Agroforestry and carbon sequestration

Reference 1

Muchane, MN; Sileshi GW; Gripenberg, S; Jonsson, M; Pumariño, L; Barrios, E. 2020 Agroforestry boosts soil health in the humid and sub-humid tropics: A meta-analysis. Agriculture, Ecosystems & Environment, 295, 106899 doi: 10.1016/j.agee.2020.106899

Background and objective

Although several studies assessing the effects of agroforestry on various soil properties have been published in the last three decades, a quantitative synthesis of the results from those studies is still lacking. Quantify the contribution of agroforestry practices to soil-mediated ecosystem services, specifically: 1) regulation of soil erosion, 2) storage of soil carbon (C), 3) storage of soil nitrogen (N), 4) availability of soil N, 5) availability of soil phosphorus (P), and 6) alleviation of soil acidity. Here, only results regarding objective 2 (soil organic carbon) are reported.

Search strategy and selection criteria

Literature search was focussed on well-designed and randomized studies that compared plots where crops were associated with trees (agroforestry) with adjacent plots where crops were grown without trees (crop monocultures). Publications for the meta-analysis were first identified using the ISI Web of Science focusing on literature published up to July 2017. It was searched published studies that reported the effects of agroforestry on soil health covering the aggregate ecosystem functions of C transformations.

1)The study originated in the humid or sub-humid tropics; 2) The study compared plots representing one or more simultaneous or sequential agroforestry practices with plots of crop monocultures. Studies in which the agroforestry practice involved organic inputs coming from outside (e.g. biomass transfer systems) or in which the tree effect could be confounded with other inputs (e.g. manure inputs as in silvopastoral systems) were excluded from the analysis. Furthermore, rotational woodlots (trees grown>3 years) and home-gardens, often classified as agroforestry practices, were excluded from the current analysis due to lack of studies reporting a proper control plot; 3) The study had the same crop species grown in the agroforestry plotand the corresponding control plot; 4) The study quantified one or several of the indicators of aggregate ecosystem function and soil health; 5) Only studies conducted on research stations and at the farm scale were included, but those at landscape scale and in the laboratory were excluded.

Data and analysis

Data were extracted from the results section, tables, appendices, graphs and figures from each of the papers. Data from graphs were extracted using IMAGE J software. Whenever multiple agroforestry treatments with different tree species were presented in a given paper, each treatment by control comparison was considered as a separate data point in the meta-analysis. The study also considered treatments based of different tree species compared with the same control as unique observations. If a paper reported results from more than one soil depth, only the upper soil layer (till layer) was considered. In cases where tests were repeated over the growth period, the authors selected the soil measurements made before the last growing season of the experiment to capture the cumulative effects.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
71	Crop production systems in tropics.	1)simultaneous agroforestry where trees and crops occur on the same piece of land during the same cropping season (e.g. alley cropping, intercropping, multi-storey agroforests); and 2) sequential agroforestry where trees and crops occur on the same piece of land but in a temporal sequence as part of a rotation (e.g. improved fallows).	Crop monoculture	Logarithm of ratio of soil organic carbon in agroforestry practices to soil organic carbon in crop monoculture.	75%

Results

- With overall effect size of 1.21 (CL: 1.15–1.27), agroforestry significantly increased SOC storage compared to crop monocultures although effects varied with study.
- Effect size did not significantly differ between simultaneous and sequential agroforestry practices.
- Aggregate-associated C was significantly higher under agroforestry than in the crop monocultures.
- Closer examination using soil physical fractionation techniques shows that 13–29 % more soil C is stored in macroaggregates under agroforestry practices.
- NA

Factors influencing effect sizes

SOC storage under agroforestry was significantly greater in sandy soils compared to loamy soils.

Conclusion

While the effect of agroforestry may vary with soil, climate, crop type and tree management, this analysis has demonstrated that agroforestry practices significantly increase SOC compared to crop monocultures.