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Land Suitability Evaluation of Soils on Two Mapping Units for Some Arable Crops in South Eastern Nigeria

Nuga, B.O.[1] and Akinbola, G.E.[2]
[1]*Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, Port Harcourt.*
[2]*Department of Agronomy, Faculty of Agriculture and Forestry, University of Ibadan. Ibadan*

Abstract: *A study was carried out to evaluate the suitability of soils of two mapping units formed on coastal plain sand and shale parent materials in South-eastern Nigeria for the cropping of Maize, Oil Palm, Cassava, Cashew and Upland rice. The soils at the order level were classified as Inceptisols and at the series level were classified as Ahiara series. The soils of mapping unit 1 were rated as highly suitable (S1) for upland rice, cashew and cassava but moderately suitable (S2) for oil palm and maize. Soils of mapping unit 2 were rated as were rated as highly suitable (S1) cassava but moderately suitable (S2) for upland rice, cashew, oil palm and maize.*
Keywords*: Land- Suitability, Evaluation, Mapping unit, Inceptisols, Parent –Material*

I. Introduction

Nigeria's land masses are facing intensive competitive uses that very often lead to their misuse and degradation (Akamigbo, 1999), this in effect hinders meaningful national development. It is therefore pertinent that for the potentials of agricultural land to be maximised, there is the need to have a good understanding of the different alternative uses that a land can be put. Land use ought not to be based primarily on the needs and demands of the users, but rather on the understanding of the suitability of such a land for the intended use in order to achieve environmental sustainability. Physical land evaluation is the first step in agricultural planning for sustainable crop production. This evaluation is essential in that it will guide decisions on land utilization in such a way that the resources of the environment are optimally used, resulting in sustainable management (Fasina and Ogunkunle, 1995). Hence the need to provide more information on the quality of our soil resources is more essential now than before, principally because of the new urge to open up several hectares of land for commercial agriculture (Okusami, 1988; Fasina, 1997). Unguided conversion of agricultural land to non-agricultural land or inappropriate land use systems (policies) will ultimately lead to environmental and socio-economic problems, including poverty and unsustainable use of land resources (Stevenson and Lee, 2001). There is an urgent need for evaluation of agricultural landscapes and associated planning, owing to problems faced in recent years in the form of increasing pressure on agricultural lands from other uses, coupled with increasing demand for agricultural products due to population growth (Saroinsong et al, 2006). The agricultural produce value chain in Nigeria is in a period of growth, but there is still the need to provide growers and other stakeholders with information on land suitability which will make for sustainable management and production. The present study was aimed at assessing the suitability of soils on two mapping units in Ikwuano area of South Eastern Nigeria for some crops.

II. Materials And Method

Description of the Study Area

The study area is located in the South eastern region of Nigeria. It is one of the seventeen local government areas making up Abia State. The area lies between latitudes 5° 20' and5° 30'N, longitudes 7° 28' and 7° 42'E, and it covers an area of about 310 sq.Km with elevation ranging from 109 to 152m above mean sea level. The study area is bounded in the north by Umuahia LGA,in the south by Ikot-Ekpene,Akwa Ibom State, in the east by Bende LGA and in the west by Isiala Ngwa LGA. Fig. 1, shows the administrative map of the study area, while a 10 year average climatic data of the area is presented in Table 1. Nuga and Akinbola (2011), classified the soils of Mapping Unit 1 and 2, at the sub-order level as Typic Dystrudepts and Vertic Dystrudepts respectively.

Evaluation procedure.

The evaluation procedure use by Ogunkunle (1993) was adopted

i. Conventional method.

Each mapping units were first placed in suitability classes by matching the Land use (crop) requirements (Tables 2-6), with the characeristics of the mapping unit (Table 7). The suitability class of a mapping unit (aggregate suitability) is that indicated by its most limiting characteristics (Table 8).

ii. Parametric method.

For the parametric method, each limiting characteristic was rated as in Table 3.9. The index of productivity (IP) for each pedon was then calculated using the equation

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

where A is the overall lowest characteristic rating, and B, C,..... F are the lowest characteristics ratings for each land quality group. In this study there are five land quality groups (e.g. Table 3.3) : Climate (c) , topography (t) , soil physical properties (s), wetness (w) and chemical fertility (f). Only one member in each group was used because there are usually strong correlations among members of the same group (e.g. texure and structure in group 's'). Suitability classes S1 , S2 , S3 and N are equivalent to IP values of 100 -75, 74 – 50, 49 – 25 and 24 – 0 , respectively.

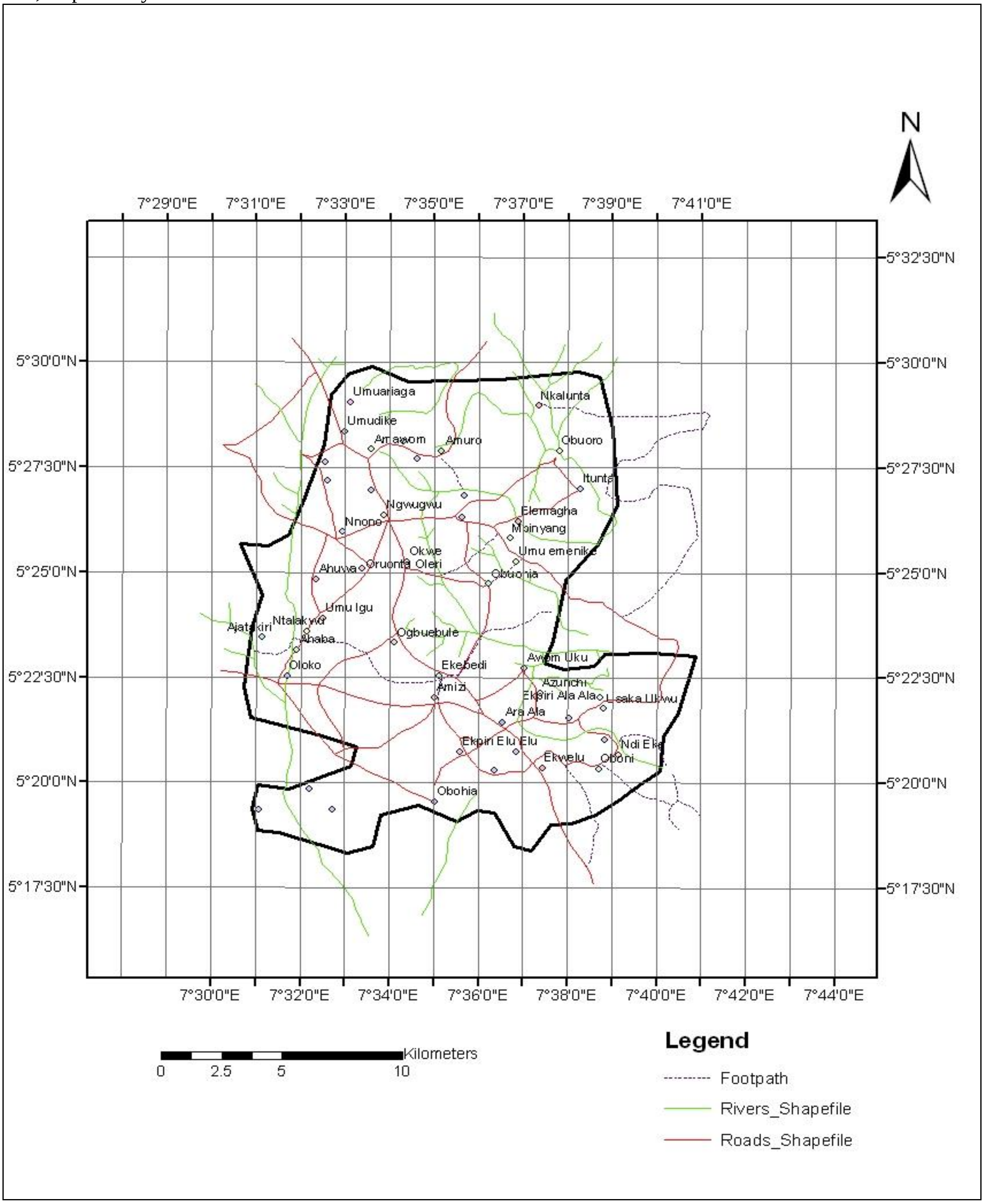

Table 1.Ten (10) years average climatic data of the study area

MONTH	R/F Total(mm)	Days	T.(^{O}C)max	T.(^{O}C)min	RH 0900H(%)	RH 1500H(%)	Windrun (km/day)	Sunshine(hrs)
JAN	7.51	1.00	32.00	20.90	63.00	43.00	97.00	4.59
FEB	14.30	2.00	34.00	22.60	67.00	42.00	110.90	5.47
MAR	148.10	7.00	33.00	23.30	77.00	57.00	107.50	3.81
APR	145.00	10.00	32.30	23.40	80.00	66.00	113.20	3.23
MAY	244.90	16.00	31.40	22.90	85.00	72.00	100.00	2.79
JUNE	269.40	17.00	30.10	22.70	85.00	75.00	107.60	2.57
JULY	300.40	22.00	28.50	22.10	88.00	80.00	114.10	1.77
AUG	352.00	21.00	28.50	22.30	88.00	81.00	121.10	1.54
SEPT	356.70	21.00	29.20	22.20	86.00	78.00	112.60	1.93
OCT	260.30	16.00	30.00	22.20	84.00	74.00	90.70	2.32
NOV	42.80	3.00	31.20	22.70	79.00	66.00	77.70	2.93
DEC	95.60	1.00	31.50	22.70	68.00	52.00	77.30	4.25
AVG.ANN	2237.0	137.0	31.0	22.5	79.2	65.5	102.5	3.1

Source : National Root Crop Research Institute , Umudike, Meteorological Station

Table 2 . Land requirements for suitability classes for rainfed upland rice cultivation (modified from Sys,1985)

Land qualities	S1	S2	S3	N1	N2
Climate (c) :					
Rainfall growing season (mm)	>1400	>1000	>800	<800	<800
Mean temp ^{o}C, crop dev. stage	24-36	18-42	10-45	-	-
Relative humidity (%) vegetative stage	50-90	Any			
Relative humidity (%), milky stage	40-70	>30	<30		
Topography (t)					
Slope (%) (1)	<4	<8	<16	<25	<25
(2)	<8	<16	<30	<30	≤ 30
Wetness (w) :					
Flooding	No	no	no-slight	no-slight	Any
Drainage (3)	good	moderate/beter	imperfect/beter	poor/beter	Very poor /beter
(4)	imperfect	imperfect/moderate	good, moderate or imperfect	good, moderate or imperfect	
Soil physical properties (s):					
Surface Coarse fragments (Vol %)	<15	<35	<55	<55	<55
Depth (cm) to impermeable layer	>90	>50	>20	>20	>20
Subsurface coarse fragments.	<35	<55	<55	<55	<55
Fertility (f) :					
Cation exchange capacity (Cmol/Kg)	>16	>0, - charge	>0, - charge		
Base saturation (%) 0-15 cm	>50	>35	>15		
Organic carbon (g/Kg), 0-15cm	>15	> 8	> 8		

(1) intensive fully mechanized agriculture (2) primitive farming (3) fine loamy or clayey families (4) coarse loamy or sandy families.

Table 3 . Land requirements for suitability classes for oil palm cultivation (modified from Sys,1985)

Land qualities	S11 (85-95%)	S12 (60-85%)	S2 (40-60%)	S3 (25-40%)	N1 (25-40%)	N2 (0-25%)
Climate (c) :						
Annual rainfall (mm)	> 2000	1700-2000	1450-1000	1250-1450	-	<1250
Lenght dry season	< 1	1-2	2-3	3-4	-	>4
Mean annual temp ^{o}C	>29	27-29	24-27	22-24	-	< 22
Relative humidity (%)	>75	70-75	65-70	60-65	-	<60
Topography (t)						
Slope (%)	0-4	4-8	8-16	16-30	>30	-
Wetness (w) :						
Flooding	F0	F0	F1	F2	-	F3
Drainage	perfect	Mod.well	Mod.well	Poor,aeric	Poor drainable	Poor, v.poor, not drainable
Soil physical properties (s):						
Texture	CL,SCL,L	CL,SCL,L	SCL	SCL – LFS	Any	C, Cs,
Structure	blocky	blocky				massive, single grain
Coarse fragments (Vol %)						
0 – 10 cm	3-10	10-15	15-35	35-55	-	>55
Depth (cm)	>100	90-100	50-90	25-50	-	<25
Fertility (f) :						
Cation exchange capacity (Cmol/Kg)	<10	8-10	6-8	<6	-	-
Base saturation (%)	>35	20-35	<20	-	-	-
pH	5.5-6	5.5-6	5.5-6	6.5-7	<4,>7.0	<4,>7.0
Organic carbon (g/Kg), 0-15cm	>12	12 - 8	< 8	-	-	-
K (mole fraction)	>1.75	1.5-1.75	1.2-0.5	<1.2	<1.2	<1.2
Mg : K ratio	>3.5	>3.5	2-3.5	1.2	-	-
Salinity and alkalinity (n):						
EC (mmhos/cm)	<1	1-2	2-3	34	4-8	>8

**F0, no fooding; F1, 1-2 months flooding in >10years; F2, not more than 2-3 months in 5 years out of 10; F3, 2-4 months almost every year; F4, >4 months in almost every year.

CL, clay loam; SCL, sandy clay loam; L, loam; LFS, loamy fine sand; C,clay; CS,clayey sand

Table 4. Land requirements for suitability classes for cashew cultivation (modified from Sys,1985)

Land qualities	S11 (100%)	S12 (95%)	S2 (85%)	S3 (60%)	N1 (40%)	N2 (25%)
Climate (c) :						
Annual rainfall (mm)	1600-2000	1200-2000	800-1200	500-800	-	<500
Lenght dry season (months)	2-3	<2	4-5	5-6	-	>6
Mean annual temp ^{o}C	>18	-	10-18	4-10	-	<4
Topography (t)						
Slope (%)	0-4	4-8	8-16	>16		
Wetness (w) :						
Drainage	good	Moderate	Imperfect flucuating ground water	Imperfect permanent high ground water	Poor drainage	Very poor drainage
Soil physical properties (s):						
Texture	SiCL,CL,SiL ,SC	L,SCL,SL, LFS,LS	LCS,FS	S,CS	-	C
Coarse fragments (Vol %)	<3	<15	<35	<55	-	>55
Depth (cm)	>100	100-75	75-50	50-25	-	<25
Fertility (f) :						
Cation exchange capacity (Cmol/Kg)	any					
Base saturation (%)	>35	20-35	<20			
Organic carbon (g/Kg) 0-15cm	>15	8 - 15	< 8			

Table 5. Land requirements for suitability classes for maize cultivation (modified from Sys,1985)

Land qualities	S11	S12	S2	S3	N1	N2
Climate (c) :						
Annual rainfall (mm)	850-1250	850-750	750-600	600-500	-	<500
Lenght growing season (days)	150-220	220-270	270-325	325-345	-	>345
Mean annual temp ^{o}C	22-26	22-18	18-16	16-14	-	<14
Relative humidity (%)	50-80	50-42	42-36	36-30	-	>30
Topography (t)						
Slope (%)	0-2	2-4	4-8	8-16	-	>16
Wetness (w) :						
Flooding	F0	-	-	F1	-	F2
Drainage (4)	good	moderate	imperfect	poor	poor	poor and very poor
(5)	imperfect	moderate	good	aeric	drainable	not drainable
Soil physical properties (s):						
Texture	SiC,SiCL,CL ,SiL,	SC,L,SCL	SL,LfS, LS	LcS,Fs,	-	S,
Coarse fragments (Vol %)						
0 – 10 cm	<3	3-15	15-35	35-55	-	>55
Depth (cm)	>100	75-100	50-75	20-50	-	<20
Fertility (f) :						
Cation exchange capacity (Cmol/Kg)	>24	16-24	<16	<16		
Base saturation (%)	>50	35-50	20-35	<20		
Organic carbon (g/Kg), 0-15cm	>20	12 -20	8- 12	< 8		

Table.6 . Land requirements for suitability classes for cassava cultivation (modified from Sys,1985)

Land qualities	S11	S12	S2	S3	N1	N2
Climate (c) :						
Annual rainfall (mm)	1400-1800	1000-1400	600-1000	500-600	-	<500
Lenght dry season (months)	3-4	4-5	5-6	6-7	-	>7
Mean annual temp °C	26-20	26-30	>30			
Topography (t)						
Slope (%)	0-4	4-8	8-16	16-30	30-50	>50
Wetness (w) :						
Drainage	good	-	moderate	imperfect	poor drainable	poor non drainable
Soil physical properties (s):						
Texture	L,SCL	SL,SiC, SiCL,CL,SiL ,SC	LfS,LS, LCS,Fs	CS	-	Si
Coarse fragments (Vol %)						
0 – 10 cm	no	<3	<15	<35	-	>35
Soil Depth (cm)	>125	>100	>75	>50	-	<50
Fertility (f) :						
Cation exchange capacity (Cmol/Kg)	>16	Any				
Base saturation (%)	>35	35-20	<20			
Organic carbon (g/Kg), 0-15cm	>15	8-15	< 8			

Table 7. Land qualities/characteristics (ranges) of soil mapping unit in Ikwuano LGA.

Mapping unit	Annual rainfall (mm)	Lenght of dry season (months)	Mean Temperature (°C)	Relative Humidity(%)	Drainage	Soil depth (cm)	Coarse Fragments	Texture	CEC (Cmol/Kg)	Base saturation (%)	pH
1	>1900	4	≥27	≥75	good	>100	Nil	SL-SCL	2.48 -2.29	24 - 93	4.1-6.4
2	>1900	4	≥27	≥75	good	>100	Nil	SCL-C	1.77-4.0	24 -56	4.4 -7.7

Table 8: Ratings of limiting characteristics

Limitation	Rating
Slight - None	100 - 95
Slight	94 -98
Moderate	84 – 60
Severe	59 – 40
Very severe	39 – 0
(1) can be corrected	39 -20
(2) cannot be corrected	19 -0

III. Results And Discussions

The FAO (1976) system as modified by Sys (1985) was used for the suitability evaluation. The land use requirements of the five crops for which the land was evaluated were given in Tables 2 – 6. The matching of the land qualities /characteristics of the mapping units (Table 7) with the land use requirements of the various crops (land use) produced the various suitability classes using the parametric and non-parametric methods. The suitability groupings are given in Tables 9 – 10. The soils of mapping unit 1 are highly suitable (S1) for the growing of upland rice, cashew and cassava but is moderately suitable (S2) for maize and oil palm.

The soils of mapping unit 2 is highly suitable for cassava while being moderately suitable for upland rice, oil palm, cashew and maize. The major limitation in the two mapping unit is soil fertility, which is more pronounced in mapping unit 2. The suitability evaluation of the soils of the two mapping units show that the soils ranged between highly suitable (S1) and non-suitable (N) for five (5) major crops evaluated. Major limitation to the cultivation of most crops is the soil fertility status (CEC, base saturation and organic carbon). Due to the low level of exchangeable cation content of the soils, economic crop production will depend on proper and adequate application of both organic and inorganic fertilizers. The soils are found to range between being highly suitable (S1) to moderately suitable (S2) for cassava and upland rice; and as being moderately suitable (S2) for oil palm, maize and cashew. One of the most important requirement for rice production is the availability of water. Soils of the study area by virtue of their characteristics are considered highly – moderately suitable for upland rice cultivation hence the soils can be improved upon for intensive rice cultivation using the appropriate level of technology.

In the face of the fertility limitation in the soils of the area, the locals were found to be operating the shifting cultivation and homestead farming systems, which includes the addition of animal waste/ crop residues to the soils e.t.c , as was observed in a number of villages around the study area. These practices help in ameliorating the low fertility status and thus improving the soils productive status.

Table 9: Suitability class scores and suitability classification of mapping unit 1

	Rainfed Upland Rice	Oil-Palm	Cashew	Maize	Cassava
Climate					
Annual Rainfall (mm)	S1(1)	S1(1)	S11(1)	S11(1)	S1(1)
Mean temp ^{o}C	S1(1)	S1(1)	S11(1)	S12(.95)	S1(1)
Length of growing period/ length of dry season	S1(1)	S2(.85)	S12(.95)	S11(1)	S1(1)
Relative Humidity					
Vegetative stage	S1(1)	S1(1)	S11(1)	S11(1)	S1(1)
Milky Stage	S1(1)		S11(1)		
Topography					
Slope %	S1(1)	S1(1)	S11(1)	S11(1)	S1(1)
Wetness					
Flooding	S1(1)	S1(1)	S11(1)	S11(1)	S1(1)
Drainage	S1(1)	S2(.85)	S2(.85)	S2(.85)	S2(.85)
Soil Physical Properties					
Depth to impermeable layer	S1(1)	S1(1)	S11(1)	S11(1)	S12(.95)
Soil Fertility					
CEC meq/100g	S2(.85)	S3(.60)	S11(1)	S3(.60)	S2(.85)
Base Saturation %	S2(.85)	S1(1)	S11(1)	S2(.85)	S2(.85)
Organic Carbon	S2(.85)	S2(.85)	S12(.95)	S11(1)	S2(.85)
	85.0%	51.0%	85.4%	53.9%	76.4%
Parametric	S1	S2	S1	S2	S1
Non Parametric	S2f	S3f	S1	S2f	S2f

Table 10: Suitability class scores and suitability classification of mapping unit 2.

	Rainfed Upland Rice	Oil-Palm	Cashew	Maize	Cassava
Climate					
Annual Rainfall (mm)	S1(1)	S11(1)	S11(1)	S11(1)	S11(1)
Mean temp ^oC	S1(1)	S11(1)	S11(1)	S12(.95)	S11(1)
Length of growing period/ length of dry season	S1(1)	S2(.85)	S2(.85)	S11(1)	S11(1)
Relative Humidity					
Vegetative stage	S1(1)	S11(1)	S11(1)	S11(1)	S11(1)
Milky Stage	S1(1)				
Topography					
Slope %	S1(1)	S11(1)	S1(1)	S11(1)	S11(1)
Wetness					
Flooding	S1(1)	S12(.95)			S11(1)
Drainage	S2(.85)	S12(.95)	S12(.95)	S2(.85)	S2(.85)
Soil Physical Properties					
Depth to impermeable layer	S1(1)	S11(1)	S11(1)	S11(1)	S11(1)
Soil Fertility					
CEC meq/100g	S3(.60)	S3(.60)	S1(1)	S3(.60)	S12(.95)
Base Saturation %	S1(1)	S11(1)	S11(1)	S11(1)	S11(1)
Organic Carbon	S3(.60)	S2(.85)	S2(.85)	S2(.85)	S12(.95)
	30.60%	39.12%	68.63%	53.9%	90.25%
Parametric	S2	S2	S2	S2	S1
Non Parametric	S3f	S3f	S3f	S3f	S2f

IV. Conclusion

The major management problems of the soils of the study area which are relevant to agricultural production are those related to soil liming requirement and the maintenance of soil fertility under continuous cropping. Lime application aim at lowering acidity can be employed. The general practice for correcting soil acidity and nutrient deficiency especially of P is by lime and P fertilizer application. However, several factors might limit the use of inorganic P fertilizers. Hence the key to sustainable food production the studied soils with its high P sorption capacity and low organic matter content is the development of a cropping system that makes greater use of locally sourced inputs. Hence a way out of the expenses / limitations and at the same time enhancing fertility is the addition of locally sourced inputs such as locally sourced rock phosphate,organic matter such as crop residues and green manure. The use of on-farm generated organic fertilizers can be a good means for a sustainable agriculture on the studied soils. Also the use of P-efficient and acid-tolerant cultivars can be adopted, thus reducing the need for expensive input.

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