



**1<sup>st</sup> INTERNATIONAL APPLE SYMPOSIUM**

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Topic 2: Orchard Environment, Tree and Fruit Physiology,  
and Cultivation Management.

# Apple Tree Architecture and Cultivation

## A Tree in a System

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*(Tropical and Mediterranean Cropping System*

*Functioning and Management)*



***Montpellier, France***



## **The apple tree**

Past decades: from the whole-tree typology to detailed analysis of flowering and fruiting

↳ Concepts for tree management

## **... in a system**

A societal concern: « growing more with less inputs ».

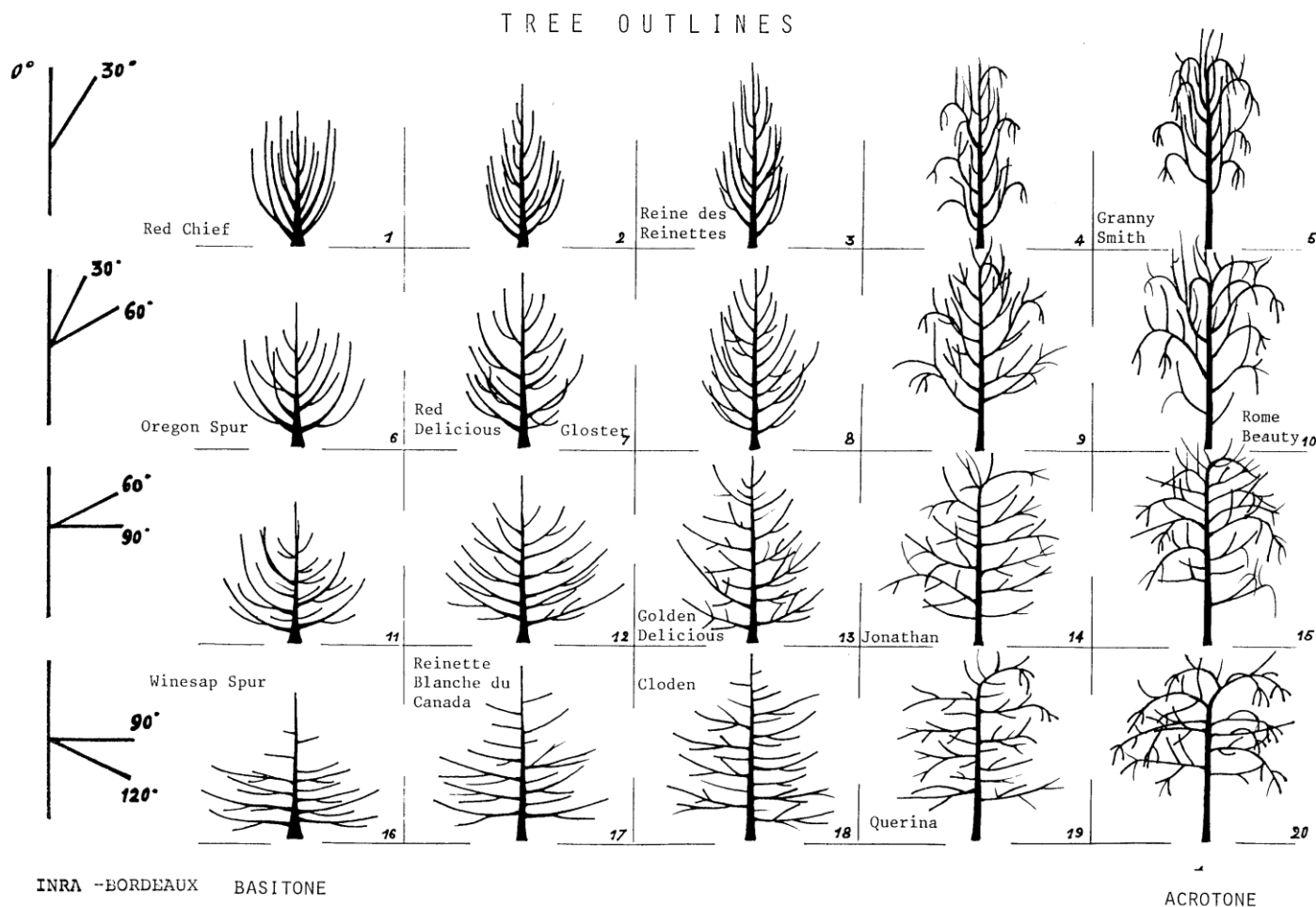
↳ The interest of agroforestry



# The apple tree

## Whole-tree Typology

(Lespinasse and Delort, 1986)



**BUT,**

**Some cultivars are tip-bearing and have an alternate-bearing pattern (Clones of Fuji)**

**Others are spur-type but with less alternate-bearing when grafted on vigorous rootstocks**

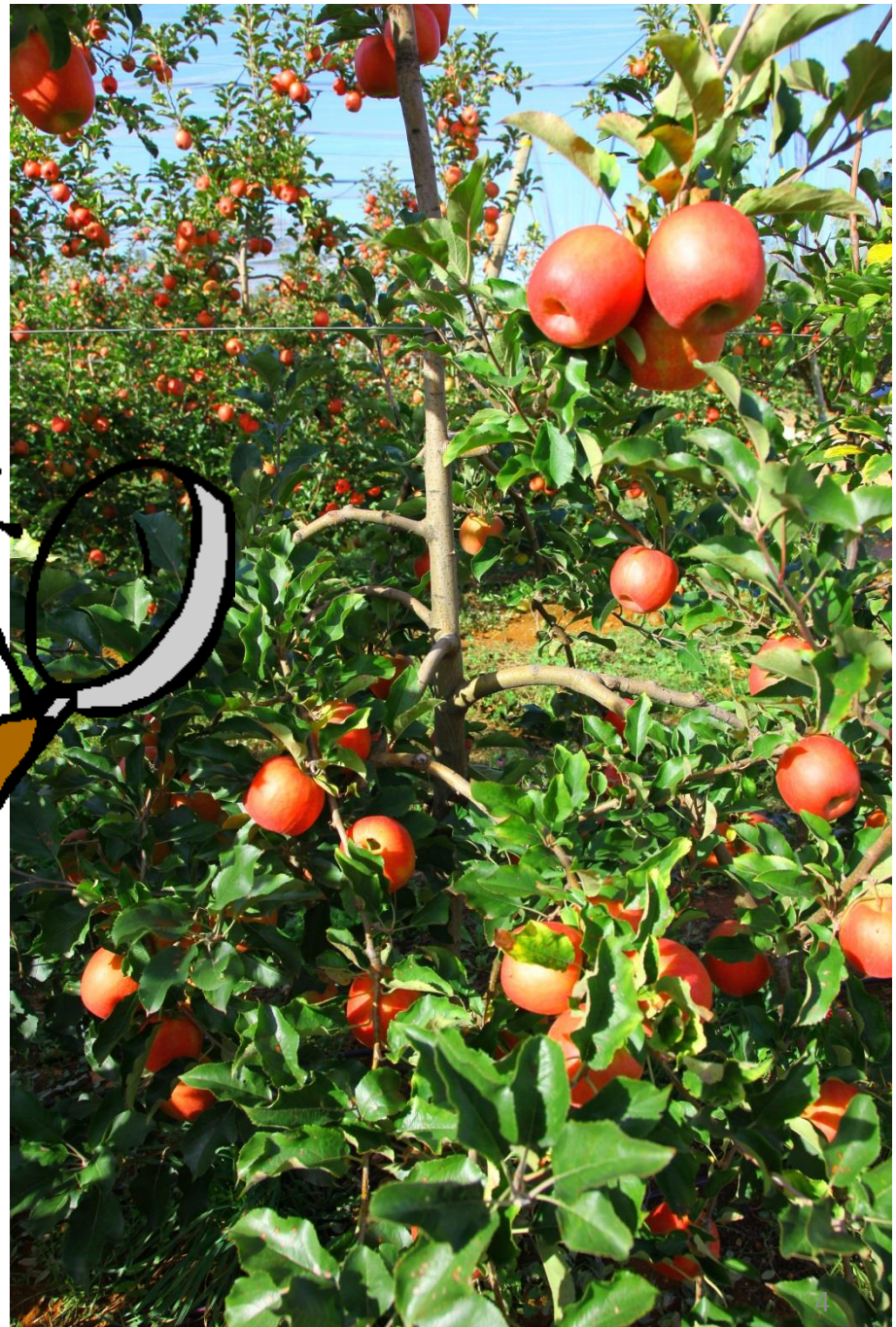
**(Barritt et al. 1997)**

**Increasing regular bearing**

# The apple tree

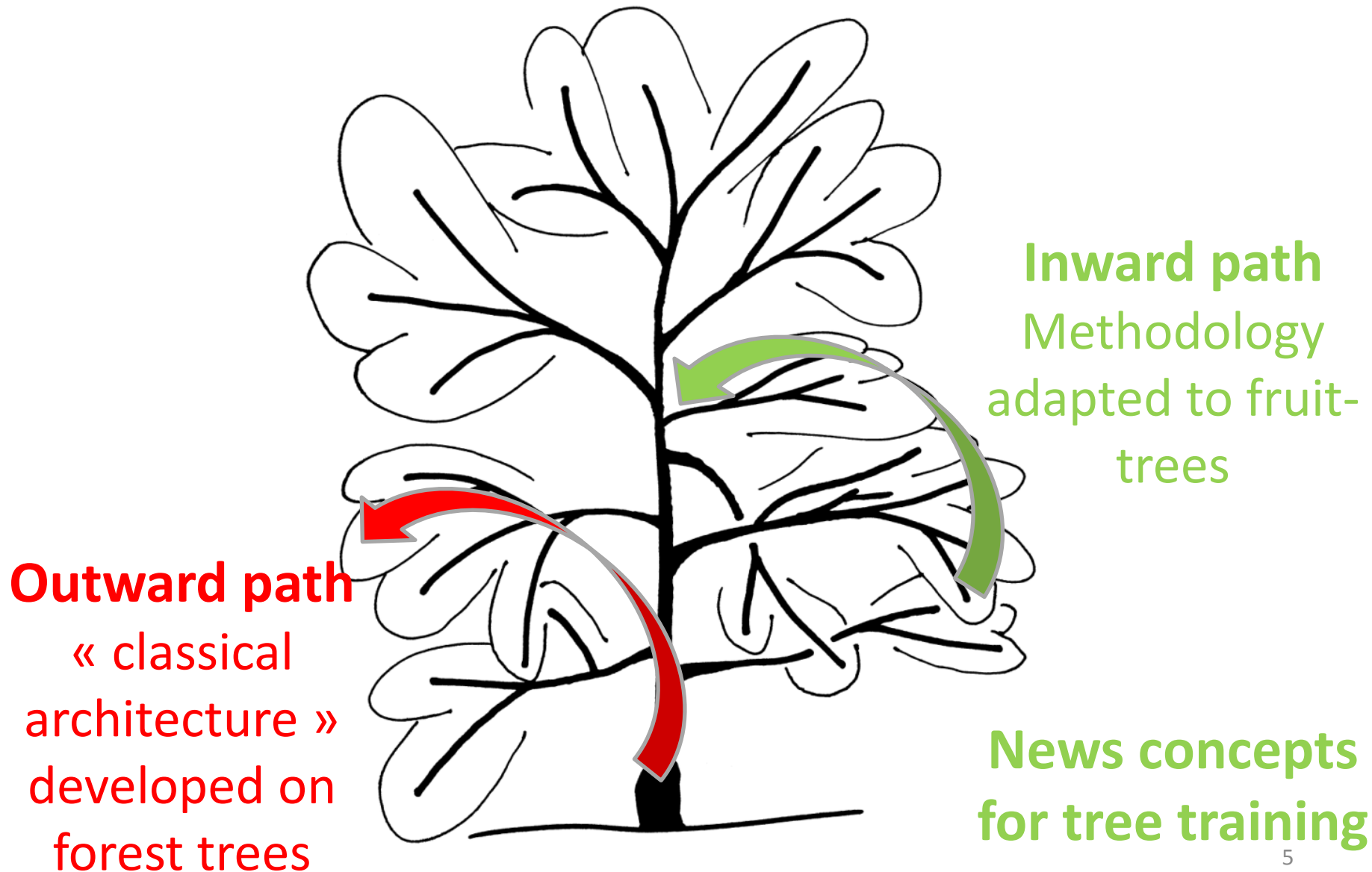
The need to develop  
detailed analyses on  
the flowering and  
fruiting patterns

- 1- Where are the  
good fruits?
- 2- How can we  
manage the tree to  
get them?





# Towards a methodological framework for efficient research on apple tree architecture and physiology



## **Two Main results:**

- ✓ **What shoots to select?**

- ✓ **Can we optimize pruning?**

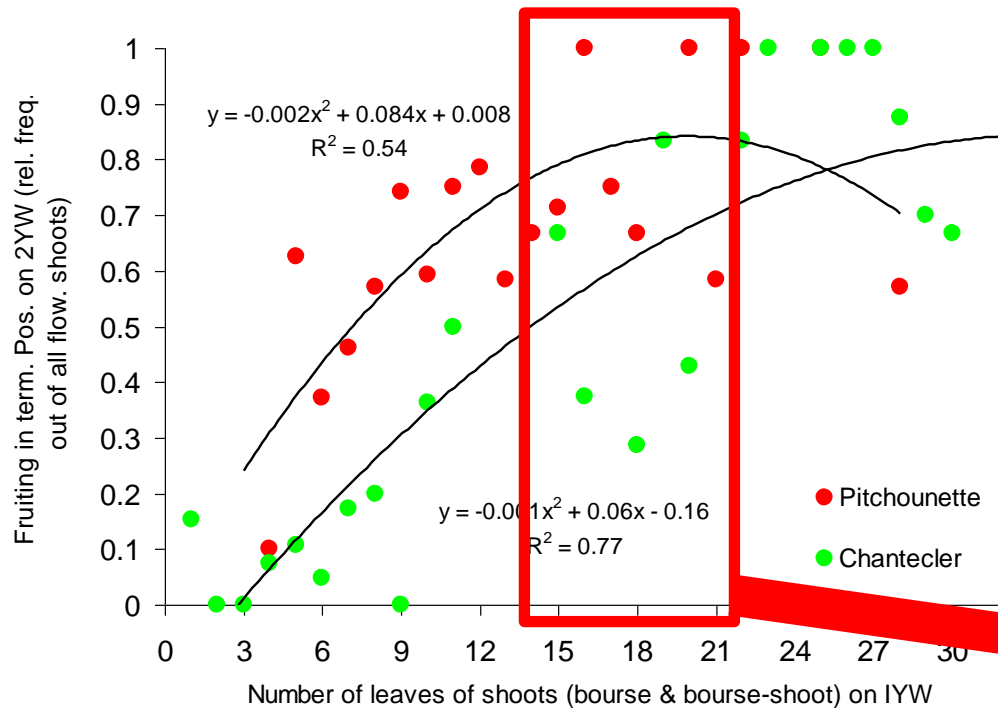
# 1 - Shoot length, fruit-set and fruit size

*i.e.*, at least one fruit developed

Fruit-set on the terminal  
flower cluster  
(year N+1)



Subtending shoot  
(year N)



**'Chantecler' & 'Pitchounette': parabolic relation**

→ **Higher fruit-set on 15-20 leaves**  
→ **Idea of a threshold of leaf area developed in the previous year**

**= « flower quality » or « floral strength » (aptitude to set fruit)**

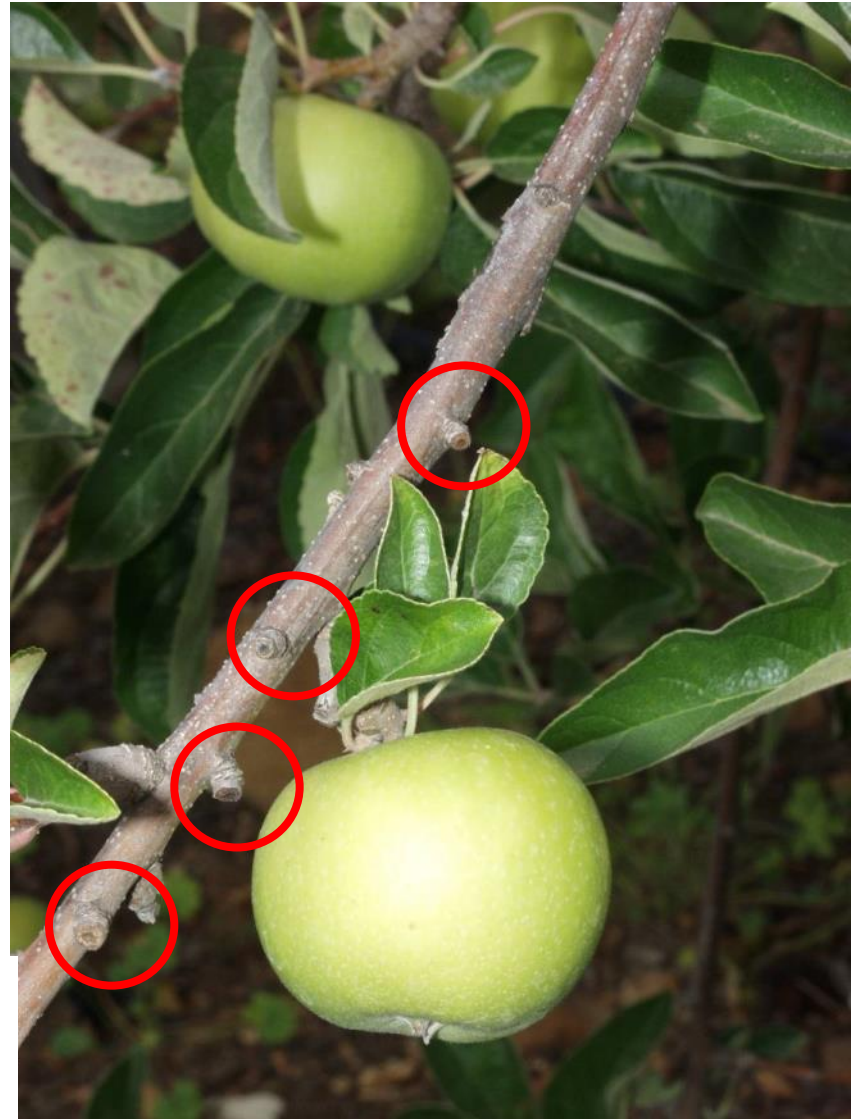
**« Crown brindle »: larger fruits on 10-20 cm-long shoots (Breen et al. 2007; Tustin et al. 2011)**

(Lauri & Trottier 2004; Lauri & Corelli-Grappadelli 2014)

## 2 - Spur extinction

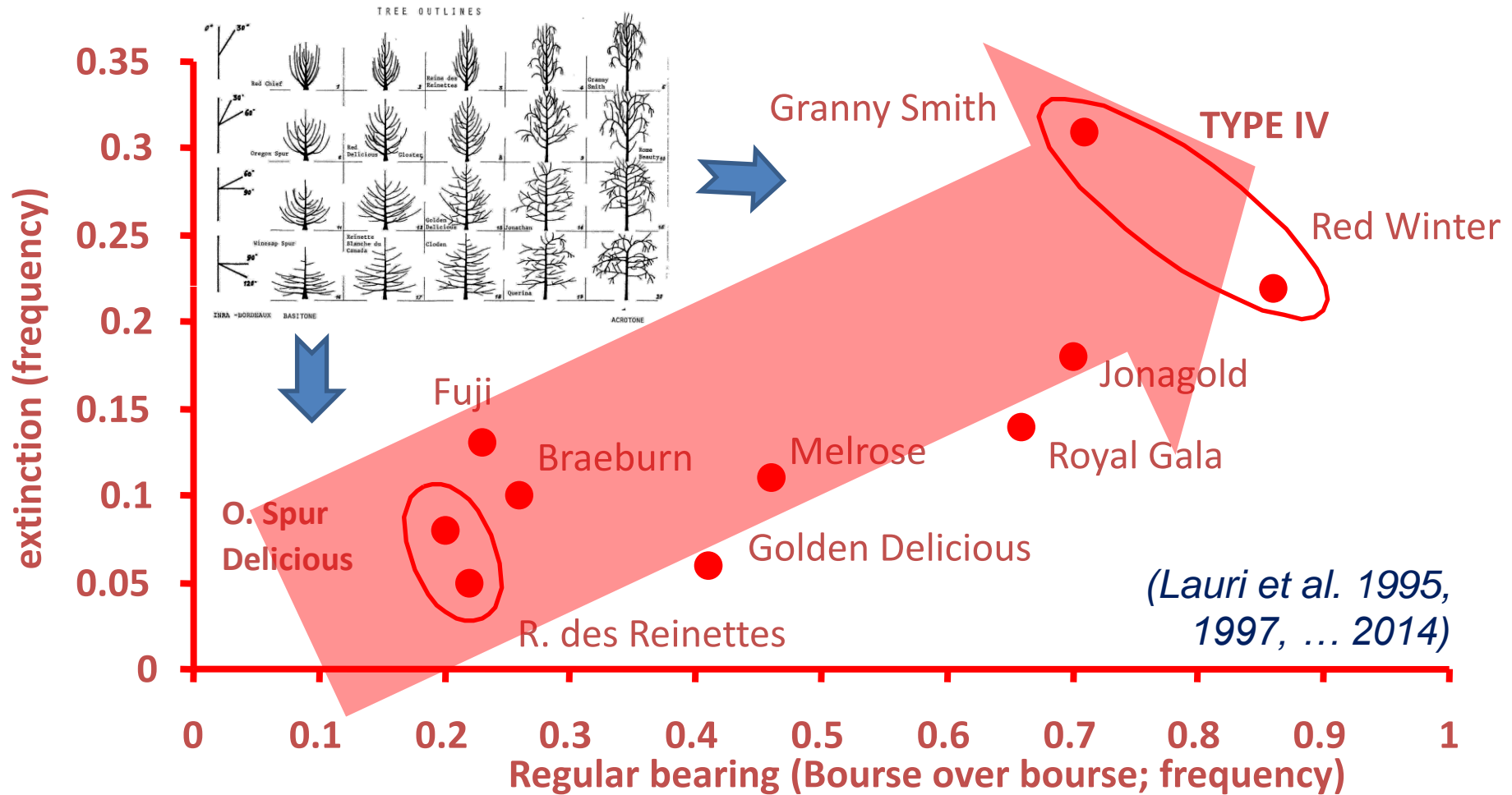


**Physiological mechanisms?**  
**Relations with hydraulics**  
(Han *et al.* 2007; Lauri *et al.* 2008)





### 3 - Extinction ↔ Regular bearing

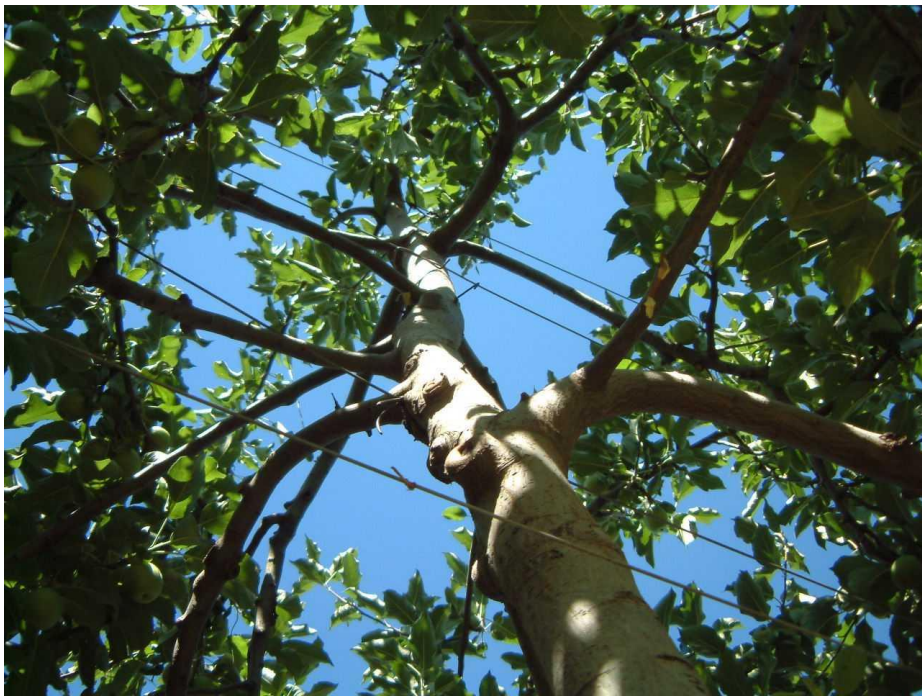


➡ Each cultivar has its own **architectural strategy** (shoot length, extinction,...) related to the **fruiting pattern**

- ↪ Results suggest a **negative relationship between spur density and regular bearing.**
- ↪ Idea to do « **artificial spur extinction** » (ASE) on cultivars with alternate bearing **to improve regular bearing and also to increase canopy porosity.**



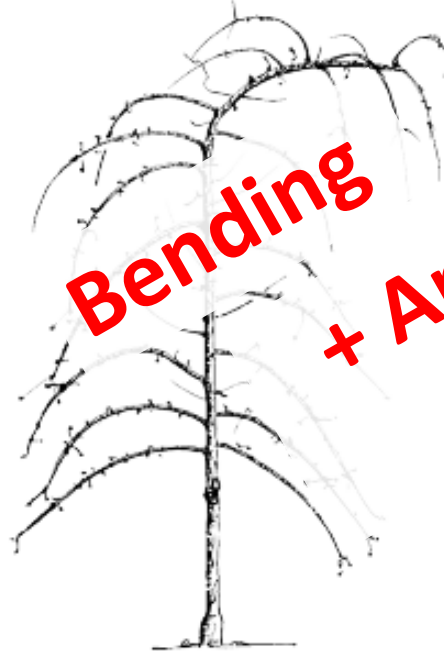




## Example: trend in France...



**Vertical Axis**  
(Lespinasse 1977,  
1980)



**Solaxe**  
(Lespinasse &  
Lauri 1996)



**Centrifugal  
Training**  
(Lauri 2009)



**Salsa**  
(Lauri et al. 2016)

*Paradigm:*

« single trunk – fruiting branch - fruiting spur »

*Paradigm:*

« reiterative trunk–  
fruiting spur »

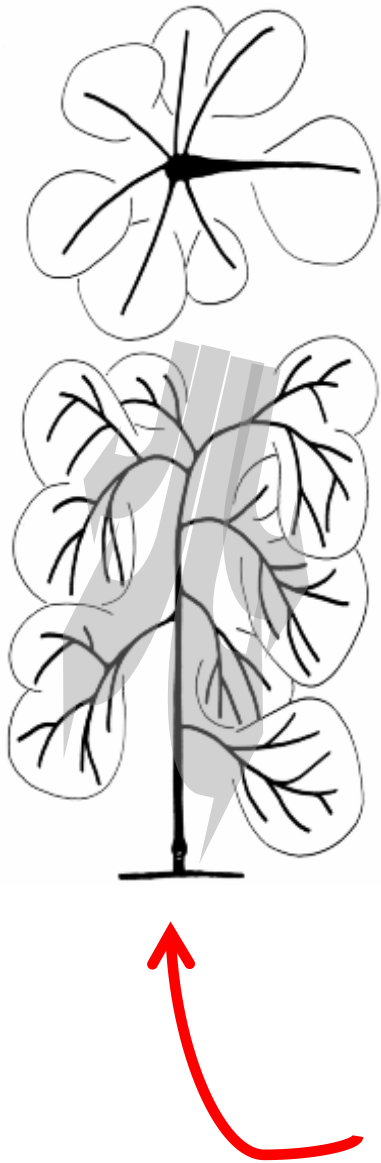


# The need to adapt to the cultivar

Strong variations of branching depending on the cultivar (especially immediate branching in the 1<sup>st</sup> year of planting)

← 'Braeburn': well adapted to a cylindrical shape, Centrifugal Training

'Granny Smith': interest to use ALL reiterative trunks →



'Braeburn'/M7- 9YO (INRA)



'Granny Smith'/M7- 3YO (INRA)





# A Tree in a System



Monocropping / monocultivar orchards

High performance ... with external resources as needed

Intensive inputs: water, fertilizers, phytosanitary treatments

➡ **A societal concern: pollution, leaching ...**

# Are there alternatives?

Can we develop **agroforestry systems (AFS)** to buffer such externalities?

**1, to mitigate climate extremes combining timber-trees above fruit-trees.**

A long-term timber-tree is more prone to buffer extreme climatic events than an annually fruiting tree (Stigter et al. 2011, Shoeneberger et al. 2012).

**2, to increase biodiversity** to better fight pests and pathogens (Lin 2011; Simon et al. 2016).

☺ **Such systems can increase productivity per land area**, concept of **LER (Land Equivalent Ratio)**: area of single-crop farming needed to produce the same amount of production (fruit, wood, grain) as 1 ha of agrosystem (eg, wheat-maize, Zhu et al. 2015; Rapidel et al. 2015; Gaba et al. 2015).



**LER of AFS are usually more than 1**  
**← optimization of space and time.**



**Example:**

**Production of timber-trees + barley > Production of timber-trees alone + of barley alone**

**↳ Use on the inter-row space otherwise not used, and during the whole growing season**



# AFS: traditional systems all over the world

Cameroon –  
Cocoa trees associated  
with oil palm, mango,  
timber trees.



Lebanon –  
Olive & apple trees +  
small fruits

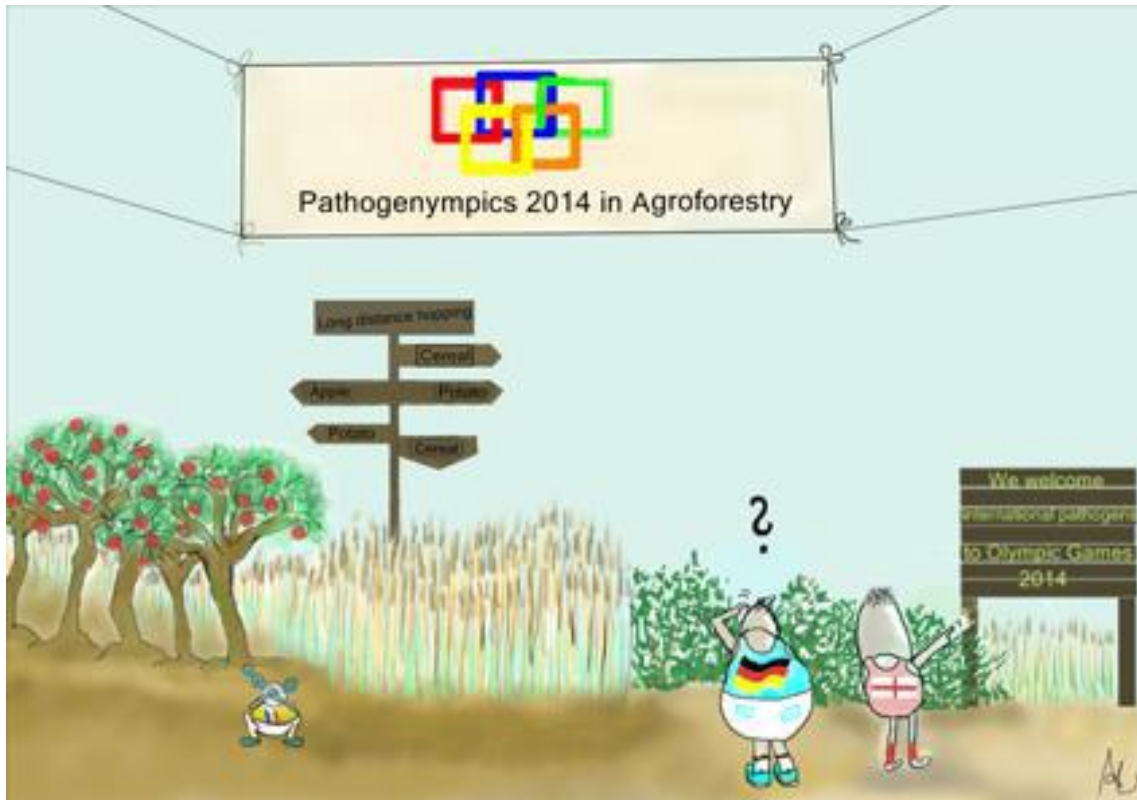


☺ **European programme – CO FREE (Copper Free), 2012-2016.**

<http://www.co-free.eu/index.php/co-free-project-details>

**Objective: Development of strategies for copper-free production**

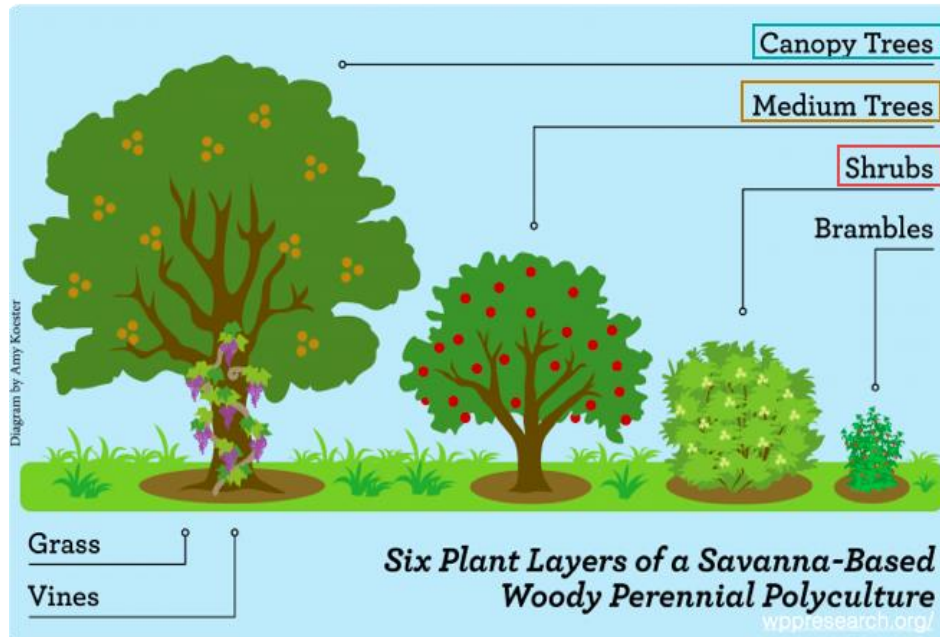
**AFS as a means to reduce the use of copper**



**Eg, apple – *Venturia inaequalis* (Scab).  
Playing with lower tree densities.**



☺ USA – “A plan to broaden Midwest agroforestry *via* tree crops and multifunctional woody polyculture” – Fruit-trees as a component in multifunctional agro-ecosystem (Revord *et al.* 2015)



Various combinations of fruit species, with annual plants

➡ Pest and disease issues

# Building AFS for apple trees:

## ~~✗~~ Increasing functional biodiversity



In the past: the orchard had to be  
« clean » (no grass in the alley!)

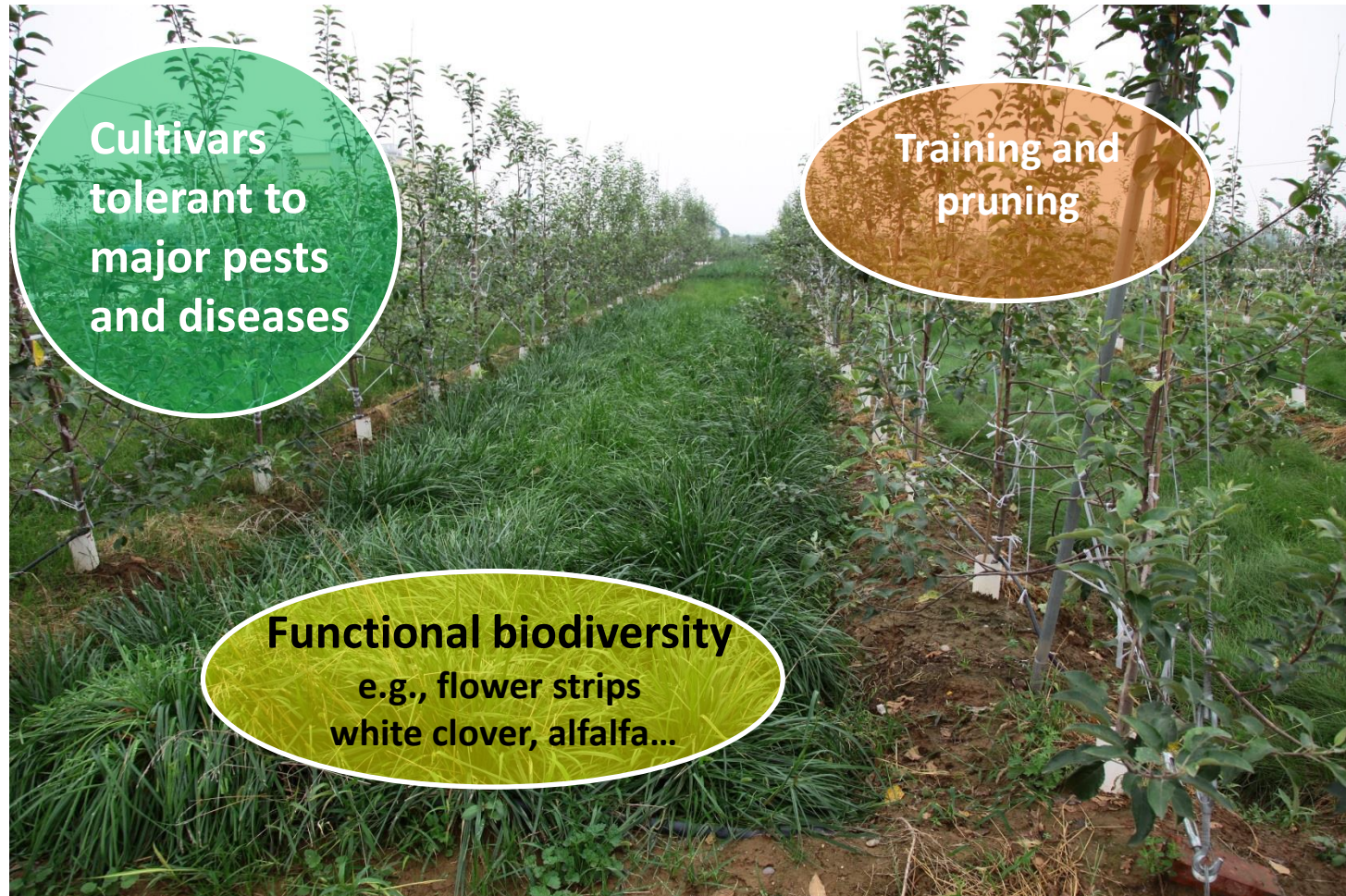
Grass alleys as a biocontrol against  
pests and diseases





## **Annual and perennial plant assemblages** as a way to foster,

- **bottom-up** and **top-down** processes in the food web,
  - **barriers** and **dilution** effects,
- ↳ to control pests and diseases and to decrease pesticide use on fruit-trees.





# Going further: interest to introduce larger trees (timber or nut)?



↗ Biodiversity AND ↗ LER:

3 vertical strata:

- **Herbaceous:**  
annuals: wheat in rotation with other crops  
OR perennials: alfalfa...
- **Woody perennials:**
  - Apple
  - Timber / nut-trees



# Scientific and practical issues raised by AFS

AFS increase interactions between plants: good or bad?

➡ Classical research framework: competition OR facilitation

✂ **Aboveground (light):**

**Competition AND facilitation:**

interest to decrease photooxidative damages and sunburn on the apple.

😊 **A good alternative to shade nets**



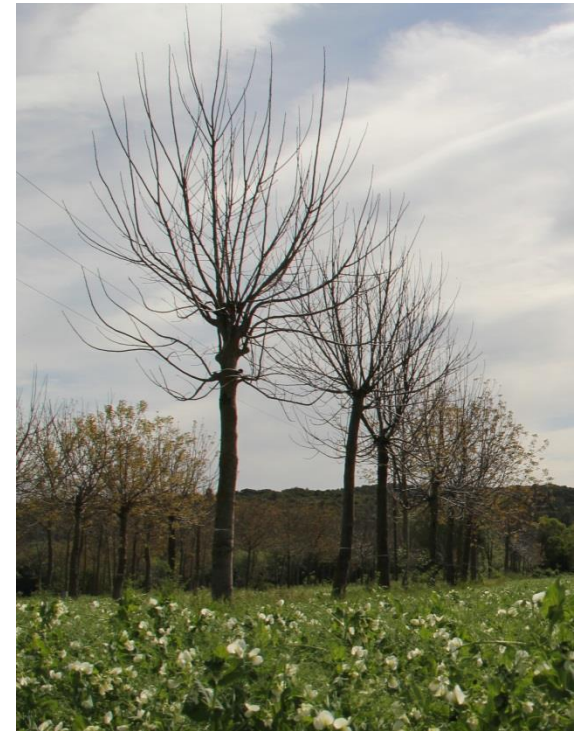
# Scientific and practical issues raised by AFS

**1 – Management of apple tree architecture (↗ tree porosity to light).**



**Free standing walnut**

**2 – Pruning of the timber tree to control shading on the apple and herbaceous in the lower strata**



**Pollarded walnut**



# Scientific and practical issues raised by AFS

✂ **Belowground (water, nutrients):**  
**Competition:**

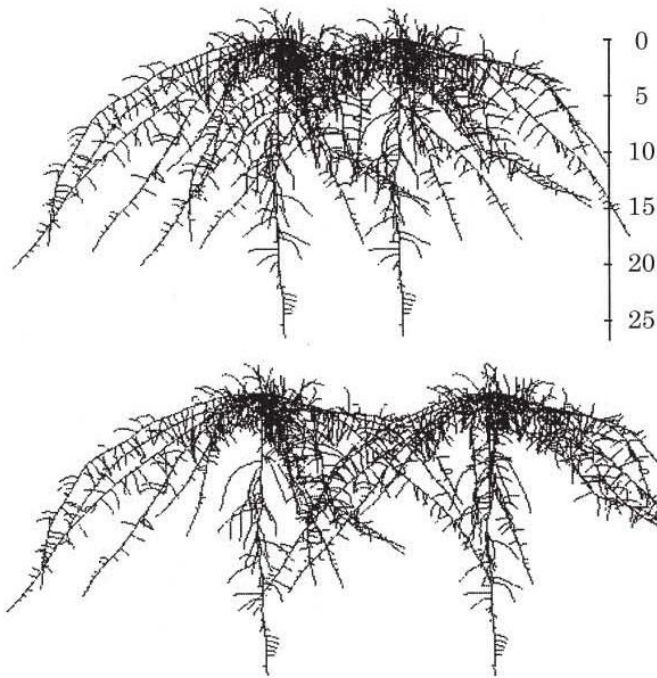


FIG. 4. Two competing Carioca (intermediate) root systems with different distances between plants (axis shown in cm).

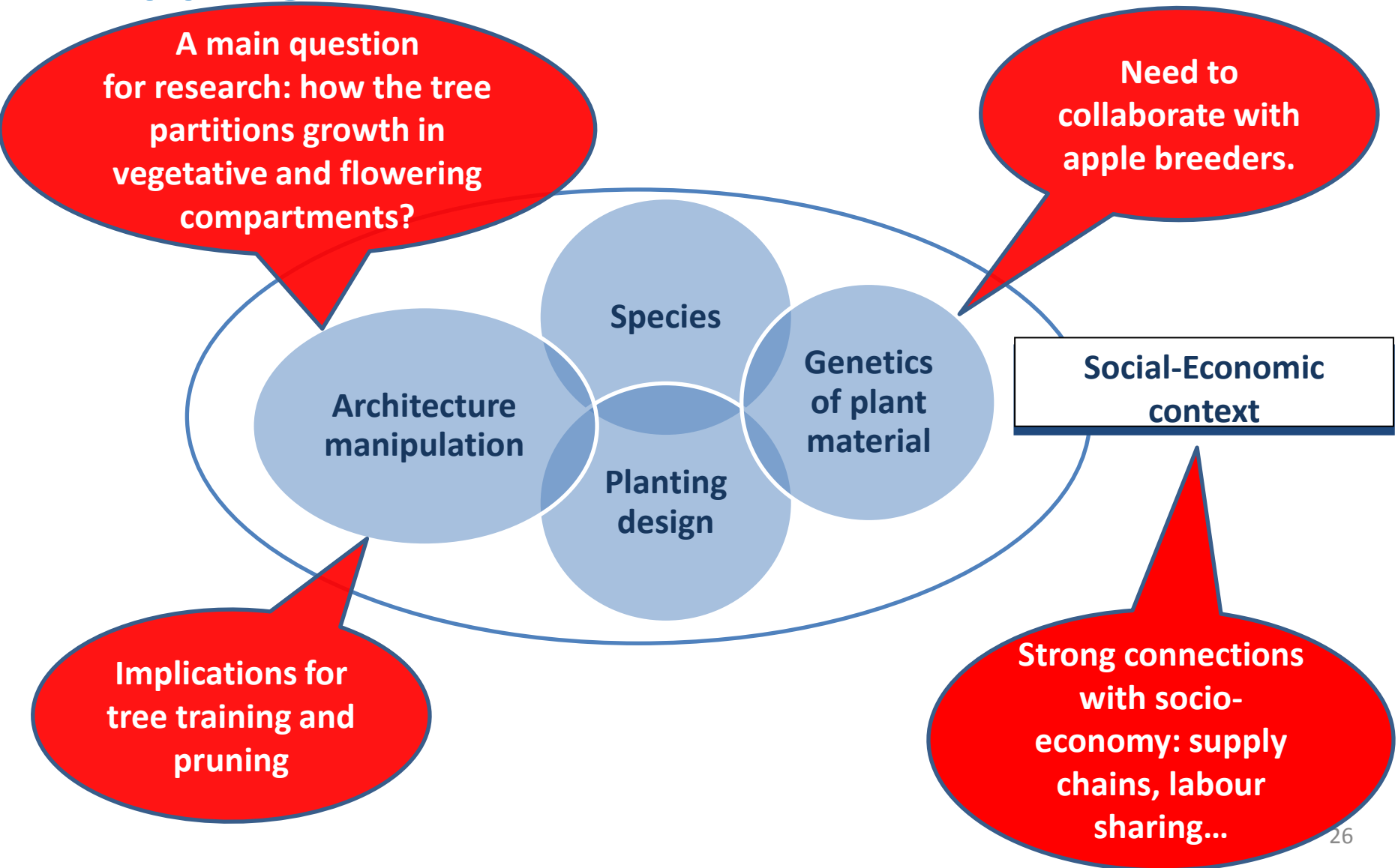
(Rubio et al., 2001)



**Facilitation:**

Leguminous plants: tree or herbaceous  
Eg, alfalfa - apple

# AFS, agrosystems, inter-cropping, relay-cropping ...: new contexts for new researches



**Thank you**

**Xie Xie**

**Merci**



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