TECHNICAL REPORT ON

SOIL FERTILITY SURVEY OF SELECTED RICE AND SORGHUM FARMS IN SIX LOCAL GOVERNMENT AREAS IN NIGER STATE.

BY

DR. OBIAGELI UMEUGOCHUKWU

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

SUBMITTED TO

NIGER STATE FADAMA III ADDITIONAL FINANCING, FARM CENTRE, TUNGA MINNA.

Contents

Project team

Prof V.O Chude	Project coordinator
Dr. Obiageli Umeugochukwu	Team leader
Adewale Nafiu	Pedologist
Mr. Usman Yahaya	GIS expert.

CHAPTER ONE

1.0. Introduction

One of the challenges of increasing rice and sorghum production in Niger State is declining fertility. This is very challenging as fertility management in a sustainable way to increase production cannot be achieved unprofessionally. Adesanwo et al., (2009), stated that management of soil fertility is one major limiting problem to sustainable rice production in Nigeria. The nutrient depleted soils deserve attention to ensure sustainable production of crops. Despite the increased production due to increased land area of farming, Niger State Fadama III + AF, still reported decreased yield of about 2.5 metric tons annually and poor quality of rice produced due to declining fertility of the soils. It is therefore very important, to understand the soil nutrient conditions of the area, to enable accurate application of the required nutrients.

The situation of Nigeria today is such that increased production per unit area is paramount. The paradigm shift from oil country to agricultural country necessitates the strengthening of fertility management. Despite the fact that, rice and sorghum are among the five high ranked cereals mostly consumed in the country. 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.

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 fertilizer use could increase the acidity of the soils as well as other farmer's inappropriate use of the soil. 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 in the farm. The survey will expose the other environmental and inherent causes of low production in the farm.

It is therefore our aim to conduct a fertility survey so as to provide scientific baseline information for crop nutrient application and other management practices to ensure increased production.

This study will objectively establish nutrient status of the soils under survey and provide fertilizer recommendation for the production of rice and sorghum in Niger State.

CHAPTER TWO

2.0. Location and Extent of the Project Area

Niger State is centrally located in Nigeria with the largest land mass of 76,363 km². The State is comprised of 25 LGAs, zoned agro ecologically into northern and southern guinea savanna basically. For the purpose of this work, two local governments were each chosen from the three different agro-ecological zonation by the Niger State Agricultural and Mechanization and Development Authority (NAMDA. A total of six local governments were selected. Lavun and Katcha from the Southern Guinea Savanna, Munya and Bosso from Northern Guinea Savanna and Kontagora and Wushishi from derived Savanna. These agro-ecological zones were as described by Ojanuga. 2006. A total of six LGAs were selected. From each LGA chosen, one clusters was selected and from each clusters, ten farmers were chosen. Listed below are the LGAs used for the project and labeled as follows see Fig 1.

1. Munya M1-10
2. Bosso B1-10
3. Wushishi W1-10
4. Kontgora KO1-10
5. Lavun L1-10
6. Katcha K1-10

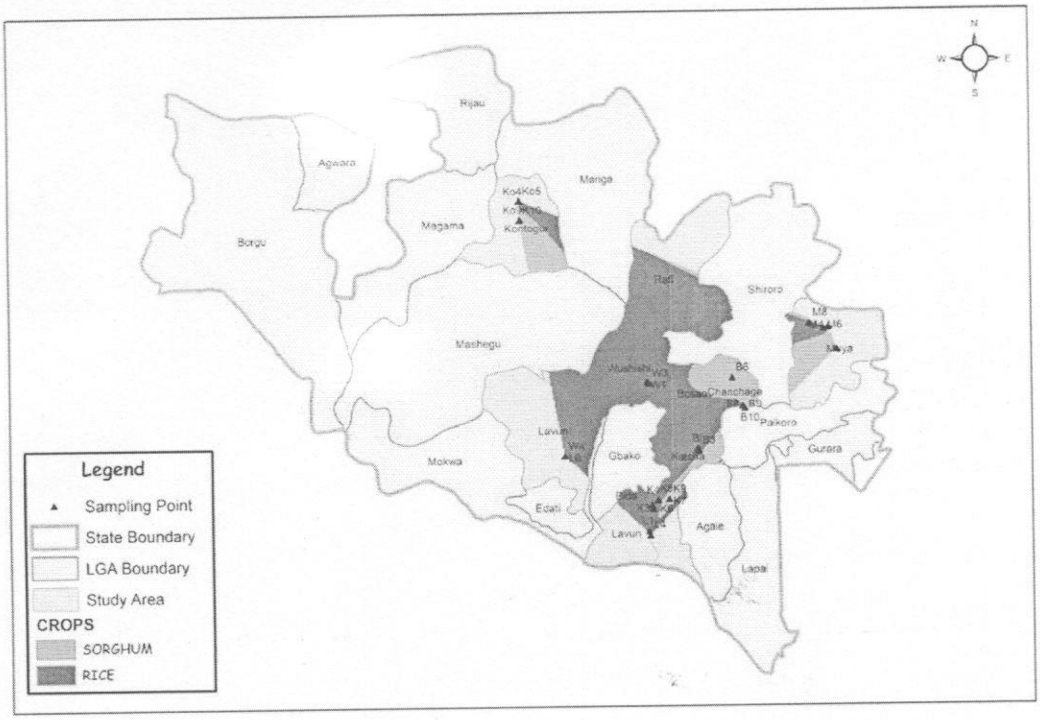


Figure 1. Map showing the surveyed sites for rice and sorghum

2.1. Geology of the area, geomorphology and drainage

The entire State of Niger is covered by two major rock formations; the sedimentary and basement complex rocks. The sedimentary rocks to the south are characterized of sandstones and alluvial deposits, particularly along the Niger valley and in most parts of Bida, Lavun, and Wushishi LGAs. To the north is the basement complex, characterized by granitic outcrops or inselbergs, which can be found in the vast topography of rolling landscape. Such inselbergs dominate the landscape in Shiroro, Chanchaga, and Gurara. The basement rocks extends to the Zungeru and Kotongora area and consist of gneisses, schists, migmatites and intercalations of amphibolites and quartzites (Agbor 2014). The State is endowed with many flood plain soils which probably are the reason the area is used for a lot of rice production.

Morphological study of the area revealed that Emegi sites in Bosso had strong and plastic soils with presence of mottles. While the rest of the Bosso sites surveyed for rice were friable, non-sticky and had presence of mottles, with no gravel. Bosso sites surveyed for sorghum were more of less marginal lands with earthworm casts, anthills and gravels staggered. There were presence of Calcrete stones as well at the sites surveyed. Munya sites had fairly strong, friable soils, no mottles with few spots of gravels present. The Katcha sites had black colored soils unlike the other soils. There were presence of mottles and gravels also. Presence of anthills, and mottles were observed also in Lavun with soil color being more of white soil. Majority of the surveyed sites had presence of mottles, gravel and anthill.

Generally, the landscape of Niger consists of gently undulating terrain with occasional granite and gneiss hills and steeply rising quartzite ridges. The drainage system of the Niger State is dominated by the River Niger as all the rivers on the State drains into the Niger River.

2.2. Agroclimate

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 1,600mm 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. The sub mid Minna zones records distinct dry season of about 5 months. The other zones have similar agro climate except that it is more humid in the central zone.

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.

2.3. Soils and Vegetation:

Three major soils types can be found in the State. These include the ferruginous tropical soils, hydromorphic soils and Ferrasols. The most predominant soil type is the ferruginous tropical soils which are basically derived from the Basement Complex rocks, as well as from old sedimentary rocks. Such ferruginous tropical soils are ideal for the cultivation of guinea corn, maize, millet and groundnut. (Okunlola et al. 2014) reported that the field mapping done along river Bosso in Minna showed granite, granite-gneiss and schist of basement complex suite underlie the area and granite is more prominent than granite-gneiss and schist. The sub humid minna zone is dominated by weathered and deeply altered remains [Saprolites] of varied basement complex as parent materials. The zone and Kontagora is covered with soils on gently undulating plains with broad convex uplands and narrow valley and scattered vegetated inselbergs and low outcrops. Then the sub humid central Niger-Benue trough [Lavun and 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 Emagi site in Bosso LGA and the Wushishi site had very dark greyish colours and poorly drained. Ferasols which developed on sandstone formations can be found within the Niger trough.

Their characteristic red colour enriched with a clay sub soil is noticeable in the landscape. Termite hills are found on the landscape, particularly between Bosso, Mokwa and Kontagora

These can be seen along the major highways in the state. Most of the surveyed sites are farmlands except the Shaitti cluster site in Bosso LGA. This site has been fallowed for about five years. There were a lot of termite hills on that site and the terrain was very undulating. The Southern Guinea Savannah vegetation covers the surveyed landscape except for Kontagora.

2.4. Ecological Problems:

The major ecological problem in the state is flooding, particularly in Kuchi sites near the Shiroro dam that was surveyed. During such incidents, as happened recently (1999), several villages were nearly submerged, thousands of people displaced and property worth millions of naira destroyed. Uncontrolled bush burning is another ecological problem in the State but was not experienced at the sites surveyed.

3.3. Field studies

On arrival at the field, the decision to collect the samples among group of clustered farmers from which we selected five hectares was taken. According to Asadu and Nweke [1999], sampling plans are among others called, judgment sampling and simple random sampling. Judgment sampling is done from specified points in the field because of noticeable soil or crop differences in order to evaluate the cause of such differences. Simple random sampling is used where the differences in soil properties and crop properties are not apparent. It is used to eliminate bias.

It was observed that the soils were varied in a hectare of land. Considering those variations in one hectare, simple random sampling as well as judgment sampling was employed and the subsets of the strata samples were pooled to form a random sample or a composite sample. Twenty auger samples were composited to represent a hectare. This simple sampling technique is a traditional approach that works for uniform fields with little variation. The composited samples were labelled thus; for example, W1-W10 for Wushishi, W1-W5 was collected from the rice farm and W6-W10 from a sorghum farm. The mean values of the composited samples collected were presented in Table 12.

A total of 60 composited samples were collected and analyzed, ten from each LGA. At each sampling auger point, sampling was done to the depth of 30 cm considering the rooting depth of the crops of interest. The GPS coordinates of each sampling point as well as that of the composite samples were taken.

3.4. Soil Preparation and laboratory analysis

The collected samples were packaged into polyethylene bags for transportation to the laboratory. The composite soil samples collected 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 following analysis using standard analytical procedures.

- Particle size distribution was by the Bouycous hydrometer method (Gee and Bauder, 1986).
- Electrical conductivity (EC) was determined in a soil/water ratio of 1:1 using EC meter.
- The pH was determined in distilled water and calcium chloride solution (1:2 soil: water ratio) using a glass electrode pH meter (Mclean, 1982).

• Exchangeable cations (Calcium, Magnesium, Potassium and Sodium) were extracted with neutral normal ammonium acetate (NH4OAc at pH 7.0).

• Calcium and magnesium in the ammonium acetate extract were determined by atomic absorption spectrophotometry, while potassium and sodium were determined by flame photometry (Thomas, 1982).

• Cation exchange capacity (CEC) was determined in Ammonium Acetate (Rhoades, 1982)

• Organic carbon was determined by the wet oxidation method of Walkley-Black (Nelson and Sommers, 1982).

• Total nitrogen was by the modified micro-Kjeldhal method (Bremmer and Mulvaney, 1982).

• Available phosphorus was by the Bray No1 method (Bray and Kurtz, 1945).

Micro nutrients were extracted using 0.1MHCl and were determined by atomic absorption spectrometer.

Base saturation was calculated by summing the bases divided by the CEC and multiplied by 100.

CHAPTER FOUR

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 samples collected. The interpretation of results and recommendations were based on established critical levels, obtained from laboratory. The results of the laboratory analysis of the physical and chemical properties of the soils from 0 – 30 cm depth are shown in Tables [1-8] below. It is only the Lavun site that has depths deeper than 30 cm. This was done due to the famers request to investigate the cause of very poor performance in that area despite fertilizer application The rest of the analysis were based on the 30 cm depth.

The results will be presented for each required nutrient. Rice farms will be presented first followed by the sorghum farm.

Particle size distribution

All the soils studied had very similar textures. The dominant size fraction was sand which ranged in value from 43-81 percent in most of the soils. The silt content had values of between 6 and 44 percent. Clay fraction was the least in value and ranged from 5-25 percent. The dominant texture was sandy loam but loam textures were also recorded in the Kontagora and the Lavun soils [Table 1] with increased depths. The texture of the soils indicated that of a good soil for upland rice. It has moderately good water holding capacity for rice farming. However, the soils were generally moderately suitable for the cultivation of most grain and fruit crops.

Table 1. Textural classes of the studied sites

Site	Sample Name	Clay	Silt	Sand	Tex. Class (USDA)
Munya	M1	17	10	73	Sandy Loam
	M2	15	20	65	Sandy Loam
	M3	17	6	77	Sandy Loam
	M4	9	10	81	Loamy Sand
	M5	7	12	81	Loamy Sand
Bosso	B1	11	8	81	Sandy Loam
	B2	15	10	75	Sandy Loam
	B3	15	2	83	Sandy Loam
	B4	12	19	69	Sandy Loam
	B5	11	30	59	Sandy Loam
Wushishi	W1	17	20	63	Sandy Loam
	W2	17	30	53	Sandy Loam
	W3	11	16	73	Sandy Loam
	W4	7	16	77	Sandy Loam
	W5	5	14	81	Loamy Sand
Kontagora	KO1	19	36	45	Loam
	KO2	11	30	59	Sandy Loam
	KO3	8	25	67	Sandy Loam
	KO4	13	32	55	Sandy Loam
	KO5	13	44	43	Loam

Lavun	L1	7	26	67	Sandy Loam
	L2	13	30	57	Sandy Loam
	L3	7	30	63	Sandy Loam
	L4	7	30	63	Sandy Loam
	L5	7	28	65	Sandy Loam
20-40 cm	L5B1	19	38	43	Loam
40-60 cm	L5B4	25	32	43	Loam
60-80 cm	L5B5	23	44	33	Loam
katcha	K1	11	22	67	Sandy Loam
	K2	13	42	45	Loam
	K3	13	18	69	Sandy Loam
	K4	11	18	71	Sandy Loam
	K5	13	16	71	Sandy Loam

Soil reaction (pH) and soil micro nutrients

The most important indicator to observe in a soil test is the pH. It gives the information of the various nutrient status in the soil. The favorable pH range of soil test for rice farming is 5.5-7.0. The Emagi cluster in Bosso LGAs had favorable soil pH for rice cultivation ranged between 5.40-5.92. [Table 2]. The Emagi site II in Bosso, labelled B5 falls below the favorable range for rice farming. It has a pH of 5.40 and its exchangeable acidity was low and does not require liming. The other LGAs studied were; Munya, Kontagora, Lavun and Wushishi also had suitable pH range for rice farming. These ranges are the values where the nutrient especially P is made available to plants. However, katcha LGA recorded pH [4.78-5.12] below the required level but also did not record high exchangeable acidity level. This means that the liming is not needed. The low base content resulted in the resisted pH changes and hence low exchangeable acidity with the pH content of the soil.

However, the low pH level did not affect the ferrous iron [Iron II] content of the area. Munye had more ferrous iron and low Mn level at pH [5.91-6.22] which is very suitable except for M1 and M2. Wushishi, kontagora and Lavun showed low ferrous iron content at pH level of 5 [Table 2]. Lavun site at the depths below 30 cm had high Mn level and hence stabilizing the ferrous iron to ferric ion and making the later immobile hence Mn toxicity. In the presence of ferric iron, the plants will grow well between the pH of 4 and 6 provided the Mn level is low. But in the case of high Mn level, as it is the case in Lavun, the growth will be retarded slightly at PH of 6. When the Mn level is high, iron uptake is reduced. This phenomenon defines the reason Katcha did relatively better than Lavun, because the pH of Katcha is lower. This high Mn level in the area has to be reduced with the application of Zinc Sulphate fertilizer as stated in the recommendation section.

None of the sampled sites recorded low iron II content. The iron content ranged from medium to very high. The zinc levels in Badeggi cluster in Katch LGA ranged from medium 2.0 to high 7.32 mg/kg [Table 2]. The Lavun sites ranged from medium to high. This is the same with all the sites sampled for rice. The addition of $ZnSO_4$ fertilizer will be appropriate to increase the uptake of all the other nutrients.

Table 2. Soil reaction and micro nutrient levels of the rice studied sites

Site	SAMPLE NAME	pH H_2O	pH $CaCl_2$	$Fe^{2=}$ (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Munya	M1	6.22	4.41	23.61	52.45	1.77
	M2	6.13	3.31	90.73	73.24	6.99
	M3	6.08	4.13	224.85	19.00	2.77
	M4	5.67	3.95	433.64	28.31	0.00
	M5	5.81	4.06	144.65	22.01	2.23
Bosso	B1	5.92	4.62	131.31	39.22	6.82
	B2	5.48	4.59	99.53	21.01	8.00
	B3	5.55	4.89	231.58	52.67	8.87
	B4	5.81	4.17	143.29	29.39	2.79
	B5	5.40	3.84	222.34	78.94	4.61
Wushishi	W1	6.34	4.37	41.31	25.40	9.62
	W2	5.56	3.85	26.34	39.47	2.75
	W3	5.52	3.94	56.24	32.71	4.17
	W4	5.59	3.87	36.94	19.60	1.59
	W5	5.30	4.00	16.10	12.42	2.27
Kontagora	KO1	5.43	3.98	29.78	17.69	3.11
	KO2	5.42	3.94	66.09	22.42	5.82
	KO3	5.49	4.07	44.84	25.48	3.40
	KO4	5.64	4.21	21.64	28.82	5.49
	KO5	6.75	4.70	21.51	19.23	13.34
Lavun	L1	7.32	4.97	2.57	15.05	6.38
	L2	6.85	4.45	100.33	34.74	5.15
	L3	7.13	4.41	33.60	22.95	2.90
	L4	6.88	4.51	36.94	13.72	5.01
	L5	6.81	4.38	221.97	84.52	2.56
20-40 cm	L5B1	6.85	4.85	24.39	14.30	5.13
40-60 cm	L5B4	6.42	4.28	8.41	1.94	5.63

60-80 cm	L5B5	6.34	4.32	8.38	3.55	4.41
Katcha	K1	5.12	3.96	27.34	44.75	6.63
	K2	4.93	3.90	31.15	43.65	4.93
	K3	4.78	4.11	226.25	25.20	7.32
	K4	5.57	4.09	305.59	36.22	5.83
	K5	4.81	4.21	100.37	8.05	2.00

Soil

Nitrogen

This is one of the most important nutrient for rice growth. In Bosso LGA, N levels ranged from moderately high to very high in all the composite sampled soils. Wushishi also had moderately to high N levels except for W4 which is moderately low. Munya also recorded varied results, M1, M2 had very low N, M3 and M4, these sites were at the Shiroro dam and they had high N While M10 was moderately low in N, though also close to the dam [Table 3]. Lioji site in Kontagora recorded very high to medium N for rice cultivation. The Badegi sites K1 and K2 in Katcha LGA recorded moderately high N level while the Badeggi site K3 had medium N level. It was only Lavun site L2 that recorded high N, the rest of the sites sampled in Lavun were all very low. The Lavun samples at the depths below 30 cm, labeled L5B1-5 recorded high N. The top soil of the Lavun lacked N and hence needed to be supplied adequately. With the high N values in some studied sites, addition of N should follow the recommendations as stated below. Some of the organic N will be released from the organic amendments. There is need to study the reason for high N. It is likely the N supplied does not mineralize.

Carbon

The studied sites had similar organic carbon content which ranged from very low 1.5 g/kg to low 8.9 g/kg. Besides, Chibani site M6 cluster and the Kuchi cluster M7 near the dam in Munye LGA had medium level of organic carbon ranging from 10.80 – 11.30 g/kg [Table 3]. The soils of the northern Nigeria generally records low carbon content. It is important to add organic fertilizer to all the sampled sites appropriately. This is to enable sufficient amendment to other nutrients and as well enhance organic carbon.

Table 3. Organic carbon and the total nitrogen and the critical values of the rice studied sites

Site	SAMPLE NAME	OC (g/kg)	Critical level	Total N (g/kg) Wrong Supposed to bein percent	Critical level
Munye	M1	1.30	Medium	0.00	V. Low
	M2	1.40	Medium	0.05	V. Low
	M3	4.80	Low	0.34	High
	M4	1.80	Medium	0.34	High
	M15	7.70	Low	0.14	Medium
Bosso	B1	0.80	V. low	0.62	V. high
	B2	7.50	Low	1.24	V. high
	B3	5.70	Low	1.00	V. high
	B4	2.80	Low	0.24	Medium
	B5	4.90	Low	0.38	High
Wushishi	W1	6.70	Low	0.29	High
	W2	6.10	Low	0.24	Medium
	W3	8.20	Low	0.29	High
	W4	3.60	V. Low	0.11	Low
	W5	1.60	Medium	0.58	High
Kotongora	KO1	8.70	Low	0.58	V. high
	KO2	7.90	Low	0.43	V. high
	KO3	4.40	Low	0.62	V. high
	KO4	7.90	Low	0.72	V. high
	KO5	7.10	Low	0.19	Medium
Lavun	L1	2.50	V. low	0.10	Low
	L2	7.40	Low	0.62	High
	L3	0.00	V. low	0.00	V. low

	L4	2.50	V. low	0.05	V. low
	L5	5.20	V. low	0.05	V. low
20-40 cm	L5B1	1.30	Low	0.00	V. low
40-60 cm	L5B4	4.40	V. low	0.38	High
60-80 cm	L5B5	3.60	Low	0.72	High
	K1	8.90	Low	0.29	High
Katcha	K2	1.50	V. low	0.48	High
	K3	2.10	V. low	0.58	High
	K4	7.10	Low	0.19	Mod high
	K5	0.00	V. low	0.19	Mod. high

Phosphorus

The P levels in the studied sites were varied. Munya [49.90] and Bosso [184.10] recorded high P as well as Lavun [130.84] LGAs. However, Katcha, and kontagora recorded low to medium levels of P especially where there seems to be problem of fixation due to pH. While, Wushishi ranged from low to medium levels of P [Table 4]. For the places that recorded high P levels, low P fertilizer should be applied. The rice will first take the soil P before absorbing the applied P. This means that the P should be applied as required to suit the need. The application of lower P in areas that recorded high P is to avoid much of the unused P. The little problem with P in the studied sites could easily be corrected with both organic amendment and the basic nutrient application eg. ZnSO4

Potassium

In Munya LGA, we samples two sites, the Kuchi site 1 and the Kuchi site II near the dam. The Kuchi site 1 had medium 0.52 and low 0.29 K level where the Kuchi site II ranged from medium 0.52 to very high 1.89 K levels. All the Bosso sites recorded low K levels. Wushishi site W1 had a medium value of 0.42 while the rest of the sampled sites were very low except for W5 which had high level of K [Table 4]. High K level reduces yield. The Lioji site in kontagora ranged from very low 0.13 to high 0.72. The Badeggi sites recorded medium levels of K while site K2 was low and the site three K3 was medium 0.42 and high 0.98 in Katcha LGA. It is interesting to note that Lavun site L2 that recorded high N had low K. The rest of the sampled sites were medium to high. The L5 site samples beyond 30 cm recorded low K down the depth up to 60 cm depth.

Table 4. Potassium and Phosphorus values and rates of the rice studies sites

Site	SAMPLE NAME	Available P mg/kg	Critical level	K cmol/kg	Critical level
Munya	M1	25.80	High	0.29	Low
	M2	36.30	High	0.52	Medium
	M3	17.20	Medium	1.89	High
	M4	49.90	High	0.55	Medium
	M5	33.50	High	0.72	High
Bosso	B1	1.40	V. low	0.23	Low
	B2	38.70	High	0.23	Low
	B3	184.10	High	0.23	Low
	B4	15.80	Medium	0.23	Low
	B5	34.60	High	0.29	Low
Wushishi	W1	54.30	High	0.42	Medium
	W2	13.90	Medium	0.13	V. low
	W3	4.40	Low	0.10	V. low
	W4	4.20	Low	0.24	Low
	W5	13.70	Medium	0.94	High
Kontagora	KO1	63.90	High	0.20	Low
	KO2	4.40	Low	0.13	V. low
	KO3	24.70	High	0.16	V. low
	KO4	4.60	Low	0.20	Low

	KO5	4.80	Low	0.72	High
Lavun	L1	14.80	Medium	0.75	High
	L2	109.40	High	0.23	Low
	L3	130.80	High	0.33	Medium
	L4	43.60	High	0.81	High
	L5	13.10	Medium	0.23	Medium
20-40 cm	L5B1	65.40	High	0.13	V. low
40-60 cm	L5B4	88.60	High	0.42	V. low
60-80 cm	L5B5	99.40	High	0.49	Low
Katcha	K1	3.90	Low	0.49	Medium
	K2	3.50	Low	0.49	Medium
	K3	3.90	Low	0.29	Low
	K4	17.40	Medium	0.98	High
	K5	8.60	Medium	0.42	Medium

Recommendation

1. Time and quantity of application of N is very important. Since most of the sites had high N values, application time will be very necessary. Application at the middle of the season before or after the panicle initiation should be used. We recommend the N use efficiency of the area to be studied since with the high N content, the yields were still low. The recommended rate of application for the high N values is 40 kg N. The N application rate more than 90kg/ha may not be needed as it will reduce yield. N fertilizer should be applied at different time as well as considering the N requirement of the species of rice and crop of interest. The recommended N rates based on the results are listed in Table 5 below.

2. From the result of Carbon obtained, the integrated application of about 2 tons of organic manure to supply micro nutrients S as well as enrich the soils OC is highly recommended.
3. This study also recommends the application of Zn as zinc sulphate to reduce the manganese toxicity in rice farms. Manganese toxicity starts to show as low as 10 mg/kg level under low zinc level as we have in the sites tested. The better growth performance and higher yield will be expected at Mn 0.1 ppm and Zn 10 ppm. The major identified problem of the studied site is Mn toxicity and low Zn levels. Most of the major nutrients, except K were in their required amounts but the micro nutrients tested were found low.
4. The K and organic carbon were low and possibly lead to low yield and the adequate addition of K fertilizer will be needed.
5. There is need to conduct a validation exercise to make sure that the projected recommendations are effective before the rest of the farmers are allowed to implement the recommended rates. This study is very necessary as it is cheaper and more effective in solving the yield problem of the area. This will be used to single out the very micro nutrient that is mostly required in the area and the exact quantity needed.
6. There is need for exact water level determination so as to inform the irrigation requirement in the areas surveyed. This will definitely increase yield due to the soil texture of the area studied.

It will be advisable to use this fertilizer application system for effective production and the fertilizer requirement as also presented in Table 5:

(i) For lowland rice (shallow swamp, irrigated, hydromophic and inland valley swamp) apply half the recommended N and all P and K at planting/transplanting and the remainder broadcast at 6 - 7 weeks after planting/transplanting or at panicle initiation stage.

(ii) For lowland rice (deep water and floating and mangroove ecologies), apply all N, P and K at planting.

(iii) For upland rice in Sahel, Sudan and Northern Guinea, apply half N and all P and K at 1 - 2 weeks after planting, broadcast the remainder of N at 6 weeks after planting (Chude et al., 2011)

Table 5. Fertilizer recommendations for upland and lowland rice

Nutrient	Fertility Class	Upland Rice	Lowland Rice
N	Low	80kg N	100kg N
	Medium	60kg N	80kg N
	High	40kg N	40kg N
P	Low	30 - 40kg $P_2 0_5$	40 - 50kg $P_2 0_5$ "b"
	Medium	30kg $P_2 0_5$	40kg $P_2 0_5$
	High	NIL	NIL
K	Low	30 - 40kg $K_2 0$	30 - 40kg $K_2 0$
	Medium	30kg $K_2 0$	30kg $K_2 0$
	High	NIL	NIL

SORGHUM

The textural classes of the sorghum soil studied were not discussed due to the similarity of the textures with the sites for rice. To avoid repetition, see Table 12.

Soil reaction [pH] and micro nutrients

Soil pH measurements indicated that all the soils are strongly acid to slightly alkaline ranging from 4.81-7.56 [Table 6]. Judging from the soil reaction, none of the soils will require lime treatment. Sorghum is a cereal crop that can grow in a wide variety of soils ranging from heavy clay in the Southern Guinea savanna to sandy loam in the Sudan/Sahel savanna ecologies. It does best in soils with high moisture retention capacity, well drained and fertile clay loam in nature. It is fairly tolerant to alkalinity and salinity. It can tolerate some drought situations that is why it is described as a hardy crop.

The best pH range for sorghum farming is 4.5-7.5. The Emagi clusters in Bosso LGAs had favorable soil pH ranging from 5.63-5.81. The other LGAs studied were; Munya, Kontagora, and Wushishi also had good pH range for sorghum farming ranging from slightly acid to neutral, it is only in Lavun, that the pH ranged from strong acid to slightly alkaline.

Across all the LGAs, the low pH level did not affect the Fe, Mn, and Zinc contents of the area. The study revealed that all the sites where sorghum were cultivated in all the LGAs had high content of Fe, Mn, Zinc levels, however, this will not have negative impact on the growth and yield of the crop. The only site that needs Zn fertilizer is the Munya site M9 [Table 6]. The rest of the sites have above 1 mg/kg which is very high level for sorghum and requires no additional zinc.

Table 6. Soil reaction for Sorghum sitess

Site	Sample Name	pH H_2O	pH $CaCl_2$	Fe^{2+} (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Munya	M6	6.22	4.41	23.61	52.45	1.77
	M7	6.13	3.31	90.73	73.24	6.99
	M8	6.08	4.13	224.85	19.00	2.77
	M9	5.67	3.95	433.64	28.31	0.00
	M10	5.81	4.06	144.65	22.01	2.23
Bosso	B6	5.81	4.82	46.87	51.14	2.12
	B7	5.83	4.01	96.83	46.61	1.44
	B8	5.76	3.71	23.78	22.59	1.33
	B9	5.65	3.82	7.70	13.11	2.74
	B10	5.63	4.12	25.16	25.52	2.86
Wushishi	W6	5.32	3.71	14.24	16.70	1.83
	W7	5.24	3.79	5.73	18.47	3.65
	W8	5.21	3.99	5.89	36.29	3.22
	W9	5.16	4.06	10.18	65.89	4.42
	W10	5.20	3.95	4.87	38.82	4.71
Kontagora	KO6	6.50	4.55	5.07	36.99	1.44
	KO7	5.89	4.67	4.11	29.60	4.13
	KO8	5.80	4.54	5.40	24.66	3.71
	KO9	5.25	4.39	4.37	25.06	2.71
	KO10	5.40	4.37	25.31	26.65	5.20
Lavun	L6	5.40	4.54	2.26	35.73	2.61
	L7	5.51	4.53	2.09	29.96	3.80
	L8	5.49	4.51	2.83	38.54	3.16
	L9	5.65	4.58	2.92	33.99	4.63
	L10	7.55	4.69	3.89	48.69	1.28
Katcha	K6	4.81	4.32	23.46	34.47	1.67
	K7	5.78	4.50	3.07	22.26	5.14

Katcha	K8	5.63	4.47	3.19	22.24	5.13
Katcha	K9	5.57	4.53	3.70	22.23	5.12
	K10	5.33	4.63	3.26	32.28	5.11

Soil Nitrogen

This is one of the three (3) most important nutrients for sorghum and other cereal's growth. In the studied areas; Bosso LGA, N level ranged from very low to medium in all the sampled composites. Wushishi also had moderately to high N levels while, Munya recorded from very low to low which poorest soil nitrogen available across the areas where sorghum is planted in the State. Lioji site in Kontagora recorded low to medium N for sorghum. The Badeggi sites in Katcha LGA also recorded low to medium N level [Table 6], while the Lavun site for sorghum recorded very low to high N level. Additional application of N should be used and applied at intervals. One at the beginning and the next after the plant has got 3-5 leafs. The N requirement of sorghum is high and the utilization is rapid after the five leaf stage.

Organic Carbon

The studied sites had almost similar organic carbon content which ranged from very low 0.00 g/kg to medium 10.7 g/kg. The sorghum cluster in Munya LGA had low to medium level of organic carbon ranging from 1.0- 10.80g/kg [Table 6]. The other sites for Sorghum in Lavun, Kontagora, Wushishi, Katcha and Bosso recorded very low organic carbon contents. The recommendation for rice is also applicable here.

Table 7.Total N and Organic Carbon contents of samples sites for sorghum in all the LGAs covered

Site	Sample Name	OC (g/Kg)	Critical Level	Total N (g/kg)	Critical Level
Munya	M6	10.5	Medium	0.8	V. Low
	M7	10.7	Medium	0.04	V. Low

	M8	1.0	V. Low	0.00	V. Low
	M9	2.0	V. Low	1.03	Low
	M10	1.1	V. Low	1.43	Low
Bosso	B6	0.8	V. Low	3.84	Medium
	B7	7.4	V. Low	0.03	V. low
	B8	4.4	V. Low	0.04	V. low
	B9	5.7	V. Low	1.44	Low
	B10	3.3	V. Low	1.44	Low
Wushishi	W6	7.5	V. Low	7.21	High
	W7	6.7	V. Low	5.76	Medium
	W8	8.0	V. Low	5.76	Medium
	W9	8.4	V. Low	7.21	High
	W10	5.6	V. Low	6.75	High
Kontagora	KO6	3.6	V. Low	1.44	Low
	KO7	3.1	V. Low	1.92	Low
	KO8	1.5	V. Low	1.44	Low
	KO9	0.8	V. Low	3.84	Medium
	KO10	4.1	V. Low	2.40	Medium
Lavun	L6	3.9	V. Low	4.81	Medium
	L7	3.6	V. Low	4.33	Medium
	L8	5.6	V. Low	4.81	Medium
	L9	1.8	V. Low	8.65	High
	L10	4.4	V. Low	0.96	V. low
	K6	0.00	V. Low	2.40	Low
Katcha	K7	2.3	V. Low	1.92	Low
	K8	0.5	V. Low	3.36	medium
	K9	0.5	V. Low	3.36	medium
	K10	0.00	V. Low	5.28	medium

Phosphorus

All the sites in Munya LGA recorded high P levels, while Bosso, Kontagora and Katcha LGAs recorded low P contents in all the sites where Sorghum was cultivated, and this calls for attention. However, it is only in Lavun (4.8- 34) and Wushishi (1.8-66) that low to high P contents were recorded. In Lavun [Table 7], L8 and L 10 had high P, L6 & L7 recorded low P and only L9 was medium. While in Wushishi, W6 and W7 recorded medium P, W8 and W9 had high P, and W10 recorded low P. The sites with low to very low P levels would need additional P but should not be made to be high but at medium for better sorghum performance. The amendments with fertilizers that would increase the pH and organic carbon content is preferred.

Potassium

In Munya LGA, the sites had medium 0.42 to high 1.16 K level while the Bosso site ranged from medium 0.41 to very high 1.89 K levels [Table 7]. Wushishi site had low to medium level, while the all sampled sites in Kontagora were medium. The sites in Katcha LGA and Lavun also recorded low to medium level of K. The addition of K will not be necessary in this places

Table 8. Potassium and Phosphorus contents in the sampled sites for sorghum in all the LGAs covered

Site	Sample Name	P mg/kg	Critical levels	K mg/kg	Critical levels
Munya	M6	42	High	1.16	High
	M7	120	High	0.90	Medium
	M8	20	Medium	0.55	Medium
	M9	130	High	0.52	Medium
	M10	84	High	0.42	Medium
Bosso	B6	1.8	Very low	0.23	Low
	B7	1.6	Very low	0.26	Low
	B8	1.5	Very low	2.33	High

	B9	1.2	Very low	0.26	Low
	B10	1.2	Very low	0.23	Low
Wushishi	W6	8.3	Medium	0.33	low
	W7	8.7	Medium	0.46	Medium
	W8	34	High	0.46	medium
	W9	66	High	0.52	medium
	W10	1.8	Very low	0.46	medium
Kontagora	KO6	3.2	Low	0.68	high
	KO7	2.8	Very low	0.68	medium
	KO8	2.6	Very low	0.81	high
	KO9	4.8	Low	0.81	high
	KO10	4.9	Low	0.49	medium
Lavun	L6	4.8	Low	0.39	low
	L7	5.9	Low	0.29	Low
	L8	34	High	0.42	Medium
	L9	13	Medium	026	low
	L10	27	High	0.23	low
Katcha	K6	1.2	Very low	0.33	low
	K7	1.8	Very low	0.46	Medium
	K8	1.0	Very low	0.46	Medium
	K9	1.2	Very low	0.52	Medium
	K10	1.1	Very low	0.46	Medium

Recommendation for Sorghum

Time and Method of fertilizer application. The existing recommended practice is to apply P fertilizer in furrow bottoms before splitting the old ridges; N fertilizer is applied in two splits half at 2 - 3 weeks after planting and the other half at 6 - 8 weeks after planting. It is suggested that applying P and K fertilizers in old furrows before re-ridging and planting and the placement of all the N in grooves 8 cm from the row of plants at 3 - 4 weeks after planting would result in improved yields and a reduction in application costs.

Compound fertilizers can be used to supply half of N and all the P & K at planting or at 2 - 3 weeks after planting [WAP]. The remaining N can be given as urea or CAN at 6 - 8 WAP.

Table 9. Fertilizer recommendations for sorghum production (based on soil test)

NUTRIENT	FERTILITY CLASS	NUTRIENT RATES HA^{-1}	FERTILIZER RATE AND SOURCE HA^{-1}
Nitrogen	Low	64kg N	Urea (142kg or 3 bags) or CAN (246kg or 5 bags) or 20-10-10 (320kg or 6¼ bags)
	Medium	32kg N	Urea (71kg or 1½ bags) or CAN (123kg or 2½ bags) or 20-10-10 or (160kg or 3¼ bags)
	High	16kg N	Urea (35kg or ¾ bag) or CAN (61kg or 1¼ bags) or 20-10-(10 180kg or 1¾ bags)
Phosphorus	Low	32kg P_20_5	SSP (178kg or 4 bags) or (71kg or 1½ bags
	Medium	16kg P_20_5	SSP (89kg or 2 bags) (36kg or 1 bag)
	High	NIL	NIL
Potassium	Low	30kg K_20	MOP (50kg or 1 bag)
	Medium	15kg K_20	MOP (25kg or ½ bag)
	High	NIL	NIL

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.

Agbor A.T. 2014. Geology and Geochemistry of Zungeru Amphibolites , North Central Nigeria. Univers J Geosci [Internet]. 2:116–122. Available from: http://www.hrpub.org

Fertilizer Use & Management Practices For Crops in Nigeria (1).

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. Editors. Berding E, Chude V.O . Publ. Food and Agricultural Organisation of the United Nations [FAO] and Federal Ministry of Agriculture and Rural Development [FMARD]. pp 32-48.

Okunlola I.A, Abdulfatai I A, Kolawole L.L, Amadi A.N. 2014. Geological and Geotechnical Investigation of Gully Erosion along River Bosso , Minna , North Central Nigeria. J Geosci Geomatics. 2:50–56.

Appendix 1;

Table 10. Details of the study sites with coordinates and brief history.

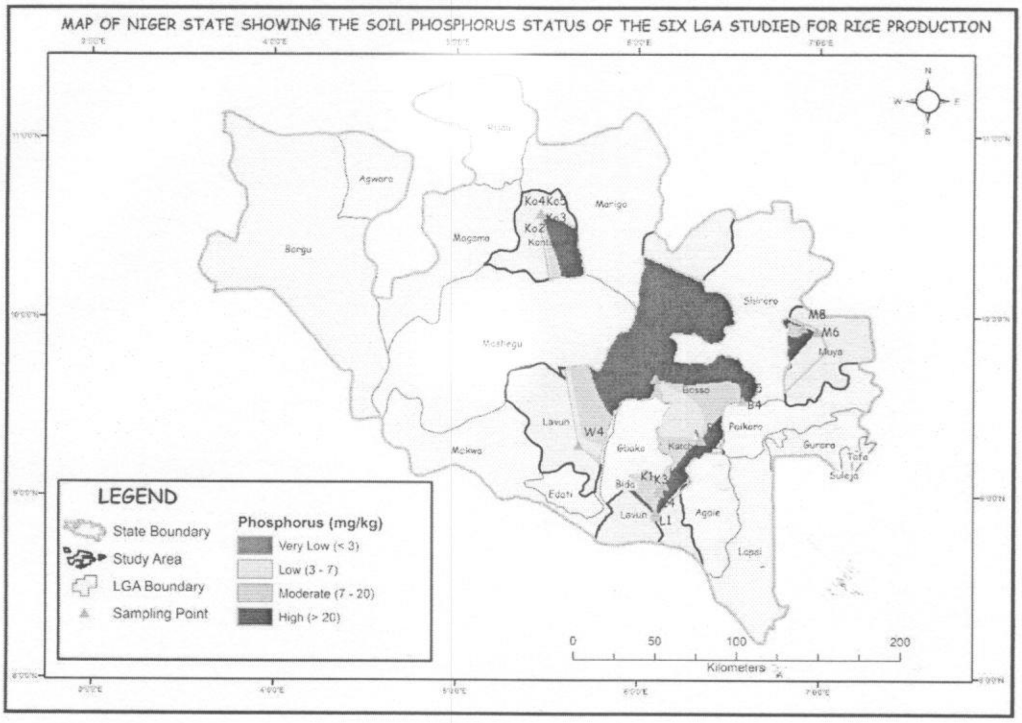
LGA	CLUSTER	VILLAGE	TAG	HISTORY OF CROP	GPS COORD.(hh.ddd)	GPS COORD. (UTM)	Remarks
Bosso	Emagi	Chanchaga farm site 1	BI	Rice	N09. 32116^0 : E006. 34619^0	0233960 :1055043	relatively flatland, fadama,
Bosso	Emagi	Chanchaga farm site 1	B2	Rice			relatively flatland, fadama,
Bosso	Emagi	Chanchaga farm site 2	B3	Rice	N09.31238^0 : E006.35200^0	0235163 :1054092	relatively flatland, fadama,
Bosso	Emagi	Chanchaga farm site 2	B4	Rice	N09.53637^0 : E006.57549^0		relatively flatland, fadama,
Bosso	Emagi	Chanchaga farm site 2	B5	Rice	N09.53622^0 : E006.57623^0		relatively flatland, fadama,
Bosso	Emagi	Dadafiba	B6	Sorghum	N09.68081^0: E006.52461^0	0228382 :1071070	stony, undulating toposgraphy, presence of termiatrum
Bosso	Emagi	Dadafiba	B7	Sorghum	N09.53791^0 : E006.57732^0		stony, undulating toposgraphy, presence of termiatrum
Bosso	Emagi	Dadafiba	B8	Sorghum	N09.53749^0 : E006.57749^0		stony, undulating toposgraphy, presence of termiatrum
Bosso	Emagi	Dadafiba	B9	Sorghum	N09.52588^0 : E006.58740^0		stony, undulating toposgraphy, presence of termiatrum
Bosso	Emagi	Dadafiba	B10	Sorghum	N09.52588^0 : E006.58740^0		stony, undulating toposgraphy, presence of termiatrum
Munyan	Kukab	chibani	M1	Sorghum	N09.81955^0 : E007.04574^0	0285595 :1085835	flatland,
Munyan	Kukab	chibani	M2	Sorghum			flatland,
Munyan	Kukab	chibani	M3	Sorghum			flatland,
Munyan	Kukab	kuchi	M4	Sorghum	N09:92976^0: E007. 00465^0	0261230 :1098304	flatland,
Munyan	Kukab	kuchi	M5	Sorghum			

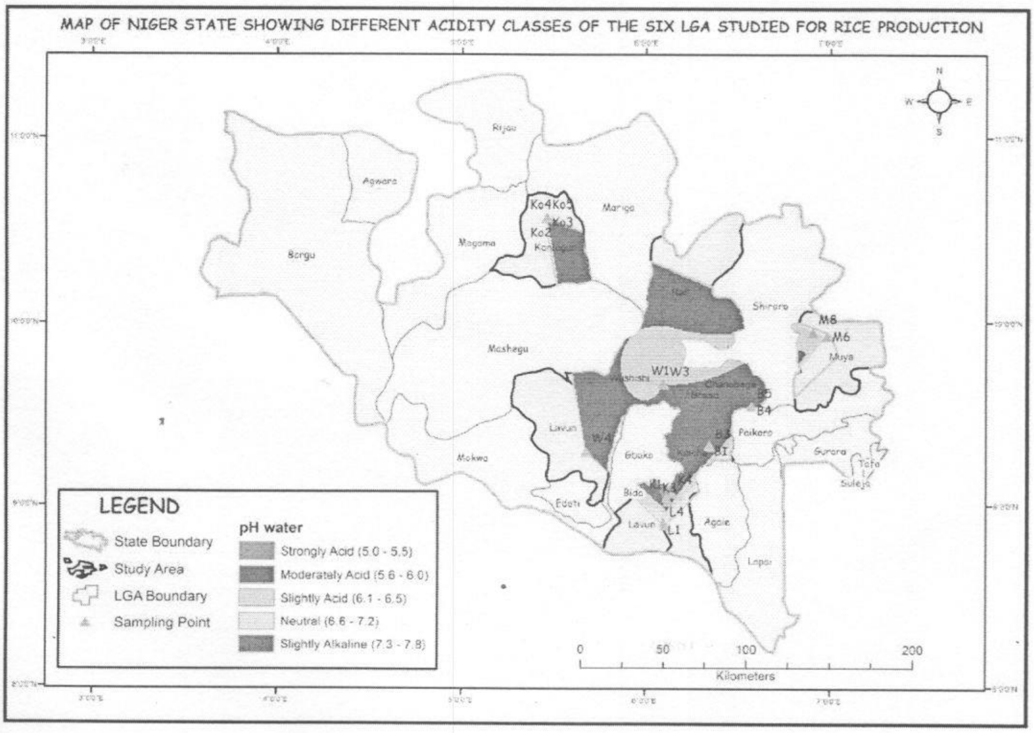
Munyan	Kukab	kuchi	M6	Rice	N09.92406^0 : E006. 98300^0	0278903 :1097746	fadama, undulating topography,
Munyan	Kukab	kuchi	M7	Rice			fadama, undulating topography,
Munyan	Kukab	kuchi	M8	Rice	N09. 94717^0 : E006.90954^0	0270811 :1100384	fadama, undulating topography, close to a big dam
Munyan	Kukab	kuchi	M9	Rice			fadama, undulating topography, close to a big dam
Munyan	Kukab	kuchi	M1 0	Rice			fadama, undulating topography, close to a big dam
Katcha	Egbanti Boro site 1	Baddegi	K1	Rice	N09.03864^0 : E006.11433^0	0182766 : 1000457	Relatively flatland ,close to Gbako riverine
Katcha		Baddegi	K2	Rice			Relatively flatland ,close to Gbako riverine
Katcha		Baddegi	K3	Rice	N09.02090^0 : E006.12075^0	0153912 : 0993410	Relatively flatland ,close to Gbako riverine
Katcha	baddeg i site 2	Baddegi	K4	Rice	N09.06301^0 : E006.14657^0	0185742 : 1000347	fadama site , prescence of white patches on soil surface,dark sub soil
Katcha		Baddegi	K5	Rice			fadama site ,prescence of white patches on soil surface, dark sub soil
Katcha	Enuma n Nwogi		K6	Sorghum	N09.06999^0 : E006.20118^0	0192397 : 0003769	Flatland , prêsence of pocket of termitarium
Katcha	Enuma n Nwogi		K7	Sorghum	N09.06763^0: E006.20303^0		Flatland , presence of

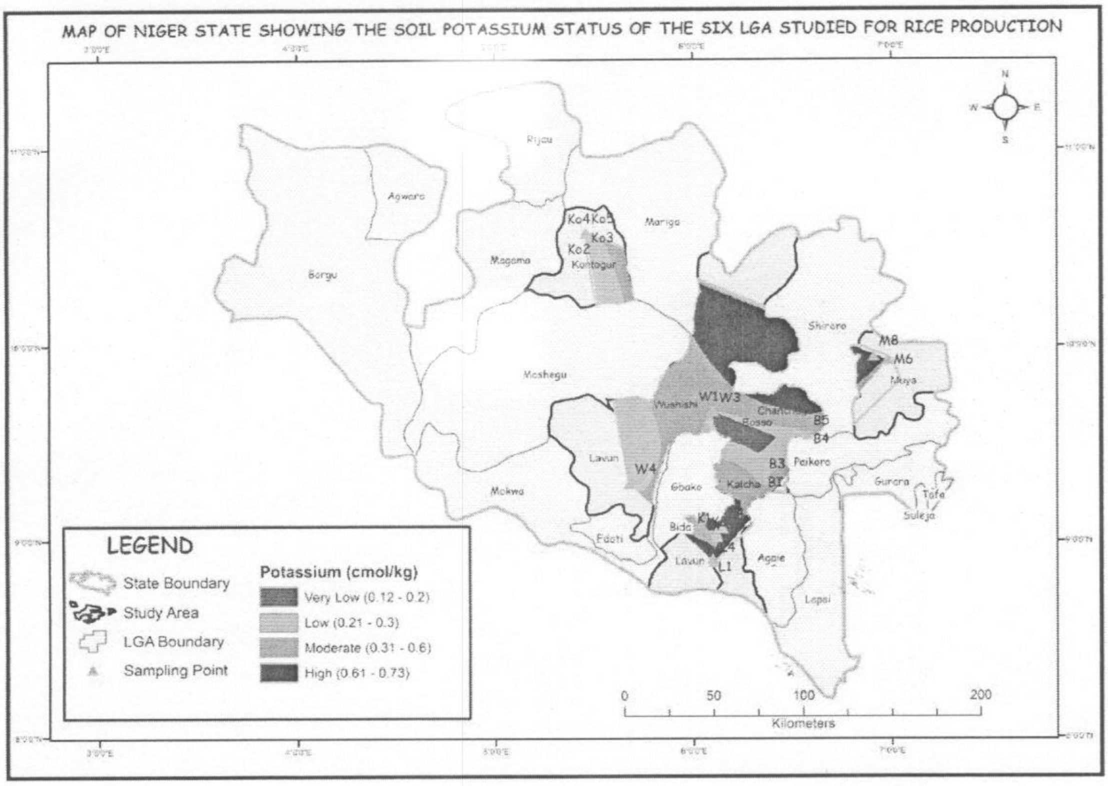
							pocket of termitarium
Katcha	Enuma n Nwogi		K8	Sorghum	N09.06796^{0}: E006.20295^{0}		Flatland , presence of pocket of termitarium
Katcha	Enuma n Nwogi		K9	Sorghum	N09.06735^{0}: E006.20284^{0}		Flatland , presence of pocket of termitarium
Katcha	Enuma n Nwogi		K10	Sorghum	N09.06780^{0}: E006.20262^{0}		Flatland , presence of pocket of termitarium
Lavum	Enuwa n sheshi bikum	Gusu	L1	Rice	N08.91059^{0} : E006.09772^{0}	0180778 : 0986184	flatland , observation of toxicity of Fe^{2+} /Mn (needs further evaluation)
Lavum	Enuwa n sheshi bikum	Gusu	L2	Rice			flatland , observation of toxicity of Fe^{2+} /Mn (needs further evaluation)
Lavum	Enuwa n sheshi bikum	Gusu	L3	Rice			flatland , observation of toxicity of Fe^{2+} /Mn (needs further evaluation)
Lavum	Enuwa n sheshi bikum	Gusu	L4	Rice	N08.89192^{0} : E006.10521^{0}	0184987 : 0984194	flatland , observation of toxicity of Fe^{2+} /Mn (needs further evaluation)
Lavum	Enuwa n sheshi bikum	Gusu	L5	Rice			flatland , observation of toxicity of Fe^{2+} /Mn (needs further evaluation)

Lavum	Yebojin	Kutigi	L6	Sorghum	N09.28649^0 : E005.67764^0	0794184 : 1027625	flatland , observation of termitarium, sandy soil in nature
Lavum	Yebojin	Kutigi	L7	Sorghum			flatland , observation of termitarium, sandy soil in nature
Lavum	Yebojin	Kutigi	L8	Sorghum			flatland , observation of termitarium, sandy soil in nature
Lavum	Yebojin	Kutigi	L9	Sorghum			flatland , observation of termitarium, sandy soil in nature
Lavum	Yebojin	Kutigi	L10	Sorghum			flatland , observation of termitarium, sandy soil in nature
Wushishi	Lauma	Zungeru/Wushishi 1	W1	Rice	N09.662194^0 : E006. 09 414^0	0181071 : 1069498	Upland
Wushishi	Lauma	Zungeru/Wushishi 1	W2	Rice			Upland
Wushishi	Lauma	Zungeru/Wushishi 1	W3	Rice	N09.65580 : E006. 10129^0		Upland
Wushishi	Lauma	Wushishi 2	W4	Rice	N09. 28649^0 : E005.67764^0	1181850 : 1068699	Upland
Wushishi	Lauma	Wushishi 2	W5	Rice			Upland
Rafi	Lauma	Yakila	W6	Sorghum	N10.06601^0 : E006.17037^0	0189822 : 1114042	flatland
Rafi	Lauma	Yakila	W7	Sorghum			flatland
Rafi	Lauma	Yakila	W8	Sorghum			flatland
Rafi	Lauma	Yakila	W9	Sorghum			flatland
Rafi	Lauma	Yakila	W10	Sorghum			flatland

Kotangora	Lioji	Ko1	Rice	N10.56450^0 : E005.46608^0	0769329 : 8168879	fadama site, close to dam
Kotangora	Lioji	Ko2	Rice	N10.56409^0 : E005.46184^0		fadama site, close to dam
Kotangora	Lioji	Ko3	Rice	N10.56456^0 : E005.46208^0		fadama site, close to dam
Kotangora	Lioji	Ko4	Rice	N10.56229^0 : E005.46080^0		fadama site, close to dam
Kotangora	Lioji	Ko5	Rice	N10.56379^0 : E005.46230^0		fadama site, close to dam
Musaga	Lioji	Ko6	Sorghum	N10.46844^0 : E005.46717^0	0769329 : 8168879	flatland
Musaga	Lioji	Ko7	Sorghum	N10.46751^0 : E005.46765^0		flatland
Musaga	Lioji	Ko8	Sorghum	N10.46786^0 : E005.46625^0		flatland
Musaga	Lioji	Ko9	Sorghum	N10.46776^0 : E005.46459^0		flatland
Musaga	Lioji	K10	Sorghum	N10.46555^0 : E005.46232^0		flatland


MAP OF NIGER STATE SHOWING THE SOIL PHOSPHORUS STATUS OF THE SIX LGA STUDIED FOR RICE PRODUCTION
Agwara
Borgu
Magama
Mariga
Ko4Ko5
Ko3
Ko2
Mashegu
Shiroro
M8
M6
Muya
Bosso
B5
B4
Lavun
W4
Paikoro
Gurara
Tafa
Suleja
Mokwa
Gbako
Katcha
Edati
Bida
K1
K3
L4
L1
Lavun
Agaie
Lapai
LEGEND
State Boundary
Study Area
LGA Boundary
Sampling Point
Phosphorus (mg/kg)
Very Low (< 3)
Low (3 - 7)
Moderate (7 - 20)
High (> 20)
0 50 100 200
Kilometers


MAP OF NIGER STATE SHOWING DIFFERENT ACIDITY CLASSES OF THE SIX LGA STUDIED FOR RICE PRODUCTION
Rijau
Agwara
Borgu
Magama
Mariga
Ko4Ko5
Ko3
Ko2
Kontagora
Rafi
Mashegu
Shiroro
M8
M6
Muya
W1W3
Wushishi
Chanchaga
Bosso
B5
B4
Lavun
W4
B3
B1
Paikoro
Gurara
Tafa
Suleja
Mokwa
Gbako
Katcha
Edati
Bida
L4
L1
Lavun
Agaie
Lapai
LEGEND
State Boundary
Study Area
LGA Boundary
Sampling Point
pH water
Strongly Acid (5.0 - 5.5)
Moderately Acid (5.6 - 6.0)
Slightly Acid (6.1 - 6.5)
Neutral (6.6 - 7.2)
Slightly Alkaline (7.3 - 7.8)
0 50 100 200
Kilometers



MAP OF NIGER STATE SHOWING THE SOIL POTASSIUM STATUS OF THE SIX LGA STUDIED FOR RICE PRODUCTION

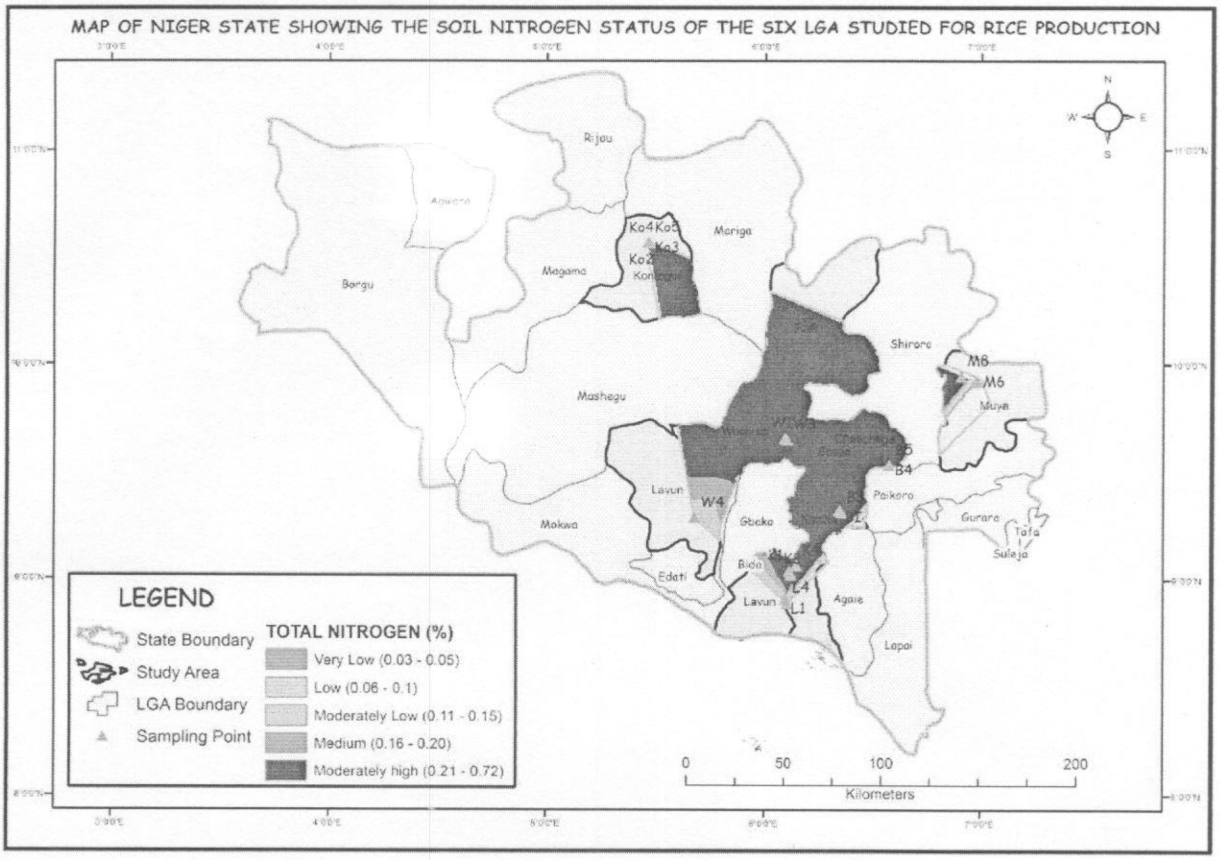


Table 11. Critical level of certain parameters determined

Properties	Very Low	Low	Medium	High
Zinc	-	<1.0	1.0-5.0	>5.0

Source- Chude V.O, Jayeoba O.J and Berding F.