OWC 2020 Paper Submission - Science Forum

Topic 1 - Ecological approaches to systems' health

OWC2020-SCI-846

CO-DESIGN OF AGROECOLOGICAL TEMPERATE FRUIT TREE SYSTEMS: APPROACH, TRADEOFFS AND OUTPUTS

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Preferred Presentation Method: Oral or poster presentation

Full Paper Publication: Yes

Abstract: Crop diversification and ecological intensification are a way to foster ecosystem services and produce in very low input systems. We analyzed the design process of three experimental sites that shared the same objective of ecological intensification and diversification in fruit tree production. Agronomic, ecological and organizational aspects were involved in the approach. Pest suppressive plant diversification, resource sharing among cultivated and associated plants, and feasibility were key elements. Identifying the expected functions of each plant species or assemblage (e.g. barrier, trap, production) was also crucial. Co-design brought experiences and expertises and was a powerful way to obtain trade-offs between targeted services in the design of innovative fruit production systems being now experimented. Further research and evaluation of the experimented prototypes are still required but the present analysis opens avenues for agroecological design in perennial crops.

Introduction: Fruit production is challenging. Current orchards are intensively managed monoclonal crops. As perennial crops, they face possible cumulative pest populations or pathogen inoculum (in short pests). Moreover, fruit damage is not tolerated since fresh fruit are marketed. Both conventional and organic orchards therefore rely on plant protection inputs to control pests (Labeyrie et al. 2018). Ecological intensification through an increase in plant diversity is a way to foster ecosystem services and pest suppression, and produce in very low input systems. Such a novel approach in orchards entails to consider interactions among fruit trees, associated plants and practices in the system design. Both time and space dimensions are also tightly intertwined. This is complex, and case studies are scarce and not always documented. The aim of this work is to analyze the co-design process of three diversified fruit production systems and propose avenues for agroecological design in perennial crops.

Material and methods: We analyzed the design process and the outputs of three experimental sites that shared the same objectives of ecological intensification and diversification in fruit tree production. If local contexts differed, the general aim was to produce fruit through the re-enforcement of ecosystem services, especially pest suppression, rather than the use of external inputs –even though organic. All sites were located in Southern France. The work was carried out within the frame of the French 'ALTO' project (2018-2023) which involves the three experimental sites and a participatory approach (Simon et al. 2019). The three experimental sites explored: (i) *de novo* and (ii) step-by-step 'pest suppressive' design, and (iii) the way to optimize resource use between associated and cultivated plants, and between vertical layers. Orchards were designed using expertise and multi-actor workshops (Penvern et al. 2018). They were planted between 2016 and 2019, and are organic-managed. Main practices to control pests are sanitation, mechanical practices and biocontrol. The analysis considered the co-design approach to identify targeted ecological and biophysical processes, the way to foster them, and the possible prioritization and tradeoffs to achieve a consistent and manageable fruit production system. The sites' managers and partners as well as traceability documents were the sources of information for this analysis.

Results: In the three case studies, agronomic, ecological and organizational aspects were involved, namely pest control, resource sharing among plants and technical feasibility (Fig. 1).

The 'pest suppressive' design aimed to prevent the arrival, installation, development and dispersion of the main pest groups of fruit trees (i.e., aphids, moths and fungus) through barrier and dilution effects, push-pull, conservation biocontrol, low-susceptibility cultivars and general design.

Ressource sharing was also a key to grow diversified producive agroecosystems. Light interception is modulated by tree height, row orientation but also co-planting or delayed planting of cultivated plants. Reduction in available light can affect yield, but conversely, shade projected by upper layer trees can avoid fruit sunburn and leaf disfunctioning under excessive light and heat. On the other hand, combining various plant species in a same plot may increase competition for belowground water and nutrients but also, alternatively, enhance water re-distribution from moist to drier zones of the soil via the different zones explored by the root systems of large and small plants.

Finally, work load (quantity, diversity) along the year as well as distances to walk or drive to manage trees were considered.

In the three systems, diverse spatial arrangements resulted from the diversification of fruit tree species and cultivars, within- and supra-plot management of food resource and habitat for beneficial predators (arthropods, birds, bats etc.) and companion plants, connectivity patterns, planting distances and ergonomic considerations:

-A vertical organization in an agroforestry system comprizing a leguminous intercrop, and a fruit tree layer under a timber tree layer;

-A between-row diversification in an existing orchard by replacing rows to alternate pome, stone and citrus fruit trees and mix companion plants, with the addition of productive layers (vegetables, aromatic plants, lianas);

-A circular shaped orchard to limit edge effects and pest arrival and organize biodiversity areas, combined with alternate pome, stone and other fruit circles; six nested spirals were organized to mix fruit species, ease traffic and grow a similar number of fruit trees per species.

Basic and applied knowledge on ecological and biophysical processes, feedbacks and experiences of various stakeholders in the fruit chain were important to make proposals but also tradeoffs between agronomic, ecological and organizational aspects. Orchard 'despecialization' (from one fruit production service to the provision of fruits and other services) questionned the position of the fruit tree in the agroecosystem. Since everything cannot be at best for every element in the system, the capacity to obtain tradeoff is a key for design, and co-design was a powerful way to obtain it. Lastly, identifying the functions expected from plants and plant assemblages (e.g. barrier, trap, production) contributed both to the genericity of the approach and the general consistency of the designed prototypes.

Discussion: This analysis is an attempt to propose an operational approach based on agronomic, ecological and organizational aspects to design agroecological fruit tree production systems. Identifying the expected functions of each plant species or assemblage was crucial in the design as well as co-design to obtain trade-off between targeted services. The paradigm was not to maximize a given service, wether production or pest suppression, but to reach a sustainable state of the whole system where prioritized services are optimally re-enforced and combined. Of course, further research and the multicriteria evaluation of the still young experimented prototypes will support, implement or alter this analysis. Besides, experimented prototypes are likely to evolve with time integrating further exchanges with stakeholders and on-going management and evaluation (Lauri et al. 2016). More generally, those long-term experiments create a place for scientific, technical and educational interactions around temperate fruit production systems.

Acknowledgements

The ALTO project is partly supported by the French national Ecophyto II program within the frame of the DEPHY EXPE network. Ecophyto II program is managed by the French Ministries of Agriculture and Environment, and benefits the financial support of the French Biodiversity Agency and the taxes for diffuse pollution allocated to the program.

References: Labeyrie B. et al. (2018) Réseau DEPHY EXPE : synthèse des résultats à l'échelle nationale – filière Arboriculture. Cellule d'Animation Nationale DEPHY Ecophyto, 64 p.

Lauri P.É. et al. (2016) Interdisciplinarity and Multiagent Interactions for Innovations in Horticulture – Paradigms beyond the Words. Acta Hort 1137, 255-266. http://dx.doi.org/10.17660/ActaHortic.2016.1137.37

Penvern S. et al. (2018) Trade-offs between dreams and reality: Agroecological orchard co-design. Proceedings 13th European IFSA Symposium, 1-5 July 2018, Chania (Greece).

Simon S., Ricard J.-M., Lauri P.-É. (2019) Temperate fruit-based agroforestry systems: three case studies in Southern France in the framework of the 'ALTO' project. Book of abstracts 4th World Congress on Agroforestry, 20-22 May 2019, Montpellier, FRA, 635. https://agroforestry2019.cirad.fr/replay/book-of-abstracts

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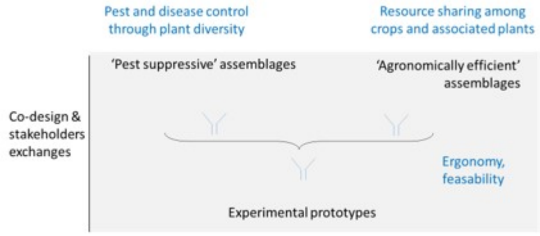

Figure 1: Main aspects involved in the co-design of the studied agroecological fruit production systems

Disclosure of Interest: None Declared

Keywords: agroecology, co-design, ecosystem service, fruit, orchard