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“Bridging the gap between increasing knowledge and decreasing resources”

## Sustainable Intensification in Cocoa Agroforests

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### Abstract

The inclusion of trees in cocoa agroecosystems has great potential to improve ecosystem functioning and maximise long-term crop production. The benefits trees can provide may not only be dependent on absolute shade cover but also on particular traits (*e.g.* nitrogen fixing capacity, deep rooting, fruit production) of the trees included in cocoa agroforests. Despite these potential positive effects of trees, agricultural intensification has traditionally led to the reduction of tree cover in many agroforestry systems worldwide. While this provides farmers with short term positive effects on overall crop production, the removal of trees may lead to negative long term effects on yields, resilience to climate change, and ecosystem service delivery. Trade offs between short- and long-term beneficial effects of the inclusion or removal of trees - and trees with specific traits in particular - of agroforests are still poorly understood. To fill some of these knowledge gaps, we investigated how the inclusion of trees affects cocoa production systems in Ghana, one of the worlds leading cocoa producers. More specifically, we quantified the links between cocoa yields, soil functions (*e.g.* stability, soil C stabilisation, nutrient retention), ecosystem services (water and nutrient provision) and vegetation structure (cover and traits of shade trees) along tree cover gradients of cocoa based agroforests. We present first results of the effects of agroforests differing in shade cover and tree trait combinations on cocoa yields, cocoa nutritional status, soil carbon, nitrogen and phosphorus, nitrogen and phosphorus availability, exchangeable cations, soil aggregation, water holding capacity, and infiltration; and estimated resulting nutrient and water use efficiencies. Our results yield a better preliminary understanding of the short- and long-term beneficial effects of the inclusion or removal of trees in cocoa agroforests.

**Keywords:** Agroforestry, carbon sequestration, ecosystem services, intensification, soil degradation, soil restoration, sustainability, *Theobroma cacao*