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Fertility status of fadama soils in Asaba, Delta State, Nigeria

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ABSTRACT

An experiment investigated the fertility status of fadama soils in the Asaba environment, Delta State. The study area was divided into twelve blocks, and ten representative soil samples were taken from each block to form one composite sample that was air-dried at room temperature and sieved with a 2 mm sieve. Particle size distribution, soil pH, organic carbon, total N, available P, exchangeable bases and micronutrients, as well as exchangeable acidity, were measured. In contrast, effective cation exchange capacity and percentage base saturation were calculated. Data were analyzed with the descriptive statistic, while a correlation coefficient was used to measure the relationship between nutrient parameters. The soils texture were sandy clay loam and acidic with pH values that ranged within 5.0-5.5. Organic carbon values ranged between 1.20 and 1.64 %, while total N varied between 0.14 and 0.31 %. Available phosphorus was 10 mg/kg, exchangeable bases and ECEC were low, while percentage base saturation was moderate. Manganese and Fe were high while Cu and Zn were low. Soil pH and P were fewer variables, while organic carbon was moderately and N was highly variable.
Phosphorus positively and significantly correlated with Ca while Ca also correlated considerably with K. Organic carbon positively correlated with N and P.

1.0 Introduction

Fadama is wetland soils that are seasonally flooded, fertile and can easily be cultivated. They are primarily used for vegetable cultivation, probably due to high soil moisture content and nutrient availability. They are more resilient to land use pressure than the upland soils due to their fine texture (Wills, 2017). It was estimated to be 55 million ha in Nigeria; unfortunately, only about 10% are put to agricultural uses (Wills, 2017). This means that the soils are grossly underutilized. Adigbo and Adigbo (2011) estimated fertile fadama soils in Nigeria to be about 3 million ha with high moisture content during the dry season. This can offer an excellent opportunity for agricultural use, especially crop cultivation but has not been fully utilized. The fadama soil can withstand continuous cropping due to its moisture content during most parts of the year (Mustapha et al., 2005). The streams and rivers proximity promote their suitability for crop production, but limited information on the nutrient status is currently hindering its exploitation for agricultural practices.

Soil is a valuable natural resource that is not easily renewable; its fertility changes with time due to natural and human-induced forces (Kavitha and Sujatha, 2015). The knowledge of soil fertility is required to predict the productive strength of the soil. Farmers must know the soil nutrient strength to adequately apply corrective measure that will guarantee optimum crop production rather than blanket fertilizer application being practiced. Crop productions with appropriate soil management practices can ensure sustainable cultivation and will prevent soil degradation that has negative impacts on its fertility (Ezeaku, 2011). Changes in land use systems due to population increase and urbanization contributed to the high soil degradation rate that plays a significant role in soil fertility depletion. This is perceived as a threat to a farmer's ability to produce good crop yield to meet the growing populations' needs (Ezeaku and Iwuanyanwu, 2013). The fertility of soil determines the growth rate and yield potential of the crop because it is governed by the presence or absence of plant nutrient. Therefore, the knowledge of nutrient contents of fadama soils will help proper soil management that can guarantee continuous production of the crop. Still, due to the limited information, it has been underutilized. Hence, this work assesses the fertility status of fadama soils in Asaba.

2.0 Materials and Methods

2.1 Study area: The study was conducted along with the seasonally flood plain ban of River Niger that stretches from Asaba to Illa in Oshimilli North and South Local Government Areas of Delta State rainforest zone with longitude 6^o 14$'$E and latitude 6^o 14$'$N. It has a bi-modal rainfall pattern from March to October, while the dry season from November to February with an average temperature of 29.5^o C.

2.2 Soil samples collection: The area was divided into twelve blocks while soil samples were taken at 0-30 cm depth in each block. Ten (10) representative soil samples were purposively taken from each block and were mixed to form a composite sample. A total of twelve (12) soil samples were taken from the area.

2.3 Preparation of samples: The **s**oils were air-dried at room temperature and sieved with a 2 mm mesh sieve. Particle size distribution, Soil pH, Organic carbon, Total nitrogen, Available phosphorus, Potassium, Calcium, Magnesium, Sodium, Cation exchange capacity and Exchangeable acidity, and manganese, iron, copper and zinc, were measured. At the same time, ECEC and percentage base saturation were calculated.

2.4 Laboratory analysis: The samples were analyzed in the Analytical Laboratory, Department of Agronomy, the University of Ibadan, following standard procedures.

2.5 Data analysis: Data obtained were subjected to descriptive statistics, and correlation analysis was further used to show the relationship between soils properties.

3.0 Results

3.1 Particle size distribution

The particle size distribution is presented in Table 1, and it is sandy clay loam. Percentage sand values ranged from 60 – 70±3.84 % with a mean of 66±3.84 % and coefficient of variation of 5.8 %. Silt content ranged from 9 - 19±3.09 % with a mean of 12.8±3.09 and CV of 23.9%, while the clay content ranged from 20 - 24±0.95 % with a mean of 21.4 % and CV of 4.4 %.

Table 1 Soil particle size distribution

	Sand	**Silt**	**Clay**	**Textural name**
Blocks	----------------------%	--------------		
1	68	11	21	Sandy clay loam
2	65	12	22	“
3	68	11	21	“
4	65	14	21	“
5	63	15	22	“
6	60	16	22	“
7	60	19	21	“
8	60	16	24	“
9	70	10	20	“
10	68	11	21	“
11	70	9	21	“
12	70	9	21	“
Mean	66	12.8	21.4	
SD	3.84	3.06	0.95	
CV	5.8	23.9	4.4	

SD- Standard deviation, CV- coefficient of variation

3.2 Soil chemical properties

Table 2 shows the soil chemical properties, and the soils were generally acidic with values that ranged from 5.0 – 5.5±0.16 and a mean of 5.2±0.16 while the CV was 15.5 %. Soil organic carbon was generally low, with values that ranged from 1.20 – 1.99±0.22 % with a CV of 30 %. Total nitrogen in the area was low to medium level, and the values ranged from 0.13 – 0.31±0.05 with a mean of 0.18±0.05 % while the CV was 30 %. Available P was low. The values ranged from 8.07 – 12.41±1.39 mg/kg with a mean of 10.0±1.39 mg/kg and CV of 13.9 %. The exchangeable acidity was high, and the values ranged from 0.55 – 1.20±0.24 cmol/kg with a mean of 0.81±0.24 cmol/kg and CV of 29.8 %. The exchangeable bases were generally low; the Ca content values ranged from 0.15 – 0.41±0.08 cmol/kg with a mean of 0.25±0.08 cmol/kg and CV of 30.8 %. Magnesium content ranged from 0.29 – 0.71±0.13 cmol/kg with mean of 0.51±0.13 cmol/kg and CV of 25.1 %. Potassium content ranged from 0.13 – 0.41±0.07 cmol/kg with mean of 0.29±0.07 cmol/kg and CV of 24.4 % while Na contents ranged from 0.23 – 0.43±0.06 cmol/kg with mean of 0.35±0.06 cmol/kg and CV of 17.2 %. The ECEC was low, and the values ranged from 1.56 – 2.79±0.33 cmol/kg with a mean of 2.20±0.33 cmol/kg and CV of 15 %. The percentage base saturation also low, and the values ranged from 48.9 – 71.3±11.37 cmol/kg with a mean of 60.9±11.37 cmol/kg and CV of 18.7 %.

3.3 Soil micronutrients

Table 3 showed the micronutrient status of the fadama soils. The soil's Mn content ranged from 1.5 – 26.3±7.6 mg/kg with a mean of 15.5±7.6 mg/kg and CV of 49 %. Iron content was generally high, and the values ranged

Table 2 Soil chemical properties

	pH	OC	TN	P	Acid	Ca	Mg	K	Na	ECEC	BS
Block	H_2O	------%------		Mgkg	----------------------cmolkg----------------------						%
1	5.4	1.24	0.14	8.07	0.96	0.15	0.29	0.13	0.35	1.88	48.9
2	5.2	1.99	0.24	10.3	0.88	0.30	0.58	0.26	0.43	2.45	64.1
3	5.2	1.46	0.16	8.75	0.32	0.19	0.47	0.23	0.35	1.56	79.5
4	5.0	1.20	0.13	8.75	1.20	0.18	0.55	0.33	0.43	2.69	55.4
5	5.1	1.25	0.14	9.12	0.71	0.17	0.66	0.23	0.31	2.08	65.9
6	5.2	1.48	0.16	10.4	0.66	0.18	0.71	0.33	0.23	2.11	34.4
7	5.1	1.34	0.17	11.1	0.64	0.22	0.65	0.31	0.41	2.23	71.3
8	5.0	1.51	0.18	12.4	0.55	0.31	0.56	0.29	0.35	2.06	73.3
9	5.4	1.21	0.11	11.1	1.11	0.41	0.46	0.41	0.40	2.79	60.2
10	5.5	1.24	0.24	9.91	1.01	0.32	0.34	0.38	0.35	2.40	57.9
11	5.1	1.34	0.31	8.41	0.92	0.23	0.41	0.28	0.29	2.13	56.8
12	5.0	1.61	0.17	12.1	0.93	0.31	0.39	0.27	0.28	1.98	63.1
Mean	5.2	1.41	0.18	10.0	0.81	0.25	0.51	0.29	0.35	2.20	60.9
SD	0.16	0.22	0.05	1.39	0.24	0.08	0.13	0.07	0.06	0.33	11.37
CV %	3.1	1.55	30.0	13.9	29.8	30.8	25.1	24.4	17.2	15.0	18.7

SD- Standard deviation, CV- coefficient of variation

from 353 - 448±27.2 mg/kg with a mean of 415±27.2 mg/kg and CV of 6.6 %. Copper contents were generally low, and the values ranged from 1.08 – 2.21±0.30 mg/kg with a mean of 1.63±0.30 mg/kg and CV of 18.4 %, while Zn content values ranged from 0.29 – 0.65±0.13 mg/kg with a mean of 0.47±0.13 mg/kg and CV of 26.5 %.

Table 3 Soil micronutrients

	Mn	Fe	Cu	Zn
Block	------------- mgkg--------			
1	1.5	353	1.86	0.52
2	4.1	448	1.08	0.54
3	14.4	426	1.37	0.63
4	24.9	396	1.84	0.65
5	23.4	441	1.47	0.65
6	11.9	451	1.55	0.43
7	15.3	422	1.44	0.42
8	26.3	432	1.38	0.29
9	21.4	421	2.01	0.38
10	18.1	399	2.21	0.41
11	15.4	389	1.67	0.29
12	8.9	401	1.68	0.38
Mean	15.5	415	1.63	0.47
SD	7.6	27.2	0.30	0.13
CV %	49	6.6	18.4	26.5

SD- Standard deviation, CV- coefficient of variation

3.4 Correlation of soil nutrient

Table 4 showed the correlation matrix of the study area. Soil pH negatively correlated with all the other parameters measured except exchangeable acidity and Ca that showed a positive correlation. Phosphorus/Ca, Ca/K and Na/ECEC were positively correlated and significant at 0.05 %. Exchange acidity was positively correlated with ECEC and negatively correlated with BS, while both were significant at 0.01 % level.

Table 4 Correlation matrix

	pH	OC	TN	P	Acid	Ca	Mg	K	Na	ECEC	BS
pH	1	-.268	-.002	-.260	.331	.236	-.476	.141	.100	.130	-.371
		.400	.996	.415	.293	.459	.118	.662	.758	.687	.235
OC		1	.346	.376	-.345	.214	.222	-.180	.022	-.175	.326
			.270	.229	.272	.505	.487	.576	.945	.587	.300
TN			1	-.123	.021	.126	-.217	.023	-.163	-.014	-.052
				.704	.949	.695	.499	.943	.613	.965	.874
P				1	-.241	.663*	.256	.438	-.021	.115	.389
					.451	.019	.421	.155	.948	.721	.211
Acid					1	.240	-.338	.341	.360	.779**	-.816**
						.452	.282	.278	.251	.003	.001
Ca				*		1	-.231	.628*	.237	.547	.107
							.470	.029	.459	.066	.740
Mg							1	.192	-.011	-.081	.390
								.550	.974	.803	.210
K						*		1	.148	.559	-.007
									.647	.059	.983
Na									1	.706*	.104
										.010	.748
ECEC					**				*	1	-.285
											.369
BS					**						1

** Correlation is significant at the 0.01 level
* Correlation is significant at 0.05 level

4.0 Discussion

The percentage of silt and clay in the area could be attributed to the seasonal flooding that deposition fine soil fraction from upland. Run-off water could transports and deposits fine soil fractions in the flooded area due to its hilly nature, and these give the characteristic of clay loam domination in fadama soils (Mamzing et al., 2014). The mean values of the soil pH were within the moderate range of acidic reaction classes (5.0-5.6); this is considered satisfactory for most crops in the tropics (Redi et al., 2016). High annual rainfall could be responsible for the soil pH in the study area that resulted in the loss of exchangeable bases through leaching and promoting Al_3^+ and H^+ activity in the soil solution that eventually increases soil acidity (Redi et al., 2016).

The percent organic carbon was low and cannot support crop production without proper soil amendment, especially organic fertilizer application. The low level could be due partly to the high rate of organic matter decomposition and mineralization, coupled with the poor soil management, most especially the inadequate application of organic fertilizer (Mulima et al., 2015). Frequent and uncontrolled burning of the area as practised by the farmers could lead to low organic carbon, and the soils could be prone to leaching of nutrients. Total nitrogen was in low and medium rating class corresponding to the nitrogen contents in tropics as generally low (Ekpe et al., 2017). The means that the area requires nitrogen fertilization for improved crop production. Continuous cultivation with high crop removal and insufficient soil amendment could be responsible for the high deficiency level recorded in the area. The phosphorus content was low compared to the established critical value of 17 mg/kg, as stated by Umeri (2017). This shows that the area cannot be cultivated without phosphorus fertilizer application.

The soils were found to be deficient in calcium compared to the established critical level of 3.80 cmol/kg (Abdullahi et al., 2010). The mean exchangeable K of most soils are in the range of 0.31 - 41 cmol/kg categorized under the range of medium (0.3 - 0.6 cmol/kg) rating. This indicated that the exchangeable K contents are similar to the threshold level. This is sufficient for crop production (Redi et al., 2016). The values were generally high (Above 0.20 cmol/100g); therefore, the area would not require potassium fertilization. Exchangeable magnesium ranged from 0.29 to 0.71 cmol/kg indicated low magnesium compared to the critical level of 1.9 cmol/kg (Umeri et al., 2017). The effective cation exchange capacity (ECEC) was 2.20 cmol/kg, which was low. An attempt should be made to improve the content through soil management practices.

The critical level of iron was given as 3-4.5 mg/kg, which was lower than the values found in the areas (Lawal et al., 2013). Zinc contents were low compare to the critical level of 5 - 9 mg/kg. Cu's values were low compared to the critical level of 6.35 mg/kg, and Mn contents were low compared to critical values of 10.3-15.7 mg/kg (FDALR, 2012). Relationships among the nutrient parameters showed that P had a positive and significant correlation with Ca. Ca had a positive and significant correlation with K. Organic carbon positively correlates with total nitrogen and available P.

5.0 Conclusion

Soil fertility fluctuates due to alteration in the quantity and availability of plant nutrients due to crop removal, fertilizer addition and leaching. These led to the assessment of the fertility status of the fadama soil in Asaba. The study found that the soil organic carbon, available P and ECEC were low while total nitrogen was moderate. This information will provide the basis for fertilizer recommendations for the studied area.

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