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Modelling Crop Growth, Soil Fertility and Water Retention under Agroforestry and Slash-and-Burn Systems in Nicaragua

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Abstract

Soil degradation due to soil organic matter (SOM) depletion and erosion is frequently observed in tropical areas under agricultural intensification, typically affecting the poorest. Restoring those landscapes and enhancing sustainable food production should be a research goal.

Smallholder farmers in drought-prone northwestern Nicaragua highly depend on soil fertility and water regulation capability to produce sufficient subsistence crops. Practicing slash & burn agriculture (s&b) with common bean cropped after maize, loss of SOM results in poorly structured and unprotected soils. Farmers experience topsoil and nutrient loss via water erosion under maize in the early and water shortage for bean development in late rainy season. The Quesungual slash and mulch agroforestry system (QSMAS) as an alternative to conventional s&b consists of a maize-bean rotation under thinned secondary forest without burning and ploughing. Trees are heavily pruned and mulch covers the soil and augments SOM.

QSMAS is thus assumed to be superior to conventional cropping in terms of yields and soil protection. The research goal of this study was to evaluate the agroforestry system and identify key processes limiting or enhancing plant growth. WaNuLCAS, a plant growth model for crop-tree interactions at plot scale, is used for verification and to test improvement options for Quesungual set-up and management (tree species, planting density, pruning and animal browsing). Existing data on soil physical and chemical parameters on three QSMAS and s&b plots, respectively, in Somotillo, Nicaragua, were combined with own measurements soil moisture, photosynthetically active radiation (PAR), canopy light interception, crop growth, mulch quantity and quality .

First modelling results without trees show nutrient availability to be limiting for maize and bean. Under agroforestry, competition for water becomes limiting to crops at higher tree densities, which appears to be supported by measured soil moisture dynamics under three different tree densities. Although results for tree mulch quantities show higher amounts with higher tree density, beneficial mulch effects for soil water retention seem to be overcompensated by additional tree water demand. Furthermore, with tree canopies intercepting 50 to 70 % of PAR, light competition may counteract beneficial effects of enhanced litter production at high planting densities.

Keywords: Crop-tree interactions, maize-bean, quesungual agroforestry, SOM dynamics, WaNuLCAS

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