VERTICAL PROJECT: DESIGN OF FRUIT AGROFORESTRY SYSTEMS FOR A RENEWED HORTICULTURE

Warlop F.1*, Castel L.²

*Correspondence author : francois.warlop@grab.fr

(1) GRAB (Research Group for Organic Farming), Avignon, France (2) Chambre d'Agriculture de la Drôme, Valence, France

Introduction

Modern agriculture is facing more and more challenges and has to reduce its environmental footprint, including its global warming effects. As perennial systems, orchards are among cropping systems that most depend on pesticides. New sustainable orchard designs have to be proposed.
In the meantime, consumers are asking for a closer relationship with farmers and for safer products. Periurban farming is a new emerging trend, and land access is another issue leading to the necessity of agricultural intensification.
By increasing both within-field crop production and ecosystem services through crop diversity, agroforestry is a promising way to address these challenges. However, agroforestry under temperate climates is mainly focused on the association of forest trees and rotational cropping systems. Agroforestry mixing fruit trees and annual crops (such as vegetables) could address such issues in horticulture but has not been well documented. Therefore, the benefits of planting fruit species in diversified systems are poorly studied, as the effect of neighbouring crops on fruit trees health, and the global ecosystem balance.

One expected amenity of agroforestry is to increase biodiversity and natural pest control within the plot. We made the hypothesis that introduction of annual crops in the perennial system can lead to enhanced biocontrol and to input reduction, while developing other functions (organic matter increase, soil fertility, etc.) and synergies between crops (shadow beneficial effects, water limitation, etc.) or social amenities.
However, fruit trees have other characteristics and requirements than forest species (such as height, pruning, crop protection) and their relevance in agroforestry needs to be better shown. Can plot diversification lead to a higher resilience, and reduce trees' dependence on pesticides? Is fruit trees (grafted on regular rootstocks) shadow significant enough to have a beneficial effect, under various climatic conditions? How do fruit tree rootstocks behave in such agrosystems? Can they help in reducing water and nutrients use and losses?
The aim of this paper is to investigate such questions through the analysis of the specificities of two fruit agroforestry systems co-designed to answer different agronomic and economic challenges.
It also shows how co-design may be a strong tool to share expertise and knowledge, and bring innovation.

Additionally, evaluation tools for such complex agrosystems do not exist yet, though they could be useful to support design (*ex ante* evaluation) or to better assess performance (*ex post* evaluation).

Material and methods

Systems design

On two locations (Durette[3]/TAB[4]) in Southern France (Rhone Valley, see **figure 1**), each one with specific context and constraints (i.e. crops, rotation, market channels, economical organization, cultivated surface...) but sharing the general aim to reduce pesticide use, the

3 http://www.grab.fr/durette

4 http://rhone-alpes.synagri.com/portail/parlons-plate-forme-tab

partners of a 6-year project called Vertical, funded by the French Ministry of Agriculture, co-designed in 2012 and 2013 innovative fruit agroforestry systems under a participative approach.

The iterative design process as described by Pelzer et al. (2012) was used (**figure 2**). Stakeholders (farmers invited, advisors, researchers) were brought together in both cases, for long discussions on several scenarii that were proposed to them. Farmers were actively involved in the process, as their expertise and know-how remained decisive in the selection of final scenario to be experimented. This produced original orchard design and decisional systems, as a deliverable of the Vertical project.

Meanwhile, models have been built to forecast the global production of fruits and vegetables in such agroforestry systems, according to ratio between species, space dedicated to each. These tables are helpful for design support.

Systems evaluation

Classical sustainability indicators have also been discussed and selected to (i) monitor and (ii) assess the systems. Some specific biodiversity groups were monitored in the field following the national program dedicated to ordinary biodiversity monitoring in arable land (called OAB[5]) to characterize the initial environmental situation.

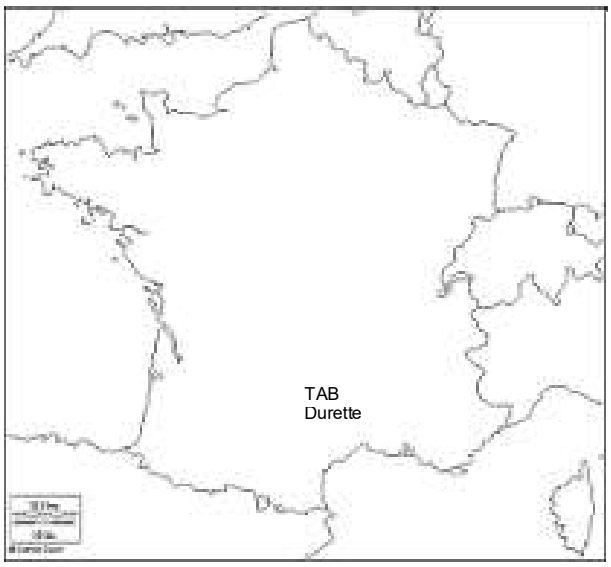

Figure 1. Locations of TAB and Durette sites

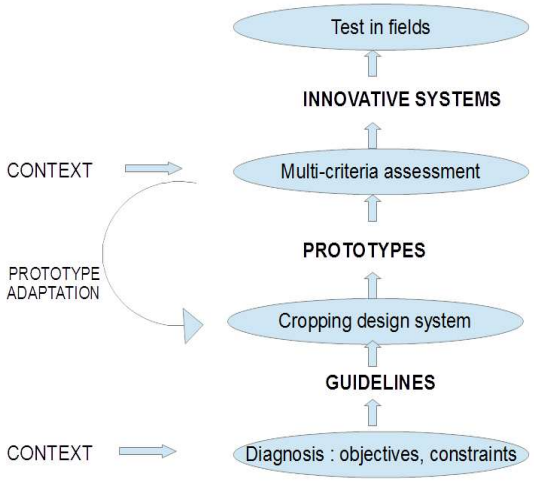

Figure 2. Multi-criteria assessment process for complex inovative cropping systems

5 http://observatoire-agricole-biodiversite.fr/

Results & discussion

Systems design

Co-design meetings were organized in 2012 and 2013 on both sites. They produced compromises as most prospective and alternative designs did not fit farmers expectations, as these were not reproducible. Intermediate designs, still innovative but closer to commercial feasibility had to be discussed.

The systems were implemented in 2013 and 2014 (**figure 4**). Although the general objectives were the same in the two sites, each location made specific choices according to their constraints and organization frame (**table 1**).

Table 1 : Main characteristics and leverages used in each agroecological system

	TAB platform	***Durette***
Starting date	2013	Trees : 2013 Vegetables/poultry : 2016
Marketing	Organic farming, Long marketing channels	Organic farming, Short marketing channels
Economical organization	Experimental farm with employed people	2 farmers with economical autonomy
Rotation crops	Cereals, grain crops (rapeseed, maize, wheat, soybean, faba beans)	High crop diversification (vegetables)
Fruit system	Peach, low-susceptible cultivar	All rosaceous species Vigourous rootstocks Low susceptible cultivars
Diversification	High stem timber trees	Animal introduction (chicken) High stem timber trees
Agroecological infrastructures	Hedges, strips, nests boxes, flower strips, grass rocks & wood piles	
Cultural practices	Reduced fertilization Adapted pruning Long rotations Organic plant protection when needed	
Input strategy	Application according to decision rules	No input unless needed for key pests No fungicides

Main re-design and diversification features were related to fruit tree planting at the TAB platform and animal introduction/high-stem fruit trees at Durette. Decision rules were implemented in order to manage the experimented systems in a proper way to reach the objectives of pesticide use reduction and multiperformance.

Systems evaluation

The first years of experimentation already permit to outline the technical feasibility to grow alternating rows of rotation crops and fruit trees (3-row peach trees alternating with 25 m-wide arable crop at the TAB platform, 2-row fruit trees alternating with 10-m wide rotation crop at Durettte site). No detrimental effect was yet noted either for the fruit trees or for the rotation crops, and fruit setting at the TAB platform has started in the second year as in conventional peach orchards.
An e*x ante* assessment tool has been developed under a participatory approach, to stimulate the co-design of new performant plots, taking into account stakeholders priorities and expertise... Most determining components of sustainability have been decided and weighed through concertation and negociation (**figure 3**). This tool was useful to hierarchize and select most promising leverages.

Figure 3. Partial overview of a multi-criteria assessment tool for agroforestry systems

This tool will be adapted to *ex-post* assessment, so that advisors but also farmers managing fruit agroforestry systems can identify their main bottlenecks and assets. A link to the national bottom-up network of commercial fruit agroforestry systems (called *Smart*[6]) could be achieved this way.

Performance criteria will be collected for a pluriannual assessment of the prototypes sustainability.
The approach and the experimented prototypes are innovative and promising. We need to carry on studying the performances of both experimented fruit agroforestry systems in the following years, in order to contribute to research on mix cropping for horticulture.

Figure 4: First TAB prototype (2013) associates peach trees with rapeseed and faba bean under rotation with other arable crops

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Reference :
Pelzer, E. *et al.* 2012. Assessing innovative cropping systems with DEXiPM, a qualitative multi-criteria assessment tool derived from DEXi. *Ecological indicators,* **18**, 171-182. doi:10.1016/j.ecolind.2011.11.019

6 http://www.agroforesterie.fr/smart