CLIMATE-SMART Agriculture 2015

Global Science Conference

March 16-18, 2015
Le Corum, Montpellier France

Towards genotypes adapted to climate change

via combination of phenotyping and modelling:

The projects DROPS and Phenome

Francois Tardieu
INRA Montpellier

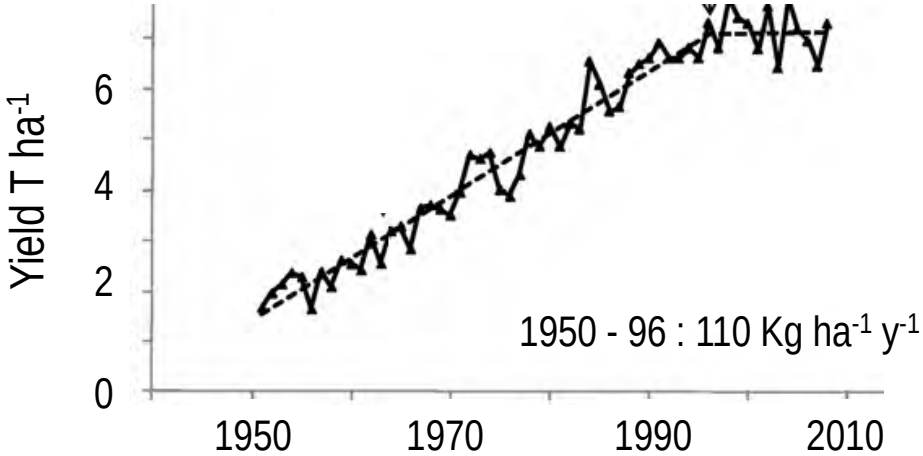
INRA SCIENCE & IMPACT

PHENOME Réseau Français Phénomique végétale FPPN

DROPS

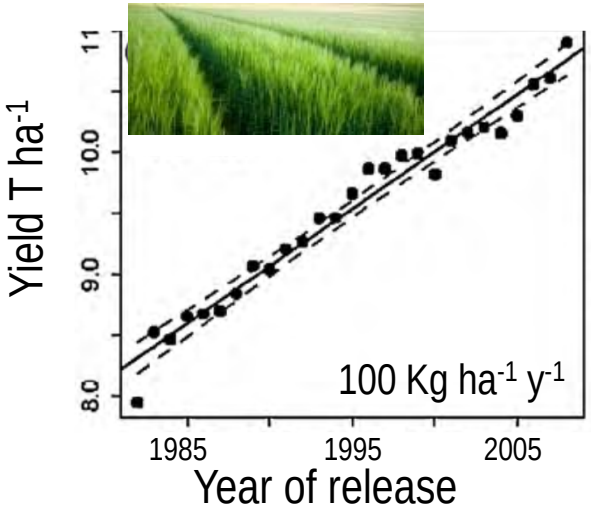
A continuous genetic progress challenged by climate change

	NW	NE	SW	SE
1950	2.1	2.4	2.7	2.7
1955	2.3	1.9	1.5	1.5
1960	3	3.1	3.3	3.3
1965	3.5	3.3	3.8	3.6
1970	4.1	4.1	4.3	4.2
1975	4.5	4.1	3.7	3.9
1980	5.1	5.0	5.4	5.2
1985	5.5	5.6	5.8	5.5
1990	6.3	5.8	6.1	5.9
1995	7.1	7.3	7.1	7.3
2000	7.2	7.1	7.5	7.4
2005	7.1	6.8	6.8	7.2
2010	7	7.3	7.8	8.0
2015	7.1	6.7	6.6	6.2

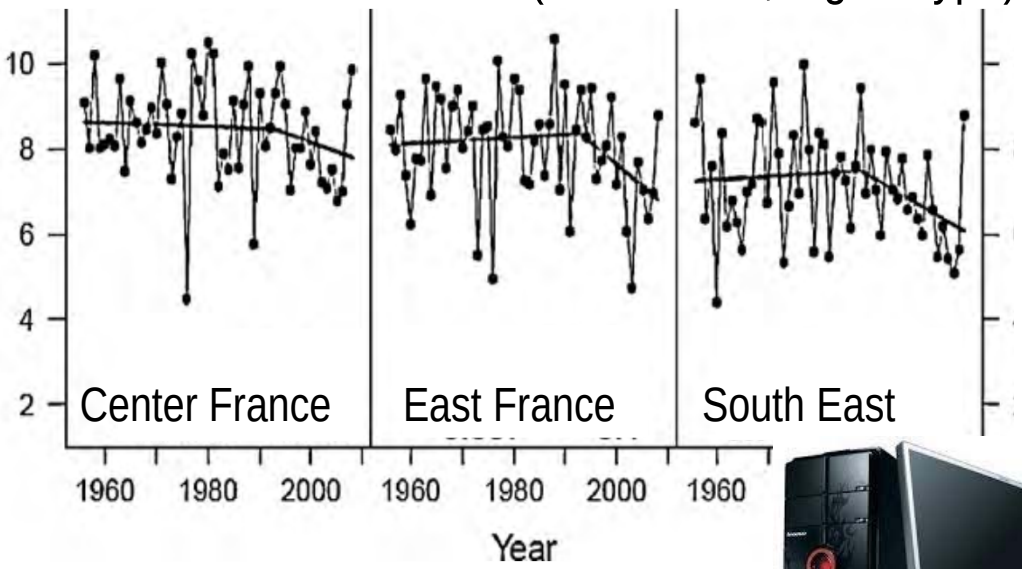


similar in all EU,
barley, canola, sunflower...

Genetic progress



Environmental effect (simulations, 1 genotype)

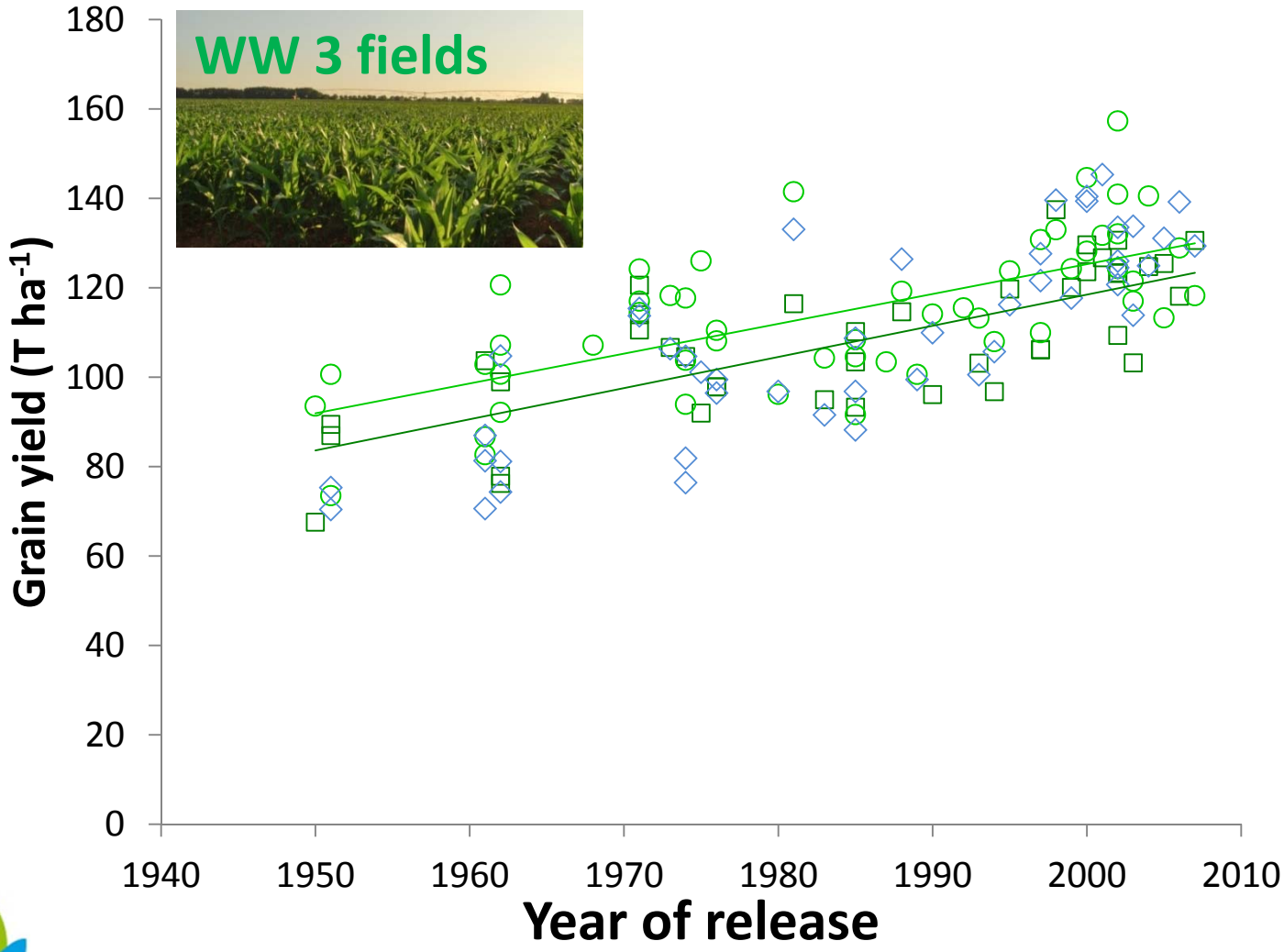


We need a new generation of genotypes better adapted

Brisson et al. 2010 FCR 119,201

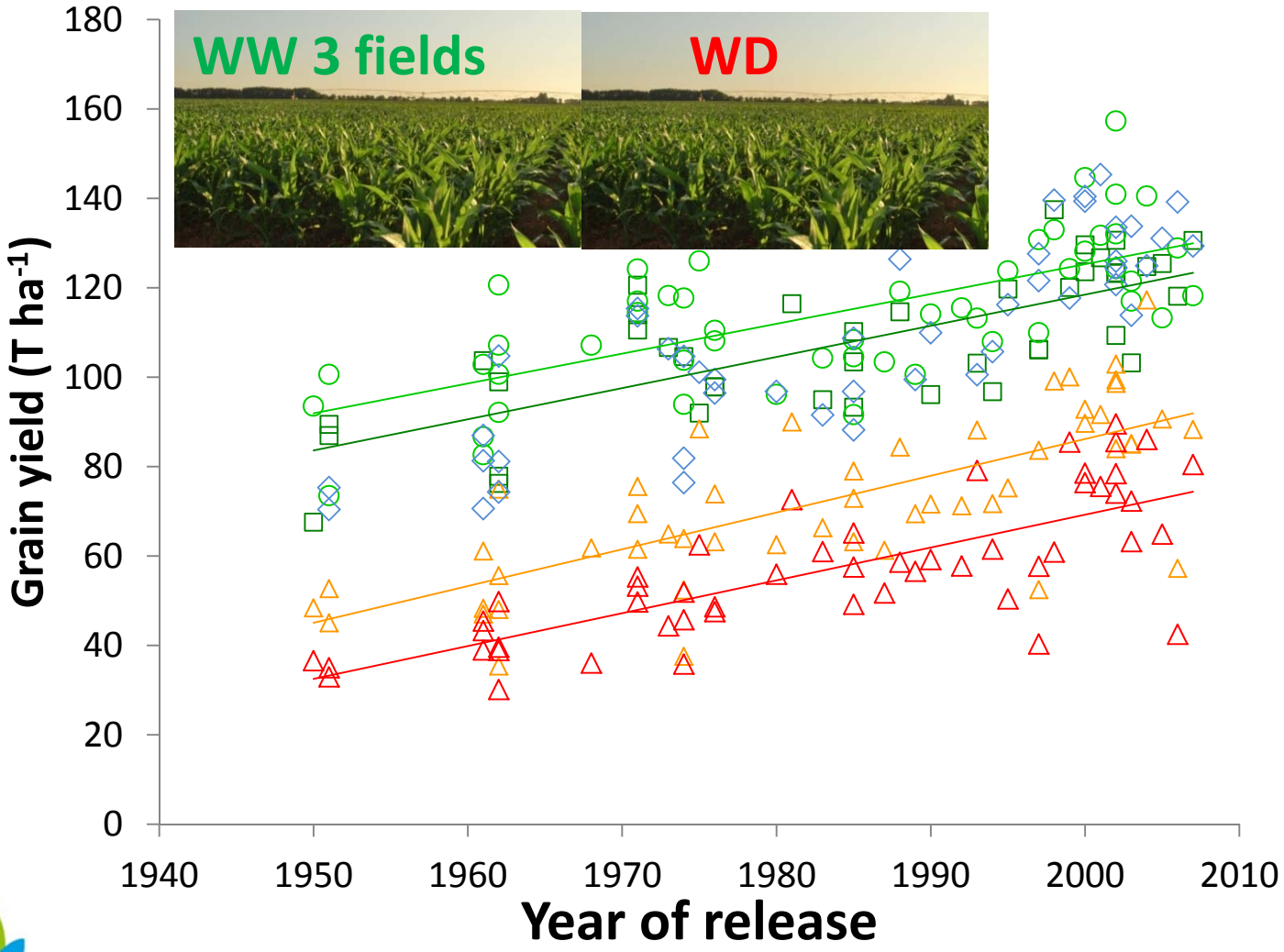
A continuous genetic progress challenged by climate change

Maize : 80 Kg ha^{-1} year^{-1} in a European series,

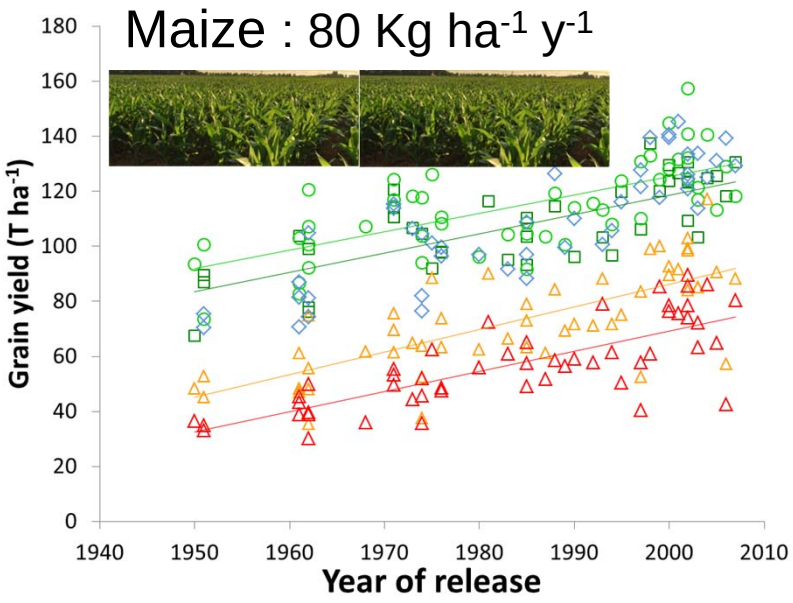


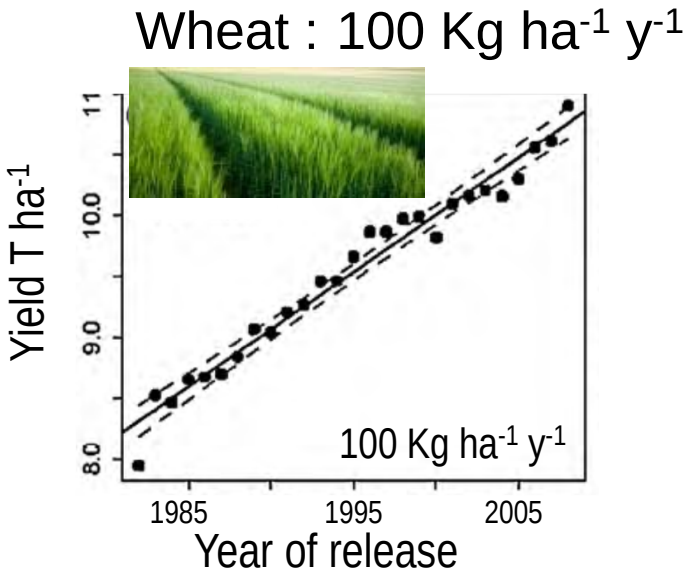
A continuous genetic progress challenged by climate change

Maize : 80 Kg ha^{-1} year^{-1} in a European series,
same progress in water deficit



A continuous genetic progress challenged by climate change





- Breeders have done their job…

- Crop models deal with ‘maize’ or ‘wheat’ not genotypes
  Not the same plants in 2050 !

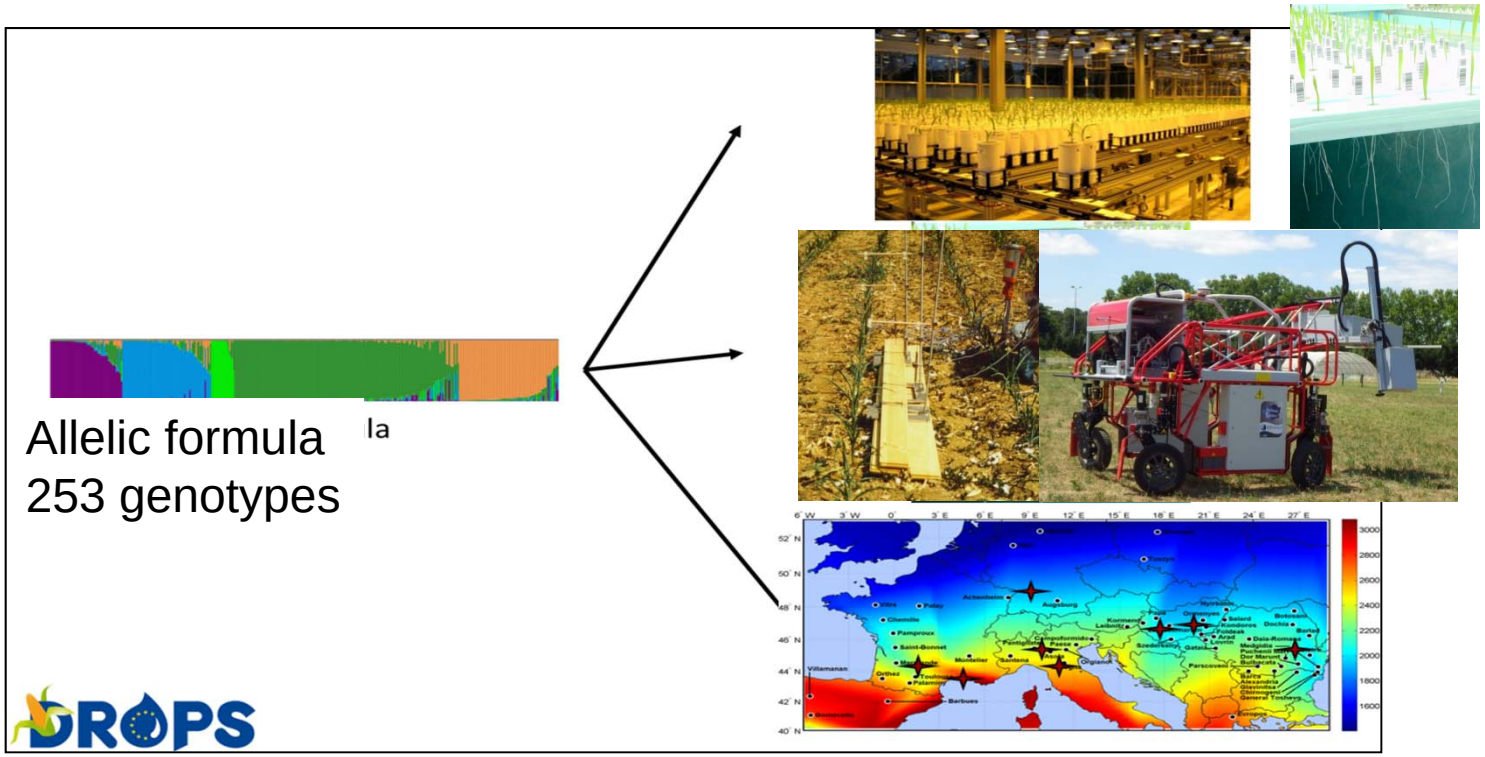
- We want progress to continue

Approach

Allelic formula a
253 genotypes

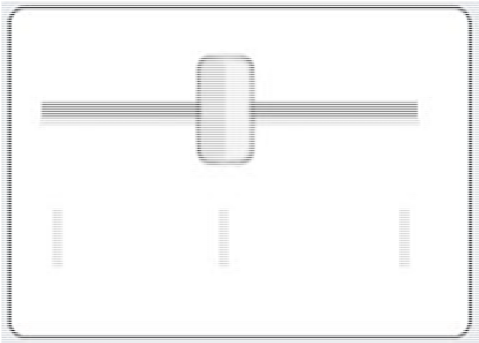
- **Explore genetic resources**

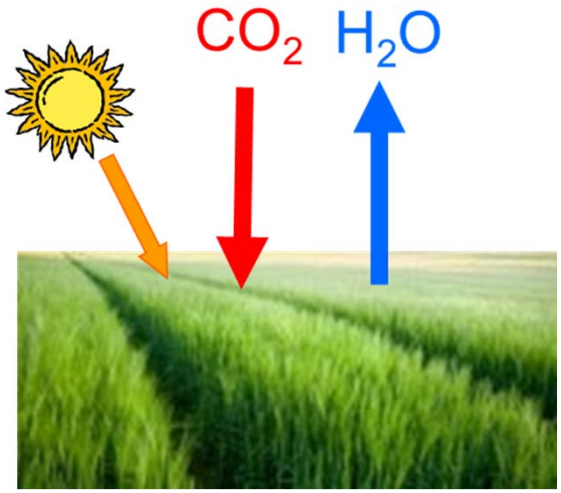
Approach



- **Explore genetic resources**
- **Identify genomic regions that control traits and performances in a variability of climates** ***100s genotypes (throughput)***

Breeding for optimisation, not for resistance to stress





Optimisation between traits (alleles) of tolérance
traits (alleles) for productivity

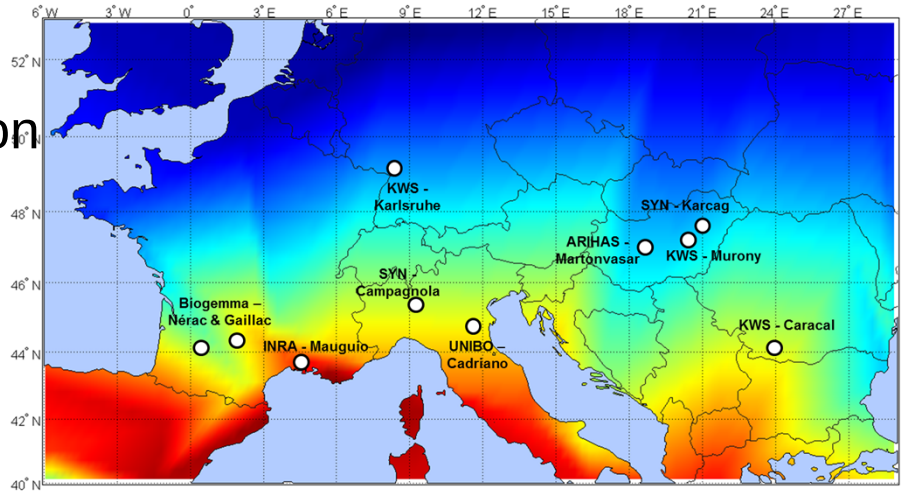
- **Explore genetic resources**
- **Identify genomic regions that control traits and performances in a variability of climates** ***100s genotypes (throughput)***
- **Where and when alleles are favorable ?**

measure environmental conditions (sensors), many sites x years (throughput)

CLIMATE-SMART Agriculture 2015

A large genetic variability of yield, difficult to interpret

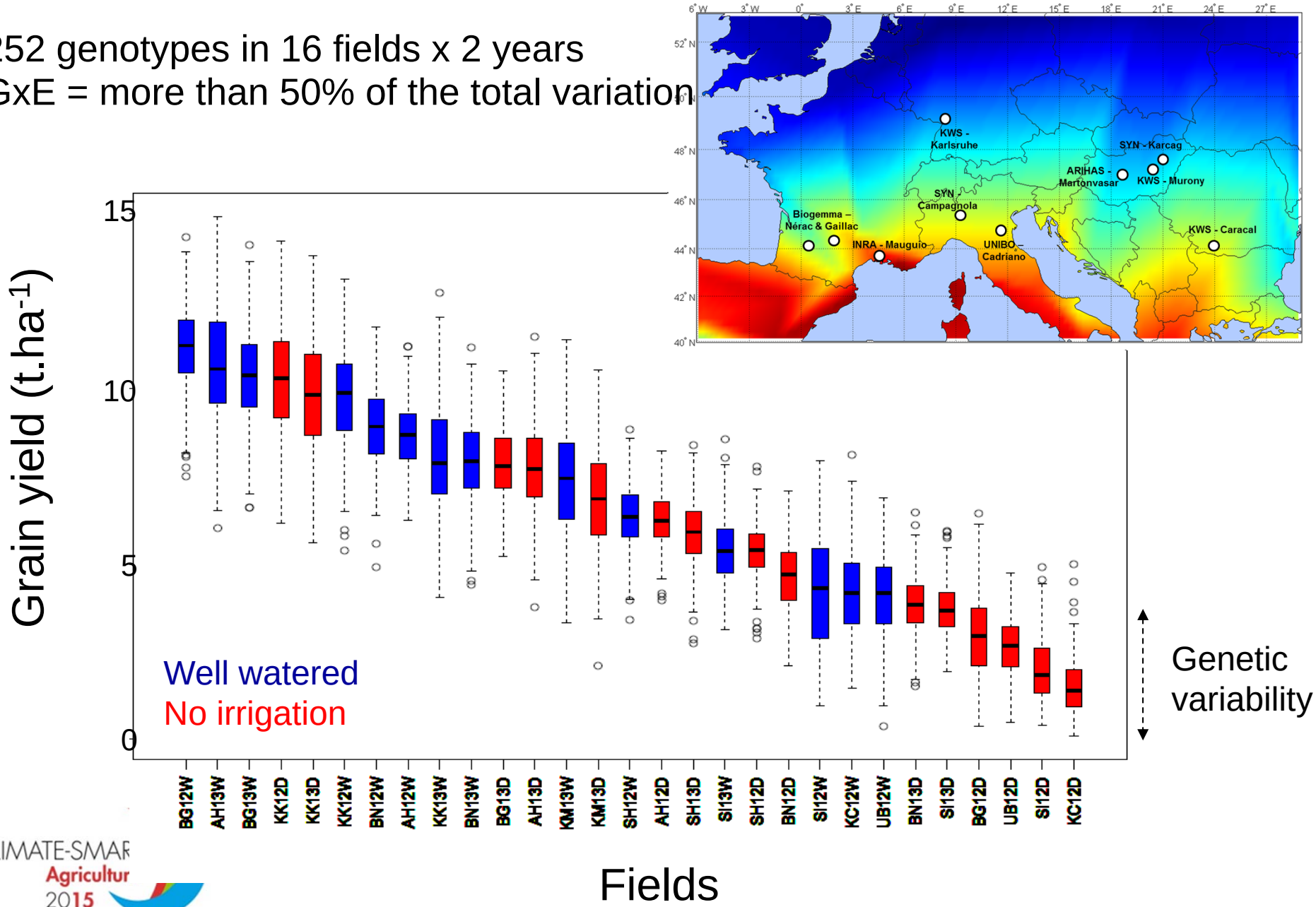
253 genotypes in 16 fields x 2 years
GxE = more than 50% of the total variation



CLIMATE-SMART Agriculture 2015

A large genetic variability of yield, difficult to interpret

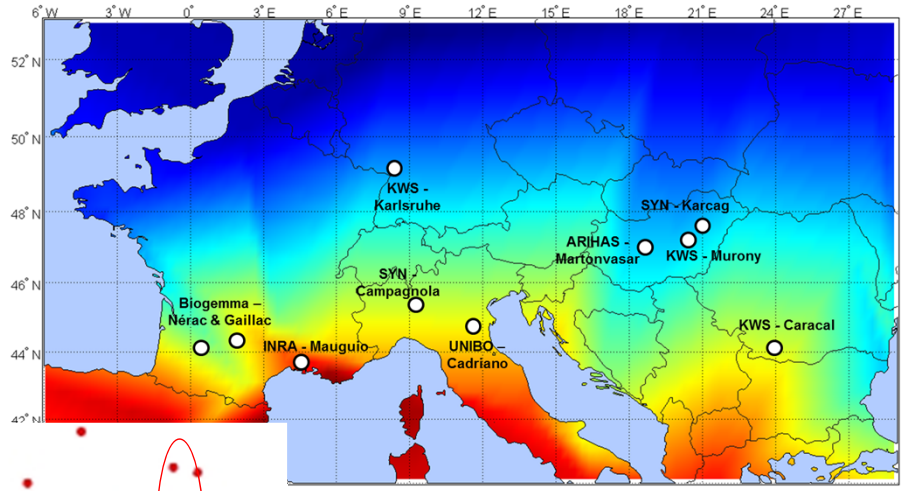
252 genotypes in 16 fields x 2 years
GxE = more than 50% of the total variation

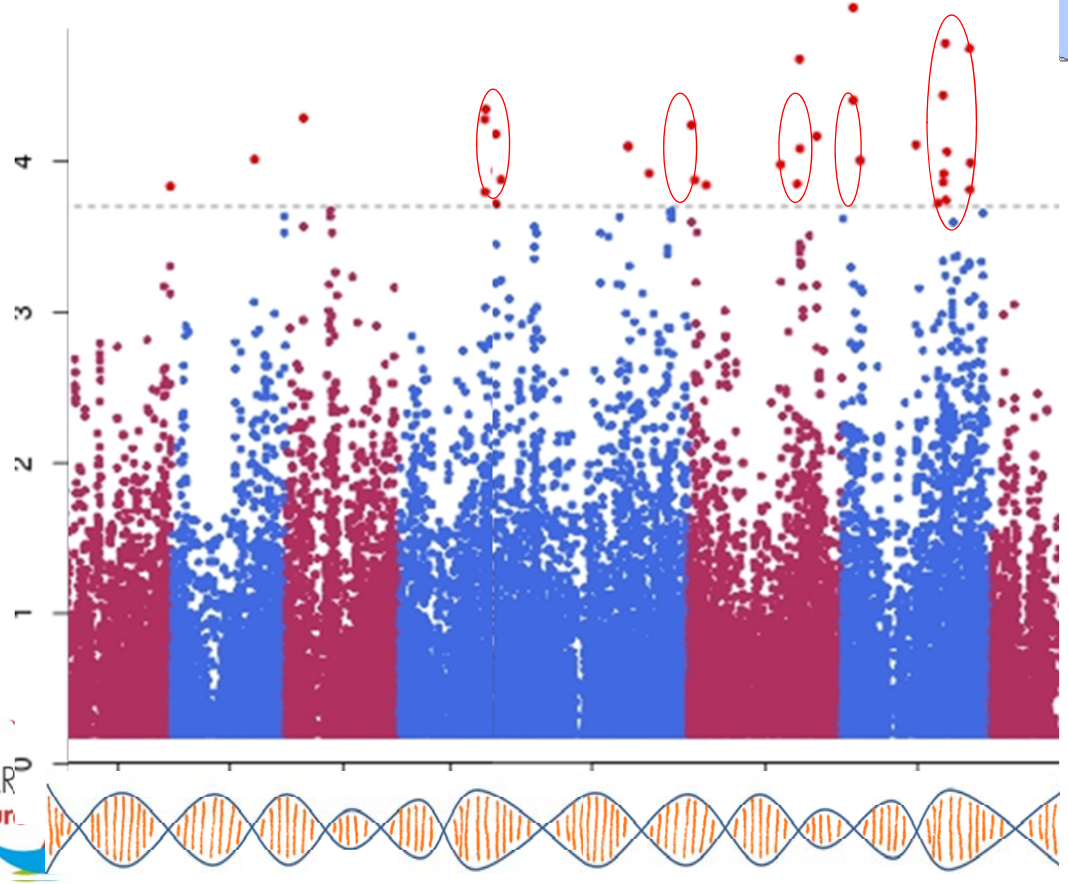


CLIMATE-SMART Agriculture 2015

A large genetic variability of yield, difficult to interpret

Some genomic regions control yield
BUT highly unstable between fields





W. Kruijer & S. Negro
WUR INRA
Biometris Moulon

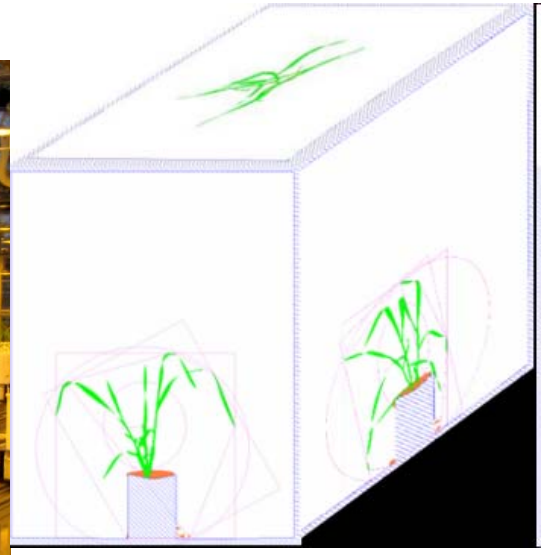
CLIMATE-SMART Agriculture 2015

Disentangling the genetic varaibility

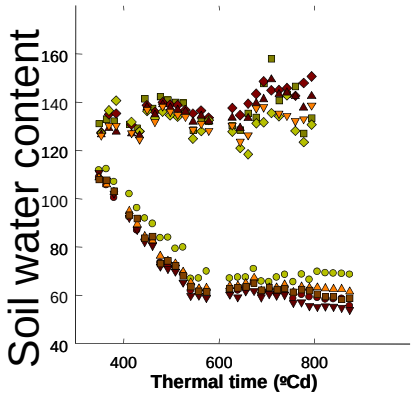
Disentangling the genetic varaibility

PhenoArch

http://bioweb.supagro.inra.fr/PhenoArch/



1650 plants

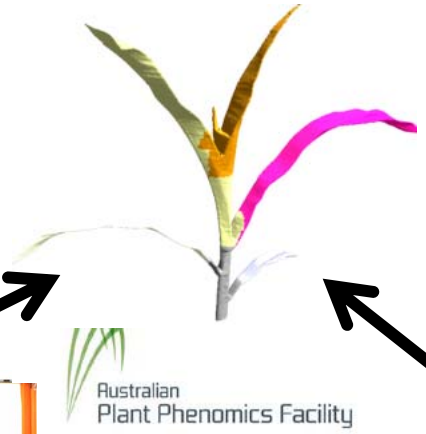


Disentangling the genetic varaibility

PhenoArch

http://bioweb.supagro.inra.fr/PhenoArch/

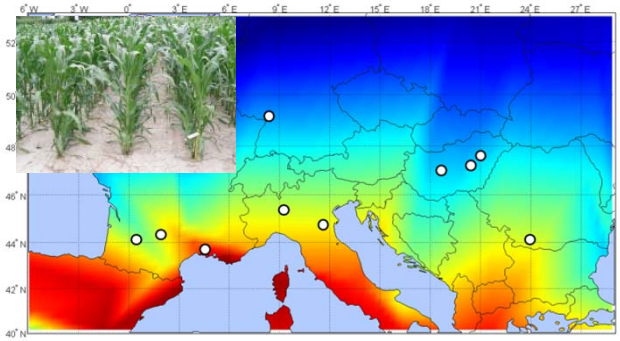
3D imaging



Model

Ll Cabrera C. Fournier

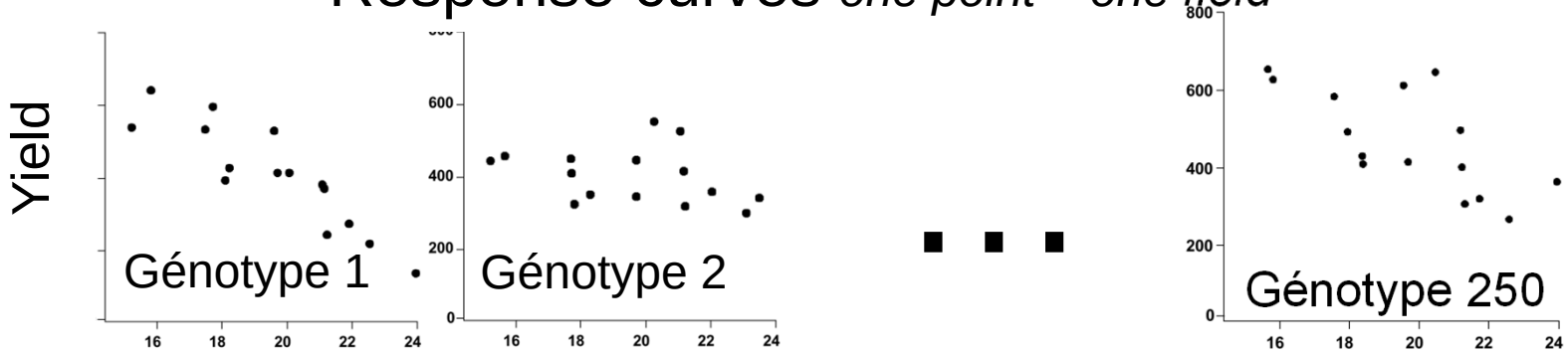
Disentangling the genetic varaibility



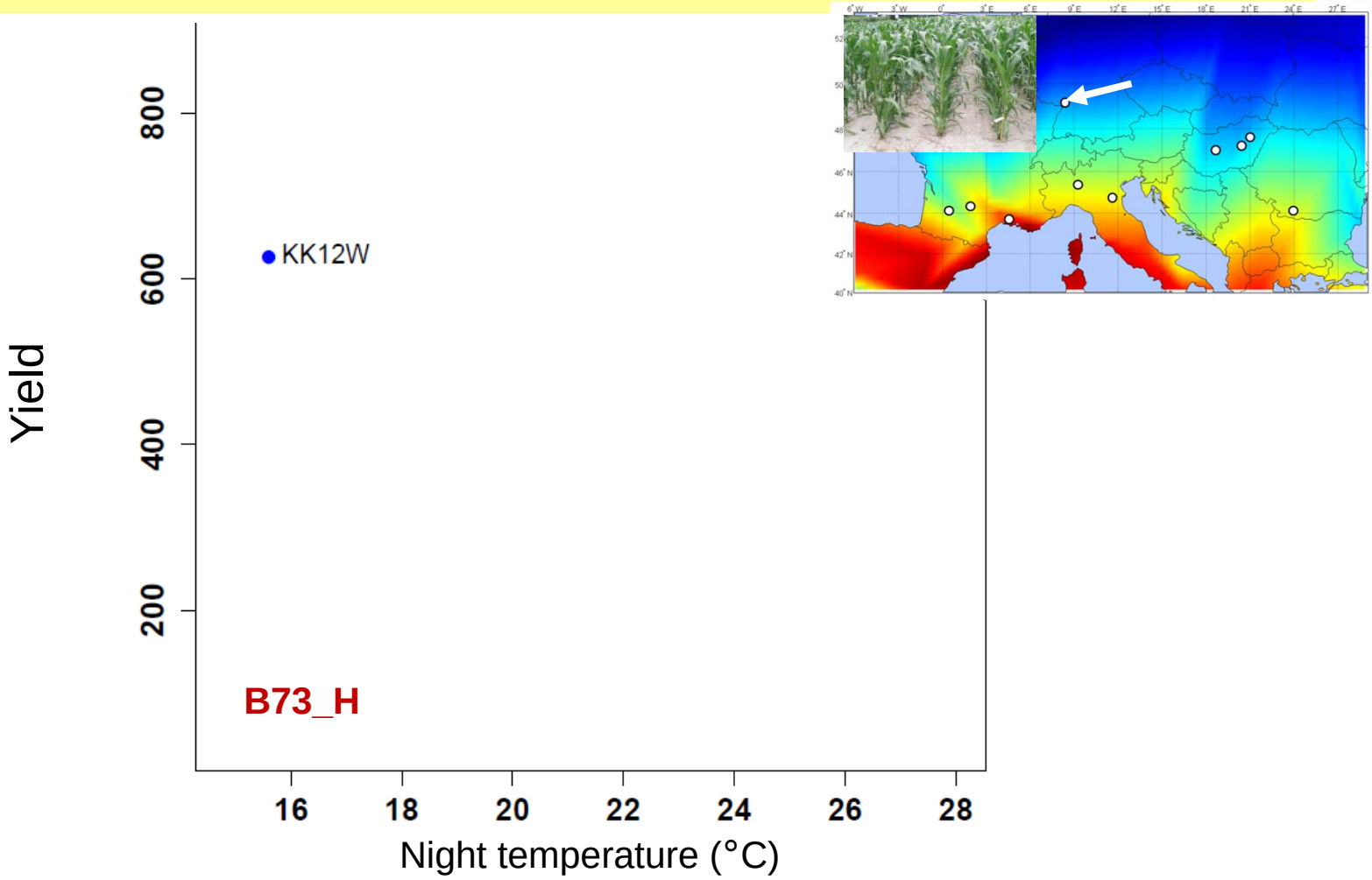
Climate and grain number

Precise development
250 genotypes

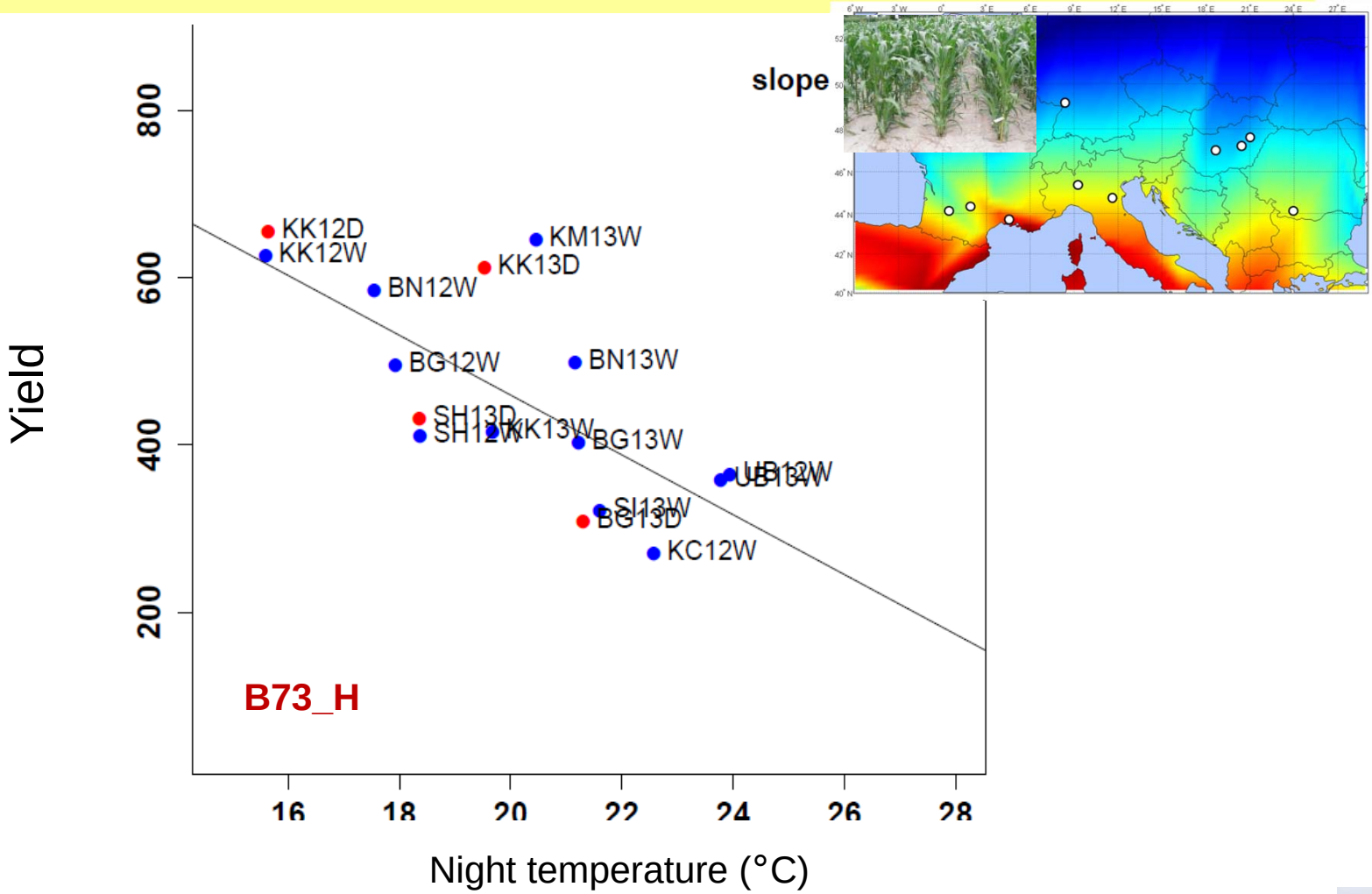
Response curves *one point = one field*



Disentangling the genetic varaibility



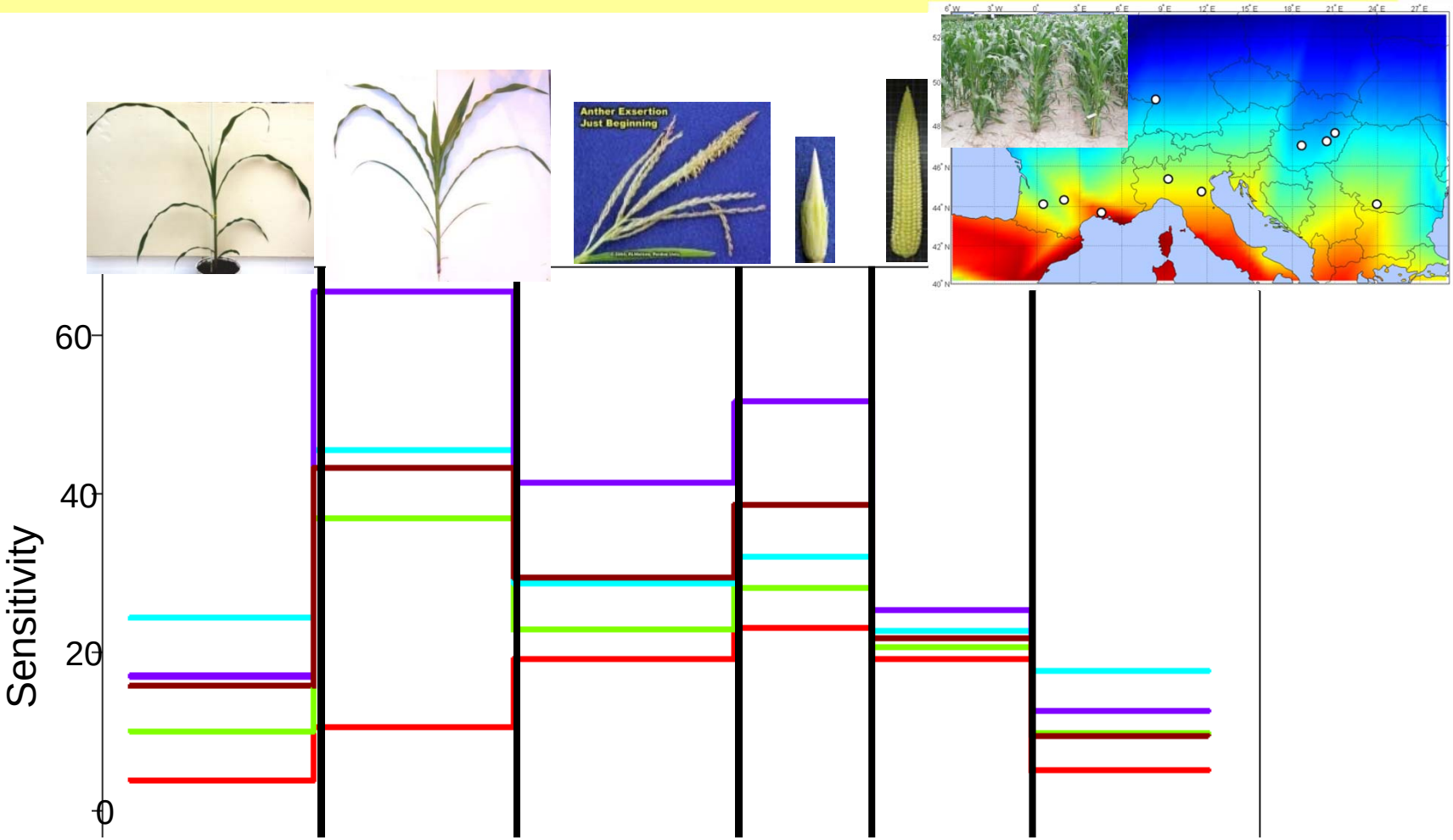
Disentangling the genetic varaibility



➔ 50% of yield varies with night temperature around flowering

E. Millet

Disentangling the genetic varaibility



Sensitivity to temperature -changes with plant stages
- varies between genotypes
(reproducible)

E. Millet

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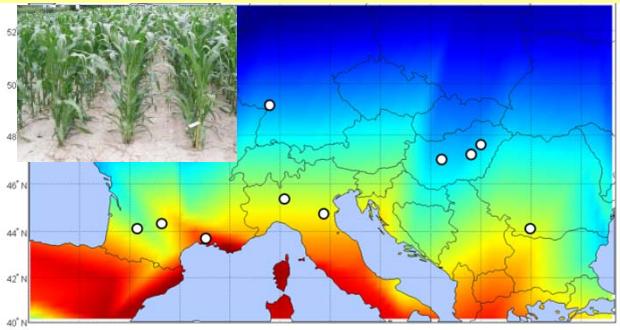
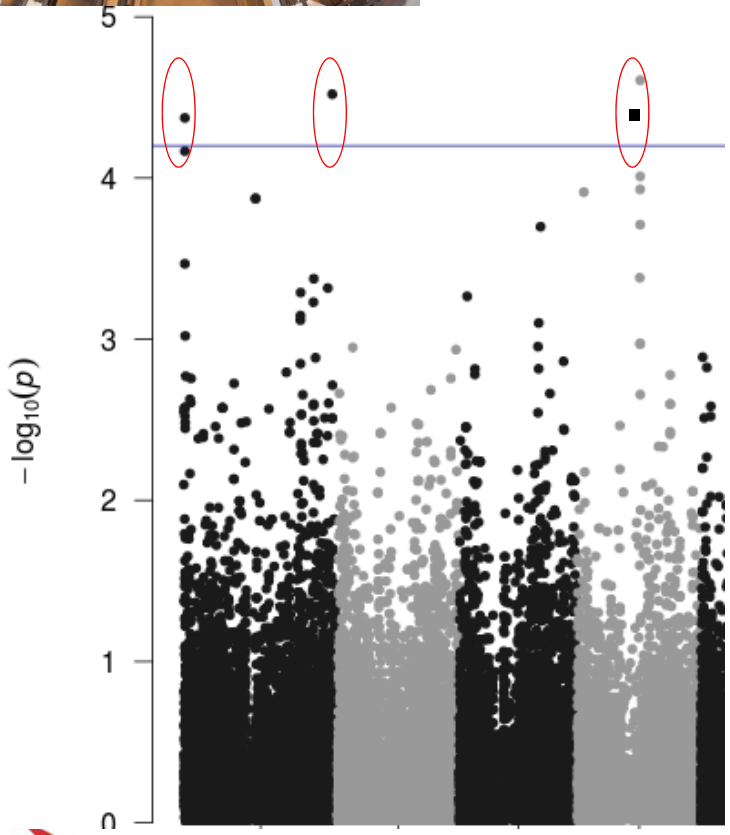
Disentangling the genetic varaibility





A large genetic variability of sensitivity, usable for breeding :

Genomic regions associated with sensitivity to temperature

in the field

But using a phenotyping platform

E. Millet

Disentangling the genetic varability : water deficit

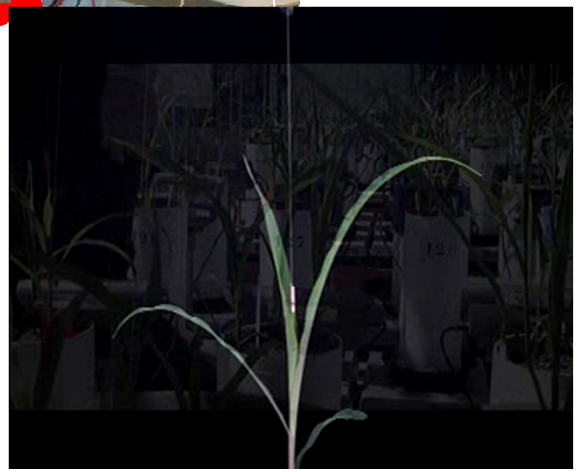
PHENODYN

http://bioweb.supagro.inra.fr/phenodyn/

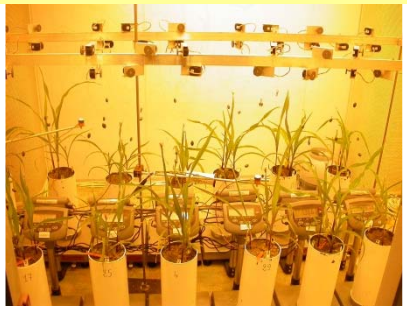
Environment

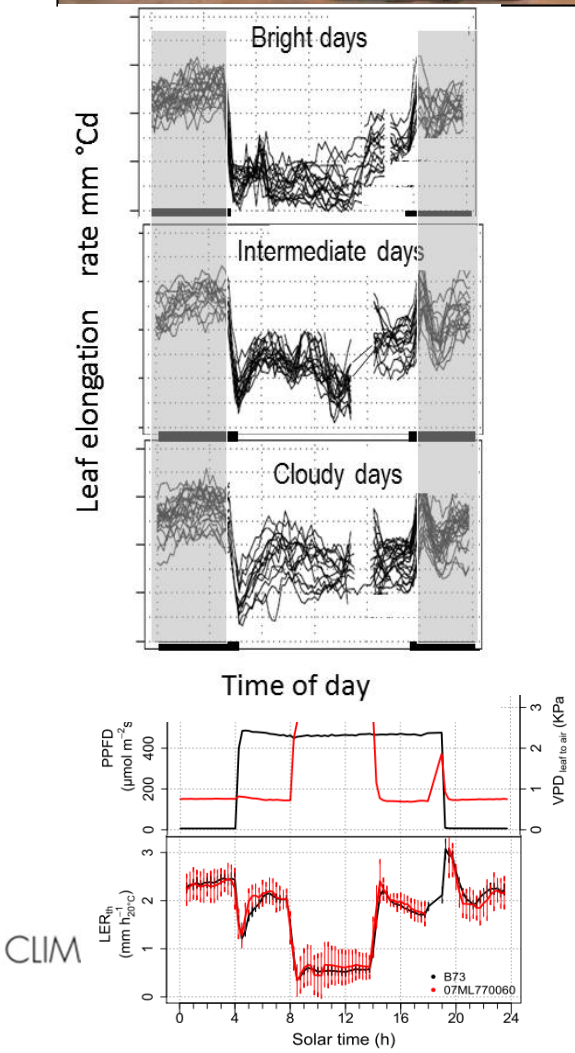
Transpiration

growth



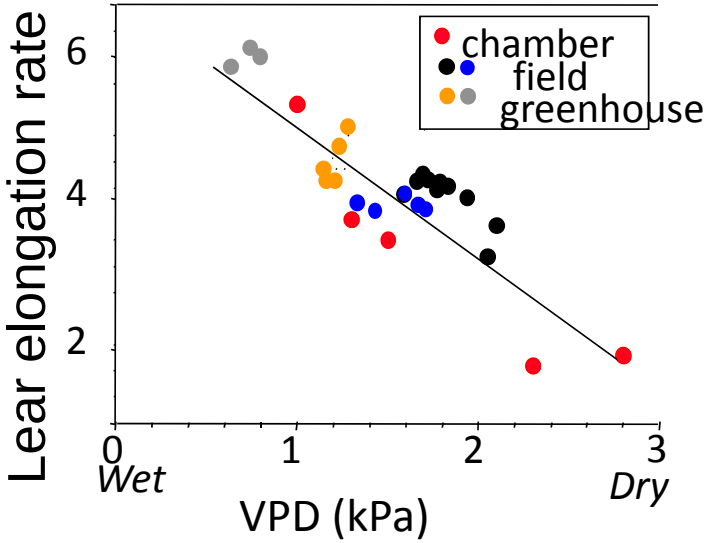
Disentangling the genetic varability : water deficit



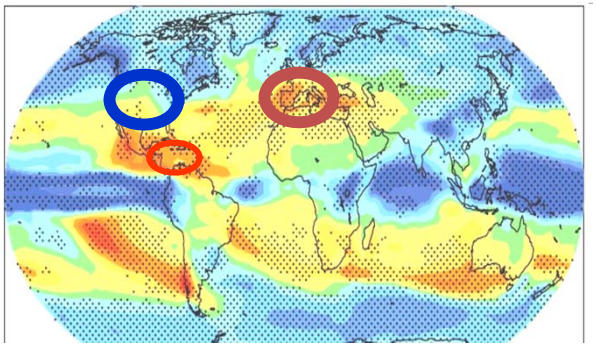


Response to water deficit

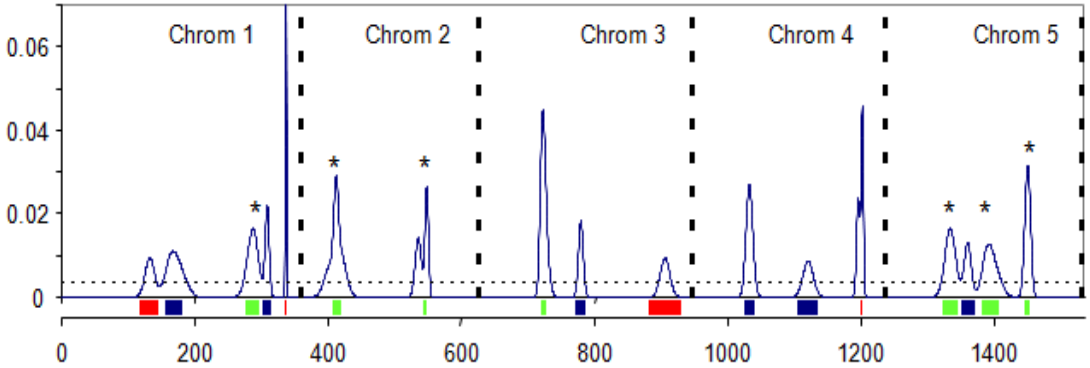
Stable between experiments

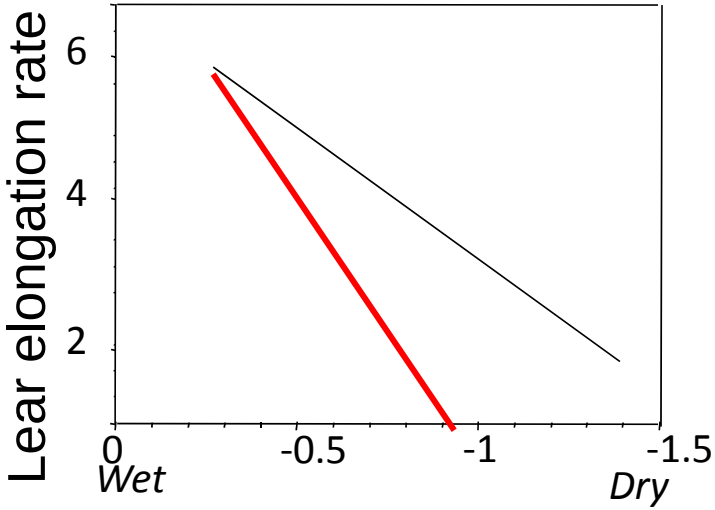


Disentangling the genetic varability : water deficit



Mapping sensitivity on the maize genome
(3 mapping populations)

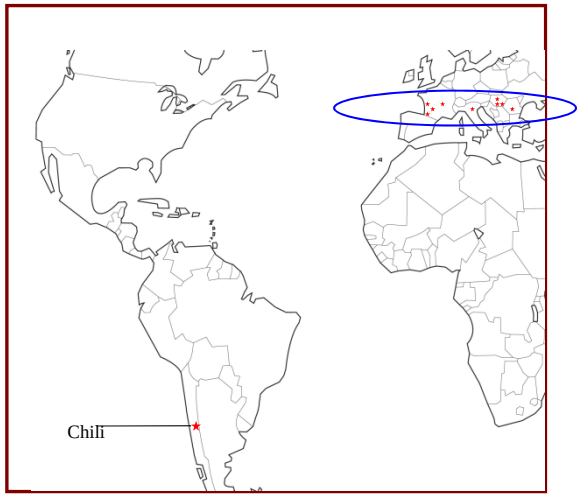


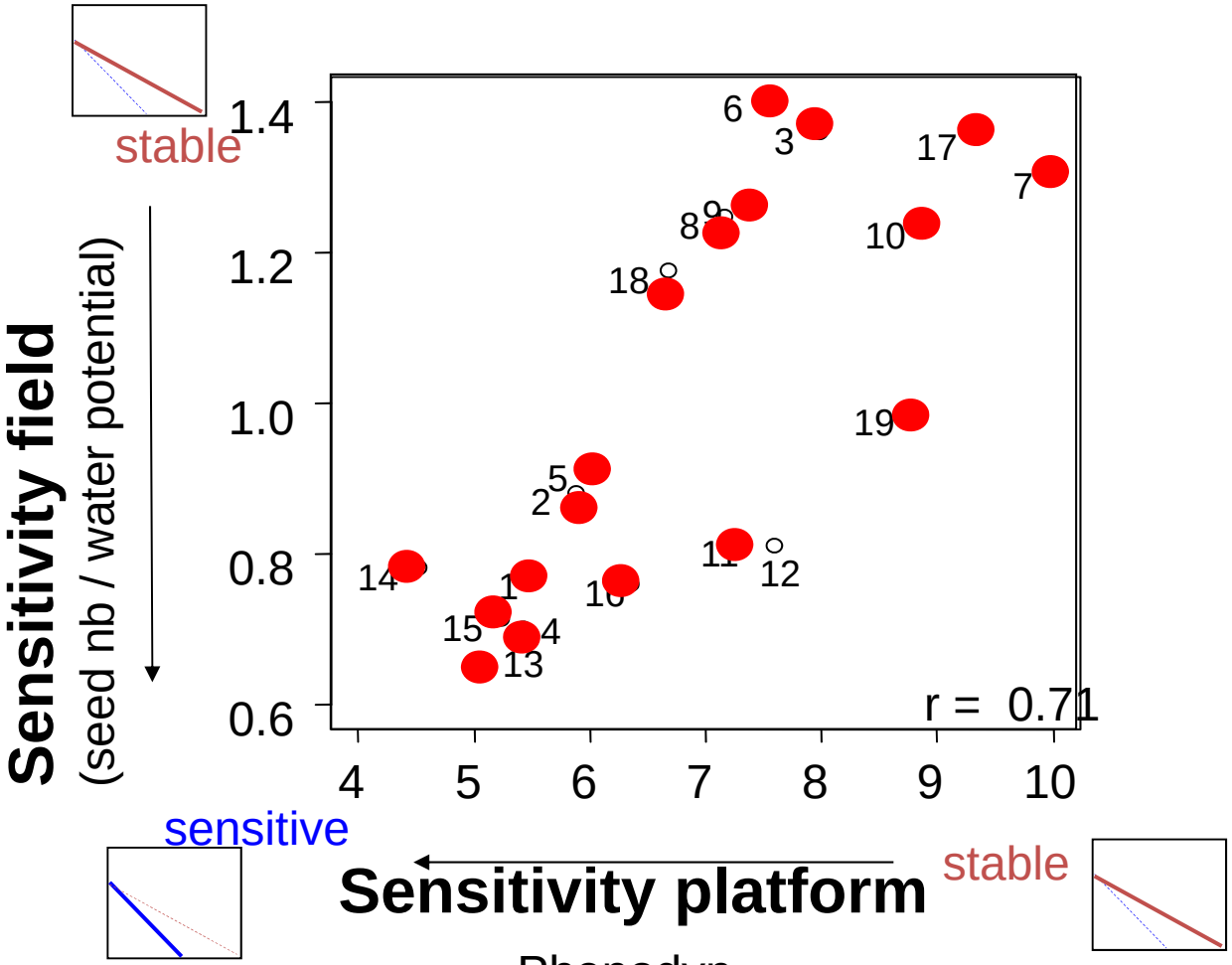


C: Welcker

Welcker et al. 2011 Plant Phy

Sensitivity to water deficit in field and platforms





C: Welcker

Welcker et al. 2011 Plant Phy
Chapuis et al 2012 EJA

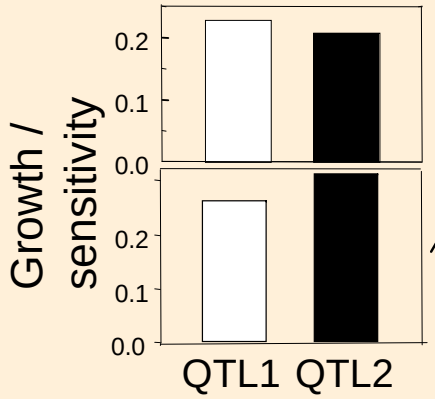
Phenodyn

Yield simulation from QTLs identified in platforms :

Environment

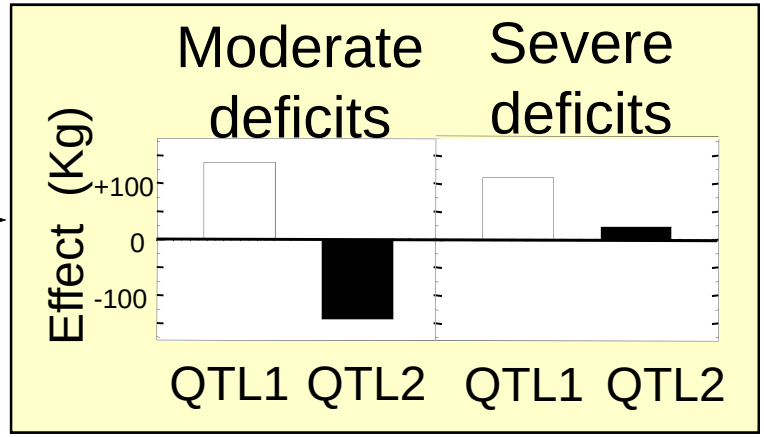
Allelic info

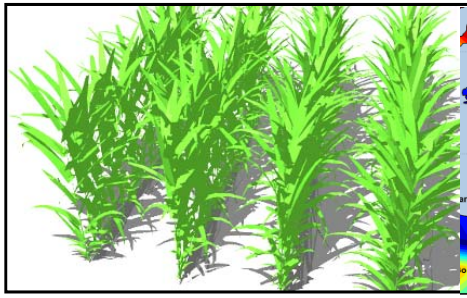
QTL effects

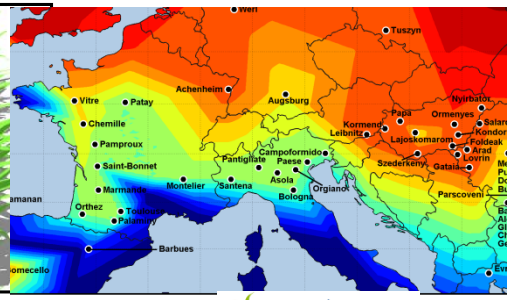


Model :
Leaf area
Biomass
Transpiration
Yield

Plant performances: 100s simulations

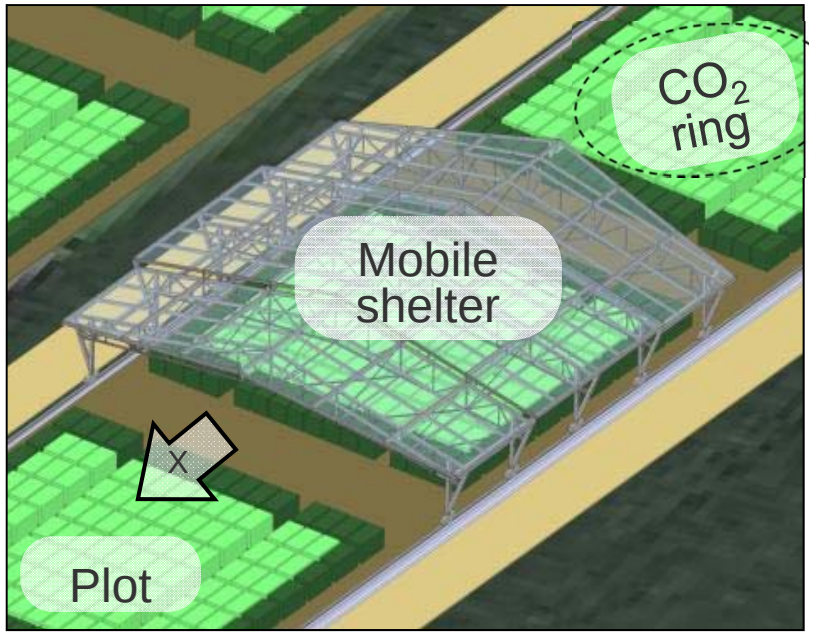






Tardieu and Tuberosa 2010 Current Opinion Plant Biol

Going further with phenotyping



CO2 enrichment (FACE)

INRA Clermont Ferrand

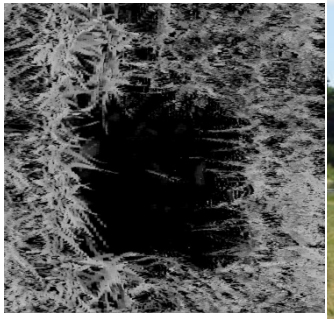
…

Rainout shelters

Ouzouer
PhenoField

CLIM

Going further with phenotyping

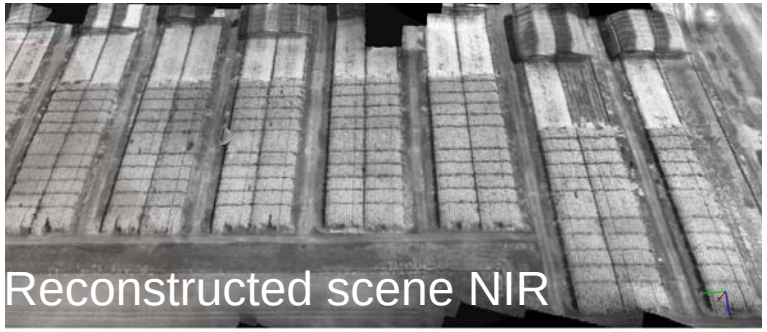


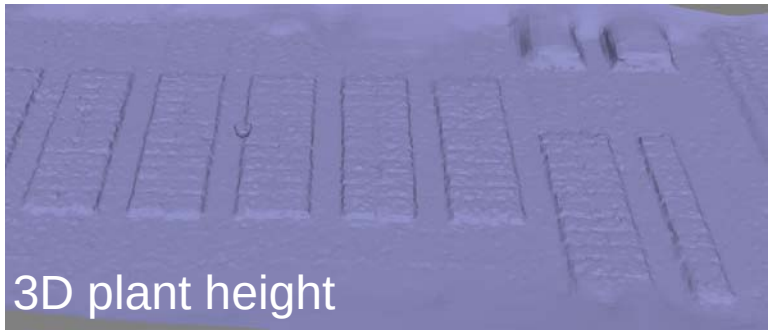
100s genotypes :

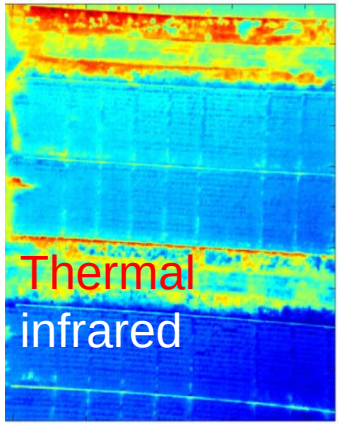
biomass, leaf area, nb spikes, [N],
leaf angles, transpiration…

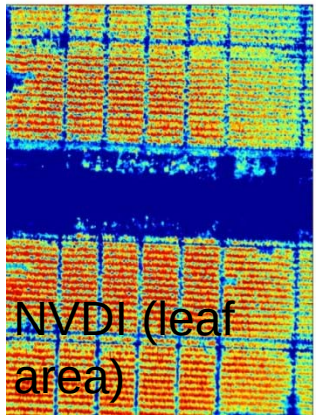
LiDAR, imaging in RGB, NIR, Nbands etc

Going further with phenotyping









Conclusion

Essential to take into account the genetic progress
in models of climate change impacts

A large genetic variability of sensitivities to high temperatures
water deficit

… Progress continues

Combining equipped field experiments and phenotyping platforms is a key for breeding for mitigating the effects of CC