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Evaluation of Fertility Status of Surface Soils for Maize Production at Solomon Mahlangu Campus Farm, Morogoro Tanzania

KEYWORDS: Soil fertility; physico-chemical properties; management; crop production

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ABSTRACT *This study was carried out on the surface soils in 2014/2015 cropping season at the Mazimbu, Sokoine University of Agriculture farm Morogoro, Tanzania, to investigate the current fertility status of surface soil for arable cropping. Composite soil samples were collected from each block at the depth of 0 - 30cm and analyzed for physico-chemical properties. Results 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). Mean values for organic carbon, total Nitrogen, available phosphorus, cation exchange capacity, Base saturation, exchangeable bases were low in four blocks of the study area. The study concludes that, the soils were rated low in surface soil fertility, therefore, requiring field management through application of organic residues, manures and chemical fertilizers for sustain arable crop production.*

INTRODUCTION

The most prominent constraint to food production in most part of the world is low soil fertility (Bationo and Mokwunye, 1991). Thus, proper soil fertility management remains the key factor for increased food production. Stockdale et al. (2002) defined soil fertility as the ability of soil to provide the conditions required for plant growth, as a result of physical, chemical and biological processes that acts together to provide nutrients, water, aeration and stability to the plant as well as freedom from any substances that may inhibit growth. Soil fertility evaluation is defined as the process of assessing the nutrient supplying capacity of the soil, the selection of nutrients to be replenished and in the proper quantities to be applied based on the nutrient requirements of the crops (Nandwa, 2003).

This study entails; a comprehensive and critical evaluation of the fertility status and productivity of the soils of the SMC farm. This investigation was undertaken to ensure optimal use of the farm through understanding of the soils in terms of their outstanding characteristics and constraints, thus guaranteeing optimum productivity and sustainability of the farm.

MATERIALS AND METHODS

The study area

The study was conducted in the Solomon Mahlangu Campus, one of the Sokoine University of Agriculture campuses, Morogoro, Tanzania. The area lies between latitude and longitudes 6^0 47'S and 37^0 37'E. The site generally experiences bimodal rainfall pattern (long and short rain) with a mean total annual rainfall and temperature of 850 mm and 24^0C respectively (Figure 2).

Figure I: Map of Tanzania showing experimental site

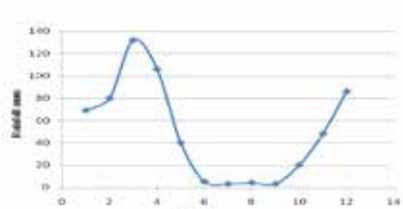

Figure II: Mean monthly rainfall of Mazimbu for Ten years

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Soil Sampling for Fertility evaluation
The area was broadly divided into four major blocks based on the local indicators of soil fertility (BK 1-4)). Surface soil sample for general soil fertility evaluation was done by collecting twenty soil samples from each block at the depth of 30cm in a zigzag pattern using a Dutch auger. The collected samples were air-dried, ground and sieved using a 2mm sieve meshes for routine laboratory analysis.

Soil analysis
Chemical and physical analyses were done as follows: pH was measured potentiometrically in water and in 1M KCl at the ratio 1/2.5 soil-water and soil-KCl. Organic carbon was determined by wet oxidation method (Nelson and Sommers, 1982). Kjeldahl method (Bremner and Mulvaney, 1982) was employed to determine total nitrogen. Phosphorus was extracted by Bray and Kurtz-1 method (Bray and Kurtz, 1945) and determined spectrophotometrically. The cation exchange capacity and exchangeable bases were extracted by saturating soil with neutral 1M NH4OAc and the adsorbed NH4+ displaced with K+ using 1M KCl and then determined by Kjeldahl distillation method for the estimation of CEC of soil. The bases Ca++, Mg++, Na+, and K+, displaced by NH4 + were measured by atomic absorption spectrophotometer. Texture was determined by Bouyoucos hydrometer method (Day, 1965).

Data Analysis
Data collected were summarized using descriptive statistics and subjected to analysis of variance using the GenStat Discovery14th Edition software.

RESULTS AND DISCUSSION
Physical properties
The values mean and standard deviation of some important physical properties of the soils of the study area were presented in Table 1. The particle size distribution of the soils 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 appears to be the dominant size separates in all the blocks.

The textural classes varied from loamy sand to sit loam. 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 statistically similar in distribution between the farm blocks.

Table1: Some soils physical properties of representative's blocks of the study area (0-30 cm)

	% Particle Size Distribution				
Blocks	**Sand**	**Silt**	**Clay**	**Text.**	**S:C**
BK IA	84.24	3.64	12.12	LS	0.3
BK IB	84.24	1.64	14.12	LS	0.12
BK II	80.24	3.64	16.12	SL	0.23
BK III	86.24	3.64	10.12	LS	0.36
BK IV	86.24	3.64	10.12	LS	0.36
Means	**84.24**	**3.24**	**12.52**	___	**0.27**
SD	**2.45**	**0.89**	**2.61**	___	**0.10**

Chemical properties
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. Organic Carbon generally ranges from 0.1 to 0.47% with a mean of 0.29%, indicating low in the soils. The low level of organic carbon (below1%) 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. Total N in the Soils varied within range of 0.04 - 0.06 (mean = 0.044gKg^{-1}) indicating low levels of N as per the rating scale in Table 4. Available P values were generally to medium (6.16 to 13.32; mean = 9.0mg/Kg). The CEC values of the soils ranged from 7.6 - 10.4Cmol/Kg with a mean of 9.84Cmol/Kg. The low CEC value may have been caused by the soils lower organic matter content occasioned by the burning and grazing in the area

Table 2: Some soils chemical properties of representative's blocks of the study area (0-30 cm)

Blocks	pH	Avail. P mg/kg		Exchangeable bases and CEC (cmol(+)/kg						ECE	BS %	Cu	Zn	Fe	Mn	Ec
	H_2O	KCL		OC(%)	TN	Ca	Mg	K	Na	CEC						
BK1A	7.083	5.68	6.68	0.21	0.04	0.37	0.8	0.11	0.2	10.2	10.7	16.68	0.28	0.19	21.2	31.5	0.02
BK1B	7.27	5.64	8.08	0.47	0.04	0.84	0.79	0.38	0.22	10	2.21	22.12	0.46	0.26	21.2	31.5	0.03
BKII	7.12	6.1	13.32	0.21	0.06	1.77	1.27	0.36	0.19	11	3.28	32.59	0.61	0.32	28.53	41.5	0.04
BKIII	5.96	5.16	10.16	0.33	0.04	0.37	0.52	0.24	0.22	10.5	1.34	12.92	0.25	0.12	33.77	21.5	0.02
BIV	6.72	5.5	6.16	0.33	0.04	0.37	0.85	0.22	0.22	7.6	1.61	21.73	0.25	0.16	19.63	29	0.02
Means	**6.83**	**5.62**	**9.01**	**23.72**	**0.04**	**0.74**	**0.85**	**0.31**	**0.21**	**9.84**	**4.10**	**21.21**	**0.37**	**0.21**	**24.9**	**31**	**0.026**
SD	**0.53**	**0.24**	**0.01**	**8.99**	**0.01**	**0.61**	**0.27**	**0.07**	**0.01**	**1.21**	**4.34**	**7.14**	**0.16**	**0.08**	**6.06**	**7.16**	**0.01**

Exchangeable calcium ranged from 0.37 to 1.77Cmol/Kg with a mean of 0.74Cmol/Kg; and exchangeable magnesium ranges from 0.52 to 1.27Cmol/Kg with a means of 0.85Cmol/Kg. while exchangeable potassium and sodium ranges from 0.22 and 0.19 Cmol/Kg to 0.38 and 0.22Cmol/Kg with a means of 0.31 and 0.21 Cmol/Kg respectively. The low content for these exchangeable bases (especially Ca and Mg) was due to low in CEC of the soil resulting in the low content of clay and organic matter. Percentage base saturation of soils ranged from 12.92 to 32.59% with a mean of 21.21%. The BS percent were low and this may be due to low content of organic matter in the surface soils.

Total copper had a range of 0.25 to 0.61mg/Kg^{-1} with a mean of 0.37mg/Kg^{-1} the range of Zinc content for these soils is 0.12 to 0.32mgKg^{-1} with a mean of 0.21mgKg^{-1}. While the mean value of Iron (Fe) is 24.87mgKg-1 with a range of 21.2 to 33.77mgKg^{-1} for manganese value (range = 21.5 - 31.5mg/Kg; mean = 31mgKg^{-1}. The values of Fe and Mn in these soils are ratio medium to high which indicate a presence of volcanic parent rock. The EC value ranged between 0.02 to 0.4 ds/m with a mean of 0.03ds/m. This indicates that the soil is naturally non-saline.

Table 3: Rating for the status of copper, Zinc, manganese, iron, exchangeable acidity (H^+ AL^{3+}) and (CEC) in the savannah zone.

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)(ppm)	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}

Sources: - after Tisdale et al. (1995).

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Table 4: Guidelines for rating soil fertility indicators (IL-ACO,1981)

Rating	Exchangeable bases (cmol (+)/100g			TN(%)	Av.P(ppm)	OM (%)	C/N
	Ca	Mg	K				
Very High	>20	>8	>1.2	>0.300	___	>6.0	>25
High	16-20	3-8	0.6-1.2	0.226-3.00	>50	4.3-6.0	16-25
Medium	5-10	1.5-3	0.3-0.6	0.126-0.225	15-50	2.1-4.2	11-15
Low	2-5	0.5-1.5	6.2-0.3	0.050-0.125	<15	1.6-2.0	8-10
Very low	<2	<0.5	<0.2	<0.050	___	1.0	<8

CONCLUSION

The results of this study indicate that the general surface soil fertility was low Vis - a - Viz the rating scale of the critical values limit of soils parameters. The predominant textures of these soils were loamy sand. The CEC values, which were low to moderate due to low clay content. The soil reaction was slightly acidic to mildly alkaline. Available micronutrients (Fe and Mn) status were 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+}). However to improve soil productivity and sustain production of crops in the area, fertility improvement methods such as use of organic manures, organic mulches and chemical fertilizers, crop rotation and planting over crops has to be adopted.

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