Restoration of Degraded Highlands through *Acacia Decurrens* Plantation and

Introduction

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Mondal et al., 2018).

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an innovative form of *A. decurrens* plantation has been evolved recently in Fagta Lekoma district of the Amhara National Regional State (Figure 1) that directly or indirectly supports the strategy of the country towards environmental management and energy expansion. Gojam highland is one of the water towers of the country and it is under serious degradation (Simane *et al.*, 2013). Fortunately, the new form of *A. decurrens* is evolved in one of the districts of Gojam highland and expands with fast rates

years. Because of the high population density (innovated by the community) and excellent performance of the species in the study area, high biomass is produced. Charcoals are produced at the sites of the plantation at multiple charcoal making points depending on the size of the plantation. This distribution helps for the management of the charcoal production process and it is part of the innovation made by the community. These charcoal making spots are parts that could not be separated from *A. decurrens* plantations as they have substantial area coverage. These charcoal producing spots may affect the soil properties as reported by ,
Msuya *et al.* (2011) and Oguntunde *et al.* (2008). Despite the expansion of the plantation with high rates, there is a lack of empirical evidence about the associated impacts of on soil properties for its

Materials and Methods

The study sites

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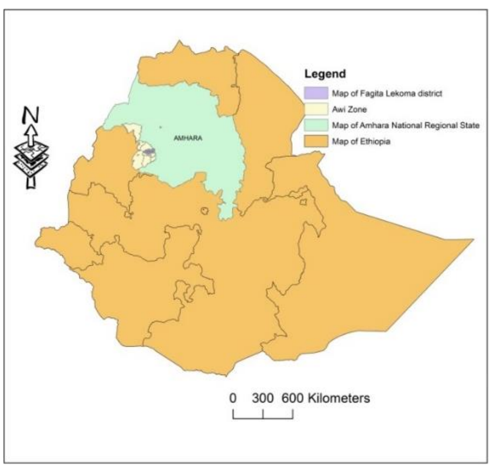

Figure 2. Location of the study site

Soil sampling procedures

The research comprised of two sets of independent activities as briefly indicated below.

Effects of A. decurrens at different ages of plantation compared to cropland on soil properties

Distributions and effect of charcoal production spots (sites) on soil properties

Figure 3. Charcoal production and associated activities. Numbers in the figure show: (1) Harvesting of plantation at age of 5 year; (2) leaf-debris; (3-6) charcoal production process; (7) charcoal marketing, (8) Soils after charcoal production and the major target of this study and (9) ploughing after 5 years of plantation for the planation of annual crops with *Acacia decurrens*.

Soil preparations and analysis

All collected soil samples were analyzed at Adet Agricultural Research Center. The samples were air dried under shade, ground using pestle and mortar, and sieved to pass through 2 mm sieve. Soil pH was determined in a 1:2.5 soil to water suspension following the procedure outlined by Sertsu and Bekele (2000). The organic carbon content was determined by wet digestion method using the Walkley and Black procedure (Nelson and Sommers, 1982). Available phosphorus was determined following the Olsen procedure (Olsen and Sommers, 1982). The cation exchange capacity (CEC) was determined after extraction of the samples with 1N ammonium acetate at pH 7. The soil moisture content was determined following a gravimetric procedure with the formula:

$$\text{Percent moisture (weight)} = \frac{(\text{A} - \text{B})100}{\text{B} - \text{weight of tin}}$$

Where: A is weight of air-dry soil and B is weight of oven-dry soil in grams (Sertsu and Bekele, 2000).

Data analysis

The impacts of independent variables such as the age of plantation and soil heating on soil properties were statistically evaluated. Analysis of variance (ANOVA) was carried out to evaluate the presence of a significant difference between and among treatments. For variables showing a statistically significant difference between treatments ($p<0.05$), further analysis of mean separation was carried out using the Least Significant Difference (LSD) at 5% probability.

Results and Discussion

Effects of *A. decurrens* at different ages of plantation and cropland on soil properties

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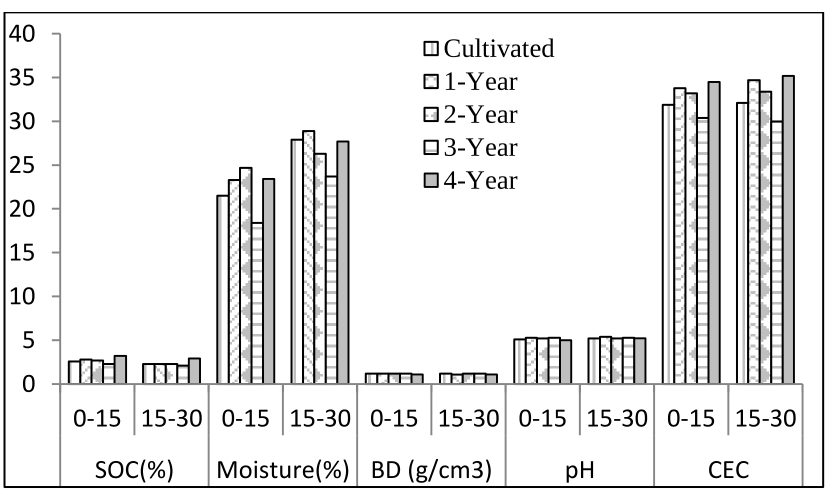

Figure 4. The effect of depth (cm) on soil properties for different ages of plantation and cropland

Table 1 Soil response to different ages of *A. decurrens* compared to cropland

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Effect of charcoal production spots (sites) on soil properties

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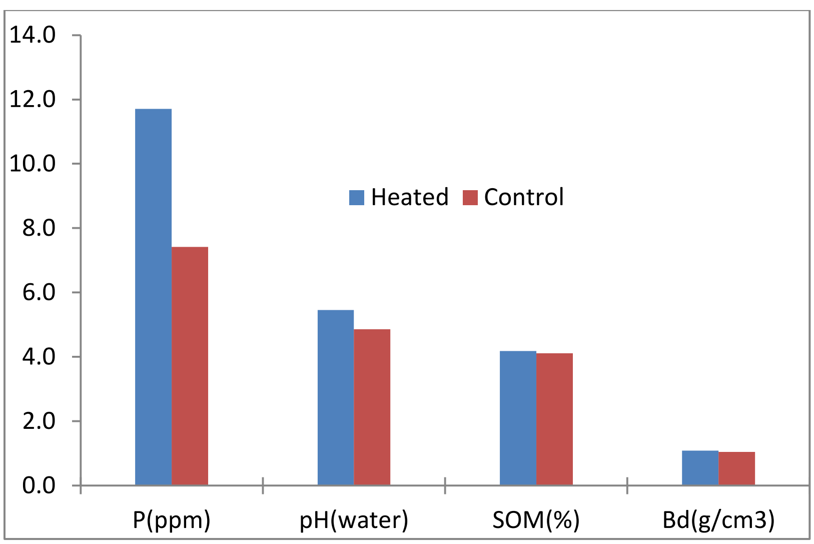

Figure 5. Effects of heating on selected soil properties (the mean values of depths)

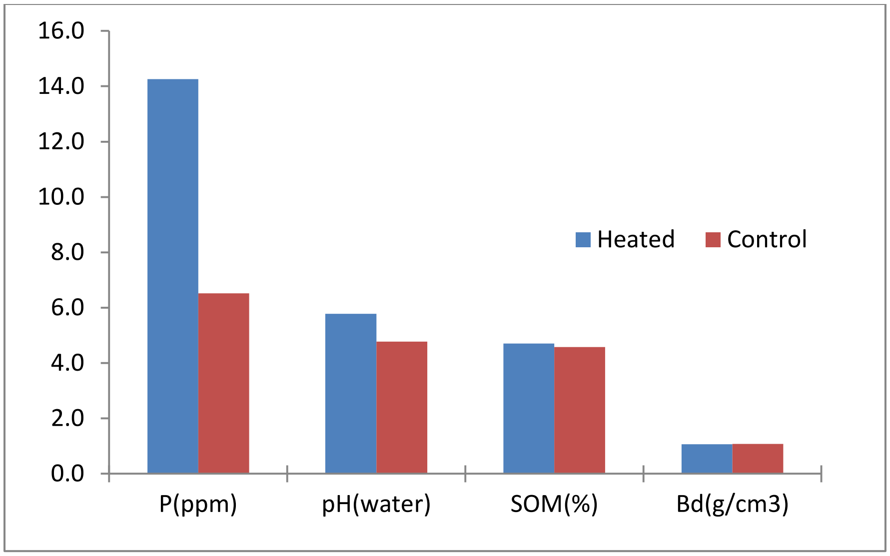

Figure 6. Effect of heating on selected soil properties at 0 to15 cm soil depth

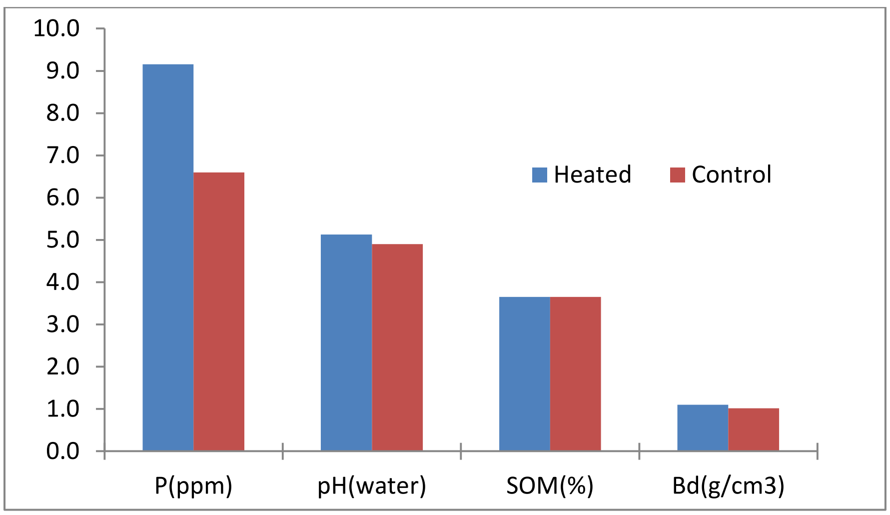

Figure 7. Effect of heating on selected soil properties at 15 to 30 cm soil depth

Available phosphorus from heated soil was increased by 120% as compared to the non-heated one while the pH increased by one unit that is about the effects of the application of four ton of lime per hectare (Figure 6). For the lower parts of the soil depth (15-30 cm) the effect of heating resulted in an increase of 39% of available phosphorus and 0.2 unit of pH over the non-heated one (Figure 7). The implication of this research finding is important in the acid soil where a low level of available phosphorus and low pH are among the challenges for crop productivity. The "guie" system in the central highlands of Ethiopia similarly increased the pH and available phosphorus but significantly reduced SOC (Amare *et al.*, 2013). The finding of this research is in line with the findings of Wahabu *et al.* (2015) who reported the positive effect of charcoal production on soil pH while SOC was negatively affected in their findings may be due to different degree of exposure to heat. In our research, the effect of heating on SOC and bulk density was not significant at all depths (Figure 5-7).

Conclusion and Recommendation

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