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NUTRIENT STATUS OF SOME SOILS SUPPORTING RUBBER *(HEVEA BRASILIENSIS ARG. MUELL)* IN MIDWESTERN NIGERIA

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ABSTRACT

A study was conducted to determine the nutrient status of soils in a budded rubber plantation in the high rainforest region of Midwestern Nigeria. Results obtained showed that the soils were acidic and low in most essential nutrients. Total N and available P ranged from 0.010 0.045 % and 0.075 1.694 mg kg^{-1} respectively. Exchangeable acidity was high and ECEC was generally low. Fertilizer recommendations based on the nutrient status of the soils were proposed. The use of organic or slow releasing forms of fertilizer was advocated.

INTRODUCTION

Rubber is grown both in large and smallholdings throughout the expanse of Coastal Plain Sands of Southern Nigeria but the largest concentration of rubber is in Midwestern Nigeria with approximately 56% holdings (RRIN 1998). The vast majority of the soils supporting natural rubber in Nigeria are ultisols that are known to be very low in most essential nutrients, highly leached and acidic. The soils are characterised by low water holding capacity, low CEC, poor structural stability and the predominance of low activity kaolinitic clay fractions (Eshett, 1989; Eshett, 1991 and Asawalam and Ugwa, 1993). The high rainfall nature of these areas predisposes the soil to erosion and leaching that depletes the native soil fertility thereby necessitating fertilizer application. For most humid tropical soils, a good fertilizer management is required especially for perennial crops such as rubber that are highly nutrient demanding during the immature phase (1 - 6 years) i.e. before canopy closure. Rubber seedlings or budded stumps are often introduced into newly cleared forest or old rubber plantation.

An optimum six monthly rate of P of 16-108g as Triple super phosphate per plant for the first five years has been proposed by Tambunan *et al* (1993) while K as murate of potash at the rate of 33g per tree per year was recommended by Samarapulli *et al* (1993). Other fertilizer materials proposed by different authors include Rock phosphate, latex sludge, rubber factory effluents, natural legumes as well as urea and single super phosphate (Manurung, 1993; Punnose, *et al.* 1994; George *et al*, 1994 and Soyza, 1994).

Appropriate soil fertility management is central to the sustainability of rubber plantations. This paper therefore discusses the physico-chemical properties

Of the highly leached ultisols of Midwestern Nigeria with a view of proposing fertilizer use based on the nutrient status and physical properties of the soils.

MATERIALS AND METHODS

The study was carried out in a fertility stressed young plantation of budded rubber (Nig 800 clone) in the Rubber Research Institute of Nigeria main station in Iyanomo, near Benin City. The area is located in the high humid rainforest region with a mean annual rainfall of 2018.7mm and a mean annual temperature of 32.4°C. A systematic grid pattern of soil sampling was laid out to cover the 12.8 ha young plantation to represent the whole area. Twenty-four points were sampled with a bucket auger at three depths: 0-30, 30-60 and 60-100 cm due to the deep rooting nature of rubber plant. At each sampling point, a composite was collected for each depth. The samples were air dried, passed through 2mm sieve, and subjected to routine analysis using standard laboratory procedures.

The pH was determined at soil/water ratio of 1:1 using a glass electrode Beckham pH meter. Organic carbon was determined by the chromic acid oxidation method described by Black (1965) and the percentage organic mater content was obtained by multiplication with a factor of 1.729. Total nitrogen was extracted by micro kjehdahl digestion procedure and was determined using a Technicon Auto-analyser. The available phosphorus was extracted with Bray I solution and the phosphate in solution assayed by the Molyldenum blue colour method. Exchangeable Cations were extracted with neutral 1N Ammonium acetate solution. The Ca and Mg in the extract were determined by EDTA titration while Na and K were determined by Flame photometry. Exchangeable acidity was extracted with IN KCl solution and the acidity was obtained volumetrically. Effective Cation Exchange Capacity was obtained by summation. Particle size analysis of the soil was by the hydrometer method of Bouyoucus as modified by Day (1965) and soil textural classes were obtained by the USDA triangulation method. The soil content of cations on hectare basis was calculated by first determining their milliequivalent in the soil which was converted to Cmol kg^{-1} by multiplying by 10E where E is the equivalent weight of the cations. The value obtained was then multiplied by the soil content. The amount in hectare basis was obtained by multiplying with the constant 1.12×10^6 kg.

RESULTS AND DISCUSSION

Morphological properties

The soil physical and chemical properties of the study area are presented in Table I. The soils had been classified as Typic Paleudult (FDLAR, 1990). The textural classes of the soils varied from sandy loam at 0-30 cm depth to sandy clay loam in the lower depths 60-100cm. The higher clay contents (16 30 %) noticed in the sub-horizons showed the degree of clay eluviation as the low silt contents 1-5 % in all indicate intense weathering. This contributes to the transformation of clay fractions to the low activity 1:1 silicate clays (largely kaolinite) obtainable in most ultisols of the Southern Nigeria (Eshet, 1989). The sandy texture of the surface soil with higher subsoil clay content has been described as very desirable for rubber growth under high rainfall conditions (Asawalam and Ugwa. 1993).

Chemical properties of the soil

The pH values ranged from 3.80 to 5.40 with a gradual decrease with soil depth. High acidity is typical of soils of the coastal plain sands of Midwestern Nigeria. This is as a result of strongly leached soil conditions and a preponderance of inherently acidic parent material (Akamigbo and Asadu, 1983). Organic matter was generally low with a mean of 0.68% at the 0-30cm depths, which is supposed to be the zone of highest accumulation of organic matter. This might have been brought about by the rapid rate of mineralization occurring in the humid tropics. Agboola (1994) had previously established a positive correlation between

Table 1: Some Selected Physico–Chemical Properties of an Acid Ultisol of Midwestern Nigeria

Soil Properties	Soil Depth: 0 – 30 cm			30 – 60cm			60 – 90cm		
	Range	Mean	SE	Range	Mean	SE	Range	Mean	SE
Organic matter (%)	0.36 -0.90	0.68	0.06	0.36 – 0.86	0.53	0.06	0.21 – 0.60	0.35	0.04
P^H (H_2O)	4.80 - 5.40	5.01	0.07	4.30 – 4.80	4.54	0.06	3.80 – 4.20	4.09	0.05
Available P (mg kg^{-1})	0.521 - 1.20	1.08	.0.13	0.212 – 1.053	0.556	0.10	0.025 – 0..20	0.125	0.002
Ca (Cmol kg^{-1})	0.34 – 1.28	0.83	0.09	0.41 – 1.20	0.71	0.08	0.30 – 0.58	0.46	0.04
Mg Cmol kg^{-1}	0.04 -. 0.50	0.23	0.06	0.93 – 0.44	0.16	0.05	0.04 – 0.22	0.10	0.02
Na ,,	0.04 – 0.06	0.05	0.002	0.03 – 0.05	0.04	0.003	0.01 – 0.05	0.03	0.004
K ,,	0.08 – 0.14	0.16	0.01	0.05 0.11	0.08	0.005	0.03 – 0.08	0.06	0.006
Exch. Acidity	0.70 – 2.09	1.56	0.17	0.98 - 2.05	1.64	0.12	1.16 – 2.02	1.80	0.15
ECEC	2.11 – 3.07	2.78	0.14	1.53 - 3.04	2.55	0.16	1.28 – 3.00	2.42	0.20
Base Saturation(%)	23.09 – 67.3	44.12	5.20	28.07 51.64	37.42	2.44	9.38 – 36.0	24.78	2.50
Sand %	78 – 89	85	1.32	74 - 85	81.75	1.42	68 – 82	75.9	1.71
Silt %	2 – 3	2.5	0.20	2 - 4	2.9	0.24	1 – 5	2.6	0.43
Clay %	9 – 19	11.9	1.25	12 – 22	15.38	1.37	16 – 30	21.5	1.95
Textural Class	Sandy Loam			Sandy Clay Loam			Sandy Clay Loam		

organic matter, total nitrogen and phosphorus. Therefore, the low mean per cent Nitrogen and available P, which were 0.034 % and 1.08 mg kg-1 respectively, encountered were the direct effect of the low organic matter. The low concentration of native available P could also be attributed to high phosphate absorption capacity of acid ultisols due to the presence of oxides and hydroxides of Fe and Al (Eshett, 1991). Exchangeable bases in the soils were also very low with Ca having the highest values, which ranged from 0.30-1.28 Cmol kg^{-1} and is still considered low for the optimum rubber development. The liming effect of Ca could therefore not be felt resulting in the very low pH values. Other cations such as K and Mg were also very low. This is characteristic of soils derived from coastal plain sands. The lithology is inherently low in exchangeable bases and the situation is worsened by the low organic matter content and the preponderance of kaolinite with Iron and Aluminium oxides in the clay fractions (Eshett, 1991). A direct consequence of this is the very low effective cation exchange capacity (ECEC), which is a more accurate index of soil fertility in the humid tropics than the conventional CEC.

The ECEC ranged from 1.28 3.07 Cmol kg^{-1} and this is less than the marginal requirements of rubber (Watson, 1989). Exchangeable acidity was 1.56, 1.64, and 1.80 Cmol kg^{-1} at 0-30, 30-60 and 60-90 cm respectively representing 56.1 %, 64.31 % and 74.38 % of the ECEC respectively. The percentage base saturation was expectedly low (44.12 % at 0-30 cm) as a result of high precipitation leading to strong weathering and leaching conditions of the area. This is further indicative of low fertility status of some soils of the coastal plain sands as corroborated by earlier studies (Eshett, 1991; Asawalam and Ugwa, 1993 and Sylla *et al*, 1996).

Soil Fertility Management For Budded Rubber

The soils under consideration by virtue of their physico chemical properties fall within the range of low to marginally fertile for rubber (Sys, 1975; Watson, 1989). Therefore, a judicious soil management measure that would improve the soil resource base is advocated. Based on the soil test results obtained in this study, a fertilizer application rate for rubber production on these soils has been proposed in Table 2. During the immature phase of rubber, nitrogen is lost as NH_4^+, NO_3^- and NO_2^- through leaching as well as through volatilisation, denitrification, microbial

Table 2: Fertilizer rates for young rubber on an ultisol of mid-western Nigeria based on soil test results

Nutrient Element	Fertility Ratings: Available Soil Content (0 – 30cm) kg/ha	Minimum Rubber Requirement Kg/ha	Fertilizer Material	Rate of Application Kg/ha/yr
N	38	112	$(NH_4)_2SO_4$	352.0
			Urea	186.70
P (P_2O_5)	1.50	12.8	SSP	62.94
			TSP	24.63
			RP	56.5 – 70.8
K (K_2O)	34.85	87.58	MOP	87.71
Mg (MgO)	54.45	68.5	Commercial MgO	23.4

SSP – Single superphosphate, TSP – Triple super phosphate, RP - Rock phosphate
MP - Murate of potash.

uptake and clay fixation so much so that large amounts of Nitrogen are lost over a short period of time. In predominantly sandy to sandy-loams, it has been found that only about 10 % of total N in the soil is available to the crop (Onuwaje and Uzu, 1982). The relative importance of N, P, K and Mg fertilizers in rubber husbandry in Southern Nigeria has been highlighted by Esekhade and Ugwa (1999). Apart from the direct nutritional roles of these elements, K performs a remediatory role in water stress conditions in rubber during the dry seasons. As a result of the sandy nature and low water holding capacity of soils supporting rubber, water stress is a constraint in the dry season (Samarapulli *et* al 1993), while Magnesium prevents the physiological disorder that brings about Tapping Panel Dryness (TPD) at latter stages of rubber growth. Onuwaje and Uzu (1982) have described phosphorous as the most important single nutrient element in the growth of rubber especially at the juvenile stage.

In the final analysis, a fertilizer application programme consisting of approximately 352 kg ha^{-1}, $(NH_4)_2SO_4$ or 186 kg ha^{-1} Urea; 62.94 kg ha^{-1} single Super phosphate (24.6 kg ha^{-1} TSP or 56.7-70.8 kg ha^{-1} Rock phosphate); 87.7 kg ha^{-1} murate of potash and 23.4 kg ha^{-1} commercial MgO on a yearly basis is proposed for the Optimum growth of budded rubber in this acidic ultisol of Nigeria (Table 2). The addition of organic materials such as mulch, leguminous cover or outright integration of livestock as proposed by Kobat *et al* (1985) will help a long way in ameliorating the soil physical conditions. Addition of phosphate fertilizers in acid sandy soils faces the risk of added P being fixed by the oxides and hydroxide of Fe and Al which are usually present in abundance in the coastal area. Therefore insoluble or slow releasing forms of phosphate fertilizers such as rock phosphates, rubber factory effluent or latex sludge is preferred and recommended by various authors (Manurung, 1993; Nair *et al* 1998) rather than the soluble forms such as super phosphates.

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