FERTILITY CAPABILITY CLASSIFICATION OF SOILS OF OGBESE RIVER FLOODPLAIN, SOUTHWEST NIGERIA

***Fasusi, O. M., Amusan, A. A., Ojetade, J. O. and Muda, S. A.**

Department of Soil Science and Land Resources Management,
Faculty of Agriculture, Obafemi Awolowo University, Ile-Ife, Nigeria.
*fasusiolakiitan@yahoo.co.uk

ABSTRACT

The potentials of wetlands have remained relatively untapped and under-utilized in rural West Africa as a result of the neglect of most of the floodplain soils due to absence of useful pedological information on them over the years. Therefore, the objective of this study is to evaluate the Fertility Capability Classes of floodplain soils in the upper basin of Ogbese river. The study was conducted at Ogbese in Akure North Local Government Area of Ondo State, Southwest Nigeria. Nine soil profile pits were dug and described along three transects (i.e. upper reach, middle reach and lower reach) within the floodplain. Soil samples were collected from pedogenic horizons for laboratory analyses of physical and chemical properties that are directly related to plant growth following standard procedures. The results showed that six FCC dominated the floodplain. SLke characterized by sandy topsoil, loamy subsoil, low nutrient capital reserve and high leaching potential; SLgke characterized by sandy topsoil, loamy subsoil, gleying, low nutrient capital reserve and high leaching potential; Lke characterized by loamy topsoil and subsoil, low capital nutrient reserve and high leaching potential. Ske characterized by sandy topsoil and subsoil, low capital nutrient reserve and high leaching potential; LCke characterized by loamy topsoil, clay subsoil, low nutrient capital reserve and high leaching potential; LCgke characterized by loamy topsoil, clay subsoil, gleying, low nutrient capital reserve and high leaching potential; SLgke, LCke and LCgke classes had higher potential for high yield in arable crop production than other classes in the study area.

Keywords: condition modifier, fertility classes, floodplain soils, soil classification and soil constraints.

INTRODUCTION

It has been observed thatcultivation of tropical soils has been on the increasing side in order to meet the requirement for food and fibre of a rapidly expanding population (Osei and Okusami, 1994). Arable land for increased food production is a very important resource to be considered (Udo *et al.*, 2009). Agricultural production in most sub-Saharan countries is under threat due to declining soil fertility (Tabi *et al.*, 2013). According to Mutsaers (1990), one of the major problems confronting farmers in Nigeria is poor soil fertility replenishment strategy that could allow for a sustainable agricultural productivity. Furthermore, Okusami *et al.* (1987) and Fasina *et al.* (2005) observed that the major factor limiting the growth and development of agriculture in the tropics especially in Nigeria is the lack of detailed information and adequate knowledge of the soil and land characteristics. Therefore, a thorough understanding of the processes of soil formation and soil physical and chemical properties in relation to its fertility is important for optimum utilization of available soil resources for agriculture (Delgado and Gomez, 2016). According to Raju *et al*. (2005), the inherent ability of soils to supply nutrients for crop growth and the maintenance of soil physical conditions to optimize crop yields are the most important components of soil fertility that virtually determine the productivity of agricultural systems. Thus, a good knowledge of the soil resources of any given territory is indispensable for planning its agricultural development (Sangita, 2015). In sub-Saharan Africa, wetlands are estimated to cover 228 million ha (Adigbo *et al.*, 2011). Unfortunately, in rural West Africa, only less than 10% of an estimated 55 million ha of wetlands are currently being used for agriculture which is an indication that the potentials of wetlands have remained relatively untapped and under-utilized (Ogban and Babalola, 2009; Adigbo *et al.*, 2011). Fertility of most of our upland soils is fast reducing due to continuous cropping of the limited available land for agriculture hence the need to explore floodplain soils. The Fertility Capability Soil Classification (FCC) is a technical system for grouping soils according to the kind of problems they present for agronomic management, though it was developed for upland soils, FCC was extended to wetland soils by Sanchez and Buol (Buol, 1986; Sanchez 1997 and Adhikary *et al.*, 2010). It focuses quantitatively on the physical and chemical properties of the soil that are crucial to soil fertility management (Sanchez *et al*., 1982). It emphasizes quantifiable topsoil parameters as well as subsoil properties directly relevant to plant growth and yield performance (Sanchez *et al.*, 2003). Existing works on river floodplain have been on the fertility status and potentials of these soils. However, absence of useful pedological information on floodplain soils over the years contributed to the neglect of most of the floodplain soils. In this regard, the objective of this study is to evaluate the FCC of floodplain soils in the upper basin of Ogbese River, Ogbese, Akure North Local Government Area, Ondo State, Nigeria with a view to evaluating its fertility status and increasing food production in the area.

MATERIALS AND METHODS

Study site

The study was conducted in Ogbese, Ondo State, Southwest Nigeria. The area lies between Latitudes 7˚ 17.053 N and 7˚ 17.059 N and Longitudes 5˚ 12.558 E and 5˚ 12.564 E in the rain forest zone with a mean annual rainfall of about 1800 mm. The atmospheric temperature ranges between 27 ˚C and 31˚C with a mean annual relative humidity of about 80 per cent. The soils are mainly formed from alluvial deposits. There is a riparian forest which forms a boundary between the floodplain and Ogbese River. The area is intensively cultivated to varieties of crops such as rice (*Oryzasativa*), sugarcane (*Saccharumofficonarum*), maize (*Zea mays*), cowpea (*Vignaunguiculata*), cassava (*Manihotesculenta*), oil palm (*Elaeisguineensis*) and vegetables which include okra (*Abelmuscusesculenta*), water leaf (*Talinumtriangulare*), amaranth (*Amaranthusvirides*), fluted pumpkin (*Telfairiaoccidentalis*) and field pumpkin (*Curcubita pepo*). Grasses such as elephant grass (*Pennisetum purpureum,*), giant star grass (*Cynodonplectostachyus*), siam weed (*Chromolaenaodorata*), goat weed (*Ageratum conyzoides*) and clusters of bamboo (*Bambusa vulgaris*) and shrubs are common plants in the study area.

Field work

Nine modal profile pits were dug along three transects i.e. upper, mid and lower reaches (about 300 metres apart). The soil profile pits were described following FAO (2006) guidelines for soil profile description and horizon designation of the Soil Survey Staff. Soil samples were collected from both the surface and subsurface horizons for laboratory analyses. The distances between the profile pits were also measured and recorded. Collected soil samples were air dried, sieved and their physical and chemical characteristics were analysed as per standard procedures (Black, 1965).The soils were evaluated for the fertility constraints using the fertility capability classification (FCC) system developed by Buol, Sanchez and co-workers (Buol *et al*., 1975), consisting of three levels: Type, sub-strata type and condition modifiers as shown in Tables 1 and 2. The morphological data and laboratory analyses results were compared with criteria for identifying fertility capability classes (i.e. types and substrata type with condition modifiers). The FCC mapping unit was formed by the combination of the class designation from the three classification levels.

TABLE 1: Types and substrata types of the FCC system

FCC textural class	Symbol	Meaning
Type: Texture is the average of plough layer		
or 0 to 20cm depth whichever is shallower	S	Sandy topsoil: loamy sands and sands
	L	Loamy topsoil: < 35% clay
	C	Clayey topsoil: > 35% clay
Substrata type: used if textural change is		
encountered within top 50 cm	S	Sandy subsoil: texture as in type
	L	Loamy subsoil: texture as in type
	C	Clayey subsoil: texture as in type
	R	Rock or other root-restricting layer within 50 cm
	R^-	As above but layer can be ripped, plowed or blasted to increase rooting depth

Source: Sanchez *et al*. (2003)

TABLE 2: Criteria for identifying the FCC system modifiers

Modifier	Symbol	Definitions and some interpretations
Modifiers related to soil physical properties		
Waterlogging (gleying):	g	Aquic soil moisture regime; mottles < 2 chroma within 50 cm for surface and below all A horizons or soil saturated with water for > 60 days in most years.
	g^+	Prolonged waterlogging; soil saturated with water either naturally or by irrigation for > 200 days/ year with no evidence opf mottles indicative of Fe^{3+} compounds in the top 50 cm; includes paddy rice soils in which an aerobic rice crop cannot be grown without drainage; continuous chemical reduction can result in slower soil N mineralization and Zn deficiencies in rice.
High erosion risk:	SC, LC, CR, LR, SR,>30%	Soils with high erodibility due to sharp textural contrasts (SC, LC), shallow depth (R) or steep (> 30%) slope.
Modifiers related to soil reaction		
Aluminium toxicity:	a	When > 60% Al saturation within 50 cm or < 33% base saturation of CEC (BS_7) determined by sum of cations at pH 7 within 50 cm or < 14% base saturation of CEC ($BS_{8.2}$) by sum of cations at pH 8.2 within 50 cm or pH < 5.5 except in organic soils (O)
	a^-	10 to 60% Al saturation within 50 cm for extremely acid-sensitive crops such as cotton and alfalfa
Salinity:	s	When > 0.4 sm^{-1} of saturated extract at 25°C within 1 m; salic groups; solonchaks
	s^-	0.2 – 0.4 sm^{-1} of saturated extract at 25°C within 1 m (incipient alkalinity)
Alkalinity:	n	When > 15% Na saturation of ECEC within 50 cm; most solonetz
	n^-	6 to 15% Na saturation of ECEC within 50 cm (incipient alkalinity)

Source: Sanchez et *al*. (2003)

TABLE 2: Criteria for identifying the FCC system modifiers (Cont'd)

Modifier	Symbol	Definitions and some interpretations
Low nutrients capital reserves (K deficiencies):	k	When < 10% weatherable minerals in silt and sand fractions within 50 cm or siliceous mineralogy, or exchangeable K < 0.20 $cmol_cKg^{-1}$ soil or exchangeable K < 2% of sum of bases, if sum of bases is < 10 $cmol_cKg^{-1}$ soil.
Cracking clays (vertic properties): very sticky plastic clay, severe topsoil shrinking and swelling.	v	> 35% clay and 50% of 2:1 expanding clays or coefficient of linear expansibility > 0.09 or vertisols and vertic groups.
High leaching potential (low buffering capacity, low ECEC):	e	< 4 $cmol_cKg^{-1}$ soil as ECEC or < 7 $cmol_cKg^{-1}$ soil by sum of cations at pH 7 or <10 $cmol_cKg^{-1}$ soil by sum of cations + Al^{3+} + H^+ at pH 8.2.
Modifier related to soil biological properties		
Low organic carbon saturation (Soil organic matter depletion, C sequestration potential):	m	80% total organic C saturation in the topsoil compared with a nearby undisturbed or productive site of the same soil, which is equal to 100% or < 80% 333mM $KMnO_4$-extractable topsoil organic carbon saturation compared with a nearby undisturbed or productive site of the same soil which is equal to 100%.

Source: Sanchez *et al.* (2003)

RESULTS AND DISCUSSION

The morphological data and results of the soil analyses are presented in Tables 3 and 4 below. The soils had constraints of gleying (g), low nutrient capital reserve (k) and high leaching potential (low ECEC) (e).

Gleying (g) at the lower reach

The study revealed that water logging is one of the constraints to crop production in the floodplain soils of Ogbese River. Soils in the lower reach of the study area are poorly drained especially during the raining season, thereby affecting their overall usefulness for crop production. This is in line with Ojanuga and Lekwa (1984), who observed that waterlogging is a key feature that tends to reduce maximum utilization of wetland soils for crop production. According to (Sanchez *et al*. 1982), wetland soils have been associated with environmental hazard such as the release of harmful gases like methane and nitrous oxide into the atmosphere. Also, prolonged submergence has been found to result in Zn deficiency and H_2S toxicity if the soil is high in organic matter (Minh, 2011). Gleying takes place when conditions of a periodic or permanent excess of water occur in soil. This is otherwise known as waterlogging. In conditions of anaerobic environment, the reduced forms of iron and manganese are soluble, so they can be displaced to impart greenish, bluish and purple colours on soils. Surfaces of peds and linings of pores become reduced under water-logged conditions, producing the grey colour that contrasts with the mottled unreduced ped interiors (Umeugochukwu, 2009). It was observed from the study that waterlogging is a major constraint to the use of the soils of the lower reach area of the study site for all year round agricultural production. However, waterlogging raises the level of available phosphorus in flooded soil (Udo *et al.*, 2009). This makes it very suitable for growing paddy rice (Olaleye, 1998). Field drains, making of mounds, planting of water logged resistant plants and dry season farming such as planting of vegetables could help to increase the productivity of the soils.

Low nutrient capital reserve (k)

This is another agronomic constraint in the study area. According to (Sanchez *et al.* 2003), there are two major sources of plant nutrients supplied by the soil. First, is the dissolution of primary or weatherable minerals which contains the phosphorus, potassium, calcium, magnesium and micronutrients in sand and silt fractions of soils. The other source is the decomposition and mineralization of organic matter (which contains all the nitrogen and much of phosphorus and sulphur) in soils. The low levels of exchangeable bases and effective cation exchange capacity (ECEC) at the upper reach (upland part of the area) compared to the lower reach in the studied soils could be attributed to leaching of basic cations which is very prevalent in the area (Eze, 2015). Low K^+ reserve in sandy soils has been widely reported in many literatures which consequently had led to low yield especially in grains and tuber crops (Udo *et al.*, 2009; Minh, 2011). IFPRI (1999), reported higher loss of K^+ to occur in wetlands. The low availability of exchangeable K^+ and other basic cations may be caused by heavy rainfall leading to leaching at both the upper and middle reaches of the study area (Babalola *et al.*, 2011). The sandy texture of pedons 2, 5 and 7 at the mid reach explains why the soils have low K^+ reserves and low ion exchange capacity (Edem, 2007; Udo *et al*., 2009 and Babalola *et al*., 2011). It was observed that the clay content increased with depth in pedons 1, 3, 6 and 9 as shown in Table 4 as was also observed by Fagbami and Udo (1982) and Akhtaruzzaman *et al*. (2014). The higher clay content often observed in subsoil horizons of many soils may be attributed to illuviation and pedoturbation processes (Malgwi (2001); Tripathi *et al*. (2006) and Bera *et al*. (2014)). This probably suggests the presence of argillic horizon in the pedons. The argillic horizon, according to Soil Survey Staff (2010) is a subsurface diagnostic horizon with a significantly higher percentage of silicate clay than the overlying soil material. However, the soils have sufficient and incremental clay contents (>200 g/kg or 20%), thus take care in nutrient management provided water is not limiting as also reported by Vasu *et al*. (2016). Generally, these soils have limited capacity to retain nutrients and the potassium, calcium and magnesium added can be easily lost. Therefore, Potassium fertilizers or organic amendments with a significant content of K should be applied (Minh, 2011). Potassium is one of the indices for ascertaining the fertility status of soils (Table 2), therefore its availability in adequate quantity and form should be ensured. Moody *et al.* (2008) was of the opinion that crops should be closely monitored for K deficiency symptoms for optimum productivity.

TABLE 3: Morphological characteristics of the soils

Horizon	Depth (cm)	Colour (moist)	Mottles	Texture	Structure	Consistence	Boundary	Remarks
Pedon 1 (07° 17′ 053″ N – 005° 12′ 559″ E) Upper Reach – Oba series								
A	0 - 17	10YR 3/3	nm	ls	2fsbk	wsssp	cw	Many fine and medium roots
AB	17- 35	10YR 4/3	nm	ls	1fsbk	wsp	cs	Few roots and scattered slickensides
Pedon 2 (07° 17′ 053″ N – 005° 12′ 558″ E) Mid Reach/Break of slope – Gambari series								
Ap	0 - 21	10YR4/2	nm	sl	2fgr	wsnp	gw	Many fine and medium roots
AB	21- 59	10YR4/4	nm	ls	2fgr	wnsnp	gw	Few fine roots
Pedon 3 (07° 17′ 054 N – 005° 12′ 558″ E) Lower reach – Jago series								
Ap	0 - 20	10YR 3/3	nm	fsl	2fgr	wsssp	gw	Many fine roots
AB	20 - 73	10YR 5/6	m	fsl	2fgr	wvsvp	gw	Few roots with many fine tubular imped pores. Fe mottles
Pedon 4 (07° 17′ 057″ N – 005° 12′ 560″ E) Upper Reach – Oba series								
Ap	0 - 20	7.5YR4/4	nm	ls	3fsbk	wsssp	cs	Many fine roots, slickensides and interstitial pores
AB	20 - 36	10YR4/4	nm	cosl	3msbk	wsp	cw	Many roots, coarse and gravelly.
Pedon 5(07° 17′ 059″ N – 005° 12′ 560″ E) Mid Reach/Break of slope – Gambari series								
Ap	0 - 15	10YR3/3	nm	cs	1mabk	wnsnp	cw	Many roots, tubular pores
AB	15 - 52	10YR 5/3	nm	cs	1mabk	wssnp	cs	Few roots
Pedon 6 (07° 17′ 057″ N - 005° 12′ 561″ E) Lower Reach– Adio series								
Ap	0 - 20	10YR4/2	nm	ls	3fsbk	wvsvp	aw	Many roots, scattered slickensides and imped pores
AB	20 - 55	10YR 4/2	m	c	1fsbk	wvsvp	aw	Many roots. Fe mottles

TABLE 3: Morphological characteristics of the soils (Cont'd)

Horizon	Depth (cm)	Colour (Moist)	Mottles	Texture	Structure	Consistence	Boundary	Remarks
Pedon 7 (07° 17′ 059″ N – 005° 12′ 562″ E) Upper Reach – Oba series								
Ap	0 - 20	10YR4/2	nm	cosl	2mgr	wnsnp	cw	Many fine roots
AB	20 - 69	10YR5/4	nm	sl	2mgr	wsp	cw	Few roots
Pedon 8 (07° 17′ 058″ – 005° 12′ 562″ E) Lower Reach – Jago series								
Ap	0 - 18	10YR3/1	nm	sl	1fsbk	wsssp	dw	Very many fine roots
AB	18 - 66	10YR3/1	m	sl	1fsbk	wsp	dw	Few roots, Fe mottles
Pedon 9 (07° 17′ 059″ – 005° 12′ 564″ E) Lower Reach– Adio series								
Ap	0 - 17	10YR 3/3	nm	scl	1fabk	wsp	cw	Many roots
B21	17 - 34	10YR4/2	m	vc	1fabk	wvsvp	gw	Weakly developed black spots of Fe/Mn concretions

Mottles: m – mottled, nm – no mottles;
Texture: f – fine, v – very, co – coarse, c – clay, s – sandy or sand, l – loamy or loam;
Structure: 1 – Weak, 2 – Moderate, 3 – Strong, f – fine, m – medium, gr – granular, sbk – subangular blocky, abk angular blocky;
Consistence: wnsp – wet, non-sticky, plastic; wsp – wet, sticky, plastic; wssp – wet, slightly sticky, plastic; wnsnp – wet, nonsticky, nonplastic, wvsvp – wet,very sticky, very plastic; wsssp – wet, slightly sticky, slightly plastic; wssnp – wet, slightly sticky, nonplastic; wsnp – wet, sticky, nonplastic;
Boundary: aw – abrupt wavy, cw – clear wavy, dw – diffuse wavy, gw – gradual wavy, cs – clear smooth.

TABLE 4: Physico-chemical characteristics of the soils

Horizon	Depth (cm)	Particle size distribution (%) Sand	Silt	Clay	Bulk Density (gcm^{-3})	pH (KCl)	Exchangeable Bases Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Sum of Bases	TEA	ECEC
		←	(g/kg)	→			→			cmol$_{(+)}$ kg^{-1} ←			
Pedon 1 (07° 17′ 053″ N – 005° 12′ 559″ E) Upper Reach – Oba series													
A	0 - 17	670	150	180	1.15	4.9	0.200	0.045	0.039	0.003	0.287	0.19	0.347
AB	17 - 35	660	100	240	1.39	4.9	0.178	0.043	0.030	0.002	0.253	0.10	0.283
Pedon 2 (07° 17′ 053″ N – 005° 12′ 558″ E) Mid Reach/Break of slope – Gambari series													
Ap	0 - 21	770	110	120	1.16	5.1	0.156	0.042	0.034	0.003	0.235	0.14	0.275
AB	21 - 59	770	190	40	1.21	4.9	0.108	0.039	0.028	0.003	0.178	0.13	0.218
Pedon 3 (07° 17′ 054 N – 005° 12′ 558″ E) Lower Reach – Jago series													
Ap	0 - 20	600	210	190	1.07	6.0	0.334	0.068	0.054	0.006	0.462	0.11	0.502
AB	20 - 73	570	120	310	1.14	4.8	0.295	0.069	0.049	0.007	0.420	0.11	0.470
Pedon 4 (07° 17′ 057″ N – 005° 12′ 560″ E) Upper Reach – Oba series													
A	0 - 20	680	110	210	0.92	5.9	0.367	0.050	0.062	0.013	0.492	0.25	0.572
AB	20 - 56	780	50	170	1.26	5.7	0.178	0.035	0.036	0.008	0.257	0.15	0.287
Pedon 5(07° 17′ 059″ N – 005° 12′ 560″ E) Mid Reach/Break of slope – Gambari series													
A	0 - 15	790	20	190	1.12	4.7	0.119	0.034	0.021	0.002	0.176	0.17	0.206
AB	15 - 52	790	60	150	1.15	4.8	0.081	0.021	0.017	0.001	0.120	0.17	0.150
Pedon 6 (07° 17′ 057″ N - 005° 12′ 561″ E) Lower Reach – Adio series													
A	0 - 20	280	390	330	0.95	4.0	0.244	0.055	0.045	0.012	0.356	0.14	0.396
AB	20 - 55	320	330	350	1.01	3.2	0.164	0.049	0.021	0.005	0.239	0.16	0.269
Pedon 7 (07° 17′ 059″ N – 005° 12′ 562″ E) Upper Reach – Oba series													
Ap	0 - 20	790	120	90	1.25	4.5	0.081	0.025	0.017	0.001	0.120	0.10	0.150
AB	20 - 69	760	230	10	1.43	4.8	0.056	0.013	0.019	0.001	0.094	0.20	0.144
Pedon 8 (07° 17′ 058″ – 005° 12′ 562″ E) Lower Reach – Jago series													
A	0 - 18	560	270	170	1.08	5.0	0.31	0.057	0.045	0.006	0.417	0.14	0.457
AB	18 - 66	590	230	180	1.20	4.9	0.24	0.052	0.042	0.006	0.389	0.12	0.419
Pedon 9 (07° 17′ 059″ – 005° 12′ 564″ E) Lower Reach – Adio series													
Ap	0 - 17	280	390	330	0.99	3.8	0.236	0.056	0.049	0.006	0.346	0.09	0.376
B21	17 - 64	260	390	350	1.16	3.7	0.193	0.052	0.049	0.003	0.297	0.16	0.347

TEA – Total exchangeable acidity

High leaching potential (low cation exchange) (e)

Findings from the study showed that the effective cation exchange capacity of the soils was low. The soils are submerged during the rainy season. During submergence, the release of large concentration of Fe^{2+} and Mn^{2+} displaces exchangeable basic cations from the soil exchange complex out of the soil profile (Babalola *et al.*, 2011). According to Ernest and Onweremadu (2016), high annual precipitation, the low buffering capacity to retain them against leaching and removal by erosion probably explain the low ECEC in soils of the floodplain. Eze (2015) reported that the low levels of exchangeable bases and effective cation exchange capacity (ECEC) in soils could be attributed to near complete absence of weatherable primary minerals under the prevailing tropical environment coupled with leaching of basic cations. According to Udo *et al*. (2009), the quantity of K held in an easily exchangeable format any one time is very small, though K is found comparatively in high levels in most mineral soils. Abe *et al.* (2010) reported that soils from inland valleys and plains in thirteen countries including Nigeria, in West Africa generally were low in fertility and was well associated with the mineralogical composition, suggesting that the soils in the region have low nutrient-holding capacity and limited potential for inherent nutrient supply. Minh (2011) opined that the use of mineral fertilizers is not recommended in these soils in their natural state, as nutrients are not retained by these soils due to the low capacity to retain nutrients.Therefore, heavy applications of these nutrients and of N fertilizers should be split meanwhileorganic matter application is highly recommended to increase soil cation exchange capacity since it is less susceptible to leaching.

Fertility Capability Classes

The results of the FCC units of the floodplain soils are as shown in Table 5 which indicated that the nine locations (Profiles) P1, P2, P3, P4, P5, P6, P7, P8 and P9 were classified into six FCC units which are *SLke, SLgke, Lke, Ske, LCke* and *LCgke*. Profiles P1 and P2 were in the same FCC class *SLke* indicating that the soils were characterized by sandy topsoil, loamy subsoil, low nutrient capital reserve and high leaching potential. P3 and P8 were placed in *SLgke* characterized by sandy topsoil, loamy subsoil, gleying, low nutrient capital reserve and high leaching potential.P4 and P7 belonged to *Lke* characterized by loamy topsoil and subsoil, low capital nutrient reserve and high leaching potential. P5 was placed in *Ske* characterized by sandy topsoil and subsoil, low capital nutrient reserve and high leaching potential. P6 was placed in *LCke* characterized by loamy topsoil, clay subsoil, low nutrient capital reserve and high leaching potential while P9 was placed in *LCgke* soil class characterized by loamy topsoil, clay subsoil, gleying, low nutrient capital reserve and high leaching potential.

TABLE 5: FCC units of pedons in the study area

Pedon	Type	Substrata Type	Condition modifiers			FCC class
			g	k	e	
1	S	L	-	+	+	SLke
2	S	L	-	+	+	SLke
3	S	L	+	+	+	SLgke
4	L	L	-	+	+	Lke
5	S	S	-	+	+	Ske
6	L	C	-	+	+	LCke
7	L	L	-	+	+	Lke
8	S	L	+	+	+	SLgke
9	L	C	+	+	+	LCgke

Type/substrata type: S = Sand, L = Loam and C = Clay

Condition modifiers: g = gleying or waterlogging

k = low nutrient capital reserves

e = high leaching potential (low buffering capacity, low ECEC)

CONCLUSION

The soils were classified into six FCC units: *SLke*, *SLgke*, *Lke*, *Ske*, *LCke* and *LCgke*. Each of the identified units has various limitations that could limit crop production. The commonest of these limitations were low nutrient capital reserves and high leaching potential. The FCC classes *SLgke*, *LCke* and *LCgke* had higher potential for high yield in crop production than other classes in soils of the floodplain as shown from the results of laboratory analyses. The agronomic constraints in the floodplain soils could be easily managed through incorporation of organic residue like burnt rice husk which was abundant in the area to solve the soil physical and chemical constraints. Biochar can also be used to solve the problem of leaching of nutrients prevalent in the area to improve the inherent soil fertility.

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