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EFFICACY OF GEO-PLUS FERTILIZER ON SOIL PROPERTIES AND AMARANTHS (AMARANTHUS CRUENTUS L.) GROWTH, YIELD AND NUTRIENTS CONTENT IN OBUBRA DERIVED SAVANNA CROSS RIVER STATE, NIGERIA.

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Abstract
Field and screen house experiments were conducted at the Teaching and Research Farm of the Cross River University of Technology, to evaluate the suitability of Geo Plus fertilizer on Amaranthus growth, yield and nutrient content and soil properties. The experiment was laid out in RCBD for the field and CRD for the screen house. The treatments were Zero application, GeoPlus 1, GeoPlus 2, and NPK 20:10:10 which were replicated three times. Results indicated (P>0.05) GeoPlus 1 and 2 produced tallest plants (36.6 cm and 31.1 cm) in the field and screen house respectively, largest stem girth and highest number of leaves; highest vegetable yield and unaffected initial soil properties in both field and screen house than the other treatments. Plant nutrients content of all the treatments were below FAO/WHO toxic threshold levels. GeoPlus fertilizer is suitable for sustainable and consumable Amaranthus production.

Keywords: GeoPlus, Suitability, Amaranthus, Nutrients, Yield

1. Introduction

Nigeria is an agriculturally endowed country for production of crops for both self-sufficiency and export produce and products. Ojanuga (2006) stated that Nigeria spread over 92 million hectares of land of which 72 million hectares (78%) is considered suitable for crops. It was also reported that our high potential to produce agricultural commodities is attributed to a combination of favorable climatic condition, undulating topography and amenable soils for cultivation.

The limitations to exploring the Nigeria vast cultivatable land is the sustainability of these soils. Agboola and Unamma (1991); Chude *et al.*, (2014) noted that tropical soils are highly weathered, kaolinitic and low in cation exchange capacity, and base saturation and low in organic matter content. Soil nutrients replenishment from organic and mineral sources is a pre-requisite for continuous productivity of such soils, particularly under continuous cultivation. Declining soil fertility has been identified as the fundamental cause of declining crop yields in many parts of Africa (Olowoake*et al*., 2013).

Hole *et al.,* (2005) reported that each year about 5 – 10million hectares of crop land are taken out of production because of soil erosion, nutrients depletion, salinization and water logging.

These limitations and potentials of Nigerian soils can be overcome and explored respectively, through proper fertilizer management practices such as using appropriate fertilizer at adequate rate, time and method of application. Amaranthus is a short duration crop which is harvestable within three weeks of transplanting and a single crop can be harvested fortnightly severally (Grubben and Denton, 2004). This leafy vegetable is an integral part of Nigeria diet that provides consistent source of income for the farmer throughout the year (Orhue *et al*., 2015)

Leafy vegetables require well drained soils rich in N, P, and K (Ogunlade*et al*., 2011) with

optimal performance in non-acid soil condition. This optimal pH requirement of the crop ensures release of available essential nutrients. Leafy vegetables contribute to balanced diet, particularly in areas where animal protein is deficient. Makinde (2012) had observed that about 40% of Amaranthus produced is consumed by the farmer's family while the remaining is marketed to boost farmers economies.

Generally, adequate soil N, P and K are essential nutrients which can be supplied by organic and inorganic fertilizer sources. However, the organic based fertilizers are more effective being rich in both macro and micro nutrients which are required for optimum growth and yield of crops (Omotoso and Shittu 2008). Moreover, organic based / organo mineral fertilizers are environmentally friendly as they minimize soil pollution.

Geo Plus is a multi-nutrient fertilizer containing the primary nutrient elements N, P and K (commonly called the fertilizer elements) formulated as 24:10:10, and fortified with five (5) essential micronutrient elements.

Organic and inorganic fertilizers have been used to solve the problem of nutrients losses in tropical soils (Olowoake, *et al*., 2013). But the drawbacks of fertilizers, especially inorganics in our fragile soils has led to producing alternative methods of nutrients application to avert soil acidification and nutrients imbalance such as Geo Plus.

No research has been conducted on the response of this foliar applied fertilizer in this agro-ecological zone. Hence the choice of this research area with the objective of evaluating the efficacy of GeoPlus foliar fertilizer comparatively with the conventional soil applied NPK 20:10:10 on Amaranthus.

2. Methodology

Location: The Demonstration was carried out at the Teaching and Research Farm of the Cross River University of Technology, Obubra Campus on latitude 6^0 06" Nand 8^0 18" E in the rainforest / derived savanna belt of Nigeria. Obubra is characterized by a mean annual rainfall density of 2250 mm - 2500mm with an annual temperature range of 25^0C – 32^0C. Obubra in Central Cross River State has similar climate and general soil properties with Northern Cross River.

Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) in the field and CRD in the Screen house, both replicated three times. The treatments consisted of control and four other fertilizers treatments viz: T_1 – Control (no fertilizer), T_2 – Geo Plus fertilizer (1g/litre water), T_3 – Geo Plus fertilizer (2g/litre water) and T_4 – NPK 20: 10: 10 (soil applied). Each experimental plot measured 5m x 4m and a gross experimental plot of 18m x 17m ($306m^2$) or 0.03 Ha for the field experiment. In the screen house each treatment was made of 5 polythene pots.

Geo Plus Fertilizer Composition

Geo Plus: NPK 24:10:10 + Fe, Zn, Cu, Mn and Ni

Experimental Material and Agronomic Practices

The variety of the Amaranthus was the common cultivar, *Amaranthus cruentus* grown and consumed generally in Cross River State and Nigeria (Olowoake and Ojo, 2014).The crop passed through a nursery for two weeks and transplanted into main field.

Cultural Practices.

After transplanting, manual weeding, insect pests' control and fertilizer application were carried out. Both fertilizers were applied one week after transplanting. Geo Plus was foliar applied using hand spraying knapsack while NPK 20:10:10 was soil applied by band placement.

Data Collection

Soil sampling and processing. At the commencement of the experiment, composite soil sample was collected at random points

within the experimental plot which was bulked using a soil auger at 0 – 25 cm soil depth. Post cropping soil samples were collected from each treatment at the end of the experiment. These samples were air dried and sieved through a 2mm mesh for laboratory analysis.

Plant Sampling: A net plot of inner ridges for each treatment was used with five tagged plants for growth and the yield parameters while a plant from each net plot was cut for tissue analysis. The plants were sampled for height, number of leaves per plant, stem girth, harvestable shoot yield per unit area (field) and weight of each plant (screen house).

Soil Analysis: Routine analysis was conducted for the composite sample and the postharvest soil samples to determine the fertility properties of the soils using standard laboratory procedures as outlined as follows:

Soil Physical properties

Bulk density (Db) was determined from the oven dried soil sample and core dimensions using the equation:

$Db = Ms/Vb$ in g/cm^3 where
Ms = Oven driedmass of soil
Vb= bulk volume of the soil (core volume)

Particle Size Distribution (PSD): This was determined by the Bouyoucos (Hydrometer) method procedure by Udo *et al.*, (2009). This involves the suspension of soil samples with sodium hexametaphophate (calgon). The reading on the hydrometer was taken at 40 seconds. Second reading was taken three hours later. The particle size was then calculated using the following formulae:

$Sand = 100- (H_1 + 0.2 (T_1 – 68)-2.0)2.,$
$Clay = (H_2 + 0.2 (T_2 (T_2-68) -2.0)2$
Silt= 100 – (% sand + % clay)
Where;
H_1 = Hydrometer first reading at 40 seconds
T_1 = temperature first reading at 40 seconds
H_2 = Hydrometer second reading after 3 hours
T_2 = Temperature second reading after 3 hours

Soil Chemical Properties

i. Soil pH:

This was determined in both water and 0.1 N KCL in a ratio of 1:1 soil: water and 1:2.5 soil: Kcl respectively. After stirring the soil suspension for 30 minutes, the pH values were read using the glass electrode pH meter (Mclean, 1982).

ii. **Organic Matter**

This was determined by the Walkley-Black method as outlined by Page *et al*., (1982) which involves the oxidation with dichromate and tetraoxosulphate (vi) acid ($H_2 SO_4$). The excess was titrated against Ferrous Sulphate. The organic carbon was then calculated using the relationship:

$$\% \text{ Org. C} = \frac{N (Vi – V_2)}{} 0.3f$$

Where;
N = Normality of Ferrous Sulphate solution
V_1 = Ml Ferrous Ammonium Sulphate for the black
V_2 = ml Ferrous Ammonium Sulphate for the sample
W = mass of sample = farm
F = correction factor = 1.33
% Organic matter in soil = % Org. C x 1.729

ii. Nitrogen in soil.

Total nitrogen in soil was determined by the macro kjeldahlmethod as described by Udo *et al., (*2009). The soil samples were digested with Tetraoxosulphate (vi) acid ($H_2 S0_4$) after addition of excess caustic soda. This was distilled into a 2% Boric acid (H_3Bo_4) and then titrated with 0.01 HCl. And the nitrogen was obtained from the relationship.

$$\% N = \frac{T \times Mx14 \times 100}{N}$$

Where;
T = Titre value
M = Molarity of Hcl
W = Weight of soil used
N = Normality of H_2SO_4

iii. Available phosphorus

Available P was determined by Bray 1 method as outlined

by page *et al.*, (1982). This involved mechanical shaking of the sample in an extracting solution then centrifuging the suspension at 2000 rotations per minutes for 10 minutes. Using Ascorbic acid method, the percentage transmittance on the spectrophotometer at 660 nm wave length was measured. The optical density (OD) of the standard solution was then plotted against the phosphorus ppm and the extractable P of the soil was then calculated.

iv. Cation Exchange Capacity (CEC) and Exchangeable acidity (EA)

This was determined by the kjeldahl distillation and titration method as outlined by IITA (1979) using ammonium acetate solution the soil samples were leached then the soil washed with methyl alcohol and allowed to dry. The soil was then distilled in kjeldahl operation in to a 4% Boric acid solution. The distillate was then titrated with standard solution of 0.1 N HCl.

v. Exchangeable cations

This was determined by ammonium acetate extraction method as described by IITA (1979). The soil samples were shaken for 2 hours then centrifuged at 2000 rpm for 5-10 minutes after decanting into a volumetric flask, ammonium acetate (30 ml) was added again and shaken for 30 minutes, centrifuged and the supernatant transferred into same volumetric flask. Atomic Absorption spectrophotometer (AAS) was used to read the cations.

Plant Samples analysis: A net plot of inner plants for each treatment was used with five tagged plants for growth parameters. At 4 weeks after planting (WAP), the plants height was measured using meter rule and thereafter the shoots were carefully harvested by destructive sampling. This was done for both field and the screen house.

The shoots were later oven dried in paper bags at a temperature of 65 ^{0} C to constant weight and the dry matter weight determined.

The tissues were later digested with conc. H_2SO_4 and 30 % H_20_2 after which the contents were read; K was in Flame Photometer. Total N was determined using Micro Kjeldahl digestion and distillation process (Bremmer and Mulvaney 1982). P was determined by the molybdate blue colorimetry method using Spectrophotometer. Micro nutrients concentration of the Amaranthus plants extracts were read in the Atomic Absorption Spectrophotometer (AAS).

Statistical Analysis

Analysis of variance (ANOVA) for RCBD (field) and CRD (Screen house) was performed on the Amaranthus growth and yield parameters using the computer software Genstat (Genstat 2005). FLSD was calculated on the means at $P > 0.05$ to separate the means.

3. Results

Pre-treatment and postharvest soil properties.

Result of the pre-treatment composite sample and postharvest soils of the experimental site are presented in Tables 1, 2 and 3. The soils of the experimental sites were sandy loam in texture, low OM, total N and available P. The CEC was low as well as exchangeable cations of K, Mg and Ca with Na being moderately low. The pH of the experimental site was moderately acidic. There was no significant difference between the two soils.

Table 1 Pre-treatment soil properties

Particle Size Analysis		Value
Sand	(%)	83.98
Silt	(%)	5.62
Clay	(%)	10.40

pH		5.90
EC	ds/m	0.051
Organic Matter	(%)	3.90
Total N	(%)	0.10
Avail P	(mg/kg)	2.49
Exchangeable Bases:		
Calcium	(Cmol/kg)	8.0
Magnesium	(Cmol/kg)	2.72
Sodium	(Cmol/kg)	0.08
Potassium	(Cmol/kg)	0.21
Exchange Acidity	(Cmol/kg)	2.6
Effective cation exchange capacity	(Cmol/kg)	13.61
B. Saturation	(%)	80.89

Table 2: Post harvest soil chemical properties as affected by Geo-plus fertilizer in the field

Treatment	pH	OM%	Total N%	Av. P mg/kg	Exch.K	Exch. Ca	Exch. Mg
No. Fertilizer	5.62	2.61	0.10	2.10	0.09	6.4	1.2
Geo-plus	5.82	3.60	0.13	3.14	0.22	8.2	2.0
Geo-plus 2	5.75	3.58	0.12	3.16	0.21	8.1	2.0
Green World	5.59	3.49	0.11	3.13	0.21	7.9	2.1
NPK 20.10.10	5.30	3.04	0.13	3.18	0.25	8.3	2.0
LSD	NS	NS	NS	NS	NS	NS	NS

Table 3: Post harvest soil chemical properties as affected by Geo-plus fertilizer in the screen house

Treatment	**pH**	**OM%**	**Total N%**	**Av. P mg/kg**	**Exch. K**	**Exch. Ca**	**Exch. Mg**
No. Fertilizer	5.61	2.62	0.10	2.09	0.09	6.1	1.2
Geo-plus	5.81	3.61	0.12	3.12	0.23	8.0	2.0
Geo-plus 2	5.92	3.52	0.13	3.23	0.21	8.3	2.1
Green World	5.61	3.41	0.12	3.18	0.21	8.0	2.1
NPK 20.10.10	5.40	3.14	0.11	3.12	0.26	8.2	2.0
LSD	NS	NS	NS	NS	NS	NS	NS

Results of plant height, stem girth, number of leaves per plant and harvestable vegetable yield per unit area for field and screen house experiments are presented in Tables 4, 5 and 6.

The plant height of Amaranthus plants at 4 weeks after transplanting (Table 4) indicated that Geo-plus fertilizer produced tallest plant (34cm and 36cm) in field and in screen house and Green world produced 31.8cm tall plants. Statistically although Geo-Plus plants were taller, this was not different from Green World. This was followed by plants treated with NPK 20:10:10 and the least plant height was obtained from the control.

The stem girth of Amaranthus (Table 5) was largest in Geo-Plus and Green World treated plants (13.51 and 13.01mm and 11.04mm) respectively in the field, followed by plants in NPK 20:10:10 plots and the least stem girth in the control (3.42mm). In the scream house, Geo-plus treated plants produced largest stem girth (10.06 and 10.92mm) followed by Green World treated plants (10.41 mm) then NPK 20:10:10 (9.51mm) and the least plant girth of 3.31mm was obtained from the control.

Number of leaves per plant result indicated that Geo-plus produced highest number of leaves per plant in the field and screen house (24.6 and 26.2 and 20.1 and 22.4) respectively but when compared with Green world with 22.7 and 19.8 leaves per plant (in the field and screen house respectively), statistically there was no difference.

NPK 20:10:10 produced 21.3 and 17.2 leaves per plant respectively in the field and screen house while the least number of leaves was produced in the control with 14.2 and 12.3 leaves per plant for field and screen house respectively.

Results of harvestable vegetable yield of Amaranthus (Table 6) indicated that Geo-plus (1g/lit and 2g/lit water) produced 6.40kg/plot and 6.9kg/plot (5.33 t/ha and 5.75 t/ha) respectively in the field while green world yield was 5.8kg/plot (4.83 t/ha). Although Geo-plus produced higher yield values, statistically the yield was same with Green world. NPK 20:10:10 followed with yield of 4.7kg/plot (3.75t/ha) and the least yield was obtained in the control (without fertilizer) with yield of 3.2kg/plot (2.67t/ha). In the screen house, Geo-plus produced visually highest values by weight per plant of 203.4g and 209.2g for Geo-plus 1g/lit and 2g/lit and Green world 198g mean weight per plant. These weights per plant were, however, statistically same.

NPK 20.10.10 produced plants with mean weight per plant of 181g and the least yield per plant of 112g was obtained from the control plants that received no fertilizer.

Table 4: Plant height of Amaranthus at 4 weeks after transplanting (Cm) as influenced by Geo-plus fertilizer.

Treatment	**Plant Height (cm) at 4 WATP**	
	Field	**Screen house**
Control	14.4	12.8
Geo-plus	34.4	29.6
Geo-plus 2	36.6	31.1
NPK 20: 10:10	26.4	23.7
FLSD	5.2	3.0

Table 5: Stem girth and number of leaves per plant of Amaranthus as influenced by Geo-plus fertilizer at 4 WATP

Treatment	Stem girth (mm)		Number of leaves/plants	
	Field	Screen house	Field	Screen House
Control	3.42	3.31	14.2	10.2
Geo-plus	12.51	10.92	24.6	20.1
Geo-plus 2	13.01	11.06	26.8	22.4
NPK 20: 10:10	10.04	9.51	21.3	17.2
FLSD	6.42	0.62	2.8	2.5

Table 6: **Harvestable vegetable yield of Amaranthus as affected by Geo-plus fertilizer at 4 WATP.**

Treatment	Field		Screen house
	Kg/ plot	t/ha	Plant (g)
Control	3.2	2.67	112.3
Geo-plus	6.4	5.33	203.4
Geo-plus 2	6.9	5.75	209.2
NPK 20: 10:10	4.7	3.75	181.3
FLSD	1.3	-----	12.4

The plant nutrient content for macro and micronutrient (Tables 7 and 8) indicated that geo-plant fertilizer has the highest content of nitrogen (protein) phosphorus and potassium over NPK 20:10:10. The least amount of nutrient in plants was obtained in the control (no fertilizer treatment). The result showed same trend in the screen house. The micronutrient content of the vegetable was in the order of Geo-plus> NPK 20:10:10 > control (no fertilizer): for zinc in Geo-plus as 6.4 and 6.6 mg/kg, NPK 20:10:10: 5. 26 mg/kg and control 4.0 mg/kg; copper was in the order of NPK 20:10:10 0.18 mg/kg > geo-plus 0.09 and 0.10mg/kg > control 0.04mg/kg; manganese was in the order of Geo-plus 0.11 mg > NPK 20:10:10:0.07 mg/kg> control with 0.05 mg/kg; nickel was the order of NPK 20:10:10> Geo-plus > control while lead was in the order of NPK 20:10:10 > geo-plus > control.

Table 7: Nutrients Content of Amaranthus affected by Geo-plus fertilizer in the field

Treatment	Nutrient's content (g/kg)					
	N Field	N Screen house	P Field	P Screen house	K Field	K Screen house
Control	12.62	12.48	0.81	0.84	1 4.80	14.78
Geo-plus	28.58	28.67	2.20	2.18	17.42	17.51
Geo-plus 2	28.98	28.74	2.31	2.21	18.20	18.09
NPK 20. 10.10	17.89	17.91	1.34	1.35	16.05	16.10
LSD	**4.21**	**3.99**	**0.56**	**0.59**	**2.12**	**2.13**

Table 8: Micro Nutrient Content of Amaranthus as affected dry Geo-plus fertilizer in the field

Treatment	**Micro nutrients content (mg/kg)**					
	Fe	**Zn**	**Cu**	**Mn**	**N**	**Pb**
Control	0.08	4.0	0.04	0.05	0.01	0.05
Geo-plus	0.21	6.4	0.09	0.11	0.09	0.01
Geo-plus 2	0.25	6.6	0.01	0.11	0.03	0.02
NPK 20. 10.10	0.03	5.26	0.18	0.07	0.14	0.04
LSD	**0.08**	**1.12**	**0.07**	**NS**	**NS**	**NS**

Discussion

The low nutrient content of the pre- treatment soils used for this trial indicated the low inherent nutrients characteristics nature of tropical soils as stated by Chude *et al*. (2014). The increased plant height, stem girth, number of leaves per plant and the harvestable vegetable yield obtained from Geo-plus fertilizer, which was higher than the other treatments, particularly, NPK 20.10.10 (soil applied) corroborate the assertion of other researchers. Chude *et al*; (2004) in his findings reported that foliar nutrient application is particularly important for mobile element such as N which easily leaches out of the soil profile if not taken up immediately by plants. Fageria *et al*; (2002) noted that foliar sprays of inorganic fertilizers are more effective than soil treatments particularly where soil pH and other factors limit applied nutrient availability. The favourable growth and yield of the Amaranthus due to Geo-plus fertilizer application could also be attributed to the fortification of Geo-plus with essential micronutrient elements. It was also noted that foliar sprays are more economical as less of the fertilizer (one fifth to one tenth) is needed if the material is sprayed. The higher yield of amaranths in this study also corroborates the findings of Ogunlade *et al*., (2011); Olowoake and Lawal (2016) where organo-mineral fertilizer out yielded NPK 15:15:15. Similarly, Bello and Adekunle (2013) reported increased yield of maize from the application of organo mineral fertilizer over sole application of pig dung and poultry droppings.

The macro and micronutrients content of the plants as analysed were within and below the thresh hold limits of toxicity and at acceptable level in both field and screen house samples as stated by FAO/WHO (2011). This result indicated that Geo-plus fertilizer plants are safe for both human and livestock nutrition.

Furthermore, the post-harvest soil properties in both field and screen house showing lower soil nutrients levels in the control than the Geo-plus treatments which were the same with the initial soil properties indicated that foliar Geo-plus fertilizer nutrient met he nutrient needs of the Amaranthus plants. This adequacy of the Geo-plus fertilizer nutrient prevented the depletion of native soil fertility.

Conclusion

The growth and yield performance of Amaranthus in this trial showed the same trend in both field and screen house. This trend and the better performance of crops with Geo-plus over the control and NKP 20:10:10 statistically, and the visual better performance of Geo-plus over Green World proves the suitability of this fertilizer in crop production in this study area especially vegetables. Moreover, the non-depletion of the initial soil nutrients content is an indication that this

fertilizer could be used for sustainable crops production.

The nutrients content of vegetable as affected by Geo-plus were within and below the toxic thresh hold levels by FAO/WHO in both field and screen house, thereby guaranteeing the safety of crops produced with Geo-plus fertilizer.

Recommendation:

- Geo – plus fertilizer is suitable for crops (leafy vegetables) investigated in this trial at the rate of 1g/litre of water or 2.4 sachets (140g ha $^{-1}$)
- Geo-plus fertilizer should be applied to other long gestating crops at varying spray frequencies to obtain a valid recommendation for sustainable crops yield.

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