Journal of Applied Biosciences 25: 1573 - 1578
ISSN 1997–5902

Nutrient dynamics in soil and cashew (*Anacardium occidentale* L.) leaf and kernel in Kogi State, Nigeria

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Original submitted on 2nd November 2009; revised version received on 16th December 2009; accepted and published online at www.biosciences.elewa.org on January 11, 2010

ABSTRACT

Objective: Cashew production in Nigeria continues to be limited by low yield, variable nut yield and quality. This work was carried out to assess the nutrient dynamics in soils, cashew foliage and nut kernels.

Methodology and results: Soil samples, foliage and nut kernels were collected from the farms of ten major cashew farmers across three local government areas in Kogi State. Samples were prepared according to standard procedure and analyzed chemically to determine their nutrient contents. Results showed that the soils were sandy loam and were deficient in magnesium, potassium, available phosphorus and nitrogen content. Foliar samples from all the farms were deficient in Mg, nine in P and seven in N. Phosphorus, Mg, K, Fe and Zn in the nut kernel were below FAO recommended values.

Conclusions and application of findings: The low clay and organic matter content of the soils had negative influence on the soil's fertility status which reflected in the minerals and nutrient contents of the foliage and nuts. Regular fertilizer and compost application should be done on the farms to replenish the lost nutrients and improve the water holding capacity of the soil. The findings of this study will form the basis for recommending fertilizer application to increase cashew production and yield in Kogi state.

Key words: Cashew, nutrient deficiency, foliage and nut, Nigeria.

INTRODUCTION

Cashew (*Anacardium occidentale* L.) is next to cocoa in importance as an export crop and a major source of income to many small holder farmers in the central and northern part of Nigeria (Topper *et al*., 2001; CBN, 2005) Cashew contributes about $1,045,000 to the Gross Domestic Product (FAO, 2008) and thus generation of foreign exchange. Cashew was probably introduced in Nigeria in the 16th Century, at the same time it was introduced into other parts of Africa by the Portuguese (Johnson, 1973). It grew in the wild until mid 1950s when it attained commercial status with establishment of the first set of large plantations in the western and eastern regions of the country. However, the commercial strength of cashew was never realized until the 1970s with increased demand by Indian merchants seeking raw cashew nuts for processing in India.

Nigeria is the 2nd largest producer of cashew nut in the world with seven diverse agro-ecologies (ADAN, 2002). However, cashew can only be economically cultivated in woodland-tall-

grass savanna and rainforest ecologies. These types of lands spread across 27 states of the country (ADAN, 2002). Producers are grouped into minor (concentrated in south-west, south-south and northern states and major south eastern states). Ayodele *et a*l. (2001) reported that about 100,000 hectares of land has been put under cashew in Nigeria as at the year 2000 while annual production stands at 70,000 metric tons. An increasing awareness of the economic potential of cashew kernels in the global market has further led to the influx of farmers, government and non-government organizations (NGO) into the business of cashew production, with the total area of land planted to cashew reaching about 320,000 hectares, and about 256,000 metric tons annual nut production in 2003 (Aliyu, 2004). However, cashew production in Nigeria continues to be limited by low yield, variable nut yield and quality.

The limited production may be as a result of nutrient deficiency in the soil since most of the soils on which cashew is grown in Nigeria is sandy loam in nature (Ayodele, 1993), which cannot hold nutrients for prolonged periods. It has been observed that most Nigerian cashew farmers do not use fertilizer and thus the nutrients being mined by the plants are not replenished. In view of this, this research work was carried out to evaluate the nutrient dynamics in soil, cashew foliage and nuts in Kogi State which is one of the major cashew producing states in Nigeria.

MATERIALS AND METHODS

Soil samples, cashew leaves and nuts were collected on farms belonging to ten major cashew farmers in the three major cashew producing local government areas of Kogi (Dekina, Ofu and Odolu). The area of the study were: Omaga, Idah,Ochaja, Igalamela, Umomi, Abocho, Aruna Abocho and Ochadamu.

Soil samples were collected using auger at 0 – 30cm depth. Young fresh but matured leaf samples and matured nuts were collected from the same trees under which the soil samples were collected. The soil samples were air dried and passed through 2mm sieve. The leaves samples were also air dried, milled and digested for chemical analysis. The nut was broken and the kernel was roasted at 45^{o}C for 15 minutes before milling. The roasted milled cashew nut was digested in Kjehdalh flask with sulphuric acid at 300^{o}C for six hours. Soil pH was measured electrometrically with glass electrode pH meter in water using soil/ water ratio of 1:2.5. Organic carbon was determined by the Walkley-Black procedure (1934); total nitrogen by microkjeldahl digestion, while available phosphorus was determined colorimetrically by the Molybdenum blue method (Bray & Kurtz, 1945). The exchangeable cations were extracted by leaching 5g soil with 50ml of 1N ammonium acetate at pH 7 (Schollenberger & Simon, 1945). The Potassium and Sodium in the leachate were determined with a flame photometer (Corning EEL model 100); the calcium and magnesium was determined with Hitachi model 207 atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

The calcium content of the soil varied from 0.817 – 0.960cmol/kg soil with a mean value of 0.868 (Table 1). All the values of soil calcium from the various cashew farms were above 0.8cmol/kg which is the critical value for ideal soils for cashew (Egbe *et al*., 1989) Magnesium content of the soils varied from 0.004 – 0.01cmol/kg with an average value of 0.007cmol/kg (Table 1). Soil magnesium from all the various cashew farms were grossly lower than the critical value of 0.08cmol/kg soil. The deficiency may be as a result of the high sand, low clay and low organic matter content of the soil. Dolomite is therefore needed for the soils to supply enough magnesium to the planted cashew trees.

The sodium content of the soil ranged between 0.12 – 0.26cmol/kg with an average value of 0.17 cmol/kg (Table 1) while the potassium content ranged between 0.07 – 0.24cmol/kg soil with an average value of 0.11 cmol/kg. Out of the ten cashew farms investigated, three farms had the required K for cashew cultivation while the remaining had K content below the critical level of 0.12 cmol/kg according to Egbe *et al.* (1989).The soil available P content was 2.00 – 7.27 ppm in the soil under cashew cultivation with an average value of 4.07ppm (Table 1). The results indicated that only three out of the ten farms investigated had adequate phosphorus for cashew cultivation. The soil pH values ranged from 5.10 - 5.85

with an average value of 5.49 (Table 2) The pH value range is adequate for cashew production according to Owaiye (1988) who reported that cashew grows well within pH range of 3.0 - 6.5 while the best growth is obtained between pH 4.5 - 5.0 and with 4.5 as the optimal.

Table 1: Concentration of some cations in cashew soils in Kogi state, Nigeria.

Farm	Ca	Mg	Na	K	Fe	Mn	Zn
Omaga	0.833	0.006	0.18	0.11	1.68	3.71	5.1
Idah	0.822	0.005	0.14	0.11	2.58	12.81	4.32
Ochaja A	0.832	0.008	0.18	0.13	2.04	11.17	4.32
Igalamela	0.922	0.007	0.26	0.24	1.92	11.32	4.51
Ochaja B	0.824	0.007	0.16	0.07	2.28	9.7	3.53
Umomi	0.817	0.004	0.14	0.06	2.64	3.02	4.45
Abocho	0.96	0.01	0.12	0.08	1.2	21.2	3.86
Ochaja C	0.935	0.009	0.18	0.08	0.66	7.48	3.66
Ugbolawo	0.92	0.007	0.22	0.12	1.44	13.48	3.47
Ochadamu	0.821	0.004	0.15	0.09	1.84	13.23	3.56
Mean	**0.868**	**0.007**	**0.17**	**0.11**	**1.83**	**10.71**	**4.08**
Std dev.	**0.0547**	**0.0019**	**0.0395**	**0.0487**	**0.584**	**4.986**	**0.515**

The Fe content of the soil ranged between 0.66 – 2.64 mg/kg soil with an average value of 1.83mg/kg.The high iron content might have contributed to the acidity of the soil. Soil manganese ranged between 7.48 – 21.20mg/kg with an average value of 10.71mg/kg; zinc ranged from 3.53 – 5.10mg/kg soil with an average value of 4.08mg/kg (Table 1).

The total nitrogen content of the cashew soil ranged from 0.02 – 0.11% N soil with an average value of 0.04% (Table 3). This value is grossly below the critical level of 0.1% N required for cashew cultivation. The low N content could be due to the low organic matter content of the soil. The particle size analysis of the soil (Table 2) showed that the soil is sandy loam. By implication, the soils are sandy and thus are less compact which predisposes them to erosion and associated nitrogen loss. According to Thompson and Troeh (1978), a 10 ton loss of soil through erosion containing 4% organic matter would amount to 20kg of N loss. Another factor which could be responsible for the low N content is losses through leaching, since the soil is sandy, and thus highly permeable.

Soil organic carbon (SOC) ranged from 0.40 - 1.30% with an average value of 0.69%. The low values of organic carbon indicate that the rate of decomposition and mineralization of leaf litter and other plant residues under cashew farms was not sufficient to counter oxidation and loss of soil organic carbon (SOC). Soil organic matter might have also been lost through erosion.

The soil particle size analysis (Table 2) showed that the soils investigated are sandy loam in nature. The sand content of the soils ranged from 62.24 - 86.24% with an average value of 76.42% while the clay content ranged from 9.20 - 21.20% with an average value of 15.20%, the silt content ranged from 2.56 -18.56% with an average value of 8.16%. The soil composition affects its characteristic properties, e.g. water holding capacity, permeability, susceptibility to erosion and leaching.

The cashew leaf calcium content ranged from 0.31-0.76% with a mean value of 0.45% (Table 3).The leaf calcium content in all the farms was higher than the critical level for calcium in cashew foliage, indicating adequate calcium availability in the soils.

The magnesium content of the leaves ranged from 0.160 - 0.25% with a mean value of 0.2% (Table 3). The values are below the critical levels for Mg in cashew foliage which is 0.88% according to Egbe *et al. (*1989). This is a reflection of Mg deficiency in the investigated soils. Application of magnesium fertilizer is needed in these study areas.

The sodium content of the leaves ranged from 0.22-0.52% with a mean value of 0.40% (Table 3). The potassium content of the leaves ranged from 0.31-0.62% with a mean value of 0.42% (Table 3). The low values of potassium in the leaves reflected potassium deficiency in the soils, and reaffirms the need for potassium fertilizer application. Potassium is important

in carbohydrate and protein metabolism (Thompson & Troeh, 1976).

Phosphorus content of the leaves ranged from 0.01-0.70% with a mean value of 0.148 % (Table 3). The values of phosphorus in the foliage were below the critical value of 0.12% except in Idah farm. Phosphorus is an essential component of the genetic material of the cell nucleus. Phosphorus deficiency therefore causes stunting, delayed maturity and shriveled seed (Thompson, 1976).

Table 2: Soil particle size, Carbon, available Phosphorus (P) and pH.

Farm		Organic C	Sand%	Clay%	Silt%	Available P	pH
Omaga	0.03	0.63	78.24	17.2		5.55	5.85
Idah	0.03	0.63	72.24	13.2	14.56	6.36	5.1
Ochaja A	0.05	1.03	62.24	21.2	16.56	3.64	5.41
Igalamela	0.02	0.55	82.24	15.2	2.56	7.27	5.67
Ochaja B	0.04	0.87	72.24	9.2	18.56	3.64	5.63
Umomi	0.03	0.47	86.24	11.2	2.56	3.5	5.34
Abocho	0.04	0.63	80.24	17.2	2.56	2	5.82
Ochaja C	0.02	0.4	82.24	11.2	6.56	3.22	5.4
Ugbolawo	0.05	0.94	76.24	19.2	4.56	2.29	5.3
Ochadamu	0.04	0.78	74.24	17.2	8.56	3.2	5.38
Mean	**0.04**	**0.69**	**76.42**	**15.2**	**8.16**	**4.07**	**5.49**
Std dev.	**0.010**	**0.195**	**6.499**	**3.687**	**5.851**	**1.652**	**0.229**

Table 3: Concentration of some cations, nitrogen and phosphorus in cashew foliage.

Farm	Ca	Mg	Na	K	Fe	Mn	Zn	N	P
Omaga	0.52	0.22	0.44	0.5	0.056	0.019	0.008	1.02	0.01
Idah	0.4	0.2	0.37	0.51	0.062	0.01	0.006	1.35	0.12
Ochaja A	0.76	0.25	0.43	0.41	0.027	0.02	0.007	1.06	0.09
Igalamela	0.42	0.23	0.52	0.62	0.055	0.021	0.007	0.97	0.14
Ochaja B	0.28	0.19	0.27	0.36	0.03	0.004	0.006	1.18	0.06
Umomi	0.51	0.16	0.22	0.31	0.039	0.014	0.005	0.96	0.08
Abocho	0.43	0.23	0.41	0.32	0.055	0.013	0.007	1.17	0.11
Ochaja C	0.43	0.17	0.45	0.33	0.02	0.009	0.006	1.43	0.09
Ugbolawo	0.31	0.21	0.51	0.4	0.057	0.015	0.006	1.42	0.08
Ochadamu	0.46	0.18	0.33	0.42	0.052	0.018	0.005	1.05	0.7
Mean	**0.452**	**0.204**	**0.395**	**0.418**	**0.0453**	**0.0143**	**0.0063**	**1.161**	**0.148**
Std dev.	**0.125**	**0.0276**	**0.0929**	**0.0942**	**0.0141**	**0.00517**	**0.009**	**0.1717**	**0.187**

Iron content of the leaves ranged from 0.02 – 0.062% with a mean value of 0.045% (Table 3), manganese ranged from 0.009 – 0.021% with a mean value of 0.014%, and zinc content ranged from 0.005 – 0.008% with a mean value of 0.006%.

Nitrogen content of the leaves ranged from 0.97-1.43% with a mean value of 1.16% (Table 3). This confirmed the deficiency of nitrogen in most of Cashew soils in the three local government areas. In cocoa production Wood and Lass (1985) reported that 45kg nitrogen is lost for every tone of cocoa beans harvested. This might also be applicable to cashew since the plant needs large amounts of N for fruit and nut development. Plant uptake and loss of nitrogen through leaching and erosion in cashew farm calls for regular fertilization of the soil in order to maintain Nitrogen equilibrium within the soil system.

The calcium content of the cashew nut ranged from 0.13 – 0.28% with a mean value of 0.066% (Table 4). Five out of the ten cashew farms investigated had their calcium content in cashew nut above the FAO (2007) standard set for cashew nut of 0.04% Ca. Magnesium contents of the cashew nut ranged from 0.01-0.19% (Table 4). Nonetheless, the magnesium content in and all the cashew nuts from the entire investigated farms were below the 0.28% mg (Table 4) set by the FAO. This is also an implication of low magnesium contents in the soil. Sodium content of the cashew nuts ranged from 0.01-0.10% (Table 4) which is above the sodium content in cashew nut set by FAO of 0.005%.The potassium content of the nuts range from

0.17-0.35% with a mean value of 0.23%, below the FAO standard. The iron content of the nuts ranged from 0.004-0.01% with a mean value of 0.007% (Table 4). Four out of the ten farms investigated had their iron content in cashew nuts up to the FAO standard (Table 4). This is a consequence of low iron content of the soils. The manganese content of the nut ranged from 0.001-0.002% with a mean value of 0.002% (Table 4). Five out of the ten farms investigated had their manganese content up to 0.002% Mn set by the FAO while remaining five farm are below.

Zinc content of the nut ranged from 0.001-0.004% with a mean value of 0.003% (Table 4). Two out of ten were up to the FAO value. Phosphorus content of the nut range from 0.15-0.48% with a mean value of 0.31% (Table 4). All the phosphorus values were lower than 0.88% phosphorus of the FAO, 2007. The low phosphorus content in the soil might be responsible for the phosphorus values of the nuts. Total Nitrogen content of the nut ranged from 0.052-0.122% with a mean value of 0.088%.

The results of the chemical investigation carried out on the various soil samples from the selected Cashew farmers within the three Local Government areas of Kogi State clearly showed that the soils were deficient in vital macronutrients nutrients needed by Cashew for optimal yield and good quality. In view of this, the following fertilizer application rate (Table 5) has been recommended based on the soil test result. Compliance to this recommendation with other climatic factors being equal, will correct the prevailing nutrient deficiency in investigated Cashew soils.

Table 4: Concentration of some cations, nitrogen and phosphorus in cashew kernel.

Farm	Ca	Mg	Na	K	Fe	Mn	Zn	N	P
Omaga	0.014	0.13	0.09	0.27	0.009	0.001	0.003	0.052	0.16
Idah	0.013	0.16	0.06	0.28	0.008	0.001	0.004	0.075	0.33
Ochaja A	0.015	0.17	0.08	0.19	0.004	0.002	0.001	0.063	0.15
Igalamela	0.18	0.16	0.1	0.35	0.007	0.001	0.004	0.1	0.47
Ochaja B	0.07	0.1	0.07	0.18	0.005	0.002	0.003	0.096	0.27
Umomi	0.16	0.1	0.06	0.16	0.006	0.002	0.002	0.086	0.38
Abocho	0.051	0.19	0.06	0.21	0.007	0.002	0.002	0.122	0.43
Ochaja C	0.016	0.1	0.08	0.17	0.004	0.001	0.003	0.077	0.16
Ugbolawo	0.013	0.18	0.02	0.25	0.009	0.002	0.003	0.11	0.23
Ochadamu	0.13	0.17	0.09	0.2	0.01	0.001	0.002	0.094	0.48
Mean	**0.066**	**0.146**	**0.071**	**0.226**	**0.007**	**0.002**	**0.0027**	**0.088**	**0.306**
Std dev.	**0.062**	**0.034**	**0.022**	**0.057**	**0.002**	**0.001**	**0.001**	**0.02**	**0.124**

Table 5: Nutrient deficiency level and fertilizer recommended rate based on soil test for optimal Cashew production.

Farm	Mg Deficiency level (mg/kg)	K Recommended rate (kg/ha)	P	N	Mg	K	P	N
Omaga	17.76	3.7	-	700	35.52	7.4	-	1400
Idah	18	3.9	-	700	36	7.8	-	1400
Ochaja A	17.28	-	0.06	500	34.56	-	0.12	1000
Igalamela	17.52	-	-	800	35.04	-	-	1600
Ochaja B	17.52	19.5	0.05	600	35.04	39	0.1	1200
Umomi	18.24	23.4	0.2	700	36.48	46.8	0.4	1400
Abocho	16.8	15.6	1.7	600	33.6	31.2	3.4	1200
Ochaja C	17.04	15.6	0.48	800	34.08	31.2	0.96	1600
Ugbolawo	17.52	-	1.41	500	35.04	-	2.82	1000
Ochadamu	18.21	11.7	0.5	600	36.48	23.4	1	1200

ACKNOWLEDGEMENT: We acknowledged Dr Ogunlade M.O. for editing this work and Mr Adewoye A. for the assistance he rendered in the laboratory.

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