Research Journal of Agriculture and Environmental Management. Vol. 4(3), pp. 131-133, March, 2015
Available online at http://www.apexjournal.org
ISSN 2315 - 8719© 2015 Apex Journal International

Short Communication

Soil nutrient status under different vegetation cover classes of Desa'a a dry Afromontane forest in Northern Ethiopia

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Accepted 2 March, 2015

This study was conducted in Desa'a a dry Afromontane forest in Northern Ethiopia. The objective of this study was to evaluate the soil nutrient status under different vegetation cover classes. Soil samples were collected from three vegetation cover classes: open (35%), medium (55%), and dense (70%). As a result, pH and BD were significantly higher ($p < 0.001$) under the open vegetation cover class while soil TN, OM and CEC were significantly higher ($p < 0.001$) under the medium and the dense vegetation cover classes. All these differences were likely due to the addition of fallen leaves from the upper vegetation cover to the underneath soil which resulted in higher organic matter content in soil. No significant differences ($p = 0.799$) were found for Av.P at the three vegetation cover classes. Generally, the open vegetation cover class is mainly influenced by anthropogenic activities resulting poor vegetation growth and vitality are being observed.

Key words: Soil nutrient, soil chemical properties, soil physical properties, vegetation cover.

INTRODUCTION

At different spatial and time scales, vegetation cover helps in protecting the soil from harsh climatic conditions mostly soil erosion. The presence of dense vegetation affords the soil adequate cover thereby reducing the loss in macro and micro nutrients that are essential for plants growth and energy fluxes (Iwara *et al*., 2011).

In forests, a large quantity of organic matter is added to the soil by the annual litter fall and is therefore an important factor in the transfer of energy and plant nutrients to forest soils (Berg *et al*., 2006). However, the concentration of nutrient in the soil is depleted when vegetation is destroyed through numerous anthropogenic activities such as deforestation and land preparation for agricultural production, and road construction among others (Thornley 2000; Elliot 2003).

Due to the aforementioned reason, the effect of vegetation on accumulation and properties of the forest floor has for more than a century attracted scientific interest. However, so far little is known about the soil nutrient status of the present study area under different vegetation cover classes. Therefore, the objective of this study was to investigate the soil nutrient status under different vegetation classes as a basis for determining appropriate management strategies for the forest and the soil productivity in the area.

MATERIALS AND METHODS

Site description

The study was conducted in Desa'a protected area in Northern Ethiopia which lies between 13° 20' - 14° 10' North latitudes and between 39° 32' - 39° 55' East longitudes. Topographically the area exhibits moderately gentle to steep slopes. Altitude of the area ranges from

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Table 1. Comparison of soil nutrient status with respect to vegetation covers classes.

Soil properties	Vegetation cover classes			F-values	p-values
	Open	Medium	Dense		
pH	7.55 ± 0.05[a]*	7.31 ± 0.02[b]	7.27 ± 0.03[b]	14.99	<0.001
TN (%)	0.23 ± 0.01[b]	0.31 ± 0.01[a]	0.31 ± 0.01[a]	11.31	<0.001
Av.P (ppm)	4.51 ± 0.65[a]	4.57 ± 0.48[a]	5.03 ± 0.68[a]	0.22	0.799
OM (%)	1.36 ± 0.08[b]	2.22 ± 0.15[a]	2.51 ± 0.18[a]	16.68	<0.001
CEC (meq/100g)	18.48 ± 0.72[b]	21.62 ± 0.74[a]	23.68 ± 0.79[a]	12.14	<0.001
BD (g/cm^3)	1.16 ± 0.03[a]	1.04 ± 0.02[b]	0.92 ± 0.02[c]	22.88	<0.001

*Values followed by the same letters within each row are not significantly different at $p < 0.05$ level according to Tukey Honest Significant Difference (HSD) test. TN = total nitrogen, Av.P = available phosphorus, OM = organic matter, CEC = cation exchange capacity, BD = bulk density. Values are expressed as mean ± standard error.

1,500 meter above sea level at the lower limit to 2,500 meter above sea level at the plateau with the mean minimum and the mean maximum temperature of 13.4 °C and 27.95 °C, respectively (Zenebe, 1999). The dominant vegetation types of the area are *Maytenus obscura, Carissa edulis Vahl, Juniperus procera Hochstl and Olea europaea*. The geology of the area is dominated by limestone and the dominant soil type of the area includes Phaeozemes, Leptosol, calcaric Cambisol and Regosols.

Soil sampling procedure

Soil sampling was done from three different vegetation cover classes which are represented by open (35%), medium (55%) and dense (70%) having similar species with similar tree age at 20 cm sampling depth. Each vegetation cover had 3 replicated plots (20 × 20 m; 500 m apart) with similar species composition. The sample was collected in a systematically unaligned grid (zig-zag) pattern covering the entire plots in which three transects were laid at 6.66 m interval in each plot. On each transect, soil samples were collected at three sampling points. Soil auger was used for soil sampling and equal weight of soil sample was collected from the centre of the sample pit and samples were mixed to obtain a composite sample and thus a total of 54 samples were collected. Soil samples were then air dried, crashed and passed through 2 mm sieve and analyzed for soil pH, TN, Av.P, OM, and CEC. Samples for BD were collected at a depth of 10 cm by using core sampler. It was placed into an oven at 105 °C for 24 h to obtain oven dry weight of the soil sample. The oven dry soil was weighed and bulk density was determined as the mass of oven dry soil (g) divided by the total volume of soil (cm^3).

Chemical analysis

In the laboratory analyses, pH was determined using (1:2.5 ratio of soil: water) suspension using a pH meter. Soil OM was derived from OC after it was determined by the wet oxidation method. TN was determined using the Kjeldal methods (Nelson and Sommers, 1982). The soils were leached with 1 M neutral ammonium acetate to obtain leachates used to determine CEC, while Av.P was analysed by Olsen and Sommers (1982).

Statistical analysis

Statistical analyses were performed to test the soil nutrient status under the three different vegetation cover classes using analysis of variance (ANOVA) procedures. Mean comparisons were made using the Tukey Honest Significant Difference (HSD) test at 0.05 significant levels. The JMP-5 package was used to perform all the statistical analysis.

RESULTS AND DISCUSSION

The results showed that the pH and BD were significantly higher ($p < 0.001$) under the open vegetation cover class while soil TN, OM and CEC were significantly higher ($p < 0.001$) under the medium and dense vegetation cover classes (Table 1). However, Av. P was similar at the three vegetation cover classes and was statistically ($p = 0.799$) non significant (Table 1).

In this particular study, compared to the open and the medium vegetation cover classes, the dense vegetation cover class showed lower bulk density value which could be attributed to high OM contributed by leaf foliage. The medium and the dense vegetation cover classes had relatively lower pH values which might be due to the release of organic acids during decomposition of organic matter and these acids might have brought down the pH values. Vadivelu and Bandyopadhyay (1997) observed similar results in soils of Minicoy Island in Lakshadweep.

The medium and the dense vegetation cover classes were higher in OM, TN, and CEC content than the open vegetation cover class. This could be mainly due to the

addition of fallen leaves from the upper vegetation cover to the underneath soil which resulted in higher OM and CEC content in soils of the two vegetation cover classes than the open area. This result is in agreement with the works of Phil-Eze (2010) who reported that soil properties most affected by variations in vegetation cover are soil OM content and CEC. Similarly, Basava *et al*. (2005) and Walia and Rao (1996) stated that higher OM and CEC values are found under high vegetation cover than open areas.

Although the variations of soil properties are may be the outcome of several physical, chemical, or biological processes, soils are mainly affected by vegetation cover and as an inherent factor of soil formation has potential for modifying soil properties (Hartemink, 2006). Similarly, in this study an important part of the variation especially in soil OM, TN, and CEC content is most likely a result of high vegetation cover in the medium and the dense vegetation cover classes which can provide more litter to the soil that can be subsequently release some nutrients to the soil.

Conclusion

The study reveals that there are differences in soil properties under the three different vegetation cover classes. Soil properties of TN, OM, and CEC were higher at the middle and at the dense vegetation cover classes while pH and BD were higher at the open vegetation cover class. The open vegetation cover class is mostly exposed to human interferences as it is the main gate to the forest area. Consequently, poor vegetation cover has adversely impacted on soils of the area in their physical and chemical properties as against areas under the medium and the dense vegetation cover classes.

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