

The Effect of Scattered Multipurpose Trees (Erythrina Brucei Schweinf. And Croton Macrostachyus Hochst. Ex Delile) on Wheat (Triticum Aestivum L.) Yield in Southern Ethiopia

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Research Article

Keywords: Biomass, crop, agroforestry, canopy

Posted Date: December 21st, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-2389462/v1>

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Abstract

Integrating multipurpose trees on cropland with annual crops is common in Ethiopia. However, information on its impact on annual crop yield is scarce in many parts of the region. This study was to evaluate the effect of *Croton macrostachyus* Hochst. ex Delile (Euphorbiaceae) and *Erythrina brucei* Schweinf. (Fabaceae) on wheat crop yield in southern Ethiopia, Gamo Zone, Chenchu district, Ayira kebele. Ayira kebele was selected purposively based on having abundant trees on cropland. Eight trees were selected based on having an approximately similar diameter at breast height, height, and crown area from a similar site. The wheat crops were sown under the canopy and outside the canopy of the selected trees and the biomass and yield were collected from 1/3m crown radius, 2/3m crown radius, edge of the crown, and outside the canopy of the trees by establishing 0.5m*0.5m plot. The wheat yields and biomass results were analyzed using two-way ANOVA by SAS Software version 9.0 and mean separation with LSD (%) at a 5% level of significance. The combined analysis of the variance of the study showed that the effect of the two tree species on the biomass and grain yield of wheat was significantly ($P < 0.05$) higher within the canopy of the tree than outside of the canopy. The findings of the present study will be helpful in knowing the effect of *Croton macrostachyus* Hochst. ex Delile (Euphorbiaceae) and *Erythrina brucei* Schweinf. (Fabaceae) on wheat yield. In this study, we found that both tree species would be incorporated into wheat cropping systems to improve the yield of wheat crops for resource-poor farmers as scattered multipurpose trees can be used as an economically feasible, environmentally friendly, and sustainable alternative production. Since both trees have a positive effect on wheat grain yield and plant biomass, expanding the knowledge of these trees in cropland is recommended.

Background And Justification

In some countries, the alteration of tropical forests to agricultural land shows signs of declining, but in other countries like Ethiopia continues at a high rate (FAO 2015). The growing population pressure is associated with agricultural spreading out in Ethiopia. The forest resources are utilized for construction and fuel wood, etc and unsustainable forest utilization leads ultimately to the depletion of forest. The destruction of the forest cover leads to a lack of material for soil regeneration and increased soil erosion which results soil fertility decrease (Carla et al. 2001).

Agroforestry is recognized as a useful and promising approach and it is also considered useful for biodiversity conservation and to solve soil fertility and crop production-associated problems (Schroth et al. 2004). It is a sound sustainable land management system to address many of the global challenges. Agroforestry combines crop production and brings more environmental benefits than less diversified agricultural systems. It provides a myriad of benefits such as soil fertility improvement, increasing soil water holding capacity, reduction of runoff, and creation of microclimates that enhance crop production (Parwada et al. 2022).

Different agroforestry systems are practiced in many tropical regions and is improving the smallholder farmer's agricultural productivity and decreasing the pressure on natural resource. One alternative of

tropical agroforestry practices is growing crops under scattered or systematically planted trees on farms (Nair 1993).

The integrated trees affect crop growth and yield (Sida 2018). Integrated multipurpose trees with crops can fix nitrogen through leguminous and a few non-leguminous trees (Sida 2018; Nair 1993). Scattered trees decrease the rate of deforestation and land degradation with a large potential for soil organic carbon sequestration (Wolde 2013). Especially, nitrogen fixation and high biomass production trees have been widely recognized as desirable for improving soil fertility.

In Ethiopia, scattered trees have received increasing attention in recent years as a way of improving food security and environmental sustainability (Kiros et al. 2011). In the central and Eastern highland parts of Ethiopia *Faidherbia albida* (Delile) A.Chev is integrated with teff and wheat. Different Acacia species such as *Acacia nilotica* (L.), *A. seyal* (Delile), *A. Senegal* (L.), and *A. tortilis* (Forssk.) are abundant in low-lying dry savanna regions. *Cordia africana* (Lam) is also commonly observed intercropped with maize in sub-humid parts of western highlands (ACIAR 2014).

Trees on croplands are a widespread feature of landscapes across a large part of Ethiopia with an important role in improving the resilience of smallholder livelihoods farmers through the provision of ecosystem services (Agena et al. 2014; Miyuki et al. 2016). Particularly, farmers in Gamo Zone, Southern Ethiopia have been keeping and managing different tree species on croplands for different purposes i.e., firewood, soil fertility improvement, fodder, timber, shade and others, but little is known about why those particular tree species are planted or retained in the crop field.

Therefore, the objective of this study was to evaluate the effect of scattered multipurpose trees of *Erythrina brucei* and *Croton macrostachyus* on wheat (*Triticum aestivum* L.) grain yield in Gamo Zone, Southern Ethiopia.

Materials And Methods

Description of the Study Area

Geographical Location

Chencha district is one of the 13 districts of the Gamo zone, in southern Ethiopia, which is located at about 537 km and 37 km from Addis Ababa and Arba Minch, respectively. It is situated between 1,600 m and 3,200 m above sea level (Seifu et al. 2014). It forms the upper rectangular landmass of the highland with irregular topography of the mountain, marshy areas, steep slopes, and water-covered parts. It is located between 37° 29' 57" E and 6° 25'30" N (Abera 2006).

The district is bordered on the North by Kucha and Boreda, on the South by Arba Mich Zuria district, on the East by Mirab Abaya, and on the West by Dita. Its agro ecology is classified as highland > 2500 m.a.s.l, which accounts for 82% of the total area, and midland 2000–2500 m.a.s.l accounting for 18%

(Waga et al. 2016). Due to its rugged topography, the highland area is very vulnerable to soil eroding forces.

Climate

According to the district, Agricultural Report (2014) the area has a bimodal rainfall pattern with short and long rainy seasons between March-April and June-August, respectively, and the annual rainfall distribution of the district varies between 900 mm to 1200 mm.

The minimum temperature varies between 11 to 13⁰C, while the maximum temperature is in the range of 18 to 23⁰C (Belete 2006).

Soil and crop types

The soil types of the district are commonly clay loam, red clay, verity soil and sandy with low productivity due to traditional farming systems, low contents of organic matter, and nitrogen (Girmay et al. 2014; Fetena et al. 2014). According to Engdawork & Hans-Rudolf (2016), the main crop production in the district is barley (*Hordeum vulgare* L.), wheat, and enset (*Ensete ventricosum* Welw. Cheesman).

Sampling and Data Collection

The study was conducted in the Gamo zone Chenchu district at Ayira Kebele (Fig. 1). Two multipurpose trees, *Croton macrostachyus* Hochst. ex Delile (Euphorbiaceae), and *Erythrina brucei* Schweinf (Fabaceae) were selected purposefully based on their dominance in the area. Four similar isolated mature trees for each species were selected from cropland in similar site conditions.

The experiment was carried out in a factorial experiment with a randomized complete block design (RCBD), with four treatments (distance from the tree trunk) and two tree species, each of them replicated four times, $4 \times 2 \times 4 = 32$ samples were taken. The canopy coverage of each tree species were divided into four circles at 1/3 m crown radius, 2/3 m crown radius, and the edge of the crown, and the control plot was established at 12m away from the edge of the tree crown (Agena et al. 2014) (Fig. 2).

The data were collected from four compass directions in East, West, North, and South directions (Bridget et al. 2013; Daniel et al. 2013). Wheat yield was taken at 1/3 m crown radius, 2/3 m crown radius, the edge of the crown and from outside the crown (control plot) by establishing a 0.5m x 0.5m plot from all sides. Agronomic data such as biomass yield and grain yield were collected from under the crown and outside of the crown trees (control plot).

Statistical Analysis

The randomized complete block design (RCBD) with two ways ANOVA was carried out to statistically compare the difference among treatments using SAS computer software version 9.0. Treatment means were compared using LSD at 5% significance levels using the general linear model (GLM).

Results And Discussions

Effects of *Croton macrostachyus* and *Erythrina brucei* on biomass and grain yield of wheat

Effects of tree canopies (distance) on the grain yield and biomass of wheat

The distance from both the base of the tree trunks of *C. macrostachyus* and *E. brucei* to the outside open canopy (control) has a highly significant effect on both grain yield and biomass of wheat ($p < 0.05$) (Table 1). The maximum biomass of wheat was recorded at the mid of the crown at 2/3 m of the radial distance from the tree trunk, with the value of 3,341 kg/ha and 2,975.4 kg/ha under *C. macrostachyus* and *E. brucei*, respectively (Fig. 3).

The maximum grain yield of wheat was also recorded at the mid of the crown at 2/3 m of the radial distance from the tree trunk, with the value of 1,512.50 kg/ha and 2,305.7 kg/ha under *C. macrostachyus* and *E. brucei*, respectively (Fig. 4). Both biomass and grain yield of the wheat were decreased starting from the 2/3 m radial distance to the outside canopy (control) and was higher under the canopy of both trees as compared to open cropland (control). The higher grain yield and biomass of wheat under the canopy of the trees might be due to the litter input into the soil and consequently litter decomposition, nutrient cycling and nitrogen-fixing by tree species. In line with this study Komicha (2018) showed that the grain yield and biomass of wheat decreased as the distance from the tree trunks increased under the canopies of *Faidherbia albida* (Delile) A. Chev and *Acacia tortilis* (Forssk.) at Hayenin Park Land Agroforestry System in Central Rift Valley, Ethiopia. Musa (2020) also reported that the grain yield of sorghum under the canopy of *Faidherbia albida* and *Cordia africana* (L.) trees increased by 43% and 41%, respectively than outside the canopy (control) of *F. albida* and *C. africana* as compared to the open cultivated land in Fedis District, Eastern Ethiopia. Generally, the grain yield has increase under the canopy of the trees when it compared with outside the canopy of the trees.

Table 1
Effect of tree canopies (distance) on the biomass and grain yield of wheat

Productivity of Wheat			
Tree species	Distance	Grain yield kg/ha	Biomass kg/ha
<i>C. macrostachyus</i>	1/3cr	1461.25a	3150a
	2/3cr	1512.50a	3341a
	Edge	1375.00a	2775.ab
	Control (12m)	949.50b	2287.5b
	LSD	214.2	831.92
	CV	10.49	18.69
<i>E. brucei</i>	1/3cr	1538b	2695.2b
	2/3Cr	2305.7a	2975.4a
	Edge	1270.4bc	2470.3ba
	Control (12m)	1167.6c	1905.3b
	LSD (5%)	330.37	819.17
	CV (%)	13.65	21.25

Mean with the same letter are not significantly different at $p = (0.05)$; cr- is crown radius in meter; LSD-least significant difference; CV-Coefficient of Variation.

The Joint Effect of Tree Species and Distance on Grain Yields & Biomass of Wheat

The mean grain yield of wheat was highly significantly different ($p < 0.05$, Table 2) due to the distance from the tree trunk when analyzing the two tree species jointly. The highest mean value of wheat grain yield was 1909.40 kg/ha which was recorded at a crown of 2/3 m radial distance, and this value decreased to 1058.65 kg/ha at the open cropland (control). The finding indicated that wheat grown under the canopy of *C. macrostachyus* and *E. brucei* was more advantageous as compared to the open cropland (control). This finding also similar with the study conducted by Musa (2020) in which the result of the mean value of grain yield of sorghum had slightly decreased with increasing distances from the tree trunk with the mean value of 2089.51 kg/ha under the canopy to 1789.53 kg/ha outside the canopy (control) for both *F. albida* and *C. africana* species.

The mean variation at four distances from the tree trunks might be due to the modification of microclimate and soil physical and chemical properties by the tree species. Trees influence microclimate and soil properties through organic matter addition and canopy-produced shade which reduced

evaporation from the soil surface and decrease temperature. In line with this study Komicha (2018) reported that the grain yield of wheat recorded under the *Faidherbia albida* and *Acacia tortilis* trees were higher as it was compared to the open cultivated land in Central Rift Valley, Ethiopia. Musa (2020) also reported that increased grain yield of sorghum under the canopy of *Fedherbia albida* and *Cordia africana* trees as it was compared to the open cultivated land in Fedis District, Eastern Ethiopia. In another study, Abebe (2006) reported increased grain yield of sorghum and haricot bean under the canopy of *F. albida*, *C. africana*, and *C. macrostachyus* trees as compared to the open cultivated land in Hararge highlands.

Table 2
Joint effect of *C. macrostachyus* and *E. brucei* tree and distance on biomass and grain yields of wheat in the study area

Productivity of Wheat			
Parameters	Distance	Grain yield kg/ha	Biomass kg/ha
Trees species	1/3m	1499.80a	2735.2a
	2/3m	1909.40b	3158.3a
	Edge	1322.85c	2810.3a
	Control (12m)	1058.65d	2096.5b
	<i>C. macrostachyus</i>	1324.92a	2888.7a
	<i>E. brucei</i>	1570.43b	2511.5b
	LSD (5%)	152.45	518.74
	CV (%)	10.13	18.48

Means with the same letter are not significantly different at p (0.05); LSD- Least Significant Difference; CV-Coefficient of Variation.

Similarly, the mean biomass of wheat was highly significantly different ($p < 0.05$, Table 2) as the distance increase from the tree trunks. The highest value of mean biomass was 3158.3 kg/ha under both tree species which was recorded at a distance of 2/3 m radius away from the tree trunk and this value decreased to 2096.5 kg/ha at the open cropland (control) (Table 2). The case of variation among distance from tree trunk was alike to that of the grain yield stated above i.e. fertility gradient cause for biomass difference was created by the role played by the two tree species on the soil under their canopy. According to, Rhoades (1997), trees alter inputs to the soil system by increasing the capture of wet fall and by increasing soil nitrogen via N_2 -fixation. They affect the physical and chemical properties of the soil as a result of the litter inputs. Also extensive vertical root of the trees scavenge soil nutrients and redistribute them beneath tree canopies. In general, trees represent both conduits through which nutrients cycle and sites for the accumulation of nutrients within a landscape. Perhaps for this reason, higher biomass was obtained under the canopy of *C. macrostachyus* and *E. brucei* as compared to an open field (control).

The mean value of wheat grain yield and biomass recorded under the two tree species was also different. The mean grain yield of wheat recorded under the canopy of *E. brucei* was greater than the mean grain yield of wheat recorded under the canopy of *C. macrostachyus* tree species (1570.43 kg/ha and (1324.92 kg/ha), respectively. However, the mean wheat biomass recorded under *E. brucei* was less than the mean wheat biomass recorded under *C. macrostachyus* (2511.5 kg/ha and (2888.7 kg/ha), respectively (Fig. 5). This might be due to the result of phenological characteristics of the tree species as the deference in the level of light occurrence under the two trees and variation in soil fertility originating from organic litter decomposition and subsequent nutrient release under the canopies of the tree species. The study conducted by Tolera and Tessema (2021) mentioned that the tree species had a significant effect on the aboveground biomass yield of herbaceous plant due to the difference in soil nutrient availability, litter quality and light intensity under the tree species in Eastern Oromia, Ethiopia.

Conclusion And Recommendations

Generally, the study investigated on the effect of scattered multipurpose trees of *Erythrina brucei* and *Croton macrostachyus* on wheat (*Triticum aestivum*) grain yield in Gamo Zone, Southern Ethiopia by comparing under and outside of the canopy in the cropland. The study revealed that under the canopy of trees of *Erythrina brucei* and *Croton macrostachyus* the wheat yield increased more than outside the canopy of the trees. The findings suggest that both tree species would be incorporated into wheat cropping systems to improve the biomass and grain yield of wheat crop as scattered multipurpose trees improve soil fertility through adding organic matters to the soil from their leaves and other parts of their body and ameliorate the micro-climate for crops. Hence, scattered multipurpose trees involving *E. brucei* and *C. macrostachyus* can be used as an economically feasible, environmentally friendly, and sustainable alternative to increase the production of wheat crops for resource-poor farmers.

Declarations

ACKNOWLEDGEMENT

At the first and most the authors would like to thank Arba Minch University which sponsored to work this research. Next, the authors would like to thank Chenchu district farmers who allowed their farm land to do this research.

Funding. There was no source of funding either public or private.

Conflict of interest. The authors declare non-existing personal or institutional conflict of interest.

Compliance with ethical standards. Due to the nature of the study this does not apply.

Data availability. Author is ready to share the raw data upon the request subject to either meeting the conditions of the original agreements and the original research study. Further, there is no-ethical or legal

duties of user obeys on data controllers to permit for secondary use of the data outside of the original study

References

1. Abdella M (2020) Sorghum Yield under the Canopies of *Faidherbia Albida* (Delile) A Chev and *Cordia africana* (Lam) Parkland Trees in Fedis District, Eastern Ethiopia, 4:7–13.
2. Abebe N (2006) Status of soil fertility under indigenous tree canopies on farm lands in Highlands of Hararghe, Ethiopia. MSc Thesis, Haramaya University, Ethiopia.
3. Abera O (2006) Indigenous common Grazing Land Management in Chench Woreda, South Ethiopia: A Thesis Submitted to Addis Ababa University Department of Regional and Local Development Studies, Addis Ababa Ethiopia.
4. ACIAR (2014) WP1 mid-term report Ethiopia, World Agroforestry Centre.
5. Agena A T, Tilahun F E, Bekele L (2014) Effect of tree species on microclimate and soil amelioration in the central Rift Valley of Ethiopia. J. Soil Sci. Environ.Manag, 5:62-71.
6. Assefa E, Bork H R (2016) Dynamics and driving forces of agricultural landscapes in Southern Ethiopia: The case study of the Chench and Arba Minch areas. Journal of Land Use Science, 11(3): 278–293. <https://doi.org/10.1080/1747423X.2014.940613>.
7. Belete G (2006) Male Out of Migration on Rural Women's Livelihood: The Case of Chench Woreda, South Ethiopia M.A. Thesis Addis Ababa University, Addis Ababa, Ethiopia.
8. Bellow G (2004) Fruit-tree-based agroforestry in the western highlands of Guatemala: an evaluation of tree-crop interactions and socioeconomic Characteristics, university of Florida, America.
9. Bridget B, Umar Jens B, Aune and Obed I, Lungu (2013) Effects of *Faidherbia albida* the Fertility of Soil in Smallholder Conservation Agriculture Systems in Eastern and Southern Zambia: African Journal of Agricultural Research Vol. 8(2): 173-183.
10. Carla Bielli, Gezu Berhanu, Amare Isaias, Arianna Orasi, 2001. Population Growth and Environment in Ethiopia: In-Depth Studies From the 1994 Population and Housing Census in Ethiopia Italian Multi-Bi Research Project Eth/92/P01 and Central Statistical Authority (CSA), Addis Ababa, Ethiopia.
11. Daniel H B, Agena A, Abdu A, Sue E (2013) Evaluation of The Effect of *FicusThonningii* (Blume) on Soil Physicochemical Properties in Ahferom District Of Tigray, Ethiopia. Journal of Soil Science and Environmental Management, Vol. 4(2): 35-45
12. FAO (2015) FRA Terms and Definitions: Forest Resources Assessment Working Paper 180. Rome, Italy.
13. Hailemariam K, Kindeya G, Charles Y (2010) *Balanites aegyptiaca* a potential tree for parkland agroforestry systems with sorghum in Northern Ethiopia. Journal of Soil Science Environment and Management, 1 (6): 107-114.
14. Jiregna G, Rozanov A, Negasha L (2005) Trees on farms and their contribution to soil fertility parameters in Bedessa, Estern Ethiopia. Bio-Fertilizer, 42: 66–71.

15. Kahi C H, Ngugi R K, Mureithi S M, Ngethe J C (2009) The canopy effects of *prosopis juliflora* and *Acacia tortilis* trees on herbaceous plants species and soil physicchemical properties in Njemps flats, Kenya. *Tropical agroforestry systems*, 10: 441-449.
16. Kiros M H, Mowo J, Garrity D P, Sileshi G (2011) Current extent of Evergreen Agriculture and Prospects for Improving Food Security and Environmental Resilience in Ethiopia: *International Journal of Agricultural Sciences* ISSN: 2167-0447 Vol. 1(1), pp. 006-016.
17. Komicha N D (2018) Wheat Yields Under the Canopies of *Faidherbia albida* (Delile) A. Chev and *Acacia tortilis* (Forssk.) Hayenin Park Land Agroforestry System in Central Rift Valley, Ethiopia. *Agriculture, Forestry and Fisheries*. Volume 7, Issue 3: 75-81. <https://doi.org/10.11648/j.aff.20180703.12>.
18. Manjur B, Abebe T, Abdulkadir A (2016) Effects of scattered *F. albida* (Del) and *C.macrostachyus* (Lam) tree species on key soil physicochemical properties and grain yield of Maize (*Zea Mays*): a case study at umbulo Wacho watershed , southern Ethiopia.
19. Musa A, Lisanework N, Ayele A (2020) Impact of Parkland Trees (*Faidherbia albida* Delile and *Cordia africana* Lam) on Selected Soil Properties and Sorghum Yield in Eastern Oromia, Ethiopia. *Agriculture, Forestry and Fisheries*. Vol. 9, No. 3: 61-73. <https://doi.org/10.11648/j.aff.20200903.13>
20. Nair P K R (1993) An introduction to agroforestry. Kluwer Academic Publishers, Dordrecht. 499pp
21. Ndlovu E, Ngamau K, Muthuri C W, Muriuki J K (2013) Alteration of soil carbon and pH by selected common tree species on farms in Eastern Highlands of Kenya: *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)* e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 3, Issue PP 64-71 Nairobi-Kenya
22. Parwada C, Chipomho J, Mapope N, Masama E, Simango K (2022) Role of Agroforestry on Farmland Productivity in Semi-arid Farming Regions of Zimbabwe. *Research on World Agricultural Economy*, 3(2). <https://doi.org/10.36956/rwae.v3i2.515>
23. Rhoades C C (1997) Single-Tree Influences on Soil Properties in Agroforestry: Lessons From Natural Forest and Savanna Ecosystems. *Agroforestry Systems* 35: 71-94.
24. Schroth G, Fonseca G A B, Harvey C A, Gascon C, Vasconcelos H L (2004) Agroforestry and biodiversity conservation in tropical landscapes. Island Press, Washington, 523 p
25. Seifu F, Sabura Sh, Agena A, Guchie G, Fantahun W, Belete Y (2014) Survey on Apple Production and Variety Identification in Chench District of GamoGofa Zone, Southern Ethiopia, Arbaminch University. *Journal of Agriculture and Food Technology* ISSN 2090 – 424X, Arbaminch, Ethiopia.
26. Sida T S (2018) Sustainable intensification of smallholder farming systems in Ethiopia: what role can scattered trees play? In Sustainable intensification of smallholder farming systems in Ethiopia - what roles can scattered trees play? PhD thesis, Wageningen University, Wageningen, the Netherlands. <http://edepot.wur.nl/425918>.
27. Tolera F, Tessema Z (2021) Influences of Tree Species and Canopy Cover on Aboveground Biomass Yield and Ground Cover of Herbaceous Plants in Eastern Oromia, Ethiopia. *American Journal of Agriculture and Forestry* Vol. 9, No. 4: 233-240. <http://doi.org/10.11648/j.ajaf.20210904.20>.

28. Waga M D, Yenenes T G, Rogier POS, Paul C S (2016) The Analysis of Potato Farming Systems in Chench, Ethiopia: Input, Output and Constraints Am. J. Potato Res. <http://doi.10.1007/s12230-016-9521-9>.
29. Wolde M (2013) Changes in Regulating Ecosystem Services following Establishing Enclosures on Communal Grazing Lands in Ethiopia. A synthesis. Journal of Ecosystems, 2013: 1–12. <http://dx.doi.org/10.1155/2013/860736>.

Figures

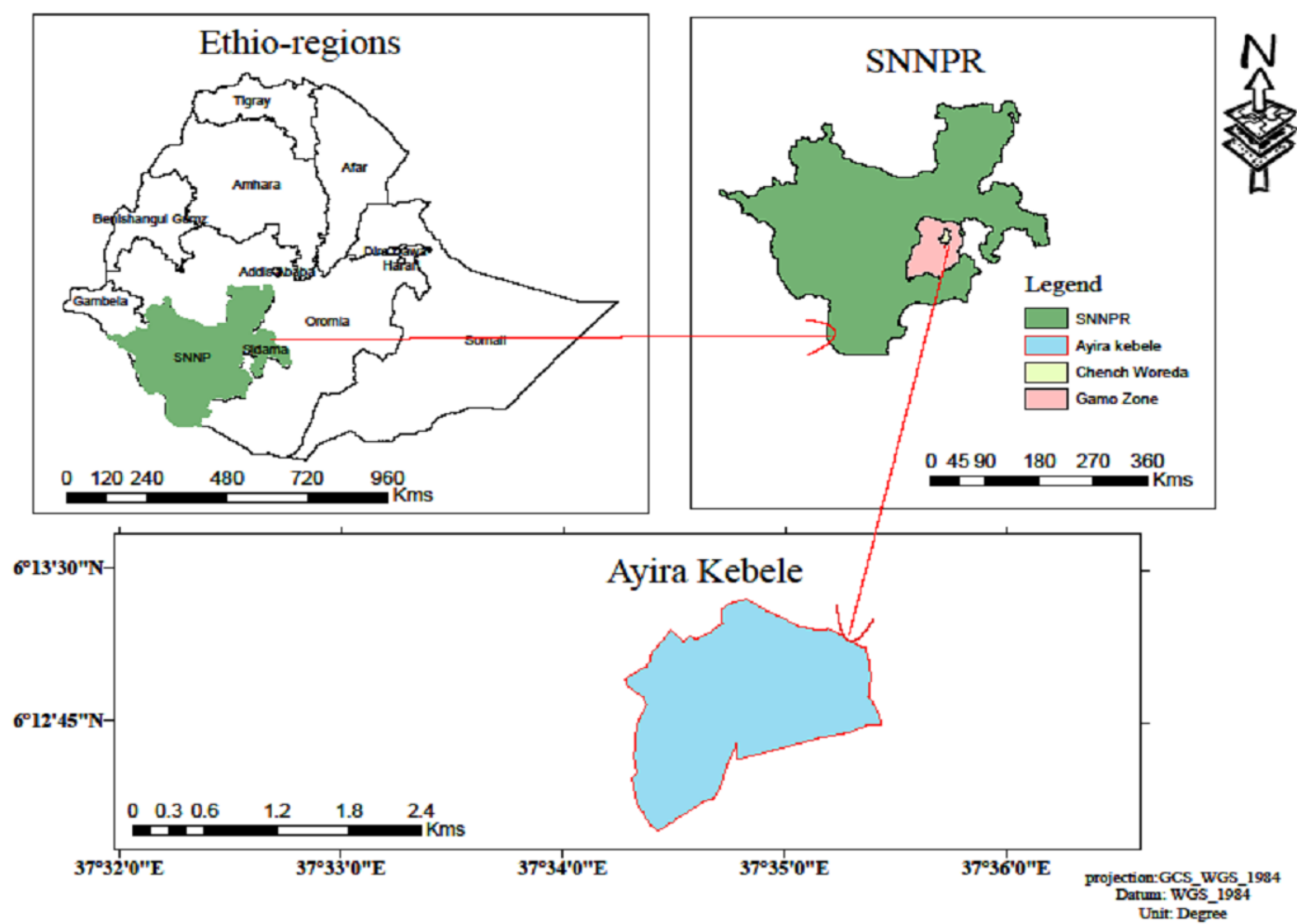


Figure 1

Map of the study area

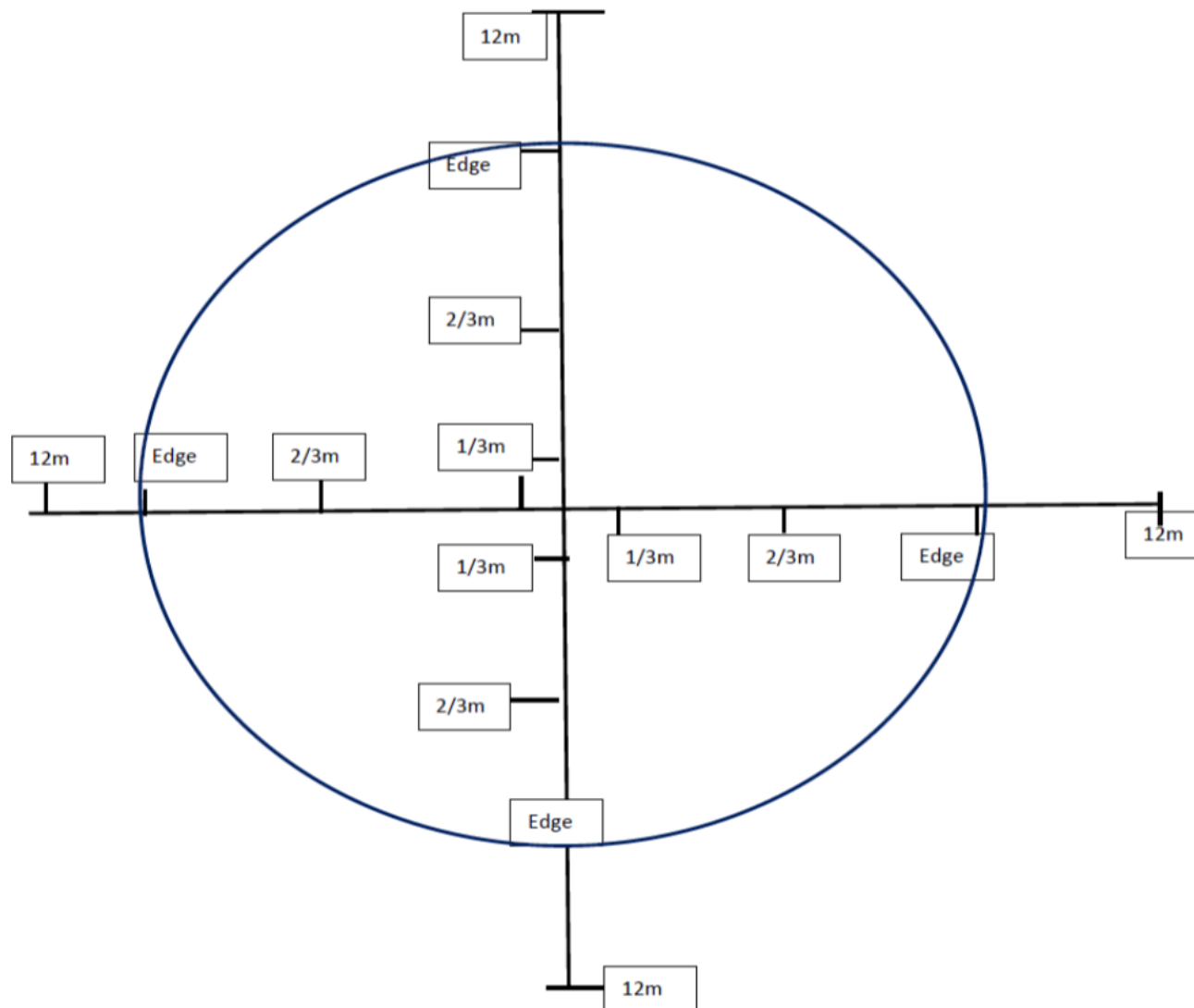


Figure 2

Schematic illustration of sampling points and direction used for data collection

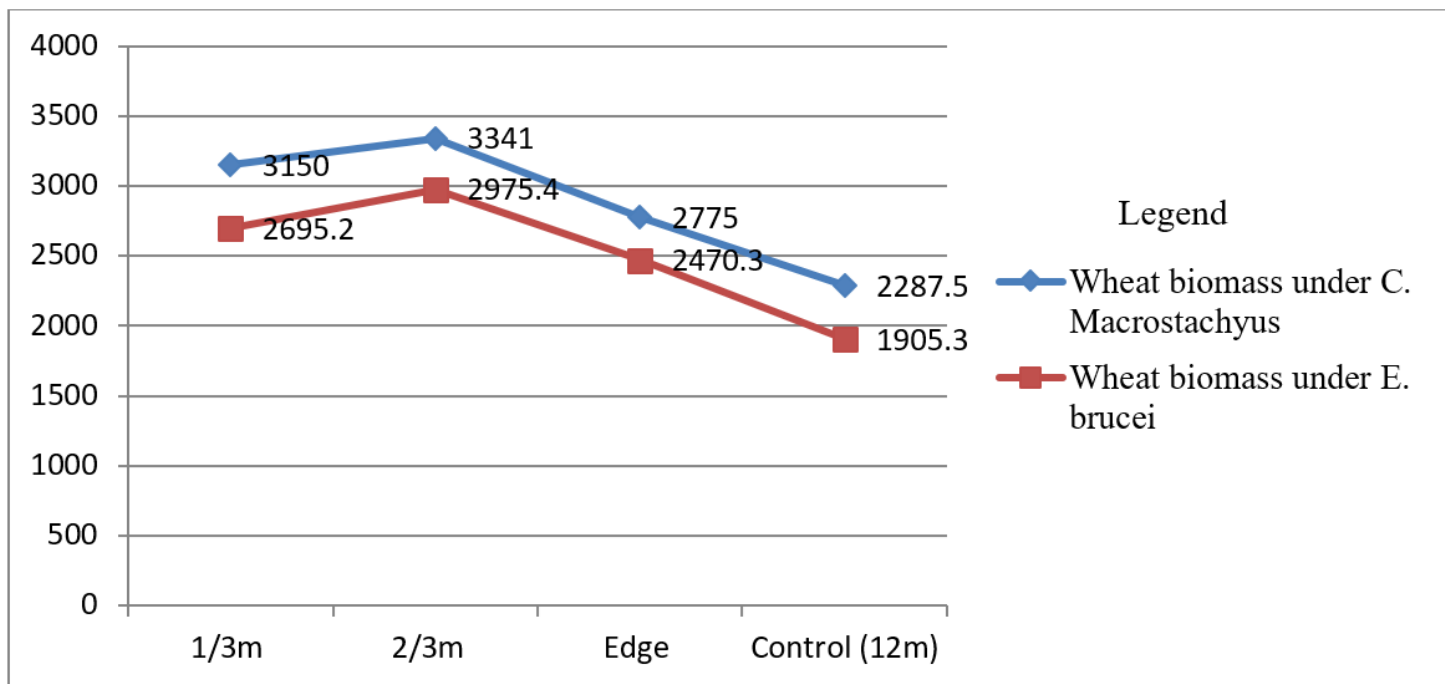


Figure 3

Wheat biomass under *Croton macrostachyus* and *Eythrina brucei*

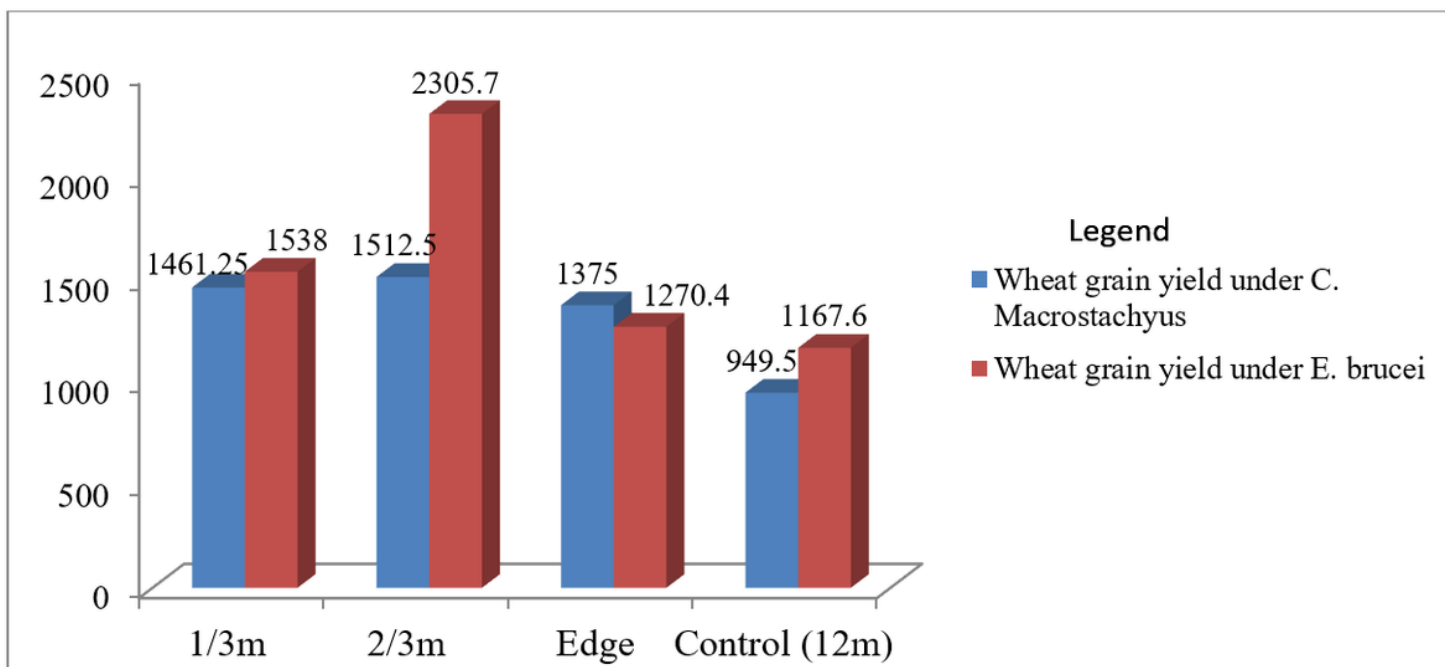


Figure 4

Wheat grain yield under *Croton macrostachyus* and *Eythrina brucei* in the study area

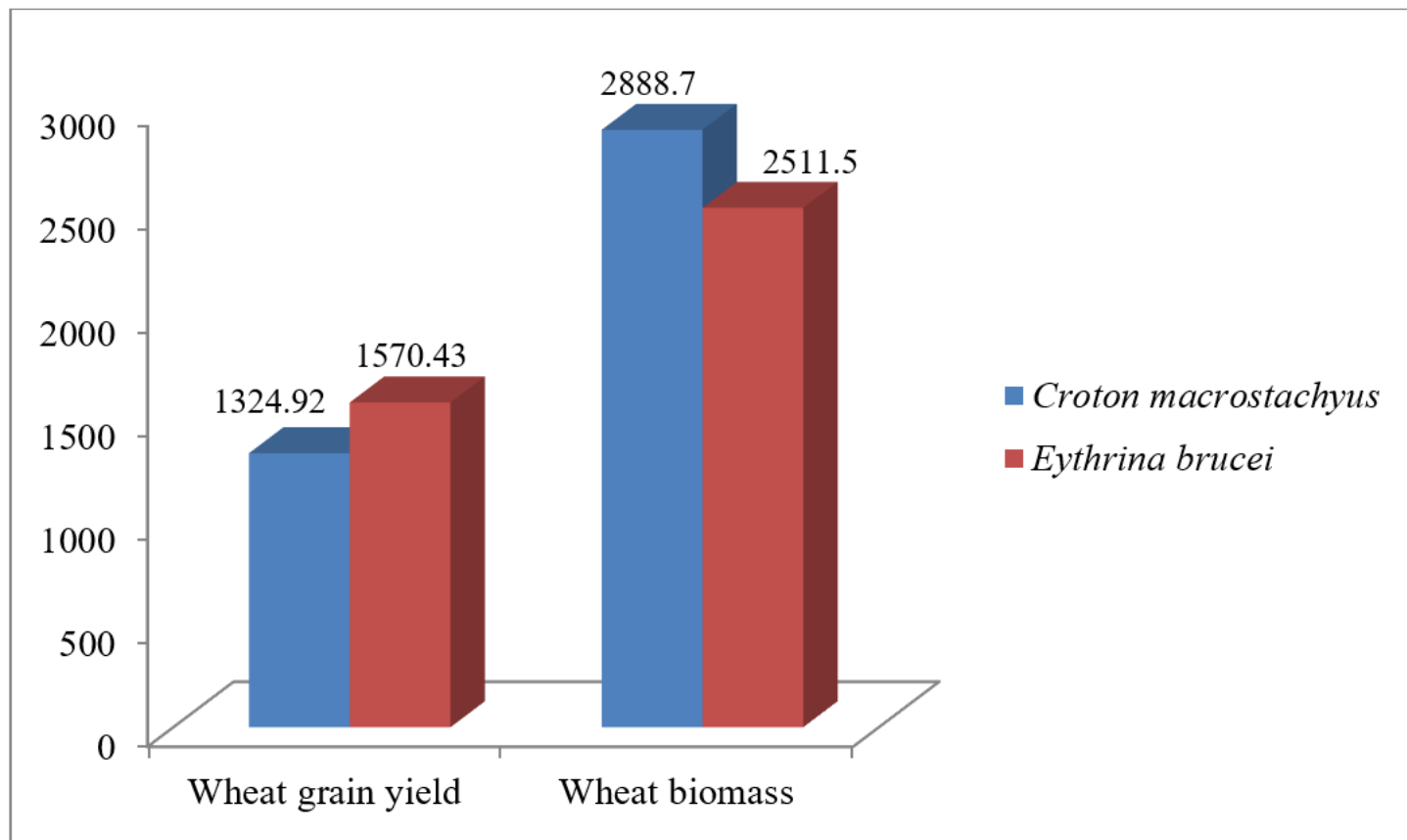


Figure 5

The mean value of wheat biomass and grain yield recorded at the two tree species in kg/ha

Supplementary Files

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