Article: https://bit.ly/JazeIssue2(2) Journal of Arid Zone Economy 2(2): (2023) 103 - 115 ISSN: 2992–4952



Properties and Classification of Soils of Magajin Gari District, Gummi

Local Government Area, Zamfara State, North-West Nigeria

Dahiru S.¹, Noma S.S.², Buji I.B.³, Hayatu N.G.² and Haruna F.D.⁴

¹Department of Agricultural Science, Federal Collage of Education Gidan Madi, Sokoto State, Nigeria

². Department of Soil Science and Agric. Engr., Usmanu Danfodiyo University Sokoto, Nigeria.

³ Department of Soil Science, University of Maiduguri, Borno State, Nigeria.

⁴.Department of Soil Science, Federal University Dutsinma, Katsina, Nigeria.

Abstract

A semi-detailed survey was conducted across 50 hectares of land in Magajin Gari District, Gummi Local Government, Zamfara State, Nigeria, using a conventional rigid grid procedure. The purpose of the survey was to gather soil data for arable crop production. Four soil units were identified, namely Kawara, Gawan Gulbi, Gidan Bita I, and Gidan Bita II. In each soil unit, four profile pits were dug and described, and soil samples were collected and analyzed in the laboratory. The results of the analysis showed that the soil textures ranged from clay loam to clay and sandy loam to sandy clay. The total porosity values were relatively high, ranging from 38% to 40%. However, the total nitrogen and organic matter contents were low, with values ranging from 0.06 to 0.20g/kg and 8.0 to 8.6g/kg, respectively. The pH of the soils ranged from 5.64 to 6.55, indicating slightly acidic to neutral conditions. Available phosphorus was found to be low, with values ranging from 0.47 to 0.49mg/kg. The bulk density values ranged from 1.53 to 1.58Mg/m³, while the base saturation, cation exchange capacity, electrical conductivity, and exchangeable sodium percentage varied within the ranges of 14.0% to 16.6%, 11.9 to 14.3cmol/kg, 0.45 to 0.56dS/m, and 6.0% to 27.8%, respectively. These results indicate that the soils are non-saline. Based on the USDA Soil Taxonomy System, the soils in Kawara were classified as Vertisols, Gawan Gulbi as Alfisols, and the soils of Gidan Bita I and Gidan Bita II as Inceptisols. Overall, the soils were found to be low in fertility and had high bulk density. To enhance Productivity and crop yield proper drainage, and good soil fertility management programme should be implemented.

Keywords: Arable Conventional Classification Properties Productivity

JEL Classification Q01, Q15

Corresponding author Buji I.B. ibrahimbuji84@gmail.com Tel: +2348030988345

1. Introduction

Regarding the increase in the global population and the demand for land toward the production of sufficient food, Soil information is essential for taking appropriate land use decisions to achieve optimal productivity, to ensure environmental sustainability and safeguard our civilization. The implications of inadequate soil information include rapid land degradation and declining productivity (Khordebin and Landi, 2011). Changes in land use and management practices often modify most soil morphological, physical and chemical properties to the extent to which it is reflected in low agricultural productivity (Teshome *et al.*, 2013).

The fundamental relationship between soil and properties, their forming factors and their corresponding sustainable use is well understood. It demonstrates that people have had a sustained interest in making inferences about important soil properties to support their classification and land management decisions. New methods for analyzing soils are constantly being developed and tested. Soil classification helps in determining the best possible use and management of soils.

Soil classification was developed to provide scientists and resource managers with generalized information about the nature of soil found in a particular location. In general, environments that share comparable soil forming factors produce similar type of soil. This phenomenon makes classification possible. Numerous classification systems are in use worldwide (Pidwirny, 2006). Modern soil classification and survey are performed in a much more systematic and quantitative manner. In the United States, the Natural Resources Conservation Service (NRCS) develop and maintains standard for soil classification and survey.

The broad aim of the study was to determine some properties and classify soils of Magajin Gari District, Gummi Local Government Area of Zamfara State, Nigeria. Purposely, to assess the capacity of the soils for agronomic activities.

2. Materials and methods

2.1 Description of the Study Area

The study was conducted in Magajin Gari District, Gummi Local Government Area of

Zamfara State. The area lies between Latitude 12º 10'30" N to 12º 11'0" N and Longitude 5º 06' 40" E to 5⁰07' 20" E (Latitude.to, 2016). It is located about 350 Kilometers North-West of Gusau the Capital City of Zamfara State and 120 Kilometers South-East from Sokoto the Capital of Sokoto State. It has a land area of about 40,000 Square kilometers and a population of 206,721 people with population growth rate of 77,979 people in an area of 2.943 km² with density of 96.73 km² (National population commission of Nigeria, 2006). It borders with Bukkuyum Local Government in the East, Kebbe Local Government to the West, Tambuwal Local Government in the North, and Danko Wasagu Local Government (Kebbi State) in the South. The area also witnesses two climatic seasons: Dry season and Rainy seasons. The Dry season last from March to May, during this period the day to day Temperature rise up to 35°C. The Rainy season lasts from late May to the end of October. Rainfall is usually heavier in the months of July, August and September and it is usually characterized by heavy rainfall. The amount of annual rainfall varies from 799-897mm per annum (ZARDA, 2015). The Hamattan period last from November to February, where most irrigation activities usually takes place. The period is usually cold, windy and dusty with dry wind blowing from the Sahara Desert with temperatures falling considerably during the period.

The vegetation of Gummi is a hybrid of Sudan and Northern Guinea Savannah. As regard to the drainage system of the area, there are two rivers: River-Ka and River Bunsuru forming a simple drainage pattern with a network of streams in the area. Hence, a map of Zamfara State showing Gummi Local Government and study site with its coordinates was shown in figure 1.



Figure 1: A Map of Zamfara State, Gummi Local Government and Study site as well as soil units Source: (GIS Lab., Geography Department Usmanu Danfodiyo University Sokoto, Nigeria 2021).

2.2 Field Work

Fifty (50) hectares of land was used for the conduct of semi-detailed soil survey using a conventional rigid grid procedure (100 m X 100 m). A baseline was established with transects aligned at 90° from the base line. Along each traverse, soil examination points using auger were made to establish soil boundaries. The augering was from 0cm up to 100cm to observe changes in the soil type. Soil units identified were delineated and mapped from Auger examinations. Four (4) Soil profile pits (2 x 1.5 x 2 m) were excavated in each of the soil unit and described according to the guidelines for soil profile descriptions (FAO, 2006). The general site description such as climate, vegetation, slope gradient, drainage type and condition and erosion were observed and recorded during the study.

Sample Collection and Preparation: The samples collected from genetic horizons both disturbed and undisturbed soil samples of the four profile pits were well labeled accordingly and taken for laboratory analysis.

2.3 Laboratory Analyses

Particle size distribution of the soils was determined using the Bouyocous Hydrometer method using Sodium Hex metaphosphate as dispersing agent (ISRIC/FAO, 2002). The textural classes of the soils were determined using USDA Soil Textural Triangle, while silt/clay ratio was determined by calculation. Bulk density was determined by drying the undisturbed core sample to a constant weight at 105°C for 48hrs. The oven-dried weight of the soil sample was divided by its volume according to the formulae:

$$Db = \frac{Mass of oven dried soil}{Total soil Volume}$$

where Db=bulk density, M=Oven-dried weight of soil, V= Volume of core sampler, (Blake and Hartage, 1986). Particle density was determined after expulsion of the entrapped air in the soil using pycnometer method by (Blake and Hartage, 1986). Porosity was determined from the relationship between particle density and bulk density using formula below:

TP=1-(Pb/Ps)X100

Soil pH was determined in a 1:1 soil/water ratios using a glass electrode pH meter (Jones, 2001). Electrical conductivity was measured with electric conductivity meter in paste of 1:1 soil/water ratio. Exchangeable sodium percentage was calculated as the proportion of the CEC (NH₄OAc) occupied by sodium as follows:

$$ESP = \frac{Exchangeable Sodium}{CEC(NH4OAC)}$$

Exchangeable acidity (H^+ and Al^{3+}) was determined by titrimetric method (Peech et al., 1962). Organic C was determined by Walkley-Black method of wet combustion involving oxidation of organic matter with potassium dichromate (K₂Cr₂O₇) and sulphuric acid (H₂SO₄) (Nelson and Sommers, 1996). Total nitrogen (N) was determined by micro Kjeldahl Digestion-Distillation method (Bremmer and Mulvaney, 1982). Available phosphorus (P) was determined by Bray P-1 method (Bray and Kurtz, 1945). Exchangeable bases [Calcium (Ca), Magnesium (Mg), Potassium (K) and Sodium (Na)] were extracted with 1 normal neutral ammonium acetate (NH₄OAc) saturation method. The amount of K and Na in solution was measured using a Flame Photometer while Ca and Mg was measured using Atomic Absorption Spectrophotometer (AAS) (ISRIC/FAO, 2002). Micronutrients such as Zinc (Zn), Copper (Cu), Manganese (Mn) and Iron (Fe) were also determined using Atomic Absorption Spectrophotometer (AAS) Exchange (ISRIC/FAO, 2002). Cation Capacity (CEC) was determined by the neutral normal NH₄OAc saturation 1 method (ISRIC/FAO, 2002). Base saturation was determined through calculation by dividing the sum of exchangeable bases by their CEC then multiplied by 100.

PBS =
$$\sum \frac{(Ca^{2+}+Mg^{2+}+K^{+}+Na)}{CEC} \times 100$$

The soils were classified using USDA Soil Taxonomy and World Reference Base for Soil Resources. (Soil Survey Staff, 2014) and the World Reference Base (WRB) (IUSS WRB Soil Working Group, 2014) classification systems.

3. Results and discussion

3.1 Data analysis

The data generated were analyzed by descriptive statistics such as means, percentages and ranges using Microsoft excel package (2010 Version).

3.2 Distribution of Soil units

The distribution of different soil units of the study site by land area were presented in Table1. The Mapping units were categorized into four different soil units, Kawara series had a land area of 12.40 ha representing 24.8%, Gawan Gulbi series had a land area of 10.10 ha representing 20.2%, Gidan Bita I series had a land area of 17.50 ha representing 35.0%, and Gidan Bita II which had a total land area of 10.00 ha representing 20.0% of the area covered.

Table 1: Distribution of the different Soil Units of the study site by land area

Mapping Units	Area (ha)	Percentage Area Covered (%)
Kawara Series	12.40	24.8
Gawan Gulbi Series	10.10	20.2
Gidan Bita I Series	17.50	35.0
Gidan Bita II Series	10.00	20.0
	G '1 CM ''	

Physical Properties of Some Soils of Magajin Gari District

u	14010 2	<u> </u>				Ouj Ou	Silt/Clav	Bulk	Particle	Porosity
op		Depth	Sand	Silt	Clay	Textural	Ratio	Density	Density	(%)
Pe	Horizon	(cm)	gkg ⁻¹	gkg ⁻¹	gkg ⁻¹	Class	gkg ⁻¹	(Mgm^{-3})	(Mgm^{-3})	· /
1	Kawara		Тур	ic Endo	aquerts		00	`U /		
	Ap	0-10	370	430	200	L	2.15	1.56	2.43	36
	Bt	10-30	230	290	480	С	0.60	1.61	2.58	38
	BC1	30-83	390	250	360	CL	0.70	1.45	2.48	42
	BC2	83-160	190	470	340	SiCL	1.38	1.57	2.34	33
	С	160-200	230	330	440	С	0.75	1.51	2.60	42
		Average	282	354	364		1.12	1.54	2.50	38
2	Gawan G	ulbi	H	aplic F	luvaqua	lfs				
	Ар	0-15	190	510	300	CL	1.70	1.45	2.61	46
	Bw	15-46	210	570	220	SiL	2.60	1.60	2.70	41
	BC	46-143	560	370	70	SL	5.30	1.64	2.70	39
	С	143-200	330	310	360	С	0.90	1.63	2.53	36
		Average	323	440	237		2.63	1.58	2.64	40
2		- -		• •	.					
3	Gidan Bi	ta I	A 7(0	renic H	apluste	ots	2.0	1.60	2.01	4.4
	Ар	0-15	/60	160	80	SL	2.0	1.62	2.91	44
	BW DC 1	15-45	55U 420	250	200	SCL	1.25	1.52	2.11	45
	BCg1	45-75	430	270	300	CL	0.90	1.40	2.43	40
	BCg2	/5-130	390	300	280	CL C	1.44	1.62	2.50	31
	C	130-200	389 504	331 274	250	C	1.20	1.00	2.39	33 40
1	Cidan	Average	504		444 o Uanlu	atonta	1.35	1.50	2.01	40
4	Bita II			Gleyi	с паріа	siepis				
	Ap	0-17	720	180	10	SL	1.60	1.61	2.38	32
	Bt	17-61	370	270	36	SCL	0.75	1.46	2.69	40
	BCg1	61-110	520	260	20	SL	1.20	1.53	2.74	44
	BCg2	110-170	580	250	16	SL	1.47	1.60	2.64	39
	С	170-200	500	300	16	SL	1.50	1.45	2.28	37
		Average	538	252	20		1.30	1.53	2.57	39
	0,0,0	1 (1)		т	C		0.11	1 T	0 10	1 T

Table 2: Physical properties of the soils of Magajin Gari District.

SC=Sandy Clay, CL=Clay Loam, C=Clay, SICL=Silty Clay Loam, SL=Sandy Loam, SCL=Sandy Clay Loam.

3.3. Particle size distribution

Sand Content

The sand content of the soils of Kawara ranged from 190gkg⁻¹ to 390gkg⁻¹ with an average of 282gkg⁻¹ and varied irregularly with depth. In the soils of Gawan Gulbi the sand contents ranged from 190gkg⁻¹ in the surface horizon to 560gkg⁻¹ in the subsurface horizon with an average of 223gkg⁻¹. In the soils of Gidan Bita I the sand content ranged from 389gkg⁻¹ in the surface horizon to 760gkg⁻¹ in the subsurface horizons with an average of 504gkg⁻¹ which indicated that the percentage of sand is higher in the surface horizon than in the subsurface horizon because of aeolian deposition. In soils of Gidan Bita II the content of the sand ranged from 370gkg⁻¹ in the surface horizon to 720gkg⁻¹with average of 538gkg⁻¹ which indicated that the sand content of this profile is changing irregularly with depth. However, the sand content in Kawara was low comparing with the soils of Gidan Bita I and Gidan Bita II which have high sand contents at the surface horizons and decreases with an increasing depth which indicated that, the soils of Kawara is better than the rest of the soils agronomically, since it can retain moisture contents as a result of low sand content. These soils are formed on aeolian sand cover (Sambroek and Zonneveld, 1971).

Silt Content

The silt content of soils of Kawara ranged from 250gkg⁻¹ to 470gkg⁻¹ with average of 354gkg⁻¹, and changed irregularly from surface to subsurface horizon. In soils of Gawan Gulbi the silt content ranged from 310gkg⁻¹ in the subsurface horizon to 570gkg⁻¹ in the surface horizon with average of 440gkg⁻¹, this indicated that, the silt content is higher in the surface horizons and decreases with depth. In the soils of Gidan Bita I the silt content ranged from 160gkg⁻¹ in the surface horizon to 360gkg⁻¹ in the subsurface horizons with average of 274gkg⁻¹, in this soils the silt content increased with increasing depth. In soils of Gidan Bita II the silt content ranged from 180gkg⁻¹ to 300gkg⁻¹ with average of 252gkg⁻¹ indicating that, the silt content of this soil unit has increased with increasing depth. However, the silt content of Kawara was observed to have slightly decreased with increasing depth.

Clay Content

The Clay content of Kawara soil ranged from 200gkg⁻¹ to 440gkg⁻¹ with average of 364gkg⁻¹. The clay content is low in the surface horizon changing irregularly in the subsurface horizon. In soils of Gawan Gulbi the clay content ranged from 70gkg⁻¹ to 360gkg⁻¹ with average of 237gkg^{-1,} this indicated clay movement (argillic horizon) in the subsurface horizon. In soils of Gidan Bita I the clay content of the soil ranged from 80gkg⁻¹ to 300gkg⁻¹ with average of 222gkg⁻¹. The clay content of this soil was low in the surface horizon and increased irregularly with depth. In soils of Gidan Bita II the content of clay ranged from 100gkg⁻¹ in the surface horizon to 360gkg⁻¹ in the subsurface horizons with average of 210gkg⁻¹, and decreased irregularly with depth. The soils of Kawara had high average clay contents at the surface horizon and increased in almost all the

horizons, which indicated that the soils were poorly drained which in turn affects the infiltration and retention of water, soil aeration, absorption of nutrients, microbial activities, tillage and irrigation practices (Foth, 1990; Gupta, 2004).

Silt/Clay Ratio

The average silt/clay ratio of all the soils in Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II were 1.12, 2.63, 1.35 and 1.30 gkg⁻ ¹respectively. Van Wambake (1962) reported that, old parent materials usually have a silt/clay ratio below 0.15% while silt/clay ratios above 0.15% are indicative of young parent materials. Therefore, this study shows that, all the soils had silt/clay ratios above 0.15% and are relatively young with high degree of weathering potentials. Silt/clay ratios are relatively higher in the surface horizons and decreased irregularly with increasing depth in the pedons. The decrease in silt/clay ratio with depth is an indication that subsoil horizons are more weathered than the surface horizon which will leads to eroding of surface soils by water or wind and the fertility of the soil will be reduced as well as the crop production in the area. Yakubu (2006) reported similar results on the upland soils of Sokoto State.

Bulk Density (BD)

The average bulk density values of the soils were 1.54, 1.58, 1.61 and 1.53Mgm⁻³ in Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II respectively. The relatively high bulk density values recorded in almost all the soils is attributed to compaction caused by water flow and overgrazing by animals which are common activities in the area. Plant performs best in bulk density values of 1.4Mgm⁻³ and 1.6Mgm⁻³ for clayey and sandy soils respectively (Donahue et al., 1990). Root growth could also be inhibited due to high bulk density because of the soil resistance to root penetration, poor aeration, slow movement of nutrients and water and buildup of toxic gasses and root exudate (Brady and Weil, 2002; Odunze, 2006). However, the soils are good for

agricultural purpose because their bulk density values fall within the favorable range.

Particle Density (PD)

The average particle density values of all the soils in Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II were 2.50, 2.65, 2.61 and 2.57Mgm⁻³ respectively. The study recorded an appreciable increase in particle density with increasing depth. Brady (1987) reported that particle density values increase with soil depth. Similar results were also reported by Idoga *et al.* (2006) in the study of soils in Samaru Zaria, Nigeria.

Porosity (TP) Total

Total Porosity values in almost all the soil units of the study area ranged from 38-40% Fetter (1998), and recommended that soils having porosity of over 50% and 45-50% of volume are good agricultural soils. Consequently, soil porosity values were high in all the soils, hence the soils are potentially good for agricultural production.

3.4 Chemical Properties of some Soils of Magajin Gari District

Soil Reaction (pH)

The average pH values o

f the soils were 6.55, 5.64, 6.22 and 5.92 for soil units Kawara, Gawan Gulbi,Gidan Bita I and Gidan Bita II respectively. The pH values were observed to vary irregularly with increasing depth. Similar trends were observed and reported by Yakubu (2001). According to Landon (1991) a pH range of 5.5 to 7.0 is the preferred range for most crops. The pH values of all the soils indicated that the soils are good for agricultural purposes.

Total Nitrogen (TN)

Values of total nitrogen in the soils were 0.13, 0.09, 0.06 and 0.20gkg⁻¹ in soils of Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II respectively. The total nitrogen values were low which indicated that, the soils needs to be supplemented with organic materials for effective agronomic activities. Similar results

of low nitrogen values were reported by Kparmwang (1993). Total Nitrogen values of the soils in the area changed irregularly with increasing depth which could be attributed to influence of continuous cultivation, a common practice in the area that is accompanied by nearly total crop residue removal (Noma *et al.*, 2011).

Organic Matter (OM)

Average organic matter values for all the soils were 8.0, 16.4,18.6 and 15.4% for soils of Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II respectively. Organic matter was generally low in the soils according to Landon (1991) Rating (>20% very high, 10-20% high 4-10% medium, 2-4% low and < 2% very low). Buji et al. (2017) noted that low organic carbon content of the soils might be due to continuous cultivation and frequent burning of farm residues which tend to destroy much of the organic materials that could have been added to the soil. Ukut et al. (2014) also said that it might be due to the effect of high temperature and relative humidity which favors rapid mineralization of organic matter. Low organic matter content in the soils could be attributed to factors such as continuous cultivation, and frequent burning of farm residues commonly carried out by farmers in the area which tends to destroy much of the organic materials that could have been added to soils (Yakubu, 2001). Furthermore, Agbu and Ojanuga (1989) stated that, low organic matter content in soils could be due to rapid decomposition and mineralization of organic materials contributed by sparse vegetation in the hot semiarid climate as promoted by radiation.

Available Phosphorus (AP)

Average available phosphorus content of the soils ranged from 0.47 to 0.49mgkg⁻¹ in all the soil units of the study site, which indicated that there was no much variation between the upland soils and lowland soils in the quantity of available phosphorus in the study site. Generally, the values of available phosphorous were low in both the upland and low lowland

110

soils according to the rating scale of Esu (1991). Which leads to stunted growth and affect the yield of crops.

Electrical Conductivity (EC)

Average electrical conductivity values of the soils of Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II were 0.56, 0.45, 0.47 and 0.53dSm⁻¹ respectively, this shows that, the

soils are non-saline. Schoeneberger *et al.*, (2002) stated that, a soil having an EC value of less than $2dSm^{-1}$ in all the horizon are non-saline. This study indicated that, the soluble salts are very negligible, and results from reduced leaching of salts in the argillic soils (subsoil) and higher leaching of salts in the sandy soils (surface horizon) Yakubu, (2006).

Table 3. Chemical Properties of the Soils of Magajin Gari District

			Organic	Total				
Pedon	Depth	рН	Matter	N.	Avail. P.	EC	\mathbf{H}^+	Al^{3+}
/Horizon	(cm)	(H ₂ O 1:1)	(gkg ⁻¹)	(g/kg)	(mgkg ⁻¹)	(dSm ⁻¹)	cmoll	xg ⁻¹
Kawara		Typic	Endoaque	aerts				
Ap	0-10	6.67	3.8	0.11	0.48	0.49	0.40	0.50
Bt	10-30	6.78	7.9	0.11	0.47	0.46	0.40	0.50
BC1	30-83	6.50	6.9	0.19	0.47	0.48	0.40	0.50
BC2	83-160	6.37	7.9	0.12	0.47	0.75	0.40	0.60
С	160-200	6.42	13.4	0.10	0.47	0.62	0.40	0.60
	Average	6.55	8.0	0.13	0.47	0.56	0.40	0.54
Gawan G	ulbi	Ha	plic Fluva	qualfs				
Ap	0-15	5.75	16.8	0.09	0.49	0.42	0.50	0.60
Bw	15-46	5.66	20.6	0.09	0.49	0.64	0.50	0.60
BC	46-143	5.76	12.7	0.09	0.50	0.40	0.50	0.50
С	143-200	5.40	15.5	0.09	0.50	0.32	0.40	0.50
	Average	5.64	16.4	0.09	0.49	0.45	0.50	0.55
Gidan Bit	a I	Ar	enic Haplu	istepts				
Ap	0-15	5.81	19.3	0.08	0.49	0.24	0,50	0.50
Bw	15-45	6.28	17.2	0.07	0.48	0.52	0.50	0.50
BCg1	45-75	6.83	1.41	0.05	0.48	0.52	0.30	0.40
BCg2	75-130	6.20	19.9	0.05	0.47	0.50	0.30	0.40
С	130-200	5.98	22.7	0.04	0.47	0.59	0.40	0.30
	Average	6.22	18.6	0.06	0.48	0.47	0.40	0.42
Gidan Bit	a II	Gl	eyic Haplu	stepts				
Ap	0-17	6.03	11.3	0.07	0.48	0.56	0.50	0.30
Bt	17-61	5.95	21.3	0.31	0.47	0.67	0.40	0.30
BCg1	61-110	6.03	11.1	0.31	0.47	0.45	0.40	0.30
BCg2	110-170	5.83	12.0	0.31	0.47	0.44	0.40	0.30
С	170-200	5.78	21.3	0.02	0.47	0.51	0.40	0.30
	Average	5.92	15.4	0.20	0.47	0.53	0.40	0.30

Total N.= Total Nitrogen, Avail. P.= Available Phosphorus, EC= Electrical Conductivity, H⁺=Hydrogen, Al³⁺= Alluminium.

Exchangeable Acidity (H and Al)

Average values of the exchangeable acidity in the four soils of Kawara, Gawan Gulbi, Gidan

Bita I and Gidan Bita II were (Al^{3+} 0.54, 0.55, 0.42 and 0.30cmolkg⁻¹) (H^+ 0.40, 0.50, 0.47 and 0.47cmolkg⁻¹) respectively. This indicated

that, Al and H were lower than the exchangeable bases Ca and Mg and also shows that the soils of the study area have relatively negligible amount of acidic cations on the exchangeable complex, therefore, most crops can be cultivated in the soils of the area. However, exchangeable acidity values are generally higher than the Na and K which indicated the neutrality of the soils which is good for agricultural purposes.

Exchangeable Bases

Values of exchangeable bases are presented on Table 5. Calcium were generally low with an average values of 0.70, 0.72, 0.75 and 0.64cmolkg⁻¹ for the Soils of Kawara, Gawan Gulbi. Gidan Bita I and Gidan Bita II respectively. Magnesium had an average value of 1.02, 1.00,1.01 and 0.94cmolkg⁻¹ for the soils of Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II respectively. Sodium and potassium also recorded with very low values in all the horizons. Therefore, the exchangeable bases in the soils were generally low. Similar results were reported for soils of Sokoto by Noma et al. (2004). Calcium and Magnesium were the predominant basic cations in the soils. Similar observations have been made in the past for West African Soils in general (Kowal and Knabe, 1972). The results of this study are also in tune with the findings of Noma et al. (2004); Yakubu, (2006), and Yakubu et al. Therefore, the values of the (2001). exchangeable bases in the soils indicated that, the soils could be used for agricultural activities when the limitations were corrected.

Cation Exchange Capacity (CEC)

Average cation exchange capacity of all the soils of Kawara, Gawan Gulbi, Gidan Bita I and Gidan Bita II in both the upland and lowland were 14.3, 13.2, 12.9 and 11.7cmolkg⁻¹ respectively. Therefore, cation exchange capacity of the soils were generally high according to Esu (1991) rating of < 6 low, 6-12 medium and > 12 high, which causes poor drainage, reduces crop growth and activities of soil organisms which is beneficial in

agriculture. The high CEC values of the soils of the study area could be attributed to the nature of clay minerals (Kaolinite). (Opuwaribo and Odu 1978; Juo and Moorman, 1981; Hassan *et al.* 2011). Yakubu *et al.* (2001) opined that organic matter content of the soils which normally influence the CEC were generally high and therefore, the CEC values may not be attributed to the amount of organic matter.

Base Saturation

Base saturation values ranged from 14% to 16% in all the soils of the study area. Therefore, base saturation were very low in all the soils. This could be due to the washing away of bases by moving water and wind in the soils. The high base saturation values (an average of >50%) is an indication of higher fertility level of the soils, while the low base saturation (an average of <50%) is an indication of low fertility level of the soils (FAO, 1998). The base saturation values in this study indicated that, the soils of this site in both the upland and lowland are infertile and it can be good for agricultural purposes when the limitation was corrected by application of organic material in the soils.

Exchangeable Sodium Percentage (ESP)

Average values of the exchangeable sodium percentage (ESP) for the soils of Kawara.Gawan Gulbi, Gidan Bita I and Gidan Bita II were 20.7, 6.80, 8.60 and 27.8% respectively. The value of exchangeable sodium percentage (ESP) in soils of Kawara and Gidan Bita I were generally above 15% while soils of Gawan Gulbi and Gidan Bita II had values below 15% (Table 5) which is the critical limit for sodicity (Brady and Weil, 2002). The values of sodium in Gawan Gulbi and Gidan Bita I were below threshold value of 13 for sodic soils (Sanda et al., 2007). While Kawara and Gidan Bita II were above the threshold value of 15%. This indicated the neutrality of the soil's sodium percentage which could not affects the cultivation of crops in the study area.

		Depth	Ca	Mg	Κ	Na	CEC	BS	ESP
Pedon	Horizon	(cm)		-		(cm	nolkg ⁻¹)	(%)	(%)
1	Kawara	Typic Endoaquerts							
	Ap	0-10	0.50	0.55	0.31	0.43	13.7	13.1	15.7
	Bt	10-30	0.75	0.40	0.38	0.43	13.7	14.3	15.7
	BC1	30-83	0.65	0.35	0.51	0.40	13.5	14.1	14.8
	BC2	83-160	0.80	0.63	0.50	0.43	15.1	16.0	27.5
	С	160-200	0.80	0.60	0.30	0.47	15.3	14.2	27.1
		Average	0.70	0.51	0.40	0.43	14.3	14.3	20.7
2	Cowon				Hanlia		l f a		
2	Gawan Culhi				парис 1	ruvaqua	<i>JS</i>		
	Ap	0-15	0.95	0.60	0.40	0.30	13.4	16.8	11.1
	Bw	15-46	0.75	0.65	0.31	0.13	13.5	15.5	4.80
	BC	46-143	0.55	0.53	0.21	0.13	12.9	11.1	5.00
	С	143-200	0.66	0.53	0.26	0.17	13.1	12.4	6.50
		Average	0.72	0.58	0.29	0.18	13.2	14.0	6.80
3	Gidan			A	Arenic H	aplustept	5		
	Bita I								
	Ap	0-15	0.55	0.55	0.26	0.13	13.1	11.4	4.90
	Bw	15-45	0.70	0.55	0.33	0.35	13.4	14.4	12.9
	BCg1	45-75	0.70	0.55	0.26	0.35	12.8	14.5	13.5
	BCg2	75-130	0.85	0.53	0.38	0.13	12.8	14.8	5.00
	С	130-200	0.95	0.35	0.38	0.17	12.5	14.8	6.80
		Average	0.75	0.51	0.32	0.23	12.9	14.0	8.60
4	Gidan			G	leyic Ha	plustepts			
	Bita II	0.45	o 4 -		0 -	0.55	10.4	1 - 0	
	Ap	0-17	0.45	0.42	0.51	0.65	13.6	15.0	23.9
	Bt	17-61	0.55	0.53	0.36	0.34	13.2	13.5	12.9
	BCg1	61-110	0.70	0.50	0.38	0.38	12.6	15.5	30.9
	BCg2	110-170	0.55	0.43	0.28	0.26	10.8	14.1	25.5
	С	170-200	0.95	0.25	0.26	0.54	8.1	24.7	45.7
		Average	0.64	0.43	0.36	0.43	11.7	16.6	27.8

Table 4. Values of Exchangeable Bases in the Soils of Magajin Gari District

Key: Ca= Calcium, Mg=Magnesium, Na=Sodium, K=potassium, CEC=Cation Exchange Capacity, BS=Base Saturation, ESP=Exchangeable Sodium Percentage.

Soil Classification-The study soils of the area were classified using USDA Soil Taxonomy (Soil Survey Staff, 2010) and was correlated using World Reference Base (WRB) for Soil Resources (2014).

Soil correlation According to USDA Soil Taxonomy and World Reference Base (WRB) for Soil Resources

The soils of Kawara were classified as *Vertisols* at order level because of the presence of more than 30% clay content in the soils, as well as cracks and swell-shrink properties. It is

classified as *aquerts* at the suborder level because of the aquic moisture regime, redoximorphic features in some horizons (evidenced by mottle colours in the subsurface horizons). It is classified as *Endoaquerts* at the Great group level because of the presence of watertable near the surface, moderately leached and with clay accumulation. At the Subgroup level it is further classified as *Typic Endoaquerts* because it satisfies the conditions of other *aquerts*. It was further classified as Kawara at Series level because it was first identified near Kawara farms.

The soils of Gawan Gulbi was classified as *Alfisols* at order level because of the presence of an argillic horizons. It is classified as *aqualfs* at the Suborder level because of the Aquic

moisture regime. It is classified as *Fluvaqualfs* at the Great group level because it was found in floodpains, moderately leached and with some clay accumulation. At the Subgroup level it is further classified as *Haplic Fluvaqualfs* because it does not satisfy the conditions of other *aqualfs*. It was further classified as Gawan Gulbi at Series level because it was first identified near Gawan Gulbi floodplains.

Table 5: Correlation of Soils between USDA Soil Taxonomy System and World Reference Base (WRB) for Soil Resources of Soils of Magajin Gari District.

Soil Units	Local Name	USDA Soil Taxonomy	World Reference Base
S1P1	Kawara Series	Typic Endoaquerts	Haplic Vertisols (Albic)
S1P2	Gawan Gulbi Series	Haplic Fluvaqualfs	Haplic Luvisols (Siltic)
S2P3	Gidan Bita I Series	Arenic Haplustepts	Arenic Gleysols (Loamic)
S2P4	Gidan Bita II Series	Gleyic Haplustepts	Luvic Gleysols (Loamic)

The soils of Gidan Bita I were classified as Inceptisols at order level because of the presence of one or more pedogenic alteration or concentration with little accumulation of clay translocated materials. It were further classified as Ustept at the Suborder level because of the presence of Ustic Soil Moisture regimes. It is further classified as Haplustepts at Great group level because it does not satisfy the conditions of other Ustepts (Durustepts and Dystrupts). At the Subgroup level it is classified as Arenic Haplustepts because of the presence of sandy texture at 50-100 cm in the soil surface. It was further named as Gidan Bita I Series because it was first identified near Gidan Bita Settlement.

The soils of Gidan Bita II were classified as *Inceptisols* at order level because of the presence of one or more pedogenic alteration or concentration with little accumulation of Argillic materials. It was further classified as *Ustept* at the Suborder level because of the presence of Ustic Soil Moisture regimes. It is further classified as *Haplustepts* at Great group level because it does not satisfy the conditions of other *Ustepts* (*Calciustepts and Dystrupts*). At the Subgroup level it is classified as *Gleyic Haplustepts* because of the presence of *Gleyic* properties throughout and reducing conditions in the soil surface. It was further named as Gidan Bita II because it was first identified near Gidan Bita settlement. There are some redoximorphic features in the soils (evidenced by the presence of mottle colour in some subsurface horizons) which indicated that the soils were poorly drained and there is manganese reduction in the soils.

Classification of the Soils According to the World Reference Base (WRB)

The soils in Kawara were classified as *Vertisols* at the Reference Soil Groups (RSGS) for having a *Vertic* horizon starting less than or equal to 100cm from the soil surface, greater than 30% clay between the soil surface and *vertic* horizon throughout as well as shrink-swell and cracks that starts at the base of a plough layer and at soil surface. At the lower level the soils were classified as *Haplic Vertisols* for having a simple texture of clay loam, *argillic* horizon overlain by silty clay loam and lighter colored Silty clay loam in the subsurface horizons. And (*Albic*) for having an *Albic horizon* Lighter clay accumulation.

The soils in Gawan Gulbi were classified as *Luvisols* at the Reference Soil Groups (RSGs) for having an argillic horizon within two hundred centimeters of the soil surface overlain by loamy sand. At lower level it was classified as *Haplic Luvisols* for having a simple texture of Argilic horizons overlain by silty clay loam in the surface and subsurface horizons. (*Siltic*) with silty texture.

The soils in Gidan Bita I were classified as *Gleysols* at the Reference Soil Groups (RSGS) for having a layer greater than or equal to 25cm thick, and starting less than or equal to 40cm from the mineral soil surface that has gleyic properties throughout, and reducing conditions in some parts of every sublayer. At the lower level the soils were classified as *Arenic Gleysols* for having texture of sandy loam in the 100cm from the soil surface and some physical alteration in the subsurface horizon. (*Loamic*) and with loamy texture.

The soils in Gidan Bita II were classified as *Gleysols* at the Reference Soil Groups (RSGS) for having a layer greater than or equal to 25cm thick, and starting less than or equal to 40cm from the mineral soil surface that has gleyic properties throughout, and reducing conditions in some parts of every sublayer. At the lower level the soils were classified as *Luvic Gleysols* for having an *Argic* horizon starting less than or equal to 100cm from the soil surface. And *(Loamic)* for having a reducing conditions in some parts of the Horizons.

4. Conclusion

In conclusion, the study findings suggest that the soils in Magajin Gari District are suitable for agronomic activities due to their clay loam to clay and sandy loam to sandy clay texture. The pH levels were within the normal range for crop production. The high Cation exchange capacity (CEC) and Porosity levels indicate the soils' effectiveness in supporting crop growth. However, the low levels of Total nitrogen (TN), Organic matter (OM), and Available Phosphorus (AP) in the soils need to be addressed as they contribute to poor crop production in the area. Based on the USDA Soil Survey Staff (2010), the soils in the study area were classified as Vertisols, Alfisols, and Inceptisols. To improve crop production, it is recommended to apply organic manure and phosphate fertilizers, while also avoiding excessive bush burning and land clearing by machineries. Proper maintenance of these practices will be crucial.

References

- Agbu, P.A., and A.G. Ojanuga (1989). Properties and classification of soils of Dange area of Sokoto State, Nigeria. *Samaru Journal of Agricultural Research*, **6**:37-47.
- Blake, G.R., and K.H. Hartge (1986). Bulk density. In Methods of Soil Analysis. Klute A. (Ed). Part I. 2nd ed. Agron. Monogr. 9 ASA and SSSA, Madison, WI. P 363-375.
- Brady, N.C. (1987). *The Nature and Properties* of Soils, 8th edition, Macmillan, New York.
- Brady, N.C. and R.R. Weil. (2002). *The Nature* and Properties of Soils 13th edition, Pearson Prentice Hall inc. Pte. Ltd.Indian Branch, Delhi, India. 976pp.
- Bray, R.H., and L.T. Kurtz. (1945.) Determination of total, organic, and available forms of phosphorus in soils. Soil Sci. 59:39–45.
- Bremmer, J.M. and C.S. Mulvaney (1982). Total nitrogen. In: C.A. Black. (Ed.) *Methods of Soil Analysis*, Part 2, Agronomy 9. American Society of Agronomy Inc. Madison, Wisconsin: pp. 1149-1178.
- Buji, I.B., Okafor, B.N., Adamu, I. and Akinbola, G.E. (2017). Characterization of selected Valley Bottom soils in University of Ibadan Nigerian Journal of Agriculture and Environment, 13 (2) 169-180.
- Donahue, R.L., M.W. Raymond and J.C. Chickluna. (1990). *Soils: An introduction to soils and plant growth.* Prentice-Hall of India. 667pp.
- Esu, I.E. (1991). Detailed Soil Survey of NIHORT FARM at Bunkure, Kano State. A consultancy study project commissioned by the National Horticultural Research Institute, Ibadan, Nigeria. 72 pp.
- FAO (1998). World Reference Base for Soil Resources (FAO, ISRIC, ISSS). World

Soil Resource Reports 84, FAO, Rome, Italy. 161 pp.

- FAO (2006), Guidelines for Soil Description.
 4th ed. Food and Agriculture Organization of the United Nations, Rome, Italy. 07pp.
- Fetter, C.W., (1998). Contaminant Hydrology. 2nd Edn., Prentice Holl, Delhi, India, ISBN-13:9780130802293, pages: 500.
- Foth, H.D., (1990). Fundamentals of soil science, 8th Ed. John Wiley and Sons, Inc., New York, USA. 360p.
- Gupta, P. K., (2004). Soil, plant, water and fertilizer analysis. Shyam Printing Press, Agrobios, India. 438p.
- Hassan, A.M., B.A. Raji,W.B. Malgwi, and J.O. Agbenin (2011). The Basaltic Soils of Plateau State, Nigeria. Properties, classification and management practices. In M.K.A. Adebayo, A.J. Odofin, A.O. Osunde, A. Bala, and S.O. Ojeniyi. Soil Resource Management, Global Climate Change and Food Security. Proceedings of the 35th Annual Conferences of SSSN/Minna, Nigeria. March 7-11, 2011.
- Idoga, S., I.J. Ibanga, and W.B. Malgwi. (2006). Variation in Soil morphological and physical properties and their management implications on а toposequence in Samaru area, Nigeria. In 31st Proceedings of the Annual Conference of Soil Science Society of Nigeria. Ahmadu Bello University, Zaria, Nigeria. November, 13-17.
- ISRIC/FAO (2002). Procedures for Soil Analysis. Sixth edition L.P. Van Reeuwijk (ed). International Soil Reference and Information Centre/Food and Agriculture Organization, 119pp.
- Jones, J.B. (2001). Laboratory Guide for Conducting Soil Tests and Plant Analysis. CRC Press LLC. 363pp.
- Khordebin, S. and A. Landi (2011). Comparison of the land qualitative suitability with the use of FAO method and Ales Model for major crops in Sardasht of Behbahan Khuzestan Province, Iran. *Middle-East Journal of Scientific Research*, 10(4):477-481.

- Kowal, D. and D.J. Knabe (1972). An Agroclimatologically Atlas of the Northern State of Nigeria. Institute of Agric. Res. Samaru Zaria.
- Kparmwang, T. (1993). Characterization and classification of Basaltic Soils in the Northern Guinea Savanna Zone of Nigeria. Unpublished Ph.D thesis. Dept. of Soil Science, ABU, Zaria, 176 pp.
- Landon, J.R. (1991). Booker Tropical Soil Manual. Longman Scientific and Technical Essex, UK. 474 pp.
- Latitude. to (2016).

latitude.to/map/ng/nigeria/cities/gummi# gmapz Accessed on Tuesday 2nd-August, 2016.

- Munsell Colour Company (2009). Munsell Soil Colour Chart. 2009 revised edition. Macbeth Division of Kollmorgen Corporation. Baltimore, Maryland, USA.
- National Population Commission of Nigeria, (2006). National Bureau and Statistics web *Accessed 16/02/2021*.
- Nelson, D.W. and Summers, L.E. (1996). Total carbon, Organic carbon and Organic matter. In: Sparks, D.L. (ed), *Methods of Soil Analysis, Part 3. Chemical Methods No. 5.* ASA and SSSA, Madison, WI. 961-1010pp.
- Noma, S.S., A.G. Ojanuga, S.A. Ibrahim and M.A. Iliya (2004). Detailled Soil Survey of Sokoto Rima Flood Plains at Sokoto, Nigeria. In Salako, F.K., Adetunji, M.T., Ojanuga, A.G., Arowolo, T.A., and Ojeniyi, S.O. (Eds.). *Managing Soil Resources for Food Security and Sustainable Environment*. Proceedings of the 29th Annual Conf. of SSSN/University of Agriculture, Abeokuta, Nigeria. Dec. 6-10, 2004.
- Noma, S.S., I.I. Tanko, M. Yakubu, A.U. Dikko, A.A. Abdullahi and M. Audu (2011). Variability in the physicochemical properties of soils of Dundaye District, Sokoto State, Nigeria. In Hassan, W.A. Kyiogom, U.B. Tukur, H.M. Ipinjolu, J.K. Maigandi, S.A. Singh, A., Ibrahim, N.D., Dikko, A.U., Bashir, Y.A.,

and Muhammad, N. (Eds). *Mobilizing agricultural research towards attaining food security and industrial growth in Nigeria.* Proceedings of the 45th Annual Conference of the Agricultural Society of Nigeria held at the Faculty of Agriculture, Usmanu Danfodiyo University Sokoto, Nigeria. 24th to 28th Oct.

- Odunze, A.C. (2006). Soil properties and management strategies for some subhumid savanna zone Alfisols in Kaduna State, Nigeria. *Samaru Journal of Agricultural Research* 22: 3-14.
- Opuwaribo, E. and C.T.I. Odu (1978). Ammonium fixation in Nigeria Soils: 5 types of clay minerals and relationships with ammonium fixation. *Soil Science Society*, **25**:283-293.
- Peech, M., Cowan, R.L., Baker, G.H. (1962). A critical study of the BaCL₂triethanolamine and the Ammonium acetate methods for determining the exchangeable hydrogen content of soils. Soil Sci. Soc. Proc. 26: 37-40.
- Pidwirny, M.I. (2006). "Soil Classification" Fundamentals of Physical Geography, 2nd Edition. Date viewed, <u>http://University</u> of British Columbia. Okanogan.
- Sanda, A. R., J.O. Ogunwale, K.O. Oluwasemire and B.A Raji (2007). Effects of Drainage Water Recycles and Irrigation Scheduling on Soil Properties and Yield of Tomato under a high water table in Northern Nigeria. In Oyobisere E.O., B.A. Raji, A.A. Yusuf, J.O. Ogunwale, L. Aliyu and S.O. Ojeniyi (Eds). Soil and water management for puberty alleviation and sustainable environment. Proceeding of the 31st annual conference of SSSN/ABU, Zaria, Nigeria. Nov. 11th to 17th, 2006.
- Scheoeneberger, P.J., D.A. Wysocki, E.C. Benham., W.D. Broderson (2002). Field Book for Describing and Sampling Soils, Version 2.0. National Soil Survey Center, Natural Resource Conservation Service, U.S. Department of Agriculture, Lincoln, NE.

- Soil Survey Staff (2010). Keys to Soil Taxonomy. 11th Edition. USDA-NRCS, Washington, DC. 338pp.
- Soil Survey Staff (2014). Keys to Soil Taxonomy: 12th edition. USDA-Natural Resources Conservation Service, Washington, DC. 360pp.
- Sombroek, W.G., and I.S Zonneveld (1971). Ancient Dunes Fields and Fluviatile Deposits in the Rima Sokoto River Basin Soil Survey Paper No.5, Netherland Soil Survey Institute, Wageningen, 109 pp.
- Teshome, Y., G. Heluf, K. Kibret, B. Sheleme (2013). Impacts of Land Use on Selected Physicochemical Properties of Soils of Abobo Area, Western Ethiopea. *Agriculture, Forestry and Fisheries*. Vol. 2, No.5, 2013 pp. 177-183.
- USDA-NRCS (2005). National Soil Survey Handbook, Title 430-VI. (Online), Available at http://soils .usda.gov/technical/handbook (accessed 30 DA-NRCS, Lincoln, NE.
- Van Wambeke, A.R. (1962). Criteria for classifying tropical soils by age. *Journal* of soil sci. 13:124-132.
- Yakubu, M. (2001). Survey, Classification and Genesis of soils of Kalambaina area, Sokoto State, Nigeria. M.Sc. Thesis, Department of Soil Science and Agricultural Engineering, University of Agriculture, Abeokuta (Unpublished).
- Yakubu, M. (2006). Genesis and classification of soils over different geological formations and surfaces in the Sokoto plains Nigeria. Ph.D Thesis. Soil science and Agricultural Engineering Department, Usmanu Danfodiyo University Sokoto (Unpublished)
- Zamfara Agricultural and Rural Development Authority (ZARDA), (2015). Meteorological Data from Planning Monitoring and Evaluation Section (PME) Gummi.