Innovation - Lessons from the APMED programme Apple and peach in Mediterranean orchards - Integrating tree water status and irrigation management for coping with water scarcity and aphid control

Pierre-Eric Lauri

Young Researchers Seminar

Innovation - Lessons from the APMED programme

Apple and peach in Mediterranean orchards - Integrating tree water status and irrigation management for coping with water scarcity and aphid control

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FRANCE

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Plan

1 - APMed: objectives and some results.

2 – Thoughts on how to design an **optimized collaboration network** which **includes end-users concerns.**

Context

Water scarcity: most studies on annuals.

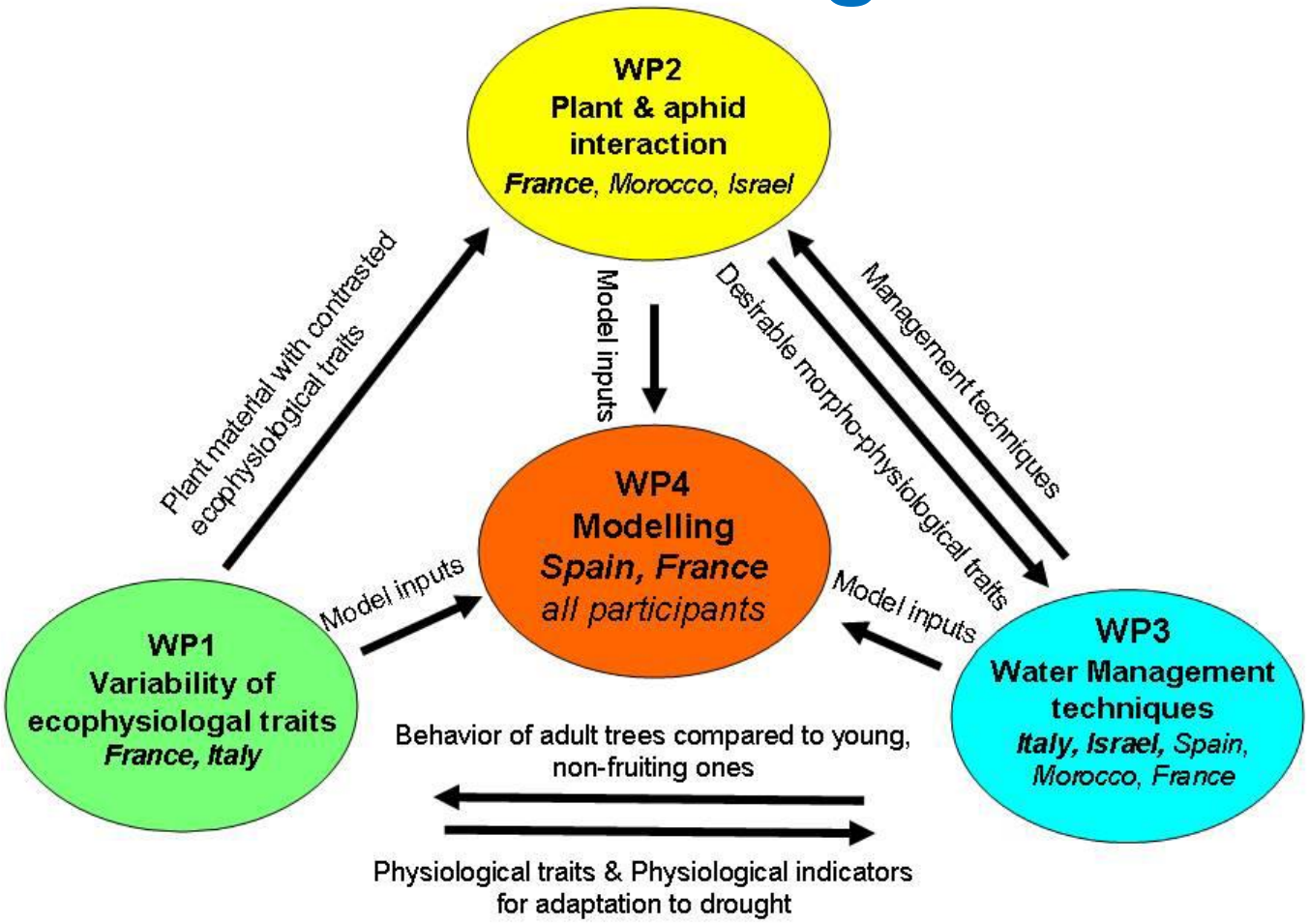
- **Perennials**: effects in the same year AND in the following years.
- **Fruit tree**: fruit quality AND regularity of bearing.

Apple and Peach – high added value in the Mediterranean area.

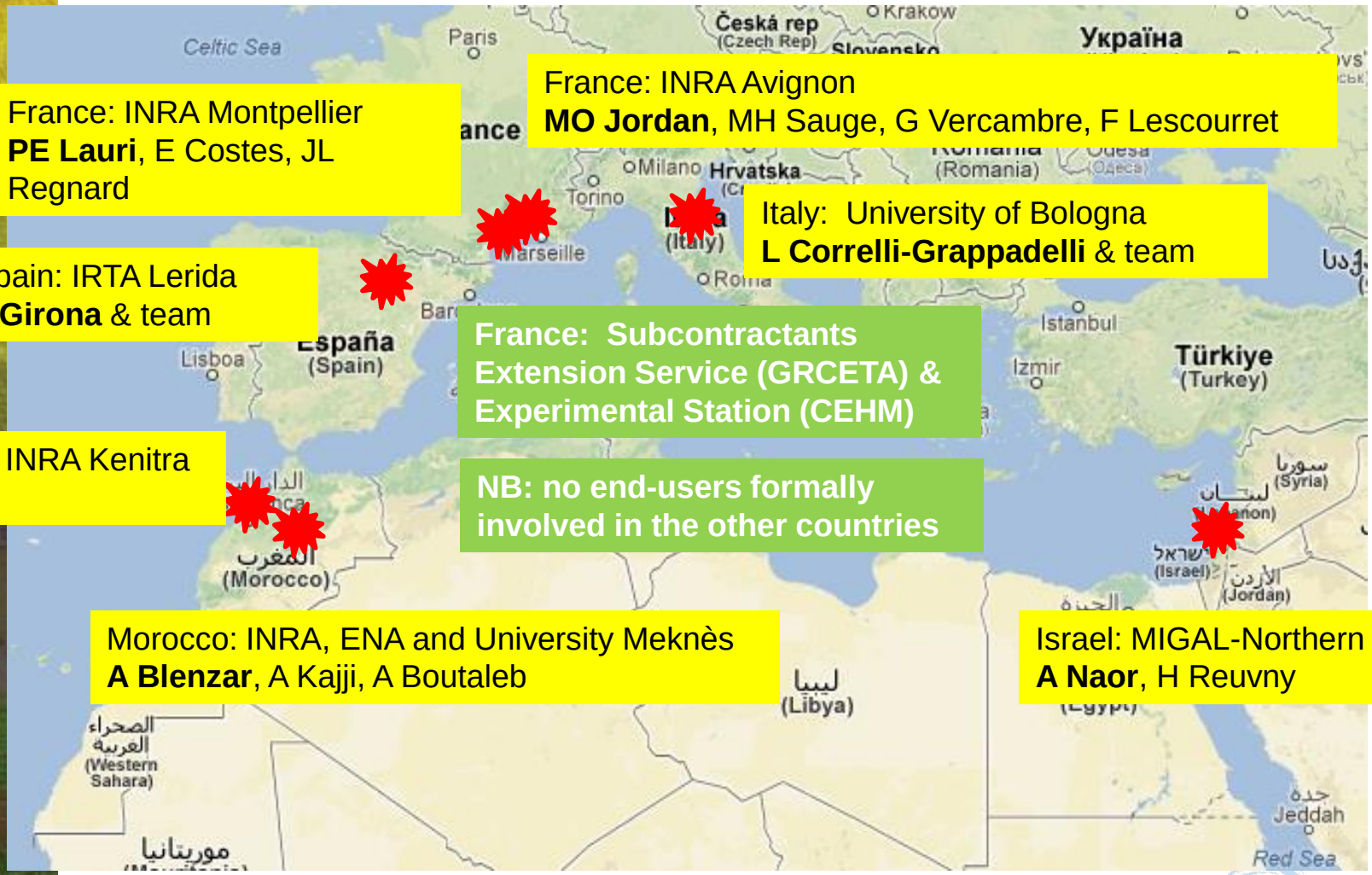
Key questions

- to gain knowledge on **how the fruit tree adapts to water scarcity**,
- to investigate the **effects of tree water status on pests (aphids),**
- to examine **how the grower can improve tree water status through,**
  - **irrigation scheduling**
  - and/or through a **reduction of tree water consumption and transpiration.**

The scientific organization



The consortium



France: INRA Montpellier
PE Lauri, E Costes, JL Regnard

France: INRA Avignon
MO Jordan, MH Sauge, G Vercambre, F Lescourret

Italy: University of Bologna
L Correlli-Grappadelli & team

Spain: IRTA Lerida
J Girona & team

France: Subcontractants Extension Service (GRCETA) & Experimental Station (CEHM)

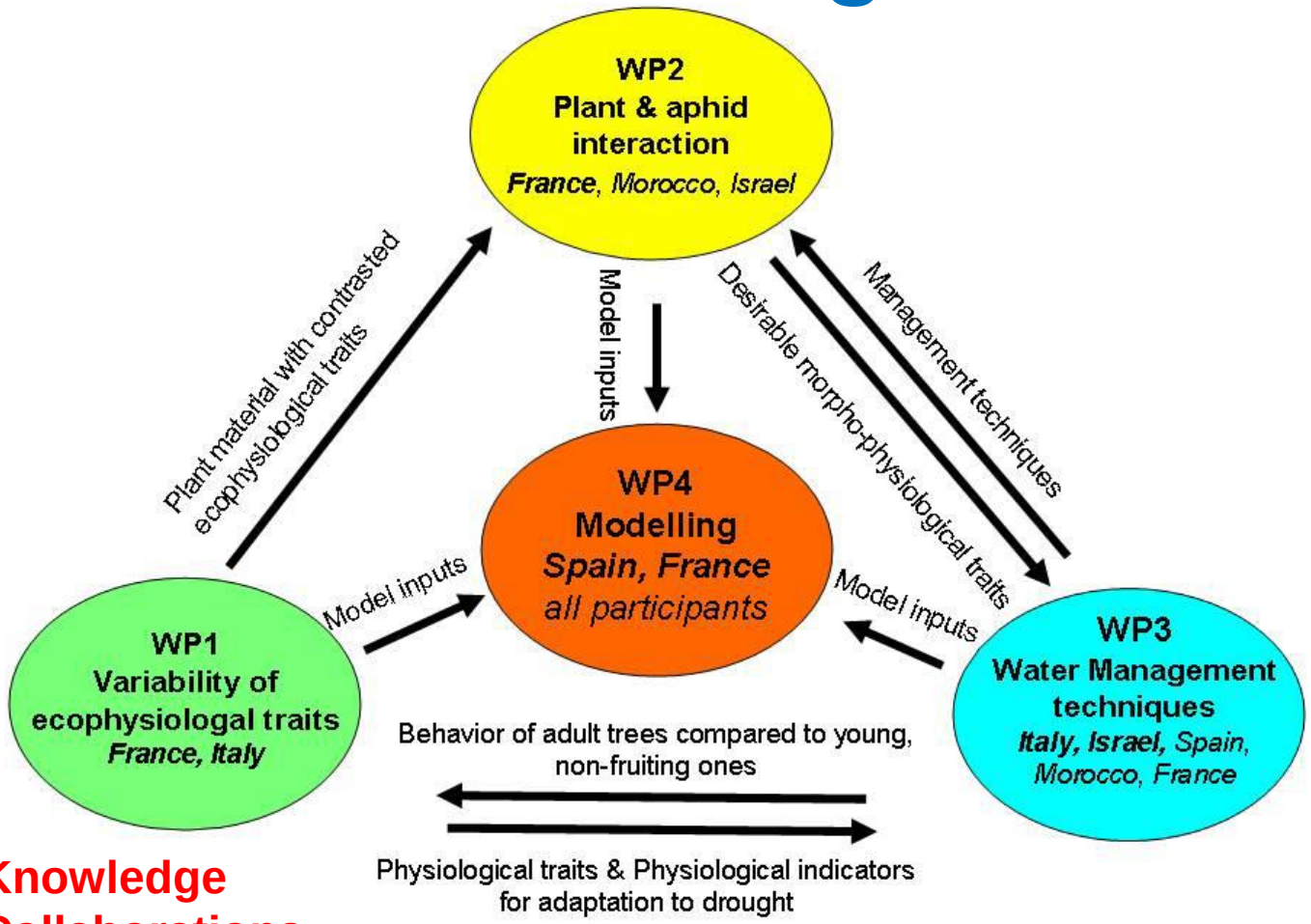
Morocco: INRA Kenitra
S Charif

NB: no end-users formally involved in the other countries

Morocco: INRA, ENA and University Meknès
A Blenzar, A Kajji, A Boutaleb

Israel: MIGAL-Northern R&D
A Naor, H Reuvny

The scientific organization



1-Knowledge
2-Collaborations with breeders

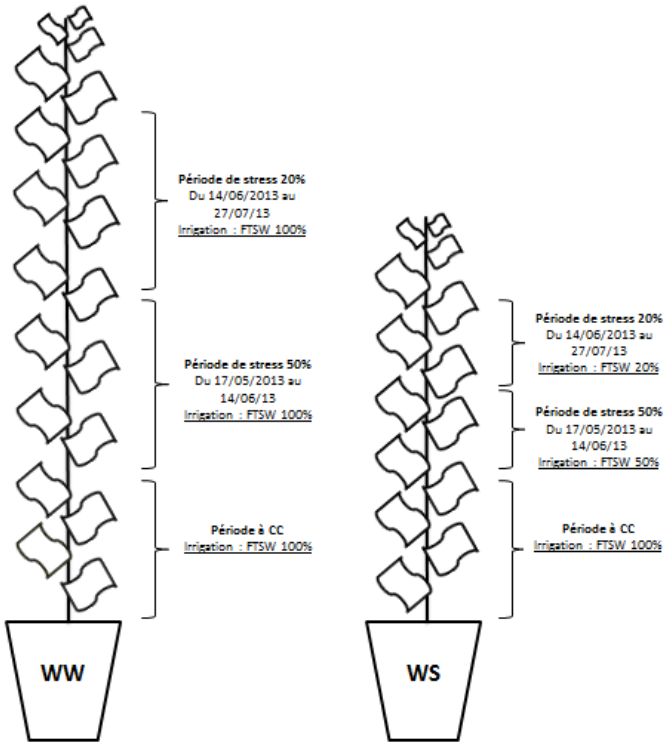
1-Genetic variability to water restriction

Apple - France & Italy

- **21 genotypes** of a same progeny
- **Well-watered vs. drought-stressed** plants with increasing drought : ***moderate*** (4W) and then ***severe*** (4W)

↳ **Morphology**: leaf area, stem length, temporary growth cessation

↳ **Functioning**: stomatal conductance, photosynthesis, loss of xylem conductivity



Genetic variability to water restriction

Apple - France & Italy

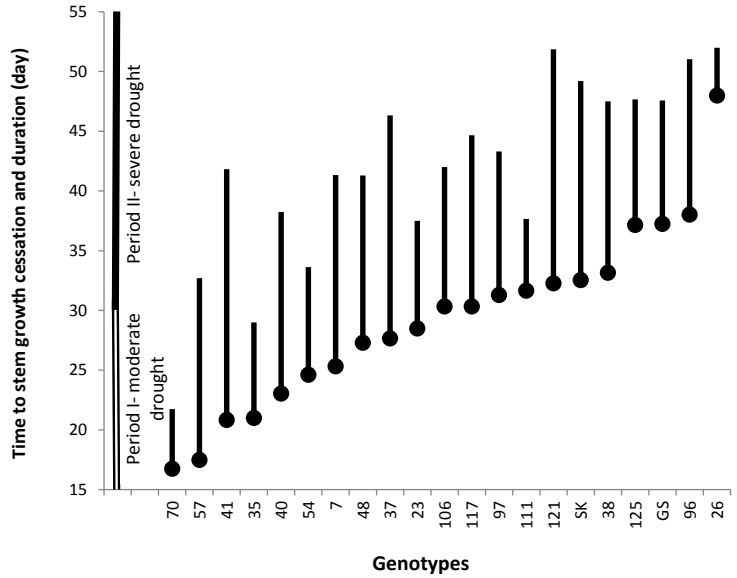
- ↘ Leaf area, stem length

  All genotypes:

***Moderate drought (MD)*: -66%**

***Severe drought (SD)*: -78%**

- **Good correlation between P_n and g_s** with similar relationships in WW and MD.
- Great variations in **temporary stem growth cessation**



1-Genetic variability to water restriction

Apple - France & Italy

Take home message:

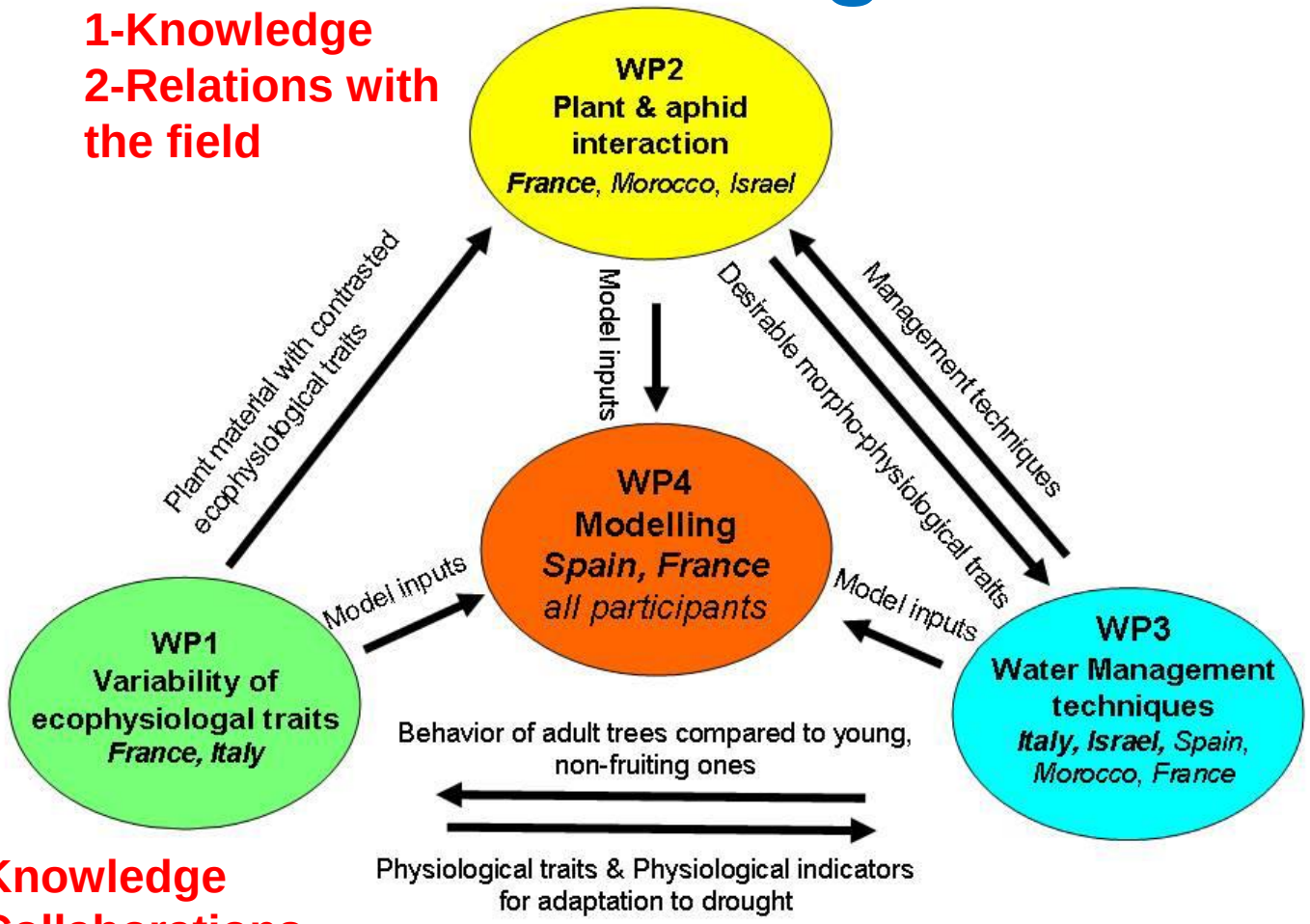
Interest for the **breeder** : phenotyping progenies with easy-to-use traits.

- Temporary stem growth cessation,
- Leaf area ← high throughput phenotyping platforms

(collaboration with *FruitBreedomics* European programme).

The scientific organization

1-Knowledge
2-Relations with the field



1-Knowledge
2-Collaborations with breeders

2-Tree – aphids interactions

France, Israel & Morocco

- Three plant-pest models, *Aphis pomi*–Apple, *Dysaphis plantaginea*-Apple and ***Myzus persicae*–Peach**, as young non-fruiting trees.
- **Relationships between N, growth and infestation**
  - 1st phase – pos. correlation between aphid abundance and nitrogen status.
  - 2nd phase – pos. correlation between aphid abundance and shoot development.

2-Tree – aphids interactions

France, Israel & Morocco

Take home messages:

Non-monotonic responses of aphids to water and nitrogen: importance of timing and tree architecture.

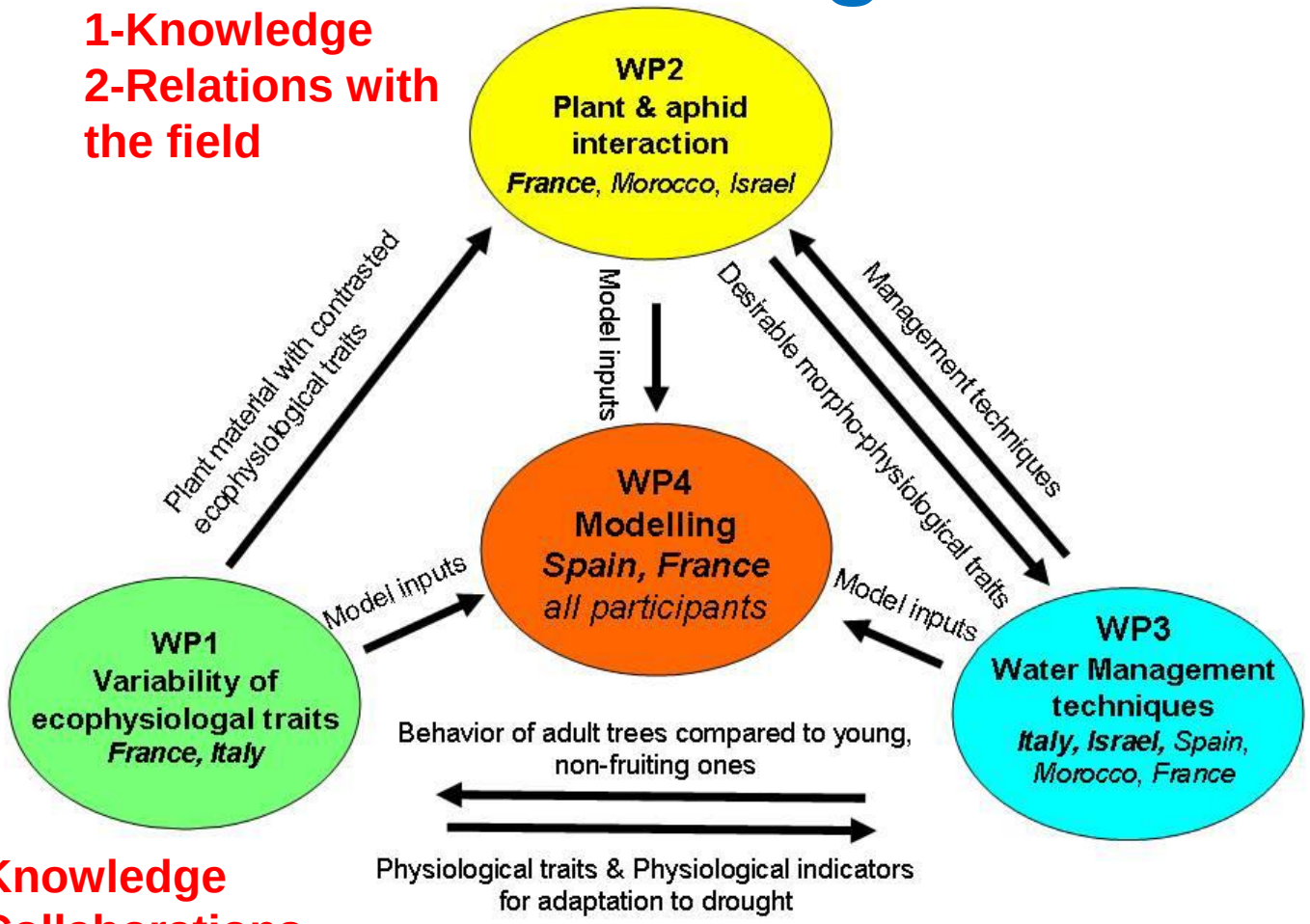
↳ Interest in a modelling perspective (connection with WP Modelling).

From the pot to the field:

Works with growers (Morocco; France, ongoing *RegPuc* programme).

The scientific organization

1-Knowledge
2-Relations with the field



1-Knowledge
2-Collaborations with breeders

1-Knowledge
2-Coordinating exchanges among existing models

4-Modelling - Integrating knowledge in FSPM

France, Spain

Main objective: *Functional Structural Plan Model* adapted to the fruit-tree to simulate apple and peach functioning in realistic conditions.

Two specific objectives:

- To make three modelling teams working together on the fruit-tree:

MAppleT (architecture based).

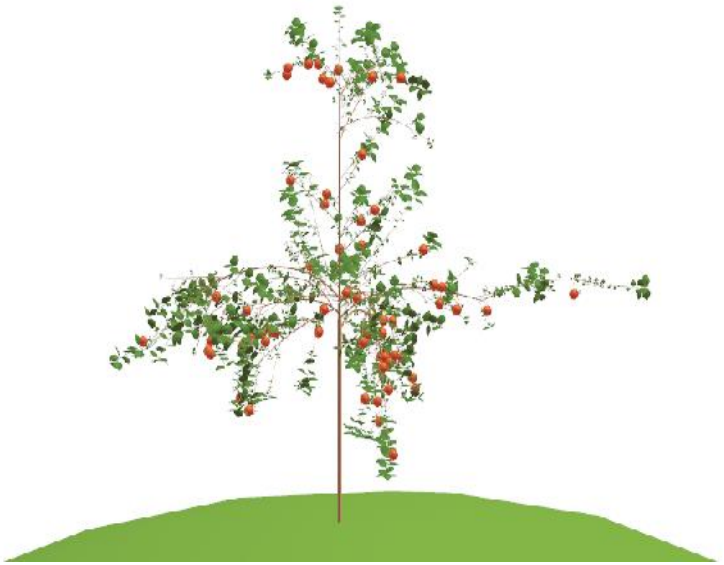
QualiTree (function based).

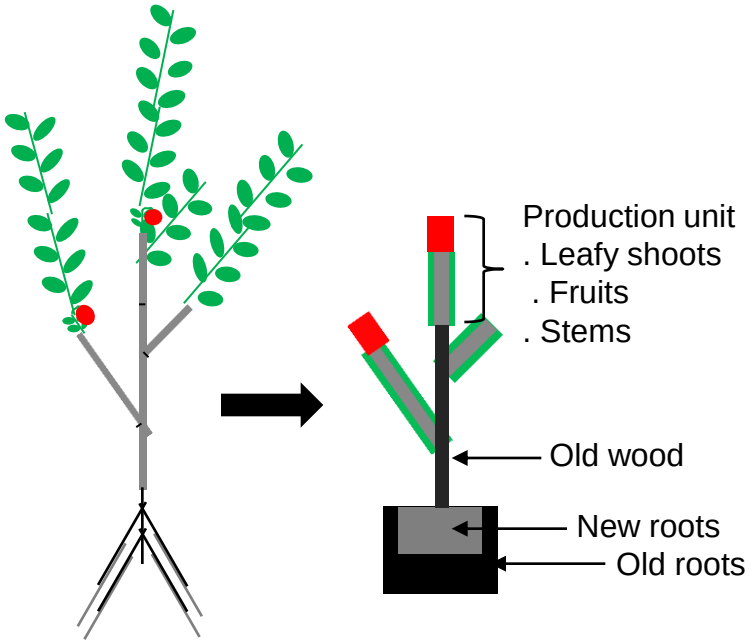
CropSyst (cropping system model).

- … with an applied objective: to implement realistic fruit size distribution.

4-Modelling - Integrating knowledge in FSPM

France, Spain





MappleT: stochastic models of topology and geometry + biomechanics. No physiology

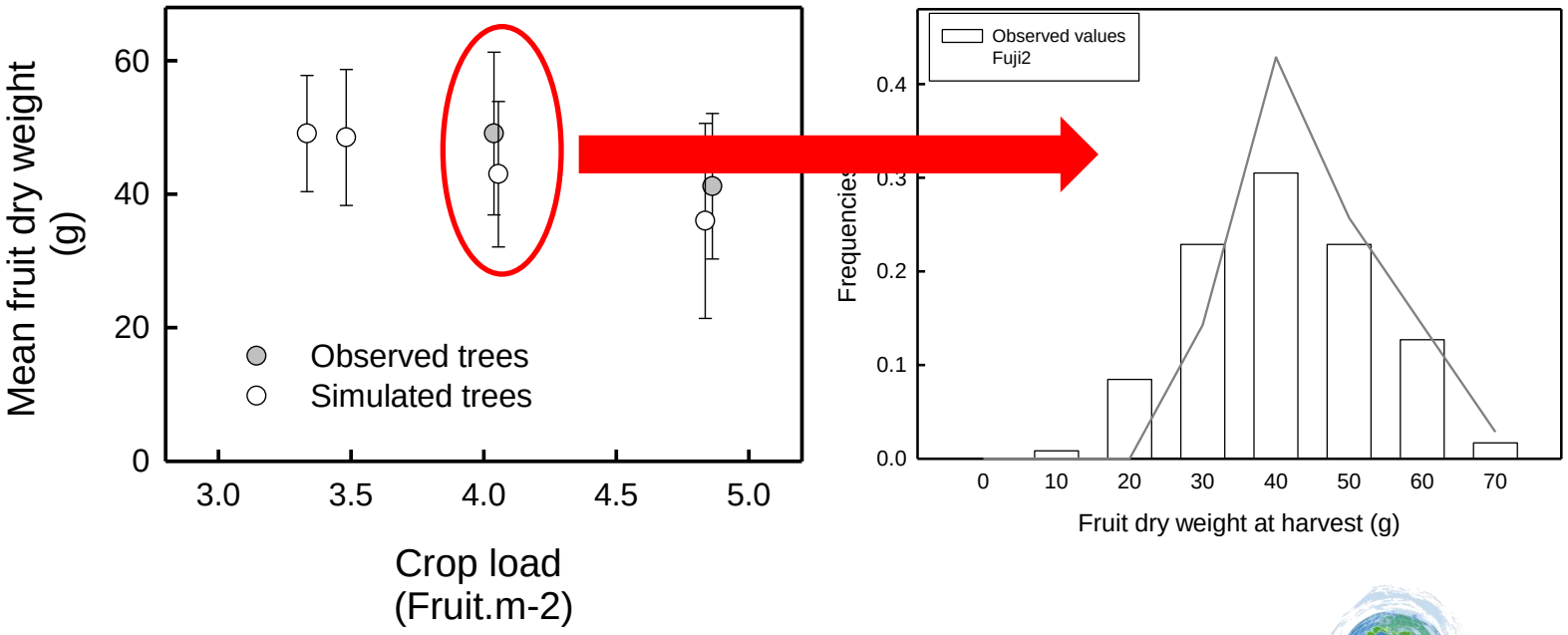
&

Qualitree: simplified topology and geometry. C supply by leaves/reserve ⇔ growth demand by fruit

4-Modelling - Integrating knowledge in FSPM

France, Spain

Output: Validation of fruit growth variability.
The case of cultivar *Fuji.*



4-Modelling - Integrating knowledge in FSPM

France, Spain

Take home messages:

Satisfactory coupling between tree architecture (topology-geometry), and functioning.

↳ outputs for fruit size under well-watered conditions.

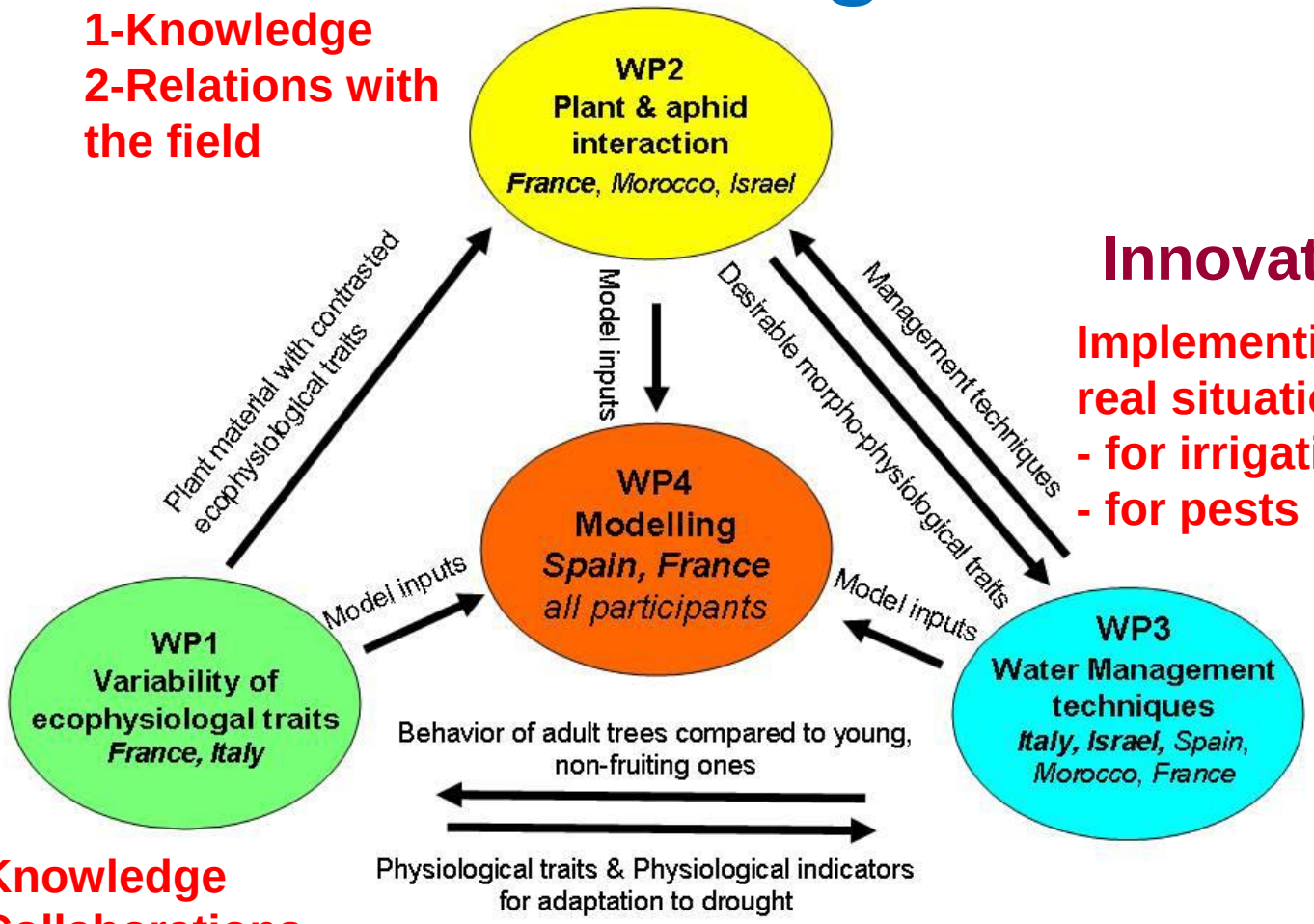
Perspectives:

- Validate the outputs for different crop load conditions.

- Test the model under water stress conditions (ongoing work on APMed data).

The scientific organization

1-Knowledge
2-Relations with the field



Innovation?

Implementing in real situations
- for irrigation
- for pests

1-Knowledge
2-Collaborations with breeders

1-Knowledge
2-Coordinating exchanges among existing models

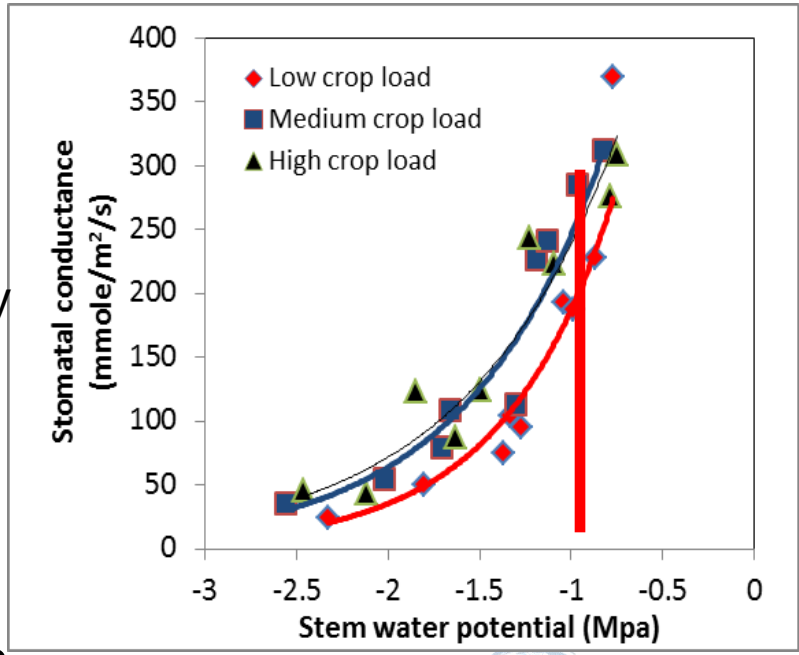
3-Water management in the orchard

France, Israel, Italy & Morocco

1 - Interaction between stem water potential (SWP) & crop load (Peach)

SWP is used to monitor irrigation.

BUT the demand for assimilates (fruits) affects leaf functioning: for a same SWP low crop load (179 fr/tree) decreases stomatal conductance (= loss of water by transpiration) compared to high crop load (892 fr/tree).



↳ **Less irrigation is needed when low crop load: water use can be better controlled considering crop load.**

3-Water management in the orchard

France, Israel, Italy & Morocco

2 - Water management and light conditionning (Apple)

Four different light management treatments (shade nets):

- control (no net)
- red
- white shading
- neutral

X

Three WS severities:

- 100% (control; ETc),
- 60%
- 30%

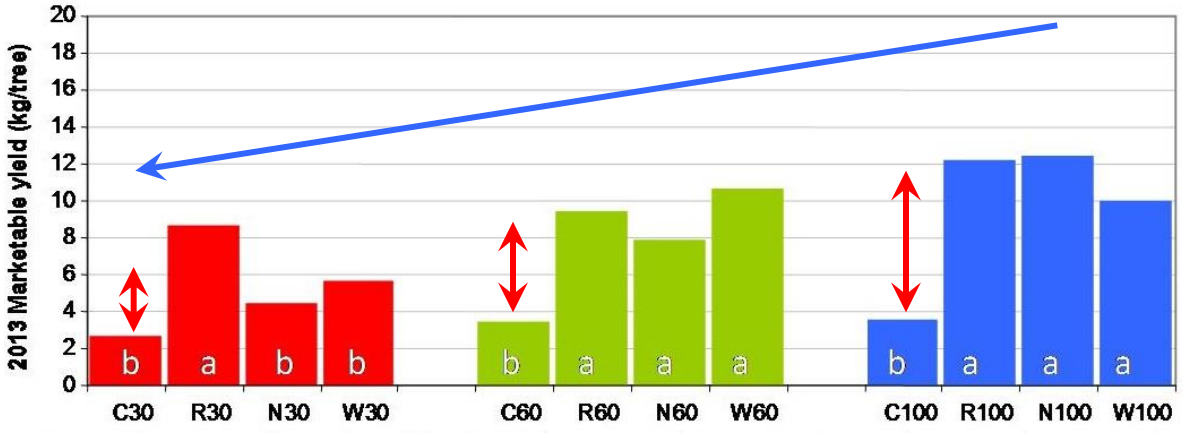
3-Water management in the orchard

France, Israel, Italy & Morocco

2 - Water management and light conditioning (Apple)

WS decreases marketable yield: 100% > 60% > 30%

BUT for each WS severity, **colored nets give higher marketable yield than the control.**



3-Water management in the orchard

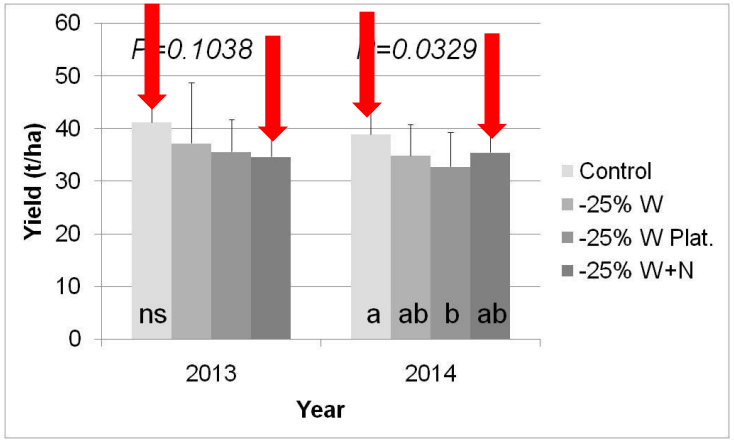
France, Israel, Italy & Morocco

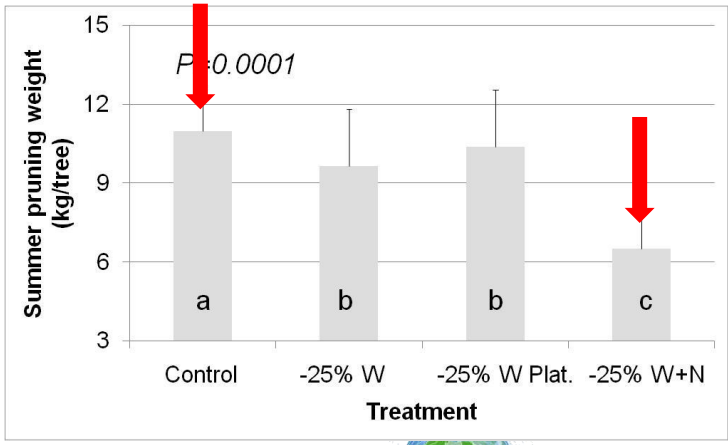
3 - Regulated Deficit Irrigation, RDI (Peach)

↘ 25% [water & N] compared to crop coefficient-driven irrigation.

a- No effect on total yield.

b- ↘ the need for summer pruning.



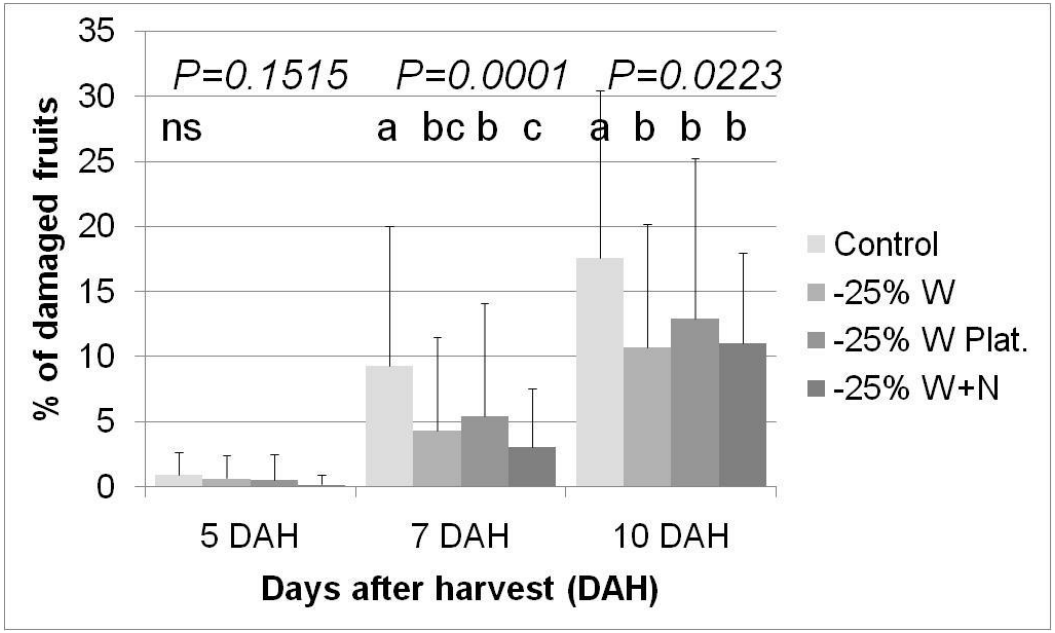


3-Water management in the orchard

France, Israel, Italy & Morocco

3 - Regulated Deficit Irrigation (Peach).

c- ↘ post-harvest diseases: ↗ shelf-life of the fruit.



3-Water management in the orchard

France, Israel, Italy & Morocco

Take home messages:

RDI interacts with crop load

Extending previous results (Naor et al. 2008)

adapted to each

Colored net

Extending previous results (Girona et al. 2012)

produced.

RDI may be optimized

high marketable yield,

reduci

Innovation

(summer and winter) and

post-h

diseases (*Monilia* sp).

3-Water management in the orchard

RDI may be optimized to give high marketable yield, reducing the need for pruning (summer and winter) and post-harvest diseases.

- **Strong interest for the grower,**
  - "pruning": to save skilled labour during the growing season,
  - "fruit shelf life": to secure the market with less fruit waste in the retail market or in the consumer house.

- **How these findings were obtained and interpreted?**

3-Water management in the orchard

✍ **Initially,**

Only studies on **peach ⇔ aphids interactions** were scheduled in relation to research experiments in pots.

Scientific objective: coupling between pot experiments and field

Post-harvest diseases were not included in the study.

NB: only later connected to previous works on cuticular crack surface and infections by *Monilia laxa* (Gibert et al. 2009).

During the project,

Decision to explore further fruit quality AFTER fruit were harvested.

Post-harvest diseases emerged as a main concern for growers and subcontractants

A point on serendipity.

3-Water management in the orchard

- **Serendipity** ← tale from Sri Lanka called "The Three Princes of Serendip": "… they were always making discoveries, by accidents and sagacity, of things which they were not in quest of...."

  (Horace Walpole, writer, 1754).

- **Definition**: "The faculty of making fortunate discoveries by accident."

  Royston M. Roberts,1989:

  "Serendipity: Accidental Discoveries in Science"

  Patrick J. Hannan, 2006:

  "Serendipity, Luck and Wisdom in Research"

Sylvie Catellin, 2014:

"Sérendipité - Du conte au concept"

To **pay attention to unexpected events (open mind,…)**

AND

to have a **relevant interpretation (creativity,...)**.

How to design a network to address innovation in research?

= What are the conditions to foster innovative progresses in the project?

- (multi-) **interdisciplinarity**.

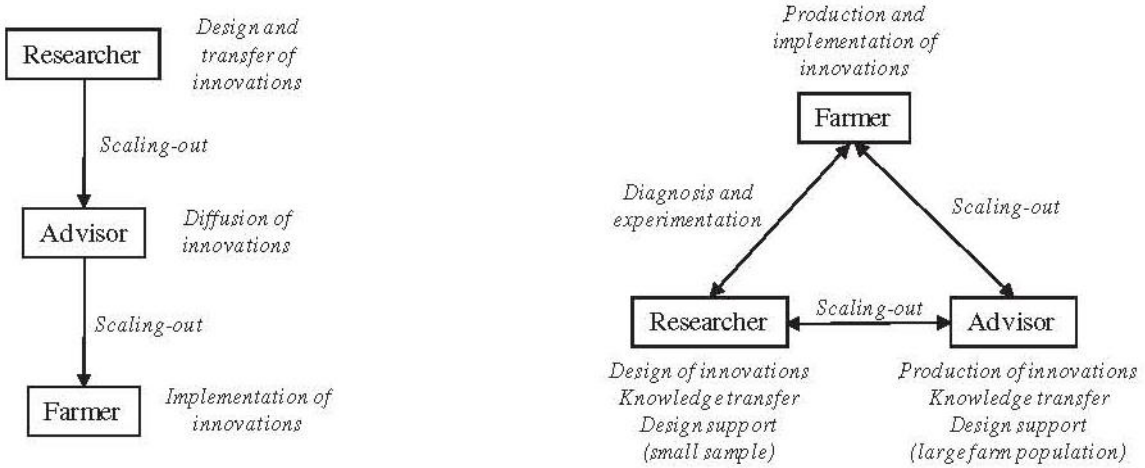
  APMed: tree biology, ecophysiology, entomology, pathology, agronomy, modelling,

  + end-users practical knowledge.

- **to make people really working together**.

How to design a network to address innovation in research?

- Two main Innovation processes: linear vs. interactive and participative (Le Gal *et al.* 2011)



a. Linear and diffusionist paradigm of innovation process

b. Interactive and participative paradigm of innovation process

Fig. 1. Schematic representation of two innovation process paradigms including farmers, advisors and researchers. The concept of «innovation» includes both new technologies and new ways of organizing and managing production systems. In paradigm (b) researchers and advisors carry out similar tasks but at different scales, which requires an efficient scaling-out process.

How to design a network to address innovation in research?

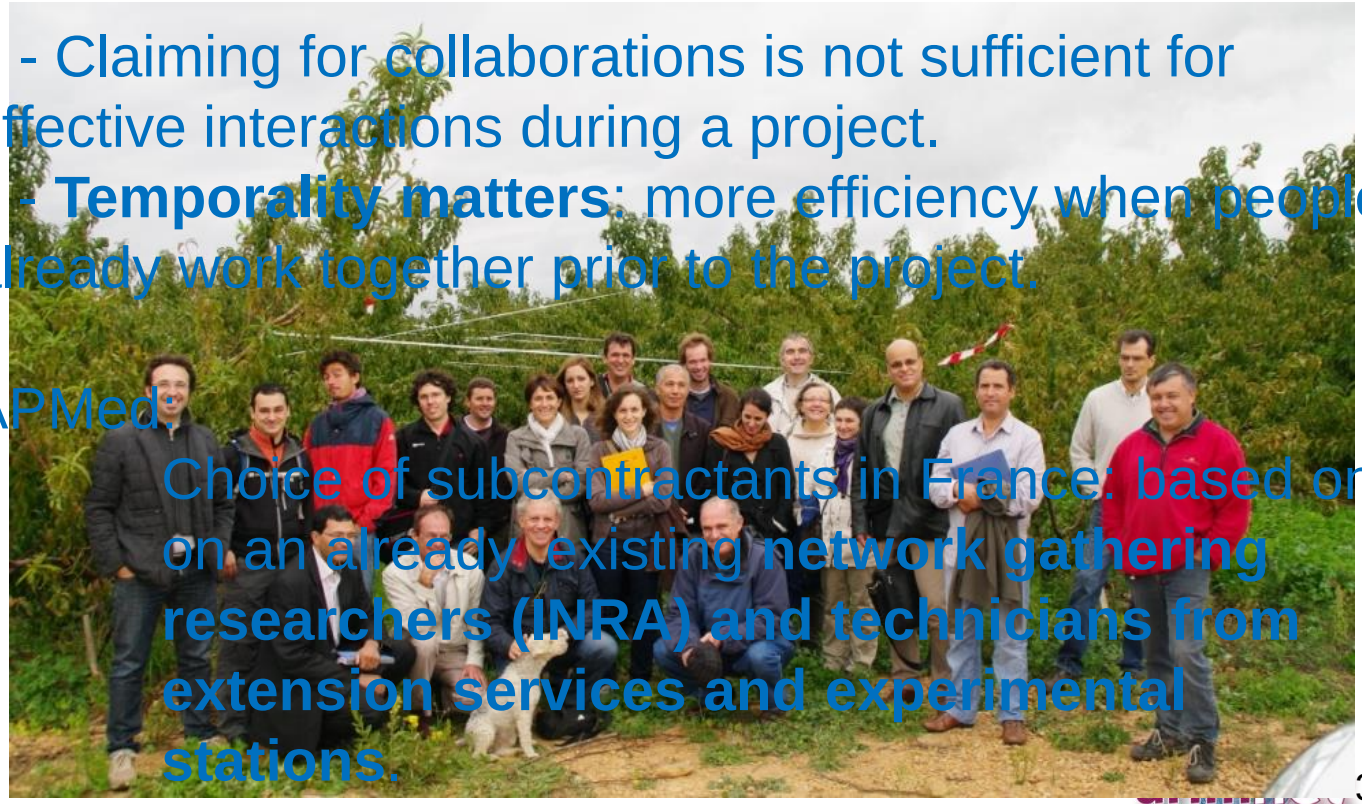
* For the scientist: research questions are chosen depending on the conceptual/technical tools we have in our toolbox … not often from « external » question (Kuhn, 1970).

* Innovation: what the end-users tell you bring and not what you think you bring.

How to design a network to address innovation in research?

- **The project should imply people already connected**:

1 - Claiming for collaborations is not sufficient for effective interactions during a project.
2 - **Temporality matters**: more efficiency when people already work together prior to the project.



APMed:

Choice of subcontractants in France: based on on an already existing **network gathering researchers (INRA) and technicians from extension services and experimental stations**.

Applied research network MAFCOT (knowledge on fruit-tree architecture to innovate in training and pruning strategies; from 20 years).

2003 - Master thesis on an analysis of « Trajectory of a work collective around the apple tree »

2006 – Special issue in a French horticultural journal

"Progress in science is not regular and smooth but rather through jerks and possibly steps backward".

"Scientific planning is an illusion".

Claude Allègre, 1995. La défaite de Platon. Fayard, Paris

↳ *A fortiori* true for an invention / discovery or an innovation!

← We need to combine open mind and optimal conditions to foster exchanges among disciplines and collaborators.