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Research article

Characterization of Agricultural Soils of Meki and Adamitulu in the Central Rift Valley of Ethiopia

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Soil pits were used to provide characterization of soil profiles for soil morphological, physical and chemical characteristics in two areas of the central rift valley's agricultural soils. Hence, the composite surface soils of Adamitulu (7.7 to 7.8) were moderately alkaline and that of Meki was neutral to slightly alkaline. The profiles and the composite surface soil samples of the areas (Meki and Adamitulu) had very low OM, OC, available nitrogen and P content that would limit production of many crops. Hence, there is a need for external application of the above nutrients for both locations. The soil exchange complex was mainly dominated by Ca and Mg where the order of occurrence was Ca > Mg >K > Na. The soils of the study areas are not deficient with micro nutrients like zinc, Cu, Fe and Mn that doesn't need external application of the above soil minerals. The soils of the study sites fails to meet the criteria listed for diagnostic epipedons than ochric, as it has high color value for most of the horizons. The sub surface horizon had high percentage of clay than the overlying soil material. Therefore, the soils of the subsurface meet the requirement of Argilic horizon. Referring to the weather data of the site it can be concluded that the area is characterized by an aridic soil moisture regime. Thus, considering the morphological, physical and chemical properties of the surface and sub surfaces horizons, soils of the sites falls under the Aridisols soil Order of Soil Taxonomy.

Key words: physico-chemical properties, soil profile, composite surface soil

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INTRODUCTION

Soil is a vital natural resource and must be well managed for sustainable agricultural production (Benton, 2003). In Ethiopia, declining soil fertility presents a major challenge to bring about increased and sustainable productivity in order to feed the ever-growing population of the country. As a result, millions are suffering from poverty and malnutrition.

The severe problem of soil degradation in Ethiopia is mainly due to the overexploitation (over-cultivation, overgrazing) of the soil resources which causes billions of tons of soil removal every year and worse loss of the functions and services soil provide. Soil in Ethiopia is thus needs a high attention on soil specific management, which in turn requires a major investigation across the country (Engdawork, 2015). Soil fertility and health management is the key to the development of sustainable agriculture which is concerned with chemical reactions in soil, amount and availability or unavailability of essential plant nutrients, mechanism of nutrition depletion and replenishment in soil (Prasad and Power, 1997). For sustainable agricultural production, the soil should be managed properly, as the soil can easily be lost if care not taken. The study and understanding of soil properties and their distribution over an area has proved to be useful for the development of soil management plan for efficient utilization of limited land resources. Moreover, it is very important for agro technology transfer (Buol *et al.*, 2003).

Replenishing soil fertility is the primary biophysical requirement for increasing food production in sub-Saharan Africa countries (Sanchez, 2010). In Ethiopia, where agriculture is the mainstay of the national economy, agricultural production has been highly dependent on natural resources for centuries (Amsalu et al., 2007). As a result, agricultural lands have expanded to meet the additional food demand for an increasing population (Kidanu, 2004). Therefore, the study and understanding of soil properties and their distribution over an area has proved to be useful for the development of soil management plan for efficient utilization of limited land resources. Moreover, it is very important for agro technology transfer (Buol et al., 2003). The information on characterizations, classification, fertility status and others are very important for decision making which is crucial for food and fiber production hence minimizing environmental risks which is a current global issue (fulfilling the green economy).

MATERIALS AND METHODS

Descriptions of the study areas

This study deals with two districts of Oromia regional State, Dugda Bora and Adamitulu Jido kombolcha. They are located in East Shewa zone. Before embarking on description about the districts an over view of East Shewa zone will be presented. East Shewa zone occupies central part of Oromia region. the study areas are located at 8001’to 8025'N Latitude and 38032' to 39004'E Longitude and 7037'-8004'N latitude and 38032'-39004'E Longitude for Dugda and ATJK respectively. All areas of the district (Dugda) lie within sub-tropical agro climatic zone with a range of temperature 15 to 20^{O}C and rain fall of 700 to 800mm.

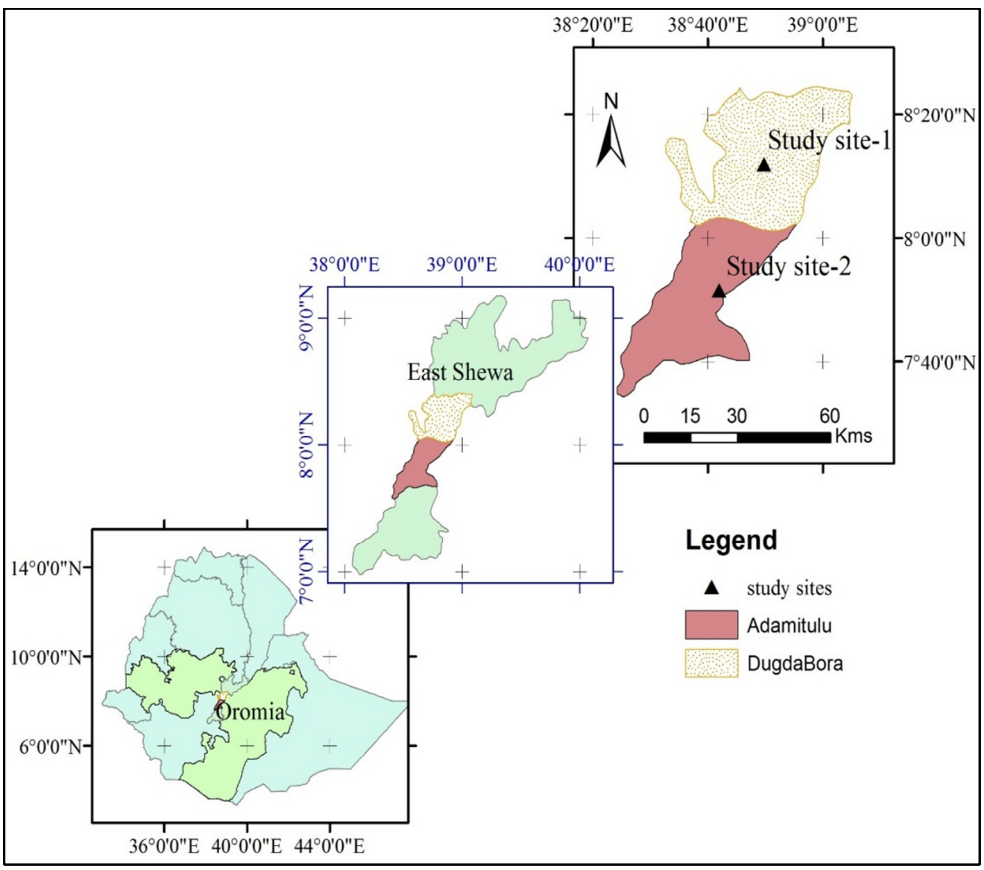

Figure 1. Map of the study locations

Climate Data

According to the meteorological records of Adamitulu Research Center, the total rainfall during the current (2017) cropping season was about 675 mm, which is lower than the mean annual rainfall of 874 mm of the past 30 years and the average monthly maximum and minimum temperatures of these years were 28.627 and 12.566°C, respectively (Figure 2 & 3 respectively). There was high rainfall during the months of July, September, and August followed by a completely dry periods during the whole of October, November, December and January, a trend that is different from the long-term condition.

Meki area receives a mean monthly rainfall of 75.55 mm during the current season (2017) which was higher than the mean monthly rainfall (1990-2017) of 58.88mm. The 29 years' rainfall data indicates that the maximum rainfall occurs during the months of July and August followed by the complete dry periods of October, November and December.

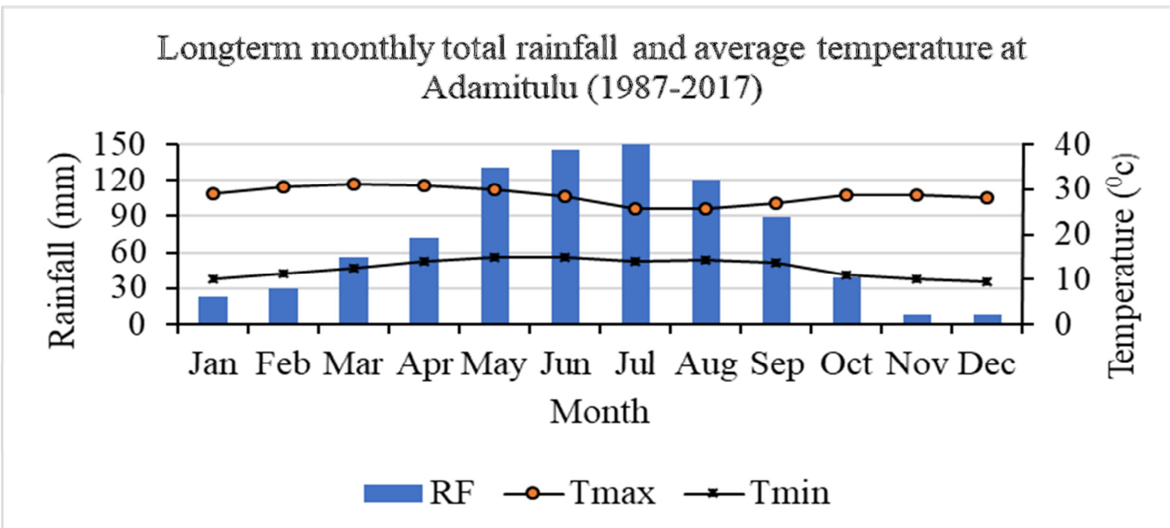

Figure 2. Long term (1987-2017) mean monthly rainfall, maximum and minimum temperatures of Adamitulu

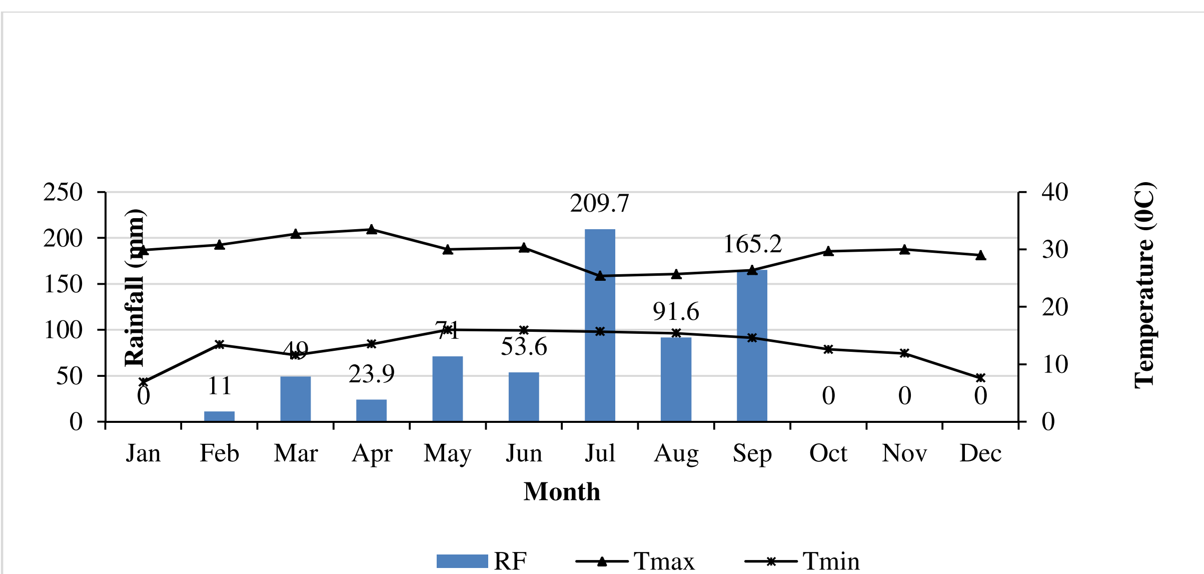

Figure 3. Monthly total rainfall and average temperature at Adamitulu

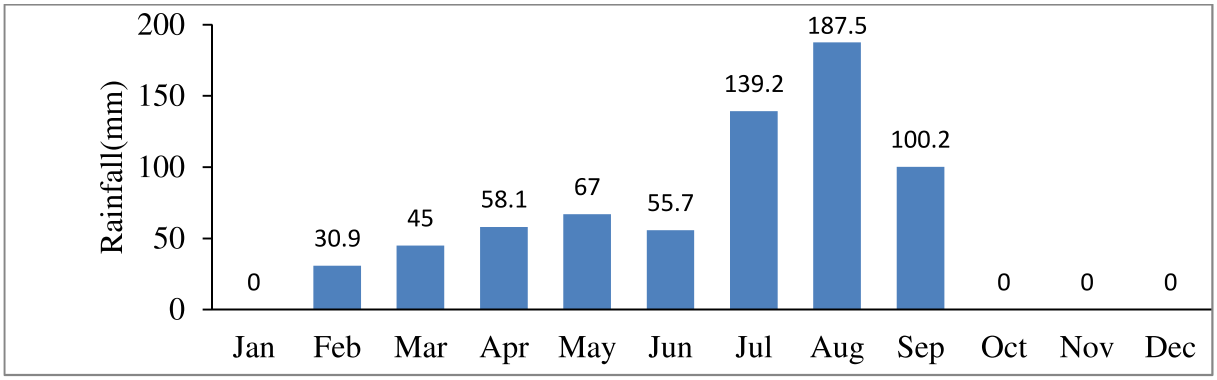

Figure 4. Monthly total rainfall and average Rainfall at Meki in 2017 cropping season

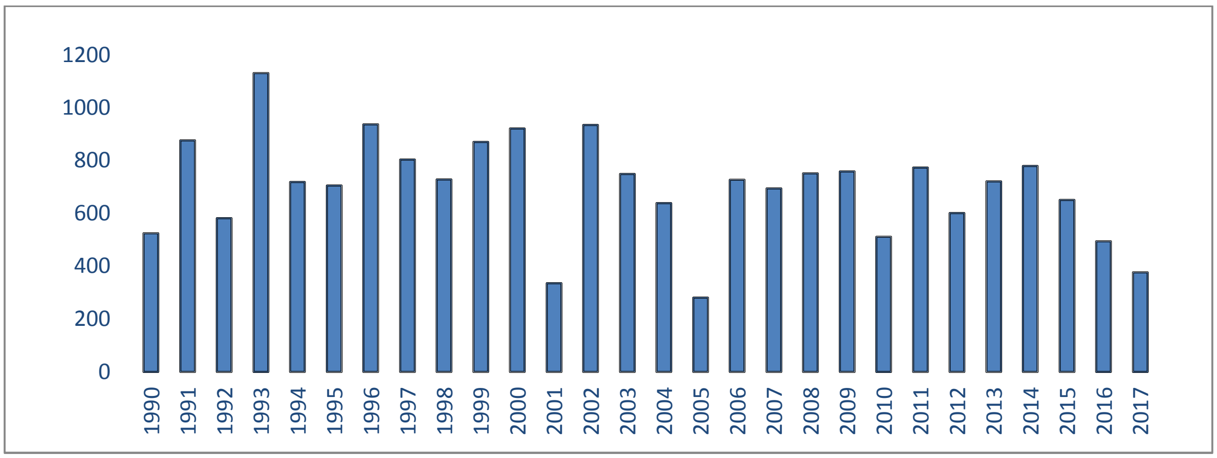

Figure 5. Average Annual rain fall (mm) at Meki (1990-2017)

RESULTS AND DISCUSSION

Morphological properties of the soil in the profile at Adamitulu

In order to place a soil in its perfect position in the classification system, a detailed knowledge on its morphological characteristics is necessary. Morphological properties of soil are the most important tool than physical and chemical properties of soil in soil classification because it is perceived under natural undisturbed condition (Sharma, 2002).

The soils of Adamitulu are dark grayish brown (2.5Y3/2) in color when moist with typically higher values ($\geq$ 3) in all layers of the profile (pedons). The soils are characterized by Ap, Bw1, Bw2, and C, horizon sequence (Table 2). Higher color values indicate poor OM content and chromas more than 2 suggest deeper water table in these soils (Sharma et al., 2006). Absence of mottling (red, yellow or brown splotches) in all horizons of the profile suggests that the soil pores have not been water-filled for prolonged periods (Sharma et al., 2006). Soil texture is dominated by sandy loam (Table 2). The soil structure is granular at AP and sab angular blocky for the rest of the horizons. Surface and sub-surface horizons are found to be slightly sticky and slightly plastic except the lowest horizon which is none sticky and none plastic. The very friable and slightly sticky/slightly plastic consistency observed in the Ap and Bw horizons could be attributed to the relatively higher OM content of the surface than subsurface layers (C horizon). These results were in agreement with that of Wakene (2001) who argued that although consistency is an inherent soil characteristic and mainly a reflection of the particle size composition of the soil, high OM content changed stickiness and plasticity of surface soil layer.

The profile had fine, medium to common root hairs on the first horizon of the profile followed by fine, few to common root hairs on the second layer (20-75cm) of the profile, very fine to few root hairs on the third (75-120 cm), no root hairs observed at the bottom of the profile. In general, no iron coatings were found in all layers of the soil profile opened at Adamitulu. The horizon boundary within the soil profile varied from distinct and smooth at the top and middle layer of the profile (0-75cm) to clear and smooth in the lower horizon (75-120 cm (Table 2)

Table 1. Morphological properties of the soil in the profile at Adamitulu, central rift valley of Ethiopia

Horizon	Depth (cm)	Boundary	Color (Moist)	Structure	Consistence	Abundance and size of roots
Ap	0-20	D, S	2.5Y3/2	we, vf, Gr	vfr, fir, sst, pl	f, me, co
Bw1	20-75	D, S	2.5Y4/2	we, vf, me, co, sb	vfr, fir, sst, pl	f, co
Bw2	75-120	D, S	2.5Y5/2	we, f to me, sb	fr, sst, pl	vf, f
C	120-200	-	2.5Y5/3	we, f, sb	Sst, npl	n

Morphological Properties of the soil profile at Meki

The profile at Meki had weak, very fine granular structure in the surface layer that changed weak, very fine to coarse sub angular blocky in B horizon and at the lower sub surface soil layer to strong, fine to medium sub angular blocky structures in the bottom horizon (Table 3).

The moist consistency of the Ap and Bw layers were very friable that changed to lose in bottom horizon. When wet, the consistency of the surface soil was slightly sticky and slightly plastic that changed to slightly sticky and non-plastic in the Bw horizon to non-sticky and non-plastic at the bottom (Table 3). This might be due the low organic matter and clay content. The soil was moist throughout and iron coatings were absent in all horizons. Very fine to fine roots and which were very few were found on the first (0-20cm) and second (20-85cm). Very common biological activities by worms like termites were observed at the surface layer of the profile. The color of the surface soil was very dark grey (10 YR 3/1) when moist that was changed to very dark greyish brown (10 YR 3/2) in the B horizon and then to weak red (2.5YR5/2) at the bottom of the horizon.

The horizon boundary within the soil profile varied from clear and smooth at the surface soil (0-20cm) to clear and wavy for B horizon (20-85cm) (Table 3). The porosity of the soil was dominated by few and medium sized voids at the surface and B horizon, whereas the C horizon had very coarse and high voids in the bottom soil horizons.

There were no cementation/compaction and mineral concentrations in all layers of the horizons. The soil of the study area occurs on very gently sloping lands (1.5% slope). During the study, color or structure development was observed in the second horizon of the profiles at both study sites (Adamitulu and Meki). According to FAO (2006), the horizons on initiation of color or structure were designated by w, this is used only with B. it is therefore nominated as Bw, this only indicates the color or structure development of soil in B horizon. This type of color initiation in the B horizon shows that the soils of the study area moderate weathering.

Table 2. Morphological properties of the soil in the profile at Meki, central rift valley of Ethiopia

Horizon	Depth (cm)	Boundary	Color (Moist)	Structure	Consistence	Abundance & size of roots
AP	0-20	c, s	10YR3/1	we, vf, Gr	fr, sst, spl	vf, vf
Bw	20-85	c, w	10YR3/2	we, vf, me-co, sb	fr, sst, npl	vf, vf
C	85+	-	2.5Y5/2	st, co, me, sb	lo, nst, npl	n

Key: Abbreviations are as used in the FAO (2006) guidelines for soil profile description (except the use of lower cases) and are described as:1Boundary (distinctness/topography) where c = Clear, g = Gradual, s = Smooth and w = Wavy; 2 Structure (grade/size/type) where st = Strong, we= weak, mo = Moderate, me = Medium, co = Coarse, vc = Very coarse, ab = angular blocky; sb = Sub-angular blocky and Gr = Granular; 3 Consistence (dry/moist/wet) where ha = Hard, fir = Firm, fr = Friable, vfr = Very friable, st = Sticky, sst= Slightly sticky, vst = Very sticky, pl = Plastic, spl = Slightly plastic and vpl = Very plastic; and 4 Roots (abundance/size) where m = Many, c = Common, vf = very fine, vf=very few and n = No roots,5.Slicken side & pressure=no slicken sides, 6. Cracks, n= no cracks.

Physical properties of the soils of Adamitulu and Meki

Soil texture

The sand content in Adamitulu soil was >53% and silt/clay ratios were greater than 1.92, (Table 10) indicating that the soils are relatively young with high degree of weathering potential (Asomoa, 1973). This could be due to the fact that parent materials around Adamitulu are composed of volcanic rocks, with alkaline lavas, ashes and ignimbrites, mainly of Tertiary and younger age (Meron 2007) which can eventually lead to young soils with courser texture. The soil textural class of both the profile and the composite surface soil samples at Adamitulu were sandy loamy and did not vary with profile depth except for the bottom horizon (C), which was sandy (Table 4). The soil profile contained more than 40% silt and 50% sand throughout the profile while the clay content of the soil of the profile was very low. The proportions of clay, silt and sand ranged from 9% to 18%, 31 to 46%, and 40 to 57%, respectively (Table 4). On the other hand, the clay content decreased with soil depth from 16% at the surface horizon to 8% at the bottom layer of the profile.

The sand content in Meki soil was also >72% at the top surface of the soil and the silt/clay ratios were greater than 1.00 (Table 5) indicating that the soils are relatively young with high degree of weathering potential (Asomoa, 1973). This could be also due to the fact that parent materials around Meki are composed of volcanic rocks, with alkaline lavas, ashes and ignimbrites, mainly of Tertiary and younger age (Meron 2007) which can eventually lead to young soils with courser texture.

The soil textural class of both the profile and the composite surface soil samples at Meki were sandy loam and did not vary with the profile depth except for the bottom horizon (C), which was sandy (Table 4 and 5). The soil profile contained more than 50% sand throughout the profile (Table 9). The proportions of clay to silt ranged from 3% (in the 3rd layer of the profile (Bw_2) to 11% (the composite soil surface around the profile) to 8(in the 3rd layer of the profile (Bw_2) to 22 % (the composite soil surface around the profile), respectively (Table 4 and 5).

The silt to clay ratio of the present study ranged from 1.93 to 4.43 for the profile and from 2.23 to 3.46 for the composite surface soil samples at Adamitulu (Table 4and 5) indicates that it is less weathered soils. The silt to clay ratio of the soil ranged from 1.00 to 2.23 for the profile and from 1.18 to 1.89 for the composite surface soil samples at Meki (Table 10 and 11). This ratio is one of the indices used to assess the rate of weathering and determine the relative stage of development of a given soil. In agreement to our results, high silt to clay ratio (1.5) was reported with Alfisol from southern Ethiopia (Wondewosen and Sheleme, 2011), while silt to clay ratio of 1.1 to 2.0 was reported across soils of Ziway and Hawassa area (Girma and Endalkachew, 2013). It is important to note that the silt to clay ratio has been used as an index of stage of soil development by many investigators, and high clay content showed complete alteration of weatherable minerals into secondary clays and oxides (Buol *et al*., 2003).

According to Young (1976), a ratio of silt to clay below 0.15 is considered as low and indicative of an advanced stage of weathering and/or soil development while greater than 0.15 indicates that the soil is young containing easily weatherable minerals. Hence, the silt to clay ratio of the soil observed in the present study sites (Adamitulu and Meki) was generally high (greater than 0.15) both for the profile and the composite surface soils (Table 10 and 11) suggesting low degree of weathering and the soil is at development stages at both study sites.

Bulk density

The bulk density (BD) values of the horizons in the profile at both study sites varied inconsistently with depth ranging from 0.92 g cm^{-3} at the surface layer (Ap horizon) to 0.82 g cm^{-3} at the 4thlayer of the profile at Adamitulu and from 1.08 g cm^{-3} at the surface layer (Ap horizon) to 0.36 g cm^{-3} at the 3rd layer) at Meki (Table 4 and 5).

Therefore, the bulk density values at the surface layer and at the bottom of the profile at both Adamitulu and Meki was not close to the normal range of bulk density for mineral soils which is 1.3-1.4 g cm-3 as indicated by Bohn *et al.,* 2001. Most Andosols show a low bulk density of 0.9 g/cm^3 or less and lowest among mineral soils (Akiro et al., 2014). Only organic soils or organic horizons have lower bulk densities than Andosols. This low bulk density could be due to the parent materials of the Andosols which is pumice nature.

Table 3. Selected Physical Properties of the Study Profile at Adamitulu and Meki, Central Rift valley of Ethiopia

Adamitulu

Soil class	Bulk density	Particle size			Textural class	Silt/clay ratio
		Clay	Silt	Sand		

Table 3. continues

AP	0.92	8.8	38.7	52.5	Sandy loam	4.43
Bw1	0.87	18.8	36.2	45.0	Loam	1.93
Bw2	0.93	16.3	31.2	52.5	Sandy loam	1.92
C	0.82	18.2	32.8	49.0	Sandy	3.86
			Meki			
Ap	1.08	13.8	13.2	73.0	Sandy loam	1.00
Bw	0.82	12.5	22.5	65.0	Sandy loam	1.80
C	0.36	4.0	8.8	87.2	Sandy	2.33

Table 4. Selected physical properties of composite surface soils at Adamitulu and Meki, central rift valley of Ethiopia

Adamitulu						
Soil class	Bulk density	Particle size			Textural class	Silt/clay ratio
		Clay	Silt	Sand		
S1	0.89	16.2	36.3	47.5	Loam	2.23
S2	0.86	16.3	36.2	47.5	Loam	2.23
S3	0.9	13.8	46.2	40.0	Loam	3.36
Mean	0.88	15.46	39.64	45	Loam	2.61
			Meki			
S1	1.02	11.0	21.0	67	Sandy loam	1.89
S2	1.05	13.8	18.2	68	Sandy loam	1.36
S3	1.08	13.8	16.2	70.0	Sandy loam	1.18
mean	1.05	12.8	18.2	69.0	Sandy loam	2.33

Selected Soil Chemical Properties of Adamitulu and Meki

Soil Reaction (pH)

The Analytical results showed that the pH of the soil in the profiles increased consistently with depth from 7.6 at the surface horizon (Ap) to 7.9 to the bottom of the horizon (C horizon) at Adamitulu and from 6.4 at the top layer of the profile to 8.1 to the bottom of the profile at Meki (Table 6). According to Tekalign, 1991, the pH ranges from 6.0-6.6 rated as slightly acidic, 6.7-7.3 is rated as neutral and from 7.4-8 is moderately alkaline. Therefore, the pH of composite surface soils of Adamitulu (7.7 to 7.8) was moderately alkaline and that of Meki study site was neutral to slightly alkaline (Table 6).

Soil organic matter

The organic matter content of the surface soil samples at Adamitulu was 1.42% whereas the that of the Meki site was 1.48%. The organic matter content of the profile at Adamitulu decreased consistently with depth ranging from 1.1% at the surface layer (Ap horizon) to 0.03% at the extreme bottom layer (C horizon). According to the OM rating established by Landon (1991), both the profile and the composite surface soil samples had very low OM content. The reasons for the very low content of OM could be intensive cultivation of the land and the total removal of crop residues for animal feed and source of energy. Moreover, there is no practice of organic fertilizers addition, such as animal manure and green manure that would have contributed to the soil OM pool in the study area.

Total nitrogen and organic carbon

The composite surface soil collected from the experimental plots of Adamitulu study site had a mean TN (0.083%) that increased to TN (0.14%) at Meki study site. The TN of the profile at Adamitulu varied from 0.001% at the C2 horizon to 0.09% at the surface (Ap horizon) layer (Table 6). The total N content of the surface layer of the profile (0.09%) and the mean total N content of the composite surface soil samples (0.083%) of the study area are normally rated as very low based on the classification of Landon (1991). However, the relatively higher value of total N (0.09%) corresponds to the layer of the profile having higher value of OM (0.741%) and the lowest amount of total N (0.001%) was recorded in the lower surface layer with the lowest OM content (0.086%). In line with OM contents of the profile, the contents of the total N also decreased consistently with depth suggesting the strong correlation between the two soil parameters. The low total N contents indicates that the soils of the study areas are deficient in N to support proper growth and development of crops, which confirms that the site must be fertilized with external N inputs.

Organic carbon is one of the most important components of crop yield, crop residue and other organic sources such as manure. The mean SOC content of Adamitulu and Meki experimental site were 0.34% and 0.84% respectively. According to the rate set by Tekalign (1991), soil having organic carbon of >3 qualify as high, 1.5-3.0 medium, 0.5-1.5 low and <0.5 as very low. Therefore, the soils of Adamitulu and Meki study sites qualifies to very low OC class (OC <0.5).

The organic carbon content of the soil profile opened at Adamitulu ranges from 0.43 mgkg^{-1}at the top layer of the profile (Ap horizon) to 0.05 mg kg^{-1} at the lower layer of the profile (C horizon). According to the above person, the organic carbon content of the soil through all layers the profile at Adamitulu and Meki study areas were qualified as very low. With similar to the variations in total Nitrogen content, organic carbon also exhibited some degree of variability among soils with soil depth. This implies that total N and organic carbon content of the soils at both locations (Adamitulu and Meki) were comparatively higher in the surface horizons and showed a decreasing trend with soil depth. Similarly, Nega, 2006; reported that average total N decreased with increasing depth from surface to subsurface soils indicating the potential supply of N for crop growth largely lies in the surface horizon. Hence, calls for protection and maintenance of the surface soil to secure sustainable crop production without any external addition of K fertilizers. The reasons for the low OC and total Nitrogen levels observed at the study areas could be the removal of crop residues for animal feed and source of energy. Moreover, the practice of organic fertilizers addition such as manure and/or green manure is at a very low level.

Available phosphorus

The mean available P content of the composite surface soil collected from the experimental plots were 4.34 mg kg^{-1}at Adamitulu and 4.37 mg kg^{-1} at Meki study sites (Table 6). With regard to the levels of Olsen extractable P in the soil, Olsen *et al.* (1954) have indicated that extractable phosphorus below 5 mg kg^{-1} is considered as low; phosphorus between 5 to 10 mg kg^{-1} as medium, and phosphorus greater than 10 mg kg^{-1} as high. Thus, the available P contents, 4.34 ppm at Adamitulu and 4.37 ppm at Meki study sites of the composite surface soils were rated as low. This could be related to the high P fixation power of Andosols in general. According to Lindsay et 1989, in alkaline soils P can precipitate with Ca forming insoluble hydroxyapatite, octacalcium phosphate, and di-calcium phosphate. Therefore, P fertilization to the soils of Adamitulu and Meki experimental sites is very crucial.

Exchangeable bases

Exchangeable Ca followed by Mg was the predominant cation in the exchange sites of both the profile and the composite surface soil colloidal materials at both Adamitulu and Meki study sites (Table 6). The exchangeable Ca decrease with soil depth across the profile. The exchangeable calcium content at the testing profile varied from 38.3 cmol$_c$ kg^{-1} at the top of the surface (Ap horizon) to 20 cmol$_c$ kg^{-1} at the C horizon at Adamitulu and ranged from 28.37 cmolc kg at the upper surface of the horizon (Ap horizon) that decreased to 6.05 at the lower horizon of the profile (C horizon) at Meki. On the other hand, exchangeable Mg has shown a slight change with depth varied from 7.46 cmol$_c$ kg^{-1} at the top (Ap) to 4.41 mgkg^{-1} at the bottom horizon (C horizon) at Adamitulu and a similar trend was observed at Meki study site.

The Ca/Mg ratios, which in most cases were below 10 throughout the profiles, may increase the uptake of Mg and phosphates by crop roots (Landon, 1991). Hence, deficiency of magnesium will not be the case for the study sites. In most of the horizons of the profiles and composite surface soil, the proportions of the cations were in the order of Ca > Mg > K > Na. This might be related to the parent material from which the soils have been developed *i.e.* volcanic ash pumice nature. Calcium accounted for 79 % and Magnesium for 15 % of the exchange site at Adamitulu study site while 64 % of the exchange site was accounted for calcium and 20 % of the exchange site was accounted for Magnesium at Meki testing site. Moreover, Ca to Mg ratio ranging from 5:1 up to 1-meter depth indicates the presence of Ca and Mg in good proportions and it is in optimum range for most crops based on the rating described by Landon (1991).

The cations (calcium and Magnesium) in the exchange site reconfirms that these soils are young and are found in their early stages of development that observed during characterization of the morphological properties of the soils of the profile at both Adamitulu and Meki study sites. On the other hand, the other two cations (Na and K) contributed very small proportion (0.8 to 5%) of the CEC. Nevertheless, according to Landon (1991), the observed exchangeable K value was high for the surface horizon where it generally showed a decreasing trend with depth of the profile. This indicates that the potential supply of K for crop growth largely lies in the surface horizon and hence, calls for protection and maintenance of the surface soil to secure sustainable crop production without any external addition of K fertilizers. The content of exchangeable Na in the soil relative to the CEC was below the critical value and, hence, Na toxicity was unlikely to occur. Yet, the content of exchangeable Na showed an increasing trend with soil depth.

The Exchangeable potassium content of the profile at Meki study site has shown decreasing trend from 1.9 mg kg^{-1} on the upper soil layer (Ap horizon) to 1.7 mg kg^{-1} at medium layer (Bw horizon) and 0.9 mg kg^{-1} at the lower layer (C horizon) of the profile. Soils of Adamitulu study site exchangeable potassium has shown a similar trend which has shown a slight decrease with depth from 1.92 mg kg^{-1} at upper surface of the profile, 1.78 and 1.68 mg kg^{-1} in the middle layers of the profile (Bw1 and Bw2) that changed to 0.6 mg kg^{-1} in the bottom of the layer of the soil (C).

Based on the rate of exchangeable potassium, FAO, 2000, established >1.2 as very high, 0.6-1.2 as high, 0.3-0.6 as medium, 0.2-0.3 as low and <0.2 as very low. Therefore, the soils of Meki and Adamitulu study sites were very high in exchangeable potassium content. The observed exchangeable K and Ca value were high for the sub surface layer of the horizon (Bw) where it generally showed a decreasing trend with depth of the profile at both study sites (Adamitulu and Meki). This shows that the upper surface of the soil is rich in potassium and calcium that do not need external applications of the cations. Magnesium (Mg) has also shown a decreasing trend through all layers of the profile at both study sites except for the bottom of the profile at Adamitulu.

Moreover, the current study investigated that the Exchangeable value for K at Adamitulu testing site even though sufficient for crop production was lower than Meki study site at the surface as well as in the layers of the profile. Therefore, soils of Adamitulu testing site needs more protection and management practices that can improve the exchangeable K on the exchange site of the soil.

Table 5. Selected Soil Chemical Properties of the Soil Profile at Adamitulu and Meki, Central Rift Valley of Ethiopia

Horizon	pH	EC ds m^{-1}	OM %	OC %	TN (%)	Ap Mg kg^{-1}	Exchangeable bases and CEC					
							Na mgkg^{-1}	K Mg kg^{-1}	Mg Cmolc kg^{-1}	Ca Cmolc kg^{-1}	Ca/Mg	CEC ($Cmol_c$ kg^{-1})
Adamitulu												
Ap	7.8	3.43	0.741	0.43	0.09	4.2	0.36	1.92	7.46	38.3	5.1	45.6
Bw1	7.9	2.31	0.362	0.21	0.06	3.4	0.46	1.78	5.53	30.7	5.6	40.43
Bw2	7.8	1.90	0.241	0.14	0.04	2.6	0.47	1.68	4.26	26.0	6.1	34.34
C	7.9	1.95	0.086	0.05	0.001	1.2	0.43	0.6	4.41	20.0	4.5	30.15
Meki												
Ap	6.4	0.91	0.759	0.44	0.14	4.26	0.35	1.7	4.83	22.17	4.83	32.5
Bw	7.0	2.28	0.139	0.08	0.05	3.70	0.37	1.9	3.33	28.3	3.33	33
C	8.1	3.94	0.103	0.06	0.03	2.98	0.44	0.9	2.50	6.05	2.5	16.25

Table 6. Selected Soil Chemical Properties of the Composite Surface soil at Adamitulu and Meki study sites

Soil sample	pH	EC Ds m^{-1}	OC %	OM (%)	TN (%)	Ap Mg kg^{-1})	Exchangeable bases and CEC					
							Na mg kg^{-1}	K mg kg^{-1}	Mg Cmolck g-1	Ca Cmolck g-1	Ca/Mg	CEC ($Cmol_c$ kg^{-1})
Adamitulu												
S 1	7.8	1.90	0.34	0.58	0.081	4.81	0.3	2.3	7	34.7	4.96	42.6
S 2	7.7	4.91	0.24	0.41	0.052	4.45	0.2	1.89	5.4	29.0	5.37	37.9
S 3	7.7	1.27	0.45	0.78	0.116	3.77	0.3	1.66	4.3	27.0	6.28	35.1
Mean	7.7	2.69	0.34	0.59	0.083	4.34	0.26	2.0	5.56	30.23	5.44	38.53
Meki												
S1	7.5	1.37	0.86	1.483	0.153	4.2	0.2	2.23	3.4	10.4	3.06	20.4
S 2	6.7	1.42	0.85	1.465	0.144	5.2	0.3	2.12	4.2	12.6	3.00	19.5
S 3	6.5	1.05	0.83	1.431	0.137	3.7	0.2	1.94	5.4	14	2.59	21.6
Mean	6.9	1.28	0.84	1.448	0.14	4.37	0.23	2.1	4.3	12.33	2.87	20.5

Key: S1= surface 1, S2= surface 2, S3= Surface

Availability of Micro Nutrients in the soils at Adamitulu and Meki Study Sites

Deficiencies of micronutrients emerged as a new problem to crop productivity in Ethiopia. Particularly, deficiencies of Zn and Cu are widespread in different parts of the country (Yifru and Sofia, 2017). According to FAO (2006), zinc with 3-5, Cu 0.8-3, Fe 6-10 and Mn 3.5-6 μg/g soil qualifies for high availability. Hence, the analysis shows that the soils of the study sites are not deficient with the above mentioned micro nutrients. Therefore, no need of external application of the minerals. However, the availability of these minerals was limited to the upper surface of the horizon. Deficiencies may occur in the long run due to the increasing cropping intensity, the use of high-yielding varieties and the more extensive use of nitrogen, phosphorus and potassium fertilizers (Yifru and Sofia, 2017).

Table 7. Selected Soil Status of Micro Nutrients of the Profile at Adamitulu and Meki

Depth (cm)	Horizon	Mn ($mgkg^{-1}$)	Fe ($mgkg^{-1}$)	Cu ($mgkg^{-1}$)	Zn ($mgkg^{-1}$)	Bo (ppm)
Adamitulu						
0-20	Ap	8.8	7.0	0.2	0.8	< 0.004
20-75	Bw1	1.9	2.0	0.1	0.4	< 0.005
75-120	Bw2	1.3	0.19	0.1	0.3	< 0.003
$120\text{-}200^{+}$	C	0.3	0.15	0.2	0.21	< 0.0004
Meki						
0-20	Ap	10.5	7.0	0.25	2.88	0.0004
20-85	Bw	10.8	7.0	0.1	1.02	0.0003
85+	C	6.2	2.0	1.33	2.53	0.0003

CONCLUSIONS AND RECOMMENDATIONS

Soil pits were used to provide characterization of soil profiles for soil morphological, physical and chemical characteristics in two areas of the central rift valley's agricultural soils.. The soils composite surface soils of Adamitulu (7.7 to 7.8) were moderately alkaline and that of Meki was neutral to slightly alkaline. The profiles and the composite surface soil samples of the areas (Meki and Adamitulu) had very low OM, OC, available nitrogen and P content that would limit production of many crops. Hence, there is a need for external application of the above nutrients for both locations. The soil exchange complex was mainly dominated by Ca and Mg where the order of occurrence was Ca > Mg >K > Na. The soils of the study areas are not deficient with micro nutrients like zinc, Cu, Fe and Mn that doesn't need external application of the above soil minerals. However, the availability of these minerals was limited to the upper surface of the horizon. Deficiencies may occur in the long run due to the increasing cropping intensity, the use of high yielding varieties and the more extensive use of nitrogen, phosphorus and potassium fertilizers. The silt to clay ratio of the soil observed in the current study sites, was generally high (greater than 0.15) of the study areas were for both the profile and the composite surface soils suggesting low degree of weathering and the soil is at development stages (young soil).

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