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Exploring Trade-offs Associated with Banana Canopy Management and Legume Intercropping Using a Multi-objective Optimisation Model

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Abstract

High population density in banana-based systems of east and central Africa has led to reduced farm sizes, making practices e.g. fallowing and rotations impracticable. It's further complicated by poor land-use planning, widespread land fragmentation, limited use of external inputs. Banana is mostly intercropped to optimally use available land to meet dietary and income needs. This practice is often accompanied with pruning of banana leaves to allow light to the understorey crops. Leaf pruning not only affects the overall farm profitability, but spreads bacterial wilt disease, a major constraint to banana. Potential knowledge-intensive production objectives such as nutrient yield and environment objectives are often not considered or difficult to conceptualise. We used results from an empirical experiment as input for a computer-based FarmDESIGN model to explore trade-offs between economic, production and environmental objectives, and to identify optimal farm configuration from different banana-legume intensification options. The experiment assessed three banana leaf pruning intensities (i.e. retaining all, seven and four leaves) to integrate legumes (bush, climbing and soy beans). Banana monocrops at the three leaf-pruning levels and legume monocrops served as controls while retaining 4 banana leaves mimicked severe leaf pruning by farmers. The FarmDESIGN model couples to a bio-economic farm model, a multi-objective optimisation algorithm to generate a large set of Pareto-optimal alternative farm arrangements. The model optimised for maximisation of gross margins, key nutrients and soil organic matter balance while minimising losses of key soil nutrients. Nitrogen (N), phosphorus (P) and potassium (K) balances were negative across the treatments while soil carbon (C) was positive. The legumes compared with banana and banana-legume intercrops had a more positive balance for N, P and K, but low for C. Higher gross margins, energy (kcal/ha), iron, zinc yields were realised for the banana and banana-legume intercrops. Leaf pruning reduced nutrient losses through uptake, gross margins and nutrient yields. Severe leaf pruning had a sub-optimal outcome. Small

adjustments obtained several farm configurations that performed better for the selected farm objectives. The integration of such models are useful in making outcome of empirical studies more robust, and are helpful in decision making/ planning of farms.

Keywords: Banana, FarmDESIGN, multi-objective, Pareto-optimal, trade-offs