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Influence of Mineral Fertilizer on the Growth of Maize (*Zea mays* L.) and Soil Fertility Improvement for Food Security, Environmental Development and Sustainable Agriculture

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ABSTRACT

Influence of mineral fertilizer on the growth of maize (*Zea mays* L.) and soil fertility improvement for food security, environmental development and sustainable agriculture were studied. Five treatments viz: 0, 5, 10, 15, and 20 kg of NPK (15:15:15) mineral fertilizer per hectare (kg ha^{-1}) were used in a Randomized Complete Block Design (RCBD) with three replicates. These treatments were applied once to five week-old seedlings of *Zea mays* (L.) using ring method. The effects of these treatments on plant height (PH) and number of leaves (NOL) were monitored weekly. Soil samples were taken and analyzed in the laboratory, before and after cropping. The study showed that NPK (15:15:15) mineral fertilizer increased plant height, number of leaves and nutrient (N, P,K, Ca, Na, Mg, Organic matter, Cation Exchange Capacity and pH) content of the soil. The highest ($p = 0.05$) plant height and number of leaves were obtained from NPK treatment at 20 kg ha^{-1} which stands significantly ($p < 0.05$) different over the control. At $p < 0.05$, there were significant difference among treatments. The use of NPK mineral fertilizer at an application rate between 15 and 20 kg NPK (15:15:15) ha^{-1} seems effective, responsive and productive for maximum growth of maize (*Zea mays* L.), for soil fertility improvement, food security, environmental development and for sustainable agricultural production.

***Keywords*:** Soil fertility; Food security; Environmental development, Maize growth; NPK mineral fertilizer

1. INTRODUCTION

Soil is the part of the outer mantle of the earth which forms from mixture of minerals, decaying organic matter, water, air including billions of micro and macro organisms. Soil is the primary source of life on earth, providing anchorage for plant root, emitting/absorbing gases/dust, absorbs; hold; and purify water, in addition to providing nutrients which nourish crops. As important as the soil is, its mismanagement/deterioration is on the increase, especially in the humid tropics where soil-nutrient deterioration is on the increase. Tropical soils has been identified by White (1987) to be kaolinitic, resulting in it poor nutrient status, stressing the point that parent material plays a key role in nutrient status/productivity of a particular soil (FFD/NSPFS, 2011), which is one of the propelling reasons for low-nutrient nature of tropical soils, and for these soils to be used effectively for sustainable crop production, then the need for mineral fertilizer arises.

Aeration, water/nutrient holding capacity, adequate soil depth and proper temperature has been identified as factors to be considered for effective crop production in the tropics (FFD/NSPFS, 2011). Toxic levels of certain elements, nutrient deficiency, adverse temperature and poor physical characteristics of soil have been stressed as unfavorable growth factors for crop production.

Man has always explore crops for his benefit, achieving development, nutrition, economic, research, exchange, medical including herbal value from crops. Wheat, Rice and Maize has been widely explored by Mankind, owing to the high value of these crops. Maize exploration has been huge. From Central American tropics and Mexico where the crop (maize) originated (Brewbaker, 2003) to all parts of the earth. It uses/utilization and economic importance increases as science further widens knowledge on the crop. Maize is of the grass family *Poaceae*, with it botanical name name as *Zea mays* (L.). The crop is also known as corn. It uses ranges from medical (Dilip and Aditya, 2013), pharmaceutical (Dilip and Aditya, 2013), herbal (Abdulrahama, 1997). 80% carbohydrate (CHO), 10% protein, 3.5% fiber, 2% mineral have been reported to be among the nutritional benefit derived from maize consumption (IITA, 2001). Industrial uses of maize include; wet-milling, production of biofuel, including ethanol production (Watson, 1988).

Corn is cultivated to a large area of land in the United States of America, producing 177.3 million tons of world corn and yield of 3.6tons per acre, placing USA as the largest corn producer in the world (Brewbaker, 2003; Purseglove, 1992). China as at 2003 recorded her production at 81.8 million tons, with yield of 1.9 tons/acre, presenting China as the 2nd largest world maize producer, Brazil accounts for 21.8 million tons, and yield of 0.8 tons/acre. Mexico produces at 11.8million tons and 0.8 tons/acre of yield (Brewbaker, 2003). France, Russia, South Africa, India have also been identified as leading producers of world maize. Nigeria records a value of world maize production at 1.8 million tons, and yield of 0.6 tons/acre. IITA (2014) report indicates 8 million tons of maize production in Nigeria. Annual production of maize in Nigeria accounts to a value of 5.6 million tons (CBN, 1992). Hartmans (1985) findings revealed that maize is cultivated to 1 million hectares in Nigeria, out of the 9 million hectares cultivated in Africa, presenting Nigeria as the largest African producer of maize. Apart from food (nutrition), maize production has raised standard of living of local farmers, provide income/development and reduce poverty rate in Nigeria. The crop has grown to be a commercial crop (Iken and Amusa, 2004) servicing; agro-base, medical, pharmaceutical, herbal and related industries in Nigeria. Fajemisin (1978) finding presents maize has having dual role of feeding the fast growing human population and supporting buoyant Agricultural industrialization. Maize uses in Nigeria varies in a multitude of ways, the crop is use as food, prepared into pap tuwo, and other Nigerian traditional maize meal. The grains are used as one of the major feedstuff in livestock feed formulation (Kassam 1977). IITA (2001) reported maize grain, leaves, stalk, tassel and cob been used for production of a variety of food and noon-food products in Nigeria.

Nigerian soils has been described by various researchers to be light textured and low in Cation Exchange Capacity (CEC), with low clay minerals, low pH, and also low in Calcium (Ca), Magnesium (Mg), Potassium (K), Organic Matter (OM) and other important plant nutrients, with sandstones having the lowest fertility rate, with OM content varied from 1 – 2.55%, this view was also confirmed by Ojuola (2015). Findings of Nigerian Country Profile NCP (1997) revealed Nigerian soil having potentials of low, medium to high productivity. Problems of topical soils include: low organic matter, high soil acidity level including low activity clay (Agboola and Omueti, 1982).

Environmental challenges facing soil management in Nigeria include, erosion which is severe in Anambra and Enugu States of Nigeria, with cases of over 50 gullies (NCP, 1997). Soil salinity, which reduces crop productivity/performance; flooding, which wash farmland resulting in low produce/product turnout and reduction in Agricultural activities. A severe case was reported by Punch Editorial Board (2012), where they stated over 20 States out of 36 States of Nigeria been wash, with Nasarawa State been the most hit, where over 2,000 hectares of farmland been lost and keep out of production. Desert encroachment and drought is one of the problems facing Nigerian soils and its productivity. Etuonovbe (2009) report indicated oil pollution problem, like spills and well blow-out as been adversely affecting environmental sustainability, soil and aquatic productivity in Niger Delta areas of Nigeria. Land misuse/mismanagement by farmers who lack or misuse extension information also generates soil fertility problems in the country. Inadequate Extension services and more severely inadequate soil guide information and classification has jointly resulted to rapid deterioration of tropical soils of Nigeria.

Nitrogen (N) is a vital plant nutrient and a major yield determining factor for a nutrient indicator-crop like maize (Adediran and Banjoko, 1995). N functions as a constituent of chlorophyll, protoplasm, protein and nucleic acids. The importance of Phosphorus (P) as an essential nutrient element and yield limiting factor has been reported by (Adepetu and Corey, 1976). P is necessary for cell division, a constituent of chromosomes, P also aids in stimulation of roots development. Potassium (K) is also essential for plant (maize) growth. K enhance the plants ability to resist diseases, increase size of grains or seeds and improves the quality of fruits and vegetable, K is an activator of enzymes involved in photosynthesis, protein and carbohydrate (CHO) metabolism.

Over the years, fertilizer trials on various lands have always been effective with increase in crop production and yield quality. Onasanya *et al* (2009) experiment further confirmed increased maize growth/yield after application of mineral (N, P) fertilizer. Okonwu and Mensah (2012); Adiaha (2016); Adiaha and Agba (2016) experiments also confirms increase in crop growth with application of NPK (15:15:15) mineral fertilizer. Increase in soil fertility status has been stressed over the years with the use of mineral fertilizer, a report by Adiaha (2016); Okonwu and Mensah (2012) and Abd El-Aziz recorded increased in soil properties after application of mineral fertilizer.

Against the increase tropical soil-nutrients deterioration, global food storages/insecurity, with rapid environmental pollution/degradation provides the bed-rock for conducting this research findings with the following objectives:

1. To determine the influence of mineral fertilizer on maize (*Zea mays* L.) growth for increase production and food security in the study area and its environs
2. To determine the effect of mineral fertilizer on soil fertility improvement for environmental development and sustainable agriculture

2. MATERIALS AND METHODS

2. 1. Experimental Site (The Study Area)

The experiment was conducted at the Teaching and Research Farm, Faculty of Agriculture and Forestry, Cross River University of Technology (CRUTECH), Obubra campus, Nigeria. The study area lies between Latitude 6° 06' North and Longitude 8° 18' East in the rainforest zone of Nigeria. Obubra has an annual mean rainfall of 2250 – 2500 mm per annum (CRADP, 1992), with a temperature of 25 °C to 27 °C. The area is described as Derived Savanna, with anthropogenic activities including farming, lumbering and deforestation which adversely deplete vegetation, causing soil erosion, land degradation and fertilizer spilt, thereby polluting/degrading the environment. Subsistence farming at a peasant level is the major socio-economic activities of the people. Fishing and hunting has been on the increase in the recent years, since soil productivity/associated land acquisition problems is on the increase. The people of the area practice fallowing system, mainly to restore the soil fertility, application of fertilizer is also been practice, but only to a minimal level. The experiment was conducted between March and August 2014 and repeated in 2015.

2. 2. Source of Material

Maize seed (Ikom Local White), a widely grown maize cultivar in the area were obtained from Agricultural Extension office, Ikom, Cross River State (CRS), Nigeria. Seed dressing chemical (Apron plus was obtained from Crop Protection unit of the Department of Agronomy, Faculty of Agriculture and Forestry, CRUTECH. Mineral fertilizer (NPK 15:15:15) was also obtained from Agricultural Extension office, Ikom, CRS.

2. 3. Soil Sampling and Processing

Soil samples were collected from Teaching and Research Farm, Faculty of Agriculture and Forestry, CRUTECH, Obubra. The samples were taken at different point within the experimental farm. Composite soil samples were randomly collected for pre-planting soil analysis using soil auger at (0-30 cm) depth. The samples were transferred to the laboratory for analysis. The samples were air-dried at room temperature (22-23 °C). The sample was ground into fine particle with the aid of a laboratory mortar and pestle, the particle was sieved using 2 mm sieve.

2. 4. Soil Analysis

All soil samples collected were subjected to standard laboratory analysis.

2. 5. Laboratory Analysis

Soil Physical Properties:

- Particle size distribution:

The particle size distribution was determined by hydrometer method as described by Gee and Bauder (1986).

Soil Chemical Properties:

- Soil pH: Soil pH was determined in water 1:2 soil: water ratio using pH meter with glass electrode (Thomas, 1996).
- Organic Carbon (OC): Organic Carbon was determined by the dichromate wet-oxidation method as described by Nelson and Sommers (1996).
- Organic Matter (OM): The value of organic carbon (OC) was multiplied by 1.732 to obtained Organic Matter content.
- Total Nitrogen (TN): Total Nitrogen was determined by the micro-kjeldahl digestion and distillation method as described by Bremmer (1996).
- Exchangeable Cations (EC): The bases were extracted with neutral NH_4OA_c. Calcium and Magnesium were determined in the extract by EDTA titration, Potassium and Sodium by the use for flame photometer (Udo *et al.*, 2009).
- Available Phosphorus: Available Phosphorus was determined by the Bray-1 method as described by method described by Kuo (1996)
- Cation Exchange Capacity (CEC): Cation Exchange Capacity was determined by method described by Summer and Miller (1996).

2. 6. Land Preparation

A land dominated by grasses was used for the study. The land was cleared, packed and tilled manually into bed experimental plots. Soil samples were taken. The experimental plot was plotted out (mapped) into 15 treatment plots, with each plot measurement of 2m x 2m with furrow of 1m.

2. 7. Treatment

The treatments used in the experiment were:

Treatment one (T_1) 5 kg ha^{-1} NPK (15:15:15) Mineral fertilizer
Treatment two (T_2) 10 kg ha^{-1} NPK (15:15:15) Mineral fertilizer
Treatment three (T_3) 15 kg ha^{-1} NPK (15:15:15) Mineral fertilizer
Treatment four (T_4) 20 kg ha^{-1} NPK (15:15:15) Mineral fertilizer
Treatment five (T_5) Control

Five (5) treatments were used and replicated three (3) times. The experiment was a Randomized Complete Block Design (RCBD).

2. 8. Planting and Cultural Practices

Maize (*Zea mays* L. variety Ikom Local White), an early maturing maize cultivar seeds were subjected to germination test. Healthy and clean seed were collected and treated with Apron plus, a widely used seed dressing chemical in the area, this was done to get a disease/insect free seeds and to control soil borne pathogens before sowing.

- Date of Sowing: The seeds were sown on 6th March, 2014.
- Seed rate: Three (3) seeds were sown per hole.
- Planting Distance: Maize seed were planted at 1m x1m , this planting distance had also been investigated by Adiaha and Agba (2016) to be effective for maize growth and high productivity.
- Pest Control: An insecticide- Sniper (Vinyl dimethyl phosphate DDVP, 1000EC) was sprayed to keep the growing plant free of pest especially stem borer attack.
- Thinning Operation: Maize seedlings were later thinned to one plant per stand after 14 days of planting (AF 14 DOP).
- Weed Control: Weeds were control manually with the aid of a weeding hoe, this was done first at three (3) weeks after planting (3WAP) and repeated at every 2 weeks interval (2WI).

Fertilizer Application

Mineral fertilizer (NPK 15:15:15) was applied five (5) weeks after planting (5WAP). 5 kg ha^{-1} of NPK (15:15:15) fertilizer was applied by ring application method in treatment one (T_1). 10 kg ha^{-1}, 15 kg ha^{-1} and 20 kg ha^{-1} NPK (15:15:15) mineral fertilizer was also applied by ring method to treatments two, three and treatment four respectively.

Ring method of fertilizer application was achieved by creating (opening) a ring of 10cm radius and 5cm depth round each stand of maize plant, fertilizer was then applied and the ring was then covered with soil.

2. 9. Data Collection

Data was collected on the following growth parameters; plant height and number of leaves across all the tag plants in all the replicates.

Plant height were measured first at 5 Weeks after planting (WAP) (Week of fertilizer application (WOFA)). Subsequent measurements of plant height were taken at one Week interval (WI) in all the plots. Number of leaves were counted and recorded for each treatment throughout all the replications. This was done at 5WAP (WOFA) and at 1Week Interval (1WI).

Statistical Analysis

All the data collected were analyzed using the procedure for Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD).Significant means among treatments were separated using Fishers Least Significant Difference (f-LSD) at 0.05% probability level.

3. RESULTS AND DISCUSSIONS

3. 1. Nutrient Composition of soil

Result of the Physico-chemical properties of the experimental site soil used for growing the crop before NPK (15:15:15) fertilizer application is presented in Table 1. Texturally, the soil was sandy-loam, with sand particle content of 833 g/kg, clay and silt content of (82 g/kg and 70 g/kg). The soil was acidic with pH of (5.93) in H_2O and 5.11 in KCl. The organic matter content and total Nitrogen were low with values 1.87 g/kg and 0.072 g/kg. the available phosphorus was low with value of 3.60 Mg/kg. The exchangeable Cations (Ca, Mg, Na and K) were equally low in status with values of 3.45 cmol/kg for Ca^{2+} and 1.50 cmol/kg for Mg^{2+}. The value obtained for Na^{+} was 0.58 cmol/kg, which was also low. The CEC was 6.30 cmol/kg.

The low N, P, Organic Matter (OM), pH and other nutrients are characteristics of tropical soils as described by Ojeniyi (2010).

The low values of soil nutrients status observed in the laboratory soil analysis indicates the need for soil fertility improvement in the area for increase crop production, and good soil performance. FAO (2006) findings also points to this situation, stating; that where soil nutrients is below its critical stage, then improvement of its fertility is crucial. Hence, the need for mineral fertilizer application arises for improve crop performance, increase soil fertility status and further protection of the degraded soil/land.

Fertilizer rate and selected application method used in the study are presented in Table 2. NPK (15:15:15) mineral fertilizer supplies three essential nutrients to plant; Nitrogen (N), Phosphorus (P) and Potassium (K) which increases crop growth and soil-nutrient status. Hence application of mineral fertilizer will help to produce the expected crop growth/yield in addition to increasing the fertility status of soil thereby enhancing environmental development for sustainable agriculture.

Table1. Physico-chemical Properties of Experimental site soil before cropping/NPK (15:15:15) fertilizer application
2014 Experiment

Soil Property Analyzed	Unit	Value Obtained
Sand	(g/kg)	833
Silt	(g/kg)	70
Clay	(g/kg)	82
Textural Class	SL	Sandy-loam
pH (H_2O)		5.93
pH (KCl)		5.11
Organic matter	(g/kg)	1.87
Total N	(g/kg)	0.072

Available P	(mg/kg)	3.60
Exchangeable K	(cmol/kg)	0.23
Exchangeable Mg	(cmol/kg)	1.50
Exchangeable Ca	(cmol/kg)	3.45
Exchangeable Na	(cmol/kg)	0.58
CEC	(cmol/kg)	6.30

SL: Sandy-loam

Table 2. Details of treatments, fertilizer application method and fertilizer rate.

Treatment S/N	Treatment	Treatment Code	Fertilizer Application Method	Fertilizer Rate (kg ha^{-1})
T_1	5 kg ha^{-1} Mineral Fertilizer	5 $kgha^{-1}$ MF	Ring Application method	5 kg ha^{-1} NPK (15:15:15) fertilizer
T_2	10 kg ha^{-1} Mineral Fertilizer	10 $kgha^{-1}$ MF	Ring Application method	10 kg ha^{-1} NPK (15:15:15) fertilizer
T_3	15 kg ha^{-1} Mineral Fertilizer	15 $kgha^{-1}$ MF	Ring Application method	15 kg ha^{-1} NPK (15:15:15) fertilizer
T_4	20 kg ha^{-1} Mineral Fertilizer	20 $kgha^{-1}$ MF	Ring Application method	20 kg ha^{-1} NPK (15:15:15) fertilizer
T_5	Control	Control	No Application	No fertilizer

T_1, T_2, T_3, T_4, T_5: Different treatment used. MF: Mineral Fertilizer

The experiment was repeated in 2015: Maize seeds were sown, growth parameters taken and statistically analyzed, soil sampling was done, samples collected was transferred to the laboratory, processed and subjected to standard laboratory analysis, repeating the procedure used in 2014 for soil analysis. Result obtained is presented in Table 3.

Table 3. Physico-chemical Properties of Experimental site soil before cropping/NPK (15:15:15) fertilizer application
2015 Experiment

Soil Property Analyzed	Unit	Value Obtained
Sand	(g/kg)	830
Silt	(g/kg)	69
Clay	(g/kg)	80
Textural Class	SL	Sandy-loam
pH (H_2O)		5.91
pH (KCl)		5.07
Organic matter	(g/kg)	1.83
Total N	(g/kg)	0.071
Available P	(mg/kg)	3.56
Exchangeable K	(cmol/kg)	0.21
Exchangeable Mg	(cmol/kg)	1.48
Exchangeable Ca	(cmol/kg)	3.42
Exchangeable Na	(cmol/kg)	0.55
CEC	(cmol/kg)	6.27

SL: Sandy-loam

The Physico-chemical analysis of the experimental site soil as presented in Table 3, showed that texturally, the soil was a sandy-loam soil, dominated by sand fraction of (830g/kg). The soil was acidic with pH value of (5.91 in H_2O and 5.07 in KCl). Low values was observed for exchangeable cations of (Ca, Mg, Na, and K), presenting the soil to be inadequate in its cations supply. The organic matter content was low (1.83g/kg). The total Nitrogen and available Phosphorus (P) was also low with values of (0.071cmol/kg and 3.56cmol/kg). The CEC of the soil was 6.27cmol/kg, indicating the low fertility status of the soil.

Result obtained in 2015 soil analysis before cropping/mineral fertilizer showed a slide decrease in the soil nutrient status compared to 2014 analysis and therefore confirms the findings of Chude (1998) whose report indicates that tropical soil are low in N, P, Organic Matter (OM), pH, including the problem of rapid deterioration of soil nutrients especially in the humid tropics were this experiment was conducted.

3. 2. Plant Height

Effect of treatments on the plant height is presented in Table 4. Results showed that the treatments significantly ($p < 0.05$) increased the plant height over the control.

Table 4. Influence of Mineral Fertilizer on Maize (*Zea mays* L.) Height (cm) 2014 Experiment

Treatment S/N	Treatment	Weeks after planting (WAP) 5WAP	6WAP	7WAP	8WAP
Treatment 1 (T_1)	5 kgha^{-1} NPK (15:15:15) mineral fertilizer	57.84	88.04	132.86	165.22
Treatment 2 (T_2)	10 kgha^{-1} NPK (15:15:15) mineral fertilizer	59.99	90.00	135.44	168.22
Treatment 3 (T_3)	15 kgha^{-1} NPK (15:15:15) mineral fertilizer	62.90	93.61	138.00	171.19
Treatment 4 (T_4)	20 kgha^{-1} NPK (15:15:15) mineral fertilizer	64.99	94.70	139.50	172.22
Treatment 5 (T_5)	Control	49.89	79.60	124.50	157.23
LSD (P<0.05)		4.24	5.16	7.62	6.73

T_1, T_2, T_3, T_4, T_5: Different treatments used
Mean with the least value produced minimum plant height
All means were separated using (f-LSD) Fisher Least Significant Difference at 0.05%

Result obtained from ANOVA analysis of plant height at five (5) Weed after Planting WAP (Week of Fertilizer Application WOA), showed that plant height increased across all the treatments, with 20 kg ha^{-1} of NPK (15:15:15) fertilizer (Treatment four (T_4)) producing the tallest ($p = 0.05$) plants (64.99cm). treatment three (15 kg ha^{-1} NPK 15:15:15) significantly ($P<0.05$) increased the height of maize plant over the control, indicating the potential of the treatment when compared to 10 kg ha^{-1} and 5 kg ha^{-1} of mineral fertilizer application, recording a height at (62.9cm) over the control. Application of mineral fertilizer (NPK 15:15:15) at 10 kg ha^{-1} recorded a mean plant height to the tune of (59.99cm), presenting the treatment to be significant ($P<0.05$) over the control, and further indicating that for good growth to occur in the infertile tropical soils, mineral fertilizer should be applied when cultivating maize crop. 57.84cm was recorded as the mean value in treatment one (T_1), which stands over the control, also proofing the effectiveness of mineral fertilizer in accelerating the height of the plant. The least plant height was recorded in the control with a mean height of 49.87cm.

At 6 Weeks after planting (6WAP), all treatments significantly ($P<0.05$) increased the height of maize plant except the control where minimum plant height was recorded, with treatment four (20 kg ha^{-1} NPK 15:15:15 fertilizer) recording a mean height of (94.70cm), which significantly (P = 0.05) stands over all other treatments, presenting the treatment as preferred when compared to (5 kg ha^{-1}, 10 kg ha^{-1}, 15 kg ha^{-1} and 0 kg ha^{-1} NPK 15:15:15) mineral fertilizer application rates. Application rate at 15 kg ha^{-1} NPK (15:15:15) fertilizer (T_3) recorded a mean height at 93.61cm which stands significant ($P<0.05$) over (T_2, T_2, and T_5), placing the treatment as advantageous and further indicating the point that for effective maize cultivation in the humid tropical soil, sufficient quantity of mineral fertilizer should be applied with the understanding of the crop nutrient-use-efficiency. 90,00cm was recorded as the mean height for 10 kg NPK (15:15:15) fertilizer application rates, presenting he treatment as significant ($P<0.05$) over the control, indicating that it is better to apply 10 kg NPK fertilizer than to cultivate without fertilizer especially in the infertile soils of the humid tropics where this experiment was conducted. Treatment one (T_1)5 kg ha^{-1} NPK (15:15:15) fertilizer) recorded a mean height at 88.04cm which was significantly ($P<0.05$) different over the control, further pointing to the benefit derived from mineral fertilizer in increasing the maize growth and boosting the crop potentials (vigorous growth, green leaves including healthy root development) which is a signal to high yield capacity of the crop. ANOVA analysis result showed/presented 79.60 cm as the mean plant height in the control. The control produced the minimum height, clearly presenting the effectiveness of fertilizer on maize growth. At 7 WAP, treatment four still increased the height of maize over the control, recording a value at (139.50cm) which was significantly ($P<0.05$) different over all other treatments. This was closely followed by (138.00cm) , recorded for treatment three (T_3), indicating that supply of mineral fertilizer to a nutrient-indicator crop like maize will not only effectively increase the crop growth but sustain crop production especially in acidic humid tropical soils. 10 kg NPK (15:15:15) fertilizer application rate recorded a mean plant height to the tune of 135.44cm which stands significant ($p = 0.05$) over the control and higher than treatment one, further proofing the positive influence of mineral fertilizer in increasing maize growth and development. However, treatment one (5 kg NPK 15:15:15) produced plants with a mean height of (132.86cm) which stands above the control. The least mean height of maize plant was observed and recorded in the control, giving it value at 124.50cm.

ANOVA analysis for plant height at 8 Week after Planting indicates a significant ($p < 0.05$) difference in maize height across all the treatments, presenting treatments (T_4, T_3, T_2, and T_1) as preferred over the control. With treatment four (20 kg NPK (15:15:15) fertilizer) producing the tallest (172.22cm) plant ($p=0.05$),indicating /pointing to the fact that for an increased/vigorous growth in maize to be expected certain quantities of mineral fertilizer need to be applied, this should be in accordance with the crop variety, soil-nutrient requirement and plant spacing. 171.19cm was recorded as the mean height for application at 15 kg NPK (15:15:15) at 8WAP, placing the treatment above T_2, T_1 and the control. Pointing to the fact that no matter how small the quantity of mineral fertilizer maybe, it will still have an impact (effect) on the soil-crop performance, especially for a nutrient-indicator crop like maize where it performance will stand above the control. Application rate at 10 kg NPK (15:15:15) fertilizer produced plants with a mean height of 168.22cm, placing the treatment as better than treatment one (T_1 (5 kg NPK 15:15:15 and the control (T_5). However, treatment one (T_1) recorded a significant ($p = 0.05$) increased in plant height over the control, producing plants with a mean height of (165.22cm). The least plant height at 8WAP was produced in the control, placing the control as disadvantageous over all the other treatments, recording a mean height of (157.23cm) which stands far below T_4, T_3, T_2 and T_1. However, it can be written that the influence of mineral fertilizer observed and recorded for maize plant height in this experiment presents 20 kg NPK (15:15:15) mineral fertilizer (T_4) < 15 kg NPK (15:15:15) mineral fertilizer (T_3) < 10 kg NPK (15:15:15) mineral fertilizer (T_2) < 5 kg NPK (15:15:15) mineral fertilizer (T_1) < Control (T_5). Findings of this experiment agrees with the submission of Onasanya *et al*. (2009) whose experiment recorded increased in growth/yield of maize after N and P mineral fertilizer application. Okonwu and Mensah (2012) experiment is also in accordance with this finding, where they reported increase in plant growth after application of NPK (15:15:15) mineral fertilizer.

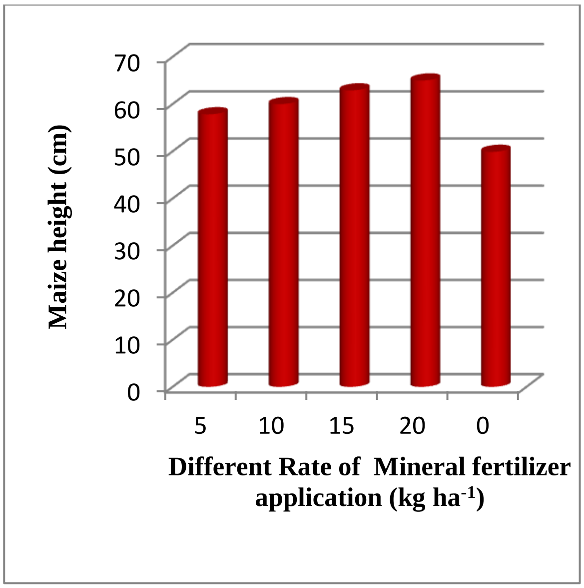


Fig. 1. Influence of Fertilizer on Maize height at 5 WAP

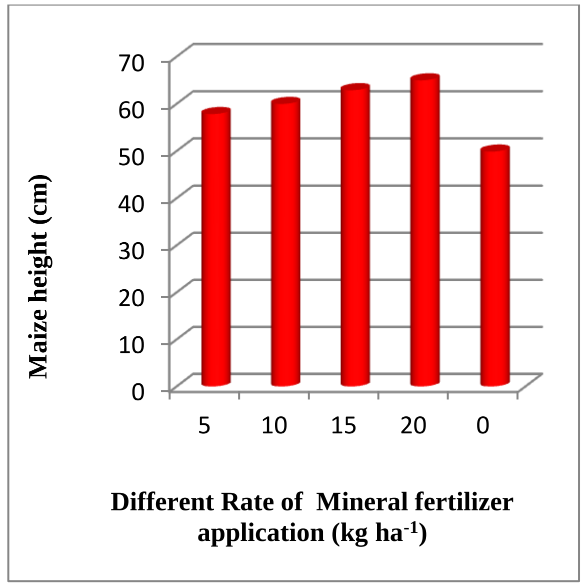


Fig. 2. Influence of Fertilizer on Maize height at 6 WAP

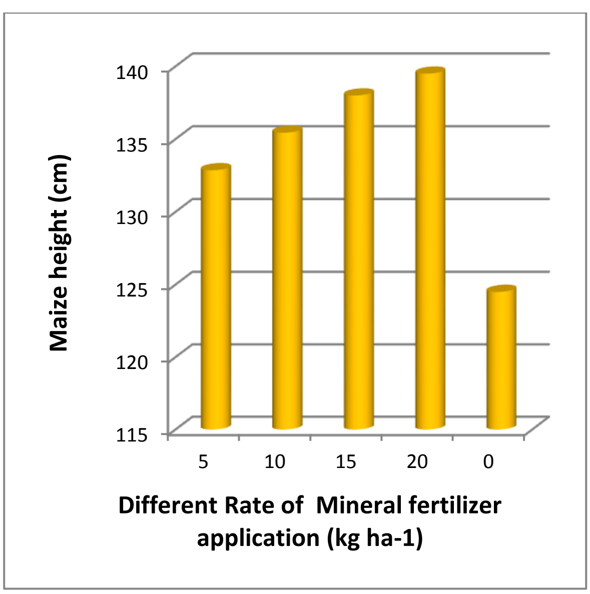


Fig. 3. Influence of Fertilizer on Maize height at 7 WAP

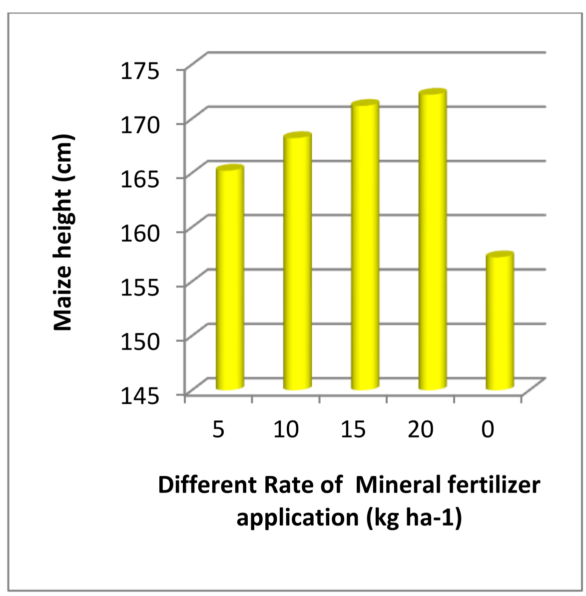


Fig. 4. Influence of Fertilizer on Maize height at 8 WAP

Experiment of Adiaha (2016) is also in-line with this finding, where the experimenter recorded increased in maize growth parameter over the control after NPK (15:15:15) mineral fertilizer application. Recent findings by Adiaha and Agba (2016) also confirms the finding of this experiment, where they recorded a significant ($p = 0.05$) increased in maize plant height over the control.

The trend observed and recorded for plant height in 2015 experiment is presented Table 5. ANOVA result presents treatments to be significant ($p < 0.05$) across all the stages of growth and development of the plant, with treatment four (T_4) producing the tallest plants over all other treatments.

Table 5. Influence of Mineral Fertilizer on Maize (*Zea mays* L.) Height (cm) 2015 Experiment

		Weeks after planting (WAP)			
Treatment S/N	Treatment	5WAP	6WAP	7WAP	8WAP
Treatment 1 (T_1)	5 kgha^{-1} NPK (15:15:15) mineral fertilizer	56.99	86.79	131.50	164.29
Treatment 2 (T_2)	10 kgha^{-1} NPK (15:15:15) mineral fertilizer	59.00	88.80	133.51	166.30
Treatment 3 (T_3)	15 kgha^{-1} NPK (15:15:15) mineral fertilizer	60.88	90.68	135.39	168.18
Treatment 4 (T_4)	20 kgha^{-1} NPK (15:15:15) mineral fertilizer	63.89	93.69	138.40	171.19
Treatment 5 (T_5)	Control	48.79	78.59	123.30	156.09
LSD (P<0.05)		4.80	6.61	1.33	8.46

T_1, T_2, T_3, T_4, T_5: Different treatments used
Mean with the least value produced minimum plant height
All means were separated using (f-LSD) Fisher Least Significant Difference at 0.05%

2015 Analysis of Variance result for plant height at 5WAP, showed the trend in plants height, recording all treatments to be significantly ($P < 0.05$) different over the control, with 20 kg ha^{-1} NPK (15:15:15) fertilizer application rate producing the tallest (63.89 cm) plants which significantly ($p = 0.05$) stands over all other treatments, proofing the consistency of the treatment in increasing the plants height, and further presenting a guide, that for vigorous growth of maize plant to occur, then sufficient rate, but not excess mineral fertilizer should be applied to the crop at 5 Weeks after Planting, to enhance ultimate performance. 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_3) produced plants with a mean value at 60.88cm which was ($p < 0.05$) different over the control, presenting treatment three (T_3) to be preferred over T_2, T_1 and the control (T_5), hence, further stressing the potential of chemical fertilizer in improving maize growth compared to the traditional no-fertilizer cultivation on infertile soils of the humid tropics found in the study area. Treatment two ((T_2) 10 kg ha^{-1} NPK (15:15:15) fertilizer) at 5WAP in 2015 experiment indicated increased over the control, recording a mean plant height to the tune of (59.00cm), placing the treatment as significant ($p = 0.05$) over the control, however, it can be said that 10 kg ha^{-1} NPK (15:15:15) fertilizer < 5 kg ha^{-1} NPK (15:15:15) fertilizer application, in their capacity to increase the growth (height) of maize plant. 56.99 cm was recorded as the mean value for application of mineral fertilizer at 5 kg ha^{-1}, the treatment (T_1) was significant ($p < 0.05$) over the control, hence presenting a guide, that no matter the rate (quantity of fertilizer) applied to maize plant, growth increase expected will always be more profitable than traditional no-fertilizer (peasant) cultivation. The least plant height of (48.79 cm) was recorded in the control, presenting the control to be deficient in its ability to supply plant nutrients to enhance crop vigorous growth/development.

At 6 Week after Planting/fertilizer application, treatment four (T_4) recorded a mean plant height at (93.69cm) which was significantly ($p < 0.05$) different over the control, producing the tallest plants, which stands over all the other treatments. Further, presenting the consistency of high rate of mineral fertilizer in promoting (increasing) maize growth. Treatment three (15 kg ha^{-1} NPK 15:15:15) fertilizer produced plants with height at (90.68cm) which was significantly ($p < 0.05$) different over the control. Presenting the treatment as preferred over 10 kg ha^{-1}, 5kg ha^{-1} of NPK (15:15:15) including the control. Treatment two (10kg ha^{-1} NPK 15:15:15 (T_2)) at 6WAP recorded a mean plant height to the tune of (88.80cm) placing the treatment as preferred when compared to 5 kg ha^{-1} NPK (15:15:15) fertilizer application and the control. However, 5 kg ha^{-1} NPK (15:15:15) fertilizer application (T_1) produced plants with mean height recorded at (86.79cm), further proofing the effect of mineral fertilizer in increasing the growth of maize plant over the control (traditional no-fertilizer, peasant cultivation). Treatment five (T_5), the control recorded a mean height at (78.59cm) hence, clearly presenting a guide that for vigorous growth/high yield to be expected, then mineral fertilizer should be applied to crops at the desired quantity depending on soil-crop needs.

7Week after planting recorded a significant ($p<0.05$) increase in plant height over the control with treatment four (20 kg ha^{-1} NPK (15:15:15)) recording the tallest plant with mean heights of (138.40cm) which was significantly different over all treatments, presenting the treatment as the best when compared to (T_3, T_2, T_1 and T_5), indicating the high potential of mineral fertilizer in consistently and productively producing plants with vigorous height. 135.39cm was recorded at application rate of 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer, presenting the treatment as preferred and productive compared to treatment (T_2, T_1 and the control). Treatment two (5 kg ha^{-1} NPK (15:15:15) mineral fertilizer) significantly ($p < 0.05$) increased plant height over the control, recording a mean plants height at 133.51cm, presenting the treatment as preferred when compared to treatment one and the control. 131.50cm was produced at the application rate of 5 kg ha^{-1} NPK (15:15:15) mineral fertilizer at 7WAP, which significantly ($p < 0.05$) increased the height of maize plant over the control, presenting a guide, hence, pointing to the fact that mineral fertilizer; no matter how low the quantity (rate) applied, it will still have the potential to increase plant growth over no-fertilizer traditional production. The minimum mean height of 123.30cm was observed and recorded in the control, indicating the positive influence of mineral fertilizer on the height of the cultivated maize (*Zea mays* L.) plant. At 8 Weeks after Planting significant ($P<0.05$) increased was also observed and recorded with treatment four (20 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_4) producing the tallest plants with mean value at (171.19cm), proofing the high potential of this treatment in positively influencing the height of the plant in 2015 experiment, hence grading itself as the best treatment over the other treatments used in this experiment. Treatment three (5 kg ha^{-1} NPK (15:15:15) mineral fertilizer) produced plants with a mean height of (168.18cm) which followed treatment four, hence, it can be said that treatment four and treatment three are the two best treatments, since the plant height recorded for these treatment stands higher than T_2, T_1 and T_5. 166.30cm mean plant height was observed and recorded for application of 10 kg ha^{-1} NPK (15:15:15) mineral fertilizer, presenting the treatment as superior and preferred over treatment one (5 kg ha^{-1} NPK (15:15:15) mineral fertilizer) and the control. However, 164.29cm was observed and recorded as the mean maize height at 8WAP in 2015 experiment. A minimum mean maize height of 156.09cm was produced in the control, clearly indicating the weak nature of the infertile tropical humid soils to compete with mineral fertilizer in improving/increasing the maize height. Hence, it can be written that plant height produced with treatment four (20 kg ha^{-1} NPK (15:15:15) mineral fertilizer) < plant height produced with treatment three (15 kg ha^{-1} NPK (15:15:15) mineral fertilizer) < plant height produced with treatment two (10 kg ha^{-1} NPK (15:15:15) mineral fertilizer) < plant height produced with treatment one (5 kg ha^{-1} NPK (15:15:15) mineral fertilizer) < treatment five (control).

Findings of the 2015 experiment is similar to 2014 experiment, although some variation was observed which could be attributed to inconsistency in the soil system due to the action of man and nature on the soil, hence, the experiment agrees with the research findings of Onasanya *et al*. (2009) whose experiment recorded increased in maize growth after application of mineral fertilizer. Omotoso and Shittu (2007) experiment also agrees with the findings obtained in the experiment, where their report indicates increased in *Abelmoschus esculentus* (L.) growth parameters after NPK fertilizer was applied. Adiaha (2016); Adiaha and Agba (2016) experiment also agrees with this finding, where their experiments recorded increased in plant growth after application of NPK mineral fertilizer on maize (*Zea mays* L.) plant.

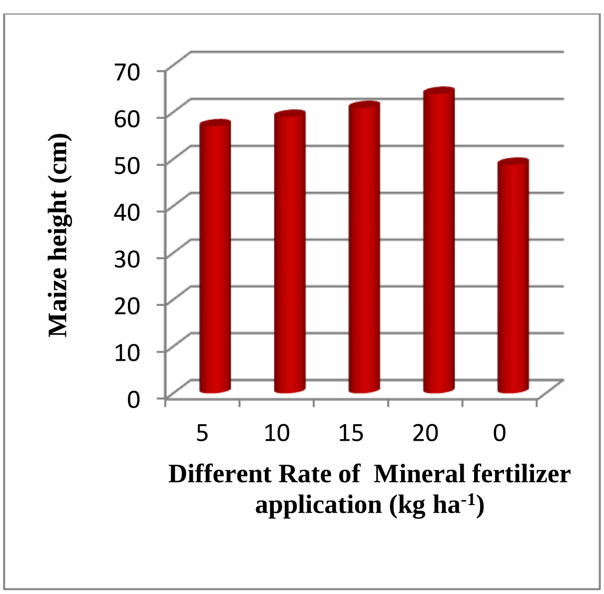


Fig. 5. Influence of Fertilizer on Maize height at 5 WAP

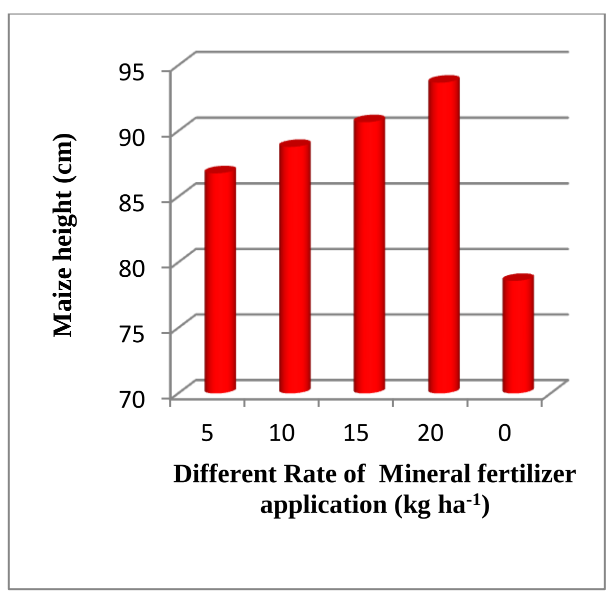


Fig. 6. Influence of Fertilizer on Maize height at 6 WAP

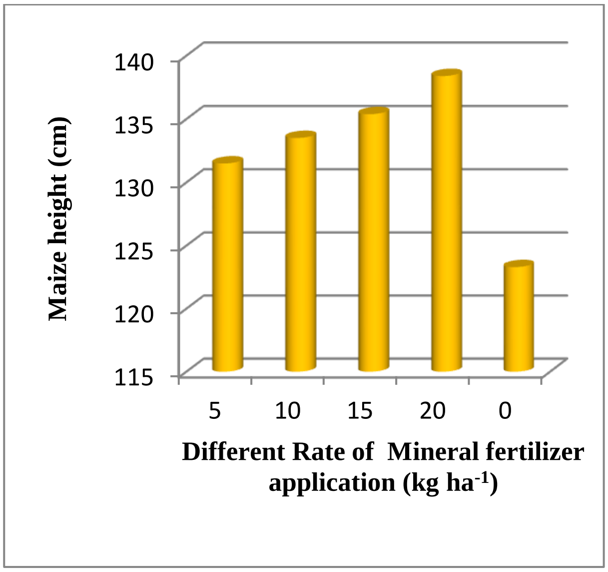


Fig. 7. Influence of Fertilizer on Maize height at 7 WAP

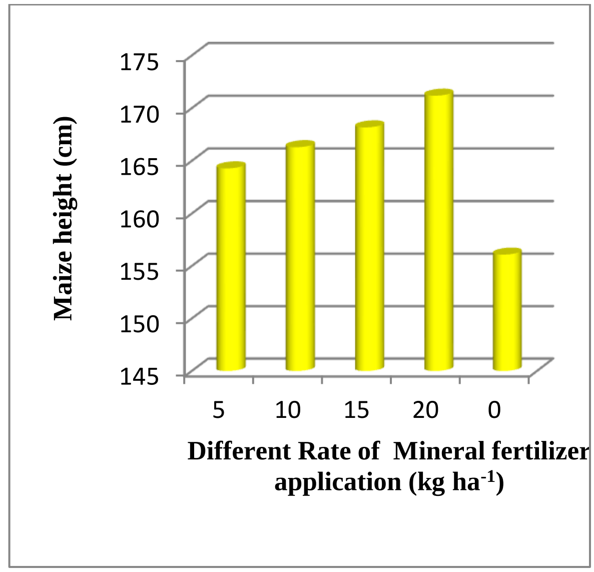


Fig. 8. Influence of Fertilizer on Maize height at 8 WAP

3. 3. Number of Leaves

The trend observed and recorded in number of leaves as influenced by the mineral fertilizer is presented in Table 5.

Table 6. Influence of Mineral Fertilizer on Maize (*Zea mays* L.) Number of Leaves 2014 Experiment

		Weeks after planting (WAP)			
Treatment S/N	Treatment	5WAP	6WAP	7WAP	8WAP
Treatment 1 (T_1)	5 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	5.99	6.87	7.99	9.03
Treatment 2 (T_2)	10 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	6.18	7.05	8.17	9.20
Treatment 3 (T_3)	15 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	7.99	8.85	9.96	11.00
Treatment 4 (T_4)	20 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	8.20	9.08	10.20	11.24
Treatment 5 (T_5)	Control	4.80	5.67	6.79	7.83
LSD ($P<0.05$)		0.75	0.67	1.71	1.08

T_1, T_2, T_3, T_4, T_5: Different treatments used
Mean with the least value produced minimum plant height
All means were separated using (f-LSD) Fisher Least Significant Difference at 0.05%

Analysis of Variance for number of leaves at 5WAP indicates a significant ($p<0.05$) difference, with 20 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_4) application rate producing (8.20) maximum plant ($p = 0.05$) number of leaves over all other treatments, further stressing the potential of high rate of mineral fertilizer on maize growth, hence, presenting application at 20 kg ha^{-1} as the preferred when compared to T_3, T_2, T_1 and T_5. Application at 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer produced a mean value of 7.99, followed by 6.18 in application of 10 kg ha^{-1} NPK (15:15:15) fertilizer, presenting these treatments as effective compare to the control. Treatment one (5 kg ha^{-1} NPK 15:15:15 (T_1) recorded a figure at 5.99, indicating the effect of this treatment over (4.80) the control. However minimum number of leaves at 5WAP was observed and recorded in the control with a mean number of leaves at 4.80. At 6WAP after planting (2 Weeks after fertilizer application (WAFA) a significant ($p<0.05$) difference was observed and recorded for all treatments over the control. With 20 kg ha^{-1} NPK (15:15:15) mineral fertilizer application rate producing the maximum ($p=0.05$) number of leaves over all other treatments, with a mean value figured at (9.08), reflecting the positive influence this treatment to consistently increasing the growth (number of leaves) of the plants. Result obtained for T_3 shows significant ($p = 0.05$) increase in the number of leaves over the control with its mean value recorded at (8.85). Treatment two (10 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_2)) and treatment one (5 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_1) produced a mean number of leaves at (7.05 and 6.87) respectively. The least number of leaves was observed and recorded in the control plot with a mean number of leaves at (5.67).

At 7 WAP significant ($p = 0.05$) increase was observed and recorded for number of laves after ANOVA analysis. With 20 kg ha^{-1} application rate still maintaining its effectiveness over all other treatments further indicating its potential to increase the number of leaves over T_3, T_2, T_2 and T_5, placing T_4 as preferred over all other treatments used in this experiment, recording its mean value at 10.20 which stands maximum ($p = 0.05$) over the control. 9.96 mean number of leaves was produced at application rate of 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer at 7WAP, further indicating the potential of this treatment to consistently following 20 kg ha^{-1} which recorded the highest number of leaves, proofing T_3 as effective and preferred compared to T_2, T_1 and T_5. (8.17 and 7.99) was observed and recorded for application rate at 10 kg ha^{-1} and 5 kg ha^{-1} NPK (15:15:15) mineral fertilizer respectively, clearly presenting that $8.17 < 7.99$, hence, giving a guide that increased application rate enhance the rapid/vigorous growth of the plant. However T_3 stands preferred when compared to T_2, T_1 and the control (T_5). Minimum number of leaves at 7 Weeks after planting in 2014 experiment was produced in the control, with its man value at (6.79).

At 8 Weeks after Planting, a significant ($p<0.05$) difference was recorded for plant number of leaves, with treatment four (20 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_4)) recording the highest ($p = 0.05$) mean number of leaves (11.24) over all other treatments. This was closely followed by treatment three (15 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_4)) which recorded a mean value at (11.00), presenting treatment T_4 and T_3 as the two most preferred treatments when compared to T_2, T_1 and the control T_5. (9.20 and 9.03) was recorded for treatment two (10 kg ha^{-1} NPK (15:15:15) mineral fertilizer) and (5 kg ha^{-1} NPK (15:15:15) mineral fertilizer) respectively, indicating the point that these two treatments have the ability to increase growth (number of leaves) of maize over the low yield: traditional, peasant, no-fertilizer cultivation. The least number of leaves at (7.83) was recorded in the control plot at 8WAP.

Findings of this experiment agrees with the experiment of Onasanya *et al*. (2009), where they recorded increased number of leaves after N, P fertilizer application on maize. Findings of Omotoso and Shittu (2007), also confirms the report of this experiment, where they reported increase in plant growth parameter, including number of leaves after NPK fertilizer application. Adiaha (2016); Adiaha and Agba (2016); Kogbe and Adediran (2003) experiments further agrees with this experiment, where their various work recorded increased in maize (*Zea mays* L.) growth parameter after NPK mineral fertilizer application. Okonwu and Mensah (2012) experiment is also in-line with this findings, where they recorded increased plant growth indices after NPK (15:15:15) mineral fertilizer application.

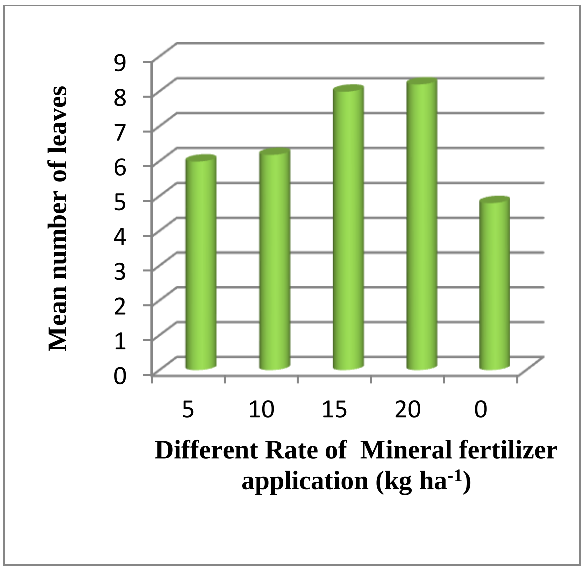


Fig. 9. Influence of Fertilizer on Maize No of Leaves at 5 WAP

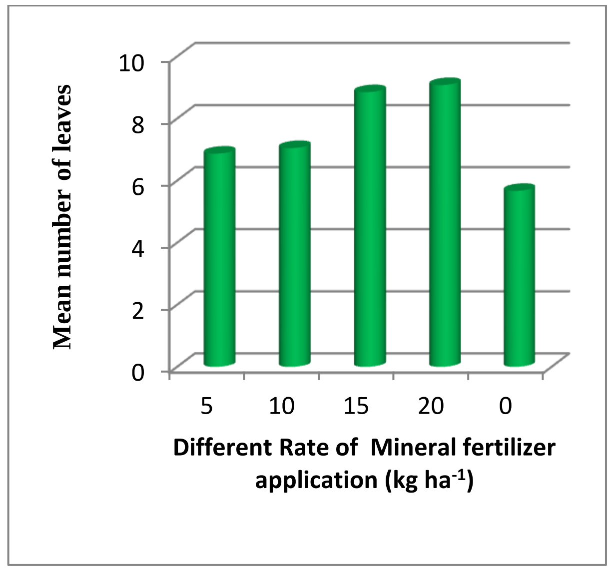


Fig. 10. Influence of Fertilizer on Maize No of Leaves at 6 WAP

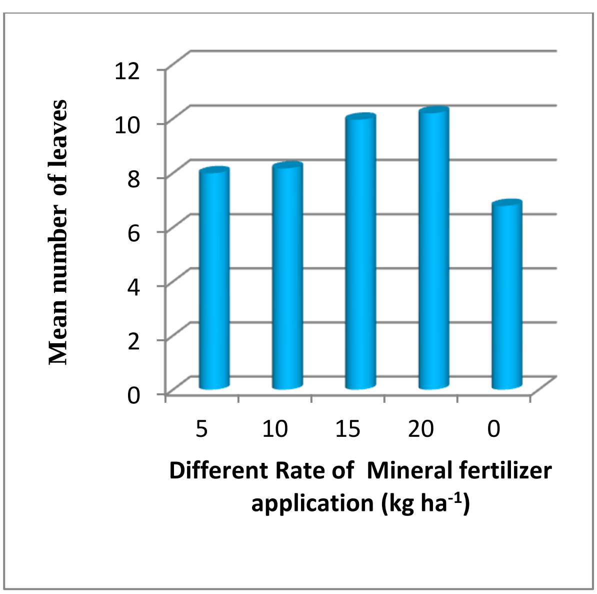


Fig. 11. Influence of Fertilizer on Maize No of Leaves at 7 WAP

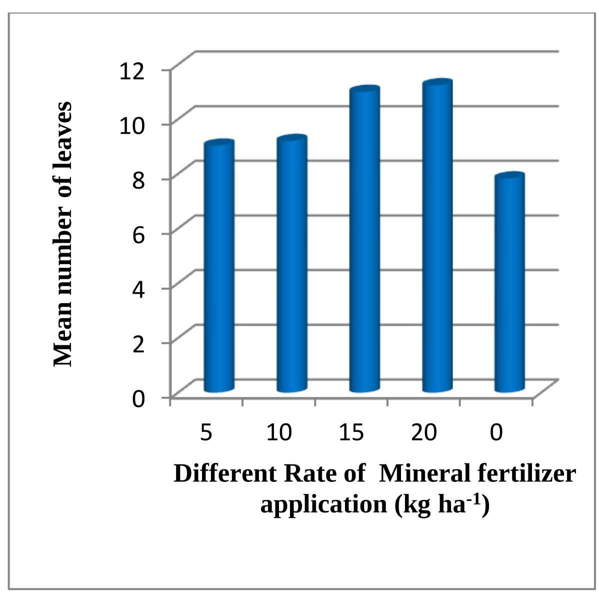


Fig. 12. Influence of Fertilizer on Maize No of Leaves at 8 WAP

Influence of mineral fertilizer on number of leaves as presented in Table 7 in 2015 experiment shows Analysis of Variance result across treatments to be significant ($p < 0.05$) across all stages of the plant growth and development.

Table 7. Influence of Mineral Fertilizer on Maize (*Zea mays* L.) Number of Leaves 2015 Experiment

Treatment S/N	Treatment	Weeks after planting (WAP) 5WAP	6WAP	7WAP	8WAP
Treatment 1 (T_1)	5 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	5.35	6.35	7.46	8.36
Treatment 2 (T_2)	10 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	6.11	7.10	8.21	9.11
Treatment 3 (T_3)	15 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	7.00	8.01	9.12	10.02
Treatment 4 (T_4)	20 $kgha^{-1}$ NPK (15:15:15) mineral fertilizer	7.99	8.99	10.10	11.00
Treatment 5 (T_5)	Control	4.99	5.00	6.11	7.00
LSD (P<0.05)		0.63	0.06	1.41	1.67

T_1, T_2, T_3, T_4, T_5: Different treatments used
Mean with the least value produced minimum plant height
All means were separated using (f-LSD) Fisher Least Significant Difference at 0.05%

Result obtained in number of leaves at 5 Weeks after planting (1 Week of fertilizer Application), showed that number of leaves increased across the treatment at all stages of growth, with 20 kg ha^{-1} NPK (15:15:15) fertilizer application rate producing the highest ($p = 0.05$) mean number of leaves of (7.99) which stands significantly ($p < 0.05$) different over the control. Treatment three (15 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_3)) produced plants with mean number of leaves at (7.00), indicating the treatment ability to closely follow treatment four (20 kg ha^{-1} NPK (15:15:15) mineral fertilizer) which recorded the maximum ($p = 0.05$) number of leaves at 5WAP. (6.11 and 5.35) was observed and recorded as mean height for treatment two and one (10 kg ha^{-1} and 5 kg ha^{-1} NPK (15:15:15) mineral fertilizer) respectively, indicating the positive influence of the treatment on the maize plant number of leaves over the control. The least number of leaves (4.99) was produced in the control.

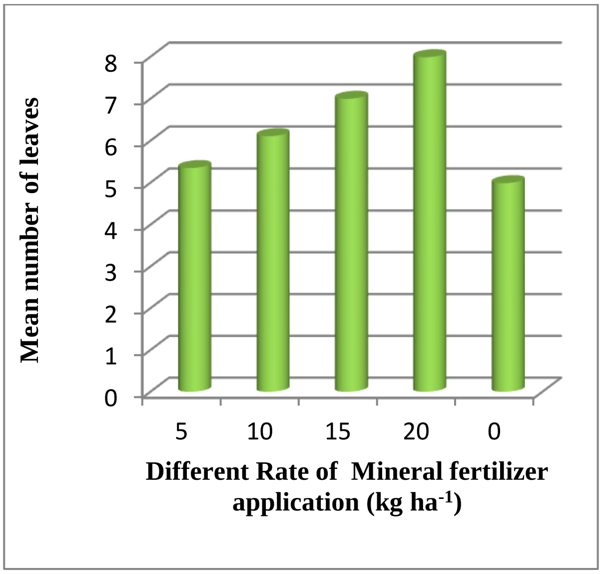
A significant ($p = 0.05$) increased was recorded across all the treatments at 6 Week after Planting, with 20 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_4) application rate significantly ($p<0.05$) increasing the number of leaves over all the other treatments. (8.01) mean number of leaves was recorded in treatment three (15 kg ha^{-1} NPK (15:15:15) mineral fertilizer) which stands preferred when compared to T_2, T_1 and T_5, indicating the potential of the treatment in positively influencing the number of leaves of maize, which closely follow treatment four (T_4)

in its productive capacity. However, treatment two (10 kg ha^{-1} NPK (15:15:15) mineral fertilizer) produced mean number of leaves to the tune of (7.10) which stands significantly ($p < 0.05$) different over treatment one (T_1) and the control (T_5). Treatment one recorded a mean number of leaves to the tune of (6.35), which stands significantly ($p < 0.05$) higher than the control. The minimum plant number of leaves was observed and recorded in the control plots with a mean of (5.00), which stands below all the other treatments, further proofing the positive/productive influence of mineral fertilizer over no fertilizer cultivation.

Significant ($p < 0.05$) difference was observed and recorded after ANOVA analysis at 7WAP, with treatment four producing the highest/maximum ($p=0.05$) number of leaves, indicating a positive influence of the treatment in increasing the number of leaves of the plant, giving it mean height at (10.10) over all the other treatments used in the experiment. Treatment three produced plants with (9.12) mean number of leaves which stands significantly ($p<0.05$) different over the control (8.21 and 7.46) mean number of leaves was produced in treatment two and one respectively, which stands higher than the control. Hence, it can be said 8.21 < 7.46, presenting a guide, that 10 kg ha^{-1} NPK fertilizer application rate produced plants with higher number of leaves than 5 kg ha^{-1} NPK fertilizer, further stressing the point that for vigorous growth to be expected in maize production, sufficient NPK mineral fertilizer should be applied to the crop especially in the humid tropical soils where soil-nutrient deterioration is a major problem. The least number of leaves at 7WAP was observed and recorded in the control plots, giving it mean value at (6.11) which stands below all the other treatments used.

After 8 Weeks of planting (A 8 WOP), ANOVA analysis indicated a significant ($p < 0.05$) increased in the number of leaves across all the treatments, with the least (minimum) mean leaves recorded in the control. (11.00) mean value produced in treatment four, which was followed by 10.02 mean number of leaves produced at an application rate of 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer. (9.11 and 8.36) mean number of leaves was produced at the rate of 10 kg ha^{-1} and 5 kg ha^{-1} NPK (15:15:15) mineral fertilizer respectively. (7.00) minimum number of leaves was observed and recorded in the control, further stressing the productive and positive effect (influence) of the mineral fertilizer application on the number of leaves. However, it can be said 20 kg ha^{-1} NPK (15:15:15) mineral fertilizer influence < 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer influence < 10 kg ha^{-1} NPK (15:15:15) mineral fertilizer influence < 5 kg ha^{-1} NPK (15:15:15) mineral fertilizer influence < Control. Thus, pointing to the fact that for maximum production of maize in infertile tropical humid soils, mineral fertilizer application becomes necessary in other to keep the soil nutrient balanced after crop utilization, to produce maize in large quantities effectively and for environmental/agricultural sustainability.

The result obtained in number of leaves in 2015 experiment is similar to the 2014 experiment and agrees with the submission of Onasanya *et a.l* (2009) whose experiment recorded increased in maize number of leaves after mineral fertilizer application. Experiment of Omotoso and Shittu (2007) is also in-line with this finding, were they reported increased in plant growth parameters after application of NPK mineral fertilizer. Adiaha (2016); Adiaha and Agba (2016); Kogbe and Adediran (2003) surveys also agrees with the finding of this experiment, where their various experiments indicated increased in maize (*Zea mays* L.) growth parameters after NPK (15:15:15) mineral fertilizer application.



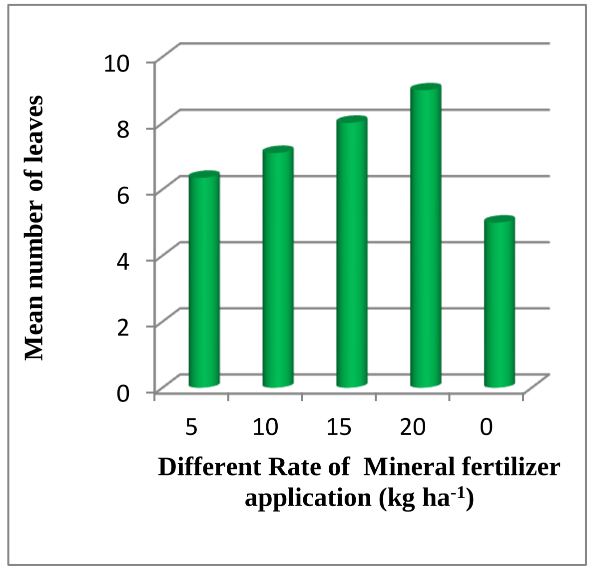
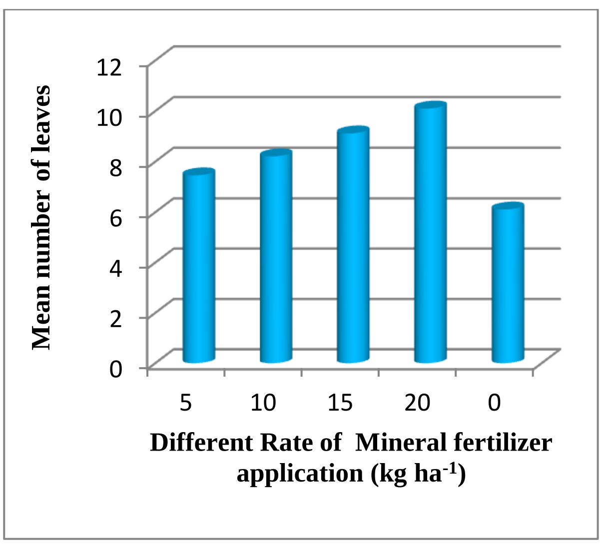


Fig. 13. Influence of Fertilizer on Maize No of Leaves at 5 WAP **Fig. 14.** Influence of Fertilizer on Maize No of Leaves at 6 WAP



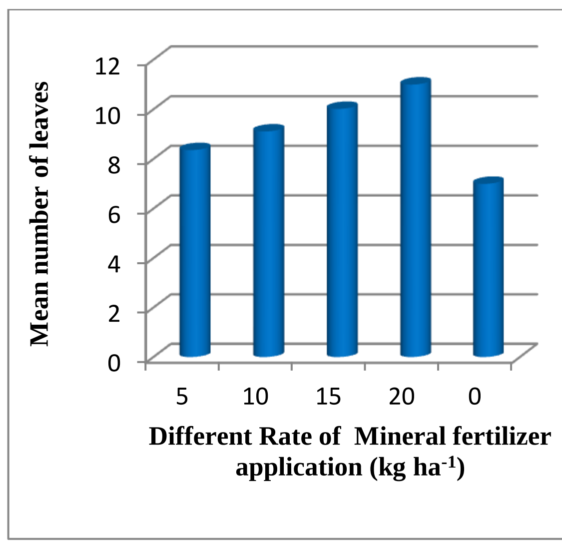


Fig. 15. Influence of Fertilizer on Maize No of Leaves at 7 WAP **Fig. 16.** Influence of Fertilizer on Maize No of Leaves at 8 WAP

3. 4. Influence of NPK (15:15:15) mineral Fertilizer on Physico-chemical Properties of the soil

Influence of the mineral fertilizer on soil Physical and chemical properties of the experimental site soil after cropping is presented in Table 8 and 9 respectively. Result obtained showed that NPK (15:15:15) mineral fertilizer had no effect on the soil textural class in 2014 and 2015 experiment respectively as the textural class remains sandy loam, this finding agrees with experiment of Adaikwu *et al*. (2012); Onwudike *et al*. (2012), where their various experiments indicated no change in textural class of the soil after soil amendments. Adiaha (2016) survey also agrees with the report of this experiment, where the experimenter recorded no change in soil textural class after NPK (15:15:15) mineral fertilizer application on soils of the humid tropics.

Table 8. Influence (Effect) of NPK (15:15:15) Mineral Fertilizer on Soil Physical Properties 2014 and 2015 Experiments

Soil Textural Class (STC)	NPK 5 Kg ha^{-1}	NPK 10 Kg ha^{-1}	NPK 15 Kg ha^{-1}	NPK 20 Kg ha^{-1}	Control Kg ha^{-1}
Soil Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Soil Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Soil Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Soil Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Soil Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Table 9. Influence (Effect) of NPK (15:15:15) Mineral Fertilizer on Soil Physico-chemical Properties 2014 Experiment

							Exchangeable cation (cmol/kg)				
Treatment	TN g/kg	Av. P Mg/kg	pH H_2O	pH KCl	Org. C g/kg	Org. M g/kg	Ca	Mg	Na	K	CEC cmol/kg
5kg ha^{-1} MF	0.99	4.08	6.19	5.48	1.15	1.99	3.70	1.89	0.68	1.00	7.73
10kg ha^{-1} MF	0.100	5.70	6.21	5.88	1.21	2.10	3.87	1.99	0.89	1.04	7.81
15kg ha^{-1} MF	0.103	6.52	6.28	5.99	1.84	3.19	3.99	2.68	1.51	1.20	8.41
20kg ha^{-1} MF	0.106	7.89	7.30	6.79	1.99	3.45	4.00	2.89	1.70	1.28	8.70
Control CR	0.060	3.00	6.00	5.26	0.61	1.06	2.60	0.46	0.52	0.20	4.89

Kg: Kilogram, MF: Mineral Fertilizer
T_1, T_2, T_3, T_4, T_5: Different treatment used in the experiment, CR: Control
TN = Total Nitrogen, Av. P = Available Phosphorus, OC = Organic Carbon,
OM = Organic Matter, CEC = Cation Exchange Capacity

Laboratory soil analysis result after cropping showed that the treatments increased soil pH when compared to the control. With treatment four (20 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_4)) recording the highest pH value of (7.30) in H_2O and (6.76) in KCl, this was followed by application rate of 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_3)) which recorded a pH value at (6.28) in H_2O and (5.99) in KCl. Treatment two (10 kg ha^{-1} NPK (15:15:15) mineral fertilizer (T_2)) recorded a pH value of (6.21 in H_2O and 5.88 in KCl) while 5 kg ha^{-1} NPK (15:15:15) fertilizer application rate recorded 6.19 pH value in H_2O and 5.48 in KCl respectively. However, the least pH value of 6.00 in H_2O and 5.26 in KCl was recorded in the control. The NPK treatments also increased the soil total Nitrogen, available phosphorus, exchangeable calcium, and soil organic matter in all the treatments except the control which showed reduction in nutrients values. There was a reduction in the CEC in the control.

The soil properties improvement after NPK treatment application indicates the positive influence (impact/effect) of NPK mineral fertilizer on soil chemical properties. The report of this experiment agrees with the finding of Okonwu and Mensah (2012), where they recorded increased in N, P, K, Ca, Na, Mg, OC including OM content in soil properties after NPK (15:15:15) mineral fertilizer application. Report of this experiment also agrees with the work of Abd El-Aziz (2007) whose findings presents fertilizer as a nutrient source which can supply the soil back with its original natural nutrients. Experiment of Adiaha (2016) also agrees with this finding, where the experimenter recorded increased in soil chemical properties after application of NPK (15:15:15) mineral fertilizer.

Table 10. Influence (Effect) of NPK (15:15:15) Mineral Fertilizer on Soil Physico-chemical Properties 2015 Experiment

Treatment	TN g/kg	Av. P Mg/kg	pH H_2O	pH KCl	Org. C g/kg	Org. M g/kg	Exchangeable cation (cmol/kg) Ca	Mg	Na	K	CEC cmol/kg
5kg ha^{-1} MF	0.97	4.00	6.17	5.44	1.12	1.94	3.68	1.79	0.78	1.00	7.71
10kg ha^{-1} MF	0.98	5.67	6.20	5.87	1.18	2.05	3.79	1.88	0.80	1.03	7.79
15kg ha^{-1} MF	0.102	6.49	6.24	5.89	1.80	3.11	3.82	2.60	1.61	1.21	8.38
20kg ha^{-1} MF	0.104	7.82	7.28	6.74	1.95	3.38	3.99	2.80	1.68	1.24	8.68
Control CR	0.058	2.99	5.88	5.00	0.52	0.90	2.51	0.39	0.48	0.18	4.80

Kg: Kilogram, MF: Mineral Fertilizer
T_1, T_2, T_3, T_4, T_5: Different treatment used in the experiment, CR: Control
TN=Total Nitrogen, Av. P= Available Phosphorus, OC= Organic Carbon,
OM=Organic Matter, CEC= Cation Exchange Capacity

Mineral fertilizer influence on soil chemical properties as presented in Table 10, indicated that the application of NPK (15:15:15) mineral fertilizer produced an increased in soil pH over the control, with treatment four (20 kg ha^{-1} NPK (15:15:15) mineral fertilizer) consistently increasing the pH from 5.91 to 7.28 in H_2O and from 5.07 to 6.74 in KCl. Treatment three (15 kg ha^{-1} NPK (15:15:15) mineral fertilizer) recorded an increased soil pH over the control, with a value at (6.24 in H_2O and 5.89 in KCl), indicating an increased in soil chemical properties compared to no-fertilizer traditional cultivation. Treatment two (10 kg ha^{-1} NPK (15:15:15) mineral fertilizer) recorded an incased pH to the tune of (6.20 in H_2O and 5.87 in KCl). However, treatment one (5 kg ha^{-1} NPK (15:15:15) mineral fertilizer) application also recorded an increased in soil properties over the control, giving its pH value at 6.17 in H_2O and 5.44 in KCl respectively. The laboratory analysis revealed a reduction in pH value in the control from the initial (5.91 to 5.88 in H_2O and 5.07 to 5.00 in KCl), hence, presenting the positive influence of NPK mineral fertilizer in increasing the soil properties over the traditional no-fertilizer cultivation.

Thus, presenting a guide that for successful cropping and for soil fertility improvement mineral fertilizer becomes crucial especially in the highly weathered, non-fertile tropical humid soils where this experiment was conducted. However, it can be said that; increased in soil pH in 20 kg ha^{-1} (T_4) < 15 kg ha^{-1} (T_3) < 10 kg ha^{-1} (T_2) < 5 kg ha^{-1} (T_1) < Control (T_5). The NPK mineral fertilizer treatments also increased the soil total Nitrogen, available Phosphorus, exchangeable Calcium, organic Carbon and soil organic matter across all the treatments except in the control where reduction of the soil nutrients was observed, which may be attributed to nutrient uptake/utilization by the cultivated maize for growth. Reduction in CEC value was observed in the control, the reduction may be attributed to nutrient uptake and further utilization by the plant.

Findings of this experiment is similar to the 2014 experiment, although variation was observed in soil properties value, this variation can be attributed to inconsistency in the soil system due to regular rainfall and rapid deterioration of tropical soils due to human and nature action on the soil. Hence, findings of the experiment agrees with the research experiment of John *et al*. (2004) whose report indicated mineral fertilizer as an important source of Nitrogen (N) which is associated with vigorous vegetative growth and increased soil nutrients. Experiment of Adiaha (2016) is also in accordance with this experiment, where the experimenter recorded increased in soil properties after NPK (15:15:15) mineral fertilizer application. Okonwu and Mensah (2012) survey also confirms the finding of this experiment, where their report indicated increased (N, P, K, Ca, Na, including Mg) after NPK (15:15:15) mineral fertilizer application.

4. CONCLUSION

Result of this investigation further confirms the positive influence of mineral fertilizer on maize growth and soil fertility improvement. 20 kg ha^{-1} NPK (15:15:15) mineral fertilizer application increased maize growth and (N, P, K, Ca, Na, Mg, OM, CEC and pH) status of the soil over the control, presenting the treatment as significantly ($p<0.05$) different over all other treatments and closely followed by 15 kg ha^{-1} NPK (15:15:15) mineral fertilizer application rate. Studying the influence of mineral fertilizer on the growth of maize and soil fertility improvement, it is concluded that NPK (15:15:15) mineral fertilizer at 20 kg ha^{-1} is effective and efficient for maximum maize production, for food security, soil fertility improvement and for environmental development/agricultural sustainability.

Recommendation

For increase cultivation of maize, environmental sustainability, food security and to effectively cultivate maize on infertile tropical humid soils, then application of NPK (15:15:15) mineral fertilizer is recommended, at an application of 20 kg ha^{-1} or more rate depending on the existing soil-fertility status.

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