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RESEARCH ARTICLE

CHANGES IN SOIL FERTILITY STATUS AFTER FIVE YEARS OF CONTINUOUS CROPPING

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ABSTRACT

Knowledge of the kinds and quantities of nutrient elements removed from the soil system by crops during the growing period is critical to determining crop nutrient requirements, and hence, fertilizer recommendation. In view of this, this study was designed to appraise the influence of five years of continuous cropping on fertility status of an Alfisol. The experiment was carried out at the Teaching and Research Farm of the Ekiti State University, Ado –Ekiti, Ekiti State, Nigeria, between 2009 and 2014. The experiment was laid out in a randomized complete block design with three replications. The five -year- continuous cropping treatments included: continuous yam cultivation (CYC); continuous cassava cultivation (CCC); continuous maize cultivation (CMC); continuous cowpea cultivation (CC_oC); and natural fallow, which served as the check or control (C). The results indicated existence of significant (P = 0.05) differences among the five years of continuous cropping treatments as regards their effects on soil fertility status. Relative to the control, five years of continuous cropping significantly (P = 0.05) reduced soil organic carbon (SOC) from 2.93 g kg^{-1} for C to 0.32, 0.38, 0.25 and 0.46 g kg^{-1} for CYC, CCC, CMC, and CC_oC, respectively. Similarly, continuous cropping resulted in significant decreases in total N from 1.89 g kg^{-1} for C to 0.24, 0.29, 0.19 and 0.93 g kg^{-1} for the respective CYC, CCC, CMC and CC_OC. Continuous cropping significantly reduced available P from 0.66 mg kg^{-1} for C to 0.50, 0.62, 0.26 and 0.20 mg kg^{-1} for CYC, CCC, CMC and CC_OC, respectively.

Key Words: Continuous, Cropping, Fertility, Soil, Status.

INTRODUCTION

Empirical evidence from many parts of the world has indicated that, continuous cropping, without fertilizer input results in declined soil fertility and crop productivity. Studies by Tare (2009); Ation (2013) and Nair (2014) had established that, the rate of soil fertility decline under continuous cropping, depends on the population density and species of crops. For instance, Ation (2013) and Nair (2014) reported significant decreases in soil fertility, following five years of continuous cultivation of maize, cassava and yam. The authors also noted that, the problem of soil fertility decline, associated with continuous cropping became increasingly aggravated by increasing planting density of these crops.

However, Irwin (2010); Beader (2013); Adaso (2014) and Ikegba (2014) reported that, continuous cultivation of certain tropical legumes resulted in significant increases in available phosphorus, cation exchange capacity and total nitrogen Cassava (*Manihot esculenta* Crantz); yam (*Dioscorea spp*) and sweet potato (*Ipomoea batatas*) are heavy feeders; exploiting large volume of soil for nutrients, notably, nitrogen, phosphorus and potassium. Thus, continuous cultivation of these crops will consequently result in soil nutrient depletion, except an appropriate fertilizer package, involving application of organic and/or inorganic fertilizers is embarked upon. According to Olorunda (2010); Aweto (2014) and Salami (2014), cassava removes as much as 120 kg N and 70 kg K per hectare. Also, Aden (2013) and Pukwu (2013) reported a sharp decline in soil N and K after five years of continuous cassava cropping. These authors, however, reported a very slight decline in soil available P, suggesting that, cassava did not remove much P from the soil system, compared to N and K. Maize (*Zea mays* L.) requires relatively high soil fertility, particularly N, P and K, and hence, removes a lot of these primary nutrient elements from the soil. Daukan (2012); Sesato (2013) and Molta (2014), in their studies on effects of five years of continuous maize cultivation on fertility status of an Alfisol, reported a sharp decline in soil N, P, and K after the investigation. The non – sustainability of shifting cultivation, due to increasing population pressure and demand for land for agricultural and other human activities, has forced Nigerian farmers to opt for continuous cropping. Empirical evidence has shown that, continuous cropping results in declined soil fertility and crop yields, hence, to make it sustainable, there is need for recommended fertilizer application to replenish nutrients lost to continuous cropping. However, to make a sound fertilizer recommendation, it is important to have an idea of the nutrient requirements of crops, by assessing the kinds and quantities of nutrient elements removed from the soil during the growing period. To this end, this study was designed to appraise the influence of five years of continuous cropping of yam, cassava, maize and cowpea on fertility status of an Alfisol.

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MATERIALS AND METHODS

Study site: A field experiment was carried out at the Teaching and Research Farm of the Ekiti State University, Ado – Ekiti, Ekiti State, Nigeria, between 2009 and 2014. The soil of the study site belongs to the broad group Alfisol (SSS, 2003). The soil was strongly leached, with low to medium organic matter content. Prior to this investigation, the study site had earlier been under intensive and continuous cultivation of a variety of arable crops for many years.

Experimental design and treatments: The experiment was laid out in a randomized complete block design with three replications. The five -year- continuous cropping treatments included: continuous yam cultivation (CYC); continuous cassava cultivation (CCC); continuous maize cultivation (CMC); continuous cowpea cultivation (CC_oC); and natural fallow, which served as the check or control (C). Each plot size was 6 m x 6 m.

Planting: 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 at 1 m x 1 m (10,000 cassava plants ha^{-1}). Similarly, yam was planted at 1 m x 1 m (10,000 yam plants ha^{-1}). Maize was planted at a spacing of 75 cm x 30 cm, with two seeds per stand (888,888 maize plants ha^{-1}). Three cowpea seeds were planted per stand at 60 cm x 30 cm, but later thinned to two seedlings per stand (55,556 cowpea plants ha^{-1}), 3 weeks after planting (WAP). In maize and cowpea plots, weeding was carried out at 3, 6 and 9 WAP, while in yam and cassava plots, four properly timed weedings at 4, 8, 12 and 16 WAP, were carried out, using a hand hoe.

Collection and analysis of soil samples: Prior to the commencement of the investigation in 2009, 20 core soil samples, randomly collected from 0 – 15 cm soil depth, were mixed inside a plastic bucket to form a composite sample, which was analyzed for chemical properties. Similarly, at the end of the experiment in 2014, 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).

Data analysis: All the data collected on soil chemical properties were subjected to analysis of variance (ANOVA), and treatment means were compared, using the Duncan Multiple Range Test (DMRT) at 5% probability level.

RESULTS

Chemical properties of soil in the study site prior to investigation

Table 1. The chemical properties of soil in the study site before investigation

Soil properties	Values
pH	6.4
Organic carbon (g kg^{-1})	0.87
Total nitrogen (g kg^{-1})	0.68
Available phosphorus (mg kg^{-1})	0.56
Exchangeable bases (cmol kg^{-1})	
Potassium	0.59
Calcium	0.47
Magnesium	0.44
Sodium	0.51
Exchangeable Acidity	0.22
Effective Cation Exchangeable Capacity (ECEC)	2.23

Changes in soil fertility status after five years of continuous cropping

Table 2 shows fertility status of an Alfisol as affected by five years of continuous cropping. Relative to the control, continuous cropping significantly decreased pH of the soil from 8.5 for C to 5.2, 5.7, 4.7 and 4.2 for CYC, CCC, CMC and CC_OC, respectively. Similarly, continuous cropping significantly decreased soil organic carbon (SOC) from 2.93 g kg^{-1} for C to 0.32, 0.38, 0.25 and 0.46 g kg^{-1} for the respective CYC, CCC, CMC and CC_OC. Continuous cropping significantly decreased total N from 1.89 g kg^{-1} for C to 0.24, 0.29, 0.19 and 0.93 g kg^{-1} for the respective CYC, CCC, CMC and CC_OC. Continuous cropping significantly decreased available phosphorus from 0.66 mg kg for C to 0.50, 0.62, 0.26 and 0.20 mg kg for the respective CYC, CCC, CMC and CC_OC. Continuous cropping significantly decreased exchangeable K from 0.86 cmol kg^{-1} for C to 0.18, 0.16, 0.30 and 0.35 cmol kg^{-1} for the respective CYC, CCC, CMC and CC_OC. Similarly, continuous cropping significantly decreased exchangeable Ca from 0.79 cmol kg^{-1} for C to 0.28, 0.33, 0.22 and 0.17 cmol kg^{-1} for the respective CYC, CCC, CMC and CC_OC. Continuous cropping significantly decreased exchangeable Mg from 0.69 cmol kg^{-1} for C to 0.25, 0.30, 0.20 and 0.15 cmol kg^{-1} for the respective CYC, CCC, CMC and CC_OC. Continuous cropping significantly decreased exchangeable Na from 0.73 cmol kg^{-1} for C to 0.28, 0.35, 0.21 and 0.16 cmol kg^{-1} for the respective CYC, CCC, CMC and CC_OC.

Table 2. Changes in soil fertility status after five years of continuous cropping

Treatments (continuous cropping)	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	8.5a	2.93a	1.89a	0.66a	0.86a	0.79a	0.69a	0.73a
CYC	5.2c	0.32d	0.24d	0.50b	0.18d	0.28c	0.25c	0.28c
CCC	5.7b	0.38c	0.29c	0.62a	0.16d	0.33b	0.30b	0.35b
CMC	4.7d	0.25e	0.19e	0.26c	0.30c	0.22d	0.20d	0.21d
CC_OC	4.2e	0.46b	0.93b	0.20d	0.35b	0.17e	0.15e	0.16e

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05 (DMRT).CYC = Continuous yam cultivation; CCC = continuous cassava cultivation; CMC = continuous maize cultivation; CC_OC = continuous cowpea cultivation

DISCUSSION

Relative to the control, the observed significant decreases in pH, adduced to continuous yam, cassava, maize and cowpea cropping, are in conformity with the reports of Adaso (2014) and Ikegba (2014), who, in their studies on effects of five years of continuous yam, cassava, maize and cowpea cropping on soil fertility, noted significant decreases in pH of an Alfisol. The significant decreases in pH, associated with five years of continuous yam, cassava, maize and cowpea cultivation, can be ascribed to significant decreases in concentration of the exchangeable bases at the exchange sites of the soil, following five years of continuous yam, cassava, maize and cowpea cropping. The decreases in the exchangeable basic cations at the exchange sites of the soil, can be attributed to two reasons:

First, the decreases in the exchangeable bases can be attributed to their continuous uptake by yam, cassava, maize and cowpea during the period of five years of continuous cropping.

Second, the decreases in exchangeable bases can be adduced to leaching. This is because, the tillage operations, involved in the five – year –continuous yam, cassava, maize and cowpea cultivation may have rendered the soil porous, thus, increasing its vulnerability to leaching losses, unlike what obtained in the control plots. The lowest soil pH value, associated with continuous cowpea cropping, compared to other crops, agrees with the findings of Irwin (2010); Beader (2013); Adaso (2014) and Ikegba (2014), who noted that, five years of continuous cowpea cropping resulted in lowest pH value. This observation can be ascribed to the release of hydrogen ions (H^+) from the roots of this legume (cowpea) because of its high uptake of cations, in comparison to anions (Irwin, 2010; Adaso, 2014). Besides, the highest degree of acidification (lowest pH value) of soil in cowpea plots can be attributed to the release of hydrogen ions, due to rapid nitrification (i.e. microbial conversion) of soil organic nitrogen (SON), in the form of ammonium ions (NH_4^+) to nitrate – nitrogen (NO_3^- - N), as shown by the chemical equation below:

$$NH_4^+ + 2O_2 \longrightarrow NO_3^- + H_2O + 2H^+$$

This suggests that, legumes, through their high nitrate concentration, have the potential to acidify and degrade soil in the same way as nitrogen – fertilizers, such as ammonium sulphate [(NH_4)2SO4], particularly, in soils of low cation exchange capacity (CEC). So, in view of the potential problem of soil acidification, associated with nitrogen – fixing legumes, to avert the problem of soil acidity, and hence, achieve sustainability of farming systems, the addition of liming materials to soil that has been under continuous legume cropping, is strongly recommended. Relative to the control, the significant decreases in soil organic carbon (SOC), that attended the five years of continuous cultivation of yam, cassava, maize and cowpea, can be attributed to of oxidation of soil organic matter (SOM) in the yam, cassava, maize and cowpea plots. This is because, the tillage that attended hoe – weeding operations in the plots of these crops, may have caused exposure of previously inaccessible and preserved SOM to action of soil microbial biomass (Beare *et al*., 1992; Angers *et al*., 1993). So, oxidation of SOM in the plots of these crops can be implicated for the significant decreases in SOC value, adduced to five years of continuous cultivation of these crops. This is because part of the organic carbon content of the organic matter may have been oxidized or converted into CO_2 gas, and consequently, organic carbon is lost in the form of carbon dioxide – C emission from the soil system.

The lowest available P value for continuous cowpea cultivation, can be attributed to the lowest pH value of soil in the cowpea 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). The non – significant difference between available P value of soil in the control plots and that of soil in the plots of five years of continuous cassava cropping, confirm the observations of Obaba (2013) and Kunji (2013), who reported non – significant difference in available P value between soil under natural fallow and soil under five – year –continuous cassava cropping. This observation implies that, cassava did not remove a significant amount of P from the soil, compared to the quantity of other nutrients removed by cassava. Kunji (2013) and Obaba (2013), in their studies on P nutrition of cassava, reported insignificant P uptake in cassava, relative to other nutrients. The low correlation between soil P and plant – content and yield, testifies to low uptake of P by cassava (Kunji, 2013). One factor that can be implicated for the low P uptake by cassava is that of mycorrhizal association, which provides as much as 15 ppm P to the soil from fixed P by soil mycorrhiza (Obaba, 2013; Kunji, 2013). The practical implication of the low P uptake of cassava is that, P perhaps, is not a limiting nutrient element in mineral nutrition of cassava, hence, a high root yield of cassava can still be obtained in a soil of inherently low P, provided other essential nutrients are not limiting. The highest values of all plant nutrients, consistently recorded in the control plots (natural fallow) can be attributed to the return of a large amount of organic matter (which is a reservoir of plant nutrients) to soil in the control plots, following decomposition of fallen leaves or litter produced by the fallow vegetation, as pointed out by previous researchers. According to Nottidge *et al*. (2010), plant residues have a high potential of increasing SOM and maintaining soil fertility. Similarly, Singh (2008), noted that, the amount of plant nutrients, contained in plant residues is 60 times as high as the nutrients supplied to the soil through application of synthetic fertilizers. This implies that, natural or planted fallow has the ability of ameliorating a – once degraded soil, especially if the fallow period is long.

REFERENCES

Adaso, F.D. 2014. 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.

Angers, D. A., N.Samson and A. Legege 1993. Early changes in water stable aggregate induced by tillage in a soil under barley production. *Canadian Journal of Soil Science.* 73: 51 – 59.

Aweto, C. O. 2014. Potassium nutrition and fertility aspects of cassava production in southwestern Nigeria. *Plant Nutrition and Fertilizer Research.* 21:231-23.

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

Ation, A. D. 2013. Fertility status of an Alfisol after five years of continuous cassava cropping.

Soil Fertility. 58:1082 – 1088.

Beare, M.H., Parmelee, R.W and D.A. Crossley 1992. Microbiology and fauna interactions and effects of litter nitrogen and decomposition in agro – ecosystems. *Ecology Monograph.* 62:569 – 591.

Ikegba, A. N. 2014. Uptake of soil nitrogen by groundnut as affected by symbiotic N – fixation. *Soil Biochemistry*. 44:1111 – 1118

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

Beader, R.I. 2013. Study on mineral nutrition of cassava under different tropical legumes. *International Journal of Science and Technology*.23(2):552 – 558.

Daukan, M. Y. 2012. Study on nitrogen fertilization of maize. *Plant Nutrition.* 43: 1222 – 1229.

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. 2010. Fertilization and mineral nutrition of cassava. *Fertilizer and Food Science Research.*16(1):342 – 349.

Kunji, A. N. 2013. Effects of inorganic fertilization on hydrocyanic acid content of cassava root. *Journal of Agriculture and Food Science*. 15(2):330 – 336.

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 and Microbiology*. 56: 181 – 187.

Molta, B. J. 2014. Growth and yield responses of maize to fertilizer types in ssouthwestern Nigeria. *Plant Nutrition and Crop Improvement*. 23:444 – 449.

Nair, A. A. 2014. Effects of continuous cassava cropping on soil fertility status. *Soil Science Bulletin.* 8(2):12 – 19.

Nottidge, D. O; S.O. Ojeniyi and C.C. Nottidge 2010: Grain legumes residues effects on soil physical conditions, growth and grain yield of maize in an Ultisol. *Nigerian Journal of Soil Science*. 20(1):150 – 153.

Obaba, A. N. 2013. Uptake of phosphorus by cassava as affected by NPK fertilizer application. *Soil Biochemistry*. 44:1111 – 1118.

Olorunda, N. B. 2010.Trends of cassava responses to fertilization in southwestern Nigeria. *Journal of Biology and Physical Sciences*. 19:412 – 418.

Pukwu, W. J. 2013. Study on fertilizer effects on yield and nutrient content of cassava. *Journal of Root and Tuber Crops.* 23:332 – 338.

Salami, O. O. 2014. Study on N, P, and K nutrition of cassava in Eastern Nigeria. *International Journal of Food Technology and Agricultural Research*. 21(2):342 – 349.

Singh, P. I. 2008: Influence of plant residues management techniques on soil fertility and maize performance. *Soil Fertility and Plant Nutrition*. 12: 6 – 12.

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.

Sesato, I. G. 2013. Effects of fertilizer types on growth and yield attributes of maize. *Crop Protection.* 11(2):1 – 6.

Tare, M. I. 2009. Influence of K fertilizers on the yield and chemical composition of cassava root. *Crop Improvement*. 12(1):22 – 28.

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