TECHINICAL REPORT OF THE SOIL FERTILITY SURVEY IN NIGER STATE, NIGERIA.

IFAD
INTERNATIONAL FUND FOR AGRICULTURAL DEVELPMENT

SOIL FERTILITY SURVEY FOR RICE PRODUCTION IN (KATCHA AND WUSHISHI) TWO LOCAL GOVERNMENT AREAS OF NIGER STATE.

Submitted in November, 2017

by

Dr. Obiageli Umeugochukwu

Department of Soil Science and Land Management,

Federal University of Technology, Minna. Niger State.

Table of Contents

Executive Summary

The need to increase rice yield in Niger State is high. Many studies have been conducted on the yield and production of rice in Niger State. However, very few studies have been conducted on the critical factors, fertility status of the soils, which is one of the factors determining yield. One of the few studies was at a reconnaissance level for agro ecological zones and not site specific. Recommendations on the fertilizer to apply was therefore not based on the fertility status of the soils of each farmer field. Thus, there is the need to evaluate the fertility status of the soils on each farmer field for rice production.

The lack of site specific soil fertility status of the different rice farms brought about this study. The objective of the study was to evaluate the nutrient status of the soils of the rice farms in Katcha and Wushishi Local Government Areas (LGA) of Niger State, so as to provide fertilizer recommendations for increased rice production. A field study was carried out and soil samples were collected from different groups of farmers in the LGAs. The group of farmers were selected from the clusters in the LGAs. Fifty percent of the clusters in the LGAs were selected and from each cluster, three groups were randomly selected making a total of 27 groups that were visited for soil sample collection. From each group, three farmers were selected randomly and interviewed totaling 81 respondents. Questionnaires were administered to the respondents to ascertain the farmer's management practices and the environmental factors that contributed to low yield. A group is made up of 25 farmers with each farmer having not less than a hectare under rice cultivation.

Results showed that there were nutrient differences between the properties of the soils of Katcha and Wushishi. The soils of Katcha had more sand than those of Wushishi LGA with the average sand percentage of 53 and 27 percent respectively. This means that the Katcha soils might not be retaining nutrients as much of those of Wushishi. The soil chemical properties were low and also differed. Generally, the soil pH range of the two areas were suitable for rice production as the optimum is 5.5-7.0. The organic carbon (OC) content recorded higher values in Wushishi than Katcha. The nitrogen content ranged from very low to high. The high N were suspected to be due to the recent application of N fertilizer prior to sampling. The phosphorus contents were all relatively high except at Emiworo site that recorded 0.014 % and was the lowest. The relatively high P could also be as a result of recent application of P fertilizer. The statement that the relative high values could be from recent applications was because the values were not in consonant with

the physical properties and the OC content of the area. The exchangeable bases were low and could result to low yield due to inefficient uptake of N as a result of low K, despite the high N. These bases were lower in Katcha and could be the reason it had immobilized N. The micronutrients were high but was not showing toxicity effects on the crops due the mitigating effects of OC and other nutrients. Generally, Wushishi soil inherent nutrient status were better than that of Katcha. Among the management practices, other crops rotated with rice were significant at 5 percent level and positively affected rice yield. Use of organic manure also significantly affected yield, though not in all the clusters. Flooding and erosion significantly affected yield negatively and could be due to climatic/environmental changes. The study found out that there is a particular unidentified weed that affected yield negatively in Yelwa cluster.

Standard recommendation or blanket application of same quantities of NPK by all the farmers was not advised due to the variability in soil properties. The study therefore gave site fertilizer recommendations as required in every group. It was also recommended that integrated fertility management strategies like use of organic manure, crop rotation and moderate use of inorganic fertilizer be used to achieve optimum yield. Also change in time of planting was advised to align with the metrological information to avoid flooding sweeping the fertilizers applied.

1. INTRODUCTION

1.1. Background of study

The International Fund for Agricultural Development (IFAD) seeks to ensure that poor rural farmers have access to improved natural resource management and conservation practice. In line with this mandate, soil fertility survey is necessary to enhance rice production in Niger State in this era of low yield. Soil fertility survey is targeted to provide the data to develop or fine-tune a sound fertility management plan. With a good fertility management strategy, other factors like water use efficiency, crop yields as well as lowest possible production cost could be improved. The decline in productivity in most of the soils is due to inappropriate use of fertilizer. Wrong inorganic fertilizer use could increase the acidity of the soils as well as other farmer's inappropriate use or management of the soil. For example, intensive cropping which is rarely unavoidable due to the teaming population. Knowledge of the nutrient status of the soil will be used to recommend quantity and type of fertilizer required. Notwithstanding, the other possible causes of the decline in agricultural production will be identified during a soil fertility survey. The survey will expose the other environmental and inherent causes of low production in rice fields.

Over 4,000,000 metric tons of rice is imported into the country annually to meet the demand of the populace (Nkwazema, 2016). Local production is 49 percent of the consumption rate, still very low. Niger State reported decreased yield of about 2.5 metric tons annually due to declining fertility of the soils. Suffice therefore to understand the soil nutrient conditions of the soil, to enable accurate application of the required nutrients. Adesanwo et al., (2009), stated that management of soil fertility is one major limiting problem to sustainable rice production in Nigeria.

1.2. Objective of the consultancy

Main Aim- The objective of this study is to investigate nutrient/fertility status of the soils of Katcha and Wushishi LGAs so as to provide recommendation of fertilizer and other practices for increased production of rice in these local government areas.

Specific Objectives-

1. To ascertain the effect of famers management practices on yield.
2. To understand the effect of environmental factors such as erosion and flooding on yield
3. To investigate the effect of inherent soil factors on yield.

2. OVERVIEW OF THE STUDY AREA

2.1. Target area of survey and sample collection technique

This study was conducted in Niger State, Nigeria. The State has three agricultural zones (Nmadu et al 2012) of which the LGAs of interest fall between zone I (Katcha) and zone III (Wushishi). Niger State is located in the north central region of the country. It lies between latitude 8° and 11° 20'N and longitude 4° 30' and 7° 40'E. It covers a land area of 76,363 square km and about 85 percent of the land is arable.

The State experiences two distinct seasons, the dry and wet seasons. The climate of the area as designated by Koppen Aw is sub humid. The annual rainfall varies from about 1,600 mm in the South to 1,200 mm in the North. The duration of the rainy season ranges from 150-210 days or more from the north to the south. Mean maximum temperature remains high throughout the year, hovering about 32-42 °C, particularly in March and June. However, the lowest minimum temperatures occur usually between December and January when most parts of the State come under the influence of the tropical continental air mass which blows from the north. Dry season in Niger State commences in October.

This project covered two of the five local government areas that are under FGN/IFAD assisted VCDP intervention. Agro ecologically, Wushishi belongs to the North Guinea savanna while Katcha belongs to the Southern Guinea Savanna regions of the State. These agro-ecological zones were as described by Ojanuga (2006). The two largest LGAs among IFAD/VCDP intervention LGAs (Wushishi and Katcha) were purposefully selected due to the large production of rice in the area.

From each of these LGAs, fifty percent of their total number of clusters were randomly selected. From each selected cluster, three groups were also selected randomly. A group is made up of 25 farmers with not less than a hectare of land each. From each selected group, a farm site of one hectare was mapped out for soil sample collection. A total of 27 groups were visited for soil sample collection. Table 1 has list of all the sites from where soil samples were collected and theircoordinates as well.

Questionnaire sample collection.

Structured questionnaires (Appendix 2) were administered to the same groups as selected above. In this case, three farmers were randomly selected from each of the groups selected above. A total of 81 respondents were interviewed. Questions aimed at extracting the farmers' management practices as well as the environmental factors that have affected their yield were asked. IFAD extension agents assisted in administering the questionnaire to the farmers.

2.2. Geology of the study area, geomorphology and drainage

The two areas surveyed fall under the region of Niger State that is covered with sedimentary rock. Wushishi is covered with weathered basement complex rock and Katcha is covered with Nupe sandstones. They are in the southern part that is characterized with deposits of sandstone and alluvial soil types. Niger State landscape generally consist of gently undulating terrain with occasional granite and gneiss hills and steeply rising quartzite ridges. Niger State is dominantly drained into the Niger River. All the other rivers drain into it.

2.3. Soils and Vegetation

The ferruginous tropical soils which are derived basically from the basement complex rocks and the old sedimentary rocks are the soils of the surveyed area. Such ferruginous tropical soils are ideal for the cultivation of guinea corn, maize, millet and groundnut.

The sub humid zone is dominated by weathered and deeply altered remains (Saprolites) of varied basement complex as parent materials. Then the sub humid central Niger-Benue trough (Katcha) are dominated by weathered tertiary Nupe sandstones and on nearly level gently undulating plains. Their soils are deep and Dystric Nitrosaol with sandy loam or sandy clay loam. Hydromorphic or waterlogged soils are largely found in the extensive flood plain of the Niger River. The soils are poorly drained and are generally greyish or sometimes whitish in colour due to the high content of silt. The Wushishi soils had very dark greyish colours and poorly drained.

Table 1. Details of the surveyed sites for soil sample collection in Katcha and Wushishi, their coordinates and designations

Cluster Names	Group Names	Coordinates	Sample designation
Badeggi	Aminchiegbantitwaki	9° 01' 46.542, 6 ° 07' 42.060	KDG1
	Managi Badeggi	9 ° 03' 25.842, 6 ° 08' 10.678	KDG2
	Emiworo coop	9 ° 03' 12.240, 6 ° 08' 06.795	KDG3
Kakakpagi	Kakakpagi Rice	9° 15' 41.544, 6 ° 10' 22.560	KEG1
	Sakiwa Natsu coop	9° 15' 39.162, 6 ° 10' 20.490	KEG2
	Emi-Ndamakun	9 ° 13' 40.440, 6° 13'58.506	KEG3
Katcha	Bangi	8 ° 46' 40.536, 6° 17' 45.066	KAG1
	Tsadoyag Civil Servants	8° 49' 18.988, 6° 17' 24.648	KAG2
Shabawoshi	Banana	8° 49' 21.504, 6° 15' 54.966	KCG1
	Zandodobasokoadua	8° 49' 18.804, 6° 15' 59.142	KCG2
	Yegborolo	8° 49' 33.618, 6° 15' 45.438	KCG3
Adelichi	Kashe	8° 48' 20.934, 6° 15' 19.554	KBG1
	Edotsunjinjinwugakuyema	8° 48' 11.274, 6° 17' 34.074	KBG2
	Edotsun Groundnut	8° 48'14.322, 6° 17' 32.184	KBG3
Maito cluster	Nakwarai	9° 40' 03.516, 6° 03' 36.168	WDG1
	Nargarta	9° 40' 05.094, 6° 03' 39.996	WDG2
	ImaniKutukpachi	9° 39' 11.058, 6° 03' 10.500	WDG3
Dankwagi	Dankwagi Dogara	9° 39' 52.260, 6° 05' 52.530	WCG1
	Dankwagi Youth	9° 39' 50.550, 6° 06' 00.014	WCG3
	Hakuriemiworo	9° 39' 51.606, 6° 06' 01.322	WCG2
Agwa/jada	Alheri Jayawa	9° 44' 32.100, 6° 01' 03.108	WAG3
	Anaruwa	9° 44' 56.240, 6° 01' 04.740	WAG2
	Aminikowa	9° 44' 50.385, 6° 02' 21.744	WAG1
Kanko	Yelwa karemi manoma	9° 54' 38.414, 6° 06' 43.866	WBG1
	Yelwa Angwarliman	9° 34' 46.068, 6° 06' 46.920	WBG2
	Ndabazan kodo	9° 35' 54.714, 6° 07' 07.632	WBG3

Source- Data from field survey-2017

3. METHODOLOGY AND APPROACH

3.1. Terms of Reference

The consultant was expected to carry out a survey on 27 hectares of rice farms in two Local Government Area (LGAs) of Niger State. A hectare represented one farmer and the farmer was selected from a group of 25 farmers farming in same area. The site selection has been described in section 2.1 above.

Site identification was with the aid of the area facilitators and the coordinates of the areas were collected. The survey was designed to have two main activities;

1. Soil auger sample collection to determine the soil inherent nutrient status
2. Questionnaire data collection to determine the farmer's management practices and the environmental factors that also affect yield.

The method of soil auger sample collection was designed thus;

- Reconnaissance visit to familiarize the surveyors with the site. During this visit, the coordinates of the sites were taken for the main field work.
- A composite soil sample from 20 auger points were collected from each hectare.
- Sample collection was at the depth of 0-15 cm.
- The collected samples were taken for laboratory analysis.
- Fertility evaluation of the samples was done.
- Recommendations on the fertility management were reported based on the soil analysis of the sites.

Questionnaire data collection from the farmers was done as stated below;

a. Individual questionnaire was administered before the soil sample collection.
b. Data collected was validated, cleaned and coded using Excel software.
c. Analysis of the coded data was done using Stata statistics/data analysis software.
d. The following variables; farmers practice, environment, soil nature were used to understand the causes of low yield.
e. Regression model was used to analyze the data to understand which variable was affecting the yield more.

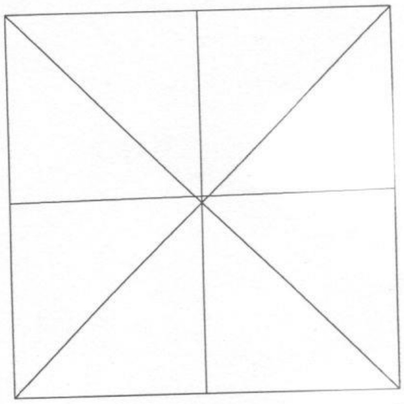

Figure 1. Diagram showing the four dimensional transect lines made in a hectare for core sample collection

3.2. Field Studies

The sampling technique employed in this study to collect soil samples was four dimensional transect sampling. Figure one shows the traverses from which 20 samples were collected. The four dimensional transect lines were made within a hectare, soil sample collection from five points on each traverse line (Fig 1), giving a total of 20 sample points. The 20 core samples were pooled and thoroughly mixed and a composite soil sample was collected from the hectare (plate 1). The composited samples were labelled and taken to the laboratory for analyses. The samples were air-dried and ground to pass through 2-mm sieve and stored for physical and chemical analyses.

The less than 2 mm fraction was stored for the under listed analysis using standard analytical procedures; Particle size, pH, EC, exchangeable bases, exchangeable acidity, organic carbon, total N, P, S, Fe, Mn, Zn, Cu.

A total of 26 groups were visited and 26 samples collected. One of the groups in katcha cluster was omitted due to the fact that it looked the same with its neighboring group. The sample collection was done with hoe. The samples were collected from top to bottom at the depth of 0-15 cm.

Plate 1. Showing the consultant and a farmer mixing the pooled core samples to collect a composite sample to represent one hectare

3.3. Method of data analysis

Data analysis was done using Stata Statistics/Data analysis 11.2 software (Stata, 2009). The analysis included description of the socio economic characteristics of the respondents using frequency and percentages descriptive statistics. The study also determined other factors that affected soil fertility such as farmer's management practices and environmental factors using regression model.

A few management practices such as the cultural practice, crop rotation, shifting cultivation fallowing, addition of ash or charcoal, slash and burn, thinning, transplanting, use of organic manure, irrigation, weeding, use of pests and diseases measures, use of inorganic fertilizers were analysed. The following environmental factors were also investigated, the effect of erosion, how long the rice is submerged in water, flooding and the planting seasons they practiced. The farmers were expected to indicate if they practice the above mentioned variables (see appendix for the questionnaire). The following independent variables as included in the data were represented thus in the model;,do you practice any of the above mentioned practices (yes 1, No 0). A few basic soil properties were also investigated using regression model (pH and the carbon content) to see how they affected yield. The coefficients of variations was investigated to understand the variations of the determined variables among the clusters.

4. RESULTS AND DISCUSSION

4.1. Assessment of the present soil fertility status of the studied area

Assessment of the fertility status of the studied area was based on the results of the physical and chemical analyses of the soils as well as the information generated from the interview using questionnaires. The interpretation of results and recommendations were based on established critical levels of the soil parameters determined (Table 3). The results of the laboratory analysis of the physical and chemical properties of the soils from 0 – 15 cm depth are shown in Tables 2. The distribution of the determined parameters were presented for the different groups sampled with respect to the relevant nutrient status required for increased rice yield.

4.2. Soil physical properties

The texture of the soils surveyed ranged from sandy loam to clay loam. The soils recorded more silt over sand and clay probably due to the influence of river deposition. The clay content ranged from 6-37 % while silt and sand ranged from 32-59 % and 29-54 % respectively. Majority of the soils were clay loam especially the soils in Wushishi. The soils in Wushishi are derived from weathering of basement complex rocks, while that of Katcha are derived from Nupe sandstones, hence the variation in their clay and sand content. The weathering of basement complex rocks provides soils with clayey texture, while that of sandstones produces soils with sandy texture. According to Tabi et al. (2012), soils with high clay and silt content are recommended for lowland rice cultivation as a result of their being able to retain water for long period and ensure ponding which is required for lowland rice production. However, soils from the following groups were sandy loam, Banji and Tsadoyag groups in Katcha, Edotsunjinjiwuga in Adelichi, Zandobasokoadua in Shabawoshi and Aminchiegbanglitwak and Emiworo in Badeggi, Katcha LGA. These soils would need organic amendment to improve its nutrient content and retention for rice production.

Table 2. Physical and chemical properties of the soils

SAMPLE NAME	SAND	SILT	CLAY	TEX. CLASS (USDA)	PH Ratio 1:2.0 H2O	pH 0.01M $CaCl_2$	OC g/kg	Total N (%)	Available P (%)	Exch. Bases (Cmol/kg) Ca	Mg	K	Na	Micro Nutrients (mg/kg) Fe2	Mn	Cu	Zn	SO4
	---(%)----																	
KAG1	53	35	12	SANDY LOAM	5.39	4.31	4.5	0.143	0.303	0.337	0.146	0.07	0.06	106.29	13.00	0.16	3.42	6.271
KAG2	53	32	15	SANDY LOAM	5.20	3.99	6.7	0.190	2.627	0.631	0.289	0.08	0.10	240.49	50.98	1.16	5.31	7.027
KBG1	42	59	9	LOAM	5.48	3.75	6.4	0.190	1.560	0.916	0.239	0.16	0.21	267.74	65.48	1.94	3.92	6.870
KBG2	54	39	7	SANDY LOAM	5.53	3.00	7.0	0.022	0.275	0.640	0.201	0.16	0.12	269.77	50.29	1.27	8.75	9.073
KBG3	43	49	8	LOAM	5.40	3.67	15.0	0.097	3.396	0.864	0.205	0.23	0.21	297.01	51.26	3.05	13.73	8.391
KCG1	40	49	11	LOAM	5.50	3.70	8.8	0.381	4.864	1.079	0.240	0.08	0.13	231.22	75.70	1.38	6.46	8.240
KCG2	54	39	7	SANDY LOAM	5.68	3.19	5.1	0.337	0.044	0.532	0.188	0.14	0.10	191.80	35.51	0.60	3.92	12.702
KCG3	37	49	14	LOAM	5.34	3.87	8.8	0.570	0.032	1.079	0.230	0.15	0.18	212.09	65.07	1.16	14.93	8.391
KDG1	45	49	6	SANDY LOAM	5.35	3.98	10.4	0.285	2.203	0.959	0.238	0.33	0.21	233.25	86.34	1.27	5.96	7.785
KDG2	25	47	28	CLAY LOAM	5.10	3.76	19.0	0.238	8.372	2.067	0.327	0.40	0.41	304.84	139.93	7.74	12.49	6.573
KDG3	54	40	6	SANDY LOAM	5.24	3.77	2.7	0.285	0.014	0.384	0.150	0.10	0.16	164.84	18.80	0.82	2.97	10.058
KEG1	22	46	32	CLAY LOAM	5.45	3.70	11.0	0.428	4.589	2.102	0.321	0.35	0.35	259.33	98.36	4.62	5.41	12.307
KEG2	21	48	31	CLAY LOAM	4.85	3.50	14.7	0.041	6.333	1.926	0.322	0.41	0.44	289.48	105.12	6.40	5.11	11.601
KEG3	23	48	29	CLAY LOAM	5.55	3.50	6.4	0.096	7.628	1.378	0.289	0.18	0.35	199.04	93.11	2.61	2.42	10.582
WAG1	27	47	26	LOAM	5.80	3.73	7.5	0.571	0.048	1.027	0.235	0.09	0.15	219.33	64.93	2.16	6.01	12.375

WAG2	21	40	39	CLAY LOAM	5.54	3.88	13.4	0.604	3.212	1.807	0.297	0.12	0.18	138.17	48.77	3.72	3.02	11.094
WAG3	23	49	28	CLAY LOAM	5.45	3.91	15.2	0.618	7.723	1.805	0.304	0.25	0.23	152.96	46.42	4.95	3.67	10.586
WBG1	23	49	28	CLAY LOAM	5.40	3.88	12.6	0.333	1.931	1.411	0.273	0.20	0.23	254.99	125.70	2.83	4.91	11.095
WBG2	24	47	29	CLAY LOAM	4.46	3.88	18.2	0.651	7.566	1.599	0.282	0.25	0.48	255.28	143.80	3.50	3.72	10.584
WBG3	21	51	28	CLAY LOAM	5.12	4.03	11.2	0.661	0.087	1.964	0.291	0.15	0.17	214.70	101.67	2.05	3.62	10.588
WCG1	22	45	33	CLAY LOAM	5.64	4.37	19.0	0.476	3.672	2.380	0.352	0.18	0.61	300.78	158.44	7.18	7.11	9.756
WCG2	22	44	34	CLAY LOAM	5.60	4.00	18.4	0.095	2.503	2.537	0.344	0.27	0.37	257.01	135.23	4.17	6.16	8.161
WCG3	21	43	36	CLAY LOAM	5.45	3.86	17.4	0.285	4.430	2.225	0.344	0.30	0.33	296.43	161.06	6.18	7.11	9.306
WDG1	21	44	35	CLAY LOAM	4.20	3.38	19.2	0.143	3.247	2.52	0.340	0.77	0.55	251.80	89.04	6.51	5.61	9.530
WDG2	20	44	36	CLAY LOAM	4.88	3.66	18.4	0.096	3.029	2.667	0.331	0.45	0.38	305.42	127.09	8.74	6.26	10.207
WDG3	21	42	37	CLAY LOAM	4.88	3.37	12.4	0.038	5.423	1.986	0.327	0.18	0.23	294.70	136.34	7.85	6.56	8.840

4.3. Soil reaction

The pH of the sampled fields ranged from 4.20 (strongly acidic) in Nakworei (WDG1) to 5.8 (slightly acidic) in Agwaiamini (WAG1) (Table 2). Majority of the soils had favorable pH for rice production. The favorable pH range of soil test for rice farming is 5.5-7.0. However, Maito cluster and Sakiwa Natsu cooperative group in Kakakpagi cluster recorded slightly lower pH of 4.2 – 4.8 which might still be suitable for rice production if the iron content is not high. Notwithstanding, their pH were not alarming as the corresponding exchangeable bases were low and hence the area does not need liming. Rice can be grown on soils with pH as low as 4.2 (Tabi *et al.*, 2012). The low soil pH in Kakakpagi (KEG3) was evident by the soil having rusty color (plate 2). The acidic condition resulted in more soluble ferrous iron in soils with high iron content.

Plate 2. Soil of Sakiwa in Kakakpagi with rusty colors as evidence of high ferrous iron on the soil surface.

Table 3. Soil fertility interpretation for the surface soils.

Critical levels	N %	P Mg/Kg	K cmol/kg	C g/kg	Ca	Mg	Na	Fe 2 mg/kg	Zn mg/kg	SO_4 mg/kg	Mn mg/kg	Cu mg/kg
					-----cmol/kg--------							
V. low	0.03 - 0.05	< 3	0.12–0.2	< 4.0	<2	<0.5	<0.1		< 1.0	0-7.5	0-1.0	0-0.2
Low	0.06 – 0.1	3 - 7	0.21-0.3	4.0 - 10	2-5	0.5-1.5	0.1-0.3	<10				
M. low	0.1 – 0.15	7 - 20	0.31-0.6	10 - 14								
Medium	0.16 – 0.2				5-10	1.5-3	0.3-0.6		1.0 - 5.0			
High	0.21 – 0.24	>20	0.61-0.73	14 - 20	10-20	3-8	0.6-1.2	50	> 5.0	>7.5	>1.0	>0.2
V. High	>0.30			> 20	>20	>8	>1.2	>75				

Source-(Fertilizer Use & Management Practices for Crops In Nigeria, 2012.) and (Tabi *et al.*, 2012).

4.4. Soil Organic Carbon and Nitrogen

Soil Organic carbon (SOC) ranged from very low, (2.7g/kg) to high, (19.2 g/kg). Wushishi soils had higher OC compared to Katcha soils. These results could be related to their soil texture as most of the Wushishi soils were majorly clay loam soils. The SOC is closely associated with clay particles. The groundnut group in Adelichi (KBG3) recorded high SOC while the lowest in Katcha was at Emiworo group in Badeggi. The Emiworo site is situated on high land and does not flood easily, hence the soil does not pond for the plant to have sufficient water. Moreover the soil type was sandy loam and needs to be amended with organic manure to enhance its water and nutrients content retention. The quality of the organic matter in the surveyed areas are good as reflected in their C/N ratios except for a few sites with high C/N ratios. Their organic matters are mineralizable.

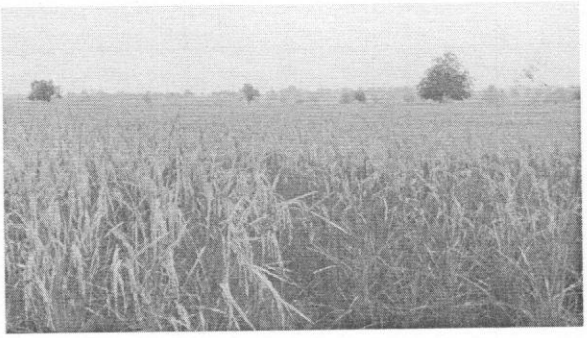

Plate 3. Yellowing rice showing evidence of low nutrient status at Emiworo group soil in Badeggi cluster.

Nitrogen status of the surveyed soils ranged from very low 0.022 % and high 0.651 %. The highest value was recorded in Yelwa Agwa Leman WBG2 in Kanko cluster in Wushishi while the lowest was recorded in Edotsujiu group in Adelichi cluster in Katcha. The Agwa/Jada and the Kanko clusters had higher N than the rest of the sampled soils. Although there were other clusters that had more N than required for example the Shabawoshi cluster [Table 2]. The three sites (Edotsujiu group, Imalikutakwach and Sakiwanatsu) with very low N content had high C/N ratios and thus, there will be N immobilization. Cereal crops, rice inclusive have high affinity for N. The low values obtained were in consonant with most soils all over the world. The plant available N in form of nitrate is easily leached from the soils. The soils with relatively high N could be due to recent application of N just prior to the sampling. The Emiworo site had yellow rice as observed in the field (Plate 3) indicating lack of enough N nutrients.

4.5. Soil phosphorus

The phosphorus ranged from 14 -154.23 mg/kg with the highest value in Iminikutukpachi in Maito cluster. All the sampled soils had relatively high phosphorus content except the Emiworo group in Badeggi with 14 mg/kg which was moderately low. The relatively high content could be due to the same reason as suggested for N that is the application of P fertilizer. This high rate could also be due to the favorable pH of the soils and low calcium content of these soils. For the places that had relatively high P levels, there might be no need to apply P fertilizer.

4.6. Soil Exchangeable bases

Calcium and Magnesium contents were very low to low. Calcium value of 0.33 cmol/kg was recorded in Bangi in Katcha and the highest 2.66 cmol/kg was in Nargrata in Maito (Table 2). Magnesium had the lowest in KAG1 with value of 0.143 cmol/kg and the highest in WCG1 with value of 0.352 cmol/kg. These results could be as a result of their leaching from the soil leading to acidic nature of the soils. Potassium ranged from very low to high. Some of the soils had medium K like the Aminchiegbaniglitwaki and Managi in Badegi, Katapanta and Sakiwa in Kakakpagi, the Dankwagi youths group in Dankwagi, and Nagrata in Maito. Nakwarai in Maito had relativley high values of K 0.77 cmol/kg. Potassium is very important in N transport in plants. It could lead to low yield when it is low, even when the N is high because the N will not be transported to the required regions of the plant. The low content of the exchangeable bases reflected in the pH values and could be due to its inherent values in the soil. However, the bases were higher in Wushishi than in Katcha.

4.7. Soil Micronutrient

Iron levels ranges from 106.29 ppm in KAG1 to 305.42 ppm in WDG2. The critical level [Table 3] of iron in the soils to become toxic to rice varies. Some researchers (Mitra *et al.*, 2009, Ajayi *et al* 2015) reported the critical levels to be 10 ppm, while some reported 50 ppm. All these are dependent on the soil texture, crop type and the pH of the soil. For soils with pH of 5 like the studied soils, 75 ppm, iron is considered relatively high and may be toxic to rice variety not tolerant to iron toxicity. High iron level decreases uptake of N, P K and Zn. It can be said that all the soils in this study recorded relatively high iron content [Table 2]. The reason the toxicity sign were not visible on the rice plants could be due to the mitigation effects of P and OC.

In the presence of ferric ion, there will be no iron toxicity between the pH of 4 and 6 provided the Mn level is low. But in the case of high Mn level, the growth will be retarded slightly at PH of 6. When the Mn level is high, iron uptake is reduced. This could be another reason the high iron content is not affecting the plants. The pH is between 4 and 5 and the Mn level is high and this is reducing iron uptake. Soils with SO_4 greater than 7.5 ppm are not likely to respond to fertilizer sulfur application. The Cu and Zn levels were adequate and does not need to be added to the soils.

4.8. Effect of other soil fertility factors on yield performance

Since the soil nutrient contents were not very low as in Wushishi and yet the yields were poor, there was need to look at the management practices. The description of the cultural practices, farming system and the age of the farmers are presented in Table 4. The results showed that all the farmers interviewed were male and their ages ranged from 20-51 years. Forty three percent of them fall between the age brackets of 31-40. This age bracket is very important as they are at the active age for optimum production. They have the potentials to provide the needed labor in rice production.

Some of the respondents employed good management practices to rotate the crops after harvesting rice. Twenty five percent of them rotated rice with maize while 20 rotated with cowpea and 10 with cassava and 19 with sorghum (Table 4). Grain yield of rice was significantly ($p<0.05$) affected by the crop it was rotated with. Rice yield are expected to be higher when it is rotated with legumes, as legumes help in improving the nitrogen of the soil. Most farmers rotated with cowpea (result not shown) and that have affected their yields positively. It is interesting to also note that the farmers also practiced shifting cultivation, irrigation farming, slash and burn method of clearing, fallowing, and some even added ash or charcoal to their soil (Table 4). The addition of charcoal and slash and burn increased the soil organic matter content of the soil and is therefore encouraged. All the farmers interviewed carried out thinning, transplanting, weeding and used pest and disease control measures and 70 percent of them practiced stumping. They all applied inorganic fertilizer, though the number of times they applied it differed (Table 5). The application was mainly by broadcast or ring method. About 50 percent of the farmers added organic manure to their plots, mostly compost and poultry manure. This practice had a positive effect on yield, though not in all the clusters. The clusters that did not apply organic manure had lower yield. The use of organic manure significantly positively affected yield ($p<0.05$) while erosion and use of local variety had a significant negative effect on the yield (Table 8). However, use of organic manure was not significant in Badeggi cluster. Erosion gave a significant negative effect in Badeggi cluster and pH also negatively affected the yield in Kakakpagi cluster. Meanwhile, 85 percent of these farmers never tested their soil to ascertain the soil nutrient content before applying fertilizer. The farmer whose photograph is shown below reported that the last soil test on their farm was done 30 years ago by white men. They took the samples to Lagos and never gave them a feedback (plate 4). Beside his picture is the picture of his farm that has not been fertilized due to lack of fertilizer and was abandoned to weeds. This confirmed that management practices and fertilizer application is effective to increasing yield.

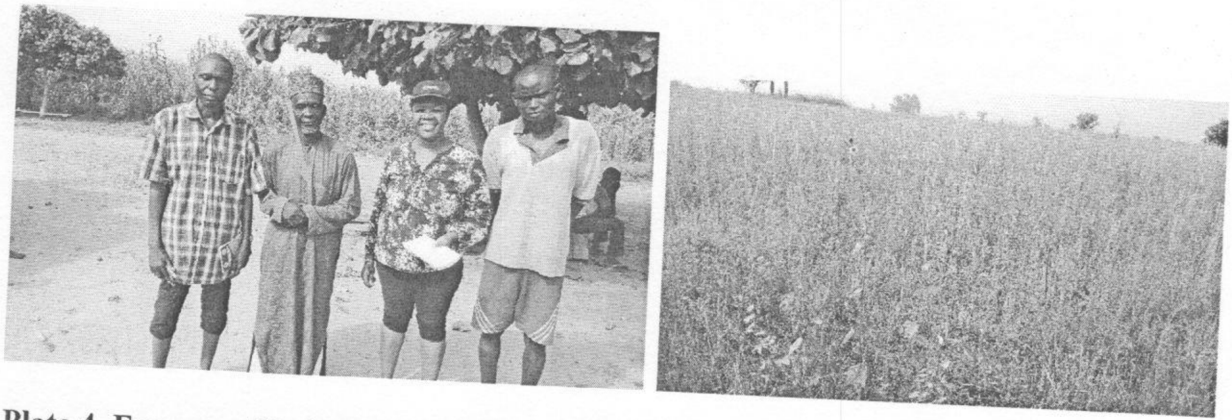

Plate 4. Farmer at Emindamaku in Kakakpagi and their farm that lacked management

Table 4. Descriptive statistics of the age, farming system and cultural practices of the farmers

Farming system	Frequency	Percentage (%)	Cultural Practices	Frequency	Percentage (%)	Age	Frequency	Percentage (%)
Crop rotation	32	40	Slash and burn	62	78	20-30	25	31
shifting cultivation	10	13	Fallowing	5	6	31 -40	34	43
irrigation farming	38	47	Adding ash or charcoal	9	11	41 -50	17	21
Total	80	100	Grazing	4	5	51 and above	4	5
						Total	80	100

Table 5. Showing number of times the fertilizers are applied by the farmers in their plot.

Number of times fertilizer is applied	Frequency	Percentage (%)	Use of organic fertilizer	Frequency	Percentage (%)	Erosion on site	Frequency	Percentage (%)
once	3	4	No	50	63	no	59	73.8
twice	63	79	Yes	30	38	yes	21	26.3
three times	2	3	Total	80	100	Total	80	100
four times	12	15						
Total	80	100						

4.9. Other causes of low yields as observed

The other identified causes of low yield were weed infestation, the Yelwa farmers complained of unidentified weed (Plate 5) that is seriously reducing the yield of their rice. In the other groups like the Bangi in Katcha cluster, Angwa anaruwa and Kakapkegi, flooding was another cause of low yield (Plate 6). The floods sweeps the nutrients applied. The farmers had no knowledge of the metrological information and were using their original planting dates in this changed climate season.

Plate 5. Showing the unidentified weed in Yelwa

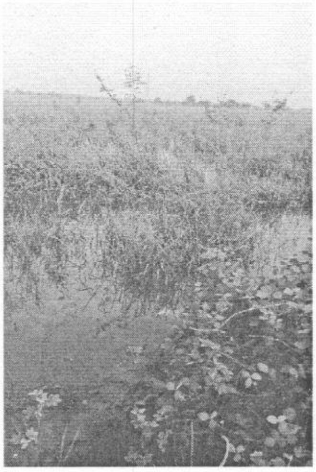

Plate 6. Showing flooding in the farm

5. Conclusion

In conclusion, the inherent properties of the soil were suitable for rice cultivation but will need amendments for optimum production. There is serious need for intensive management practices or integrated management technologies to improve yield and as well combat the encroaching effect of climate change that was noticed in the area. Flooding and erosion were reported to have given a negative impart to yield. Among the management practices, other crops grown and use of organic manure should be encouraged. Weeds were found to negatively affect yield and should be considered as the next area of interest.

6. Recommendations

Low cost fertility management technologies like use of organic manure, charcoal and rotating with legumes are recommended together with moderate amount of inorganic fertilizer for optimum and sustainable productivity of rice.

The use of charcoal and organic manure is to be encouraged in Katcha areas where their soils were mostly sandy loam while only organic manure could be applied to Wushishi. This will enhance the nutrient retention of the soils and improve the soil physical and chemical properties. The low exchangeable base content of the soils will be improved as well as the soils nutrient release. This will be very beneficial to farmers who are practicing three season planting. Increase in yield has been recorded in places where these charcoals were applied to rice farms. In line with the use of charcoal, it will also be recommended to the farmers to be applying organic manure.

The fertilizer recommendation for K and N using the data obtained from the field. The following surveyed groups do not need K fertilizer KDG1, KDG2, KEG1, KEG2, WDG1, WDG2 but they need N fertilizers, while WCG2 and WCG3 would need from 60 kg of K fertilizer to give optimum yield for rice.

The nitrogen need of the surveyed sites have also been categorized into three groups (Table 6). Group 1 do not need N fertilizer application and group 2 will need low dose of N while group 3 will need a high dose of N as stated in Table 7. The N application should be in split dose.

It will be advisable to have a demonstration plot to find out the optimum quantities/rates of biochar/charcoal plus organic manure that will increase yield up to 5 tons/ha in moderate addition of inorganic fertilizer. This is because of the variations in the soil properties of the area. This organic demonstration plot will be compared with the inorganic demonstration plot. The inorganic demonstration plot will be made with the new recommendations of the inorganic fertilizer. There will be need to have an economic analysis to see the profit of practicing either of the two systems.

Furthermore, the crop rotation or rather the effect of other crops rotated with rice resulted in a positive effect and should be encouraged. But it will be better to rotate with legumes especially in between the planting seasons especially for the low N areas.

A change in time of planting will be advised especially as flooding erodes the nutrients applied. The Niger State metrological station [Nimet] data could be used to determine the appropriate time of planting to avoid the flooding menace. If biochar is used, it could protect the nutrient from being eroded during flooding or being leached quickly from the soil.

Places like Angwa Jada could have irrigation farming introduced to optimize the yield in that area. It is only rain fed that is practiced there and they have no control over flooding.

It would be recommended to involve the weed scientists to manage the weed infestation that contributed to low yield in Yelwa. Alternatively, the use of change in planting dates could also be helpful in weed control. This will have allowed the rice to mature before the weed infestation.

Table 6. Different N requirements levels of the sampled sites.

Group 1 0 Kg/ha N	Group 2 low dose Kg/ha N up	Group 3 High Kg/ha N
KCG1	KAG1	KBG2
KCG2	KAG2	KBG3
KCG3	KBG1	KEG2
KEG1	KDG1	KEG3
WAG1	KDG2	WCG2
WAG2	KDG3	WDG2
WAG3	WDG1	WDG3
WBG1	WCG3	
WBG2		
WBG3		
WCG1		

Table 7.Recomendation for Nitrogen and Potassium Fertilizers for the Surveyed Sites.

Soil K levels	Kg/ha K	Recommendation	
		Kg/ha of K	Kg/ha of N
Very low	60	60	80 - 100
Low	61-90	50	60 - 80
Medium	91-130	30	60
High	131-175	0	40

Project team

Prof A. O Osunde	Project coordinator
Dr. Obiageli Umeugochukwu	Team leader
Dr. Abubarkar Lawal	Pedologist
Mr. Paschal Umeugokwe	GIS expert.

References

Adesanwo, O.O., Adetunji, M.T., Adesanwo, J.K., Osiname, O.A., Torimiro, D.O., 2009. Evaluation of Traditional Soil Fertility Management Practices for Rice Cultivation in Southwestern Nigeria. Am. J. Agron. 2, 45–49.

FERTILIZER USE & MANAGEMENT PRACTICES FOR CROPS IN NIGERIA (1), n.d.

Mitra, G.N., Sahu, S.K., Nayak, R.K., 2009. AMELIORATING EFFECTS OF POTASSIUM ON IRON TOXICITY IN SOILS OF ORISSA Iron toxic soils • Iron toxicity is a problem associated primarily Predisposing factors for iron toxicity • Low lands adjacent to uplands . There is Land situations for manifestation of 5–7.

Nkwazema, S., 2016. The Rice Debate_ Why Nigeria Can't Meet Local Rice Production Demand. THISDAYLIVE 17.

Ojanuga. A.G, 2006. Agroecological Zones of Nigeria Manual, Ist ED. ed. Food and Agricultural Organisation of the United Nations (FAO) and Federal Ministry of Agriculture and Rural Development (FMARD), University of Agriculture Abeokuta, Nigeria.

Tabi, F.., Omoko, M., Boukong, A., Ad, M.Z., Bitondo, D., C, F.C., 2012. Evaluation of lowland rice (Oryza sativa) production system and management recommendations for Logone and Chari flood plain – Republic of Cameroon. Agric. Sci. Res. Journals 2, 261–273.

Table 8. Regression showing the effect of the independent variables to yield

dr oby Monday November 13 05:44:12 2017 Page 2

```
4 . reg yield agerange cropsgrown culturalpractises useoforganicfertilizer effectoferosion noof
> thoftimericesubmerged inorganicfertilzer
```

Source	SS	df	MS
Model	17.3250378	9	1.92500421
Residual	12.4704611	70	.178149445
Total	29.795499	79	.377158215

Number of obs =	80
F(9, 70) =	10.81
Prob > F =	0.0000
R-squared =	0.5815
Adj R-squared =	0.5277
Root MSE =	.42208

yield	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
agerange	.1111906	.0622885	1.79	0.079	-.01304	.2354211
cropsgrown	.1790619	.119999	1.49	0.140	-.0602685	.4183923
culturalpr~s	.2135306	.1327524	1.61	0.112	-.0512357	.4782969
useoforgan~r	1.303077	.3224672	4.04	0.000	.6599362	1.946217
effectofer~n	-1.041981	.2195252	-4.75	0.000	-1.47981	-.604152
nooffertil~n	-.0160238	.0903663	-0.18	0.860	-.1962537	.1642061
localvariety	-.0469249	.0134217	-3.50	0.001	-.0736937	-.0201562
lengthofti~d	.4617681	.2819495	1.64	0.106	-.1005624	1.024099
inorganicf~r	-.2751373	.2178969	-1.26	0.211	-.709719	.1594443
_cons	3.317925	.3045276	10.90	0.000	2.710564	3.925287

5 .

1

Appendix 1

IFAD
INTERNATIONAL FUND FOR AGRICULTURAL DEVELPMENT

QUESTIONNAIRE FOR THE SOIL FERTILITY SURVEY FOR RICE PRODUCTION IN TWO LOCAL AREAS OF NIGER STATE

KEY INFORMANT INTERVIEW SCHEDULE

SECTION A: IDENTIFICATION DETAILS:

1. Farmer's Name: ____________________ 2. Phone no: ______________________

3. Extension Agent's Name: ______________________4 Age of the farmer: ___

5. L.G.A.:_______________6.Community/Cluster: ______________________________

7. Name of Group: ___________________________

8. Population of Group: ________ 9. Sex of the farmer: __________________________

SECTION B: FARMERS MANAGEMENT STRATEGIES

10. Do you grow rice in this cluster/site? (i) Yes (ii) No

11. If Q10 is yes; what other crops do you grow in rotation with rice?

(i)________________ (ii) ________________ (iii) ________________

12. Provide percentage of crop area: Rice: _____%; Crop 2 ( ) ________%; Crop 3 ( )______%; Crop 4 ( ):_____%.

13. What farming system do you practice? (a) Crop rotation (b) shifting cultivation (c) irrigation farming

14. Please indicate the cultural practices that you practice

(i) Slash and burn (ii) fallowing (iii) Adding ash or charcoal (iv) grazing.

15. Which land preparation operations do you practice

i. Do you do stumping? (i) Yes (ii) No
ii. Do you practice nursery and transplanting? (i) Yes (ii) No
iii. Do you do thinning? (i) Yes (ii) No

iv. Do you weed? (i) Yes (ii) No

v. Do you apply pest and disease control measures? (i) Yes (ii) No

16. Do you use fertilizer? (i) Yes (ii) No

17. If Q16 is yes; what type of fertilizer do you use?
Specify the type, NPK, Urea, etc. ____

i. How many times do you apply the fertilizer in a season? ------------------

ii. What method of application do you use? (a) Broadcasting (b) Ring method (c) Hydroponics- through irrigation (d) others---------------------------------

iii. Where do you get your fertilizer from? Government; Agricultural Development; open market, IFAD; Input Dealer

iv. What quantity do you apply? -----------------------

v. How do you get your fertilizer recommendations? ------------------------------

18. Do you use organic fertilizer? (i) Yes (ii) No

i. What type do you use? (a) Compost (b) poultry manure (c) others ---------

ii. What quantity do you apply? ---------------------------------

iii. How many times do you apply in a planting season? ------------------

19. What is the rainfall pattern in this site?

iv. How long is your planted rice submerged in water?

v. Is there water deposition in the lower parts of the paddy in this site? (i) Yes (ii) No

vi. Do you have erosion on this site? (i) Yes (ii) No

20. Choose all the management strategies you use in this site

i. What variety do you use?

ii. Which planting season do you practice? (i) dry season (ii) raining season

iii. Do you construct bunds? (i) Yes (ii) No

iv. Have you conducted soil test on this site. (i) Yes (ii) No

21. Please state your yield rate -----------------------------