RESEARCH ARTICLE

Effect of *Eucalyptus* tree on selected soil physico-chemical properties in Gidami District, West Ethiopia

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The study was conducted in district of Gidami, western Oromia region, Ethiopia. The aim was to investigate effects of *Eucalyptus* tree (*Eucalyptus camaldulensis*) on soil physico-chemical properties. *Eucalyptus* is widely planted in farmland in the study area largely because of construction purpose and financial income. However, the cultivation of eucalyptus is becoming a major concern because of its long-term site impact. Long-term consequences have been observed, including drying up of water courses, effects on soil physico-chemical characteristics, ability to drain soil nutrients and fertility, suppression of other plants, forest biodiversity decline, and reduced agricultural yields in agroforestry systems. However, eucalyptus plantations on study area farmland are expanding regardless of its impacts on soil fertility and competition for crop land. On the other hand, human population is increasing from time to time and hence the demand for agricultural crop is increasing, however; the environment is degrading. Therefore, this study was conducted with the aim to study the effects of *Eucalyptus* tree on selected soil physico-chemical properties in Gidami District, West Ethiopia. For this study, Randomized Complete Block Design (RCBD) was used. Three farmers land 50 m by 50 m *Eucalyptus* plantation forest having similar age was selected, which served as experimental plot. Each experimental plot (farmland) was subdivided into 5 sub blocks. Then, sampling points (treatments) were randomly assigned to each block. Soil samples were collected by using auger at five different sampling points (at middle of canopy, 5 m, 10 m, 15 m and, 40 m distances) with two depths (0-15 cm and 15-30 cm). 10 soil samples were collected from each block and a total composite soil samples collected were 30. Each composite sample soil was prepared by mixing three sub samples. Soils sampled at 40 m distance were used as control group. Soil physico-chemical property analyses were conducted in Nekemt soil laboratory. The two ways ANOVAs were carried out by SAS version 9.0. The effects of *Eucalyptus* tree were insignificant on soil bulk density, exchangeable acidity, organic matter, exchangeable base, organic C, and Pat different distance, and pH with depth. Soil moisture, pH, CEC increased in further distance from the *Eucalyptus* trees. However, total N decreased as distance increased further from *Eucalyptus* tree. Surface soils (0-15 cm) were higher in total N, K, C, and organic matter than sub soil (15-30 cm) depth.

Keywords: Control group; Exotic tree; Experimental plot; *Eucalyptus* tree; Indigenous people; Physico-chemical properties; RCBD; Soil; Soil fertility

INTRODUCTION

Indigenous and peasant peoples have long planted trees, both in the global North and the global South. Some trees are sacred, while others provide delicious fruit, cooking oils, medicines, durable wood for building homes, and other tools and materials, among other things. People have planted exotic tree species, particularly since colonial times, when interaction and exchange of products across continents in the global South rose substantially. People planted a variety of native and alien species to provide a variety of benefits, and *Eucalyptus* became one of them. The first *Eucalyptus* plantations were established mostly following overexploitation of native forest. The plant kingdom produces few species as numerous or versatile as the *Eucalyptus*, which has over 500 kinds [1,2].

In Ethiopia, this tree was introduced in 1894/95 as cited in Albert, to alleviate the country's fuel and construction wood shortages, particularly in Addis Ababa, the countries new and rapidly growing capital city. Friis reported that in Ethiopia about 5-10 *Eucalyptus* species are planted across the country for multipurpose uses. According to Mulugeta Lemenih, *Eucalyptus* trees are commonly integrated into various agricultural systems in Ethiopia's highlands because they provide more economic benefits than agricultural land for crop production. According to Lemenih, *Eucalyptus* trees are commonly integrated into various agricultural systems in Ethiopia's highlands because they provide more economic benefits than agricultural land for crop production. In most parts of Ethiopia, *Eucalyptus* is now a distinctive element of the rural environment and a vital component of smallholder subsistence [3,4].

Ethiopia is now the country with the largest *Eucalyptus* plantation in East Africa, as well as one of the first countries to introduce the species. Currently, in this country, *Eucalyptus globules* (*Baargamoo adii*) and *Eucalyptus camadulensis* (*Baargamoo diimaa*) are the two most important commercial *Eucalyptus* species. *E. citriodora*, *E. regnans*, *E. saligna*, and *E. tereticornis* are however, the most widely distributed species.

Despite controversy, country reviews of the situation in India, Australia, Brazil, Argentina, Spain, China, South Africa, Ethiopia, Kenya, Uganda, Tanzania, and other countries showed that *Eucalyptus* planting has increased and by providing construction materials, fuel wood, poles, and farm timber it helped to raise people's living standards. Many poor farmers on terrain unsuitable for sustainable agriculture have benefited from eucalypt plantations, and in many developing nations, private planting was significantly more than that planted by government agencies or industry.

Socio-economic evaluations of *Eucalyptus* species, mainly on *E. globules* and *E. camadulensis*, have been carried out in Ethiopia. They found that planting the genus increased household income significantly more than growing agricultural crops, especially in areas where the indigenous woodland had been damaged and people were experiencing fuel shortages, water scarcity, erosion, and land degradation. In the country, *Eucalyptus* plantations have spread from state-owned plantations to community woodlots and home compounds. In the degraded and drier portions of Ethiopia, it has become the primary source of income. According to Asaye, *Eucalyptus* plantations provided at least 26% of total family income on average.

Currently, concerns about the probable detrimental effects of *Eucalyptus* on the environment began to be raised, leading to the prohibition of their planting on cropland, stream banks, and around catchment. Many of the

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criticisms, according to Davidson, are unjust, biased, nationalistic, or emotive. He pointed out that the criticisms could be applied to any alien tree species planted in many nations; not exclusive to eucalypts. On the one hand, the *Eucalyptus* genus is popular among farmers as a cash crop, but it is also blamed for a slew of problems, including the drying up of water courses, the suppression of other flora, erosion, and negative impacts on nutrient cycling and soil characteristics.

The purported harmful environmental effect of *Eucalyptus* is a worldwide problem; FAO sought to provide neutral perspectives by funding a number of global, regional, and country-level studies, such as Davidson and FAO. Growers, environmentalists, and researchers appear to be the three groups involved. Environmentalists, backed by agriculturists, underline the detrimental effect, whereas *Eucalyptus* growers definitely encourage its planting. The third groups, researchers, call for a careful and balanced assessment of the benefits and drawbacks. The primary arguments against *Eucalyptus* are that it depletes soil nutrients, drains water resources, aggravates soil erosion, suppresses undergrowth, and brings allelopathic effects. The arguments supporting the genus include: It is a fast growing tree, requires minimum care, grows in wide ecological zones and poor environments, coppices after harvest, resists environmental stress and diseases the seeds are easy to collect, store and no pre-sowing treatment is required.

On the other hand, Lane et al. found in China described that the expansion of *Eucalyptus* plantation on lands previously used for crops and occupied by indigenous trees and grass lowers water tables and reduces water availability for irrigation due to soil hydrophobicity (water repellency) and its deep and dense root network. The study conducted in Sudan by EI-Amin et al. reported that *Eucalyptus* caused crop output decline due to nutrient depletion and the formation of toxic exudates (allelochemicals). Cutting down of this tree for timber sales and fuel wood had exported nutrients from the plantation's soil system. However, the aforesaid authors did not clearly study the effects of *Eucalyptus* tree on soil moisture, cation exchange capacity and the relationship between selected soil physical properties and soil chemical properties.

In the study area (Gidami district), human population is increasing from time to time and hence the demand for agricultural crop is increasing however, the environment is degrading. Even though, in the area, *Eucalyptus* plantations on farmland are expanding regardless of its impacts on soil fertility and competition for farmlands no scientific data was available in the study area on the effects of *Eucalyptus* tree (*E. camaldulensis*) on selected soil physicochemical properties. Hence, the main goal of this study is to investigate the effects of *Eucalyptus* tree plantation (*E. camaldulensis*) on selected soil physico-chemical properties in the Gidami district, west Ethiopia. To study environmental impacts of *Eucalyptus* plantation on farmland and on soil physicochemical properties is important to give some guideline information to policy makers, land use planners, decision makers, Non-Governmental Organizations (NGO) and environmental protection agencies about existing effects of *Eucalyptus* plantation on soil physicochemical properties. This paper started by stressing the effects of *Eucalyptus* plantations on farmland and soil physico-chemical properties and followed by the methodology and main findings of the analysis.

MATERIALS AND METHODS

The study area's description

The study was conducted in Gidami district, west Ethiopia, which is located at 688 km west of Addis Ababa. Gidami district is geographically located between the coordinates of 8^0 38' 0" N to 9^0 12' 0" N Latitude and 34^0 10' 0" E to 34^0 42' 0" E longitude, altitude ranges 1500-2300 m.a.s.l. and it covers a total land size of about 219,031 ha due to its elevation differences, the traditional agro ecological zones of Dega (highland/cold), Woyna dega (middle/moderate), and Kolla respectively cover 8%, 75%, and 17% of the district. The maximum temperature ranges from 23°C to 26°C with an average annual temperature of 25.2°C and the lowest annual temperature ranges from 7.6°C-19.8°C with an average of 12.1°C. The district receives precipitation ranged between 941-1635 mm and uni-modal rainfall. The rain seasons are spring (March-May), summer (June-August) and autumn (September-November) (Figure 1).

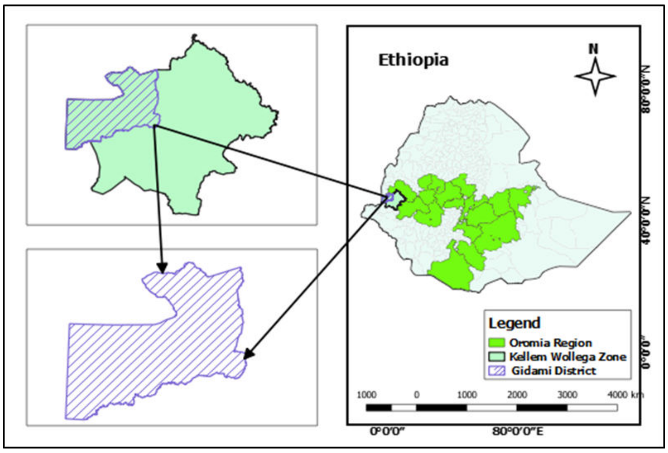

Figure 1) *Map of the study area*

Sample size determination and field experimental design

To conduct this study, three kebeles of Gidami district namely Kumbabi Shapi, Kellem and Mole were selected purposively. These sample kebeles were selected deliberately considering time, budget and the occurrences of abundant plantation of *Eucalyptus* trees in the area and therefore they can represent the other kebeles of the district. In addition to this, these kebeles are also nearly under similar biophysical conditions.

For this paper, to study soil physicochemical properties randomized complete block design was used with two treatments (distance and depth). Three experimental plots of 50 meter by 50 m *Eucalyptus* plantation forest were selected for the study. Each experimental plot (farmland) was subdivided into 5 sub blocks. The treatments (MC, 5 m, 10, 15 m, and 40 m) were randomly assigned to each sub block on the three farmers land. Each sub block has 10 raw *Eucalyptus* plantations with a spacing of 1 m by 1 m as shown below (Figure 2). Furthermore, from each block three *Eucalyptus* trees were selected randomly to be sampled. Eventually, by mixing three sub samples in a sub block one composite sample was prepared.

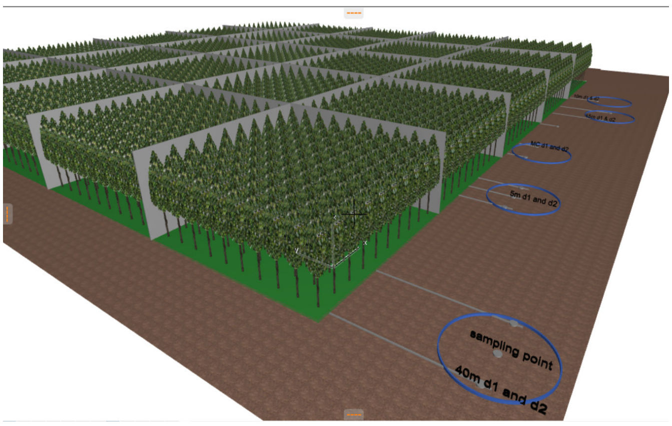

Figure 2) *Partial view of field layout*

Sampling method

To investigate the effects of *Eucalyptus* tree on soil physicochemical properties (bulk density, soil moisture, available phosphorus, total nitrogen, organic carbon, exchangeable base, cation exchange capacity, organic matter and exchangeable acidity), soil samples were collected by using screw auger at five different points from *Eucalyptus* tree. The sampling points were at middle of canopy, 5 m, 10 m, 15 m and, 40 m distances from *Eucalyptus* tree. After 1 to 2 cm of soil surface removed, soil samples were taken from two levels of soil depths (0-15 cm and 15-30 cm) using a core sampler with 5.4 cm diameter and 15 cm height by carefully inserting in to the soil. Finally, soil sample were taken on three farmers land and total of 30 composite soil samples were taken through mixing of 3 sub-samples from *Eucalyptus* plantation forest. Soil sampled at 40 m distances from *Eucalyptus* plantation were control group alike. The trees considered in the study had approximately similar age. And all farm lands selected for soil sample were cultivated similar crop previous years. The sampled soil was immediately packed by plastic bag and transported by using ice box to control moisture lose [5]. The analyses were conducted in Nekemt soil laboratory for the physicochemical property determination.

Soil sample laboratory analyses

Soil moisture: Gravimetric technique was used to determine soil moisture following Kolay. The collected soil samples were weighed by sensitive balance and then oven dried for 24 hours. Then, the oven dried soils removed and allow it to cool.

Eventually, oven-dry basis moisture content percentage was then computed by using the formula:

$$\frac{\text{Wt. of moist soil} - \text{Wt. of oven dried soil} * 100}{\text{Wt. of oven dried soil}}$$

Bulk Density (BD): The core technique, which is suggested for undisturbed soils, was used to estimate the bulk density of the soil. The soil beneath the core sampler was cut off and the earth around it was evacuated. A straight edge knife was used to cut and rinse both ends of the core sampler. The core sample was oven dried for 24 hours at 105°C to achieve a consistent weight. The BD of the soil was then calculated using the following formula:

Bulk density (g cm^{-3})=Wt. of soil core (oven-dry basis) (g)/Vol. of soil core (cm^{-3})

pH: A digital pH meter was used to determine the pH of the soil. The measurements were done using 1:2.5 ratio (soil/water) suspensions by transferring 10 g of air dried soil in to 100 mL beakers and adding 25 mL distilled water. After that, the samples were transferred to an automatic stirrer and swirled for 30 minutes before the pH was measured on the upper section of the suspension.

Phosphorus: Phosphorus extraction was made in accordance with Olsen et al. At a pH of 8.5, soil samples were extracted with sodium bicarbonate solution. 5 g of <2 mm sieved (accuracy 0.01 g) air dried soil sample placed in to a 250 mL polythene shaker bottle with two blanks and references samples. Also 100 mL $NaHCO_3$ was added, which was shaken for 30 minutes on a motorized shaker before being filtered through what man no. 42 filter paper. 3 mL of blanks and samples were added by pipette and swirled into 25 mL volumetric flasks, followed by 3 mL of mixed reagent. Then, using a spectrophotometer, the absorbance was measured at 882 or 720 nm.

Soil P (ppm or mg/kg soil)=(a-b) × 100/s × mcf

Where,

a=mg/L P in sample extract, b=mg/l P IN blank, s=Sample weight in gram (5 g), mcf=moisture correction factor and 100=mL of extracting solution

Organic carbon: In this study, we used titration technique to estimate soil organic matter. 0.4 g of air dried soil sample was transferred to a 500 mL Erlenmeyer flask and 10 mL of 1 N $K_2Cr_2O_7$ solution was added by pipette to both the sample and the blank. 20 mL of concentration of H_2SO_4 with graduated cylinder in a fume hood and shaker and then allowed to stand on the stopper for 30 min. 200 mL distilled water was added and allowed to cool. 10 mL conc. orthophosphoric acid and 0.5 mL barium diphenylamine sulfonate indicator were added, and the color was titrated with ferric sulfate solution from both the sample and the blank until it turned purple or blue. Then drip the ferric sulfate solution until it turns green then continues to the light green endpoint.

% C=N × (V1-V2)/S × 0.39

Where,

N=Normality of ferrous sulfate solution (from blank titration), V1=mL ferrous sulfate solution used for blank, V2=mL ferrous sulfate solution used for sample, S=Weight of air dry sample in gram. 3 × 10^{-3} × 100% × 1.3 (3=Equivalent weight of carbon). % Organic matter=1.724 × %carbon

Total Nitrogen (TN): Based on Bashour and Sayegh, total soil nitrogen content was determined using the Kjeldahl method of wet digestion procedure. 1 g of air-dried soil sample was weighed into 500 mL. Kjeldahl flask two blank solutions were included. 2 g catalyst mixture and 7 mL H_2SO_4 were added and swirled together, then the digestion tube stand with the samples was placed on the digestion block, and the tubes with rack and exhaust manifold were digested for 3 hours at 3800 and allowed to cool. After that, 50 mL of distilled water was added and the mixture was cooled once more. After washing with distilled water, the acid digest was transferred to macro-Kjeldahl flasks. 20 mL boric acid solution was measured from a dispenser into an Erlenmeyer flask that corresponded to the number of samples. 2 drop of indicator solution was added and placed under the condenser and 75 mL of 40% NaOH solution was poured down to the neck of the distillation flask containing the digests. And the solution was carefully mixed and fitted the digest-filled 250 mL Kjeldahl distillation flasks to the proper holder closed and distillated by heating. With the addition of a stirrer bar, the receiver flask solution was titrated with 0.1 N H_2SO_4 from green to pink. The magnet is transferred by means of magnetic rod to the next flask to be titrated.

Calculation

Let V be the volume of 0.1 N H_2SO_4 used after correcting for the blank

N × V=meq of N/g of soil

N × V × 14=mg of N per g of soil

N × V × 0.014=g of N per g of soil

%N=(a-b)/s × N × 0.014 × 100 × mcf

Where,

a=ml of H_2SO_4 required for titration of samples, b=ml of H_2SO_4 required for titration of blank, N=Normality of H_2SO_4 (0.1 N), 0.014=meq weight of nitrogen in gram and mcf=moisture correction factor.

Exchangeable base: We used ammonium acetate technique to estimate exchangeable base of soil. In a 250 mL beaker, a 5 g soil sample was inserted, and 100 mL of ammonium acetate 1 M pH 7.0 solutions was added. Soil samples were washed 8 times every 15 minutes with 25 mL of ammonium acetate. The volumetric flasks were then removed and refilled with distilled water.

Determination of exchangeable K and Na by flame photometer: The original ammonium acetate leachate and the standard into flame and the transmittances of K and Na were measured at wavelength of 768 and 598 nm respectively.

Determination of Ca and Mg by EDTA method: In a 250 mL Erlenmeyer flask, 10 mL of the ammonium acetate soil extract obtained from the exchangeable bases extraction was added, followed by 40 mL of distilled water to bring the volume up to 50 mL. A 2 mL KCN solution was added, and the solution was buffered to a pH of 10. A pinch of Eriochrome black T and a NaCl solution were also added. The extract solution was eventually titrated to a pure turquoise blue without any traces of red using 0.02 EDTA disodium salt.

Exchangeable acidity: In a funnel set in a 100 mL volumetric flask, 10 g fine earth was transferred to dry filter paper. Two blanks were included. 10 portions of 10 mL and 1 M KCl solution were added with 15 minutes interval to percolate soils. It takes two and half hours. The funnel was withdrawn when the last percolation was completed, and the volumetric flask was filled with 1 M KCl solution and homogenized. After adding 5 drops of phenolphthalein solution titrated with 0.02 M NaOH, a 25 mL aliquot was percolated into a 250 Erlenmeyer flask and then the color turns pink. 25 mL of aliquot of percolate into a 250 Erlenmeyer flask and 5 drop of phenolphthalein solution titrated with 0.02 M NaOH the color turns to pink.

Method of data analysis

After laboratory analyses completed, obtained data were subjected to statistical analysis. ANOVA was carried out by using SAS software version 9.

RESULTS AND DISCUSSION

The effect of *Eucalyptus* tree on soil physical properties

Soil moisture: For the moisture content in the study area significant difference were observed in distance and depth. The mean values are in upward trends from *Eucalyptus* tree for the effects as shown in Table 1. The moisture content at the middle of canopy, 5 m, and 10 meter distance were significantly less than the moisture content at 15 and 40 m distance from *Eucalyptus* tree ($p<0.05$). The moisture content at the middle canopy was significantly less than the moisture content at 10 m, 15 m, and 40 m distance. The moisture content at 5 m distance were significantly less than the moisture content at 15 m and 40 m distance. And also the moisture content at 10 m distances were less than the moisture content at 15 m and 40 m distance from *Eucalyptus* tree. From *Eucalyptus* tree variation was not significant in soil moisture content at 15 m and 40 m distance. The moisture content at middle of canopy and 5 m insignificant difference were observed.

TABLE 1
Soil moisture content means for the interaction of distance and depth

Treatment	Distance from the tree (meter)				
	MC	5	10	15	40
0-15 cm	7.94000[de]	18.6666[bcde]	23.68666[bc]	34.04333[a]	44.87333[a]
15-30 cm	6.89000[e]	14.3633[cde]	24.2566[bcd]	33.78333[a]	44.20333[a]
Mean			27.64467		
CV (%)			16.95191		
LSD			5.6843		

Note: Results connected by the similar later are not significantly different to other each at α<0.05

Moisture content analysis of sampled soil were significant at ($p<0.01$) between all five distances from *Eucalyptus* tree. The soil moisture content was increased when far from *Eucalyptus* tree as in shown below (Table 2).

In the study area soil moisture content has the following order, moisture content at middle of canopy <5 m, 10<15<40 m.

TABLE 2
The mean % soil moisture content along distance from the

No	Treatment	% soil moisture content
1	MC	7.415[c]
2	5 m	16.515[d]
3	10 m	23.972[b]
4	15 m	33.763[a]
5	40 m	34.558[a]
	Mean	27.64467
	CV (%)	16.95191
	LSD	5.6843

Note: Results connected by the similar later are not significantly different to each other at α<0.05

Soil moisture at the middle of canopy were significantly less than the moisture content at 5 m, 10 m, 15 m, and 40 m distance from *Eucalyptus* tree. However, percent of soil moisture were insignificant ($p<0.05$) in the two depth (0-15 and 15-30 cm). In the other words soil moisture content on surface and sub soil was almost similar.

In the study area, soil moisture increases with distances and interaction of distance and depth from *Eucalyptus* tree [6]. Significant difference was detected but not for the depth. Soil moisture under the middle of canopy and 5 m was significantly lower than soil moisture contents at 10 m, 15 m and, 40 m distances for the interaction effect of distance and depth. Furthermore soil moistures at 10 m distance were less than soil moisture at 15 m and 40 m distance from *Eucalyptus* tree. As the distance increased from *Eucalyptus* tree soil moisture increased significantly up to 15 m. This might occur due to high root density which may cause high water harvesting ability of *Eucalyptus* for fast growth. The water absorption capacity of *Eucalyptus* species must vary with the type of root system; with some species having shallow roots while others are more rooted. *Eucalyptus* species have been shown to adapt their consumption to the availability of water. Lima cited in FAO reported that structure of the root system and the depth of root penetration is the main factors determine soil water absorption. Jagger and Pender reported as *Eucalyptus* extracts 5 times more water from the 0-150 cm than mustard.

It was observed that at a distance of 10 m from *Eucalyptus*, mustard yield was reduced by 47% and wheat yield by 3%. According to Cao et al., cited in Albert, soil moisture in the topsoil (0-10 cm depth) of four *Eucalyptus* species planting regions in China was low, ranging from 20.2 to 30.5%. The effect on soil water content is the most contentious water-related issue associated with *Eucalyptus* plants. *Eucalyptus* trees claimed that it absorb more water from the soil than any other tree type. In agreement with Tilashwork, moisture content was considerably lower at the end of the wet monsoon period than moisture content further away from the *Eucalyptus* tree (p=0.01). This trend was not detected in *Croton macrostachyus*, which showed no significant variation in moisture content as distance from the trees increased. Surprisingly, moisture content near the *Eucalyptus* stand did not differ statistically from moisture content near the *C. macrostachyus* stands at distances of 15 m and beyond. In the winter and spring at the Berg river catchment in the Western Cape Province of South Africa, Tererai et al., found that sites colonized by E. camadulensis significantly reduced soil moisture compared to un-colonized sites in riparian soils.

Bulk Density (BD): Significant variation was observed (p>0.05) when soil BD compared at different distances, depth, and interaction effect of distance and depth. BD under the middle of canopy, 5 m, 10 m, 15 m, and 40 m distance were in low range (1.0–1.3 gcm^{-3}). BD for surface soil layer (0-15 cm) and sub soil (15-30 cm) were 1.115333 gcm^{-3} and 1.142667 gcm-3, respectively which were low in range [7]. According to Birru et al., there was no significant variation in BD (gcm^{-3}) between different land uses for soil depth of 0-20 cm and 20-40 cm. However, in absolute value, arable land had the greatest BD of 1.11 gcm^{-3} and 1.24 gcm^{-3} in 0-20 and 20-40 cm soil layers, respectively. In addition to this, study made by Tilashwork et al. on Koga irrigation watershed also found that soil BD at all depths and distances from *E. camadulensis* and *C. macrostachyus* stands is low, ranging from 1.0 to 1.1 g cm^{-3}. For *Eucalyptus* spp. plantations in Australia, FAO observed an increase in soil BD from 0.58 mg m^{-3} to 0.70 mg m^{-3}. This is in line with Fekadu et al., who showed that BD did not show significant variation between different land uses and soil depths in the Wondo Gent area of Ethiopia, with a range of (0.93-1.07 g cm^{-3}).

The BDs of soils under *Eucalyptus* woodlots and soils under land use conversion from *Eucalyptus* to croplands were similar; both had lower BDs than arable land at both soil levels [8]. In contrary, in Brazil, Ravina found that *Eucalyptus* species plantation (1.24 g cm^{-3}) had a greater soil BD (1.24 g cm^{-3}) than native forest (0.66 g cm^{-3}) in the 0-20 cm soil layer.

The effect of *Eucalyptus globules* tree on soil chemical properties

Soil pH (H_2O): In the study area, the soil pH was showed significant variation (p<0.05) with distance to the *Eucalyptus* stand. In general, pH increases with distance from *Eucalyptus* tree (Table 3). PH was insignificant for soil depth and interaction of distance and depth at (p<0.05). But the top soil layer (0-15 cm) has lower pH than soil sub layer (15-30 cm) and moderately acidic. In the study area, soils under the middle of canopy (acidic) were significantly different from soil sampled at 5 m, 10 m, and 40 m distance (moderately acidic) [9]. Regarding soil chemical properties soil pH increased with distance from *Eucalyptus* trees. Soils under the middle of canopy were acidic; this may be due to release of certain chemicals through litter fall.

TABLE 3

The means value of pH (H_2O) in soil along distance from the tree

No	Treatment	pH-value
1	Mc	4.97833^{c}
2	5 m	5.16500^{ab}
3	10 m	5.1883a^{b}
4	15 m	5.21000^{a}
5	40 m	5.25667^{a}
	Mean	5.135667
	CV (%)	2.494125
	LSD	0.1554

Note: Means with similar later are not significantly different from each other α<0.05

Because of root activity, decomposition of organic matter, nitrification, and other processes, soils are exceedingly diverse, with substantial pH fluctuations over short distances, according to Robson and Abbott, as mentioned in Birru et al. Similarly, studies conducted by found that *Eucalyptus* leaves have phenolic acids, tannins and flavonoids.

Although the soil under *Eucalyptus* had a lower pH (5.20) and higher exchangeable acidity (0.78) than land converted from *Eucalyptus* to cropland (5.41 pH and 0.60 c mlc kg^{-1} EA value), land converted from cultivated land, *Eucalyptus* plantation, and *Eucalyptus* woodlots to croplands had acidity. When compared to soil under *Eucalyptus* land cover, the land uses changed to farmland showed an improvement in soil pH of 0.29 units and a reduction in exchangeable acidity of 0.12 c mol kg^{-1}, despite the fact that the pH of the area is recognized as acidic. In agreement with Albert, the pH of the soils in the *Eucalyptus* plantation (which were severely acidic) was much lower than that of the soil in the Native forest (medium acidic) [10]. This is supported by Aweto and Moleele's findings in Botswana, who found that soil pH under *E. camaldulensis* was significantly lower than that of native Acacia forest in soil depths of 0-10 and 10-20 cm. The lower pH in *Eucalyptus* tree could be attributed to the tree's strong cation uptake and elimination of cations due to frequent tree harvesting. According to Binkley et al., intensive management practices such as frequent harvesting of high nutrient content aboveground biomass can reduce the all soil nutrients availability and cause soil acidification. In disagreement with Baber et al., as distance increased from *Eucalyptus* tree pH increased with distance in subsoil (15-45 cm) but surface soil were basic in nature.

Exchangeable acidity: The analysis of the exchangeable acidity of soil samples showed that there were no significance differences with distance, depth and their interaction effect at (p<0.05) in all soil samples. In contrast, Zerfu reported that sites with *Eucalyptus* tree species plantation indicated high level of active acidity or low pH as compared to farm land. But in the study area the exchangeable acidity decreased as distances increased from *Eucalyptus* tree. However, the sub soil samples have higher exchangeable acidity than surface soil samples. On the other hand, Birru reported as no significant difference was observed between exchangeable acidity of land uses (cultivated land, *Eucalyptus* plantation and *Eucalyptus* woodlots) converted to crop land.

Exchangeable bases: Laboratory analysis result of exchangeable base such as: Ca^{++}, Mg^{++}, and Na^{+} were indicating no significance difference (p<0.05) in all the distance and depth and also for the interaction effect. But the mean values are in upward trend with distance from *Eucalyptus* trees. In other words, the concentration of Ca^{++}, Mg^{++}, and Na^{+} increased as distance further from *Eucalyptus* tree. The concentration of Na in soil at different distances, under the middle of canopy, 5 m, 10 m, 15 m, and 40 m distance were, 1.27, 1.13, 1.5, 1.40, and 1.60 (c mol (+)/kg) respectively. The concentrations of Na increase with distances from the tree. But the concentration of Na in 0-15 cm soil layer was higher than that of 15-30 cm soil depth, mean value of 1.47, and 1.27 (c mol (+)/kg) for surface (0-15cm) and sub soil (15-30cm) respectively. Generally, the concentration of Na both with distance and depth were belong high range when compared with standards (0.7–2.0 (c mol (+)/kg). The concentrations of Ca^{++} in all distance were in medium range (5–10) except 40 m distance in high range (10–20). The concentration of Mg^{++} in all distance were in very high range (>8) when compared with standard value [11].

Unlike the other cations K were significant in depth ($p<0.05$). But the mean values of distance and depth were in high range (0.7–2.0) (Table 4). The concentration of K^+ in soil depth of 0-15 cm and 15-30 cm were 1.7200 and 1.45333 ppm respectively. The concentrations of K with depth were significantly different, the distribution of K on surface soils (0-15 cm) was higher than sub soils (15-30 cm) but both mean values are in high range when compared with standards.

TABLE 4

The means concentration of K^+ in soil depth

No	Treatment	Conc. K^+ (ppm)
1	0-15 cm	1.72000^a
2	15-30 cm	1.45333^b
	Mean	1.586667
	CV (%)	16.44391
	LSD	0.3165

Note: Results connected by the similar later are not significantly different to each other at α <0.05.

This variation might be due to addition of k through litter fall on surface soil (0-15 cm). Lemma et al. found that afforesting farmland with exotic trees increased exchangeable K^+, in surface soils. Nutrients strongly cycled by plant such as P and K, were more concentrated in top soil under 20 cm than nutrients usually less limited for plant such as Na and Cl.

According to Sangiga and Switt reported that in the miombo woodland no effect of depth was observed for K, whereas the amount of K decreased in the *Eucalyptus* stand with depth. Fisher studied the influence of eleven distinct plantation species on soil accessible K over four years on grazing land in Costa Rica, and found that four species (*Pithecellobium macradenium*, *S. microstachyum*, *Virolakoschnyi* and *Vochysia guatemalensis*) showed a considerable increase in soil available K. In disagreement with these, Aweto and Moleele showed reduced exchangeable nutrient cation content for soil under *Eucalyptus* species plantation in both the 0-10 and 10–20 cm soil layers in Gaborone, South Eastern Botswana [12]. In contrast, Baber et al., found that K concentration increased with increased distance from *Eucalyptus* tree in subsoil (15-45 cm). The other reason for lower K content in sub soil (15-30 cm) might be high nutrient up take by crop from subsoil (15-30 cm).

Cation Exchange Capacity (CEC): The calculated CEC were significant ($p<0.05$) with distance from Eucalyptus tree. But CEC were insignificant ($p<0.05$) for soil depth and their interaction (Table 5).

TABLE 5

The means value of CEC in soil along distance from the tree

No	Treatment	CEC (c mol/kg
1	Mc	23.450^a
2	5 m	18.183^b
3	10 m	27.717^a
4	15 m	25.333^a
5	40 m	29.283^a
	Mean	24.79333
	CV (%)	22.88352
	LSD	6.8819

Note: Results connected by the similar later are not significantly different to each other at α <0.05.

The CEC, under the middle of canopy and at 5 m, were in moderate range (12–25 c mol kg^{-1}). While at 10 m, 15 m, and 40 m were in high range (25–40 c mol kg^{-1}) when compared with standard. The mean value of cation exchange capacity increased with distance from *Eucalyptus* tree. Cation exchange capacities at 5 m distance were significantly ($p<0.5$) lower than MC, 10 m, 15 m and 40 m distance.

The calculated cation exchange capacity was significantly different with distance from *Eucalyptus* trees. As expected the calculated cation exchange capacity increased with distance from *Eucalyptus* tree. The first reason might be high nutrient up take by *Eucalyptus* and poor nutrient content of litter fall made lower nutrient closer to the *Eucalyptus* trees [13]. According to the FAO, all fast-growing tree crops deplete the nutrients on a site, regardless of whether they are leguminous or not. In Senegal, Jaiyebo discovered a lower concentration of exchangeable bases in *Eucalyptus* species plantations.

The second reason for increasing of CEC might be increased in soil pH due to lower allellophatic effects with distance which may lower the accumulation of total exchangeable acidity and increased basic cations. Low soil pH leads to low soil base saturation. The abundance of positive charges in the soils beneath *Eucalyptus* has grown despite the increased soil organic matter level. Because of the loss in cation retention capacity, as well as the likelihood of an increase in the specific adsorption of anions such as phosphate and sulfate, such a pattern may have an impact on soil quality. According to Bailey et al., as cited in Albert, acidification causes the depletion of soil base cations (e.g., K^+, Mg^{2+}, Ca^{2+}) due to the replacement of the basic cations at the exchange site by Al^{3+} and H^+ ions.

The third reason might be lower soil colloid that adsorption basic cation due to lower decomposition of organic matter under the tree this may occur due to shading and allelopathic effects of Eucalyptus tree. Ravina reported that humus compounds, which are separated into humic and fulvic acids, and humins, which comprise nitrogen, sulphur, and phosphorus bound in the form of organic, dominate the composition of the SOM. When compared to non-humic components such as cellulose, hemicelluloses, proteins, and lipids, the chemical makeup of these will result in a slower decomposition rate due to their stability [14]. Monoculture plantation forestry can affect soil chemical characteristics in two ways: Depletion of nutrients from the soil into tree components, and changes in chemical status of the soil surface when the litter layer and organic matter become dominated by one species. Birru et al., reported that statistically there was no significant variation (P >0.05) between CEC of different land uses. Similarly, Lalisa et al., reported that no significant variation was observed among CEC of the different land uses in the central highlands of Ethiopia. This was also consistent with Yechale and Solomon who reported that statistically no significant variation between CEC of soils among the different land uses studied in the Hare river watershed, Ethiopia.

Soil organic carbon: As the soil analysis results indicated that there was highly significant variation (p<0.05) in soil organic carbon at the soil layers of 0-15 and 15-30 cm (Table 6).

TABLE 6
The means value of % organic C content in soil depth

No	Treatment	% organic carbon
1	0-15 cm	2.04000[a]
2	15-30 cm	1.64000[b]
	Mean	1.84
	CV (%)	13.37393
	LSD	0.2985

But with the distances and interaction of distance with depth soil organic carbon were insignificant (p<0.05). All the mean values along distances from the trees were moderate in range (1.60–1.79%) in Soil Organic Carbon (SOC) and very high range (1.72–2.14%) organic carbon content for soil depth. The organic carbon in surface soil was higher than subsoil.

SOC contents in the study area were significantly different for different soil depths. The content of organic carbon in soil was 2.04 and 1.64 % on surface (0-15 cm) and sub soil (15-30 cm) respectively. The organic carbons on surface soil were higher than sub soil; this might be due to litter fall from *Eucalyptus* and crop residue which may cause an increased SOC. Study conducted in Swaziland by Singwane and Malinga found that Soil Organic Matter (SOM) and Soil Organic Carbon (SOC) content are strongly related to the soil beneath *Pinus* and *Eucalyptus* plantations. According to Ravina et al., the carbon content of SOM is typically around 50%.

Organic matter: From organic carbon, organic matter was calculated. The analyses of organic matter showed insignificant difference (p<0.05) for distance and interaction effects of distance and depth [15]. But the all the mean values of organic matter insignificantly decreases as distance far from *Eucalyptus* tree. Similarly, Tilashwork found that *Eucalyptus* did not significantly affect soil organic matter content over a long distance. Organic matter on surface soil (0-15 cm) were significantly different (p<0.05) from subsoil (15-30 cm) (Table 7).

TABLE 7
The means value of %organic matter content in soil depth

No	Treatment	% organic matter
1	0-15	3.5173[a]
2	15-30	2.8273[b]
	Mean	3.172333
	CV (%)	13.37599
	LSD	0.2985

Note: Results connected by the similar later are not significantly different to each at α<0.05.

In disagreement with Baber et al. discussed soil organic matter decreased as distance increased from the *Eucalyptus* tree. Fernando et al., on the other hand, found that SOM levels were substantially greater in *Eucalyptus*-dominated soils than in pastures. One of the main causes is the vast number of forest residues (leaves, branches, bark, and especially roots) left in the area.

Calculated organic matter on surface soil (0-15 cm) were significantly lower than (p<0.05) sub soil (15-30 cm) in depth. In the study area organic matters on surface soil (0-15 cm) were higher. The reason might be due to addition of organic matter on surface soil (0-15 cm) through litter fall and crop residue. Agree with Birru et al., the largest amount of organic matter (3.65%) was found in the soil layer of 0-20 cm, followed by 3.07% at 20-40 cm soil layer and 2.71% at soil depth of 40-60 cm. Similarly, Lelisa et al. also reported that with increasing soil depth the organic carbon content was found to be lower for homestead, cereal farm and w oodlots (using *Eucalyptus* soil). It is clear that topsoil has large accumulations of organic matter, where large amounts of root biomass and other plant debris can be found [16]. This was also confirmed by Muluneh as cited in Birru who reported that with increasing soil depth down soil under *Eucalyptus* showed a decrease in SOM (study made at Jufi site of Achefer district, Ethiopia).

Phosphorus: The available phosphorus content of all soil samples were in low range (5-7 mg kg^{-1}). The analysis of phosphorus showed that insignificant (p<0.05) difference were observed in distance, depth and their interaction effects. All means p are similar with distance from *Eucalyptus* tree except at 40 m distance with the value of 7%. In disagreement with Tilashwork, in this study, the estimated available P content was in the very low range (less than 5 mg kg^{-1}). The increase with distance from the *Eucalyptus* stand reveals a very big difference (P 0.001) in one-way ANOVA.

Soil total N: The TN recorded was in dawn ward trend with distance from *Eucalyptus* tree (Table 8). The total nitrogen concentration at the MC, 5 m, 10 m, 15 m and 40 m distance were in medium range (0.15–0.25%) when compared with the standard. At 40 m distance % total N were significantly different ($p<0.05$) from MC, 5 m, 10 m, and 15 m distance [17]. The means % total N were lowest at 40 m distance while between the other mean values insignificance difference ($p<0.05$) were observed.

TABLE 8

The % of total N means value in soil along distance from *Eucalyptus globules* tree

No	Treatment	% total N
1	Mc	0.24500[a]
2	5 m	0.23667[a]
3	10 m	0.21000[a]
4	15 m	0.21000[a]
5	40 m	0.15500[a]
	Mean	0.215
	CV (%)	17.2086
	LSD	0.0449

Note: Results connected by the similar later are not significantly different to each at α<0.05

The total N content of soil in the study area decreased with distance from *Eucalyptus* tree. In the study area the % of total nitrogen content of soil at 40 m distance were lower than from middle of canopy, 5 m, 10 m, and 15 m distance and total N contents at 40 m distance were low in range. The reason might be less addition of organic matter from crop residue than *Eucalyptus* tree this made soil lower in organic matter at 40 m distance. Overall, due to the increased amount of soil litter such as foliage, branches, and roots, forest systems have more soil organic matter than agricultural systems. The total N content of soil might be depends on organic matter addition. According to Ravina organic matter is source of nitrogen, phosphorus sulfur and potassium. While at the middle of canopy, 5 m, 10, and 15 distances addition of organic matter were observed but decreased with distance. The reason might be less nutrient up take of crops due to allellophatic effects closer to *Eucalyptus*. According to Ravina the allopathic effect of *Eucalyptus* decreased so that cereal crops may take-up high amount of N. The second reason for the increase in total N in *Eucalyptus* trees could be the existence of more organic matter in the topsoil, whereas the low N content in cropland could be due to the high rate of decomposition on the surface soil of the plow and more N absorption of cereal crops. According to the above author, the third reason for the high N content in *Eucalyptus* woodlots could be related to low temperature and limited radiation reaching the soil surface, resulting in low NH_3-N volatilization [18].

Under *Eucalyptus* in the study area the reason might be less nutrient up take from surface soil (0-15 cm) due to the older age *Eucalyptus* developed tap root system take nutrient deeper. According to Selamyhun, cited in Birru et al., fine roots (10 mm diameter) accounted for 80% of total root mass per unit area after eight years, and they mostly extend to >20 m of lateral distance and a depth of 60–100 cm in adjacent croplands in the Nit soils of Ethiopia's central highlands. Similarly, Tilashwork found that as the distance from the *Eucalyptus* stand increased, so did the soil macronutrient status. Cupressus and *Eucalyptus* soils were determined to have the lowest nutrient concentration in general (mainly low nitrogen). Alemie also found that in Ethiopia soil total N concentration decreased under *Eucalyptus* species plantations. Lisanework and Michelsen provide empirical evidence that depletion of soil nutrient under Cupressus and *E. globulus* is compared to indigenous juniper and natural forest soils [19].

The percentage (%) of total N contents of surface soil (0-15 cm) were showed significant variation ($p<0.05$) from sub soil depth (15-30 cm). The% total N content for both depth (0-15 and 15-30 cm) were in medium range. % Total N content on surface soil was higher than subsoil in the study area (Table 9).

TABLE 9

The means value of % total N content in soil depth

No	Treatment	% total N
1	0-15 cm	0.24733[a]
2	15-30 cm	0.18267[b]
	Mean	0.215
	CV (%)	17.2086
	LSD	0.0284

Note: Results connected by the similar later are not significantly different to each at α <0.05

There was high N content on surface soil (0-15 cm) than sub soil (15-30 cm). More N in the topsoil under *Eucalyptus* trees could be attributed to a considerable amount of root biomass in deeper or subsurface soil layers, as well as the addition of organic matter through crop residues at a greater distance. Davidson also revealed that a significant proportion of plant nutrients are contained in foliage that is periodically returned to the soil. The other reason might be leftover of N from fertilizer application. Lemma et al. found that afforesting farmland with exotic trees increased total N, in surface soil in Belete forest, which is part of government afforestation programme [20].

Relationship between selected soil physicochemical properties: Correlation analysis was done to establish relationship between the selected soil physico-chemical properties. The preason correlations between organic matter and soil bulk density is about -0.4692, which indicate that there is moderate negative relationship between variables. The correlation between organic matter and pH is 0.5467, the relationship between these variables is moderately positive, which indicates that, as organic matter increased, PH increased and bulk density decreased. The correlation between CEC and exchangeable acidity is -0.2819 which indicates that there is weak negative relationship between CEC and exchangeable acidity. As exchangeable acidity increased CEC decreased. The correlation between organic matter and total N is 0.2455, which indicates that there is weak positive relationship between the variables as organic matter addition increased total N content of soil increased.

CONCLUSION

The experimental finding on effects of *Eucalyptus* tree on soil physicochemical properties in the study area showed that due to *Eucalyptus* plantation on farm land, soil physico-chemical properties such as soil bulk density, organic matter (distance), organic carbon (distance), exchangeable base (Ca^{++}, Mg^{++}, Na^{+}, K^{+}) and phosphorus did not vary within soil in the study area whereas soil moisture, pH, and CEC increase significantly along distance from *Eucalyptus tree*. The total N significantly decrease further from Eucalyptus tree and K^{+}, organic matter, and organic carbon significantly lower in sub soil (15-30) than surface soil (0-15cm).

From the perspective of research findings the following recommendations are conveyed. *Eucalyptus* species should not be planted near farm area to guarantee environmental sustainability and food security. It is preferable to conduct additional research in order to identify less resource-intensive *Eucalyptus* species. Moreover, most of the controversy over *Eucalyptus* trees is due to the lack of universality of data and information available regarding all aspects of the *Eucalyptus* tree. The ecological, economic and social aspects, both positive and negative, must be widely disseminated. As many studies have shown that the net contribution of *Eucalyptus* to soil through litter fall is likely to be positive on degraded hillsides and wastelands. *Eucalyptus* trees also have good potential for retaining topsoil on degraded sloppy areas; it is better to plant *Eucalyptus* on hillside and degraded land. Currently, Ethiopia has established policy concerning the plantation forest, Gidami district agricultural office should implement the policy and discourage *Eucalyptus* plantation, and initiate planting of multipurpose trees and maintain food security and environmental sustainability. Research should be conducted on agricultural crop that resist effect and/or adapt adverse impact of *Eucalyptus* trees. According to reviewed literatures Eucalyptus have so many problems not only on soil physico-chemical properties but also on crop productivity. Crop production near *Eucalyptus* plantation forest decreased due to is allellopathic effects in many regions including in Ethiopia. According to many literatures and experimental results, it has been clearly shown that in order to sustain and improve the physico-chemical properties of the soil in *Eucalyptus* forests, the nutrient balance must be strictly controlled, mainly through lightly planting, fertilizing, silvicultural treatment, and liming and crop residue management to prevent depletion of soil nutrient and plant deficiency.

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