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Assessment of Soil Chemical Quality for Upland Rice Cultivation in Selected Communities in Bwari Area Council, FCT, Nigeria

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Abstract
Rice is a major staple food in Nigeria with increase in demand due to interest in rice meal. This study, therefore, attempts to examine the suitability of the soil chemical properties in selected communities in Bwari Area Council in the Federal Capital Territory of Nigeria, for the cultivation of upland rice. Igu, Gyeyidna, Kuchiko, Piawe, Dutse, Jikoko, Shere, Piko, Ushafa and Jigo communities were selected as non-contiguous pair from five geographical wards (Igu, kuduru, Dutse, Shere and Ushafa) in the Area Council. They were purposively selected using the criteria of 500 metres and above elevation (upland condition) and agricultural preponderance. The soil samples were collected from farmland in each of the communities using systematic sampling procedure, which involved measuring a 100 by 100 metres quadrat and dividing it into sixteen equal grid squares with a dimension of 25 by 25 metres. Soil samples were taken at the mid points of each grid square at a depth of 0 – 30cm. The collected sixteen (16) soil samples for each quadrat were uniformly mixed into one bulk composite sample for each community. The soil results were compared with the standard land quality requirements for upland rice cultivation for Southern Guinea Savanna. pH, organic carbon, total nitrogen, available phosphorus, calcium, magnesium, potassium, and cation exchange capacity (CEC) were assessed. Furthermore, the soil chemical properties were statistically compared with the standard requirement for upland rice cultivation using the paired sample t-Test. Results reveal that there was no significant difference between the soil quality of the study area and standard soil quality requirements for the cultivation of upland rice. Based on this, it was concluded that the chemical soil properties of the sampled communities in Bwari Area Council will support the cultivation of upland rice.

Key Words*: upland rice, non-contiguous, purposive sampling, quadrat, composite.*

1. Introduction

Soil, as a natural phenomenon on the earth's surface is as vital as air and water for human survival and continuity of life in general. There has been an innate understanding in man noticed in the siting of ancient settlements and migration of ancient people which were in accordance with areas of fertile soils (Robinson, 1977 and Allison-Oguru et al., 1999).

Soil survey by United States Department of Agriculture (USDA) attempted a broad definition of soil as the natural medium for the growth of plants, whether with or without horizons. They stressed further that, people all over the world have attached so much importance to soil for its support for a variety of highly significant features on earth such as food supply, production of fibres and drugs, infiltration of surface water, purification of groundwater, recycling of solid wastes (especially, organic wastes), and other human wants (Eli, 2012).

Development of settlements and growth in population have been increasing the human demand for land as well as increase in the demand for food crops like rice and maize, among others. In recent years, the price for grains (especially rice) has increased with the cost of cultivation and production (Balogun, 2001). Sadly, in terms of area and production, rice is one of the least cultivated grain crops grown in the Federal Capital Territory. But in terms of economic importance, it is one of the most consumed staple crops. It is widely regarded as a superior food which, until recently, was mainly consumed by city dwellers, middle and higher income earners (Dawam, 2000).

Rice is the most important staple food for about half of the human race (Hawksworth, 1985). The earliest cultivation of improved rice varieties (*Oryza sativa*) started in about 1890 with the introduction of upland varieties to the high forest zone in western Nigerian (Hardcastle, 1959; Atanda et al. 1978). Over the years, there has been a steady increase in rice production and consumption in Nigeria (Imolehin and Wada, 2000). However, this production increase has not been enough to meet the consumption demand of the ever increasing population in Nigeria.

Nigeria, together with other countries in the world, has an ecology that is suitable for different rice varieties which can be harnessed to boost rice production to meet domestic needs as well as for export. In addition, in terms of landmass and suitable ecology, Nigeria has the potential to be self-sufficient in rice production for both local consumption and for international export. Nevertheless, a number of constraints, especially suitability issue, have been identified as limiting rice production efforts in Nigeria. Therefore, this study seeks to assess the soil suitability of the Bwari Area Council of the Federal Capital Territory for upland rice cultivation in a bid to combating food security challenges with focus on realizing self-sufficiency for local rice production in Nigeria.

2. Study Area

2.1 Location

Bwari Area Council is located at the North Eastern part of the Federal Capital Territory (FCT). It lies between latitudes 9^{o} 6’ N and 9^{o} 25’ N, and longitude 7^{o} 12’ E and 7^{o} 44’ E. It shares boundaries with Tafa Local Government Area (LGA) of Niger State to the West, Kagarko LGA of Kaduna State to the North, Abuja Municipal Area Council (AMAC) in the FCT to the South East, Gwagwalada Area Council in the FCT to the South West, and Karu Local Government Area (LGA) in Nasarawa State to the East (Bwari Area Council Information Unit, 2010). The location of Bwari Area Council makes it a prime area for study.

2.2 Relief and Topography

According to Akpata *et al.* (2017), Bwari Area Council (Figure 1) comprises of complex gently undulating plains with scattered rock outcrops. The terrain, which is highly undulated is dotted with granitic inselbergs. The area has a varying elevation ranging from 300m to 900m above mean sea level. The much dissected topography is characterized by numerous valley depressions that are occupied by streams.

2.3 Soils

The soils of Bwari Area Council are basically from the crystalline rock of the basement complex rocks, which spans the northern two-thirds of the Federal Capital Territory (Chup, 2004). The soils are predominantly tropical ferruginous but the streams and river valleys have hydromorphic and alluvial soils. The soil are not deeply weathered partly because of much erosion experienced on the hilly terrain. Consequently, the solid bedrock of basement complex from which the soils were formed is encountered a few meters below the ground surface when digging. The soils are generally clayey hence sticky and are of medium fertility (Mallo and Ochai, 2009). Among others, the soil type is good for rice cultivation.

2.3 Geology

The local geology of the study area comprises essentially of four geological classes. These include; coarse porphyritic biotite/biotite hornblende, Biotite-hornblende gneiss finely bonded, muscovite/quartz-muscovite-schist, and medium to coarse grained biotite granite. All of these belong to the pre–cambrian/cambrian basement complex (Mallo and Mgbanyi, 2013).

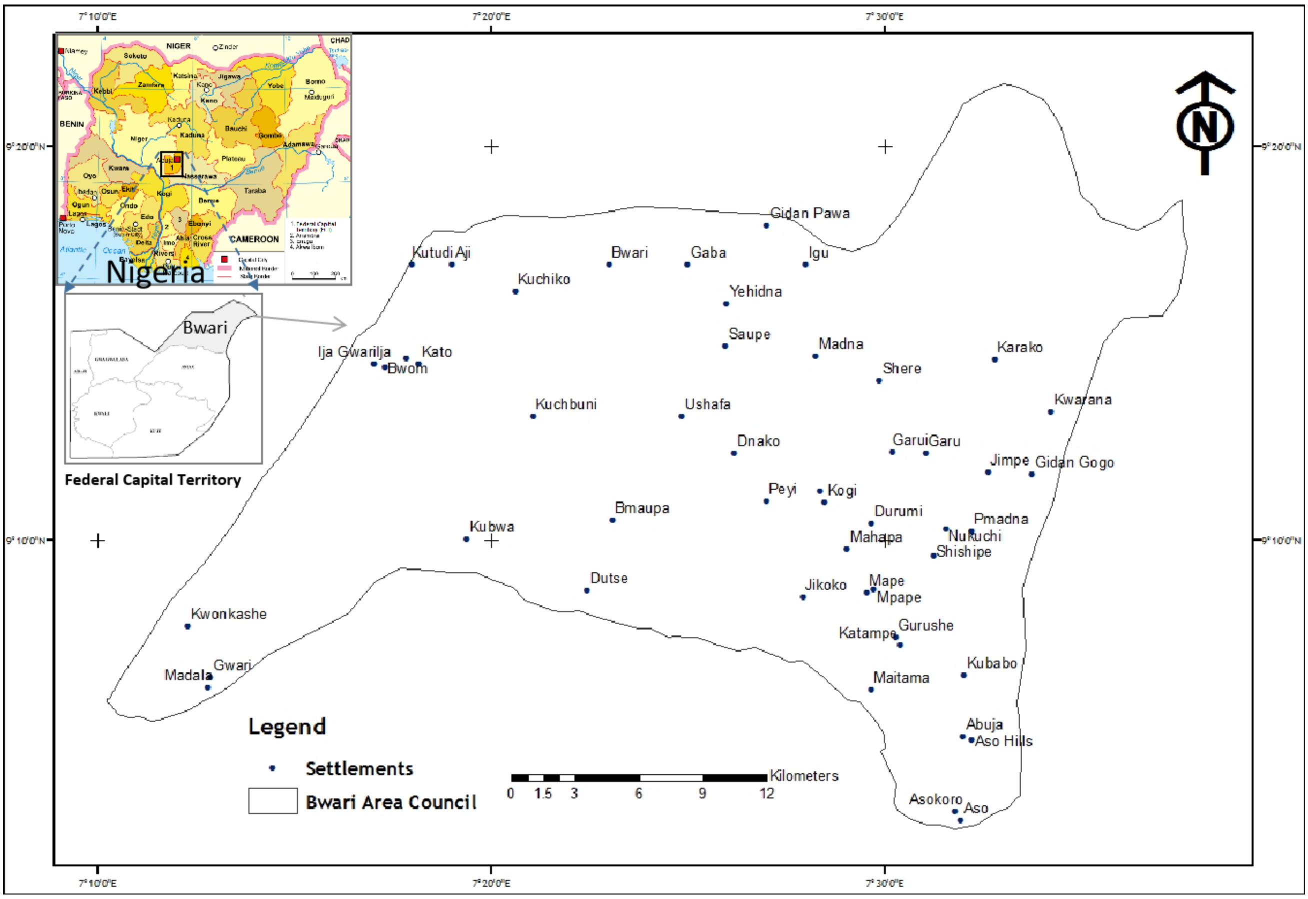

Figure 1: Location of Bwari Area Council in FCT, Nigeria

2.4 Climate

Like the entire FCT and northern Nigeria in general, Bwari Area Council has tropical continental of "Aw" type of climate according to Koppen's climatic classification. A dry season from November to April is followed by a wet season lasting from May to October. The temperature is high all through the year, but it is often lowered a little by the heavy rains in the wet season. The above description of Bwari Area Council has shown that the cultivation of upland rice is possible though further investigation of soil samples is needed to ascertain the suitability for growing the staple crop in practical terms.

3. Methodology

3.1 Method of Data Collection

The soil data used in this study were collected from the field using soil auger (topsoil: 0-15cm and Subsoil, 15-30cm). Soil samples were collected from one farmland each in a selected pair of non-contiguous communities across five of the ten geographical wards in Bwari Area Council. The ten wards are: Kawu, Igu, Bwari Central, Shere, Ushafa, Dutse, Kubwa, Usuma, Byazhin and Kuduru. From these, five wards (Igu, Shere, Dutse, Ushafa and Kuchiko) were selected via purposive sampling method using the criteria of elevation that satisfies the upland condition for rice cultivation as well as areas with agriculture as the predominant landuse.

According to the International Rice Research Institute -IRRI (2008), upland rice areas vary in altitude from steeply sloping highlands of 2,500 meters to gently sloping areas only a few meters above sea level. For this study, upland areas are areas with altitude of 500 meters and above.

The ten selected communities that most satisfy the upland and agricultural preponderance conditions are: Igu, Gyeyidna, Kuchiko, Piawe, Dutse, Jikoko, Shere, Piko, Ushafa and Jigo. Secondary sources of data, such as climatic information were obtained from NIMET records, demographic data from the National Population Commission, socio-economic records of the study area were obtained from the Information Unit of Bwari Area Council, soil quality standard required for rice cultivation as well as information on the physical setting of the study area were also collected.

For this study, soil samples were collected from a measured quadrat of 100 by 100 meters (length and breadth) from one farm each in the ten selected communities. The quadrat was divided into 16 equal grid squares with a dimension of 25 by 25 meters. Soil samples were taken at the mid points of grid square at a depth of 0 – 30cm. Figure 2 gives a graphical illustration of sample collection.

The sixteen composite soil samples for each quadrat was mixed into one bulk composite soil sample for each of the selected community. This gave ten (10) bulk composite soil samples, one (1) each for the ten selected communities. Global Positioning System – GPS was used to take coordinates of the soil sample points as presented in Table 1. Samples were collected in polythene bags, aptly labelled with the sample code, time of collection, location and coordinates. The samples were thereafter analysed in the laboratory. Collected samples from selected communities in Bwari Area Council were subjected to laboratory test and eight chemical parameters were examined.

The examined soil properties and their units of measurements include: Soil pH, Organic Carbon (%), Total Nitrogen (%), Available Phosphorus (ppm), Calcium (CmoL kg-1), Magnesium (CmoL kg-1), Potassium (CmoL kg-1), and Cation Exchange Capacity - CEC (CmoL kg-1).

3.2 Method of Data Analysis

Soil quality standard for rice cultivation in Southern Guinea Savanna by Kyuma *et al.*, 1986 as cited by Aondoakaa and Agbakwuru (2012) was used in this assessment. These standards were a result of detailed and comprehensive study of the soil properties of the different regions in Sub-Saharan Africa and their suitability for rice cultivation.

In the work of Kyuma *et al.* (1986), soil properties of the topsoil (0 - 15 cm) and subsoils (16 - 30 cm) were used to evaluate the fertility status of the different geographic regions of Sub-Saharan Africa as well as to determine the tolerable ranges of these soil qualities for rice cultivation.

The soil quality standard for rice cultivation in Southern Guinea Savanna (Kyuma *et al.*, 1986) was then statistically compared with the composite bulk soil samples for each of the ten selected communities across the five (5) wards, using the one sample student t-Test (SPSS 16.0) to test for significant difference between each of the eight soil parameters from the ten composite soil samples and the corresponding mid-point value of the standard soil quality for rice cultivation.

The One Sample t-Test, which is used to determine whether the sample mean of a set of observation is statistically different from a known or hypothesized population mean, in the case of this study, was used to assess the soil chemical parameters (pH, organic carbon, total nitrogen, available phosphorus, cation exchange capacity, calcium, magnesium and potassium) of the ten (10) composite soil samples obtained, one each from the respective communities sampled, against the identified standard for rice cultivation. This analysis was undertaken with the aid of the SPSS (Version 16.0) software package.

The calculated t value is then compared to the critical t value from the t distribution table with degrees of freedom df = n - 1 and chosen confidence level. If the calculated t value > critical t value, then we reject the null hypothesis.

Furthermore, the Paired sample t-Test was used to test the hypothesis that: the soil chemical quality of the study area is not significantly different from the standard soil quality requirements for the cultivation of upland rice. Here, the averages of each of the respective chemical parameters for the ten communities sampled was obtained. These were statistically compared with the soil standards for rice cultivation at 95% confidence level.

Table 1: Coordinates for soil samples across the selected communities of the study area

Igu		Gyeyidna		Kuchiko		Piawe		Dutse		Jikoko		Shere		Piko Panda		Ushafa		Jigo	
Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)	Lat. (N)	Long. (E)
9° 16’ 15.25”	7° 28’ 32.00”	9° 16’ 52.09”	7° 26’ 16.77”	9° 15’ 33.94”	7° 19’ 18.03”	9° 14’ 52.48”	7° 22’ 00.52”	9° 10’ 07.28”	7° 22’ 25.59”	9° 08’ 19.28”	7° 28’ 11.56”	9° 13’ 53.92”	7° 30’ 00.36”	9° 14’ 31.48”	7° 29’ 04.98”	9° 11’ 54.25”	7° 23’ 31.51”	9° 13’ 19.98”	7° 23’ 08.44”
9° 16’ 15. 54”	7° 28’ 32.84”	9° 16’ 52.44”	7° 26’ 17.42”	9° 15’ 34.34”	7° 19’ 18.76”	9° 14’ 52.58”	7° 22’ 01.19”	9° 10’ 07.44”	7° 22’ 26.34”	9° 08’ 18.77”	7° 28’ 12.11”	9° 13’ 53.98’	7° 30’ 01.18”	9° 14’ 31.16”	7° 29’ 05.75”	9° 11’ 54.24”	7° 23’ 32.49”	9° 13’ 20.00”	7° 23’ 09.23”
9° 16’ 15.70”	7° 28’ 33.45”	9° 16’ 52.83”	7° 26’18.20”	9° 15’ 34.73”	7° 19’ 19.45”	9° 14’ 52.17”	7° 22’ 01.91”	9° 10’ 07.06”	7° 22’ 27.21”	9° 08’ 18.22”	7° 28’ 12.75”	9° 13’ 54.00”	7° 30’ 02.05”	9° 14’ 30.18”	7° 29’ 06.56”	9° 11’ 54.28”	7° 23’ 33.34”	9° 13’ 19.99”	7° 23’ 10.08”
9° 16’ 16.03”	7° 28’ 34.25”	9° 16’ 53.18”	7° 26’ 19.01”	9° 15’ 35.13”	7° 19’ 20.17”	9° 14’ 51.78”	7° 22’ 02.63”	9° 10’ 07.77”	7° 22’ 27.98”	9° 08’ 17.67”	7° 28’ 13.34”	9° 13’ 53.99”	7° 30’ 02.86”	9° 14’ 30.42”	7° 29’ 07.26”	9° 11’ 54.29”	7° 23’ 34.10”	9° 13’ 20.06”	7° 23’ 10.87”
9° 16’ 14.64”	7° 28’ 32.33”	9° 16’ 51.50”	7° 26’ 17.24”	9° 15’ 33.37”	7° 19’ 18.43”	9° 14’ 52.36”	7° 22’ 00.07”	9° 10’ 06.58”	7° 22’ 25.76”	9° 08’ 18.61”	7° 28’ 10.83”	9° 13’ 53.16”	7° 30’ 00.29”	9° 14’ 30.82”	7° 29’ 04.55”	9° 11’ 53.36”	7° 23’ 31.53”	9° 13’ 19.23”	7° 23’ 08.44”
9° 16’ 15.05”	7° 28’ 33.03”	9° 16’ 51.82”	7° 26’ 17.97”	9° 15’ 33.87”	7° 19’ 19.20”	9° 14’ 51.95”	7° 22’ 00.84”	9° 10’ 06.75”	7° 22’ 26.55”	9° 08’ 18.12”	7° 28’ 11.46”	9° 13’ 53.16”	7° 30’ 01.20”	9° 14’ 30.37”	7° 29’ 05.40”	9° 11’ 53.30”	7° 23’ 32.45”	9° 13’ 19.20”	7° 23’ 09.22”
9° 16’	7° 28	9°	7° 26’	9°	7° 19’	9°	7° 22’	9°	7° 22’	9°	7°	9°	7° 30’	9°	7° 29’	9°	7° 23’	9°	7° 23’

15.25”	’33.95”	16’ 52.19”	18.73”	15’ 34.22”	19.99”	14’ 34.22”	01.55”	10’ 06.93”	27.32”	08’ 17.59”	28’ 12.13”	13’ 53.20”	02.05”	14’ 30.01”	06.14”	11’ 53.35”	33.44”	13’ 19.21”	10.16”
9^{o} 16’ 15.39”	7^{o} 28’ 34.60”	9^{o} 16’ 52.54”	7^{o} 26’ 19.48”	9^{O} 15’ 34.61”	7^{O} 19’ 20.67”	9^{O} 14’ 51.10”	7^{O} 22’ 02.22”	9^{O} 10’ 07.11”	7^{O} 22’ 28.11”	9^{O} 08’ 17.02”	7^{O} 28’ 12.78”	9^{O} 13’ 53.21”	7^{O} 30’ 02.85”	9^{O} 14’ 29.67”	7^{O} 29’ 06.89”	9^{O} 11’ 53.43”	7^{O} 23’ 34.06”	9^{0} 13’ 19.28”	7^{0} 23’ 10.97”
9^{o} 16’ 13.88”	7^{o} 28’ 32.68”	9^{o} 16’ 50.89”	7^{o} 26’ 17.82”	9^{O} 15’ 32.76”	7^{O} 19’ 18.99”	9^{O} 14’ 51.69”	7^{O} 22’ 59.71”	9^{O} 10’ 05.84’	7^{O} 22’ 25.93”	9^{O} 08’ 18.11”	7^{O} 28’ 10.31”	9^{O} 13’ 52.38”	7^{O} 30’ 00.33”	9^{O} 14’ 30.02”	7^{O} 29’ 04.19”	9^{O} 11’ 52.55”	7^{O} 23’ 31.51”	9^{0} 13’ 18.34”	7^{0} 23’ 08.51”
9^{o} 16’14.12”	7^{o} 28’ 33.57”	9^{o} 16’ 51.22”	7^{o} 26’ 18.53”	9^{O} 15’ 33.21”	7^{O} 19’ 19.77”	9^{O} 14’ 51.19”	7^{O} 22’ 00.57”	9^{O} 10’ 06.03”	7^{O} 22’ 26.73”	9^{O} 08’ 17.53”	7^{O} 28’ 10.96”	9^{O} 13’ 52.44”	7^{O} 30’ 01.18”	9^{O} 14’ 29.64”	7^{O} 29’ 05.03”	9^{O} 11’ 52.54”	7^{O} 23’ 32.50”	9^{0} 13’ 18.40”	7^{0} 23’ 09.27”
9^{o} 16’ 14.34”	7^{o} 28’ 34.27”	9^{o} 16’ 51.58”	7^{o} 26’ 19.28”	9^{O} 15’ 33.64”	7^{O} 19’ 20.53”	9^{O} 14’ 50.79”	7^{O} 22’ 01.18”	9^{O} 10’ 06.19”	7^{O} 22’ 27.49”	9^{O} 08’ 16.99”	7^{O} 28’ 11.58”	9^{O} 13’ 52.49”	7^{O} 30’ 02.09”	9^{O} 14’ 29.24”	7^{O} 29’ 05.80”	9^{O} 11’ 52.64”	7^{O} 23’ 33.28”	9^{0} 13’ 18.41”	7^{0} 23’ 10.10”
9^{o} 16’ 14.59”	7^{o} 28’ 35.01”	9^{o} 16’ 51.96”	7^{o} 26’ 20.06”	9^{O} 15’ 33.96”	7^{O} 19’ 21.17”	9^{O} 14’ 50.39”	7^{O} 22’ 01.85”	9^{O} 10’ 06.34”	7^{O} 22’ 28.37”	9^{O} 08’ 16.51”	7^{O} 28’ 12.24”	9^{O} 13’ 52.39”	7^{O} 30’ 02.81”	9^{O} 14’ 28.89”	7^{O} 29’ 06.53”	9^{O} 11’ 52.60”	7^{O} 23’ 34.02”	9^{0} 13’ 18.46”	7^{0} 23’ 10.94”
9^{o} 16’13.07”	7^{o} 28’ 33.12”	9^{o} 16’ 50.27”	7^{o} 26’ 18.32”	9^{O} 15” 32.10”	7^{O} 19’ 19.60”	9^{O} 14’ 50.97”	7^{O} 22’ 59.31”	9^{O} 10’ 04.96”	7^{O} 22’ 26.16”	9^{O} 08’ 17.54”	7^{O} 28’ 09.82”	9^{O} 13’ 51.51”	7^{O} 30’ 00.31”	9^{O} 14’ 29.35”	7^{O} 29’ 03.82”	9^{O} 11’ 51.88”	7^{O} 23’ 31.55”	9^{0} 13’ 17.57”	7^{0} 23’ 08.52”
9^{o} 16’13.	7^{o} 28’ 33.94	9^{o} 16’	7^{o} 26’ 19.04	9^{O} 15’	7^{O} 19’ 20.42	9^{O} 14’	7^{O} 22’ 00.14	9^{O} 10’	7^{O} 22’ 26.95	9^{O} 08’	7^{O} 28’	9^{O} 13’	7^{O} 30’ 01.20	9^{O} 14’	7^{O} 29’ 04.63	9^{O} 11’	7^{O} 23’ 32.42	9^{0} 13’	7^{0} 23’ 09.28

30”	”	50.61”	”	32.57”	”	50.48”	”	05.16”	”	16.96”	10.48”	51.57”	”	28.97”	”	51.83”	”	17.54”	”
9^{o} 16’ 13.47”	7^{o} 28’ 34.67”	9^{o} 16’ 51.01”	7^{o} 26’ 19.77”	9^{O} 15’ 32.97”	7^{O} 19’ 21.18”	9^{O} 14’ 50.27”	7^{O} 22’ 01.27”	9^{O} 10’ 05.39”	7^{O} 22’ 27.72”	9^{O} 08’ 16.40”	7^{O} 28’ 11.11”	9^{O} 13’ 51.55”	7^{O} 30’ 02.08”	9^{O} 14’ 28.59”	7^{O} 29’ 05.48”	9^{O} 11’ 51.95”	7^{O} 23’ 33.35”	9^{0} 13’ 17.59”	7^{0} 23’ 10.12”
9^{o} 16’ 13.71”	7^{o} 28’ 35.60”	9^{o} 16’ 51.32”	7^{o} 26’20.52”	9^{O} 15’ 33.40”	7^{O} 19’ 21.85”	9^{O} 14’ 50.05”	7^{O} 22’ 01.98”	9^{O} 10’ 05.58”	7^{O} 22’ 28.52”	9^{O} 08’ 15.86”	7^{O} 28’ 11.71”	9^{O} 13’ 51.56”	7^{O} 30’ 02.82”	9^{O} 14’ 27.72”	7^{O} 29’ 06.23”	9^{O} 11’ 51.87”	7^{O} 23’ 34.07”	9^{0} 13’ 17.65”	7^{0} 23’ 10.95”

4. Results and Discussion

The results obtained for this study are shown in table 2 to 6 and discussed further below with respect to their requirement limits for upland rice cultivation.

i. *pH*

As shown in Table 4, the average *soil pH* of the study area (7.84) tilts towards alkaline; which is higher than what is required for rice cultivation (4.20) to grow optimally. It is important to note that the high pH level of the soil, which did not suit rice, is not completely a defect. In fact, Radujevic and Bechkin (1999) earlier explained that acidic soils with pH from 4.0 to 5.5 can have high concentration of soluble aluminium and manganese ions, which may be toxic to the growth of some plant. Winterhalder (1984) also earlier noted that toxicity may rise if pH is below 5 and also argued that a pH range of approximately 6 to 7 can release most readily available plant nutrients.

Table 2: Sampled communities, coordinates and elevation

S/N	Community	Ward	Sample Code	Coordinates		Elevation (m)
				Latitude (N)	Longitude (E)	
1	Igu	Igu	SS 01	9°16'14"	7°28'36"	659
2	Gyeyidna	Igu	SS 02	9°16'51"	7°26'18"	672
3	Kuchiko	Kuduru	SS 03	9°15'33"	7°19'21"	530
4	Piawe	Kuduru	SS 04	9°14'52"	7°22'00"	554
5	Dutse	Dutse	SS 05	9°10'07"	7°22'26"	501
6	Jikoko	Dutse	SS 06	9° 08'18"	7°28'12"	656
7	Shere	Shere	SS 07	9°13'52"	7°30'01"	700
8	Piko Panda	Shere	SS 08	9°14'30"	7°29'04"	682
9	Ushafa	Ushafa	SS 09	9°11'53"	7°23'33"	567
10	Jigo	Ushafa	SS 10	9°13'19"	7°23'10"	524

Table 3: Soil standard for rice cultivation in Southern Guinea Savanna

Parameter	Soil Quality (Ranges) for Rice Cultivation	Midpoint Value (X)
Soil pH	3.1 - 5.3	4.20
Organic Carbon (C) %	0.20 - 21.0	10.60
Total Nitrogen (N) %	0.02 - 0.10	0.06
Available Phosphorus (P) ppm	8.60 - 83.0	45.80
Calcium (Ca) CmoL kg^{-1}	0.85 - 2.70	1.78
Magnesium (Mg) CmoL kg^{-1}	0.10 - 0.84	0.47
Potassium (K) CmoL kg^{-1}	0.04 - 0.23	0.14
Cation Exchange Capacity (CEC) CmoL kg^{-1}	2.12 - 11.39	6.76

Table 4: Soil Test Results for the Study Area

Parameter	Igu	Gyeyidna	Kuchiko	Piawe	Dutse	Jikoko	Shere	Piko	Ushafa	Jigo	Average
Soil pH	7.50	7.60	8.00	7.80	7.70	8.00	8.10	7.90	8.00	7.80	7.84
Organic Carbon (C) %	0.78	0.69	0.26	0.31	0.64	0.59	0.82	0.79	0.90	0.68	0.65
Total Nitrogen (N) %	0.78	0.51	0.35	0.47	0.38	0.42	0.50	0.61	0.56	0.58	0.52
Available Phosphorus (P) ppm	0.44	7.89	9.64	8.58	11.36	10.04	7.45	6.90	8.60	7.95	7.89
Calcium (Ca) CmoL kg^{-1}	5.30	4.80	6.10	7.02	5.61	4.50	4.90	5.81	3.98	3.36	5.14
Magnesium (Mg) CmoL kg^{-1}	0.34	0.80	0.56	0.74	0.81	0.93	1.10	1.14	2.07	2.11	1.06
Potassium (K) CmoL kg^{-1}	1.69	1.72	2.00	1.96	1.63	1.63	0.94	0.89	1.36	1.40	1.52
Cation Exchange Capacity (CEC) CmoL kg^{-1}	2.62	2.78	3.13	3.59	3.05	2.78	2.85	3.21	3.30	3.11	3.04

Table 5: One-Sample t-Test for soil chemical parameters

Parameter	Test Value	t	Df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Soil pH	4.200	58.877	9	0.000	3.64000	3.5001	3.7799
Carbon	10.60	-149.005	9	0.000	-9.95400	-10.1051	-9.8029
Total Nitrogen	0.06	11.470	9	0.000	0.45600	0.3661	0.5459
Phosphorus	45.80	-40.889	9	0.000	-37.91500	-40.0126	-35.8174
Calcium	1.78	9.951	9	0.000	3.35800	2.5946	4.1214
Magnesium	0.47	3.154	9	0.012	0.59000	0.1669	1.0131
Potassium	0.14	11.542	9	0.000	1.38200	1.1111	1.6529
CEC	6.76	-40.466	9	0.000	-3.71800	-3.9258	-3.5102

t - The Calculated Value
d.f - Degree of Freedom
95% Confidence Level (0.05)

Table 6: Paired Samples t-Test (Average Soil Quality for Study Area and Standard Soil Quality for Rice)

Paired Differences							
			95% Confidence Interval of the Difference				
Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	Df	Sig. (2-tailed)
-5.26875	13.91266	4.91887	-16.90002	6.36252	-1.071	7	0.320

Furthermore, an assessment of the ten communities sampled individually show that none of the communities possessed soil pH that suits rice cultivation. All the samples showed that the soils of the study area were generally alkaline and must require some level of treatment to reduce the pH level to make them tolerable for rice production.

ii. Organic Carbon

The Organic Carbon level of average of 0.65% (Table 4) falls very short of the average requirement. However, the study further indicate that the Organic Carbon from the sampled communities all fall within the range of the standard requirement for upland rice cultivation.

It is important to note that Organic matter, which makes up just 2–10% of the soils mass, has a critical role in the physical, chemical and biological function of agricultural soils; Carbon is a measurable component of soil organic matter (Griffin *et al.*, 2013). Organic Carbon is one of the most important constituents of the soil due to its capacity to affect plant growth as both a source of energy and a trigger for nutrient availability through mineralization (Edwards *et al.*, 1999).

iii. Total Nitrogen

The average Total Nitrogen contained in the samples is 0.52% as against the standard requirement of 0.06%. This is actually a case of possessing Total Nitrogen in amount that is above upland rice tolerable threshold in all the soils across the study area. Kunda *et al*. (1996) already postulated that Nitrogen, as a macro-nutrient of rice, is needed in considerable quantity for high yield. It is equally important to stress that Total Nitrogen in soils is not a good index of nitrogen availability as the Nitrogen in soils occur in complex organic compounds that have to be biochemically transformed to ammonia (NH_4^+) and nitrate (NO_3^-) that can be taken up by plants. Therefore, the high amount of Total Nitrogen in the soil of the study area may not be a hindrance to upland rice cultivation after all.

iv. Available Phosphorous

Standard requirement for Available Phosphorus for rice is 8.60 to 83.0 ppm. From the study area, there are only four communities with soils that possess requisite amount. These are Kuchiko with 9.64 ppm, Dutse with 11.36 ppm, Jikoko with 10.04 ppm and Ushafa with 8.60 ppm.

As an important mineral for rice cultivation, Phosphorous (P) is an essential plant nutrient important for root development, tillering, early flowering, and ripening. It is mobile within the plant, but not in the soil. Rice crops require about 3-4 kg Phosphorus for the production of one ton of rough rice including straw (De Datta, 1981; Ponnamperuma and Deturck, 1993; Sahrawat, 2000). This element is involved in the supply and transfer of energy for biochemical processes in the rice plant.

v. Calcium

An assessment of the levels of Calcium from the soils of the ten communities sampled, showed that all the communities possessed Calcium levels that are higher than the average standard requirement for rice (1.78 CmoL kg-1). In fact, the level of Calcium in the sampled soils exceeded the standard range of 0.85 - 2.70 CmoL kg-1 (i.e, 3.36 in Jigo and 7.02 in Piawe).

According to Dobermann and Fairhurst (2000), Calcium (Ca) deficiency impairs root function and predisposes plant to iron toxicity. It causes stunting and death of growing points. High content of Calcium has the potential to limit rice yield (Aondoakaa and Agbakwuru, 2012). The very high levels of exchangeable Calcium in the soils could be attributed to high contents of Calcium in the parent materials of the soils, the pH of the soils and concentration of Ca^{2+} in the surface horizons of the soils as a result of insignificant leaching due to insufficient rainfall amount.

vi. Magnesium

The range of Magnesium required for rice is 0.10 and 0.84 CmoL kg-1. From the ten communities sampled, five communities have soils that possessed an average Magnesium level that is slightly above the standard requirement. These communities include, Jikoko, Shere, Piko, Ushafa, and Jigo. Ushafa has the highest record of 2.11 CmoL kg-1, while Igu is lowest (0.34 CmoL kg-1) and fits in.

The exchangeable Magnesium in the soils are rated as high (>0.5 CmoL(+) kg-1 soil) according to Landon (1991). However, the availability of Magnesium of the soils might be reduced by the high Ca to Mg ratio greater than 5:1 due to antagonistic effects of calcium (Landon, 1991).

The high exchangeable Magnesium in the soils could be attributed to high contents of Magnesium in the parent materials of the soils and limited uptake by plants because of the limited plant/vegetation growth due to inadequate soil moisture and probably the presence of layer silicate clay minerals (chlorites) in the soils. The soils in the study area, therefore, possesses above par exchangeable Magnesium for upland rice cultivation.

vii. Potassium

Across the ten communities sampled, the Potassium level exceeds the standard requirement for rice cultivation.

The exchangeable Potassium in the soils (Table 4) with 0.89 in Piko, 2.0 in Kuchiko, with average of 1.52 CmoL K kg-1 are rated high when compared with the standard of 0.4 CmoL K kg-1 according to Landon (1991). However, exchangeable Potassium levels in soils are of limited value in predicting crop response to Potassium as there is no direct relationship between soil Potassium values and its availability to plants (Landon, 1991).

It has been reported that soils with large amounts of available Potassium lose some of the Potassium through fixation and those with low amounts have their exchangeable Potassium increased through transformation of the non-available Potassium to available/exchangeable forms under field conditions (Pillia, 2005). However, on a general note, the level of Potassium in the study area exceeds tolerable limits for rice cultivation.

Viii Cation Exchange Capacity (CEC)

Looking at the range of CEC required for rice (2.12 - 11.39 CmoL kg-1), all the ten communities sampled possess average CEC level (3.04 CmoL K kg-1) that fall within the tolerable range for upland rice. In fact, the lowest record of 2.62 CmoL K kg-1 was recorded in Igu Community while the highest value of 3.59 CmoL K kg-1 was recorded in Piawe soils respectively.

It is, therefore, pertinent to note that low CEC in soils is attributed to the nature of the parent materials from which the soils were developed and the type of the layer or amorphous silicate clay minerals in the soils. The low or fairly medium CEC of the soils in the study area is an indication of the moderate capacities of the soils to retain nutrients added to the soils in the form of fertilizers and manures. Based on the CEC of the soils, the dominant clay minerals in the soils include the 1:1 layer silicate clay minerals and hydrous oxides of Fe, Al and Si.

For the paired sample t-test results, the p-value obtained as shown in Table 6 (0.320) reveals that p-value is not less than 0.05, and as such there is clear empirical evidence to accept the null hypothesis and conclude that there is no significant difference ($P < 0.05$) between the soil quality of the study area and standard soil quality requirements for the cultivation of upland rice. In other words, the result of the statistical test confirms that the chemical soil properties of the sampled communities in Bwari Area Council will support the cultivation of upland rice, and optimal results will be obtained in the specific areas where some of the soil properties were favourable or close to required quantities for better growth/yield.

5. Conclusion and Recommendation

From the findings in this study, the following conclusions are made:

a) The soil chemical parameters assessed like Organic Carbon and CEC levels fell within the standard requirement for upland rice cultivation. Likewise, available Phosphorus in Kuchiko, Dutse, Jikoko and Ushafa possessed levels that fell within the standard requirement for upland rice. Magnesium levels in Igu, Gyeyidna, Kuchiko, Piawe and Dutse are within the standard requirement, while pH, Total Nitrogen, Calcium and Potassium in all the ten (10) sampled communities exceeded the range of the standard requirement for upland rice cultivation.

b) There is clear empirical justification to conclude that there is no significant difference between the soil chemical quality of the study area and standard soil quality requirements for the cultivation of upland rice. Implying that the chemical soil properties of the sampled communities in Bwari Area Council will support the cultivation of upland rice; hence, the need to improve agricultural venture towards achieving food sufficiency and by extension, food security in the middle belt of Nigeria where Bwari Area Council, FCT is situated.

Based on the research findings earlier discussed in this study, the following recommendations are made:

i. There is need to reduce the soil pH in the study area from its fairly alkaline state to moderately acidic level suitable for upland rice cultivation. Elemental sulphur may be used to acidify alkaline soil to the desirable pH range. It may also be used to maintain pH in the desirable range, on soils that tend to become alkaline with management. The acidification of the soil will adjust the level of the Calcium and Potassium to tolerable limits for upland rice.

ii. Inspite of the fact that the soil chemical properties of the sampled communities in Bwari Area Council will support the cultivation of upland rice, it is very important to continuously monitor the fertility status of the soil as per quality evaluation. This will improve the suitability of the land for upland rice cultivation. It will also benefit both the government and the farmers and invariably improve the production and supply of food for consumption and revenue generation among the increasing population. In addition, it will bring about sustained growth and development in agriculture especially in the area of rice cultivation.

iii. It is also very important to add that fertilizer should be applied following the locality-specific recommendations for rice for optimum yield. This will extenuate the levels of Nitrogen, Phosphorus and Potassium in the soil. It will also boost soil water holding capacity.

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