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Research article

THE POTENTIALS OF ENYONG CREEK FLOODPLAIN FOR RICE (*ORYZA SATIVA*) CULTIVATION IN AKWA IBOM STATE, NIGERIA

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ABSTRACT

Field soil survey and land suitability evaluation were carried out to assess the potentials of the Enyong Creek Floodplain for rice cultivation in Akwa Ibom State, Nigeria. Data were obtained from nine pedons, three each, from three study sites located within the floodplain. Both the non-parametric (FAO) and the parametric approaches were used in the evaluation. The result showed that despite the favourable climatic factors, soil depth and wetness or ground water table, there was no highly suitable (S1) land for rice cultivation in the study area. Evaluation by the non-parametric method (potentially and currently) showed that all the pedons were marginally suitable (S3) for rice cultivation. On the other hand, by the parametric approach, currently, 33%, of the pedons were marginally suitable (S3) while 67% were not suitable (N1), but potentially, 67% of the pedons were marginally suitable while 33% were not suitable for rice cultivation. The major constraints to rice cultivation in the study area were iron toxicity, soil fertility and soil texture.

Key words: Land suitability, rice cultivation, iron toxicity, Enyong Creek, Akwa Ibom State.

INTRODUCTION

Rice (Oryza sativa L.) being the second largest consumed cereal (after wheat) shapes the lives of millions of people. Over half of the world's population depends on rice for 80 percent of its food calorie requirements. According to the Food and agriculture Organization (FAO) the global rice requirements in 2025 will be in the order of 800 million tones. The present production is little less than 600 million tones and additional 200 million tones will have to be produced both by increasing productivity per hectare and the hectares of land under cultivation to meet the future requirements (Swaminathan, 2006).

In Nigeria, rice is a major cereal crop and an important staple food in many households. It is widely regarded as a superior food, which until recently was mainly consumed by city dwellers and middle to high income earners (Dawan, 2000).

Recently, the Federal Government of Nigeria in collaboration with the Akwa Ibom State Government has embarked on large-scale cultivation of certain crops including rice (Udoh *et. al.*, 2011). This is with a view to increasing food production to meet the rising food needs of the people occasioned by the country's growing population.

The alluvial soils of the Enyong Creek floodplain in Ini Local Government Area of Akwa Ibom State are recognized as having some potentials for rice cultivation (Tahal, 1982; Udoh *et. al.*, 2011). Although some investigations have been carried out to assist in raising the level of rice production, more relevant studies are still needed to ensure optimum and sustainable rice production in this environment. In many developing countries like Nigeria, agricultural productivity is adversely affected by ineffective and unplanned use of agricultural land. A major function of land evaluation is to show the farmer the suitability or potential of his land for specific uses and its limitations. This is achieved by matching the land qualities/characteristics with the requirements for the envisaged land use (FAO, 1976; Braimoh, 2000; Udoh *et. al.*, 2011). Therefore, the aim of this study was to evaluate the suitability of the Enyong Creek floodplain for wetland rice cultivation in Akwa Ibom State, Nigeria.

MATERIALS AND METHODS

The Study Area

Akwa Ibom State, located in south-south geo-political region of Nigeria, lies entirely on the coastal plain with in latitudes 4^o30^1 and 5^o30^1N and longitudes 7^o30^1 and 8^o20^1E. The climate is humid tropical, annual rainfall ranges from more than 3000 mm along the coast to about 2250 mm at the extreme north with 1-3 dry months in the year (Udoh, 2009).

The natural vegetation comprises the lowland rainforest, mangrove forest and coastal vegetation. But after devastation by man, most of this has given way to a mosaic-farmland/oil palm forest, riparian forest and oil palm forests (Peters *et. al.*, 1989).

Field Work

Three locations were selected for the study within the Enyong Creek floodplain in Ini Local Government area, Akwa Ibom State. In each of the locations, namely, Mbiabet Ikpe, Ekoi Mbat and Ibiono Ewuro respectively, three soil profiles were dug and studied. All the pits were sampled according to the FAO (2006) guidelines for soil profile description. After the profile description, soil samples were collected from each genetic horizon for laboratory analysis.

Laboratory Analysis and Soil Classification

Laboratory analyses of soil samples were carried out using appropriate standard procedures (Udo *et al.*, 2009; IITA, 1979; 1981). From the results of the laboratory analyses and field morphological properties, the nine pedons encountered in the study area were classified, following the USDA Soil taxonomy (Soil Survey Staff, 2010) and correlated with FAO/UNESCO Legend (FAO, 1990)/World Reference Base.

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Land Evaluation

The suitability of the nine pedons for rice cultivation was evaluated both by the conventional (non-parametric) and the parametric methods. For the conventional evaluation (FAO, 1976), pedons were first scored (rated) by matching their land qualities/characteristics (Table I), with the established requirements for wetland rice cultivation (Moormann and Dudal (1965); Tanaka and Yoshida (1970); Sys (1985); Ponnamperuma (1994)).

For the parametric method, the index of productivity (IP) for each pedon was calculated using the ratings or class scores for each pedon (in Table 3) in the equation:

$$IP = A \times \sqrt{\frac{B}{100} \quad \frac{C}{100} \quad \times \ldots \times \frac{F}{100}}$$

where: A is the overall lowest characteristic rating and B, C, …F, are the lowest characteristic ratings for each land quality group (Udoh and Ogunkunle, 2012).

Both the potential index of productivity (IPp) and current index of productivity (IPc) were calculated for each pedon. In calculating IPp, exchangeable K, Ca, Mg: K ratio and available P which are easily altered are not part of the 'f' group. But in calculating IPc, properties which are easily altered, listed above, are taken into consideration as well as the requirements for potential fertility – those 'f' group members which are not easily altered, e.g. cation exchange capacity (CEC), pH and organic mater content.

RESULTS AND DISCUSSION

Land Qualities/Characteristics of the Study Area, Land Use Requirements for Rice Cultivation and Suitability Class Scores of Pedons.

By the central concept of FAO (1976) framework for land evaluation, the determination of the suitability of a piece of land for a specified use involves the matching of land qualities/characteristics with the requirements of the envisaged land use. The five land quality groups used in this study are presented in Table 1. The requirements for wetland rice, cultivation are as outlined by Moormann and Dudal (1986); Tanaka and Yoshida (1970); Sys (1985) and Ponnamperuma (1994).

Suitability Class Scores of Pedons – The Result of Matching Land Qualities with the Requirements for Rice Cultivation

The suitability class scores (ratings) of the nine pedons used in the study are presented in Table 2.

Climate (c)

When climatic requirement for rice (Sys, 1985) were matched with the land characteristics (rainfall and solar radiation) of the study area (Table 1), annual rainfall and solar radiation scored 100% and 95% (Table 2). This result indicates that the study area is very highly or nearly optimally suitable for rice cultivation with respect to climatic requirements.

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Soil Physical Characteristics (s)

Soil physical characteristics considered for wetland rice cultivation were soil depth and soil texture (Moormann and Dudal, 1986). Soil depth was excellent as it scored 100% in all the pedons (Table 2). On the other hand, soil texture (clay content) posed moderate to severe limitation to rice cultivation (scored 85-60%).

Wetness or Ground Water Table (w)

By matching the requirements for rice cultivation in terms of wetness or ground water table (Moormann and Dudal (1986) with the land qualities in Table 1, the result showed that both the drainage and flood duration were nearly in optimum condition (95% suitable) for rice cultivation in the area, therefore wetness or ground water table is not a limitation to rice cultivation in the Enyong Creek floodplain.

Soil Fertility (f)

Soil fertility parameters used for the evaluation were pH, total N, organic carbon, available P, exchangeable K, Ca and ECEC. The result of matching the requirements of rice for these parameters (Tanake and Yoshida, 1970), with the land qualities (Table 1) showed that some of these characteristics were serious constraints to rice cultivation in the study area. The result of the rating in Table 2 shows that soil pH was rated 95% suitable in two of the nine pedons and only 85-60% in seven pedons. Also, total N was limiting (60% suitable) in all nine pedons. Organic carbon was moderately limiting (85% suitable) in almost all the pedons. Similarly exchangeable K, Ca and ECEC were limiting (60 – 85%) in most of the pedons.

Furthermore, available P was severely limiting (40% suitable) in all the pedons in Mbiabat and Ibiono Ewuro and moderate (85 – 60%) in Ekoi Mbat (Table 2). The result shows that soil fertility is generally a major limiting factor to rice cultivation in the Enyong Creek floodplain. Edem and Ndaeyo (2006) had observed that wetland soils in this region generally have low exchangeable basic cations (Ca, Mg, K and Na) and high acidic cations. This is a major problem of the humid tropical soils. Soils even when derived from basic parent materials become acidic due to leaching of basic cations (Donahue *et al.*, 1983), and replacing of many of them by H^+ from carbonic acid formed from water and dissolved CO_2.

Toxicity (t)

Toxicity, as a land quality used in the evaluation, was represented by active (available) Fe (Moormann and Dudal, 1986). By matching the requirement for wetland rice cultivation with the land quality (Table I) with respect to toxicity, the result showed that all the pedons in the area of study were only marginal (scored 40%) in their suitability rating for rice cultivation. The result showed that iron toxicity is the most severe constraint to rice cultivation in the study area. It is also the most wide-spread, affecting all the pedons in the Enyong Creek floodplain area.

Aggregate (Average) Suitability Classification of Pedons for Rice Cultivation in the Study Area

In Table 3 are the aggregate (average) suitability scores and suitability classification of the nine pedons evaluated for rice cultivation. For the non-parametric evaluation, aggregate score for each pedon is determined

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by the most limiting (least scored) land quality / characteristic for that pedon in Table 2 (FAO,1976). For the parametric evaluation, the aggregate score for each pedon is the average of all the scores (ratings) of all the characteristics considered for that pedon (in Table 2). Aggregate suitability classes S1, S2, S3, N1 and N2 are equivalent of index of productivity (IP) values of 100 – 75, 74 – 50, 49 – 25, 24 – 15 and 14 – 0, respectively (Sys, 1985; Ogunkunle, 1993; Udoh, *et al*; 2006, Udoh and Ogunkunle, 2012).

The result in Table 3 shows that by the parametric method, potentially, all the pedons in locations 1 (Mbiabet Ikpe) and 2 (Ekoi Mbat), and one pedon in location 3 (Ibiono Ewuro), were marginally suitable (S3) for rice cultivation while two pedons in location 3 were not suitable (NI). But currently, only the three pedons of location 2 were marginally suitable while all pedons in locations 1 and 2 were not suitable for rice cultivation (Table 3).

On the other hand, by the non-parametric evaluation, both potentially and currently, all the pedons in the study area were marginally suitable (S3), for rice cultivation. The major constraints to rice cultivation in the area were soil fertility (f) and toxicity (t). Also soil physical characteristics, particularly soil texture/clay content (s) was also a serious constraint.

Table 1: Land Qualities/Characteristics of Pedons in the Study Area

Land qualities/ Characteristics	Unit	Mbiabet Ikpe Pedon 1	Mbiabet Ikpe Pedon 2	Mbiabet Ikpe Pedon 3	Ekoi Mbat Pedon 1	Ekoi Mbat Pedon 2	Ekoi Mbat Pedon 3	Ibiono Ewuro Pedon 1	Ibiono Ewuro Pedon 2	Ibiono Ewuro Pedon 3
Climate (c)										
Annual rainfall	mm	1629.58	1629.85	1629.85	1629.85	1629.85	1629.85	1629.85	1629.85	1629.85
Mean temperature	^{0}C	26-28	26-28	26-28	26-28	26-28	26-28	26-28	26-28	26-28
Relative humidity	%	80	80	80	80	80	80	80	80	80
Solar radiation	$Mjm^{-2}day^{-1}$	12.32	12.32	12.32	12.32	12.32	12.32	12.32	12.32	12.32
Soil physical Characteristic (s)										
Soil depth	Cm	165	140	160	150	150	160	120	125	120
Clay	%	18.8	16.7	17.6	12.6	10.8	13.4	11.4	12.5	12.2
Texture		Sandy loam	Sandy loam	Sandy loam	Loamy sand	Loamy sand	Sandy loam	Loamy sand	Loamy sand	Loamy san
Wetness (w) or ground water table										
Drainage	-	2	2	2	2	2	2	2	2	2
Flood duration	Months	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5	4-5
Ground water table	Cm	165	140	160	150	150	160	120	125	120
Fertility (f)										
pH (H_20)	-	5.50	4.76	5.44	5.49	5.47	5.46	5.50	4.73	5.48
Total N	%	0.08	0.06	0.06	0.07	0.08	0.07	0.08	0.09	0.07
Organic carbon	%	1.72	1.40	1.73	1.71	1.81	1.72	1.63	2.05	1.57
Available P	$Mgkg-^1$	2.91	2.34	1.91	20.86	17.91	14.52	5.83	3.84	6.09
Exc. K	$Cmolkg-^1$	0.11	0.09	0.12	0.11	0.10	0.12	0.10	0.08	0.11
Exc. Ca	$Cmolkg-^1$	3.42	3.94	5.36	3.49	4.20	3.81	5.07	5.80	7.82
ECEC	$Cmolkg-^1$	9.76	9.59	12.87	10.82	11.49	10.19	9.44	9.86	12.19
Organic matter	%	2.96	2.42	2.75	2.96	3.18	2.97	2.82	3.83	2.22
Base saturation	%	48.9	48.35	56.8	46	50.2	51	82	69	87
Exc. Mg	$Cmolkg-^1$	1.16	1.32	1.78	1.32	1.43	1.29	1.91	1.92	2.78
Toxicity (t)										
Fe	$Mgkg-^1$	358.11	310.22	272.56	376.57	500.73	471.31	518.69	371.08	279.58

Key: **Drainage:**
Imperfectly drained = 1

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Moderately or poor drained	= 2
Good or well drained	= 3
Very poor drained	= 4

Table 2: Suitability Class Scores of Pedons for Rice Cultivation in the Study Area

	Mbiabet Ikpe			**Ekoi Mbat**			**Ibiono Ewuro**		
	Pedon 1	Pedon 2	Pedon 3	Pedon 1	Pedon 2	Pedon 3	Pedon 1	Pedon 2	Pedon 3
Climate (c)									
Animal rainfall	SI(100)	SI(100)	SI(100)	SI(100)	SI(100)	SI(100)	SI(100)	SI(100)	SI(100)
Solar radiation	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Soil physical Characteristic(s)									
Soil depth	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)	S1(100)
clay	S2 (85)	S2 (85)	S2 (85)	S3 (60)	S3 (60)	S3 (60)	S3 (60)	S3 (60)	S3 (60)
Wetness (w) or Ground water table									
Drainage	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Flood duration	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)	S1(95)
Fertility (f)									
pH	S1(95)	S3 (60)	S2(85)	S2 (85)	S2 (85)	S2 (85)	S1 (95)	S3 (60)	S2 (85)
Total N	S3 (60)	S3 (60)	S3 (60)	S3 (60)	S3 (60)	S3 (60)	S3 (60)	S3 (60)	S3 (60)
Organic carbon	S2 (85)	S2 (85)	S2 (85)	S2 (85)	S2 (85)	S2 (85)	S2 (85)	S1 (95)	S3 (60)
Available P.	N1 (40)	N1 (40)	N1 (40)	S2 (85)	S2 (85)	S3 (60)	N1 (40)	N1 (40)	N1 (40)
Exchangeable K	S2 (85)	S3 (60)	S2 (85)	S2 (85)	S2 (85)	S2 (85)	S2 (85)	S3 (60)	S2 (85)
Exchangeable Ca	S3 (60)	S3 (60)	S2 (85)	S3 (60)	S3 (60)	S3 (60)	S2 (85)	S2 (85)	S2 (85)
ECEC	S3 (60)	S3 (60)	S2 (85)	S2 (85)	S2 (85)	S2 (85)	S3 (60)	S3 (60)	S2 (85)
Toxicity (t)									
Fe	N1 (40)	N1 (40)	N1 (40)	N1 (40)	N1 (40)	N1 (40)	N1 (40)	N1 (40)	N1 (40)
Aggregate Suitability									
Potential	27.1	27.1	32.3	33.2	33.2	33.2	22.8	22.8	27.1
Actual (current)	22.2	22.2	22.2	27.9	27.9	27.9	18.6	18.6	18.6

Aggregate Suitability Class Scores

100 – 75	=	S1
74 – 50	=	S2
49 – 25	=	S3
24 – 15	=	N1
14 – 0	=	N2

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Table 3: Suitability aggregate Scores and Suitability Classification of Pedons for Rice, Indicating Limiting Characteristics

		Aggregate Suitability			
		Parametric		**Non-Parametric**	
	Pedon	Potential	Current	Potential	Current
Location 1 Mbiabet Ikpe	1	S3 (27.1)	N1 (22.2)	S3ft	S3ft
	2	S3 (27.1)	N1 (22.2)	S3ft	S3ft
	3	S3 (32.3)	N1 (22.2)	S3ft	S3ft
Location 2 Ekoi Mbat	1	S3 (33.2)	S3 (27.9)	S3fts	S3fts
	2	S3 (33.2)	S3 (27.9)	S3fts	S3fts
	3	S3 (33.2)	S3 (27.9)	S3fts	S3fts
Location 3 Ibiono Ewuro	1	N1 (22.8)	N1 (18.6)	S3fts	S3fts
	2	N1 (22.8)	N1 (18.6)	S3fts	S3fts
	3	S3 (27.1)	N1 (18.6)	S3fts	S3fts

1: Aggregate suitability class score: 100 – 75 = S1; 74 – 50 = S2; 49 – 25 = S3; 24 – 15 N1; 14 – 0 = N2
2: f = fertility limitation; t = toxicity limitation; s = soil physical characteristics limitation

The Potential of Enyong Creek Floodplain for Rice Cultivation

From the ratings (scores) of the land qualities and characteristics (Table 2), the result of the study has shown that some land qualities and characteristics (climate, soil wetness or ground water table and soil depth) were optimum or nearly so, for wetland rice cultivation in the study area (Moormann and Dudal, 1986). In a previous study (Tahal, 1982) this area had been recommended as being suitable for rice cultivation based on a general assessment. However some land qualities/characteristics (clay content/texture, fertility and toxicity) imposed constraints to rice cultivation in the area. Soil clay content, pH, total N, available P, organic carbon, exchangeable K, Ca and cation exchange capacity (CEC) posed moderate limitations to rice cultivation.

Inspite of the favourable condition offered by some of these land characteristics, the final result of the evaluation (aggregate suitability classification) in Table 3, shows that the area is only marginally suitable for wetland rice cultivation. The most severe constraint to rice cultivation in the area was iron toxicity which affected all the pedons in the study are. Some previous studies (Udoh *et al.*, 2011) have similarly noted that soils in this area are generally high in available Fe. This may be attributed to the soil parent material and the low pH (acidic nature) of these soils. Enwezor *et. al.*, (1989) have observed that iron toxicity occurred in strongly acid Ultisols used for rice cultivation. Furthermore, Bhandari and Randhawa (1985) have reported that the availability of Cu, Fe and Mn was found to be significantly and negatively correlated with soil pH. Similarly, Prasad (1991) in a study of old alluvial rice soils of Bihar, observed variability in micronutrients and also reported that Fe, Cu and Mn were negatively and significantly correlated with soil pH.

CONCLUSION

Despite the favourable climatic condition, wetness or ground waters table and soil depth which were optimum or nearly so in the study area, there was no highly or moderately suitable (S1 or S2) land for wetland rice cultivation in the area. Low available P, low clay content and high iron toxicity in the soils have rendered the land of the Enyong Creek floodplain only marginally suitable (S3) for wetland rice cultivation.

In order to raise the productivity of the land to optimum for wetland rice cultivation, management techniques to be adopted should enhance the nutrient and moisture holding capacity of the soils and minimize leaching of the basic cations. Also appropriate soil amendments, including careful selection of fertilizers would be required to control the soil pH and ameliorate iron toxicity.

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