Ph. D. THESIS POSITION

Garden orchard systems: research into the soil-plant-atmosphere continuum

Context:

The goal of this Ph.D. thesis project is to study a particular agroforestry system, the garden orchard: this type of system combines fruit and vegetable production, to react to the increasing societal demand for the production of quality fruit and vegetables that are produced locally, sustainably, and with low pesticide levels. Generally, agroforestry systems have shown their agronomic and socioeconomic interest, via indicators like the 'Land Equivalent Ratio' (Dupraz and Liagre 2008).

However, existing models are not directly applicable, since the garden orchard distinguishes itself from classical agroforestry systems by its diversity and the rapid succession of vegetable rotations, as well as by the numerous interventions applied to the aerial part of the fruit trees, which alter at the same time root growth and thus root-soil interactions, and aerial interactions between fruit trees and vegetables, via shading effects. These characteristics imply an important temporal variability of the function of this system, thereby rendering the search for an optimal equilibrium between the different supplies and demands of water and nutrients more complex.

Aims of the thesis:

On the scientific level, this thesis aims at integrating and quantifying the principal mechanisms implied in the soil-plant-atmosphere continuum, more specifically those mechanisms controlling the cycles of carbon, nitrogen and water, at the field scale, in order to optimize the efficiency of the production system.

With respect to the carbon cycle, the formation of the different forms of organic matter will be studied in-depth, resulting from soil characteristics and from the multiple modalities of biological activity encountered. This focus is adding a scientific dimension, so far little explored, to the investigation of these systems. Two emerging and partly related knowledge sectors will be investigated in particular: the first one concerns the phenomena of root deposition and root turnover in fruit trees; the second one is linked to the necessity to find alternatives for chemical fertilizers.

The integration of these processes will be realized by conceiving a mathematical model describing the functional traits of the soil-plant-atmosphere system of the garden orchard, which will be constructed based on the hypothesis that an aggregation of simpler, already known and validated, models is possible. The aggregated model should represent the spatiotemporal dynamics of the carbon, nitrogen and water cycles, at the scale of the garden orchard.

This methodological choice will mobilize the complementary competences of five disciplines: soil science and bioclimatology on the one hand (Research Unit EPHor, Agrocampus Ouest, Angers), and agronomy, plant nutrition and ecophysiology on the other hand (Mixed Research Unit IRHS, QualiPom team, Angers). It will be reinforced by the recognized experience in modelling (conceptual, mathematical, and computer graphical) of the different members of the supervision team.
Nevertheless, this exercise in modelling raises the need for the development of a workflow of conceptualisation and technical equipment suitable to create a data set and parameters to be used in the mathematical models.

Thanks to interactions between the field measurements (under realistic production conditions) and the conception and adaptation of specific models, this doctoral thesis will establish the basis for the development of monitoring tools, in order to hierarchize the main processes involved in this type of production system and to create a management guide for it in a professional context. These tools will allow the conception of a mathematical model of the functional traits of the soil-plant-atmosphere system of a garden orchard, which will be used to test production scenarios (prototypes).

Time plan and organisation of the thesis:

In order to provide satisfying answers to the above-mentioned set of problems, the general approach has to consist of the construction of a simple model that represents and computes the principal fluxes (C, N, and water).

This model will be essentially modular and based on submodels already used in a production context (simplified photosynthesis model [optionally coupled to a light interception model], mineralisation model by Hénin-Dupuis ...). The project will consist of six stages:

1. Identification of the principal processes and their subsequent formalisation in a conceptual model describing the functioning of the soil-plant-atmosphere continuum ;
2. Algorithmic implementation of a mathematical model from a conceptual model, with the support of the supervision team;
3. Identification / creation of simple tools for measuring and quantifying the dynamics of C, N and water reserves in the different plants and the soil. These tools and methods will be used on two dedicated experimental plots reserved for the acquisition of elementary data;
4. Use of these data in the implemented model, for calibration and rule specification ;
5. Verification, test, and final validation of the model by coherence analysis of the simulation results as well as by comparison with an independent data set.

As the stages number 2 and 4 are likely to be very complex and time-consuming, the qualified members of the supervision team will anticipate the work for the Ph.D. student.

Researched candidate profile and prerequisites:

Applicants for this position must have a background in soil science and/or agronomy with an Engineering or Master degree. Even if actual programming of mathematical models is not a prerequisite skill, an affinity for modelling is necessary, and skills in this field are a clear advantage.

The successful candidate will have a strong inclination for doing scientific research and will be a team player, both in the field and in the laboratory. He or she will also have a certain fluency in the English language, both orally and in writing.

Application for this position is done in writing. Documents to be prepared include a CV, a letter of motivation, and the certificates of notes of the level M1 and M2 (Master). The acceptance of the application follows the procedure of the EGAAL (« Ecologie, Géosciences, Agronomie, Alimentation ») graduate school. The successful candidate will be registered as a Ph.D. student at this graduate school, while being based at Agrocampus Ouest, Angers.

Envisaged start date of the thesis: October 2018

The Ph.D. student will be co-supervised by the research units Environnement Physique de la plante Horticole (EPHor, Agrocampus Ouest) and the mixed research unit (UMR) Institut de Recherche en Horticulture et Semences (IRHS), at Angers.

Supervision team:

Patrice CANNAVO (Thesis supervisor and director), EPHor-Agrocampus Ouest, patrice.cannavo@agrocampus-ouest.fr
Gerhard BUCK-SORLIN (Thesis co-supervisor and co-director), IRHS-Agrocampus Ouest, gerhard.buck-sorlin@agrocampus-ouest.fr
Etienne CHANTOISEAU (tutor), EPHor-Agrocampus Ouest, etienne.chantoiseau@agrocampus-ouest.fr