International Research Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) Vol. 1(6) pp. 193-204 August 2011
Available online http://www.interesjournals.org/IRJAS

Full Length Research Paper

Land evaluation studies of two wetland soils in Nigeria

[1]Babalola TS, [2]Oso T, [2]Fasina AS* and [3]Godonu K

[1]College of Agriculture, Ahmadu Bello University, Kabba, Nigeria
[2]*Department of Crop, Soil and Environmental Sciences, University of Ado-Ekiti, Nigeria
[3]School of Agriculture, Lagos State Polytechnic, Ikorodu, Nigeria

Accepted 05 April, 2011

Land Evaluation studies were carried out on two wetland soils (Ado-Ekiti and Kabba) in Nigeria. FAO Frame work and fertility capability classification (FCC) systems were used to evaluate the sites for rice production. The influence of two management practices (Local and Improved) on rice yield were evaluated on the field. Soil samples were collected under eight rice stands in each plot for regression analysis to determine the influence of individual soil properties on rice yield. An economic analysis was carried out to assess the more profitable site for rice production. The wetland soil at Ado-Ekiti was classififed as Fluvaquept Endoaquept, while the Kabba wetland soil was classified as Typic Halaqeupt. The pedon at Kabba was classified as Lgh and that of Ado-Ekiti as Leghk using the FCC System, with cation Exchange capacity and K status accounting for differences between the two. Kabba sites was classified as presently not suitable (N1) for rice production and Ado-Ekiti as N2 because of limitations imposed by soil chemical properties. With proper soil fertility management, the potentials of these soils can increase to moderately suitable (S2), for rice production. Improved management system gave significantly higher yields than the local management (t=2.50). Stepwise regression of rice yield on soil properties revealed that Seventeen soil properties contributed to rice yield within the study areas with R^2 values of 92.81% and 93.56% at Ado-Ekiti and Kabba respectively. Economic analysis of rice production in the two sites showed that the cost benefit ratio was positive at both sites but best return on investment was obtained from Kabba with gross margin of ₦532,775/ha.

Keywords: Wetland, Land evaluation, Management Systems, Rice,Ado-Ekiti and Kabba.

INTRODUCTION

The occurrence of wetland soils in Nigeria has been associated with three landforms namely; inland depressions, floodplains and coastal plains (Fasina, 2005). Wetland soils in Nigeria exhibit wetness characteristics such as mottling or gleying in their profiles – gleyic and histic horizons. The major wetland soils in Nigeria have been classified into Gleysols/Fluvisols and Alfisols, Inceptisols, Entisols, Histosols and Vertisols (Olaleye, 1998).

Wetlands are grossly underutilized in Nigeria. Rice and sugar cane are grown on them in the raining season. Wetlands in Nigeria may be appropriately described as the "breadbasket in the land because they serve as the main source for growing crops and for water supply to livestock.

The unsustainable use of wetland in Nigeria as a whole has led to the disruption of natural hydrological cycles. Wetland is, however, very fragile ecosystems and their conversion to cropland has resulted in many cases to severe ecological and environmental deterioration and degradation. This has often resulted in higher frequency and severity of flooding, drought and pollution. The most common and direct consequences of conversion are severe erosion of the wetland soils, disruption of water flow regulation and deterioration of environmental quality, all leading to biodiversity. In most parts of Nigeria, poorly managed cultivation has resulted on the abandonment of wetlands by cultivators as fertility has become exhausted and the soils have become eroded and desiccated.

*Corresponding author email: sundayfash2002@yahoo.com

Appropriate protection and allocation of water to wetlands is essential to enable these ecosystems survive and continue to provide important goods and services to local communities. It is therefore necessary that policy makers carefully determine appropriate strategies for the sustainable use and management of wetlands for agriculture or other purposes. Development of such policies and strategies can only be possible where information, on the characteristics and functioning of wetlands is carefully collected, assembled and interpreted. The process of assessing these wetlands to meet the user's need is called land evaluation and this serves as the basis for proper land use planning (Fasina and Adeyanju, 2007).

It was in view of the above stated background that this research was carried out. This research was designed to generate information about two wetlands soils in Nigeria with a view to develop a sustainable management system for this ecosystem. The research output will contribute to the database required for the precise characterization, classification, evaluation and understanding of wetland resources in Nigeria. Therefore, the major objective of this research is to carry out a detail land evaluation studies on two wetland soils in Nigeria. The specific objectives are:

a To characterize and classify the two wetland soils in Ado-Ekiti and Kabba.

b To evaluate the potential of the wetland soils for rice production.

c Examine the influence of some topsoil properties controlling yield variation in rice yield.

e Compare the influence of two different crop management practices (farmers' practice and improved management practice) on rice yield in these two wetland soils.

f To carry out an economic analysis of the two sites for rice production.

MATERIALS AND METHODS

Sites

This study took place in two agro-ecological zones of Nigeria namely: (i) Rainforest Zone (Ado-Ekiti), and (ii) Southern Guinea savannah Zone (Kabba). Ado-Ekiti is situated in Ekiti State of South Western Nigeria. The experiment was conducted at the Teaching and Research Farm, University of Ado-Ekiti, Ekiti State. The area lies between latitude 7°31'N and 7°49'N and longitude 5°14'E and 5°23'E. Kabba is located in the southern part of Kogi State of the Southern Guinea Savannah and lies between latitude 7° 52'N and 7° 34'N and longitude 6° 02'E and 7° 42'E. The experiment was conducted in College of Agriculture, Kabba. The geology of the two study sites are dominated by crystalline rocks of the basement complex which provide mostly granitic materials. At the valley bottoms are wetland soils formed as a result of deposition.

Field Work

At each location an experimental area of 100m×90m was chosen and a profile pit was dug and described. The soil properties described include: color, mottles, texture, consistence, presence/absence of concretions, stoniness, and depth to ground water table. The following data were recorded for the general site description: climate, vegetation, land use, gradient of slope, drainage type, soil surface form, type and degree of erosion, field texture, micro-relief and depths to the ground water table. Soil samples were taken from the horizons in each profile pit The soils were classified using the criteria set by Soil Taxonomy (Soil Survey Staff 1996), the FAO/UNESCO (FAO, 1974), Higgins (1964) and Smyth and Montgomery (1962).

Soil sampling

Profile soil sampling was done after the soil profile has been demarcated and described. Soil samples were collected from each identified soil horizons from the two study sites.

Laboratory Analyses

The soil samples were air-dried and crushed to pass through a 2mm sieve, and analyzed for the following parameters:

Particle size analysis (Bouyoucos, 1951), Soil pH (water and KCl), Organic carbon, (Walkley and Black, 1934), Exchangeable cations, Exchangeable acidity (IITA, 1992), Effective Cation Exchange Capacity (ECEC, Total N (Black, 1965), Available P (Bray-1-P) (Bray and Kurtz, 1945), Total iron oxide (Mehra and Jackson, 1960).

Land Evaluation

The potentials of these soils for rice production were assessed using the following land evaluation methods:

1. Land Capability Classification (LCC) as modified by USDA (Klingebiel and Montgomery 1961)
2. Land Suitability Evaluation (LSE): (FAO 1976),
3. Fertility Capability Classification (FCC) (Buol *et al*; 1975).

Field Trials

Two levels of management (local and improved ma-

Table 1. Morphological Properties of soils in Kabba and Ada-Ekiti

	Depths (cm)	Colour (moist)	Boundary	Texture	Structure	Consistence	Quart stone	Concretion	Roots	Drainage	Mottles
						Kabba					
	0-13	10YR 2/2	w	SCL	Mab	St	A	A	F	ID	-
	13-51	10YR 2/2	w	SL	Mab	sl-st	A	A	F	ID	f:f
	51-56	10YR ¾	w	SC	Mab	St	A	A	f.	ID	f:f
						Ado-Ekiti					
	0-11	10YR 4/1	w	SCL	Fab	sl-st	A	A	F	ID	-
	11-28	10YR 3/3	w	SCL	Fab	sl-st	A	A	F	ID	f:f
	28-55	10YR 3/3	w	SCL	Fab	sl-st	A	A	F	ID	f:f
	55-100	10YR 3/3	w	SCL	Fab	sl-st	A	A	-	ID	f:f

Key:
Boundary: w= wavy, **Structure**: Mab=Massive angular blocky, Fab= Fine angular blocky, **Consistence**: st=sticky, sl-st=slightly-sticky, **Roots:** f=fine, **Mottles:** f.f= fine few, **Drainage:** ID= impeded drainage, **Textural class**= SCL= sandy clay loam, SL= sandy loam, SC=sandy clay

nagement practices), were replicated four times each, giving a total of eight (8) experimental units and laid out in a randomized complete block design (RCBD). Each plot was 5m x 5m. The components of improved management practice are: chemical weed control, application of fertilizer at the rate of 0.3kg/plot, covering of the plants with nets (to prevent attack by birds and rodents) and the planting at 20cm × 20cm spacing. The farmers (local) management practice did not involve definite spacing (the seeds were broadcast on the field) and fertilizer application, scare crow was used for controlling birds and rodents and manual (hand weeding) weed control was used to control weeds.

Data Collection and Sampling

At the flowering stage, eight (8) soil samples were randomly collected from each experimental plot around eight tagged stands and a total of sixty-four (64) soil samples were collected.

At maturity, the panicles from the hill/stands where soil samples were previously collected were harvested, threshed and grains sun-dried to about 12% moisture content. The yields per plot and per ha were calculated.

Coding of Soil Morphological Properties

Soil morphological properties: namely texture, structure, consistence and colour were coded. The coding methods used were those developed by the Soils Survey of England and Wales (Avery and Bascomb, 1974). All the coded data were then subjected to statistical analysis

Data Analysis

All the data collected were subjected to t-test analysis. Also, regression analysis was used to determine the influence of soil properties on rice yield. Differences in grain yield in relation to management practices were analysed. Gross margin analysis was carried out to determine the more profitable location for rice production.

RESULTS AND DISCUSSION

Morphological characteristics

Data on morphological properties of the soils of the study sites are presented in Table 1. Differences were observed in texture, consistence and presence of mottles. All the soils are mottled or gleyed and have a hue of 10YR and low chroma which reflects poor drainage (aquic soil moisture) or seasonal mottling. The major morphological features such as grey or low chroma (<3) colours, mottles observed in these pedons is an indication of soil wetness brought about by oxidation-reduction cycles due to ground water fluctuation. Ahn (1970), Smyth and Montgomery (1962) reported inter-relationship between these features. The reduced Fe present in these soils impact grayish colour on the soil matrix.

Physico-Chemical Characteristics of the Study Sites

The main physico-chemical properties of the soil of the study site are presented in Tables 2 and 3. The particle size distribution pattern showed that the sand content is high in both sites between 55 to 70% in Kabba and 48-72.4% in Ado-Ekiti. The low silt to clay ratio is an indication of low weathering intensity as a ratio of <0.15 indicates low to moderate weathering intensity, while a ratio of >0.15 indicates high intensity of weathering (Young, 1976).

Table 2. Chemical Properties of Kabba and Ado-Ekiti Soils

Depth (cm)		pH	0rg.C (%)	Total N (%)	P (Bray) $mg.kg^{-1}$	Exchangeable Bases ($cmol.kg^{-1}$)				-----cmol kg^{-1}-------		Base Sat %	EC (dsm-1)	ESP %	-----(cmol/kg)---	
		H20				K	Ca	Mg	Na	Exch. Al	ECEC				Exch Fe	Exch Mn
Kabba -Typic Halaquept/Eutric Gleysol/Oshun series																
0-13		5.5	2.65	0.18	14.19	0.85	3.00	0.32	2.80	0.26	7.49	96.40	0.76	37.40	0.37	0.01
13-51		6.0	0.90	0.20	19.62	0.87	0.16	0.16	2.55	0.26	4.00	93.50	0.78	63.80	0.26	0.02
51-56		5.9	0.75	0.12	19.80	0.40	0.69	1.12	2.99	0.26	5.46	95.23	0.75	54.80	0.24	0.02
Ado-Ekiti- Fluvaquentic Endoaquept/Dystric Fluvisol/Adio Series																
0-11		5.03	4.44	0.38	12.5	0.24	0.08	0.04	0.07	1.84	0.44	19.30	94	16.00	0.98	3.4
11-28		6.02	1.15	0.10	3.30	0.24	0.03	0.05	0.06	1.62	0.20	10.99	89	30.50	0.98	2.64
28-55		5.35	0.58	0.05	3.81	0.06	0.06	0.03	0.06	1.20	0.21	14.67	106	29.05	1.02	2.54
55-100		7.28	0.58	0.05	3.54	0.06	0.03	0.02	0.05	0.80	0.96	16.67	106	32.50	0.81	1.24

Clayey texture in Kabba is a characteristic of wetland soil and that probably gives its characteristically high water table at 56cm during the dry period of the year. High sand content coupled with heavy rainfall may have resulted in the exchangeable cations being leached out of the profiles. Also during soil submergence, the release of large concentrations of $Fe2^{+}$ and Mn^{2+} is known to also displace the exchangeable macro-nutrients out of the soil profile (Fasina 2005; Olaleye, 1998). The soil pH recorded at both sites (Kabba 5.5 to 6.0 and Ado-Ekiti 5.03 to 7.28) is an indication that the soil exchange complex is dominated by Al^{+++} and H^{+} ions. Also the pH 7.28 recorded at the lower horizon in Ado-Ekiti pedon may be an indication of leaching of minerals. Rice has been reported to grow under variable pH conditions which ranged from 3.5 to 8.4 (Fasina, 2005). The organic carbon decreases with depth and this is an indication of continuous deposition of organic materials (a fluvic property), Soil Survey Staff, 1996) and its higher content 2.65% and 4.44% at the surface horizons in Kabba and Ado-Ekiti respectively is an indication of poor natural drainage (aquic soil moisture regime) which may have slowed the rate of decomposition. Organic matter have been reported to have positive influence on the CEC, base saturation, structure, pH, buffering capacity and water holding capacity of soils (Fasina et al., 2007). The organic matter content in the surface horizon of both pedons can sustain rice cultivation under continuous land use. The total N is low in Kabba (0.18-0.2%) compared with the critical value of 0.2% recommended (FPDD 1989). This compares well with the report of Enyi (1984) and Olaleye (1998) that N is normally deficient in most wet soils for growing rice. The low levels may be associated with leaching coupled with intermittent flooding and drying which is known to favour N loss through nitrification-denitrification process (Wong et al., 1991). However, at Ado-Ekiti, total N is above the critical value (0.38%) and this value corresponds with organic carbon content. Relationship between organic carbon and total N content has been established (Adeyanju, 2005). Available P (Bray) is generally low compared with critical level of 20mg kg^{-1} (Tanaka and Yoshida, 1970). P is the second most important nutrient limiting rice yield and it has also been reported to be deficient in soils grown to lowland rice (Olaleye, 1998). The organic carbon content and total Fe observed in these pedons may have resulted in low P status in the subsoil.

Exchangeable cations- Ca, Mg, K and Na are low but Na seems to be higher in Kabba (2.55-2.99 cmol/kg). This may be due to the nature of parent material in the location and has a great influence on the Exchangeable Sodium Percentage (ESP) of the soils thereby resulting in high values which range between 37.4% to 63.8%. These values are greater than the critical value of ESP (15%) indicating

Table 3. Physical and Land Properties of Soils in Kabba and Ado-Ekiti

Depth (cm)	Sand %	Silt %	Clay %	Stones/ Gravels %	Texture	Quartz stones	Structural Stability	Erosion	Slope %	Effective Soil Depth (cm)
Kabba										
0-13	59	21	20	0.20	SCL	-	High	None	2	56
13-51	70	11	19	0.90	SL	-	medium	-	-	
51-56	55	15	30	1.10	SC	-	High	-	-	
Ado-Ekiti										
0-11	48.4	29.88	22.22	-	SCL	-	high	slight	3	55
11-28	64.4	11.28	24.32	-	SCL	-	high	-	-	
28-55	64.4	11.28	24.32	-	SCL	-	high	-	-	
55-100	72.4	2.4	25.2	-	SCL	-	High	-	-	

that the soils are sodic. Sodic soils are usually more dispersed, less permeable to water and are of poor tilth, usually plastic and sticky when wet and are more prone to form clods and crust on drying.

The low contents of exchangeable cations may be due to intense leaching weathering and ferrolysis hence low inherent fertility status with regards to the major and micro-nutrients. This was in agreement with the findings of Olaleye (1998), Fasina (2005) Fasina and Adeyanju (2007). In ferrolysis, excessive Fe(II) in the soil solution displaces exchangeable cations from the exchange complex into the soil solution and these are eventually replaced mainly by Al from clay lattices after oxidation. This process is dependent on the volume of water passing through the soil which eventually leads to clay mineral and Cation Exchange Capacity destruction. The sandy nature of the soils coupled with heavy tropical rainfall also promotes leaching. The release of large amount of Fe^{2+} and Mn^{2+} into the soil solution during soil submergence is also known to displace the exchangeable cations from the soil exchange complex (Patrick and Reddy, 1978).

The soils are imperfectly drained, which is a characteristic of wetland soils while soil depth was optimum for all the pedon for rice production. The optimum soil depth of >50cm was proposed by Moorman and Dudal (1965) for evaluating wet soils for rice cultivation and Nagari (1958) reported that most rice roots in the lowland soils are confined to the top soil 20cm. The result in this research agrees with this. The soil texture (SCL-SC) in Kabba site and SCL in Ado-Ekiti were optimum for the growth of lowland rice. Olaleye (1998) noted that soils should have at least 40% clay and silt for lowland rice production. Also, Grant (1960) reported that the optimum texture most favourable for lowland rice cultivation is silt loam but in the absence of precise information on soil-water relationship, texture per se may be an unreliable guide to the usefulness of a soil for rice production. Grant (1964), Olaleye (1998) and Grant (1960) all found that sandy soils well supplied with irrigation water and fertilizer (nutrient) produce superior yields. The negative influence of the sandy texture could be overcome by N application provided water supply was assured (Moorman, 1973). The N application was said to have compensated for the loss of N through leaching in sandy soil but the cost implication can make it uneconomical (Olaleye, 1998). In west Africa, Moorman and Van Breemen (1978) reported soil texture and hydrology as being very important in evaluating wetlands for rice and significant relationship was also found between texture and rice yields (Higgins 1964; Moorman 1973) CEC is low for all the pedons ranging from 4.00-7.49 cmol/kg in Kabba and 0.8-1.2 cmol/kg in Ado-Ekiti, in line with the values reported for Nigerian soils (Ogunwale and Ashaye, 1975; Fasina, 2005 and Fasina, 2004)

Soil Classification

Kabba soil is embryonic in nature with few diagnostic horizons; ground water is within 100cm of the mineral soil surface (56cm water table). The colour matrix hue is 10YR and ESP of 35% or more within 50cm mineral surface. All these characteristics made the soil to be classified as Typic Halaquept (USDA) and Eutric Gleysol (FAO, 1974) because of >50% Base Saturation as stated by FAO/UNESCO soil classification system while at series level it was classified as Oshun series.

Ado-Ekiti study site pedon was classified as Fluvaquentic Edoaquept in the USDA system as well as Dystric Fluvisol in the FAO soil classification system while at series level it was classified as Adio Series. This soil was classified so because of its embryonic nature, characteristic wetness, high water table at 55cm soil depth, its gleyic

Table 4. Summary of the capability grouping of the soils

Capability	Location	Main Limitation	Amendment Possible
III	Kabba	Texture, Effective soil depth	Plant soils to crops that can respond to nature of texture. Plant shallow rooted crops.
IV	Ado-Ekiti	Effective Soil depth, Erosion	Always maintain cover in the surface soil. Plant cover crops in the surface of the soil to prevent erosion Incorporate plant residue

Table 5. Land Characteristics of Soils in Kabba and Ado-Ekiti

Land Qualities	Land Characterist-ics	Units	Kabba	Ado-Ekiti
Climate (c)				
	Rainfall	Mm	1200	1367
	Solar Radiation	MJ Cm^{-2} day^{-1}	401	460
Soil Physical Characteristics				
	Soil Depth	Cm	>56	>55
	Texture	%	SCL	SCL
Wetness (w)	Drainage	-	IL	II
	S.W.D	Cm	No	0-15
	F.D	Months	No	2-3
Fertility Status (f)				
	pH (M KCL)		5.50	5.03
	Total N	%	0.18	0.38
	Organic carbon	%	2.64	4.44
	P (Bray)	$mg.kg^{-1}$	14.19	12.5
Fertility Status (s)				
	K	$cmol.kg^{-1}$	0.85	0.24
	Ca	$cmol.kg^{-1}$	3.00	0.08
	Mg	$cmol.kg^{-1}$	0.32	0.04
	CEC	$cmol.kg^{-1}$	7.62	2.28
Toxicity (t)				
	Active-Fe	%	0.01	0.98
	Total Mn	%	0.53	3.40

Key: S.W.D= Surface Water Depth**, F.D=** Flooding Duration**,** Drainage, ii= 1mperfectly, poorly drained
SCL= Sandy Clay Loam, LS= Loam Sand

property with hue of 10YR and irregular decrease in organic carbon content between 25cm-125cm soil depth.

Land Evaluation

Capability Classification

Summary of land capability rating is given in Table 4. Kabba belongs to Capability Class III while Ado-Ekiti soil was classified in Capability Class IV. The limitations identified in these soils are soil texture, effective soil depth and erosion. These limitations override other good qualities in these soils which bring them into lower classes other than Cass I. Only erosion as a limitation can be controlled while effective soil depth and texture are more permanent characteristics. Since these two properties are relevant to crop production, these soils must be properly managed in a sustainable way to ensure optimum production of crops on them. The use of crop residues, compost and cover crops are hereby recommended as soil management strategies.

Suitability Classification for Rice

Suitability classes are defined with regards to the number and intensity of limitations. Table 5 shows that climate, soil physical characteristics and wetness does not place limi-

Table 6. Suitability Class Scores of Pedons at Kabba and Ado-Ekiti

Land Qualities	Land Characteristics	Kabba	Ado-Ekiti
Climate (c)			
	Rainfall(mm)	S2	S2
	Solar Radiation	S2	S2
Soil Physical Characteristics (s)			
	Soil Depth (cm)	S1	S1
	Texture	S3	S2
Wetness (w)			
	Drainage	S1	S1
	S.W.D (cm)	S1	S1
	F.D (months)	S1	S3
Fertility Status (f)			
	pH (M KCL)	S1	N1
	Total N (%)	S1	S1
	Organic carbon (%)	S1	S3
	P (Bray) (mg/kg)	S2	S3
	K (cmol/kg)	S1	S2
	Ca (“)	S3	N2
	Mg (“)	N1	N2
	CEC (“)	N1	N1
Toxicity (t)	Active-Fe (%)	S1	S2
Aggregate Suitability			
Current Suitability		N1(f)	N2(f)
Potential Suitability		S3(s,f)	S3(w,f)

Key: S.W.D= Surface Water Depth F.D= Flooding Duration

Table 7. Fertility Capability Classification of Soils at Kabba and Ado-Ekiti

			---------Modifiers-----------------					
Location	**Soil Classification**	**Type**	**Substrata type**	**E**	**G**	**H**	**I**	**K**
Kabba	Typic Halaquept/ Eutric Gleysol/ Oshun Series	**L**	**-**	**-**	**+**	**+**	**-**	**-**
Ado	Fluvaquentic Endoaquept/ Dystric Fluvisol/ Adio Series	**L**	**-**	**+**	**+**	**+**	**-**	**+**

Key: L: Loamy topsoil **e:** Low CEC **g:** gleyic condition, mottles **h:** acidity **i:** high P-Fixation by Iron **K:** Low in reserve K

tation to rice production at both sites. The major limitations in Kabba soils are exchangeable Mg and ECEC which make the area to be placed in Suitability Class N1, that is, currently not suitable for lowland rice production as a result of the soil fertility limitation imposed on it presently. In Ado-Ekiti, the major limitations are Exchangeable Ca and Mg which placed the soil in suitability class N1 that is the site is currently not suitable for lowland rice production. The limitations imposed on these soils are soil chemical properties. These soils can be made moderately suitable by applying appropriate fertilizer technology to correct the soil fertility deficiency.

Fertility Capability Classification

The results of Fertility Capability Classification (Table 6) classified Kabba soil as Lgh while Ado-Ekiti was classified as Leghk. The interpretation of this is that Kabba soil has complex soil fertility problems of low cation exchange capacity (CEC) and acidic in nature while Ado-Ekiti Soil has problem of low cation exchange capacity, acidic in nature and low in potassium content. Low CEC indicates that continuous prolonged rice cultivation may not be feasible on both soils without fertilizer application as the soils have very limited ability to retain nutrients. If the soil organic

Table 8. T-test Result Showing Influence of management systems on grain yield of Rice per hill

Sites	Improved Management	Local Management
Ado-Ekiti	0.0138a	0.0103b
Kabba	0.2205a	0.1130b

Table 9. Yield Prediction (R^2) with increasing number of properties in Regression (Ado-Ekiti)

No	List of properties																	R_2	R%
1	K																	25	-
2	K	pH																39	14
3	K	pH	Ca															49	10
4	K	pH	Ca	Mg														59	10
5	K	pH	Ca	Mg	OM													66	7
6	K	pH	Ca	Mg	OM	Na												73	7
7	K	pH	Ca	Mg	OM	Na	Sand											80	7
8	K	pH	Ca	Mg	OM	Na	Sand	Silt										82	2
9	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay									84	2
10	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N								86	2
11	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N	P							88	2
12	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N	P	Mn						90	2
13	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N	P	Mn	CEC					91	1
14	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N	P	Mn	CEC	Bs				91	1
15	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N	P	Mn	CEC	Bs	Texture			91.67	0.67
16	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N	P	Mn	CEC	Bs	Texture	ESP		91.91	0.91
17	K	pH	Ca	Mg	OM	Na	Sand	Silt	Clay	N	P	Mn	CEC	Bs	Texture	ESP	Fe	92.89	0.98

matter is properly managed using crop residues, compost and inorganic fertilizer these soils can be use for sustainable rice production. This result is in agreement with the findings of Olaleye (1998) and Fasina (2003) who all classified some soils as Leghik which means that the soil capability is conditioned by texture of the surface soil, low CEC, low nutrient reserves and Al toxicity.

Influence of Management Practices on grain yield

Yield data obtained for the crop management practices in Ado-Ekiti and Kabba site are summarized in Table 8. Significant differences in rice yields were obtained between the improved management and local management (t=2.50). The yield of rice obtained under improved management practices were better than that of the local farmers' practices. The increase in rice yield due to improved management ranged between 3.75 and 5% in Ado-Ekiti and 4.5% and 6% in Kabba. An average total yield of 1.76tons/ha and 1.18tons/ha was obtained for improved management while it was 0.617tons/ha and 0.83tons/ha for local management in Kabba and Ado-Ekiti respectively. The comparison of the two crop management practices clearly showed that the yield of improved management practice was superior to the yield obtained under local Farmer's practice. It is combination of some factors (fertilizer application, good weeding and optimum plant population), that resulted in the higher yield obtained from the improved management practice. The result obtained in this study agreed with the findings of Olaleye (1998) who also obtained significantly higher yields ($P<0.05$) on rice plots to which fertilizer was applied.

Relationship between soil properties and Rice Yield

In order to have an idea of the contributions of each of the individual soil properties to the variations in the yield of rice under the two management systems, an analysis of the data on yield of rice and soil properties was carried out using a stepwise regression model Tables (9 and 10).

The stepwise regression of rice yield (dependent variables) on the soil properties reveals that 17

Table 10. Yield Prediction (R^2) with increasing number of properties in Regression (Kabba)

No	List of properties																	R^2	R%
1	CEC																	13	-
2	CEC	N																26	13
3	CEC	N	P															37	11
4	CEC	N	P	Mg														46	9
5	CEC	N	P	Mg	OM													55	9
6	CEC	N	P	Mg	OM	Na												64	9
7	CEC	N	P	Mg	OM	Na	K											70	6
8	CEC	N	P	Mg	OM	Na	K	BS										76	6
9	CEC	N	P	Mg	OM	Na	K	BS	Silt									82	6
10	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand								84	2
11	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand	ESP							86	2
12	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand	ESP	Clay						88	2
13	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand	ESP	Clay	Mn					90	2
14	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand	ESP	Clay	Mn	pH				91	1
15	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand	ESP	Clay	Mn	pH	Ca			92	1
16	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand	ESP	Clay	Mn	pH	Ca	Fe		93	1
17	CEC	N	P	Mg	OM	Na	K	BS	Silt	Sand	ESP	Clay	Mn	pH	Ca	Fe	Texture	93.56	0.56

(Seventeen) soil properties contributed significantly ($P<0.01$) to the prediction of rice yield within the two study areas. R^2 values of 92.81% and 93.56% were obtained for Ado-Ekiti and Kabba respectively. With 9 (nine) soil properties in regression 82% of the variations in rice yield were explained in Kabba while it was 84% for Ado-Ekiti. The regression analysis also revealed that the soil variables were not equal as far as their influence on the yield of rice was concerned. For instance, from the report from the two sites K, pH, CEC and total N were among the first two relevant soil properties that contributed significantly to the yield of rice. This result is in agreement with the findings of Ismunadji (1990), Sahrawat et al (1996) and Olaleye (1998) who all reported that K, P and N improved the grain yield of rice. These three nutrient elements (K, P and N) with Zn had been highlighted by many authors as being important for optimum rice yields on iron toxic soils because it improves the oxidizing capacity of rice roots when present in adequate amount (Ota, 1968; Trolldenier, 1973;1979). It has also been known to increase the nitrogenase activity of rice plants (Trolldenier, 1981; Olaleye, 1998). As a result of these roles, it has been reported to contribute to the yield increase of rice on soils with inherent low fertility and high Fe contents (Ismunadji, 1990; Sahrawat et al, 1996). P on the other hand is involved in energy transfer and several other synthetic processes in plants (Wyn and Lunt, 1967) and it is also known to stimulate root growth when present in adequate concentrations. The result of the regression showed the importance of different soil properties in predicting the yield of rice on the field. The differences observed in the yield predictions at both sites might be due not only to the influence of individual soil properties but also to the effect of management practices imposed on these soils.

Economic Analysis of Rice production in the Sites

The Economic analysis of rice production at Ado-Ekiti and Kabba sites is presented in Table 11. Kabba site gave the highest yield of 7,055kg/ha. The respective yield followed the same sequence of N846.600 total revenue. This suggests that Kabba (guinea savannah zone) has the best rice output under improved management system of rice production. The Highest total variable cost of ₦313, 825 was incurred in Kabba with the cost of processing accounting for 22.48% of the total variable cost. Cost of processing has been identified to be a constraint of rice production in the developing and under-developed world (FAO, 2004). The total fixed cost did not vary between the sites with both having a value of ₦80, 000. This reflected on the economic parameters of gross margin, net returns and benefit cost ratio with the highest

Table 11. Economic Analysis of Rice Production in Ado-Ekiti and Kabba Sites

Rice Gross Margin in Kabba Under Improved Management					**Rice Gross Margin in Ado-Ekiti Under Improved Management**	
Harvest Yield in Kg/ha	7055.0					4,700
Total Revenue (TR)						
Sale of rice		@	120/Kg	846,600		564000
VARIABLE COSTS						
Tractor Costs						
Ploughing		@	3,500/ha	3,500	@' 3000/ha	3000
Harrowing		@	3,000/ha	3,000	@' 2500/ha	2500
Ridging		@	3,500/ha	3,500	@" 3000/ha'	3000
Planting						
Seeds	60kg	@	500/kg	30,000		30000
Sowing Labour	10 Labours	@	1,200/Manday	12,000	@' 1500/manday	15,000
Fertiliser						
Fertiliser cost	4 Bags	@	6,500/bag	26,000		26000
Weed Control						
Herbicides	5 liters of 2,4 D	@	2,800/liter	14,000		14000
Bird Control		@	25,000/ha	25000	@' 23000/ha	23000
Disease Control		@	5,000/ha	5,000		5000
Harvesting						
Picking	10 labours for 3days	@	1200/Manday	36000	@" 1500/manday'	45000
Processing		@	10/kg	70,550		47000
Handling/Packing						
Packing		@	5/Kg	35275		23500
Other Cost						
Supervision	5 months	@	8,000/Month	40,000		40000
Transportaion		@	10,000	10,000		10000
Total Variable Cost	**(TVC)**			313,825		287000
GROSS MARGIN per ha		**TR-TVC**		532,775		277000
Total Fixed Cost	**(TFC)**					
Impliments				80,000		80,000
Return/N invested		**GM/TFC**		6.66		3.46
Net Return		**GM-TFC**		452,775		197000
Total Cost of Production		**TVC+TFC**		393825		367000
Benefits-Cost ratio		**NR/TCP**		1.15		0.54

of N532, 775, 452,775 and 1.15 respectively coming from Kabba. The cost benefit ratio obtained for Kabba site was positive.

CONCLUSION

The land evaluation studies carried out within the two sites revealed the following:

1. The characteristics and suitability of these soils for wetland rice production were highly variable hence their management must be site specific
2. The identified major limitation to rice yields on these soils for wetland rice production is basically soil fertility problem. The soil fertility problem can be amended using appropriate fertilizers to move these soils to moderately suitable (S2) for lowland rice production.
3. K, pH, CEC, total N were the most relevant soil properties that contributed to the yield of rice at both sites. This can be useful in soil fertility evaluation studies when determining optimum levels of nutrients for wetland rice production thereby concentrating more on the most relevant soil properties, in order to save cost on fertilizer use.
4. The improved management system of rice production was better than the local. Tentatively, farmers can adopt this method pending the time more studies will be carried out on the field.
5. The site in Kabba appears to be more profitable for rice production than Ado-Ekiti site hence the potential of this area for rice production should be exploited by farmers in the area.
6. More research studies can be carried on soil fertility evaluation to determine the optimum levels of K and total N necessary for wetland rice production.
7. The results of this research also suggest that land evaluation may not have much practical relevance in terms of crop yield prediction without reference to crop management level.

REFERENCES

Adeyanju A (2005). Evaluation of the potential of some soils around University of Ado-Ekiti, Ekiti-State for Arable Crop Production. Unpublished B.Sc Project Report, Department of Crop Soil and Environmental Sciences 117pp.

Avery JB, Bascomb CL (1974) (Eds.) Soil Survey on England and Wales. *Tech monogr Soil Survey Great Britain*. No. 6 : 120pp.

Ahn PM (1970). West African Soils. Oxford University Press, Oxford, 232pp.

Black CA (1965). Methods of Soil Analysis. Agronomy No. 9. *Am. Soc. Agronomy*, Madison, Wiscosin. pp121

Bray RH, Kurtz LT (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Sci.*59: 39 - 45.

Brinkman R (1970). Ferrolysis: a hydromorphic soil forming process. Geoderma 3: 199 - 206.

Buol SW, Sanchez PA, Cate Jr RB, Granger M (1975). Soil Fertility capability classification: a technical soil classification system for fertility management. *In: Soil management in Tropical America.* North Carolina State University, Raleigh, North Carolina: E. Bornemisza and Alvarado, A. (eds).

Bouyoucos GH (1951). A recalibration of the hydrometer for making mechanical analysis of soils. Agronomy. J. 43: 434 – 438 Enyi, B.A.C. (1984). Upland rice production in West Africa. *Oryza* 20:5-14.

Dalal R C (1975). Effect of associated anions on ammonium adsorption and desorption from soils. *J. Agric. and Food Chemistry*. 23: 684 - 687.

Fasina AS (2004). Influence of land utilization types on topsoil properties of an alfisol in Southwestern Nigeria. *J. Sustainable Agric. Environ.* 6 (2): 171 – 178.

Fasina AS (2005). Properties and classification of some selected Wetland soils in Ado Ekiti, Southwest Nigeria. *Applied Tropical Agriculture*, 10 (2): 76-82

Fasin AS, Adeyanju A (2007). Comparison of three Land Evaluation Systems in Evaluating the Predictive Value of some selected soils in Ado-Ekiti, Southwest Nigeria. J. soil sci. 17:113-119.

Fasina AS (2007). Irrigation suitability evaluation of Asu River Basin Soils, South Eastern Nigeria. Int. Niger. J. Soil Sci. 3 (1): 35 -41.

Fasina AS, Omueti JAI, Ayodele OJ (2007). Characterization, Classification and Crop Production Potentials of Soils of Asu River Basin, Anambra State. In Proc. Of the 33rd Annual Conference of Soil Science Society of Nigeria held at University of Ado-Ekiti, Nigeria pp49-59.

FAO (1984). Guidelines: Land Evaluation for Rainfed Agriculture. Soils Bull No 52, Food and Agricultural Organisation, Rome 237pp

FAO-UNESCO (1974). Soil Map of the World 1:5,000,000 Volume I Legend. UNESCO, Paris, France

FAO (1976). A framework for land evaluation. *Soils Bull.* 32. FAO, Rome. Pp74

FAO (2004). Document Reviewing of the International Year of Rice and Setting the Agenda for future for Wider Dissemination. FAORome 9pp.

FPDD (1989). Fertilizer Use and Management Practices for Crops in Nigeria 163pp. Series No.22. In W.O. Enwezor, E.J. Udo, N.J., Usoroh, K.A. Adepetu, V.O. Chude and C.I. Udegbe (Editors) produced by the fertilizer procurement and distribution division of the Federal Ministry of Agriculture, Water resources and Rural Development, Lagos, Nigeria.

Grant CJ (1960). The Soil and Agriculture of Hong Kong. Government Printer Hong Kong 154pp.

Grant CJ (1964). Soil characteristics associated with the wet cultivation of rice In : The Mineral Nutrition of the Rice Plant. *Proc. of a symposium at the Int. Rice Res. Inst.* February, 1964. IRR, Los Banos, Philippines: P15 - 28.

Higgins GM (1964). Soils of some rice growing areas in Northern Nigeria. Afri. Soils. 9(2):242-265.

IITA (International Institute of Tropical Agriculture) (1992). Automated and semi-automated methods for soil and plant Analysis. *Manual Series of IITA*, Ibadan, Nigeria.

Ismunadji M (1990). Alleviating iron toxicity in lowland rice. IARD J. 12:67-72.

Klingebiel AA, Montgomery PH (1961). Land Capability Classification. *Agric Handbook* No 210. USDA Soil Cons. Ser.

Mehra OP, Jackson ML (1960). Iron oxide removal from soils and clays by dithionite-citrate system buffered with sodium bicarbonate. *Clays and Clay Mineral* 7: 317 - 327.

Moormann FR (1973). General assessment of land on which rice is grown in West Africa. Paper presented at the Seminar on Rice Soil Fertility and Fertilizer Use, January, 1973. WARDA, Monrovia, Liberia: 22-27

Moormann FR, Dudal R (1965). Characteristics of soils in which paddy is grown in relation to their capability classification. Soil Surv. Rep. No. 32, Dept. Land Dev., Bangok, Thailand: pp34-67

Moormann FR, Van Breemen N (1978). Rice: Soil, water and Land. In International Rice Research Institute's Report, Manila, Philippines, 102pp.

Nagai I (1958). Japonica Rice: Its Breeding and Culture. Yokando Tokyo. 384pp

Ogunwale JA, Ashaye TI (1975). Sandstone derived Soils of a Catena at Iperu, *Niger. J. Soil Sci.* 26:22-31

Ota Y (1968). Studies on occurrence of the physiological disease called "bronzing" Bull. Nat. Inst. *Agric. Soil Japan.* 18: 31 - 104.

Olaleye AO (1998). Characterization, Evaluation, Nutrient dynamics and Rice Yields of Selected Wetland soils in Nigeria. PhD Tesis in the Department of Agronomy, University of Ibadan. 202 pp

Okusami TA, Rust RH (1992). Occurrence, Characteristics and Classification of some hydromorphic soils from South Nigeria. *In:* Correlation Meeting (viii ISCOM): Characterization,Classification and Utilization of Wetland Soils. USDA. Soil Conservation Service. Natural Soil Survey Center Lincol N.E

Patrick WH Jr, Reddy CN (1978). Chemical changes in rice soils. *In: Soil and Rice*. Int. Rice Res. Insti, Los Banos, Philippines.: 361-379
Ponnamperuma FN (1972). The chemistry of submerged soils. *Advances in Agronomy*. 24: 29-96.
Sanchez PA, Buol SW (1985). Agronomic taxonomy for wetland soils. *In: IRRI (ed) Wetland Soils: Characterization, Classification, and Utilization. Proc. of a Workshop* 26 March-April 1984. Los Banos, Philippines. IRRI: 207-227
Sahrawat KL, Mulbah CK, Diatta S, Delaune RD, Patrick Jr Wh, Singh BN, Jones MP (1996). The role of tolerant genotypes and plant nutrients in the management of iron toxicity in lowland rice. *J. Agric. Sci*. 126:143-149.
Soil Survey Staff (1996). Soil Taxonomy; a Basic System of Soil Classification for Making and Interpreting Soil Surveys. USDA Agric. US. Govt. Printing Office, Washington D.C: 780pp
Smyth AJ, Montgomery RF (1962). Soils and Land Use in Central Western Nigeria. Govt. Printer, Ibadan, Western Nigeria: 264pp.
Tanaka A, Yoshid S (1970). Nutritional Disorders of the Rice lant in Asia. Int. Rice res. Inst. Tech. Bull. 10. 51pp
Trolldenier G (1973). Secondary effects of potassium and nitrogen on rice: changes in microbial and iron reduction in the rhizosphere. *Plant and Soil* 38: 267-297.
Trolldenier G (1979). Effect of mineral nutrition of plants and soil oxygen on rhizosphere organisms *In Schippes B and Gams, W (eds): Soil-borne Plant Pathogens*. London-New York. Academic Press: 235-240.
Trolldenier G (1981). Iron toxicity in rice plants and nitrogenase activity in the rhizosphere as related to potassium application *In: Proc. Sympo. paddy Soil*. Institute of soil Science. New York: Springer Verlag: 375-380.
Walkley A, Black IA (1934). An examination of the Degtjareff method for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Science* 37:29 - 38.
WARDA (1993). Rice Trends in subSaharan Africa: A Synthesis of Statistics on Rice Production, Trade and Consumption. 214pp. West Africa Rice Development Association
Wong MTF, Wild A, Juo ASR (1991). Retarded leaching of nitrate measured in monolith lysimeters in south-east Nigeria. *J. Soil Sci*. 38: 511-518.
Wyn RG, Lunt OR (1967). The function of calcium in plants. *Bot. Rev*. 33:407-426.
Young A (1976). Soil Survey and land evaluation in developing countries: a case study in Malawi. *Geo. J*. 143: 407-431.