Journal of Agriculture, Environmental Resources and Management
ISSN2245-1800(paper) ISSN 2245-2943(online)
6(3)1-800; **March**.2024; pp1-11

www.saerem.com

Effects of Geoplus Foliar Fertilizer on Maize Yield, Nutrients Content and Soil Properties in Two Soil Types of Cross River State Nigeria.

Kekong, M. A.

University of Cross River State Calabar; Email: matikekong@gmail.com

ABSTRACT

Field research was conducted at the Teaching and Research Farm of the University of Cross River State, Obubra Campus (latitude 600N and longitude 8018'E) and the Agricultural Development Project (ADP) farm, Ikom (latitude 5057'N and longitude 80420E) during the 2021 cropping season to evaluate the efficacy of Geoplus foliar fertilizer on yield, nutrient content of maize, and soil properties. The design of the experiment was a randomized complete block (RCBD). The five treatments consisted of absolute control, Geoplus application at 4 WAP, Geoplus application at 3 and 6 WAP, Geoplus applications at 3, 6, and 8 WAP, and optimal control NPK 20:10:10, replicated three times. The results obtained indicated that the application of Geoplus (3 and 6 WAP), 3 applications (3, 6, 8 WAP), and NPK 20.10.10 produced significantly the highest plant dry matter and the least yield in the absolute control. Three applications (3, 6, and 8 WAP) of Geoplus produced the highest cob yield per unit area of 13.37 t/ha and 13.20 t/ha of fresh cobs, respectively, for Obubra and Ikom. The least yield was from the absolute control of 3.07 t ha-1 and 4.59 t ha-1, respectively, for Obubra and Ikom. Plant micronutrient contents of Fe, Zn, Cu, and Mn were increased in the order of Geoplus > 20:10:10> absolute control, which were all within the threshold safety limits. Soil properties were unaffected by the fertilizers except for the absolute control, whose levels were lower than those of the fertilized plots. Geoplus fertilizer, therefore, was found to be suitable for the optimal yield of safe consumable maize in Ikom and Obubra, Nigeria.

Key words: *Geoplus, absolute control, optimal control, maize yield, micro nutrients, soil properties.*

INTRODUCTION: Maize is one of the major staple food crops in Nigeria, grown in all agro-ecological zones. The crop provides a major source of calories for both humans and livestock in Nigeria and around the world. Idem and Showemimo (2004) noted that three-quarters of maize is transformed into meat, milk, eggs, and other animal products. Maize is also used as a raw material in the industrial manufacturing of starch-related items, lubricants, proteins, alcoholic drinks, biofuel, food candies, pharmaceuticals, make-up, films, fabrics, gums, packaging, and paper industries (Naveenumar, Sen and Khanna, 2018).

It is estimated that 1.5 million hectares of maize are cultivated in Nigeria, with a yield of about 12.75 million metric tons (Sasu, 2023). Nigeria is currently the tenth-largest producer of maize in the world and the largest producer of maize in Africa (IITA 2012). Maize (Zea mays L.) is one of the most important cereal crops in the world, and it has the highest global production of all cereals due to its high yield potential. It is one of the most important cereal crops in the world after rice with respect to cultivated area. (FAOSTAT 2014). The major constraints to crop production among tropical farmers are the excessive loss of soil nutrients and the pressure on land that limits natural restorative processes. The limitations to exploring the vast cultivable land in Nigeria are the sustainability of the soils. Agboola and Unamma (1991) noted that tropical soils are highly weathered, kaolinitic, and low in cation exchange capacity. Declining soil fertility has been identified as the major setback and cause of declining crop yields in many parts of Africa (Shah and Wu, 2019). Monkwunye and Batiano (2001) reported that tropical soils are generally low in organic matter, poorly buffered, and low in cation exchange capacity.

Hole et al. (2005) reported that each year, about 5–10 million hectares of crop land are taken out of production because of soil erosion, nutrient depletion, salinization, and water logging. Amanullah et al., (2009) reported that judicious use of proper fertilizer combination, to replenish the nutrient supply systems, is a key factor in the system aiming at intensification of crop production for sustainable agriculture.

The N requirement of maize is relatively high. This high requirement of N by maize coupled with the inherently low N status of soils, particularly, the savannah agro-ecological zone of Nigeria make N to be one of the most important constraints to maize production (Afolabi 2019). From an economic perspective, Lovatt (2013) noted that adding fertilizers to the soil is the most common practice of supplying plant nutrients; foliar fertilization was reported to be more cost-effective than soil-applied nutrients.

In another report, Dixon (2003) opined that since P can be very immobile in the soil, foliar applications can be up to 20 times more effective than soil applications. The challenge for Nigerian farmers today is access to appropriate fertilizer that will bring good returns while at the same time being compatible with our fragile, low-OM, and poorly buffered soils for continuous and sustainable production of maize. These inherent soil characteristics pose constraints on fertilizer use efficiency. The limitations and potentials of Nigerian soils can be overcome and explored through proper fertilizer management practices, such as appropriate fertilizer at an adequate rate, time, and method of application. It is on this premise that this research thrust was designed to evaluate the suitability of Geo-Plus foliar fertilizer in these locations with dissimilar soil characteristics in Cross River State, with the objectives of determining the effect of Geo-Plus fertilizer on the growth and growth attributes of maize, the yield and yield components of maize, the nutrient content of maize, and some postharvest soil properties in the study area.

METHODOLOGY: Location: The trial was carried out at the Teaching and Research Farm of the University of Cross River State, Obubra Campus, on latitudes 60 06’ N and 80 18’ E in the derived savanna belt of Nigeria, and at the Agricultural Development Project (ADP) Seed Multiplication Farm, Ikom, on latitudes 50 57’ N and 80 42’ E. Obubra and Ikom are characterized by a mean annual rainfall density of 2250 mm–2500 mm and an annual temperature range of 250 °C–320 °C.

Experimental Design and Treatments : The experiment was laid out in a randomized complete block design (RCBD) replicated three times. The treatments consisted of control and four other fertilizer treatments, viz., T1: Control (no fertilizer), T2: Geo Plus fertilizer applied once (3 WAP), T3: Geo Plus fertilizer applied twice (3 WAP and 6 WAP), T4: Geo-Plus fertilizer applied thrice (3, 6, and 9 WAP), and T5: NPK 20: 10: 10 (soil applied). Each experimental plot measured 5 m x 4 m and had a gross experimental plot of 18 m x 17 m (306 m2), or 0.03 ha, for the field experiment in each location.

Experimental Material and Agronomic Practices : The variety of maize was the common cultivar: Ikom Local White and Obubra Local White.

Cultural Practices. : After planting, manual weeding, insect pest control, and fertilizer application were carried out following the design of the experiment.

Data Collection: Soil sampling and processing. At the commencement of the experiment, a composite soil sample was collected at random points within the experiment plot, which was bulked using a soil auger at 0–25 cm. Post-crop soil samples were collected from each treatment and replicated at the end of the experiment. These samples were air dried and sieved through a 2 mm 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 component parameters, while a plant from each net plot was cut at 8 WAP for dry matter and leaf tissue analysis. The plants were sampled for height, number of leaves per plant, leaf area, number of seeds per cob, and weight of cobs per unit area.

Soil Analysis:**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. The second reading was taken three hours later. The particle size was then calculated using the following formulas:

Sand = 100- (H1 + 0.2 (T1 – 68)- 2.0)2.,

Clay = (H2 + 0.2 (T2 (T2-68) - 2.0)2

Silt= 100 – (% sand + % clay)

Where:

H1 = Hydrometer first reading at 40 seconds

T1 = temperature first reading at 40 seconds

H2 = Hydrometer second reading after 3 hours

T2 = Temperature second reading after 3 hours

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).

Organic Matter: This was determined by the walkley-Black method as outlined by Page et al., (1982) which involves the oxidation with dichromate and tetraoxosulphatevi acid (H2 SO4). The excess was titrated against Ferrous Sulphate. The organic carbon was then calculated using the relationship:

% org.C = N(Vi – V2) 0.3f

Where:

N = Normality of FerousSulphate solution

V1 = Ml Ferrous Ammonium Sulphate for the black

V2 = 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

Nitrogen in soil: Total nitrogen in soil was determined by the macro Kjeldahl method as described by Udo et al., (2009). The soil samples were digested with Tetraoxosulphate (Vi) acid ($H_2 SO_4$) after addition of excess caustic soda. This was distilled into a 2% Boni acid (H_3BO_4) and then titrated with 0.01 HCl. And the nitrogen was obtained from the relationship.

% N = T x Mx14 x100

N

Where:

T = Titre value

M = Molarity of Hcl

W = Weight of soil used

N = Normality of H_2SO_4

Available phosphorus: Available P was determined by the 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 minute for 10 minutes. Using the ascobic 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.

Cation Exchange capacity (CEC) and Exchangeable acidity (EA): This was determined by the Kjeldahl distillation and titration method as outlined by IITA (1979). Using an 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 the Kjeldahl operation to a 4% Boric acid solution. The distillate was then titrated with a standard solution of 0.1 N HCl.

Exchangeable cations: This was determined by the 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, shaken for 30 minutes, centrifuged, and the supernatant transferred into the same volumetric flask. An atomic absorption spectrophotometer (AAS) was used to read the cations.

Statistical Analysis: An analysis of variance (ANOVA) for RCBD was performed on the maize growth and yield parameters using the computer software Genstat (Genstat 2005). F-LSD was calculated on the means at $P > 0.05$ to separate the means.

Results and Discussion

Plant Height of Maize as Influenced by Geo-plus Fertilizer: The plant height of maize affected by Geoplus fertilizer is presented in Table 1. The result indicated that Geo-Plus fertilizer significantly increased the height of maize measured at 8 and 12 weeks after planting (WAP). In Obubra, application of Geo-Plus fertilizer twice, at 3 and 6 weeks after planting, produced the tallest plants. Although the plants were taller than the plants that received the fertilizer three times, there is no statistical difference. This was followed by plants applied with NPK 20.10.10, then plants that were applied with Geo-Plus only once (at 3 WAP), and the least plant height was obtained from the control where no fertilizer was applied. The plant height in Ikom location showed same trend in the growth of maize, (Table 1).

Table 1: Plant Height of Maize (cm) as influenced by Geo-Plus fertilizer

Treatment	*Obubra*		*Ikom*	
	8 WAP	12WAP	8WAP	12WAP
Control	83.1	148.4	78.7	154.2
Geo-plus 1	112.4	205.2	116.4	199.6
Geo-plus 2	130.9	239.7	141.2	241.5
Geo-plus 3	131.4	248.4	140.8	249.1
NPK 20.10.0	122.2	231.2	124.6	233.4
F.LSD	6.9	7.6	10.2	7.2

Number of leaves and leaf Area. Result of number of leaves produced per plant and Leaf area are presented in Table 2.The result showed that Geo-plus fertilizer applied on the maize plants twice at 3 and 6 weeks and plants that were applied with NPK 20.10.10 produced a higher number of leaves per plant than the plants that received Geo-plant fertilizer once and the plants that did not received any fertilizer (control) in both Obubra and Ikom experimental sites. The result of leaf area (Table 2) showed that plants that received Geo-plant fertilizer twice at 3 and 6 weeks after planting produced largest leaves (402.1cm2 and 401.8cm2) and (400.8cm2 and 401.2cm2) respectively for Obubra and Ikom. Maize plants grown with NPK 20.10.10 ranked second with leaf area of 388.5cm2 and 283.9cm2 respectively for Obubra and Ikom. The least (smallest) leaves were produced in the control plots where no fertilizer was applied.

Table 2: Number of leaves and leaf area of maize as influenced by Geo-plus fertilizer

Treatment	*Number of leaves 8WAP*		*Leaf Area (cm^2)*	
	Obubra	Ikom	Obubra	Ikom
No Fertilizer	11.0	11.2	148.5	150.0
Geo-plus 1	11.8	11.1	301.2	298.9
Geo-plus 2	13.2	13.4	402.1	400.8
Geo-plus 3	13.6	12.9	401.8	401.2
NPK 20.10.0	12.4	12.6	388.5	383.9
F.LSD	2.1	2.1	11.2	12.4

Yield and yield Components of Maize. : The result of cob yield and yield components of maize as influenced by Geo- plus fertilizer is presented in Table 3.The result indicated that plant dry matter was highest in plants that received two applications of Geo-Plus at 3 and 6 weeks after planting (7.99 and 8.09 g/plant) for Obubra and 8.06 and 8.01 g/plant for Ikom. This was followed by plants applied with NPK 20.10.10, then Geo Plus with one application, and the least plant dry matter was in the control (Table 3). The number of seeds per cob indicates that cobs from plants that received two and three applications of Geo-Plus fertilizer produced the highest number of seeds, although the number was higher in cobs that received three applications, but this was statistically the same. This number of seeds was followed by NPK 20.10.10, and the least number of seeds per cob were produced in the control plants.

The weight of each cob and the cobs yield per unit area (Table 3) showed that three applications of Geo Plus at 3, 6, and 9 weeks after planting produced the heaviest cobs (0.89 and 0.88 kg) per cob, respectively, for Obubra and Ikom, and the highest cob yield per unit area of 16.05 kg and 15.84 kg of cobs weight per plot of 12 m2, or 13.37 t/ha and 13.20 t/ha of fresh cobs, respectively, for Obubra and Ikom. This yield was followed by cobs and plots that received two applications of Geo Plus fertilizer at 3 and 6 weeks after planting (WAP).Then NPK 20.10.10 followed which was followed by one application of Geo plus and the least yield was obtained from the control were no fertilizer was applied.

Table 3: Yield and Yield Components of Maize as affected by Geo-plus fertilizer

Treatment	*Dry matter g/plant*	*No. of seeds/cob*	*Weight per Cob (Kg)*	*Fresh cob Yield kg/plot*	*Fresh cob Yield t/ha*
			Obubra		
No Fertilizer	6.01	221	0.32	6.08	5.07
Geo-plus 1	6.98	316	0.54	10.26	8.55
Geo-plus 2	6.98	358	0.76	14.44	12.03
Geo-plus 3	8.19	360	0.89	16.05	13.37
NPK 20.10.10	7.12	348	0.63	11.97	9.97
F.LSD	0.61	8.2	0.11	1.43	--
		Ikom			
No Fertilizer	5.98	230	0.29	5.51	4.59
Geo-plus 1	6.88	319	0.51	9.69	8.07
Geo-plus 2	7.96	351	0.79	14.32	11.93
Geo-plus 3	8.21	358	0.88	15.84	13.20
NPK 20.10.10	7.43	343	0.70	13.30	11.08
F.LSD	0.42	7.8	0.08	0.97	--

Plant tissue nutrient content : Result of the leaf nutrient content of maize influenced by Geo plus fertilizer is presented in Tables 4 and 5. The result showed that plants that received two applications of Geo plus fertilizer produced plants with highest content of Nitrogen and calcium in Obubra and highest content of nitrogen, calcium and potassium in Ikom. This was followed by plants that received soil applied NPK 20,10,10 and the least concentration of these nutrients was in the plant tissue in the control where fertilizer was not applied. The tissues content of phosphorus and magnesium was not different among the treatments. The micro nutrient content of maize leaf tissue (Table 5) indicated that Geo plus fertilizer significantly increased the Fe, Zn, Cu, Mn content of maize more than the NPK 20,10,10 soil applied fertilizer and the least concentration of these nutrients was in the control where no fertilizer was applied. The concentration of Nickel in the leaf tissue was not affected by the fertilizers as there was no difference statistically among the mean values.

Table 4: Tissue Nutrients Content of Maize as influenced by Geo-plus fertilizer (%)

Treatment	*Obubra*					*Ikom*				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg
No Fertilizer	2.01	0.35	0.69	0.86	0.11	2.12	0.35	0.65	0.85	0.12
Geo-plus 1	2.61	0.36	0.73	0.89	0.13	2.64	0.37	0.71	0.83	0.13
Geo-plus 2	3.21	0.37	0.72	0.92	0.13	3.22	0.36	0.73	0.91	0.14
Geo-plus 3	3.38	0.36	0.73	0.94	0.14	3.34	0.37	0.73	0.92	0.13
NPK 20.10.10	2.98	0.36	0.71	0.93	0.13	3.01	0.36	0.72	0.91	0.14
F.LSD	0.35	NS	NS	0.02	NS		NS			NS

Table 5 Micro Nutrient content of maize leaf as influenced by Geo plus fertilizers.

Treatment	***Micro nutrient (ug g^{-1})***					
	Fe	**Zn**	**Cu**	**Nn**	**Ni**	**Pb**
Obubra						

No fertilizer	26.0	3.9	2.3	7.9	0.09	0.00
Geo-plus 1	50.20	15.9	4.9	13.10	0.10	0.50
Ge- plus 2	67.30	16.6	7.6	14.1	0.18	0.61
Geo-plus 3	66.20	16.6	7.8	14.12	0.19	0.63
NPK 20,10,10	39.6	10.7	3.4	10.3	0.14	0.62
F-LSD	5.1	4.2	2.1	2.1	NS	0.14
Ikom						
No fertilizer	26.4	9.2	2.4	8,1	0.08	0.11
Geo-plus 1	58.6	15.1	5.8	13.3	0.10	0.52
Ge- plus 2	59.8	16.8	7.2	14.2	0.14	0.61
Geo-plus 3	69.9	16.7	7.1	14.3	0.13	0.64
NPK 20,10,10	39.4	10.2	3,4	10.6	0.16	0.60
F-LSD	9.8	4.9	2.2	2.5	NS	0.13

Pre-treatment and Postharvest Soil Properties :

The results of the pre-treatment composite sample and post-harvest soils at the experimental sites are presented in Tables 6 and 7. Texturally, the soils are classified as Sandy-loam and sandy clay-loam respectively for Obubra and Ikom with sand particle content of 83.00 % and 58.00 and Clay particle of 10.4 % and 26.00 %, respectively for Obubra and Ikom. The soil is moderately acidic with pH of (5.90) and 5.40 in H_2O for Obubra and Ikom respectively. The organic matter content and total Nitrogen and organic matter content were low with values of 0.11% and 0.12% and 1.32% and 1.43g/kg for 2021 and 2022 respectively. The available Phosphorus was low with value of 2.74mg/kg. The exchangeable cations (Ca, Mg, Na, and K) were equally low in status with values of 3.14 and 3.74 cmol/kg for Ca^{2+} and 1.49 and 1.36 cmol/kg for Mg^{2+}. The value obtained for Na^{+} was 0.59 and 0.49cmol/kg, which were moderate while that for K^{+} were 0.23 and 0.25cmol/kg, which were low. The CEC was 5.80 and 6.30 cmol/kg respectively, for 2021 and 2022. The soils of the experimental sites were sandy loam in texture with low OM, total N, and available P. The CEC was low, as were the 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 6: Pre-treatment soil properties

Particle Size Analysis		*Value*	
		Obubra	Ikom
Sand	*(%)*	83.98	58.00
Silt	*(%)*	5.62	16.00
Clay	*(%)*	10.40	26.00
Ph		5.90	5.40
EC	*ds/m*	0.051	0.026

Organic Matter	*(%)*	1.30	1.43
Total N	*(%)*	0.10	0.15
Avail P	*(mg/kg)*	2.49	3.40
Exchangeable Bases:			
Calcium	*(Cmol/kg)*	8.0	6.20
Magnesium	*(Cmol/kg)*	2.72	1.96
Sodium	*(Cmol/kg)*	0.08	0.06
Potassium	*(Cmol/kg)*	0.21	0.18
Exchange Acidity	*(Cmol/kg)*	2.6	1.67
Effective cation exchange capacity	*(Cmol/kg)*	13.61	10.36
B. Saturation	*(%)*	80.89	82.00

Table 7 Post harvest soil chemical properties as affected by Geo-plus fertilizer

Treatment	*pH*	*OM%*	*Total N%*	*Av. P mg/kg*	*Exch.K*	*Exch. Ca*	*Exch. Mg*
		OBUBRA					
No. Fertilizer	5.62	2.61	0.10	2.10	0.09	6.4	1.2
Geo-plus 1	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
Geo-plus 3	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
		IKOM					
No. Fertilizer	5.25	2.91	0.07	2.10	0.09	6.4	1.6
Geo-plus 1	5.42	3.20	0.10	3.44	0.20	7.5	2.0
Geo-plus 2	5.45	3.58	0.11	3.46	0.21	7.8	2.1
Geo-plus 3	5.49	3.39	0.10	3.43	0.22	8.4	2.2
NPK 20.10.10	5.30	3.14	0.12	3.38	0.25	8.3	2.1
LSD	NS	NS	NS	NS	NS	NS	NS

DISCUSSION : Geo Plus fertilizer application significantly influenced the growth, yield, and nutrient content of maize. The plants that received second and third applications gave better results than the other treatments, including NPK 20.10.10. The production of the tallest plants, the highest number of leaves, the largest leaf area, the highest plant dry matter, the highest number of seeds per cob, and the highest yield of maize per unit area by Geo Plus with three applications makes this fertilizer a better source of plant nutrients than the conventional NPK 20.10.10 fertilizer. This result could be attributed to the foliar nature and the high solubility of the nutrients in Geo Plus. The result corroborates the assertion of Chude (2004), who reported that foliar nutrient application is particularly important for mobile elements such as nitrogen, which leaches out of the profile if not taken up immediately by plants. Fageria et al. (2002) also noted that foliar sprays of inorganic fertilizers are more effective than soil treatments, particularly where soil pH and other growth factors limit the availability of applied nutrients.

The growth and yield increases of maize due to Geo-Plus fertilizers could also be attributed to the higher nitrogen content (24%) in Geo-Plus in addition to the fortification of this fertilizer with micronutrients. Abd EL-Fattah et al. (2012) reported a similar result with the use of foliar NPK fertilizer to increase maize grain yield over the soil application method. Aziiba et al. (2019) noted that N is one of the most important constraints to maize production. According to Ivanov et al. (2019), the application of foliar fertilizer containing Zn showed positive effects on maize yield and quality. The implication of micronutrients in the good growth and yield of maize by Geo Plus fertilizer agrees with the report and opinion of Welch and Shuman (1995), who reported that interest in micronutrients has escalated within the last decade because of their roles in plant diseases and root stress resistance. Similarly, Manasa and Devaranavadagi (2015) observed higher zinc, iron, and boron content in maize leaves in foliar applications of micronutrients compared to soil applications.

The increased plant tissue nitrogen, calcium, potassium; iron, zinc and copper nutrients by Geo plus fertilizer over NPK 20.10.10 and the Control treatment is in agreement with the reports of Niu, Liu, Huang,Liu and Yan (2020) who noted that foliar fertilizers have higher fertilizer efficiency over soil applied fertilizers. Amoah and Tetteh (2022), also reported that the main benefit of foliar fertilizer is that it can have up to 90 % efficiency rate as opposed to 10 % efficiency rate from soil applied. The fortification of the Geo plus fertilizer with micro nutrients could have increased the micro nutients content in the maize tissues, thereby making the crop more nutritious. Furthermore, the macro and micro nutrients content of the maize leaf tissue were within and below the critical limit of toxicity and at acceptable levels set by FAO/WHO (2011). This plant tissue nutrient concentration makes maize grains produced from Geo-Plus fertilizer safe for human and livestock food and feed. They also show that the straw and residues from these maize plants are suitable for grazing livestock and for their roughages.

The low nutrients 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); Ojeniyi (2002). The non depletion of soil nutrients in the Geoplus foliar applied fertilizer plots indicates building of soil nutrients reserves with foliar fertilizers. This attribute of Geoplus fertilizer tend to address the deleterious effects of soil applied inorganic fertilizers. This is so because Isherwood, (2008) had noted that fertilizer use in tropical soils has been a major challenge when sustainable crop production is envisaged because inorganic mineral fertilizers have been implicated in soil acidification, decrease in base saturation and deterioration and degradation of soil physical properties.

Conclusion : Geo Plus foliar fertilizer was found to be more efficient than the conventional NPK 20 10.10 for the growth and yield of maize in the derived savannah and rainforest soils of Obubra and Ikom. The readily available macro- and micronutrients in Geo Plus fertilizer that manifested in the growth, yield, and tissue nutrient content of the maize and the non-depletion of initial soil nutrient stocks in the study area prove the suitability of Geo Plus for sustainable staple food crops like maize, production in Nigeria, and other fragile tropical low-fertility soils. The fortification of the fertilizer with micronutrients makes it an ideal and unique multi-nutrient fertilizer most suitable for our soils, which are generally deficient in essential elements for crops. For optimum yield of maize in Nigerian savannah and rain forest zones, therefore, Geo Plus fertilizer at the rate of 2 ml/liter of water at intervals of 3, 6, and 9 weeks after planting can guarantee optimum and sustainable yield of maize.

REFERENCES

Abd El-Fattah AA, Selim EM, Awad EM (2012). Response of corn plants (Zea mays) to soil and foliar applications of mineral fertilizers under clay soil conditions. Journal of Applied Science Research 8(8):4711-4719.

Afolabi, G. S. (2019) Response of Maize (*Zea Mays* L.) to Rates ||of Nitrogen and Zincapplication in Minna, Southern Guinea Savanna of Nigeria. Journal of Agricultural Sciences Vol. 64, No. 2, 2019 121 – 131

Amoa, A. A. and Tetteh, C. K. U (2022). Effect of Soil-Applied and Foliar Fertilizer on Rice (Oryza sativa). Africa Journal of Agricultural Research 18 (8) 657 – 663.

Amanullah1, Khair M. K., Azam K., Imran K., Zahir S. and Zahid H. (2014) Growth and yield response of maize (Zea mays L.) to foliar NPK-fertilizers under moisture stress condition. Soil and Environment 33(2): 116-123

Aziiba, E. A., Qiang, C. and Coulter J.A. (2019) Mechanisms of Nitrogen Use in Maize : *Agronomy* 2019, *9*(12),775

Chude, V.O, Malgwi, W.B., Amapu, I.Y. and Ano, A.O. (2004) Manual on Contaminants. Joint FAO/WHO Food Standards programme.

Chude, V.O, Malgwi, W.B., Amapu, I.Y. and Ano, A.O. (2014) Manual on Soil fertility Assessment FFP in collaboration with National Special Food programme for Food Security – NSPFFS, Abuja, Nigeria.

Dixon, R.C. 2003. Foliar fertilization improves nutrient use efficiency. Fertilizer Technology 40: 22-23.

Fageria, N.K; Baligar, V.C. and Clark R.B. (2002) Micronutrients – crop production. Advances in Agronomy 77:185-268

FAO/WHO, (2011) Codex Alimentarius commission. Food additives and contaminants. Joint FAO/WHO Food Standards programme, ALINORM 01/12A, 1 -289

FAOSTAT (2014). Food and Agriculture Organisation Statistics Database. http://faostat3.fao.org/faostat-gateway/go/to/home/E

Genstat (2005). Genstat Release 4.24DE (PC/Windows XP) Copy right 2005, Laves Agricultural Trust (Rothamstal) Experimental Station) Discuring edt. 2

Hole, D. G., A. J. Perkins, J. D. Wilson, I. H Alexander, P. V. Griece and A. D. Evans (2005). Can Organic farming benefit biodiversity? Biological Conservation 122: 113.

IITA (1979). Selected methods for soil and plant analysis. International Institutes for Tropical Agriculture, Ibadan Nigeria. Manual series No. 1.

Ivanov, K.; Tonev, T.; Nguyen, N.; Peltekov, A.; Mitkov, A. (2019). Impact of foliar fertilization with nanosized zinc hydroxy nitrate on maize yield and quality. *Emir. J. Food Agric.* 597–604 Lovatt CJ (2013). Properly timing foliar-applied fertilizer increases efficacy: A review and update on timing foliar nutrient applications to citrus and avocado. Horticulture Technology 23(5):536-541.

Manasa,L.P and Devaranavadagi, S. B. (2015) Effect of foliar application of micronutrients on growth, yield and nutrient uptake of maize. Karnataka Journal of Agricultural Sciences, Vol. 28, No. 4, 474-476

McClean, E. O. (1982), Soil pH and Lime requirement. In: Page D. C. (eds) Methods of Soils Analysis part 2. Chemical and soil microbial properties. Agronomy series No. 9 ASA, SSSA, Madison

Mokuwunte, U. and Bations A, (2010, Mating the Phosphorus needs of the soils and crops of West Africa the role of indigenous phosphates rocks integrated plants nutrients management in sub-saharan Africa from concept to practice Ed. CAB international M 209-224.

Naveenumar K.L, Sen D, Khanna V.K (2018). Effect of Maize Production in a Changing Climate: Its Impacts, Adaptation, and Mitigation Strategies through Breeding. Open Access Journal of Oncology and Medicine 2(4):2018.

Niu, J., Liu, C., Huang, M., Liu, K., Yan, D. (2020). Effect of Foliar Fertilization: a Review of

Current Status and Future Perspectives. Journal of Soil Science and Plant Nutrition 21 (1): 1 – 15.

Ojeniyi, S. O. (2002) Soil Management, Natural Resources and Environment. Adeniran Press Ibadan pp 30.

Page, A. L., R. H. Miller, and D. R. Keeney (1982). Methods of soil Analysis part 2. Chemical and microbiological properties. American Society of Agronomy, Madison 55 pp.

Sasu, D.D (2023) Production of Maize in Nigeria. https://www.statista.com/statistics/1300743/production-volume-of-maize-in-nigeria

Shah, F. and Wu, W. (2019). Soil and Crop Management Strategies to ensure higher crop productivity within sustainable environments. Sustainability 11(1485) 1 – 9.

Udo, E. J., T. O. Ibia, J. O. Ogunwale, A. O. Ano and I. Esu (2009), Manual of Soil, Plant and Water Analysis, 183pp., Sibon Books Ltd. Lagos.

Welch, R.M. and Shuman, L.(1995) Micronutrients Nutrition of Plants. Critical Reviews in Plant Sciences. 14:1,49 – 82.