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Fertility Status and Suitabilty Assessment of Soils for the Production of Maize at Solomon Mahlangu Campus Farm, Morogoro, Tanzania

U. K. Adamu[1*], Jerome P. Mrema[2] and J. J. Msaky[2]

[1]*Department of Soil Science, Kano University of Science and Technology Wudil, Kano State, Nigeria.*
[2]*Department of Soil Science, Sokoine University of Agriculture Morogoro, Tanzania.*

Authors' contributions

This work was carried out in collaboration between all authors. Author UKA designed the study, wrote the protocol and wrote the first draft of the manuscript. Author JPM managed the literature searches, analyses of the study performed the spectroscopy analysis and author JJM managed the experimental process and identified the species of plant. All authors read and approved the final manuscript.

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ABSTRACT

The low soil fertility status of many soils in Morogoro area and non-use of fertilizers by small scale farmers contributes to the low yields of most annual crops, including maize. This study was carried out in 2014/2015 cropping season at the Mazimbu, part of SUA farm Morogoro, Tanzania, to evaluate the current fertility status and suitability of these soils for maize cropping on the farm. Four soil profiles designated as I, II, III and IV were dug to represent each of the soil units. Soils samples were collected from delineated horizons and analyzed for physical and chemical properties. Composite soil samples were also collected from each block (mapping unit) at the depth of 0 - 30cm and analyzed for different physico-chemical properties using standard laboratory procedures of soil, plant and water analysis advocated by [1]. Results obtained indicated that, the soils were loamy sand to silt loam in texture with a slightly acidic to mildly alkaline in reaction (pHwater = 5.96 - 7.27). As per the critical nutrients limit for maize production the mean values for organic carbon

**Corresponding author: E-mail: ukadamu@gmail.com;*

(0.29 %), total nitrogen (0.04%), available phosphorus (9.0 mg kg^{-1}), cation exchange capacity (9.84 $cmol.kg^{-1}$), base saturation (21.2%) and exchangeable bases (Ca=0.7, Mg=0.85, K=0.31 and Na=0.21 $cmol.kg^{-1}$) were low in all four blocks of the study area. The mean EC value (0.03 ds/m) was below the critical limit indicating that the soils were naturally non-saline. The suitability of the soils to maize plant was assessed following conventional approach (FAO) and parametric method. The evaluation of the soils revealed that, all the soils of the four mapping units are moderately suitable (S2) for maize production. For increased and optimal maize production on the farm, it is recommended that, the best soils management practices such as planting cover crops, reducing overgrazing, burning and complementary use of organic and inorganic manure should be established.

Keywords: Soil suitability classification; soil mapping unit; maize; land evaluation.

1. INTRODUCTION

The most prominent constraint to food production in most part of the world is low soil fertility [2]. Thus, proper soil fertility management remains the key factor for increased food production. The rate of nutrient depletion of African soils has been reported to be on the increase [3]. In Tanzania the low productivity on the part of small-scale farmers is a major constraint to growth in the agricultural sector, and a fundamental challenge to improve the productivity and sustainability of farm production. The low soil fertility status of many soils in Morogoro area, as reported by previous studies [4], and non-use of fertilizers by small scale farmers contributes to the low yields of most annual crops, including maize.

Making effective decisions regarding agricultural land suitability problems are vital to achieve optimum land productivity and to ensure environmental sustainability. According to FAO, the term “land suitability evaluation” could be interpreted as the process of assessment of land performance when the land is used for specified purpose. Many workers have used crop yield to confirm the suitability of soils for crop production. Attempts have been made to predict the yield of crops through studies on land evaluation at different management levels [5].

Land suitability refers to the ability of a portion of land to tolerate the production of crops in a sustainable way. Such kind of analysis allows identifying the main limiting factors for the agricultural production and enables decision makers to develop crop management packages to increase land productivity. Land suitability is the fitness of a given land for defined use. The land may be considered in its present condition or after improvements. There is therefore the need to classify and estimate the potential of land for one use or several alternatives uses in order to develop agriculture efficiently and enhance precision farming [6].

Maize (*Zea mays* L.) is an important cereal crop which ranks the third after wheat and rice in the world [7]. Maize is grown widely in many countries of the world. Maize is the major and most preferred staple food and cash crop in Tanzania [8]. The popularity of maize is evidenced by the fact that it is grown in all the agro-ecological zones in the country. Over two million hectares of maize are planted per year with average yields of between 1.2 – 1.6 tons per hectare. Maize accounts for 31 percent of the total food production and constitutes more than 75 percent of the cereals consumed in the country. About 85 percent of Tanzania’s population depends on it as an income generating commodity [9]; the annual per capita consumption of maize in Tanzania is over 115kg; national consumption is projected to be three to four million tonnes per year.

More so, there is no land suitability assessment that has been done in detail to indicate the suitability of the SMC soils for maize production which could be used as a component of feeds of livestock in the SMC University farm. Similarly, each soil type has specific properties which affect directly its functions in relation to support crop growth and performance; and hence, the need to assess the suitability of the soils occurring in the farm for the various crops commonly grown. Specifically the study was undertaken to establish and evaluate the suitability classes of the soils of SMC farm to maize production.

2. MATERIALS AND METHODS

2.1 The Location of the Study Area

The study was conducted in the Solomon Mahlangu Campus (SMC), one of the Sokoine

University of Agriculture campuses, Morogoro, about 200 km west of Dar Es-Salaam, the major business town of Tanzania. The area covered 60 ha with an elevation ranging between 500 - 600 m above sea level. The area is located between latitudes 6°47'S and 37°37'E in Mazimbu and Lukobe villages. The area receives an annual rainfall ranging between 1200 and 3100 mm. The long rains (masika) usually fall in February to June, followed by dry season between July and September. The short rains (vuli) occur in October to January, but small amount of precipitation usually prevails throughout the year [10]. Rainfall data relevant to the study are shown in Figs. 1 and 2.

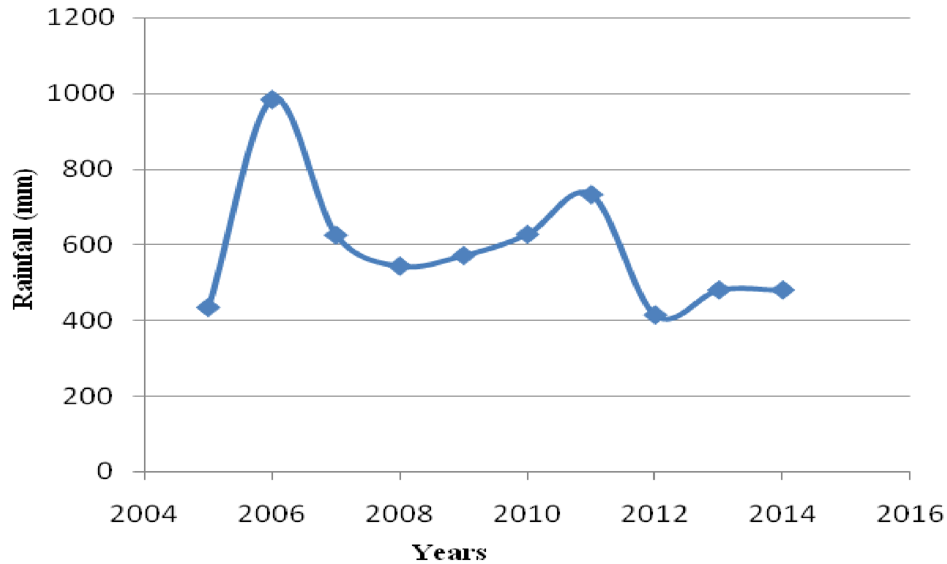

Fig. 1. Yearly total rainfall of the study area for 10 years (Mazimbu Meteorological Station, 2014)

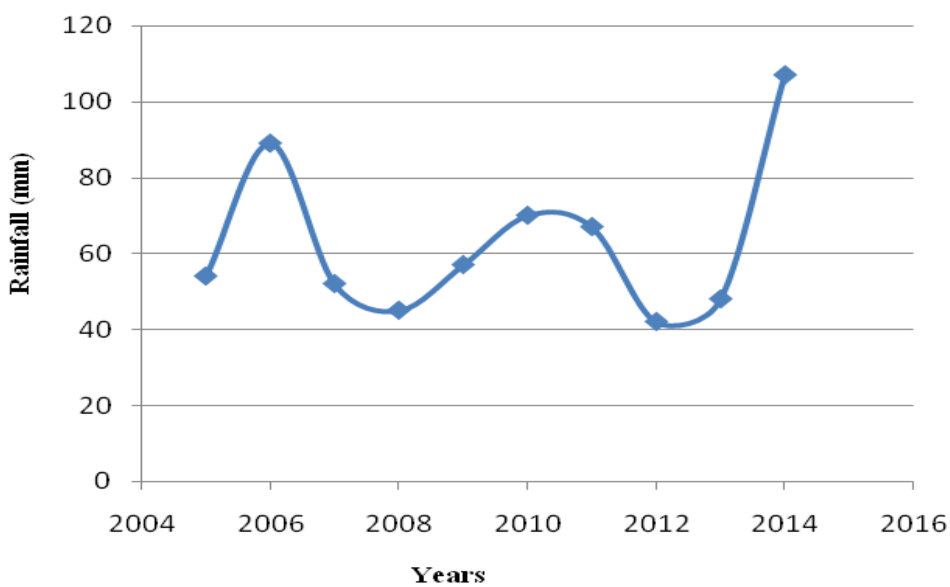

Fig. 2. Mean yearly rainfall for the study areas (10 years) (Mazimbu Meteorological Station, 2014)

2.2 Field Survey

The study area was soil surveyed using the grid method. Auger point investigations were carried out at 100 m intervals along traverses cut at 100 m apart on the baseline. Four soil mapping units were identified based on soil colour, texture, depth and surface characteristics. A profile pit (1.5 x 1.5 x 2 m or to a paralithic contact zone or limited layer) was dug in each of the four mapping units. In total 4 fully geo-referenced soil profile pits were excavated, opened, studied, described and sampled. Geo-referencing was done with the aid of the portable global positioning system (GPS) receiver (MODEL GARMIN 12 x L). A sketch map of the study area showing different soil units, profile pits and sampling sites is shown in Fig. 2. Soil horizons of the 4 identified profiles were described as per [11,12] soil profile description guidelines. Soil samples were collected from identified horizons and carefully labeled for laboratory studies. Also 4 core samples were taken by using cores sampler and geological hammer for bulk density and moisture characteristics. The collected soil samples were air-dried, gently crushed and sieved to obtain the fine earth fraction (< 2 mm) for laboratory investigation.

2.3 Soil Sampling for Fertility Evaluation

Surface soil sample for general soil fertility evaluation was done by collecting twenty soil samples from each block at the depth of 30 cm in a zig-zag pattern using a Dutch auger. The collected samples were air-dried, ground and sieved using a 2 mm sieve meshes and brought to the laboratory for routine analysis.

2.4 Land Evaluation

The agricultural potentials of the soils are developed by matching the characteristics of the soils with the requirements of the maize crop. The land suitability evaluation was done using the principles of the FAO Framework for land evaluation and the FAO Guidelines on land evaluation for rain fed agriculture [13]. Using the climatic data, the information obtained from field and laboratory, together with the ecological requirements of the selected crop (maize), the relevant land qualities were used in rating the land by matching crop requirements with the land qualities of each mapping unit. The overall land suitability class for each mapping unit was obtained by subjective combination of the individual ratings. The land qualities used in this evaluation include moisture availability, temperature regime, oxygen availability to roots, rooting conditions, nutrient availability, nutrient retention capacity, and conditions for land preparation. The suitability of the soils was assessed for maize crop in the study area following the principles of the FAO Framework [13].

2.5 Analysis of Soil Chemical Properties

The [14] wet digestion method was used to determine soil Organic carbon content and percent soil organic carbon was obtained by multiplying percent soil OC by a factor of 1.724 following the assumptions that OM is composed of 58% carbon. Total N was analyzed using the Kjeldahl digestion, distillation and titration method as described by [15]. Available soil P was analysed according to the standard procedure of soil, plant and water analysis advocated by [1] extraction method. Cation exchange capacity (CEC) and exchangeable bases (Ca, Mg, K and Na) were determined after extracting the soil samples by ammonium acetate (1M NH_4OAc) at pH 7.0. Exchangeable Ca and Mg in the extracts were analyzed using atomic absorption spectrophotometer, while Na and K were analyzed by flame photometer [16]. Cation exchange capacity was thereafter estimated titrimetrically by distillation of ammonium that was displaced by sodium from KCl solution (Chapman, 1965). Percentage base saturation (PBS) was calculated by dividing the sum of the charge equivalents of the base-forming cations (Ca, Mg, Na and K) by the CEC of the soil and multiplying by 100. The pH of the soils was measured in water and potassium chloride (1M KCl) suspension in a 1:2.5 (soil: liquid ratio) potentiometrically using a glass pH meter. The electrical conductivity (EC) of soils was measured from soil water ratio of 1:2.5 socked for one hour by electrical conductivity method as described by [1]. Available micronutrients (Fe, Cu, Zn and Mn) were extracted by DTPA and all these micronutrients were measured by atomic absorption spectrophotometer.

2.6 Data Analysis

The data of physical and chemical properties were summarized using descriptive statistics such as minimum, maximum, means and standard deviation. The soil physical and chemical properties were subjected to analysis using the [17]. Simple linear regression analysis between the measured characters was done to assess the relationships between parameters.

3. RESULTS AND DISCUSSION

The most important local indicators of soil fertility with their technical equivalents are presented in Table 1. As presented the local indicators of soil fertility identified include soil colour, soil texture, soil moisture retention capacity, soil structure, gravel and rock, soil depth, plant species and vegetations cover. Based on these soil properties, the soil was divided into good and poor soils.

3.1 Physical Properties of Surface Soil

The mean values of the physical and chemical properties of the soils of the study area were presented in Table 2. The particle size distribution of the soils properties of the soils of the study area as presented in Table 2 shows that sand separates ranged from 80.64 to 86.24% with a mean of 84.24%.

Clay separates ranged from 10.12 to 16.12% with a mean of 12.52% while silt separates ranged from 1.64 to 3.64% with mean of 3.24%. Sand appeared to be the dominant size separates in all the blocks. Sand separates accounted for over 80%, clay accounted less than 20% and silt had less than 5% in all the 4 blocks of the study area.

The textural classes varied from loamy sand to sit loam. Silt separates significantly correlated with silt to clay ratio (r = 0.846. p = 0.05). The values of silt and clay were generally low and this indicate that the soils are highly weathered. Both the silt + clay and silt/clay ratio were similar and these may reflect similarity in the parent materials of the soils from different blocks. The soil separates were similar in distribution between the four blocks. [19,20], reported similarity of means and medium values of particle size distribution in their study of alluvial soils.

3.2 Chemical Properties

The chemical properties values and mean of soils as presented in Table 2 show that the inherent fertility status of the soils which were observed Vis - a - Vis the rating scale given in Tables 3 and 4.

Soil reaction as indicated in Table 2 shows that the pH in water (range = 5.96 - 7.27; mean = 6.83) and pH in KCL (range = 5.16 - 5.68; mean = 5.61). These results indicate slightly acid to mildly alkaline reaction. In all blocks, pH values in water suspension were higher than corresponding values in IM KCL solution, indicating that the soils in their natural state were negatively charged [21]. Organic carbon generally ranges from 0.1 to 0.47% with a mean of 0.29%, indicating low in the soils. The organic carbon which is an indicator of organic matter (sole source of N) was uniformly distributed and rated low in all the blocks of the study area. The low level of organic carbon (below 1%) could be attributed to high range of organic matter decomposition and burning of organic residues and these indicate impossibility of obtaining potential crop yield in the area. Electrical conductivity of the saturation extract was low in

Table 1. Most important local indicators of soil fertility

Local indicators	Technical equivalent
Good soil	
1. Black color	Rather high organic matter content
2. Cracks during dry season	High clay content
3. Good crop performance	Adequate supply of growth factors
4. Presence/vigorous growth of certain plan	Large supply of plant nutrients
5. Presence of plants in a dry environment	High water holding capacity (WHC)
6. Low frequency of watering	High infiltration rate and WHC
7. Abundance of earth worms	High biological activity, high organic matter content and neutral Ph
Poor soil	
1. Yellow and red colors	Low soil fertility/low organic matter content
2. Compacted soils	Presence of cementing materials (Al, Fe_2O_3 heavy clays) and low biological activity
3. Stunted growth	Physical, chemical and biological limitation
4. Presence of bracken ferns	Low pH
5. Salt visible on surface	High pH, high osmotic pressure
6. Presence of rocks and stones	Shallow soils

a Source: [18], b According to participatory assessments in Same and Maswa districts.
c e.g., Solunium indicum, Commelina spp., a.o.

Table 2. Analytical data for Surface soil

Parameters	Horizons					Means	STDEV	Range
	BLK1A	BLK1B	BLK2	BLK3	BLK4			
Depth (cm)	0-30	0-30	0-30	0-30	0-30			
Clay %	12.12	14.12	16.12	10.12	10.12	12.52	2.61	10.12-16.12
Silt %	3.64	1.64	3.64	3.64	3.64	3.24	0.89	1.64-3.64
Sand %	84.24	84.24	80.24	86.24	86.24	84.24	2.45	80.24-86.24
Text.	LS	LS	SL	LS	LS			
S:C	0.3	0.12	0.23	0.36	0.36	0.274	0.10	0.12-0.36
pH $_{H2o}$	7.08	7.27	7.12	5.96	6.72	6.83	0.53	5.96-7.27
pH $_{KCL}$	5.68	5.64	6.1	5.16	5.5	5.616	0.34	5.50-6.10
Org. C %	0.21	0.47	0.1	0.33	0.33	0.288	0.14	0.1-0.47
Total N %	0.04	0.04	0.06	0.04	0.04	0.044	0.01	0.04-0.06
C:N	5.11	11.14	1.74	7.89	7.89	6.754	3.52	1.74-11.14
Avail P mg-^{1}	6.68	8	13.32	10.86	6.16	9.004	3.02	6.16.13.32
CEC cmol.kg-^{1}	10.2	10	11	10.4	7.6	9 .84	1.31	7.6-11
Ex. Ca cmol.kg-^{1}	0.37	0.84	1.77	0.37	0.37	0.744	0.61	0.37-1.77
Ex. Mg cmol.kg-^{1}	0.8	0.79	1.27	0.52	0.85	0.846	0.27	0.52-1.27
Ex. K cmol.kg-^{1}	0.33	0.38	0.36	0.24	0.22	0.306	0.07	0.24-0.38
Ex. Na cmol.kg-^{1}	0.2	0.21	0.19	0.22	0.21	0.206	0.01	0.20-0.22
TEB cmol.kg-^{1}	11.7	2.21	3.58	1.34	1.65	4.096	4.34	1.34-11.7
BS (%)	16.68	22.12	32.59	12.92	21.75	21.212	7.41	16.68-32.59
Ex. Cu mg-^{1}	0.28	0.46	0.61	0.25	0.25	0.37	0.16	0.25-0.61
Ex. Zn mg-^{1}	0.19	0.26	0.32	0.12	0.16	0.21	0.08	0.12-0.32
Ex. Fe mg-^{1}	21.2	21.2	28.53	33.77	19.63	24.866	6.06	21.2-33.77
Ex. Mn mg-^{1}	31.5	31.5	41.5	21.5	29	31	7.16	21.5-41.5
EC dSm-^{1}	0.02	0.03	0.04	0.02	0.02	0.026	0.01	0.02-0.04

all pedons, indicating that the soils were naturally non-saline. As per the critical limit for rating of land use requirements for maize production the land quality characteristics are not very suitable for the production of maize.

The percentage organic carbon nitrogen and organic carbon were generally low. Available phosphorus and exchangeable bases were also low, calcium and magnesium being most dominants exchangeable bases in all the pedons.

The low level of organic carbon, nitrogen and exchangeable bases may be attributed due to rapid decomposition and mineralization of organic matter and annual burning of the sparse vegetation commonly carried out by the farmers and cattle rearers especially Masaye nomads. The organic carbon, nitrogen and organic matter decreased down the profile depth indicating the maturity of the soil profiles and have implications for the stabilization of soil aggregate and the environment. Organic carbon and subsequently organic matter was reported to be the main agent for building particles and stabilizing soil aggregates in soils of both humid and sub-humid tropics and the organic matter is the sole source of N in the soil [22]. These nutrient levels are not supportive for optimum maize production hence there is the need to supplement from application of both organic and inorganic fertilizers. The results of soils physical and chemical analyses were used to produced the soil map of the farm area shown in Fig. 3.

3.3 Relationships between the Soil Physical and Chemical Properties of Surface Soil

Correlation analysis was carried out between the soils physical and chemical properties (Table 5). There was significant ($P<0.05$) negative correlation between the percent sand (% sand) and soils content of P, CEC, Clay, Cu, Fe, Mn2+, OC, Zn2+ and pH in both H2O and in KCl. The correlation coefficient (r) values for these relationships varied from -0.96 to -0.12 indicating a decrease in the values of these soil chemical properties with increasing sand content.

While the clay content of these surface soils was significantly and positively correlated with the pH in KCl, Zn^{2+}, TEB, Mn, K^{+}, EC, Cu and BS, thus means the higher the clay content, the higher will be the content of these chemical properties.

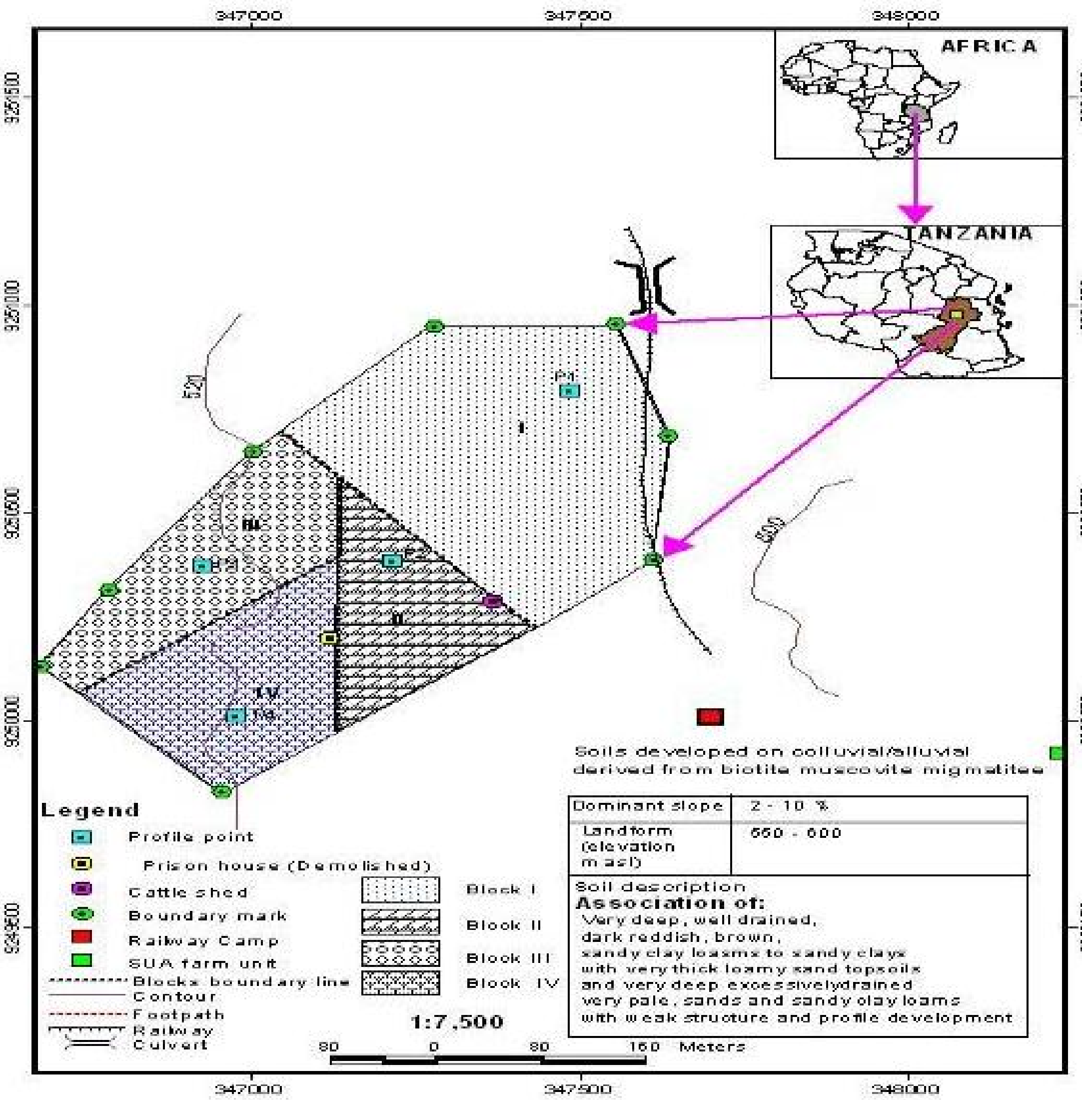

Fig. 3. Soil map of the farm

Table 3. Critical limits for interpreting levels of analytical parameter

Parameter	Rating			
	Low	**Medium**	**High**	**Unit**
Ca	<2	2 – 5	>5	cmol (+) kg^{-1}
Mg	<0.3	0.30-1.0	>1.0	cmol (+) kg^{-1}
K	<0.15	0.15-0.30	>0.30	cmol (+) kg^{-1}
Na	<0.1	0.1-0.30	>0.30	cmol (+) kg^{-1}
ECE	<5	5.0-1.0	>10.0	cmol (+) kg^{-1}
CEC (Soil)	<6	6-12	>12	cmol (+) kg^{-1}
CEC (cky)	<15	15-25	>25	cmol (+) kg^{-1}
Exch. Acidity	<2	2-5	>5	cmol (+) kg^{-1}
Base saturation	<50	50-80	>80	percent
Org. C	<10	10-15	>15	gkg^{-1}
Total N	<0.1	0.1-0.2	>0.2	gkg^{-1}
Avail. P	<10	10-20	>20	$mgkg^{-1}$

Source: [23,24]

Table 4. Rating for the status of copper (Cu) Zinc (Zn) manganese (Mn) iron (Fe) exchangeable acidity (H^+ and AL^{3+}) and (CEC) in the savannah zone as adopted by [25]

Parameters	Rating		
	Low	Medium	High
Copper (Cu) (ppm)	0-2.5	2.6-4.5	>4.5
Zinc (zn) (ppm)	1.0	_____	>1.0
Manganese (mn)(pp)	1.0	1.0	>1.0
Iron (fe) (ppm)	0.25	2.6-4.5	>4.5
Exchangeable acidity	2	2-5	>5(mo(+)kg^{-1}
CEC (soil)	6	6-12	>12(mo(+)kg^{+1}

Table 5. Pearson correlation of some surface composites soil parameters

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	1/8	19	20	21	22	23
P	1																						
BS_%	0.4663	1																					
CEC	0.7226	0.1513	1																				
C_N	-0.5476	-0.5203	-0.4135	1																			
Ca	0.7575	0.9063*	0.534	-0.5796	1																		
Clay_%	0.5466	0.8126*	0.6103	-0.4306	0.9118*	1																	
Cu	0.6575	0.874*	0.5518	-0.4133	0.9697**	0.9697**	1																
EC_dS_m	0.7053	0.8922*	0.5304	-0.4473	0.9861**	0.9432**	0.9948***	1															
Fe	0.8106*	-0.1205	0.6015	-0.2838	0.2319	0	0.1133	0.169	1														
K	0.2368	0.4962	0.6233	-0.1541	0.6152	0.8827*	0.7624	0.6934	-0.1919	1													
Mg	0.4172	0.9604**	0.1853	-0.6991	0.8602*	0.7855	0.8019*	0.8159*	-0.1558	0.4891	1												
Mn	0.3664	0.9201*	0.31	-0.6376	0.8571*	0.8839*	0.8504*	0.8394*	-0.2263	0.6862	0.9672**	1											
Na	-0.323	-0.7841	-0.3557	0.7971*	-0.7399	-0.7736	-0.6982	-0.6864	0.1894	-0.6067	-0.9146	-0.9495	1										
OC_%	-0.5186	-0.485	-0.3999	0.9989***	-0.5413	-0.3966	-0.373	-0.4063	-0.2747	-0.1317	-0.6733	-0.6125	0.7845	1									
OM_%	-0.5186	-0.485	-0.3999	0.9989***	-0.5413	-0.3966	-0.373	-0.4062	-0.2747	-0.1317	-0.6733	-0.6125	0.7845	1***	1								
S_C_ratio	-0.1567	-0.4824	-0.3997	-0.2058	-0.5495	-0.7876	-0.7367	-0.675	0.2476	-0.8942	-0.356	-0.5269	0.3238	-0.238	-0.238	1							
Sand_%	-0.6496	-0.84	-0.6248	0.7125	-0.9393	-0.9393	-0.9177	-0.9129	-0.1234	-0.7304	-0.8802	-0.9267	0.8951*	0.6847	0.6847	0.5296	1						
Silt_%	0.1855	-0.0688	-0.0684	-0.6958	-0.0857	-0.343	-0.3141	-0.25	0.338	-0.5734	0.1205	-0.039	-0.1961	-0.7188	-0.7188	0.846*	0	1					
TEB	0.6609	0.9439**	0.4689	-0.6126	0.9879***	0.9264*	0.9621**	0.972**	0.0976	0.6449	0.9224*	0.9261*	-0.8228	-0.5769	-0.5769	-0.5541	-0.9601	-0.0715	1				
TN_%	0.798*	0.8578*	0.4962	-0.7952	0.9432**	0.7717	0.8377*	0.875*	0.338	0.4067	0.8761*	0.8199*	-0.7845	-0.7656	-0.7656	-0.252	-0.9129	0.25	0.9362**	1			
Zn	0.4673	0.8765*	0.4751	-0.4029	0.9089*	0.9869***	0.9669**	0.9429**	-0.1162	0.8489*	0.8401*	0.9216**	-0.7907	-0.3678	-0.3678	-0.7872	-0.9201	-0.3576	0.9381**	0.7641	1		
pH_H2O	-0.1682	0.6226	0.093	-0.1415	0.477	0.7282	0.6056	0.5414	-0.6763	0.8091*	0.6484	0.7875	-0.7079	-0.1261	-0.1261	-0.7398	-0.6047	-0.4671	0.582	0.3079	0.7856	1	
pH_KCl	0.3414	0.8904*	0.3343	-0.6435	0.8343*	0.884*	0.8338*	0.8173*	-0.2432	0.7126	0.951**	0.9975***	-0.9618	-0.6204	-0.6204	-0.5316	-0.9266	-0.0395	0.9076*	0.7976*	0.9164*	0.8067*	
	P	BS_%	CEC	C_N	Ca	Clay	Cu	EC_dS_m	Fe	K	Mg	Mn	Na	OC_%	OM_%	S/C	Sand%	Silt%	TEB	TN_%	Zn	pHH2O	pHKCl

Table 6. Land qualities/Characteristics of site for the suitability classification

Parameters	Profile I			Profile II			Profile III			Profile IV		
	Means	**Range**	**SD**	**Means**	**Range**	**SD**	**Means**	**Range**	**SD**	**Means**	**Range**	**SD**
Clay %	23.73	8.12-30	8.92	24.79	12.12-38.12	10.62	24.79	12.12-38.12	18.69	24.79	12.12-38.12	11.70
Silt %	1.64	1.64-1.64	0.01	2.31	1.64-3.64	0.94	2.31	1.64-3.64	0.01	2.31	1.64-3.64	1.91
Sand %	74.64	68.24-90.24	8.99	72.91	60.24-84.24	9.84	72.91	60.24-84.24	18.69	72.91	60.24-84.24	10.96
pH_{H2o}	6.89	6.29-7.23	0.37	6.45	6.22-6.78	0.23	6.45	6.22-6.78	0.96	6.45	6.22-6.78	1.00
pH_{KCL}	5.79	5.05-6.54	0.55	5.01	4.50-5.86	0.60	5.01	4.50-5.86	0.61	5.01	4.50-5.86	1.40
Org. C %	0.22	0.02-0.34	0.13	0.34	0.27-0.49	0.10	0.34	0.27-0.49	0.15	0.34	0.27-0.49	0.12
Total N %	0.03	0.01-0.04	0.01	0.04	0.04-0.04	0.01	0.04	0.04-0.04	0.01	0.04	0.04-0.04	0.01
Org .M (%)	0.36	0.03-0.57	0.23	0.60	0.47-0.84	0.17	0.60	0.47-0.84	0.24	0.59	0.47-0.84	0.20
Avail P mg^{-1}	5.18	2.65-11.52	3.87	4.89	3.33-6.73	1.38	4.89	3.33-6.73	3.44	4.89	3.33-6.73	2.21
CEC $cmol.kg^{-1}$	12.96	9.00-15.40	2.69	11.80	9.20-15.00	2.41	11.80	9.20-15.00	3.00	11.80	9.20-15.00	2.61
Ex. Ca $cmol.kg^{-1}$	2.70	1.30-5.03	1.47	0.68	0.37-1.30	0.44	0.68	0.37-1.30	0.60	0.68	0.37-1.30	1.11
Ex. Mg $cmol.kg^{-1}$	2.02	0.58-2.62	0.84	1.90	1.03-2.91	0.77	1.90	1.03-2.91	1.07	1.90	1.03-2.91	1.53
Ex. K $cmol.kg^{-1}$	0.16	0.09-0.28	0.08	0.31	0.25-0.39	0.06	0.32	0.25-0.39	2.18	0.32	0.25-0.39	0.08
Ex. Na $cmol.kg^{-1}$	0.26	0.21-0.35	0.06	0.58	0.24-1.10	0.37	0.58	0.24-1.10	0.38	0.58	0.24-1.10	0.24
BS (%)	38.80	26.36-52.61	11.23	29.27	25.21-31.84	2.72	29.27	25.21-31.84	20.10	29.27	25.21-31.84	17.4
Ex. Cu mg^{-1}	0.56	0.40-0.73	0.15	0.52	0.40-0.76	0.17	0.52	0.40-0.76	0.07	0.76	0.40-0.76	0.21
Ex. Zn mg^{-1}	0.15	0.08-0.31	0.22	0.16	0.08-0.26	0.09	0.16	0.08-0.28	0.06	0.16	0.08-0.28	0.05
Ex. Fe mg^{-1}	13.66	7.07-20.68	5.28	44.24	25.39-64.14	15.84	44.77	12.75-18.24	3.27	44.24	25.39-64.14	12.05
Ex. Mn mg^{-1}	26.50	20.25-31.50	4.42	14.77	12.75-18.27	2.49	14.77	12.75-18.27	5.42	14.77	12.75-18.27	2.03
Ec	0.03	0.02-0.04	0.01	0.03	0.01-0.05	0.02	0.03	0.01-0.05	0.03	0.03	0.01-0.05	0.01

Table 7. Rating of land use requirements for maize, groundnut, onion, rice and sugarcane

Soil characteristics	Rating			
	S1	S2	S3	N
Maize	SCL	SiCL . Cl	Si, Sl, Sc	hc, ls, S
Texture	WD	MWD	ED	VPD
Drainage	6.5 – 7	5.8-6, 7-7.5	5.5 – 5.8	<5.5, >8
P^H (1:1 water)	> 12	9 – 12	5 – 8	<5
CEC cmol(+)kg^{-1}	> 10	10 – 5	5 – 2	<2
Org. C. (gkg^{-1})	> 50	50 – 30	30 – 20	<20
BS (%)	> 120	50 – 120	30 – 50	<30
Wheat				
Texture	1, CL, Sil	C, SCL	Si, Ls	Sl, CS
Drainage	WD	MWD	SPD	VPD
P^H (in water)	6 – 8.2	5-6, 8.2 – 8.3	5.2-5.6, 8.3-8.5	<5.2, >8.5
CEC cmol(+)kg^{-1}	> 10	10 – 5	5 – 2	<5
Org. C. (gkg^{-1})	> 50	50 – 35	35 – 20	<2
BS (%)	> 100	70 – 100	40 – 70	<20
Soil depth (cm)	> 100	70 – 100	40 – 70	<40
EC (ds/m)	> -3	3 – 5	5 – 6	<
ESP (%)	0-20	20 – 35	35 – 45	
Onion				
Texture	L, SC, SCL	C	S	Si. Hc
Drainage	WD	MWD – SPD	PD	VPD
P^H (in water)	6 – 7.8	5.8-6.7, 8-8.0	5.5-5.8, 8.0-8.2	<5.5, >8.2
CEC cmol(+)kg^{-1}	>20	15 – 20	10 – 15	<10
Org. C. (gkg^{-1})	>12	12 – 8	8 – 5	<5
BS (%)	>35	35 – 25	25 – 20	<20
Soil depth (cm)	>100	70 – 100	40 – 70	<40
Rice/Sugarcane				
Texture	C, SC, Sic	L, SCL, CL	hc	S
Drainage	PD, VPD	MWD, SPD	WD	VWD, ED
P^H (in water)	5.5-7.5, 7.5-7.8	4.5-5.5, 7.8-8.0	4-4.5, >8.0	<4.0
CEC cmol(+)kg^{-1}	>12	9 – 12	5 – 8	<5
Org. C. (gkg^{-1})	>15	10 – 15	5 – 10	<5
BS (%)	>50	50 – 35	35 – 20	<20
Soil depth (cm)	>100	70 – 100	40 – 70	<40
EC (ds/m)	0-2	2 – 4	4 – 6	>6
ESP (%)	0-20	20 – 30	30 – 40	>40

Source: [13]

Table 8. Land suitability assessment of SMC soils to maize

Land quality/land use requirement	Unit	Mapping units and their suitability – rating			
		SMCF-1	SMCF-2	SMCF-3	SMCF-4
		Pedon 1	Pedon 2	Pedon 3	Pedon 4
Moisture availability	Mm	s2	s2	s2	s2
Temperature regime	°C	s1	s1	s1	s1
Oxygen availability	Drain. C	s1	s2	s1	s1
Rooting Conditions	Cm	s2	s2	s3	s2
Nutrient availability					
Soil reaction	pH	s2	s2	s2	s3
Top soil org. C	%	N	N	s3	N
Top soil N	%	s3	s3	s3	s3
Top soil availability P	Mg/kg	s2	s3	s3	s3
Nutrient retention capacity					
Base saturation	%	s2	s3	s2	s2
Top soil CEC		s2	s2	s2	s2
Potential for mechanization	Me/100 g	s1	s1	s1	s1
Erosion hazard	Slope angle	s1	s1	s1	s1
Overall land suitability.	Slope angle	s2 fmr	s2 fwr	s2 frm	s2 fwr

Land suitability class symbols: S1 = highly suitable; S2 = moderately suitable S3 = marginally suitable; N1 = currently not suitable; Land suitability subclass symbols; w = oxygen availability limitation, if = Soil Fertility limitation, t = Soil texture limitation ; N2 = conditionally unsuitable, e = erosion hazard limitation; m = moisture availability limitation; v= land preparation limitation

3.4 Land Suitability for Maize

The suitability of the soils was assessed for maize commonly and currently grown in the adjacent of the study area following the procedures of matching principle. Table 7 (above) represents the detailed land and soil qualities/characteristics of all mapping units and Table 7 (above) represent the land and soil rating requirements for rain fed maize. The matching of the land qualities/characteristics of the mapping units (Table 6) (above) with the land requirements of maize (Table 7) (above) produced various suitability of maize cultivation as given in Table 8 (above). The agricultural potentials of these soils are judged by matching the characteristics of the soils with the requirements of the maize crop, in this suitability rating emphases were laid on the limitations of the soils and their negative effect on the crops and environment. The various limitations of the four soil units identified in the farm are limited soil fertility (unit I - IV) and land preparation limitation (Unit III). These limitations are considered alongside with the requirements of the maize crop in the area. The suitability of the soils for maize production as shown in Table 8 revealed that all the soils in land mapping units which were currently grown in the adjacent area are currently moderately suitable (S2).

4. CONCLUSSION

This study was undertaking with a view to establish and evaluate the suitability classes of the soils of SMC farm with a special emphasis on maize. The studied soils have varying properties and can be classified into soil categories with different potentials and constraints to use and management. The LISF plus soil analytical data produced land suitability classes on the farm.

The study concludes that:

- Some of the fertility indicators have moderate, low or very low values in all units.
- The major limitations in the surveyed area are low fertility status.
- None of the four mapping units falls under highly suitable (SI) class, for maize production.
- The general surface soil fertility was low. The predominant textures of these soils were loamy sand.
- The soil reaction was slightly acidic to mildly alkaline.
- Available micronutrients (Fe and Mn) status in these soils were however found to be sufficient in the soil but deficient in the major nutrient such as N, P and exchangeable bases (Cu^{2+}, Mg^{2+}, K^{+} and Na^{2+}).
- To improve soil productivity and sustain production of crops in the area under investigation fertility improvement methods such as use of organic manures, organic mulches and chemical fertilizers, crop rotation and planting over crops have to be adopted.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Udo EJ, Ibia TO, Ogunwale JA, Ano AO, Esu IE. Manual of soil plant and water analysis. Sibon books Ltd flat 15, BK 6 Fourth Avenue Festac, Lagos; 2009.
2. Bationo A, Mokwunye AU. Alleviating soil fertility constraints to increased food production in West Africa: The experience of the Sahel. Fert. Res. 1991;29:95-115.
3. Julio HA, Carlos B. Nutrient depletion in the agricultural soils of Africa. A 2020 Vision Brief International Food Policy Research Institute Washington. DC, USA. 1999;62:1-2.
4. Msanya BM, Kaaya AK, Araki S, Otsuka H, Nyadzi G. Pedological characteristics, general fertility and classification of some benchmark soils of Morogoro district, Tanzania African Journal of Science and Technology (AJST) Science and Engineering Series. 2003;4(2):101-112.
5. Fasina AS, Ogunkunle. Land quality and crop yield, an experience in maize southwestern Nigeria. African Soil. 1995; 28:539-550.
6. Osei BA. Evaluation of some soils in South – Western Nigeria for arable crop production. Common Soil and Plant Analysis. 1993;24(788):757-773.
7. David, Adams. Crops of Drier Regions of the Tropics-Longman Publishing Limited, Singapore. 1985;92-98.
8. Rates. Maize market assessment and baseline study for Tanzania. Regional

Agricultural Trade Expansion Support Program, Nairobi, Kenya; 2003.
9. Sassi M. Improving efficiency in the agriculture sector as an answer to Globalization, Growth and Equity: The case of Tanzania "Quaderno diricercan.4. pavia, Italy; 2004.
10. Mwango SB. Automated land evaluation for alternative uses in south western part of the uluguru mountains in morogoro rural district, Tanzania Disertation for Award of M.Sc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania. 2000;1–4.
11. Food and Agriculture Organization of the United Nations (FAO). /IUSS Guidelines for soil description. 4th edition; 2006.
12. Soil survey staff. key to soil taxonomy, 11th (Ed). Basic system of soil classification for making and interpreting soil survey Natural Resource Conservation Services Agricultural Dept., soil survey Div, Washington D.C. USA; 2010.
13. FAO. A Framework for land evaluation. Soils Bulletin 3. FAO, Rome. 1976;72.
14. Walkley A, Black A. An examination of Degtjaredd method of Determining Soil Organic Matter and a proposed modification of the chromic acid titration method. Soil Science. 1934;37:29-38.
15. Black CA. Method of Soil Analysis Agronomy No. 9 part A. American Society Agronomy Medison, Wisconsin. 1965;12–3.
16. Chapman HD. Cation exchange capacity. In: Black CA. (ed) Methods of soil analysis. Part 2, ASA. Wisconsin, U.S.A. 1965;891-901.
17. Genstat Discovery Edition. 14th edition Statistical software. For license. Available: http://www.vsni.co.uk
18. Mrema JP, Mowo JG, Shetto MC, Kajiru GJ, Ngatoluwa R, Rwehumbiza FB. Local strategies of soil fertility management and their impacts on soil fertility and productivity. NRSP Project R 8115; 2003.
19. Iqbal J, Thomasson JA, Jenkins JN, Owens PR, Whister FD. Spatial variability analysis of physical properties of alluvial soils. Soil Sc. AM.J. 2005;69:1338-1350.
20. Obi JC, Ogunkule AO. Influence of termite infestation on the spatial variability of soil properties in the guinea savanna region of Nigeria. Geoderma. 2009;148:357-368.
21. Villapando RR, Greatz DA. Phosphorus absorption and desorption properties of the soil. Spodic horizon from selected Florida spodosols. Soil Science Society of American Journal. 2001;63:331-339.
22. Adebayo MK, Osunde AO, Ezenwa MI, Odofia AJ, Bala A. Evaluation of the Fertility Status and suitability of some soils for Arable cropping in the southern Guinea Savannah of Nigeria. Nigerian Journal of Soil Science. 2009;19(2):115–120.
23. Esu IE. Detailed soil survey of NIHORT farm Bunkure, Kano state, Nigeria. Institution for Agricultural research, Ahmadu Bello University Zaria. 1991;7.
24. Enwezor WO, Udo EJ, Sabulo RA. Fertility Status and Productivity of the "Acid Sands". In: Udo EJ, Sabulo RA. (eds) " Acid Sands of Southern Nigeria. Soil Science Society Nigeria Special Publication Monograph. 1981;1:56-73.
25. Tisdale SL, Nelson WL, Beaton JD, Havlin JL. Soil fertility and fertilizer, 5th Ed. Prentice-Hall of India, New Delhi. 1995; 684.

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