# Indigenous tree and shrub species for soil fertility improvement in Galessa and Jeldu areas, Western Shewa, Ethiopia

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**Abstract**

A study was conducted from 2004 to 2006 to identify and prioritise indigenous species for soil fertility improvement, and to assess soil properties, nutrient concentration and other quality characteristics of green biomass of indigenous tree and shrub species. The most preferred species for soil fertility improvement in Galessa-Jeldu areas were *Senecio gigas*, *Hagenia abyssinica*, *Dombeya torrida* and *Buddleja polystachya*. The foliage and flower bud of *S. gigas* contained a higher P and K content. *H. abyssinica* had less lignin content in its foliage and flower bud. The variation among species for soluble phenolics in the foliage was from 10 to 169 mg $g^{-1}$ and in the flower bud from 9 to 234 mg $g^{-1}$. The soil pH values under *H. abyssinica* and *S. gigas* were >6.34. The soil organic C content at 0-15cm depth was higher under *H. abyssinica* than under *B. polystachya*. Similarly, the soil under *H. abyssinica* and *S. gigas* had a high content of K at the 0-15cm depth. The contents of organic C, N, P, K, Ca and Mg showed a decreasing pattern from the top to the lower soil depths and from the closest to the distant horizontal positions. The soil under the vicinity of *H. abysinica*, *S. gigas* and *Chamaecytisus palmensis* contained a substantial amount of soil nutrients. Hence, the three species should be tested in farmlands and other land-use types of the high altitude areas, where soil erosion and soil depletion are critical problems.

## 1. Introduction

Soil degradation, poor crop productivity and limited vegetation diversity are major problems in high altitude (> 2900) Galessa-Jeldu areas (German *et al.* 2005). The local people utilise both indigenous and introduced practices to manage soil degradation problems. Trees can potentially improve soils through numerous processes, including maintenance or increase of soil organic matter, uptake of nutrients from below the reach of crop roots, biological N-fixation, reduced loss of nutrients by erosion and leaching, increased water infiltration and storage, improved soil-physical properties, reduced soil acidity and improved soil-biological activity (Young 1997).

The use of green biomass of tree and shrub species is one of the traditional practices that are currently in use in the Galessa-Jeldu areas to improve soil fertility and thereby increase crop productivity. This type of approach helps to sustain agricultural productivity in tropical regions where the use of mineral fertilisers is limited. Green biomass of trees and shrubs can be classified into high quality, intermediate-high quality, intermediate-low quality and low quality (Palm *et al.* 2001). A high quality green biomass contains N >25mg $g^{-1}$, lignin <150mg $g^{-1}$ and soluble phenolics <40mg $g^{-1}$; intermediate-high quality green biomass contains N >25mg $g^{-1}$, lignin >150 mg $g^{-1}$ or soluble phenolics >40 mg $g^{-1}$; and low quality green biomass contains N <25 mg $g^{-1}$, lignin >150 mg $g^{-1}$ or soluble phenolics >40 mg $g^{-1}$. The capacity of the high quality biomass to supply N is high and immediate. The low quality green biomass has a low direct nutrient effect and a high indirect mulching effect (Kumar *et al.* 2003).

Studies on soil properties under indigenous species and nutrient concentration of green biomass of trees are limited in the high altitude areas. A study was conducted in Galessa - Jeldu areas (a) to identify and prioritise indigenous species for soil fertility improvement and (b) to assess soil properties, nutrient concentration and other quality characteristics of green biomass of indigenous tree and shrub species.

## 2. Materials and methods

The study area is situated in the upper plateaus of Dendi and Jeldu weredas (districts) of western Shewa zone, Oromia region, Ethiopia (Figure 1). The altitude of the study area ranges from 2900 to 3200m. Barley is the most dominant crop, followed by potato and enset (*Ensete ventricosum*). The soil is characterised as Haplic Luvisol. The chemical and physical properties of the soil are shown in Table 1.

Two weredas (districts) and four kebeles (lower administrative units in the government structure) in the highlands of central Ethiopia were considered for the study. Accessibility and diversity of soil improving species were given much attention for the selection of the study area. Tree and shrub species growing location and composition were investigated through direct observation, as well as group and individual discussions approaches. The farmers' tree species preference criteria for soil fertility improvement were identified and prioritised through group discussion. A total of 150 farmers (respondents) participated for questionnaire survey (Roothaert and Franzel 2001, Thapa *et al.* 1997, Morrison *et al.* 1996, Mayr 1996).

*Senecio gigas* Vatke (basionym: *Solanecio gigas* (Vatke) C.Jeffrey; Kew Bull. 41(4): 923 (1986)), *Hagenia abyssinica* (Bruce) J.F. Gmel., *Dombeya torrida* (J.F. Gmel.) P. Bamps, *Buddleja polystachya* Fres. and *Chamaecytisus palmensis* (Christ) Bisby & K. Nicholls were included in the soil and plant sampling scheme. *Chamaecytisus palmensis* (tree lucerne) was recently introduced an exotic N-fixing woody species. A transect approach was considered for soil sampling. Sampling locations were 75, 150 and 225cm distances (position) at both sides from the base of each marked tree or shrub species (Power *et al.* 2003, WEZEL 2000, Hailu *et al.* 2000). Sampling depths were 0-15, 15-30 and 30-50cm (Kindu *et al.* 1997). A total of 135 composite soil samples were collected under the four indigenous and one exotic tree and shrub species attributed as soil improvers. Soil samples collected from similar depths and positions were thoroughly mixed to obtain composite samples.

A total of 30 composite foliage and flower bud samples were collected from *S. gigas*, *H. abyssinica*, *D. torrida*, *B. polystachya* and *C. palmensis*. Sub-samples were collected from all samples for water content determination. The fresh mass of each sub-sample was immediately recorded in the field. All foliage, stem and flower bud samples and sub-samples were oven-dried at 80°C for 24 hours. The dry-mass of the sub-samples was recorded and the moisture percentage was calculated.

The total N content of the foliage and flower bud was determined by Kjeldahl digestion using $Na_2SO_4$ and $CuSO_4$ as catalysts. Oven dried foliage and flower bud samples were extracted with a mixture of $HNO_3$ and $HClO_4$. The total P, K, Ca, Mg and S content of the extracts were determined by the use of a simultaneous ICP-OES (Inductively Coupled Plasma – Optical Emission Spectroscopy) with axial plasma (Perkin Elmer, OPTIMA 3000 XL).

The soil pH was determined in 1:3 soil suspensions in deionised water for active acidity, using a potentiometric pH-meter (ÖNORM L1083 2005). Organic carbon was determined by C/S-Element analyzer LECO S/C 444, using oven-dry samples. Dry combustion at 1400°C in pure O2 atmosphere and infrared detection of evolved CO2 was applied (ÖNORM L1080, 2005). Total N was determined by the Semi-micro-Kjeldahl procedure, using the air-dry samples (ÖNORM L1082 2005). Available P was determined by the Olsen method (Olsen and Sommers 1982). Exchangeable element contents ($K^+$, $Ca^{2+}$, $Mg^{2+}$, $Mn^{2+}$ and $Al^{3+}$) were extracted from air-dried samples with 0.1M $NH_4OAc$ at pH 7.0. The elements in the extracts were determined using a simultaneous ICP-OES.

A one-way analysis of variance (ANOVA) was carried out on CP, mineral composition, ADF, NDF, ADL, condensed tannins and IVDMD using SAS (SAS institute 1999). Significance between means was tested using the Least Significant Difference (LSD).

## 3. Results and discussion

### 3.1. Tree and shrub species identified and ranked for soil fertility improvement

Farmers identified more than 15 tree and shrub species that they believe potential for improving soil fertility (Table 2). The tree and shrub species located mainly around homesteads and in forests. About 92% of the farmers need to plant more indigenous soil improving trees around homesteads for better management and protection purposes. Farmers ranked the existing indigenous tree and shrub species for soil fertility improvement based on their own criteria (Table 3). They also considered change of soil colour, status of soil moisture, crop growth and yield, and soil structure as indictor for soil fertility improvement near or under the canopy or hedge of tree and shrub species. The most preferred species for the farmers include: *S. gigas*, *H. abyssinica* and *D. torrida* (Table 4).

### 3.2. Green biomass nutrient concentration and other quality characteristics

The macronutrients content in foliage and flower bud differed depending on the species. The content of N in the foliage of *H. abyssinica* was comparatively lower than the N content of the other tree and shrub species (Figure 2). Similarly, *C. palmensis* had a low N content in its flower bud as compared to the other four tree and shrub species. *Senecio gigas* showed a higher P and K content in its foliage and flower bud. The high content of P, K and S in *S. gigas* may be traced back to the scavenging of these nutrients in a large soil volume and their accumulation in the aboveground organs. According to Garrity and Mercado (1994), members of the *Asteraceae* family, to which *S. gigas* belongs, are effective nutrient scavengers.

*Hagenia abyssinica* had less lignin content in its foliage and flower bud as compared to other species (Table 5). The lignin content of *H. abyssinica, D. torrida* and *S. gigas* was lower in the foliage than in the flower bud. On the other hand, *B. polystachya* and *C. plamensis* had more lignin content in their flower bud than in the foliage. The lignin contents of the foliage of most of our tree and shrub species are below the critical level of 150mg $g^{-1}$ dry matter. Lignin content above 150mg $g^{-1}$ impairs the decomposition of tree foliages, since lignin protects the cellulose in the cell wall from microbial attack (Chesson 1997, Palm and Rowland 1997).

The content of lignin and soluble phenolics in the foliage and flower bud differed from species to species. The variation among species for soluble phenolics in the foliage is from 10 to 169mg $g^{-1}$ and in the flower bud from 9 to 234mg $g^{-1}$ (Table 5). According to Constantinides and Fownes (1994), the soluble phenolics content of green foliage of tree and shrub species can reach as high as 100mg $g^{-1}$. Soluble phenolics content > 30 to 40mg $g^{-1}$ results in the immobilization of N (Palm 1995).

### 3.3. Soil properties under the indigenous tree and shrub species

The soil pH values under *H. abyssinica* and *S. gigas* are above 6.34 (Figure 3). At the 0-15cm depth, the soil OC content under *H. abyssinica* is higher by 23.25, 24.53 and 21.03mg $g^{-1}$ than under *B. polystachya* in the closest, midst and distant positions, respectively (Table 6). Similarly, the difference in soil N at the 0-15cm depth is 1.85, 2.27 and 1.83mg $g^{-1}$. The content of soil P has the following order in the top 0-15cm soil depth of the closest and midst horizontal positions: *H. abyssinica* > *S. gigas* > *C. palmensis* > *D. torrida* > *B. polystachya* (Table 7). The contents of K vary significantly at the 0-15cm soil depth of the three horizontal positions. The soil under *H. abyssinica* and *S. gigas* has a high content of soil K at the 0-15cm depth in all three horizontal positions.

The high content of OC, N, P and K under the vicinity of *H. abyssinica* as compared *to B. polystachya* can be associated with the fact that the former has a more efficient nutrient cycling power than the latter. *H. abyssinica* constantly sheds a high amount of leaves and provides the soil in its vicinity with mulch and green manure. Kindu *et al.* (2006) reported the presence of a high amount of litter deposition under 64 months old *H. abyssinica* and *Grevillea robusta* on Nitisols of central Ethiopia. *D. torrida* and *S. gigas* shed a substantial amount of leaves, even though their leaf shedding pattern is not as regular as that of *H. abyssinica*.

Soil pH, organic C, N, P and depicted a decreasing pattern from the 0-15 to the 30-50cm soil depths and from the closest to the midst and distant positions under most of the tree and shrub species. An improvement of soil nutrients by various tree and shrub species in topsoil and close to the tree stems has been reported earlier (Abebe *et al.* 2001, Ashagrie *et al.* 1999, Gindaba *et al.* 2005, Hailu *et al.* 2000).

## 4. Conclusions

Indigenous species in general and *S. gigas* in particular showed superiority in terms of the amount of macronutrients in the foliage and flower bud. The exotic species had a reasonable amount of soluble phenolics in the foliage. Based on the content of N, lignin and soluble phenolics, indigenous species have intermediate to high quality foliage and flower bud whereas exotic species have high quality foliage and flower bud for managing soil fertility. The soil under the vicinity of *H. abyssinica* and *S. gigas* contains a substantial amount of nutrients. This is an indication of the species' potential to improve the fertility of soils. *H. abyssinica*, *S. gigas* and *C. palmensis* can play a great role in farmlands and other land-use types of the high altitude areas, where soil erosion and soil depletion are critical problems. Hence, further research is urgently needed to evaluate the performance of *S. gigas*, *H. abyssinica* and *C. palmensis* outside homesteads of the high altitude agroecologies.

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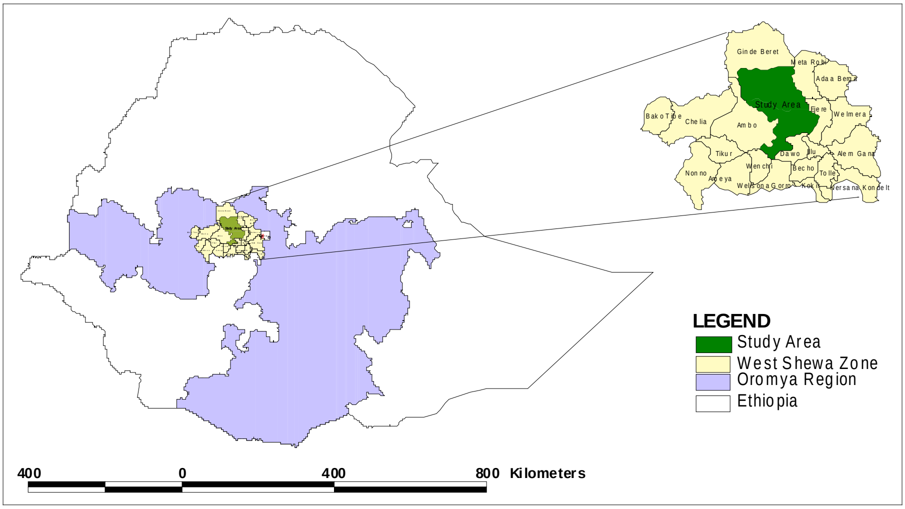


**Figure 1: Location map of the study area.**

**Table 1: Some physical and chemical properties of the soil in the study area.**

Table 1. Some physical and chemical properties of the soil in the study area.

| Depth (cm) | pH ($H_2O$) | OC (mg $g^{-1}$) | Tot. N (mg $g^{-1}$) | Av. P (mg $g^{-1}$) | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|---|---|---|
| 0-18 | 6.28 | 48.280 | 4.796 | 0.083 | 12 | 47 | 41 |
| 18-60 | 6.19 | 15.290 | 1.316 | 0.018 | 11 | 37 | 52 |
| 60-125 | 5.66 | 4.356 | 0.459 | 0.021 | 4 | 34 | 62 |
| 125-160 | 5.97 | 2.027 | 0.198 | 0.022 | 28 | 33 | 39 |

Tot. N - total N, OC - organic C, Av. P - available P

**Table 2: Soil improving tree and shrub species identified in Galessa-Jeldu areas.**

| Species | Local names | Family names |
|---|---|---|
| *Dombeya torrida* (J.F. Gmel.) P. Bamps | Danisa | Sterculiaceae |
| *Hagenia abyssinica* (Bruce) J.F. Gmel. | Heto | Rosaceae |
| *Buddleja polystachya* Fres. | Anfari | Loganiaceae |
| *Rubus apetalus* Poir. | Gora/Yedega Injore | Rosaceae |
| *Rubus pinnatus* Willd. | Gura/ Yedega Injore | Rosaceae |
| *Vernonia auriculifera* Hiern. | Chochinga | Asteraceae |
| *Maytenus senegalensis* (Lam.) Exell. | Kombolcha | Celastraceae |
| *Myrica salicifolia* Hochst. ex A. Rich. | Reji | Myricaceae |
| *Juniperus procera* Hochst. ex Endl. | Gatira | Cupressaceae |
| *Phytolacca dodecandra* L' Her | Indode | Phytolaccaceae |
| *Urtica simensis* Hochst. ex steud. | Dobi (sama) | Urticaceae |
| *Schefflera abyssinica* (Hochst. ex A. Rich.) Harms | Luke | Araliaceae |
| *Senecio gigas* Vatke | Osolie | Asteraceae |
| *Kalanchoe deficiens* (Forsk) Asch. & Schweinf. | Bosokie | Crassulaceae |
| *Dracaena steudneri* Schweinf. ex. | Lankuso/Hareg | Agavaceae |
| *Trichilia roka* (Forsk.) Chiov. | Anona | Meliaceae |
| *Leonotis ocymifolia* (Burm.f.) M.Iwarsson | Bokolu | Lamiaceae |

**Table 3: Criteria used by farmers to evaluate indigenous tree and shrub species for soil fertility improvement in Galessa-Jeldu areas of western Shewa.**

Table 3. Criteria used by farmers to evaluate indigenous tree and shrub species for soil fertility improvement in Galessa-Jeldu areas of western Shewa.

| Criteria | Number of respondents[a] | Score | Rank |
|---|---|---|---|
| *Fertility related criteria* [b] | | | |
| Regular leaf shedding | 148 | 649 | 1 |
| Fast decomposition of leaves | 139 | 514 | 2 |
| Fast growth | 120 | 228 | 4 |
| Easy propagation | 118 | 204 | 5 |
| Production of high biomass | 138 | 469 | 3 |

*Note:* [a] Number of respondents who identified the criteria. Sample size was 150 households.
[b] If a farmer selected the criteria first, it received a value of 5; if second, a value of 4; if third, a value of 3; if fourth, a value of 2 and if fifth, a value of 1.
Score is sums of individual farmer value given to the respective criteria.

**Table 4: Indigenous tree and shrub species ranked for soil fertility improvement based on farmers' criteria in the Galessa-Jeldu areas of central Ethiopia.**

| Soil improving species | No. of respondants[a] | Score |
|---|---|---|
| *Senecio gigas* | 142 | 743 |
| *Hagenia abyssinica* | 147 | 734 |
| *Dombeya torrida* | 133 | 512 |
| *Vernonia auriculifera* | 122 | 357 |
| *Buddleja polystachya* | 99 | 272 |
| *Myrica salicifolia* | 100 | 205 |
| *Leonotis africana* | 60 | 106 |
| *Kalanchoe deficiens* | 9 | 39 |
| *Dracaena steudneri* | 5 | 16 |
| *Juniperus procera* | 3 | 10 |
| *Maytenus senegalensis* | 3 | 8 |

*Note:* Sample size was 150 households.
Each household scored six preferred fodder tree species.
[a] Number of respondants who selected the species in the top 6.
If a farmer selected a species first, it received a value of 6; if second, a value of 5; if third, a value of 4; if fourth, a value of 3; if fifth, a value of 2 and if sixth, a value of 1.
Score is sums of individual farmer value given to the respective species.

**Table 5: Lignin and soluble phenolics composition of foliage and flower bud in five tree and shrub species.**

| Foliage | *H. abyssinica* | *D. torrida* | *B. polystachya* | *C. palmensis* | *S. gigas* | SEM |
|---|---|---|---|---|---|---|
| Lignin | 53[c] | 100[bc] | 173[a] | 124[ba] | 80[bc] | 12.37 |
| Soluble | 169[a] | 54[b] | 82[b] | 10[c] | 79[b] | 14.41 |
| Flower bud | | | | | | |
| Lignin | 73[d] | 199[a] | 161[b] | 98[dc] | 106[c] | 12.84 |
| Soluble | 234[a] | 15[c] | 14[c] | 9[c] | 38[b] | 23.16 |

Lignin and soluble phenolics are in mg $g^{-1}$ dry matter.
SEM - Standard error of the means (n = 15).
Means with different letters within a row are significantly different ($p < 0.05$).

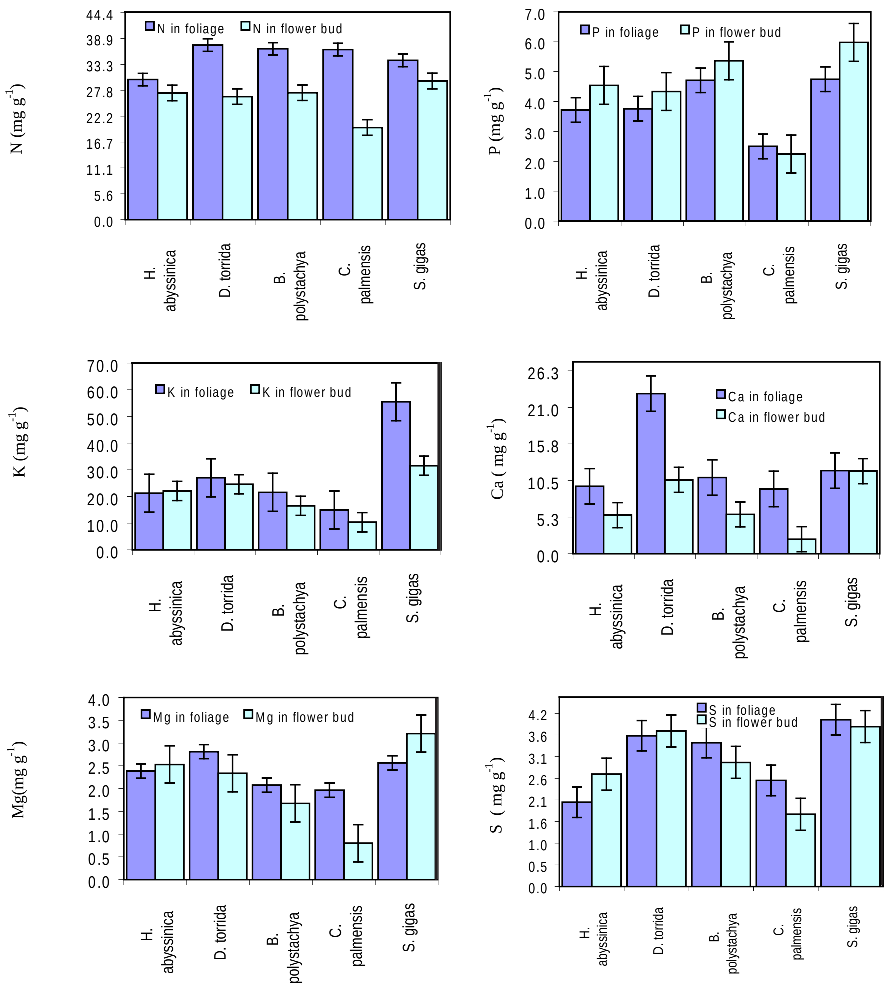


**Figure 2: Trends of macronutrients in the foliage and flower buds of five tree and shrub species. Error bars are SEM with n=15.**

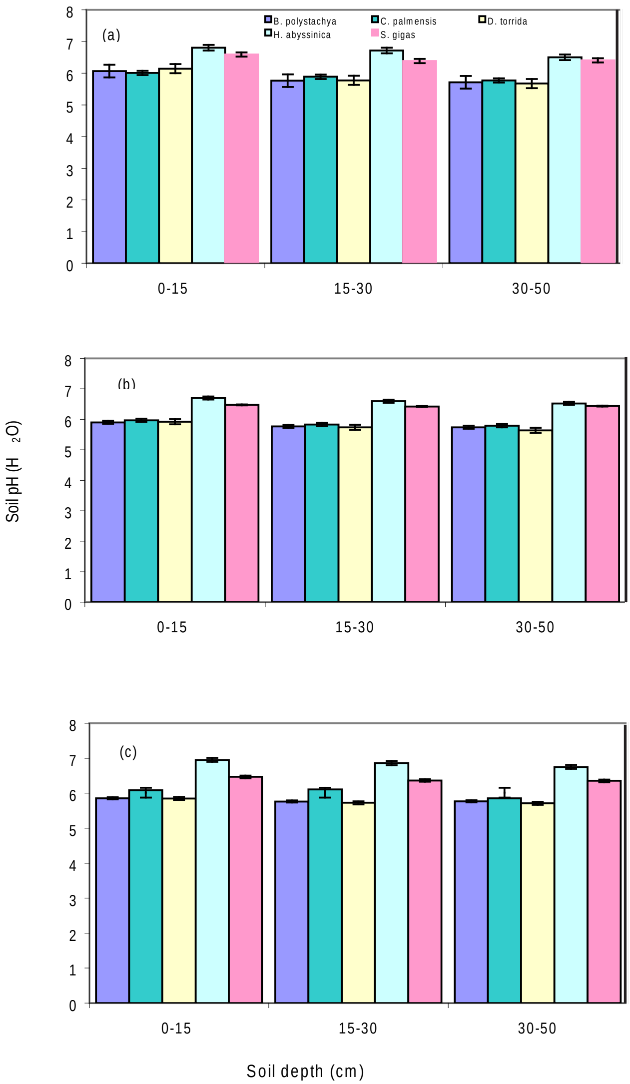


**Figure 3: Trends of soil pH at (a) 75cm position (b) 150cm position and (c) 225cm position from the stem of five species. Error bars are SEM with n=15.**

**Table 6: Total N, organic C and pH at different depths and positions from five tree and shrub species.**

| Species | Depth (cm) | Organic C (mg g$^{-1}$) 75 cm position | 150 cm position | 225 cm position | Total N (mg g$^{-1}$) 75 cm position | 150 cm position | 225 cm position |
|---|---|---|---|---|---|---|---|
| *B. polystachya* | 15 | 51.31$^{b}$ | 40.33$^{b}$ | 39.73$^{b}$ | 4.75$^{a}$ | 3.99$^{b}$ | 3.83$^{b}$ |
| *C. palmensis* | | 61.37$^{ba}$ | 58.63$^{ba}$ | 56.36$^{ba}$ | 5.92$^{a}$ | 5.74$^{ba}$ | 5.19$^{ba}$ |
| *D. torrida* | | 63.50$^{ba}$ | 59.86$^{ba}$ | 57.59$^{a}$ | 4.92$^{a}$ | 5.36$^{ba}$ | 5.36$^{ba}$ |
| *H. abyssinica* | | 74.56$^{a}$ | 64.86$^{a}$ | 60.76$^{a}$ | 6.60$^{a}$ | 6.26$^{a}$ | 5.66$^{a}$ |
| *S. gigas* | | 58.93$^{ba}$ | 55.11$^{ba}$ | 53.00$^{ba}$ | 5.36$^{a}$ | 5.15$^{ba}$ | 5.04$^{ba}$ |
| SEM | | 3,302 | 3,372 | 2,899 | 0,335 | 0,333 | 0,274 |
| *B. polystachya* | 30 | 38.00$^{a}$ | 32.52$^{a}$ | 33.01$^{a}$ | 3.64$^{a}$ | 2.66$^{a}$ | 3.03$^{a}$ |
| *C. palmensis* | | 50.84$^{a}$ | 44.82$^{a}$ | 39.34$^{a}$ | 4.94$^{a}$ | 3.98$^{a}$ | 3.82$^{a}$ |
| *D. torrida* | | 44.04$^{a}$ | 37.70$^{a}$ | 38.63$^{a}$ | 4.22$^{a}$ | 3.68$^{a}$ | 3.68$^{a}$ |
| *H. abyssinica* | | 56.29$^{a}$ | 43.92$^{a}$ | 44.42$^{a}$ | 5.21$^{a}$ | 4.13$^{a}$ | 4.14$^{a}$ |
| *S. gigas* | | 43.76$^{a}$ | 36.95$^{a}$ | 33.84$^{a}$ | 4.07$^{a}$ | 3.28$^{a}$ | 2.89$^{a}$ |
| SEM | | 3,199 | 2,654 | 2,279 | 0,280 | 0,284 | 0,227 |
| *B. polystachya* | 50 | 32.41$^{a}$ | 24.96$^{a}$ | 21.12$^{b}$ | 2.92$^{a}$ | 2.14$^{a}$ | 1.96$^{b}$ |
| *C. palmensis* | | 29.12$^{a}$ | 26.50$^{a}$ | 28.18$^{ba}$ | 2.67$^{a}$ | 2.45$^{a}$ | 2.51$^{ba}$ |
| *D. torrida* | | 31.25$^{a}$ | 28.24$^{a}$ | 28.49$^{ba}$ | 2.91$^{a}$ | 2.60$^{a}$ | 2.28$^{ba}$ |
| *H. abyssinica* | | 38.37$^{a}$ | 35.37$^{a}$ | 36.30$^{a}$ | 3.36$^{a}$ | 3.19$^{a}$ | 3.19$^{a}$ |
| *S. gigas* | | 39.37$^{a}$ | 22.57$^{a}$ | 21.48$^{b}$ | 3.46$^{a}$ | 1.93$^{a}$ | 1.91$^{b}$ |
| SEM | | 2,120 | 1,992 | 2,099 | 0,200 | 0,213 | 0,183 |

Means with different letters within a column at similar depth and position are significantly different ($p < 0.05$).
SEM - Standard error of the means (n = 15).

**Table 7: Exchangeable cations at different depths and positions from five tree and shrub species.**

| Species | Depth (cm) | Available P (ppm) position | 150 cm position | position | Exchangeable K (µg g$^{-1}$) position | position | position |
|---|---|---|---|---|---|---|---|
| *B. polystachya* | 15 | 15.53$^{b}$ | 14.47$^{b}$ | 13.87$^{a}$ | 826$^{b}$ | 568$^{a}$ | 455$^{c}$ |
| *C. palmensis* | | 54$^{ba}$ | 53.07$^{ba}$ | 55.23$^{a}$ | 1428$^{ba}$ | 1409$^{a}$ | 1291$^{bac}$ |
| *D. torrida* | | 19.27$^{b}$ | 26$^{ba}$ | 24.47$^{a}$ | 927$^{b}$ | 771$^{a}$ | 639$^{bc}$ |
| *H. abyssinica* | | 99.8$^{a}$ | 81.40$^{a}$ | 72.53$^{a}$ | 1929$^{ba}$ | 1592$^{a}$ | 1642$^{a}$ |
| *S. gigas* | | 78.4$^{ba}$ | 76.47$^{a}$ | 72.67$^{a}$ | 2306$^{a}$ | 1518$^{a}$ | 1507$^{ba}$ |
| SEM | | 11,77 | 10,16 | 9,76 | 215,11 | 175,62 | 167,27 |
| *B. polystachya* | 30 | 12.40$^{a}$ | 9.93$^{a}$ | 9.80$^{b}$ | 489$^{a}$ | 444$^{a}$ | 424$^{a}$ |
| *C. palmensis* | | 39.47$^{a}$ | 22.93$^{a}$ | 17.67$^{ba}$ | 1171$^{a}$ | 1154$^{a}$ | 1389$^{a}$ |
| *D. torrida* | | 12.87$^{a}$ | 13.40$^{a}$ | 12.67$^{b}$ | 539$^{a}$ | 531$^{a}$ | 482$^{a}$ |
| *H. abyssinica* | | 55.40$^{a}$ | 33.27$^{a}$ | 27.60$^{a}$ | 1483$^{a}$ | 1205$^{a}$ | 1324$^{a}$ |
| *S. gigas* | | 49.13$^{a}$ | 36.20$^{a}$ | 25.67$^{a}$ | 1544$^{a}$ | 1259$^{a}$ | 1222$^{a}$ |
| SEM | | 8,3 | 4,37 | 2,36 | 183,33 | 178,74 | 183,44 |
| *B. polystachya* | 50 | 10.13$^{b}$ | 9.13$^{b}$ | 8.27$^{a}$ | 339$^{a}$ | 480$^{a}$ | 470$^{a}$ |
| *C. palmensis* | | 15.53$^{b}$ | 13.93$^{ba}$ | 13.80$^{a}$ | 840$^{a}$ | 876$^{a}$ | 915$^{a}$ |
| *D. torrida* | | 9.80$^{b}$ | 11.00$^{ba}$ | 9.80$^{a}$ | 343$^{a}$ | 325$^{a}$ | 344$^{a}$ |
| *H. abyssinica* | | 20.40$^{ba}$ | 10.80$^{ba}$ | 11.90$^{a}$ | 1048$^{a}$ | 938$^{a}$ | 1141$^{a}$ |
| *S. gigas* | | 31.13$^{a}$ | 15.73$^{a}$ | 14.60$^{a}$ | 1372$^{a}$ | 1232$^{a}$ | 1197$^{a}$ |
| SEM | | 2,57 | 0,94 | 0,99 | 166,41 | 158,13 | 157,64 |

Means with different letters within a column at similar depth and position are significantly different ($p < 0.05$).
SEM - Standard error of the means (n = 15).