Agricultural Greenhouse Gases Program (AGGP2)

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High Plant Species Diversity Increases Carbon Accumulation in Agroforestry Systems

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Introduction

Agroforestry is a globally practiced land-use system that aims to maximize biomass production and other ecological benefits such as carbon (C) sequestration (Nair 2011). Agroforestry systems such as shelter belt systems, alley cropping, and riparian systems are widely practiced across Canada as well. Those land-use systems can include diverse plant species both in the overstory and understory components. While agroforestry systems have been shown to have the ability to sequester more C in both biomass and soil than monocultural agricultural systems, how plant species diversity affects C storage in agroforestry systems is not well understood. In this work, we used a meta-analysis approach to explore the plant-species diversity-C storage relationship in agroforestry systems at the global scale.

Methods

We searched for journal articles published before April 2019 that report C stocks (in soil and/or vegetation) within agroforestry systems using the ISI Web of Science and Google Scholar databases. We established a data set that includes 509 paired comparisons (agroforestry system and adjacent crop- or pastureland, either within or outside the agroforestry system, as control plots) from 141 published studies. Biomass C includes shoot and coarse root C; a baseline of 0 tonne C/ha stored in trees at age = 0 was assumed for biomass C stock. For soil C stock, the baseline was the SOC stock in the control plot (the adjacent cropland or pastureland). Structural equation modelling was used to evaluate the relationship between biomass C stock and changes in soil organic C.

The Result

There is 46.1 tonne/ha more C (95% confidence interval, 36.4–55.8 tonne/ha) in plant biomass (mostly tree biomass) in agroforestry systems than in sole cropland- or grassland-based land uses. There are greater biomass C stocks and biomass C increased faster in agroforestry systems with multiple tree species than those with a single tree species. The effect of agroforestry practices on soil C stock increased with tree age although such effects are dependent on the climatic zone. Soil C increases at a slower rate but peaks at a greater overall level in temperate zones as compared to other climatic zones. Structural equation modelling indicates that there is no direct linkage between biomass C pool size and changes in total soil C stock.

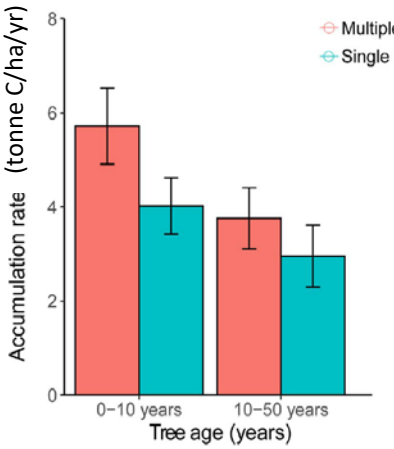

Fig. 1. Annual rates of biomass C accumulation in relation to tree age and tree species richness in agroforestry systems (Ma et al. 2020)

Implications

When establishing agroforestry systems with C sequestration as one of the objectives, consider to include multiple tree species to improve the C sequestration potential. Trees should be allowed to mature, as appropriate to the climatic region (but particularly in temperate regions), to achieve the maximum soil C sequestration potential.

Further Reading

Ma, Z.L., Chen, H.Y.H., Bork, E.W., Carlyle, C.N. and Chang, S.X. 2020. Carbon accumulation in agroforestry systems is affected by tree species diversity, age and regional climate: A global meta-analysis. Global Ecology and Biogeography 29: 1817–1828.

Nair, P. K. R. 2011. Agroforestry systems and environmental quality: Introduction. Journal of Environmental Quality, 40, 784–790.

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