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Physicochemical Characteristics of Soils Used for Cultivation of Garlic (*Allium sativum* L.) in Ambo District, Ethiopia

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Abstract

This study was undertaken to investigate the physicochemical characteristics of Ambo District soils collected from four Kebeles (Awaro Qora, Gosu Qora, Qibafkube and Elamu Goromti), Ethiopia. The soil was analyzed for the parameters like soil pH, electrical conductivity, (EC), moisture content (MC), total dissolved solid (TDS), cation exchange capacity (CEC), organic carbon (OC), organic matter (OM), available nitrogen, available phosphorous, and available potassium. K and CEC values were analyzed using flame photometer, available phosphorous was analyzed using ultraviolet-visible spectrophotometer while conventional analytical methods were employed for the determination of the rest of the physicochemical parameters. During the course of study fluctuation in the various parameters were recorded. The results obtained revealed that the concentrations of physicochemical parameters in the soil samples were: MC (19.31–28.25%), pH (5.68–7.63), EC(0.11–0.27 mS/cm), TDS (72.7–172 mg/L), OC (1.61–2.84%), OM (2.78–4.89%), CEC (36.28–65.73 cmol$_{(+)}$/kg), available N (0.012–0.020%), available P (14.01–26.14 kg/ha), and available K (116.59–345.19 kg/ha). Statistical test of significance using ANOVA revealed that there were significant differences ($p < 0.05$) between the values of moisture content, TDS, CEC and available nutrients (N, P and K) in the soil samples obtained from all the sampling sites. This variation of values observed in the different parameters is due to the soil quality in different places. The soil studied can be considered as good sources of available nutrients and this information will help farmers to solve the problems related to soil nutrients, the type and amount of fertilizers to be used to increase the yield of crops.

Keywords: Physicochemical characteristics, Soil, Garlic, Flame photometer, Ultraviolet-visible spectrophotometer.

Introduction

Soil as a general term usually denotes the unconsolidated thin, variable layer of mineral and organic material that is biologically active and covers the earth surface. Soil has been described as a mixture of minerals, organic matter gases, liquids and amyriad of micro and macro organisms that support plant life. It is the basic life support components of biosphere (Borkar, 2015).

Soil as a component of the terrestrial ecosystem fulfills many functions including those that are essential for sustaining plant growth. Some of the function includes partitioning of applied water into drainage and runoff, and storage of the plant - available water. Supply of adequate oxygen to roots, provision of favourable conditions for seedling establishment, store of nutrients that are essential for plant growth. These functions constitute the criteria against which soil quality is assessed (Ahamed *et al*., 2015).

For optimum plant growth the nutrient elements and water in the soil must be available in adequate amounts and suitable proportion, a term that is widely referred to as "soil fertility". To evaluate the soil fertility status of soil, there is a need to determine its physical, chemical and biological characteristics (Rajesh *et al*., 2015).

Soil properties play a major role in assessing nutritional status of agricultural lands for cultivation of different crops with different cropping patterns (Sharma and Rani, 2013). The soil characteristics mainly depend on various factors such as, climatic conditions, land forms, and total ionic contents (nutrients) in the soil (Granados, 2006; Divya and Belagali, 2015). Among the various parameters, total ionic content of soil has greater influence on soil geochemistry and distribution of vegetation of a particular place. The continuous application of nutrients in the form of chemical fertilizers helps to improve the nutritional status of deficient soils (Dubey*et al*., 2012; Divya and Belagali, 2015). The monitoring of soil characteristics is essential in order to know the information about the nutritional status of soil during cropping season and harvesting period, which helps to manage soil health as well as production of crops. Since there are disadvantages associated with use of chemical fertilizers, the complete soil analysis during and after harvesting the crops help for the complete soil fertility management for increasing the crop yield as a part of soil fertility management (Dubey*et al*., 2012; Divya and Belagali, 2015).

Soil test based nutrient management has emerged as a key issue in an effort to increase agricultural productivity and production since optimal use of nutrients based on soil analysis can improve crop productivity and minimize wastage of these nutrients, thus minimizing impact on environment, leading to improvement of optimal production (Patel*et al*., 2014). Soil parameters play a key role in the management of plant nutrition and optimal supply of nutrients depends on their optimization. The pH is a synthesizing factor in soil fertility due to its influence on the assimilation of soil nutrients by plants. In fact, the absorption of minerals such as phosphorus, potassium and nitrogen by the plant becomes more difficult as the pH decreases. Land use has been reported to affects the physicochemical properties of soils (Moussa *et al*., 2015).

Ethiopia has several regions in which garlic is grown in bulk quantities under small scale farmers sectors. These regions among others include Ambo, Debre Werk, Adet, and Sinana among others (Worku and Dejene, 2012). Ambo district is well known for the growing of garlic. Garlic (*Allium sativum* L.) is the most widely used bulb crop next to onion in Ethiopia. It contributes significant nutritional value to the human diet. Garlic has been used throughout recorded history for both culinary and medicinal purposes (Wodaje and Alemayehu, 2014). The soil condition under which the crop is grown is important because it is a universal medium for plant growth, which supplies essential nutrients to the plants. In Ethiopia now a day, large number of fertilizers are used instead of manures due to this the crop productivity increases speedily but the quality of the soil is decreased due to inappropriate applications. So it is essential to analyze the physicochemical characteristics of soil because as with the increasing use of chemical fertilizer to the soil, it is difficult to control the adverse effect of the chemicals fertilizer to the soil, plants, animals and human beings. The information on the physicochemical characteristics of soil on the study area is scarce. Therefore, this study was under taken to determine the physicochemical characteristics of soils used for cultivation of garlic in Ambo District.

Materials and Methods

Description of the study area

This study was carried out in 4 Kebeles (Awaro Qora, Gosu Qora, Qibafkube and Elamu Goromti) in Ambo District, West Shoa Zone, which is about 112 km West of Addis Ababa, the capital city of Ethiopia. Ambo district is located between latitude 8°59'N and longitude 37°51'E with an elevation of 2101 meters above sea level, The temperature ranges from 15°C-29°C with average temperature of 22°C and the mean annual rain fall of 1300 to 1700 mm (Figure 1) (Wodaje and Alemayehu 2016).

Soil sample collection and preparation

Soil samples were collected from garlic agricultural fields in the month of February, 2015. Five sub-sites were taken randomly from each of the four main sites. From a particular sub-site, five sub-soil samples were collected from the immediate vicinity of the garlic bulb roots at a depth of 0–20 cm using soil auger. The collected sub-samples were then pooled together to form a composite sample that represents each sampling site. Finally, the four soil bulk samples one from each stated areas were collected in polyethylene bags, labeled and transported to the laboratory for further processing.

The soil samples were air-dried at room temperature in the laboratory. The dried soil samples were ground with porcelain mortar and pestle and then sieved through a 2.0 mm mesh sieve, for analyzing soil pH, EC, TDS and CEC.

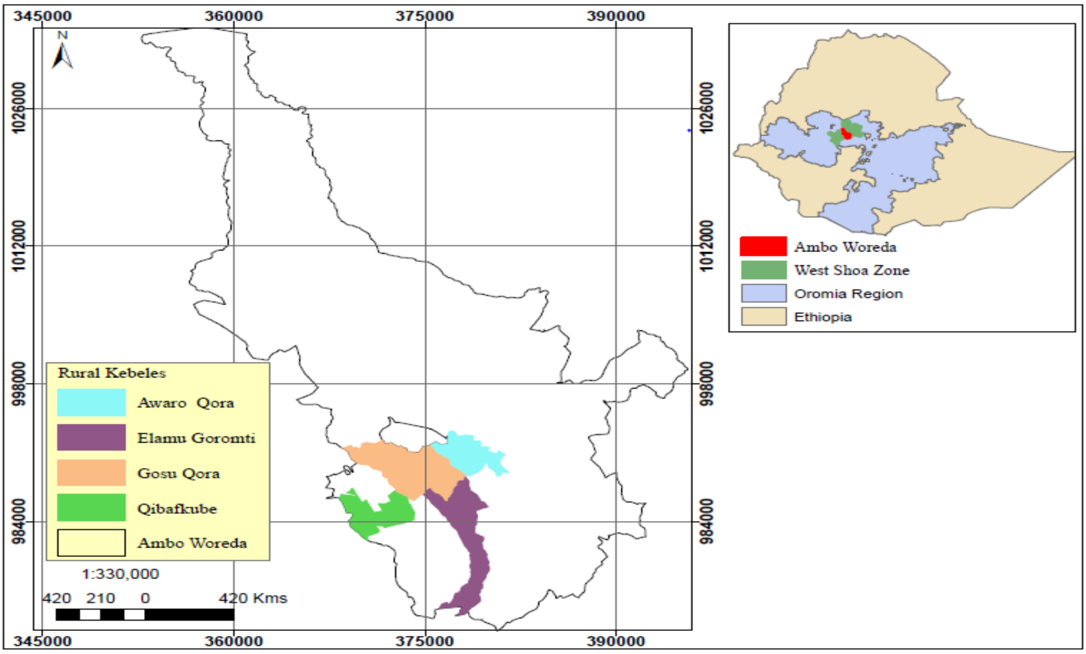

Fig 1. Map of the study area

Some portion of the individual sieved soil samples were further pulverized to a fine powder and passed through a 0.5 mm sieve for analyzing organic carbon, organic matter, available nutrients. The samples were stored in plastic containers in refrigerator at 4 °C until analysis.

Physicochemical analysis of soil samples

Soil samples were analyzed for the following physicochemical characteristics: pH, moisture content, electrical conductivity, total dissolved solid, cation exchange capacity, organic carbon, organic matter, available nitrogen, phosphorous and potassium.

Moisture content

Soil moisture content was determined by oven drying method (Jackson, 1967). 10 g of composite soil sample was taken. The sample was oven dried at 105 °C for 24 hrs. Dry weight of the sample was taken till a constant weight was attained. The loss in weight corresponds to the amount of water present in the soil sample. The percentage of moisture content in each of the soil samples were calculated according to equation (1).

$$\text{Moisture (\%)} = \frac{\text{Loss in weight on drying (g)}}{\text{Initial sample weight (g)}} \times 100 \quad (1)$$

The moisture correction factor (mcf) for analytical results was calculated using the formular as indicated in equation 2.

$$\text{Moisture correction factor (mcf)} = \frac{100 + \%\ \text{moisture}}{100} \quad (2)$$

Soil pH, Electrical conductivity and Total dissolved solids (TDS)

The soil pH is a measure of hydrogen ion activity in the soil solution, and expresses the acidity and alkalinity of the soil. The pH of the soil was determined in 1:2.5 soil: water suspension. Air dried soil of 20 g was taken in a beaker, and to this 50 ml of water was added. The mixture was stirred with glass rod for 10 minutes, and was allowed to stand for 30 minutes. The pH was measured using electronic digital pH meter (Model: Elmetron CPI-501, Poland). The pH meter was calibrated by using 4.01, 7.01, 9.22 buffer solutions. The Electrical conductivity (EC) of same soil sample used prepared for pH determination was determined by digital electronic conductivity meter (Model: SCHOTT handylab LF11, Germany). The total dissolved solid (TDS) of the prepared soil was determined with the help of a Conductivity/TDS/ salinity meter (Model: (SCHOTT handylab LF11, Germany)). The device was calibrated with 0.01 M KCl before the determination procedure was carried out.

Organic carbon and organic matter

The organic carbon content of the soil was estimated by the following the method of Walkey and Black (1947). 1 g of finely ground soil sample was passed through 0.5 mm mesh size sieve without loss was put in to a 500 ml conical flask, to which 10 ml of 1 N $K_2Cr_2O_7$ and 20 ml concentrated H_2SO_4 was added and the contents shaken for a minute and allowed to stand for 30 minutes. Then 200 ml distilled water, 10 ml ortho phosphoric acid and 1 ml diphenylamine indicator were added. The solution was titrated with 0.5 N ferrous ammonium sulfate till the color flashed from blue-violet to green. The blank titration was carried out at the beginning without any soil sample. The OC and OM of the sample were calculated using equation (3) and equation (4) respectively.

$$\text{Organic carbon \%} = \text{N x} \frac{(V_1 - V_2)}{S} \text{ x 0.39 x mcf} \quad (3)$$

Where: N = Normality of ferrous ammonium sulfate (FAS); V_1= Volume of 0.5 N FAS required to neutralize 10 ml of 1 *N* $K_2Cr_2O_7$ i.e. blank reading (ml); V_2 = Volume of 0.5 N FAS needed for titration of soil sample (ml); S = Weight of air-dry sample (g) 0.39 = 0.003 x 100 % x 1.3 (0.003 is the milliequivalent weight of carbon in g). It is assumed that only 77% of the organic matter is oxidized and a fraction of 100/77 = 1.3

$$\text{Organic matter (\%)} = \text{Organic carbon (\%) x 1.724} \quad (4)$$

Where: 1.724 = Van Bemmelen factor = average content of carbon in soil organic matter is 58%.

Cation exchange capacity

Cation exchange capacity (CEC), usually expressed in milliequivalents per 100 g of soil, is a measure of the quantity of readily exchangeable cations neutralizing negative charge in the soil. CEC was determined by the method described by Raman and Sathiyanarayanan (2009). 1.3 g of soil was taken in the centrifuge tube; 11 ml of 1 N sodium acetate solution was added and shaken well then centrifuged. The supernatant liquid was decanted and 11 ml of isopropyl alcohol was then added. The centrifuge tube was shaken well and centrifuged. The supernatant liquid was decanted. 11 ml of 1 N ammonium acetate solution was added into the centrifuge tube. The centrifuge tube was shaken well and centrifuged. The supernatant liquid was poured into the 100 ml flask. The solution in the 100 ml standard measuring flask was made up to 100 ml. The flame photometer was calibrated with standard sodium solution. The prepared solution was injected into the instrument and the reading was taken (Raman and Sathiyanarayanan, 2009). CEC value was then determined using equation (5) (Herk, 2012).

$$\text{CEC, cmol(+) kg-1 soil} = \frac{\text{10 x Na concentration in mg/L}}{\text{Mass of sample (g)}} \quad (5)$$

Available nitrogen

Nitrogen of soil mainly present in organic form together with small quantities of ammonium and nitrate forms. The nitrogen supplying ability of the soil was determined by distilling soil with alkaline potassium permanganate solution (Subbaiah and Asija, 1965). During the distillation easily utilizable and amino-N hydrolyzed nitrogen liberated as ammonia is measured. This serves as an index of nitrogen status of soil.

In 250 ml round bottom distillation flask, 5 g soil was taken to which 20 ml distilled water was added to moist the soil. Then 25 ml each of 0.32 % potassium permanganate and 25 ml 2.5% NaOH solution were mixed and immediately connected to keelhaul assembly. The froth during boiling was prevented by adding liquid paraffin (1ml) and bumping by adding a few glass beads. The contents were distilled in a kjeldahl at a steady rate and liberated ammonia collected in an Erlenmeyer flask (250 ml), containing 20 ml of 2% boric acid solution with methyl red and bromocresol green indicator. With the absorption of ammonia, the pinkish colour turns to green. The ammonia collected in boric acid was titrated with 0.02 N H_2SO_4 till the colour changed from green to pink color (initial color). Blank (without soil) was also run simultaneously. Available nitrogen was calculated using equation (6) and equation (7) respectively.

$$\text{Available N (\%)} = \frac{\text{(A−B) x N x 0.0014 x 100}}{\text{weight of soil in (g)}} \quad (6)$$

Where: A (ml) = volume of standard acid required for soil; B (ml) = volume of standard acid required for blank; and N = Normality of sulfuric acid

$$\text{Available nitrogen (kg/ha)} = \text{\% N x } \frac{2240000}{100} \text{ (Bhat et al., 2011)} \quad (7)$$

Available phosphorus

The available phosphorus content of the soil was estimated by Olsen`s method (Olsen *et al*., 1954). 5 g of soil was weighed and transferred to a 250 ml polythene conical flask and 100 ml of 0.5 M $NaHCO_3$ (pH 8.5) was added, followed by one teaspoonful of activated charcoal, shaken for 30 min on a mechanical shaker and filtered through Whatman No. 41 filter paper. 5 ml of the filtrate was pipetted into 25 ml volumetric flask. 5 ml of the freshly prepared mixed reagent (ascorbic acid, ammonium molybdate, 4 M H_2SO_4, and potassium antimony tartarate solution were added). The solution was well shaken and kept for one hour for the blue color to develop and the volume was made up to the mark with the extracting solution. The blank and standard curves were prepared with the extracting solution. The absorbance and color intensity were measured on spectrophotometer at 882 nm wavelength. The quantity of phosphorus was calculated as kg per hectare of the soil using equation (8).

$$P\ (kg/ha) = P\ (ppm) \times 2.24 \quad (8)$$

Available potassium

5 g of air dry soil was weighed and transferred to a 150 ml conical flask. 25 ml of 1 *N* ammonium acetate solution was added. The contents were shaken for five minutes on a mechanical shaker at 200 to 220 oscillations per minute and filtered through Whatman No. 41 filter paper. 5 ml of filtrate collected was taken and diluted with 25 ml distilled water. The blank solution was prepared similarly. The concentration of potassium in the filtrate was determined using the flame photometer. The quantity of potassium was calculated as kg per hectare of the soil using equation (9) (Bhat *et al*., 2011).

$$K\ (kg/ha) = K\ (ppm) \times 5 \times 2.24 \quad (9)$$

Data analysis

Data collected were subjected to statistical tests of significance using analysis of variance (ANOVA) at $P < 0.05$ to assess the significant differences in the mean concentrations the physicochemical parameters of the soils. Pearson's correlation analysis was also applied to study the relationships between the concentrations of different physicochemical characteristics of the soils. A probability level of $P < 0.05$ was considered statistically significant. All statistical analyses were done by SPSS version 16.0 software for windows.

Results and Discussion

The results of physicochemical characteristics of the soil samples such as moisture content, pH, and electrical conductivity, total dissolved solid, organic carbon, organic matter and cation exchange capacity, available nitrogen, available phosphorous and available potassium are presented in Table 1.

Moisture content

The moisture content which is directly proportional to the water holding capacity of the soil ranged from 19.31% to 28.25 %. Soil collected from Gosu Qora site has relatively higher moisture content than the other studied sites. Statistical test of significance using ANOVA revealed there was significant difference ($p < 0.05$) between the values of moisture content in the soil samples obtained from the four sites. The moisture content of this study were higher than the previous studies of Ambo district in Ethiopia by Attah (2010) who reported in the range of 8.5 to 10.8%. Borkar (2015) reported 5.8–10.25% and Ganorkar and Chinchmalatpure (2013) reported 2.5-10% moisture content in Indian soil.

Soil pH

Soil pH is a measure of the acidity of the soil and is a primary factor in plant growth. Soil pH values in the four sites ranges from 5.68 to 7.63. The lower pH observed was in Qibafkube soil and the higher pH in Gosu Qora soil. The soils studied from Qibafkube and Elamu Goromti farmlands were slightly acidic, Awaro Qora soil was neutral, and Gosu Qora soil was slightly alkaline. ANOVA test revealed that there was no significant difference ($p > 0.05$) between the values of pH in the soil samples obtained from Qibafkube and Elamu Goromti sites. In contrast to our results, Attah (2010) reported 6.2–6.7 soil pH in the previous studies of Ambo district in Ethiopia. Similarly, Wagh *et al*. (2013) and Ganorkar and Chinchmalatpure (2013) reported higher soil pH 7.32-8.45 and 7.8-8.46, respectively in Indian soil.

Electrical conductivity (EC)

Electrical conductivity value ranges from 0.11 mS/cm to 0.27 mS/cm (Table 1). The electrical conductivity of Awaro Qora and Gosu Qora soils are high as compared to the other sites which may be due to excess use of fertilizer like P and K. Electrical conductivity is used to estimate the soluble salt concentrations in soil and is commonly used as a measure of salinity. Soil with EC below 0.4 mS/cm are considered marginally or non-saline while soils above 0.8 mS/cm are considered severely saline (Wagh *et al.,* 2013). The soils under analysis were found non-saline. Statistical test of significance using ANOVA revealed there was no significant difference ($p > 0.05$) between the values of EC in the soil samples obtained from Awaro Qora and Gosu Qora sites, and Qibafkube and Elamu Goromti sites. The results of this study on electrical conductivity are also in agreement with the previous work of Attah (2010) who reported 0.13 to 0.19 mS/cm.

Total dissolved solids (TDS)

The TDS values for Awaro Qora, Gosu Qora, Qibafkube and Elamu Goromti soils were 172 mg/L, 168 mg/L, 83.3 mg/L and 72.7 mg/L, respectively (Table 1). Statistical test of significance using ANOVA revealed there was significant difference ($p < 0.05$) between the values of TDS in the soil samples obtained from the different Kebeles. However, Ganorkar and Chinchmalatpure (2013) reported TDS value that ranges from160-222 mg/L in Indian soil.

Organic carbon and organic matter

Organic carbon (OC) is the index for nitrogen content in the soil. The source of organic carbon in cultivated soil included crop residue, animal manure, cover crops, green manure and organic fertilizer etc (Borkar, 2015). Organic matter (OM) plays an important role in supplying nutrients and water and provides good physical conditions to the plants. The organic carbon content of the soil ranges from 1.61% to 2.84% (Table 1). The organic matter ranges from 2.78 to 4.89 %. Statistical test of significance using ANOVA revealed there was no significant difference ($p > 0.05$) between the values of OC and OM in the soil samples obtained from Gosu Qora and Qibafkube sites. Our results indicate that the OC values of the soil samples are similar to those reported values of soil samples from similar studies by Attah (2010) which ranges from 1.51–1.81%. However, Borkar (2015) reported lower organic carbon content 0.3-1.5% in Indian soil.

Cation exchange capacity

Cation exchange capacity (CEC) is an important measure of the soil's ability to retain and to supply nutrients. The CEC values ranged between 36.28 $cmol_{(+)}/kg$ to 65.73 $cmol_{(+)}/kg$. The lower CEC is observed in Qibafkube soil and the higher is in Gosu Qora soil (Table 1). Statistical test of significance using ANOVA revealed there was significant difference ($p < 0.05$) between the values of CEC in the soil obtained from the four sites. The results of this study on CEC are higher than the findings of Gizachew *et al*. (2015) who reported 16.2 to 36.2 $cmol_{(+)}/kg$ in Northwestern Ethiopia.

Table 1. Results of physicochemical parameters of the soils (mean ± standard deviation, n = 3).

Parameters	Sample sites			
	Awaro Qora	Gosu Qora	Qibafkube	Elamu Goromti
Moisture (%)	22.34 ± 2.42[a]	28.25 ± 0.87[b]	19.31 ± 1.47[c]	25.97 ± 0.91[d]
pH (H_2O)	7.02 ± 0.04[a]	7.63 ± 0.02[b]	5.68 ± 0.01[c]	5.88 ± 0.10[c]
EC (mS/cm)	0.24 ± 0.02[a]	0.27 ± 0.02[a]	0.12 ± 0.01[b]	0.11 ± 0.01[b]
TDS (mg/L)	172 ± 3.96[a]	168 ± 3.74[b]	83.3 ± 5.90[c]	72.7 ± 1.69[d]
OC (%)	1.61 ± 0.06[a]	2.76 ± 0.01[b]	2.84 ± 0.08[b]	1.91 ± 0.07[c]
OM (%)	2.78 ± 0.10[a]	4.76 ± 0.02[b]	4.89 ± 0.14[b]	3.29 ± 0.12[c]
CEC ($cmol_{(+)}\ kg^{-1}$)	58.67 ± 6.95[a]	65.73 ± 4.90[b]	36.28 ± 0.95[c]	43.5 ± 1.95[d]
Available N (%)	0.013 ± 0.002[a]	0.012 ± 0.001[b]	0.017 ± 0.002[c]	0.020 ± 0.002[d]
Available P (kg/ha)	20.12 ± 0.06[a]	26.14 ± 1.33[b]	18.37 ± 1.64[c]	14.01 ± 0.27[d]
Available K (kg/ha)	270.29 ± 20.28[a]	345.19 ± 26.11[b]	150.65 ± 13.72[c]	116.59 ± 6.62[d]

Key: Mean values in the same row with different alphabets are significantly different ($p < 0.05$). EC = electrical conductivity; TDS= total dissolved solid; OC = organic carbon; OM = organic matter, CEC= cation exchange capacity.

Available nitrogen

The data shown in Table 1 indicate that the available nitrogen content ranged from 0.012% to 0.020 %. The soil sample taken from Elamu Goromti has the highest available nitrogen and Gosu Qora soil has the lowest. Continuous use of nitrogenous fertilizer increases the available nitrogen status of soil. Statistical test of significance using ANOVA revealed there was significant difference ($p < 0.05$) between the values of available nitrogen in the soil samples obtained from the different Kebeles.

Available phosphorous

Available phosphorous vary from 14.01 kg/ha to 26.14 kg/ha. Elamu Goromti soil recorded minimum value 14.01 kg/ha and the Gosu Qora soil recorded maximum value 26.14 kg/ha (Table 1). The moderately high value of available phosphorus in Gosu Qora soil may be due to use of excessive phosphorous fertilizers. The available phosphorous content of Awaro Qora, Qibafkube and Elamu Goromti soil is rated as medium. The findings of this study on available phosphorous are higher than the findings of Attah (2010) who reported 1.4 to 1.8 mg/kg in the previous studies of Ambo district soil in Ethiopia. Wagh *et al*. (2013) reported available phosphorous content ranges from10 to172.9 mg/kg in Indian soil. Statistical test of significance using ANOVA revealed there was significant difference ($p < 0.05$) between the values of available phosphorous in the soil samples obtained from the different Kebeles.

Available potassium

The level of available potassium ranges from 116.59 kg/ha to 345.19 kg/ha (Table 1). The lowest value of available potassium was obtained in Elamu Goromti soil and the highest value was recorded in Gosu Qora soil. Qibafkube and Awaro Qora soils have 150.65 and 270.29 kg/ha of available potassium. The moderately high value of available potassium in Gosu Qora soil may be due to use of excessive potash fertilizers. The results of this study on available potassium are higher than the findings of Attah (2010) who reported 240 to 395 mg/kg in the previous studies of Ambo district soil in Ethiopia. However, the values obtained in this study are lower than the reported values of Ganorkar and Chinchmalatpure (2013) who reported available potassium in the range of 445-545 kg/ha. Statistical test of significance using ANOVA revealed there was significant difference ($p < 0.05$) between the values of available potassium in the soil samples obtained from the different Kebeles. Generally, the variation of values observed in the different parameters at different sites is due to the soil quality in different places. The irregular distributions of available nutrients recorded during the present investigation which may be attributed to the added fertilizers during the crop formation.

Correlation analysis

The relationships between the concentrations of different physicochemical parameters were analyzed by Pearson's correlation coefficient and the results are presented in Table 2.

Table 2. Pearson's correlation coefficients between soil physicochemical parameters.

	MC	pH	EC	TDS	OC	OM	CEC	Available nutrients		
								N	P	K
MC	1									
pH	0.597	1								
EC	0.441	0.983*	1							
TDS	0.312	0.940	0.983*	1						
OC	-0.028	-0.021	-0.031	-0.151	1					
OM	-0.026	-0.017	-0.027	-0.148	1*	1				
CEC	0.651	0.990**	0.962*	0.925	-0.142	-0.138	1			
Available N	-0.123	-0.857	-0.928	-0.932	-0.169	-0.172	-0.791	1		
Available P	0.365	0.865	0.878	0.808	0.451	0.454	0.786	-0.915	1	
Available K	0.455	0.976*	0.986*	0.947	0.132	0.136	0.936	-0.940	0.944	1

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

The high correlation coefficient (near +1 or -1) indicates a good relation between two variables, and its concentration around zero means no relationship between them, it can be strongly correlated, if $r > 0.7$, whereas r values between 0.5 to 0.7 indicates moderate correlation between two different parameters (Rakesh and Raju, 2013). From Table 2, we can observe a strong positive correlation were noticed for the parameters between pH with (EC, TDS, CEC, P and K), EC with (TDS, CEC, P and K), TDS with (CEC, P and K), OC with OM, CEC with P and K, P with K. This strong positive correlation shows that the parameters are closely associated, thus suggesting their common origin. Moderate positive correlations were observed between MC, with pH and CEC. A strong negative correlation was found between N with (pH, EC, TDS, CEC, P and K). The other correlations are week.

Conclusion

Based on the study result the physicochemical characteristics of soil used for the cultivation of garlic in Ambo District, Ethiopia indicated that the soil pH is acidic to slightly alkaline; the electrical conductivity values showed of the soils were non-saline, while the soils have an appreciable organic matter level, cation exchange capacity and available nutrients. Significant difference ($p < 0.05$) exist between the values of moisture content, TDS, CEC and available nutrients in the soil samples obtained from the different Kebeles. Generally, the soil studied can be considered as having a good fertility status and sustainability of continuous garlic production and productivity can be maintained. Further study to investigate the levels of heavy metals of the soils in the study area is suggested.

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