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Assessment of Soil Fertility Status Using Nutrient Index Approach of Ovu Sub-Clan, Delta State, Nigeria

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ABSTRACT

Background: Amendment of soil fertility through regular nutrient assessment is a necessary intervention for sustainable crop production. Ovu, is a sub-clan in Delta State, Nigeria which comprised of: Ovu-Inland, Okoemaka, Ekpan, Urhodo, Okoroke and Oviorie that are mostly farmers without the knowledge of their soil fertility. The study investigated soil fertility status of Ovu Sub-Clan.

Methods: Cassava, oil palm and plantain farms were randomly selected in the six community and 118 representative soil samples were taken. Soil pH, organic carbon, total nitrogen, available phosphorus content of soil and exchangeable bases were measured. Data were analyzed with descriptive statistics and Parker's nutrient index was used to compare the fertility level.

Result: The cassava, oil palm and plantain farms were slightly acidic mean values of 6.4±0.38, 6.5±0.31 and 6.4±0.30, respectively indicating slight acidity. Organic carbon was low to high while total nitrogen was high except at Okoemaka that was moderate (0.19±0.04 %). Available phosphorus content was low to medium while exchangeable potassium and calcium were medium to high, exchangeable magnesium was low to medium. Nutrient index showed that soil pH was moderate and while total nitrogen was high.

Key words: Delta sate, Nutrient assessment, Nutrient index, Ovu community, Soil fertility.

INTRODUCTION

Soil fertility is the intrinsic ability of soil to supply crop needed nutrients at the appropriate time and right quantity for plant growth requires good management. One of such ways is through regular soil fertility assessment (Turamyenyirijuru *et al*., 2019) and it is too complex for only peasant farmers to handle considering the mirage of factors involved. Farmers have the potential to produce high crop yields if they are supported with information on the nutrient status of their farms (Collier and Dercon, 2014). Assisting the farmers on how to combat soil fertility problem with effective nutrient management strategies will eventually increase crop yields (Evert-Jan and Aniek, 2014). Uncontrolled use of fertilizers most especially inorganic types without soil test result had disrupted its properties thereby hindering the potential to produce good crop yields (Sanchez, 2002 and Rituraj, 2018). It is against this back ground that it is important to investigate nutrient status of the farm lands so that the information can be used to develop soil management strategies for farmers (Hadole *et al*., 2019). Site-specific soil fertility evaluation is useful aspect of nutrient management strategy and it can only be achieved through an orderly planned soil fertility assessment.

Crop yields reduction attributed to poor soil fertility has attracted the attention of agriculturist and efforts are to development good soil management practices especially now that government emphasis is how to increase food production for the growing population in Nigeria (Olue, 2014). It is pertinent that soil fertility inventory in farming communities be taken (Sachan and Krishna, 2018). The information will aid in making decision on fertilizer formulations and uses. Ovu is a sub-clan in Delta Sate, Nigeria that comprises of six communities predominately farmers producing crops without the knowledge of the fertility status of their farms. Therefore, if the fertility status of their farms is investigated, the information will guarantee appropriate fertilizer recommendations and uses. Hence, objective of this study is to evaluate the fertility status of Ovu Sub-Clan in Delta State, Nigeria.

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MATERIALS AND METHODS

Description of study area

The study was conducted in Ovu Sub-Clan in Ethiope East Local Government Area, Delta State in February to March, 2019. The Sub-Clan is made up of six farming communities: Ovu-Inland (5°39′0″N and 5°56′0″E), Oviorie (5°40′0″N and 5°55′0″E), Ekpan (5°44′45.4″N and 5°54′07.7″E), Okoroke, Urhodo (5°42′0″N and 5°54′0″E) and Okoemaka. The communities are situated in rainforest zone with bi-modal rainfall pattern starting from March to October and dry season between November to February with average temperature of 29.5°C.

Land use are based on rain fed agriculture and crops cultivated were melon, water melon, okra, fluted pumpkin, maize, cassava, oil palm, plantain *etc*. The topography of the area is low-lying that belong to the Soil Order Ultisols and Suborder psammatic paleudults (Akamigbo, 2001).

Field study

Detailed soil survey was conducted using ArcGIS software at a scale of 1: 50,000 and based on the observation, Cassava, Oil palm and Plantain Farms were randomly selected and sampled with Nested technique (Wahua, 1999). A total of 118 representative soil samples were taken at a pre-determine depth of 0-30 cm with soil augur from the six communities.

Samples preparation and laboratory procedures

The soil samples were air dried at room temperature of 27°C, crushed and sieved with a 2 mm mesh, properly labeled and packaged for laboratory analysis using standard procedures at the International Institute of Tropical Agriculture, Ibadan. Soil pH, organic carbon, total nitrogen, available phosphorus and exchangeable bases were parameters measured. Soil pH was measured in 1:2 soil water ratio. Organic carbon was determined by the method given by Walkley-Black (Walkley and Black, 1934), total nitrogen was by Micro-Kjeldhal Digestion method (Anderson and Ingram, 1993). Available phosphorus was extracted with Bray-1 and further reading was done Colormetrically. Exchangeable bases were extracted with 1N ammonium acetate (Jackson, 1964) and Mg and Ca were measured with Atomic Absorption Spectrophotometer (AAS) while flame photometer was used to determine exchangeable K.

Data analysis

Data were subjected to descriptive statistics such as mean, standard deviation and coefficient of variation.

Determination of nutrient availability index

Nutrient availability index was calculated based on fertility rating chart in Table 1 (FMARD, 2012) and nutrient index introduced by Parker *et al*. (1951) and modified by Kumar *et al*. (2013) was used to compare soil fertility level in the Ovu Sub-Clan.

$$\text{Nutrient index} = \{(1\times A) + (2 \times B) + (3 \times C)\} / NS$$

Where
A = Number of samples in low category.
B = Number of samples in medium category.
C = Number of samples in high category.
NS = Total number of samples.

Soil pH, organic carbon, total nitrogen, available phosphorus, potassium, calcium and magnesium were used to calculate nutrient index values based on specific rating chart on Table 2.

RESULTS AND DISCUSSION

Nutrient status of the farms and communities

Soil pH values ranged from 5.7-6.9 (cassava farm), 6.0- 6.9 (oil palm farm) and 5.8 - 6.8 (plantain farm) (Table 3). Organic carbon content of soils of cassava farm ranged from 1.28-2.80 % and 2.00-2.30% in oil palm farm while it ranged between 177-3.44% in plantain farm. Total nitrogen was high in all the farms. Available phosphorus ranged from 10.0-16.75 mg/kg (cassava farm), 14.1-26.22 mg/kg (oil palm farm) and 13.1-18.28 mg/kg (plantain farm). Exchangeable potassium was highest in cassava farm and lowest in oil palm farm. Calcium values ranged from 0.45-5.47 cmol/kg in cassava farm and 3.00-9.80 cmol/kg in oil palm farm while it was 2.00-7.26 cmol/kg in plantain farm. Magnesium was highest in oil palm farm and lowest in cassava farm.

Ovu-Inland had the highest mean soil pH value and Oviorie had the lowest (Table 4). Organic carbon content ranged from 1.28-3.44% with highest mean in Oviorie and lowest in Okoemaka. Total nitrogen was high in the communities except Okoemaka where it was moderate. Highest mean of available phosphorus was recorded in Ekpan while the lowest was in Okoroke. Exchangeable potassium was highest in Okoemeka and was lowest in Oviorie. Highest exchangeable calcium was found in Ovu and the lowest was in Okoemaka. Exchangeable magnesium content was highest in Urhodo.

The soil pH is adequate for crop production according to Onwudike *et al*. (2016). Higher pH values in oil palm farm could be as a result of the litter falls that releases exchangeable bases after decomposition which reduced accumulation of H^+ and Al^{+++} ions on soil exchange complex (Ibrahim and Idoga, 2015). Lower soil organic carbon content

Table 1: Soil rating chart and their nutrients indices.

Soil properties	Range		
	Low	Medium	High
Soil pH	5.5-6.0	6.1-6.9	7.1-8.5
	Moderately acidic	Slightly acidic	Slightly alkaline
Organic carbon (%)	< 2.0	2.0-3.0	> 3.0
Total nitrogen (%)	< 0.15	0.15-0.20	> 0.20
Available phosphorus (mg/kg)	< 15	15-25	>25
Exchangeable potassium (cmol/kg)	< 0.2	0.2-0.4	>0.4
Exchangeable calcium (coml./kg)	< 1.5	1.5-4.5	>4.5
Exchangeable magnesium (cmol/kg)	< 1.5	1.5-4.5	>4.5

Source: FMARD (2012)

in cassava farm could be attributed to the yearly clearing and burning of the residues that exposes the soil to harsh climatic factors. Burning is a common practice used to destroy the organic materials that could have added organic matter to the soil (Onwudike *et al.,* 2015). Musinguzi *et al*. (2016), pointed out that for good fertilizer response, a soil should have 1.9 – 2.2 % of soil organic carbon. Highest value of total nitrogen and available phosphorus found in oil palm farm could be due to higher organic materials generated from palm tree litters. Decomposition of organic materials can produce humus which protects and reduce phosphorus fixation in the soil (Kavitha and Sujatha, 2015). Higher exchangeable bases in plantain and oil palm farms could be due to the effects of higher organic matter content which improves base status of the soils (Sharu *et al*., 2013).

Table 2: Nutrient index and the rating.

Nutrient index	Range	Remarks
A	< 1.67	Low
B	1.67-2.33	Medium
C	>2.33	High

Source: Parker *et al.* (1951).

Nutrient variability in the Ovu Sub-Clan

Soil pH was less variable in Ovu-Inland, Urhodo, Okoroke and Oviorie while the values were similar in Okoemaka and Urhodo (Table 5). Organic carbon was less variable in all the communities except in Oviorie that it was highly variable and moderately variable in Okoemaka. Total nitrogen was less variable in Ovu, Ekpan and Urhodo but moderately variable in Okoemaka and Okoroke while it was highly variable in Oviorie. Available phosphorus was less variable in Ekpan and Okoroke, moderately variable in Ovu, Okoemaka, Urhodo and Oviorie farms. Exchangeable **c**alcium was less variable in Ekpan and Okoroke but moderately variable in Oviorie while it was highly variable in Ovu, Okoemaka and Urhodo. Exchangeable magnesium in Ovu, Okoroke and Oviorie was less variable but moderately variable in Ekpan and highly variable in Okoemaka and Urhodo. Exchangeable potassium was moderately variable in Ovu, Ekpan, Okoroke and Oviorie while it was highly variable in Okoemaka and Urhodo.

The variation in the measured parameters could be due to the differences in agricultural use of the soil and micro variability. Rate of variation depends on farming system,

Table 3: Nutrient status of the farms.

Farms	Percent of samples falling within range				
	Low	Medium	High		
Soil pH	(5.5-6.0)	(6.0-7.0)	(7.0-8.5)	Range	Mean±SD
Cassava	22	78	0	5.7-6.9	6.4±0.38
Oil palm	11	89	0	6.0-6.9	6.5±0.31
Plantain	11	89	0	5.8-6.8	6.4±0.30
Organic carbon	<2.0 %	2-3%	>3.0%		
Cassava	28	72	0	1.28-2.80	2.23±0.49
Oil palm	0	78	22	2.00-3.20	2.71±0.38
Plantain	17	66	17	1.77-3.44	2.52±0.52
Total nitrogen	<0.15 %	0.15-0.20 %	>0.2%		
Cassava	6	11	83	0.13-0.35	0.26±0.06
Oil palm	0	0	100	0.21-0.87	0.44±0.23
Plantain	0	22	78	0.17-0.59	0.34±0.13
Available P	<15mg/kg	15-25mg/kg	>25mg/kg		
Cassava	83	17	0	10.0-16.75	12.50±2.11
Oil palm	17	78	5	14.1-26.22	18.79±2.84
Plantain	0	28	72	13.1-18.28	15.48±1.88
Potassium	<0.2 cmol/kg	0.2-0.4 cmol/kg	>0.4 cmol/kg		
Cassava	33	67	0	0.16-1.80	0.51±0.54
Oil palm	11	44	45	0.18-0.80	0.43±0.20
Plantain	0	56	44	0.20-1.22	0.48±0.30
Calcium	<1.5 cmol/kg	1.5-4.5 cmol/kg	>4.5 cmol/kg		
Cassava	33	50	17	0.45-5.47	2.49±1.60
Oil palm	0	33	67	3.00-9.80	5.89±2.32
Plantain	0	50	50	2.00-7.26	4.74±1.88
Magnesium	<1.5 cmol/kg	1.5-4.5 cmol/kg	>4.5 cmol/kg		
Cassava	67	33	0	0.68-2.24	1.31±0.51
Oil palm	11	72	17	1.26-4.64	2.37±1.09
Plantain	28	72	0	1.30-2.272	1.77±0.37

Table 4: Soil properties in Ovu farming Communities.

Villages	Percent of samples falling within range				
	Low	Medium	High		
Soil pH	(5.5-6.0)	(6.0-7.0)	(7.0-8.5)	Range	Mean ± SD
Ovu-Inland	0	100	0	6.4-6.9	6.8±0.16
Okoemaka	0	100	0	6.5-6.9	6.7±0.11
Ekpan	0	100	0	6.4-6.8	6.5±0.16
Urhodo	0	100	0	6.6-6.8	6.7±0.06
Okoroke	33	77	0	5.9-6.5	6.1±0.17
Oviorie	56	44	0	5.7-6.2	6.0±0.17
Organic carbon	<2.0%	2-3%	>3%		
Ovu-Inland	0	78	22	2.45-3.12	2.81±0.24
Okoemaka	67	33	0	1.28-2.20	1.79±0.31
Ekpan	0	78	22	2.68-3.19	2.85±0.17
Urhodo	22	78	0	1.82-2.33	2.12±0.18
Okoroke	0	100	0	2.00-2.78	2.32±0.29
Oviorie	0	67	33	2.70-3.44	3.02±0.29
Total nitrogen	<0.15 %	0.15-0.20 %	>0.2%		
Ovu-Inland	0	0	100	0.28-0.38	0.31±0.03
Okoemaka	11	56	33	0.13-0.25	0.19±0.04
Ekpan	0	0	100	0.29-0.33	0.31±0.02
Urhodo	0	22	78	0.19-0.31	0.24±0.04
Okoroke	0	0	100	0.25-0.58	0.44±0.12
Oviorie	0	0	100	0.26-0.87	0.58±0.23
Available P	<15mg/kg	15-25mg/kg	>25mg/kg		
Ovu-Inland	33	56	11	12.3-26.2	18.18±4.30
Okoemaka	67	33	0	10.9-17.0	14.09±2.47
Ekpan	0	67	33	16.6-22.0	18.56±1.95
Urhodo	33	67	0	10.0- 19.0	14.57±3.24
Okoroke	100	0	0	12.0-14.3	13.15±0.91
Oviorie	67	33	0	11.0-18.4	13.42±5.01
Potassium	<0.2 cmol/kg	0.2-0.4 cmol/kg	>0.4 cmol/kg		
Ovu-Inland	0	33	11	0.22-0.52	0.39±0.08
Okoemaka	0	67	0	0.31-1.80	1.04±0.58
Ekpan	0	0	33	0.28-0.62	0.42±0.11
Urhodo	11	0	0	0.19-0.83	0.50±0.23
Okoroke	22	78	0	0.17-0.32	0.25±0.05
Oviorie	22	78	0	0.16-0.30	0.23±0.04
Calcium	<1.5 cmol/kg	1.5-4.5 cmol/kg	>4.5 cmol/kg		
Ovu-Inland	0	33	67	3.01-9.80	6.57±2.65
Okoemaka	33	67	0	0.84-3.34	2.02±0.94
Ekpan	0	0	100	5.39-6.49	5.93±0.42
Urhodo	33	0	67	0.45-9.16	5.00±3.29
Okoroke	0	100	0	2.60-3.53	3.17±0.39
Oviorie	0	67	33	2.30-4.87	3.57±0.95
Magnesium	<1.5 cmol/kg	1.5-4.5 cmol/kg	>4.5 cmol/kg		
Ovu-Inland	11	89	0	1.26-1.90	1.60±0.16
Okoemaka	33	67	0	0.74-2.87	1.78±0.84
Ekpan	56	44	0	1.28-2.40	1.68±0.40
Urhodo	34	33	33	0.70-4.64	2.59±1.58
Okoroke	0	100	0	1.51-2.24	1.89±0.27
Oviorie	78	22	0	1.21-1.54	1.38±0.11

Table 5: Nutrient variability in the Ovu Sub-Clan.

Communities	pH	OC	TN	P	Ca	Mg	K
		%		Mg/kg		cmol/kg	
Ovu-Inland	3.79	8.16	7.90	22.1	40.3	2.52	16.6
	L	L	L	M	H	L	M
Okoemaka	-	16.5	17.4	17.5	46.5	47.3	55.1
		M	M	M	H	H	H
Ekpan	0.73	5.6	4.0	10.3	6.95	22.9	23.8
	L	L	L	L	L	M	M
Urhodo	-	8.1	8.6	24.0	65.0	60.9	45.8
		L	L	M	H	H	H
Okoroke	2.03	12.0	26.0	6.2	12.2	14.1	22.0
	L	L	M	L	M	M	M
Oviorie	0.78	49.0	41.2	18.9	26.3	7.9	17.9
	L	H	H	M	M	L	M

Key: L- Low, M- Moderate, H- High.

Table 6: Soil fertility index.

Farms	Soil pH		Organic C		Nitrogen		Phosphorus		Potassium		Calcium		Magnesium	
	Nutrient Index	Rating	Nutrient Index	Rating	Nutrient Index	Rating	Nutrient Index	Rating	Nutrient Index	Rating	Nutrient Index	Rating	Nutrient Index	Rating
Cassava	1.78	M	1.72	M	2.78	H	1.17	L	1.67	M	1.83	M	1.33	L
Oil palm	1.89	M	2.22	M	3.00	H	1.89	M	2.33	M	2.67	H	2.06	M
Plantain	1.89	M	2.00	M	2.78	H	2.72	M	2.44	H	2.50	H	1.72	M
Communities														
Ovu	2.00	M	2.22	M	3.00	H	1.78	M	2.33	M	2.67	H	1.89	M
Okoemaka	2.00	M	1.67	M	2.22	M	1.33	L	2.67	L	1.67	M	1.67	M
Ekpan	2.00	M	2.22	M	3.00	M	3.33	H	2.44	H	3.00	H	1.44	L
Urhodo	2.00	M	1.78	M	2.78	H	1.67	M	2.56	H	2.33	M	2.00	M
Okoroke	1.67	M	2.00	M	3.00	H	1.00	L	1.78	M	2.00	M	2.00	M
Oviorie	1.44	L	2.33	M	3.00	H	1.33	L	1.78	M	2.33	M	1.22	L

type of crop cultivated and soil management practices (Onwudike *et al.,* 2016 and Fashaho *et al*. 2019). This could be responsible for variation in soil fertility parameters measured. Higher organic carbon in oil palm farms could be due to these two reasons: litters from the oil palm trees that undergo decomposition and the shade the palm trees provided that reduced the rate at which soil organic matter decomposed by regulating the temperature of soil (Musinguzi *et al*., 2016 and Fashaho *et al*. 2019).

Soil fertility index

Soil pH was slightly acidic, organic carbon was medium and total nitrogen was high (Table 6). Available phosphorus was low in cassava farm, medium in oil palm farm while it was high in plantain farm. Exchangeable potassium was medium in cassava and oil palm farm but high in plantain farm. Exchangeable calcium was medium in cassava farm but high in oil palm and plantain farms. Exchangeable magnesium was low in cassava farm while it was medium in both oil palm and plantain farms. Soil pH range (6.0-7.0) belongs to soil reaction index B that is slightly acidic except Oviorie that belong to soil reaction index A (moderately acidic). Organic carbon was medium in all the communities, total nitrogen was high except at Okoemaka and Ekpan that it was moderate. Available phosphorus was high in Ekpan, moderate in Ovu-Inland, Okoemaka and Urhodo while it was low in Okoroke and Oviorie. Exchangeable potassium was high in Okoemaka, Ekpan and Urhodo while it was medium in Ovu-Inland, Okoroke and Oviorie. Exchangeable calcium was high in Ovu-Inland and Ekpan but medium in other communities. Exchangeable magnesium was low in Okoemaka and Oviorie but it was also medium in other communities.

CONCLUSION

The soil fertility status of Ovu Sub-Clan was low to high, soil pH was slightly acidicating that is optimum condition for crop cultivation. Organic carbon was medium, total nitrogen was high and available phosphorus was low to medium. Exchangeable potassium and calcium were medium to high while magnesium was low to medium. The level of organic carbon demand management practices that will include application of organic fertilizer which will increase the organic nutrient.

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