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IMPLICATIONS OF N, P, K, AND NPK COMBINED ON CASSAVA (*MANIHOT ESCULENTA* CRANTZ) ROOT YIELD AND SOIL NUTRIENT STATUS

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ABSTRACT

In Nigeria, the ever increasing demand for cassava to meet the industrial and domestic needs of the people, has necessitated the need to accord cassava husbandry, more research attention in order to raise the present level of cassava yield on farmers' farms. To partly meet this need, this study was designed to evaluate efficacy of N, P, K, and NPK combined in improving cassava root yield and soil fertility status. The experiment was laid out in a randomized complete block design with three replicates. The different nutrient elements included: N, P, K, NPK combined and control or check (C). The results obtained indicated existence of significant ($P = 0.05$) differences among the nutrient elements with respect to their effects on nutrient status of an Alfisol and cassava root yield. At the end of 2012 cropping season, nutrient elements significantly increased soil organic carbon (SOC) from 0.40 g kg^{-1} for C to 0.51, 0.59, 0.64 and 0.47 g kg^{-1} for N, P, K, and NPK, respectively. Similarly, at the end of 2013 cropping season, nutrient elements significantly increased SOC from 0.35 g kg^{-1} for C to 0.45, 0.54, 0.60 and 0.40 g kg^{-1} for the respective N, P, K, and NPK. At the end of 2012 cropping season, nutrient elements significantly increased total N from 0.35 g kg^{-1} for C to 0.46, 0.36, 0.35 and 0.41 g kg^{-1} for N, P, K, and NPK, respectively. At the end of 2013 cropping season, nutrient elements significantly increased total N from 0.32 g kg^{-1} for C to 0.42, 0.32, 0.33 and 0.37 g kg^{-1} for N, P, K, and NPK, respectively. Mean values of cassava root yield data across the two years of experimentation indicated that, nutrient elements significantly increased cassava root yield from 6.40 t ha^{-1} for C to 7.25, 6.90, 7.70 and 7.90 t ha^{-1} for N, P, K, and NPK, respectively.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a heavy feeder crop; exploiting large volume of soil for nutrients, especially, nitrogen and potassium and water (Obisegbor, 2014, Alasa, 2014). It follows therefore, that continuous cassava cultivation will result in nutrient depletion or exhaustion, except an adequate fertilizer input, involving addition of organic and/ or inorganic fertilizers is embarked upon. The ability of cassava plant to forage for nutrients from impoverished tropical soil has remained its chief attribute (Irwin, 2009; Baduf, 2011; Tera, 2014). The ability of cassava to maintain relatively high potassium and nitrogen in dry matter production and the ability to regulate its growth under low nutrient supply conditions, are the special features that are responsible for cassava adaptation to low fertility status (Irwin, 2009; Baduf, 2011; Tera, 2014). Cassava, however, benefits from fertilization, especially N – and K – fertilization (Obisegbor, 2014; Alasa, 2014).

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Wirta and Aga (2012) and Irwin (2014) reported significant growth responses of cassava to nitrogen at 22 kg N ha^{-1}, in the derived savanna zone of southwestern Nigeria. Abesuya (2010) and Deysil (2012) showed that shoot growth responded strongly and root growth moderately to applied N, resulting in high shoot/root ratios. Adequate N supply promotes growth, and hence, yield, but excess N, either added or native to the soil, has favoured shoot growth at the expense of root yield (Oyekanmi, 2008; Obigbor, 2010). Uptake of phosphorus by cassava is usually low, relative to the other nutrients. The element, however, plays an important role in the development of efficient root system (Obigbor, 2010). Kim *et al*. (2013) noted that the omission of P from fertilizer mixtures resulted in the poorest yields and a reduction in starch content parallel to a fall in root weight. Essien (2009) observed a marked reduction in the root yield of cassava in an experiment to evaluate the effects of a continuously maintained P – stress on root bulking in cassava. Eledan (2009) and Asoro (2013) reported a quadratic root yield and a linear foliage response to P application, thus, indicating that foliage production is more responsive to P than root production.

Relative to N and P, potassium is absorbed by cassava in large amounts. Nitis (2012) reported significant root yield responses to applied K in soil where the level of extractable K was low. The tremendous quantities of K removed in cassava tubers at harvest, the significant reduction in cassava root yield due to K deficiency, as well as the extraction of a lot of K by cassava from the soil system, testify to the significance of K in mineral nutrition of cassava (Ogedengbe, 2012; Melanby, 2013). High K concentration is known not only to sustain high root yield, but also resists cassava bacteria blight (CBB) (Ogedengbe, 2012) and cassava anthracnose disease (CAD) (Iyayi, 2008; Bada, 2013). K – fertilization has been reported to improve the quality of cassava by reducing the glucoside content of roots (Melanby, 2013). Sughai (2010) and Bada (2013) obtained 20 – 27% reduction in HCN content in cassava variety, TMS 60506 on application of 100 kg K_2O ha^{-1}.

Combination of N, P and K in fertilizer mixtures has been reported to give better quality and higher root yield of cassava. Sughai (2010) and Nitis (2012) indicated that efficiency of each nutrient proved to be highly dependent on the amount of other nutrients available, particularly nitrogen and potassium. Numerous investigations have established better utilization of P by crops in the presence of N (Sena, 2009; Obigbor, 2010). Tissa (2012) and Makitt (2013) reported 36% increase in dry matter root yield from NPK combined, as against 11% increase for N alone. In Nigeria, the ever increasing demand for cassava to meet the industrial and domestic needs of the people, has necessitated the need to accord cassava husbandry, research attention in order to raise the present level of cassava yield on farmers' farms. To partly meet this need, this study was designed to evaluate efficacy of N, P, K, and NPK combined in improving cassava root yield and soil fertility status.

MATERIALS AND METHODS

Study site: A two – year field experiment was conducted at the Teaching and Research Farm of the Ekiti State University, Ado – Ekiti, Ekiti State, Nigeria, during 2012 and 2013 cropping seasons. The soil of the study site belongs to the broad group Alfisol (SSS, 2003). The site had earlier been cultivated to arable crops, among which were maize, cassava, sweet potato, cocoyam, melon etc before it was allowed to fallow for four years. During the fallow period, cattle, sheep, and goat used to graze on the fallow land. At the commencement of this study, the fallow vegetation was manually cleared, after which the land was ploughed and harrowed.

Collection and analysis of soil samples: Prior to 2012 cropping season, ten core soil samples, randomly collected from 0 – 15 cm soil depth, were bulked inside a plastic bucket to form a composite sample, which was analyzed for chemical properties. At the end of 2012 and 2013 cropping seasons, another sets of soil samples were collected in each treatment plot and analyzed. The soil samples were air – dried, ground, and passed through a 2 mm sieve. The processed soil samples were analyzed in accordance with the soil analytical procedures, as outlined by the International Institute of Tropical Agriculture (IITA) (1989).

Experimental design and treatments: The experiment was laid out in a randomized complete block design with three replicates. The different nutrient elements included: N, P, K, and NPK combined and control or check (C). The source of N was urea (100 kg ha^{-1}), the source of P was single superphosphate (100 kg ha^{-1}), the source of K was muriate of potash (100 kg ha^{-1}), while NPK was applied at the rate of 400 kg ha^{-1} (Nitis, 2012). The fertilizer materials were applied in two split doses, at two and four months after planting (MAP). Each plot size was 4 m x 4 m.

Planting, weeding, collection and analysis of data: Planting was done on March 1 and March 3 in 2012 and 2013, respectively. Stem – cuttings (20 cm long each) of early maturing cassava variety, Tropical Manihot Series (TMS) 30572, obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, were planted on the flat, at 1 m x 1 m (10,000 cassava plants ha^{-1}). Weeding was done manually at 1, 2, 3, 4 and 5 MAP, using a hoe. At harvest (12 MAP), data were collected on cassava root yield and yield components. All the data collected were subjected to analysis of variance (ANOVA), and treatment means were compared, using the Duncan Multiple Range Test (DMRT) at 5% level of probability

RESULTS

Table 1. The chemical properties of soil in the study site prior to 2012 cropping season

Soil properties	Values
pH	6.3
Organic carbon (g kg^{-1})	0.89
Total nitrogen (g kg^{-1})	0.62
Available phosphorus (mg kg^{-1})	0.73
Exchangeable bases (cmol kg^{-1})	
Potassium	0.60
Calcium	0.54
Magnesium	0.51
Sodium	0.43
Exchangeable Acidity	0.26
Effective Cation Exchangeable Capacity (ECEC)	2.34

Soil nutrient status as affected by N, P, K, and NPK combined after 2012 and 2013 cropping seasons

Tables 2 and 3 show the effects of N, P, K, and NPK on nutrient status of soil in the study site after 2012 and 2013 cropping seasons. At the end of 2012 cropping season, nutrient elements significantly increased soil pH from 3.6 for C to 4.6, 5.1, 5.6 and 4.1 for N, P, K, and NPK, respectively. At the end of 2013 cropping season, nutrient elements significantly increased soil pH from 3.1 for C to 4.3, 4.8, 5.3 and 3.8 for N, P, K, and NPK, respectively. At the end of 2012 cropping season, nutrient elements significantly increased soil organic carbon (SOC) from 0.40 g kg^{-1} for C to 0.51, 0.59, 0.64 and 0.47 g kg^{-1} for N, P, K, and NPK, respectively. Similarly, at the end of 2013 cropping season, nutrient elements significantly increased SOC from 0.35 g kg^{-1} for C to 0.45, 0.54, 0.60 and 0.40 g kg^{-1} for the respective N, P, K, and NPK. At the end of 2012 cropping season, nutrient elements significantly increased total N from 0.35 g kg^{-1} for C to 0.46, 0.36, 0.35 and 0.41 g kg^{-1} for N, P, K, and NPK, respectively. At the end of 2013 cropping season, nutrient elements significantly increased total N from 0.32 g kg^{-1} for C to 0.42, 0.32, 0.33 and 0.37 g kg^{-1} for N, P, K, and NPK, respectively.

Table 2. Soil chemical properties as affected by N, P, K, and NPK c ombined after 2012 cropping season

Treatments	pH	Org. C ($g\ kg^{-1}$)	Total N ($g\ kg^{-1}$)	Av. P ($mg\ kg^{-1}$)	Exchangeable bases ($cmol\ kg^{-1}$) K	Ca	Mg	Na
Check	3.6e	0.40e	0.35c	0.55c	0.30b	0.35a	0.30a	0.23a
N	4.6c	0.51c	0.46a	0.61b	0.33b	0.36a	0.29a	0.25a
P	5.1b	0.59b	0.36c	0.67a	0.31b	0.34a	0.33a	0.25a
K	5.6a	0.64a	0.35c	0.60b	0.41a	0.36a	0.31a	0.27a
NPK	4.1d	0.47d	0.41b	0.65a	0.42a	0.35a	0.30a	0.28a

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05 (DMRT).

Table 3. Soil chemical properties as affected by N, P, K, and NPK combined after 2013 cropping season

Treatments	pH	Org. C ($g\ kg^{-1}$)	Total N ($g\ kg^{-1}$)	Av. P ($mg\ kg^{-1}$)	Exchangeable bases ($cmol\ kg^{-1}$) K	Ca	Mg	Na
Check	3.1e	0.35e	0.32c	0.55c	0.24b	0.30a	0.25a	0.20a
N	4.3c	0.45c	0.42a	0.61b	0.27b	0.30a	0.24a	0.22a
P	4.8b	0.54b	0.32c	0.67a	0.28b	0.32a	0.28a	0.21a
K	5.3a	0.60a	0.33c	0.60b	0.38a	0.31a	0.28a	0.23a
NPK	3.8d	0.40d	0.37b	0.65a	0.37a	0.32a	0.27a	0.24a

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05 (DMRT).

Table 4. Cassava root yield and yield components as affected by N, P, K, and NPK combined at harvest

Treatments	Cassava root yield ($t\ ha^{-1}$) 2012	2013	Mean	Cassava root length (cm) 2012	2013	Mean	Cassava root diameter (cm) 2012	2013	Mean
Check	6.60e	6.20e	6.40	12.00e	11.80e	11.90	6.80e	6.60e	6.70
N	7.40c	7.10c	7.25	14.74c	14.54c	14.64	9.00c	8.84c	8.92
P	6.80d	6.60d	6.70	13.10d	12.88d	12.99	8.80d	8.60d	8.70
K	7.80b	7.60b	7.70	14.80b	14.50b	14.65	9.60b	9.30b	9.45
NPK	8.00a	7.80a	7.90	16.20a	16.00a	16.10	10.44a	10.20a	10.32

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05 (DMRT).

At the end of 2012 cropping season, nutrient elements significantly increased available P from 0.55 mg kg^{-1} for C to 0.61, 0.67, 0.60 and 0.65 mg kg^{-1} for N, P, K, and NPK, respectively. At the end of 2013 cropping season, nutrient elements significantly increased available P from 0.55 mg kg^{-1} for C to 0.61, 0.67, 0.60 and 0.65 mg kg^{-1} for the respective N, P, K, and NPK. At the end of 2012 cropping season, values of exchangeable K, adduced to nutrient elements were 0.30, 0.33, 0.31, 0.41 and 0.42 cmol kg^{-1} for C, N, P, K, and NPK, respectively. At the end of 2013 cropping season, values of exchangeable K, adduced to nutrient elements were 0.24, 0.27, 0.28, 0.38 and 0.37 cmol kg^{-1} for C, N, P, K, and NPK, respectively.

At the end of 2012 cropping season, values of exchangeable Ca, adduced to nutrient elements were 0.35, 0.36, 0.34, 0.36 and 0.35 cmol kg^{-1} for C, N, P, K, and NPK, respectively. At the end of 2013 cropping season, values of exchangeable Ca, adduced to nutrient elements were 0.30, 0.30, 0.32, 0.31 and 0.32 cmol kg^{-1} for C, N, P, K, and NPK, respectively. At the end of 2012 cropping season, values of exchangeable Mg, adduced to nutrient elements were 0.30, 0.29, 0.33, 0.31 and 0.30 cmol kg^{-1} for C, N, P, K, and NPK, respectively. At the end of 2013 cropping season, values of exchangeable Mg, adduced to nutrient elements were 0.25, 0.24, 0.28, 0.28 and 0.27 cmol kg^{-1} for C, N, P, K, and NPK, respectively. At the end of 2012 cropping season, values of exchangeable Na, adduced to nutrient elements were 0.23, 0.25, 0.25, 0.27 and 0.28 cmol kg^{-1} for C, N, P, K, and NPK, respectively.

At the end of 2013 cropping season, values of exchangeable Na, adduced to nutrient elements were 0.20, 0.22, 0.21, 0.23 and 0.24 cmol kg^{-1} for C, N, P, K, and NPK, respectively.

Cassava root yield and yield components as affected by N, P, K, and NPK combined at harvest

Table 4 shows the effects of N, P, K, and NPK combined on cassava root yield and yield parameters at harvest. Mean values of cassava root yield data indicated that, nutrient elements significantly increased cassava root yield from 6.40 t ha^{-1} for C to 7.25, 6.90, 7.70 and 7.90 t ha^{-1} for N, P, K, and NPK, respectively. Similarly, nutrient elements significantly increased cassava root length from 11.90 cm for C to 14.64, 12.99, 14.65 and 16.10 cm for the respective N, P, K and NPK. Nutrient elements significantly increased cassava root diameter from 6.70 cm for C to 8.92, 8.70, 9.45 and 10.32 cm for the respective N, P, K and NPK.

DISCUSSION

The chemical properties of soil in the study site, prior to cropping, indicated that the soil was slightly acidsic, with a pH of 6.3. The soil organic carbon (SOC) value of 0.89 g kg^{-1} was below the critical level of 7.6 g kg^{-1} for soils in Southwestern Nigeria (Adenle, 2010; Abbet, 2012). The total nitrogen content of 0.62 g kg^{-1} was below the critical level of 1.20 g kg^{-1}, according to Abbet (2012) and Lege (2012). The K status of 0.60 cmol kg^{-1} was above the critical level of 0.38 cmol kg^{-1} (Lege, 2012).

The Ca, Mg and Na contents were all below the established critical levels for soils in Southwestern Nigeria (Abbet, 2012; Liya, 2013). The lowest soil pH value for NPK fertilizer, of all the nutrient elements, can be attributed to acidifying effects of NPK fertilizer, as a result of its acid – forming nature, due to its N and P content (Heald, 2009; Abbet, 2012). Relative to the control treatment, the significant increases in soil organic carbon (SOC), adduced to N, P, K, and NPK combined, can be explained in the light of the significant increases in pH values of soil in the plots of N, P, K, and NPK combined.

This is because, previous studies (Exma, 2012; Agbeni, 2013) had established positive correlation between the rate of soil organic matter decomposition and pH of the soil medium, with the rate of organic matter decomposition increasing with increasing pH (i.e. decreasing acidity) of the soil medium. These authors also added that, the rate of organic matter decomposition becomes negligible at soil pH value below 5.1. So, the increasing pH values (decreasing acidity) of soil in the plots of N, P, K, and NPK combined, can be implicated for the observed significant increases in SOC value for N, P, K, and NPK combined, since this condition of increasing pH value may have enhanced microbial decomposition of organic matter of soil in the plots of N, P, K, and NPK combined, with resultant higher SOC value. The lowest available P value for the check or control treatment, can be attributed to the lowest pH value of soil in the check plots. This is because, the availability of P in the soil, depends on the pH of the soil medium, with available P decreasing with decreasing pH (Liya, 2013). The decreasing available P phenomenon, associated with increasing acidity or decreasing pH, is due to the conversion of P into unavailable forms under acid soil conditions, as a result of fixation by micro – nutrients, such as Fe and Al, which abound in acid soils (Lege, 2012; Liya, 2013).

Values of soil nutrients in the plots of N, P, K, and NPK combined, at the end of the second year cropping activities, were lower than what obtained at the end of the first year cropping activities, suggesting that, application of N, P, K, and NPK combined, unlike their organic fertilizer counterparts, did not produce any residual effects on soil. This implies that, soil fertility and crop production cannot be maintained or sustained on a long term basis through inorganic fertilization. Thus, to avert this problem of declined soil fertility, associated with inorganic fertilization, there is need for a judicious and balanced integrated application of organic and inorganic fertilizers to achieve sustainability of crop production. The highest cassava root yield and yield components, adduced to NPK combined, are in conformity with the findings of Tissa (2012) and Makitt (2013), who, in their studies on mineral nutrition of cassava, reported 36% increase in dry matter root yield from NPK combined, as against 11% and 19% increases for N and K alone, respectively. These observations can be attributed to better utilization of P by cassava plants in the presence of N (Sena, 2009; Obigbor, 2010). This is because Sughai (2010) and Nitis (2012) had indicated that efficiency of each nutrient proved to be highly dependent on the amount of other nutrients available, particularly nitrogen and potassium.

From the results of this study, it is apparent that, NPK combined gave the highest values of cassava root yield, suggesting the need for a judicious and balanced combination of these three nutrient elements in order to achieve the desired level of cassava root yield.

The lowest values of cassava root yield and yield components for P, agree with the findings of Tissa (2012) and Makitt (2013), who reported lowest cassava root yield and yield components for P, relative to N and K. This suggested that, although, P has been known to play crucial roles in the development of efficient root system in plants, however, as far as cassava root yield is concerned, P does not seem to play crucial roles in tuberization and bulking processes in cassava, unlike K. Eledan (2009) and Asoro (2013), in their studies on P nutrition of cassava, confirmed a quadratic root yield response and a linear foliage response to P application, thus, indicating that, foliage production is more responsive to P application than root production

The values of cassava root yield and yield components were lower at the end of the second year than the first year under the nutrient elements, and this can be adduced to declined soil fertility during the second year, as a result of nutrient removal by cassava during the first year cropping season. These observations testify to the assertions of Abbet (2012) and Liya (2013), who established that, soil fertility and crop yield tend to decline under continuous cropping, with or without application of inorganic soil amendment(s).

REFERENCES

Abbet, F.S. 2012. Biomass production and nitrogen fixation potentials of four cowpea varieties and their effects on maize yield in southwestern Nigeria. *International Journal of Soil Science and Land Development*, 67: 502 – 508.

Abesuya, C. O. 2010. Potassium nutrition and fertility aspects of cassava production in southwestern Nigeria. *Plant Nutrition and Fertilizer Research*, 21:231-237.

Adenle, E. O. 2010. The role of soil organic matter in sustainable arable farming in the tropics. *Soil and Crop Science Researc*, 41(2): 56 – 63.

Agbeni, T. O. 2013. Improving the fertility status of a degraded acid Alfisol and cocoyam performance through application of plant residues and inorganic fertilizers. *Agricultural Science Journal*, 23: 653 – 658.

Asoro, M. J. 2013. The potassium requirements of cassava (*Manihot esculenta* Crantz). *Journal of FoodTechnology and Applied Science*,10(2): 45 – 52.

Bada, S. O. 2013. Study on mineral nutrition of cassava. *Journal of Forestry and Crop Science*,12:243 – 250.

Baduf, R.I. 2011. Study on mineral nutrition of cassava under different tillage practices. *International Journal of Science and Technology*, 23(2):552 – 558.

Deysil, A. D. 2012. The effects of nitrogen nutrition on the development of soil acidity in southwestern Nigeria. *Soil Chemistry*, 58:1082 – 1088.

Eledan, A. M. 2009. Microbial biomass and mineral N transformation in soil planted with turnips. *Biochemistry Journal*, 56: 181 – 187.

Essien, B. V. 2009. Influence of NPK fertilizer on cassava anthracnose disease (CAD). *Crop Science*, 13:6 – 13.

Exma, L. K. 2013. Responses of an acid Alfisol and maize yield to wood – ash based soil amendments. *Journal of Food and Agricultural Research*, 22:321 – 328.

field in southwestern Nigeria. *International Journal of Food and Agricultural Sciences*. 67: 1222 – 1228.

Heald A. N. 2009. Uptake of soil nitrogen by groundnut as affected by symbiotic N–fixation. *Soil Biochemistry*, 44:1111 – 1118.

International Institute of Tropical Agriculture (IITA) 1989. Automated and semi – automated methods of soil and plant analysis. *Manual Series,* No 7, IITA, Ibadan, Nigeria.

Irwin, B.Y. 2009. Fertilization and mineral nutrition of cassava. *Fertilizer and Food Science Research*,16(1):342 – 349.

Iyayi, A. N. 2008. Effects of inorganic fertilization on hydrocyanic acid content of cassava root. *Journal of Agriculture and Food Science*, 15(2):330 – 336.

Kim, L. O., Besar O. and Aseri, M. P. 2013. Crop residues types and placement methods on mineralization of soil organic matter. *Soil Microbiology*, 48: 1222 -1228.

Lege, B. N. 2012. Soil chemical properties as affected by phosphorus and nitrogen- based manure and compost application. *Soil Science Research*, 71: 666 – 673.

Liya, A. M. 2013. Microbial biomass and mineral N transformation in soil planted with turnips. *Biochemistry Journal*, 56: 181 – 187.

Makitt, B. J. 2013. Growth and yield responses of cassava to fertilizer types in southwestern Nigeria. *Plant Nutrition and Crop Improvement*, 23:444 – 449.

Melanby, U. A. 2013. Assessing cassava growth and root yield performance under mineral nutrition. *Crop Physiology*, 5:67 – 73.

Nitis, A. A. 2012. Effects of farmyard manure and nitrogen fertilizer on growth, yield and anthracnose disease of cassava. *Crop Science Research*, 8(2):12 – 19.

Obigbor, A. N. 2010. Uptake of soil nitrogen by groundnut as affected by symbiotic N – fixation. *Soil Biochemistry*, 44:1111 – 1118.

Obisegbor, N. B. 2014.Trends of cassava responses to fertilization in southwestern Nigeria. *Journal of Biology and Physical Sciences*, 19:412 – 418.

Ogedengbe, W. J. 2012. Study on fertilizer effects on yield and nutrient content of cassava. *Journal of Root and Tuber Crops*, 23:332 – 338.

Oyekanmi, P.O. 2008: Soil fertility and cassava yield performance under different weed species in a cassava. *Food and Agricultural Science Research*,12:1 – 6.

Robertson, C.A., Cruse, R. M. and K. A. Kohler 1994. Soil management. In: Hatfield, J.L. Karlen, D.L. (eds.). *Sustainable Agricultural Systems*, Lewis Publishers, CRC Press, Boca Raton, F.L. USA, pp. 109 – 134.

Sena, O. O. 2009. Study on N, P, and K nutrition of cassava in Eastern Nigeria. *International Journal of Food Technology and Agricultural Research*, 21(2):342 – 349.

Soil Survey Staff (SSS) 2003. Keys to soil taxonomy, 9th edition. United States Department of Agriculture and Natural Resources Conservation Services, US Department of Agriculture, Washington D. C. 306 pp.

Sughai, I. G. 2010. Effects of fertilizer types on bacterial blight and root yield of cassava. *Crop Protection,* 11(2):1 – 6.

Tera, M. I. 2014. Influence of K fertilizers on the yield and chemical composition of cassava root. *Crop Improvement*, 12(1):22 – 28.

Tissa, B. S. 2012. Effects of poultry manure and NPK fertilizer on maize grain yield and soil chemical properties. *Journal of Food and Agricultural Sciences*, 65: 722 – 728.

Wirta, G. I. and Aga, B. M. 2012. Evaluating potentials of organic wastes as nutrient sources in improving soil fertility and maize yield. *International Journal of Food Science and Agricultural Research,* 23:45 – 53

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