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Full Length Research Paper

Assessment of nutritional status of soil supporting coconut (*Cocus nucifera*) cultivation in some localities of Edo State of Nigeria

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Coconut cultivation and information on the nutritional status of soils and fertilizers recommendations for its cultivation are limited in Nigeria. Since a high yield of coconut is related to the fertility status of the soil, a study was conducted to evaluate the status of soils supporting coconut cultivation. The evaluation of the surface soil (0 – 15 cm) and the subsoil (15 – 30 cm) of seven localities showed that the average pH was 5.75 ± 0.21 and 5.51 ± 0.15, respectively, indicating that the subsoil was slightly acidic than the surface soil. Highest values for the surface soil parameters were found to be 0.58 ± 0.08 gkg-1 for exchangeable acidity, 2.55 ± 0.02 gkg-1 for organic carbon (C), 0.13 ± 0.02 gkg-1 for total nitrogen (N), 20.24 ± 1.10 gkg-1 for the carbon : nitrogen ratio, 17.45 ± 0.60 for available phosphorus (P), 0.21 ± 0.02 Cmolkg-1 for sodium (Na), 0.14 ± 0.01 Cmolkg-1 for potassium (K), 2.91 ± 0.10 Cmolkg-1 for calcium (Ca) and 0.79 ± 0.06 Cmolkg-1 for magnesium (Mg). On the other hand, the subsoil parameters were 0.74 ± 0.15 gkg-1 for exchangeable acidity, 1.85 ± 0.03 gkg-1 for organic C, 0.09 ± 0.01gkg-1 for total N, 19.69 ± 0.67 gkg-1 for the carbon : nitrogen ratio, 10.15 ± 0.38 for available P, 0.16 ± 0.01 Cmolkg-1 for Na, 0.09 ± 0.01 Cmolkg-1 for K, 1.59 ± 0.04 Cmolkg-1 for Ca and 0.46 ± 0.04 Cmolkg-1 for Mg. The results showed the samples were not generally ideal for coconut growth and production of good yields because of marginal deviation from acceptable limits. It is recommended that the soils in these localities need fertilization especially with nitrogen and potassium carriers for the purpose of coconut cultivation.

Key words: Coconut, *Cocus nucifera*, physicochemical properties, fertility elements, surface soil, subsoil.

INTRODUCTION

Coconut palm, *Cocus nucifera* (Linn), of the order Palmae and family Arecaceae is widely dispersed in most regions of the tropics. The wide distribution is primarily due to floatation of coconut fruit in sea water where they are readily established in the sandy beaches (Ohler, 1999) as well as its distribution, transportation and cultivation by man (Woodroof, 1979). The palm is very useful to mankind for it supplies food, drink and shelter. It also provides raw materials for industries such as the wood and furniture industry, food and beverages industry, soap industry and agriculture (Woodroof, 1979; Ohler, 1984; Jones, 1989; Persley, 1992). Infact coconut plays a vital role in the economics of many countries (Persley, 1992).

The oil has been found to contain many saturated fatty acids like lauric, myristic and palmitic acids as well as monosaturated and polysaturated acids. Other constituents include sucrose, sugars and other carbohydrates, ascorbic acid, minerals and vitamins. The kernel also contains protein, fats, carbohydrate, minerals and vitamins. Coconut have been found to have varying pharmacological activities such as antidotal, anthelmintic, antiseptic, aphrodisiac, bactericidal, diuretic, hemostat, stomachic and many other properties (Duke, 1983; Fife, 2000).

A high fertility status of the supporting soils is required for high productivity of coconut per unit land area. Coconuts grow better and give higher yields under suitable

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soil conditions like well drained soils, good soil depth, soil texture, proper layout of land and nutritionally fertile soil (Persley, 1992). Pandalai (1953) indicated that with suitable cultivation, conservation, adopting amelio-rative measures and application of manure, all normal soils could be used for coconut cultivation. Coconuts do not form a tap root but generates adventitious roots continuously that grow up to 30 – 120 cm deep (Persley, 1992; Reynolds, 1988). The principal fertility aspects of soil in relation to coconut cultivation are the soil moisture, soil nutrients including major and trace elements, appropriate rainfall and soil aeration, favourable soil temperature, root space and absence of toxins.

The determination of the baseline data on inherent physical and chemical properties of soil is required so as to know the limit of nutritional requirement for the cultivation of coconut palm. Small scale cultivation of oil-palm is currently undertaken in the selected localities and this study aims at evaluating the soil fertility states and make appropriate recommendations for an effective large scale production of coconut.

The localities used in this study are close to the ancient city of Benin which lie between latitudes 6, 00'N and longitudes 5, 40'E in Southern Nigeria.

MATERIALS AND METHOD

Preparation of soil sample

The surface soil and top soil samples from were collected from five different locations of the respective localities and placed on drying trays in the drying room for 48 h so as to break the lumps and ensure proper drying. After drying, the soil was ground and passed through a 2 mm nylon sieve (the materials that did not pass through the sieve were discarded). The fine particles were then placed in containers and labeled before they were subjected of following analytical methods.

Analysis of soil sample

pH: 20 g of the air-dried soil was accurately weighed and washed into a 50 ml capacity beaker and 20 ml of distilled water was added, stirred and allowed to stand for 30 min. The pH values were then taken (Folson et al 1981; Mclean, 1982).

Soil exchange acidity: 5 g of the air-dried soil was accurately weighed into a 250 ml plastic bottle and 50 ml of 1 N potassium chloride was added, stoppered and placed on the mechanical shaker for 1 h. The soil suspension was filtered into 150 ml conical flask and 2 drops of phenolphthalein indicator was added and titrated against 0.05 M sodium hydroxide to a permanent pink colour end-point. The amount of base used is equivalent to the total exchangeable acidity (Folson et al., 1981; Mclean, 1982).

Organic carbon: 0.5 g of the fine ground soil samples wasweighed into 250 ml Erlemerger flask; 10 ml of 1 N of potassium dichromate solution was added and swirled gently to disperse the soil. 20 ml of concentrated sulphuric acid was quickly added and the flask was swirled for proper mixing. The flask was then placed on the asbestos sheet for 30 min before 60 ml of distilled water, 5 ml of orthophosphoric acid and 6 drops of diphenylamine indicator were added, and titrated against 0.4 N ammonium ferrous sulphate solution (Walkley and Black, 1934; Nelson and Sommers, 1982).

Soil total nitrogen: 0.2 g of the fine ground soil samples was weighed into digestion tubes; 1 tablet of selenium catalyst and 4 ml of concentrated sulphuric acid were added. The digestion tubes were placed on the digestion block until the solution became clear and cool. The solution was then filtered into 100 ml volumetric flask and made up to the 100 ml mark with distilled water. The nitrogen content was then estimated by an auto-analyser and its reagents with sets of standards (Kjeldahl, 1883; Dahnke and Johnson, 1990).

Soil phosphorus: 50 g of the air-dried, fine soil samples was weighed into 150 ml plastic bottle and 35 ml of L-ascorbic acid was added and shaken manually for 1 min. The resultant suspension was filtered and the phosphorus content was estimated colorimetrically using ammonium molybdate as the colouring agent (Bray and Krutz, 1945).

Particle size analysis: 100 g of the air-dried fine soil was weighed into baffled cup, half filled with distilled water before 50 ml of sodium hexametaphosphate reagent and 3 ml of 1 N sodium hydroxide were added. The mixture was stoppered and shaken for 3 h with a mechanical shaker and the resulting suspension was transferred into the Bouyoucos cylinder and filled to the lower mark with distilled water. After proper mixing of the content of the cylinder the hydrometer reading was taken after 5 h (Bouyoucos, 1962).

Soil exchangeable cations: 0.5 g of the air-dried, fine soil samples were weighed into 250 ml plastic bottle. 100 ml of neutral ammonium acetate was added and then flask was stoppered and shaken for 30 min with a mechanical shaker. The resultant suspension was filtered and the filtrate was estimated for calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) (Thomas, 1982).

RESULTS

The mean values ± standard error of mean (SEM) for the selected physicochemical properties of the surface soil and the subsoil for the coconut fields in the seven localities used in this study are shown in Tables 1a and 1b. The mean values ± standard error of mean (SEM) for the amount/concentration of basic fertility elements of the surface soil and the subsoil samples for the coconut fields in the seven (7) localities used in this study are summarized in Table 2a and 2b. The pH values ranged from 5.40 ± 0.07 for the subsoil at Okunuvbe locality to 6.16 ± 0.11 for the surface soil at Ekobodo locality. For the particle size analysis, the soils were found to be mainly coarse with the percentage sand ranging from 84.30 – 95.51%. Sand content were higher for the surface soils than for the sub-soils. Silt contents were low to moderate and varied from 1.94 ± 0.09% for the surface soil of Okunuvbe locality to 5.02 ± 0.18% for the surface soil of Ishiokuku locality. On the other hand, the clay contents were moderate and ranged from 2.56 ± 0.09% for the surface soil of Okunuvbe locality to 11.22 ± 0.23% for the subsoil of Ishiokuku locality. Also the percentage content of clay and sand were higher in for surface soils than for the sub-soils.

The organic carbon present was higher for the surface soil than for the subsoil with the lowest value of 0.45 ± 0.02 gkg-1 for subsoil of Ugbogiobo locality and highest values of 2.55 ± 0.02 gkg-1 for the surface soil at the NIFOR locality. The nitrogen content for the seven localities was almost similar ranging from 0.040 ± 0.004 gkg-1

Table 1a. Phytochemical properties of the surface soils (0 – 15 cm) of the seven localities.

Name of Locality	pH	C (gkg-1)	N (gkg-1)	C/N	Clay (%)	Slit (%)	Sand (%)
NIFOR	5.62 ± 0.08	2.55 ± 0.02**	0.13 ± 0.02**	20.10 ± 0.88	6.54 ± 0.10**	2.66 ± 0.09	90.8
Ekobodo	6.16 ± 0.11**	1.40 ± 0.02	0.09 ± 0.004	16.13 ± 0.16	2.56 ± 0.14*	2.09 ± 0.15	95.3
Okunuvbe	5.76 ± 0.11	1.21 ± 0.22	0.08 ± 0.004	15.51 ± 0.28	2.56 ± 0.09	1.94 ± 0.09*	95.5**
Ishiokuku	5.70 ± 0.07	0.76 ± 0.03*	0.06 ± 0.002*	12.17 ± 0.22	6.18 ± 0.18	5.02 ± 0.18**	88.8*
Evboneka	5.50 ± 0.07*	0.96 ± 0.02	0.08 ± 0.005	11.58 ± 0.27*	6.52 ± 0.11	4.68 ± 0.11	88.8*
Ugbogiobo	5.80 ± 0.07	0.81 ± 0.03	0.07 ± 0.001	12.16 ± 0.42	4.10 ± 0.10	2.10 ± 0.10	93.8
Eko-Enobori	5.70 ± 0.07	2.01 ± 0.03	0.10 ± 0.01	20.24 ± 1.10**	3.64 ± 0.13	2.56 ± 0.13	93.8

** Highest values. * Lowest values n = 5 (number of samples collected) Values are given as mean ± SEM.

Table 1b. Phytochemical properties of the sub-soils of the seven localities.

Name of Locality	pH	C (gkg^{-1})	N (gkg^{-1})	C/N	% Clay	% Slit	% Sand
NIFOR (15 - 30cm)	5.42 ± 0.08	1.85 ± 0.03**	0.09 ± 0.01**	19.69 ± 0.67**	8.58 ± 0.11	2.12 ± 0.11*	89.3
Ekobodo (15 - 30cm)	5.74 ± 0.11**	0.80 ± 0.01	0.07 ± 0.004	12.03 ± 0.13	3.64 ± 0.17	3.06 ± 0.17	93.3
Okunuvbe (15 - 30cm)	5.40 ± 0.07*	0.68 ± 0.01	0.06 ± 0.003	12.50 ± 0.59	3.56 ± 0.09*	2.14 ± 0.09	94.3**
Ishiokuku (15 - 30cm)	5.62 ± 0.15	0.54 ± 0.01	0.05 ± 0.003	11.84 ± 0.53	11.22 ± 0.23**	4.48 ± 0.23**	84.3*
Evboneka (15 - 30cm)	5.40 ± 0.07*	0.60 ± 0.02	0.05 ± 0.005	12.10 ± 0.18	9.58 ± 0.11	3.12 ± 0.11	87.3
Ugbogiobo (15 - 30cm)	5.54 ± 0.09	0.45 ± 0.02*	0.04 ± 0.002*	11.32 ± 0.39*	4.64 ± 0.13	2.56 ± 0.13	92.8
Eko-Enobori (15 - 30cm)	5.44 ± 0.05	0.65 ± 0.01	0.05 ± 0.002	12.97 ± 0.31	5.60 ± 0.10	3.60 ± 0.10	90.8

** Highest values * Lowest values n = 5 (corresponding to the number of samples collected) Values are given as mean ± SEM

for the subsoil at Ugbogiobo locality to 0.13 ± 0.02 gkg-1 for the surface soil at NIFOR locality. Considering the carbon and total nitrogen values, the carbon: nitrogen ratio ranged from 11.32 ± 0.39 for the subsoil at Ugbogiobo locality to 20.24 ± 1.10 for the surface soil at Eko-Enobori locality. For phosphorus content, the values obtained ranged from 7.04 ± 0.15 mgkg-1 for the subsoil at Ekobodo locality to 17.45 ± 0.60 mgkg-1 for the surface soil at NIFOR coconut fields. The lowest mean value of 0.56 ± 0.01 Cmol/kg of calcium was obtained for subsoil at Ekobodo locality while the calcium content was as high as 2.91 ± 0.10 Cmol/kg for the surface soil at Ugbogiobo locality. The magnesium concentration of the soil samples of the seven localities showed little variation and ranged from 0.25 ± 0.04 Cmolkg-1 for the subsoil at Okunuvbe locality to 0.79 ± 0.08 Cmolkg-1 for the surface soil at Eko-Enobori locality.

The highest value of 0.21 ± 0.02 Cmolkg-1 was obtained for sodium from the surface soil at NIFOR coconut fields while the lowest value of 0.10 ± 0.01 Cmolkg-1 were obtained for subsoil at Ekobodo, Eko-Enobori and Ugbogiobo localities. For potassium, the surface soil of NIFOR locality gave the highest values of 0.14 ± 0.02 Cmolkg-1, while the subsoil of Okunuvbe locality showed lowest value of 0.06 ± 0.01 Cmolkg-1.

DISCUSSION

The values obtained suggest that the pH of the soil samples were slightly acidic. The values for exchangeable acidity also suggest that the soil samples are more acidic. The pH values obtained for the various surface soils were found to be slightly higher than that of the subsoil. This means that the subsoil is slightly more acidic than the surface soil. Child (1974) observed that the best soils for coconuts are clayed alluvial soils, which are not too acidic and are also rich in nutrients. Generally, therefore, the soil pH of these localities seems to be ideal for coconut cultivation. The soil net ability to hold nutrients and water is higher with increasing pH. This is especially true with soils with high organic matter content and also certain types of clays. The reason is that when the exchangeable acidity is removed, the exchange sites will now be able to adsorb other ions. Thus, the cation exchange capacity (CEC) of the soil will vary with pH (Rhoades, 1982).

Also the particle size of soil and texture are important factors determining soil fertility status of soils that supports the cultivation of coconut. According to Chan (1978) and Child (1974), coconut requires deep, stone free, well-drained clayed alluvial soils, which have no hard pan near the surface soil likely to impede root development. This is because the efficient root system of the coconut palm is not strong enough to penetrate hard layers and will flourish and give better yields if the surface soil is physically suitable and chemically rich.

The percentage organic carbon present was higher for the surface soil than for the subsoil and the values obtained correspond with those reported by Ukpebor et al. (2003). But these values are low for coconut cultivat-

TABLE 2a. Concentrations of some Fertility elements in the Surface Soils of the Seven Localities

Name of locality	Concentration values						
	P (mgkg^{-1})	Ca (Cmolkg^{-1})	Mg (Cmolkg^{-1})	Na (Cmlokg^{-1})	K (Cmolkg^{-1})	EA (Cmolkg^{-1})	ECEC (Cmolkg^{-1})
NIFOR (0 - 15cm)	17.45 ± 0.60**	2.03 ± 0.04	0.55 ± 0.03	0.21 ± 0.02**	0.14 ± 0.02**	0.58 ± 0.08**	3.52 ± 0.12
Ekobodo (0 - 15cm)	10.76 ± 0.18	0.95 ± 0.04*	0.62 ± 0.05	0.12 ± 0.01*	0.07 ± 0.01*	0.52 ± 0.04	2.28 ± 0.07*
Okunuvbe (0 - 15cm)	9.13 ± 0.11	1.29 ± 0.02	0.40 ± 0.06*	0.15 ± 0.02	0.08 ± 0.01	0.58 ± 0.08**	2.49 ± 0.08
Ishiokuku (0 - 15cm)	13.62 ± 0.44	2.50 ± 0.07	0.63 ± 0.08	0.20 ± 0.01	0.12 ± 0.01	0.40 ± 0.07*	3.84 ± 0.06
Evboneka (0 - 15cm)	11.23 ± 0.36	1.60 ± 0.04	0.47 ± 0.07	0.20 ± 0.01	0.11 ± 0.01	0.54 ± 0.11	2.95 ± 0.12
Ugbogiobo (0 - 15cm)	12.50 ± 0.42	2.91 ± 0.10**	0.54 ± 0.04	0.19 ± 0.01	0.11 ± 0.02	0.50 ± 0.07	4.25 ± 0.09**
Eko-Enobori (0 - 15cm)	8.62 ± 0.13*	1.30 ± 0.02	0.79 ± 0.08**	0.12 ± 0.01*	0.08 ± 0.01	0.56 ± 0.05	2.86 ± 0.05

Table 2b. Concentrations of some Fertility elements in the Sub-soils of the Seven Localities.

Name of locality	Concentration values						
	P (mgkg^{-1})	Ca (Cmolkg^{-1})	Mg (Cmolkg^{-1})	Na (Cmlokg^{-1})	K (Cmolkg^{-1})	EA (Cmolkg^{-1})	ECEC (Cmolkg^{-1})
NIFOR (15 – 30cm)	9.43 ± 0.31	0.87 ± 0.02	0.46 ± 0.04**	0.15 ± 0.01	0.08 ± 0.01	0.72 ± 0.08	2.28 ± 0.11
Ekobodo (15 – 30cm)	7.04 ± 0.15*	0.56 ± 0.01*	0.31 ± 0.02	0.10 ± 0.01*	0.07 ± 0.01	0.44 ± 0.05*	1.47 ± 0.07*
Okunuvbe (15 – 30cm)	8.41 ± 0.35	0.80 ± 0.08	0.25 ± 0.04*	0.12 ± 0.02	0.06 ± 0.01*	0.74 ± 0.15**	1.96 ± 0.13
Ishiokuku (15 – 30cm)	10.15 ± 0.38**	1.55 ± 0.07	0.42 ± 0.07	0.16 ± 0.01	0.08 ± 0.01	0.46 ± 0.05	2.66 ± 0.07**
Evboneka (15 – 30cm)	9.50 ± 0.47	1.31 ± 0.05	0.42 ± 0.10	0.17 ± 0.02**	0.07 ± 0.01	0.52 ± 0.08	2.48 ± 0.15
Ugbogiobo (15 – 30cm)	9.52 ± 0.13	1.59 ± 0.04**	0.30 ± 0.05	0.10 ± 0.01*	0.09 ± 0.01**	0.48 ± 0.08	2.56 ± 0.14
Eko-Enobori (15 – 30cm)	7.79 ± 0.19	0.71 ± 0.05	0.39 ± 0.07	0.10 ± 0.01*	0.07 ± 0.01	0.66 ± 0.05	1.93 ± 0.12

** Highest values * Lowest values n = 5 (corresponding to the number of samples collected) Values are given as mean ± SEM

ion when compared with the value of 3.00 gkg-1 which Chan (1978) considered optimum value for normal coconut growth and good yield response. Blakemore et al. (1972) reported that 0.30 gkg-1 of total nitrogen is critical for tropical soils and so the values obtained in this investigation are very low. For the carbon and total nitrogen values, Tinker and Ziboh (1959) reported similar values for soils of the Southern Nigeria.

The effective cation exchange capacity (ECEC) are very low as they are less than 15 cmolkg-1 soil, hence their nutrient retaining ability for plant nutrient will be very low which makes the application of fertilizer to these soils to be a necessity (Rhoades, 1982). Generally, phosphorrus values obtained compared well with the critical phosphorus values of Bray 1 levels in the soils of Southern Nigeria as reported by Agboola and Corey (1972) as well as Bray and Krutz (1945). The value of calcium was found to be very low in Ekobodo, Okunuvbe, Evboneka and Eko-Enobori localities. The exchangeable sodium is on the high side especially when low sodium is required by coconut palms (Amalu and Obigbesan, 1986). The values for potassium are less than the 0.2 cmolkg-1 soil values reported for the optimum growth of coconut in Malaysia (Chan, 1978).

In conclusion, the results obtained in this work shows that the soil supporting the growth of coconut in these localities are sandy, slightly acidic, and low in carbon content, nitrogen and phosphorus. The concentrations of exchangeable calcium and magnesium are moderate while the available phosphorus content compare well with the critical values that have been considered optimal for coconut cultivation. The soil pH, organic carbon, total nitrogen, carbon: nitrogen ratio, available phosphorus, exchangeable potassium, magnesium and calcium all declined with soil depth, whereas the sodium content remained uniformly distributed. With the sandy texture and low to moderate fertility status of the studied soils, amelioration of the physicochemical properties of the soil and fertilization especially with nitrogen and potassium carriers are necessary to boost coconut yields in these localities.

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