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Fine-Root Growth and Dynamic in Five Cocoa Production Systems Affect Biomass and Yield

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Abstract

Competition for resources in mixed cropping systems is feared by the producers but may be accompanied by complementarities in resource use and other benefits resulting in trade-offs between the production goal and ecosystem services.

Cocoa is a tree with a shallow rooting system and often produced in association with shade trees. Rooting characteristics of these associated trees are often not known and depend on several factors like species composition and soil characteristics. We were interested in fine-root distribution and growth in five cocoa production systems, comprising monocultures and agroforestry systems, both under conventional and organic farming, and a successional agroforestry system. Therefore, we measured cocoa fine-root parameters at three distances from the cocoa stem in 10 cm depth and installed ingrowth-donuts to measure total fine-root growth increment over a twelve-month period in 0–25 and 25–50 cm depth. We compared fine-root data with aboveground performance of the five production systems, i.e., tree and herbaceous plants biomass, and the cocoa and whole system yield.

Cocoa fine-roots were homogenously distributed below the surface, only the mean fine-root diameter decreased with distance to the stem. Around 80 % of total fine-roots were located in the upper 25 cm. Total fine-root biomass increment was three times higher in agroforestry systems than in the conventional monoculture and the same was observed for the aboveground biomass. Cocoa yield was lower in agroforestry systems but additional crops make up a whole system yield that exceeds the reduced cocoa yield. Higher above- and belowground biomasses also refer to enhanced carbon sequestration in agroforestry systems. While fine-root growth in the organic monoculture was also three times higher than in the conventional monoculture, aboveground cocoa biomass and yield were lower. The soil in the organic monoculture was covered by a perennial leguminous crop that increased the herbaceous plant material tenfold to the conventional monoculture. This must be responsible for the high fine-root biomass and also for the lower cocoa performance due to competition with the cocoa roots.

In contrast to organic monocultures, agroforestry systems are suitable alternatives to conventional monocultures due to high system yield and biomass despite the reduced cocoa production.

Keywords: Organic, root biomass, system yield, *Theobroma cacao*

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