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Soil Morphology, Physico-Chemical Properties and Classification of Typical Soils of Abelo Area Masha District South Western Ethiopia

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Abstract

A soil profile representative of typical soils of Abelo area Masha District, South-west Ethiopia, was dug to study its morphology, physico-chemical characteristics and to classify it using two internationally known soil classification systems. Disturbed and undisturbed soil samples were taken from designated pedogenic horizons for physical and chemical analysis in the laboratory. Soil morphological observations revealed that the pedon was well drained and very deep with dark brown to dark yellowish-brown topsoil overlying brown to strong brown sandy clay loam to sandy clay subsoil. Clay eluviation - illuviation was a dominant process influencing soil formation in the study area as indicated by the clay gradient between the eluvial and illuvial horizons in the subsoil. The soil was characterized by weak fine sub angular blocky structure throughout its Pedon depth. Laboratory analysis indicates that the soil was very strongly acid (pH 4.49-5.2) throughout the profile, the pedon has low N (0.1-0.13), low to medium OC (1.3-1.87%). Low Av. P (3.4-8.5 $mgKg^{-1}$), low C:N (13-14.38), Available. K (25–54 $mgKg^{-1}$), Low to medium Ca (5-7.12 cmol (+) kg^{-1}soil), medium Mg (1.5-2.16 cmol (+) kg^{-1} soil), medium K(0.32-0.41 cmol (+) kg^{-1}soil), TEB (6.82-9.69), Ac(2.4-3.58), Al(1.8-2.52), moderate CEC(18.8-21.44 cmol (+) kg^{-1}), ECEC (9.22-13.28) CECclay (37.6-46.41 cmol (+) kg^{-1}), high Pals (9.81-13.59%), high PAcs (11.11-16.66%), low (PBS<50%), low Ca/Mg (3.06-3.33), medium Mg/K (4.41-6.68), high K/TEB (0.035-0.05), low Calcium saturation (26.88-34.67%), low Magnesium saturation (8.06-10.80%), Textural class (sandy clay loam-sandy clay), Bd (1.32-1.36 gcm^{-3}), high Pd (2.708-2.766 gcm^{-3}), and porosity (50.83-51.25%). Using field and laboratory analytical data, the representative pedon was classified to the series level of the USDA Soil Taxonomy as Abelo, fine-loamy, siliceous, thermic, Rhodic Paleudults and to Tier-2 of WRB as Rhodic Nitosols Ortho dystric. The general fertility of the soils of the area is discussed highlighting their potentials and constraints.

Keywords: Soil characterization; Soil morphological properties; Soil physical properties; Soil chemical properties; Soil classification; Soil fertility evaluation

Introduction

Land degradation is a serious and widespread problem for Sustainable agricultural development and food security in developing countries [1,2]. The soil erosion problem in Ethiopian high land is quite pronounced with soil loss of 137 tons per hectare (t ha^{-1}) and loss of 10 mm soil depth per year [3].The average annual soil erosion rate nationwide was estimated at 12 tons ha^{-1}, giving a total annual soil loss of 1,493 million tons [4]. As a result, most of the Ethiopian soils, especially in the highlands, are low in nutrient content due to erosion, leaching and absence of nutrient recycling [4].

The major causes of land degradation in Ethiopia high-land areas natural and anthropogenic factors such as rapid population growth, deforestation, overgrazing, low vegetative cover and unbalanced crop and livestock production. Topography, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, leading to low nutrient content [4]. Due to increase in population, continuous tillage of soil by farmers, burning of crop residues, deforestation, over-grazing, slash and burn, depletion of soil organic matter results in rapid deterioration of the biological, chemical and physical properties of the soil [5,6]. There is land use alteration of natural forests, shrubs, marshes and woodland to cultivated, grazing and settlement land in the Sheka zone [7,8]. In lined with this, in Masha werda sheka zone in south-west Ethiopia, rapid expansion of large-scale private cash crops like coffee, tea, endod, rubber tree, pepper and cereals has resulted in the large-scale destruction of ecologically important forest resources resulting in the large-scale degradation of forestland [9-11]. Continuous mono-cropping of potato, maize, small cereals such as wheat, barley, teff, millet etc. is traditionally practiced resulting in a decline of soil fertility which in turn leads to low tuber yield. This mono-cropping practice coupled with the heavy feeder nature of potato plant and the high rainfall in the area results in soil fertility decline. Farming communities are not well aware of the long-term consequence of continuous mono-cropping practices on soil fertility and productivity. This situation is currently challenging in the study areas where the potato is the main mono-cropping production systems which threaten sustainable productivity in next generation [12].

The use of fertilizers is essential for mitigation of existing crop nutrient deficiencies, the combination of manure, verm compost, NP, sulfur, and boron-containing fertilizer could increase the yield of the crop. Land productivity or sustained agricultural productivity depends on adequate supply of all the nutrients required for plant growth, the yield potential of the crop, variety grown, the availability and cost of fertilizers [13,14].

The intensification of agriculture on land will require a thorough knowledge of the soil as a resource and attributes of the land, its potential, and constraints for appropriate soil and water management systems [15]. However, acquisition of this information is a challenge due to the limited information on crop nutrient requirements, characteristics of soils and high level of variation in soil properties that are experienced across many areas [16]. Assessment of the potential and limitations of soil for the different land use provides the basis for formulating the appropriate management strategies which target specific management problems to improve crop production and soil and water conservation strategies. This information is generated by detailed biophysical characterization of the soils [16]. Two internationally known soil classification systems have been used to classify soils namely the United States Department of Agriculture (USDA) Soil Taxonomy and World Reference Base for Soil Resources. The main purpose of any classification is to establish groups or classes of soils under study in a manner useful for practical and applied purposes in (a) Predicting their behavior, (b) Identifying their best uses, (c). Estimating their productivity and (d) providing objects or units for research and for extending and extrapolating research results for this kind of purpose, soil survey forms an essential ink for its practical application. A soil profile or pedon representative of typical soils is dug to study its morphology, soil physico–chemical characteristics and hence classify. The current study is aimed at the characterization of the soils in Masha District south -west Ethiopia and to provide the needed basic information of the soil and ecological conditions. Specifically, the study was done to (i) Characterize the soils based on their morphology, physicochemical properties and hence their general fertility (ii) Classify the soils using the 'United States Department of Agriculture (USDA) Soil Taxonomy' and the 'World Reference Base for Soil Resources' scheme of classification and (iii) provide basic soil information to researchers working in the study area that will guide activities related to the management of the existing land resources.

Material and Methods

Description of the study site

Masha Woreda is located in Southern Nation, Nationalities and People‟s Regional State (SNNPRS), Sheka Zone. This woreda has 17 Kebeles and one chartered town called Masha and it is the capital of Sheka Zone. And those kebele lays UTM WGCs 1984 Zone 36 N between 861,000 MN-873,000 MN and 105,000-120,000 ME. Attitudinally, those kebele lies between n 1600-2400 m. The woreda is bounded to the west by Sele- Nonno Woreda of Oromia region, to the south by Diddo-Lallo Woreda of Oromia region and to the north by Andracha Woreda of Sheka Zone and has a total land area of 90,802.82 hectares. Out of this land area, about 23.9% is cultivated, 2.8% is grazing the land, 40.5% is covered by forest, 5.5% arable land, 5.9% non-arable land and 21.4% is settled the land area [16]. There is decreasing trend of dense closed forests from 39% to 31%, open forests from 33% to 25% in sheka zone, However, the portion of agriculture and tea plantations increased to 10% and 0.5%, respectively from 1987 to 2009 still continue to decrease forest and increase agricultural land expansion at speed rate due to population pressure Conversion of forest land to other land use types [10].

Lithology and soils

The south-western Ethiopian highlands developed along the western margin of the Rift Valley as a result of uplifting over the past 18 million years [17,18]. The underlying basement rock is of Precambrian origin. These strongly folded and faulted basement rocks are mostly directly covered by Tertiary volcanic rocks that dominate the geology of the area [19]. Following the uplift, the region has been dissected by rivers, resulting in elevations ranging from 900 to 3500 m a.s.l. Southwest Ethiopia drains partly to the White Nile through the Akobo-Baro river system, and partly to the Omo-Turkana basin [10].

The major reference soil groups of the south-western highland plateaus are Nitisols, Vertisols, Leptosols, Regosols, Cambisols, and Acrisols [20]. Nitisols are the dominant reference soil groups in coffee-growing areas of southwest Ethiopia. Nitisols have a depth of more than 1.5 m, are clayey and red in color. They primarily occupy slopes steeper than 5%. These soils are well-drained with good physical properties; they have high water-storage capacity, a deep rooting depth, and stable soil aggregate structure. Nevertheless, rates of decomposition of organic matter and leaching of nutrients are extremely fast. Acidity ranges from medium to strong, and pH is generally less than 6 [21,22].

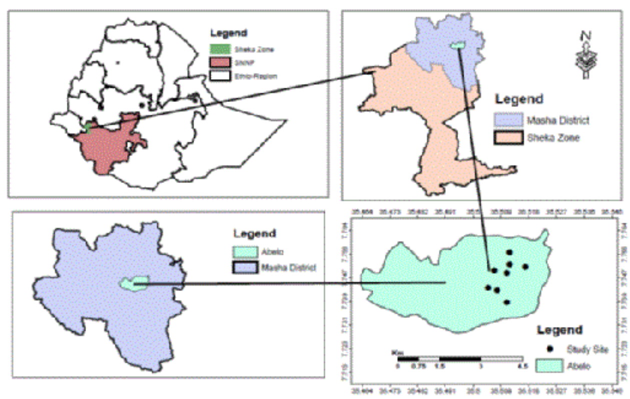

Figure 1: Map of Ethiopia showing the location of SNNPRS (A), map of SNNPRS showing the location of the study area (B) and map of the study area showing the location of soil sampling points.

The experiments were conducted at Abelo in Masha district Sheka Zone, of south-western Ethiopia, in 2016 and 2107 'belg' and 'meher' cropping seasons. MASHA district is one of the districts in sheka zone and located 677 km southwest from Addis Ababa. The total land area of the Zone is 2387.52 km^2. There are three woredas and a Zonal town administration in the Zone with the total population of 222,311 [23]. The altitude of the district varies from 1600-2400 m and receives 2000 mm rainfall annually. Agro climatically, the area is largely Woina dega type covering about 75% of the total area, while 22% and 3% are in Dega and Kola zones respectively. The Woreda receives all the year-round rainfall [24]. There is large forest cover in the Woreda. The relief of the Woreda is a rugged terrain comprising hilly areas which impose their respective influence on agricultural practice and settlement patterns. The Woreda is drained by relatively bigger rivers in the Woreda like Meneshi, Wonani, Tatamayi and Gahamayi [25].

The area is known as the mixed crop-livestock farming system in which majority of working population of Masha Woredas engaged in

Agriculture activities. Like Potato (*Solanum tuberosum* L.), enset (*Ensete ventricosum* Welw Cheesman), cereals such as maize (*Zea mays* L.), barley (*Hordeum vulgare* L.), and common bean (*Phaseolus vulgaris* L.), field pea (*Pisum sativum* L.), are the major cropping activity. In addition, and different kinds of spices, coffee and honey are the major sources of cash. Out of this land area, about 23.9% is cultivated, 2.8% is grazing land, 40.5% is covered by forest, 5.5% is arable land, 5.9% non-arable land and 21.4% is for settlement [26,27]. The worda is known for its regular rainfall providing the opportunity for at least two crop production cycles per year [28].

Result and Discussion

Climate analysis

Historic daily rainfall data of thirty-five years (1983-2017) was used to characterize the study area Generally, rainfall follows monomodial pattern which includes short (NDJ) medium (FMAM) long (JJASO) rainy season the mean daily maximum and minimum are 23 and 12.30c respectively while the average annual rainfall is 1614.91 short (NDJ) medium (FMAM) long (JJASO) rainy season Where SOS is start of seasons. EOS=end of seasons, LGP=length of growing period calculated using instat software 2005.

Rainfall

The climatic condition of the study Woreda is divided into two agro-climatic zones. These are Dega and Woina Dega. Dega part gets the maximum rainfall annually. Distribution of rainfall varies from one season to another as that of another area in Ethiopia and basically, the Woreda has monodial rainfall, that is, Belg rainfall (February to may) and Mehar rainfall (June to October).

Year	Annual RF	FMAM -Masha	JJASO Masha	NDJ- Masha	SOS	EOS	LGP
1983	1814	670	917	227	36	344	308
1984	1764.1	634	983	147.1	20	355	335
1985	1548.3	467	784	297.3	28	326	298
1986	1787.8	575	834	378.8	32	321	289
1987	1871.9	569	976	326.9	48	360	312
1988	1833.5	559	952	322.5	46	355	309
1989	1701.2	520	861	320.2	38	338	300
1990	1454.1	469	787	198.1	49	316	267
1991	1731.8	676	926	129.8	45	353	308
1992	1660.3	655	928	77.3	43	360	317
1993	1627.2	518	774	335.2	32	321	289
1994	1512.2	492	716	304.2	48	360	312
1995	1584.2	458	802	324.2	28	355	327
1996	1501.2	520	861	120.2	38	338	300
1997	1482.3	524	851	107.3	34	275	241
1998	1401.2	520	761	120.2	40	323	283
1999	1309.4	418	715	176.4	23	360	337
2000	1309.7	322	706	281.7	32	325	293
2001	1222.3	523	621	78.3	36	328	292
2002	1434.1	562	777	95.1	33	290	257
2003	1483.6	479	802	202.6	50	298	248
2004	1315.3	455	768	92.3	32	290	258
2005	1663.6	577	942	144.6	32	342	310
2006	1677.6	582	949	146.6	35	301	266
2007	1785.8	525	1053	207.8	33	285	252

2008	1688.2	494	1036	158.2	39	316	277
2009	1734.1	532	877	325.1	34	364	330
2010	1522.3	528	871	123.3	34	332	298
2011	1663.6	507	842	314.6	49	355	306
2012	1568.2	404	694	470.2	36	312	276
2013	1551.8	463	736	352.8	29	316	287
2014	1690.6	412	705	573.6	33	333	300
2015	1657.6	570	789	298.6	37	358	321
2016	2071	633	1153	285	35	350	315
2017	1897.71	607.2	953.31	337.2	21	295	274
Average	1614.91	526.26	848.64	240.01	35.94	330	294.06
Stranded deviation	184.78	77.53	115.72	117	7.62	25.05	24.8
Coefficient of variation	11.44	14.73	13.64	48.75	21.21	7.59	8.43

Table 1: Historic daily rainfall data of thirty-five years (1983-2017) in months at Masha south-western Ethiopia.

These results of the initial soil test analysis showed that the soils at the sites were low in fertility, acidic, with low amounts of total N, organic carbon, total and extractable phosphorus and exchangeable bases (Table 2). This could be attributed to the poor management of crop residue, thus resulting in nutrient reduction and the decline in soil fertility. The crop response to added organic and mineral fertilizer at different season is expected to show responses on crops and soils

Following the rating of total N of <0.05% as very low, 0.05-0.12 low, 0.12-0.25 Medium, > 0.25 high N status as indicated Tekalign et al. [29] the surface Soils of both the belg and meher season qualify low status of N.

Prior to planting, surface (0-20 cm) soil samples, from five spots across the experimental fields, were collected in a zigzag pattern, in 2016 belg and mehre cropping seasons, composited and analyzed in Teppi Soil Testing Research Centre for soil physico-chemical properties as per the procedures are given in experiment I and the results are depicted in Table 2.

The soil physico-chemical analysis of the study sites revealed that the soils of the experimental field were loam in texture in both belg and mehre cropping season. The results also indicated that the soil of belg and mehre cropping season are strongly and very strongly acidic with pH of 5.2 and 4.8, respectively. The soils have low organic carbon, total N (g kg^{-1}) and available P (ppm) Na and medium in exchangble base, CEC and high in micronutrient cation Fe Mn Cu Zn both in belg and meher season and for trace exchangeable sodium [30-37].

Soil parameters	Soil 2016 Belg (short rain season February to May)		Soil 2016. Meher (long rain season-June to October)		References
	Value	Rating	Value	Rating	
Bd (g cm-3)	1.37	Medium	1.38	Medium	[30]
PD (g cm-3)	2.58	Medium	2.6	Medium	[30]
%porosity	46.80		46.92		[31]
%Sand	45	-	48	-	
%Slit	31	-	30	-	
pH (1:2.5)	5.01	Strongly acidic	4.8	Very strongly acidic	[29]
EC(uscm^{-1})	169	Ver low	85	Very low	[32]
N (g kg-1)	0.1	Low	0.08	Low	[29]

Exchangeable Ca (cmol (+) kg-1 soil)	6.5	Medium	6.3	Medium	[33]
Exchangeable Mg (cmol (+) kg-1 soil)	2.1	Modrate	1.4	Modrate	[33]
Exchangeable K (cmol (+) kg-1 soil)	0.42	High	0.36	High	[33]
Exchangeable Na (cmol (+) kg-1 soil)	0.06	Very low	Nill	Very low	[34]
CEC (cmol (+) kg-1 soil)	20	Medium	19.3	Medium	[35]
Pbs (%)	45.4	Medium	41.7	Medium	[35]
Exchangeable Al (cmol (+) kg-1 soil)	2.01	High	2.46	High	[36]
Exchangeable acidity (cmol (+) kg-1 soil)	3.83	High	3.82	High	[36]
O.C(g kg^{-1})	1.2	Low	1.02	Low	[29]
N (g kg^{-1})	0.1	Low	0.08	Low	[29]
C: N	12	Low	12.75	low	[35]
Available P (mg kg-1)	5.5	Low	5	Low	[37]
Cu (mg kg-1) (DTPA)	8	High	6	High	[37]
Fe (mg kg-1) (DTPA)	120	High	80	High	[37]
Zn (mg kg-1) (DTPA)	1.5	High	1.2	High	[37]
Mn(mgkg-1) (DTPA)	25	High	20	High	[37]

Table 2: Physical and chemical characteristics of soil of the experimental sites before planting in Belg and mehre cropping season at Masha south-western Ethiopia.

Soil Data

The pedon was located in the farmer's field (Latitude 07^{0},07"47') and (Longitude 35^{0}.50"9'). The land was under cultivation for more than 50 years following traditional practice (maize fallow cereals) or cereals fallow legume or potato- legume-potato.

Soil profile description was made from the 2-m deep pit on the experimental site. Following the WRB classification system soil morphological data such as horizon boundary, soil colour when moist and dry, structure, consistency, root abundance and carbonate were identified in the field while soil physical properties (soil texture, bulk density, particle density, porosity, and soil chemical properties like ph, O.C, T.N, C:N, available Phosphorous , Ca, Mg, K, Na, TEB, Exchangeable acidity, Exchangeable Aluminum were analyzed in teppi at the soil laboratory of Teppi Soil Testing Research Centre. The soil parameters used are listed in Tables 3, 4 and 5.

Key morphological properties of the profile are shown in Table 3. This profile is well drained with friable moist consistency and slightly hard to hard when dry. The profile is very deep (>160 cm), with weak friable subangular blocky (0-25 cm), medium to strong sub angular blocky dark brown to strong brown colors (Table 3).

The moist color of soil

The consistency in profile with depth (0-25 cm) was friable sticky and slightly plastic when (dry, moist and wet) depth of (25-70 cm) depth within profile slightly friable, slightly sticky and plastic and depth of (70-130 cm) within profile was slightly hard stick and moderately plastic and (130-160 cm) depth hard very sticky and moderately plastic when (dry, moist wet) moderate medium subangular block in (25-70 cm) soil depth strong coarser sub angular block in third and fourth (70-130 and 130-160 cm) soil depth.

Horizon	Depth (cm)	Texture	Color		Consistency	Structure	Roots	Horizon Boundary	Carbonates
			Moist	Dry					
Ap	0-25	SCL	drb (5YR ¾)	drb (5YR 4/4)	Fr, ss, and s	1 fgr	Many fine	gs	eo
AB	25-70	SCL	db (7.5YR ¾)	drb (5YR ¾)	Ss, s and p	2 msbk	Many fine	ds	eo

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Bt	70-130	SL	drb (7.5YR ¾)	drb (5YR 3/3)	ss, s and p	3 msbk	Few fine	dw	eo
BC	130-160+	SL	sb (7.5YR 3/8)	drb (5YR3/4)	ss, s and p	3 msbk	none	di	eo

Table 3: Main morphological character of the pedon at Abelo area Masha District. 1) SL=sandy loam; SCL=sandy clay loam; SL=sandy loam, 2) drb=dark reddish brown; db=dark brown; sb=strong brown; 3) fr=friable; s=sticky; ss=slightly sticky; p=plastic 4) sbk=sub-angular blocky; w-f=weak fine, 5) d=diffuse; g=gradual; i=irregular; s=smooth: w=Wavy: eo=No effervescence.

The structure of soil in the profile with in-depth showing strong variation from surface to subsurface horizon revealing that there is strong variability in the development of soil structure weak fine and granular structure was observed in the upper 25 cm sampling depth. The root distribution of profile was many fines in the surface layer (0-25 cm) to common fine in the second and third (25-70 and 70-130 cm) and not at the extreme bottom (130-160 cm).

No effervescences were observed in all depth within profile in addition to dilute 10% HCl indicated the absence of calcium carbonate.

Soil horizon	Soil depth	pH in H^2O	pH in KCL	ΔpH	EXac- (cmol (+) kg^{-1} soil)	EXa (cmol (+) kg^{-1} soil)	O.C (g kg^{-1})	N (g kg^{-1})	C: N	Av. P ($mgKg^{-1}$)	Av.K ($mgKg^{-1}$)
Ap	0-25	4.49	4.2	0.25	3.58	2.52	1.87	0.13	14.38	8.5	54
AB	25-70	5.1	4.5	0.7	3.2	2.3	1.66	0.12	13.83	6.4	43
Bt	70-130	5.2	4.4	1.2	2.72	2.1	1.36	0.1	13.6	5.6	29
BC	130-160+	5.2	4.5	1	2.4	1.8	1.3	0.1	13	3.4	25

Table 4: selected soil Chemical Characteristics of soils of Abelo area Masha District. EXac= acidity, EXa=Exchangeable aluminium, Av. P=available phosphorous, Av.K=Available potassium.

Positive value for ΔpH indicates negatively charged clay surface. There is slight increase in soil pH. Soil pH value measured in water were higher than the respective value measured in KCL solution n throughout the profile (Table 4) the decreased in pH when measured in KCL indicates appreciable quantity of exchangeable hydrogen(H) had been realized into soil solution through exchange reaction with K in KCL solution

The lowest soil pH (H2o) 4.49 and pH (KCL) 4.2 which is strongly acidic value (pH<5.5) values were recorded on the surface soil of profile this might be due to continuous removal of basic cations by high yielding crop variety, oxidation of organic matter and leaching of basic cation leads to the low calcium saturation and continues release of acid cations from the acidic parent materials.

The highest total carbon (1.77), total nitrogen (0.14) and C:N ratio was recorded in surface horizon the content of soil organic carbon and total nitrogen and C:N ratio decreased consistently with increasing soil depth within profile.

The highest concentration of available phosphorus (8.5) by Bray II method and available potassium (54) by curve method in surface horizon (Ap) and decreases consistently in bottom horizon (BC) with depth [38,39].

CEC clay=CEC of soil–(%OM*200)/ %Clay

Pals=Exchangeable Al/CEC

PAcs=Exchangeable Acidity/CEC

PBS (%)=Exch. Na + Ca + Mg + K/ CEC

The highest exchangeable bases calcium (Ca^{2+}), magnesium (Mg^{+2}), potassium (K+) were recorded in the surface horizon (Ap) and decreased linearly with depth to the last horizon (BC). This is clearly related to organic matter (plant and animal residue) degradation in the last horizon (BC). Exchangeable potassium level above 0.2 cmol (+) Kg^{-1} suggests that plant response to application of potassium fertilizer is not possible particularly when addition organic amendment is added that replaces heavy removal of the crop by harvesting.

(cmol (+) kg^{-1} soil)													
Soil depth	Soil horizon	Ca	Mg	K	Na	TEB	Ac	Al	CEC	ECEC	CEC clay	PAls (%)	PAcs (%)	PBS (%)
0-25	Ap	7.12	2.16	0.41	0.01	9.69	3.58	2.52	19.5	13.28	43.5	13.59	15.91	49.69
25-70	AB	6.55	2.14	0.39	trace	9.08	3.2	2.3	19.2	12.28	40.83	11.97	16.66	47.29
70-130	Bt	6.43	2.02	0.34	trace	8.79	2.72	2.1	21.4	11.51	46.41	9.81	12.71	41.07

130-160+	BC	5	1.5	0.32	trace	6.82	2.4	1.8	18.8	9.22	37.6	11.11	11.11	36.27

Table 5: Selected soil Chemical Characteristics of soils of Abelo area Masha District (continued) TEB=Total exchangeable bases; Ac=Acidity; CECsoil and CECclay=Cation exchange capacity of the soil and clay fraction, respectively; ECEC=Effective cation exchange capacity; PAls, PACs and PBS=Percentage of Al saturation, acid saturation and base saturation, respectively.

The highest Exchangeable acidity (3.58 cmol (+) kg^{-1} soil) and exchange aluminum (2.52 cmol (+) kg^{-1} soil) was higher in surface horizon and almost decreases linearly with depth from surface (Ap) to bottom horizon (BC) respectively and the contribution of exchangeable aluminum to exchange acidity were 70.39, 71.8, 77.20, 75 In abelo area Masha district south-western Ethiopia, large proportions of exchangeable acidity were due to exchangeable Al. (Table 4) The highest aluminium and acid saturation percentage of (13.59) in surface horizon (Ap) and (16.66) in the second horizon(AB) respectively and decrease linearly to (11.11) of both acid and aluminium saturation percentage Acid saturation percentage of >10 will affect plant growth and this can be toxic to sensitive plant such as Cabbage, carrot , tomato, pepper, cotton, brassica, but tolerant plant like Soybean, maize, lupine, groundnut, Potato, Teff can be grown under current condition or without lime The highest CEC (21.4 cmol (+) kg^{-1} soil) and CEC clay (46.41 cmol (+) kg^{-1} soil) was recorded in (Bt) horizon this indicates the presence of accumulation of highly weather able minerals in the horizon and there is general decrease of CEC of soil and clay down profile while the highest ECEC (13.28 cmol (+) kg^{-1} soil) was recorded in surface horizon(Ap) and decreased linearly down profile. This decreases with depth due to strong association with organic carbon which also decreases linearly with depth. The saturation of the CEC with basic cations calcium (Ca^{+2} cmol (+) kg^{-1} soil), magnesium (Mg^{+2} cmol (+) kg^{-1} soil), potassium (K+ cmol (+) kg^{-1} soil), sodium (Na+ cmol (+) kg^{-1} soil)) decreases linearly from 49.69 percent at top horizon (0-25) to about 36.27 percent at last most horizon (130-160), causing a great decrease in the amount of exchangeable nutrient cations in middle and lower horizons. In essence, intensive weathering results in acid soils that are naturally infertile the percent base saturation was <50% throughout profile this indicated that the low soil fertility status of profile.

Soil depth	Soil horizon	Ca/Mg	Mg/K	K/TEB	Calcium saturation percentage	Magnesium saturation percentage
0-25	Ap	3.33	4.41	0.05	26.88	8.06
25-70	AB	3.18	4.92	0.046	33.48	10.52
70-130	Bt	3.28	5.79	0.038	34.67	10.56
130-160+	BC	3.06	6.68	0.035	33.08	10.80

Table 6: Soil nutrient ratios of the pedon at abelo area, Masha District.

The ratio of calcium to magnesium is in the range 3.06-3.33, below the range of 4-6 indicating that calcium (Ca^{+2}) is deficient or external application of calcium (Ca^{+2} cmol (+) kg^{-1} soil), is required to maintain soil fertility and leaching is the predominant translocation, pedogenetic process. Overall, the result shows that the ratio of Ca/Mg values was below 4.0, telling deficiency of calcium [34] the condition is more series at low pH. Especially more series in plant with fibrous root system facing difficult to take nutrients from deeper horizon in search of leached nutrients

The high Mg/K ratios in pedon indicates that the soil has developed from mafic parent materials and values of Mg/K ratios are in the range of 4.41 in surface horizon (Ap) to 6.68 in subsurface horizon (BC). These ranges are being considered favourable for most crops showing magnesium is available to crop the overall K/TEB (total exchangeable bases) ratios are above 0.02 which is said to be favourable for most tropical crops.

Calcium saturation percentage (CSP), magnesium saturation percentage (MSP), potassium saturation percentage, acid saturation percentage(AcSP) and aluminum saturation percentage (ASP) were calculated as the ratio of the exchangeable Calcium, magnesium, and potassium to CEC of soil samples taken from the respective horizon. The lowest Calcium saturation percentage (26.88) in the surface horizon (Ap) and almost increased linearly down profile which is below optimum ranges of 65% to 75%. Cation saturation range reflecting external application calcium-containing material must be added for better crop production or for a higher soil calcium, increase the lime application. The lowest cation saturation percentage for magnesium (8.06) in surface horizon (Ap) and increased linearly with depth bottom horizon (10.80) which is below the optimum range of 10 to 15% of cation saturation for magnesium. These conditions may prevent the growth of plants if dolomite or other materials are not added to correct the proportion. Cation saturation percentage value for potassium ranged from 1.61 in the subsurface horizon (BC) to (2.13) in the 2nd horizon (AB); all ranges are in optimum saturation value of 1-5%, so there is no need of potassium-containing fertilizer as an amendment.

Table 6 presents the data on soil texture. The soil texture was sandy clay loam in the upper and middle horizons and, sandy clay in the 3rd and bottom horizons with an overall average texture of sandy clay loam (53% sand, 34.25% clay, 12.75% silt). Results on bulk density, particle density, and total porosity are presented in Table 6. The mean bulk density and particle density ranged from (1.32 and 2.71 Mgm^{-3}) in the lowest horizon (BC) to (1.36 and 2.76 Mgm-3) in the surface horizon (Ap), with an overall average of 1.345 and 2.7462 Mgm^{-3} respectively (Table 6). The low bulk and particle density in the most bottom layer (Ap) can be attributed to increasing clay content down the profile (Table 6). Soil bulk density has a major impact on the dynamics of water and air in the soil and crop root development which ultimately affects crop growth and yield.

The lowest porosity in the surface horizon (50.83) and it increases with increasing depth in bottom horizon (51.25) though this indicates there is slight increase in total porosity of soil with depth this shows factors that decrease bulk density of soil such as increase in clay content improves total porosity of soil

Since porosity is calculated from the relation between bulk density and particle density of soil, it is very much influenced by the soil bulk density and the particle density for any given soil, the lower the bulk densities, the more compacted the soil is and the lower the pore space as also observed in this profile, Therefore, organic matter addition is required to improve porosity or any features that can reduce bulk density and these soils were categorized as sandy clay loam, in the upper (Ap) and second middle horizon(AB) and Sandy clay in third(Bt) and bottom horizon(BC).

The liner declines of silt/clay ratio of (0.46) in surface horizon (Ap) to 0.35 in bottom most horizon(Bt)with depth also implies weathering of coarse particles, thus indicate advanced soil development also implies that the rate of weathering increase with increase in soil depth and shows the presence of clay migration.

Soil depth (cm)	Soil horizon	% sand	% slit	% clay	Silt/clay ratio	Textural class	Bd (gcm^{-3})	Pd (gcm^{-3})	% porosity
0-25	Ap	56	14	30	0.46	sandy clay loam	1.36	2.766	50.83
25-70	AB	54	13	33	0.39	Sandy clay loam	1.35	2.758	51.05
70-130	Bt	52	12	36	0.35	Sany clay	1.35	2.7528	50.96
130-160+	BC	50	12	38	0.31	sandy clay	1.32	2.708	51.25

Table 7: Selected soil Physically Characteristics of soils of Abelo area Masha District.

A soil profile representative of typical soils of Abelo area Masha District, south-west Ethiopia, was dug to study its morphology, soil physico-chemical characteristics and to classify it using two internationally known soil classification systems. Disturbed and undisturbed soil samples were taken from designated pedogenic horizons for physical and chemical analysis in the laboratory. Soil morphological observations revealed that the pedon is well drained and very deep with dark brown to dark yellowish-brown topsoil overlying brown to strong brown sandy clay loam to sandy clay subsoil.

Clay eluviations-illuviation is a dominant process influencing soil formation in the study area as indicated by the clay gradient between the eluvial and illuvial horizons and the presence of clay cutans in the subsoil. The soil is characterized by weak fine sub angular blocky throughout its pedon depth. Laboratory analysis indicates that the soil is very strongly acid (pH 4.6-5.0) throughout the profile, has very low N (20 mg kg^{-1}) in the topsoil and low OC (0.6-1.25%). The pedon has low CEC (6.0-12.0 cmol (+) kg^{-1}) and low base saturation (<50%). Using field and laboratory analytical data, the representative pedon was classified to the series level of the USDA Soil Taxonomy as Abelo, fine-loamy, siliceous, thermic, Rhodic Paleudults and to Tier-2 of WRB as Rhodic Nitosols Ortho dystric. The general fertility of the soils of the area is discussed highlighting their potentials and constraints

USDA soil taxonomy						FAO - WRB Soil Classification	
Order	Suborder	Great group	Subgroup	Family	Series	Reference Soil Group	WRB soil name
Ultisols	Udults	Paleudults	Rhodic Paleudults	fine-loamy, siliceous, thermic, Rhodic Paleudults	Abelo, fine-loamy, siliceous, thermic, Rhodic Paleudults	Nitosols	**Rhodic** Nitosols Ortho dystric

Table 8: Summary of the morphological and diagnostic features of the Pedon at Abelo area, Masha District.

Conclusion

Continuous cultivation without application of organic and inorganic fertilizer amendment have enhanced the degradation of selected soil chemical properties under the research farm, however, soil fertility status of the farmer's field that was continuous cultivate indicating that farmers have conservation based. Implementing integrated soil fertility management could improve the existing soil condition and replace the degraded soil chemical properties moreover soil analysis alone cannot go beyond the detection of toxicity sufficiency or deficiency level therefore soil analysis along with field experiments are crucial in giving conclusive recommendation on soil management for sustainable production and productivity of soil in the abelo area Masha distinct sheka zone south-west Ethiopia.

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