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Dispersed trees on smallholder farms enhance soil fertility in semi-arid Ethiopia

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Abstract

Introduction: Dispersed trees such as *Oxytenanthera abyssinica* (A. Rich.) and *Dalbergia melanoxylon* (Guill. & Perr.) which are objectively maintained or planted on farmland provide a significant contribution to soil fertility improvement. However, there was no quantitative information on the level of soil nutrient additions of these trees to the soil system.

Methods: This study was conducted on the farmers' fields in Kafta Humera district, Tigray region (northern Ethiopia), where mature stands of *O. abyssinica* and *D. melanoxylon* trees exist. Radial distance-based soil sampling (under the canopy, near to canopy, and far from canopy) was adopted to quantify the role of these trees on soil fertility improvement. Soil parameters tested were soil reaction (pH), total nitrogen (TN), available phosphorus (AvP), electrical conductivity (EC), cation exchange capacity (CEC), and organic carbon (OC).

Results: There was a negative linear relationship between the radial distance of the *O. abyssinica* tree trunk and soil TN, OC, CEC, and AvP contents but not for pH. Similarly, negative linear relationship between distance from *D. melanoxylon* and TN, OC, and AvP was obtained. The average total nitrogen (0.26% and 0.13%), available phosphorus (7.21 ppm and 6.37 ppm), and organic carbon (1.73% and 1.02%) contents were respectively higher under the tree canopies of *O. abyssinica* and *D. melanoxylon* compared with the adjacent open canopies. The amount of soil OC, TN, AvP, and CEC under *O. abyssinica* tree species was also significantly higher by 69%, 100%, 13%, and 42% compared to that of *D. melanoxylon* tree species. However, the amount of EC and soil pH was significantly lower by 57% and 19%, respectively.

Conclusion: In general, *O. abyssinica* and *D. melanoxylon* added a significant amount of nutrients to the soil. Thus, retaining these important tree species on farmland played a positive role in replenishing soil fertility for resource-constrained households so as to reduce chemical fertilizer amendments.

Keywords: Scattered tree, *Oxytenanthera abyssinica*, *Dalbergia melanoxylon*, Soil properties

Introduction

Soil nutrient degradation is considered as a major challenge in achieving food security and natural resource conservation in sub-Saharan Africa such as Ethiopia (Sanchez and Swaminathan 2005; Bationo et al. 2007). In Ethiopia, soil degradation is the most immediate environmental problem (Bishaw 2001). The loss of soil through erosion that deteriorates soil fertility, moisture storage capacity, and soil structure contributed to reduced agricultural productivity in the country (Bishaw 2001). Even though, there is no study conducted on the monetary value of soil loss in the country. A study by Bationo et al. (2007) for the entire continent of Africa revealed that Africa loses US$4 billion per year due to soil nutrient degradation. The problem is pervasive among mixed crop and livestock farming systems of the region where competing uses for crop residues such as livestock fodder or household fuel that do not sufficiently replenish the soil exist. Nutrient replacement using mineral fertilizers is a limited option for many smallholder farming households of the region. At only eight kilograms per hectare, the region has the lowest mineral fertilizer application rates in the world and concomitantly, much lower crop yields than achieved in other developing regions (Morris et al. 2007).

Hence, implementing agroforestry systems in resource-poor farming households is considered to mitigate soil nutrient mining (Bishaw 2001; Gladwin et al. 2002).

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Integration of legume trees into agricultural systems, therefore, adds biologically fixed nitrogen and other agriculturally important nutrients to the soil (Rosenstock et al. 2014) in a way that complements the crops grown in association with the trees (Akinnifesi et al. 2010). These trees are also known to bring about changes in edaphic, micro-climatic, and other components of the ecosystem through bio recycling of mineral elements, environmental modifications (including thermal and moisture regime), and changes in floral and faunal composition (Shukla 2009).

There are numerous examples of traditional land-use practices that incorporate trees into agricultural crop fields on the same piece of land (Mosquera-Losada et al. 2009). Cultivating and use of trees and/or shrubs like *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* together with crops and livestock is a long-standing tradition in many parts of Ethiopia such as Kafta Humera District in northern Ethiopia (Kamara and Haque 1992; Sisay and Mekonnen 2013). These trees have been either purposely planted or naturally grown on farmlands and left to stand to support agriculture (Ajake 2013; Aladi and John 2014) by reducing nutrient losses from erosion and leaching, increasing nutrient inputs through nitrogen fixation, and increasing biological activities by providing biomass and suitable microclimate (Ogunkunle and Awotoye 2010). Moreover, farmers in Kafta Humera District revealed that these trees provide firewood, timber (for local construction), medicine (bark, root, and leaves), bee forage, carving, and other benefits that are vital to the rural communities (Bein et al. 1996; Bekele-Tesemma 2007).

However, the contribution of these trees to soil fertility enhancement, regardless the farmers maintain these trees on their crop field, was not adequately studied. Hence, this study tried to quantify the effects of *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* trees on soil properties following a distance gradient from the tree canopy.

Materials and methods

Study area description

The study was conducted at Adi-Goshu village in Kafta Humera district, Northern Ethiopia (Fig. 1). Geographically, the area lies between 36° 27′ 4.70″–37° 33′ 7.12″ E and 13° 39′ 46.47″–14° 26′ 34.87″ N within an altitudunal range of 499–1849 m above sea level. The area is classified in the semi-arid climate and is characterized by a mean annual rainfall of 609 mm in which the rainy season is from June to September. The mean maximum temperature varied between 32.3 °C in August and 42.5 °C in May, while the mean minimum temperature is between 17.8 °C in January and 25.1 °C in April (Fig. 2). The major soil types found in the area are vertisols, cambisols, and luvisols. The area is also characterized by a mixed farming system which composed of annual crops, trees, and livestock. Sesame (*Sesamum indicum*), sorghum (*Sorghum bicolor*), and cotton (*Gossypium*) are the commonly grown cereal crops in the area. The common type of agroforestry practice noticed in the study area is parkland agroforestry that is known for retaining indigenous trees on farmlands (Gebrewahid et al. 2018). The dominant tree species grown on farmlands include *Pterocarpus leucens*, *Oxytenanthera abyssinica*, *Ziziphus spinachristi*, *Dalbergia melanoxylon*, and *Combretum* spp.

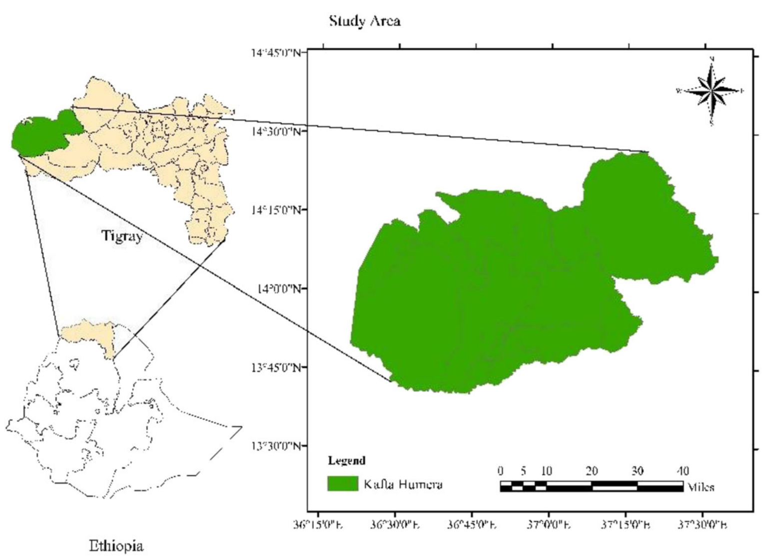

Fig. 1 Map showing location of study area

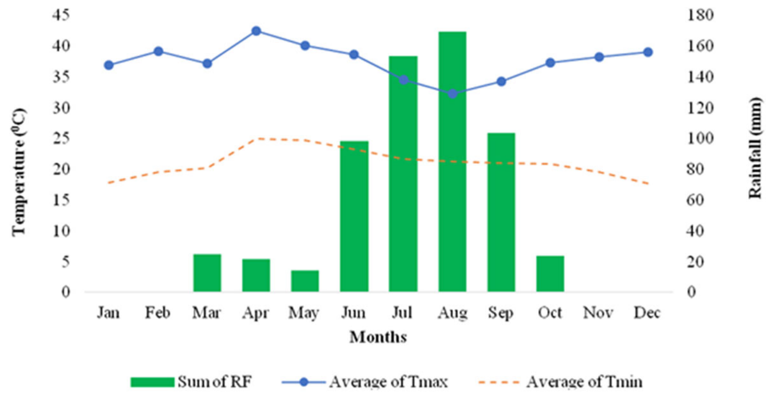

Fig. 2 Mean monthly maximum temperature, minimum temperature, and rainfall of Kafta Humera from 1996 to 2011 (National Metrological Agency)

Experimental design and field layout

The study was carried out on farmers' fields to compare the soil fertility status under traditionally retained scattered *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* trees against open farmland outside the canopy cover of each tree. Both species are native to Ethiopia, endemic to the site, and are well represented in this environment (Bein et al. 1996; Bekele-Tesemma 2007). To collect data on soil properties, 16 isolated and nearly identical trees of each species grown on similar site conditions were systematically selected based on diameter at breast height (DBH), tree height (TH), and crown diameter (CR). Radial distance-based soil sampling (under the canopy, near to canopy, and far from canopy) was adopted. The three different radial distances were (i) the canopy radius under the tree (1.7 m for *Oxytenanthera abyssinica* and 1.2 m for *Dalbergia melanoxylon*), (ii) canopy edge (3.1 m for *Oxytenanthera abyssinica* and 2.5 m for *Dalbergia melanoxylon*), and (iii) outer radius (14.5 m for *Oxytenanthera abyssinica* and 14.5 m for *Dalbergia melanoxylon*) following the procedure outlined in Pandey et al. (2000) and Gindaba et al. (2005). Generally, the design was 1 × 3 arrangements of treatments (three radius) in randomized complete block design replicated 16 times (16 scattered trees of each species). In total, 96 soil samples were collected (Fig. 3).

Tree characteristics and distribution

Oxytenanthera abyssinica is a woody perennial belonging to the family of Poaceae with unique characteristics (Wang 2006). It is a fast-growing and self-sustaining species once established (Bystriakova et al. 2004). In Ethiopia, *Oxytenanthera abyssinica* is well known as a multipurpose tree with different functions such as construction material, furniture, fence, handicraft, pulp and paper, edible shoots, and animal fodder (Bein et al. 1996; Bekele-Tesemma 2007). The leaves of *Oxytenanthera abyssinica* is blue-green, rounded base, long tip, and spiny, usually 15 × 2.5 cm long but can reach up to 30 × 5 cm (Bein et al. 1996; Bekele-Tesemma 2007).

Dalbergia melanoxylon is a small woody perennial which belongs to the family of Papilionoideae (Bein et al. 1996). In Tigray, the tree is also well known as a multipurpose tree with different functions such as firewood, timber (construction), carving, medicine (bark, roots, leaves), fodder (fruit, leaves), bee forage, nitrogen fixation, and walking sticks (Bekele-Tesemma 2007). The leave of *Dalbergia melanoxylon* is compound, having stalk length of 20 cm, 9–13 leaflets, and rounded or notched tip. Both trees species shade their leaves during the dry season.

Canopy cover in agroforestry system is directly related to the degree of light and rainfall interception (Jackson 2000) that may affect soil physical properties such as soil temperature and moisture (Ritter et al. 2005). The sampled *Oxytenanthera abyssinica* tree had an average DBH, TH, and CR of 7.8 cm, 4.9 m, and 5.2 m, respectively, whereas the sampled *Dalbergia melanoxylon* tree had DBH, TH, and CR of 17.6 cm, 5.5 m, and 4.4 m, respectively. The estimated age of *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* was 20–28 and 35–45 years old, respectively.

Data collection

A total of 96 composited soil samples were taken at a depth of 20 cm representing the topsoil as proposed in FAO (2006) and at three distances (radius) in four different directions (North, South, East, and West of each tree). The collected soil samples were analyzed for soil reaction (pH), soil organic carbon (SOC), total nitrogen (TN), available phosphorus

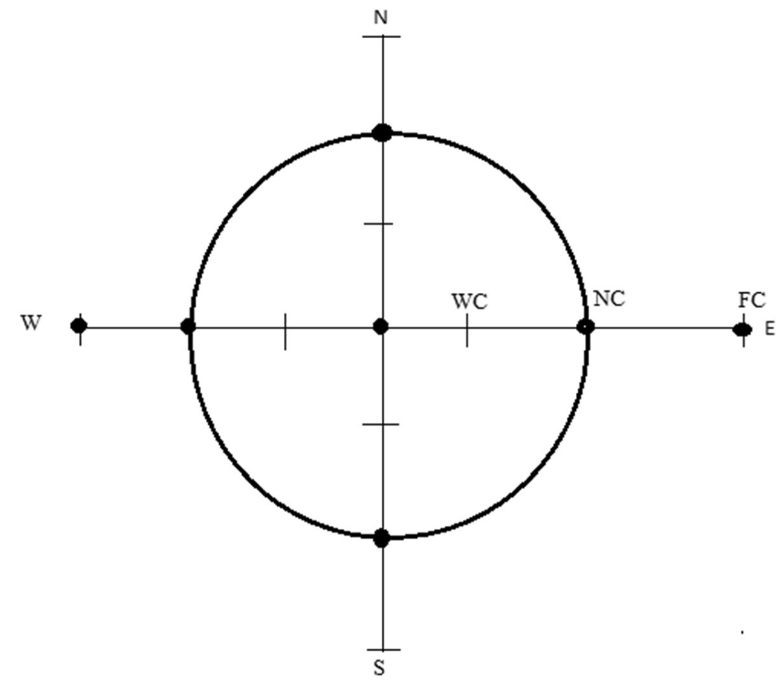

Fig. 3 Design of soil sampling from *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* tree, where N is North, S is South, E is East, W is West, WC is under the canopy, NC is near to the canopy, and FC is far to the canopy

(AvP), electrical conductivity (EC), and cation exchange capacity (CEC).

Soil laboratory analysis

Prior to analysis, each composite soil sample was air-dried and passed through a 2-mm sieve for most of the selected soil properties and further sieved to pass through a 0.5-mm sieve size for analysis of total nitrogen. Soil organic carbon (SOC) was analyzed using the Walkley-Black oxidation method (Chesworth 2008), total nitrogen (N) using the Kjeldhal method (Jackson 1958), available phosphorus (P) using the Olsen method (Olsen and Sommers 1982), pH using the potentiometer method (McLean 1982), electrical conductivity (EC), and cation exchange capacity (CEC) using the ammonium acetate method (Houba et al. 1989).

Statistical analysis

The impact of trees on soil properties was compared using one-way analysis of variance (ANOVA) following the linear model (GLM) procedure at $P < 0.05$ with the help of R software for Window versions 3.4.3. Whenever statistical difference existed, it was subjected to Tukey's HSD test to separate the means. Two-sample t test was also used to compare soil properties between tree species.

Results

Impact of *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* on soil properties

Soil organic carbon (SOC)

In this study, the soil organic carbon content of *abyssinica* and *D. melanoxylon* ranged from 0.58 to 2.86% and 0.33 to 1.41%, respectively, and was highly significantly ($P < 0.001$) affected by distance from the tree base. It was higher under the canopies of both tree species. All soil properties decreased with increasing distance from the base of the tree (Table 1).

Total nitrogen (TN)

Total nitrogen significantly ($P < 0.001$) decreased with increasing distance from each tree trunk base. It decreased from 0.26% at the smaller distance to 0.12% at the far distance of *O. abyssinica* and from 0.13% at the smaller distance to 0.07% at the far distance of *D. melanoxylon* (Table 1).

Available phosphorus (AvP)

The mean available phosphorus significantly decreased with increased distance from the tree base of both tree species. The AvP at the tree base of *O. abyssinica* and *D. melanoxylon* was higher by 7.21 ppm and 6.37 ppm respectively as compared to the open fields (Table 1).

Table 1 OC, TN, AvP, EC, CEC, and pH under *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* trees with different radii from trunk of the tree

Tree	Radius from the tree (m)	OC%	TN%	AvP	EC	CEC	pH	C-to-N
Oxytenanthera abyssinica	Under canopy	1.73 (0.16)[a]	0.26 (0.01)[a]	7.21 (0.20)[a]	0.07 (0.01)	55.74 (1.35)[a]	6.13 (0.10)[a]	6.50 (0.47)[a]
	Near to canopy	1.28 (0.09)[b]	0.13 (0.01)[b]	6.55 (0.19)[a]	0.07 (0.01)	48.02 (1.45)[b]	6.30 (0.08)[ab]	12.10 (2.10)[b]
	Far from canopy	1.30 (0.11)[b]	0.12 (0.01)[b]	6.02 (0.21)[b]	0.08 (0.01)	45.02 (2.18)[b]	6.56 (0.09)[b]	11.44 (0.43)[b]
	F value	4.179	57.337	9.125	0.852	10.569	5.922	5.806
	P value	*	***	***	0.4333	***	**	**
Dalbergia melanoxylon	Under canopy	1.02 (0.06)[a]	0.13 (0.005)[a]	6.37 (0.28)[a]	0.11 (0.01)	39.27 (3.20)	7.29 (0.14)	7.74 (0.5)
	Near to canopy	0.70 (0.06)[b]	0.09 (0.005)[b]	5.78 (0.21)[ab]	0.11 (0.01)	30.32 (3.81)	7.16 (0.18)	8.59 (1.0)
	Far from canopy	0.65 (0.05)[b]	0.07 (0.004)[c]	5.32 (0.17)[b]	0.14 (0.01)	32.56 (3.68)	7.15 (0.21)	10.02 (1.1)
	F value	11.924	51.841	5.525	3.073	1.699	0.193	1.601
	P value	***	***	**	0.056	0.194	0.825	0.212

Note: Rows with the same superscript letters are not significantly different at $P < 0.05$. Standard error (SE) mean is shown in parenthesis, * are given when *P* values less than 0.05, ** are given when *P* values less than 0.01, and *** are given when *P* values less than 0.001

OC % organic carbon percent, *Total N%* total nitrogen, *Available P (ppm)* available phosphorus, *EC (dS/m)* electrical conductivity, *CEC meq/100 g* cation exchange capacity

Soil electrical conductivity (EC)

The analysis of variance revealed that soil EC was not significantly affected by distance from the tree base of both tree species (Table 1). It ranged from 0.02 to 0.14 dS/m and 0.04 to 0.21 dS/m respectively for *O. abyssinica* and *D. melanoxylon.*

Soil cation exchange capacity (CEC)

CEC values were highly significantly ($P < 0.001$) affected by distance from the tree base in *O. abyssinica* but not significantly different in *D. melanoxylon* tree. The average cation exchange capacity values of soils for *Oxytenanthera abyssinica* species were 55.74, 48.02 and 45.02 meq/100 g at 1.7 m, 3.1 m and 14.5 m far from the tree trunk respectively. These values decreased with increasing distance from *Dalberigia melanoxylon* tree base (Table 1).

Soil reaction (pH)

Soil pH significantly increased with increased distance from tree trunk for *O. abyssinica* (Table 1). It increased from 5 at the smaller distance to 7.02 at the far distance. However, the soil pH of *D. melanoxylon* was not significantly ($P = 0.825$) affected by distance.

Carbon to nitrogen ratio (C:N)

The concentration of soil organic carbon to soil nitrogen (C:N) ratio significantly increased with increasing distance from the tree trunk of both species (Table 1). The soil C:N ratio in surface soil ranged from 3.44 to 43 and 3.3 to 21 for *O. abyssinica* and *D. melanoxylon*, respectively.

Comparable results between the trees on soil properties

Except for the C:N ratio, the concentration of soil nutrients on the studied species did not show significant variation ($P > 0.05$) along distance from each tree species (Table 2). However, *Oxytenanthera abyssinica* had significantly higher ($P < 0.05$) OC, TN, AvP, and CEC but lower EC and soil reaction (pH) compared with the *Dalbergia melanoxylon* (Table 2).

Table 2 Comparison on soil nutrient concentration between *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* trees of under, near, and far to canopy

Radius from the tree (m)	OC%	TN%	AvP	EC	CEC	pH	C-to-N
Under canopy	***	***	*	**	***	***	0.082
Near to canopy	***	**	**	***	***	***	0.143
Far from canopy	***	***	*	****	**	*	0.240

Note: Rows with the same superscript letters are not significantly different at $P < 0.05$, * are given when *P* values less than 0.05, ** are given when *P* values less than 0.01, and *** are given when *P* values less than 0.001

OC % organic carbon percent, *Total N%* total nitrogen, *Available P (ppm)* available phosphorus, *EC (dS/m)* electrical conductivity, *CEC meq/100 g* cation exchange capacity

Discussion

Impact of *O. abyssinica* and *D. melanoxylon* on soil properties

Organic carbon content was significantly ($P < 0.05$) higher under canopies of both trees than the outside canopy. It was higher by 33% and 57% under the canopies of the scattered *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* tree species, respectively, than an open field. The range of OC content (0.65–1.73%) in both species is often what is encountered in soils of the semiarid areas, which is > 1% (Bationo et al. 1993). This finding is in agreement with previous studies in different sites of Ethiopia, where Hailu et al. (2000) reported for *Millettia ferruginea*, Asfaw and Agren (2007) for *Millettia ferruginea* and *Cordia africana*, Kassa et al. (2010) for *Balanites aegyptiaca*, Manjur et al. (2014) for *Faidherbia abida* and *Croton macrostachyus*, Kewessa et al. (2015) for *Hypericum revolutum*, and Asaye (2017) for *Acacia tortilis*. This might be related to the higher leaf fall and litter decomposition from the tree species (Asaye and Zewdie 2013).

Total nitrogen was significantly ($P < 0.001$) affected by species and increased with increasing distance from the tree trunk of both species (Table 1). Total nitrogen concentration under the tree canopy of *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* was respectively higher by 117% and 86% as compared to the far distance canopy. This finding is in agreement with previous studies reported for different area of Ethiopia such as Hailu et al. (2000) for *Millettia ferruginea*, Yadessa et al. (2001) for *Cordia africana*, Asfaw and Agren (2007) for *Millettia ferruginea* and *Cordia africana,* and Berhe et al. (2013) for *Ficus thonningii.* This might have been resulted from the high organic matter inputs from fine root degeneration and litterfall followed by microbial activities under tree crowns (Manjur et al. 2014). Taking the average number of trees in parkland agroforestry as 20, if framers retain and/or plant *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* tree on their farmland they can respectively save about 23% and 12% inorganic fertilizer (urea).

Available phosphorus was significantly ($P < 0.001$) affected by distance from the tree trunk. It showed a decreasing trend with increasing distance from the tree trunk. It was 20% higher under the canopy of both trees than the open field. A similar study in other parts of Ethiopia such as Hailu et al. (2000) for *Millettia ferruginea*, Manjur et al. (2014) for *Faidherbia albida* and *Croton macrostachyus* tree, Asaye (2017) for *Acacia tortilis* trees reported higher available phosphorus under the canopy than the open cultivated land. The higher concentration of available phosphorus under the canopy of these tree species was likely due to increased leaf fall and biological activities (Belsky et al. 1989), which might facilitate the release of phosphorus from both organic matter and inorganic sources. Taking the average number of trees in parkland agroforestry as 20, if framers retain and/or plant *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* trees on their farmland they can respectively save about 4% and 3% inorganic fertilizer (DAP).

EC was lower by 12.5% and 21.4% under the tree canopy of *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* respectively as compared to the open field. The finding of the current study is consistent with that of Berhe et al. (2013) reported for *Ficus thonningii* in Ahferom district (in Tigray, Ethiopia). The lower soil EC under tree canopies might be due to increased above ground litter accumulation and associated cation uptake by the *Oxytenanthera abyssinica* and *Dalbergia melanoxylon* trees (Manjur et al. 2014).

The average soil cation exchange capacity was highly significantly ($P < 0.001$) affected by distance from the tree in *Oxytenanthera abyssinica* but not significantly different in *Dalbergia melanoxylon* tree. CEC content under both tree canopies was by 24% higher than that of an open field. A significant increase in soil CEC has also been reported by Hailu et al. (2000), Manjur et al. (2014) and Asaye (2017) in other parts of Ethiopia. This phenomenon could be due to higher organic matter accumulation at the tree bases (Jones 2001). According to these authors, with an increase in organic matter under the canopies of trees, the total negative charge of the soil increases, which in turn increases the CEC of the soil.

The soil pH values for the within the canopy (6.13) was lower than that of the open field (6.56) for *Oxytenanthera abyssinica* showing a decrease by 7.02% (Table 1). Unlike *Oxytenanthera abyssinica*, there was no significant difference in soil pH among the three distance zones of *Dalbergia melanoxylon* tree. According to Marx et al. (1999) and Sanchez et al. (1982), the generally lower soil pH values under the canopy as compared to open fields might be due to several mechanisms of the trees which release H^+ ions, such as soil base cation uptake (or depletion) by the tree, decomposition of organic matter to organic acids and carbon dioxide, root respiration, and nitrification (Rhoades 1996; Ballard 2000).

The C:N ratio under *Oxytenanthera abyssinica* trees was also lower than that of open field, implying improved availability of N to plants under the trees. The higher C to N ratio also indicates lower N availability to plants because of increased immobilization of N by micro-organisms (Handayanto et al. 1997). Results of the present study are in agreement with the findings of different authors elsewhere such as Enideg (2008) and Tadesse et al. (2000). For instance, Enideg (2008) reported a C to N ratio that increases with increasing distance from *Ficus thonninigii*. Yet, Hailu et al. (2000) observed lower C to N ratio under *Millettia* tree than in the open areas for both the surface and the subsurface soils.

Comparison of the impact of *O. abyssinica* and *D. melanoxylon* on soil properties

The soil OC, TN, AvP, and CEC under the canopy of *Oxytenanthera abyssinica* were significantly higher by 69%, 100%, 13%, and 42%, respectively, as compared to that under the canopy of *Dalbergia melanoxylon*. However, the soil reaction (pH) and EC were significantly lower by 19% and 57%, respectively, under the canopy of *Oxytenanthera abyssinica* than *Dalbergia melanoxylon*. For the C to N ratio, there was no significant difference between tree species. The soil OC, TN, AvP, and CEC near to canopy of *Oxytenanthera abyssinica* were significantly higher by 82%, 44%, 13%, and 58%, respectively, than that of *Dalbergia melanoxylon*. However, the soil reaction (pH) and EC were significantly lower by 14% and 58%, respectively, in near to the canopy of *Oxytenanthera abyssinica* than that of *Dalbergia melanoxylon*. The soil OC, TN, AvP, and CEC values for the open field were significantly higher by 100%, 71%, 13%, and 38%, respectively, than that of *Dalbergia melanoxylon*. However, the soil reaction (pH) and EC were significantly lower by 9% and 75%, respectively, in the respective open farm of *Oxytenanthera abyssinica* than that of *Dalbergia melanoxylon*.

Conclusions

Our results revealed that OC, AvP, TN, CEC, and pH for *Oxytenanthera abyssinica* and OC, AvP, and TN for *Dalberigia melanoxylon* were significantly higher under the canopy of the tree as compared to the open field. Hence, the management/growing of *Oxytenanthera abyssinica* and *Dalberigia melanoxylon* trees on small holder farms improve soil fertility. As compared to *Dalbergia melanoxylon*, *Oxytenanthera abyssinica* had a significantly higher contribution to soil property enhancement. Hence, retaining these species and in particular *Oxytenanthera abyssinica* on farms in the study area and elsewhere having similar biophysical profile is of paramount importance for soil fertility enhancement so as to improve food security of small farming households. Moreover, further study on soil microbial population associated with *Oxytenanthera abyssinica* and *Dalberigia melanoxylon* trees such as mycorrhizae and rhizobial associations and rooting systems is needed.

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Authors' contributions
YG, KT, TG, and EB designed the study. YG conducted the laboratory experiment. YG and KT analyzed the data. YG, KT, TG, ST, EB, GE, and EM wrote the manuscript. All authors read and approved the final manuscript.

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Please contact the author for data requests.

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Competing interests
The authors declare that they have no competing interests.

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