Orchard redesign towards pesticide-free fruit production

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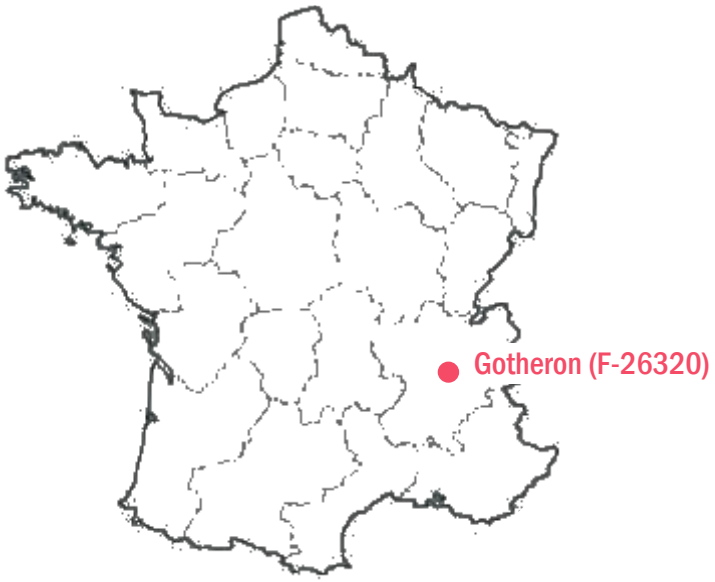
INRAE

Short introduction

The place



-Middle Rhone valley

-(Sub)mediterranean climate

The people: team SaVAGE ‘Système Verger AGroEcologique’ – INRAE Gotheron

The experimental site: UERI INRAE Gotheron

https://ueri.paca.hub.inrae.fr/

-A 80 ha experimental station devoted to fruit production

-Organic farming

-General aim of the research work: to increase orchard sustainability

A few words about fruit production

-Fruit production is highly **dependent on pesticides**

-**Need to change intensive specialized orchard systems** towards more sustainable fruit production areas

-Aims of the present study: To explore how **crop diversification and ecological intensification** through an increase in plant diversity can reinforce ecosystem services towards pesticide-free orchards

The design approach and the first feedbacks

Challenge

To design from scratch a pesticide-free fruit production area relying on ecosystem services, especially pest suppression...

Proof of concept

Our partners (ALTO project)

Farmers, teachers, advisers, experimenters, researchers (biotechnical and social sciences), naturalists...

How did we proceed?

De novo design

Step by step design

Towards pesticide-free orchards

Workshops

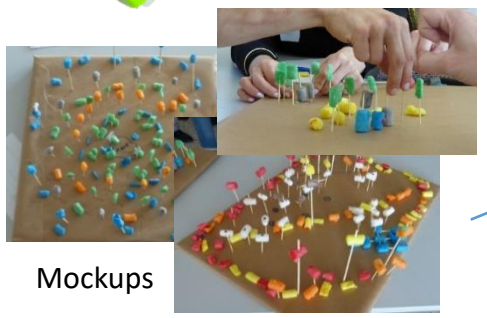
Planting

On the way management...

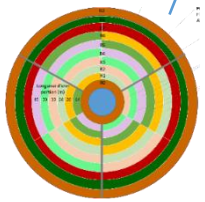
2015 — 2017 — 2018 — 2030

Context, main objectives = framework definition

Basic research on processes



Mockups



Final prototype

Co-design: learning, experience sharing, multi-actor dynamics...

After C. Goutines (internship 2016-2017), B. Chieze (internship 2017)

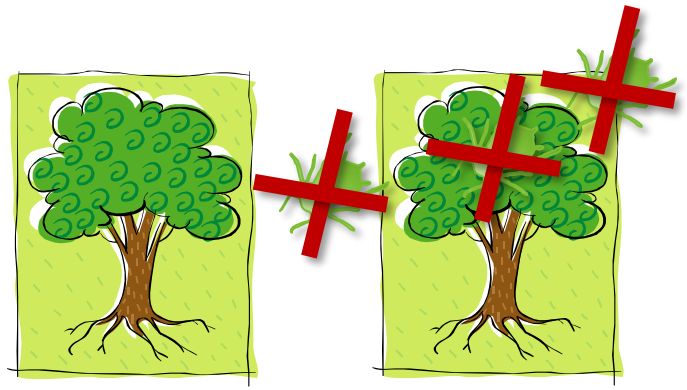
General approach to design

Pest control through plant diversification

Pest-suppressive plant assemblages

‘Pest suppressive’ design: diversification of crops, companion plants, habitats…

> Design of biodiversity-based agroecosystems



To disadvantage pests & diseases and to welcome natural enemies

A few natural enemies of pests in orchards

Coccinelles

Syrphes

A few natural enemies of pests in orchards


Chrysope

Hyménoptère parasitoïde

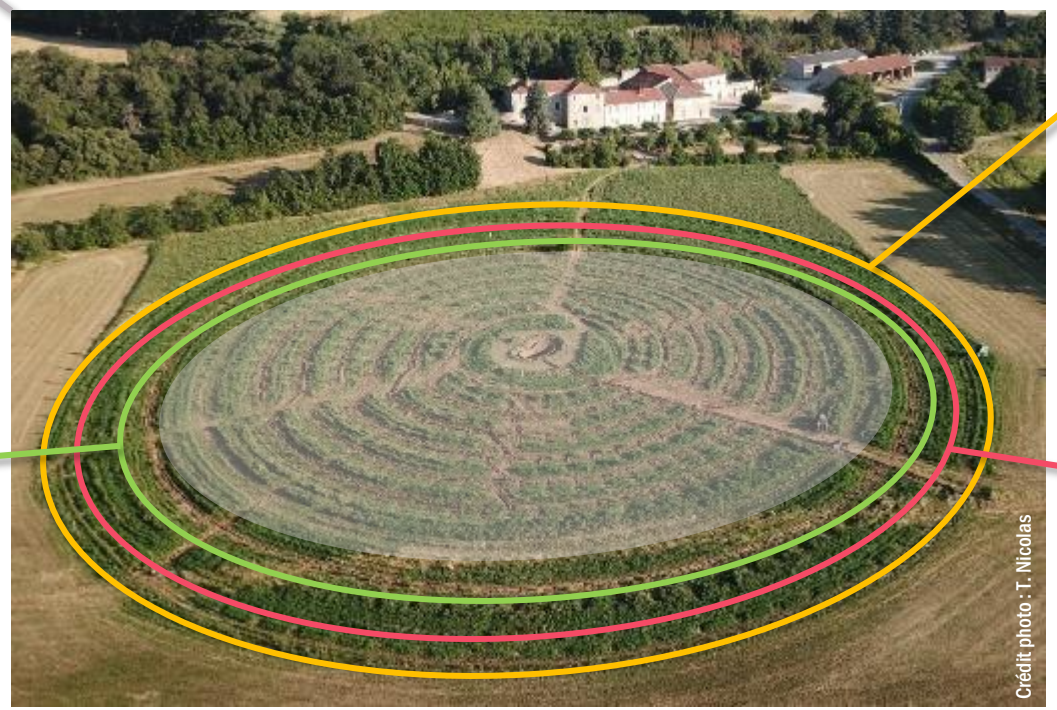

Araignées

‘Pest suppressive’ design: diversification of crops, companion plants, habitats…

General outline
Barriers
Trap cv, repellent plants
Plant mixture
Low-susceptibility cv

Species (between circles) and cultivar (within circles) mixture
Low-susceptibility cv

Barrier: hedgerow



Barrier: diversified fruit production circle (fig, hazelnut, soft fruit…)

‘Trap’ apple cultivars (e.g., aphid low-susceptibility cv)
Repellent aromatic plants

Surface area = 1.7 ha (including hedges), organic certified

‘Pest suppressive’ design: diversification of crops, companion plants, habitats…

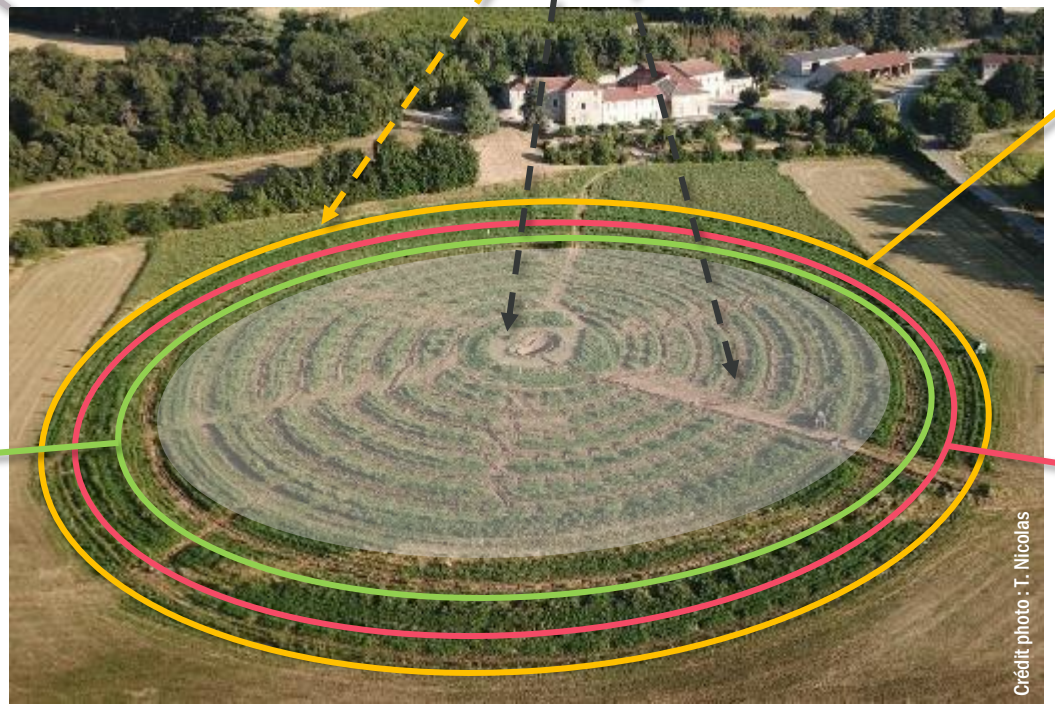




Conservation biological control : plant assemblages and habitats

Species (between circles) and cultivar (within circles) mixture
Low-susceptibility cv

Barrier: hedgerow



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General approach to design

Pest control through plant diversification

Resource sharing among crops and associated plants

Pest-suppressive plant assemblages

Agronomic efficient assemblages

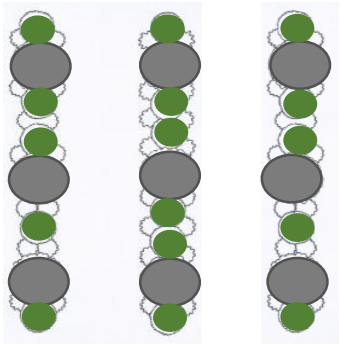
Resource sharing to design ‘efficient’ assemblages

Temporal and spatial scales: Co-planting or delayed planting? Species choice to optimise resource sharing?

Light interception

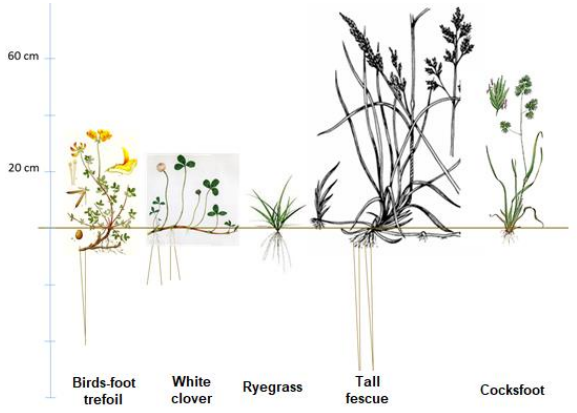
- Tree height and shape
- Row orientation (if any)
- **Spatial** arrangement

(vertical & horizontal)



Water and nutrients

- Rhizosphere: with different root system behaviour and distribution



Here: fruit trees planted in alfalfa that is used as fertilizer

General approach to design

Pest control through plant diversification

Resource sharing among crops and associated plants

Work organisation and load

Pest-suppressive plant assemblages

Agronomic efficient assemblages

Operationality

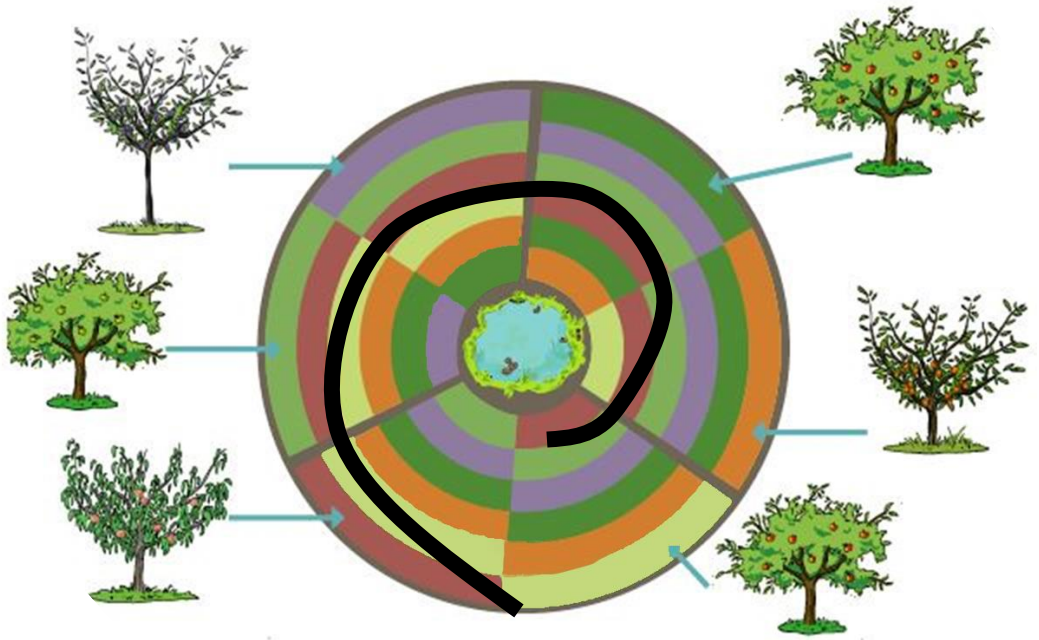
Orchard design for operationality

Work organisation

- To ease within field orientation and traffic (avoid empty runs)

Workload and sales

- Sufficient fruit quantities for sale
- Workload distributed over time



Dessins : © INRA C. Ulrich

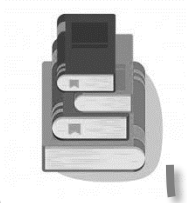
Central part of the orchard : 6 tree spirals of various tree species

General approach to design

Pest control through plant diversification

Resource sharing among crops and associated plants

Work organisation and load



Pest-suppressive plant assemblages

Agronomic efficient assemblages

Operationality

Tradeoffs!

The prototype

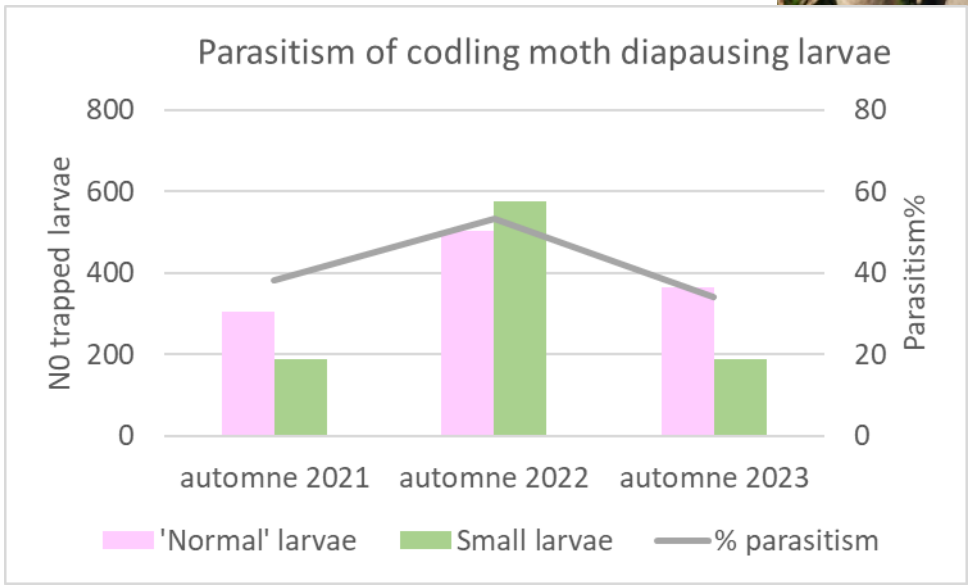
1.8 ha including the lining circular hedgerow
15 fruit species and 33 cultivars
23 companion plant bushes
Planted in 2018

First feedbacks: Increase in biodiversity

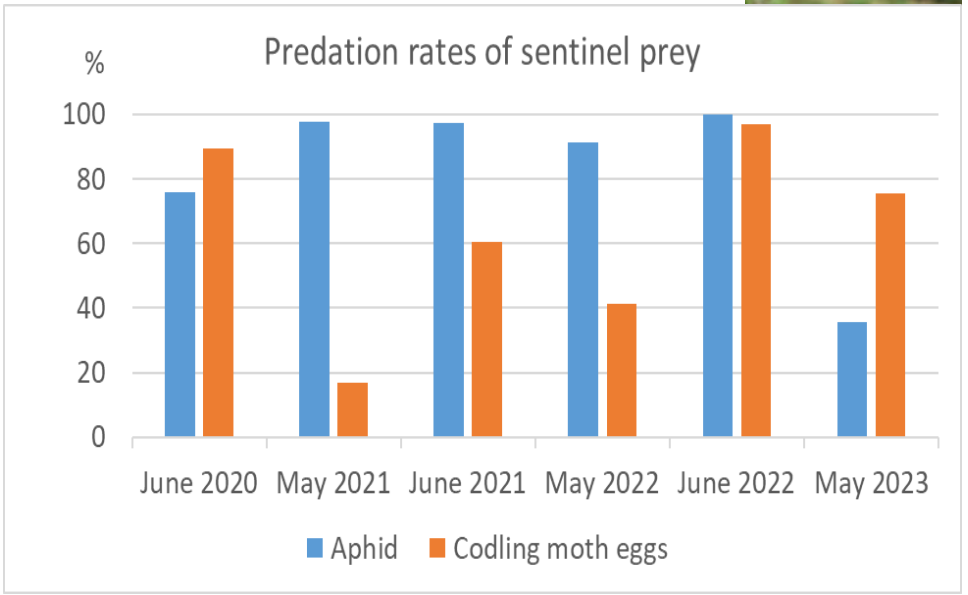
Abundant and diversified communities and predatory groups

First feedbacks: Increase in parasitism and predation

Parasitism rate



Predation



First feedbacks: Pest control

Pest and disease control varies according to year and bio-aggressor

PESTS	2018	2019	2020	2021	2022	2023
Rosy apple aphid	☺	😐	😐	😐	☺	☺
Green aphid *Aphis* spp.	☹ 😐	😐	☺	☺	☺	☺
Codling moth	x	x	😐	😐	😐	😐
Bugs	x	x	☺	😐	😐	😐
Scab	☺	☺	☺	☺	☺	☺

Rosy apple aphid

In 2022-23 (after the juvenile stage of apple trees), **pest regulation (no damage) vs. high infestation as regional context**

Codling moth

10-20% fruit damage with no increase accross the 3 years of study
(no mating disruption, no granulosis virus; mass trapping and augmentorium)

Bugs (among which *Hyalomorpha halys*)
Increasing damage

-> High potential for pest regulation, to preserve and reinforce

'Augmentorium'

First feedbacks: Fruit production (1/2)

No pesticide (synthetic, biological), no mating disruption

- Trees: good establishment

- **/!\ Climate!**
  Hail (2019), early snow (2019) et frost (2021, 2022)
  and also heat waves (sunburn on fruit)

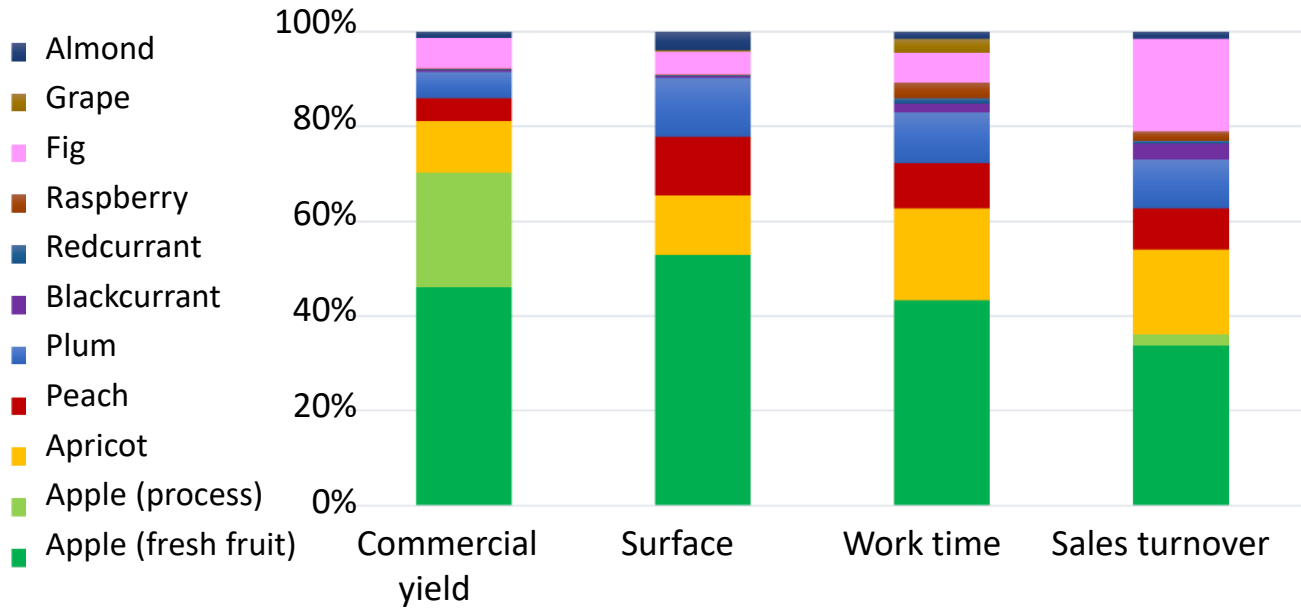
First feedbacks: Fruit production (2/2)

-Yields vary according to fruit species and years (because of climatic hazards and pest damage), to be validated across years

-Production every year whatever the context & very low input loads

-> Need to value production, e.g. through direct marketing

Multicriteria evaluation of a multiproduction orchard (données en cours de stabilisation)



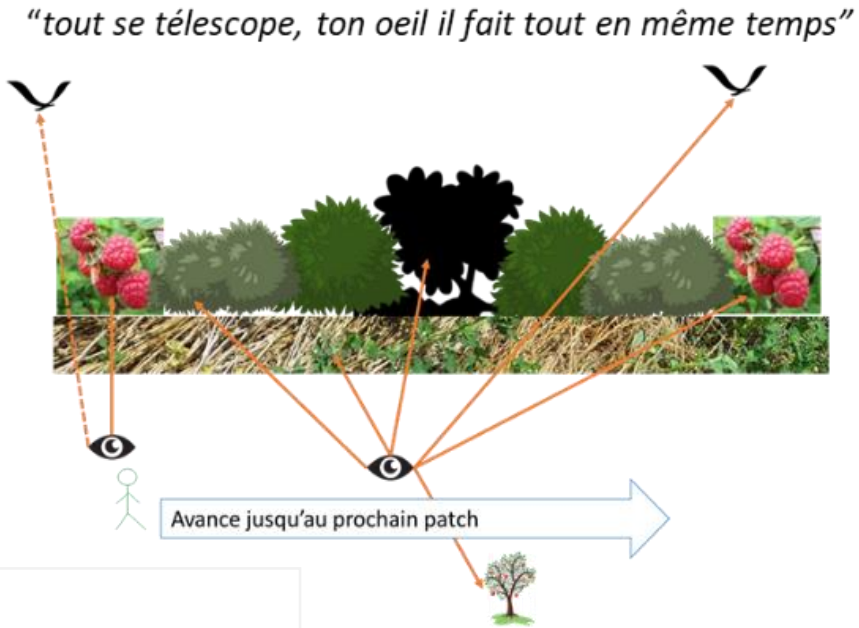
Source MIN LYON Bio 2023

	prix HT /kg
Pommier	2
Abricotier	4,48
Pecher	5,1
Prunier	5,1
Cassisier	21
Groseiller	12,4
Framboisier	20
Figuier	8,38
Raisin de tab	3,31
Amandier	3

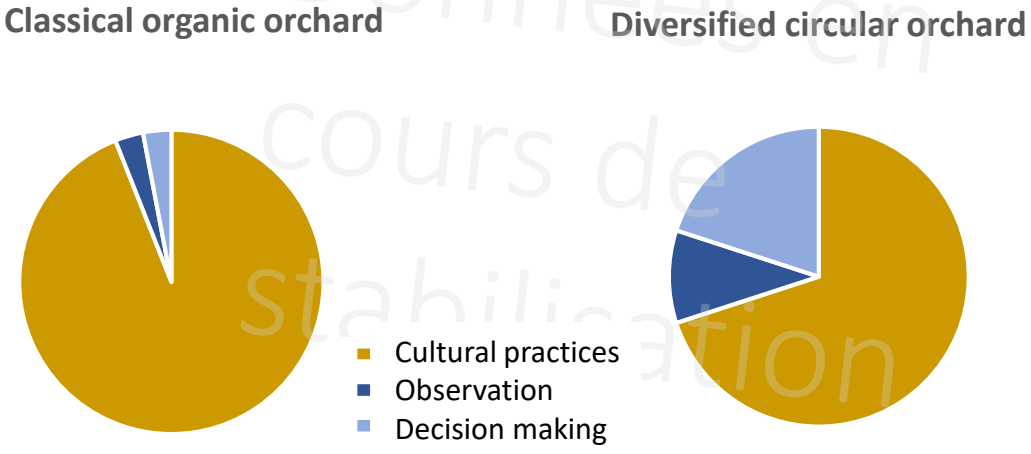
Young orchard ! Only 1 year of fruit production because of climate hazards

First feedbacks: Work in diversified orchards

‘Vigilant’ observation of this complex system to build benchmarks and have an adaptative management



Work type



Open innovation

Scarce stabilized knowledge on diversified systems or innovations in fruit production

The ‘Cafés Agro’, for information exchanges and experience sharing among research and farmers to explore innovations

-One theme generally proposed by previous attendees, e.g. poultry in orchards
-One or a few guests (farmer, researcher) who is experienced on the subject
-Facilitation
-Field visit for concrete experience
And coffee!

-> 13 Cafés Agro in 6 ans

To conclude

> Co-design is a key element to obtain tradeoff between all presented axes and to consider agroecosystem interactions and complexity

> ‘Proof-of-concept’ approach

-A knowledge-intensive project: to design, to understand the underlying processes such as pest suppression

> Agroecological co-design and a sharing and learning experience... but also many questions related to the agricultural sector and the food system!

A design to assess across time...

Photo credits: INRAE Gotheron unless otherwise specified




Thank you for your attention!

For further information

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https://ueri.paca.hub.inrae.fr/contrats-et-projets/expe-dephy-ecophyto-ii-alto

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Le projet ALTO

Système agroforestier pommiers, noyers et légumineuses (2016, 1.5 ha)

3 dispositifs AB très bas-intrants & une dynamique multi-acteurs

Verger multi-espèces re-conçu de novo et biodiversité (2018, 1.7 ha, 0 pesticide)

Vergers monovariétaux -> multi-espèces, zone de biodiversité (2019, 1.2 ha)