Research Article

Effect of Eucalyptus Globules Woodlot Plantation on Selected Soil Physico-Chemical Properties and Wheat Yield in Wogera District, Amhara Region, Ethiopia

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Abstract

Currently, a Eucalyptus globule is a common smallholder plantation species in the Wogera district. The species is significantly expanding on marginal and fertile farmlands. The objective is to analyze the effects of Eucalyptus globules woodlots plantation and their directions on selected soil physicochemical properties and yield of wheat crop. Three woodlots with similar site conditions were selected for this particular study. Soil samples were taken at a soil depth of 20 cm in RCBD design with three replications. Soil samples were taken at four directions (East, West, South, and North) of woodlots plantation at five different horizontal distances from the woodlots; the center of the woodlot, 5 m, 10 m, 15 m, and 40 m. For the wheat yield study: Quadrates of 1 m^2 area at each distance within directions were laid for wheat grain yield measurement. The finding indicated that electric conductivity, available phosphorus, cation exchange capacity, soil texture, and exchangeable cations were not significantly different across the different directions and distances, whereas soil bulk density, pH, total nitrogen, organic matter were significantly different. This could be attributed to the high organic matter addition via litter-fall, root biomass, uptake, and return of nutrients from deeper soil profiles under the tree canopies. The biomass and grain yield of wheat were significantly different across distance and direction from the sampled woodlot in increasing trend in all directions, this study recommends Eucalyptus should planting on marginal lands with appropriate distance from croplands about 20 m to minimize its effect on crop yields.

Keywords

Eucalyptus, Soil properties, Wheat, Distance, Direction

Introduction

The *Eucalyptus* is the diverse genus of flowering plants in the globe. It belongs to the family Myrtaceae and comprises about 800 species [1]. Worldwide area coverage of *Eucalyptus* plantation was estimated at about 17.9 million hectares [2]. The species was introduced to East Africa in the late 19th century and by the early 1970s. Currently, *Eucalyptus* plantation covers about 12 million hectares overall in the tropical zone. In Ethiopia, *Eucalyptus* was introduced during the regime of Emperor Menilek II (1868-1907) in 1894/95 [3]. The purpose was to supply fuel wood and construction timber to the new and growing capital city, Addis Ababa. Currently, about 5 to 10 *Eucalyptus* species are commonly established for multipurpose uses [4]. *Eucalyptus globules* species are commonly planted on wide areas of land previously cultivated to crop production. Currently, an estimated area of 500.000 ha of the land is covered by *Eucalyptus* plantation in Ethiopia [5]. Among these, *Eucalyptus globules* plantations cover more than 100,000 ha that growing well at elevations ranging from 1400-3200 m.a.s.l. The major energetic factors that farmers to

grown *Eucalyptus* are: Increasing demand for wood products in the market, high-income generation, high rate of biomass production, easy to establish, adaptability on infertile soils [6]. Farmers' increased their concentration in *Eucalyptus* plantation which caused the conversion of croplands into *Eucalyptus* plantation [7] However, the unrestrained expansion of *Eucalyptus* on productive croplands has a great alarm, due to the detrimental effects on soil productivity. E*ucalyptus* tree might cause crop yield loss through extract

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essential nutrients and compete with crops and impoverish the soil [8].

In recent years, the expansion of *Eucalyptus globules* plantation on and around the cropland is expanding from year to year in an alarming rate especially in northern Ethiopia highlands including the present study area. Increasing plantations would create competition among land area of crops and *Eucalyptus globules* woodlot plantations. Similar trends of replacement of cropland with *Eucalyptus* woodlots have been observed across Ethiopian highlands [4]. Reports showed that *Eucalyptus* trees change watercourses, soil physical and chemical properties, propensity to exhaust soil nutrients, and fertility eventually affects crop production and productivity [9]. However, the effects of *Eucalyptus* species on soil physical and chemical properties and exhaustion of the soil essential nutrients still remain unclear [10] and scientific reports are insufficient [6]. Therefore, additional documentation on the specific effects of *Eucalyptus globules* plantations in relation to crop yield and soil properties in the district is required. Thus, this study was undertaken with the aim to analyze the effects of *Eucalyptus globules* plantation on soil selected properties and wheat crop yield performances that grown neighboring to plantations. The results of the study can effectively create awareness for the community concerning specific effects of *Eucalyptus globules tree* species on crop performance and soil properties.

Materials and Methods

Description of the study area

The study was conducted in the Wogera district, it geographically situated at 12°46'06.5"N and 37°37'26.5"E in the North Gondar Zone of the Amhara region (Figure 1). It is situated about 32 km away from Gondar town and 213 km Northwest of Bahir Dar, the capital city of the Amhara region. The District covers an estimated area of 1821 km². According to the Amhara Finance and Economic Development Bureau, 2012 the District has a total population of 250,493 out of this 127,858 are males and 122,635 are females, from the total population 94% live in rural areas, the population density is 137 people/km.

Climate and soil type

According to the agro-ecological classification of Ethiopia, the study area is characterized by three agro-climatic zones highland (56%), Semi-lowland (26%), lowland (14%), and 4% frost (Wogera District agricultural office, 2013). The mean annual average temperature ranges between 14 °C to 33 °C. The rainfall pattern is orographic type, stretching from May to September. Annual average rainfall ranges between 1000 and 1600 mm which varies along the geographical zone. The District has an average altitude of 2812 meters above sea level (Wogera District agricultural office, 2013). Cambisol is the dominant soil type in the area and actually considered fertile soils [11]. They are deep, well-drained, red, tropical soils. However, the area is highly populated there is severe erosion in the area. Since the landscape has lost its natural vegetation, the soil of the surrounding hills is degraded with frequent rock outcrops.

Land use and Land cover

The major land uses of the study area include cultivated land, grazing land, and plantation of exotic species mainly *Eucalyptus* globulus. A large portion of the district is intensively cultivated land (Almost 68% of the land is under crop cultivation during cropping season). After crop
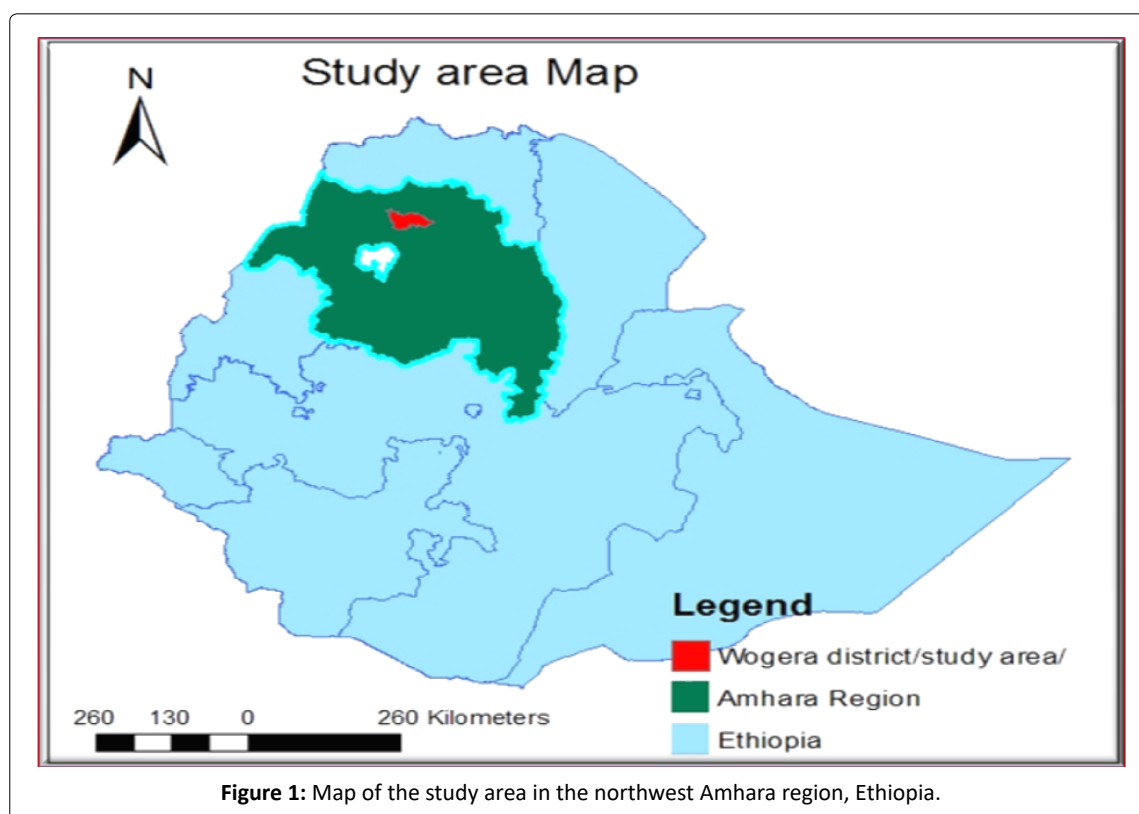

Figure 1: Map of the study area in the northwest Amhara region, Ethiopia.

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harvesting, the land is opened up for cropping and grazing livestock. Apart from a few trees around homesteads and farm borders, native trees are rarely seen in the landscape of the study area... The community faced a shortage of wood for construction and firewood, therefore most farmers adopt and expand *Eucalyptus* plantation on their land to alleviate the problems (Wogera District agricultural office, 2016).

Livelihood

The study area community mainly depends on mixed agriculture. Agriculture is characterized by crop oriented small-scale subsistence farming-system with a wide range of cereals, pulses crops grown for household consumption. Commercial farming mainly involves the growing of *Eucalyptus globulus* and some food crops such as chickpea. In spite of the fact that the diversified potential of crop productivity farmers has widely planted *Eucalyptus globules* on croplands, due to its fast growth and requires less care. The main plantation practices are woodlot, cropland boundary plantation, and road borders plantations to fulfill the needs for fuel wood, construction, and income generation.

Sampling and data collection methods

Combinations of methods were applied for the collection and analysis of data to meet the objectives of the study. Thus the selected and applied methods discussed in three categories below: i) Soil sampling and analysis techniques to evaluate the effect of selected physical and chemical properties and ii) The method used to evaluate the effect of the woodlots on crop yield along with different directions and distances.

Sampling of *Eucalyptus globulus* woodlot stands: The experiment was set on existing *Eucalyptus* woodlots plantation and their surrounding wheat crop... A reconnaissance survey was carried out through transect walk and then three *Eucalyptus globulus* woodlot stands bordered by wheat crop were selected. The woodlots stand were selected purposely having nearly similar soil management practices, altitude, slope gradient, and *Eucalyptus* stand characteristics such as

height, and diameter at breast height, age (all were ≈ 13-14 years age). Measurements of three dimensions taken such as: Diameter at breast height using diameter tape, tree height using clinometer, and the crown diameter at crown base using a measuring tape. The slope gradient and elevation of the study area were measured by using a clinometer and global positioning system respectively (Table 1).
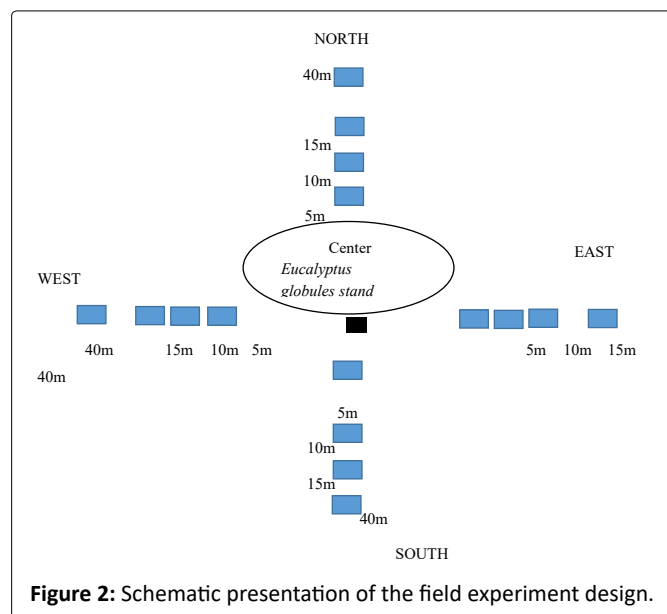
The plantations were established in 2005 and were harvested three times. The average area of the woodlots was 0.375 ha, ranging from 0.25 ha to 0.5 ha. All woodlots were owned by farmers and planted in an irregular pattern. The stand rotation age ranged from 4 to 5 years. Stand ages were 13-14 years and stand densities ranged from 9,500 to 12,000 individuals tree per ha.

Experimental design and data collection of crop yield: The test crop was *wheat (Triticum aestivum),* the most commonly grown crop variety within the study area. According to the farmer's crop calendar, the wheat crop was sown during 10 June to 25 June, 2016 and harvested at the end of December, 2016. The wheat crop was locally seeded 120 kg and fertilized with 100 kgha^{-1} DAP (Di-Ammonium phosphate) and 100 kgha^{-1} Urea (nitrogen fertilizer at planting time). Most Farmers have practiced weeding three times. As described by development agents and local farmers, growers could harvest greater than 50 quintals (5 tons) per hectare.

Under farmers' crop production circumstances, the effects of *Eucalyptus globules* woodlot plantation on the neighboring wheat crop performances were assessed in the 2015/2016 cropping season. The fields experimental independent variable considered were the distances (at 5 m, 10 m, 15 m, and 40 m) and direction (oriented north, south, east and west) of the *Eucalyptus globules* woodlot stand (Figure 2). At harvesting time, plot areas of 1 m*1 m (1 m^2) were marked at 5 m, 10 m, 15 m, and 40 m [12] far from the woodlot stand along with the four directions (East, West, North, and South)of the woodlot base. The 40m distance represented the sampling point, which was assumed to be free from tree influence, and thus used as control. The experimental factors

Table 1: Characteristic features of the sampled *Eucalyptus* woodlot stands.

Attributes	Sampled *Eucalyptus* globules stands		
	Stand 1	Stand 2	Stand 3
Stand type (Coppice, standard crop)	2 times coppice	2 times coppice	2 times coppice
Age (years)	14	13	13
Average height (m)	12.5	9.5	11
Average DBH (cm)	20	16	18
Slope (%)	5.5	6.25	7
Location (m.a.s.l)	2955	2959	2961
Previous land use	Cropland	Cropland	Cropland
Surrounding land uses	Wheat cropland	Wheat cropland	Wheat cropland
Tillage frequencies	3 times	3 times	3 times
Rate of fertilizers (kg / ha	100 kg DAP 100 kg Urea	100 kg DAP 50 kg Urea	100 kg DAP 100 kg Urea
Soil texture	Loam	Clay loam	Clay loam
Soil color	Blue	Blue	Blue
Distance from homestead	300 m	265 m	290 m

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Figure 2: Schematic presentation of the field experiment design.

and levels were four directions and four distances, were arranged in RCBD (Random Complete Block Design) with three replications. Thus, a total of 48 (4 distance × 3 woodlot × 4 direction × 1 depth) samples were collected.

Samples of wheat yield that grown at each sampled plot at harvesting time were collected at each distance in the four directions from the stand. The samples were air-dried, threshed manually, and then weighted the grain yield in grams in December, 2016. After the yield was determined, the total dry biomass yield was also measured in a similar way.

Soil sampling: The soil samples were collected in the 2016 cropping season after wheat crops have been harvested. A similar design was followed for wheat yield sampling illustrated in Figure 2. Moreover, the soil samples were collected at the center of the woodlot stands. The soil samples were collected from four corners of each plot (1 m²), with one from the center by auger from each laid distance and direction at the depth of 20 cm. A total of 255 soil samples were collected from the three woodlot stands. Then the collected soil samples of the sub-plot (at the four corners and center) of the plot were thoroughly mixed to form a composite sample. In this way, a total of 255 soil samples were converted into 51 composite soil samples for convenient laboratory analysis.

Soil Sample preparation and analytical procedures

Before conducting the analysis, soil samples were air-dried, then grinded and sieved through the 0.5 and 2mm sieve to remove unwanted materials (crop/plant residue, gravels) from the sample except that of the bulk density sample. The soil samples were analyzed for chemical and textural properties at Gondar Soil Testing Laboratory using the following standard laboratory procedures [13]. Organic matter and total nitrogen contents of the soil were determined following the wet combustion method of the Walkley and Black method, and the wet digestion procedure of Kjeldhal method, respectively [14]. Available P was extracted by the Olsen method [15]. P^H and Electric conductivity (EC) (1:2.5, Soil:Water) of the

soil were measured in water using a pH meter with a glass-calomel combination electrode [16]. Cation exchange capacity was determined following the 1nitrogen ammonium acetate method at pH 7 [17], and exchangeable calcium and magnesium were determined using EDTA (Ethylene diamine-tetra acetic acid) titration, whereas exchangeable potassium and sodium were determined from the same extraction with flame photometry. Soil texture was determined by using bouyoucos hydrometer method. An undisturbed core sample from the topsoil was taken to determine the bulk density [18]. Soil samples were oven-dried at 105 °C for bulk density determination.

Data analysis

Different analytical procedures were followed for the analysis of the two sets of crop yield and soil properties data. Analysis of variance using SAS (version 9) was performed to determine the effects of *Eucalyptus globules* woodlot plantation on parameters of both crops and soil properties to the entire woodlot direction and distance. All analyses were performed at a probability level of 0.05, *i.e.*, statistical differences were determined by two-way ANOVA employing a 95% level of confidence. Descriptive statistical procedures were also applied.

Results and Discussion

Effect of Eucalyptus globules plantation on grain and biomass yield of wheat

Eucalyptus globules plantations were assessed for their effect on the above-ground biomass and grain yield of wheat crop. The main effects (direction and distance) had a highly significant effect on the grain and biomass yield of wheat (P < 0.001) (Table 2). The grain and biomass yield of wheat increased significantly as the distance (10 m) from the *Eucalyptus* stands increased in all directions (Figure 3).

The present findings concurred with that of [19] who concluded that the yield of wheat grain and straw increased significantly with an increase in distance from the stand. The increase in grain yield away from the woodlot could be due to less competition of nutrients, moisture, and shading effect under the woodlot canopies than the open fields. The maximum yield of wheat grain and biomass were 4893 and 5831 kg/ha respectively, recorded at the distance of 40 m away from the woodlot at the Eastern direction, while the minimum yield of grain and above ground-biomass were 2309 and 3772 kg/ha respectively recorded at the distance of 5 m away from the woodlot at the western direction (Table 2). Consistent with the present findings, [20] also reported that the adjacent tree decreased maize height and biomass by 42.9% and 74.6% respectively in Tanzania. Similarly [21] also reported that 40% of crop yield reductions when crops close to trees in Kenya.

The variation in grain and biomass yield between northern and southern directions was non-significant at respective woodlot plantation distance and direction. However, the grain and biomass yield between Eastern and Western directions varied significantly at all distances except 40 m (Table 3).

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Figure 3: The morning shading effect of *Eucalyptus globules* plantation on croplands.

Table 2: Main effect of direction and distance on wheat crop yield.

Components		Wheat yield	
		Grain yield	**Biomass/ straw/yield**
Directions	East	438.58a	528.19a
	West	335.27b	447.40b
	South	412.55c	500.36c
	North	409.73c	502.40c
	LSD	51.22	43.60
	Significant		
Distances (m)	5	335.71a	437.57a
	10	370.24a	472.50b
	15	411.27b	503.53c
	40	478.91c	564.75d
	LSD	40.24	30.40

Note: Column refers along a direction and rows refer distance with the same letters are not significantly different at p < 0.05.

Table 3: Effect of *Eucalyptus* plantation on wheat grain and biomass yield (kg/ha).

Parameters	Directions	Distance (m) from the woodlot			
		5	**10**	**15**	**40**
Grain yield	East	3927a	4200b	4521c	4893d
	West	2309b	2644c	3813d	4643e
	North	3600a	3873b	4109c	4805e
	South	3591a	4091c	4006c	4813e
	CV (%)	2.69			
	LSD 0.05	17.85			
Biomass/ straw/ Yield	East	4730a	5086b	5480c	5831d
	West	3772b	4032bc	4502d	5588ed
	North	4443a	4931b	5164b	5556d
	South	4556a	4850b	4327c	5613d
	CV (%)	3.16			
	LSD 0.05	26.0			

Note: Column refers along direction and a row refers distance with the same letters are not significantly different at p < 0.05. The first letter represents significance comparison between distances and b represent between directions.

The maximum crop and biomass yield was observed on the Eastern side of the woodlot stand base.

The interaction effect between distance and directions was significant (Table 3). There was a decline of nearly 35.3 and 52.8 percent of wheat grain and biomass yield respectively

while comparing 5 m and 40 m intervals from the woodlot (Table 3). The effects of all directions at a 40 m distance were non-significant. These results are supported by other works, such as [22] that the high yield of wheat grain in areas without trees was presumably because of less competition of soil moisture, nutrients, and sunlight between agricultural crops and trees. They [23] studied the yield potential of inter-crop with *Eucalyptus* and its shading effect on adjoining wheat crops. The orientation of the tree line and the distance on which the associated crop they have grown contributed significantly towards crop growth and yield.

Effect of *Eucalyptus globules* plantation on the physical properties

Soil texture: According to the USDA textural classification, the texture of the area was clay loam soil. The sand proportions were (36.29%), silt (34.67%) and clay (29.04%) (Table 4). The soil of the areas was predominantly sand (> 36.29%). The clay content in the soil was small (29.04%). The mean silt proportion of the soil under the woodlot center was lower than the open farmland (Table 4). Soil texture might affect soil physical and chemical and to some extent soil biological properties, was not significantly affected (Table 4) across distance and direction from woodlot the texture is more related to parent material than tree influence. According to Landon [24], clay, clay-loam, and silt-loam soils show low bulk density values (1.0 to 1.6 gcm^{-3}) as compared to sands and sandy loam soils which show high bulk density values (1.2 to 1.8 gcm^{-3}). The non-significant differences in the mean proportions of sand, silt, and clay fractions between the soils under the *Eucalyptus* woodlot and in the farmland suggests that the soils, are texturally similar, being clay loam and have derived from the same parent material, under the same climate, and similar topography.

Bulk density: The bulk density of the soils ranged from 1.13 (center of woodlot) to 1.34 gcm^{-3} (Table 4), which categorized as low [25,26] suggested that lower bulk density under *Eucalyptus* plantation which ranges 1.07 for topsoil for clay soil in the Amhara Regional State of Ethiopia. According to [27] lower bulk density under *Eucalyptus* plantation and *Croton macrostachyus* ranged 1.0 to 1.1 g/cm^{-3} for topsoil (0-20 cm) in loamy clay soil in Lake Tana plain of the same region. The soil bulk density increased from 1.13 to 1.34 g/cm^3 from the woodlot center towards adjacent farmland in all directions (Table 4). However, there was no significant difference in

bulk density among the distance from the woodlot of the *Eucalyptus* plantation. Meanwhile, there was not significantly difference in bulk density along with the directions and interaction effect. However, the highest bulk density of (1.34 gcm^{-3}) was observed at 40 m distance in the north direction. The findings show that lower bulk density was recorded in the east direction. On contrary, [28] suggested that lower bulk density in croplands as compared to *Eucalyptus* plantation. The lower bulk density might be because of organic matter accumulation and microbial activity.

Effects of *Eucalyptus globules* plantation on soil chemical properties

Soil pH: According to the finding, the pH values of the samples taken from the surface layer were ranged from 5.28 to 5.84 (Table 5). Soil pH was not significantly different on the main and interaction effects of the woodlot stand. Generally, lower mean soil pH values were recorded at the center of the woodlot as compared to soils away from the woodlot which might be due to several mechanisms that release H+ ions, such as soil base cation uptake by the tree, decomposition of organic matter to organic acids and CO_2, root respiration and nitrification.

According to [29] rating of soil pH, soils with pH (H_2O) > 8.0 are characterized as strongly alkaline; 7.4-8.0 as moderately alkaline; 6.7-7.3 as neutral, while soils with pH of 6.0-6.6, 5.3-5.9, 4.5-5.2 and < 4.5 were rated as slightly acid, moderately acid, strongly acid and very strongly acid, respectively. According to the study result, the soil was moderately

acidic, which ranges between 5.7 and 6.8, which is good for crop production as most nutrients for field crops are available at pH values of greater than 5.5 [24]. These findings supported by others; lower soil pH recorded under *Eucalyptus* woodlot plantation as compared to farmlands and grazing lands in Ethiopian central highlands [26,30]. Also found that lower pH under *Eucalyptus globules* plantations than agricultural lands (Table 6) .

Soil Organic Matter: Soil organic matter was ranged from 2.32% to 6.42% (Table 7) classified as high Soil organic matter level [31] who classified organic carbon as low (0.6-1.16%), moderate (1.16-1.74%) and high (> 1.74%). There was a significant difference in soil organic matter between the distance of the woodlot and directions (P < 0.05). The interaction effect between distance from the woodlot and directions was not significant (Table 7). The soil organic matter was higher at the center of the woodlot than away the woodlot of the nearby cropland that showed a reducing trend with increasing distance from the center of the woodlot towards the crop field within all directions.

Soil organic matter content at the eastern direction was high whereas less content at the western direction was recorded than other directions (Table 7), thus might be passive microbial activities because of late sunlight coming due to shading in the western. The soil organic matter of the woodlot center was 2.76 times higher than the respective soil surface of control (40 m away from the woodlot stand). This variation in soil organic matter with distance away from the woodlot center could be due to accumulation of leaf litters, seeds fall, and dead roots from the tree as compared to the

Table 4: The main effect of *Eucalyptus* plantation direction and distance on soil texture and bulk density.

		Soil texture			
		Sand	Clay	Silt	Bulk density
Directions	East	37.94a	27.52a	34.53a	1.30a
	West	34.61a	30.58a	34.80a	1.21a
	South	36.44a	28.58a	34.97a	1.25a
	North	35.78a	28.58a	35.64a	1.27a
	LSD	5.67	6.36	5.74	0.11
	Significant	Ns	Ns	Ns	Ns
Distances (m)	Center (0)	37.94a	32.40a	29.65a	1.13a
	5	34.78a	30.80a	34.41a	1.19a
	10	35.44a	28.74a	35.80a	1.25a
	15	37.11a	26.52a	36.36a	1.26a
	40	37.44a	29.18a	33.36a	1.34a
	LSD	8.61	9.11	6.02	0.12

Note: Column refers along a direction and rows refer distance with the same letters are not significantly different at p < 0.05.

Table 5: The effect of *Eucalyptus* plantation on soil pH at different distances and directions.

Parameter	Directions	Distance(m) from the woodlot				
		Center	5	10	15	40
pH	East	5.28a	5.68b	5.84b	5.67b	5.59b
	West	5.28a	5.69b	5.58b	5.63b	5.68b
	North	5.28a	5.50b	5.54b	5.39b	5.37b
	South	5.28a	5.79b	5.67b	5.45b	5.51b
	CV (%)	5.01				
	LSD 0.05	0.38				

Note: Column refers along a direction and rows refer distance with the same letters are not significantly different at p < 0.05; the first letter represents significance comparison between distances and b represent between directions.

Table 6: The main effect of Eucalyptus plantation directions and distances on soil chemical properties.

Soil chemical properties									
	pH	EC	OM	TN	CEC	Av. P	Ex. Ca	Ex. Mg	Ex. K
East	5.69a	0.027a	3.16a	0.16a	32.81a	25.61a	17.43a	13.63a	1.52a
West	5.64a	0.024a	2.45a	0.12a	33.15a	15.17a	16.96a	13.97a	1.54a
South	5.61a	0.025a	3.03a	0.14a	33.73a	24.41a	17.24a	14.63a	1.50a
North	5.45a	0.028a	3.04a	0.15a	31.77a	17.39a	14.62b	14.88a	1.42a
LSD	0.25	0.010	1.22	0.06	5.53	15.29	2.12	5.26	0.27
Sig.									
Center	5.28a	0.030a	6.41a	0.32a	35.73a	8.41a	14.90a	18.07a	1.44a
5	5.66b	0.025a	3.26b	0.16b	34.76a	21.10b	17.71a	14.85a	1.58a
10	5.65b	0.030a	2.97b	0.14b	34.57a	23.80b	16.87a	13.26a	1.59a
15	5.54b	0.025a	2.64b	0.13b	32.03a	19.97b	15.39a	13.12a	1.39a
40	5.40b	0.024a	2.82b	0.13b	30.10a	17.71b	16.28a	15.88a	1.43a
LSD	0.34	0.014	1.70	0.08	5.41	22.68	3.53	6.24	0.33
Sig.									

Note: Column refers along a direction and rows refer distance with the same letters are not significantly different at p < 0.05; 'a' letter represents significance comparison between distances and 'b' represent between directions.

Table 7: The effect of *Eucalyptus* plantation on soil organic matter and total nitrogen at different distance and direction.

Parameters	Directions	Distance (m) from the woodlot				
		Center	5m	10m	15m	40m
Soil organic matter (%)	East	6.42a	3.50b	3.45b	2.82b	2.89b
	West	6.42a	2.46b	2.47b	2.56b	2.33b
	North	6.42a	3.52b	3.01b	2.73b	3.27b
	South	6.42a	3.57b	2.96b	2.82b	2.79b
	CV (%)	38.6				
	LSD 0.05	2.9				
Soil total nitrogen (%)	East	0.32a	0.17b	0.17b	0.14b	0.14b
	West	0.32a	0.12b	0.12b	0.12b	0.11b
	North	0.32a	0.18b	0.15b	0.12b	0.16b
	South	0.32a	0.18b	0.15b	0.14b	0.14b
	CV (%)	40.3				
	LSD 0.05	0.14				

Note: column refers along a direction and rows refer distance with the same letters are not significantly different at p 0.05; 'a' letter represents significance comparison between distances and 'b' represent between directions

adjacent croplands while the source of soil organic matter outside the woodlot was mostly crop residues which might be removed as a fuel wood and also grazing.

Soil total nitrogen: The finding shown that the total nitrogen contents of the soils were ranged from 0.11% to 0.32% (Table 7), which could be categorized as medium to high [32]. Who categorized soil total nitrogen rate as very low (< 0.1), low (0.1-0.15) medium (0.15-0.25), and high (> 0.25). Total nitrogen was significantly different among directions from the woodlot stand (Table 7). In the western direction, lower total nitrogen was observed. However, soil nitrogen was not significantly affected by the distance and directions from the woodlot. Total nitrogen was significantly higher at the center of the woodlot than the adjacent farmland and this might be attributed to more organic matter and nitrogen mineralization at the center of the *Eucalyptus* plantation. The other reason for high soil nitrogen under *Eucalyptus* woodlot might be because of the low temperature and very limited radiation reached on the surface of the soil that leads to low volatilization of NH_3- N [33].

There was a slight decrease in total nitrogen with distances, higher in the eastern direction as compared to other directions. Soil nitrogen concentration showed a decreasing trend with increasing distance from woodlot plantation within all directions (Table 7), this could be due to the effect of intensive and continuous cultivation forced oxidation of organic carbon of field that releases nitrogen from organic matter decomposition [34].

The deep root structure of *Eucalyptus* can operate as a nutrient pump for leached nitrogen from deep soil or slow down leaching. Soils under *Eucalyptus* plantation reported as it has larger soil nitrogen due to a long time under tree cover and soil nitrogen mineralization could be increased under *Eucalyptus* plantation by 11-14 ppm per year [26]. He stated the total nitrogen increased with distance from the *Eucalyptus* trees, their result showed that near the *Eucalyptus* stand the soil total nitrogen was significantly larger than the average soil total nitrogen of the field and the nitrogen content declines with increasing distance up to 5 m away from the woodlot plantation (Table 7). Generally, higher soil nitrogen

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Table 8: The effect of *Eucalyptus* plantation on available phosphorus, cation exchange capacity and electric conductivity at different distance and direction.

Parameters	Directions	Distance (m) from the woodlot				
		Center	5m	10m	15	40m
Available phosphorus (ppm)	East	8.42a	21.50a	28.80a	30.31a	21.83a
	West	8.42a	18.70a	14.92a	12.62a	14.47a
	North	8.42a	18.16a	21.20a	17.02a	13.21a
	South	8.42a	26.04a	30.31a	19.93a	21.36a
	CV (%)	83.06				
	LSD 0.05	27.4				
Cation exchange capacity (Cmol/kg)	East	36.73a	33.96a	34.44a	29.19a	33.66a
	West	36.73a	35.31a	31.28a	30.64a	34.38a
	North	36.73a	32.13a	29.48a	28.11a	37.35a
	South	36.73a	35.67a	32.92a	32.45a	32.89a
	CV (%)	14.60				
	LSD 0.05	8.00				
Electric conductivity(ds/m)	East	0.03a	0.026a	0.03a	0.023a	0.023a
	West	0.03a	0.02ba	0.023ba	0.026ba	0.026ba
	North	0.03a	0.03ab	0.03a	0.026ab	0.023a
	South	0.03a	0.026ba	0.023a	0.023a	0.02a
	CV (%)	40.63				
	LSD 0.05	0.01				

Note: Column refers along a direction and rows refer distance with the same letters are not significantly different at p < 0.05; 'a' letter represents significance comparison between distances and' b' represent between directions.

near *Eucalyptus* trees might be due to the higher nitrogen in the foliage of *Eucalyptus tree* and low uptake by the tree from the topsoil.

Available soil phosphorus: The available phosphorus contents of the soils were ranged from 8.42 to 30.31 ppm (Table 8) that could be medium to high phosphorus, according to [35] who categorized as very low (< 3), low (4-7), medium (8-11), and high (> 12). Soil phosphorus concentration was not affected by the main effects of distance from the woodlot and directions and their interaction effect (Table 8). Soil phosphorus concentration increased with increasing distance from the woodlot in all directions. The mean soil phosphorus concentration at the center of the woodlot was 8.42 ppm lower than the nearby cropland. The lower soil phosphorus accumulation was observed at the center of the woodlot zone than adjacent cropland (Table 8) this could be due to fertilizer application on the adjacent farmland annually. The phosphorus concentration at the western direction was lower towards the cropland.

These findings supported by other works; [36] who reported that the available phosphorus content of farmland is higher than forest lands, which suggests that the annual leftover of phosphorus from fertilizer application is more than obtained from leaf decomposition from trees [26]. Also found that the amount of available phosphorus content in croplands is much larger than in forest and *Eucalyptus* woodlots. Bewket and Stroosnijder [37] reported that lower available phosphorus content at forest lands is due to a high proportion of phosphorus retained and immobilized by microbes. Another possible reason for low available phosphorus under *Eucalyptus* woodlots plantation could be due to the lower pH conditions that can permanently fix phosphorus. Under acid conditions, phosphorus is precipitated as Fe or Al phosphates

of low solubility [26], whereby maximum availability of phosphorus generally happens in the range of 6.0 to 7.0 soils P^H.

Cation exchange capacity: The cation exchange capacity of the soils was not significant for their main and interaction effect between distance and direction from the woodlot, but the higher value of cation exchange capacity was observed at the center of the *Eucalyptus* woodlot stand (Table 8), this could be depletion of exchangeable bases as a result of intensive cultivation and application of inorganic application fertilizers which reduced the cation exchange capacity. Generally cation exchange capacity decreased with increasing distance from the woodlot within all directions (Table 8). This could be mainly because of the high accumulation of organic matter at the center of the woodlot than the nearby cropland. The higher amounts of soil organic matter under the tree *Eucalyptus* plantation may imply that more cations would be released to the soil through mineralization as a result; the number of negative charges in the soil would be higher. Our result is confirmed that cation exchange capacity didn't show any significant difference among the land uses in the central highlands of Ethiopia [26].

Soil electrical conductivity: The analysis of variance for soil electrical conductivity revealed that they were not significantly affected by the interaction effect and the main effects of distance and directions (Table 8). This could probably be due to the high rainfall amount that removes base-forming cations from the surface soil. In general, higher soil electrical conductivity at the center of the woodlot than the adjacent cropland, might be due to the increased accumulation of above-ground biomass and associated cation uptake by the tree [38]. Suggested that soils with soil electrical conductivity value of below 0.80 dS m^{-1} are considered normal and

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suitable for all crop types. The soil electrical conductivity of the soil at the center of the woodlot was 0.03 dSm^{-1} while that beyond the woodlot ranged from 0.03 to 0.02 dSm^{-1} (Table 8). Hence, the soils adjacent to cropland are suitable for most crops. According to [39] in the soil, the determination of the electrical conductivity serves to give an idea of the total quantity of soluble salts, and the degree of salinity. The critical level of electrical conductivity of saturated soil paste extracts (EC) for most crops is 4 dSm^{-1}. Soils with EC greater than 4 dSm^{-1} are saline soils. These are considered restrictive for most crops and values as low as 2 dSm^{-1} may affect the more sensitive crops.

Soil exchangeable cations: The values of three primary exchangeable cations (calcium, magnesium, and potassium) were not significantly different within distance, direction, and the interaction effect between distances and direction from the woodlot, but gradually level of exchangeable cations decreasing with increasing distance from the woodlot at all directions (Table 8). There was higher exchangeable magnesium at the center of the woodlot plantation (Table 8), which could be due to the high accumulation of litter under the plantation and decrease their reduction from leaching or erosion. But a lower level of exchangeable calcium and potassium were observed at the of the *Eucalyptus* woodlot stand (Table 8). Findings supported by [40] who found a lower level of calcium, magnesium, and potassium under *Eucalyptus* tree at 0-20 cm soil depth, The result shows that lower exchangeable calcium and potassium cations amount under plantation; this indicated that the *Eucalyptus* trees absorb these nutrients in standing biomass faster than recycle i.e. nutrients back to the soil. The immobilization of exchangeable bases, especially calcium resulted in lower soil pH under *Eucalyptus* plantation at 0-20 cm soil depth [41]. According to [42] the prevalence of calcium followed by magnesium and potassium in the exchange site of soils is favorable for crop production.

Conclusion and Recommendation

Conclusion

The experimental result showed that the *Eucalyptus* tree and its direction significantly affect crop yield. The crop yield shown that increasing progressively as the distance from the *Eucalyptus* woodlot stands base increases at all directions, hence higher yields were recorded in the eastern direction whereas lower yields were found in the western direction. This work revealed that there was around 14.2 fold wheat grain yield difference from the stand as compared with the control plot (40 m) and so did for biomass yield. The *Eucalyptus* woodlot and its direction have a considerable effect, in that the western direction is more pronounced. This study indicated that under the *Eucalyptus* woodlot plantation, soils did not vary significantly in texture cation exchange capacity, electric conductivity, potassium, available phosphorus, exchangeable calcium, magnesium and potassium cations, and electric conductivity, on the other hand, soil properties such as organic matter, total nitrogen, soil pH, and bulk density were significantly higher at the center of *Eucalyptus* woodlot plantation than in the adjacent cropland with decreasing trend with distance from the woodlot stand in

all directions. Soil organic matter status under *Eucalyptus globules* plantation stand is higher, this may be leaf and root litter addition. Higher values of organic matter, total nitrogen, and available phosphorus were found in the eastern direction, but lower in the western direction. Overall, the studied results lead that *Eucalyptus* globules plantation affects wheat crop yield and selected soil physical and chemical properties. To minimize the adverse effects and improve the environmental importance of *Eucalyptus* tree plantation, the choice of a suitable site and management methods is very important. Moreover, when grown on cropland, *Eucalyptus* plantation should be limited to appropriate sites with right the management and utilization so that it will not unfavorably affect neighboring crop productivity.

Recommendation

For sustainable crop production, the *Eucalyptus* tree should be planted in the order of west, north, south, and east direction of the cropland. The result of wheat yields reported in this study was under farmer's crop production and management practices which may not be applied the same management practice. So, further study is needed under a controlled experiment in association with this *Eucalyptus* plantation. Hence, further research required on the effect of its leave on soil physical and chemical properties. Moreover, soil microbial population and their activities with *Eucalyptus* plantation aspects should be studied in detail.

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