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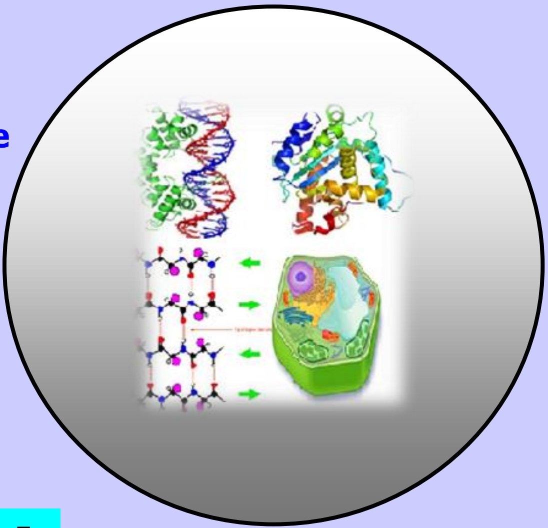

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RESEARCH PAPER

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Evaluation of Selected Floodplain Soils of Wukari Local Government Area of Taraba State, Nigeria for Sustainable Arable Cropping

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ABSTRACT

Floodplain soils have potentials for sustainable agricultural production. This study was carried out to evaluate the suitability of five floodplain soils in Wukari Local Government Area of Taraba state, Nigeria using Fertility Capability Classification (FCC).The results showed that the soils of the Wukari Floodplains are generally clay loam. Both the particle and bulk densities as were as porosity were moderate. The water holding capacity being high and the soil colour predominantly dark yellowish brown. The soil show very slight acidic reactions but fertility is generally moderate (Low EC, moderate organic matter content, moderately low total nitrogen, moderate available phosphorus, low exchangeable K, moderate to low exchangeable Ca, low exchangeable Mg and low exchangeable Sodium). The exchangeable acidity is moderate and CEC is low. The most important constraint of crop production is low chemical fertility. This constraint can be alleviated by the use of mulching and other natural products (bio fertilizers) to enhance nitrogen and phosphorus availability. This study has demonstrated the relatively moderately high potentials of Wukari flood plains, which can be harnessed to relieve some of the pressures on upland soils, which are being rapidly degrade. Rice is recommended to be grown in the area since it is known to tolerate relatively acid condition.
Key words: Floodplain, sustainable, Arable and Wukari.

INTRODUCTION

Sustainable agriculture has been defined as a practice that involves the successful management of resources for the agriculture to satisfy human needs, while maintaining or enhancing the quality of the environment and conserving natural resources (Spencer and

Swift, 1992).Within this context, the tropical regions of the world face interrelated problems dealing with per capita food production and progressive deterioration of the environment. Recent years have seen a dramatic increase in per capita food production in some areas of the tropics. This improvement is based mainly on the introduction of new crop varieties on fertile soils, well supplied with water, fertilizers and pesticides (Spencer and Swift, 1992). In large parts of the tropics however and particularly those with less fertile soils, the per capita food production has actually been declining during the past 20 years (FAO, 1989). In Nigeria, agricultural productivity and total animal food and the fibre production is poor and much below expectation. It has been observed that while population has been growing steadily at 2.8%, food production records a mere 1.5% growth per annum (Ano, 1996). Nigeria had depended so much on land expansion as a strategy for increasing food production leaving the potentials of the wetlands untapped. This has led to the rapid degradation of the uplands (Turner, 1991). Opening up and efficient management of floodplains offers an acceptable alternative for sustainable food production in Nigeria, (Ano, 1996, Ojanuga, 2006a).Studies have shown that Nigeria has started exploiting the resources of her wetlands or seasonally damp or flooded lands for agricultural production (Singh, 1997). The establishment of the National “Fadama” Development Programme tried to develop most wetlands of the country through drilling of wells and provision of motorized irrigation pumps (Sangari, 1995). One of such wetlands area proposed to be developed include wetlands of Wukari LGA particularly flood plains such as Chinkai, Tsokundi, Gidin-Dorowa, Bantaje and Jibu. The floodplain soils of Wukari Local Government Area over the years are being used commonly for the growing of paddy rice and sugarcane under rain fed condition. The available information on soils resources utilization and potentials in the study area is scanty. This study therefore, was carried out to evaluate the suitability of five floodplain soils in Wukari Local Government Area of Taraba state, Nigeria using Fertility Capability Classification (FCC).

MATERIALS AND METHODS

The study was carried out in Wukari Local government Area of Taraba state, Nigeria. Five floodplains namely: Chinkai, Tsokundi, Gindin-Dorowa, Bantaje, and Jibu were identified from the baseline survey of hydrogeology and soils of Taraba state ar (Figures 1 and 2). Wukari local government area lies on latitude 7^0 51' N and longitude 9^0 47' E. Total land area is 4,308 km^2 (1,663.3 Sq miles) and total Population (2006 census) is 241,546. Wukari local government area is located in Northern guinea savannah agro ecological zone of Nigeria and has two distinct seasons; wet and dry. The wet season starts from April and ends in October with mean bannual rainfall of 1300 mm and mean air temperature of 28.

Soil samples were collected from each floodplain at 0-15cm depth . Each of the sites was partitioned using the half hectare grid method and samples were collected from each half hectare of the various sites and bulked to a total of fifty (50) composite samples for analysis (Ten composite samples from each of Chinkai, Tsokundi, Gindin-Dorowa, Bantaje, and Jibu floodplains).All the samples were air-dried, ground and pass through 2mm sieve mesh and for analysedThe soil colour was determined using munsell colour chart.The particle-size distribution was determined using Bouyoucous hydrometer method (Trout et al, 1987).

The bulk density was determined by the core Method (Fuller and Warrick, 1985). Particle density (D_p) of the soil was calculated using the equation;

$$D_p = \frac{mass\ of\ dry\ soil}{volume\ of\ solids}$$

Soil porosity was calculated from the soil densities; bulk and particle densities using the equation;

$$Porosity, \% = 1 - \frac{Bulk\ density}{\text{Particle density}}$$

Water holding capacity was determined as gravimetric water content of a quantity of soil fully saturated with water. It was determined using porous cup method as follow:

$$\text{Water holding capacity} = \frac{mass\ of\ water\ in\ saturated\ soil}{mass\ of\ saturated\ soil} \times 100\%$$

Soil pH was determined in water and in 1NKCI suspension at a ratio of 1.1 using Beckman Zero metric pH meter. The Electrical conductivity (EC) was determined alongside pH (soil water suspension) using Cole and Parmer 1.500-10EC meter.Total Nitrogen was determined by the macrokjedahl method by Jackson (1962).The organic carbon content was determined by Black (1965) potassium dichromate wet oxidation method. The organic matter in the soil was determined according to Black, 1965 as;$\%\ Organic\ matter = \%\ Organic\ carbon \times 1.729$. Available Phosphorus was determined using the conventional (Brady and Kurtz, 1984) method.

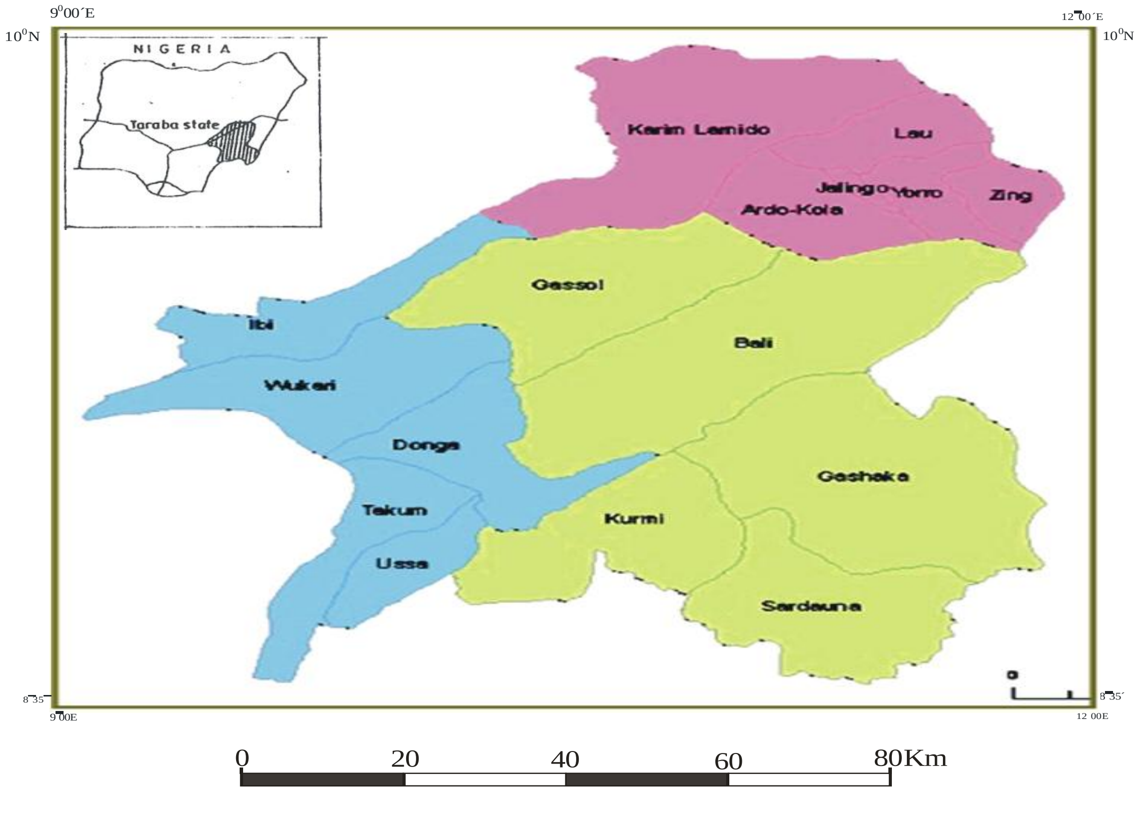

Figure 1. Map of Taraba State showing Wukari Local Government Area

Source: (TSMEUD, 2012)

Exchangeable calcium (Ca) and magnesium (Mg) were determined by the EDTA titration method. While potassium (k) and sodium (Na) were determined by flame photometry (Black, 1965). Exchangeable Acidity was determined by titration method. Cation Exchange Capacity (CEC), Percentage Base Saturation (% BS), Sodium Absorption Ratio (SAR), Exchangeable Sodium Percentage (ESP) and C-N Ratio were all determined by mathematical expression in form of formula as follows:

i. Cation exchange capacity(CEC) $= TEB + TEA$
ii. Percentage base saturation, % BS;$= \frac{Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}}{CEC} \times 100$
iii. Sodium absorption ratio (SAR)$= \frac{Na^{+}}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}}$
iv. Exchangeable sodium percentage$(ESP) = \frac{Exchangeable\ \ Na}{CEC} \times 100$
v. C-N ratio; $= \frac{Organic\ \ carbon}{Nitrogen}$

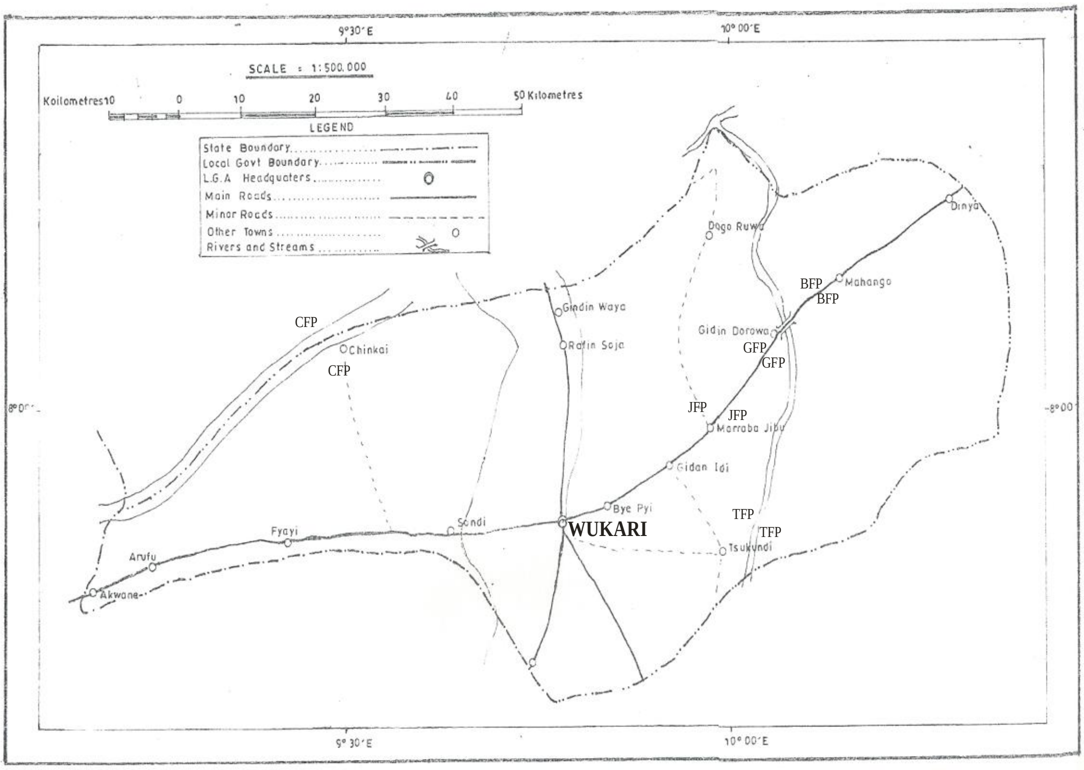

Figure 2. Map of Wukari Local Government Area showing Floodplain Areas.

Source: (TSMEUD, 2012)

JFP = Jibu Floodplain
CFP = Chinkai Floodplains
BFP = Bantaje Floodplains
TFP = Tsokundi Floodplains
GFP = Gidin-Dorowa Floodplain

The statistical analysis follows a one-factor effect in a Completely Randomized Design (CRD) with ten observations (treatments) per experimental unit. All data collected were subjected to analysis of variance (ANOVA) to test for significant effects at 95 % confidence limit using the procedure recommended by Steel and Torrie (1980). When significant difference was observed, treatment means were separated using the F-LSD. The Fertility Capability Classification developed by Buol (1972) and later modified by Sanchez et al., (1982) shown in Table 1 was further used in evaluating the soils for sustainable arable cropping.

Table 1. Critical limits for interpreting levels of analytical parameters

Parameter	Low	Medium	High
Ca^{2+} ($CMol_{(+)}$ Kg^{-1})	<2	2 – 5	>5
Mg^{2+} ($CMol_{(+)}$ Kg^{-1})	< 0.3	0.3 – 1	>1
K^{+} ($CMol_{(+)}$ Kg^{-1})	< 0.15	0.15 – 0.3	>0.3
Na^{2+} ($CMol_{(+)}$ Kg^{-1})	< 0.1	0.1 – 0.3	>0.3
CEC ($CMol_{(+)}$ Kg^{-1})	< 6	6 – 12	>12
Org. C (gKg^{-1})	< 10	10 – 15	>15
Total N (gKg^{-1})	< 0.1	0.1 – 0.2	>0.2
Avail. P. ($mgKg^{-1}$)	< 10	10 – 20	>20
B. S (%)	<50	30 – 80	>80

Source: Esu (1991)

RESULTS

Soil Physical Properties

The data on physical properties of the Wukari floodplains soils is shown in Table 2. The mean values for sand, silt and clay in the surface (0 – 15cm) soils for Chinkai floodplains were 35.1, 27.5 and 37.4 percent respectively, and the percent sand silt and clay for Tsokundi floodplains were 34.0, 29.6 and 36.4 respectively, while for Jibu floodplains mean values recorded are 39.3, 24.7 and 36.4 respectively. The soils were predominantly evidently, clay loam (mean for sand silt and clay are: 36.18, 27.18 and 36.4 respectively) at the surface layer and the dominant soil colour was dark brown, this soils were probably derived from colluviums/alluvium quaternary (recent geological) parent materials (Ogban and Ibia, 1998). The soil become sticky and plastic during the wet season and hard, crusty and difficult to work during the dry season, therefore, excellent rice soil but may pose severe constraints and poor seedbed to the cultivation of upland rice.

The characteristic high clay texture may, however, be modified by large application of organic materials (Spencer and Swift, 1992). Clay and organic matter of the soil is dominantly dark yellowish brown. This can be attributed to the constant water logging of the soil resulting from seasonal flooding, this agree with the findings of Issaka *et al* (1996), that water logged soil are usually dark yellowing brown in colour due to accumulation of organic matter transported and deposited by the flood water. Yang and Wander (1999) reported that organic matter has effect on the soil colour, from brown to black pedons exhibit a strong structure forming depositions.

There was a significant difference in the particle density and water holding capacity of Wukari flood plain soils. However, there was no significant difference in the bulk density and porosity of Wukari flood plain soils. The particle density of the Wukari Floodplains is moderate (2.52g/cm^3) which proves that it is a mineral soil probably high in organic matter, this agree with Brady (1988), who reported that the average arable minerals soils of high organic matter may be considered to have a particle density of 2.4 to 2.5g/cm^3. The bulk density is also moderate (1.31g/cm^3). These values also agree with Brady (1988) that density of clay loam surface normally ranged from 1.00 to 1.60g/cm^3. The porosity (47.79%) and water holding capacity (81.52) showed that the soils have fairly high water holding capacities. These values agree with the findings of Issaka *et al* (1996) that fine textured soils with high organic matter have moderate total porosity and so have high water holding capacity.

Table 2. Physical Properties of selected Wukari Floodplain Soils.

Location	Sand	Silt	Clay	Texture	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	Porosity	WHC (%)
CFP	35.1	27.5	37.4	Clay loam	1.30	2.50	46.44	80.8
BFP	34.8	28.5	36.7	Clay loam	1.32	2.52	47.47	76.1
TFP	34.0	29.6	36.4	Clay loam	1.30	2.51	48.3	83.4
GFP	37.7	25.6	36.7	Clay loam	1.29	2.50	48.48	83.5
JFP	39.3	24.7	36.0	Clay loam	1.33	2.58	48.19	83.8
Mean	36.18	27.18	36.64	Clay loam	1.31	2.52	47.19	81.52
Significance					NS	*	NS	*
FLSD $_{(0.05)}$						0.0031		5.83

CFP = Chinkai Floodplains TF= Tsokundi Floodplains JFP= Jibu Floodplains
BFP = Bantaje Floodplains GFP= Gidin-Dorowa Floodplains

Soil Chemical Properties

Tables 3and 4 shows mean values of chemical properties of wukari floodplains soils. There was a significant difference in the pH, total exchangeable acidity, electrical conductivity, C-N Ratio , magnesium content and cat ion exchange capacity of Wukari flood plain soils. However, there was no significant difference in organic carbon, organic matter, total nitrogen content , available phosphorus content, calcium content, potassium content , sodium content , exchangeable bases , percentage base saturation, exchangeable sodium percentage and sodium absorption ratio of Wukari flood plain soils.

The pH of the surface soils was very slightly acidic (pH6.69). Esu *et al* (1991) rated such soil pH as very slightly acidic. This indicates slight tendency towards acidity build-up. Exchangeable acidity of 4.79 indicates moderate values as suggested by soil pH of 6.69 for the surface during recent year, the EC (in mS/cm) for the surface soils have a mean value of 1.28. This value suggests no salinity risk to these soils since none of the values is up to 4mS/cm, the limits set by US.The Nitrogen content (0.165%) of the Wukari Floodplains is low but slightly higher than the values obtained in some irrigated lands. The low nitrogen content in these soils could probably be due to the continuous leaching as a result of the seasonal flooding and the resultant anaerobic conditions during the flooding. Rendig and Taylor (1989) as cited by Usman and Abdulmumuni (1998) reported that nitrogen mineralization under anaerobic condition does not proceed through the ammonium stage which is subsequently lost as a gas to the atmosphere. Similarly, if crop rotation involving legumes is adopted, the productivity of the soils can be maintained on a sustainable basis.Organic carbon is moderate (1.51%). This may be due to seasonal flooding of the areas, which results in anaerobic conditions hindering the complete decomposition of organic matter (Rendig and Taylor, 1989).The available phosphorus content of these soils is moderate with a mean value of 16.51mg/kg. These values are below the values recorded for Borno State (Turner, 1991) and Lake Geriyo (Usman and Abdulmumuni, 1998) which are also semi-arid environments. These moderate values may be due to the fact that phosphorus is characteristically immobile, and tend to remain fixed at the surface. Leaching has little or no effect on phosphorus availability and so is clay. Exchange calcium values were low 4.5 Cmol (+)/kg at the surface of the Wukari Floodplains. The values of exchangeable magnesium (0.81cmol $(^+)$/kg) were also low. These low values of calcium and magnesium could be due to the leaching of basic cations. Exchangeable sodium and potassium values were also low. All the exchangeable bases of these soils are rated as low. The low values all correspond to the values reported for Bakolori Irrigation project, Zamfara State (Graham and Singh, 1997), which are soils of sem-arid regions. This indicates that these soils are slightly saturated with bases and should be managed carefully to avoid acidity development. Issaka *et al* (1996) reported that the floodplains of Sudan Savannahs tends to have low to moderate exchangeable cations which also agrees with foth (1990), who observed that exchangeable cations are low to moderate in wet lands.Cation exchange capacity of these soils are low with a mean value of 10.69 cmol (+)/kg. This value is very low. The mean values of 14.6cmol (+)/kg of soils reported by Usman and Abdulmumuni (1998) for semi-arid soils of Borno State. This low values could be attributed to the moderate level of exchangeable basic cations. Also fine textured soils have moderate values of CEC. As Brady (1988) puts it, textural groups and the amount and kind of clay influences CEC. When CEC was correlated with clay, the result shows less correlation between them (R^2=17% at P=0.5), that mean clay has little effect on the values of CEC. However, the correlation between CEC, organic matter and pH shows less correlation. The CEC of these soils is low thereby requiring appropriate soil management steps to be employed, if applied fertilizers are to benefit crops. If the bases are leached out, the buffering capacity of the soil will be lowered with a rapid change in pH resulting in soil acidity which can be detrimental to crop production. The percentage base saturation for the surface soils are 56.72%. This value is moderate in view of criteria for determining critical limits of parameters in soil (Table 5).

Table 3. Chemical Properties of Wukari Floodplain Soils.

Location	pH (H_2O) OC (%)	OM (%) Total N (%)	C:N Ratio TEA	EC (mS/cm) ESP	**SAR** **%BS**	TEA	EC (mS/cm)
CFP	6.79 1.42	2.74 0.180	9.55 5.1	1.22 2.02	0.14 53.8	5.17	1.22
BFP	7.04 1.47	2.54 0.125	11.95 4.72	1.28 2.37	0.16 52.71	4.72	1.28
TFP	6.40 1.56	3.97 0.127	12.57 4.45	0.77 2.27	0.14 57.12	4.45	0.77
GFP	6.56 1.55	2.68 0.117	13.31 4.50	1.77 2.07	0.14 56.58	4.50	1.77
JFP	6.64 1.56	2.69 0.230	12.26 5.11	1.38 2.16	0.13 63.39	5.11	1.38
Mean	6.69 1.51	2.92 0.165	11.95 4.79	1.28 2.18	0.14 56.72	4.79	1.28
Significance	*	NS NS	* *	* NS	NS NS	*	*
FLSD $_{(0.05)}$	0.149		5.22 0.435	0.155		0.435	0.155

*- significant at 5 %; NS - not significant at 5 %
CFP = Chinkai Floodplains TF = Tsokundi Floodplains JFP=Jibu Floodplains
BFP = Bantaje Floodplains GFP = Gidin-Dorowa Floodplains

Table 4. Chemical Properties of Wukari Floodplain Soils.

Location	Cmol (+)/kg					
	Ca^{2+}	Mg^{2+}	K^+	Na^+	TEB	CEC
CFP	4.7	0.83	0.28	0.23	6.04	11.32
BFP	4.1	0.73	0.27	0.23	6.23	10.81
TFP	4.5	0.81	0.28	0.24	5.83	10.15
GFP	4.7	0.81	0.28	0.22	6.01	10.65
JFP	4.3	0.86	0.32	0.21	6.69	10.54
Mean	4.5	0.81	0.29	0.23	5.88	10.69
Significance	NS	*	NS	NS	NS	*
FLSD $_{(0.05)}$		0.01				0.716

*- significant at 5 %; NS - not significant at 5 %
CFP = Chinkai Floodplains
BFP = Bantaje Floodplains
TFP = Tsokundi Floodplains
GFP = Gidin-Dorowa Floodplains
JFP = Jibu Floodplains

Table 5. Summary of Critical limits ratings of the analysed chemical parameters of Wukari floodplain soils

Parameter	Low	Medium
Ca^{2+} ($CMol_{(+)}$ K g^{-1})		**M**
Mg^{2+} ($CMol_{(+)}$ K g^{-1})	**M**	
K^{+} ($CMol_{(+)}$ K g^{-1})		**M**
Na^{2+} ($CMol_{(+)}$ K g^{-1})		**M**
CEC ($CMol_{(+)}$ K g^{-1})		**M**
Org. C (gKg^{-1})		**M**
Total N (gKg^{-1})		**M**
Avail. P. ($mgKg^{-1}$)		**M**
B. S (%)		**M**

CONCLUSION

The results showed that the soils of the Wukari Floodplains are generally clay loam. Both the particle and bulk densities as were as porosity were moderate. The water holding capacity being high and the soil colour predominantly dark yellowish brown. The soil show very slight acidic reactions but fertility is generally moderate (Low EC, moderate organic matter content, moderately low total nitrogen, moderate available phosphorus, low exchangeable K, moderate to low exchangeable Ca, low exchangeable Mg and low exchangeable Sodium). The exchangeable acidity is moderate and CEC is low.The most important constraint of crop production is low chemical fertility. This constraint can be alleviated by the use of mulching and other natural products (bio fertilizers) to enhance nitrogen and phosphorus availability. This study has demonstrated the relatively moderately high potentials of Wukari flood plains, which can be harnessed to relieve some of the pressures on upland soils, which are being rapidly degrade. Rice is recommended to be grown in the area since it is known to tolerate relatively acid condition.

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