High throughput phenotyping... What's going on

Christophe Salon

High throughput phenotyping..

What's going on

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Goals

Scientific : Understand plant response to environmental factors : get a enhanced agronomic production, with a better quality, less fertilizers…

Technical : Reduce the gap between genotyping and phenotyping flows

Economic : Offer to companies the possibility to SME the possibility to access/develop tools and methods at the same level as foreign ones

Goals

Offer to the plant science communty high throughput phenotyping infrastructure :

Academic and private Research, breeding companies, technical institutes:

Platforms + asscoiated methods and tools

Caracterize large genotype series such as needed for genetic variability studies:

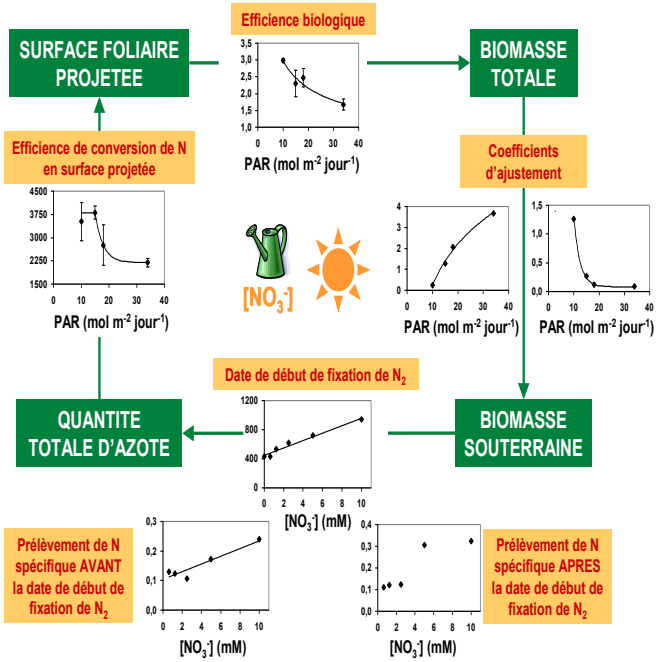
100x field plots- 1000x plants

Populations - varieties- mutants - GMO

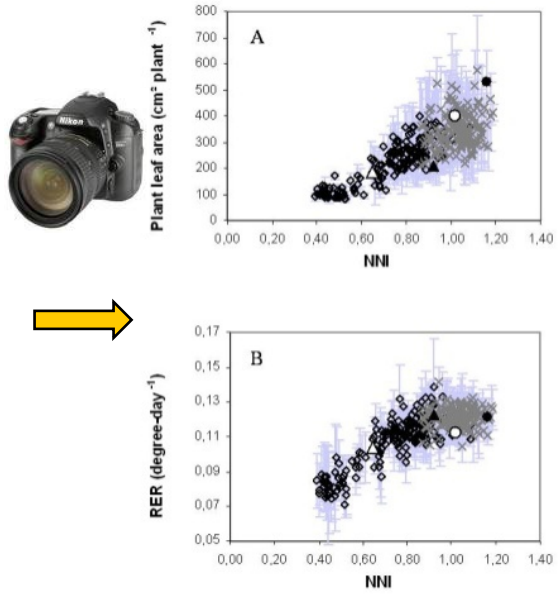
Create diverse environmental scenarios including climatic changes

hydric constraints, N stress, parasites, combinations with other constraints : [CO2], temperature, …

Before: Detect contrasted N nutritions



Model



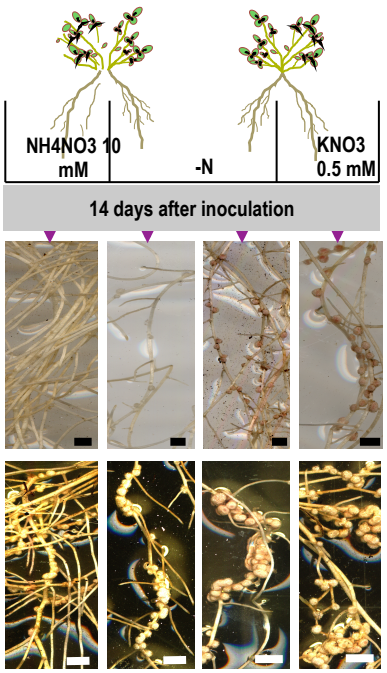
Dynamic leaf area measurement

Genotypes of Medicago RIL ranked for ability to uptake N

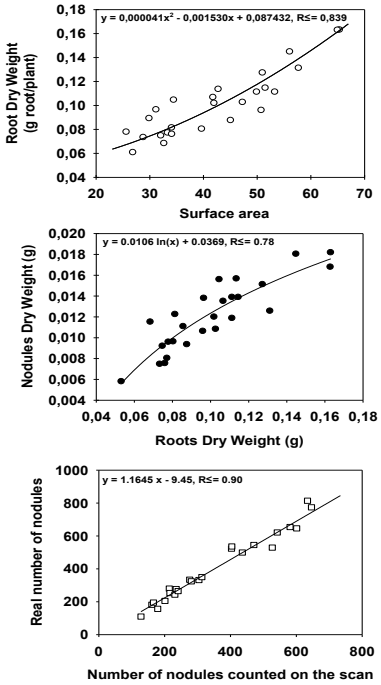
Moreau et aL. (2006), Plant, Cell and Envir., 29:1087-1098.
Moreau et aL. (2007), Plant, Cell and Envir., 30:213-224.
Moreau et al. (2008), J. Exp. Bot., 59:3509–3522.

Before: Identify a strategy

Adaptative strategy of plants faced to a N constraint



Split roots



Nodules number and size, appearance

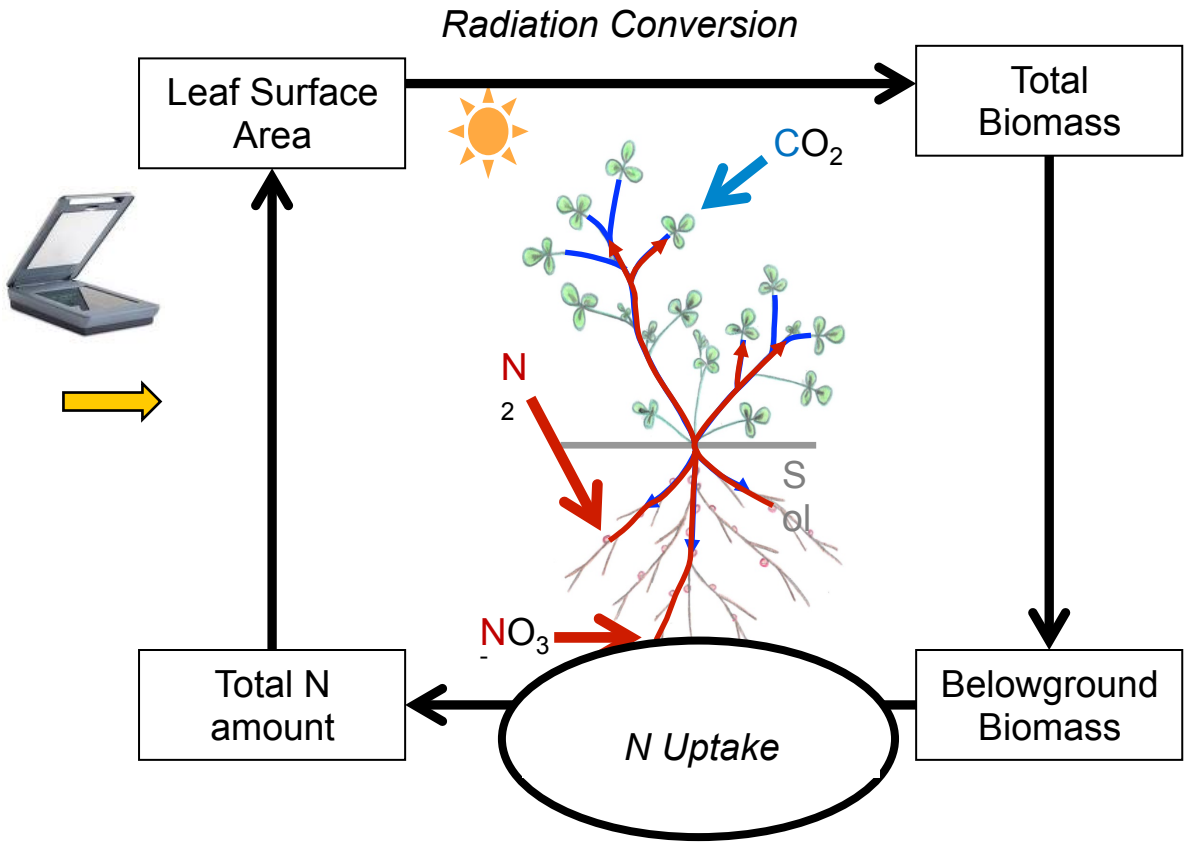
Morphometry versus functional strategy identifcation

Ruffel et al. (2008), Plant Physiol. 146: 2020-2035.
Salon et al. (2009), CRAS, 332 :1022-1033.
Jeudy et al. (2010), New Phytol, New Phytol., 185:817-828.

Before: Functional characterization of a mutant

Characterizing the functional behavior of a mutant: hyper ramified TR 185

Contrasted root architecture



No modifications of C acquisition rules

Lower N uptake efficiency

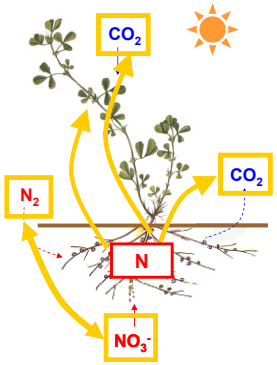
Salon et al. CR Biologies 2009

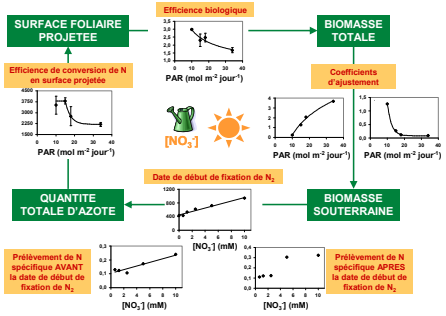
Bourion et al submited

Food for thoughts…

Combine approaches

Phenotyping + **Analytical appraoch** + **Modelization**





Identify differences between genotypes

Interpret detected differences

Validate in the field to handle G*E*M interactions

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Large Research Unit « Agroecology »

Goals

⇒ **A variety of research objects**

EcolDur	GEAPSI	IPM	MERS
			
Legumes, Weeds, Cereals, Brassica	**Legumes, Legumes/ Cereals Associations**	**Legumes, Arabidopsis, Wine, Tobacco, Tomato**	**Listeria and root tissues**

PPHD, Missions

- **Produce plant material in characterized environmental conditions.**
- **Use and develop innovative techniques for high throughput morphometry**

… of a large number of biological units, their interactions…

… under various environmental conditions…

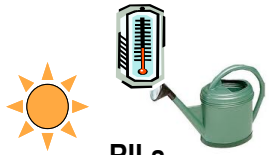
$[Co_2]$ ↗

… at various organisational levels (organ /plant)

… and phenotyping equipment

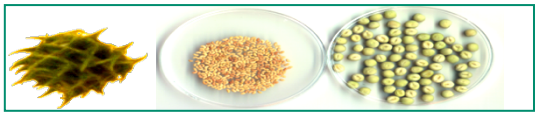
Aerial architecture

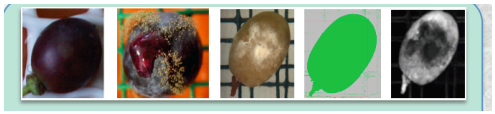
20 units/h



RILs
Mutants (Tilling..)
Ecotypes

Organs (seeds…)





Small plants

6 units/h

Germination

2 units/h

Root system

Licence INRA

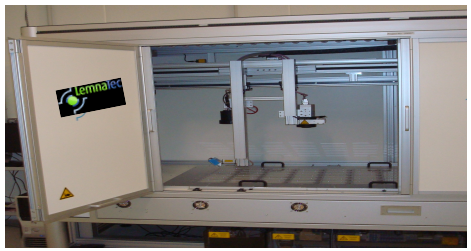
120 units/h

100 units/h

VIS

NIR

FLUO

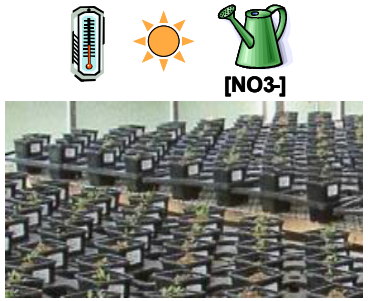


Analyze genetic variability by large genotypes series, various environmental scenarios.

Example: focus on legume plants

Phenotyping plant architecture, flowering, senescence, …

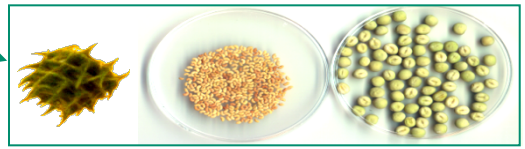
P. sativum *M. truncatula*



- **Mutants** (Tilling..)
- **RILs**
- **Ecotypes collections**

CONTROLED ENVIRONMENTAL CONDITIONS

Phenotyping pods and seeds

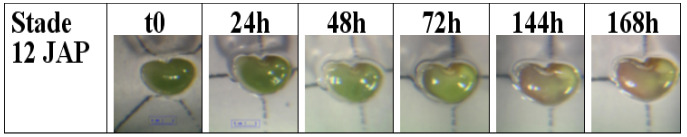


✓Seeds : Number, size and shape

Kroj et al. Development (2003) 130, 6065-6073

✓Fluorescence: GFP

✓ *In vitro* kinetic development

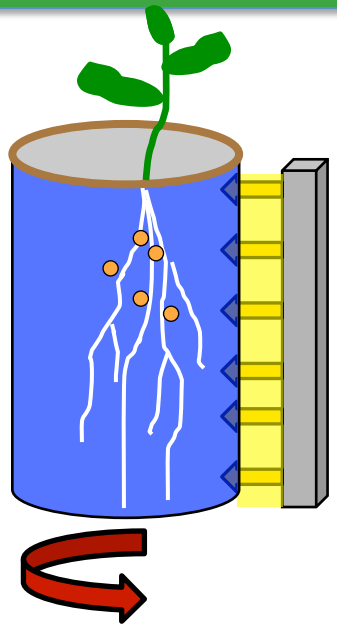


Phenotyping roots and interactions with micro organisms (nodules, µR), …

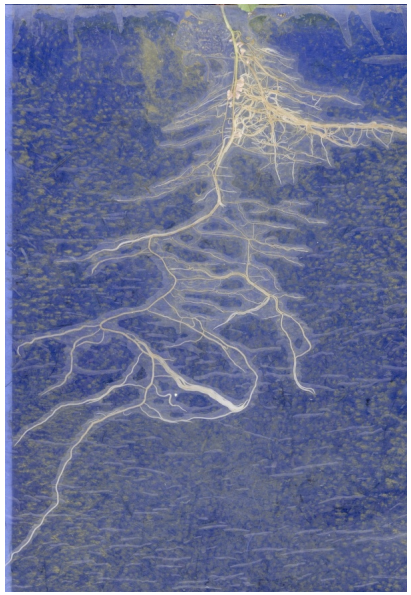
Rhizotron (INRA-Inoviaflow EU licence)

HD Rhizotrons (1300 units planed)

....

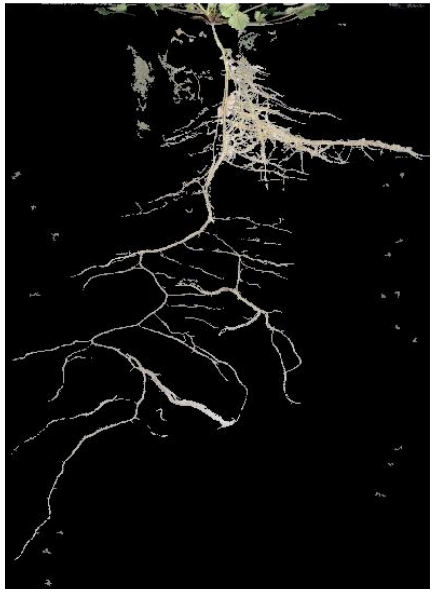


Rotating scan



RBG Image

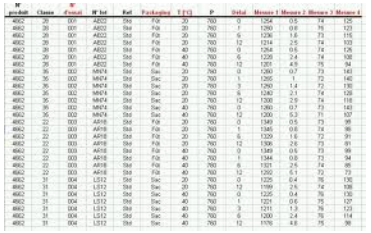
Image treatment



Phenotyping Traits :

- projected root area
- projected nodule area
- total nodule numbers
- nodule size classification
- total root length

....



Brief summary of root phenotyping tools

	RGB/NIR	X rays	MRI	Thz
« analysis » window	+++	++	+	++
Analysis length	1 mn	1 mn	20 mm	m
Resolution	1 mm	0,2 mm	1	1 cm
Dangers	None	Ionisation	ield	None
Price	+++	+	--	--
Real time	+++		+++	+++

Plus other project for automatization on going

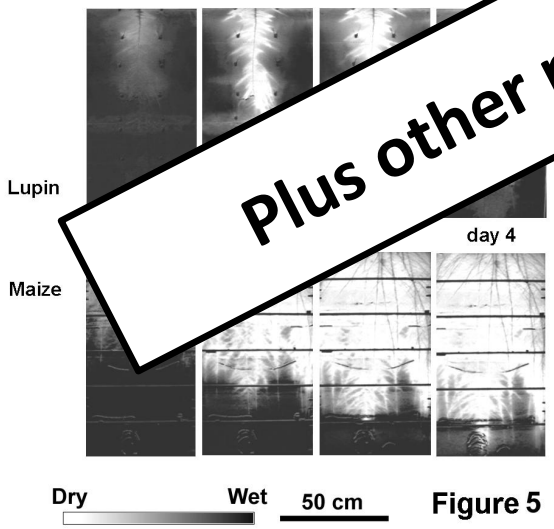
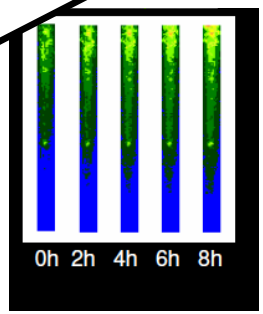
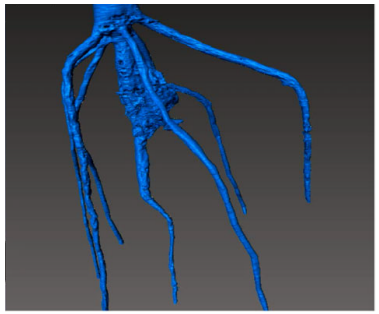
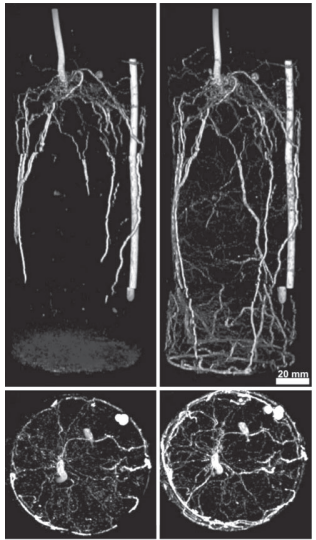


Figure 5

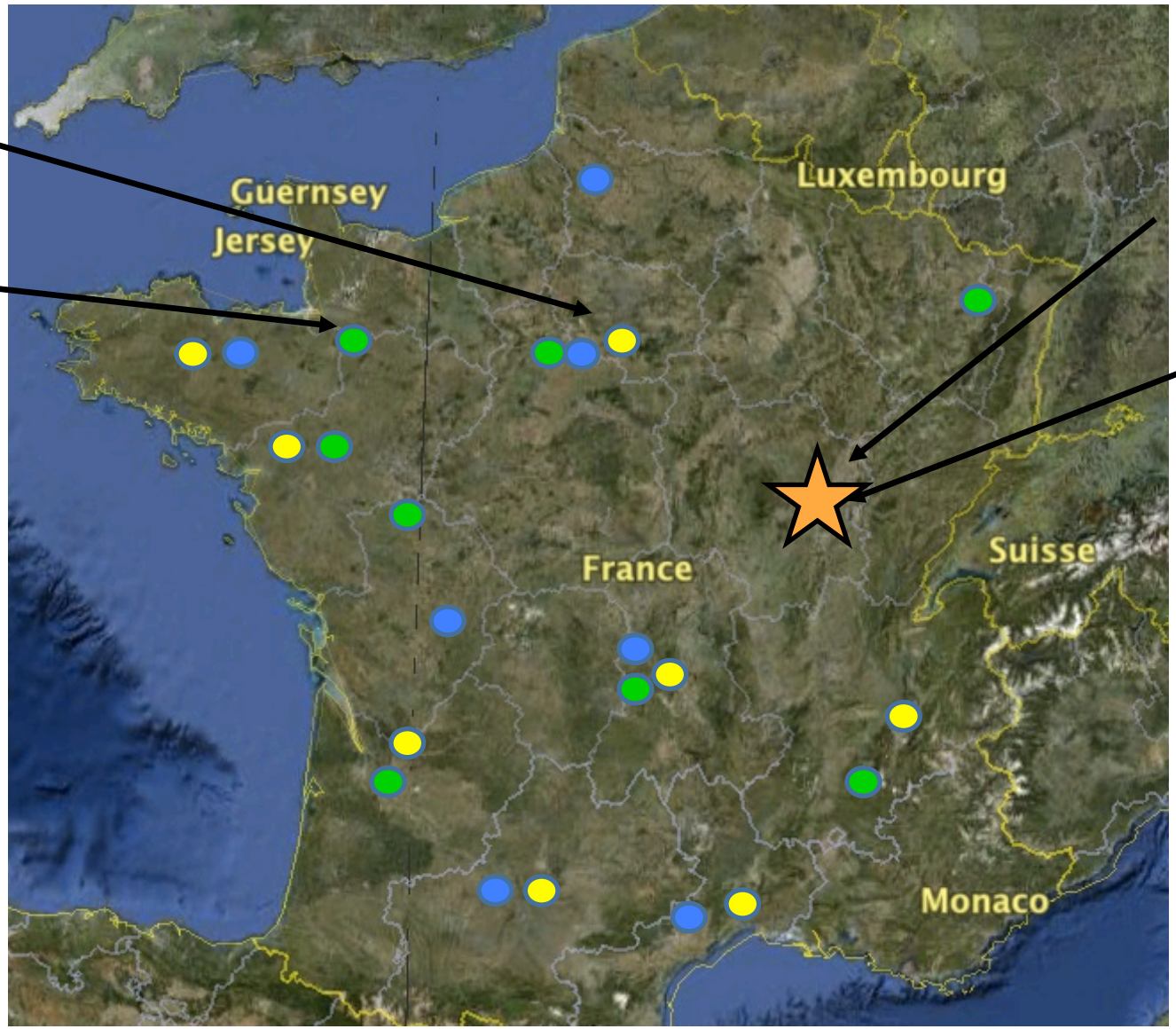






Phenotyping structuration: local, national

Plateforme Phénotypage Haut Débit



EFOR

FUI
SERAPIS

Valorial
L'ALIMENT DE DEMAIN

VEGEPOLYS
PÔLE DE COMPÉTITIVITÉ
La + value végétale

AGRO SUP DIJON

VITAGORA
PÔLE DE COMPÉTITIVITÉ
GOÛT-NUTRITION-SANTÉ

CAQ40
ACCAF

PEAMUST

PHENOME

International

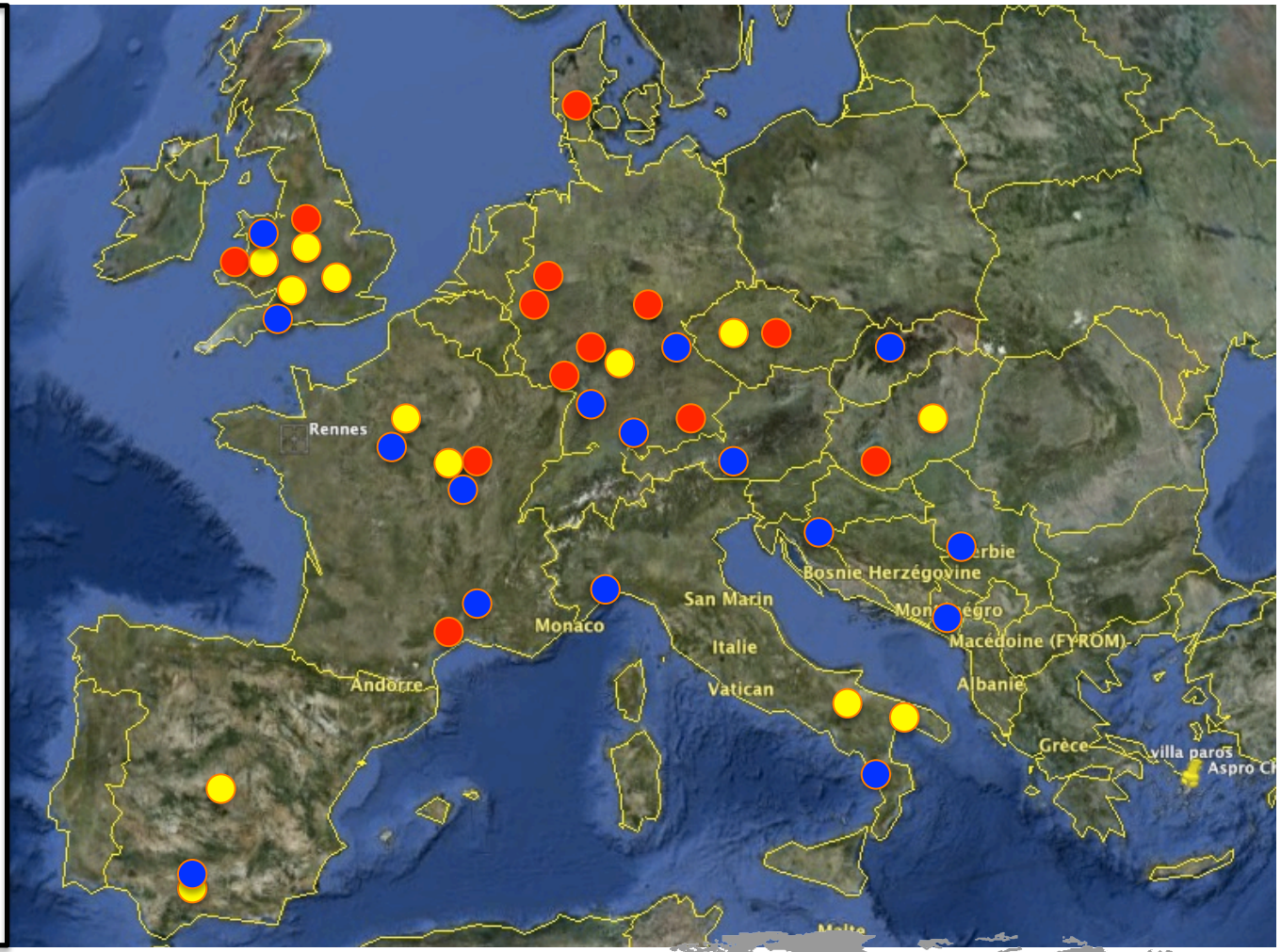
European Plant Phenotyping Network

EPPN

ABSTRESS

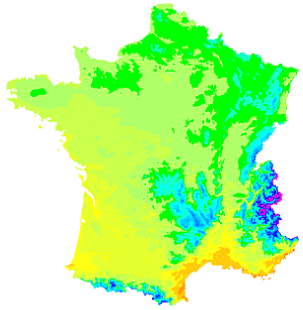
improving the resistance Abiotic and of legume crops to combined Biotic STRESS

LEGATO



Network of multi-specific platforms

Examples of :



- Phenome: French initative (30M€)

European Plant Phenotyping Network
EPPN

- EPPN: EU project(5,5 M€)

Network of multi-specific platforms

Prérequisites

- Homogenous high throughput : necessitates 200 – 500 genotypes
  "…make on these genotypes what we made on 10 plants…"

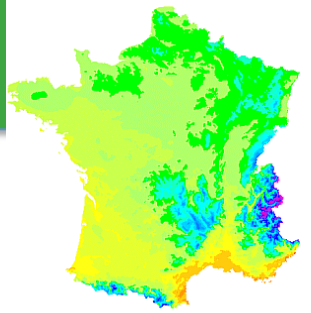
- Control / measure environmental conditions encountered by plants

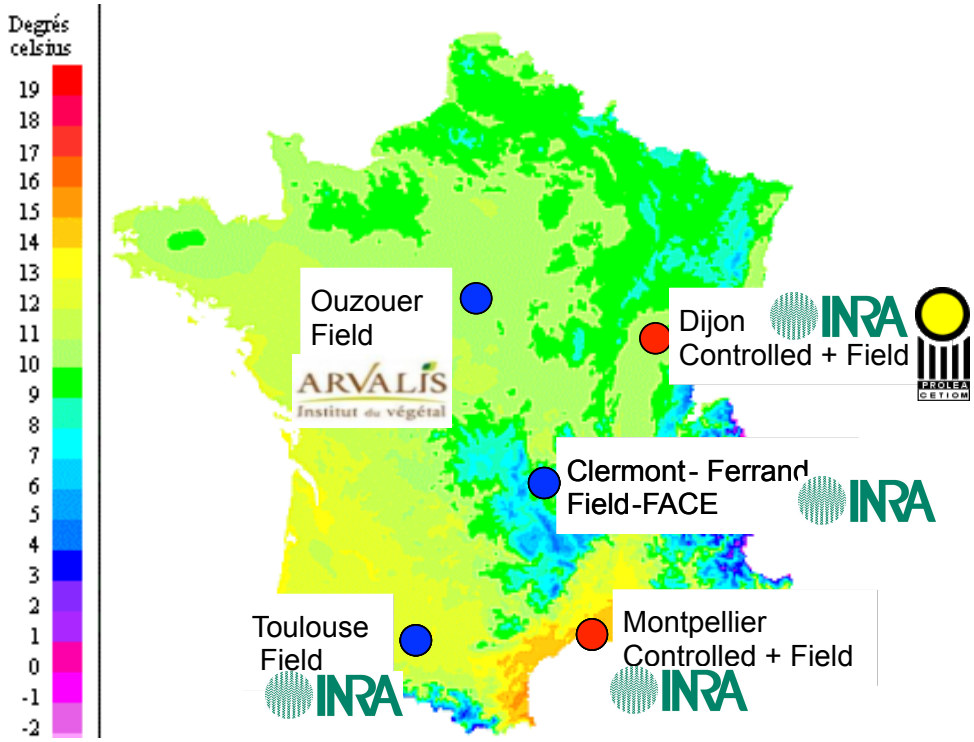
- Measure traits of interest:
  - « … In platforms (either controlled or field) we'll measure only what we cannot do elsewhere … »
  - reproducible / heritable / characters involved in yield (its quality), "hiden" (RUE rather than biomass)
  - "genotypic parameters of ecophysiological models"

- Flexibility in order to allow working on various species

Phenome Infrastructure

Five field platforms





Differents pedo-climatic conditions

Sharing characteristics:

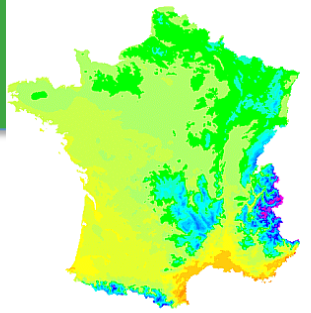
- environnement sensors (soil and air)
- sensors of plant responses
- local database

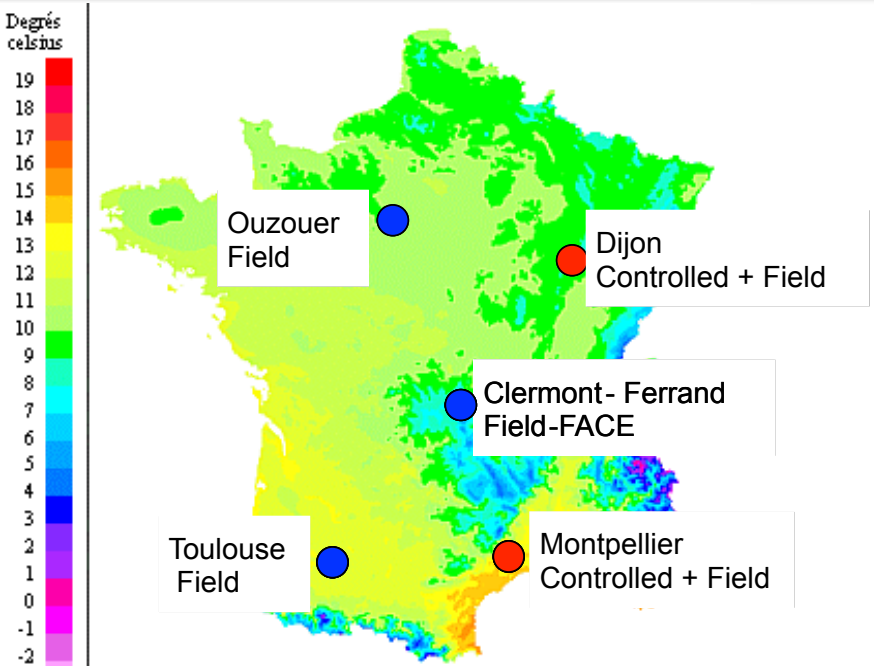
Having specificities :

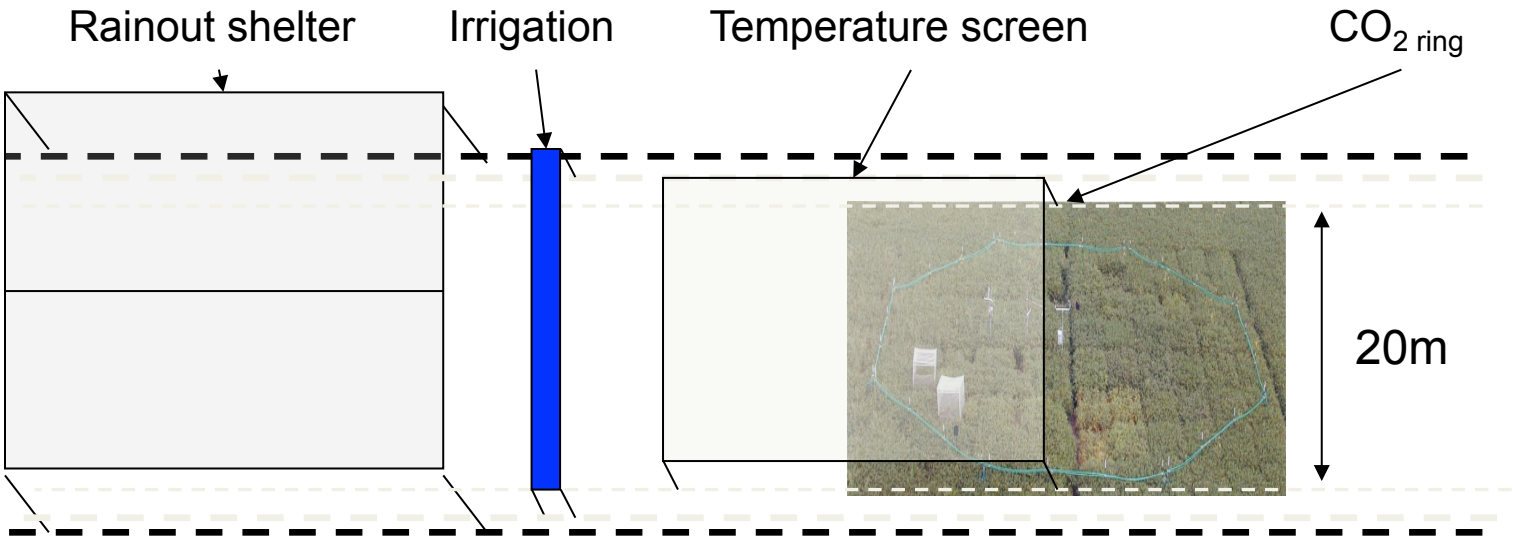
- rolling shelters = water
- FACE = [CO_2]

Phenome Infrastructure

Five field platforms



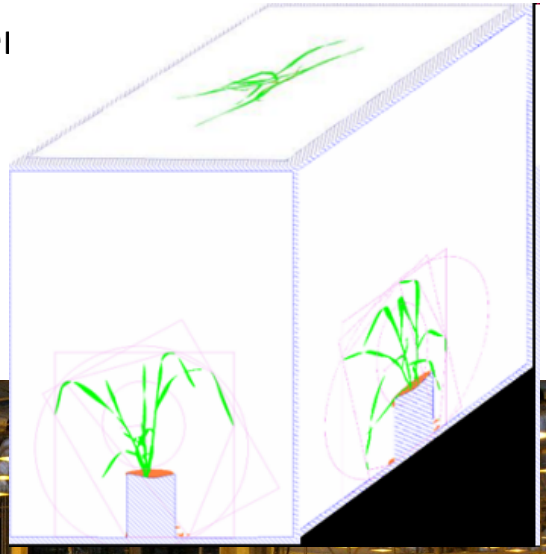


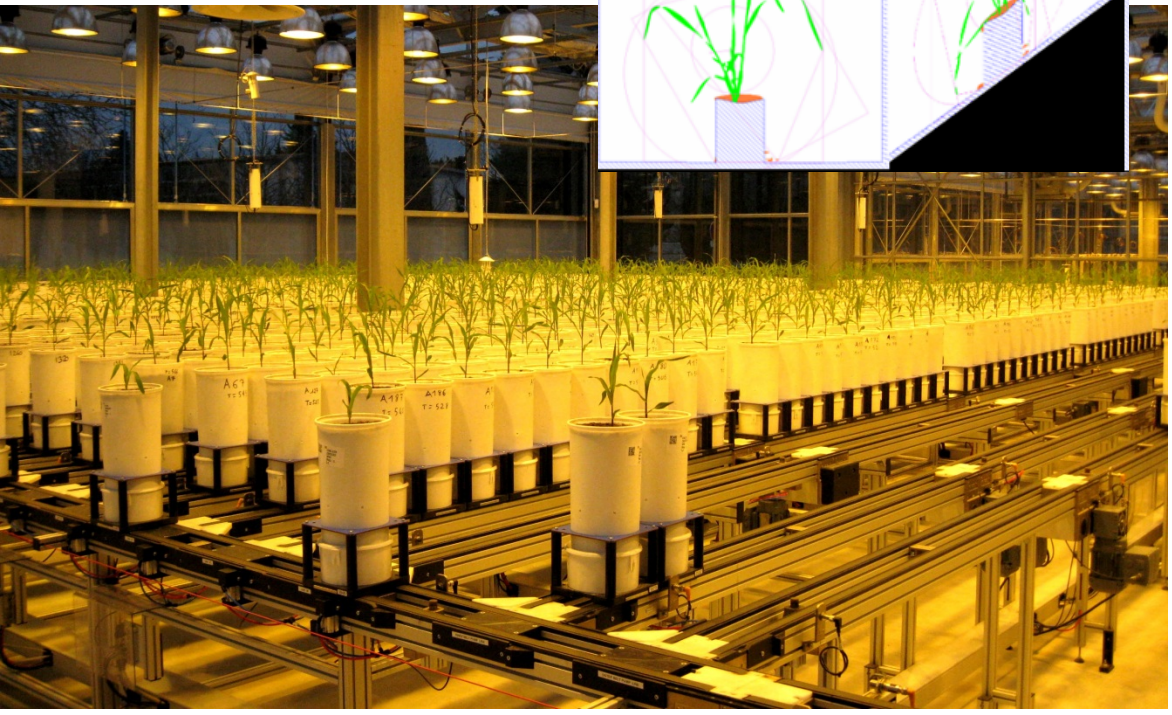


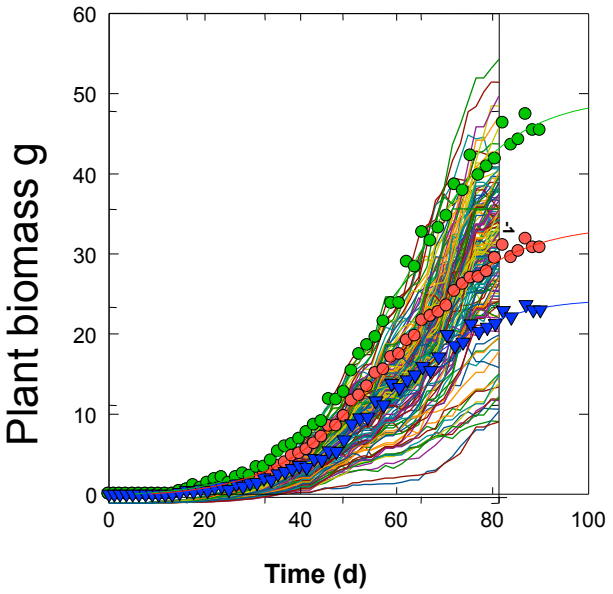
Two platforms in controled conditions

PhenoArch (Montpellier)

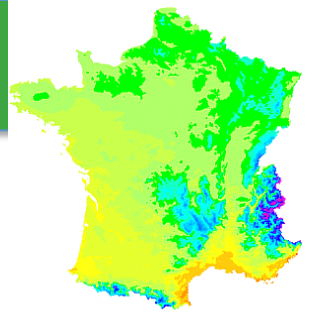
PPHD (Dijon)







Methodological projects



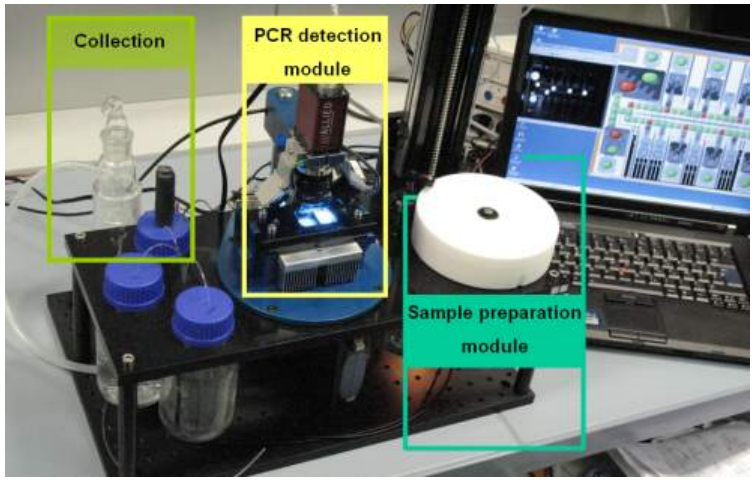
Develop new sensor and methods

Consortium INRA + INRIA + polytechnique + CEA LETI

Autonomous and miniaturized sensors:

Organ temperature, light

Pathogens pression



European Plant Phenotyping Network

EPPN

SEVENTH FRAMEWORK PROGRAMME

Grant Agreement No. 284443.

EPPN is the first integrated FP 7 EU Research Infrastructure project in Plant Sciences

Goals:

Create a European integrated network

Provide access to EPPN facilities for the user community

Develop novel instrumentation for non-invasive methods

Establish definition of standards

Duration: January 2012 – December 2015

Budget: 5 500 000 €

European Plant Phenotyping Network

EPPN

Infrastructure

Organisation	
Forschungszentrum Jülich, Germany (coordination)	FZJ
Leibniz-Institut für Pflanzengenetik und Kulturpflanzenforschung, Germany	IPK
Helmholtz Zentrum München, Germany	HMGU
Rheinisch-Westfaelische Technische Hochschule Aachen, Germany	RWTH
Institut National de la Recherche Agronomique, France	INRA
Aarhus University, Denmark	AA
University of Nottingham, United Kingdom	UNOTT
Wageningen University and Research, The Netherlands	DLO
Hungarian Academy of Sciences, Hungary	HAS
Austrlian Plant Phenotyping Facility, Australia	APPF
Global Change Research Centre, Czech Republic	CzechGlobe
Aberyswyth Unversity, United Kingdom	ABER
Keygene Inc., The Netherlands	Keygene
Phenom-Networks, Israel	Phenom

Thanks for your attention …