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Growth, Yield, and Nutrient Content of *Amaranthus SPP*. as Influenced by Organic and Inorganic Nutrient Sources

Akinmutimi, A.L.

Department of Soil Science and Land Resources Management, College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike. P.M.B. 7267, Umuahia, Abia State, Nigeria.
*Author E-mail: akinmutimi.abiola@mouau.edu.ng, +2348035666900

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ABSTRACT: Greenhouse and Laboratory studies were carried out to compare the effects oforganic and inorganic nutrient sources on the growth, yield and nutrient content of *Amaranthus Cruentus* . The experiments were conducted at the Michael Okpara University of Agriculture, and the National Root Crops Research Institute, Umudike. The treatments were: 0 tons/ha- control (T_1), NPK 20:10:10 fertilizer 400kg/ha (T_2), NPK 20:10:10 Fertilizer equivalent of 200kg/ha + 20t/ha poultry manure (T_3), NPK 20:10:10 Fertilizer equivalent of 200kg/ha + 30t/ha poultry manure (T_4),Poultry manure equivalent of 20t/ha. (T_5), Poultry manure equivalent of 30t/ha (T_6). The treatments were replicated three times and arranged in a completely randomized design (CRD) in the greenhouse. The soil used for the study was acidic, having a pH value of 4.8 and low percentage nitrogen (0.09 %), total exchangeable bases (4.46 cmol/kg) and exchangeable acidity (1.64cmol/kg). From the results, the growth parameters measured (Plant height, stem girth and number of leaves) were significant at $p<0.05$ with the treatment containing NPK 20:10:10 fertilizer equivalent of 200kg/ha + 30t/ha poultry manure (T_4) having the highest values in almost all the growth parameters measured. The same trend was observed with respect to fresh biomass and dry matter yield and the nutrient composition of *Amaranthus cruentus*. It was therefore concluded that NPK 20:10:10 fertilizer + 30t/ha poultry manure application gave the optimal performance in this study and is therefore recommended for the cultivation of *Amaranthus cruentus* in the study area.

Keywords: Growth, yield, nutrient content, *Amaranthus sp*., organic, inorganic nutrient

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INTRODUCTION

Amarranthus spp. (Family *Amaranthaceae*) is commonly known as the spiny, prickly or thorny amaranth. It is an annual vegetable that is widely distributed in the humid zone of the tropics including Nigeria (Assiak *et al.,* 2001). *Amaranthus spp* is a coarse herb with sharp spines and tiny greenish flowers (Costea and DeMason, 2001). It is a leafy vegetable which contains important mineral nutrients such as calcium, iron, phosphorus, magnesium, zinc, copper, manganese, etc. (USDA Nutrient Database, 2010). In Nigeria, this species of Amaranthus is eaten as a vegetable in some parts of Delta, Edo and Akwalbom States. It is also a very good fodder for cattle and goats. The vegetable has been reported to possess both nutritional and pharmacological properties (Ayethan *et al.,* 1995; Baral *et al.,* 2011; Alegbejo, 2013).

Organic and inorganic fertilizers are essential for plant growth. Both fertilizers supply plants with the nutrients needed for optimum performance. Organic fertilizers have been used for many centuries whereas chemically synthesized inorganic fertilizers were only widely developed during the industrial revolution. Inorganic fertilizer has significantly supported global population growth, it has been estimated that almost half of the people on the earth are currently fed as a result of artificial nitrogen fertilizer use (Erisman *et al.,* 2008). Commercial and subsistence farming has been and is still relying on the use of inorganic fertilizers for growing crops (Masarirambi *et al.,* 2010). This is because they are easy to use, quickly absorbed and utilized by crops. The chemical fertilizers used in conventional agriculture

contain just a few minerals which dissolve quickly in damp soil and give the plants large doses of minerals (Masarirambi *et al.,* 2010). Most vegetable farmers in tropical Africa are small holders who cannot afford cost of inorganic fertilizers, although soil infertility limits yield of vegetables especially in urban and surrounding environments (Makinde *et al.,* 2010).

In Nigeria, fertilizer being costly and sometimes scarce can make farmers not apply enough for good growth (Alonge *et al.,* 2007). Fertilizer application rates in intensive agricultural systems have increased drastically during recent years in Nigeria. Farmers depend largely on locally sourced organic fertilizers (Makinde *et al*., 2010).

Organic wastes are rich plant nutrients (Mahmoud *et al.,* 2009). Organic material such as farm wastes and manure improve soil physical chemical properties that are important for plant growth (Snyman *et al.,* 1998). Organic fertilizers have positive effect on root growth by improving the root conditions (structure, humidity etc.) and also plant growth is encouraged by increasing the population of microorganisms (Fatma *et al.,* 2007).

The effect of organic manures, organomineral fertilizers and NPK have been studied on the nutritional quality of *Amaranthus* (Makinde *et al.,* 2010) who reported that organic material alone or in combination with NPK significantly increased nutritive quality. Funda *et al.* (2011) studied the effect of organic and inorganic fertilizers on yield and mineral content of onion and reported in the year, that treatments influenced K content, but did not influence N, P, Ca, Na, Mg, Fe, Zn, Cu and Mn contents of the onion bulb. In the second year, the treatments influenced Na content, but did not influence the others.

Coolong *et al.* (2005) reported that N, P, Mn, Fe and Zn content of bulb were increased by N treatments but the content of N was decreased by N doses. Potassium, Cu and Mo contents were not affected by the treatments.

Akinmutimi *et al.* (2021) found out that the organic manures such as Chicken and Pig manures solely improved the height of okra *(Abelmoschus esculentus*) while chicken manure gave a better result in the number of leaves in the study area; the Agrolyser gave a better result of production of okra fruits, going by the number of fruits.

Mixture of chicken manure and bio-fertilizer increases the yield of onion and enriched nutrient content in tuber crops (Fatma *et al.,* 2007). Application of organic manures significantly increased levels of organic C and N and the formation of water stable aggregates, as compared with application of chemical fertilizers (N'Dayegamiye, 2006).

Many researchers have worked on the effect of organic and inorganic nutrient source on the growth and yield of Amaranthus in the study area, but there is need to update the findings knowing fully well that time has impact on soils. The aim of the study is to compare the effects of NPK (20:10:10) and poultry manure on the growth and yield of A*maranthus* specie, and to compare the effect of nutrient sources (NPK) and putting manure on the nutrient contents of *Amaranthus spp*.

MATERIALS AND METHODS

Location of the study

The experiment was conducted at Michael Okpara University of Agriculture, Umudike. Umudike lies within latitude 05°29'N and longitude 07°33'E at an elevation of 112m above the sea level. The area falls within the tropical rainforest zone, annual rainfall average is 2177mm and the monthly temperature ranges between 20°C and 36°C.Relative humidity ranges from 50-95% (NRCRI, 2001**).**

Soil sample collection and preparation

Representative soil samples at the depth of 0-15cm were collected from the Eastern farm of Michael Okpara University of Agriculture, Umudike. The samples were air dried and sieved through a 2mm mesh to remove roots and stones.

Physical and chemical properties of the soil

General physical and chemical analysis of the soil was carried out using standard methods as follows: The particle size analysis was carried out using Bouyoucos hydrometer method (Jackson, 1964). Soil pH was determined using glass electrode pH meter in a soil to water ratio of 1:2.5 (Thomas, 1996. Soil exchangeable acidity was determined by titration method (Mclean, 1982).Soil organic was determined by Walkley and Black (1934) method. Soil total nitrogen was determined using micro kjeldahl digestion and distillation method (Brenner, *et al.,* 2000).Available phosphorus was determined using Bray and Kurtz (1945) number two extractant. For the soil exchangeable bases, the soil was leached with IN NH_4OAc (Ammonium Acetate) at pH 7. Calcium and magnesium were determined using EDTA (Ethylene Diamine Tetra acetic Acid) titration method while potassium and sodium were determined by flame photometry. For the effective cation exchange capacity, it was calculated as the sum of exchangeable bases and exchangeable acidity. The percentage base saturation was calculated using the equation:

$$\text{Base saturation} = \frac{\text{Exchangeable bases}}{\text{ECEC}} \times \frac{100}{1}$$

Treatments

T1 Control
T2 NPK 20:10:10 fertilizer 400kg/ha
T3 NPK 20:10:10 fertilizer equivalent of 200kg/ha + 20 t/ha poultry manure
T4 NPK 20:10:10 fertilizer equivalent of 200kg/ha + 30 t/ha poultry manure
T5 Poultry manure equivalent of 20 t/ha
T6 Poultry manure equivalent of 30 t/ha

Green house experiment

10kg of soil sample was weighed into perforated 12-liter capacity plastic buckets and treatment was applied in three replicates. The buckets were arranged in a completely randomized design (CRD), and the seeds of the *Amaranthus Cruentus* was planted. The *Amaranthus Cruentus* plant was grown in a greenhouse for eight weeks. During the green house experiment, the following growth parameters of *Amaranthus Cruentus* was measured; plant height (cm), stem girth (cm), number of leaves area (cm) every week for 8 weeks in the green house. At 8 weeks after planting, the *Amaranthus Cruentus* plant was harvested for analysis

Statistical Analysis

Data generated from green experiment and laboratory analysis was subjected to analysis of variance (ANOVA) and the treatment means was separated using Fischer's Least Significance Difference (FLSD) at 5% probability level.

RESULTS AND DISCUSSION

Physical and chemical properties of the soil before planting of *Amaranthus Cruentus*

Table 1 shows the physical and chemical properties of soil before treatment application. The soil texture was loamy sand having 79.0%sand, 11.2% silt and 9.8% clay.The pH values in salt (1N KCl) and (H_2O) were 4.0 and 4.8 respectively, which is an indication of strong acidity (Chude *et al*., 2005). Available phosphorus value was critical for most soils (Enwezor *et al*., 1987). Total nitrogen, organic carbon and exchangeable bases were low (Ovie *et al*., 2013). The result obtained for the exchangeable bases agrees with the finding of Akinmutimi and Ihejirika (2016). It also agrees with the findings of Nwite *et al*. (2009), observed that utensils of South Eastern Nigeria are low in exchangeable calcium, potassium and magnesium.

Nutrient composition of treatment used for the study

The nutrient composition of the poultry manure and pig manure used for the experiment are shown in (Table 2). The poultry manure and pig manure have relatively high pH (8.60 and 9.10 respectively). Although, pig manure is higher than poultry manure. They are also high in organic matter content (55.34% and 51.72%) for poultry manure and pig manure respectively. This indicates that both of them have the potential to boost the fertility status of the soil under study. This is in line with the findings of Akinmutimi and Amaechi (2015).

Effect of treatment on plant height of *Amaranthus Cruentus*

Table 3 shows the effect of poultry manure on plant height of *Amaranthus* in the greenhouse experiment. The plant height increased steadily from week 1 to week 8of planting. Treatment 4 (200kg/ha NPK 20:10:10 fertilizer +30 t/ha poultry manure) gave the highest value. This is in agreement with the findings of Agba *et al*. (2012) who reported that yield advantages were obtained by planting *Amaranthus* with poultry manure

Effect of treatment on number of leaves of *Amaranthus Cruentus*

Table 4 shows the effect of treatment on number of leaves of *Amaranthus Cruentus* in the greenhouse. It was observed that the number of leaves increased from week 1 to week 8. Treatment 4 had the highest number of leaves, which was significantly ($p<0.05$) higher than the control almost throughout the period of the greenhouse experiment. The increase in the number of leaves by treatment 4 could be as a result of the increase in its organic matter corresponding to the findings of Orluchukwu and Amadi (2022) who reported a steady increase in the number of leaves as a result of treatment combination of poultry manure and NPK fertilizer.

The effect of treatment on stem girth (cm) of *Amaranthus Cruentus*

The effect of treatment on the stem girth *of Amaranthus Cruentus* is presented on (Table 5). The stem girth increased from week 3 to week 8 of planting; T4 (200kg/ha NPK 20:10:10 fertilizer + 30t/ha poultry manure) gave the highest mean stem girth of *Amaranthus Cruentus* across the weeks. The result is in line with the findings of Kelleher *et al*. (2002) who reported that poultry manure is an excellent fertilizer material because of its high nitrogen, potassium and phosphorus contents and slow in releasing nutrient to crops and also improving the soil physical and chemical

Table 1: Physical and chemical properties of the soil before planting of Amaranthus Cruentus.

Soil properties	Value
Sand (g/kg)	790
Silt (g/kg)	112
Clay (g/kg)	98
Texture Loamy	Sand
pH (H20)	4.8
pH (KCL)	4
Available Phosphorous (mg/kg)	14.6
Total Nitrogen (%)	0.09
Organic Carbon (%)	1.22
Organic Matter (%)	2.1
Calcium (cmol/kg)	3.2
Magnesium (cmol/kg)	0.8
Potassium (cmol/kg)	0.28
Sodium (cmol/kg)	0.18
Exchangeable Acidity (cmol/kg)	1.64
Effective Cation Exchange Capacity (cmol/kg)	6.1
Base Saturation (%)	73.15
Aluminum (cmol/kg)	0.56

Table 2: Chemical composition of the organic materials used for the experiment.

Properties	Poultry manure	Pig manure
pH (H_2O)	8.60	9.10
Total Nitrogen (%)	1.33	1.51
Organic Carbon (%)	32.10	30.00
Organic Matter (%)	55.34	51.72
Calcium (%)	0.82	0.78
Magnesium (%)	0.40	0.51
Potassium (%)	0.62	0.56
Sodium (%)	0.30	0.32
C/N Ratio	12.84	10.71

Table 3: Effect of treatment on plant height of *Amaranthus Cruentus* (cm)

Treatments	Plant Height (cm)								
	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	Mean
T1	13.00	15.60	17.97	18.83	21.00	23.20	26.50	34.30	21.30
T2	13.33	16.33	16.33	21.50	25.50	26.30	29.30	36.30	23.11
T3	18.00	22.50	25.00	29.83	36.80	39.00	45.00	51.30	33.42
T4	16.67	21.83	24.67	31.83	40.20	42.70	49.30	56.30	35.43
T5	15.33	20.17	22.33	28.50	33.50	37.30	42.00	54.70	31.72
T6	18.67	22.67	24.33	30.67	38.50	40.70	45.00	53.70	34.28
Mean	15.83	19.85	21.77	26.86	32.60	34.90	39.50	47.80	
LSD (0.05)	NS	NS	5.93	6.74	9.60	11.11	14.07	13.33	

T1 Control
T2 NPK 20:10:10 fertilizer (equivalent of 400kg/ha)
T3 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 20 t/ha poultry manure
T4 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 30 t/ha poultry manure
T5 Poultry manure (equivalent of 20 t/ha)
T6 Poultry manure (equivalent of 30 t/ha)

Table 4: Effect of treatment on number of leaves.

Treatments	Number of leaves								
	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	Mean
T1	7.00	9.00	12.00	13.00	17.00	20.00	26.00	28.00	16.50
T2	9.00	12.00	15.00	17.00	24.00	25.00	27.00	32.00	20.12
T3	8.00	11.00	16.00	21.00	35.00	37.00	41.00	66.00	29.37
T4	11.00	13.00	19.00	22.00	31.00	33.00	41.00	67.00	29.62
T5	10.00	12.00	18.00	21.00	29.00	33.00	42.00	63.00	28.50
T6	10.00	13.00	17.00	20.00	26.00	29.00	32.00	46.00	24.12
Mean	9.00	12.00	16.00	19.00	27.00	30.00	35.00	50.00	
LSD (0.05)	2.90	3.00	3.67	4.90	9.54	10.35	NS	33.85	

T1 Control
T2 NPK 20:10:10 fertilizer (equivalent of 400kg/ha)
T3 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 20 t/ha poultry manure
T4 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 30 t/ha poultry manure
T5 Poultry manure (equivalent of 20 t/ha)
T6 Poultry manure (equivalent of 30 t/ha)

Table 5: Effect of treatment on stem girth of *Amaranthus Cruentus.*

Treatments	Stem girth (cm)								
	WK 1	WK 2	WK 3	WK 4	WK 5	WK 6	WK 7	WK 8	Mean
T1	0.70	1.00	1.07	1.10	1.07	1.07	1.20	1.57	1.09
T2	1.00	1.00	1.10	1.13	1.27	1.30	1.43	2.00	1.27
T3	1.00	1.00	1.23	1.77	1.83	2.00	2.13	2.30	1.65
T4	1.20	1.20	1.40	1.67	2.33	2.37	2.53	2.70	1.92
T5	1.03	1.07	1.23	1.50	1.87	1.97	2.23	2.37	1.65
T6	1.03	1.03	1.13	1.33	1.77	1.83	2.17	2.40	1.58
Mean	0.99	1.07	1.19	1.42	1.69	1.76	1.95	2.22	
LSD (0.05)	0.39	0.14	0.28	0.59	0.79	0.82	0.91	0.95	

T1 Control
T2 NPK 20:10:10 fertilizer (equivalent of 400kg/ha)
T3 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 20 t/ha poultry manure
T4 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 30 t/ha poultry manure
T5 Poultry manure (equivalent of 20 t/ha)
T6 Poultry manure (equivalent of 30 t/ha)

Table 6: Effect of treatment on fresh matter yield of Amaranthus.

Treatments	Fresh weight	Dry weight
T1	7.7	1.34
T2	13.5	1.74
T3	36.5	4.3l
T4	51.09	6.2
T5	38.l0	4.15
T6	35.8	4.09
Mean	30.5	3.64
LSD (0.05)	28.58	3.31

T1 Control
T2 NPK 20:10:10 fertilizer (equivalent of 400kg/ha)
T3 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 20 t/ha poultry manure
T4 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 30 t/ha poultry manure
T5 Poultry manure (equivalent of 20 t/ha)
T6 Poultry manure (equivalent of 30 t/ha)

properties.

Effect of treatment on fresh biomass and dry matter yield of *Amaranthus Cruentus*

Table 6 shows the effect of treatment on fresh biomass and dry matter yield of *Amaranthus Cruentus* in the greenhouse. There were significant differences ($p<0.05$) among the treatment means. Treatment 4 had the highest fresh weight (51.03g) and highest dry weight (6.20 g) compared to other treatments. This could be as a result of the higher poultry manure content.

Table 7: Effect of treatment on Nutrient composition of Amaranthus

Treatment	N%	P%	K%	Ca%	Mg%	Protein%
T1	0.51	0.61	0.41	0.68	0.38	3.16
T2	0.83	1.03	0.50	0.81	0.46	5.18
T3	0.97	1.62	0.63	1.35	0.54	6.07
T4	1.28	1.82	0.95	1.63	0.60	8.01
T5	0.76	0.87	0.59	0.85	0.41	4.75
T6	0.87	1.14	0.73	1.02	0.50	5.44
Mean	0.87	1.18	0.63	1.05	0.48	5.43
LSD (0.05)	0.05	0.10	0.01	0.08	0.01	0.29

T1 Control
T2 NPK 20:10:10 fertilizer (equivalent of 400kg/ha)
T3 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 20 t/ha poultry manure
T4 NPK 20:10:10 fertilizer (equivalent of 200kg/ha) + 30 t/ha poultry manure
T5 Poultry manure (equivalent of 20 t/ha)
T6 Poultry manure (equivalent of 30 t/ha)

Effect of treatment on Nutrient composition of *Amaranthus Cruentus*

Table 7 shows the effects of treatment on nutrient and protein composition of *Amaranthus Cruentus* . There is significant difference ($p<0.05$) among the treatment means. However, treatment T4 gave the highest impact in terms of their nutrient and protein composition.

Conclusion

From the results, it was revealed that NPK 20:10:10 fertilizer equivalent of 200kg/ha + 30t/ha poultry manure fertilizer treatment gave the highest values of the plant height, number of leaves, fresh biomass and dry matter yield of *Amaranthus Cruentus* .Application of NPK 20:10;10 fertilizer 200kg/ha in combination with poultry manure (30 tons/ha) is therefore recommended for cultivation of *Amaranthus Cruentus* in the study area.

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