
Vigorous maize growth with irrigation and fertilisation in the Central Rift Valley, Ethiopia

Faidherbia albida Improves Maize Productivity and Carbon Sequestration in a Parkland Agroforestry System in Ethiopia

Aynalem Dilla[1], Philip Smethurst[2], David Parsons[1,3], Mekuria Denboba[4], Karen Barry[1]

[1] Tasmanian Institute of Agriculture, University of Tasmania, Private Bag 98, Hobart 7001, Tasmania, Australia
[2] CSIRO, Private Bag 12, Hobart TAS 7001, Australia
[3] Swedish University of Agricultural Sciences, Umeå, Sweden
[4] Centre for Environmental Science, College of Natural Sciences, Addis Ababa Ethiopia


Faidherbia parkland with an early-stage maize crop

Background

- *Faidherbia albida* is an important tree species in parkland agroforestry systems of semi-arid sub-Saharan Africa.
- It can improve soil fertility, crop production, and provide ecosystem services including carbon (C) sequestration.
- In the Central Rift Valley of Ethiopia, trees are pollarded every 2 or 3 years and crops are nutrient and water limited.
- Maize grain yield in the region can reach 7.3 t ha^{-1} with adequate fertilisation and irrigation (Dilla et al. 2018a).
- However, the interactive effects of tree and crop management on crop production is not well understood.

Objectives

- Quantify maize production in relation to tree pruning and fertilisation in a *Faidherbia albida* parkland agroforestry system of the Central Rift Valley, Ethiopia, in years of contrasting rainfall.
- Estimate the potential of trees to improve carbon sequestration.

Methods

- Maize was grown in 2015 (482 mm) and 2016 (1103 mm) in sub-plots of NP fertiliser treatments under trees with 0%, 50% or 100% pruning and in adjacent crop-only areas (Dilla et al. 2018b).
- Carbon sequestration of *F. albida* trees was estimated by measuring the above-ground C content of three trees and of soil in the 0-80 cm depth.

Results and Discussion

- Soil organic C, total N, and available P concentrations and gravimetric soil water contents were highest closest to the tree (0-20 cm depth, P = 0.05, Figs. 1 and 2), and evident to 80 cm depth.
- Yields were maximised with 50% pruning and NP fertilisation in the 2-6 m zone (P = 0.05, Fig. 3).
- Factors influencing maize production were in the approximate order: rainfall > distance from tree > pruning = fertiliser, but higher rates of fertiliser would have led to further increases in maize yield.
- Tree population density was 6 ha^{-1}, and trees stored 2 t C ha^{-1} in above-ground biomass.
- There was 34 t C ha^{-1} more C in soil (0–80 cm depth) under trees (Dilla et al, 2019).

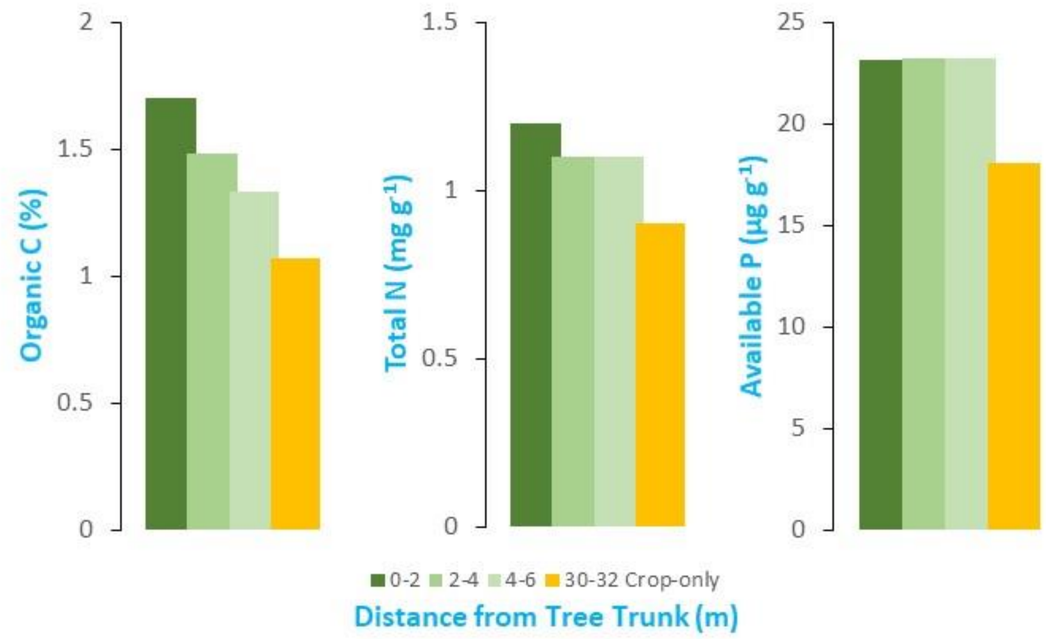

Fig. 1. Concentrations of C, N and P (0-20 cm depth) were highest closest to the tree.

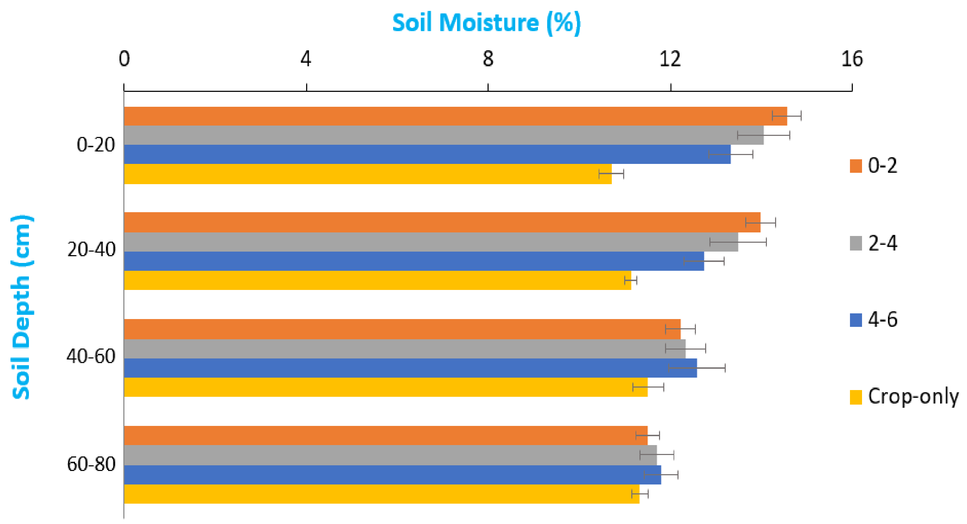

Fig. 2. Soil moisture content decreased with distance from the tree trunk (m) in the 0-40 cm soil depth. Bars indicate ± standard error (n = 3).

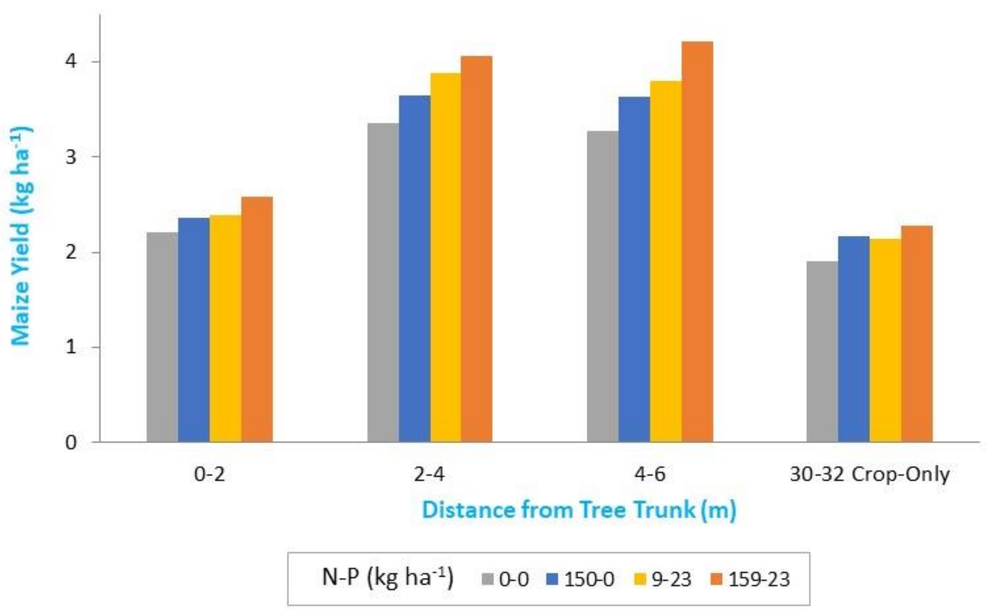

Fig. 3. Maize yield in relation to distance form tree trunk pruning level and fertilization.

- If this soil C increase could be directly attributed to a tree effect, increasing tree density to 100 ha^{-1} was estimated to result in an average C sequestration rate of 0.48 t ha^{-1} year^{-1}.
- Long-term measurements of C and nutrient dynamics under trees are needed to clarify the various direct and indirect mechanisms leading to relatively high C concentrations and nutrient and water availability under parkland trees (Smethurst et al. 2019). Microclimate was hypothesised to have a major role, but not tree litter or manure inputs.

Conclusions

- 50% pruning (instead of 100% pruning, i.e. pollarding) reduces shading enough to maximise maize grain yield under trees
- Fertilisers increase yield and are best used in normal or wet seasons.
- If *Faidherbia* trees were the cause of higher soil fertility, incorporating more trees into these farmlands could improve crop production and deliver ecosystem services including carbon sequestration.

References

Dilla AM, Smethurst PJ, Barry K, Parsons D, Denboba MA (2018a) Potential of the APSIM model to simulate impacts of shading on maize productivity. Agrofor Syst 92:1699–1709.

Dilla AM, Smethurst PJ, Barry K, Parsons D, Denboba MA (2018b) Tree pruning, zone and fertiliser interactions determine maize productivity in the *Faidherbia albida* (Delile) A. Chev parkland agroforestry system of Ethiopia. Agrofor Syst. https://doi.org/10.1007/s10457-018-0304-9

Dilla AM, Smethurst PJ, Barry K, Parsons D (2019) Preliminary estimate of carbon sequestration potential of Faidherbia albida (Delile) A. Chev in an agroforestry parkland in the Central Rift Valley of Ethiopia. For Trees Livelihoods. https://www.tandfonline.com/doi/abs/10.1080/14728028.2018.1564146

Smethurst PJ, Dilla A, Huth N (2019) Carbon Enrichment Not Fully Explained by Tree Litter or Animal Manure Inputs in a Simulated Faidherbia-Maize Parkland Poster, World Agroforestry Congress, Montpellier, France.

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