Original Research Article

Effect of Biosoil conditioner and NPK 15:15:15 fertilizers on the growth and yield of Maize (Zea mays L.) in North- Central of Nigeria

ABSTRACT

Soil degradation and nutrient depletion have become serious threat to agricultural productivity in Nigeria. Substantial improvement in the systems is required to support the ever-increasing rural and urban population. During the 2013 and 2014 cropping season, field experiments were conducted to evaluate the effect of combined application of NPK fertilizer and Biosoil conditioner on yield and growth of maize at Kilankwa (longitude 6.79316E, latitude 8.70545N) in Abuja, Nigeria. This experiment was done as a randomized complete block design with three replications. The treatments were T1 (300kgNPK/ha); T2 (300kgNPK/ha + 1 tablet of Biosoil conditioner in 50 litres of water); T3 (1 tablet of Biosoil conditioner in 50 litres of water) and T4 (control). Soil samples were collected for the determination of chemical and physical properties before planting. Data on growth parameters(plant height and number of leaves) and yield (fresh cob weight) were also collected and subjected to 2 ways Analyses of Variance (ANOVA) and means separated with Least Significant Difference (LSD) at P=0.05.

The study revealed that during dry season of 2013 cropping system, application rate of 300kg NPK/ha + 1 tablet of Biosoil conditioner in 50 litres of water had the highest fresh cob weight (6.0 t/ha), followed by 300Kg NPK/ha only (5.1 t/ha), 1 tablet of Biosoil conditioner only (3.2 t/ha) and control (2.3 t/ha) respectively. The field evaluation also showed that combined application rate of 300kgNPK/ha + 1 tablet of Biosoil conditioner in 50litres of water /ha produced the highest number of leaves (13) and plant height (251cm) compared to the least value of 10 and 123cm respectively as obtained in the control.

Similarly in the 2014 wet season, the same trend as in the 2013 was obtained with the application rate of 300kg NPK/ha+1 tablet of Biosoil conditioner in 50 litres of water had the highest fresh cob weight (10.9 t/ha), followed by 300Kg NPK/ha only (9.0 t/ha), 1 tablet of Biosoil conditioner only (7.4 t/ha) and control (3.0 t/ha) respectively.

~~Considering the overall result~~, It can be concluded that the combined application of 300kgNPK/ha and 1 tablet of Biosoil conditioner in 50 litres gave ~~performed best with~~ the highest values for growth and yield than the sole application of either NPK or Biosoil conditioner.

Key words: NPK 15:15:15 fertilizer, Biosoil conditioner, yield, maize, Nigeria

Introduction

The soil remains the main medium of growth in which plants obtain essential nutrients for their growth, development and yield. The soil must therefore be in a good state to support plants and animals including humans by producing highly in terms of yield and nourishment. Seventeen elements have been shown to be essential to plants. They are called macronutrients (N, P, K, Ca, Mg, S, O, H, and C) and micronutrients or trace elements: B, Fe, Co, Zn, Cu, Mn, Mo, and Cl (Welch, 1995). However, Soil degradation and nutrient depletion have become serious threat to agricultural productivity in Nigeria. Substantial improvement in the systems is required to support the ever-increasing rural and urban population. Under the present trend of exploitive agriculture in Nigeria, inherent soil fertility can no longer be maintained on the sustainable basis. It is said that nutrient supplying capacity of soil declines steadily under continuous and intensive cropping system. The optimum levels of N, P, and K failed to maintain yield levels probably due to increasing ~~secondary and~~ micronutrient deficiencies and also unfavorable alterations in the physical and chemical properties of soil. Micronutrient deficiencies are widespread in the world and have received the attention of research workers since early nineteenth century (Bationo and Mokwunye 1991; Sillanpaa, 1972; Murwira et al, 2002). Deficiencies of micronutrients have been increasing in some crops and the reasons for this disorder include higher crop yields which increase plant nutrient demands, use of high analyses NPK fertilizers containing lower quantities of micronutrient contaminants, and decreased use of farmyard manure on many agricultural soils. Micronutrient deficiencies have been verified in many soils through increased use of soil testing and plant analyses. Micronutrient deficiencies in African soils are assuming alarming rates and may be responsible for the declining yields and quality of crops. (Forde, 1968; Anonymous, 1980; Swaine, 1955; Osiname et al, 1973)

Apart from the soil fertility and productivity issues, use of chemical fertilizers is also becoming more and more difficult for the farmers due to their high costs and

unavailability during peak season due to monopoly. ~~On~~ Thus, increasing awareness is being created on the use of organics including biofertilizers which are the sources of macro, micro and secondary nutrients to sustain the soil fertility and productivity.

Organic matter improves water holding capacity of sandy soil and drainage in clayey soil. Organic manure provides nutrients for the soil micro-organisms, thus increases the activities of microbes in soil, which in turn help to convert unavailable plant nutrients into available form for plant growth promotion. The biofertilizers and organics are found to have positive effect on soil fertility, resulting in an increase in crop yield without causing any environmental, water or soil pollution hazards. Nitrogen fixing and Phosphorus solubilizing bacteria play an important role in nitrogen fixation and phosphorus solubilization for the benefit of plant growth (De Ridder and Van Keulen 1990).

According to study carried out by Arshad *et al*. 2004 and corroborated by Das *et al*. 2010 , the researchers found that application of organic manure or bio fertilizers had positive effect on the root development and which resulted in more nutrient uptake and, also promote vigorous plant growth.

In addition to this, crops fed with organic and biofertilizers foliar spray has earlier and more uniform maturity (e.g. attainment of 50% flowering about 21 days earlier in maize plant) due to availability of micronutrients. Other significant evidences include; better flavor of fruits and vegetables, higher nutritional levels, increase in stalk thickness and yield (maize) , better keeping quality in fruits and root cellular storage, increased growth, greater size and lush appearance of green leaves and fruits (Okra) and color intensification of crops like carrots (Lombin, 1983; Lombin,1985;Cherian,1969; Griller, 1966; Cottenie et al , 1981; Heathcote, 1973 ; FMANR, 1990;). These are all good reasons to turn our efforts toward soil–re – mineralization.

Farmers in Nigeria seldom apply micro nutrient fertilizers to their crops either directly or indirectly inform of organic fertilizers apart from the traditional fertilizer (inorganic fertilizer) because in Nigeria most fertilizer formulations are mostly based on the primary nutrients like Nitrogen (N), Phosphorus (P) and Potassium (K) and to a lesser extent on the micro-nutrients. This has serious implications on the attainment of Millennium Development Goal-1 on having people suffering from hunger and malnutrition in 2015 in Africa.

In order to address these limitations, this study was carried out to increase the awareness on the use of organic fertilizers in combination with the chemical fertilizer to improve soil fertility and productivity in the Nigerian soils.

MATERIALS AND METHODOLOGY

Study Area

The study was conducted during dry seasons of 2013 and rain-fed season of 2014 at Kilankwa Village, Gwagwalada Local Government Area of Abuja, Nigeria. It falls under the sub- humid Agro ecological (guinea savanna vegetation) zone of Nigeria. The Kilankwa site lies at longitude of 6.79316E, latitude 8.70545N, and the altitude of the area is 209 m above sea level. The daytime temperature is 28-30 degrees. Climate of this area is arid with dry and hot summer. The mean annual rainfall is about1100 mm to 1600 mm and the growing period of 180-239 days. Rainfall pattern is bimodal with the major rainy season from May to September. The soils at the study area are classified mainly Ferric luvisols according to FAO classification system (FAO, 1988) or Alfisols in USDA soil Taxonomy system (Soil Survey Staff, 1992). They are generally low in CEC owing to predominance of kaolinite in their clay fraction, low organic matter and inherent fertility. The soil characteristic of the research farm is sandy loam in texture (Table 1).

Field Experiment

Field preparation was done mechanically with one ploughing and harrowing, this was followed by manual ridging and mapping out of the plots. The plot size measuring 10m x 10m = 100m^2 with alley of 1m left in between plots was used. The plot sizes were manually prepared. The experimental design was randomized complete block design with three replications. The treatments consisted of: T1 (300kgNPK/ha); T2 (300kgNPK/ha + 1 tablet of Biosoil conditioner in 50 litres of water /ha; T3 (1 tablet of Biosoil conditioner in 50 litres of water /ha) and T4 (control).

An early maturing variety of maize (Zea mays) Oba super was planted on ridges, at inter row spacing of 75 cm and intra- row distances at 25cm. The seed rate was 2seeds per

hole, giving a population density of 54,000 plants/ha and later thinned to one plant per stand. The inorganic fertilizer (NPK 15-15-15) was applied at 2 ~~weeks after planting~~ (WAP) as basal application and then top dress with Urea at 6 weeks after planting. Biosoil conditioner solution was sprayed evenly around the base of the crop and upward, to cover the underside of the leaf. Two applications of the Biosoil conditioner were carried out at 5- 6 WAP and silking stage respectively. Soil auger was used to collect surface soil samples (0 -15cm) from the experimental site before planting. All agronomical practices were duly observed. The agronomic parameters such as plant height and number of leaves were measured from 2 ~~weeks after planting~~ (WAP) and fresh weight of cobs measured at maturity. Five randomly selected and tagged maize plants within each plot were used for measuring these parameters**.** At last data were subjected to 2 ways Analyses of Variance (ANOVA) and means separated with Least Significant Difference(LSD) at P=0.05

RESULTS AND DISCUSSION

Results of physical and chemical properties of soils of Kilankwa are shown in Table 1.

The textural class of the soil is sandy loam with sand values of 720 g kg^{-1}; silt (140g kg^{-1}) and clay (140g kg^{-1}) (Table 1).The sandy nature of this soil is attributed to the granitic and gneissic origin of the parent materials. This contributes to low cationic retention and water holding capacity. The pH (water) is 6.5 suggesting that the soils may not have acidity problems and therefore will not require liming. The organic carbon content is moderate, with a value of 4.40 g kg^{-1}. While the total nitrogen and available phosphorus values fall within the moderate fertility class. The Exchangeable cations (Ca, Mg, K and Na) values are low to moderate. (Table 1)

Cation Exchange Capacity is low to moderate. In soils of low cation exchangeable capacity (CEC), cationic holding capacity will be low. However, because of the higher percent base saturation of the soils of this study area, nutrients are readily available to plants and small doses of fertilizer could produce significant crop responses (Table 1).

Table 1: Physical and Chemical Properties of soils of Kilankwa NPFS site.

PROPERTIES	VALUES
Sand (g/kg)	720
Silt (g/kg)	140
Clay (g/kg)	140
pH(H20)	6.5
pH(Kcl)	5.2
Organic carbon (g/kg)	4.4
Nitrogen (g/kg)	0.35
Avail. Phosphorus (mg/kg)	15.6
Exchangeable Bases (meq /100g)	
Ca	1.8
Mg	1.2
K	0.16
Na	0.14
Al	0.3
CEC	4.3
BS (%)	79.07
Extractable Micronutrients (mgkg$^{-1)}$	
Zn	0.33
Mn	8.85
Fe	5.40
B	0.76

Analysis of Biosoil conditioner Fertilizers

The Biosoil conditioner was subjected to laboratory analysis to determine some physical qualities and the concentration of some essential relevant nutrients and elements considered toxic to crops, man and environment. The results as stated below show that the physical and chemical properties of the product met the specifications and the minimum acceptable investigational allowance for organic fertilizers.

Analysis of Biosoil conditioner as validated by the Department of Soil Science, Faculty of Agriculture/Institute for Agricultural Research, Ahmadu Bello University Zaria, Nigeria February, 2013 are shown below:

Physical Analysis of Biosoil Conditioner Fertilizer

State: Solid Tablet

Colour: Gray with green speckles

Odour: Odourless

Table 2: Chemical Analysis of Biosoil Conditioner Fertilizer

Nutrient /Parameter	**Concentration (%)**
Nitrogen(N)	4.91
Phosphorus (P_20_5)	1.72
Potassium (K_20)	1.14
Calcium (Ca)	0.18
Magnesium (Mg)	0.25
	mg/kg
Iron (Fe)	29.25
Manganese(Mn)	2.25
Zinc (Zn)	25.93
Cadmium(Cd)	0.00
Chromium (Cr)	10.00
Lead (Pb)	29.75
Organic Matter (%)	0.70

Maize response to Biosoil conditioner application for both seasons 2013 /2014 at Kilankwa NPFS site

Number of leaves:

Under the dry- season, maize leaf response to Biosoil conditioner treatments revealed that the highest average number of leaves (13/plot) was obtained with a combined application of NPK and Biosoil conditioner fertilizer followed by 12 leaves/ plot in crops treated with NPK only, and 10.4 leaves/plot in the Biosoil treated plot .The control plot produced the lowest average number of leaves (10/plot) (Fig. 1). Similar trend of result was obtained for the rain-fed, the highest average number of leaves (14/plot) was obtained with the combined application of NPK and Biosoil conditioner fertilizer followed by 12 leaves/ plot in crops with NPK only, and 11 leaves/plot in the Biosoil conditioner only treated plot. The control plot had the lowest average number of leaves (10/plot) (Fig 1). There were significant differences between the number of leaves, for all the levels of treatment at 6 Weeks after Planting. This result corroborated with the earlier study carried out by Lombin 1983 ~~and other researchers~~.

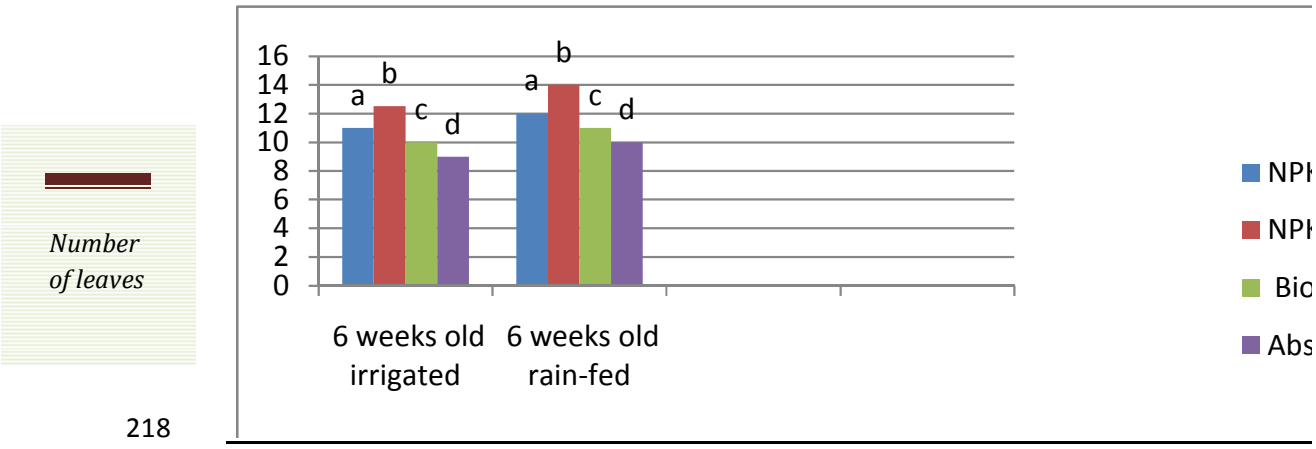


Figure 1: Number of leaves of Maize as influenced by Biosoil conditioner fertilizer at Kilankwa NPFS site both seasons ~~(2013)~~

Plant Height (cm):

The highest plant height of 251cm/plot was obtained from plot treated with NPK and Biosoil conditioner Fertilizer, followed by plot treated with NPK only (198 cm/plot), the plot with Biosoil conditioner fertilizer only gave 150 cm/plot and the least was obtained from the control treatment with value of 123 cm/plot (Fig 2). There were significant differences between the plant heights, for all the levels of treatment at 6 Weeks after

Planting. The result was obtained under the irrigation, and same trend was obtained during the rain-fed season. The highest plant height of 107 cm/plot was obtained from plot treated with NPK and Biosoil conditioner fertilizer, followed by plot treated with NPK only (91 cm /plot), the plot with Biosoil conditioner fertilizer only gave 76 cm/plot and the least was obtained from the control treatment with value of 60 cm/plot (Fig 2).The treatment differences are highly significant

This result corrobated the study by Arshad *et al*. 2004 and Das *et al*. 2010, where it was found that application of organic and bio fertilizers had positive effect on the root development and which resulted in more nutrient uptake and, also promote vigorous plant growth (Fig 2).

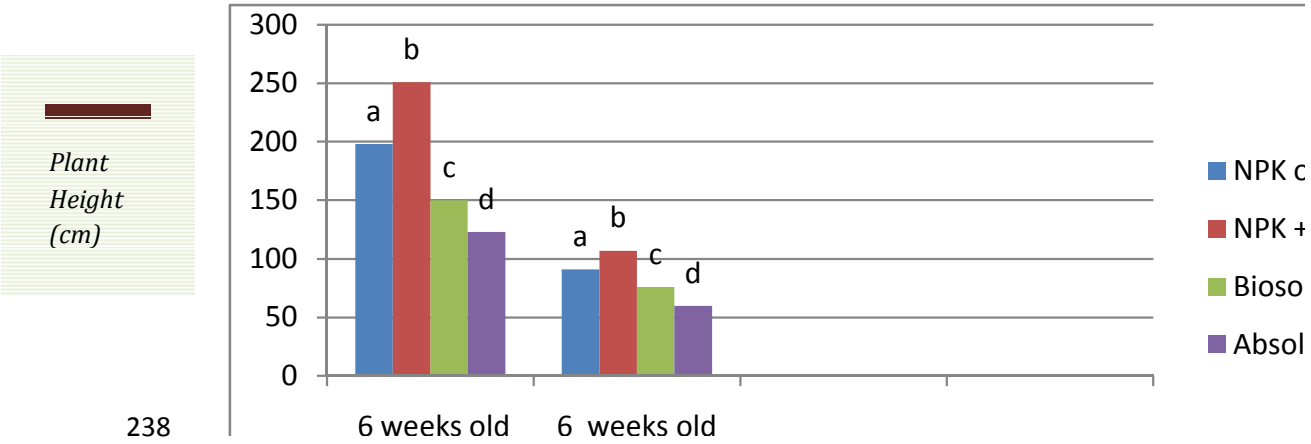


Figure 2: Effect of Biosoil conditioner fertilizer on plant height of maize (6weeks old) for both seasons at Kilankwa NPFS site

Fresh cobs weight:

The matured maize cobs of Oba super were harvested green 112 days after planting, and NPK+ FoliarBlend treated plots did much better in term of fresh cobs weight than other treated plots (Fig 3). This result corrobated the work of Heathcote in 1973, where he looked at the effect of K and trace elements on yield of cereals in northern Nigeria.

The highest Fresh weight of cobs (10.4 t/ha)was obtained from the plot treated with NPK + Biosoil conditioner Fertilizer followed by 7.2 t/ha in plot treated with NPK only, the plot treated with Biosoil only had the value of 3.8t/ha and 3.1 t/ha was obtained from the absolute control (Fig.3). The treatment differences are highly significant.

During the rain-fed season, similar result was recorded as follows; highest fresh weight of cobs (6.0 t/ha)was obtained from the plot treated with NPK + Biosoil conditioner fertilizer, 5.1 t/ha in plot treated with NPK only, 3.2 t/ha in plot treated with Biosoil conditioner only and the control with the least value of 2.3 t/ha. There were significant differences among the treatments (Fig 3).

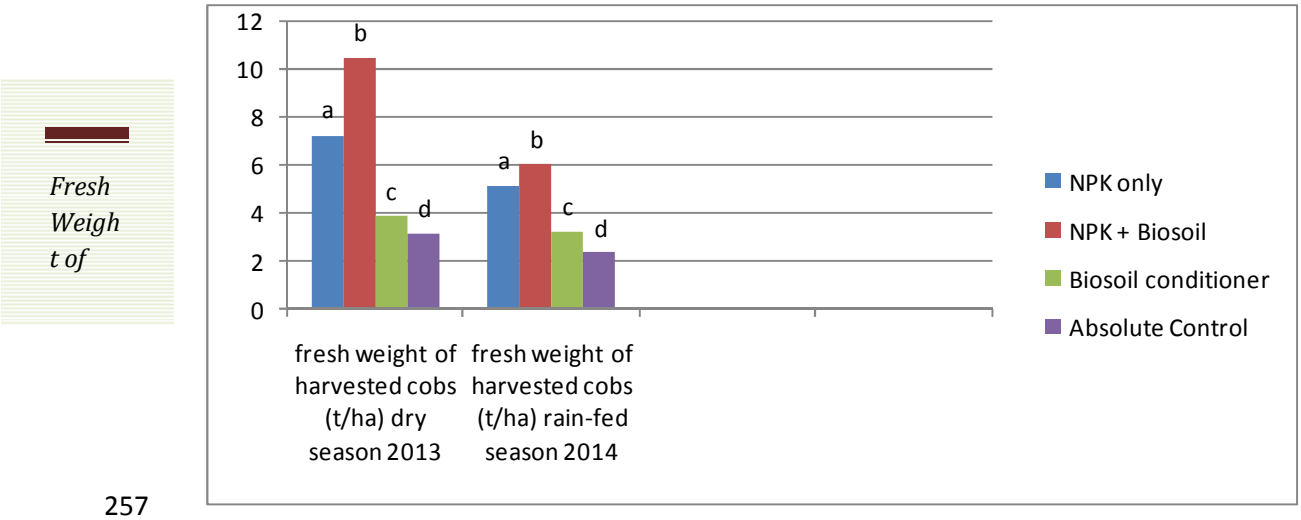


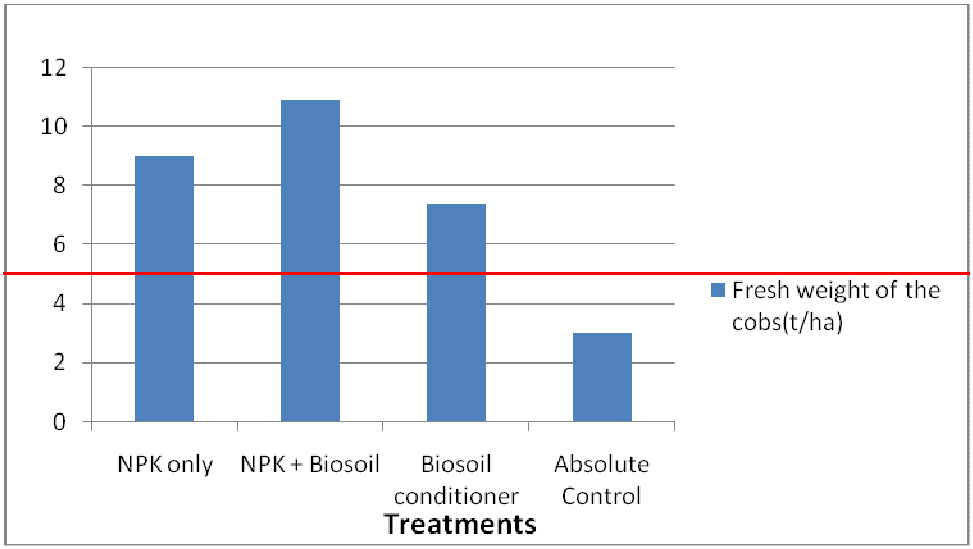
Figure 3: Fresh weight of maize cobs (t/ha) in response to Biosoil conditioner fertilizer at Kilankwa NPFS site in both seasons.

~~**Maize Response to Biosoil Conditioner at Kilankwa, NPFS site under 2014 Rain-fed season**~~

~~**Fresh weight of cobs (2014):**~~

~~Maize plots were harvested green after 112days after planting, NPK+ Biosoil conditioner treated plots did much better in term of fresh weight of cobs than other treated plots (Fig. 4).~~

~~The highest fresh weight of cobs (10.9 t/ha)was obtained from the plot treated with NPK + Biosoil conditioner fertilizer followed by 9.0 t/ha in plot treated with NPK only, while the plot treated with Biosoil conditioner only had the value of 7.4 t/ha and the control with the least value of 3.0 t/ha. The treatment differences are not highly significant.~~



~~Figure 4: Fresh weight of maize cobs (t/ha) in response to Biosoil conditioner fertilizer at Kilankwa NPFS site, Abuja (2014)~~

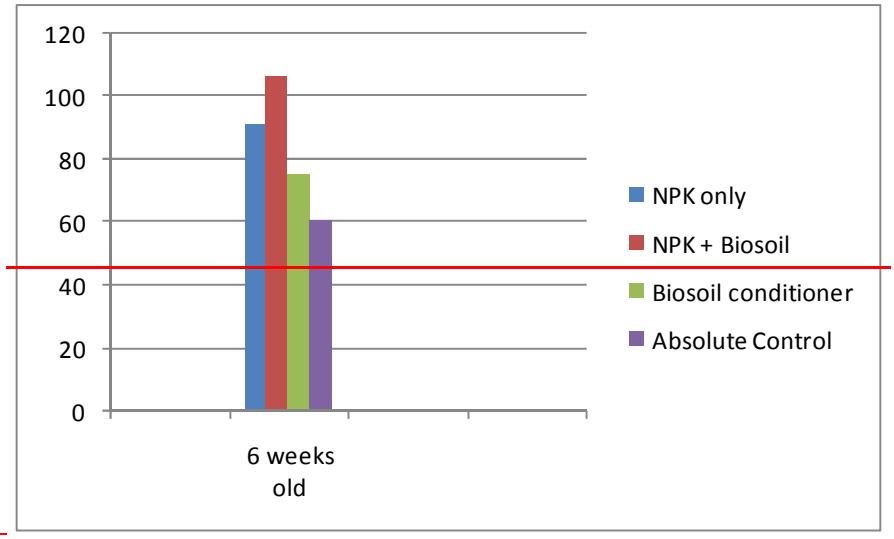
~~Number of leaves~~~~:~~

~~Maize leaf response to Biosoil conditioner treatments reveal that the highest average number of leaves (14/plot) was obtained with a combined application of NPK and Biosoil conditioner fertilizer followed by 12 leaves/ plot in crops treated with NPK only, and 11 leaves/plot in the Biosoil conditioner only treated plot .The control plot produced the lowest average number of leaves (10/plot) (Fig. 5) The treatment differences are highly significant.~~

~~Figure 5: Number of leaves of Maize as influenced by Biosoil conditioner fertilizer at Kilankwa NPFS site, Abuja (2014)~~

~~**Plant Height (cm)**:~~

~~The highest plant height of 106.7 cm/plot was obtained from plot treated with NPK and Biosoil conditioner fertilizer, followed by plot treated with NPK only (91.4 cm/plot), the plot with Biosoil conditioner fertilizer only gave 75.6 cm/plot and the least was obtained from the control treatment with value of 60.3 cm/plot.(Fig .6)The treatment differences are highly significant~~



~~Figure 6: Effect of Biosoil conditioner fertilizer on plant height of maize at NPFS site in Abuja (2014)~~

Conclusion

The study revealed that the application of 300kgNPK/ha of inorganic fertilizer and 1 tablet of Biosoil conditioner in 50 litres of water produced the highest growth parameters and yield of maize compared to sole application of NPK alone and Biosoil conditioner only, during the dry and wet seasons of 2013 and 2014 respectively. Therefore, we proposed the use of 300kg NPK/ha and 1 tablet of Biosoil conditioner in 50

litres of water as the optimum fertilizer recommendation for maize production in North-central Nigeria.

REFERENCES;

- Arshad, M., Khalid, A., Mahmood, M. H. and Zahir, Z.A.2004. Potentiality of nitrogen and L-tryptophan enriched compost for improving growth and yield of hybrid maize. *Pak. J. Agric. Sci.,***41**: 16-24.
- Anonymous. 1980. Fertilizers and their application to crops in Nigeria. Fertilizer Use Series no.1. FDA/FMARD, Dec 1980. p 102.
- Bationo A, Mokwunye AU. 1991. Alleviating soil fertility constraints to increased crop production in West Africa: The experience in the Sahel. *Fert. Res.,* **29**: 95-115.
- Cherian, E.G. 1969. Microelement nutrition of grain Sorghum. PhD thesis. Kansas State University, USA.
- Cottenie, A., B.T. Kang, L. Kienkens and A .Sajjapongse.1981. Micronutrient status in: D.J. Greenland (ed). Characterization of soils in relation to Classification and Management for crop production. Oxford Press. pp 149-163.
- De Ridder N, Van Keulen H. 1990. Some aspects of the role of organic matter in sustainable intensified arable farming systems in West African semi-arid tropics (SAT). *Fert. Res.,* 26: 299-310.
- Das, Gour, C. M., Dharmendra, P. P., Probir Kumar, G., Shishomvanao, N. and Pankaj, B. 2010. Productivity, nutrient uptake and postharvest soil fertility in lowland rice as influenced by composts made from locally available plant biomass.*Arch. of Agron. Soil Sci.,* **56** (6):671–680
- FAO. 1988. FAO/UNESCO Soil Map of the world. Revised Legend. World Resources Report 60.FAO. Rome. Reprinted as Technical paper 20.ISRIC.Wageningen, 1989.

- Forde C.M. 1968. The trace element nutrition of Oil palm seedlings. Journal of Nigerian Institute for Oil Palm Research 5:77-88.
- Federal Ministry of Agriculture and Natural Resources (FMANR). 1990. Trace elements problem in Nigeria Agriculture sector.
- Griller, 1966. Groundnuts and Molybdenum. Soil and fertilizer abstract 29
- Heathcote, R.G.1973. The effect of K and trace elements on yield in northern Nigeria. African Soils 17:85-89
- Lombin, G. 1983a.Evaluating the micronutrient fertility of Nigerian semi-arid Savannah soils 1: Cu and Mn. Soil Science 135: 377-384.
- Lombin, G.1985. Evaluating the micronutrient fertility of Nigerian semi-arid Savannah soils. 3. Boron and Molybdenum. Soil Science and Plant Nutrition 13:12-25.
- Osiname, O.A., E.E. Schutte and R.B. Corey.1973. Soil tests for available Copper and Zinc in soils of western Nigeria. Journal of Science and Food Agriculture 24:1341-1349.
- Murwira, H.K., Mutuo P., Nhamo N., Marandu A.E., Rabeson R., Mwale M. and Palm C.A. 2002. Fertiliser equivalency values of organic materials of differing quality. In: Vanlauwe B.,
  Diels J., Sanginga N. and Merkx R. (eds), *Integrated nutrient management in sub-Saharan Africa.* CAB International, Wallingford, Oxon, UK. pp. 113–122.
- Sillanpaa, M.1972. Trace elements in Soils and Agriculture. Soils bulletin 17.FAO 67
- Soil Survey Staff.1992. Keys to soil Taxonomy. 5th edition. SMSS Technical Monograph No.19. Virginia, USA.
- Swaine, D.J.1955. The trace element content of soil. Commonwealth Bureau of Soil Science. Technical Communications, no. 48. Commonwealth Agricultural Bureau, England

363 • Welch, R. M. (1995). Micronutrient nutrition of plants. *Critical Reviews in Plant*
364 *Sciences.* Vol.14, pp. 49-82