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Potassium Availability under Banana- Based Land Use Systems in Abaya Chamo Lake Basin, South-west Ethiopia

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ABSTRACT

In Ethiopia, it is widely believed that the soils are developed from potassium -rich parent material and hence, attention is not given to potassium fertilizer. A systematic soil survey was made in the Ethiopian Rift Valley flat plain areas of Abaya Chamo Lake Basin in order to study the potassium availabilility, and understand its correlation with other physicochemical propertiess of the soils. 120 soil samples were randomly collected from banana- based different land use systems, which were prepared into 12 composite soil samples and analyzed in Ethiopia Water Works Design and Supervision Enterprise Laboratory. The results revealed that exchangeable potassium, calcium, magnesium, organic carbon and total nitrogen were low in cultivated soils compared to natural forests. Soil salinity were also observed in irrigated agriculture. Available potassium was positively correlated with pH (H_2O, KCl), electrical conductivity, silt, exchangeable magnesium, and it is highly significantly correlated with exchangeable potassium. Also available potassium was negatively correlated with organic carbon, total nitrogen, available phosphorus, clay, calcium, and cation exchange capacity. Therefore, it could be recommended to include management practices that enhance potassium availability in the study area soils, however, nutrient flows and soil-plant analysis are required to give concrete recommendation.

KEY WORDS: Irrigated agriculture, Land use types, Rainfed agriculture, and Soil properties.

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INTRODUCTION

Primary Development Goal of the Ethiopian Government is to achieve food security and sustain high economic and export growth levels with the aim ending poverty. Agriculture is the dominant economic sector in Ethiopia, particularly, smallholder farming provides over 85 % of the total employment. As long as agriculture remains a soil-based industry, major increases in productivity are unlikely to be attained without ensuring an adequate and balanced supply of nutrients from the soil[1].

Trends in mineral fertilizer use have about four decades of history in Ethiopia from its introduction in the late 1960s and early 1970s to date. Recently, it is used largely on production of Teff, Maize and Wheat crops representing about 60% of the total consumption[1]. The remaining is used for other cash and food crops produced by subsistence as well as few commercial farms (only constitute 2% of the total national production). Long established blanket recommendation rates of 100 kg DAP (18-46-0) and 100 kg Urea (46-0-0) still apply for cereal crops regardless of soil nutrient reserves[1].

There are a wide set of soil fertility issues that require approaches that go beyond the application of mineral fertilizers–the only practice applied at large scale to date[1] in Ethiopia. In Ethiopia, it is widely believed that the soils are developed from potassium -rich parent material and hence, attention is not given to potassium (K) fertilizer. It is only P and N fertilizers that are being used in the country. Such a belief has emanated from the works of[2] which indicated that the K content of most Ethiopian soils is high. However, in current soil studies show that the availability of K in the soil is variable and efforts made to enhance soil fertility are constrained by lack of up-to-date data. Hence, such kinds of interventions depend on major national soil survey information dating back to the 1980s (FAO). Depending upon the parent material and extent of weathering, the TN (%) content of soil all over the world ranges from 0.015 to 0.137[3].

Traditional banana-based multi-tier cropping systems are dominantly exist in Abaya Chamo Lake Basin (ACB), which is within the High Potential Perennial Zone[4] . The deficiency symptoms quickly develop and extra N must be frequently applied even on fertile soil[5]. The cropping pattern of the area is substantially changed through time particularly with the modern irrigation systems intervention and subsequent infrastructure development such as asphalt road facility and land tenuring system during the last 20-25 years. As a result, a mixture of perennial crops (dominantly bananas and mangoes) together with monoculture banana farming, and annual characterized subsistence farming systems are the current dominant land use types (LUTs) in the study area. These systems have been implemented gradually and according to the farmer’s time. From any other plant, banana plant is always referred to as a gross feeder and requires large amounts of nitrogen and potassium followed by phosphorus, calcium and magnesium to maintain high yields[5].

Improved farming methods such as mulching, intercropping, and shifting cultivation were also well practiced in the ACB. Annual field crops grown in the rainfed agriculture include maize, sorghum, cotton and other pulse crops. Moreover, vegetation in the lowland areas of ACB is varying according to variability in rainfall, soil salinity and soil moisture condition . The dominant land use types in the ACB are classified as annual farming of maize and/or sorghum system (AC), Perennial Cropping and/or Agroforestry System (PC), Grazing Land (GL) and Natural Forest and Woodland System (NF).

Studing the inherent nature of soils that supply proper amounts of nutrients, particularly potassium status in the traditional banana-based cropping systems, found to be of paramount importance to compare it with natural forest soils' potassium in the lowland areas of ACB. Because the effects of different land use types and their management practices on soil fertility in the study area are not studies and well documented. Also knowing standard soil fertility attributes such as SOM, CEC, Soil pH, Soil texture and available phosphorus (P_2O_5) in relation to potassium is important issue in terms of crop production[4,6], and suggestion for sustainability of the LUTs.

MATERIALS AND METHODS

Descriptions of the Study Area

The study area is located within the ACB, comprises three sub-watersheds in Arba Minch Zuria and one in Dherashe Woredas. The area lies in between 05°39'36" to 06°12'2" N and 37°24'36" to 37°33'2" E at an altitude of 1100 to 1350 masl. The pattern of topography of the catchment is composed of flat plain in the west-around Lake Chamo and in the Rift Valley escarpment hills in the west and north. The parent materials of study area are alluvium along river and lacustrine along lakes[7].

The mean annual rainfall in the ACB is 930 mm. Average maximum and minimum temperature is about 33.3 and 17.4°C respectively. The rainfall distribution has a bimodal nature with the first and second rainfall during April to May and September to October respectively. The mean annual evapotranspiration is about 1644mm. The length of Growing Period in the study area is 61 days[8], the fact that annual evapotranspiration is greater than annual rainfall.

Soil Sampling and Laboratory Analysis

Surface soil samples were (0-20 cm) randomly collected from 120 sampling sites and 12 composites were prepared following the standard procedures of composite soil sampling method. These soil samples were air dried and passed through 2 mm sieve, processed and analyzed for determination of physical and chemical characteristics in *Ethiopia Water Works Design and Supervision Enterprise laboratory, 2012.* Standard procedures followed during laboratory analysis are given below:

S.No	Parameters	Standard Procedure
1	Particle size analysis	Hydrometer Method outlined by[9].
2	pH (H_2O, KCl)	1:2.5 water: solution- (pH meter) and 1:2.5 KCl: solution- (pH meter) both of them is outlined by[10].
5	TN	Kjeldahl Method outlined by[11].
6	OC	Walkley Black, (% SOM= % SOC x 1.724) outlined by[12].
7	Available P (P_2O_5)	Olsen Method outlined by[10,13] .
3	Available K (K_2O)	Ammonium acetate outlined by[14].
4	Exch. Bases and CEC	Ammonium acetate (1M at pH 7) outlined by[10].

Data analysis was carried out using SAS 8.2 Version System[15] to correlate the soil fertility factors in relation to land uses.

RESULTS

Available Potassium (K_2O)

In the studied LUTs, the K_2O content of the surface soils ranged from 132.74 to 546.59 mg/kg of soil (Table 1) with a mean value of 269.11 mg/kg, which is medium to very high range. The positive and very high correlation (r = 0.96***) obtained between exchangeable K and K_2O (Table 3) indicates exchangeable K highly contributes to K_2O content of soils. The negative correlation (r=-0.07) obtained between clay and K_2O indicates that K_2O availability is affected by clay contents, the intensity of potassium rich clay minerals (e.g. illite, micas, and feldespars) decomposition in these soils. The negative and significant correlation (r = -0.57*) obtained between exchangeable Ca and K_2O (Table 3) indicates that exchangeable Ca has antagonistic effect on K_2O availability in the studied soils. Basic elements like K removed from the soil with intensive harvest of moringa leaves.

Exchangeable Bases (K, Ca, Mg)

The CEC values ranged from 33.81 to 47.83 cmol (+) kg^{-1} with a mean value of 38.87 cmol (+) kg^{-1} (Table 1), which is high to very high range in the studied soils indicates cation exchange is the major nutrient reservoirs of K^+, Ca^{2+} and is also important in holding N in ammonium ($NH4^+$) form. Values in excess of 10 cmol kg-1 are considered satisfactory for most crops[16]. The higher the CEC, the more capable the soil can retain mineral elements. Moreover, PBS of the soils ranged from 82.33 (PN1-FsSe) to 96.29 (AP2-FrBa), which indicates a high fertility of the soil because many of the "bases" that contribute to it are plant nutrients.

Exchangeable K^+ levels ranged from 0.31-1.37cmol kg^{-1} in the soil (Table 1) with a mean value of 0.43 cmol (+)/Kg. The recommended threshold level of exchangeable K^+ for most crops is 0.3-0.6 cmol (+) kg^{-1}. This result generally suggests that exchangeable K^+ is not a limiting mineral element to crop production except in Moringa field. Generally, clay was negatively (r= -0.08) correlated with exchangeable K (Table 3), indicating that the negative association of clay with the exchangeable K^+ in the studied soils.

Exchangeable Ca^{2+} in the surface soils of the studied land uses ranged from 18.58- 36.08 cmol (+) kg^{-1} i.e., all studied land uses were rated as high to very high (Tables 1). For most crops, the recommended threshold level of Ca^{2+} is 5-10 cmol (+) kg^{-1}. Similarly, Mg^{2+} content was high to very high in all soils with values ranging from 3.02- 11.34 cmol (+) kg^{-1}. For most of the crops, the recommended threshold level of Mg^{2+} is 1.0 -3.0 cmol (+) kg^{-1}. The exchange complex of the soils is dominated by Ca followed by Mg, K and Na (Table 1). This result is in agreement with[17] findings on fluvial soils in Gamo Gofa zone, Ethiopia, that Ca followed by Mg, K, and Na in the exchange site of soils is favorable for crop production.

Organic Carbon (OC) and Total Nitrogen (TN)

The status of SOC and TN in the soils of the study area is given in Table 1. Soil organic matter (SOM) contents of surface soils varied from 1.28 to 4.88 % along LUTs. The SOM content of rainfed fields were low for sorghum and moringa fields whereas medium for all irrigated agricultural fields. The lower value of SOM in the moringa field soils was due to intensive harvest of moringa leaves for selling and home consumptiom.

The TN content of the surface soils ranged from 0.05 in moringa field to 0.37 % in NF (Table 1) with a mean value of 0.18 %. The TN content of the surface soils is categorized from low to medium except for NF, which was at high range. The difference in SOC and TN content among the land uses could be attributed to the effect of variation in land use management. The distribution pattern of TN across land uses was similar to that of SOM, since SOM contents is a good indicator of available nitrogen status in the soil. Intensive and continuous cultivation aggravated SOC oxidation, resulted in reduction of TN as compared to NF. Positive and strong correlation (r = 0.91**) was found between SOC and TN. The results are in accordance with the findings of[17] who reported that intensive and continuous cultivation forced oxidation of SOC and thus resulted in reduction of TN.

Table 1: Potassium and other soil physicochemical properties under surface soils of different LUTs; ACB, 2012.

Land Use Types (LUTs)	**AA6-CeMa**	**AP2-FrBa**	**PN2-FsAc**	**AP2-FrBa**	**AA6-FiCo**	**PN1-FxTa**	**PN2-FsAc**	**AA6-CeMa**	**AP2-FrBa**	**AP1-MfMo**	**AA4-CeSo**	**PN1-FsSe**
Replication	*1*	*2*	*3*	*2*	*1*	*3*	*3*	*1*	*2*	*2*	*1*	*3*
Sand (%)	17.41	11.23	21.52	19.98	20.28	20.03	19.10	9.41	1.86	32.02	9.96	28.36
Silt (%)	49.99	59.18	70.00	50.82	51.33	49.71	27.71	38.20	40.80	52.84	47.88	44.50
Clay (%)	32.60	29.59	8.48	29.20	28.39	30.26	53.20	52.39	57.34	15.10	42.44	27.14
Textural class	SCL	SCL	SL	SCL	CL	CL	C	C	SC	SL	SC	L
P^H-H_2O (1:2.5)	7.28	7.55	6.84	7.62	6.82	8.24	7.65	7.22	7.35	7.47	6.87	6.57
P^H-KCl (1:2.5)	6.47	6.53	6.10	7.02	6.04	7.33	7.00	6.48	6.59	6.75	6.12	5.82
EC (ms/cm) (1:2.5)	0.17	0.18	0.15	0.39	13.49	7.86	0.34	0.17	0.21	0.17	0.21	0.68
Exch. Na (meq/100gm)	0.94	1.09	0.52	0.91	1.13	1.00	1.04	0.80	0.88	0.67	0.53	0.72
Exch. K (meq/100 gm)	0.31	0.84	0.77	0.78	0.55	0.82	0.62	0.37	0.40	0.35	1.37	0.65
Exch.Ca (meq/100 gm)	28.51	23.11	23.32	28.08	26.35	29.96	36.08	32.40	26.16	27.82	18.58	24.19
Exch. Mg (meq/100 gm)	6.91	11.34	7.21	8.21	3.02	4.28	9.68	6.91	9.59	6.85	9.07	6.91
Cations (Sum) (meq/100gm)	36.67	36.37	31.81	37.98	31.05	36.06	47.42	40.48	37.03	35.68	29.55	32.48
CEC (meq/100)	37.57	37.91	36.41	39.44	33.81	39.08	47.83	42.73	38.86	37.68	35.69	39.44
OC (%)	1.19	2.17	0.97	2.33	1.79	1.80	2.83	1.31	1.83	0.74	0.93	2.70
Nitrogen (%)	0.13	0.29	0.08	0.23	0.13	0.12	0.37	0.12	0.20	0.05	0.12	0.33
P_2O_5 (mg/kg)	63.47	117.84	56.06	138.04	124.40	96.76	75.58	57.47	148.49	54.60	39.28	251.34
K_2O (mg/kg)	132.74	304.72	334.65	320.14	226.44	391.96	217.38	161.37	186.51	190.82	546.59	216.03

Notes: Land Use Type classification was based on23: Irrigated Maize Field= AA6- CeMa; Irrigated Banana Field= AP2- FrBa ; Acacia Based Natural Forest= PN2- FsAc; Irrigated Banana Field= AP2- FrBa; Irrigated Cotton Field =AA6- FiCo;Tamarix Based Grazing Land =Fn1- FxTa; Acacia Based Grazing Land =FN2- FsAc; Irrigated Maize Field =AA6- CeMa; Irrigated Banana Field= AP2- FrBa; Rainfed Moringa Field= AP1- MfMo; Rainfed Sorghum Field =AA4- CeSo, and Sesbania Based Natural Forest= FN1- FsSe. The soil textural classes were described as: C=clay, CL=clay loam L=loam,; SC= silty clay, SCL= silty clay loam, SL= Silt loam.

The C:N ratio of surface soils ranged from 8.0 to 15.6 suggesting that the studied soils had a moderate to good quality SOM. It is generally accepted that C:N ratios between 8 and 12 are considered to be the most favorable for crop production, implying a relatively fast mineralization of nitrogen from the organic materials. The observed C:N ratio status in studied sites can be considered as suitable conditions for plant growth.

Available Phosphorus (P_2O_5) in Soils

The P_2O_5 content of the surface soils ranged from 39.28 to 251.34 mg/kg (Table 1)with a mean value of 101.94 mg/Kg, which is in a very high range for all land uses. Higher P_2O_5 values in surface soils might be attributed to preferred range of soil pH (neutral and near neutral), increased solubility of Ca phosphate in calcareous soils, greater diffusion of P in flooding condition (since flooding and soil and water conservation prevalent at the study site), the mineralization of OM, and difference in land use management. The high and positive correlation (r = 0.91**) obtained between TN, OC and P_2O_5 indicates that SOM highly contributes to P_2O_5 of soils. Based the above results, it is not compulsory to apply P_2O_5 containing fertilizers in all the land use systems studied.

Soil Texture

The textural classes of soils determined by feel method in the field was found to be similar in most of the studied sites. The surface soils of different land uses had variable clay content (8.48- 57.34 %), and the textural classes of these surface soils were listed in Table 1. However, the distribution of silt, clay and sand did not uniform in all soil matrixes. This is due to the continuous translocation process of silt and clay. Deposits of buried massive clay were frequently found at deep soil layer which was the result of alluvial and erosion processes in the near past. Soil texture was not influenced by land use and management practices.

Soil pH

The pH-H_2O values of soils varied from 6.57 to 8.24 (Table 1). The lowest value (6.57) was observed in the PN1- FsSe, whereas the highest value (8.24) was found in GL. The soil pH values range indicated moderately acidic to moderately alkaline (Table 1). This is preferred for most crops. Similarly, the pH-KCl values of the soils ranged from the lowest value (5.82) which was observed in the NF to the highest value 7.33 was found in GL. Soil pH determination using KCl solution showed the presence of weatherable minerals, which is in agreement with[18,19]. In all surface soils pH (pH-H_2O -pH-KCl) values were positive, ranging from 0.60 to 0.91. The positive _pH values indicated the presence of net negative charges in soils; which increases ability to hold onto cations at negatively charged sites within the soil and show the presence of weatherable minerals[20] . As a result, the negative correlation was obtained between pH (pH-H_2O and pH-KCl) with available K_2O and exchangeable K_2O (Table 3).

Electrical Conductivity

The total soluble salt content of these soils, expressed as electrical conductivity saturation (EC), ranged from 0.15 in Acacia field to 13.49 in dSm^{-1} in Maize (Table 1). The soil samples of two land uses (Maize and GL fall in the range of salt affected quality with poor soil physical properties). This indicates a problem of soil salinity in the area. Also the salinity of the studied area soils was recognized by the presence of white crusts of salts on the soil surface which is called “White alkali” that is in agreement with[21]. The lower values of EC in the rainfed agricultural soils was due to the positive effect of moringa and sorghum plantations on re-structuring of the topsoil layer, gradual leaching of salts from the root zone, and free drainage conditions.

Cationic Balances

For most surface soils the (Ca^{2+}+$Mg2^{+}$)/ (Na^{+}+K^{+}) ratios was in between 1 and 4, and for all LUTs the Ca^{++}/Mg^{++}-ratios are varied from 2.0- 3.5 (Table 2). Therefore, these soils were characterized as calcium-dominated saline soils. Thus, these soils were dominated by Ca and Mg over Na and K and remained stable structure even when the salts were flushed out of the soils, for example in land uses (Maize and GL).

K:CEC ratios in Moringa were less than the suggested values of[22] and plants would probably respond to the addition of K_2O fertilizer (Table 2) which disproves the general believe that Ethiopian soils are rich in K_2O. Generally, Ca:Mg ratios are in between 2.05-8.73 for most studied soils (Table 3). (Ca+Mg):K ratios are very high for most LUTs, which are $\geq$40 except for Acacia and Sorghum, which indicates high Ca, Mg, Ca + Mg, for plant nutrition (Table 3). Accordingly, the exchangeable K, Ca and Mg content of the soils are above the critical values. As a result, it does not prove a balanced proportion of the exchangeable bases.

DISCUSSIONS

A systematic soil survey was made in the Ethiopian Rift Valley flat plain areas of Abaya Chamo Lake Basin. The farmers’ categorizations of the LUTs were based on watercourse soil fertility status, viz., monoculture cash crop farming (nearby watercourse); subsistence farming (mid way watercourse); and mixed farming (at extreme distant to watercourse). Accordingly, the dominant land use types are classified as annual farming of maize and/or sorghum system (AC), Perennial Cropping and/or Agroforestry System

(PC), Grazing Land (GL) and Natural Forest and Woodland System (NF)[23]. The cropping pattern of the area was substantially changed through time, particularly with the modern irrigation systems intervention and subsequent infrastructure development such as asphalt road facility and land tenuring system during the last 20-25 years, the fruit production was increased and fruits became the main plants grown in the conventionally cultivated areas. As a result, there was a breakthrough in production and transforming the livelihoods of the inhabitants (>65%) from survival level to elevated way of life at lowlands in the irrigated zone.

The whitish surface crusts of salt precipitates, also called “White alkali” were also observed on the surfaces of AA-Maize and graing land uses during dry seasons. The salinity of the studied area soils was recognized by the presence of white crusts of salts on the soil surface which is called “White alkali” that is in agreement with[21]. It was observed that natural vegetation on saline soils is sparse and xerophytes and/or ephemeral grasses are common. Only silicornica or halophyte species such as *Tamarix* species and salt-tolerant crops such as cotton are suitably grown. The EC values in the rainfed agricultural soils was lower due to the positive effect of moringa and sorghum plantations on re-structuring of the topsoil layer, gradual leaching of salts from the root zone, and free drainage conditions. The banana plants (*Musa* sp.) are generally recommended to grow on soils with no salt problems (i.e. ECe < 1 d S m^{-1})[24].

Table 2: The basic cation saturation ratio and their relative proportions under surface soils of different LUTs, ACB, 2012.

LUTs	Ca/CEC		Mg/CEC		K/CEC		Ca/Mg		(Ca+Mg)/K	
	Status		Status		Status		Status		Status	
AA6-CeMa	0.76	Adequate	0.18	Adequate	0.01	Low	4.13	proportional	114.26	Low K
AP2-FrBa	0.61	Adequate	0.30	Adequate	0.03	Adequate	2.04	proportional	41.01	Low K
PN2-FsAc	0.64	Adequate	0.20	Adequate	0.02	Adequate	3.23	proportional	30.53	favorable
AP2-FrBa	0.71	Adequate	0.21	Adequate	0.02	Adequate	3.42	proportional	46.53	Low K
AA6-CeMa	0.78	Adequate	0.09	Adequate	0.02	Adequate	8.73	proportional	53.40	Low K
FN1-FxTa	0.77	Adequate	0.11	Adequate	0.02	Adequate	7.00	proportional	41.76	Low K
FN2-FsAc	0.75	Adequate	0.20	Adequate	0.01	Low	3.73	proportional	73.81	Low K
AA6-CeMa	0.76	Adequate	0.16	Adequate	0.01	Low	4.69	proportional	106.24	Low K
AP2-FrBa	0.67	Adequate	0.25	Adequate	0.01	Low	2.76	proportional	89.35	Low K
AP1-MfMo	0.74	Adequate	0.18	Adequate	0.01	Low	4.08	proportional	99.00	Low K
AA4-CeSo	0.52	Adequate	0.25	Adequate	0.04	Adequate	2.05	proportional	20.18	Med. K
PN1-FsSe	0.61	Adequate	0.18	Adequate	0.02	Adequate	3.50	proportional	47.85	Low K

Description of basic cation saturation ratio and their relative proportions under surface soils of different land use types *was made using22, 23, 30.*

Table 3: **Correlation between soil physicochemical properties and potassium, ACB, 2012**

Soil Properties	K_2O		exchangeable K	
	r-value	p-value	r- value	p-value
$pH(H_2O)$	0.04	0.89	-0.07	0.82
pH(KCl)	0.04	0.89	-0.11	0. 47
EC	0.07	0.84	-0.003	0.99
Silt	0.31	0.32	0.23	0.47
Clay	-0.07	0.65	-0.08	0.80
Na	-0.34	0.28	-0.29	0.80
K	0.96	0.00***	1.00	
Ca	-0.57	0.05*	-0.59	0.04*
Mg	0.11	0.73	0.24	0.46
CEC	-0.31	0.32	-0.32	0.47
TN	-0.14	0.65	0.08	86
OC	-0.15	0.63	0.01	0.95
P_2O_5	-0.21	0.51	-0.09	0.78

Correlation is ** 1% highly significant * 5% significant

The K_2O content in (gKg^{-1}) can be rated as very low (<120), low (121- 240), medium (241-300), high (300- 360) and very high (>360))[25]. Cation exchange is the major nutrient reservoirs of K^+, Ca^{2+} and is also important in holding N in ammonium ($NH4^+$) form. Restoration of vegetation increases the accumulation of soil K because the nutrient-rich branches and coarse litter fraction are all-important nutrient sources. It is generally accepted that response to K fertilizers is likely when a soil has an exchangeable K value of < 0.2 cmol (+) kg^{-1} and unlikely when it is above 0.4 cmol (+) kg^{-1} soil. Thus exchangeable K^+ in the soils rated as very low (< 0.2), low (0.2- 0.3), medium (0.35- 0.6), high (0.6- 1.2) and very high (>1.2)[22] . In dry areas (where there is less soil solution), exchangeable K tends to be more important than dissolved K. Because K dissolves readily, it is highly mobile in the soil. However, it can get trapped between layers of expanding clays.

The high to very high levels of Mg^{2+} in the soils suggest that the soils have sufficient natural Mg^{2+} supplies for crop growth in the studied sites. For most of the crops, the recommended threshold level of Mg^{2+} is 1.0 -3.0 cmol (+) kg^{-1}. Thus Ca^{2+} in all studied soils indicates lower bondage of Ca^{2+} to Phosphorus. For most of the crops, the recommended threshold level of Ca^{2+} is 5-10 cmol (+) kg^{-1}. Though different crops have different optimum ranges of nutrient requirements, the response to calcium fertilizer is expected from most crops when the exchangeable calcium is less than 0.2 cmol (+) $kg^{-1}$of soil, while 0.5 cmol (+) $kg^{-1}$of soil is the deficiency threshold level in the tropics for Mg[24].

The higher the cation exchange capacity (CEC) in surface soils, the more capable the soil can retain mineral elements[24] which is generally accepted that organic matter is responsible for 25-90 % of the total CEC of surface mineral soils[26]. The high CEC values have been implicated with high yield in most agricultural soils and CEC values in excess of 10 $cmolkg^{-1}$ are also considered satisfactory for most crops[16]. Soils with high percentage base saturation (PBS) are considered more fertile because many of the “bases” in PBS that contribute to it are plant nutrients.

The SOM content of agricultural soils under rainfed fields were low for Sorghum and Moringa fields whereas medium for all agricultural soils under irrigated fields. This indicates that under both irrigated and rainfed practices application of nitrogen containing fertilizers is necessary. Also the low levels of SOM in the soil are partly because of high temperature of the area gradual rate of decomposition of organic materials. According to the results of fertilizer trials carried out in Ethiopia[27], the critical SOM values for the common cereals grown are 2.5% for barley and wheat; 3.0% for maize; 2.0% for sorghum and teff. SOM content of soils are categorized as very low (<1 %), low (1-2 %), medium (2-3 %), high (3-5 %) and Very high (>5 %)[2]. According to these categories, most of the SOM content in the studied soils is in low ranges. This indicates that for both indigenous and conventional fields, without application of nitrogen containing fertilizers no adequate yields can be achieved.

The TN content of the surface soils is categorized from low to medium except for NF. As per the suggestions made by[28], TN content of soils are categorized as low (< 0.15 %), medium (0.15 - 0.25 %) and high (>0.25 %) Accordingly, the TN content of the studied soil can be rated as low medium. The difference in OC and TN content among the land uses could be attributed to the effect of variation in land management. The distribution pattern of TN across land uses was similar to that of SOM. This is because SOM contents is a good indicator of available nitrogen status in the soil. Intensive and continuous cultivation aggravated OC oxidation which resulted in reduction of TN as compared to NF. The results are in accordance with the findings of[17] who reported that intensive and continuous cultivation forced oxidation of OC and thus resulted in reduction of TN. It is generally accepted that C:N ratios between 8 and 12 are considered to be the most favorable condition for crop production. This high level of C:N ratio implies a relatively fast mineralization of nitrogen from the organic materials. The observed C:N ratio status in surveyed sites suggests that the conditions for plant growth favorable. However, lower values of C:N ratio is due to lower content of OC and TN.

P_2O_5 contents in surface soils can be categorized as very low (<5), low (5- 9), medium (10- 17), high (18- 25) and very high (>25)[28]. In most soils there is an increase after flooding in P_2O_5, due to increased solubility of Ca phosphate in calcareous soils, and greater diffusion[28]. Based on the above results it is not compulsory to apply P_2O_5 in all the land use systems studied.

The pH values of most studied soils were in the range of neutral and near neutral indicating that there is no toxicity of aluminum, manganese and hydrogen. Therefore, it does not impair the availability of nutrients such as K, Ca, and Mg especially in alluvial soils. This is mostly due to the fact that pH changes the form of many nutrients. Accordingly, the exchangeable K, Ca and Mg content of the soils are above the critical values, indicating low leaching in dry region soils. As a result, it does not prove a balanced proportion of the exchangeable bases. Antagonistic effects are known to exist, for example, between Na and K, between Na and Ca and between Mg and K[29]. K uptake would be reduced as Ca and Mg are increased; the exchangeable Ca:Mg ratio should not exceed 10/1-15/1 to prevent Mg deficiency, thus the recommended K:Mg are < 5/1 for field crops, 3/1 for vegetables and sugar beets and 2/1 for fruit and greenhouse crops[29,30].

Furthermore, soil test categories in Table (1, 2, and 3) can be explained as “Below Optimum” (very low, low, medium) levels of nutrients are considered deficient and will probably limit crop yield. There will have a moderate to high probability of an economic crop yield response to additions of that nutrient. “Optimum” (sufficient, adequate, proportional) levels of nutrients are considered adequate and will probably not limit crop growth. There is a low probability of an economic crop yield response to additions of these nutrients. “Above Optimum” (high, very high, and excessive) levels of nutrients are considered more than adequate and will not limit crop yield. There is a very low probability of an economic crop yield response to additions of these nutrients. At very high levels there is the possibility of a negative impact on the crop if nutrients are added.

CONCLUSIONS AND RECOMMENDATIONS

The results of 120 randomly collected soil samples from different LUTs were revealed that nutrients concentrations in most of the soils showed that AC has less compared to PC in irrigated agriculture and PC less than under rainfed agriculture. PC system improves soil productivity because of long fallow period and reestablishment of deep-rooted perennial plants. For example, bananas- based land use systems return substantial quantities of OM to the soil and protect soil against erosion as compared to moringa-based agroforestry system in the rainfed agriculture. Specifically, the soil fertility factors such as OC, TN, PBS and exchangeable (K, Ca and Mg) contents were found to be low in cultivated soils compared to NF. available and exchangeable K contents were variable. Also soil pHs are in a preferred range for most crops. This result generally suggests that K^+ is not a limiting mineral element to crop production except in Moringa field. Because basic elements like K removed from the soil with intensive harvest of moringa leaves in the study area. This study revealed that most of the soil properties are influenced by differences in land use managements. Therefore, it could be recommended to include management practices that increase potassium availability in the study area soils. Furthermore, rotation and intercropping appropriate leguminous species that add N to the system is required, however, nutrient flows and soil-plant analysis are required to give concrete recommendation in the study area soils.

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