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Nitrogen Requirements of *Amaranthus cruentus* L. on Two Soil Types in Lagos State of Nigeria

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ABSTRACT

Soils from Ikorodu (Orthic Luvisol) and Lagos State University (LASU) Ojo campus (Dystric Fluvisol) were used in greenhouse experiments to determine N requirement of *Amaranthus cruentus* L. using five rates of NPK 15:15:15 at 0, 150, 300, 450 and 600 kg ha^{-1}. The experiment was arranged in a completely randomized design with four replications. Soil treated with 300 and 450 kg ha-1 NPK 15:15:15 significantly ($p<0.05$) enhanced plant height number of leaves shoot fresh and dry weight and plant N-uptake compared to other treatments at Ikorodu. Corresponding values were obtained from soil treated with 450 and 600 kg ha^{-1} NPK 15:15:15 at LASU. Optimum N requirements for *Amaranthus cruentus* at Ikorodu and LASU were 45.0 and 67.5 kg N/ha-1 respectively.

INTRODUCTION

Vegetable cultivation has become a major aspect of horticulture in view of the value of its products. According to FAO (1992), *Amaranthus cruentus L. ranked* among the best leaf vegetable in terms of its chemical composition and nutritional status. Moreover, it contributes much in ameliorating nutrient imbalance in human diet (Messiean, 1989). A *Cruentus* contains appreciable amount of crude protein, minerals (calcium and potassium) and vitamins A and C that can contribute substantially to our daily requirements when consumed in reasonable quantity (Saunder and Becker, 1983; Rubatzky and Yamaguchi, 1997). The market drive on *A. cruentus* is highly appealing and its cultivation is not labour intensive, this makes it to be one of the most important annual leaf vegetables and it develops and matures much more rapidly than any other vegetable *A. Cruentus* has a short growing period of four to six weeks, this serves as a source of encouragement to farmers, especially the peri-urban and urban dwellers where it serves as a source of employment. *A. cruentus* thrives well on soils with high organic-matter and adequate mineral however for optimum growth and yield.

Amaranthus cruentus species are extensively cultivated and 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 the traditional subsistence mixed cropping systems. *Amaranthus cruentus* is produced under different cropping systems in home gardens, farms, inland valleys *(fadamas),* and peri-urban gardens. About 40 % of total *A. cruentus* production by individual farmers is used for family consumption, while the rest is marketed Denton, (1996).

Crops mainly require major nutrients such as N, P and K. Denton and Olufolaji (2000), recommended 70 kg N, 34 kg P and 26 kg K/ha to give the highest fresh leaf yield for Amaranth, Kogbe (1980), reported that 20 - 40 t/ha^{-1} of) cured poultry manure was optimum, for *A. cruentus,* in a forest sedimentary location. Olufolaji (1996) found that well cured poultry manure at 20 t/ha^{-1} was adequate for high leaf yield in *A. cruentus*.

Yield of *A. cruentus* in the range of 4 to 14 tonnes fresh weight per hectare have been reported (Campbell and Abbott, 1982). However, *A. cruentus* yields up to 40t/ha^{-1} could be obtained with fertilizer application (NRC 1984). The various fertilizer regimes have been recommended by different workers for *A. cruentus* production. There is a dearth of information on N requirement of *A. cruentus* in Lagos State. The study was therefore set up to investigate N, P and K requirement of *Amaranthus cruentus* on two soil types (Orthic Luvisol and Dystric Fluvisol in Lagos.

The study Area

There were two study sites, namely Ikorodu farm settlement and Lagos State University (LASU) Ojo Campus. The two locations are made up of two soil types: Ikorodu (Orthic Luvisol) and LASU (Dystric Fluvisol) (FAO, 1992). Ikorodu is located in the rain forest area of south west, Nigeria (6° 37'N; 3° 53'E) and the altitude is about 15.50 meters above sea level. LASU is located at Ojo in Badagry Division of Lagos State of Nigeria. It is located in the swamp forest area of southwestern Nigeria, ($6^0$27'N; $3^0$13^0'E and the altitude is about 6.1 meters above sea level. The dominant vegetation of Lagos State is the swamp forest consisting of the fresh water and mangrove swamp forest, both of which are influenced by bi-modal rainfall pattern of the state which makes the environment a wetland region.

Soil collection

Soils used for the experiment were randomly collected at 0-20 cm soil depth in 30 core points at per location. The experimental soil at Ikorodu was classified as Orthic luvisol (F AO, 1992), formed on traditional geological area between the coast and inland complex formation. They are mainly on old coastal plain sands, while soil at LASU location was Dystric Fluvisol formed on sedimentary alluvial deposit of tertiary sediment, mainly entisol and inceptisol. (FAO 1992) The soil samples were air dried, crushed and passed through a 2 mm sieve for laboratory analysis. The test crop was *Amaranthus cruentus* variety (ED82/1019) early maturing type. The inorganic fertilizer used was NPK 15: 15: 15 fertilizer commonly used by vegetable fanners in Lagos State (CERUD, 2003). The greenhouse was located at LASU.

Experimental design

The experiment was laid out in a completely randomized design (CRD). Forty plastic pots were filled with 5 kg soil each, labelled and planted to *A. cruentus* seeds (at 20 pots per site). The NPK 15:15:15 was weighed at corresponding rates of 0, 150, 300, 450, 600 kg ha^{-1} in four replicates.

Growth parameters were taken from four to six weeks and the following parameters were measured: plant height, number of leaves, Shoot fresh and dry weights. At 6 weeks *A. cruentus* was harvested. The experiment was repeated twice to authenticate the result.

Physical and chemical analysis of soil samples

Pre-cropping chemical analysis of the experimental soil was carried out before land preparation and repeated at the first, second and third harvests to determine the nutrient status of the soil. The soil samples were air dried, crushed and sieved to pass through a 2 mm sieve after which physical analysis was carried out using the hydrometer method as described by Bouyoucos (1962);

Total N was analyzed using the macro Kjeldahl procedure as described by Jackson (1958); Organic carbon analysis was done using the Walkley and Black procedure as described by Nelson and Sommers (1982). The organic matter content was derived by multiplying organic carbon content by 1.72; pH was determined in soil/water ratio of 1:2 using a pH meter with glass electrode; Available phosphorus was by the Bray 1 method as described by Bray and Kurtz (1945); Exchangeable acidity was determined by the titration method as outlined in IITA Manual Series No. 1 (IITA, 1979); Exchangeable K, Ca and Mg were determined by extraction with 1 M ammonium acetate at pH 7.0 and the amounts of K, and Ca in the filtrate were determined using a Corning flame photometer with appropriate filter, while Mg was determined by using a Perkin-Elmer Atomic Absorption Spectrophotometer (AAS); Micronutrients: Cu, Zn, Mn and Fe were determined after extraction of the soil sample with 0.1 M HCl and the filtrate read on Perkin-Elmer AAS; and Effective cation exchangeable capacity (ECEC) of the soil samples was determined by the summation of all the cations and the exchangeable acidity.

Chemical analysis of plant

The plant materials were wet digested by weighing 0.2 g of each material into a separate 50 ml digesting tube and adding 30 ml concentrated sulphuric acid and 20 ml of hydrogen peroxide under fume cupboard. The bottles were set up on heating mantles, digests were cooled and each transferred to separate 100 ml volumetric flasks and made up to mark with distilled water and then nitrogen was determined using a Technicon Autho Analyser. Dry ashing was used for other elements. The plant material (0.2 g) was weighed into labelled crucibles, ashed furnace cooled and dissolved with 5 ml of 4 % HCl and leached with distilled water into 100 ml conical flasks and analyzed for phosphorus using Vanado-Molybdate method colorimetrically and potassium was by flame photometer.
The nutrient uptake was calculated using the formula:

Nutrient uptake = Dry matter yield (kg) x nutrient content (%).

Data analysis

Analysis of variance was carried out on data collected and means separated using Duncan's multiple range tests at 5% of level of probability.

RESULTS

The soil at Ikorodu was less acidic pH (6.1) compared with that of LASU (pH 5.3). In addition, the soil at Ikorodu had higher organic carbon and N content compared to that of LASU (table 1).The available P was similar at the two locations. Exchangeable bases at Ikorodu was twice that of Ojo while exchangeable acidity at LASU was half that of Ikorodu. However, the micronutrient content was similar.

Table 1: Pre-cropping physical and chemical characteristics of soils of the experimental sites

Parameters	Ikorodu (Orthic Luvlsol)	LASU (Dystric Fluvisol)
pH (H_20)	6.1	5.3
Total N (g kg^{-1})	1.8	1.3
Organic Carbon (g kg^{-1})	25.2	10.5
C/N ratio	14.0	7.7
Available P (mg kg^{-1})	9.0	8.3
Exchangeable bases (c mol kg^{-1})		
K	0.4	0.2
Ca	0.4	0.2
Mg	0.3	0.2
ECEC	1.4	0.7
H +Al	0.3	0.1
% Base Saturation	97.4	84.5
Micronutrients (mg kg^{-1})		
Mn	21.1	21.0
Fe	11.1	11.0
Cu	1.8	1.5
Zn	10.4	10.1
Particle size analysis (g kg^{-1})		
Sand	627	912
Silt	125	54
Clay	248	34
Textural Class	Sandy Clay Loam	Sandy Loam

Compared to control, all the treatments significantly increased (P<0.05) all the agronomic parameters under study. At 4 and 5 weeks after sowing (WAS) of *A. curentus* seed, fertilizer treatments enhanced plant height and number of leaves better than control at both locations. At 6 WAS, soil treated with 300 and 450 kg ha^{-1} NPK 15:15:15, significantly enhanced plant height and number of leaves than other treatments at Ikorodu. At LASU, corresponding values were obtained where 450 and 600 kg NPK 15:15:15 were applied (Table 2). However, *A. cruentus* grown on Ikorodu soil was more vigorous than that of LASU. Thus, plant at Ikorodu were significantly (P<0.05) taller than those of LASU, (Table 2). Similar trend was observed on shoot fresh and dry weights at Ikorodu and LASU respectively (Table 3). The yield obtained at Ikorodu was higher than that of LASU.

At Ikorodu, soil treated with 300, 450 and 600 kg ha^{-1} NPK 15:15:15 significantly (P<0.05) enhanced N-uptake better than other rates. At LASU corresponding values were obtained at 450 and 600 kg ha^{-1} NPK 15-15-15. Similar trends were obtained for P and K uptake at Ikorodu and LASU, respectively (Table 3).

Table 2: Effects of different rates of NPK fertilizers on plant height and number of leaves of *A. cruentus* at 6 WAS on Ikorodu and LASU soils in the greenhouse

Treatments NPK 15-15-15 (kg ha^{-1})	Plant height (cm)						Number of leaves					
	Ikorodu			LASU			Ikorodu			LASU		
	4	5	6	4	5	6	4	5	6	4	5	6
0	20.05c	27.35c	4048	3.75d	3.95d	5.88c	10.0b	15.5b	16.25b	4.00c	4.00d	4.5b
150	22.10b	30.43b	41.6	9.8c	10.68c	12.25c	12.0b	16.5a	16.75b	5.00b	6.25c	6.75b
300	22.95b	36.95a	47.3	13.6b	14.33b	17.45b	15.25a	19.5a	22.50a	9.00a	9.00ab	10.25a
450	31.75a	36.09a	47.0	18.75a	23.35a	26.15a	14.75a	19.25a	22.75a	9.50a	11.55a	12.25a
600	31.12a	39.30a	42.9	17.75a	22.65a	23.45a	14.75a	19.25a	19.25a	9.75a	10.75ab	11.50a

Means having the same letter(s) in the same column are not significantly different at 5% level of probability

Table 3: Effects of different rates of NPK fertilizer on yield and nutrient uptake of *A. cruentus* on Ikorodu and LASU soils in the greenhouse

Treatments NPK (kg ha^{-1})	IKORODU					LASU				
	Yield (g plant $^{-1}$)		Nutrient uptake (mgkg^{-1})			Yield (g plant $^{-1}$)		Nutrient uptake (mgkg^{-1})		
	SFW	DMY	N	P	K	SFW	DMY	N	P	K
0	3.8b	0.30b	11.93c	25.77b	13.0b	0.3c	0.01d	0.18d	0.01d	0.09c
150	4.40b	0.40b	19.11b	27.45b	13.0b	0.26b	0.03c	0.29c	0.04c	0.72b
300	5.72ab	0.48ab	26.0a	33.98a	1.8a	0.38b	0.04b	1.50b	0.08b	0.77b
450	5.84a	0.52a	28.13a	33.75ab	1.81ab	0.54a	0.06a	2.53a	0.25a	1.87a
600	5.7ab	0.48ab	25.23a	34.15a	1.92a	0.38b	0.04b	2.16ab	0.20a	1.81a

Means having the same letter(s) in the same columns are not significantly different at 5% level of probability

DISCUSSION

Nitrogen is a major nutrient limiting vegetable growth (Manga et al., 2004). The additions of N fertilizer to the soil increased plant height, number of leaves, shoot fresh and dry weight at the two study sites. Crop growth rate was significantly (P < 0.05) enhanced by N application to *A.cruentus.* Application of 45.0 and 67.5 kg N ha^{-1} significantly (P < 0.05) produced higher dry matter yield than control at Ikorodu and LASU, respectively. The increase in growth and yield could be as a result of better vegetative growth as reported by Abidin and Yasdar (1986) that N application encourages above ground vegetative growth rate, net assimilation rate and leaf area index.

The increase in N and P uptake by *A. cruentus* as a result of NPK application at 45.0 and 67.5 kg N ha^{-1} at Ikorodu and LASU, respectively was in agreement with the findings of Taylor *et al.* (1993) that NPK application increased N and P concentration in *A.cruentus.* Optimal growth rate recorded at the application of these levels of fertilizer application for the two study sites from the research findings confirmed the report of Denton and Olufolaji (2000) that plant growth was found to be sub optimal at low fertilizer application but significantly (P< 0.05) better at 400 kg ha^{-1} of NPK 15: 15: 15 (60 kg N ha^{-1}).

CONCLUSION

Fertilizer rates applied 300 and 450 kg ha^{-1} of NPK 15:15:15 was optimum for amaranth production at Ikorodu and LASU, respectively. Application of 45.0 and 67.5 kg N ha^{-1} from inorganic fertilizer adequately enhanced yield of *A. cruentus* at Ikorodu and LASU respectively.

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