CHAPTER 5

EVALUATION OF SOIL STATUS IN OIL PALM PLANTATION IN ONDO WESTERN REGION OF NIGERIA

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ABSTRACT
Oil palm is known to utilize a high amount of soil nutrients for optimum growth and development. Nutrient management is paramount to the production of high fruit bunch hence the reason for this study is to evaluate the fertility status of selected oil palm plantation in Ondo west Local Government Area. Two different species of oil palm (hybrid and non-hybrid species) were investigated for their physiochemical parameters. Soil samples from non-hybrid (B) recorded N, P and K content below the critical nutrient (NPK) content for oil palm tree. The nutrient availability index indicated a low nutrient availability of TN, OM, P and Mg for soil samples from non-hybrid (B). Therefore proper nutrient management approaches such as the application of inorganic fertilizer should be adopted especially for nutrients that are deficient and low from non-hybrid (B).

INTRODUCTION
Background to the Study
In most developing countries, oil palm is considered the most productive vegetable oil crop per unit area and contributes to economic growth mostly in developing countries (Koh, 2007). Oil palm is the second most significant tree crop in Nigeria economy after cocoa however, it is considered to be the leading cash crop in the rural economy in the forest belt of Nigeria (Ofosu-Budu, 2013). In 2010, Nigeria Ministry of Food and Agriculture (MoFA), stated the total estimated area of oil palm in Nigeria as 330,000/ha. Oil palm utilizes a high amount of nutrients from the soil for their optimum growth and development. This results in excessive removal of nutrients from the soil leading to a decline in soil fertility.

In any agricultural operation, soil is of utmost importance, as it is the cradle for all crops and plants. Soil fertility fluctuates throughout the growing season due to alterations in the quantity and availability of mineral nutrients by the addition of fertilizes, manure and composts. Soil degradation is a contributing factor to this loss of soil nutrient, especially in the sub-saharan regions. Sustainability of agriculture becomes a big problem due to loss of organic matter, nutrient depletion, soil erosion and changes in soil structure (Seutloali and Beckedahl,2015). The availability and use of inorganic and organic fertilizer have been low especially in large plantation farms, as a result, the decline in soil fertility in oil palm plantations is widespread. Ofosu-Budu (2013) emphasized inadequate demand-driven research especially in soil nutrient management is the major challenge to the local industry. Furthermore, micro variability of soil under oil palm plantation in many areas are poorly understood and fertilizers are applied without recommendation, hence leading to spatio-temporal variations of physical, biological and chemical processes as well as the anthropogenic land use patterns and the combination of these actions may result in total loss of soil nutrient and spatial variability of soil properties, leading to disparity in crop yields (Goovaerets,1998).

Therefore the main objective of this study was to evaluate the fertility status of oil palm plantations in the Mpohor district in the Western Region of Nigeria. The main hypothesis being tested is that the low oil palm yield recorded among farmers in Mpohor district is due to the low fertility of the soil.

METHODOLOGY

The Global Soil Partnership (GSP) and its Intergovernmental Technical Panel on Soils (ITPS) fundamentally sees soil health as the capability of the soil to sustain the productivity, diversity and environmental services of the terrestrial Ecosystem.

The study area is the Mpohor district of Ondo State, Western Nigeria. It has a rainfall range of 900mm to 1300mm annually. Inhabitants are predominantly farmers and traders.

Soil Analysis

Soil samples were analysed for soil Physical, biological and chemical properties using different methods.

Physical Properties

Soil Texture: The method used in determining the soil texture is the FEEL method. Simple physical feeling of the soil. Three important soil types were recognized at the study locations; sandy, silt and clay soils.

Soil Moisture: Soil sample were gotten from a desired depth using shovel. The sample were placed in a sealable paper bag and labelled properly. The weight of the sample was measured and they were oven dried for 24hrs at 105 degree Celsius or air dry for 7 days and the dry weight was measured. The soil moisture was calculated as the water content percentage **(**Tondon**, 1993).**

Formula: WQ=(Wt- Wd/Wd)× 100
Wt= weight of moist soil, Wd= weight of dry soil, WQ= Water content%

Biological Properties

Litter Decomposition: This is an important soil biological process which determines carbon and nutrient accumulation. It determines the rate and timing of nutrient release in the forms that are available on crops and plants as well as soil organisms. The method employed is the Tea Bag method. Tea bags were air dried for 7 days and their weight was recorded (initial weight). The bags were incubated at the sites of study. The tea bags were buried into the soil at a depth of 7cm below soil surface and the locations were marked with flags and labels. The bags were left for 3months and recovered after this period. Soil and organic materials attached to the bags were dusted off. The tea bags were air dried for 7 days and weight gained was measured.

Formula: ML=(WI- WF/WI)×100
ML= Mass loss, WI= Initial weight, WF= Final Weight
Earthworm Density: Sample areas were identified and soil were dug up from a depth of 20-30cm below soil surface. The soil was placed in a plastic sheet and sorted for earthworms. The earthworms were counted and total number observed were recorded.

Chemical Properties

Soil pH

Saturation paste was prepared by adding distilled water to the soil and mixing till it starts glistening on spatula. 1:2 soil water suspension is prepared by taking 20g of soil and 40ml distilled water in 100ml beaker. The suspension is shaken at regular intervals for half an hour.

PH meter is set at room temperature and caliberated by immersing the electrodes in different buffer solutions of PH 4.0, 7.0 and 9.2. Take the beaker of saturation paste and dip the electrodes into it and rote the PH reading. After each determination, the electrodes must be washed with distilled water and wiped out by ordinary filter paper (Jackson, 1973).
Organic Matter (OM)

0.5g of air-dried soil was put into a shaking bottle and 50ml of 25m $Na_4P_2O_7$ solution was added. This was shaken for 18 hours, filtered and the filtrate was diluted with 250ml of distilled water. The absorbance of this solution at 550mu in a spectrometer was measured **(**Tondon**, 1993).**

Organic Carbon (OC)
2g of soil was put in a 500ml conical flask, 10ml of the soil solution was added in $K_2Cr_2O_7$ solution using pipette and shaken to mix. 20ml of concentrated H_2SO_4 containing 1.25% of $Ag_2SO_4$was added and the flask was swirled for 20-30 times. The flask was allowed to stand for 30 minutes on an asbestos sheet for complete reaction. 200ml of distilled water was poured into the flask to dilute the suspension. 10ml 85% H_3PO_4 and 15-20 drops of diphenylamine indicator were added. The sodium was titrated with N/2 F.A.S till the colour changed from violet to bright green. The volume of ferrous ammonium sulphate (F.A.S) was noted and a blank titration (without soil) was carried out in a similar manner as a control (Tondon, 1993).

Available Phosphorus (Avail. P.)
Five grams of soil was added into a 250ml conical flask and a little amount of phosphorus free activated charcoal was added. One hundred milliliter of 0.5m $NaHCO_3$ solution was put into the flask. The conical flask for was shaken for 30 minutes on a mechanical shaker. The suspension was filtered through a whatman No. 42 filter paper and 5ml aliquot of the extract was collected and put in a 25ml volumetric flask. 5ml of ammonium molybdate solution was added to distilled water and the contents of the volumetric flask was shaken.

One milliliter of working $SnCl_2$ solution was added in each 25ml volumetric flask and brought the volume upto 25ml with distilled water and shaken well. The transmittance of the solution was measured on 660mm in a spectrophotometer. Simultaneously, run a blank without soil following the same procedure and take the reading (Tondon, 1993).

Potassium (K^+)

The plant sample was digested usingtriacid as per the method given in P determination in plant samples and was put in 100ml volumetric flask. 0, 2, 4, 6, 8 and 10ml of 100pom K solution were prepared in 100ml flask respectively. The standard was fed in a flame photometer and reading=gs were taken. The concentration was plotted on X-axis and flame photometer reading on Y-axis on a graph paper and standard curve was determined. The unknown sample was fed into the flame photometer, and the readings were noted. The concentration was determined using the standard curve. Where the reading of sample go above the standard, the extracts were diluted 5-10 times more as required (Tondon, 1993).

Total Nitrogen (TN)

20g of soil was transferred into a distillation flask and 20ml water and 100ml of 0.32 percent $KMnO_4$ solution were added. 20ml of 0.02 $NH_2SO_4$was put in a 250ml conical flask and 3 drops of methyl red indicator was added. The flask was put under the receiver tube. The top of the receiver was well dipped into H_2SO_4 solution. 100ml of 0.32% $KMnO_4$ and 100ml of 2.5% NaOHwas added to the distillation flask containing soil. The distillation flask was heated and the free ammonia released was absorbed in the H_2SO_4 solution. Distillation was continued and a moist red litmus paper was placed near the outlet of condenser, whichwill turn blue when ammonia is being released. No change in red litmus paper shows the completion of the ammonia distillation. Titrate the excess of H_2SO_4 with N/50 NaOH and note the volume (Subbiah & Asija, 1956).

Sodium (Na^+)

The Na filter of flame photometer was set and the compressor was started and burner was lit. The burner pressure was kept at 0.5kg 1cm^2 and the gas seeder was adjusted so as to have a blue sharp flame cones. The standard sodium solution was fed to the highest value in the standard series (10 meL^{-1}) and the flame photometer was adjustedto feed full value of emission in the scale i.e. 100 reading. Different standard sodium solutions were fed and the emission values were recorded (Tondon, 1993).

Magnesium (Mg^{2+}) and Calcium (Ca^{2+})

Ten milliliter (10ml) of aliquot (saturation extract) was pipetted in porcelain containing not more than 0.1meL^{-1} of Ca and Mg. 0.5ml of ammonium chloride hydroxide buffer and 3 drops of Erchrome black T indicator were added. This solution was titrated with 0.01 versenate till a colour of bright blue or green and no tinge of wine red colour is observed.

Cation Exchange Capacity (CEC)

Twenty grams of soil was put in a 400ml beaker and 100ml of ammonium acetate solution was added, stirred and then filter the content of the beaker through whatman No. 44 filter paper. After the solution has leached down, a drop of NH_4Cl solution was added and the soil was washed with 25ml of 40% alcohol. This was washed till the filtrate became chloride free (which can be tasted with $AgNO_3$ solution).

After complete washing, the soil was transferred along with the filter paper in kjedahl flask. Three (3) grams of MgO powder was added to 250ml of distilled water and the flask was connected to the distillation assembly. A 25ml conical flask was put below receiver of the distillation apparatus and collect the distilled ammonia in this acid solution till the volume of distillate reached 125ml. The excess acid was titrated with N/10 NaoHsolution and the CEC was calculated.

RESULTS AND DISCUSSION

Soil texture

The relative proportions of sand, silt and clay in a particular type of soil determine its soil class, textural class, textural grade, and texture. Soil productivity and sustainability depend on soil texture which has a direct influence on crop productivity. The properties of soil texture are dynamic. This means it changes depending on weathering rate and the initial mineralogy of the parent material or the deposition of material from streams, runoff and erosion. Soil texture influences soil quality indices. There wasn't much difference that exists among the soil in the two separate locations. For location A, the percentage of sand in soil samples was 60.8% and that of silt 9.84% while the range of location B percent of clay was 29.36.

Table 1: Physical properties of the studied area

Descriptive	Sand (%)		Silt (%)		Clay (%)	
Statistics	**(Loc A)**	**(Loc B)**	**(Loc A)**	**(Loc B)**	**(Loc A)**	**(Loc B)**
Month 1	60.8	66.8	9.84	6.59	29.36	26.24
Month 2	60.2	67.3	9.95	6.60	29.85	26.10
Month 3	61.9	68.5	9.46	6.22	28.64	25.28

Loc A – Location A
Loc B – Location B

Table 2: The chemical properties of the soil from study location

Selected soil chemical properties	Month 1		Month 2		Month 3	
	Hybrid	**Non-hybrid**	**Hybrid**	**Non-hybrid**	**Hybrid**	**Non-hybrid**
Ph	6.89	6.09	6.50	6.55	6.22	6.41
OM (%)	5.98	3.56	5.77	3.68	5.58	4.01
OC (%)	3.47	2.07	3.39	2.19	3.36	2.20
Avail. P ($mgkg^{-1}$)	5.43	5.35	5.21	5.39	5.41	5.17
K (cmol kg^{-1})	0.10	0.09	0.08	0.08	0.07	0.09
TN(%)	0.56	0.50	0.53	0.49	0.52	0.47
Na (cmol kg^{-1})	0.187	0.167	0.180	0.159	0.173	0.145
Mg (cmol kg^{-1})	0.6	0.8	0.5	0.8	0.5	0.7
Ca (cmol kg^{-1})	2.40	2.80	2.35	2.74	2.23	2.69
CEC (cmol kg^{-1})	3.28	3.86	3.29	3.57	3.56	3.19

Table 3: Range of measured parameters

Selected soil chemical properties	Hybrid	Non-hybrid
pH	Neutral 6.22 – 6.89	Neutral 6.09 – 6.65
OM (%)	Medium/ fairly adequate 5.77 – 5.98	Medium/ fairly adequate 3.56 – 4.01
OC (%)	Low 3.36 – 3.39	Low 2.09 – 2.20
Avail. P (mg kg^{-1})	Low 5.21 – 4.43	Low 5.17 – 5.39
K (cmol kg^{-1})	Low 0.07 – 0.10	Low 0.08 – 0.09
TN (%)	High 0.52 – 0.56	High 0.47 – 0.50
Na (cmol kg^{-1})	Low 0.173 – 0.187	Low 0.145 – 0.167
Mg (cmol kg^{-1})	Low 0.5 – 0.6	Low 0.7 – 0.8
Ca (cmol kg^{-1})	Medium/ fairly adequate 2.3 – 2.40	Medium/ fairly adequate 2.69 – 2.80
CEC (cmol kg^{-1})	Low 3.28 – 3.56	Low 3.19 – 3.86

Soil pH

Soil pH is an important chemical parameter of soil because it has direct effects on nutrient availability. The pH of the soil samples analyzed varied from 6.22 to 6.89 for Hybrid while non-hybrid ranged from 6.09to 6.65 (Table 3). The acidic pH recorded can be due to the application of manure and compost been done regularly by the farmers. The pH recorded for the study area was weakly acidic which plays a significant role in the metal bioavailability to plant, toxicity, microbial growth and leaching capacity of soil to surrounding areas. The factors that may influence the low pH of soil samples from Ondo are prolonged use of inorganic fertilizer, acidic rainfall and decomposition of organic matter. According to Obeng et al., (2020), palm trees are tolerant to acid soils, and oil palm can tolerate the level of acidity of the soil, therefore, liming will not be needed. Acidic soil might indicate heavy application of fertilizers.

Organic matter (OM%) and Organic Carbon (OC%)

Organic matter is a reservoir of nutrients that can be released into the soil. It improves soil structure and plays an important role in carbon sequestration. Higher organic matter results in higher organic carbon in the soil. Organic matter results from the decomposition of plants and animals which is an important source of plant essential nutrients. Organic matter increases the physiochemical properties of the soil hence, increasing soil productivity. Johnston (1986) stated that organic matter aid in availability of plant nutrient, improve the soil structure, water infiltration and retention, feeds soil micro-flora and fauna, and the retention and cycling of applied fertilizer. In the first month and second month, organic matter was recorded lower than required for non-hybrid (3.56, 3.68) while others had recorded a fairly adequate organic matter. Application of manure as well as using their pruned palm front as mulching materials could lead to the high organic matter and organic carbon.

Available Phosphorus Avail. P (mg kg^{-1})

For available Phosphorus (mg kg^{-1}), all the content recorded was lower than required both in hybrid and non-hybrid soil sample which range from 5.21 to 5.39. The low available phosphorus recorded by the soil can be due to the acidic nature of the soil. Apori et al., (2020) indicated that the application of phosphorus fertilizers, liming and phosphorus solubilizing microorganisms will be necessary to increase available phosphorus in the soils.

Exchangeable base K^+ (cmol kg^{-1})

Except for nitrogen, potassium is present in larger quantities than any mineral derived from the soil. Potassium is responsible for the metabolism in the movement of the stomata resulting in the activation of cell division. The potassium content of soil of the particular region is related to parent material and the degree of weathering. In the third month, potassium content was recorded low composition in the hybrid soil sample while others recorded a fairly adequate K content. Apori et al., (2020) suggested that farmers may be advised to either maintain or increase the potassium fertilizer rate to prevent the depletion of potassium in the soil.

Total Nitrogen TN (%)

Plants require a relatively large amount of nitrogen for their development. This explains why plant growth is restricted by a deficiency of nitrogen than any other nutrient (Apori e*t al*, 2020). The higher nitrogen recorded can be due to the high OC recorded since there is a direct relationship that exists between organic matter and nitrogen. The higher the organic matter content in the soil, the higher N content in the soil. In TN, all the content recorded was higher than required in both hybrid and non-hybrid which range from 0.47 to 0.56.

Exchangeable base Na^+ (cmol kg^{-1})

According to Roy and Chowdhury (2021), abiotic stress in soil involving salt soil are a major problem worldwide. They further stated that it is a soil composing of various salts, which are quickly dissolved in water to produce toxic ions, especially sodium ions (Na^+). Sodium ion (Na^+) is well established for negatively affecting plant growth and development before plant cell death. In the third month, Na contents recorded for non-hybrid samples was lower than required 0.145-0.187 while other samples had fairly adequate Na content. The level of sodium (Na) accumulated in the soils of the oil palm fields depends on the degree of salt treatments in terms of EC (dS m^{-1}) (Apori e*t al*, 2020).

Exchangeable base Mg^{2+} (cmol kg^{-1}) and Ca^{2+} (cmol kg^{-1})

In Mg all the content recorded for both hybrid and non-hybrid was lower than required which range from (0.5 – 0.8). Therefore, the application of magnesium source fertilizer is usually required to correct for nutrient imbalance. According to Ogeh and Osiomwan (2012), the calcium content of the soil differs at various points depending on directional changes and the distance from nearby samples. In calcium, all the content recorded was fairly adequate both in hybrid and non-hybrid soil sample which range from 2.23 – 2.80.

Base saturation and Cation Exchange Capacity (CEC) (cmol kg^{-1})

Base saturation (BS) is defined as the percentage of CEC occupied by Ca^{2+}, Mg^{2+}, K^+, and Na^+. In CEC, all content recoded for hybrid and non-hybrid was lower than required which range from 3.28 – 3.86. Farmer's application of manure can influence the high CEC in site A since Cation Exchange Capacity is soil colloids having charges which can hold cations (Apori e*t al*, 2020).

Conclusion

The study revealed that the nutrients content of the studied sites were not very different. Soil samples from the locations at the different time points showed varying concentrations in the chemical properties of the soils.There was a low nutrient availability for some nutrients like P and Mg. The low crop yield recorded by farmers in the study area might be due to the shortage in some critical nutrients in the soil. It is recommended that proper nutrient management practices such as the use of inorganic fertilizer should be incorporated to supplement for nutrients that are deficient and low.

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