better effect of organic materials on *Amaranthus* when applied in combination with inorganic...
fertilizers.
Generally, the fresh yields obtained from all the treatments except the absolute control in both the first
and second cropping seasons were higher than the 25 t/ha. These are the optimum yields reported by Tandon
(1991) and Messiaen (1992), and the maximum was 30 t/ha reported by Schippers (2000). This shows that
Amaranthus responded positively to the various types of soil amendments. The highest dry matter yields obtained
from ½ manure + ½ urea combination concurs with those obtained by Palm et al. (1997), Adeniyan and Ojeniyi
(2005) and Chen (2008).

CONCLUSION
This study showed that balanced use of both organic
manure and inorganic fertilizer enhanced optimum growth
and yield of Amaranthus compared to sole application
of either of them. The combination of 45 kg N/ha of the pig
manure (½ of full dose manure) and 30 kg N/ha of urea
(½ of full dose urea) was not significantly different. They
were also statistically similar to those from the combina-
tion of 22.5 kg N/ha of pig manure (¼ manure) and 45 kg
N/ha of urea (¼ urea). However, combination of ½ of
each full dose gave significant improvement in the
performance of Amaranthus and is therefore recommended
as the best for optimum production of Amaranthus
with similar environments and climatic conditions.

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chemical properties, yield and root growth of Amaranthus

Table 6. Effect of pig manure and urea on Amaranthus fresh and dry matter yields in the 1st and 2nd
cropping seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fresh yield (t/ha)</th>
<th>Dry matter yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st cropping</td>
<td>2nd cropping</td>
</tr>
<tr>
<td>Control</td>
<td>23.50</td>
<td>22.00</td>
</tr>
<tr>
<td>Manure</td>
<td>31.80</td>
<td>32.11</td>
</tr>
<tr>
<td>Urea</td>
<td>41.13</td>
<td>39.97</td>
</tr>
<tr>
<td>½ m + ¼ u</td>
<td>42.00</td>
<td>41.01</td>
</tr>
<tr>
<td>¾ m + ¼ u</td>
<td>37.00</td>
<td>32.51</td>
</tr>
<tr>
<td>¼ m + ¾ u</td>
<td>42.80</td>
<td>40.00</td>
</tr>
<tr>
<td>LSD(0.05)</td>
<td>9.96</td>
<td>9.87</td>
</tr>
</tbody>
</table>


