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Full Length Research

Evaluation of locally available fertilizer tree/shrub species in Gozamin Woreda, North Central Ethiopia

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The objective of the study was to evaluate the locally available fertilizer tree/shrub species in the study area. This study was conducted in two phases; in the first phase, a semi structured questionnaire was prepared to a total of 312 respondents randomly selected from the study area. In the second phase, leaf litter from the selected tree species and soil samples from both under the canopy of the selected tree species and open (controlled) area were collected for further analysis. According to response from respondents, *Cordia africana* was perceived to be the best by 26% of the respondents; while 39% of the respondents noted that *Croton macrostachyus* as the best; and 35% of the respondents acknowledge that *Hygenia abyssinica* is most importantly preferable for soil fertility improvement. Comparisons of potential leaf litter nutrient content (N, P, and K) of each selected tree species nutrient return from each selected species showed that leaf of *C. macrostachyus* had significantly higher ($P < 0.05$) K value compared with the leaf of *C. africana* and *H. abyssinica. C. macrostachyus* and *H. abyssinica* also showed higher concentration of N and P than *C. africana*. Soil properties under the canopy of all the selected tree species differed from the open (controlled) sampling point mainly as a result of nutrient addition from the fallen leaf litter to the underneath soil. Therefore, it is advisable to advise farmers to let these tree species grow on their farms and improve soil condition to achieve maximum production.

Key words: Fertilizer, tree, shrub, *C. africana*, *H. abyssinica*, *C. macrostachyus*

INTRODUCTION

In most developing countries, particularly in Ethiopia, there is declining soil fertility, and one of the biophysical constraints to increasing agricultural productivity is the low fertility of the soils (Haileslassie *et al*., 2006). Soils of Ethiopia like other tropical countries are naturally poor in nitrogen and phosphorus, but human induced losses of soil nutrients are significant threats to the livelihoods of the people (Mulugeta and Demel, 2004).

Currently, improving soil fertility levels has become an important issue in development agendas because of its linkage to food insecurity and economic well being of the population (Ajayi *et al.,* 2003). Fertilizer application is obviously an important strategy for alleviating nutrient depletion and increasing crop yields (Dudal, 2002). However, most farmers either cannot afford or have limited access to fertilizers. In addition, fertilizers alone cannot guarantee sustainable long-term productivity on many soils hence input of organic materials are needed to maintain soil organic matter levels (Syers, 1997). In this respect, the utilization of tree and shrub species for soil fertility improvement is a viable and sustainable land-use alternative to enhance agricultural productivity (Young, 1997).

Integration of soil fertility improving trees/shrubs in farming systems remains a plausible option to sustaining soil productivity under declining fertility (Cardoso and Kuyper, 2006). Because, nutrient release from the tree/shrub litter fall is believed to be the major factor for transferring of nutrients and energy from living biological components to the soil and contribute to the soil fertility

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and its associated productivity, a study on decomposition rate of different tree species is vital (Nyberg, 2001; Gindaba *et al*., 2004).

Indigenous tree/shrub species that are used for soil fertility improvement in the Eastern Gojjam, Northern Ethiopia have not been given much research attention and are still lacking. Therefore, the objective of this study was to identify farmers' perception about locally available tree/shrub species that improve soil fertility and back it up with scientific evidence. It is also aimed at filling these gaps as a basis for determining appropriate soil fertility management strategies and soil productivity in the area and many other places with similar environmental conditions.

MATERIALS AND METHODS

Site description

The study was conducted in Gozamin Woreda, East Gojjam Zone, Ethiopia which lies between 10° 20' N lat, 37° 43' E long; elevation 2200 m above sea level with an average annual temperature of 18 °C. Geographically, the area exhibits deep gorges, valleys, plateaus, hills and mountains. The mean annual rainfall of the area is 1628 mm. The soils are grouped under Vertisoil, Nitisol, Regosol, Litosol, Acrisol, and Luvisol. The most common tree/shrub species are *Hagenia abyssinica*, *Croton macrostachyus, Cordia africana, Milletia ferrugina, Accacia decurrens, Accacia saligna, Gravellia robusta, sesbania sesban,* and *leucina leucocephala* (GWoARD, 2005).

Sampling procedure and data collection

This study was carried out in two phases; in the first phase, semi-structured questionnaires were administered to 312 farmers randomly selected from the study area to solicit their perception on tree/shrub species planted and retained on the border of agricultural farms and homestead and how they are utilized, including which ones they consider best to enhance soil fertility. Field observation was carried out at different times of the year to have an idea where and when various species produce the highest biomass. Series of discussions were also made with farmers in the study area to understand characteristics of existing trees and shrubs. Trees which were ranked as the three top most were used for further analysis in the second phase. Leaf litter, and under canopy soils from the selected tree species and from the nearby open land were sampled for further analysis.

Leaf sampling and chemical analyses

In this particular study, from the selected species, the first three tree/shrub species were taken for chemical analysis. Thus, a total of nine isolated trees/shrubs, three of each selected species, located in the same soil type, same landscape position, and approximately with similar age were selected with no tillage, fire, or inorganic fertilizer use in the past years. Leaves of these trees/shrubs species were collected from all canopy positions on the trees. After air dried, leaf samples were oven dried at 65ºC for 24 hours, and grounded into powdered form to pass through the mesh screen for chemical analysis. N was determined by the micro-Kjeldahl method by digesting 0.5 g samples in 10 ml concentrated H_2SO_4, using a catalyst mixture ($CuSO_4$, K_2SO_4 and selenium powder) and distillation. P was determined in digested samples colorimetrically using the ammonium molybdate stannous chloride method (Olsen and Sommers, 1982). K was analyzed by a flame photometric method (Jackson, 1967).

Soil sampling and chemical analyses

From each sampling tree/shrub, soil samples were taken from three horizontal sampling distances: under canopy, edge of canopy, and the open area (control) at 0-15cm depth based on the methodology stated by Yadessa *et al*. (2001). Soil samples were then taken to laboratory to be analyzed for soil pH, TN, Av.P, ex.K and OC. The soil samples were air dried, crushed and passed through 2 mm sieve for laboratory analyses. Soil properties were analysed using the following analyses methods: pH was determined using a pH meter (1:2.5 ratio of soil: water suspension). Soil OC was determined by the wet oxidation method (Nelson and Sommers, 1982). TN was determined using the Kjeldahl methods; ex.K was analyzed by flame photometric method (Jackson, 1967). Av.P was analysed by Olson method (Olsen and Sommers, 1982).

Statistical analyses

Descriptive statistics was used to determine the selected species both their leaf litter, nutrient content and the soil nutrient status under their canopy and open (controlled) area. One-way analysis of variance (ANOVA) procedure was performed to see the effect of the selected tree species on the soil fertility properties, and nutrient contents in litter of each of the species. 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

According to the outcome of the questionnaire,

Table 1. Major nutrients in abscised leaves of *C. africana, C. macrostachyus* and *H. abyssinica* tree species.

Nutrients (mg g-1)	*C. africana*	*C. macrostachyus*	*H.abyssinica*
K	9.12 ± 0.01b*	12.23 ± 0.03a	10.08 ± 0.11b
N	12.21 ± 0.23b	15.31 ± 0.05a	15.62 ± 0.02a
P	2.57 ± 0.03b	2.43 ± 0.03a	2.64 ± 0.03a

*Means followed by the same letter are not significantly different at P ≤ 0.05 as determined by Tukey Honest Significant Difference (HSD) test. Values are expressed as mean ± standard error.

Table 2. Soil nutrient status of the different sampling points of the selected species

		Soil properties				
Species	**Sampling point**	**pH**	**OC (%)**	**TN (%)**	**Av.P (ppm)**	**ex.K (ppm)**
C. africana	Under canopy	5.43	1.66	0.25	18.94	0.12
C. africana	Edge of canopy	5.45	1.62	0.24	18.72	0.11
C. africana	Open area (control)	5.67	1.54	0.15	16.15	0.23
C. macrostachyus	Under canopy	5.66	1.65	0.26	12.08	6.96
C. macrostachyus	Edge of canopy	5.67	1.63	0.19	11.98	6.98
C. macrostachyus	Open area (control)	5.91	1.39	0.15	11.58	6.59
H. abyssinica	Under canopy	5.47	1.68	0.26	17.62	5.36
H. abyssinica	Edge of canopy	5.49	1.65	0.19	17.52	5.32
H. abyssinica	Open area (control)	5.52	1.42	0.15	16.67	5.12

OC (%) = organic carbon, TN (%) = total nitrogen, Av.P (ppm) = available phosphorus, ex.K (ppm) = exchangeable potassium.

among the many tree/shrub species in the study area, *C. africana* was perceived best for improving soil fertility by 26% of the respondents; 39% of the respondents noted that *C. macrostachyus* as the best; 35% of the respondents acknowledge that *H. abyssinica* is most importantly preferred tree for soil fertility improvement. These three tree species were exposed to further study for both leaf litter content and soil nutrient status under their canopy and the open (control) area.

A study on evaluating the leaf litter nutrient content is important to understand the underneath soil condition (Moore *et al*., 2006). This is because litter-fall is a major pathway for the return of dead organic matter and nutrients held in it from the aerial parts of the plant communities to the surface of the soil (Attiwill and Adams, 1993). The results obtained for the leaf litter nutrient composition revealed that there were significant ($p < 0.05$) differences between the treatments.

Comparisons of potential leaf litter nutrient content (N, P, and K) returning from each selected species showed that leaf of *C. macrostachyus* had significantly higher ($P < 0.05$) P compared with the leaf of *C. africana* and *C. macrostachyus*. *C. macrostachyus* and *H. abyssinica* also showed higher concentration of N and P than *C. africana* (Table 1) may be due to the inherent characteristics of the species.

The result of this study also showed that P content was low (Table 1) in the fallen leaf of the three tree species as compared to N and K nutrients which could be mainly because it is not so readily cycled from plant surfaces to the soil. This result is in agreement with the observations of Read and Lawrence (2003); Ca´rdenas and Campo (2007) who described that P is one of the most tightly cycled major plant nutrients and usually more than half of the P in deciduous leaves is re-translocated back to the trees before leaf abscission. Aerts (1996) also reported that most perennials reabsorb 40-65% of P from abscised leaves, permitting this nutrient to be recycled internally and used in the construction of new tissues.

Although the variations of soil properties 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). Structural differences in leaves of plants present a possible source of variability in the amount of leaves reaching to the soil under plant canopies and the amount of nutrients in the soil (Vesterdal *et al*., 2008). Litter production also varies according to habit of the tree species, its age and local environmental condition (Szott and Kass, 1993).

Results on previous study of Gindaba *et al*. (2005) do agree with the findings of this study that *C. macrostachyus*, increases soil nitrogen, which was attributed to tree leaf and root litter. Since *C. macrostachyus* is not nitrogen-fixing plant, the only way it could have improved soil nitrogen is by absorbing N from the subsoil and depositing through litter fall (Young, 1997).

The increase in soil TN, Av.P, and OC of the under canopy soil are indicators of increased fertility (Table 2).

Whereas soil pH had lower value under the canopy of the selected tree species compared to the open (controlled) area which is mainly attributed to the chemical composition of the leaves. Similar to this finding, Kahi *et al*. (2009) reported significant difference (P<0.05) in pH between the soils within and outside the canopies of both trees, with a higher pH in the open cultivated land than under the canopy areas. Kamara and Haque (1992) also reported a significant variation in soil pH horizontally under a canopy agroforestry tree species. Several other studies have also reported that soil fertility under tree situation is improved due to increased input of organic matter through litter (Campbell *et al*., 1994; Dhyani, 1997). Contrary to this finding, Gindaba *et al* (2005) reported that there was no significant difference in soil pH under the canopy of *C. africana* and *C. macrostachyus* compared to the open area.

Conclusion

In the study area, farmers are letting the selected tree species to grow in their farm because they consider these tree species can improve the fertility status of their soils. This study was therefore intended to evaluate the effect of these tree species on the quality of the soil. In this particular study, soil properties under the canopy of all the selected tree species differed from the open (controlled) sampling point mainly as a result of nutrient addition from the fallen leaf litter to the underneath soil. *C. macrostachyus* and *H. abyssinica* are amongst the most productive soil fertility improving tree species in the study area and therefore it is advisable for farmers to let these tree species grow on their farm and improve their growth to achieve maximum production.

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