Optimizing crop productivity and soil resilience of acacia-cassava agroforestry system in Central African savannas

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Agroforestry systems (AFS) integrating Acacia species are increasingly promoted in Central Africa as sustainable alternatives to slash-and-burn farming. Yet, their agronomic performance and soil fertility trajectories remain poorly documented, particularly in the Batéké plateau savannas of the Republic of Congo. This study assessed (i) the effects of farmer-preferred cassava planting densities on yield performance under two AFS models (farmer-managed and company-managed) compared to the traditional slash-and-burn system (TS), and (ii) soil nutrient dynamics across a six-year chronosequence of acacia fallows versus TS fallows. Field surveys and yield measurements were conducted in 71 cassava plots, while soil samples (0–25 and 25–50 cm) were analyzed for pH, organic carbon, nitrogen, phosphorus, and exchangeable bases. Results revealed strong yield contrasts: TS averaged 11.8 t/ha compared with 6.1 t/ha in company AFS and 5.2 t/ha in farmer AFS. Yield responses were strongly mediated by planting density. In TS, yields increased with higher densities (3,800–6,600 plants/ha), while company AFS performed best at moderate densities (2,500–3,500 plants/ha). In farmer AFS, yields declined beyond 3,000 plants/ha but remained competitive at lower densities (<2,300 plants/ha). Soil analyses indicated rapid acidification (–0.61 pH units) and phosphorus depletion (–40%) in AFS topsoils within six years, whereas TS fallows restored pH and base cations after 5–6 years. These findings reveal critical trade-offs: while AFS contributes to long-term ecological restoration, cassava productivity is constrained by density management, weed competition, and nutrient limitations. Integrating soil amendments such as biochar could mitigate acidification, enhance phosphorus availability, and strengthen yield resilience under AFS. This study provides evidence-based insights to reconcile food security, soil fertility restoration, and landscape sustainability in Central African savannas. This evidence could align AFS with both production and restoration goals, offering a scalable model for sustainable intensification in Central Africa's nutrient-poor savanna ecosystems.

Keywords: Agroforestry, cassava yield, planting density, biochar, soil fertility, Batéké plateau