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The impact of tree diversity on soil organic carbon in cocoa agroforestry systems of Guatemala

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Abstract

The capacity of agroforestry systems to provide a wide range of ecosystem services, including climate change mitigation through enhanced C sequestration,

has already been widely demonstrated. However, due to the presence of diverse structures and complex interactions within different agroforestry systems, it is still not fully understood which factors and to what extent are determining the actual soil organic carbon (SOC) content and consequent SOC stocks, with

a particularly poor understanding of the possible effect of the present tree diversity. Therefore, this study aimed to identify which biotic and abiotic factors act as important predictors of SOC content variations. Data collection took place in the Alta Verapaz department of Guatemala, where soil samples at two depths (0–20 and 20–40 cm) were collected from 28 cocoa-based agroforestry systems. Our findings for the whole 0–40 cm soil profile revealed

that, on average, studied farms had generally high SOC contents (1.91 %) and high SOC stocks (101.34±37.76 Mg C $ha^{-1)}$. However, significant differences were observed between the studied plots, with SOC content ranging from 0.77 % to 3.44 % and SOC stocks from 41.3 Mg C ha^{-1} to 179.6 Mg C ha^{-1}. Linear regression models showed that the aboveground biomass and basal area of trees, tree species richness, and Shannon diversity index were the strongest predictors of SOC content variation at both soil depths, each positively associated with higher SOC content. Additionally, accumulated aboveground litter and present tree density also had a statistically significant positive effect on SOC content, although with less pronounced influence. In contrast, an increase in slope had a significant negative effect on SOC content. The age of the agroforestry system was the only factor that did not significantly influence the SOC content ($p > 0.05$). Findings suggesting that the diversity of trees in agroforestry systems is among

the key factors positively influencing SOC content underscore potential ecological, management, and policy-related implications.

Keywords: Biodiversity, climate change mitigation, factors influencing soil organic carbon content, tree vegetation structure

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