Agroforestry and water retention

Reference 5

Felix, GF; Scholberg, JMS; Clermont-Dauphin, C; Cournac, L; Tittonell, P. 2018 Enhancing agroecosystem productivity with woody perennials in semi-arid West Africa. Agronomy for Sustainable Development 38, 57. doi: 10.1007/s13593-018-0533-3

Background and objective

In semi-arid West Africa, the question remains as to whether biomass derived from trees and shrubs can provide an adequate soil amendment to improve soil quality and crop productivity, in a way that is sustainable and accessible to farmers. The objective is to quantify the effects of the presence of woody perennials and the use of ramial wood amendments on crop productivity and soil characteristics. Here, only results on soil water content and water infiltration rates are reported.

Search strategy and selection criteria

The first series of search terms related to the source of the woody perennial (tree or shrub), the second to the management practice (mulch or (inter)cropping), the third to the response variables (e.g. soil properties and crop productivity), and the last one related to the specific environmental context (specific countries within semi-arid west Africa). a)Studies that were conducted in the defined environmental context (rainfall < 1000 mm year−1 in semi-arid agroecosystems of Sudano-Sahelian Africa. b) Studies that included woody amendments as a management practice (surface-mulched or buried branches and/or leaves, but not biochar), and describing local uses of woody residues, or the presence of woody shrub or tree vegetation in farmers' fields, and reported effects on soil quality and/or crop productivity. c) Studies conducted on either farmers' fields or experimental stations were typically included with corresponding field data; pure modelling results were excluded. d) Literature reviews were excluded from the meta-analysis but were used to cross-check data, methods, and references.

Data and analysis

Graphical analysis based on boxplots.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
47	Cropping systems with trees in Semi-arid west Africa.	Plots under or at the vicinity of tree canopy. Plots receiving ramial wood as soil amendment.	Plot outside the area of canopy influence. Plot not receiving ramial wood as soil amendment.	Logarithm of ratio of soil carbon content in plots under tree canopy (or at the vicinity, or amended with ramial wood) to soil carbon content in plots outside the area of canopy influence (or not receiving ramial wood as soil amendment).	44%

Results

- Systems with intercropped perennials show higher soil water content, making water more available for crop uptake.
- Enhanced infiltration rates may also result in higher water retention and storage in the upper layers of soil profiles underneath the canopy of the perennial species.
- In Burkina Faso, crops grown under P. biglobosa benefited from a 24% increase in soil water content as compared to control conditions (Wilson et al. 1998). In Senegal, soil water content was higher by 20 and 28% in millet cropping systems with P. reticulatum and G. senegalensis, under shrub crown
- Ramial wood applications increase soil organic matter content which likely result in enhanced soil water contents (Chiroma et al. 2006). Moreover, organic matter additions will trigger termite activity, eventually leading to increased infiltration capacity
- NA

Factors influencing effect sizes

Higher soil water contents with intercropped perennials are largely due to belowground interactions, including (1) between roots and increased water infiltration that create preferential flows into deep layers of the soil, (2) a reduction in soil evaporation under tree canopies, and (3) the hydraulic lift effect transporting deep-water and rewetting of surface soil water content, usually overnight.

Conclusion

Presence of trees, shrubs and ramial wood amendments had overall positive effects on water use efficiency. Woody perennials in agroforestry systems locally create resource islands or fertility hotspots around their base, related to both aboveground (i.e. litter addition) and underground (i.e. hydraulic lift and root decay) processes.