

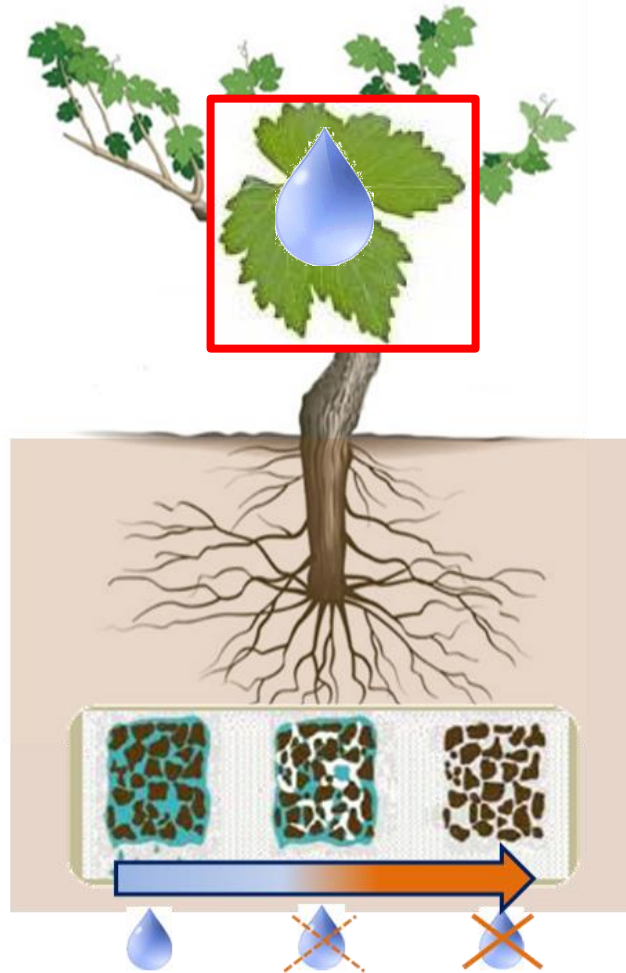
# A combination of phenotyping, genetic and physiological approaches to guide breeding for efficient water use in grapevine

Aude Coupel-Ledru,

A. Doligez, P. Hamard, P. Péchier, A. Christophe, P. This, E. Lebon,  
T. Simonneau



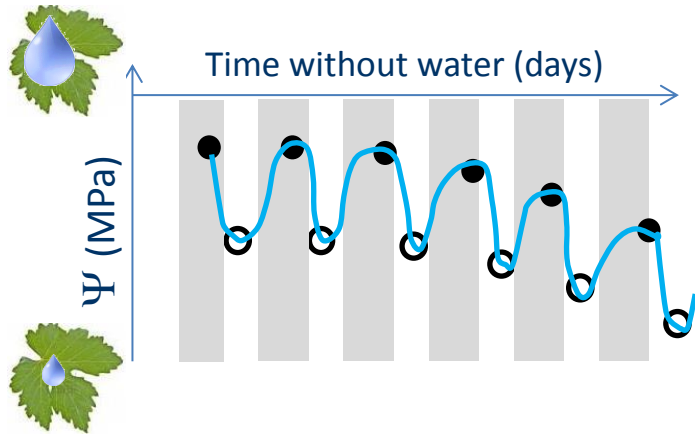
# Determinism of leaf water homeostasis (isohydry)



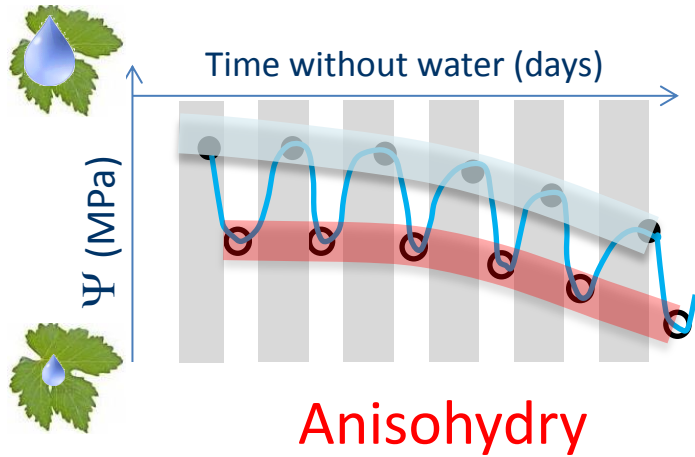
Leaf water potential  
 $\Psi$

# (An)isohydry, what, why ?

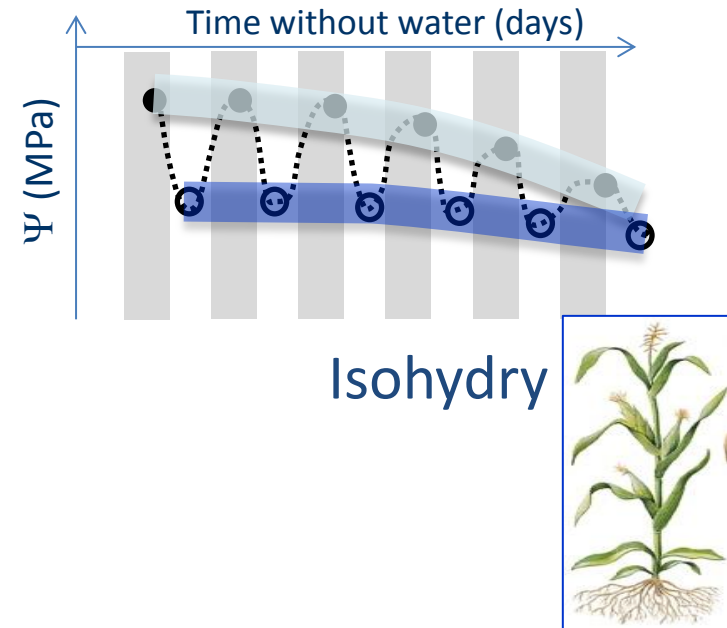
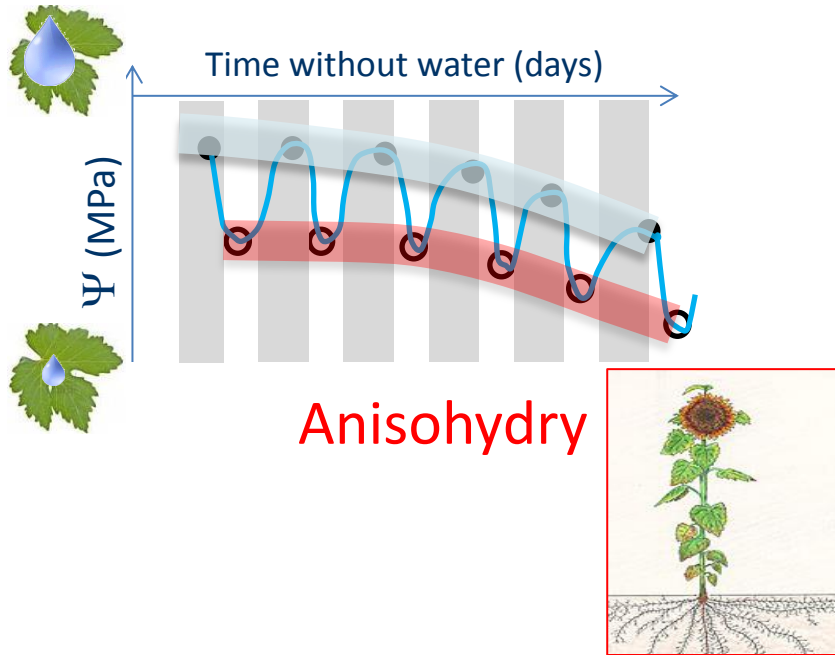
- Leaf water status fluctuates with evaporative demand and soil drying



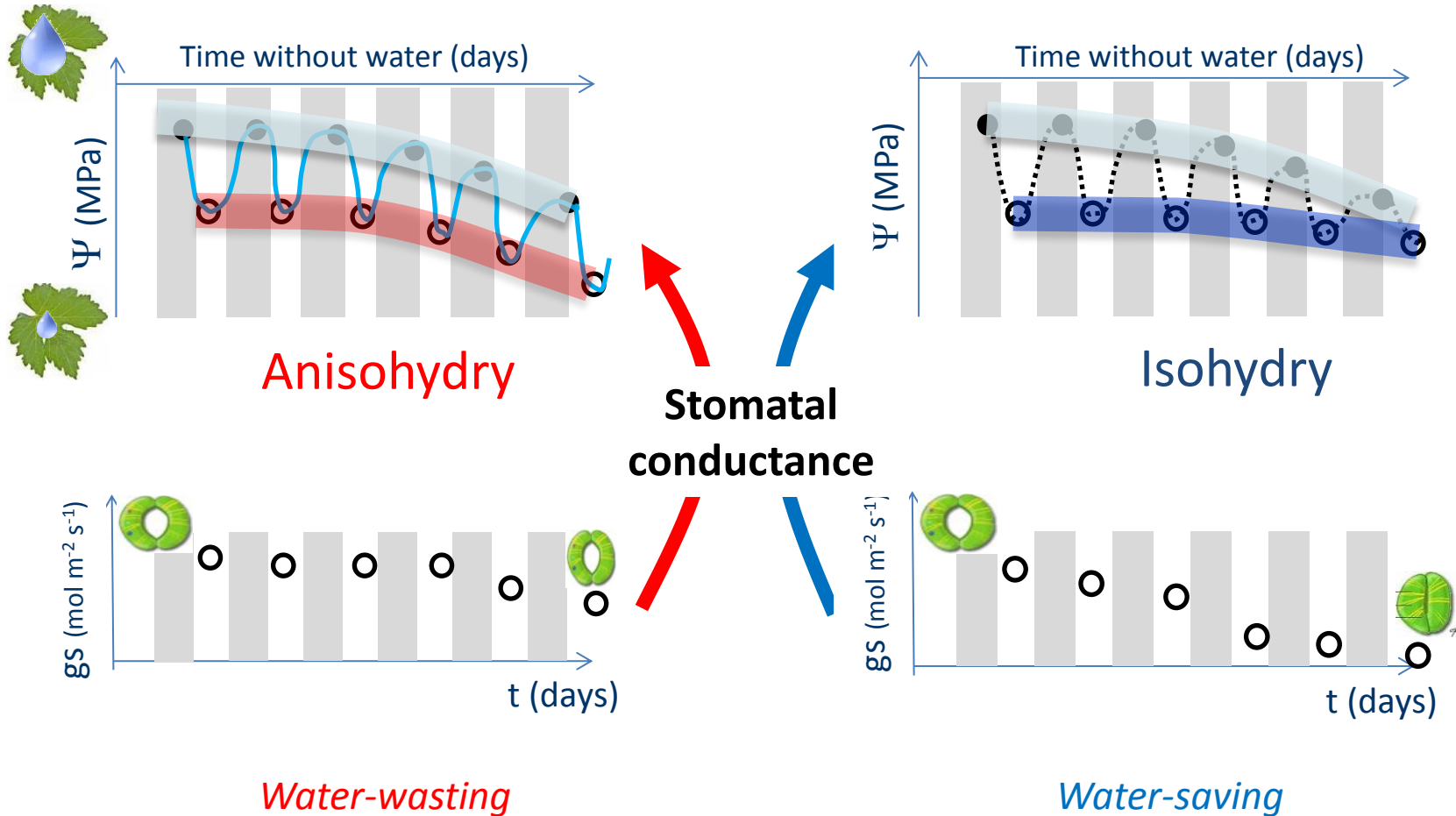
- Leaf water status fluctuates with evaporative demand and soil drying



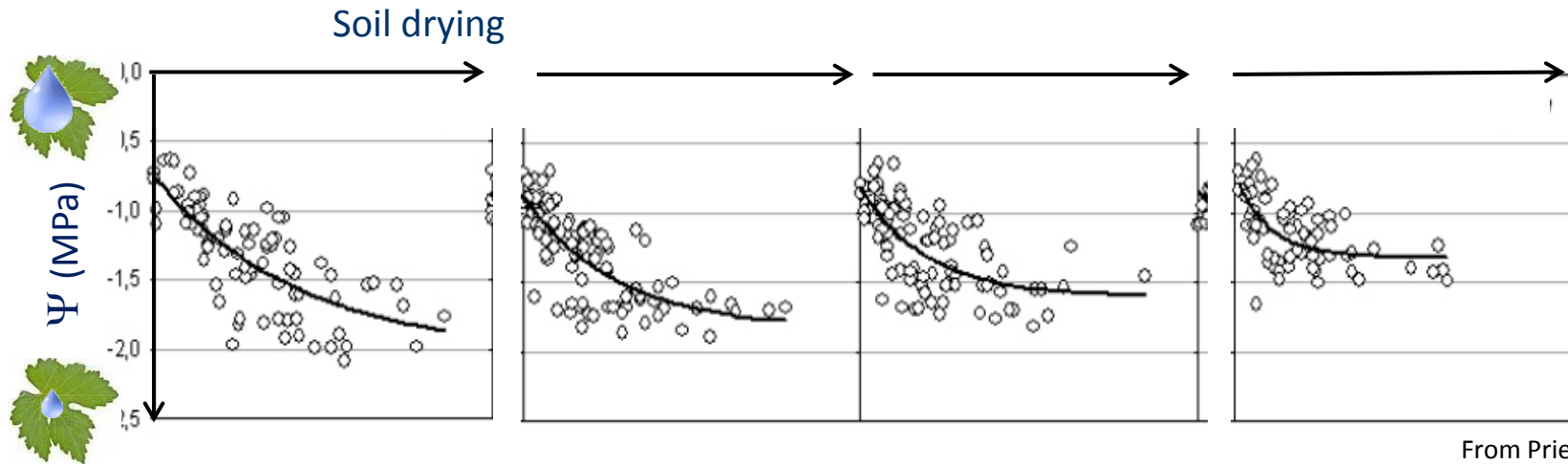
➤ Leaf water status : contrasted responses to drought across species

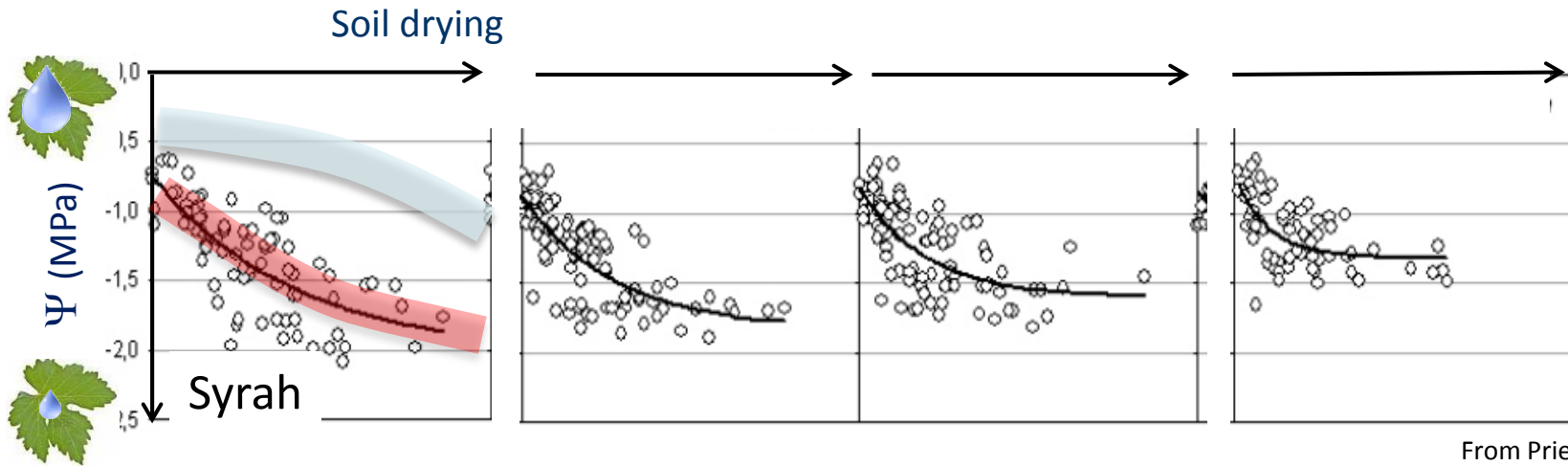


➤ Leaf water status : a major role for stomata



# (An)isohydry in grapevine





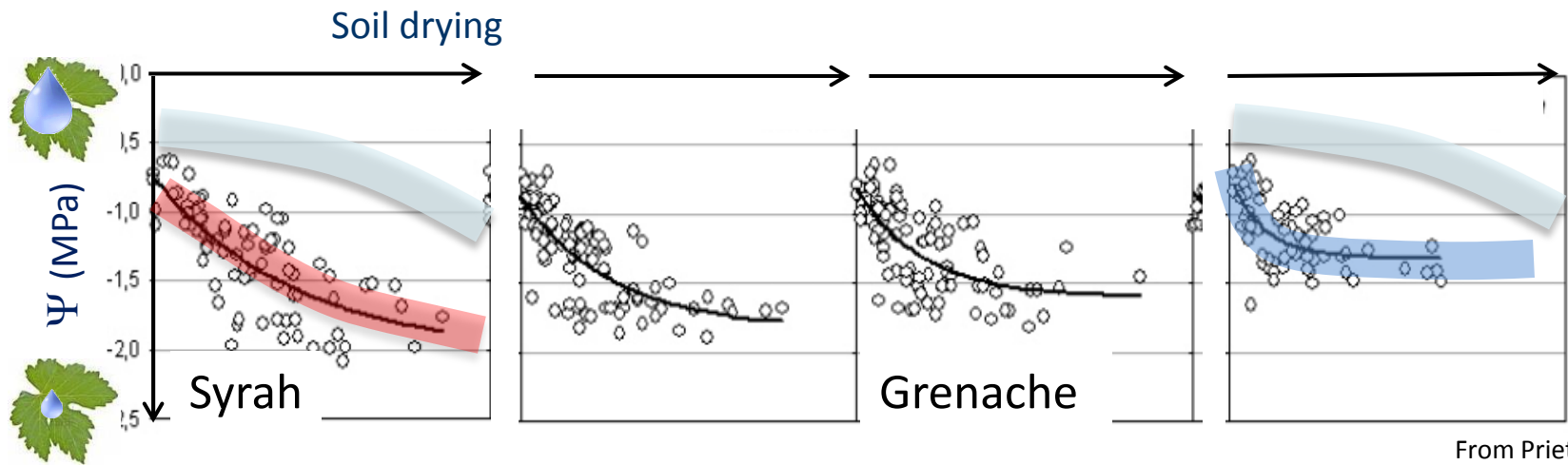
Anisohydric





Anisohydric

Isohydric



Anisohydric

Isohydric



# Plant Material

Mapping population

Syrah X Grenache

F1: 188 genotypes

➤ Vineyard

2 years of measurements

BUT difficulty to characterize water relations



## Mapping population

Syrah X Grenache  
F1: 188 genotypes



➤ Greenhouse (PhenoArch platform)



# Phenotyping water relations

Mapping population

Syrah X Grenache

F1: 188 genotypes

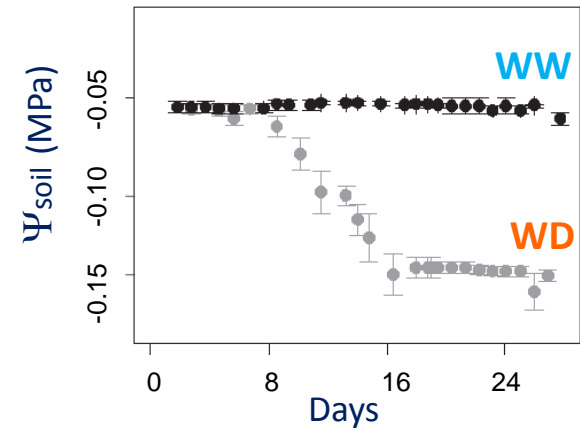
➤ Greenhouse (PhenoArch platform)



Automated watering

➤ 2 water treatments

*High reproducibility*



8 replicates >1500 plants  
2 years of experiments

## Mapping population

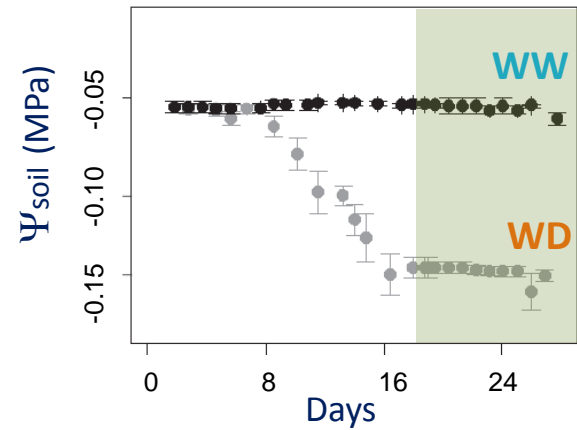
Syrah X Grenache  
F1: 188 genotypes

➤ Greenhouse (PhenoArch platform)



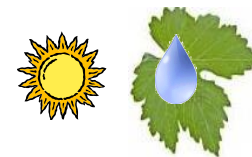
➤ 2 water treatments

*High reproducibility*

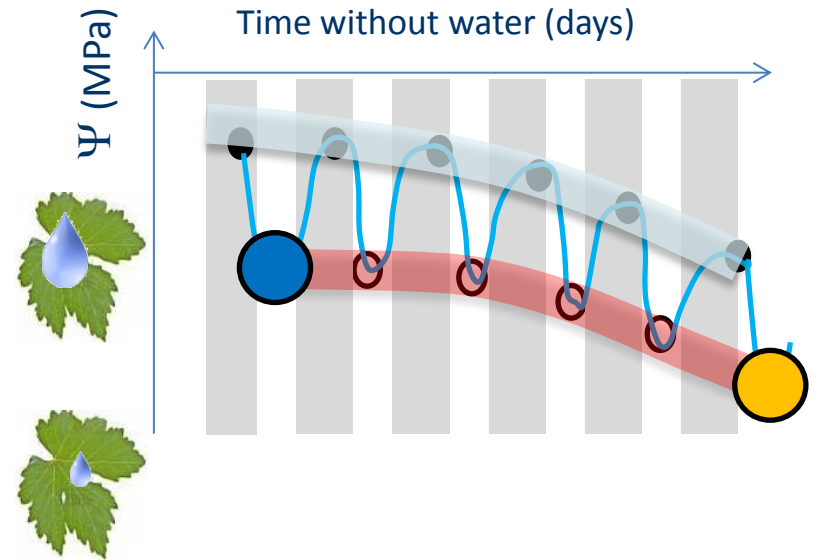
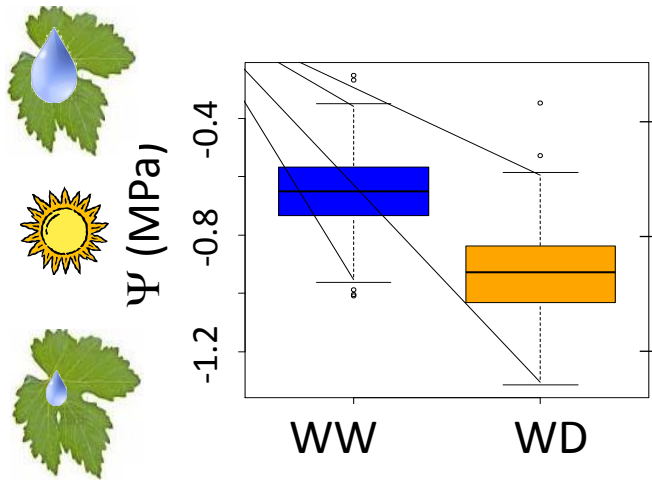


Midday leaf water potential

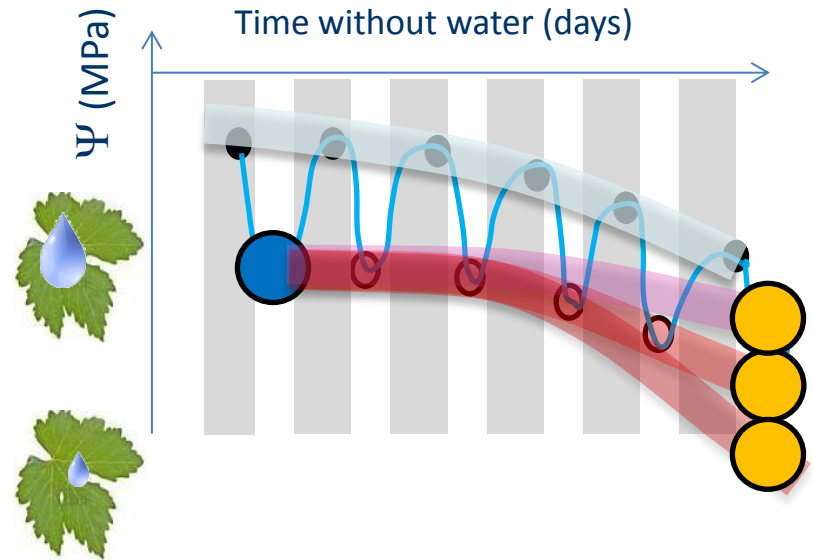
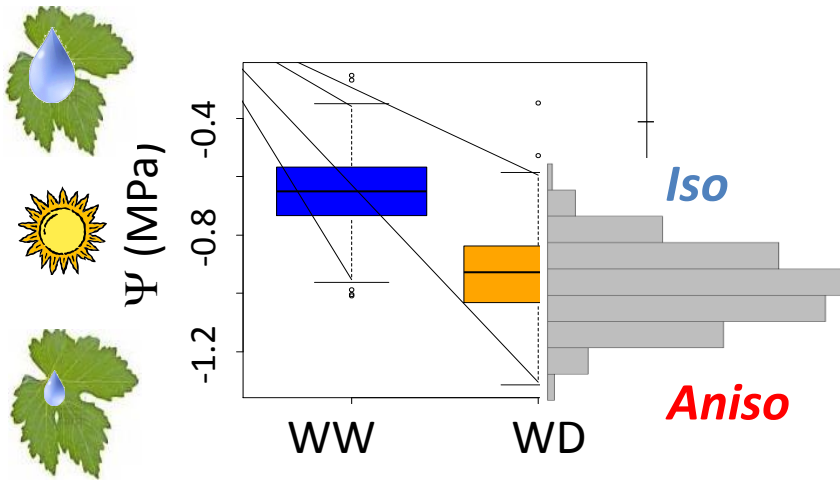
$\Psi_{\text{Midday}}$



➤ Significant impact of WD on  $\Psi_{\text{Midday}}$



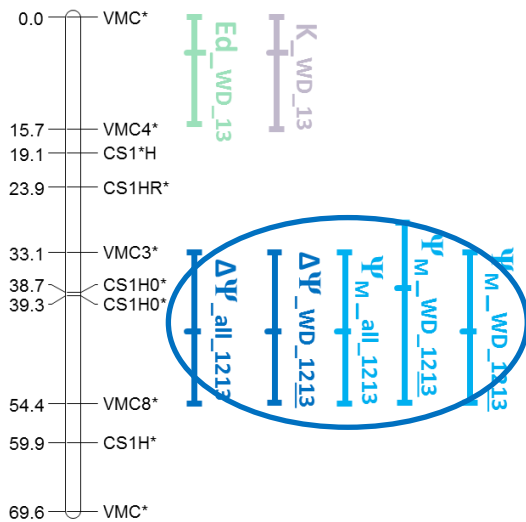
- Significant impact of WD on  $\Psi_{\text{Midday}}$
- With a large genetic variability



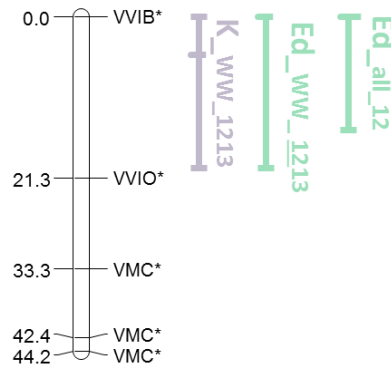


# QTLs detected for the maintenance of leaf water potential under WD

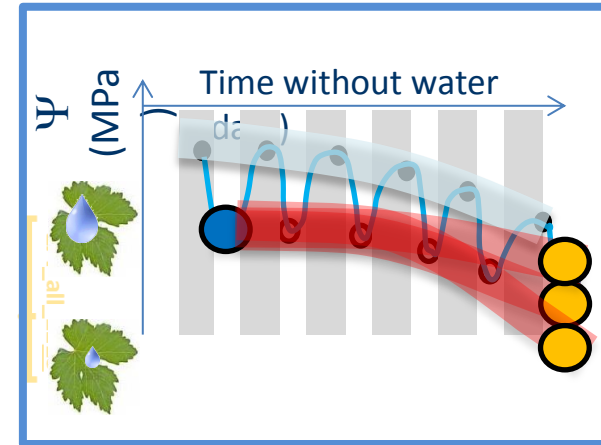
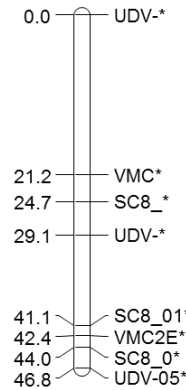
LG 01



LG 02

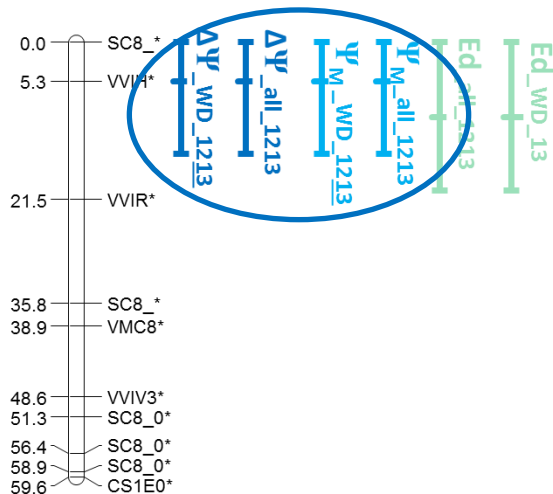


LG 03

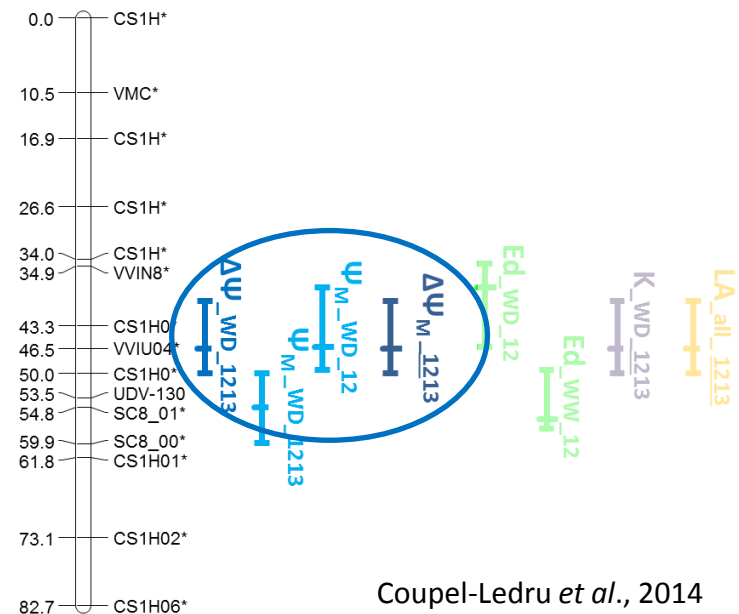
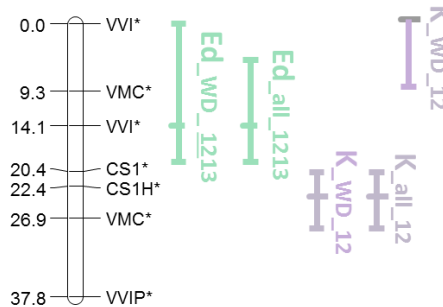


➤ (An)isohydry is genetically controlled

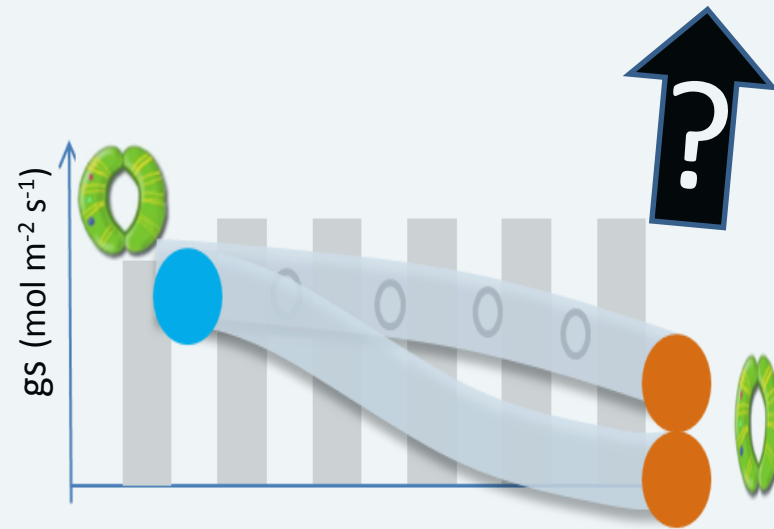
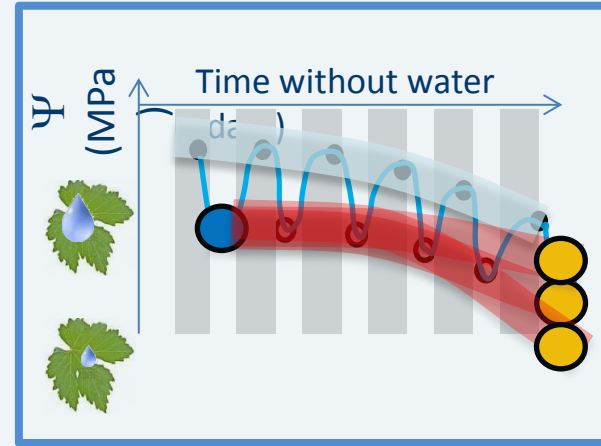
LG 10



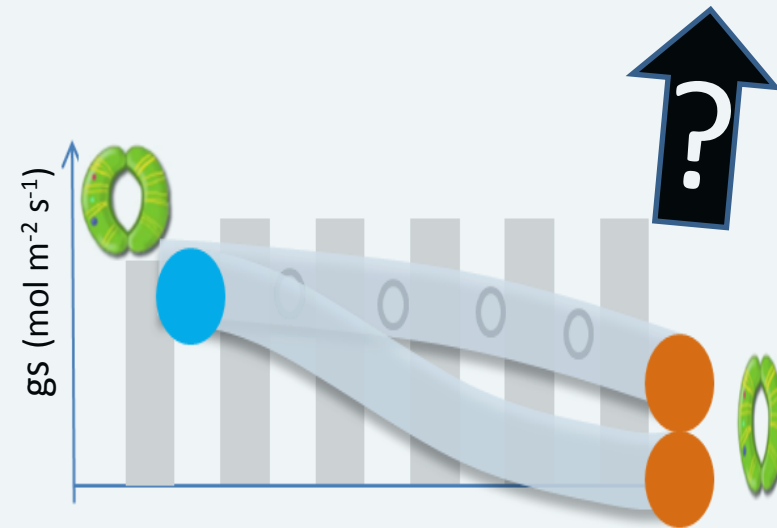
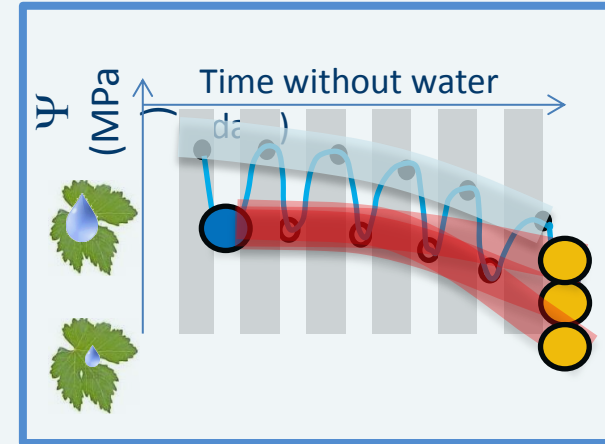
LG 17



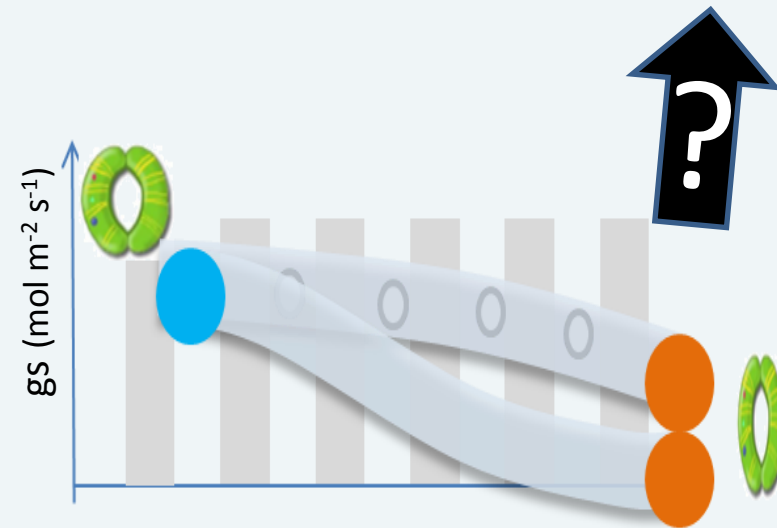
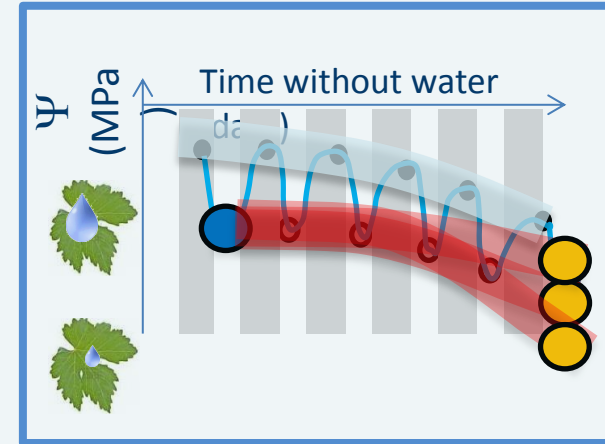
# Which role for stomata?



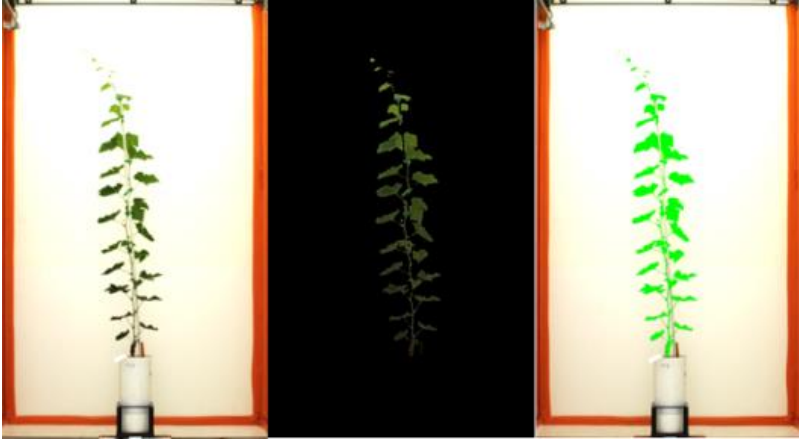
# Transpiration in controlled-environment chamber



# Transpiration in controlled-environment chamber



# Transpiration in controlled-environment chamber

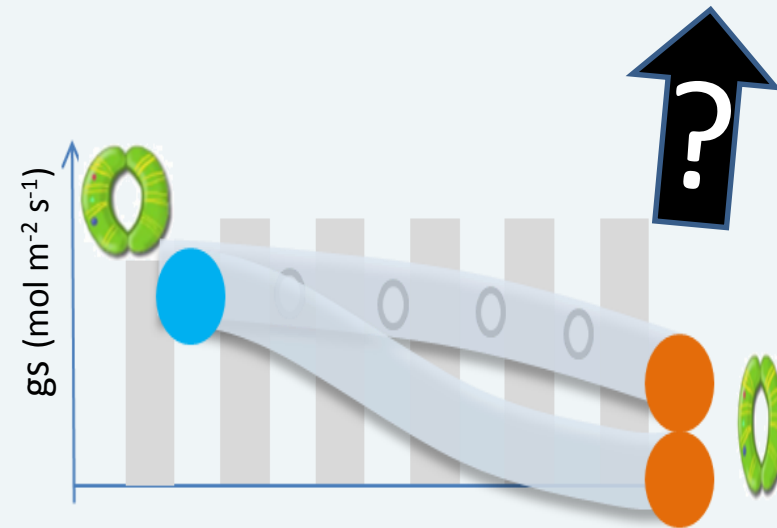
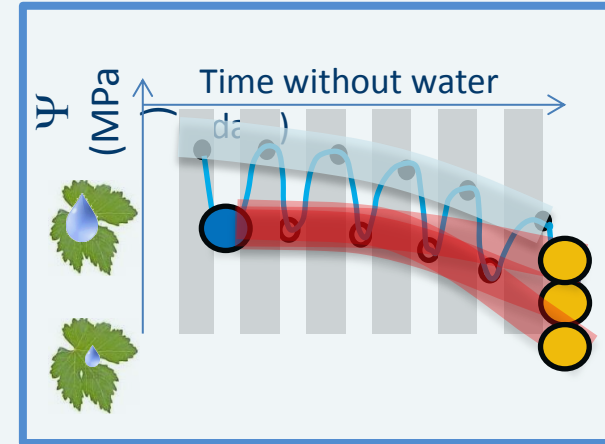


Leaf area estimation

Transpiration rate / Leaf area

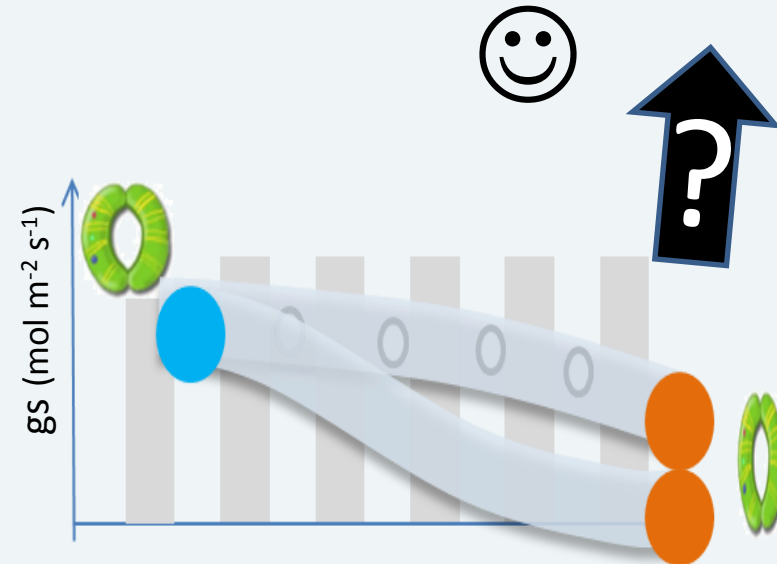
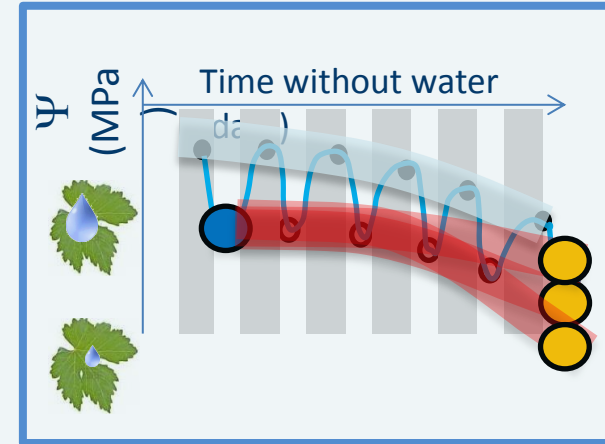
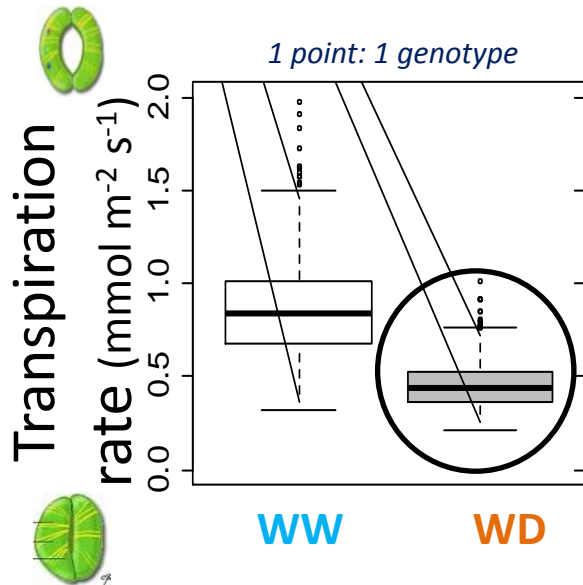


Water losses

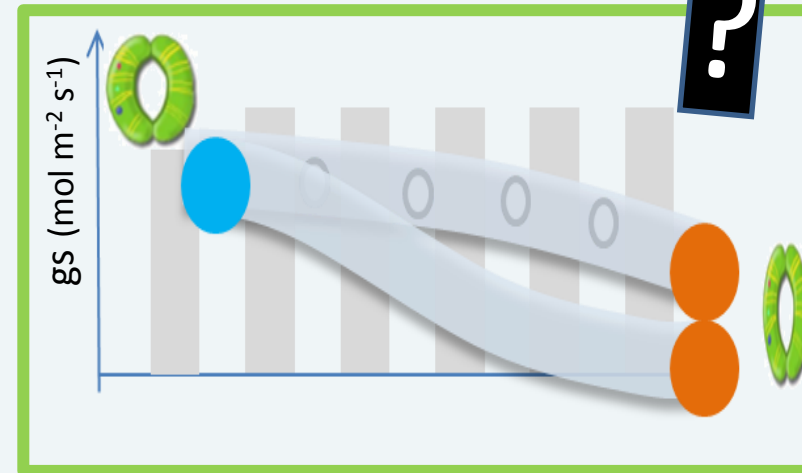
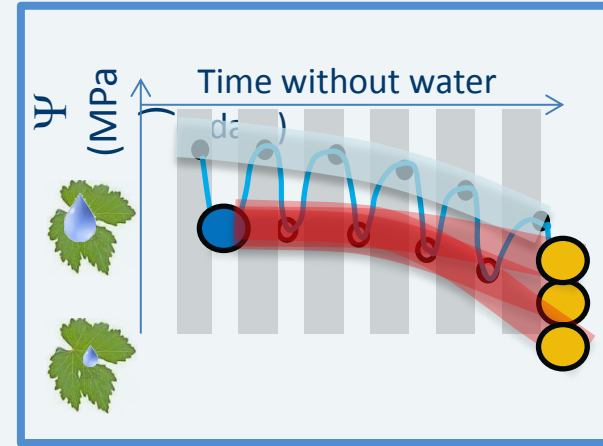
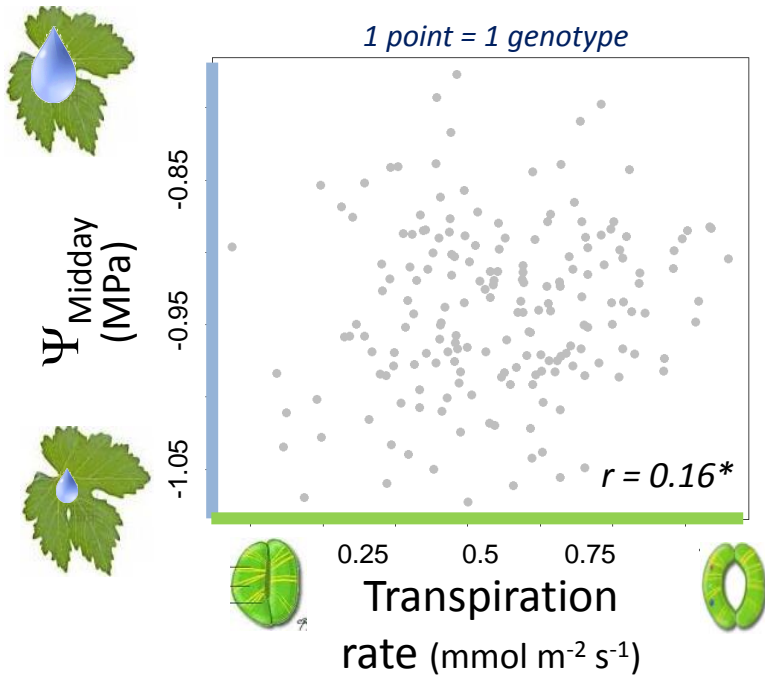


# Transpiration behaves as $\Psi_{\text{Midday}}$ in the progeny

- Reduction of transpiration by WD  
↔ stomatal closure
- Genotype effect (ANOVA,  $p < 10^{-3}$ )



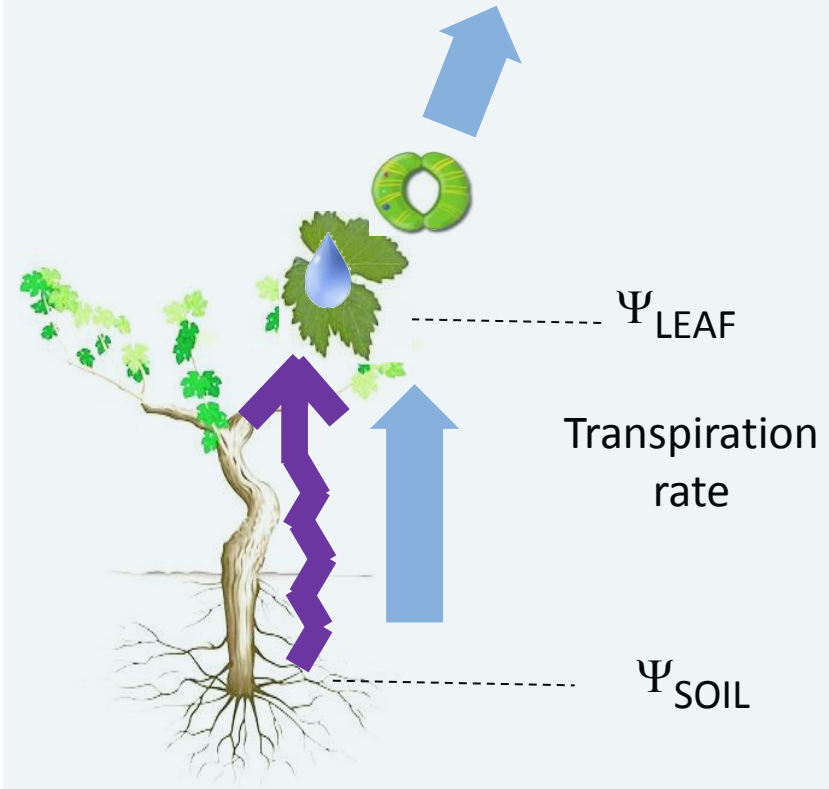
# No clear relation between Transpiration and $\Psi_{\text{Midday}}$

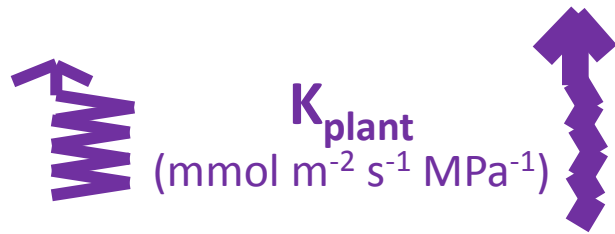




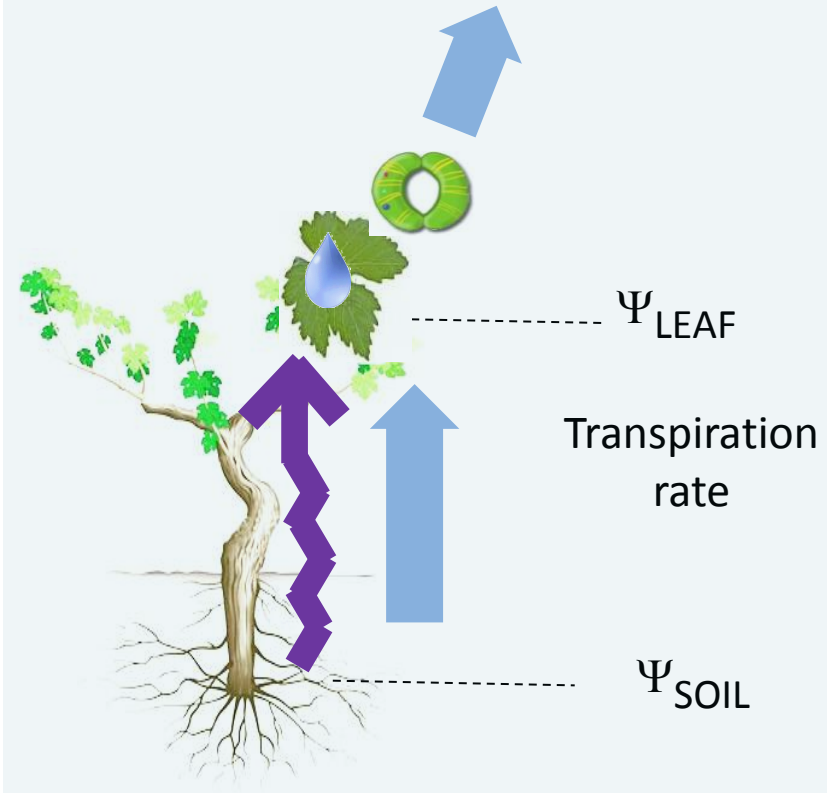


# Alternative control of leaf water potential?

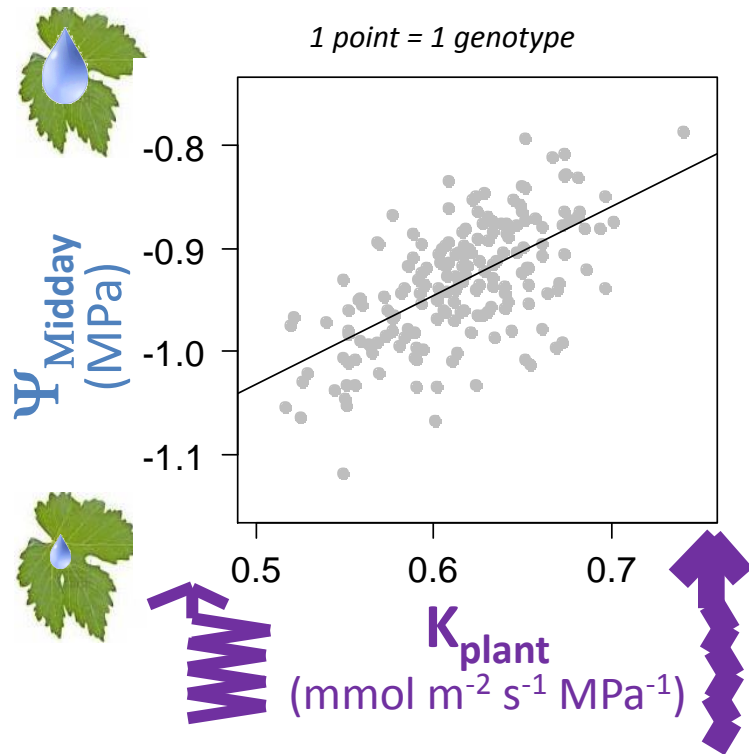




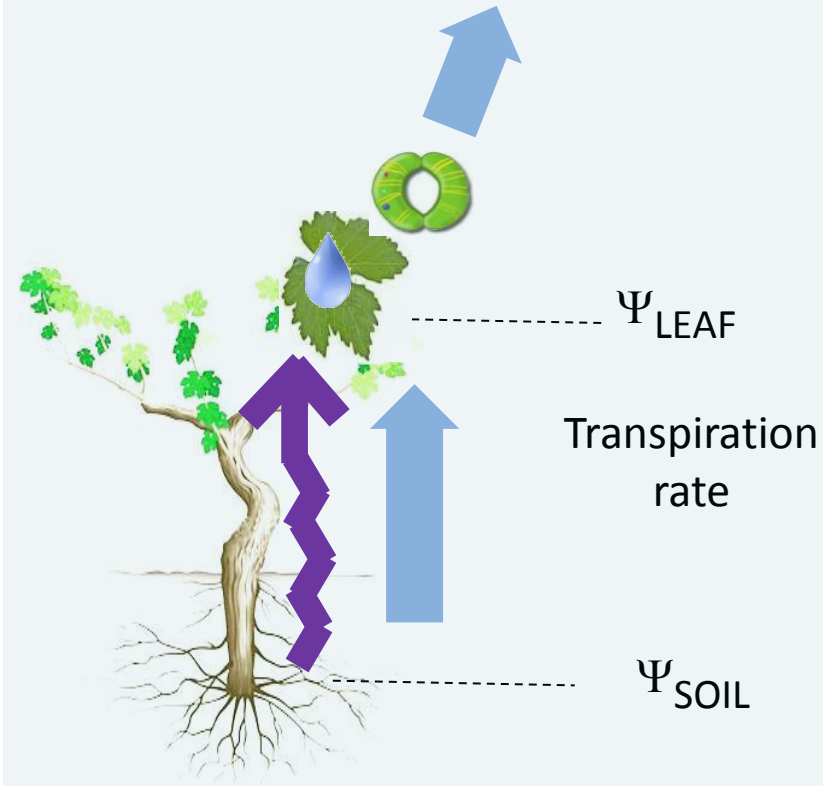
$$K_{\text{PLANT}} = \frac{\text{Transpiration rate}}{\Psi_{\text{SOIL}} - \Psi_{\text{LEAF}}} \Big/ \text{Leaf area}$$



# A possible role for hydraulic conductance from soil to leaves

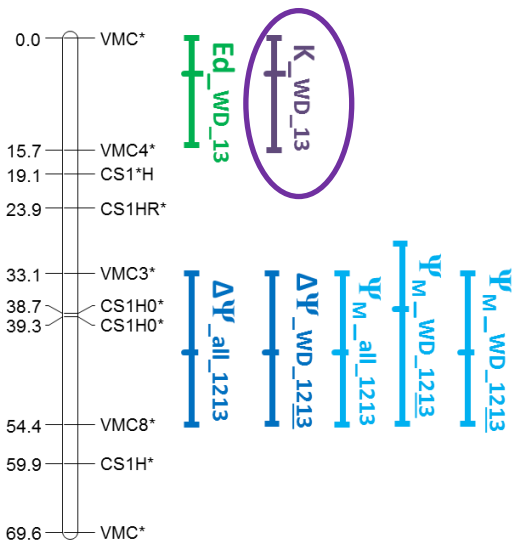


$$K_{\text{PLANT}} = \frac{\text{Transpiration rate}}{\Psi_{\text{SOIL}} - \Psi_{\text{LEAF}}} \Bigg/ \text{Leaf area}$$

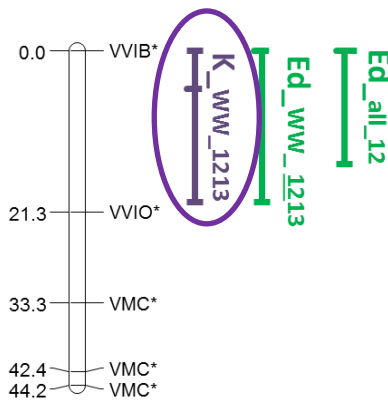


# $\Psi_{\text{Midday}}$ under WD partly shares its determinism with $K_{\text{Plant}}$

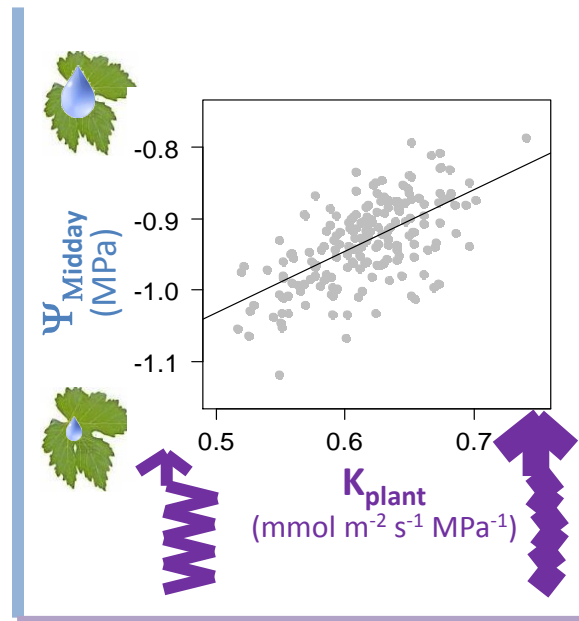
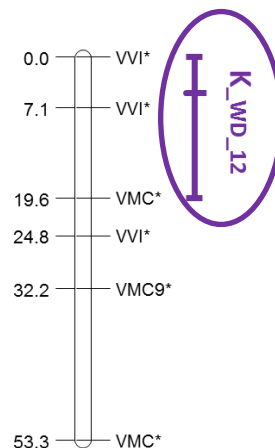
LG 01



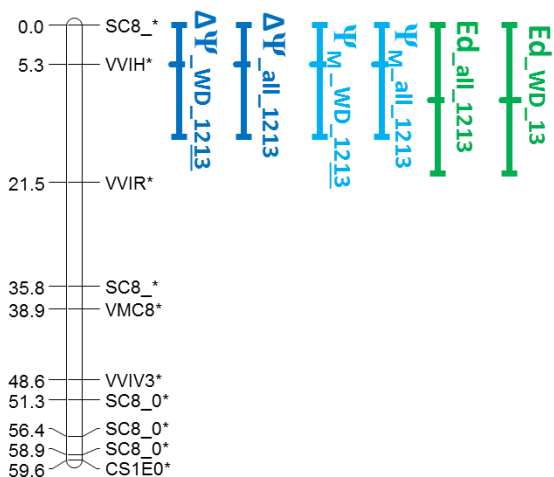
LG 02



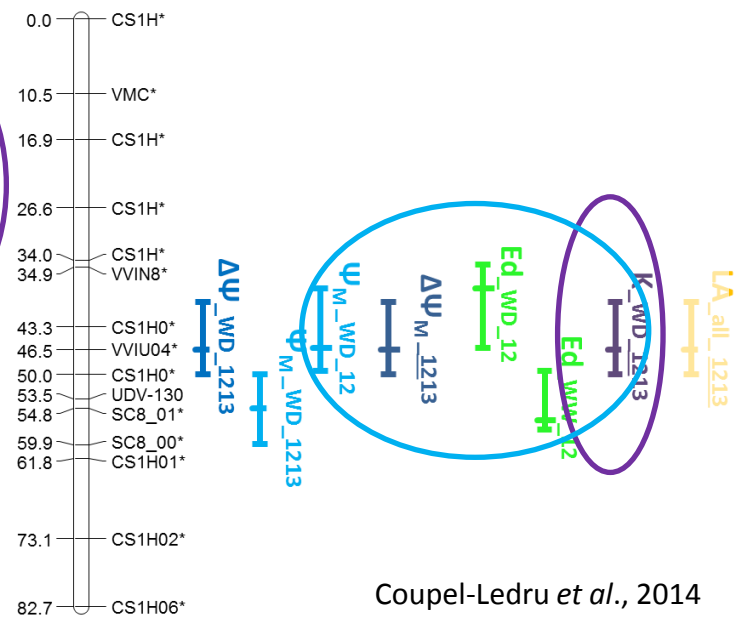
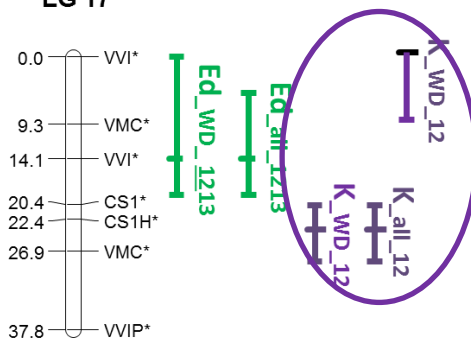
LG 13



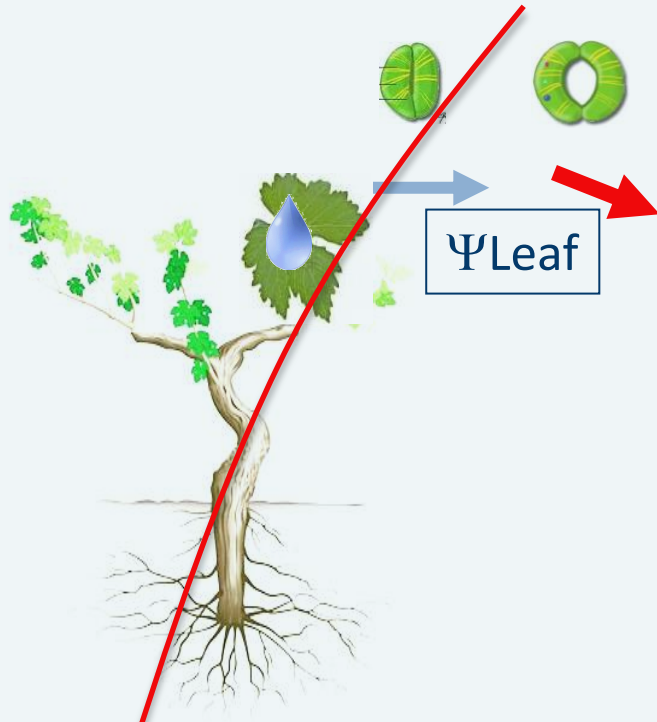
LG 10



LG 17

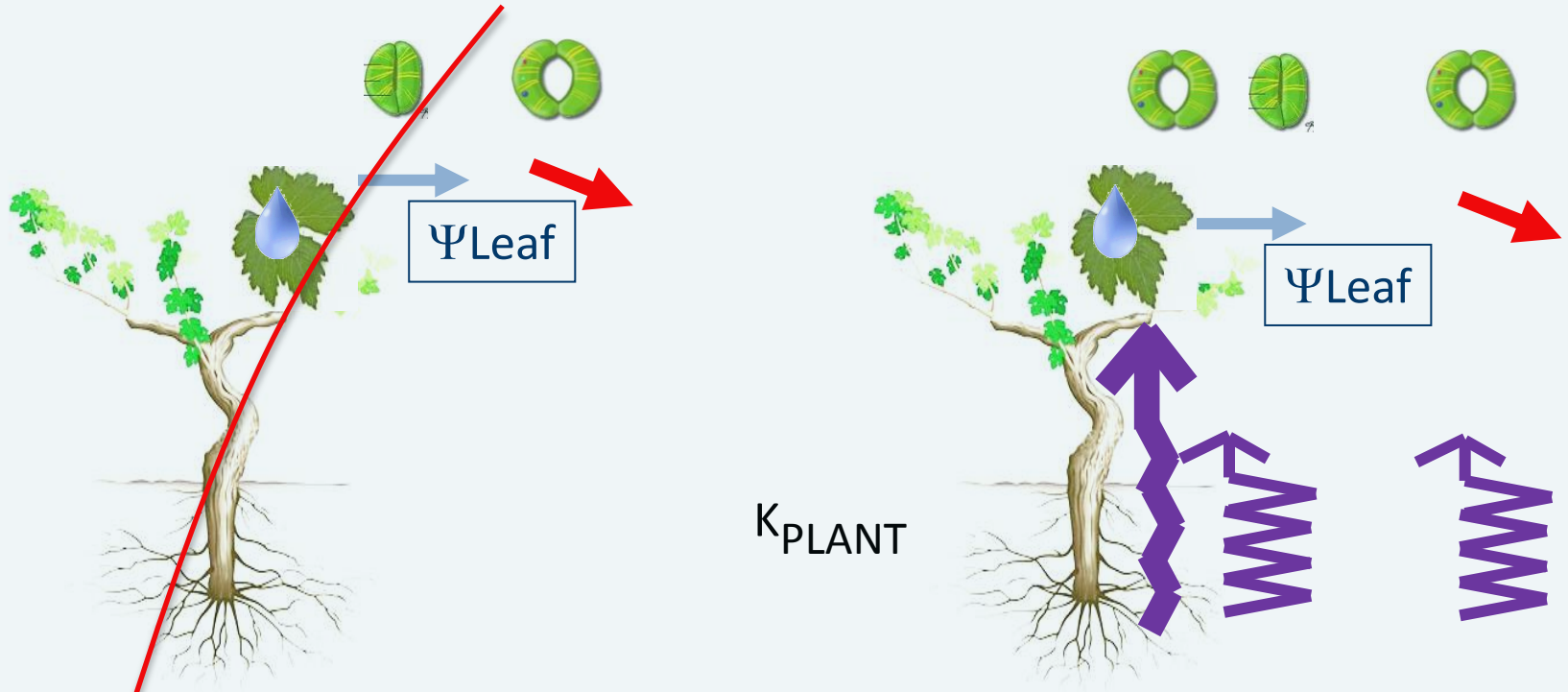


# A coordinated control of leaf water potential



Stomatal control alone

# A coordinated control of leaf water potential



Stomatal control alone



Coordinated control

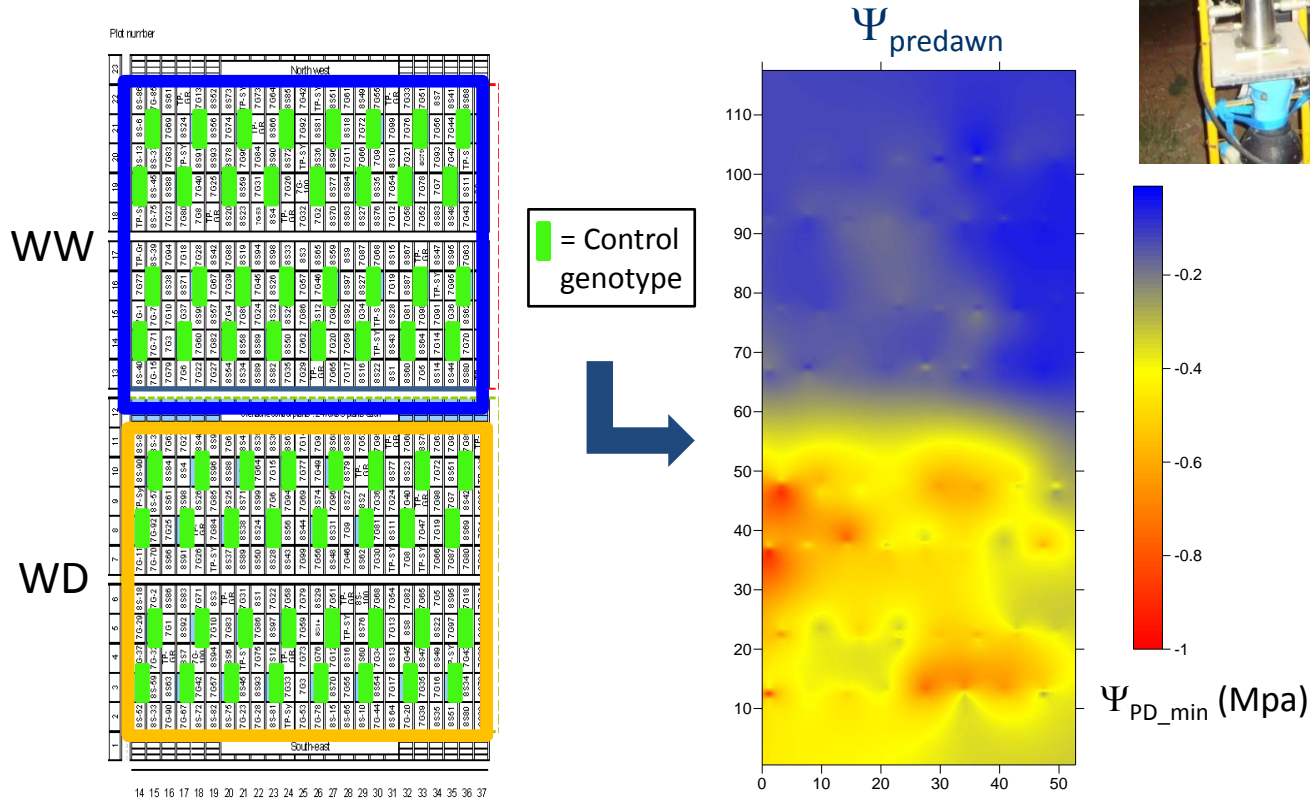
# Back to vineyard conditions ?



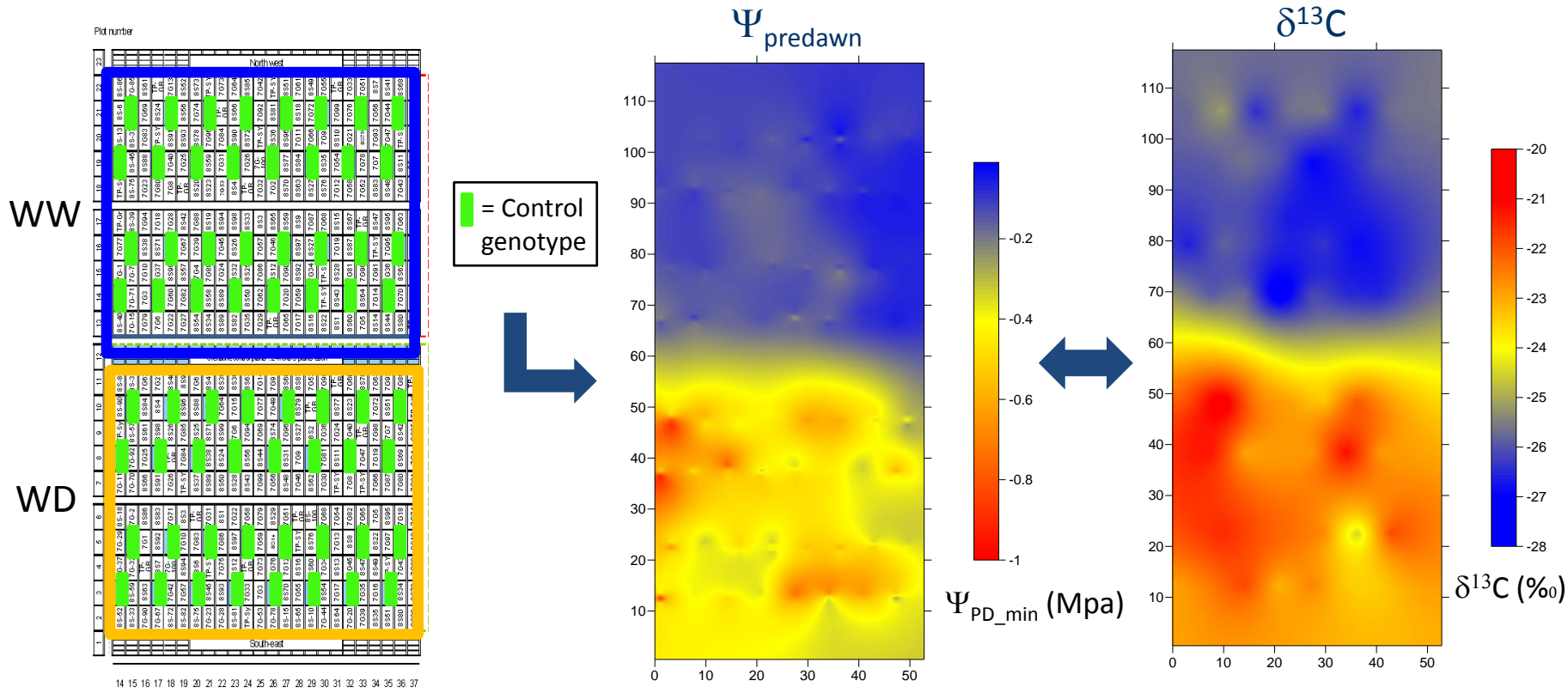




# Dealing with soil spatial heterogeneity



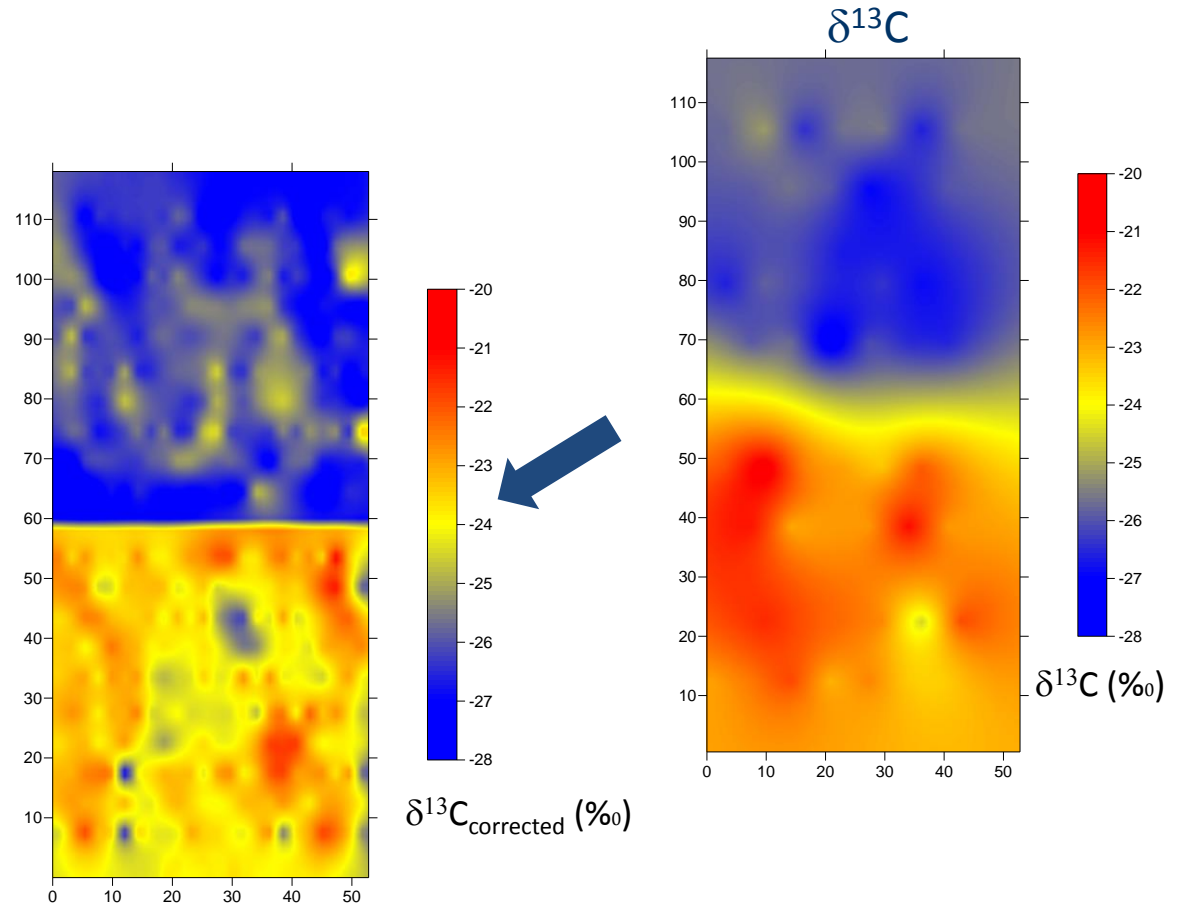
$\Psi_{\text{predawn}}$  of control genotype reveals the spatial heterogeneity



➤ Ψ<sub>predawn</sub> of control genotype reveals the spatial heterogeneity

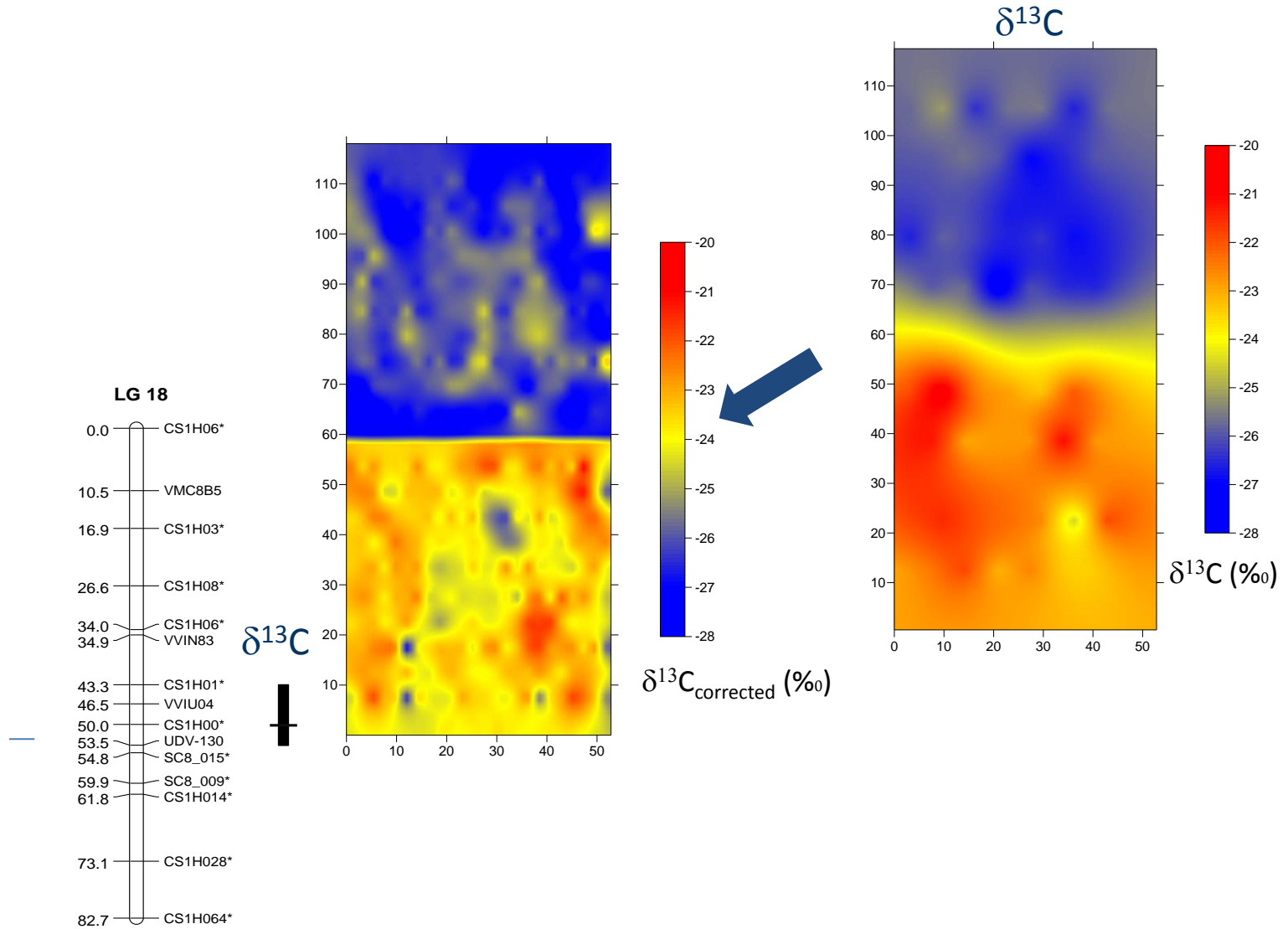
➤ This is consistent with variability of δ<sup>13</sup>C

- Correction of the heterogeneity by spatial interpolation from the control plots

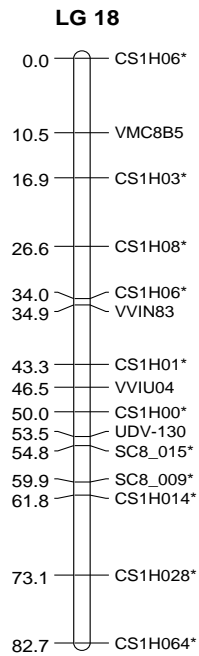


See Eric Lebon...

# Some encouraging results... after correction only



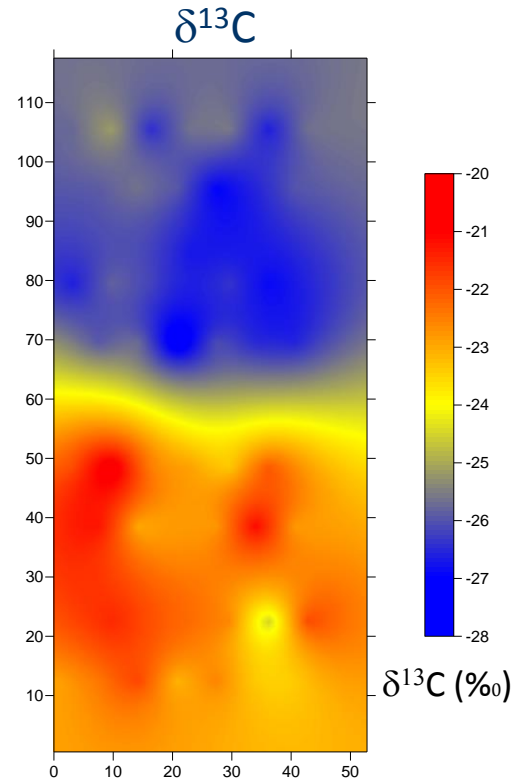
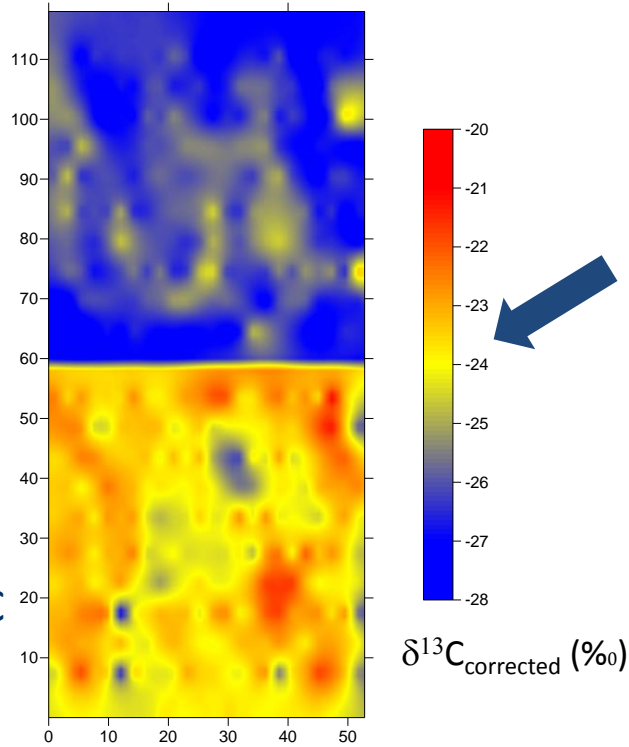
# Some encouraging results... after correction only



Water Use Efficiency



$\delta^{13}\text{C}$



# Conclusion

A highly powerful method  $\leftrightarrow$  Good control of WD



Detection of many QTLs associated with water-use

Progress in mechanism comprehension :  
iso/anisohdry as the results of an interplay  
between STOMATA and HYDRAULIC CONDUCTANCE

Dealing with spatial heterogeneity  
and complex water scenarios

But a method to face the difficulty...

...allowing detection of genetic determinism of WUE





# Thank you for your attention!



Aude Coupel-Ledru  
Eric Lebon  
Angélique Christophe

## Technicians

Philippe Pechier  
Philippe Hamard  
Claudine Morel  
Supawadee Sittichai

## Platform

Llorenç Cabrera-Bosquet  
Olivier Martin  
Antonin Grau

## Genetics QTL

Patrice This  
Agnès Doligez

## Informatics - Data Bases

Joe Ceasari  
Nicolas Brichet

## Statistics – Data analysis

Llorenç Cabrera-Bosquet  
Denis Vile