Agroforestry and soil nutrient

Reference 2

Kuyah, S; Whitney, CW; Jonsson, M; Sileshi, GW; Oborn, I; Muthuri, CW; Luedeling, E. 2019 Agroforestry delivers a win-win solution for ecosystem services in sub-Saharan Africa. A meta-analysis. Agronomy for Sustainable Development 39, 47. doi: 10.1007/s13593-019-0589-8

Background and objective

Hypothesis is that agroforestry reduces trade-offs between provisioning (crop yield) and regulating/maintenance ecosystem services (soil fertility including soil organic carbon). This meta-analysis addresses the following questions: 1) What is the impact of agroforestry on crop yield, soil fertility, erosion control, and water regulation?; 2) Under which ecological conditions (agro-ecological zone, elevation, and soil type) does agroforestry have a positive or a negative effect?; 3) What is the impact of management (site of trial and agroforestry practice) on agroforestry's effect on crop yield, soil fertility, erosion control, and water regulation?; 4) How do different shrub and tree species differ regarding their potential to regulate these ecosystem services? Here, only results regaring soil nutrients are reported.

Search strategy and selection criteria

A literature search was conducted in Web of Science covering all years from 1945 until June 2018. Other sources include a recent structured vote count review, a meta-analysis and a narrative review. All studies and bibliographies were screened for other relevant publications. Criteria: 1) Paper published in a peer-reviewed scientific journal; unpublished literature and grey literature were excluded. 2) Study conducted on a research station or farmer's field in SSA. 3) Study investigated the effect of trees on ecosystem services with a suitable control, i.e., a tree-based system compared with tree-less, or investigation beneath tree crowns compared with investigation outside tree crowns. 4) Original field observation or experimental studies, excluding laboratory studies, greenhouse experiments, modeling studies, anecdotal observations, and reviews. 5) Studies reporting quantitative information on the sample size and the mean value of the response variable.

Data and analysis

Response Ratios (RR) were calculated for all pairs (agroforestry and non-agroforestry) of independent data points, hereafter referred to as observations. Bootstrapping methods were used to estimate 95% confidence intervals around weighted means of RR for different categorical variables through the application of 10,000 iterations using the boot package in the R programming language 3.4.2. Analyses of trade-offs were performed on studies that recorded both yield and soil fertility or water regulation. The percentage of observations belonging to win-win, trade-offs, and lose-lose situations was calculated and the data were plotted in a Cartesian plane to facilitate visualization. Spearman's rank correlation tests were performed between effect sizes of different ecosystem service indicators to determine whether they co-varied positively.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
73	Agricultural systems in sub-saharian Africa.	Agroforestry practices: alley cropping, dispersed intercropping, hedgerow, planted fallow, and crops planted under tree canopies in parkland agroforestry systems.	Non-agroforestry practices (includes sole cropping, continuous cropping without trees, and plots outside tree crowns in the case of parklands).	Ratio of soil nutrients (total N, available P) in agroforestry to soil nutrients in non-agroforestry practices.	81%

Results

- Agroforestry improved total N (RR 1.2; 95% CI 1.1–1.2) and available P (RR 1.2; 95% CI 1.1–1.2), compared to non-agroforestry practices.
- Compared to non-agroforestry practices, agroforestry improved total N and available P for all soil types except on Acrisols and Luvisols in the case of total N.
- Agroforestry also improved total N and available P for all categories of agro-ecological zones (humid, semi-arid) and elevation (Lowland, Highlandand) compared to non-agroforestry practices.
- Agroforestry of all types (alley cropping, biomass transfer, hedgerows, Intercrop, mulch, planted fallows) had a significant effect on total N, and available P compared to non-agroforestry practices, although the proportion of observations with RR > 1 was low for available P, ranging between 58 and 68% for the different variables. The differences among agroforestry practices were not statistically significant.
- The differences among woody perennials (trees, shrubs, N-fixing, non-fixing) used were not statistically significant.

Factors influencing effect sizes

Effect of soil organic content depends on soil type (no effect on Andosols). Correlation between SOC and total N (rs 0.433, N = 45, P < 0.05), and SOC and available P (rs = 0.277, N = 49, P < 0.05) were positive and significant.

Conclusion

The analysis has demonstrated that soil was more fertile in agroforestry than in non-agroforestry practices. It was infered that trees were the main source of nitrogen, since crop residues are usually removed with the harvest.