Journal of Organics (JO), Volume 1 Number 1, 2014

Influence of organic, mineral and organomineral fertilizers on growth, yield, and soil properties in grain amaranth (*Amaranthus cruentus.* L)

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Abstract

A pot trial was conducted in the screen-house of Kwara State University, Malete, Nigeria during 2014 to examine the influence of organic, mineral and organomineral fertilizers on growth, yield, and soil properties in grain amaranth (*Amaranthus cruentus*) as well as residual effects. The treatments comprised of Aleshinloye Grade A (Organomineral fertilizer), Aleshinloye Grade B (Un-amended compost), Sunshine Grade A (Organomineral fertilizer), Sunshine Grade B (Un-amended compost), NPK and control. The experiment was laid out in a completely randomized design (CRD) with four replicates. All the treatments (except the control of no soil additive) were applied at the rate of 90 kg N ha^{-1}. Pre and post cropping analysis of soils used in screen house were done. Measurements of agronomic parameters were taken and data collected were subjected to analysis of variance (ANOVA) using the statistical analysis system (SAS). The parameters assessed were significantly influenced (p<0.05) by the applied fertilizer types.The results show that dry shoot weight values of *Amaranthus cruentus* were 2.3 and 2.1g respectively with Sunshine Grade A and Aleshinloye Grade A and these were significantly (p< 0.05) higher than that of NPK treatment (1.8g) after the first cropping. Residual effect of Amaranth fresh shoot weight values obtained from Sunshine Grade A and Aleshinloye Grade A were also significantly (p< 0.05) higher than that of the NPK tratment. Sunshine Grade A and Aleshinloye Grade A had a significant and additive effect on soil nutrients after harvesting of *Amaranthus cruentus* when compared with NPK in the first and second croppings. Thus organic fertilizers fortified with mineral fertilizer have great potential in the production of amaranth and could also be used effectively in increasing soil fertility for amaranth production.

Keywords: Organic fertiliser, organomineral fertiliser, *Amaranthus cruentus*, soil fertility, NPK, yield, Nigeria.

Introduction

Amaranthus cruentus is grown for its leaves and is a highly prized leaf vegetable in Nigeria due to its high nutritional and commercial significance. *Amaranthus cruentus* is rich in vitamins, including β-carotene (precursor of vitamin A), vitamin B6, vitamin C,

 ISSN 2204-1060

riboflavin, and folate, and dietary minerals including calcium, iron, magnesium, phosphorus, potassium, zinc, copper, and manganese (Musa *et al*., 2011). Grain amaranth has the potential to substitute for expensive animal protein because of its comparable protein quality and quantity (FAO, 2003).

The cooked leaves of amaranth are eaten in different ways according to local customs, either as a vegetable soup or a sauce, though it is recommended that the leaves should not be boiled for more than fifteen minutes, in order to prevent significant losses of the vitamin C in them.

In recent years there has been an increase in the demand for this crop as a vegetable, especially in the urban centres where people are not involved in primary production (Law-Ogbomo *et al*., 2009). This has made the vegetable an important commodity in our markets and amaranth production is an important economic activity for rural women.

Amaranthus cruentus species are extensively cultivated. Due to their early maturity and ability to survive in mixture with other arable crops, they remain the most preferred crop by many farmers for early revenue generation and survival while the farmers are still awaiting other crops to mature in traditional subsistence mixed cropping systems. *Amaranthus cruentus* is produced under different cropping systems in home gardens, farms, inland valleys *(fadamas),* and peri-urban gardens (Makinde, 2012).

Soils in Sub-Saharan Africa are inherently infertile and characteristically low in soil organic matter content and cannot support intensive cultivation due to the rapid rate of fertility decline under intensive cultivation (Shiyam & Binang, 2013). The use of various fertilizers have addressed these problems (Ojetayo *et al.,* 2011; Senjobi *et al*., 2012; Olowoake *et al*., 2013). The use of inorganic fertilizer to increase yield has been found to be effective as a short term solution which demands consistent use on a long-term basis. The hazardous environmental consequences and high cost of inorganic fertilizers make them not only undesirable but also uneconomical and out of reach of the poor farmers who dominate the Nigerian agricultural sector (Oyedeji *et al*., 2014).

The demand for vegetables of high ecological value has contributed to the expanding use of organic fertilizers (Vlahova & Popov, 2013). The use of organic manure cannot be over emphasized because of its usefulness in the improvement of physical and biological conditions of soil which in turn improves the crop growing environment and culminates in the better production of economic plants. Apart from the role of organic manure as a store house for plant nutrients it acts as a major contributor to cation exchange capacity and as a buffering agent against undesirable pH fluctuations (Olaniyi & Ojetayo, 2010).

Complementary use of organic and inorganic fertilizers has been proved to be a sound soil fertility management strategy (Law-Ogbomo *et al*., 2011). Organic fertilizer fortified with inorganic materials may be formulated to replenish the soil and improve plant fertilization. It releases nutrients in soil in the form that plants can easily absorb and it can activate soil micro-organisms and increase microbes, which will help the decomposition processes of organic matter. This will promote higher plant growth, healthier crops and better fruit yield. It reduces the needs of chemical fertilizer, which will lead to lower production cost and indirectly increases income (Worthington, 2001).

Many experiments have been conducted with the use of combined agro-waste and mineral fertilizers for crop production in different formulations. Ogunlade *et al*., (2011) use cocoa pod husk fortified with urea for production of African eggplant (*Solanum macrocarpon*). Olaniyi and Oyelere (2012) used Aleshinloye grade A and Sunshine grade A fertilizers to increase the growth, yield and nutritional compositions of fluted pumpkin. Little or no research havs been conducted on the response of soils and Amaranths to these fertilizers in Ilorin, North-central Nigeria.

Thus, an experiment was set up to compare the effect of organic, mineral and organomineral fertilizers on the growth and yield of *Amaranthus cruentus* and to evaluate the residual effect of different fertilizers on the soil properties in screen-house under an *Amaranthus cruentus* crop.

Materials and Methods

The potted experiment was set up in a screen-house during 2014 at Kwara State University (Latitude 8^0 71'N and Longitude 4^0 44'E), Malete. The experiment was carried out to study the effects of organic, mineral and organomineral fertilizers on the soil properties, growth and yield of *Amaranthus cruentus.* Twenty four pots were filled with 5.5kg of soil.

The treatments used were:

1. Aleshinloye Grade A (compost amended with mineral fertilizer);
2. Aleshinloye Grade B (un-amended compost);
3. Sunshine Grade A (compost amended with mineral fertilizer);
4. Sunshine Grade B (un-amended compost);
5. mineral fertilizer (NPK 15-15-15); and
6. control.

Aleshinloye Grade A and B are commercial organic fertilizer products of Aleshinloye Fertilizer Plant, Ibadan, Oyo State Nigeria. Sunshine Grade A and B are commercial organic fertilizers developed by Ondo State Government of Nigeria. The results of analyses of the fertilizer are summarized in Table 1.

Table 1: Proximate analyses for Organo-mineral fertilizer Grade A and B. Source: Ondo State Government (2012) and Aleshinloye Fertilizer Company, Ibadan, Nigeria.

Organo-mineral fertilizer	Nutrient %		
	N	P	K
Sunshine Grade B	3.5	1.0	2.5
Sunshine Grade A	3.5	2.5	4.0
Aleshinloye Grade A	5.1	4.4	1.8
Aleshinloye Grade B	1.2	0.8	2.9

All the treatments except the control were applied at the rate of 90 kg N/ha as recommended by Ejieji & Adeniran (2010) for the optimum growth of amaranth. Each treatment was mixed with soil thoroughly. The organic sources were applied a week before planting while the mineral fertilizer was applied two weeks after planting. Amaranth

(*Amaranthus cruentus*) seeds were broadcasted and thinned to maintain 2 plants /pot. The treatments were arranged in a completely randomized design (CRD) with four replicates.

Pre-cropping chemical analysis of the experimental soil used in the screen-house was carried out before the experiment and repeated at the first and second harvest to determine the nutrient status of the soil. Particle size distribution was determined by the hydrometer method (Bouyoucos, 1962) and the soil pH was determined in 0.01M $CaCl_2$. Soil organic carbon and the total N were evaluated by the Walkey & Black (1963) method and the micro-Kjeldahl digestion method (Bremmer & Mulvaney, 1982), respectively. Available P was extracted by the method of Bray & Kurtz (1945), while exchangeable bases (Ca, Mg, K and Na) contents were extracted with neutral 1M NH_4OAc at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer (AAS). Micronutrients were extracted with 0.1 EDTA and determined using atomic absorption spectrophotometer (Table 2).

Table 2. Physico-chemical properties of experimental soil.

Parameters	Soil test value
pH	6.9
Organic carbon (g kg^{-1})	11.8
Total N (g kg^{-1})	2.04
P Mehlich (mg kg^{-1})	10.2
Exchangeable bases (C mol kg^{-1})	
K	0.17
Mg	0.46
Ca	2.35
Na	1.86
Extractable micronutrients (C mol kg^{-1})	
Cu	1.58
Fe	67.8
Zn	3.2
Mechanical composition (g kg^{-1})	
Sand	872
Silt	94
Clay	34
Textural class	Loamy sand

Collection of data commenced from 3 weeks after planting and was done weekly till the sixth week. The experiment was repeated without any fertilizer application at the second planting. The data taken include, plant height, stem girth, number of leaves per plant, fresh, and dry shoot weight. The data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Duncan Multiple Range Test (DMRT).

Results and Discussion

The chemical properties of the soil used for the experiment are presented in Table 2. The soil was slightly acidic and low in total N, exchangeable K, Ca and Mg. Available P was fairly good for vegetable crop production (Table 2). The low soil contents for the major nutrients signify the need for improvement for optimal *Amaranthus cruentus* performance.

Table 3 shows data collected on the effects of fertilizer types on growth and shoot weight of *Amaranthus cruentus* at six weeks after planting during the first and second field cropping. When compared with the control, NPK 15:15:15, Aleshinloye Grade A, Aleshinloye Grade B, Sunshine Grade A and Sunshine Grade B each significantly (p<0.05) increased growth parameters after the first treatment application.

Table 3. Effects of fertilizer types on growth parameters and shoot weight of *Amaranthus cruentus* at 6 Weeks after Planting during first and second field cropping. Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Treatments	Plant Height (cm)	No of leaves	Stem girth (cm)	Fresh shoot weight (g)	Dry shoot Weight (g)
			First Cropping		
Control	16.9c	11.2b	1.0c	4.0c	1.0c
Sunshine A	29.4a	13.9ab	1.9b	9.7a	3.8a
Aleshinloye A	29.9a	1 4.4ab	2.3a	9.4a	3.6a
Sunshine B	27.9b	15.0ab	1.7b	6.6b	1.8b
Aleshinloye B	26.4b	14.1ab	1.8b	6.5b	1.7b
NPK	29.0a	15.9a	1.9b	1.3b	1.3b
			Residual effect		
Control	9.7c	9.7c	0.6c	0.8d	0.3c
Sunshine A	13.6a	14.1a	1.9a	2.3a	1.1a
Aleshinloye A	13.8a	14.7a	1.9a	2.1a	0.9a
Sunshine B	10.6c	12.0b	1.1b	1.4c	0.6b
Aleshinloye B	11.5bc	11.7b	0.9b	1.5c	0.5b
NPK	12.0b	11.4b	0.8b	1.8b	0.5b

At first planting, the height of the Amaranths that received Aleshinloye A showed the highest means of 29.9 cm, followed by Sunshine A (29.4cm) and this was significantly (p< 0.05) different from Sunshine B, Aleshinloye B and the control. The highest stem girth (2.3cm) recorded in *Amaranthus cruentus* at 6 weeks after planting (WAP) was from Sunshine A. This was significantly (p< 0.05) higher than other treatments including NPK. Mean stem girth value ranged from 3.3 cm in Sunshine A to 1.0 cm in the control. Pots treated with Aleshinloye Grade A and Sunshine Grade A fertilizer consistently had the highest increase in plant height, number of leaves, stems girth, and were significantly different from all other treatments at the second planting.

Table 3 also shows the effects of organic composts, organomineral fertilizers, and inorganic fertilizer on the fresh and dry shoot weight of Amaranthus cruentus at first and second cropping. Pots treated with NPK fertilizer, un-amended compost and organomineral fertilizers also show significant difference (P<0.05) in fresh and dry shoot weight when compared with the control.

The residual effects shows that Aleshinloye Grade A and Sunshine Grade A fertilizers significantly (p<0.05) increased both fresh and dry shoot weight of *Amaranthus caudatus*. Residual application of Aleshinloye Grade A and Sunshine Grade A on Amaranths showed that fresh shoot weight and dry shoot weight values were significantly (p<0.05) different from NPK and control. The values of growth parameters and shoot weight of *Amaranthus cruentus* were observed to be low in the plot without any treatment. This might be as a result of low nutrients status of the soil especially N and K. The high values of plant height and number of leaves of Amaranths grown in the pot treated with NPK

15:15:15 fertilizer over Aleshinloye Grade B and Sunshine Grade B during the first cropping might be as a result of its quicker release of N, P and K which are the major nutrients required by crop for vegetative growth, seed and root development. This observation is in line with the findings of Moyinjesu (2007) that mineral fertilizers quickly release their nutrients to the soil than organic wastes. Among the fertilizer treatments, organomineral fertilizers record the highest increase in plant height, number of leaves, stem girth, fresh and dry shoot weight at second planting. This might be as a result of higher N, P, and K present in organomineral fertilizer than un-amended compost (Akinyele *et al*., 2012).

Akanbi *et.al.,* (2000) has reported the plant height, leaf area and yield of Amaranth increased with application of maize stover compost amended with inorganic nitrogen. Also, Akanni *et al*., (2011) observed that fresh matter and number of leaves of grain amaranths were significantly increased by the application of organomineral fertilizer. Application of Aleshinloye Grade A and Sunshine Grade A was superior to the use of NPK fertilizer in the production of shoot weight component. This is in line with the the results of Sridhar & Adeoye, (2003) and Ogunlade *et al*., (2011) who reported that the combinations of organic and mineral fertilizer perform better on crop yield than when each of them is solely used.

Table 4. Effects of fertilizer types on some soil chemical and physical properties at harvest during the first and second field cropping. Means having the same letter along the columns indicate no significant difference using Duncan's Multiple Range Test at 5% probability level.

Treatment	pH (H_20)	Available P mg kg^{-1}	K c mol kg^{-1}	OC	N	Clay g kg^{-1}	Silt	Sand
			First Harvest					
Control	7.0d	8.38f	0.19c	10.22e	1.77f	54a	94a	852a
Sunshine A	7.4a	60.07b	1.12a	15.72a	2.72a	54a	94a	852a
Aleshinloye A	7.2c	63.18a	1.14a	14.72a	2.14b	54a	94a	852a
Sunshine B	7.3b	22.36d	1.06b	14.72b	2.04c	54a	94a	852a
Aleshinloye B	7.3b	61.60c	1.00b	11.79c	1.84d	54a	94a	852a
NPK	7.0d	20.38e	1.02b	10.60d	1.82e	54a	94a	852a
			Second Harvest					
Control	7.1d	17.93d	0.16e	4.43e	0.46f	74a	54b	872a
Sunshine A	7.9a	68.52a	0.26a	10.48a	1.09a	74a	74a	852b
Aleshinloye A	7.6c	67.77a	0.25a	9.67ab	1.00b	74a	74a	852b
Sunshine B	7.7b	45.58b	0.23b	6.45c	0.75c	74a	74a	852b
Aleshinloye B	7.6c	39.33c	0.22c	7.26b	0.67d	74a	74a	852b
NPK	7.7b	30.77c	0.19d	5.24d	0.54e	74a	74a	852b

Table 4 shows the results of fertilizer types on some soil chemical and physical properties at harvest during the first and second field cropping. The increase in the soil pH level of the pots after harvest from first cropping is an indication of the buffering capacity of the un-amended composts and organomineral fertilizer treatment applied (Olowoake & Adeoye, 2013). After first harvest, Sunshine Grade A and Aleshinloye Grade A had the highest soil available P of 68.52 and 67.77 mg kg^{-1} respectively. The available P contents

increased more than in NPK fertilizer or control pots. This reflects the high level of P available in the organomineral used. This finding corroborates the work of Olowoake & Adeoye (2013) who found that compost increase soil pH and OC, N, P and K. Also, The increases in soil OC, N, K, and P observed after harvest in soils treated with organo-mineral fertilizer, Aleshinloye Grade B and Sunshine B might be as a result of the slow rate in which their nutrients are released into the soil. Therefore, the crop could not make use of these nutrients due to its short (vegetative and reproductive) life cycle. Akinyele *et al*., (2012) opined that organic fertilizers show greater capacity than inorganic fertilizer in retaining nutrients in forms that can easily be taken by plants over a longer period.

The low fertility status of the soil treated with NPK (15:15:15) observed after harvest might be partly due to early nutrient mineralization, thereby making the nutrients readily available for plant use and partly due to nutrient leaching. Hence, the application of inorganic fertilizers does not always improve soil organic matter which is a store house for nutrients. After second harvest, Sunshine Grade A and Aleshinloye Grade A had the soil available P values of 68.52 and 67.77 mg/kg which was 54% and 55% respectively higher than the soil available P value obtained from NPK treatment. The available P contents increased more than in NPK fertilizer or control plots. Increase in the availability of P after organic manure applications has also been reported by Choudhary et al., (2006) and Eghball, et al., 2004.

Conclusion

All the five types of fertilizers used were found to increase the growth parameters and shoot weight of *Amaranthus cruentus* significantly; however, the effect of Sunshine Grade A and Aleshinloye Grade A were most prominent. Organomineral and unamended organic compost were also found to have better residual effects on soil nutrients than NPK fertilizer.

Therefore, integrated use of organic and mineral fertilizer and unamended organic compost showed promising potential for improving soil fertility and growth and yield performance of *Amaranthus cruentus* in Ilorin and in similar types of agro-ecological zones in Nigeria.

Acknowledgement

The author wishes to express gratitude to Miss Yusuff Aminat Opeyemi, a graduate student from the Department of Crop Production, Kwara State University, Malete, Kwara State, Nigeria, for her contribution towards the successful completion of this research.

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