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Determination of Physico-Chemical Properties of Soils of Bayelsa Palm Limited, Elebele – Yenagoa, Bayelsa State, Nigeria

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Abstract: *The study was conducted to determine some physico-chemical properties of the soils of Bayelsa Palm Limited Elebele – Yenagoa, Bayelsa State. The plantation, segmented into fifty-three (53) blocks of twenty-five (25) hectares each, was investigated for fertilizer requirement in 2015. Laboratory analysis revealed that the soils were generally loamy sand to sandy loam. The sand fraction was high (68.0 – 84.0%), silt moderate (7.4 – 27.4%) and clay very low to low (2.6 – 19.6%). The soil pH values were generally acidic with moderate (4.7) to high (6.4) values in surface soils. The electrical conductivity (E.C) was low; ranging from very low to moderate (22 – 1281µs/cm) indicating none saline condition. Given the amount of different types of fertilizers needed for the 53 blocks of 25 hectares each and based on a palm population density of 145 palms per hectare the following fertilizers are recommended: Urea = 182,156.25 tonnes or sulphate of ammonia (SOA) = 364,312.50 tonnes; single super phosphate (SSP) = 48,031.25 tonnes and muriate of potash (MOP) = 505,687.5 tonnes or potassium sulphate = 271,875 tonnes. All fertilizers apart from SSP should be applied in two splits; one at the onset of rains and another towards the cessation of rains. This may coincide with the months of April and October, respectively.*

Keywords: *Oil palm, soils, physical properties, chemical properties, fertilizers.*

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I. Introduction

Oil palm (Elaeis guineensis) is one of the important economic crops in the tropics. Oil palm locally called "Nkwu" (Igbo) and "Ope" (Yoruba) in Nigeria is native to West African humid tropics, the Congo basin and Central Africa, growing wild in secondary forest. Ugochukwu and Johnson (2009) assert that oil palm trees do better on plantation farms when planted on a deep, slightly acidic loamy soil with pH 5-6; under a climate condition of humid tropics with 250cm rainfall well distributed and long hours of sunlight. It is mainly propagated by seeds through pre-nursery and nursery practices. Fruiting begins at three years after transplanting depending on the variety. It is the most important source of vegetable oil of all oil-bearing plants and highest yielding oil plant.

Based on the domestic and industrial uses of oil palm, Benjamin (2009) posited that locally it is used for cooking, soap making, metal plating and lamp oil. The kernel oil however, is used for soap making, as a source of glycerine for manufacturing margarine, cooking fats and for making lubricants. The residue obtained after extraction of oil, called kernel cake, is useful in livestock feed production. The midribs and rachis of the palm fronds are used for making brooms and roofing materials. Palm oil processing is a major source of income and employment to a large proportion of the resource poor rural population in Nigeria especially in the Southern part. Oil palm production has been a source of growth in a stagnant economy because of the numerous economic potentials of the oil palm (Purvis, 2006). The benefits of oil palm production cannot be overemphasized.

Before the creation of Bayelsa State in 1996, the Low Land Oil Palm Plantation was established at Yenagoa (LOPPY) by the defunct RisonPalm Limited to encourage oil palm farmers' participation in production and processing (Vanguard, 2012). Under Governor D. S. P Alamieseigha administration, the plantation was to be expanded from 1,083 hectares to 29,000, in phases to make it the largest in the country; but the place is not functioning the way it ought to be. Sadly, the palm estate, which is equipped with modern

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processing mill and has the potential of taking off the streets hundreds of jobless youths, is still struggling to find its bearing several years after (Vanguard, 2015).

Among other management problems that have be-deviled the well-being of the estate is the problem of soil fertility management. The soil seems not to have been properly diagnosed as to ascertain the needed fertilizers to be applied to maximize the yield potentials of the crop. If this is done and recommendations strictly followed the estate could be a major money spinning enterprise for Bayelsa State which largely depends on revenue from the federal government. It is against this backdrop that the authors embarked on the soil analysis of the estate for fertilizer recommendation.

II. Materials And Methods

Site Location:

The plantation is located in Elebele, on the outskirt community of Yenagoa, Bayelsa State. Yenagoa is a local government area in Bayelsa State, Nigeria; with its headquarters in the town of Yenagoa on $4^0$55'29''N $6^0$15'51''E. The city doubles as the state capital too.

Soil Sampling and Analysis:

Stratified sampling method was adopted in the study. The entire plantation estate was segmented into fifty-three (53) oil palm blocks of twenty-five hectares each and investigated for fertilizer requirement in April 2015. At the base of the reference palm but outside the ring weeded zone, core soil samples of 0-15cm and 15-30cm were taken and bulked, air dried and sieved (2mm) for routine analysis. The samples were bulked per block. All together, 106 soil samples were collected. Methods of soil analysis were as described by Udo et al. (2009). Soil pH was measured with glass electrode in a 1:2 soil water suspension, particle size was by hydrometer method. Organic carbon was determined by dichromate oxidation method and total nitrogen was by Macro-Kjeldahl approach. Available P was determined using Bray-1 approach. After ammonium acetate extraction, K and Na were determined using flame photometer; Ca and Mg were measured by absorption spectrophotometer. Electrical conductivity was determined by soil-water extraction method.

III. Results And Discussion

The results of the soil analysis of the plantation estate are presented in table (see appendix). The pH of the soil was generally acidic, with moderate (4.7) to high (6.4) in surface soils. The soils were generally coarse textured, dominantly loamy sand to sand loam. The sand fraction was high (68.0 to 84.0%), silt was moderate (7.4 to 27.4%) and clay very low to low (2.6 to 19.6%). The electrical conductivity was low; ranging from very low (22 µs/cm) to moderate (1281 µs/cm) indicating none saline condition. Organic carbon level was very low (0.06 to 0.99%) in 14 blocks to moderate (<1.15%) in another 14 blocks and high (>1.16 to 2.02%) in other 25 blocks.

Total nitrogen was generally low in 14 blocks (0.007 – 0.115%) and less than 0.1% in 49 blocks. C:N ratio was generally high 10 to 27. C:N ratio greater than 15 indicates dominance of fresh organic matter whose mineralization would lead to nitrogen immobilization (Ezekiel, 2015). Available phosphorus level was very low (5.0 to 10.8mg/kg) in 2 blocks but generally moderate (12.0 to 20.0mg/kg) in 45 blocks of high (>30.0 to 53.2mg/kg) values. Exchangeable K was generally low; less than 0.1 Cmol kg^{-1} in 28 blocks and only 3 blocks had high values of >0.20 Cmol kg^{-1}. Exchangeable Mg was generally high (>1.0 Cmol kg^{-1}) with only 19 blocks having values less than 0.5Cmol kg^{-1}. Exchangeable Ca level was equally high ranging from 1.26 Cmol kg^{-1} to 12.64 Cmol kg^{-1}. Only 20 blocks had less than 3.0 Cmol kg^{-1} of exchangeable Ca. The effective cation exchange capacity (ECEC) was generally low (<2.0 Cmol kg^{-1}) with few moderate to high (>15.0 to 18.96 Cmol kg^{-1}). This corroborates the soils coarse texture and moderate organic carbon contents. The percentage base saturation range from as low as 38.4% to as high as 91.9%. The soil fertility status indicates varying levels of response to added nutrient fertilizers and their nutrient capacities (Chude et al., 2011).

Fertilizer Recommendations

The following fertilizers are recommended for effective production of the estate:

Nitrogen: 15kg or 3kg SOA/palm should be applied in 12 out of the 53 blocks sampled with severe N deficiency. 1.0kg urea or 2kg SOA/palm should be applied in 15 blocks with less severe N deficiency. While 0.75kg or 1.5kg SOA/palm is recommended for another 15 blocks with mild N deficiency. And 0.5kg urea or 1.0kg SOA/palm should be applied to the rest 11 blocks diagnosed with low N deficiency.

Phosphorus: Single super phosphate (SSP) should be applied at 0.25kg/palm as blanket treatment to all plants.

For potassium, muriate of potash (MOP) should be applied at 3kg/palm to 35 blocks with severe K deficiency, 2kg/palm to another 15 blocks with less K deficiency and 1.5kg/palm to the rest 3 blocks with low K deficiency.

For Magnesium, potassium sulphate should be applied at 1.5kg/palm to 44 blocks having varying levels of magnesium deficiency while the rest 9 blocks should receive 1.0kg potassium sulphate/palm.

IV. Conclusion

The total amount of the different types of fertilizer needed for the 53 blocks of 25 hectares each; that is 1,325 hectares based on palm population density of 145 palms per hectare are as follows: Urea = 182,156.25 tonnes or SOA = 364,312.50 tonnes, SSP = 48,031.25 tonnes, MOP = 505,687.5 tonnes and potassium sulphate = 271,875 tonnes. All fertilizers apart from SSP should be applied in two splits; one at the onset of rains and another towards the cessation of rains. This may coincide with the months of April and October respectively. There is need for annual sampling and analysis until optimum nutrient concentrations and balance are obtained.

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Appendix

Exchangeable Bases(cmol/kg)				Exchangeable Acidity(cmol/kg)		ECEC (cmol /kg)	Base Satn. (%)	Text. Analysis (%)			Text.
Na	K	Ca	Mg	H^+	Al^{3+}			Clay	Silt	Sand	
0.11	0.10	2.64	0.08	1.60	2.00	2.98	44.9	2.6	20.4	77.0	LS
0.08	0.07	2.08	0.32	4.00	3.40	9.95	25.6	8.6	23.4	68.0	SL
0.07	0.07	2.40	0.24	2.90	1.10	6.78	41.0	4.6	17.4	78.0	LS
0.07	0.06	1.84	0.24	2.30	3.20	7.71	28.7	7.6	17.4	75.0	SL
0.09	0.08	3.20	0.08	2.00	1.40	6.85	50.4	4.6	12.4	83.0	LS
0.10	0.05	1.84	0.40	2.80	2.30	7.49	31.9	6.6	15.4	78.0	LS
0.21	0.18	6.48	1.60	1.50	0.00	9.97	85.0	7.6	18.4	74.0	SL
0.21	0.13	5.26	0.16	2.90	1.10	9.76	59.0	14.6	12.4	73.0	SL
0.18	0.06	2.24	0.64	2.30	1.00	6.42	48.6	5.6	21.4	73.0	LS
0.11	0.08	1.26	1.20	3.90	3.30	9.85	26.9	8.6	12.4	69.0	SL
0.09	0.08	2.24	0.56	2.90	1.60	7.74	38.4	6.1	21.4	72.0	SL

Soil Analysis Results (in part)

Exchangeable Bases(cmol/kg) Na	K	Ca	Mg	Exchangeable Acidity(cmol/kg) H^+	Al^{3+}	ECEC (cmol /kg)	Base Satn. (%)	Text. Analysis (%) Clay	Silt	Sand	Text.	SN	Block	pH	EC µs/cm	Org C %	Total N (%)	Av. P mg/kg
0.11	0.06	2.00	1.12	0.70	3.30	7.29	45.1	8.6	23.4	78.0	SL	1	G54 0-15cm	4.8	874	1.28	0.066	22.60
0.06	0.09	2.00	1.36	0.30	2.80	6.61	53.1	8.6	16.4	75.0	SL	2	G54 15-30cm	5.0	253	0.38	0.030	17.01
0.08	0.08	2.48	1.44	0.40	4.40	8.88	45.9	10.6	17.4	72.0	SL	3	G64 0-15cm	5.0	517	1.09	0.062	30.12
0.07	0.06	2.72	0.40	0.40	1.10	4.75	68.4	3.6	15.9	80.5	LS	4	G64 15-30cm	5.0	269	0.51	0.021	16.78
0.07	0.05	1.44	1.20	0.40	3.50	6.66	41.4	4.6	17.4	78.0	LS	5	H44 0-15cm	5.0	619	1.63	0.061	16.81
0.05	0.05	2.72	1.36	0.30	2.00	6.43	64.3	4.6	19.9	75.5	SL	6	H44 15-30cm	5.0	611	0.45	0.028	20.31
0.11	0.06	2.88	1.60	0.40	1.40	6.45	72.1	7.1	20.4	72.5	SL	7	H51	5.1	1281	1.86	0.074	16.08
0.08	0.07	2.88	1.44	0.40	1.30	6.17	72.4	5.6	23.4	71.0	SL	8	H51 15-30cm	4.8	810	1.06	0.055	15.23
0.08	0.04	3.28	0.80	0.20	2.70	7.10	59.2	6.6	23.4	70.0	SL	9	H52 0-15cm	5.1	519	1.37	0.064	25.53
0.07	0.06	2.72	0.56	0.40	1.90	5.71	59.7	4.6	26.4	69.0	SL	10	H52 15-30cm	4.9	227	1.09	0.052	30.02
												11	H53 0-15cm	5.0	503	1.12	0.064	15.97

Exchangeable Bases(cmol/kg)				Exchangeable Acidity(cmol/kg)		ECEC (cmol /kg)	Base Satn. (%)	Text. Analysis (%)			Text.	SN	Block	pH	EC µs/cm	Org C %	Total N (%)	Av. P mg/kg
Na	K	Ca	Mg	H^+	Al^{3+}			Clay	Silt	Sand								
0.06	0.06	1.28	0.80	0.30	3.60	6.00	36.7	7.6	20.4	72.0	SL	12	H53 15-30cm	4.9	348	0.54	0.045	16.93
0.09	0.18	4.88	0.24	0.20	4.50	10.09	53.4	13.6	13.4	73.0	SL	13	H54 0-15cm	4.8	498	1.2	0.075	18.87
0.16	0.13	4.64	1.12	0.60	5.00	11.65	51.9	19.6	12.4	68.0	SCL	14	H54 15-30cm	4.9	263	0.96	0.050	18.03
0.15	0.12	4.64	0.88	0.50	0.00	6.14	91.9	9.6	11.4	69.0	SL	15	H61 0-15cm	5.1	343	1.12	0.054	18.65
0.11	0.11	3.76	2.16	0.30	1.80	8.24	74.5	9.6	22.4	68.0	SL	16	H61 15-30cm	5.1	191	0.32	0.032	19.13
0.11	0.23	3.52	1.20	0.20	2.80	7.86	61.8	9.6	19.4	71.0	SL	17	H62 0-15cm	5.1	402	0.83	0.046	15.66
0.17	0.13	1.76	3.04	0.40	4.40	9.90	51.5	15.6	16.4	68.0	SL	18	H62	5.0	323	0.70	0.043	18.03
0.14	0.08	1.76	1.12	0.30	1.60	5.00	62.0	3.6	15.4	81.0	LS	19	H63 0-15cm	5.1	569	1.63	0.091	19.38
0.10	0.09	4.64	2.69	0.40	2.70	10.62	70.8	9.6	19.4	71.0	SL	20	H63 15-30cm	4.9	390	0.77	0.043	19.34
0.09	0.12	3.60	2.00	0.60	2.50	8.91	65.2	7.6	21.4	71.0	SL	21	H64 0-30cm	5.1	403	1.06	0.069	10.84
0.13	0.10	2.72	2.80	0.30	2.80	8.85	65.0	10.6	16.4	71.0	SL							

SN	Block	pH	EC µs/cm	Org C %	Total N (%)	Av. P mg/kg
22	H64 15-30cm	5.0	134	0.77	0.067	16.81
23	J42 0-15cm	4.8	139	1.56	0.077	18.36
24	J42 15-30cm	4.8	30	0.90	0.043	14.22
25	J43 0-15cm	5.4	244	1.38	0.077	17.34
26	J43 15-30cm	5.2	139	0.80	0.039	16.08
27	J44 0-15cm	4.9	107	1.06	0.058	15.52
28	J44 [illegible]	4.9	116	0.72	0.055	16.64
29	J51 0-15cm	5.0	88	1.89	0.110	15.68
30	J51 15-30cm	5.0	58	0.93	0.073	25.78
31	J52 0-15cm	5.0	25	1.31	0.075	20.35
32	J52 15-30cm	5.0	63	0.80	0.047	18.36

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