Evaluating Changes In Fertility Status Of An Alfisol Under Different Growth Stages Of Cassava (Manihot Esculenta Crantz)

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Abstract: Evaluating changes in soil nutrient status under different growth stages of cassava, makes possible determination of the most critical stage in its vegetative growth phase, when its demand for nutrients is highest. Determining the most critical stage in cassava vegetative growth phase, when its nutrient demand is highest, will enhance properly timed fertilizer application in such a way the application will coincide with the most critical stage in cassava vegetative phase when its demand for nutrients is highest. In view of this, a two – year field experiment was designed to assess changes in nutrient status of an Alfisol under different growth stages of cassava during 2010 and 2011 cropping seasons at the Teaching and Research Farm of the Ekiti State University, Ado – Ekiti, Ekiti State, Nigeria. The experiment was laid out in a randomized complete block design with three replicates. The different growth stages of cassava when changes in nutrient status of Alfisol were evaluated included: 3, 6, 9, and 12 months after planting (MAP). The results indicated existence of significant ($P = 0.05$) differences among the different growth stages of cassava as regards their effects on chemical properties of Alfisol. During 2010 cropping season, the significant decreases in soil organic carbon (SOC) under growth stages of cassava were from 0.96 g kg^{-1} for ISNSPTC to 0.88, 0.80, 0.72 and0.64 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. Similarly, during 2011 cropping season, the significant decreases in soil organic carbon (SOC) under growth stages of cassava were from 0.96 g kg^{-1} for ISNSPTC to 0.80, 0.73, 0.66 and0.58 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2010 cropping season, the significant decreases in total N under growth stages of cassava were from 0.68 g kg^{-1} for ISNSPTC to 0.57, 0.50, 0.43 and0.35 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the significant decreases in total N under growth stages of cassava were from 0.68 g kg^{-1} for ISNSPTC to 0.54, 0.47, 0.41 and0.32 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively.

Key words: Alfisol, cassava, evaluating, fertility, growth, status

Introduction

Plants take up nutrients in inorganic forms from the soil system for growth and metabolism. The type and amount of nutrients taken up by plants, depend on the age of plants (Schim, 2014). Young plants and young plant tissues have high concentration of N, P and K, whereas, in older plants, and more mature plant parts, higher concentrations of Ca, Mn, Fe and B are often observed (Soag, 2010). The high mineral uptake by plants, especially, N, P and K, in the early growing period is due to the need for synthesis of certain organic compounds, which are required for good vegetative growth in plants and attendant accumulation of photosynthates in plant storage organs (Cever, 2008; Soag, 2010; Schim, 2014). Casava (Manihot esculenta Crantz), like any other root and tuber crops, is a heavy feeder crop; removing quite a lot of nutrients and water from the soil system, with resultant decline in soil nutrient reserve (Weig, 2008, Akinyemi, 2011). Previous studies (Wenaba, 2008; Anda, 2009; Syris, 2011) had established that, the severity of decline in soil fertility, associated with cassava cultivation, depends on the age of cassava. These authors noted increased incident of soil nutrient decline with increasing age of cassava. Although, cassava thrives well in marginal soils, however, studies by Weig (2008); Aina (2010); Akinyemi (2011) and Gliesman (2011) had demonstrated positive and highly significant responses of cassava to fertilizer application, especially during the early stages of growth. Although, cassava derives immense benefits from fertilizer application, nevertheless, for high and sustained productivity, there is a dire need for properly timed fertilizer application in such a way the application will coincide with the most critical stage of growth in cassava, when the demand for nutrients is highest. The most critical stage in vegetative growth phase of cassava, when the demand for nutrients is highest can be determined by monitoring changes in soil nutrient status under different growth stages of cassava. Consequent upon this, a two – year field experiment was designed to appraise changes in nutrient status of an Alfisol under different growth stages of cassava

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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 2010 and 2011 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 2011 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 2011 and 2012 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 growth stages of cassava when changes in nutrient status of Alfisol were evaluated included: 3, 6, 9, and 12 months after planting (MAP). Each plot size was 4 m x 4 m.

Planting, weeding, collection and analysis of data:
Planting of cassava was done on March 1 and March 3 in 2010 and 2011, 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 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. 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

Changes in fertility status of an Alfisol under different growth stages of cassava during 2010 and 2011 cropping seasons.

Tables1and 2 show chemical properties of an Alfisol under different growth stages of cassava during 2010 and 2011 cropping seasons. During 2010 cropping season, the significant decreases in soil pH under growth stages of cassava were from 8.1 for ISNSPTC to 6.8, 6.2, 5.6 and 5.0 for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the significant decreases in soil pH under growth stages of cassava were from 8.1 for ISNSPTC to 6.6, 6.0, 5.3 and 54.7 for ages 3, 6, 9 and 12 MAP, respectively. During 2010 cropping season, the significant decreases in soil organic carbon (SOC) under growth stages of cassava were from 0.96 g kg^{-1} for ISNSPTC to 0.88, 0.80, 0.72 and0.64 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. Similarly, during 2011 cropping season, the significant decreases in soil organic carbon (SOC) under growth stages of cassava were from 0.96 g kg^{-1} for ISNSPTC to 0.80, 0.73, 0.66 and0.58 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2010 cropping season, the significant decreases in total N under growth stages of cassava were from 0.68 g kg^{-1} for ISNSPTC to 0.57, 0.50, 0.43 and0.35 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the significant decreases in total N under growth stages of cassava were from 0.68 g kg^{-1} for ISNSPTC to 0.54, 0.47, 0.41 and0.32 g kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2010 cropping season, the decreases in available P under growth stages of cassava were from 0.56 mg kg^{-1} for ISNSPTC to 0.54, 0.53, 0.53 and 0.55 mg kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the decreases in available P under growth stages of cassava were from 0.56 mg kg^{-1} for ISNSPTC to 0.54, 0.53, 0.54 and 0.55 mg kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2010 cropping season, the significant decreases in exchangeable K under growth stages of cassava were from 0.61 cmol kg^{-1} for ISNSPTC to 0.54, 0.47, 0.40 and0.30 cmol kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the significant decreases in exchangeable K under growth stages of cassava were from 0.61 cmol kg^{-1} for ISNSPTC to 0.51, 0.44, 0.37 and 0.30 cmol kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the significant decreases in exchangeable Ca under growth stages of cassava were from 0.59 cmol kg^{-1} for ISNSPTC to 0.50, 0.42, 0.34 and0.25 cmol kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2010 cropping season, the significant decreases in exchangeable Mg under growth stages of cassava were from 0.48 cmol kg^{-1} for ISNSPTC to 0.41, 0.35, 0.28 and0.20 cmol kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the significant decreases in exchangeable Mg under growth stages of cassava were from 0.48 cmol kg^{-1} for ISNSPTC to 0.38, 0.32, 0.24 and0.18 cmol kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2010 cropping season, the significant decreases in exchangeable Na under growth stages of cassava were from 0.44 cmol kg^{-1} for ISNSPTC to 0.38, 0.31, 0.24 and 0.18 cmol kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively. During 2011 cropping season, the significant decreases in exchangeable Na under growth stages of cassava were from 0.44 cmol kg^{-1} for ISNSPTC to 0.36, 0.28, 0.17 and 0.12 cmol kg^{-1} for ages 3, 6, 9 and 12 MAP, respectively.

Table 1: Chemical properties of an Alfisol under different growth stages of cassava during 2010 cropping season.

Treatments (Growth stages of cassava when changes in soil nutrient status were assessed)	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
ISNSPTC	8.1a	0.96a	0.68a	0.56a	0.61a	0.59a	0.48a	0.44a
3 MAP	6.8b	0.88b	0.57b	0.54a	0.54b	0.52b	0.41b	0.38b
6 MAP	6.2c	0.80c	0.50c	0.53a	0.47c	0.44c	0.35c	0.31c
9 MAP	5.6d	0.72d	0.43d	0.53a	0.40d	0.36d	0.28d	0.24d
12 MAP	5.0e	0.64e	0.35e	0.52a	0.30e	0.28e	0.20e	0.18e

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05 (DMRT). MAP = Months after planting; ISNSPTC = Initial soil nutrient status prior to cropping.

Table 2: Chemical properties of an Alfisol under different growth stages of cassava during 2011 cropping season.

Treatments (Growth stages of cassava when changes in soil nutrient status were assessed)	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
ISNSPTC	8.1a	0.96a	0.68a	0.56a	0.61a	0.59a	0.48a	0.44a
3 MAP	6.6b	0.80b	0.54b	0.54a	0.51b	0.50b	0.38b	0.36b
6 MAP	6.0c	0.73c	0.47c	0.53a	0.44c	0.42c	0.32c	0.28c
9 MAP	5.3d	0.66d	0.41d	0.54a	0.37d	0.34d	0.24d	0.17d
12MAP	4.7e	0.58e	0.32e	0.55a	0.30e	0.25e	0.18e	0.12e

Mean values in the same column followed by the same letter(s) are not significantly different at P = 0.05 (DMRT). MAP = Months after planting; ISNSPTC = Initial soil nutrient status prior to cropping

Discussion

Relative to the initial nutrient status of the soil, prior to cropping, the significant decreases in the soil pH (i.e. increased acidity), associated with the different growth stages of cassava, can be ascribed to decreases in the exchangeable basic cations on the exchange sites of the soil under the different growth stages of cassava. In view of the problem of soil acidity, associated with cassava cultivation, and since cassava does not thrive well in acid soil (Aesop, 2004; Powel, 2011), to avert this problem of acidity, and achieve optimal yield performance of cassava, hence, the addition of limes to soil cultivated to cassava, is strongly recommended. The decreases in soil organic carbon (SOC), observed under the different growth stages of cassava, agree with the findings of Wenaba (2008) and Gliesman (2011), who noted decreases in SOC under different growth stages of cassava. These authors added that, the decreases became pronounced with increasing age of cassava. The decreases in SOC, adduced to the different growth stages of cassava can be explained in the light of oxidation of soil organic matter (SOM) under those growth stages of cassava. This is because, the tillage that attended hoe – weeding operations in cassava plots may have caused exposure of previously inaccessible and preserved SOM to action of the soil microbial biomass (Beare et al., 1992; Angers et al., 1993). So, oxidation of SOM, due to the tillage effects in cassavas plots can be implicated for the lowest SOC value, adduced to the different growth stages of cassava. 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 an inorganic form, that is, in the form of carbon dioxide – C emission from the soil system. This phenomenon of decreased SOC, implies that, there is a likely hood of decline in soil fertility under continuous cassava cultivation. To for store this problem of declined soil fertility, and achieve sustainability of cassava production on a long term basis, addition of certain organic materials (plant and animal remains) to land under cassava cultivation, is strongly recommended. The lower SOC values under the different growth stages of cassava, recorded during the second year cropping season, compared to what obtained during first year cropping, confirm the assertions of Winda (2013) and Wooas (2013), who established that, SOM declines under continuous cultivation with or without fertilizer input or application. The decreases in total N and the exchangeable bases, adduced to the different growth stages of cassava, were due perhaps to leaching losses. This is because, the tillage brought about by the hoe – weeding operation may have resulted in increased porosity of the soil, with resultant increased vulnerability of the soil to leaching. Asides, the decreases in these nutrients can be ascribed to uptake by cassava during the growing period. Much as the decreases in these nutrients can be attributed to the afore – mentioned factors, however, another factor that can be implicated for the decreases, is the decreases in SOC, observed under different growth stages of cassava. This is because, SOM has been reported as a reservoir of other plant nutrients, that is, other nutrients are integrally tied to it, hence, the maintenance of SOM is paramount in sustaining other soil quality factors (Robertson et al., 2004; Raper, 2009). The available P value of the soil prior to cropping was not significantly higher than the soil available P value under the different growth stages of cassava throughout the growing period, implying that, cassava did not remove much P from the soil system during the growing period, compared to N and K. This observed low P uptake in cassava corroborates the observations of Tryon (2009) and Syris (2011), who, in their studies on N, P and K mineral nutrition of cassava, noted non – significant difference in available P value of the soil before and after cropping. The low correlation between soil P and plant – content and yield testify to low P uptake of cassava (Tryon, 2009). Tryon (2009) and Syris (2011), adduced the low P uptake of cassava to mycorrhizal association, which provides as much as 15 ppm P to the soil from fixed P by soil mycorrhiza. The practical implication of low P uptake in cassava is that, P perhaps, is not a limiting nutrient element in the mineral nutrition of cassava, hence, cassava can thrive well in a soil of inherently low P, provided other nutrients are not limiting.

References

[1] Aesop, J. 2004. Study on mineral requirements of cassava. Plant Nutrition Research. 17:222 – 228.

[2] Aina, B. O. 2010. Performance of cassava under different inorganic fertilizer application regimes. Crop Sciencde Research. 22(2):6 – 12.

[3] Akinyemi, E. 2011. Effects of tillage practices and fertilizer application on the performance of cassava. Journal of Food and Agricultural Research. 15:45 – 51.

[4] Anda, A. A. 2009. Growth and yield of cassava as affected by time of NPK fertilizer application and frequency of weeding. Journal of Applied Sciences. 32(2):234 – 239.

[5] 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.

[6] 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.

[7] Cever, W. I. 2008. The role of N, P and K in the mineral nutrition of cassava. Crop Physiology. 20: 17 – 23.

[8] Gliesman, P. I. 2011. Molecular mechanisms of nitrogen, phosphorus and potassium uptake in cassava. International Journal of Food Science and Agricultural Research. 31:344 -349.

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

[10] Powel, A. P. 2011. Mineral sources of potassium for cassava nutrition. Journal of Sustainable Agriculture. 27:512 – 518.

[11] Raper, S. E. 2009. Effects of nitrogen and potassium application on growth, yield and cyanide content of cassava. Journal of Food and Plant Nutrition. 21(1):34 -41.

[12] Robertson, E. A., A. Atiri, Y. Hill, E. Liang. 2004. Soil and fertilizer use in the tropics. Biology and Fertility of Soils. 18:241 – 247.

[13] Schim, M. N.2004. Effects of nitrogen, phosphorus and potassium on photophosphorylation in cassava in relation to the photosynthetic rate. Crop Improvement 20:213 – 219.

[14] Soag, T. 2010. Effects of sodium and potassium on the growth and oxalate content of cassava. Fertilizer and Plant Nutrition Research. 23(1):333 - 339.

[15] 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.

[16] Syris, B. E. 2011. Nitrogen and potassium interrelations in growth and mineral content of cassava. Journal of Applied Sciences and Environmental Studies. 15:1 -6.

[17] Tryon, K. F. 2009. Field trials of nitrogen, phosphorus and potassium on yield and quality of cassava roots in Eastern Nigeria. Biological and Physical Sciences. 12:70 – 77.

[18] Weig, S. 2008. Growth and yield of cassava in relation to different sources of nitrogen and phosphorus. Basic Sciences. 18(2):321 -328.

[19] Wenaba, V. O. 2008.Enhancing cassava yield through application of organic fertilizers. Journal of Agricultural and Food Sciences. 31:555 – 562.

[20] Winda, E. O. 2013. Soil organic matter dynamics under cassava – based intercropping systems. Soil Science and Land Resources. 43:661 – 668.

[21] Wooas, E. J. 2013. Soil organic matter dynamics and sustainability of tropical Agriculture. Interrnational Journal of Forestry and Agricultural Sciences. 23(2):45 – 52..