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SUITABILITY RATING AND MANAGEENT OF PART OF COLLEGE OF AGRONOMY RESEARCH FARMS' SOILS FOR MAIZE(*Zea mays*) AND COWPEA(*Vigna unguiculata (L) Walp*)CULTIVATION AT NORTH CORE, UNIVERSITY OF AGRICULTURE, MAKURDI.

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ABSTRACT

A detailed study was conducted on Block A, New College of Agronomy Research Farms, Federal University of Agriculture, Makurdi using conventional grid method to evaluate the suitability of the soils for some commonly produced crops in the area. Three profiles were sunk in each of the two segments and morphological described. Standard analytical were procedures adapted for the required soil physico- chemical properties. Data obtained were marched with crops requirements to give suitability classes of the soils. Results showed that all the soil parameters ranged from very low to medium in their levels; pH (5.79-6.80), OC (0.01-1.20%), TN (0.03-0.61%), Av. P (2.9-4.70mgl$^{-1)}$,Cations were in the order Ca> Mg > K >Na; CEC (4.10-8.84cmolkg^{-1}) and base saturation > 80%.Soil textures; from loamy sand through sandy clay loam to clay. Most land parameters were highly suitable for the crops cultivation except mean annual maximum temperature, organic carbon and available phosphorus; soil structure and extractable K. On aggregate all the soils were highly suitable for crop cultivation as the limitations by temperature, OC and Av. P., K., and structure did not substantially reduce the soils suitability for cowpea and maize cultivation. Annual maximum temperature limitation may be corrected by planting improved crops varieties that can tolerate such temperatures; pH by slight de-acidification, OC will be remedied by incorporating organic manures into soils while Phosphorus and potassium rich fertilizers may be applied into these soils to correct their deficiency.

Keywords: *Aggregate Suitability, Crops, Analytical Procedures, Soil Parameters, Limitations, Remedy.*

INTRODUCTION

According to Eswaram(1977), some different uses of soil characterization data include to aid in the correct classification of the soil and enable other scientists place the soils in their taxonomies or classification systems and to serve as a basis for more detailed evaluation of the soil as well as gather preliminary information on nutrient, physical or other limitations needed to produce a capability class. A soil characterization study, therefore, is a major building block for understanding the soil, classifying it and getting the best understanding of the environment (Esu, 2005). Land evaluation is a systematic process of identifying and measuring land qualities and assessing them for various kinds of uses. Land suitability is the rating of portions of land for a specific use and could be determined for the present condition (Actual land suitability) or after improvement (Potential land suitability)according to Ritung*et al.,* 2007. In agriculture; is the assessment of land for a specific kind of land utilization, such as grazing, rainfed farming, irrigation agriculture (FAO, 1976).Agricultural land use, unlike other uses, is discriminatory. It is a fact that not all soils can be used for agricultural purpose and not all crops can be successfully grown on a particular soil type. It is often that a soil type suitable for a particular crop may not be suitable for another crop because crops differin their requirements. These requirements must be understood within the context of limitations imposed by land forms and other features which do not form a part of the soil but may have a significant influence on use that can be made of the land (FAO, 1978). Inadequate information on the status of agricultural lands can lead to misuse, mismanagement and degradation.

If self-sufficiency in agricultural production is to be achieved in developing and transitional countries, land evaluation techniques will be required to develop models for predicting the land's suitability for different types of agriculture (Elaalem*et al.,* 2010). A major problem of agricultural development in Nigeria is poor knowledge and appraisal of suitability of parcels of land for agricultural production. The result is poor farm management practices, low yield and unnecessarily high cost of production. Under present condition where land is a limiting factor, it is impractical to bring more area under cultivation to satisfy increasing food demand (Fischer*et al.,* 2008). Hence, it is essential to understand their nature and properties in order to preserve soils for future generations and for their most efficient use (FAO/UNEP, 1999). A proper understanding of the nature and properties of soils and their management based on their

potentials and constraints is crucial to the optimization of crop production to the potential levels. Hence the objectives of this work were to characterize the soils and determine their suitability for maize and cowpea cultivation and suggest possible management practices.

MATERIALS AND METHODS

Location: The study area: (Block A), is part of College of Agronomy Research Farms, North Core, Federal University of Agriculture, Makurdi. Thearea lies between latitudes 7° 47' 42'' and 7°47' 47.85'' N and longitudes 8°36' 44'' E and 8°36' 58.12 '' E, at elevation of 123m above sea level with land mass of 300x100m^2 (3ha). Profiles' locations, slope and height above sea levels were taken by use of GPS. The study site was demarcated into two segments: A_1 and A_2. The land was then subjected to detailed soil survey employing conventional grid method.

Soil Sampling: Three profiles pits were dug in each segment to 2m depth or impenetrable layer and morphologically described using Soil Survey Staff, 2010 (Gutherie and Witty, 1982) pattern outlined in soil survey manual. Soils were sampled from genetic horizons, properly packaged, labeled and taken to the Advanced Soil Science Laboratory for Physical and Chemical analyses. The samples were air dried, made to pass through a 2mm sieve and then analyzed employing standard analytical procedures (IIA, 1994).

Suitability Evaluation: Suitability evaluation of the land was done using the conventional parametric method (FAO, 1976). Pedons were placed in suitability classes by matching their characteristics with established requirement for each crop; Table 1. The final (aggregate) suitability class indicates the most limiting characteristics or parameters. The parameters include, mean annual rainfall and temperature, slope, wetness; drainage and flooding, soil texture, coarse fragment, soil pH, depth with fertility indicators: ECEC, base saturation, organic carbon /organic matter, available phosphorus and extractable K.

Characterization: The soils were located on a gentle slope (0-2%) with profiles depths from moderate (77cm) to very deep165cm; moderately to well drained and therefore highly suitable for both crops production.

Soil surfaces were dark brown (7.5YR3/4), from melanization to reddish yellow (7.5YR6/6). The subsurfaces ranged from yellowish red (5YR6/8) to reddish brown (2.5YR5.4) or pink(7.5YR7/4) or light brownish gray (10YR6/2) due to gleization; textures were sandy loam through sandy clay

loam to clay; structures, weak fine crumb to strong coarse subangular blocky with mottled B horizons in most profiles due toredoxmorphism, Table 2. These however, have not drastically reduced the soils' suitability for crop cultivation.

Soil reaction was slightly acidic pH (5.79-6.80), suitable for nutrients uptake in most crops (Brady and Weil, 1999); OC was low (0.10%) to medium (1.20%) with higher values in the epipedons. Abagyeh *et al.* (2017) reported similar trend in OC values of Mid Benue Trough soils and attributed this, to annual bush burning. Soils low in OC cannot perform maximally as is the case with study soils (S3-N1) unless remedied by organic manures incorporation. Nitrogen values followed the trend in OC. This agrees with works by Anande *et al.*(2019) and Abagyeh *et al.* (2017); Nitrogen is lost in soils through various mechanisms such as chemical/microbial fixation, NH_3 volatilization, leaching and so forth. Soils phosphorus ranged from very low to low(2.900-4.70mgl^{-1}); this may be attributed to the low clay content, cation exchange capacity and pH<7.0. According to Ogbu*et al.* (2019), P dissolves in surface runoff and is leached due to the coarse nature of the soils. CEC of the soils were medium(5.63-7.90cmolkg^{-1}) in their levels, the low CEC values show that the soils have low potentials for retaining plant nutrients hence limiting the soils suitability for crops cultivation (S3-N2). The very high base saturation (>78.70%) was very adequate for the cultivation of crops under study despite the fact that extractable K slightly lowered the suitability of these soils to a moderately suitable class (S2). Table 3 shows the chemical properties in the study area. Cations were in the order Ca> Mg > K >Na with corresponding values 2.00- 3.20,1.60-2.98,0.18-0.29 and 0.14-0.26cmolkg^{-1}respectively and were rated very low in all the profiles; which may be due to leaching, weathering intensity, low activity clay content and the lateral translocation of bases.

Suitability Ratings: Table 4shows that segment A_1soils were optimal for maize cultivation in all the land parameters except mean annual temperature (S3), soil CEC (S2), organic carbon (S3), available phosphorus (S3) as well as extractable K (S2). These land characteristics have reduced the suitability of segment A_1 soils to a moderately suitable (S2) class for maize cultivation on aggregate. On the other hand, segment A_2 was optimal or nearly optimal in mean annual rainfall, relative humidity, length of rainy season, slope, base saturation, texture, structure and flooding/drainage as well as soil depth for the production of cowpea.

Cation exchange capacity (CEC) and soil pH were ranked moderately suitable (S2) for cowpea cultivation. Mean annual maximum temperature and organic carbon were ranked currently not suitable (N1) while available P was permanently not suitable (N2) for cultivation of cowpea.
On aggregate, soil pH, cation exchange capacity, organic carbon and available phosphorus and mean annual maximum temperature, as limiting factors, have cumulatively lowered the suitability of segment A_2soilsfor cowpea cultivation from very highly ($S1_1$)to highly suitable ($S1_2$) subclass.

Management: Slight de-acidification of segment A_2soils will raise the pH suitable for optimal cowpea cultivation. Incorporation of organic manures will boast the entire soils' organic carbon while application of mineral NPK fertilizer will remedy the shortfalls in nitrogen, N, phosphorus, P and potassium, K; High temperature tolerant improved varieties of both cowpea and maize may be planted on Block A soils.

CONCLUSION

All soils nutrients ranged from very low to medium in their levels. They were rated moderately (S2) to high ($S1_2$) in their suitability for maize and cowpea cultivation respectively. Slight liming, organic manures incorporation, mineral fertilizer, NPK application and planting improved, temperature tolerant varieties will remedy the soils deficiency in soil pH, OC, N, P, K and high temperature.

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Table 1: Land and Soil Requirements for Suitability Rating of Cowpea (C) And Maize(M).

Land/Soil Characteristics	Rate	Crop						
		C	85 -95	60-85	40-60	25-40	25-40	0-25
		M	100-95	-	84-40	39-20	19-00	-
Class		C	$S1_1$	$S1_2$	S2	S3	N1	N2
		M	S1	-	S2	S3	N1	-
Climatic (c)		C						
Annual Rainfall (mm)		C	>1200	1000-1200	800-1000	600-800	-	<600
		M	850-1250		600-750	500-600	1600-1800	>1800
Annual Max. Temp. (°C)		C	29	27-29	24-27	22-24	-	<22
		M	22	26	18-16	36-30	32+	
Relative Humidity (%)		C	>75	70-75	65-70	60-65	-	<60
		M	50	80	>80	-	-	
Length of Rainy Season		C	>5 Months	4-5	3-4	2-3	-	<2
		M	150 Days	220	110-130	90-110	-	
Topography (t)		T						
Slope (%)		C	0-4	4-8	8-12	12-16	>16	
		M	0-2	0-2	4-8	8-16	>30	
Wetness (w)								
Flooding (Class)		C	F_0	F_0	F_1	F_2	-	F_2
		M	FO	FO	FI	Aeric	Poor	
Drainage		C	WD	WD	WD	IWD	PD	VPD
		M		Good	Poor	Poor	Drainable	
Soil Physical Properties (s)		S						
Texture (Class)		C	LS	SL	SC	SCL	Any	C, CL
		M	CL,C	LCS	CS,S	S	-	-
Structure		C	Crumb	Crumb	SBK	SBK	Columnar	Columnar
		M	-	-	-	-	-	-
Coarse Fragments (%)	Profile 0-30cm	C	3-10	10-15	15-35	35-55	-	>55
		M	<3	-	15-35	35-55	-	-
Depth (cm) 0.00-0.50cm		C	>100	90-100	50-90	25-50	-	<25
		M						
Fertility (f)								
CEC ($Cmolkg^{-1}$)		C	>10	8-10	6-8	4-6	2-4	<2

	M	-	-	-	-	-	-
Fertility (f)							
Base Saturation (%)	**C**	>70	60-70	40-60	20-40	-	0
	M	>50	-	20-35	<20	-	-
Organic Carbon/Matter (%)	**C carbon**	>1.5-2.0	1.5-2.0	1.25-1.5	1.0-1.25	<1.0	<1.0
	M Matter	>2	-	0.8-1.2	<0.8	-	-
Avail. P ($mgkg^{-1}$)	**C**	>20	16-20	12-16	8-12	4-8<	<4.0
	M	>22	-	7-13	3-7	-	-
pH (H_2O)	**C**	>6.0-6.5	6.0 7.0	5.5-6.0	5.0-5.5	4.5-5.0	<4.0
	M	5.5-7.0	-	5.0=-8.0	5.0-8.0	-	-
Total Nitrogen (%)	**C**	-	-	-	-	-	-
	M	>0.15	-	0.08-0.10	0.04-0.08	<0.08	-
Extractable K ($cmolkg^{-1}$)	**C**	-	-	-	-	-	-
	M	>0.50	-	0.20-0.30	0.10-0.20	<0.10	-

Source: USDA, 2003 (modified)

LEGEND: F_o =No Flooding, F_1= Seasonal Flooding, MR= Flooding Rare, WD = Well Drained, IWD= Imperfectly Drained,
F1 = Rarely Drained, F0 = Poorly Drained, VPD= Very Poorly Drained, C= Clay, CL= Clay Loam, SCL= Sandy Clay Loam, SC= Sandy Clay;SBK =Sub Angular Blocky, $S1_1$ = Very Highly Suitable, $S1_2$ = Highly Suitable, S2 = Moderately Suitable, S3 = Marginally Suitable, N1 = Currently Not Suitable, N2 = Permanently Not Suitable; C- Cowpea and M- Maize

Table 2: Selected Morphological Properties and Particle Size Distribution of Block A, Research Farms, North Core, University of Agriculture, Makurdi.

Horizon		Colour		Structure	Particle Size Distribution			
Design.	Depth (cm)	Matrix	Mottle	-	Texture (class)	Sand	Silt	Cl
Soil Unit 1								
AP	0-32	7.5YR3/3	-	1fcr	SL	70.8	12.0	17.2
A	32-72	5YR5/6	-	1fcr	SL	69.8	11	19.2
AB	72-103	5YR5/6	-	1fcr	SL	65.8	11.0	23.2
B	103-165	10YR8/4	5YR4/6	1fcr	SL	64.8	11.2	24
Soil Unit 2								
AP	0-29	7.5YR5/6	-	1fcr	SL	72.8	12.0	15.2
A	29-82	7.5YR6/8	-	1fcr	SL	69.64	12	18.36
AB	82-140	7.5YR8/3	2.5YR4/6	1fcr	SL	66.08	12.72	21.2
Soil Unit 3								
AP	0-25	7.5YR4/4	-	1fcr	SL	69.92	13.00	17.08
BA	25-61	2.5YR4/4	-	2f-msbk	Hgsl	68.80	10.0	21.20
B	61-142	10YR6/2	2.5YR6/8	3fsbk	C	66.08	11.72	22.20
Soil Unit 4								
Ap	0-24	7.5YR3/4	-	1fcr	SL	72.80	11.00	16.20
A	24-62	5YR5/6	-	1fcr	SL	70.80	11.20	18.00
AB	62-122	5YR6/8	-	2f-msbk	SL	70.64	11.00	18.36
B	122-134	10YR7/4	2.5YR6/8	f-csbk	SCL	68.80	11.00	20.20
Soil Unit 5								
Ap	0-21	2.5YR3/2	-	1fcr	SL	71.80	11.00	17.20
BA	21-51	5YR4/4	-	1fcr	SL	69.70	11.18	19.12
B	51-57	4YR4/6	2.5YR5/4	3f-csbk	SCL	69.36	10.64	20.00
Soil Unit 6								
Ap	0-25	2.5YR3/2	-	1fcr	SL	73.80	12.00	14.20
A	25-68	7.5YR6/6	-	1fcr	SL	73.03	11.92	15.00
AB	68-107	7.5YR7/4	-	1fcr	SL	71.80	12.00	16.20
B	107-130	7.5YR7/4	-	3f-csbk	SCL	68.82	12.00	19.00

LEGEND: Design.- Designation, hg- Highly gravelly, SL= Sandy Loam SCL =Sandy Clay Loam , C= clay,; 1fcr = Weak Fine Crumbs,2f-msbk = Moderate fine to medium subangular blocky, 3f-csbk = Fine to coarse subangular blocky ; FR= Friable, FM= Few Medium,

Table T 3: Selected Chemical Properties of Block A, Research Farms, North Core, University of Agriculture, Makurdi.

Pedon							Exchangeable Properties						
S/No	Design,	Depth	pH	OC	TN	Av. P	Ca	Mg	K	Na	Ea	CEC	BS
		Cm	H_2O				$cmolKg^{-1}$						%
1	AP	0-32	5.81	0.84	0.09	3.98	2.90	2.70	0.23	0.20	1.10	7.13	84.4
	A	32-72	5.85	0.50	0.07	3.94	2.85	2.68	0.25	0.22	1.13	7.13	84.2
	AB	72-103	5.83	0.26	0.04	4.10	3.0	2.69	0.26	0.22	1.14	7.31	85.3
	B	103-165	5.84	0.18	0.03	**3.96**	**2.99**	2.98	0.27	0.23	1.12	7.59	85.3
	Mean		**5.83**	**0.45**	**0.06**	**3.26**	**2.94**	**2.76**	**0.25**	**0.22**	**1.12**	**7.29**	**84.8**
2	AP	0-29	5.83	0.68	0.09	4.0	2.83	2.43	0.23	0.21	1.12	6.82	84.5
	A	29-82	5.79	0.28	0.04	4.15	2.87	2.68	0.24	0.20	1.08	7.07	84.8
	AB	82-140	5.83	0.16	0.03	4.30	3.04	2.80	0.26	0.23	1.16	7.47	86.5
	Mean		**5.82**	**0.37**	**0.06**	**4.15**	**2.91**	**2.64**	**0.24**	**0.21**	**1.12**	**7.12**	**85.27**
3	AP	0-25	6.0	0.5 2	0.09	3.76	2.86	2.74	0.22	0.19	1.16	7.17	84.5
	BA	25-61	5.96	0.10	0.03	3.96	3.0	2.73	0.26	0.21	1.08	7.28	84.7
	B	61-142	5.84	0.10	0.04	4.08	3.20	2.98	0.28	0.23	1.13	7.82	86.5
,	**Mean**		**5.9**	**0.24**	**0.05**	**3.93**	**3.02**	**2.81**	**0.25**	**0.21**	**1.12**	**7.42**	**85.23**
4	Ap	0-24	6.44	0.60	0.46	4.20	2.80	2.70	0.26	0.23	1.12	7.11	84.20
	A	24-62	6.40	0.16	0.32	3.60	2.50	2.20	0.20	0.18	1.10	6.18	82.20
	AB	62-122	6.60	0.18	0.35	3.80	2.10	2.00	0.21	0.18	1.14	5.63	79.80
	B	122-134	6.31	0.12	0.28	3.20	2.00	1.60	0.18	0.14	1.06	4.98	78.70

	Mean		**6.4**	**0.20**	**0.3**	**3.7**	**2.3**	**2.1**	**0.2**	**0.18**	**1.10**	**5.9**	**81.2**
5	**Ap**	0-21	6.38	1.20	0.61	4.70	2.80	2.50	0.29	0.26	1.10	6.95	84.20
	BA	21-51	6.70	0.32	0.40	4.10	3.10	2.90	0.24	0.23	1.13	7.60	85.10
	B	51-57	6.61	0.42	0.41	4.30	3.00	2.60	0.26	0.24	1.14	7.24	84.30
	Mean		**6.6**	**0.67**	**4.47**	**4.37**	**2.9**	**2.70**	**0.26**	**0.24**	**1.12**	**7.3**	**84.50**
	Ap	0-25	6.56	0.48	0,36	3.90	3.10	2.80	0.28	0.25	1.12	7.55	85.20
6	**A**	25-68	6.63	0.22	0.38	4.00	2.80	2.60	0.25	0.22	1.16	7.03	83.50
	AB	68-107	6.74	0.10	0.26	2,90	2.70	2.30	0.22	0.20	1.16	6.58	82.40
	B	107-130	6.80	0.16	0.30	3.70	2.80	2.50	0.25	0.23	1.08	6.86	84.30
	Mean		**6.7**	**0.24**	**0.32**	**3.6**	**2.8**	**2.55**	**0.25**	**0.23**	**1.13**	**7.0**	**83.8**

Table 4 : Land and Soil Characteristics Used for Suitability Rating for Maize(M) and Cowpea (C) on Block A, Research Farms, North Core, University of Agriculture, Makurdi

Land/Soil Characteristics	Unit	Block A FUAM Research Farms					
	Segment	A_1	Maize	2017	A_2	Cowpea	2019
	Soil Unit	1	11	111	1	11	111
Climate (t)							
Mean Annual Rainfall	mm	1086	1086	1086	1156	1156	1156
	R	97 = S1	97 = S1	97 = S1	80 = $S1_2$	80 = $S1_2$	80 = $S1_2$
Mean Annual Max. Temp.	°C	34	34	34	33.67	33.67	33.67
	R	37 = S3	37 = S3	37 = S3	40 = N1	40 = N1	40 = N1
Relative Humidity	%	69.50	69.50	69.50	72.29	72.29	72.29
	R	98 = S1	98 = S1	98 = S1	84 = $S1_2$	84 = $S1_2$	84 = $S1_2$
Length of Rainy Season	Dy/Mth	183	183	183	6	6	6
	R	95 = S1	95 = S1	95 = S1	93 = $S1_1$	93 = $S1_1$	93 = $S1_1$
Topography (t)							
Slope	%	0-2	0-2	0-2	0-2	0-2	0-2
	R	100 =S1	100 = S1	100 = S1	92 = $S1_1$	92 = $S1_1$	92 = $S1_1$
Wetness (w)							
Flooding	Class	FO	FO	FO	FO	FO	FO
	R	100 = S1	100 = S1	100 = S1	91 = $S1_1$	91 = $S1_1$	91 = $S1_1$
Drainage	Class	ID	WD	WD	WD	WD	WD
	R	84 = S1	98 = S1	98 = S1	90 = $S1_1$	90 = $S1_1$	90 = $S1_1$
Soil Physical Properties (t)							
Texture	Class	SL	SL	SL	SL	SL	SCL
	R	80 = S1	80 = S1	80 = S1	80 = $S1_2$	80 = $S1_2$	30 = S3
Structure	-	-	-	-	Crumbs	Crumbs	Crumbs
	R	-	-	-	82 = $S1_2$	82 = $S1_2$	82 = $S1_2$
Coarse Fragments (%)	0-50cm	0.27=	0.21=	0.35=	-	-	-
	R	97 = S1	95 = S1	98 = S1	-	-	-
Depth	cm	-	-	-	165	140	142
	R	-	-	-	92 = $S1_1$	91 = $S1_1$	91 = $S1_1$
Fertility (f)							
CEC	$cmolkg^{-1}$	5.90	7.30	7.00	7.48	6.98	7.47
	R	76 = S2	80 = S2	82 = S2	55 = S2	50 = S2	53 = S2
Base Saturation	%	81.20	84.50	83.80	84.92	85.25	85.21
	R	96 = S1	98 = S1	97 = S1	93 = $S1_1$	93 = $S1_1$	93 = $S1_1$
pH	H_2O	6.40	6.50	6.70	5.83	5.81	5.93
	R	97 = S1	98 = S1	97 = S1	57 = S2	55 = S2	58 = S2
Organic Carbon	%	0.39	0.76	0.35	0.45	0.37	0.24
	R	35 = S3	38 = S3	25 = S3	40 = N1	40 = N1	40 = N1

Avail. P	**mgkg^{-1}**	3.70 33 = S3	4.40 38 = S3	3.60 30 = S3	3.96 20 = N2	3.85 19 = N2	3.93 20 = N
Extractable K	**Cmolkg R**	0.20 70 = S2	0.30 84 = S2	0.20 70 = S2	- -	- -	- -
Aggregate Suitability	**Rate**	**79.67**	**82.40**	**74.93**	**72.60**	**72.00**	**69.13**
	Class	**S2**	**S2**	**S2**	**$S1_1$**	**$S1_1$**	**$S1_1$**

LEGEND: R- Rate, Dy/Mth- Days/Months