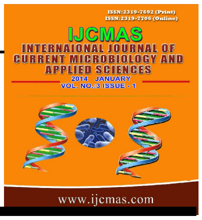

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Original Research Article

Assessing the Soil Fertility Status of Three Selected Rice Farms in Yola Metropolis, Adamawa State, Nigeria

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ABSTRACT

Ten fertility indices, viz soil pH texture, organic-carbon and total nitrogen contents, carbon/nitrogen ratio, available phosphorus, effective cation exchange capacity (ECEC), percentage base saturation (PBS), calcium/magnesium cation saturation ratio and clay activity of the soils of five profiles each, collected during the dry and rainy seasons in three selected rice farms in Yola metropolis, Adamawa State, Nigeria were examined. The results revealed that the soils were slightly to moderately acidic (pH= 5.7– 6.3) and were within the recommended range that can release nutrients for plant growth and maintenance. The values, 0.16 –45.52,8.93–14.61meq/100g and 30.16 – 45.52% were recorded for total nitrogen, ECEC and PBS respectively. These values were rated low to medium in some farm types. The clay activity, soil organic carbon and calcium/magnesium ratio ranged from 32- 43, 1.45- 4.65% and 2.14 –2.78 respectively, while carbon/nitrogen ratio ranged from 9.31–15.70. These values were considered to be low in comparison with the recommended values for plant growth. Nevertheless, the available phosphorus content (9.94 –14.13%) was well above the lower critical limit of phosphorus (6mg/kg) reported by the university of California (2012). The soils had a fair balance of sand, clay and silt with exception of dry-season Farm "A" with an overwhelming sand content (79.72 ± 2.68). Soils of this nature are known to be suitable for agriculture.

Keywords

Assessing; Soil**;** Fertility indices**;** Status; Rice farms

Introduction

Rice is a staple food and delicacy in Nigeria (and indeed in many countries in the West Africa subregion and gets to dining table in various forms (Ogunmodede, 1995). According to JICA and WARDA, as cited in (Abe et al., 2010), rice consumption has been on the increase since the 1970s owing to the rapid increase in its per capita consumption and ever-growing population. The sub-region relied solely on imports and aids to meet its rice demand which culminated in the astronomical recording - breaking import figure of 3400 metric tonnes (milled basis) in 1998 (Saeed Ghazvineh and Yousefi, 2012) .

As the global apprehensions focus on food self-sufficiency and food security to feed the teeming population of the world, nations have redoubled their efforts to actualize this dream through investments and new technologies (Swift, M.J and Woomer, 1993; Peljor, N. and Minot, N. (2010; Shamsodini et al., 2011).

One major reason adduced for impending rice self-sufficiency in the sub-region is its low yield which have seemingly remained practically stalled for the last two decades (1980 - 2000). This can be attributed to a number or combination of factors:

Adherence to the out-dated traditional shifting cultivation system of farming. Continuous farming on a particular piece of land year in year out leads to decline in soil organic carbon, which is a source and sink for nutrients and plays a vital role in soil fertility maintenance (Botiono et al., 2006). The consequence is the depletion in soil fertility, resulting in low rice yield in comparison with yesteryears harvest.

Another problem is the lack of soil test – which should have revealed the actual soil status before commencement of planting. And coupled with this aberrant practice above, is the bandwagon application of fertilizer types (Zaku et al., 2011). Additionally, the persistent negative imbalance of macronutrients in the soils arising from loss of nutrients through crop residue and crop removal which is less than compensated for by the fertilizer application (University of California, (2010).

The preference to upland rice farming system which is more prone to land degradation than the low land rice farming (Madu, E. (1990) and Over dependence of rain fed irrigation system which is governed by the vagaries of weather with its attendant uncertainties. The aim of this study was therefore, to determine some soil fertility indices in order to ascertain the soil fertility status of the soil in three selected rice farms in Yola metropolis, Adamawa State, Nigeria. And besides, proffer useful advice to the farmers.

Materials and Methods

The study area

The studied area encompassed three selected rice farms in Yola metropolis, Adamawa State, Nigeria. Figures (1 – 3) show the sketch maps of the three rice farms indicating the sites of sample collection. Farm “A” is bounded by Yola – Jimeta Road and Yola Abattoir and is close to the Chouci River. It receives atmospheric deposition from the high volume of road traffic, waste water from the abattoir and nearby wards. The farm is flooded at the peak of the rainy season and is used for both dry and rainy season farming. Farm “B” is located very close to the Yola Water Treatment plant and flooded during the rainy season by the distributory of River Benue. The river in turn receives varied amount of waste pollution load from Ladgo Dam in the nearby Cameroon Republic and a number of urban and agro-allied activities along its course. The water treatment plant also contributes its unfair share of pollutants. Furthermore, there is a dumpsite and road construction work that is in progress nearby.

Farm "C" is within the confines of Lake Gerio and has long been used for both dry and rainy season farming. The farm is flooded by this lake and River Benue with their attendant pollutant load.

Field Sampling

Sampling was done in accordance with methods of (Amri and Kimaro 2010) and (Zaku, 2006) because of difference in the size and topography of the rice farms of interest investigated.

Soil samples were collected during the dry and rainy seasons respectively from 0-5, 5-10 and 10-20cm depths. The choice of the depth range is predicated on the fact that applied fertilizer should be available within 20 cm of the surface for maximum growth, as 80-95 per cent of the roots of the rice plant are found within these horizons (Beyronthy et al., 1988).

In Farm "A" 5 spots were randomly chosen and each spot was divided into four directions (North, East, West and South). 70m away in each direction outside the spot, 4 samples were taken at the specified depths. The 4 samples so obtained were then mixed with initial sample to form a composite soil sample for the initial 5 spots, respectively. Farm "B" was divided into 3 sites, viz sites I, II and III, respectively using already existing physical features as in Figure 2.

Site I:

This site was subdivided into 2 smaller sampling sites and from each 4 soil samples were collected 20m apart along a zigzag path through the farm at the specified depths. The samples were then bulked to give 2 composite samples.

Sites II:

The same procedure adopted for site I was used to obtain 2 composite samples.

Site III:

Four (4) soil samples were collected and combined to form a single composite samples as described in site I. Farm "C" was divided into 3 areas, namely Areas I, II and III, respectively using already existing physical features as shown in Figure 3.

Area I:

Three (3) spots were randomly chosen and soil samples collected as in Farm "A" to obtain 3 composite samples.

Areas II and III:

One composite sample each was obtained from Areas II and III, respectively by the adoption of the same procedure used in site III, Farm "B".

Sample Treatment:

Stones and other foreign objects were removed from the composite samples obtained from the field. They were air-dried in the laboratory for 7 days, crushed and sieved through a 2mm- aluminium sieve. A test sample was obtained from the above by conning and quatering method (Crosby and Patel, 1995).

Sample analysis

Physico-chemical properties determination:

pH of each sample was determined in 1:2.5 ratio of soil to water suspension by a digital pH meter, while particle-size distribution analysis was determined by Bouyocous hydrometer method.

Silver-thioreagent was used as the extractant on 10g of each of the test sample (IITA, 2006). Sodium and potassium in the extract were determined by flame photometer, while calcium and magnesium were determined by Na_2 EDTA titration, respectively. Exchangeable acidity was by titration method (IFAD, 1994). ECEC was by summation of exchangeable bases and total E.A PBS was by subtraction of E.A. from ECEC and division by ECEC, while clay activity was got by division of ECEC by percentage clay content.

Elements Contents:

A given amount (0.5g) of test sample was pelletized and analyzed for calcium and magnesium content using EDXRF spectrometer (mini pal version), available phosphorus was by Bray-1 method (Bray and Kurtz, 1945). Soil organic carbon was determined on 1g of the test sample each by the method of (Mgbada, 2007) as outlined (IITA, 2006). while total nitrogen was determined spectrophetometrically (IITA, 2006)..

Soil fertility indices determination

In order to ascertain the soil fertility status of the soils of interest, the following fertility indices were examined, namely (i) soil pH, (ii) soil texture, (iii) total nitrogen and soil organic carbon, (iv) carbon/nitrogen (C/N) ratio, (v) available phosphorus, (vi) effective cation exchange capacity (ECEC), (vii) percentage base saturation (PBS), (viii) calcium/magnesium (Ca/Mg) cation saturation ratio; and (ix) clay activity.

Soil pH and Nutrient Availability in the Soil Solution

pH has a direct increase in solubility of nutrients and trace elements required for plant growth (and rice plant) is no exception, (Mahapatra et al., 1996; Maqsood, et al., 2011). However, a balance is usually struck since severe acidity will result in excess nutrients leading to element toxicity (Nwoke and Ezike, 2000).

The mean pH values of the soils ranged from 5.7–6.3 which was approximately within the bracket of 6 -7 that could release nutrients for plant growth (Sahrawat, 2005). Thus, it is reasonable to aver that some ameliorative liming would be necessary in dry-season Farm “A” and rainy-season Farms “B” and “C”.

Soil Texture:

The soils had a fair balance of sand, clay and silt with the exception of dry-season Farm “A” which recorded an overwhelming sand content (mean per cent of 79.72 ± 2.68) as shown in Table 2. Soils of this nature are suitable for agriculture (Scott et al., 1971) as the relative proportions determine the texture which is extremely important in water retention capacity and nutrient storage in root profile (Mengel et al., 2006).

Results and Discussion

Total Nitrogen and Soil Organic Carbon

The per cent mean values of nitrogen and soil organic carbon for the dry and rainy season farm “A”, “B” and “C” ranged from 0.16 – 0.33 and 1.45 – 4.65 respectively (Tables 3a – 3b).

The nitrogen and soil organic-carbon contents decreased with soil depth. Furthermore, the trend of profile distribution of nitrogen was positively correlated with organic carbon content in three farm types (dry-season Farm “A”: r = 1, rainy-season Farms “B” and “C” r”: 0.5, respectively), while the rest three Farms were either not correlated or only slightly correlated negatively.

Carbon/nitrogen (C/N) ratio

The C/N ratio ranged from 9.31 – 15.70 Tables 3a – 3b. Its highest value was 37.2 per cent of 25 – the separating index of mineralization reported by (Paul, and Clark, 1989). These values above are suggestive of only low to moderate organic-carbon endowment of the soils of the studied area for rice plant cultivation.

Available Phosphorus

Table 4 presents the available phosphorus contents of the soils of interest. The values were well above the lower critical limits of phosphorus (6mg/kg) reported by the University of California (2012). Since phosphorus is required in lower amounts than the major nutrients (Hodges, 2002) , its available content in the soils can sustain and maintain rice cultivation in the studied area.

Effective Cation Exchange Capacity (ECEC)

Tables 5a – 5b present the ECEC values of the soils in the studied area. The soils were generally low in exchangeable bases particularly sodium. The low values of sodium could be due to the low abundance of the metal in the parent materials in the soils. These low values of sodium are of little concern, but present in excess it can degrade soil structure, slow infiltration rates and interferes with calcium, magnesium and potassium uptake (Hodges, 2002).

The CEC values in the soils were low but higher than 5meq/100g, which (Hodges, 2002) described as low. These low CEC values in the soils of Farms “A” and dry-season Farm “B” can be attributed to sandy texture with low clay content which originates primarily from coarse-grained granite rocks.

According to (Abe et al., 2010), these types of findings are suggestive of characteristics that predominantly affected by soil parent materials and weathering intensity governed by rainfall (or irrigation inputs) in West Africa lowlands.

Percentage Base Saturation (PBS)

The PBS values ranged from 300.16 – 45.10 (Tables 5a – 5b) which is 38– 56 percent of the recommended 80 percent PBS upper limit to be maintained in most cropping systems (Hodges, 2002).

The PBS values decreased with soil depth in most horizons. Besides, positive relationship between PBS and pH were identified. Most often the farm with high PBS had corresponding high pH values and vice versa (Table 6).

Calcium/Magnesium Cation Saturation Ration

Calcium/Magnesium ratio determined ranged from 2.04 – 2.62 (Tables 7a – 7b). Its highest value (2.62) was 46 per cent of that of the ideal ratio - 6.5. Since Ca/Mg ratio is an ideal one for exchangeable calcium and magnesium in the soils that will optimize rice plant cultivation; the

Table.1 pH values of soil samples

Horizontal (cm)	Sample	pH	Sample	pH	Sample	pH	Sample	pH	Sample	pH	Sample	pH
0 – 5	DABY 11	5.2	RABY 11	5.8	DWTP 11	5.8	RWTP 11	6.2	DCLG 11	5.8	RCLG 11	5.8
5 – 10	DABY 12	5.5	RABY 12	5.9	DWTP 12	6.2	RWTP 12	6.3	DCLG 12	6.1	RCLG 12	6.2
10 – 20	DABY 12	5.9	RABY 12	5.8	DWTP 13	6.0	RWTP 13	6.2	DCLG 13	5.5	RCLG 13	6.1
0 – 5	DABY 21	5.5	RABY 21	6.8	DWTP 21	5.4	RWTP 21	6.1	DCLG 21	6.2	RCLG 21	6.2
5 – 10	DABY 22	5.3	RABY 22	6.7	DWTP 22	5.5	RWTP 22	5.5	DCLG 22	7.0	RCLG 22	6.3
10 – 20	DABY 23	5.6	RABY 23	6.5	DWTP 23	5.4	RWTP 23	5.8	DCLG 23	7.5	RCLG 23	6.4
0 – 5	DABY 33	5.2	RABY 3`	5.9	DWTP 31	6.3	RWTP 31	5.1	DCLG 31	6.6	RCLG 31	5.8
5 – 10	DABY 32	5.5	RABY 32	6.0	DWTP 32	6.7	RWTP 32	5.3	DCLG 32	6.2	RCLG 32	5.5
10 – 20	DABY 33	5.5	RABY 33	6.3	DWTP 33	6.6	RWTP 33	4.6	DCLG 33	6.7	RCLG 33	6.0
0 – 5	DABY 41	6.3	RABY 41	5.5	DWTP 41	6.8	RWTP 41	6.1	DCLG 41	5.6	RCLG 41	5.7
5 – 10	DABY 42	6.1	RABY 42	5.7	DWTP 42	6.3	RWTP 42	5.5	DCLG 42	5.8	RCLG 42	5.2
10 – 20	DABY 43	5.8	RABY 43	5.6	DWTP 43	6.4	RWTP 43	5.4	DCLG 43	6.6	RCLG 43	6.4
0 – 5	DABY 51	6.0	RABY 51	6.1	DWTP 51	5.6	RWTP 51	6.3	DCLG 51	5.6	RCLG 51	5.2
5 – 10	DABY 52	5.4	RABY 52	6.5	DWTP 52	6.0	RWTP 52	5.3	DCLG 52	6.1	RCLG 52	5.5
10 – 20	DABY 53	6.4	RABY 53	6.4	DWTP 53	6.0	RWTP 5 3	6.5	DCLG 53	6.6	RCLG 53	6.2
Range		5.2 – 6.4		5.5 – 6.8	5.4 – 6.8		4.6 -	5.5 – 7.5	5.3 – 6.4			
X		5.7		6.1	6.1		5.7	6.3	5.8			
±S		0.38		0.46	0.41		0.49	0.43	0.41			

Table.2 Mean particle-size distribution (in%) of soil types their ratios and clay activity

Farm	Sample	Sand	Silt	Clay	Sand	Silt	Clay	Meq/100g	Clay activity
“A”	Dry season	79.72	13.07	7.18	11.10	1.82	1	8.93	124
	Rainy season	23.32	43.04	33.85	1	1.85	1.45	10.67	32
“B”	Dry season	10.75	48.10	41.90	1	4.47	3.90	14.61	35
	Rainy season	19.19	48.70	31.26	1	2.44	1.57	12.42	40
“C”	Dry season	25.00	42.82	30.73	1	1.71	1.25	11.66	38
	Rainy season	26.33	40.33	32.57	1	1.53	1.34	14.02	43

The ± standard deviation of the soil type are contained in M. Tech. Thesis (2012), Modibbo Adama University of Technology, Yola, Nigeria.

Table.3a Nitrogen and organic carbon contents (in %) and their relative abundance in the soils of Farm "C"

Horizon (cm)	**Sample**	**N**	**C**	**C : N**	**Sample**	**N**	**C**	**C : N**
0 - 5	DCLG 11	0.17	2.15	12.65 1	RCLG 11	0.23	2.80	12.17 1
5 -10	DCLG 12	0.15	2.10	14.00 1	RCLG 12	0.20	2.50	12.50 1
10 – 20	DCLG 12	0.14	2.00	14.29 1	RCLG 12	0.18	2.40	13.33 1
0 – 5	DCLG 21	0.17	2.25	13.24 1	RCLG 21	0.16	2.20	13.75 1
5 -10	DCLG 22	0.10	1.70	17.00 1	RCLG 22	0.14	2.15	15.36 1
10 - 20	DCLG 23	0.90	1.68	1.87 1	RCLG 23	0.10	1.60	16.00 1
0 - 5	DCLG 31	0.30	2.90	9.97 1	RCLG 31	0.32	4.70	14.69 1
5 -10	DCLG 32	0.30	2.85	9.50 1	RCLG 32	0.30	4.52	15.07 1
10 - 20	DCLG 33	0.24	2.40	10.00 1	RCLG 33	0.26	4.00	15.39 1
0 - 5	DCLG 41	0.17	3.20	18.82 1	RCLG 41	0.16	3.00	18.75 1
5 -10	DCLG 42	0.15	2.60	17.33 1	RCLG 42	0.14	2.40	15.11 1
10 - 20	DCLG 43	0.13	2.00	15.38 1	RCLG 43	0.13	1.90	14.62 1
0 - 5	DCLG 51	0.18	1.90	10.56 1	RCLG 51	0.20	4.00	20 1
5 -10	DCLG 52	0.15	1.36	9.07 1	RCLG 52	0.19	3.80	20 1
10 - 20	DCLG 53	0.14	1.30	9.29 1	RCLG 53	0.16	3.00	18.75 1
Range		-	-	-		-	-	-
X		0.23	2.15	12.12 1		0.19	3.00	15.20 1
± S		0.26	0.62	-		0.06	1.01	-

Table.3b Nitrogen and organic carbon contents (in%) and their relative abundance in the soils of Farms “A” and “B”

Horizon (cm)	**Sample**	**N**	**C**	**C : N**	**Sample**	**N**	**C**	**C : N**	**Sample**	**N**	**C**	**C : N**	**Sample**	**N**	**C**	**C : N**
0 – 5	DABY 11	0.20	1.70	8.50 1	RABY 11	0.24	2.70	11.25 1	DWTP 11	0.24	2.70	11.25 1	RWTP 11	0.27	3.50	12.96 1
5 – 10	DABY 12	0.18	1.50	8.3 1	RABY 12	0.20	2.65	13.5 1	DWTP 12	0.19	2.50	13.16 1	RWTP 12	024	3.20	13.33 1
10 – 20	DABY 13	0.16	1.32	8.25 1	RABY 13	0.17	2.20	12.94 1	DWTP 13	0.16	2.00	12.50 1	RWTP 13	0.18	3.00	16.67 1
0 – 5	DABY 21	0.11	1.40	12.73 1	RABY 21	0.30	3.20	10.67 1	DWTP 21	0.16	2.40	15.00 1	RWTP 21	0.35	6.10	17.43 1
5 – 10	DABY 22	0.10	1.20	12.00 1	RABY 22	0.28	3.15	11.25 1	DWTP 22	0.12	1.80	15.00 1	RWTP 22	0.33	5.80	17.58 1
10 – 20	DABY 23	0.09	0.93	10.33 1	RABY 23	0.25	2.98	11.92 1	DWTP 23	0.10	1.40	14.00 1	RWTP 23	0.30	5.40	18.00 1
0 – 5	DABY 31	0.22	1.80	8.18 1	RABY 31	0.16	2.00	12.50 1	DWTP 31	0.30	2.50	8.33 1	RWTP 31	0.72	10.20	14.17 1
5 – 10	DABY 32	0.20	1.62	8.10 1	RABY 32	0.14	1.86	13.29 1	DWTP 32	0.28	2.40	8.57 1	RWTP 32	0.56	7.90	14.11 1
10 – 20	DABY 33	0.17	1.58	9.29 1	RABY 33	0.13	1.72	13.23 1	DWTP 33	0.24	2.20	9.17 1	RWTP 33	0.46	6.00	13.04 1
0 – 5	DABY 41	0.19	1.72	9.05 1	RABY 41	0.22	1.90	9.64 1	DWTP 41	0.24	2.00	8.33 1	RWTP 41	0.33	4.70	14.24 1
5 – 10	DABY 42	0.18	1.68	9.33 1	RABY 42	0.19	1.78	9.32 1	DWTP 42	0.21	1.25	5.95 1	RWTP 42	0.26	4.30	16.54 1
10 – 20	DABY 43	0.16	1.59	9.44 1	RABY 43	0.18	1.73	9.61 1	DWTP43	0.10	1.80	8.00 1	RWTP43	0.25	4.00	16.00 1
0 – 5	DABY 51	0.16	1.30	8.13 1	RABY 51	0.16	1.40	8.75 1	DWTP 51	0.24	1.60	6.67 1	RWTP 51	0.26	4.30	7.69 1
5 – 10	DABY 52	0.15	1.25	8.33 1	RABY 52	0.14	1.33	9.50 1	DWTP 52	0.23	1.40	6.09 1	RWTP 52	0.22	1.80	8.18 1
10 – 20	DABY 53	0.13	1.19	9.15 1	RABY 53	0.11	1.20	10.91 1	DWTP 53	0.22	1.35	6.14 1	RWTP 53	0.20	1.79	8.95 1
Range		-	-	-		-	-	-		-	-	-		-	-	-
X		0.16	1.45	9.31 1		0.19	2.12	11.14 1		0.20	1.89	9.32 1		0.33	4.65	13.93 1
±	-	0.04	0.24	-		0.06	0.66	-		0.06	0.46	-	-	0.16	2.35	-

Table.4 Concentration (in mg/kg) of extractable phosphorus in the soil samples

Horizon (cm)	**Sample**	**P**	**Sample**	**P**	**Sample**	**P**	**Sample**	**P**	**Sample**	**P**	**Sample**
0 – 5	DABY 11	6.70	RABY 11	11.22	DWTP 11	12.00	RWTP 11	11.60	DCLG 11	13.90	RCLG 11
5 – 10	DABY 12	11.10	RABY 12	10.00	DWTP 12	9.10	RWTP 12	10.90	DCLG 12	13.99	RCLG 12
10 – 20	DABY 13	12.33	RABY 13	11.40	DWTP 13	13.44	RWTP 13	12.50	DCLG 13	14.90	RCLG 13
0 – 5	DABY 21	6.44	RABY 21	11.60	DWTP 21	16.58	RWTP 21	16.90	DCLG 21	16.40	RCLG 21
5 – 10	DABY 22	8.62	RABY 22	14.32	DWTP 22	12.32	RWTP 22	12.40	DCLG 22	17.80	RCLG 22
10 – 20	DABY 23	10.00	RABY 23	13.44	DWTP 23	15.40	RWTP 23	17.60	DCLG 23	16.99	RCLG 23
0 – 5	DABY 31	11.21	RABY 31	10.66	DWTP 31	13.50	RWTP 31	12.00	DCLG 31	8.77	RCLG 31
5 – 10	DABY 32	10.45	RABY 32	12.00	DWTP 32	12.65	RWTP 32	12.90	DCLG 32	11.00	RCLG 32
10 – 20	DABY 33	11.00	RABY 33	12.22	DWTP 33	14.00	RWTP 33	13.20	DCLG 33	11.65	RCLG 33
0 – 5	DABY 41	4.32	RABY 41	8.23	DWTP 41	10.34	RWTP 41	9.34	DCLG 41	10.33	RCLG 41
5 – 10	DABY 42	10.21	RABY 42	12.00	DWTP 42	12.60	RWTP 42	12.70	DCLG 42	11.92	RCLG 42
10 – 20	DABY 43	12.40	RABY 43	12.43	DWTP 43	11.50	RWTP 43	10.66	DCLG 43	12.09	RCLG 43
0 – 5	DABY 51	10.64	RABY 51	11.50	DWTP 51	13.66	RWTP 51	12.32	DCLG 51	16.80	RCLG 51
5 – 10	DABY 52	11.70	RABY 52	11.70	DWTP 52	12.50	RWTP 52	14.63	DCLG 52	17.60	RCLG 52
10 – 20	DABY 53	11.93	RABY 53	12.50	DWTP 53	14.00	RWTP 53	15.77	DCLG 53	17.76	RCLG 53
RANGE		-		-		-		-		-	
X ± S		9.94 ± 2.39		11.68± 1.49		12.91± 1.85		13.03 ± 2.02		14.13 ± 3.14	

The dash (-) means "not applicable."

Table.5a Effective cation exchange capacity for Farm “A” and dry-season Farm “B” soil samples

Horizon (cm)	Sample	ECEC meq/100g	PBS	Sample	ECEC meq/100g	PBS	Sample	ECEC meq/100g	PBS
0 – 5	DABY 11	9.80	38.76	RABY 11	9.72	38.28	DWTP 11	15.27	44.66
5 – 10	DABY 12	9.11	36.88	RABY 12	9.76	36.48	DWTP 12	15.26	43.58
10 – 20	DABY 13	8.81	34.73	RABY 13	8.73	34.58	DWTP 13	14.40	42.01
0 – 5	DABY 21	8.57	28.24	RABY 21	9.62	36.07	DWTP 21	16.17	42.18
5 – 10	DABY 22	8.22	27.01	RABY 22	8.83	35.45	DWTP 22	15.26	39.52
10 – 20	DABY 23	7.50	21.33	RABY 23	8.61	23.34	DWTP 23	14.66	38.61
0 – 5	DABY 31	8.30	31.93	RABY 31	12.80	42.27	DWTP 31	14.23	33.59
5 – 10	DABY 32	8.18	31.54	RABY 32	11.50	43.55	DWTP 32	14.13	32.06
10 – 20	DABY 33	7.90	24.04	RABY 33	12.30	41.30	DWTP 33	14.10	31.56
0 – 5	DABY 41	14.34	38.84	RABY 41	11.66	42.82	DWTP 41	15.28	44.70
5 – 10	DABY 42	13.95	38.71	RABY 42	11.06	37.16	DWTP 42	14.93	44.07
10 – 20	DABY 43	12.65	28.06	RABY 43	11.11	38.79	DWTP 43	13.25	39.62
0 – 5	DABY 51	8.74	30.21	RABY 51	11.11	38.79	DWTP 51	14.35	40.42
5 – 10	DABY 52	8.62	29.23	RABY 52	10.97	31.63	DWTP 52	14.11	39.69
10 – 20	DABY 53	8.19	27.96	RABY 53	97.77	27.84	DWTP 53	14.02	38.66
Range	-	-			-	-		-	-
X		8.93	30.16		10.62	36.42		14.61	39.66
±	-	-			-	-		-	-

The dash (-) means “not applicable.

Table.5b Effective cation exchange capacity for rainy -season Farm “B” and Farm “C” soil samples

Horizon (cm)	Sample	ECEC meq/100g	PBS	Sample	ECEC meq/100g	PBS	Sample	ECEC meq/100g	PBS
0 – 5	RWTP 11	13.14	39.50	DCLG 11	13.72	46.14	RCLG 11	17.95	49.86
5 – 10	RWTP 12	12.76	39.29	DCLG 12	11.81	42.00	RCLG 12	14.49	40.65
10 – 20	RWTP 13	12.30	30.89	DCLG 13	11.51	36.11	RCLG 13	14.06	30.90
0 – 5	RWTP 21	13.46	37.96	DCLG 21	13.79	47.79	RCLG 21	13.89	41.68
5 – 10	RWTP 22	13.24	37.69	DCLG 22	12.10	42.48	RCLG 22	13.87	39.43
10 – 20	RWTP 23	13.17	37.28	DCLG 23	11.94	38.86	RCLG 23	13.75	38.18
0 – 5	RWTP 31	12.91	40.74	DCLG 31	10.40	49.52	RCLG 31	13.59	46.65
5 – 10	RWTP 32	12.80	40.63	DCLG 32	10.21	48.58	RCLG 32	12.76	42.00
10 – 20	RWTP 33	12.25	40.00	DCLG 33	10.10	46.53	RCLG 33	12.48	41.11
0 – 5	RWTP 41	12.39	41.08	DCLG 41	10.02	46.61	RCLG 41	15.55	48.55
5 – 10	RWTP 42	12.20	40.49	DCLG 42	9.96	42.27	RCLG 42	12.44	42.12
10 – 20	RWTP 43	11.27	37.89	DCLG 43	9.75	42.05	RCLG 43	12.40	41.13
0 – 5	RWTP 51	11.56	52.42	DCLG 51	9.54	50.73	RCLG 51	14.53	51.48
5 – 10	RWTP 52	11.55	44.16	DCLG 52	9.57	49.32	RCLG 52	14.42	44.17
10 – 20	RWTP 53	11.28	42.38	DCLG 53	9.31	48.44	RCLG 53	14.17	30.84
Range	-	-	-		-	-		-	-
X		2.42	40.09		11.66	45.10		14.02	42.52
±	-	-			-	-		-	-

The value of exchangeable –bases and total acidy (in meq/100g) are contained in M.Tech Thesis, Modibbo Adama University of Technology, Yola, Nigeria. The dash (-) means “not applicable.”

Table.6 Relation between PBS and pH values

Farm	Sample type	PBS	pH
"A"	Dry season	30.16	5.7
	Rainy season	36.42	6.1
"B"	Dry season	39.66	6.1
	Rainy season	40.09	5.7
"C"	Dry season	45.10	6.3
	Rainy season	42.52	5.8

Table.7a Concentration (in mg/kg) of calcium and magnesium and their relative abundance in the soil samples of Farms "A" and "B"

Horizon (cm)	Sample	Ca	Mg	Ca : Mg	Sample	Ca	Mg	Ca : Mg	Sample	Ca	Mg	Ca : Mg	Sample	Ca	Mg	Ca : Mg
0 – 5	DABY 11	704.20	398.67	1.77 1	RABY 11	1234.01	260.00	4.75 1	DWTP 11	964.31	286.31	3.37 1	RWTP 11	600.51	218.70	2.75 1
5 – 10	DABY 12	760.00	316.53	2.40 1	RABY 12	984.60	430.72	2.29 1	DWTP 12	750.90	400.44	1.88 1	RWTP 12	776.63	329.78	2.35 1
10 – 20	DABY 13	650.90	580.71	1.12 1	RABY 13	529.90	492.66	1.08 1	DWTP 13	1420.90	316.53	4.49 1	RWTP 13	690.32	589.72	1.17 1
0 – 5	DABY 21	840.60	432.00	1.95 1	RABY 21	890.00	411.00	2.17 1	DWTP 21	860.22	398.78	2.16 1	RWTP 21	1600.52	378.25	4.23 1
5 – 10	DABY 22	660.74	420.96	1.20 1	RABY 22	680.42	425.69	1.60 1	DWTP 22	600.78	586.39	1.02 1	RWTP 22	1000.62	376.40	2.66 1
10 – 20	DABY 23	540.78	420.60	1.29 1	RABY 23	400.51	280.00	1.43 1	DWTP 23	1500.00	320.66	4.68 1	RWTP 23	990.44	490.00	2.02 1
0 – 5	DABY 31	840.60	360.50	2.33 1	RABY 31	980.44	300.46	3.26 1	DWTP 31	1200.89	432.88	2.77 1	RWTP 31	1323.48	329.69	4.01 1
5 – 10	DABY 32	900.00	342.89	2.62 1	RABY 32	1342.60	420.58	3.19 1	DWTP 32	1000.73	347.89	2.88 1	RWTP 32	1123.73	306.98	3.66 1
10 – 20	DABY 33	960.00	400.78	2.40 1	RABY 33	890.88	600.48	1.49 1	DWTP 33	906.51	298.81	3.03 1	RWTP 33	890.61	749.23	1.11 1
0 – 5	DABY 41	860.42	694.20	1.24 1	RABY 41	600.92	762.63	1.07 1	DWTP 41	1111.12	540.69	2.05 1	RWTP 41	789.62	630.59	1.25 1
5 – 10	DABY 42	900.27	250.40	3.60 1	RABY 42	1000.82	200.00	5.00 1	DWTP 42	890.33	268.45	3.32 1	RWTP 42	1570.66	362.45	4.33 1

10 – 20	DABY 43	1200.74	400.60	3.00 1	RABY 43	1400.52	436.70	3.21 1	DWTP 43	900.33	378.22	2. 38 1	RWTP 43	890.40	390.24	2.28 1
0 – 5	DABY 51	896.88	324.94	2.75 1	RABY 51	790.62	324.86	2.43 1	DWTP 51	1246.00	380.41	3.281 1	RWTP 51	966.39	298.72	3.24 1
5 – 10	DABY 52	1006.45	368.72	2.73 1	RABY 52	1260.75	266.72	4.73 1	DWTP 52	900.31	260.59	3.45 1	RWTP 52	1000.28	300.42	3.33 1
10 – 20	DABY 53	1007.90	404.60	2.49 1	RABY 53	998.36	325.72	3.07 1	DWTP 53	1192.82	389.26	3.06 1	RWTP 53	966.36	290.77	3.32 1
Range		-	-	-		-	-	-		-	-	-		-	-	-
X				2.04 1				2.14 1				2.99 1				2.78 1
±		-	-	-		-	-	-		-	-	-		-	-	-

The value of exchangeable –bases and total acidy (in meq/100g) are contained in M.Tech Thesis, Modibbo Adama University of Technology, Yola, Nigeria. The dash (-) means "not applicable."

Table.7b Concentration (in management/kg) of calcium and magnesium and their relative abundance in the soil samples of Farm "C"

Horizon (cm)	Sample	Ca	Mg	Ca : Mg	Sample	Ca	Mg	Ca : Mg
0 – 5	DCLG 11	1500.00	300.44	5.00 1	RCLG 11	1486.96	300.14	4.95 1
5 -10	DCLG 12	1000.98	300.00	3.34 1	RCLG 12	1266.40	340.14	3.72 1
10 – 20	DCLG 12	964.30	280.68	3.44 1	RCLG 13	1000.00	408.60	2.45 1
0 – 5	DCLG 21	860.23	320.45	2.69 1	RCLG 21	920.00	280.63	3.28 1
5 -10	DCLG 22	1420.66	290.50	4.89 1	RCLG 22	1112.90	350.77	3.17 1
10 – 20	DCLG 23	860.32	400.30	2.15 1	RCLG 23	706.32	320.30	2.21 1
0 – 5	DCLG 31	1200.32	560.90	2.14 1	RCLG 31	1300.42	510.26	2.55 1
5 -10	DCLG 32	900.00	432.90	2.08 1	RCLG 32	1360.83	672.60	2.02 1
10 – 20	DCLG 33	1320.91	420.66	3.14 1	RCLG 33	1198.66	500.76	2.39 1
0 – 5	DCLG 41	890.65	267.44	3.33 1	RCLG 41	1206.40	580.98	2.08 1
5 -10	DCLG 42	760.90	420.45	1.81 1	RCLG 42	980.78	499.65	1.96 1

10 – 20	DCLG 43	860.70	430.33	2.00 1	RCLG 43	930.45	370.98	2.51 1
0 – 5	DCLG 51	1200.33	890.45	1.35 1	RCLG 51	1260.72	490.00	2.57 1
5 -10	DCLG 52	734.45	732.73	1.00 1	RCLG 52	1000.53	500.01	2.00 1
10 – 20	DCLG 53	864.44	734.89	1.18 1	RCLG 53	977.67	650.32	1.50 1
Range		-	-	-		-	-	-
X		-	-	2.64 1		-	-	2.62 1
± S								

The dash (-) means "not applicable"

Table.8 Ranking of mean fertility indices of the soils

	Farms					
	"A"		"B"		"C"	
Mean property	Dry-season	Rainy-season	Dry-season	Rainy-season	Dry-season	Rainy-season
CEC (meq/100g)	8.93^1	10.67^2	14.61^6	12.42^4	11.66^3	14.02^5
pH (H_2O)	5.7^3	6.1^5	6.1^6	5.7^3	6.3^6	5.8^4
C/N Ratio	9.31^1	11.14^3	9.32^2	13.93^5	12.12^4	15.70^6
Available P (mg/kg)	9.99^1	11.60^2	12.91^3	13.03^4	14.11^6	13.11^5
Conductivity ($X10^2uScm^{-1)}$	9.47^1	12.50^5	8.90^1	8.93^2	12.43^4	15.80^6
C/Mg Ratio	2.04^1	2.14^2	2.99^6	2.78^5	2.64^4	2.62^3
Ranking Total	10	19	24	23	27	29

Figure.1 Rice farms in Yola metropolis, Adamawa State, Nigeria

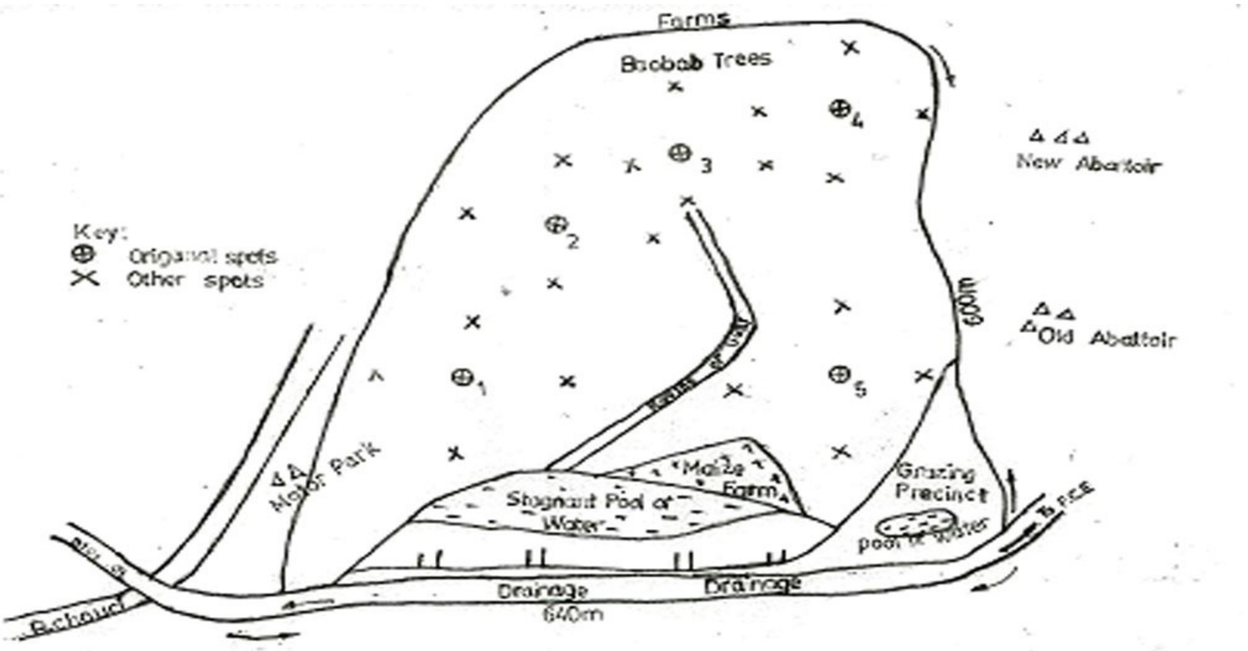


Figure.2 Rice farms in Yola metropolis, Adamawa State, Nigeria

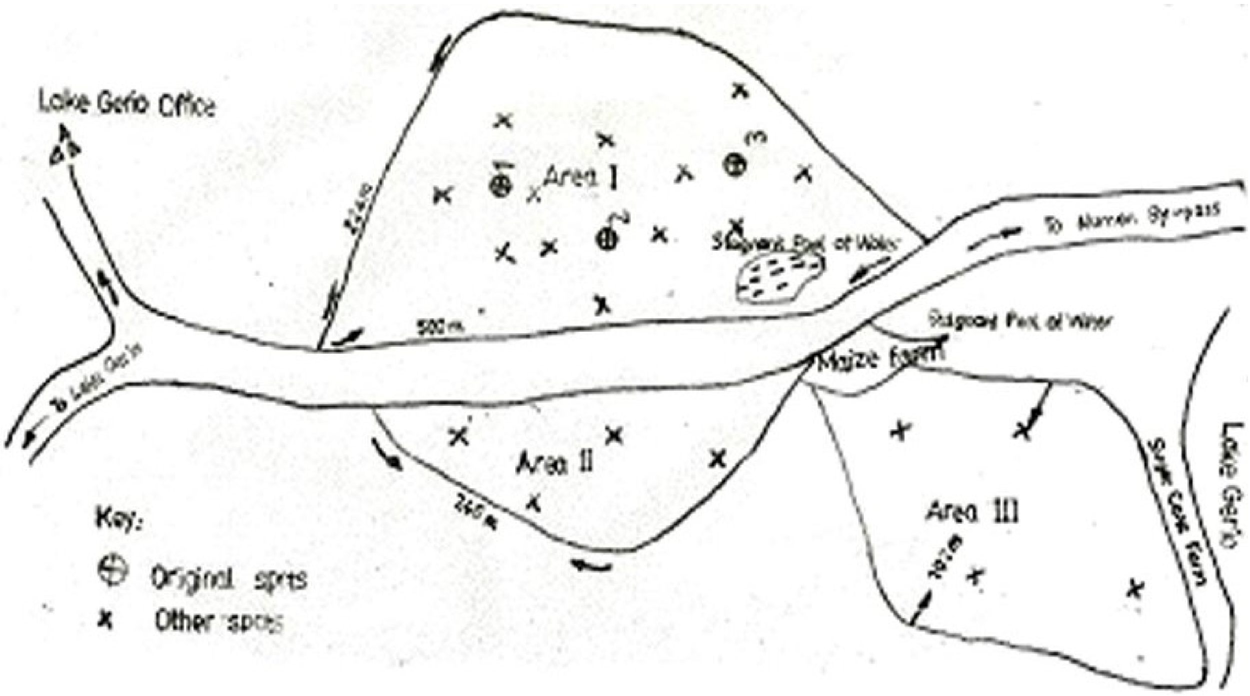
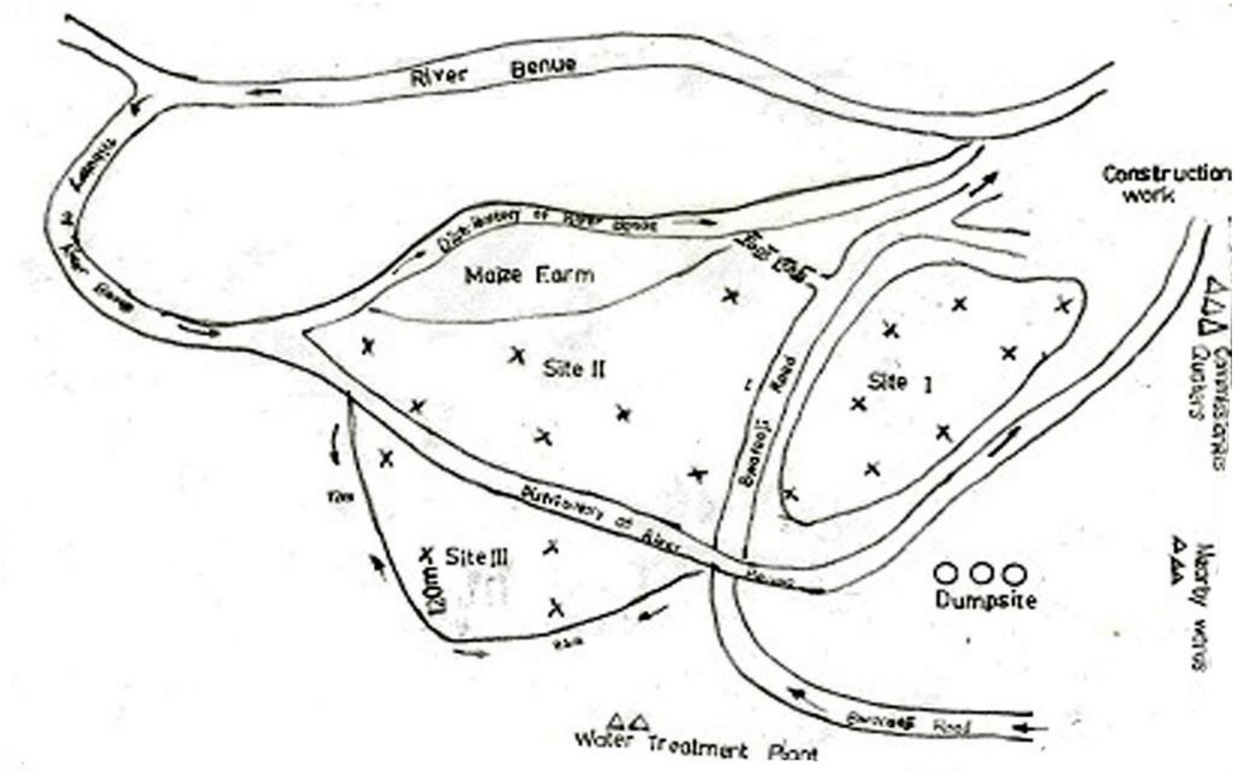


Figure.2 Rice farms in Yola metropolis, Adamawa State, Nigeria



expected rice yield would most probably be low. The low Ca/Mg values are indicative of the fact that either Ca or Mg both is deficient in the soils of the area studied.

Clay Activity

Table 6 shows the mean clay activity of the soils. The high value of 124 per cent recorded for dry-season farm "A" appeared to be suspect and was rejected based on Quest at three confidence levels of Q90, Q95 and Q99. These low values are responsible for sharp decline of soil organic matter during farming and low rice plant yield which becomes more pronounced with intensive continuous cropping (Kang, and Juo,1986).

From the results obtained in this research, and the discussion on there from, it is evident that calcium, magnesium as well as organic-carbon contents were seemingly deficient in most soils. Consequently, for better rice – crop performances in these soils of interest, some ameliorative amendments of the soils via supplementary liming in tandem with organic manure applications will be required or mandatory. Furthermore, based on the ranking of soil fertility indices (Table 8) the expected rice yield would be:

Farm "C_R" > Farm "C_D" > Farm "B_D" > Farm "B_R" > Farm "A_R" > Farm "A_D"
Where

D = dry season, and
R = rainy season

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