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Research Article

Effect of Fertilizer Types on the Growth and Yield of *Amaranthus caudatus* in Ilorin, Southern Guinea, Savanna Zone of Nigeria

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Field experiment was carried out at the Teaching and Research Farm of Kwara State University, Malete, Ilorin, to evaluate the effect of compost, organomineral, and inorganic fertilizers on the growth and yield of *Amaranthus caudatus* as well as its residual effects. *Amaranthus* was grown with compost Grade B (unamended compost), organomineral fertilizer Grade A (compost amended with mineral fertilizer), and NPK 15-15-15 and no fertilizer (control). All the treatments except control were applied at the rate of 100 kg N/ha. The results indicated that the *Amaranthus* yield of 18.9 t/ha produced from Grade A was significantly ($P < 0.05$) higher than 17.6 t/ha obtained from NPK fertilizer. Residual effect of *Amaranthus* growth parameters such as plant height, number of leaves, and yield values obtained from Grade A was also significantly ($P < 0.05$) higher than that of NPK, compost, and control values. Thus, organomineral fertilizer could be used in cultivation of *Amaranthus caudatus* in Ilorin and in similar type of soil in similar agroecology.

1. Introduction

Vegetable production in Africa is as old as peasant farming though its cultivation is still at the household level with very few farmers producing on a commercial level. This could be due to the fact that crops such as cereals, roots, and tubers and body-building crops like legumes are given much attention. Cereals and tubers form the bulk of food consumed in the tropics but they are deficient in minerals and vitamins compared to the body requirement to guarantee good healthy living [1].

Amaranths species is a leafy vegetable in the tropical region of world. It forms a high percentage of the daily intake of leafy vegetables [2]. *Amaranthus caudatus* is grown for its leaves and is among the highly prized leaf vegetables in Nigeria, due to their high nutritional and commercial significance.

There is an increasing awareness of value of leafy vegetable in contributing to balanced diet, particularly in area where animal protein is deficient. Leafy vegetables contribute significantly to the amount of carotene, vitamin c, protein, and minerals particularly calcium [3]. To grow vegetable amaranth it is necessary to know the effect of sources of nitrogen fertilization on its yield because nitrogen was found to be the primary limiting factors of *Amaranths* production [4]. Most Nigerian soils have low nitrogen and the low nitrogen status is usually supplemented with N fertilizer, and the importance of this source has increased over the year. However, the problem with the usage of chemical fertilizer is that while it can lead to high crop yield, it results into pollution of ground water after crop harvest [5]. Another major limitation to the usage of chemical fertilizers is due to the adverse effects they have on plant quality and disease susceptibility. A continual dependence on chemical fertilizers may be accompanied by a fall in organic matter content, increased soil acidity, degradation of soil physical properties and increased rate of erosion due to instability of soil aggregates [6, 7]. One of the ways to maintain or improve the soil fertility is by maintaining its organic matter. This is possible through the use of organic sources of fertilizer.

Research has shown that organic based fertilizers are less leached into ground water than the chemical fertilizer [8]. As a result of this fact, the use of organic based fertilizer has found favour in boosting crop production in Nigeria, because it is cheap and less likely to pollute the ground water as much as chemical fertilizer. It improves soil fertility status as well as increasing the income of farmers via increase in yield.

Amaranthus, like a number of other vegetables, requires soil with a high organic content and with adequate nutrient reserve for optimum yield. Hence organomineral fertilizer appears to be reliable organic source of N with a relatively large amount of N needed for growing *Amaranths*. Many researchers have reported that complimentary use of organic fertilizers is able to give the desired higher sustainable crop yields than sole use of inorganic fertilizer [1, 9, 10]. Therefore, the objective of this study is to determine the effect of inorganic, organic, and organomineral fertilizers on the growth and yield of *Amaranthus caudatus* as well as its residual effect.

2. Materials and Methods

The experimental site was located at the experimental plot of Kwara State University, Malete (08°42′48.5″N and 004°26′17.9″E), Ilorin, Nigeria, which lies in the southern guinea savanna belt of Nigeria. The annual rainfall in the area is about 1200 mm and temperature varies between 33°C and 34°C during the year, with a distinct dry season from December to March. The Kwara State University land area forms part of the South Western sector of Nigerian basement complex, a zone of basement reactivation and plutonism during the Pan-African orogeny [11]. The soil used for the trial has been cultivated in previous years; there was no record of fertilizer usage. The soil was well drained, of gentle slope. Twenty core soil samples were collected randomly from 0 to 15 cm depth in the site using soil auger thoroughly mixed and the bulk sample taken to the laboratory, air dried, and sieved to pass through a 2 mm screen for soil physical and chemical analysis. The soil sample was analyzed for soil texture, pH, organic carbon, total N, extractable P, exchangeable levels of Ca, Mg, Na and K, and cation exchange capacity. Soil texture was determined by the Bouyoucos hydrometer method [12]. Soil pH was measured electrometrically in a 1 : 2.5 soil-water suspension [13]. Organic carbon by Walkey-Black method [12]. Total nitrogen was determined by the Micro-Kjeldahl method [14], whereas extractable P was determined by Bray 1 method [15]. Exchangeable levels of Ca, Mg, K, and Na were determined by the atomic absorption spectrophotometer following the procedures outlined by Wilde et al. [16]. Micronutrients were extracted with 0.1 EDTA and determined using atomic absorption spectrophotometer.

2.1. Experimental Layout. The seeds of *Amaranthus caudatus* were sown on 23rd January, 2012, on a prepared nursery beds, watered regularly using a watering can and checked for seedling emergence. Transplanting of amaranths seedlings into their respective plots in the field took place two weeks after sowing on 6th February, 2012. The site was manually cleared and 12 raised beds were made to conserve the soil and its nutrient availability. The experimental plot was divided into three blocks each containing four beds. Each bed size was 2 m × 1 m with 1 m alley between plots and blocks. Seedlings were transplanted at 2 weeks after transplanting on beds at spacing 50 cm × 20 cm. The treatments consisted of three fertilizer types: Grade A (compost amended with mineral fertilizer), Grade B (un-amended compost), NPK 15-15-15 and control (no soil additive). Grades A and B are commercial products of Aleshinloye Fertilizer Plant, Ibadan, Oyo State, Nigeria. The results of analyses of the fertilizer are summarized in Table 1. The fertilizers were applied by ring method, 5 cm radius and about 2 cm deep around the *Amaranthus* plant at the rate of 100 kg N/ha [6]. Grades A and B fertilizers were applied a week before transplanting while inorganic fertilizer was applied a day to transplanting. Each vegetable bed contained thirty plants out of which five were randomly tagged for data collection. Collection of data commenced from 2 weeks after transplanting and was done weekly till the fourth weeks. First harvesting was carried out on 5th March, 2012. The experiment was repeated immediately after harvesting without any fertilizer application at the second planting in order to evaluate the residual effects of the fertilizers. The harvesting of vegetables grown in the pot without treatment was done on 16th April, 2012 (6 weeks after planting).

Table 1: Proximate analysis for organomineral fertilizer Grades A and B.

Nutrient element	Concentration	
	Grade A	Grade B
N ($g\,kg^{-1}$)	50.9	10.2
P ($g\,kg^{-1}$)	44.0	7.6
K ($g\,kg^{-1}$)	10.8	20.9
Mg ($g\,kg^{-1}$)	1.9	2.4
Ca ($g\,kg^{-1}$)	27.7	23.4
Na ($g\,kg^{-1}$)	3.5	2.9
Fe ($mg\,kg^{-1}$)	7152.3	8915.4
Zn ($mg\,kg^{-1}$)	1.5	1.9
Mn ($mg\,kg^{-1}$)	93.3	106.7
Cu ($mg\,kg^{-1}$)	14.9	16.9

Source: Aleshinloye Fertilizer Company, Ibadan, Nigeria.

The data taken include plant height, stem girth, number of leaves per plant, fresh root weight, and yield. The data collected were subjected to analysis of variance (ANOVA) and treatment means were separated by Duncan multiple range test (DMRT).

3. Results and Discussion

Table 2 shows the result of the physical and chemical analysis of the soil studied. The soil was clay and slightly acidic. The values of total nitrogen, available phosphorus, and potassium of the experimental soil were below the critical values of the soil of Guinea Savanna [17, 18]; this may be due to low soil organic matter. The low soil contents for the major nutrients

Table 2: Physicochemical properties of the experimental soil.

Parameters	Soil test value
pH	6.4
Org. C (g kg^{-1})	2.0
Total N (g kg^{-1})	2.44
P Mehlich (m gkg^{-1})	9
Exchangeable bases (cmol kg^{-1})	
K	1.2
Mg	3.2
Na	1.9
Ca	5.1
Extractable micronutrients (cmol kg^{-1})	
Fe	53
Zn	13
Mn	49
Cu	2.6
Textural class (%)	
Sand	56.8
Silt	10.0
Clay	33.2
Textural class	Clay

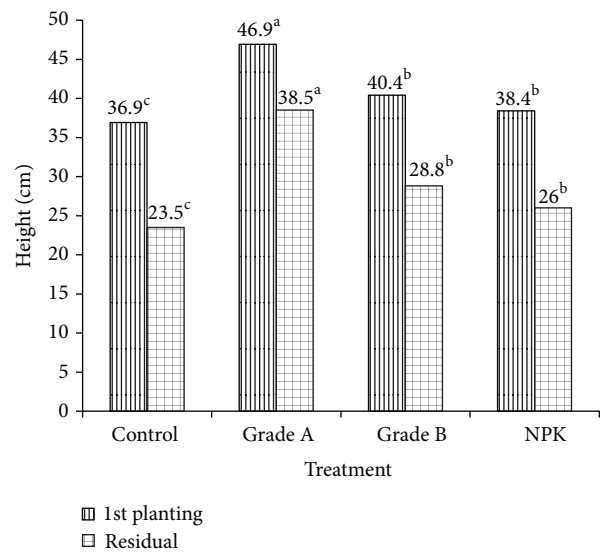

Figure 1: Plant height of *Amaranthus caudatus* as influenced by application of organic fertilizers and NPK at 4 weeks after transplanting. Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

signify the need for improvement of *Amaranthus caudatus* performance.

Plant heights as affected by organic amendments and NPK are shown in Figure 1. There were significant differences ($P < 0.05$) in plant height values obtained from the treatment of Grade B and NPK during the first and residual growing period. Results showed that at the end of 4 WAT Grade A, Grade B, and NPK plant height values differed significantly ($P < 0.05$) from control. The highest plant height 46.9 cm and 38.5 cm was obtained from organomineral Grade A both at first and residual planting, respectively.

The highest plant height obtained from Grade A may be probably due to favourable nutrient mineralization of this fertilizer as a result of the influence of the mineral component on the organic content of the compost [10, 19]. The control plants produced the shortest plants as they had to rely on the native soil fertility which from the result of chemical analysis was deficient in nutrients. Figure 2 shows that Grade A significantly enhanced the production of leaves and maintained the trend observed in plant height at both first and residual planting. Changes in the number of leaves are bound to affect the overall performance of *Amaranthus* as the leaves serve as photosynthetic organ of the plant [20].

There were no significant differences ($P < 0.05$) on number of leaves for plot treated with Grade B and NPK. The higher number of leaves produced from organomineral Grade A over the NPK throughout the growing period could be due to sustaining release of nutrients from the former over the latter [1]. Thus, the increase in number of leaves under amended, unamended, and NPK fertilizers application, reconfirmed the role of fertilizer in promoting vegetative growth in leafy vegetables [21].

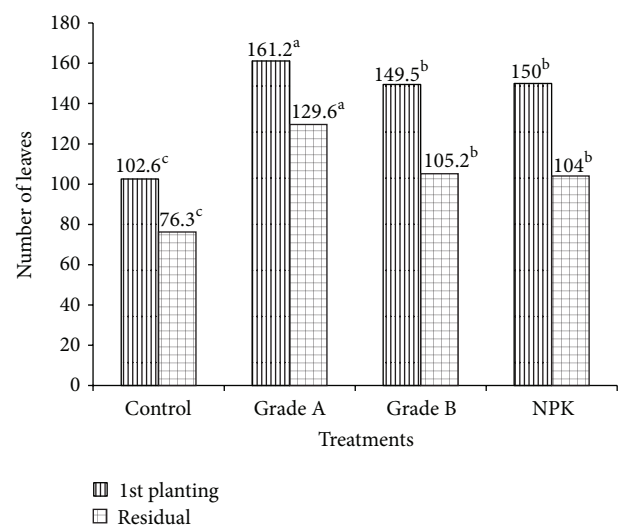

Figure 2: Number of leaves of *Amaranthus caudatus* as influenced by application of organic fertilizers and NPK at 4 weeks after transplanting. Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

Table 3 shows the response of stem girth and yield parameters of *Amaranthus caudatus* to application of organic fertilizer and NPK. All the fertilizers applied were found to increase the stem girth, root weight, and yield of *Amaranths* when compared with control. At 4 weeks after transplanting (WAT) stem girth of *Amaranths* with Grades A and B and NPK were significantly ($P < 0.05$) higher than stem girth of

Table 3: Effect of fertilizer types on the stem girth and yield parameters of *Amaranthus caudatus* at 4 weeks after transplanting.

Treatment	Stem girth (cm)	Fresh root weight (g/plant)	Yield (t/ha)
	1st planting		
Control 0	6.0^{c}	27.4^{d}	12.1^{c}
Grade A	7.5^{a}	39.2^{a}	18.9^{a}
Grade B	6.9^{b}	34.7^{b}	17.6^{b}
NPK	7.0^{b}	31.0^{c}	17.6^{b}
	Residual effect		
Control	4.4^{c}	7.8^{d}	3.6^{c}
Grade A	5.9^{a}	30^{a}	7.5^{a}
Grade B	5.0^{b}	18.3^{b}	5.0^{b}
NPK	5.1^{b}	15.3^{c}	5.3^{b}

Means having the same letter along the columns indicate no significant difference using Duncan's multiple range test at 5% probability level.

control both at first and residual planting. However, Grade A produced the highest stem girth of 7.5 cm and 5.9 cm which was 17% and 25% greater than the control.

With respect to the effects of different fertilizers on fresh roots and shoot yield at first and residual planting, all the treatments differed significantly ($P < 0.05$) from the control. The fresh roots weight of both first and residual planting were in the order Grade A > Grade B > NPK > control. The increase in root weight suggested that root growth parameters were differentially affected by application of fertilizer types.

However, the trend for shoot yield of *Amaranthus* was in order of Grade A > NPK > Grade B > control. Amaranth yield was least without application of fertilizer. This confirmed the findings of [22], who reported the application of organic, mineral and organomineral fertilizer for enhancement of *Amaranthus cruentus* yield. There were no significant difference ($P < 0.05$) in the yield of *Amaranthus* with plot treated with NPK and Grade B at both plantings. Table 3 also showed that organomineral Grade A had the highest yield of 18.9 t/ha compared to other obtained from fertilizer treatments. Residual effect of *Amaranthus* yield values obtained from organomineral Grade A was also significantly ($P < 0.05$) higher than that of NPK, compost, and control values. This was similar to the works of Akanni et al. [23], Ayeni [24], and Ogunlade et al. [1] who reported that the combinations of organic and mineral fertilizer perform better on the yield of tomato, maize, and *Solanum macrocarpon* than when each of them is solely used.

4. Conclusion

This study showed that Grade A fertilizer at 100 kg N/ha gave the best performances in all the *Amaranthus caudatus* growth parameters. Given its superior responses, organomineral Grade A fertilizer could be a very attractive fertilizer alternative particularly for annual crops with short growth cycle such as *Amaranthus*. It is therefore reasonable to recommend the use of organomineral Grade A fertilizer in the cultivation of *Amaranthus caudatus* in Ilorin and similar type of soil in similar agroecology.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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