

Analysis of Selected Physicochemical Parameters of Soil Used for Cultivation of Enset (*Ensete Ventricosum*) in West Showa Zone

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DOI: [10.36348/sijcms.2020.v03i01.001](https://doi.org/10.36348/sijcms.2020.v03i01.001)

| Received: 16.01.2020 | Accepted: 23.01.2020 | Published: 30.01.2020

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Abstract

The aim of this study was to investigate the some selected physicochemical parameters in soil samples. The soil characterization was carried out for parameters like moisture content, pH, electrical conductivity, organic carbon and organic matter, cation exchange capacity and exchangeable base (K, Na, Ca and Mg). The results obtained revealed that the physicochemical parameters in the soil samples were in the range of: 10.50-11.25% for moisture content, 6.45-6.66 for pH, 0.63-0.89 dS/m for electrical conductivity, 4.27-8.03% for organic carbon, 7.34-13.86 % for organic matter, 33.54-48.45 cmol/kg for cation exchange capacity, exchangeable base (0.77-0.86 cmol/kg for Na, 2.63-3.01 cmol/kg for K, 10.25-10.89 cmol/kg for Ca and 0.52-1.40 cmol/kg for Mg). pH was found to slightly acidic and good for maximum availability of the primary nutrients required for plant growth. The values of electrical conductivity indicated that all samples of the soil are good in soil. Statistical test of significance using ANOVA revealed that there were significant differences ($P > 0.05$) between the values of physicochemical parameters in the soil samples obtained from three sampling sites except exchangeable base. Correlation analysis was also employed to examine the relationship between the various parameters in the soil samples.

Keywords: Analysis, Ensete Vectricosum, Exchangeable base, Physiochemical, Soil.

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INTRODUCTION

Soil is one of the important, valuable resources of the nature and composed of particles of broken rock that have been altered by chemical and mechanical processes include weathering and erosion Sumithra *et al.* [1] and also the most significant ecological factors, which plants depend for their nutrients, water and mineral supply Shaikh and Bhosle [2]. All living things are directly (indirectly) dependent on soil for day to day needs and 95 % of the human food is derived from the earth. Soil has complex function which is beneficial to human and other living organism. It acts as a filter, buffer storage, and transformation system and thus protects the global ecosystem against the adverse effects of environmental pollutants Sumithra *et al.* [1]. Soil testing is the only way to determine the available nutrient status in soil and can develop specific fertilizer recommendations. Results of physical and chemical tests provide information about the capacity of soil to supply mineral nutrients Ganorkar *et al.* [3]. Soil characterization in relation to evaluation of fertility status of the soils of an area or region is an important aspect in context of sustainable agricultural production.

Nitrogen, phosphorous, potassium and sulphur are important soil elements that control its fertility and yields of crop Singh and Mishra [4]. The productivity of agricultural soil depends largely on its physicochemical properties and soil condition. Because of it is a universal medium for plant growth, which supplies essential nutrients to the plants. So it is essential to analyze the physicochemical characteristics of soil.

Organic matter is useful in supplying nutrients and water to the plants and also provides good physical condition to the plants Sertsu and Bekele [5]. Cation exchange capacity usually expressed in milliequivalents per 100g of soil is a measure of the quality of readily exchangeable cation neutralizing negative charge in the soil. Cation exchange capacity is a very important parameter of soil because it gives an indication of the type of clay mineral present in soil and its capacity to retain nutrient against leaching. It is determined by measuring the total amount of a given cation needed to replace all the cation from a soil exchange site and it expressed in cmol (+) kg^{-1} Sanledhin and Taye [6]. Electrical conductivity expresses ion contents of solution which determine the current carrying capacity

thus giving a clear idea of the soluble salts present in the soil [6]. Soil pH is important because it influences nutrient availability, solubility of toxic ions and microbial activity. The maximum availability of the primary nutrients required for plant growth is greatest at a pH value between 6.5 and 7.5 Sanledhin and Taye [6].

Potassium is a very soluble cation in solution, yet its mobility in soil is very slow. The potassium ions, on being absorbed by the colloids displaces other ions such as Ca, Mg or Na. Soils ability to absorb and hold potassium is great importance as it serves to decrease leaching and provides more continuous supply of available potassium Sumithra *et al.* [1]. Magnesium is a water-soluble cation and it is necessary for chlorophyll pigment in green plants. Calcium in soil results from passage through deposit of lime stones, gypsum etc. It plays a pre-dominant role in the composition of cell wall, protoplasm and is required for cells to divide and flowers to form Mahajan and Billore [7].

Chaudhari [8] reported that Soil physicochemical parameters are important to agricultural chemists for plants growth and soil management. So, the study area of soil sample was

analyzed for some physicochemical parameters like moisture content, pH, electrical conductivity, organic carbon, organic matter and cation exchange capacity and exchangeable base (K, Na, Mg and Ca) status in soil.

The information on the physicochemical parameters of soil that grown Enset on the study areas are scarce. Therefore, the aim of the this study was analyzed the selected some physicochemical parameters of soil used for cultivation of Enset in West Showa Zone, Oromia Regional State, Ethiopia and to correlate nutrient contents of the soils with other soil properties.

MATERIALS AND METHODS

The Study Areas

The study was conducted in selected three different agricultural sites from West Showa Zone, Oromia Regional State, Ethiopia namely: Dire Enchini, Jeldu and Jibat. The study areas were located in between 120-184 km West of Addis Ababa on the main way from Addis to Nekemte road, the capital city of Ethiopia.

Table-1: Geographical location and Distance from Ambo and Addis Ababa of sampling sites

Sample sites	Distance from Ambo(km)	Distance from Addis (km)	Altitude range (masl)	Latitude range (N)	Longitude range(E)
Dire Enchine	40	154	2505-2634	8°1-8°46'	37°35'-37°38'
Jeldu	72	120	2500-3200	9°02'47"-9°15'	38°05'-38°12'16"
Jibat	70	184	2000-3000	8°35'-8°50'	37°15'-37°35'

Sample Collection and Protocol

Surface soil samples were collected at a depth of 0–25cm using spade from three districts that used for cultivation of *Ensete ventricosum* in January, 2016. From each three district, four kebeles were taken for the purpose of sampling. Four soil samples were collected from the four kebeles and each stated areas were transferred in to the clean polyethylene bags and transported to Ambo University laboratory.

Sample Preparation

The each soil sample was air dried for three days and pooled together equal proportion to obtain a composite sample. After composite samples were grinded with clean porcelain mortar and pestle and passed through a 2.0mm sieve. The soil samples were kept in polythene packets for further analysis.

Moisture Content

Soil moisture content was determined oven drying method by Jackson (1967) described by Chaudhari [8]. 5 g air dried soil samples were weighed with analytical electronic balance to record the initial weight. The samples were dried in oven at 105°C for two days (48 hr) and again weighted. Finally, the

percentage of moisture content in each of the soil samples was calculated by Joel and Amajuoyi [9].

$$MC(\%) = \frac{\text{Loss of mass (g)}}{\text{mass of after oven dried(g)}} \times 100$$

The corresponding moisture correction factor (Mcf) for analytical results or the multiplication factor for the amount of sample to be weighed for analysis was calculated using FAO, 2008.

Method.

$$MCF = \frac{100 + \% \text{ moisture}}{100}$$

pH of Soil Sample

The pH of the soil samples was measured in water suspension as described by Sanledhin and Taye, 2000. 10 g of air-dried soil sample was weighed and transferred into nine 100 mL beakers and 50 mL of distilled water was added and the soil–water slurry in the ratio 1:5 was prepared and the soil was allowed to settle down, then the pH meter was calibrated with a buffer solution of pH 4.0, 7.0 and 9.0 using FAO, 2008 method. Finally the pH meter (Elmentro CPI-501, Poland) was placed into the prepared slurry and the pH was read and recorded.

Electrical Conductivity of Soil Sample

The EC of the soil sample was determined as described by Sanledhin and Taye [6]. 10 g air dried soil sample was taken in nine beakers, and to this 50 mL of distilled water was added to make ratio of 1:5. The mixtures were stirred with glass rod for 30min, and were allowed to stand for 1hr without any disturbances. The soil was allowed to settle down and the EC value was measured inserting electrical conductivity meter (ELMEIRON, EC-60, Germany) into the supernatant solution read and recorded data.

Organic Carbon and Matter of Soil

The organic carbon and organic matter content of the soil sample was determined by the method of Walkey and Black [10] described by Wodajo and Alemayehu [11]. 1g of air dried soil sample pass through 2 mm sieve without loss was taken into nine 500mL Erlenmeyer flask, to which 10 mL of 1 N $K_2Cr_2O_7$ and 20 mL Conc. H_2SO_4 were added with measuring cylinder. The content was shaken for a 30 min. Then, 200 mL distilled water, 10mL ortho phosphoric acid and 1mL diphenylamine indicator was added and the solution was titrated against 0.5 N ferrous ammonium sulfate till the color flashed from blue-violet to green. The blank titration was carried at the beginning without soil. The results were calculated by the formulas:

$$OC (\%) = \frac{N \times (V_B - V_S)}{S} \times 0.39 \times mcf$$
 Where, N= Normality of ferrous sulphate, V_B = Volume of 0.5 N ferrous sulphate required to neutralize 10 mL 1 N $K_2Cr_2O_7$ (i.e. blank reading in mL), V_S =Volume of 0.5N ferrous sulphate needed for titration of soil sample (mL), S=weight of air-dry sample (g), $0.39=3 \times 10^{-3} \times 100 \times 1.31$ (3 is the equivalent weight of carbon). It is assumed that only 76% of the organic matter is oxidized and a fraction of $100/76=1.31$

$OM(\%) = OrganicCarbon \times 1.724$ 1.724 Average content of carbon in soil organic matter is equal to 58%.

Cation Exchange Capacity of Soil Sample

Cation exchange capacity was determined by the method described by [6]. 5g of soil was taken in volumetric flask. 100mL of 1N of ammonium acetate solution with pH=7.0 were added into volumetric flask. Stirred with rod for 30 min and allow standing overnight. The next day soaked sample was filter into 250mL volumetric flask and washed the remaining soil with 50 mL of 1N of ammonium acetate pH 7.0 into the funnels. Three each with 25 mL of aliquot of 1N of ammonium acetate to a volume of 200mL and bring up to volume with distilled water. The soil on the filter paper was washed with ethanol (97%) under filter funnel of 250 mL plastic bottle by many times until the yellow color disappear when checked with some drop of Neassler reagent. The saturate soil sample was washed with 10% of 20 mL of NaCl collected on the filter paper in 250 mL plastic bottle after that the distilled apparatus was arranged & distilled with 0.2N

of H_2SO_4 about 75mL. Finally the distilled solution was titrated with 0.1N of NaOH and the cation exchange capacity was calculated by:

$$CEC(cmolk g^{-1}) = \frac{(V_B - V_S) \times N \times 100 \times mcf}{S}$$

Where, V_S is 0.1 N of NaOH required for titration of sample, V_B is 0.1N of NaOH required for titration of blank, S is air dry sample weight, N is normality of NaOH and mcf is moisture correction factor.

Determination of Exchangeable Base of Sodium and Potassium in Soil Sample

The available of sodium and potassium in soil were determined by the method described by [6]. 250 mL of the ammonium acetate soil extract obtaining from cation exchange capacity and exchangeable bases extraction was taken to Instrument room. Flame atomic emission spectroscopy (FAES) was calibrated with concentration of 5, 25, 50, 75, and $100mgL^{-1}$ standard of potassium and Sodium from prepared stock solution. After that the blank (ammonium acetate) and sample analysis. Finally the concentration of sodium and potassium were calculated by:

$$Kand Na cmolk g^{-1} = \frac{(V_S - V_B) \times V \times mcf}{10 \times M \times W}$$

Where, V_S is concentration of Na or K in sample (mgL^{-1}), V_B is concentration of K or Na in blank (ammonium acetate) (mgL^{-1}), V is total volume of ammonium leached (250mL), M is mass of airy dried soil (5 g) and W is atomic weights of Na or K.

Determination of Exchangeable Base of Calcium and Magnesium in Soil Sample

The available of calcium and magnesium in soil was determined by the method described by [6]. 10 mL of the ammonium acetate soil extract obtaining from cation exchange capacity and exchangeable bases extraction was taken into a 250 mL Erlenmeyer flask and added 40 mL of distilled water to bring the volume up to 50mL. 3 drop of methyl orange and 1N HCl was added until the color turn to orange. The ammonium acetate soil extract was boiled for 3 min and allow the solution to cool $60^\circ C$. 2 mL of KCN solution and 7mL of buffer solution were added to bring up to about pH 10. Finally, titrate with 0.1N EDTA disodium salt to a pure blue without any trace of red. For determination of available of calcium similar the above procedure except in steady of buffer 1N of NaOH was added to bring up to about pH=10 and calcium and magnesium value were determined by the formula Sanledhin and Taye, [6].

$$(Mg, Ca)^{2+} \left(\frac{meq}{100g} \right) = \frac{N \times V \times T \times 100 \times mcf}{A \times S}$$

$$Ca^{2+} \left(\frac{meq}{100g} \right) = \frac{N \times V \times T \times 100 \times mcf}{A \times S}$$

$$Mg^{2+} = (Mg, Ca)^{2+} - Ca^{2+}$$

Where, N is normality of EDTA, V is volume of EDTA required for sample, T is total volume of extract (250mL), A is sample taken for titration (10mL), and S is air dry weight of sample, Mcf is moisture correction factor.

STATISTICAL ANALYSIS

In this study, analysis of variance (ANOVA) and the student F-test at $p < 0.05$ are used to examine statically significant differences in the mean concentrations of metals among groups of soil. A probability level of $p < 0.05$ is considered statistically significant. All statistical analysis was done by Microsoft Office Excel 2007 was used for data analysis and SPSS Version 16.0 Software Window was used for ANOVA and correlation between physicochemical parameters in samples.

RESULTS AND DISCUSSION

Moisture Contents

As showed that (Table 2) the three soil samples were ranged 10.50 to 11.25%. Soil samples collected from Dire Enchini site has relatively highest moisture content than the other studied sites. Therefore, the air dried soil sample from three districts within the same range with the one reported by [10], which was 7.35 to 11.01%. Statistical test of significance using ANOVA revealed no significantly difference ($P < 0.05$, at 95% CI) between the value of moisture contents in soil samples obtained from Jibat and Jeldu sites.

Electrical Conductivity of Soil Sample

The Soil Electrical conductivity values in the three areas (districts) were ranged from 0.632 to 0.899 dSm^{-1} (Table 2). The Electrical conductivity of Dire Enchini soil is highest as compared to the other sites. Horneck *et al.* [16]. reported that soil EC content of 0 to 1.0 dSm^{-1} is good in soil, 1.0 to 2.0 dSm^{-1} is poor seed emergence 2.0 to 4.0 dSm^{-1} harm to some crops and $>4.0 \text{ dSm}^{-1}$ is harmful to most of crops. Therefore, based on this classification the soil under analysis of EC in this study was found good in soil. The difference in the electrical conductivity values could be attributed to differences in the soluble salt content of the soils. Statistical test of significance using ANOVA revealed significant differences ($P < 0.05$, at 95% CI) between the values of Electrical Conductivity in the soil samples obtained from the three sites.

pH of Soil Sample (H_2O)

From the three replicate measurements of 1:5 soil-water slurry the soil pH values in the three areas (districts) ranges from 6.5 to 6.7 (Table 2), which was found within the permissible limits 4.0-8.5 set by WHO [12]. The lowest pH observed was in Dire Enchini soil sample and the highest pH in Jeldu soil sample. The soils studied from the farm Lands were slightly acidic FAO. [12]. Isirimah, *et al.* [13]. reported that the maximum availability of the primary nutrients required for plants growth is greatest at a pH value between 6.5

and 7.5 Therefore; the pH values of the soil samples analysis in this presented study will enhance plant growth and possible increase soil nutrient. The soil pH from the three districts almost similar soil pH with the one reported by Wodajo and Alemayehu [11], which was 6.53 to 7.64. Odoemelam, and Ajunwa [14], studies have shown that the application of biosolids such as animal manure and compost on acid soils increases the soil pH appreciably. Statistical test of significance using ANOVA revealed significant differences ($P < 0.05$, at 95% CI) between the values of pH in the soil samples obtained from the three sites.

Organic Carbon and Organic Matter

As it can be observed that (Table 2) the organic carbon (OC) was ranged from 4.256 to 8.027%, while the organic matter (OM) ranged from 7.337 to 13.863%. Odoemelam, and Ajunwa [14] reported that soil OM content of $<2.0 \%$ as low; 2.1- 3.0% as medium and $>3.1\%$ as high. The following of this classification the agricultural soil investigated as high Organic matter for three districts soil samples. Therefore, when compared with the values of organic carbon and matter of soil samples in this study which is greater than with the one reported by Wodajo and Alemayehu [11], which was 2.16 to 3.44% and 2.16 to 5.93% respectively. Because, the higher levels of organic matter present could be attributed to the application of animal manure Reeuwijk 2002. Statistical test of significance using ANOVA revealed significant differences ($P < 0.05$, at 95% CI) between the values of organic carbon and organic matter in the soil samples obtained from the three sites.

Cation Exchange Capacity of Soil Sample

As it can be observed from (Table 2) the cation exchange values of the studied area soils ranged from 33.536 to 48.445 cmolkg^{-1} . The lowest CEC was observed in Jeldu soil and the highest was in Dire Enchini soil. Because of organic matter colloids have large quantities of negative charges and Humus, the end product of decomposed organic matter, has the highest CEC value Reeuwijk [15]. When compared the values of CEC in this study within the same range the one reported by Sanledhin and Taye [6], which lied between 30 to 41 cmolkg^{-1} . Statistical test of significance using ANOVA revealed there was significant differences ($P < 0.05$, at 95% of CI) between the values of CEC in the soil samples obtained from the three sites.

Analysis of Exchangeable Base of Sodium and Potassium in Soil

The available of sodium and potassium in soil sample values of the studied areas were ranged from 0.76 to 0.86 cmol (+) kg^{-1} and 2.49 to 2.86 cmol (+) kg^{-1} respectively The lowest Na^+ is observed in Jibat soil and the highest is in Dire Enchini soil and the lowest K^+ is observed in Jeldu soil and the highest is Dire Enchini (Table 2). The values Na and K from the three districts almost similar values with the one reported by

[15], which was 0.17 to 0.26cmolkg⁻¹ and 1.13 to 2.35cmolkg⁻¹ respectively. Horneck, *etal.* [16], reported soil K content of < 0.4 cmol(+)⁻¹kg as low; 0.4 to 0.6 cmol(+)⁻¹kg as medium; 06 to 2 cmol(+)⁻¹kg as high and > 2cmol(+)⁻¹kg as excessive K. Following this classification the soil from the studied areas are investigated as excessive. Statistical test of significance using ANOVA revealed that there was no significant differences (P>0.05, at 95 %, CI) between the values of available of sodium and potassium in the soil samples obtained from the three areas.

Analysis of Exchangeable Base of Calcium and Magnesium in Soil

The available of calcium and magnesium in soil sample values of the studied areas ranged from

10.247 to 10.89 cmolkg⁻¹ and 2.13 to 2.29 cmol (+) kg⁻¹ respectively. The lowest Ca²⁺ was observed in Jibat soil and the highest was in Jeldu soil and the lowest Mg²⁺ was observed in Dire Enchini and the highest in Jeldu (Table 5). The available Ca and Mg, from the studied areas have almost the same values with the one reported by Amos, *et al.* [17], which were ranges from 8.0 to 13.2cmolkg⁻¹ and 4.40 to 5.72cmolkg⁻¹ respectively Horneck, *et al.* [16], reported soil Mg²⁺ content of <0.5 cmol(+)⁻¹kg as low; 0.5 to 2.5 cmol(+)⁻¹kg as medium and >2.5 cmol(+)⁻¹kg as high. Based on this classification the soils from the studied areas are investigated as medium Mg²⁺. Statistical test of significance using ANOVA revealed that there was no significant differences (P >0.05, at 95% CI) between the values of available of calcium in soil in the soil samples obtained from the three areas.

Table-2: Results of physicochemical parameters of the soils (mean ± SD, n = 3)

Parameters	Sample Sites(Districts)			permissible level
	Dire Enchini	Jeldu	Jibat	
MC%	11.250±0.371	10.501±0.309	10.563±0.379	NA
pH(H ₂ O)	6.453±0.023	6.660±0.086	6.590±0.091	4.0-8.5 ^a
EC (dSm ⁻¹)	0.899±0.022	0.747±0.044	0.632±0.049	2-4dSm ^{-1b}
OC (%)	8.027±0.025	4.256±0.047	5.450±0.132	NA
OM (%)	13.863±0.043	7.337±0.082	9.483±0.141	NA
CEC (cmolkg ⁻¹)	48.445±0.445	33.536±0.121	37.536±0.121	NA
Na cmol(+) ⁻¹ kg	0.861±0.027	0.809±0.013	0.765±0.013	0.6-1.2 cmolkg ^{-1b}
K cmol(+) ⁻¹ kg	3.005±0.024	2.629±0.007	2.717±0.007	0.7-1. 2 cmolkg ^{-1b}
Ca cmol(2+) ⁻¹ kg	10.736±0.324	10.890±0.29 ^a	10.247±0. 27	10-20 cmolkg ^{-1b}
Mg cmol(2+) ⁻¹ kg	0.523±0.057	1.403± 0.303	0.526±0.013	3-8 cmolkg ^{-1b}

^a source: WHO, 2008; ^b source: Holland et al.; (1989) described by Offiong et al.,2013. NA is not available.

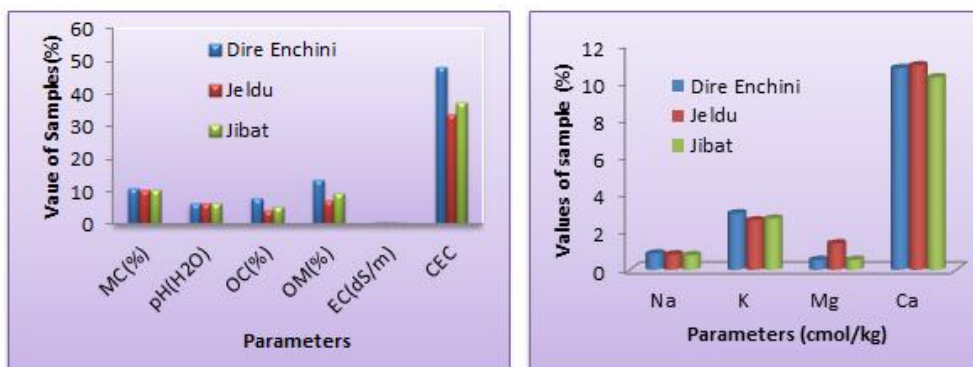


Fig-1: Physicochemical parameters of soil from the three sites (n= 3)

Table-3: Comparison of physicochemical parameters was determined in this study and other literature

Parameters	The result of this study	Physicochemical parameters reported by other literature
MC%	10.50 - 11.25	7.35-11.01 ^a
pH(H ₂ O)	6.45-6.66	6.53-7.64 ^a
EC (dSm ⁻¹)	0.63-0.89	0.09-0.34 ^a
OC (%)	4.25-8.03	1.25-3.44 ^a
OM (%)	7.34-13.86	2.16-5.93 ^a
CEC (cmolkg ⁻¹)	33.54-48.44	30.75-41.83 ^a
Na cmol(+) ⁻¹ kg	0.76-.86	0.17-0.26 ^b
K cmol(+) ⁻¹ kg	2.63-3.00	1.13-2.35 ^b
Ca cmol(2+) ⁻¹ kg	10.25-10.89	8.0-13.13.2 ^b
Mg cmol(2+) ⁻¹ kg	0.52-1.40	4.40-5.72 ^b

CORRELATION ANALYSIS

The relationships between the different physicochemical parameters were analyzed by Pearson's correlation coefficient the high correlation coefficient near +1 or -1 is a good relation between two variables and around zero no relation between them. Rakesh, and Raju [18], reported that if $> \pm 0.7$ strongly

correlation and r value between ± 0.5 to ± 0.7 moderated correlation between two different parameters.

As it can be seen in Table 3 strong positive correlation were observed for the parameters between MC with (EC, OC, OM, CEC, Na abs K), EC with (OC, OM, Na and K), OC with

Table-4: Pearson's correlation coefficients between soil physicochemical parameters

	MC	CE	pH	OC	OM	CEC	Na	K	Mg	Ca
MC	1									
CE	0.869	1								
pH	-0.965	-0.709	1							
OC	0.971	0.726	1.000**	1						
OM	0.968	0.716	-1.000**	1.000**	1					
CEC	0.982	0.761	-0.997*	0.999*	0.998	1				
Na	0.852	0.999*	-0.686	0.704	0.694	0.740	1			
K	0.989*	0.784	-0.994*	0.996*	0.995*	0.999*	0.764	1		
Mg	0.216	0.671	0.047	-0.023	-0.036	0.030	0.694	0.066	1	
Ca	-0.560	-0.083	0.761	-0.746	-0.755	-0.709	-0.051	-0.683	0.683	1

(OM, CEC, Na and K), OM with CEC and K, CEC with (Na and K) and Ca with Mg,

This strong positive correlation shows that the parameters are closely associated. Moderate positive correlations were observed between EC with (Ca), pH with (OC, OM and Na), Mg with Ca, Whereas a strong negative correlation were found between pH with OC, OM, CEC and K) EC with (pH), OM with Ca. There was also moderately negative correlation between K with (Ca) and pH with Na. The other correlations were weak.

*Correlation is significant at the level of 0.05 levels (1-tailed)

** Correlation is significant at the level of 0.01 levels (1-tailed).

CONCLUSION

This work has revealed that the physicochemical parameter of soil used for cultivation of Enset (*Ensete ventricosum*) in West Showa Zone, Oromia Regional State, Ethiopia was analyzed. The results were indicated that the soil pH is slightly acid and good for maximum availability of the primary nutrients required for plant growth. Electrical conductivity value of soil was good in soil. Soil samples have an appreciable organic carbon and organic matter as well as a cation exchangeable capacity. It is deduced that the physicochemical analysis of soil samples under study areas shows different value at different sites. In future, further study should be done to investigate the other physicochemical parameters of the soils in the study area and other sites. Results of analysis of variance (ANOVA) showed that variation between physicochemical parameters were statistically significant ($p < 0.05$).

ACKNOWLEDGEMENT

The authors would like thank to the Nono Woreda Educational office for sponsoring his study and the Department of Chemistry, Ambo University, Ethiopia, for providing the laboratory facilities and the necessary support.

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