

*Full Length Research Paper*

**EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON SOIL  
CHEMICAL PROPERTIES AND THE YIELD OF *Amaranthus species* IN A  
CONTINUOUSLY CROPPED ULTISOL**

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**ABSTRACT**

Field and laboratory experiments were conducted to evaluate the effects of poultry manure and NPK (20:10:10) fertilizer on soil chemical properties and yield of *Amaranthus species*. The treatments were: T1-Control (no fertilizer), T2-NPK 20:10:10 (200kg/ha), T3-Poultry manure (5 tons/ha), T4-NPK 20:10:10 (100kg/ha) + Poultry manure (2.5 tons/ha), T5-NPK 20:10:10 (100kg/ha)+ Poultry manure (5 tons/ha), T6-NPK 20:10:10 (200kg/ha)+ Poultry manure (5 tons/ha). The experiments were laid out in a randomized complete block design (RCBD). The soil was strongly acidic, having a pH of 5.1 and low in % total Nitrogen (0.10), % organic carbon (1.13) and the exchangeable bases. From the study, the poultry manure 5t/ha + NPK (20:10:10) 100kg/ha gave the best yield of *Amaranthus species*, followed by poultry manure 5t/ha + NPK (20:10:10) 200kg/ha which gave an increase in soil chemical properties. It is recommended that the combination of poultry manure 5t/ha + NPK (20:10:10) 100kg/ha fertilizer could be used for profitable *Amaranthus* production in the study area.

**Keywords:** Organic fertilizer, Inorganic fertilizer, Soil chemical properties, Yield, *Amaranthus species*

**1. INTRODUCTION**

*Amaranthus* is one of the most important annual leaf vegetables in the tropics. It has a growing period of 5 to 6 weeks, thus making it an advantage for the rural and urban farmers to keep cultivating it two or more times on the same piece of land in a year (Adewole and Igberaese, 2011). *Amaranthus* does well on soils with high organic matter; it is a nutritious vegetable and contains relatively high amounts of minerals and vitamins, which are needed for healthy body growth, sustenance and alleviation of problems of hunger and malnutrition mostly experienced amongst children in developing countries (Lucas and Ojeifo, 2000). *Amaranthus* is one of such important vegetables that could be domesticated and cultivated, but information on its fertility requirements is scanty due to resource-poor conditions encountered in most rural settings of the most African countries, especially southern Nigeria, northern Guinea and Sudan savannas. *Amaranthus* cultivation has emerged as an important field not only for enhancing nutritional levels especially of Indian diets, but also as a diversified profession for higher earnings. In order to make it competitive and profitable, it is important and necessary to use critical inputs to achieve higher levels of quality and productivity. Vegetable seedlings are one of the most important and costly inputs in the modern vegetable crop production. Precision in the application of this input is vital in realizing the crop potential and returns. The exclusive use of inorganic nitrogenous fertilizer to improve crop production most of the time has a negative effect on semi-arid tropical soils as this increases soil acidity, which has been well reported by several researchers (Makinde *et. al.*, 2010; Modisane *et. al.*, 2009). There is the need therefore, to investigate alternative sources of fertilizers for *Amaranthus* production in order to increase the availability of high quality *Amaranthus* throughout the wet cropping season and at affordable price.

Although the crop responds to organic manure, studies on effect of organic wastes, crop residues and integrated application of organic and inorganic fertilizers on performance of *Amaranthus* are scarce.

The objectives of the study were to:

1. Determine the yield response of *Amaranthus* to different fertilizer sources (organic and inorganic).
2. Determine the effect of the different fertilizer sources on soil chemical properties.

## **MATERIALS AND METHODS**

### **Location**

The field experiment was conducted at Agbama Ibeku in Umuahia Abia State, Nigeria. The field plot lies between latitude  $05^{\circ} 29. 059'$  N and longitude  $07^{\circ} 32.197'$  E on an elevation of 100 meters above sea level. There had been consistent farming on the land.

### **Climate**

Agbama area is a humid tropical climate area with marked wet and dry season. The rainy season

distributions are two forms with peaks in July and September. Rainfall is heavy more in October. The temperature of the area range from about 28°C during wet season to about over 35°C in dry season, with a mean temperature of 12.1°C and relative humidity ranging from 58-90% according to Meteorology Station of National Root Crops Research Institute Umudike Abia State (National Root Crops Research Institute Umudike, 2001).

## **Vegetation**

The vegetation of the area is distributed with crops, grasses, shrub and other medicinal or herbaceous plants can be seen around. There are also cultivated crops in the area by farmer or individuals for personal interest Example are plantain, maize, vegetables, cassava etc for economical usage.

## **Collection and preparation of soil samples**

Before the experiment, Soil samples were randomly collected at the depth of 0-20cm, bulked together and a composite soil sample was collected for determination of soil physical and chemical properties. At the end of the experiment, soil samples were randomly collected per plot at the same depth for determination of some chemical properties. The composite soil samples were air-dried, sieved to pass through a 2mm sieve and kept for routine laboratory analysis.

## **LABORATORY ANALYSIS**

### **The particle size distribution**

Mechanical analysis was determined using Bouyoucos hydrometer method (Sheldrick and Wang, 1993).

### **Soil pH determination**

Soil pH determination was carried out using a ratio of 1:2.5 soil to water and 1N KCl, and read with a digital pH meter (Ibitoye, 2006).

### **Total nitrogen**

Total Nitrogen was determined by the micro-kjeldahl method (Bremner, 1996).

### **Organic carbon determination**

Organic carbon content was determined by Walkley and Black dichromate oxidation method as modified by (Nelson and Sommers, 1996).

### **Available phosphorus**

Available phosphorus was extracted using Bray 2 solution and determined using the procedure proposed by the Bray and Kurtz (1945).

### **Exchangeable bases**

Exchangeable bases; Ca, K, Mg and Na were extracted with 1N  $\text{NH}_4\text{OAc}$  using a soil: solution volume ratio of 1:10. The K and Na in the extract were read using flame photometer; while Ca and Mg were determined by EDTA titration method (IITA, 1989).

### **Exchangeable acidity**

Exchangeable acidity;  $\text{H}^+$  and  $\text{Al}^{3+}$  were determined from 1N KCl extract and titrated with 1N HCl (Hendershot and Lalande, 1993).

### **Land preparation**

The land was cleared of its initial vegetation of grasses and beds were made at the measurement of 1x1 meter; a total of 18 beds with spacing of 1meter between each bed with each bed having 3 stands of *Amaranthus* plant and a total of 54 stands.

## **MATERIALS USED FOR THE STUDY**

### *Amaranthus species*

They seeds were obtained from the National Seeds Council domiciled at the National Root Crops Research Institute, Umudike, Abia State.

### **Poultry manure**

Poultry manure was obtained from the poultry unit of the University. This was to have an increase amount in quantity and quality of poultry manure.

### **N.P.K Fertilizer**

The fertilizer N.P.K 20:10:10 was used for this study as well

### **Treatment application rate**

There were six (6) treatments which were:

T1-Control (no fertilizer)

T2-NPK 20:10:10 (200kg/ha), application rate 20g

T3-Poultry manure (5 tons/ha)

T4-NPK 20:10:10 (100kg/ha), application rate 10g + Poultry manure (2.5 tons/ha)

T5-NPK 20:10:10 (100kg/ha), application rate 10g+ Poultry manure (5 tons/ha)

T6-NPK 20:10:10 (200kg/ha), application rate 20g+ Poultry manure (5 tons/ha)

### **Field experiment**

The farm site was slashed, ploughed, harrowed and marked out. The experiment was laid out in a Randomized Complete Block Design (RCBD), replicating three times with 6 treatments. The S plot size was 1m x 1m. A planting distance of 20cm x 20cm intra spacing, and inter row spacing of 50cm between experimental plot was used and the distance between blocks was 1m.

## **RESULTS AND DISCUSSION**

### **Physical and chemical properties of the soil for the experiment**

Table 1 shows the physical and chemical properties of the soil for the experiment, the soil was loamy sand and low in pH (water) 5.1 and 4.0 in KCl. This simply indicates strong acidity (Chude *et al.*, 2004).

The total Nitrogen was low (0.10%). The organic carbon value (1.13%) was also low. These could be as a result of high rainfall which is common to the southeastern Nigeria (Enwezor *et al.*, 1990). Available phosphorus value was moderate (15.20 mg/kg), the exchangeable bases calcium, sodium, magnesium, and potassium has the following value respectively (3.80, 0.17, 1.00, and 0.21) cmol/kg, the values were low. The Ultisol of South Eastern Nigeria reportedly low in exchangeable bases (Nwite *et al.*, 2009).

The organic carbon content of the soil was also low (1.13%), the exchangeable acidity value of (1.12) cmol/kg was due to acidic nature of the soil which might be because of continuous cultivation and excessive nature of rainfall in the south east.

**Table 1: Physical and chemical properties of the soil for the experiment**

| Parameters                                  | Values     |
|---|------------|
| % Sand                                      | 80.40      |
| % Silt                                      | 8.30       |
| % Clay                                      | 11.30      |
| Texture                                     | Loamy Sand |
| pH (H <sub>2</sub> O)                       | 5.10       |
| pH (KCl)                                    | 4.00       |
| Available Phosphorus                        | 15.20      |
| % Total Nitrogen                            | 0.10       |
| % Organic Carbon                            | 1.13       |
| % Organic Matter                            | 1.94       |
| Exchangeable Calcium (cmol/kg)              | 3.80       |
| Exchangeable Magnesium (cmol/kg)            | 1.00       |
| Exchangeable Potassium (cmol/kg)            | 0.21       |
| Exchangeable Sodium (cmol/kg)               | 0.17       |
| Exchangeable Acidity (cmol/kg)              | 1.12       |
| Total Exchangeable Bases (cmol/kg)          | 5.18       |
| Effective Cation Exchange Capacity(cmol/kg) | 6.31       |
| % Base Saturation                           | 82.25      |

#### **Chemical properties of the poultry manure used for the experiment**

Table 2 shows the chemical properties of the poultry manure used for the experiment. The pH was close to neutral (6.80). The organic matter content, potassium, nitrogen, phosphorus and organic carbon were 0.92%, 2.61%, 2.14%, and 17.10% respectively. This indicates the high potential for the poultry manure to improve the soil chemical properties (Adeoluwa and Adeogun, 2010).

**Table 2: Chemical properties of poultry manure used for the experiment**

| Parameters         | Values |
|--------------------|--------|
| pH                 | 6.80   |
| Nitrogen (%)       | 2.48   |
| Phosphorus (%)     | 2.14   |
| Potassium (%)      | 2.61   |
| Calcium (%)        | 0.92   |
| Organic carbon (%) | 17.10  |
| Organic matter (%) | 29.48  |

**Effect of poultry manure and npk 20:10:10 on the yield of *Amaranthus species* in the field experiment**

Table 3 shows effect of poultry manure and NPK 20:10:10 on the yield of *Amaranthus species* in the field. At harvest, application of NPK (20:10:10) 100kg/ha fertilizer + poultry manure 5t/ha gave the highest plant height. Poultry manure has been reported to increase soil fertility which promotes healthy plant (Ojeniyi and Adejobi, 2002).

On the stem girth of *Amaranthus species*, application of 100kg/ha NPK (20:10:10) + 5t/ha poultry manure gave the highest value followed by 5t/ha poultry manure.

Poultry manure at the rate of 5t/ha + NPK 20:10:10 at the rate of 100kg/ha recorded the highest number of leaves which is due to the complementary effect of poultry manure and NPK 20:10:10 fertilizer (Nweke and Nsoanya, 2013).

Fresh weight of *Amaranthus species* at harvest was improved mostly by 5t/ha poultry manure + 100kg/ha NPK (20:10:10) fertilizer, followed by 5t/ha poultry, then 5t/ha poultry manure + 200kg/ha NPK (20:10:10) fertilizer. The fresh weight yield was actually in this order: 5t/ha poultry manure + 100kg/ha NPK (20:10:10) > 5t/ha poultry manure > 5t/ha poultry manure + 200kg/ha NPK (20:10:10) > 2.5t/ha poultry manure + 100kg/ha NPK (20:10:10) > 200kg/ha NPK (20:10:10). The control gave the least fresh weight. This is not surprise because poultry manure is a good source of nitrogen. Combine application of organic and inorganic nutrients has also been reported to give better yield than sole application of each (Omar, 2013).

**Table 3: Effect of poultry manure and NPK (20:10:10) on the yield of *Amaranthus* species in the field experiment**

| Treatments                     | Plant height<br>(cm) | No of leaves<br>(cm) | Stem girth<br>(cm) | Fresh weight<br>(g) |
|--------------------------------|----------------------|----------------------|--------------------|---------------------|
| <b>Control</b>                 | 22                   | 30                   | 3.10               | 227                 |
| <b>PM 5t/ha</b>                | 65.0                 | 101                  | 7.22               | 2586                |
| <b>NPK 200kg/ha</b>            | 28                   | 48                   | 4.11               | 334                 |
| <b>PM 5t/ha+NPK 200kg/ha</b>   | 60                   | 82                   | 6.99               | 2268                |
| <b>PM 5t/ha+NPK 100kg/ha</b>   | 80                   | 131                  | 8.76               | 2958                |
| <b>PM 2.5t/ha+NPK 100kg/ha</b> | 63                   | 91                   | 6.78               | 2025                |
| <b>Mean</b>                    | 52.7                 | 80.6                 | 6.16               | 17.53               |
| <b>CV</b>                      | 12.6                 | 11.5                 | 13.2               | 9.3                 |
| <b>SE</b>                      | 6.66                 | 9.23                 | 0.81               | 161.4               |
| <b>LSD (0.05)</b>              | 19.27                | 42.99                | 2.56               | 2204.2              |

**PM = Poultry manure**

**T/ha = Tons per hectare**

**Effect of different rates of poultry manure and npk (20:10:10) fertilizer on soil chemical properties after the harvest of *Amaranthus* sp.**

Table 4 shows effects of different rates of poultry manure and NPK (20:10:10) fertilizer on soil chemical properties after the harvest of *Amaranthus* sp. in the field. At the rate of 5t/ha of poultry manure + 200kg/ha NPK (20:20:10) fertilizer, soil chemical properties were most improved. This treatment among others, gave the highest values for soil pH (H<sub>2</sub>O) (6.27); and pH (KCl) (5.80). These values were significantly higher (p<0.05) than what was obtained from all other treatment followed by 5t/ha of poultry manure + 100kg/ha NPK (20:10:10) fertilizer which was also significantly higher than the other treatments. The control gave the least value for soil pH (H<sub>2</sub>O) (4.54) and pH (KCl) (3.83). All other parameters also followed the same pattern, except for the soil exchangeable acidity where 5t/ha of poultry manure +100kg/ha NPK (20:10:10) fertilizer gave the least value (0.35 cmol/kg), followed by 5t/ha of poultry manure + 200kg/ha NPK (20:10:10) fertilizer. The ability of the manure to increase the soil pH can be aligned with the supply of K, Ca, Mg and Na. The increase in the pH of the soil after harvest could be due to the buffering from the carbonates and organic acids in the amendments (Sanniet *et al.*, 2013).

**Table 4: Effect of Different Rates of Poultry Manure and NPK (20:10:10) Fertilizer on Soil Chemical Properties after the harvest *Amaranthus sp.***

| Treatment               | pH(H <sub>2</sub> O) | pH(KCl) | Av.Pmg/kg | TN %  | OC %  | OM %  | Ca    | Mg    | K<br>Cm<br>ol/kg | Na    | EA    | AL <sup>3+</sup> | ECEC  | BS    |
|-------------------------|----------------------|---------|-----------|-------|-------|-------|-------|-------|------------------|-------|-------|------------------|-------|-------|
| ↔↔↔↔↔↔↔↔↔↔↔↔↔↔↔         |                      |         |           |       |       |       |       |       |                  |       |       |                  |       |       |
| Control                 | 4.54                 | 3.83    | 13.23     | 0.10  | 0.91  | 1.57  | 2.87  | 0.67  | 0.18             | 0.15  | 1.36  | 0.35             | 5.22  | 73.92 |
| PM 5t/ha                | 5.80                 | 4.97    | 19.20     | 0.41  | 2.34  | 4.03  | 5.77  | 3.00  | 0.48             | 0.32  | 0.44  | 0.09             | 10.01 | 95.53 |
| NPK 200kg/ha            | 5.04                 | 4.13    | 19.57     | 0.32  | 1.28  | 2.21  | 4.97  | 2.67  | 0.40             | 0.33  | 0.99  | 0.23             | 9.35  | 89.44 |
| PM 5t/ha+NPK 200kg/ha   | 6.57                 | 5.80    | 28.20     | 0.57  | 2.34  | 4.06  | 10.37 | 5.40  | 0.70             | 0.51  | 0.45  | 0.17             | 17.43 | 97.39 |
| PM 5t/ha+NPK 100kg/ha   | 6.03                 | 5.30    | 23.53     | 0.48  | 2.33  | 4.02  | 8.40  | 4.27  | 0.58             | 0.41  | 0.35  | 0.11             | 14.02 | 97.47 |
| PM 2.5t/ha+NPK 100kg/ha | 5.50                 | 4.63    | 21.27     | 0.38  | 1.76  | 3.02  | 6.73  | 3.20  | 0.53             | 0.40  | 0.49  | 0.15             | 11.34 | 95.70 |
| Mean                    | 5.58                 | 4.78    | 28.83     | 0.37  | 1.83  | 3.15  | 6.52  | 3.20  | 0.48             | 0.35  | 0.68  | 0.18             | 11.23 | 91.58 |
| CV                      | 1.10                 | 1.60    | 0.30      | 1.40  | 1.30  | 1.30  | 0.30  | 2.80  | 0.51             | 0.90  | 2.50  | 0.90             | 0.50  | 0.40  |
| SE                      | 0.060                | 0.079   | 0.060     | 0.005 | 0.023 | 0.042 | 0.016 | 0.088 | 0.003            | 0.003 | 0.016 | 0.002            | 0.053 | 0.357 |
| LSD (0.05)              | 0.18                 | 0.20    | 0.87      | 0.035 | 0.08  | 0.14  | 0.14  | 0.58  | 0.009            | 0.009 | 0.04  | 0.02             | 0.69  | 0.99  |

## CONCLUSION

The result of the study shows that the soil of the area is acidic, which results in low organic carbon, low exchangeable bases for example calcium, magnesium, sodium, and potassium. The use of poultry manure 5t/ha + NPK (20:10:10) 100kg/ha gave the best yield result followed by poultry manure 5t/ha + NPK (20:10:10) 200kg/ha which gave an increase in soil chemical properties. It is recommended that the combination of poultry manure and NPK (20:10:10) fertilizer is better for profitable production of *Amaranthus species* in the study area.

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