EVALUATION OF DIFFERENT FERTILIZER TYPES FOR IMPROVED GROWTH AND YIELD OF GRAIN AMARANTH (*Amaranthus cruentus L.*)

Ademola, J. A.[1], Aderemi, F. T.[2], Olunloyo, A. A.[1], Olomola, D. B.[3] and **Elesho, R.O.[1]**

[1]Department of Agricultural Technology, Federal College of Forestry, Ibadan, Oyo State, Nigeria.

[2]Department of Horticulture and Landscape Technology, Federal College of Forestry, Ibadan, Oyo State, Nigeria.

[3]Biotechnology Centre, Forestry Research Institute of Nigeria, Ibadan, Oyo State, Nigeria.

Corresponding author's email**:** akinrinade.zone@gmail.com

ABSTRACT

This study was carried out to investigate the effect of organic fertilizer potential of soil amendments for improved Amaranth production and also to evaluate the comparative effects of different organic soil amendments for improved growth and yield of *Amaranthus cruentus.*

The trial consisted of six treatments namely: (T0) Control, (T1) NPK 15:15:15, (T2) Poultry manure, (T3) Organomineral fertilizer, (T4) Cow dung and (T5) Cassava peel compost. Four pots per treatment were used, and the trial was arranged in Completely Randomized Design (CRD), replicated three (3) times. Data were collected on growth parameters (plant height, number of leaves and stem girth) and yield biomass. All data collected were subjected to Analysis of variance (ANOVA) and means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Results show that all fertilizers tested significantly improved plant height and number of leaves of *A. cruentus* compared to the control at all weeks after sowing but at four (4) weeks after sowing (WAS) application of poultry manure had the highest values of stem circumference at different ages after sowing, which was not significantly different from the values obtained from other fertilizers, but significantly higher than the control.

The nutrient uptake was significantly influenced by application of different fertilizer materials. Since all the fertilizers tested competed effectively with NPK fertilizer, application of organic manure or organomineral fertilizer is recommended to prevent excessive chemical loads on soils and enhance environmental friendly soil conditions for improved crop yield.

Keyword: Grain Amaranth, Organomineral fertilizer, NPK fertilizer, Cow dung, Cassava peel, yield, growth.

INTRODUCTION

Amaranthus cruentus belongs to the family *Amaranthaceae* and it is grown as a vegetable in western Africa (especially in Nigeria). *Amaranthus* species is rich in proteins, minerals, fat and dietary fiber (Tosi *et al*., 2001). It is grown all the year round (Denton and Olufolaji, 2000). It was also reported by Abu Ziada *et al*., (2008) that the green leaves of *Amaranthus* are rich in water, energy, fats, proteins, minerals, amino acids and carotenoids. *Amaranthus cruentus* is cultivated and consumed all over the country and it can be rated among the top five of the most important national vegetables. The average consumption of *Amaranthus cruentus* leaves in the tropics is estimated at about 20 - 25g per head per day which is below the recommended rate of 100g per head per day. Protein from *Amaranthus cruentus* leaves provides as much as 25% of the daily protein intake during the harvest season. The seeds of *Amaranthus cruentus* contain about 16 - 18% protein. *Amaranthus cruentus* leaves are similarly rich in protein content. Higher amino acid lysine content of the seeds makes the seeds even more important nutritionally. The protein has much lysine mixture as found in milk. On the other hand, the carbohydrate content of the *Amaranthus cruentus* leaves and seeds is 30 - 60% with the seed having higher protein-calorie content needed for growth and energy (Akanbi and Togun, 2002). The yield of the vegetable crops is generally determined by so many factors, including plant nutrient and proper spacing. Soil fertilization is one of the main factors increasing the yield of plants. It affects the accumulation, mineralization and humification of organic matter added to the soil and determines plant production potential (Nakhro and Dkhar, 2010). The amount of fertilizer introduced into the soil, including mineral fertilizers, affects the amount of mineral nitrogen available to plants and the organic carbon content of the soil (Bijlsma and Lambers, 2000).

Nitrogen fertilizer is known to have been one of the plant nutrients that influence vegetative growth in most crops and subsequently increased yield. Fertilizers are soil amendments applied to promote plants growth. The main nutrients present in fertilizers are nitrogen (N), phosphorus (P) and potassium (K) (macro nutrients), and other nutrients (micro nutrients) are added in smaller amount. Nitrogen fertilizers promote vegetative growth and mainly responsible for deep green colour in plants, which is essential for photosynthesis (Futuless and Bagale, 2007). The use of soil amendments is mainly to improve crop yields while improved yields results from improved nutrient status in soil and other soil properties such as organic matter (Mungai *et al*., 2009). Olaniyi *et al*., (2008) reported that there is limited preliminary information on fertility requirements of Amaranths.

Organic materials such as farmyard manure (FYM), poultry manure, green manure, crop residues, water weeds, city wastes etc. have been reported as suitable for inorganic fertilizers to maintain sustainable crop production and environmental quality (Pawar, *et al*., 2003). Reports on the positive responses of crops to the various organic fertilizers cut across all the classes of agricultural crops including leaf vegetables (Schippers, 2000; Adebayo and Akanni, 2002).
Therefore, this research is designed to investigate the fertilizer potential of different organic soil amendments for improved Amaranth production.

MATERIALS AND METHODS

Experimental Location

The experiment was conducted in October, 2015 at the Teaching and Research Farms of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria, which falls within the guinea savanna agro-ecological Zone of Nigeria. Ogbomoso lies on latitude 8^0 $10^{"}$ N and longitude 4^0 10" E with elevation of 390 m above sea level. Land clearing and preparation were carried out manually, following farmers conventional practice, using hoe, cutlass, mattock, rake etc. Plots of 2.0 by 2.0 m^2 size were then made.

Experimental Methodology

Amaranthus cruentus seeds were acquired from the Nigeria Institute of Horticultural Research, Ibadan and were sown in a germination box before being transplanted into 2kg polythene pots filled with soil collected. The Organomineral fertilizer was purchased from Aleshinloye Agricultural Fertilizer Company, Aleshinloye, Ibadan, Oyo State. The poultry manure, cow dung and cassava peel were collected fresh and air dried for 10 days while the cassava peel were grounded before application. The application of the fertilizer treatment was done one (1) week before transplanting. Other necessary agronomic practices were carried out such as weeding and application of insecticides.

Treatments and Experimental Design

The six treatments investigated were T0 (Control), T1 (NPK), T2 (Poultry manure), T3 (Organomineral fertilizer), T4 (Cow-dung), T5 (Cassava peel). Four pots per treatment were used. The trial was arranged in completely randomized design (CRD), replicated three (3) times. All treatments were applied at the recommended N-rate of 60 $kgNha^{-1}$ (Babajide and Olayiwola, 2014).

Soil Sampling and Analysis

The soil sample used was an Alfisol belonging to Egbeda soil series (Smyth and Montgomery, 1962). Collection of soil samples was carried out using soil auger at a depth of 0-15 cm, for laboratory analyses of the soil physical and chemical properties for the determination of particle size, pH (H_2O), total nitrogen (N), organic carbon, available phosphorus (P), the exchangeable cations (Ca, Na, Mg and K).

Data Collection

Data collection commenced at four (4) weeks after sowing (WAS) on the growth parameters of *Amaranthus cruentus* (plant height, number of leaves and stem girth). Also, on yield biomass parameters at termination of the experiment (fresh and dry shoot weight, weight of fresh leaf, fresh shoot weight, dry leaf weight and dry shoot weight).

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) using DSAASTAT excel macro enabled statistical software package (Onofri, 2007). The means were separated using Duncan's Multiple Range Test (DMRT) at 5% probability level.

RESULTS AND DISCUSSION

Physical and chemical analysis of the soil sample

The pre-cropping chemical and physical analyses of the soil sample showed that the soil was slightly acidic with pH of 5.80 (Table 1). The soil sample was grossly low in essential nutrients N (0.20g/kg), P (3.78mg/kg) and K (0.28cmol/kg). The result corresponds with the earlier findings of Babajide *et al.,* (2008) which indicated that the soil samples in the study area were grossly low in essential nutrients.

Table 1: Physico-chemical Analysis of the soil sample used.

Soil properties	Values
pH (H_2O)	5.80
Organic carbon (g kg^{-1})	2.88
Total N (g kg^{-1})	0.20
Available P(mg kg^{-1})	3.78
Fe (mg kg^{-1})	11.72
Cu (mg kg^{-1})	2.86
Zn (mg kg^{-1})	2.75
Exchangeable K (cmol kg^{-1})	0.28
Exchangeable Na (cmol kg^{-1})	0.18
Exchangeable Ca (cmol kg^{-1})	16.24
Exchangeable Mg (cmol kg^{-1})	2.94
Sand (%)	80.01
Silt (%)	10.18
Clay (%)	09.81
Textural class	Sandy loam

Growth Parameters as influenced by fertilizer types

Application of different fertilizer types significantly influenced plant height of *Amaranthus cruentus* at different weeks after sowing (WAS). All fertilizers tested significantly improved plant height of *A. cruentus* compared to the control at all weeks after sowing (Table 2).

Similar trend was observed in number of leaves of *A. cruentus* at different weeks after sowing. There were no significant differences in the value of number of leaves amongst the fertilizer tested, but the values were significantly higher than the control (Table 3).

Regarding the stem circumference, application of different fertilizers significantly influenced it at different weeks after sowing (WAS). At 4 WAS application of poultry manure had the highest values of stem circumference at different ages after sowing, which was not significantly different from the values obtained from other fertilizers, but significantly higher than the control (Table 4).

These results are in line with Babajide and Olayiwola, (2014) and Babajide and Olla, (2014), who reported significant increase in crop performance as induced by different fertilizer applications.

Table 2: Effects of different fertilizer types on plant height of *Amaranthus cruentus*

TREATMENTS	4 WAS	5 WAS	6 WAS	7 WAS
T0	15.50a	15.83b	20.16b	23.50b
T1	20.43a	28.33ab	43.16a	48.00ab
T2	22.90a	39.33a	53.66a	66.17a
T3	19.10a	35.50a	37.33ab	63.00a
T4	21.50a	32.50a	46.83a	58.83a
T5	18.97a	30.00a	46.83a	59.67a

*Means in the same column with the same letters are not significantly different ($P \leq 0.05$), using DMRT.

T0= control, T1= NPK, T2= Poultry manure, T3= Organomineral fertilizer, T4=Cow-dung and T5=Cassava peel. WAS=Weeks after sowing

Table 3: Effect of different fertilizer types on the number of leaves of *A. cruentus*

TREATMENTS	4 WAS	5 WAS	6 WAS	7 WAS
T0	8.50b	11.16b	15.66a	12.50a
T1	13.16ab	21.66a	27.16a	35.00a
T2	17.33a	21.33a	25.83a	29.66a
T3	12.16ab	17.83a	19.66a	26.83a
T4	13.33ab	15.83ab	25.33a	31.50a
T5	12.83ab	15.83ab	22.16a	23.83a

*Means in the same column with the same letters are not significantly different ($P \leq 0.05$) using DMRT.

T0=control, T1= NPK, T2= Poultry manure, T3= Organomineral fertilizer, T4=Cow-dung and T5= Cassava peel.

Table 4: Effect of different fertilizer types on stem circumference of *Amaranthus cruentus*

TREATMENTS	4 WAS	5 WAS	6 WAS	7 WAS
T0	1.23b	1.65c	1.70b	2.51b
T1	1.96ab	3.46ab	4.03a	4.58ab
T2	2.63a	3.96a	4.53a	4.86a
T3	2.30a	3.63ab	4.05a	4.71a
T4	2.16a	3.31ab	4.06a	4.43ab
T5	2.03ab	2.61b	3.61a	4.10ab

*Means in the same column with the same letters are not significantly different ($P \leq 0.05$), using DMRT. T0= control, T1= NPK, T2= Poultry manure, T3= Organomineral fertilizer, T4=Cow-dung and T5= Cassava peel.

Yield biomass parameters of *A. cruentus* as influenced by fertilizer types

Application of different fertilizers significantly influenced yield parameters of *A. cruentus*. Although poultry had highest values for all the yield parameters measured, the values were not significantly different from those obtained from other fertilizer materials tested (Table 5). These results corroborated the findings of Akanbi et al, (2009); Babajide and Olayiwola,

(2014) and Babajide and Olla, (2014), who indicated improved arable crop performance through organic and inorganic fertilizer applications.

Table 5: Effect of different fertilizer types on yield biomass of *A. cruentus*

TREATMENTS	Fresh root weight ($gplant^{-1}$)	Fresh soil weight ($gplant^{-1}$)	Dry root weight ($g\ plant^{-1}$)	Dry soil weight ($g\ plant^{-1}$)
T0	4.20b	16.40b	0.90b	1.0b
T1	17.90a	120.67a	2.20a	17.10a
T2	31.93a	138.67a	2.83a	15.13a
T3	24.53a	122.33a	2.53a	10.26a
T4	20.77a	109.13a	1.83a	7.93a
T5	25.30a	71.87a	2.73a	9.30a

*Means in the same column with the same letters are not significantly different ($P \leq 0.05$), using DMRT. T0=control, T1= NPK, T2= Poultry manure, T3= Organomineral fertilizer, T4=Cow-dung and T5= Cassava peel.

Influence of different organic and inorganic fertilizers on nutrient uptake of *A. cruentus*

Effect of different inorganic and organic soil amendment for improved chemical composition of *A. cruentus* was observed in Table 6. For nitrogen (N) content present in *A. cruentus* shows that there were significant differences between all the treatments. It was observed that poultry manure was significantly different and higher ($P \leq 0.05$) than all the other treatments, while NPK, organomineral and cassava peel were not significantly different from each other but significantly different when compared with cow dung and control also cow dung were significantly different from control. Poultry manure was higher in nitrogen composition (30.50) which was followed by cassava peel, organomineral, and NPK (26.33 and 24.26 respectively) followed by cow dung (19.50) while control had the lowest nitrogen content. For phosphorus component present in *A. cruentus* it shows that poultry manure and cassava peel were significantly higher in phosphorus level and are not different from each other also NPK, organomineral, cow dung and cassava peel were not significantly different but when all the treatments was compared with control shows significant differences among the treatment. *A. cruentus* treated with poultry manure was high in phosphorus level (22.63) followed by cassava peel (18.16). This was followed by cow dung, NPK, and organomineral (15.53, 14.96, and 14.36 respectively) while control was less in phosphorus (3.50). For the presence of potassium in *A. cruentus* cow dung was significantly higher (24.06) which was followed by cassava peel and poultry manure (22.03 and 20.43 respectively) while organomineral was followed (17.33) which was followed by NPK (14.13) while control had the least potassium concentrate. Also the presence of calcium was also refilled in Table 5 which showed that poultry manure and cassava peel were not significant different ($P \leq 0.05$) from each other but significantly different when compared with all other treatment while NPK and organomineral and cow dung were not significantly different but cow dung, NPK and control also showed no significantly different when compared. For magnesium concentrate it was observed that between poultry manure, organomineral, cow dung and cassava peel compost there were no significantly different but when compared with NPK and control it showed that there were

significantly differences also NPK and control were not significantly different from each other. Sodium was significantly higher in A. cruentus treated with NPK (1.56) and significant different when compared with other treated plant including control while poultry manure, organomineral, cow dung, cassava peel and control were not significantly different. Poultry manure and organomineral was significantly different ($P \leq 0.05$)when compared with other treatments also no significant difference was observed when NPK, poultry manure and cassava peel were compared but significantly different when they were compared with control. Poultry manure and organomineral had higher concentration of Fe (240.36 and 237.00 respectively) which was followed by *A .cruentus* treated with cassava peel, NPK, cow dung (217.66, 215.26, and 211.36 respectively) while control has least observation of Fe (108.03). For the presence of Cu. poultry manure, organomineral and cassava peel were not significantly different ($P \leq 0.05$) also poultry manure, organomineral and cassava peel were not significantly different also control, organomineral, cow dung and cassava peel were not significantly different. But when all the treated plant was compared with NPK it shows that there were significant differences ($P \leq 0.05$). The level of Mn was significantly higher in control (35.50) which was followed by NPK (30.73). This was followed by organomineral, cassava peel, cow dung and poultry manure (29.33, 26.03, 23.03 and 22.03 respectively) though control NPK and cow dung were not significantly difference in Zn content also poultry manure, organomineral and cassava peel were not significantly difference.

Table 6: Effect of different inorganic and organic fertilizers for improved chemical composition of *Amaranthus cruentus*

TREATMENT	N (g/kg)	P (mg/kg)	K (cmol/kg)	Ca (cmol/kg)	Mg (cmol/kg)	Na (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
T0	6.43d	3.50c	3.90e	0.56d	0.53b	0.76b	108.03c	14.90cd	35.50a	67.86a
T1	24.26b	14.96b	14.13d	0.90cd	0.70b	1.56a	215.26b	13.93d	30.73b	66.03a
T2	30.50a	22.63a	20.43abc	3.76a	1.80a	0.73b	240.36a	17.66ab	22.03d	56.26c
T3	25.86b	14.36b	17.33bcd	1.10c	1.56a	0.56b	237.00a	15.36bcd	29.33b	56.30c
T4	19.50c	15.53b	24.06a	0.83cd	1.76a	0.80b	211.36b	14.63cd	23.03d	64.66ab
T5	26.33b	18.16ab	22.03ab	3.56a	1.66a	0.70b	217.66b	16.80abc	26.03c	55.26c

*Means in the same column with the same letters are not significantly different ($P \leq 0.05$), using DMRT. T0=control, T1= NPK, T2= Poultry manure, T3= Organomineral fertilizer, T4=Cow-dung and T5= Cassava peel.

CONCLUSION AND RECOMMENDATION

The study showed that all fertilizers applied have significantly influenced growth and yield of *A. cruentus* compared to the control. Also, application of poultry manure had the highest values of all the growth and yield parameters measured, although the values were not significantly different from the values obtained from other fertilizers (including NPK fertilizer and organomineral). Therefore, excessive use of inorganic fertilizers may cause environmental and health threats to man, application of any of the organic manures (particularly poultry manure) is recommended. This may improve the soil quality and performance of *Amaranthus cruentus* in the study area.

REFERENCES

Abu Ziada, El-Halawany, E.F., Mashlay, I.A. and Masoud, G.F., (2008).Autecology and Phytochemistry of Genus *Amaranthus* in the Nile Delta, Egypt.*Asian J. Plant Sci*. Vol. 7: Pp 119 – 129.

Adebayo, O. and Akanni,D.I (2002).Effect of Organic Manure and Spacing on the Yield and Yield Components of *Amaranthus cruentus*. Proceeding of *Horticultural Society of Nigeria* Conference 14th – 18th April 2002, Ibadan. Nigeria pp.85 – 90.

Akanbi, W. B. (2002). Growth, Nutrient uptake and yield of maize and okra as influenced by compost and nitrogen fertilizer under different cropping systems. Ph. D. Thesis, Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan, Nigeria pp. 232.

Akanbi, W. B., Adeyeye, A. S., Ogunrinde, J. O., Babajide, P. A., Ajibola, A. T., Ilupeju, E. A.O., and Akinfasoye, J. A.(2009). Effects of Organic Fertilizer and Cutting Height on Growth, Shoot Yield and Nutrient Uptakes of Amaranth (*Amaranthus cruentus*). *Research Journal of Life and Physical Sciences*, 3(1): 7-14.

Babajide, A. P. and Olayiwola, O.A. (2014). Influence of Composted Phyto-residues and Harvesting Frequency on Growth and Forage Potentials of Grain Amaranth (*Amaranthus cruentus*) Under Oxic Paleutult Soil Conditions. *Journal of Natural Sciences Research*. Vol.4, No.17.

Babajide, P.A. and Olla, N.O. (2014). Performance of indigenous *Celosia argentea* variety and soil physico-chemical properties as affected by dual application of compost and single N-mineral fertilizer, in southern guinea savanna vegetation zone of Nigeria. *Journal of Biology, Agriculture and Healthcare*. Vol. 4 (19): 69-74.

Babajide, P. A., Olabode, O. S., Akanbi, W. B.,Olatunji, O. O and Ewetola, E. A. (2008). Influence of Composted Tithonia-biomass and N-Mineral Fertilizer on Soil Physico-Chemical Properties and performance of Tomato (*Lycopersicon lycopersicum*). *Research Journal of Agronomy* 2(4): 101-106.

Bijlsma, R.J. and Lambers, H., (2000). A dynamic whole-plant model of integrated metabolism of nitrogen and carbon. 2. Balanced growth driven by C fluxes and regulated by signals from C and N substrate. *Plant and Soil*. 220: Pp 71 – 87.

Denton, L. and A. O. Olufolaji (2000). Nigeria' s most important vegetable crops. In: M. O. Akoroda (ed.) *Agronomy in Nigeria, University of Ibadan*. Pp 55 – 93.

Futuless, K. N. and H. W. Bagale (2007). Effects of different levels of nitrogen fertilizer on the growth and yield of amaranthus (*Amaranthus cruentus* L.) in Mubi, Adamawa State, Nigeria. In: proceeding of *Horticultural Society of Nigeria (HORTSON)*, held at Adamawa State University, Mubi, Nigeria. 26th – 30th Oct. 2008.

Mungai, N.W., Bationo, A. and Wasawa, (2009). Soil properties influenced by soil fertility management in small scale Maize farms in Njoro, Kenya. *J. Agron*. 8: Pp 131 – 136.

Nakhro N. and M.S. Dkhar, (2010). Impact of organic and inorganic fertilizers on microbial populations and biomass carbon in paddy field soil. *Journal of Agronomy*, 9: 102-110.

Olaniyi, J.O., Adelasoye, K.A. and Jegede, C.O. (2008). Influence of nitrogen fertilizer on the growth, yield and quality of grain amaranth varieties. *World J. Agric Sciences* 4:506-513.

Onofri A. (2007). Routine statistical analyses of fieldexperiments by using an Excel extension.Proceedings 6th National Conference Italian Biometric Society: "La statistica nelle scienze dellavita e dell'ambiente", Pisa, 20- 22 June 2007, 93-96. Version1. 1 (Update: 18/03/2011). https://dokumen.tips/documents/ dsaastat-by-andrea-onofri.html

Pawar, V.N., Parbhani, M.K.V., Puri, S.N. and M.O., Rahurfi, K.V. (2003). Organic Farming in Organic Production.Pp 1 – 12.

Schippers, R. R. (2000). African Indigenous Vegetables: An Overview of the cultivated species. Chatham UK. Natural Resource Institute/ACP-EU Technical Centre for Agricultural Resources and Rural Cooperation.

Tosi, E.A, Re. E. D., Lucero, H.and Masciarelli R. (2001). Dietary fiber obtained from amaranth (*Amaranthus cruentus*) grain by differential milling. *Food Chem.*; 73:441-3.