Introduction

Agroecological systems are more complex than conventional ones, due to multiple-cropping and cycles, and to subtle interactions in time and space. They require specific tools to cope with this peculiar complexity. Agroforestry is a crucial agriculture that enables the addressing sustainable, biodiversity, and productivity in low-supply conditions and market diversification. However, subtle trade-offs or synergies exist between enhanced production, reduced soil erosion and competition facilitation between shade trees and the main crop.

We argue that the recent development of tools, such as refined process models (suitable to address the intra-plot variability of energy and mass fluxes) combined with remote sensing and spectrometry are very promising to optimize the shade tree management in plots, according to e.g. micrometeorology, elevation, exposure or nutrient supply level experienced by the crop. Virtual simulation combined with field verification should ease the process of adapting management practices to global changes.

The present poster aims at showing how some scientific tools can be used in novel methodology in combination with other tools, for optimizing the agroecological performances in Agroforestry systems.

Development

Question 1: How does shade affect the understorey crop?

- **Lock**: so far, heterogeneous plots such as agroforestry have been represented mainly using with 2 simplified and discontinuous situations: "below canopy" and "in full soil". However, the budget of the understorey plants is actually a continuous variable, depending on the local area of each plant in the field, of its neighbors, of the elevation, slope and time and day of finally of the distance to the shade trees.

- **Outputs**: simulation of the understorey shade for each point in a mixed heterogeneous plot (whatever plant, architecture, leaf area, layers, neighbors etc) allows to 1) study competition for light in complex plots 2) represent canopy maps, carbon and water fluxes per plant layer and per plot 3) compute light budgets per plant from the hour to several years, 4) design new experiments inside the plots (for instance for studying yield or impact of diseases) using the light absorbed as a new useful continuous co-variable 5) adapt the shade tree density to the local conditions (elevation, exposure and temperature regimes).

Question 2: Is there any link between vegetative development of the coffee plant (and its fruit yield)?

- **Lock**: yield prediction at the regional scale is crucial to adjust the whole chain of harvest and post-harvest to the annual fluctuations of production and to minimize wastes. It was suspected that the development of vegetative parts in plants is correlated positively or negatively, with the fruit yield. How does vegetation index mapping help predicting yield then?

- **Innovation**: the vegetation index map can be calculated on the regional scale using remote sensing (Fig. 3) (Taugourdeau et al., 2014), and the fruit yield is much more difficult to sense.

- **Outputs**: although coffee fruit yield is predicted at around 50% by amount the fertilizer input, adding the remotely sensed leaf area index in the model improved the prediction of 79%, considering the scale of a large farm (data not shown).

Question 3: What is explaining the variability of soil carbon stock, the land cover or the soil parameters?

- **Lock**: stocks of C in soils are very difficult to assess, due to a) the strong heterogeneity in soil organic carbon (SOC), b) deep profile, c) dry bulk density variability issues, f) high cost of SOC analyses.

- **Innovation**: using fast mapping methods for SOC assessment, as visible = Near Infrared (VIS-NIR) and Mid Infrared (MIR) spectrometry, allows mapping SOC horizontally at the landscape scale with high number of points (500-1000 points) of Fig (Kinoisin, 2012), and also according to soil depth (Fig. 5).

- **Outputs**: such strategies reveal that in the same region (Tropical Pacific coffee, the soil vertical and horizontal heterogeneity of SOC is much more relying on the heterogeneity of the soil material (clay, metal-humus complexes and alphaceous content) than on soil cover distance to shade trees or leaf area index) or topography (slope, distance to river beds etc.). This conclusion is not irreversible, and can change according to soil type variations and cover dynamics, but such rigorous tests help CC assessment a lot.

Conclusions

The recent development of tools, such as process models, remote sensing and fast-SG C analysis, when used in combination allowed refined understanding of processes (competition, facilitation, compensation), and occurring in complex and multi-layer agro-ecological systems, such as agroforestry, and drive optimization efforts. Sustainable double-cropping (and even more) and optimization of coffee (Agroforestry) productivity, and contributions to soil carbon, and biodiversity.

Reference:
