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SOIL BORON AND BIO-ACCUMULATION IN RAPHIA PALM

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ABSTRACT

Total and available Boron were determined in surface soils from 56 locations on 5 different parent materials in Southern Nigeria. Boron concentrations in leaves of Raphia palms growing in the were also determined.

Total, available and plant Boron ranged from 16.0 to 87.0; 0.08 to 2.31; 3.0 to 25.0mg/kg respectively in crystalline metamorphic and igneous rock soils; 22.3 to 69.4; 0.01 to 1.20; 6.0 to 12.0 mg/kg; in shale mixed with sandstone and clay soils; 22.3 to 69.5; 0.01 to 3.15; 4.0 to 16.0 mg/kg in coastal plain sands soils; 20.3 to 96.0; 0.01 to 1.93; 5.0 to 12.0 mg/kg in coastal alluvium soils and 28.3 to 52.6; 0.01 to 0.43; 3.0 to 12.0 mg/kg in fresh water swamp soils respectively. Percent total boron extractable by hot water varied from 0.46% to 2.5%.

From the available Boron data, there is likely inability of soils in most locations to supply sufficient Boron to support normal plant growth.

Keywords: Total Boron, Available Boron, Boron Extractability, Bio-Accumulation.

INTRODUCTION

Boron (B) is an essential plant nutrient for growth and development; but needed in very small quantities. It is implicated/important in plant cell division, cell wall formation, production of nucleic acids (DNA and RNA), nitrogen metabolism and protein formation, maintenance of balance between sugar and starch, translocation of sugar and carbohydrate across cell membrane, development of reproductive structures as pollen tube, fruits and grains and maintenance of cells internal water balance (Hall 2008). The roles of boron in oil palm and coconut palm growth, development and nutrition are well documented, (Turner & Gillbanks 2003, Carley & Tinker 2003). However, information on boron content of Raphia palm is very scanty; if at all.

Information on soil total boron and available forms generally abound for developed agriculture, because of wide spread report of boron deficiency and/or toxicity symptoms for a wide range of arable crops and pastures (Maas, 1984). However, soil testing is considered the best method for determining the presence of boron deficiency and/or toxicity as critical limits in plant cannot be easily determined partly due to uneven accumulation of boron in plant tissue.

For Nigeria soil and even in most crops, information on total boron, its availability and plant tissue concentration respectively is very scarce. The Raphia palm is native to the humic tropics (Tuley & Russell, 1966). Twenty species of the palm have been identified in Africa; eight of these are indigenous to Nigeria (Otedoh). The palms grow naturally in the wild in most wetland/hydromorphic soils of southern Nigeria. Local dwellers in these areas often exploit the most vigorous wide Raphia hookeri, dominantly for its sap (palm-wine) and piassava derived from the apical frond. The study therefore, is aimed at determining total and available boron in soils developed on different parent materials with a common factor of hydro morphism and adapted Raphia palm grown in them. The essential role boron plays in cell water management and sugar/carbohydrate translocation in plants and expectedly Raphia hookeri exploited for its sap (palm-wine), further made this work important.

MATERIALS AND METHODS

Fifty soil core samples (0-20cm) were collected randomly from fifty-six locations developed on 5 different parent materials; (Table 1). Fourteen locations were developed on crystalline metamorphic and igneous rocks, twelve locations on shale mixed with sandstone and clay, thirteen locations developed on coastal plain sands, nine locations developed on coastal alluvium and eight locations developed on fresh water swamps. Waterlogging and hydromorphism was a common factor to all the locations. The samples were bulked, sub-sampled and air-dried for analysis.

Ten Raphia Hookeri (wine palm) grown in the locations were sampled. The middle frond on each canopy was cut down and leaflets striped from al-

Table 1: Soil Parent Materials, Classification and Sample Locations

Parent Materials (USDA Taxonomy)	Sample Location (Town and Cities)
Chrystalline metamorphic igneous basement complex rocks (typictropaqualfs)	Iseyin, Fidity, Ondo, Ibadan, Asejire, Ilesha, Ado-Ekiti, Aramoko, Ikare, Owo, Akure, Akamkpa, Obubra, Ogbomosho
Shale mixed with sandstone and clay (typictropaquults)	Ijebu-Ode, Igbogila, Agwu, Okigwe, Owode, Itori, Shagamu, Ubiaja, Umuahia, Awka, Mbaise, Afikpo
Coastal plain sands (typictropaquults/Typictropaquepts)	Gbara, Ito-Eki, Ilaro, Ikorodu, Epe, Okitipupa, Evboneka, NIFOR, Abudu, Agbor, Aba, Ikot-Ekpene, Etinan
Costal Alluvium (Typictropaquents)	Egbunke, Abak, Badagry, Odo-Olowu, Ikot-Abasi, Calabar, bori, Porth-Harcourt, Abedo
Freshwater swamp (typictropaquents)	Ozubulu, Ologbo, Mosogar, Otegbo, Kwale, Degema, Ekpan-Ovu, Ahoada

ternate sides of the petiole was sampled, bulked and sub-sampled. After removal of the mid-rib, the leaflets were chopped into pieces and oven dried to constant weight at 850C and milled.

Total boron was determined using ground soil sample by the Na2C03 fusion method, (Muir, 1952; Jackson 1958). Available Boron was determined by hot-water extraction (Keren, R. 1996). Boron in plant sample was determined by dry ashing (Okalebo et al 2002). Boron in the extract was determined by colorimetric method using 1:1 diantrimide, (Garfinkel & Pollard 1954). During the analysis, plastic containers and Boron free glass-wares were used. Also, blank samples were analysed to avoid Boron interference and contamination.

Table 2: Summary of the Physico-Chemical Properties of the Soils (Mean ± Standard Deviation) and (Range) in relation to soil parent materials

Physico-chemical Properties	Cystalline metamorphic and igneous rocks	Shale mixed with sandstone and clay	Coastal plain sand	Coastal alluvium	Fresh water swamps
pH	5.9 ± 0.79 (4.8 – 7.7)	5.2 ± 0.98 (4.2 – 7.9)	5.0 ± 0.55 (4.4 – 6.4)	5.0 ± 0.59 (4.3 – 5.9)	4.9 ± 0.41 (4.4 – 5.4)
Org. C (%)	2.00 ± 1.05 (0.058 – 0.430)	2.07 ± 1.29 (0.82 – 5.20)	2.23 ± 2.52 (0.63 – 10.50)	3.38 ± 3.58 (1.36 – 12.70)	1.64 ± 1.00 (0.74 – 3.80)
N (%)	0.178 ± 0.091 (0.058 – 0.430)	0.189 ± 0.086 (0.091 – 0.350)	0.16 ± 0.20 (0.03 – 0.66)	0.222 ± 0.120 (0.091 – 0.476)	0.137 ± 0.063 (0.056 – 0.0210)
P (Bray) mg/kg	19.5 ± 39.1 (1.0 – 145.0)	9.08 ± 11.00 (2.00 – 42.00)	12.5 ± 11.3 (2.0 – 40.0)	29.3 ± 40.2 (3.0 – 130.0)	8.43 ± 6.02 (3.00 – 17.00)
Exchangeable:					
Na (cmol/kg)	0.442 ± 0.103 (0.290 – 0.570)	0.334 ± 0.084 (0.200 – 0.470)	0.256 ± 0.094 (0.120 – 0.460)	0.403 ± 0.187 (0.250 – 0.820)	0.37 ± 0.35 (0.13 – 1.15)
K "	0.229 ± 0.093 (0.100 – 0.460)	0.146 ± 0.062 (0.050 – 0.240)	0.12 ± 0.14 (0.03 – 0.60)	0.19 ± 0.12 (0.05 – 0.41)	0.11 ± 0.07 (0.04 – 0.021)
Ca "	2.43 ± 1.61 (0.90 – 6.00)	2.19 ± 3.53 (0.30 – 12.80)	0.482 ± 0.227 (0.200 ± 1.000)	1.23 ± 1.11 (0.20 – 3.80)	0.293 ± 0.084 (0.200 – 0.400)
Mg "	1.82 ± 1.19 (0.26 – 3.95)	0.79 ± 0.70 (0 – 1.98)	0.29 ± 0.20 (0.08 – 0.66)	0.70 ± 0.69 (0.06 – 2.24)	0.241 ± 0.121 (0.100 – 0.420)
H^+ "	0.20 ± 0.33 (0.02 – 1.43)	1.14 ± 2.66 (0.03 – 9.50)	0.64 ± 0.51 (0.04 – 1.62)	0.63 ± 0.52 (0.06 – 1.39)	0.96 ± 1.07 (0.17 – 3.21)
Al^3 "	0.17 ± 0.32 (0 – 1.29)	0.65 ± 0.75 (0.01 – 2.36)	0.64 ± 0.44 (0.02 – 1.44)	0.64 ± 0.51 (0.02 – 1.37)	1.00 ± 0.59 (0.50 – 2.09)
ECEC "	6.54 ± 5.57 (2.10 – 25.72)	5.34 ± 4.37 (1.43 – 15.07)	2.44 ± 0.77 (1.37 – 4.13)	3.84 ± 1.91 (1.72 – 7.63)	2.85 ± 1.63 (1.51 – 6.24)
Base Sat (%)	91.29 ± 13.71 (49.00 – 99.00)	71.2 ± 26.4 (26.0 – 99.0)	52.6 ± 26.0 (20.0 – 96.0)	61.9 ± 27.5 (28.0 – 98.0)	36.86 ± 14.16 (15.00 – 56.00)
Sand (%)	68.12 ± 13.77 (39.00 – 86.00)	71.92 ± 18.68 (39.00 – 95.00)	81.93 ± 8.19 (67.00 – 91.00)	79.89 ± 4.59 (74.00 – 88.00)	81.14 ± 5.81 (73.0 – 88.0)
Silt (%)	10.71 ± 5.69 (2.00 – 24.00)	7.50 ± 5.95 (2.00 – 18.00)	3.64 ± 2.21 (1.00 – 8.00)	4.778 ± 1.716 (3.0 – 8.0)	4.00 ± 2.31 (1.00 – 7.00)
Clay (%)	20.35 ± 9.45 (11.00 – 48.00)	20.00 ± 13.26 (3.00 – 43.00)	14.71 ± 5.94 (5.00 – 26.00)	15.33 ± 4.09 (9.00 – 21.00)	13.29 ± 3.90 (8.00 – 20.00)

RESULT AND DISCUSSION

The soil parent materials and sample locations are given in Table 1. The ecology of the areas range from moist savannah with rainfall of about 1186mm in the northern fringe to humid forest with rainfall of over 2105mm in the southern end, (Greenland 1981). A summary of the overall physic-chemical properties of the soils is given in Table 2.

Soil Boron

A summary of boron levels in soils and Raphia leaf samples is given in Table 3. On overall basis, the mean total soil boron level is 39.16mg/kg. The highest levels were in Coastal alluvium (46.1 Omg/kg) and Freshwater swamps (40.64mg/kg), while lower levels were obtained for the other locations. However, the highest mean available boron level was recorded for Coastal plain sand (0.7mg/kg) and soils on crystalline metamorphic igneous basement complex rocks (0.65mg/kg) and the least amount (0.16mg/kg) recorded for Freshwater swamps soils.

Values obtained for total boron and water extractable/available boron are comparable

Table 3: Summary of Boron levels in Soils and Raphia Palm samples

Parent Materials (USDA Taxonomy)		Boron Levels (mg/kg)			
		Total	Avail	% Extractable	Plant
Crystalline metamorphic igneous basement complex rocks (Typictropaqualfs)	Range	16.00 – 87.00	0.08 – 2.31	0.30 – 14.44	3.00 – 24.90
	Mean	36.43	0.65	2.52	8.74
	Std. Div.	17.59	0.57	3.62	6.40
	C.V.	48.30	88.5	143.76	73.30
Shale mixed with sandstone and clay (Typictropaquults)	Range	22.30 – 69.40	0.01 – 1.20	0.03 – 3.54	5.60 – 11.70
	Mean	37.38	0.50	1.40	8.80
	Std. Div.	12.77	0.36	0.96	1.97
	C.V.	34.15	72.82	68.44	22.43
Coastal plain sands (Typictropaquults/ Typictropaquepts)	Range	22.30 – 69.50	0.01 – 3.15	0.02 – 7.11	3.60 – 15.70
	Mean	38.60	0.70	1.97	7.84
	Std. Div.	11.71	0.87	2.39	3.11
	C.V.	30.35	125.02	121.25	39.74
Coastal alluvium (Typictropaquents)	Range	20.30 – 96.00	0.01 – 1.93	0.01 – 6.87	4.60 – 12.20
	Mean	46.10	0.54	1.67	4.70
	Std. Div.	22.8	0.74	2.46	2.78
	C.V.	49.56	136.65	147.52	35.91
Freshwater swamps (Typictropaquents)	Range	28.30 – 52.60	0.01 – 0.43	0.02 – 1.04	2.50 – 12.20
	Mean	40.64	0.16	0.46	6.97
	Std. Div.	9.67	0.16	0.47	3.59
	C.V.	23.80	103.39	108.79	51.56
All 58 locations	Range	16.00 – 96.00	0.01 – 3.15	0.01 – 14.44	2.50 – 24.90
	Mean	39.16	0.55	1.77	8.23
	Std. Div.	15.43	0.63	2.49	4.07
	C.V.	39.40	113.17	140.52	49.45

with reported by Nalovic and Pinta (1972) for some Cameroonian soils, Kanwar and Raundhawa (1974) in some Indian soils, Cottenie et al (1981) for some Nigeria toposequence soils and Chude (1988) for some cocoa-growing soils in South Western Nigeria.

Percentage total boron in water extractable form also varied within soils developed on the different parent materials. The highest mean percentage extractable boron was obtained for soils on crystalline metamorphic igneous basement complex rocks (2.52%) and the lowest for soils in Fresh water swamps (0.46%) other locations fell within the range of (1.40% to 1.97%). The overall range of percent extractable boron was 0.01% to 14.44% and this compares to calculated range of 0.14% to 7.33% obtained in cocoa growing soils of South Western Nigeria by Chude (1988) and 0.20% to 6.12% calculated from Nigeria soils toposequence by Cottenie et al 1981.

Plant Boron

Raphia leaf boron concentrations similarly vary with locations. It ranged from 3.00mg/kg to 24.90mg/kg for palms in basement complex soils; 5.60mg/kg to 11.70mglkg in palms on coastal plain sand; 4.60mg/kg to 12.20mg/kg in palms on coastal alluvium and 2.50mg/kg to 12.20mg/kg in palms on fresh water swamp. The lowest mean leaf concentration of boron of 4.70mg/kg was obtained in palms on coastal alluvium soils, while the highest mean concentration of 8.80mg/kg was obtained for palms on shale mixed with sandstones and clay. These compare with boron concentration in leaves of other palms as Oil palm 4mg/kg to 5mg/kg; 10mglkg to 15mglkg; 25mglkg to 30mglkg; 50mglkg to 250mg/kg depending on locations (Turner and Gillbanks, 2003) and Coconut palm (3.4mglkg to 10.0mg/kg (Jayasekara & Loganathan 1988); 7.0 mg/kg to 15.8mglkg (Broschat 2011) at different ages and leaflet portions. Plant boron did not correlate significantly with either soil total boron or water extractable boron and/or any of the soil indices. A similar observation was made by Chude, (1988) for Cocoa and Cocoa growing soils in south-western Nigeria.

Reisenauer et al. (1973) classified hot water soluble boron availability as follows:

1.0ppm: Soil may not supply sufficient B to support normal plant growth

1.0 - 5.0ppm: usually allow normal plant growth

>5.0ppm: soils may supply toxic concentrations.

CONCLUSION

From this study, there is wide spread boron deficiency in these soils most especially in areas that are inherently low in boron, such as those derived from acid granite and other similar rocks and fresh water sedimentary deposit that are predominantly sand. No location fell within the toxicity range.

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