Agroforestry and carbon sequestration

Reference 8

Background and objective

Although there are various estimates of C stocks in agroforestry, the results are highly divergent, and some studies do not have control plots for comparison, making it difficult to accurately evaluate C sequestration potential in agroforestry. The objectives are: 1) Quantify C stocks (both aboveground and soil C) in soils in four agroforestry systems compared with adjacent agricultural control plots under various soil and climatic conditions; 2) evaluate the effects of agroforestry characteristics, such as tree age, soil properties, and depth on soil C stocks; and 3) to identify knowledge gaps regarding the main processes and mechanisms in agroforestry for short-, medium-, and long-term C accumulation in agroforestry.

Search strategy and selection criteria

The studies were identified using the database Web of Science. We limited the search parameters to papers whose title, abstract, or keywords referred to agroforestry, alley cropping, windbreaks/shelterbelts, silvopasture, or homegardens in combination with soil, carbon, or organic matter. Studies included field data, and each study site had an Agroforestry system and adjacent cropland or pasture control plots. Modeling studies and reviews were excluded.

Data and analysis

Effect sizes were calculated and formal meta-analyses was conducted in R with the 'ROM' function in the 'metaphor' package. Individual effect sizes weighted according to their SDs. Mixed models were used to study the effect of covariates.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
76	Croplands or pastures in all pedo-climatic zones.	Agroforestry practices: alley cropping, windbreaks, silvopastures, and homegardens.	Adjacent plot with crop or pasture, without trees.	1)Effect sizes: Logarithm of ratio of C stocks (both aboveground and soil C) in plots with agroforestry practices to C stocks in plots without trees, back transformed and expressed as standardized difference of C stocks between plots with agroforestry practices and plots without trees. 2) Absolute values of C stocks (Mg C ha-1)	75%

Results

- Mean soil C stocks (1-m depth) in agroforestry were 126 Mg C·ha−1, which is 19% higher (with statistical significance) than that in cropland or pasture.

- Homegardens had 30% more soil C stocks than had controls, which was higher than those of other AF systems. Silvopasture has similar or even higher tree density than have alley cropping and windbreaks, but it had the lowest increase or even had no changes in soil C stocks.

- Across all age classes, increased soil C stocks in Agroforestry were reduced with tree age, indicating the highest changes in the younger trees (younger than 10 years)

- Soil C stocks in Agroforestry were similar across climatic zones.

- Agroforestry systems have much higher increases in aboveground C stocks than in soil C, especially in silvopastures. Aboveground C was correlated with tree density and growth rate, which was higher in agroforestry systems such as homegardens, windbreaks, and silvopastures. Tree management in the alley cropping system, such as pruning, might limit the biomass accumulation in stems, while increasing soil C stocks.

Factors influencing effect sizes

Level of increase of soil carbon depends on tree ages (level of increase higher with younger trees) and on soil depth (level of increase higher in the uppermost 60-80cm). The increases of soil C stocks in AF compared with controls were influenced by complex interactions among these factors: soil properties (texture, pH, and P and N content), climate (temperature and precipitation), and vegetation (tree density and cover percentage).

Conclusion

All four main Agroforestry systems—alley cropping, windbreaks, silvopastures, and homegardens—sequestered significantly more C than did cropland (or pasture).