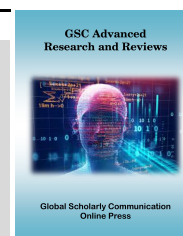


Available online at [GSC Online Press Directory](#)

GSC Advanced Research and Reviews

e-ISSN: 2582-4597, CODEN (USA): GARRC2

Journal homepage: <https://www.gsconlinepress.com/journals/gscarr>

(RESEARCH ARTICLE)



Optimum application levels of nitrogen and zinc for maize (*Zea Mays* L.) production at Abaji, Federal capital territory, Nigeria

Olowookere, B. T, Salihu D. A. and Oyerinde G.T *

Department of Soil Science, Faculty of Agriculture, University of Abuja.

Publication history: Received on 28 October 2020; revised on 08 November 2020; accepted on 11 November 2020

Article DOI: <https://doi.org/10.30574/gscarr.2020.5.2.0094>

Abstract

Efficient utilization of Nutrient will help boost crop yield in the face of rapidly increasing population and food insecurity. This study evaluates the effects of varying nitrogen and zinc rates on growth and yield of maize in Abaji, Federal Capital Territory of Nigeria. Four Nitrogen levels (0 kg N/ha, 40 kg N/ha, 80 kg N/ha and 120 kg N/ha) were evaluate with two Zinc levels (0 kg Zn/ha and 2 kg Zn/ha). The experimental factors were combined with a Factorial in Randomized Complete Block Design (RCBD). Nitrogen was applied as Urea while Zn was applied with Zinc Sulphate ($ZnSO_4$). Phosphorous was applied with Single Super Phosphate (SSP) at the rate of 60 kg P_2O_5 /ha and potassium was supplied with Muriate of Potash (MOP) at 60 kg K_2O /ha. Result shows that Nitrogen application rate of 80 kg N/ha gave the optimum yield in the study area and was recommended for adoption along with other sustainable soil nutrient management practices.

Keywords: Food Security; Soil Fertility; Fertilizer; Agronomy; Urea.

1. Introduction

Food security is causing serious problems globally and to people in the developing countries particularly Sub-Saharan Africa (SSA) (Collier *et al.*, 2008). Nigeria is a country with marked ecological diversity and climatic contrasts. The Southern Guinea Savanna zone for example, is dominated by smallholder farmers, this area of land is continually decreasing per farmer as a result of increasing population (Oldema *et al.*, 1991). With increasing pressure on soils in this part of the country, shifting cultivation is no longer sustainable and traditional bush fallow period for maintaining the productivity of the soil have become shorter; soils are no longer able to supply the quantity of nutrients required; as a result, yield level declines rapidly once cropping commences (Amhakhian *et al.*, 2010).

Maize (*Zea mays* L.) which is also known as corn is the most prominent and has been an important diet in Nigeria for centuries (Cadoni and Angelucci, 2013). Nitrogen is the most important and crucial major nutrient and it is very important for maize and other cereal crops. However, it is the most mobile and volatile and the most exhausted nutrients due to its ability to exist in different forms and its easily leached (Palm *et al.*, 1997; Mugendi *et al.*, 2003; Mucheru-Muna *et al.*, 2009). In the absence of site-specific recommendations, nitrogen management poses a serious challenge in the highlands (Shanahan *et al.*, 2008). Nitrogen management in agro ecosystems has been extensively studied due to its importance in improving crop yield and quality (Hillin and Hudak, 2003; De Paz and Ramos, 2004; Alam *et al.*, 2006; Dambreville *et al.*, 2008; Mugwe *et al.*, 2009; Mucheru-Muna *et al.*, 2010; Mucheru-Muna *et al.*, 2014). According to Lungu and Dynoodt (2008), one of the ways of addressing nitrogen limitation, is use of inorganic fertilizers. There exists inadequate use of fertilizers to replenish the mined nutrients (Makokha *et al.*, 2001). In condition where there is lack of

* Corresponding author: Oyerinde G.T
Department of Soil Science, Faculty of Agriculture, University of Abuja.

Nitrogen in soil, plant maturity can be delayed and also it minimizes yield of crop to high extent. Nitrogen mainly involves in important purposes with compounds such as minerals, co-enzymes and nucleic acid as well.

Micronutrients are not applied regularly to the soil in conjunction with common fertilizers, yet about two to six times in quantity of these elements are removed annually from the soil than applied to it (FAO, 1983). However, the intensification of cropping practices and adoption of high yielding cultivars which have high micronutrients demand have led to increased demand for micronutrients (Fageria *et al.*, 2002). These have resulted in the manifestation of the deficiencies of micronutrients on crops and in soils in many parts of the world (Sims and Johnson, 1991). In Nigeria, the deficiencies of micronutrients have started manifesting, due to reduction in length of fallowing, intensification of cropping on limited land available for farming, planting of crop varieties with high nutrients requirement and the use of high-analysis fertilizers with little or no micronutrients (Kparmwang *et al.*, 1998; Adeboye, 2011).

Objectives

Evaluation of effect of nitrogen rates on vegetative and reproductive parameters of maize.

Assessment of effect of zinc on vegetative and reproductive parameters of maize.

Evaluation of interactive effects of nitrogen and zinc on vegetative and reproductive parameters of maize.

2. Material and methods

2.1. Site Description

The experiment was conducted in the rainy season of 2017 at Abaji in Federal Capital Territory of Nigeria (Latitude 8° 28' 0" N and Longitude 6° 57' 0" E). The annual rainfall is 1623 mm with distinct dry season of about 5 months beginning from November to March. The mean annual maximum temperature is 35.5°C (Ojanuga 2006). The soil is classified as Alfisol in the USDA Soil Classification system and the main soil sub group is rhodic haplustalf; consisting of gently undulating middle slope developed on basement complex rock made up of basalts. The soil surface is smooth, well drained and no bedrock exposed. Land use of the study area is arable farming and common vegetation are *Zea mays*, *Sorghum bicolor*, *Arachis hypogaea*, also found in the study area include *Andropogon gayanus*, *Brachairia brizantha*, *Cynedon dactylon*, *Stylosanthes gyanensis* and *Mucuna prurierris*.

2.2. Land Preparation

The land was cleared of all vegetation using cutlass and then piled in a specific spot outside the experimental plot and burnt. Experimental plots were marked out from the field. Ridging was done manually with hoe which provided good seedbed for seed germination and seedling development. Each plot size for the experiment was 3m by 3m (9m²). Spacing of the plots were 0.5m within row and 1m between rows. The total area for the experimental plot size was 55.5m X 29m (1609.5m²).

2.3. Experiment Layout

The experiment design was factorial in Randomized Complete Block Design (RCBD). There were eight treatment combinations (4 levels of N x 2 levels of Zn) (Table 1) which were replicated three times to give a total of twenty four plots (Figure 1).

2.3.1. Planting

SAMMAZ-27 maize variety seeds were sown two seeds per hole at 2.5cm depth and spacing were 25 cm X 100 cm. The plants were thinned to one plant per stand at two weeks after sowing (2WAS).

2.3.2. Fertilizer Application

Single Superphosphate (SSP), Moriate of Potash (MOP) and ZnSO₄ at the rate of 60kg/ha⁻¹ P₂O₅ 60kg/ha⁻¹ K₂O and Zn were applied at 2 WAS. Four N Levels namely: N₁ (0kg/ha), N₂ (40kg/ha), N₃ (80kg/ha) and N₄ (120kg/ha) were applied with urea in split doses at two weeks after sowing (2 WAS) and six weeks after sowing (6 WAS). Two Zinc micro nutrient level were assessed (M₁ (0kg/ha) and M₂ (2kg/ha)) and was applied at 2 WAS (Table 1). Fertilizers were applied by side dressing, 5cm away from the plants and at 15cm depth.

2.3.3. Weeding

Weeding was done two times at two weeks after planting and the second weeding was at four weeks after planting. The first and second weeding were done manually with hoe.

Table1 levels of nutrients application

Treatments	levels of nutrient application
N1M1	0kg N / ha + 0kg Zn / ha
N1M2	0kg N / ha + 2kg Zn / ha
N2M1	40kg N / ha + 0kg Zn / ha
N2M2	40kg N / ha + 2kg Zn / ha
N3M1	80kg N / ha + 0kg Zn / ha
N3M2	80kg N / ha + 2kg Zn / ha
N4M1	120kg N / ha + 0kg Zn / ha
N4M2	120kg N / ha + 2kg Zn / ha

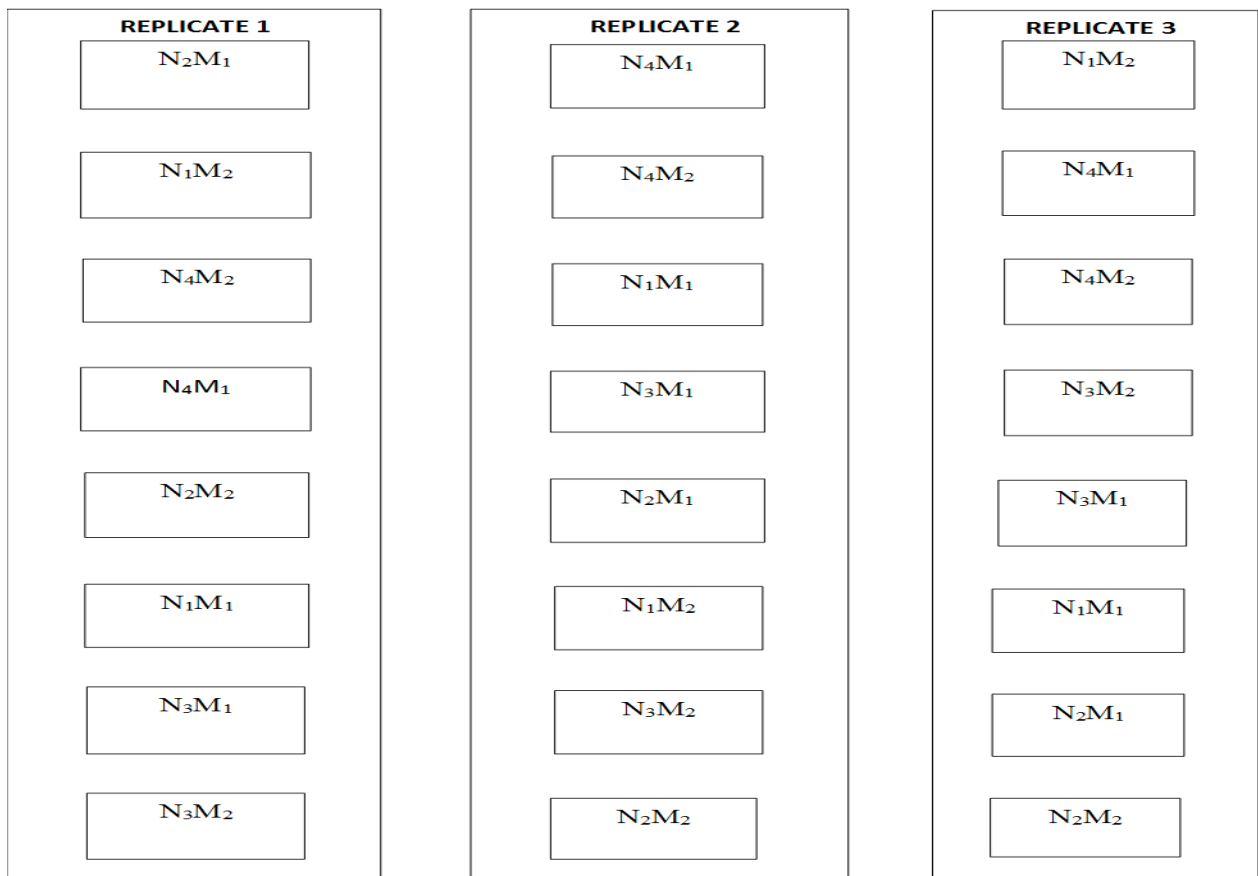


Figure 1 Experimental layout and treatment combinations

2.4. Growth Analysis

In the field, the growth parameters of the plants per plot i.e. plant height, number of leaves and plant girth were measured and recorded at intervals of two weeks after sowing until tasseling to show the response of maize variety to various treatment.

2.4.1. Plant heights

Five plants were randomly selected and tagged per plot and the heights were measured at two weeks interval after sowing until tasseling (6WAS).

2.4.2. Number of leaves

Number of leaves were counted and recorded from randomly selected sample plants per plot at two weeks intervals from two weeks after sowing until tasseling.

2.4.3. Plant girths

Diameters of five randomly selected and tagged plants per plot were measured and recorded at two weeks intervals after sowing until tasseling. The measurements were done at the base of the stalk.

2.5. Plant Yield Analysis

At week ten after sowing, the plants have fully matured and dried, harvesting was done at various plots using cutlass. All maize plants within the net plots (Five plants per plot) were cut at above ground level and the cobs harvested. Number of cobs harvested, and dry weight of cobs, 1000 grain and stovers were recorded.

2.6. Statistical analysis

All data collected from the experiments were subjected to Analysis of Variance (ANOVA) using R statistical software version 3.4.2. Significant treatment means were separated using the Duncan Multiple Range Test (DMRT).

3. Results and discussion

3.1. Effects of Nitrogen and Zinc on growth parameters

Nitrogen and Zinc sole factor influences on Number of leaves at 2WAS, 4WAS and 6WAS showed no statistically significant difference (Table 2). However, there interactive effects were significantly different with highest number of leaves being recorded on plots treated with N₃M₁ and lowest on plots with N₁M₂.

Table 2 Effects of Nitrogen (N) and Zinc (M) on Maize growth

Treatments	Number of Leaves			Plant Height (cm)			Stem Girth (cm)		
	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS	2WAS	4WAS	6WAS
Interactions									
N ₁ M ₁	6.00 ^a	9.67 ^a	11.67 ^{ab}	5.80 ^a	23.47 ^a	74.47 ^{bc}	3.33 ^a	5.60 ^a	7.20 ^a
N ₁ M ₂	5.67 ^a	9.67 ^a	11.33 ^b	4.73 ^a	25.67 ^a	67.87 ^c	3.07 ^a	5.53 ^a	7.23 ^a
N ₂ M ₁	5.67 ^a	9.33 ^a	11.67 ^{ab}	4.80 ^a	24.33 ^a	75.00 ^{bc}	3.47 ^a	5.90 ^a	7.97 ^a
N ₂ M ₂	5.67 ^a	9.67 ^a	12.00 ^{ab}	5.47 ^a	25.00 ^a	78.60 ^{abc}	3.47 ^a	5.67 ^a	7.90 ^a
N ₃ M ₁	5.67 ^a	9.33 ^a	12.67 ^a	6.20 ^a	24.33 ^a	87.00 ^a	3.20 ^a	5.97 ^a	7.70 ^a
N ₃ M ₂	5.33 ^a	9.67 ^a	12.00 ^{ab}	5.27 ^a	24.07 ^a	85.43 ^{ab}	3.07 ^a	5.83 ^a	7.90 ^a
N ₄ M ₁	5.33 ^a	9.33 ^a	12.00 ^{ab}	5.67 ^a	24.87 ^a	85.67 ^{ab}	3.20 ^a	5.60 ^a	8.50 ^a
N ₄ M ₂	5.33 ^a	9.67 ^a	12.00 ^{ab}	5.67 ^a	24.87 ^a	86.80 ^a	3.07 ^a	6.13 ^a	8.43 ^a
Nitrogen									
N ₁	5.83 ^a	9.67 ^a	11.50 ^a	5.27 ^a	24.57 ^a	71.17 ^b	3.20 ^a	5.57 ^a	7.22 ^b
N ₂	5.67 ^a	9.50 ^a	11.83 ^a	5.13 ^a	24.67 ^a	76.80 ^b	3.47 ^a	5.78 ^a	7.93 ^{ab}
N ₃	5.50 ^a	9.50 ^a	12.33 ^a	5.73 ^a	24.20 ^a	86.22 ^a	3.13 ^a	5.90 ^a	7.80 ^{ab}
N ₄	5.33 ^a	9.50 ^a	12.00 ^a	5.67 ^a	24.37 ^a	86.23 ^a	3.13 ^a	5.87 ^a	8.47 ^a

Zinc									
M ₁	5.67 ^a	9.42 ^a	12.00 ^a	5.62 ^a	24.25 ^a	80.53 ^a	3.30 ^a	5.77 ^a	7.84 ^a
M ₂	5.50 ^a	9.67 ^a	11.83 ^a	5.28 ^a	24.90 ^a	79.68 ^a	3.17 ^a	5.79 ^a	7.87 ^a

Effects of Nitrogen and Zinc nutrients at different rates of application on plant height of maize are presented in Table 2. Rates of Nitrogen applications on various plots have no significant effect on the plant height at 2WAS and 4WAS, but at 6WAS, N₄ treatments provided tallest plant than other treatments and N₂ had the lowest plant height. Zinc rates treatments on various plots provided no effect on plant height at all the evaluated weeks after sowing. The interactive effects of Nitrogen and Zinc were significant at 6 WAS where result of N₃M₁ provided the tallest plant and N₁M₂ recorded the shortest.

Nitrogen rates have no significant effect on stem girth at 2WAS and 4WAS, but was significant at 6 WAS with N₄ having the highest. However, applications of Zinc rates on various plots have no statistically significant effect on stem girth at 2WAS, 4WAS and 6WAS. Values of Nitrogen and Zinc interactions on stem girth have shown no significant effect at all the weeks assessed.

3.2. Effects of Nitrogen and Zinc on yield parameters

Influences of Nitrogen and Zinc rate on dry Stover weight at harvest are presented in Table 3. Nitrogen application rates on various plots showed no significant difference on maize Stover weight at harvest. Also, Zinc application doesn't give any significant impacts on Stover weight. The interactive effects of Nitrogen and Zinc on Stover weight were statistically significant. Plots with N₃M₂ recorded highest Stover weight and N₂M₂ has lowest.

Rates of N application have significant effects on maize cob weight with plots with N₄ recording the highest weight (1.52kg) and N₂ had the lowest (1.33kg). Application of Zinc shows no significant effect on cob weight. Results of interactive effect of Nitrogen and Zinc on cob weight show significant effects on cob weight on various plots. Plots that recorded the highest and lowest cob weights were treated with N₃M₁ and N₂M₂ respectively (Table 3).

Table 3 Nitrogen (N) and Zinc (M) on Maize Yield

Treatments	Stover weight (kg)	Cob weight (kg)	Cob length (cm)	Cob breath (cm)	Shelling weight (kg)	1000 Grain weight (kg)
Interactions						
N ₁ M ₁	2.33 ^a	1.30 ^{bc}	14.83 ^c	6.33 ^c	0.63 ^{cd}	0.50 ^a
N ₁ M ₂	1.80 ^{ab}	1.33 ^{bc}	15.33 ^{bc}	6.67 ^{bc}	0.67 ^{cd}	0.50 ^a
N ₂ M ₁	2.00 ^{ab}	1.40 ^{abc}	15.67 ^{bc}	6.50 ^{bc}	0.63 ^{cd}	0.50 ^a
N ₂ M ₂	1.60 ^{ab}	1.27 ^c	14.83 ^c	6.83 ^{abc}	0.60 ^d	0.47 ^a
N ₃ M ₁	1.88 ^{ab}	1.60 ^a	18.33 ^a	8.00 ^{ab}	0.87 ^{abc}	0.50 ^a
N ₃ M ₂	2.33 ^a	1.33 ^{bc}	16.00 ^{bc}	7.33 ^{abc}	0.73 ^{bcd}	0.47 ^a
N ₄ M ₁	1.42 ^{ab}	1.53 ^{ab}	17.83 ^{ab}	8.00 ^{ab}	1.00 ^a	0.50 ^a
N ₄ M ₂	1.83 ^{ab}	1.50 ^{abc}	17.67 ^{ab}	8.33 ^a	0.97 ^{ab}	0.50 ^a
Nitrogen						
N ₁	2.07 ^a	1.32 ^b	15.08 ^b	6.50 ^c	0.65 ^{bc}	0.50 ^a
N ₂	1.80 ^a	1.33 ^b	15.25 ^b	6.67 ^{bc}	0.62 ^c	0.48 ^a
N ₃	2.11 ^a	1.47 ^{ab}	17.17 ^a	7.67 ^{ab}	0.80 ^b	0.48 ^a
N ₄	1.63 ^a	1.52 ^a	17.75 ^a	8.17 ^a	0.98 ^a	0.50 ^a
Zinc						
M ₁	1.91 ^a	1.46 ^a	16.67 ^a	7.21 ^a	0.78 ^a	0.50 ^a
M ₂	1.89 ^a	1.36 ^a	15.96 ^a	7.29 ^a	0.74 ^a	0.48 ^a

Rates of Nitrogen application on plots have shown significant effect on cob length (Table 3). Plots N₄ recorded the highest cob length while N₂ have the least. Zinc application on various plots however showed no significant effect on cob length. Cob length show significant effect on various plots due to the interactive effect of Nitrogen and Zinc application at different rates. Plots with treatment N₃M₁ have the highest cob length and N₂M₂ have lowest.

Various Nitrogen rates showed significant influence on maize cob breadth. Plots with treatments N₄ and N₂ obtained highest and lowest cob breadth respectively. Zinc application showed no statically significant difference. The interaction between Nitrogen and Zinc indicated significant effect on cob breadth. Plots treated with N₄M₂ recorded the highest cob breadth and plots with N₂M₁ recorded lowest.

Results of Nitrogen applications showed significant impacts on maize shelling weight. Plots treated with N₄ have the highest shelling weight and N₂ plots have lowest. Zinc has no significant impacts on shelling weight. Combined effects of Nitrogen and Zinc on shelling weight have statistically significant difference. Values showed that plots with treatment N₄M₁ have the highest shelling weight and N₂M₂ recorded the least weight.

Grain weights of 1000 seeds showed no significant difference on plots when treated with various Nitrogen and Zinc fertilizer.

4. Conclusion

Nitrogen is a major limiting nutrient for maize production in the tropics. This study revealed that Nitrogen application at the rate of 80 kg/ha gave the optimum growth and yield of maize in Abaji, Federal Capital Territory (FCT), Nigeria. The fortification of the fertilizer blends with Zinc micronutrient at 2kg/ha gave no significant impacts on growth and yield of maize. Farmers in the study area need to adopt the recorded optimum Nitrogen rate to enhance efficient land, fertilizer utilization and adequate maize yield. Further studies should evaluate impacts of nutrient application on soil properties and nutrient uptake.

Compliance with ethical standards

Acknowledgments

This study received no external funding source.

Disclosure of conflict of interest

The authors declare no conflict of interest.

References

- [1] Adeboye, M.K.A. Status of total and available boron and zinc in the soils of the Gongola river basin of Nigeria. *Savannah Journal of Agriculture*. 2011; 6(1):47-57.
- [2] Alam, M.M., Ladha, J.K., Foyjunnessa, Rahman, Z., Khan, S.R., Harun-ur-Rashid, Khan, A.H. and Buresh, R.J. Nutrient management for increased productivity of rice wheat cropping system in Bangladesh *Field Crop. Res.* 2006; 96:374-386.
- [3] Amhakhian, S. O., Oyewole, C.I. and Isitekhale, H.H. Effects of Different Levels of Phosphorus on The Growth and Yield of Maize (*Zea mays l.*) In Ofere (Basement Complex) Soils Kogi State, North Central Ecological Zone, *Nigeria Continental J.Agricultural Science* vol. 2010; 4:20 – 28.
- [4] Cadoni, P. and Angelucci, F. Analysis of incentives and disincentives for Maize in Nigeria. Technical notes series, Rome: MAFAP, FAO. 2013; Pp. 41.
- [5] Collier, P., Conway, G., and Venables, T. Climate Change and Africa. *Oxford Review of Economic Policy* 2008; 24 (2):337-353. <http://dx.doi.org/10.1093/oxrep/grn019>.
- [6] Dambreville C., Morvan T. and Germon J.C. N₂O emission in maize-crops fertilized with pig slurry, matured pig manure or ammonium nitrate in Brittany. *Agr. Ecosyst. Environ.* 2008; 123: 201-210.

- [7] De Paz, J.M. and Ramos, C. Simulation of nitrate leaching for different nitrogen fertilization rates in a region of Valencia (Spain) using a GISGLEAMS system. *Agr. Ecosyst. Environ.* 2004; 103:59-73.
- [8] Fageria, N.K., Baliger, V.C. and Clark, R.B. Micronutrients in crop production. *Advances in Agronomy.* 2002; 77: 185-268.
- [9] FAO *Micronutrients*. FAO Fertilizer and Plant Nutrition Bulletin 7, Rome Italy. 1983; Pp. 82.
- [10] Hillin, C.K. and Hudak, P.F. Nitrate contamination in the seymour aquifer, northcentral texas, USA. *Bull. Environ. Contam. Tox.* 2003; 70:674-679.
- [11] Kparmwang, T., Esu, I.E. and Chude, V.O. Available and total forms of copper and zinc in basaltic soils of the Nigerian savanna. *Communication in Soil Science and Plant Analysis.* 1998; 26(17/18):2783-2796.
- [12] Lungu O.I.M and Dynoodt R.F.P. Acidification from long-term use of urea and its effect on selected soil properties. *African Journal of Food Agriculture Nutrition and Development.* 2008; 8(1).
- [13] Makokha, S., Kimani, S., Mwangi, S., Verkuijil, H. and Musembi, F. Determination of fertilizer and manure use in maize production in Kiambu District Kenya. Mexico, D.F: International Maize and Wheat Improvement Centre (CIMMYT) and Kenya Agricultural Research Institute (KARI). 2001
- [14] Mucheru-Muna, M.W., Pypers, P., Mugendi, D., Kung'u, J., Mugwe, J., Merckx, R., and Vanlauwe, B. A staggered maize- legume intercrop arrangement robustly increases crop yields and economic returns in the highlands of Central Kenya. *Field Crops Research.* 2010; 115:132-139.
- [15] Mucheru-Muna, M.W., Mugendi, D., Pypers, P., Mugwe, J., Kung'u, J., Vanlauwe, B., and Merckx, R. Enhancing maize productivity and profitability using organic inputs and mineral fertilizer in central Kenya small- hold fields. *Experimental Agriculture.* 2014; 50:250-269.
- [16] Mugendi, D.N., Kanyi, M.K., Kung'u, J.B., Wamicha, W. and Mugwe, J.N. Mineral-N movement and management in an agroforestry system in central highlands of Kenya. In: Proceedings for soil science society of East Africa Conference, Mombasa, 4 Mombasa, 2003; 4-8 December 2000: Pp. 287-297.
- [17] Mugwe J., Mugendi D., Kungu J. and Mucheru-Muna M.M. Maize yields response to application of organic and inorganic input under on-station and on-farm experiments in central Kenya. *Expl. Agric.* 2009; 45:47-59.
- [18] Ojanuga, A.G. Agroecological Zones of Nigeria Manual. In: Berding F and Chude VO (eds) National Special Programme for Food Security (NSPFS) and FAO 2006.
- [19] Oldema, L.R., Hakkeling, R.T.A. and Sombrock, W.G. Global Assessment of Soil Degradation, (2nd edn.), international Soil Reference and Information Centre, Wageningen, United Nations Environmental Programme Nairobi. 1991.
- [20] Palm, C.A., Myers, R.J.K. and Nandwa. S.M. Combined Use of Organic and Inorganic Nutrient Sources for Soil Fertility Maintenance and Replenishment. In: Buresh, R. J., and Sanchez, P. A., (Eds). Replenishing soil fertility in Africa. *Soil Science Society of America and American Society of Agronomy*, Madison, Wisconsin, U.S.A. 1997; pp. 193-217.
- [21] Shanahan J.F., Kitchen N.R., Raun W.R. and Schepers J.S. Responsive in-season nitrogen management for cereals. *Computers and Electronics in Agriculture.* 2008; 61(1):51-62.
- [22] Sims, J.T. and Johnson, G.V. 1991. Micronutrient soil test. In: J.J. Mortvedt, F.R., Cox, L.M. Shuman and R.M. Welch (editors), *Micronutrients in Agriculture.* (2nd ed.), Soil Science Society of America. Book series: 4 Madison, Wisconsin, USA.