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## Optimization of wood production in bioenergy plantations: 1. through the use of adequate plant material in terms of resource use efficiencies

Julien Toillon, Bénédicte Rollin, Erwin Dallé, Jean-Charles Bastien, Franck F. Brignolas, Nicolas Marron

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# Optimization of wood production in bioenergy plantations

Through the use of adequate plant material  
in terms of resource use efficiencies

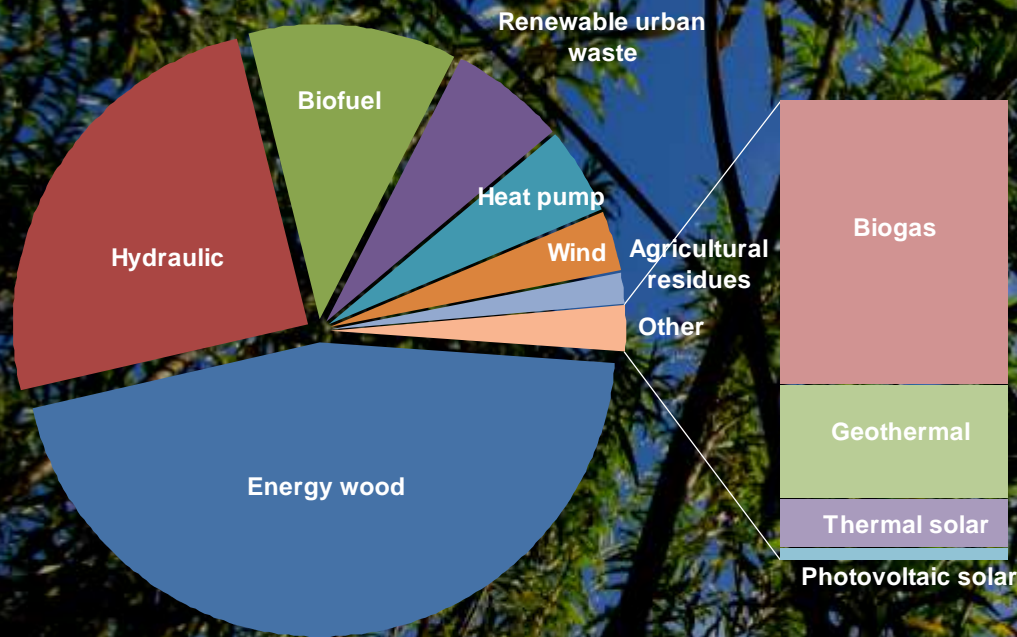
Julien TOILLON, Bénédicte ROLLIN, Erwin DALLÉ  
Jean-Charles BASTIEN, Franck BRIGNOLAS & Nicolas MARRON

# Why?

# How?

# Where?

# What?



European directive : 20% of produced energy have to be renewable

→ 7.9% in France in 2009

→ 45% from wood (forest and SRC)

→ Need of 8 to 10 millions hectares to reach the objectives...

→ ... avoiding concurrence with food agriculture

# Why?

# How?

# Where?

# What?



European directive : 20% of produced energy have to be renewable

- 7.9% in France in 2009
- 45% from wood (forest and SRC)
- Need of 8 to 10 millions hectares to reach the objectives...
- ... avoiding concurrence with food agriculture
- Use of suboptimal lands
- Optimization of wood production while reducing inputs
- Use of plant material using efficiently water and nitrogen

Why?

How?

Where?

What?



Most frequently used tree species in Europe:

- Poplar
- Willow
- Eucalyptus
- Black locust (*Robinia*)

→ 1500 to 12 000 trees / ha

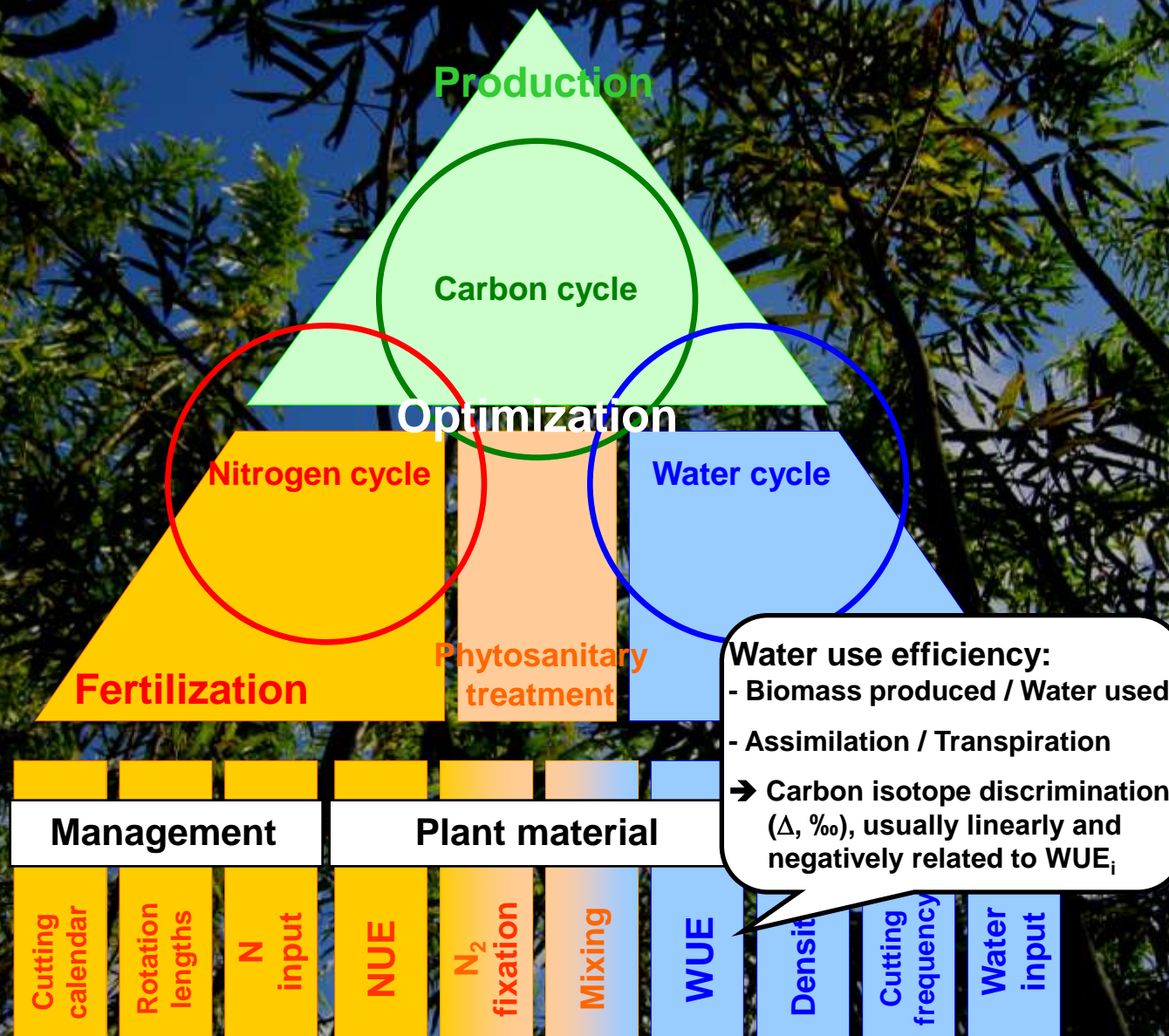
→ 2 to 8 year rotations

Why?

How?

Where?

What?



**Water use efficiency:**

- Biomass produced / Water used
- Assimilation / Transpiration

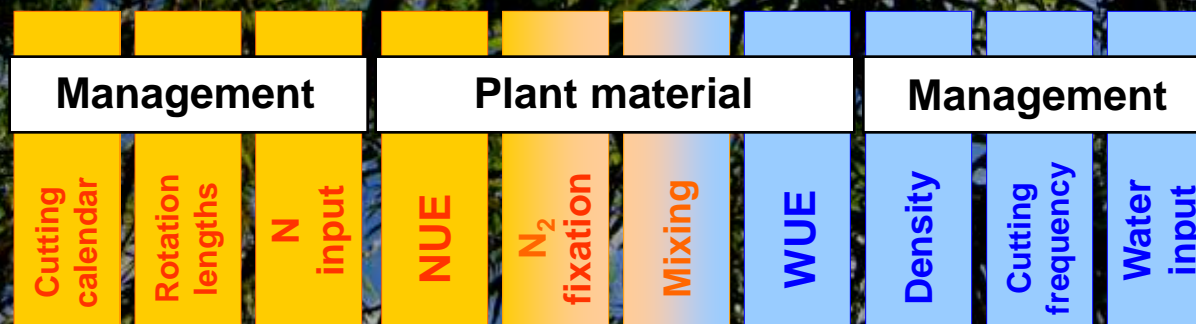
→ Carbon isotope discrimination ( $\Delta$ , ‰), usually linearly and negatively related to  $WUE_i$

Why?

How?

Where?

What?



Why?

How?

Where?

What?



- ERA-Net Bioenergy
- Franco-German cooperation
- "Cost optimization of short rotation forestry adapted plantations"
- [www.creff.eu](http://www.creff.eu)

- French National Research Agency Call "ANR Bioenergies"
- Technical and scientific consortium
- "New concepts of sustainable energy crops with woody species"

Research Agency  
 "Bioenergy"  
 m + Congo / Brazil  
 sification  
 est ecosystems"  
 rad.fr

Cutting calendar	Management
...	...
...	...
...	...
...	...
...	...
N <sub>2</sub> fixation	Plant material
Mixing	...
WUE	...
Density	Management
Cutting frequency	...
Water input	...

See poster

See poster



# Why?

# How?

# Where?

# What?

Association d'Initiatives Locales pour l'Énergie et l'Environnement

Institut National de la Recherche Agronomique

Forêt, Cellulose, Bois-construction, Ameublement

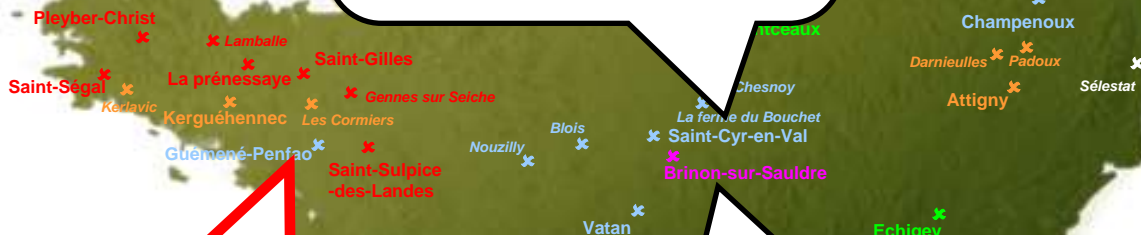
Chambres d'Agriculture

Institut pour le Développement Forestier

Laboratoire des Interactions Microorganismes Minéraux Matière Organique dans les Sols



**Poplar clonal test (60 clones) + Willow clonal test (20 clones)**



**Robinia clonal test (30 clones) + 8 willow + 1 poplar clone**



T°C : 16.7°C  
Rainfall : 148 mm  
OM : 39.5 g kg<sup>-1</sup>  
N : 1.7 g kg<sup>-1</sup>

**Brittany**

**8 willow clones**



T°C : 17.0°C  
Rainfall : 257 mm  
OM : 9.9 g kg<sup>-1</sup>  
N : 0.6 g kg<sup>-1</sup>

**Centre**

**Poplar clonal test (60 clones) + 6 willow clones**



T°C : 17.4°C  
Rainfall : 382 mm  
OM : 62.1 g kg<sup>-1</sup>  
N : 3.2 g kg<sup>-1</sup>

**Bourgogne**

**Growing conditions**

Why?

How?

Where?

What?



Poplar  
'Dorskamp'



Robinia  
2 provenances



Willow  
8 clones

The 3 species at the same site

Close  $\Delta$  / WUE values for leaves and wood

Close  $\Delta$  / WUE values for poplar and willow...

... but inferior for black locust

➔ Black locust more efficient to use water than poplar / willow?

➔ Or due to extreme conditions at this site in 2010?

More precisely for each species...

Robinia clonal test (30 clones)  
+ 8 willow + 1 poplar clone



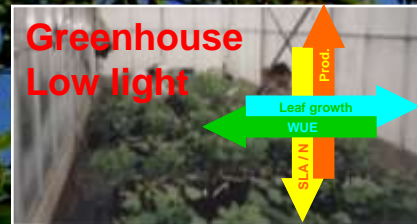
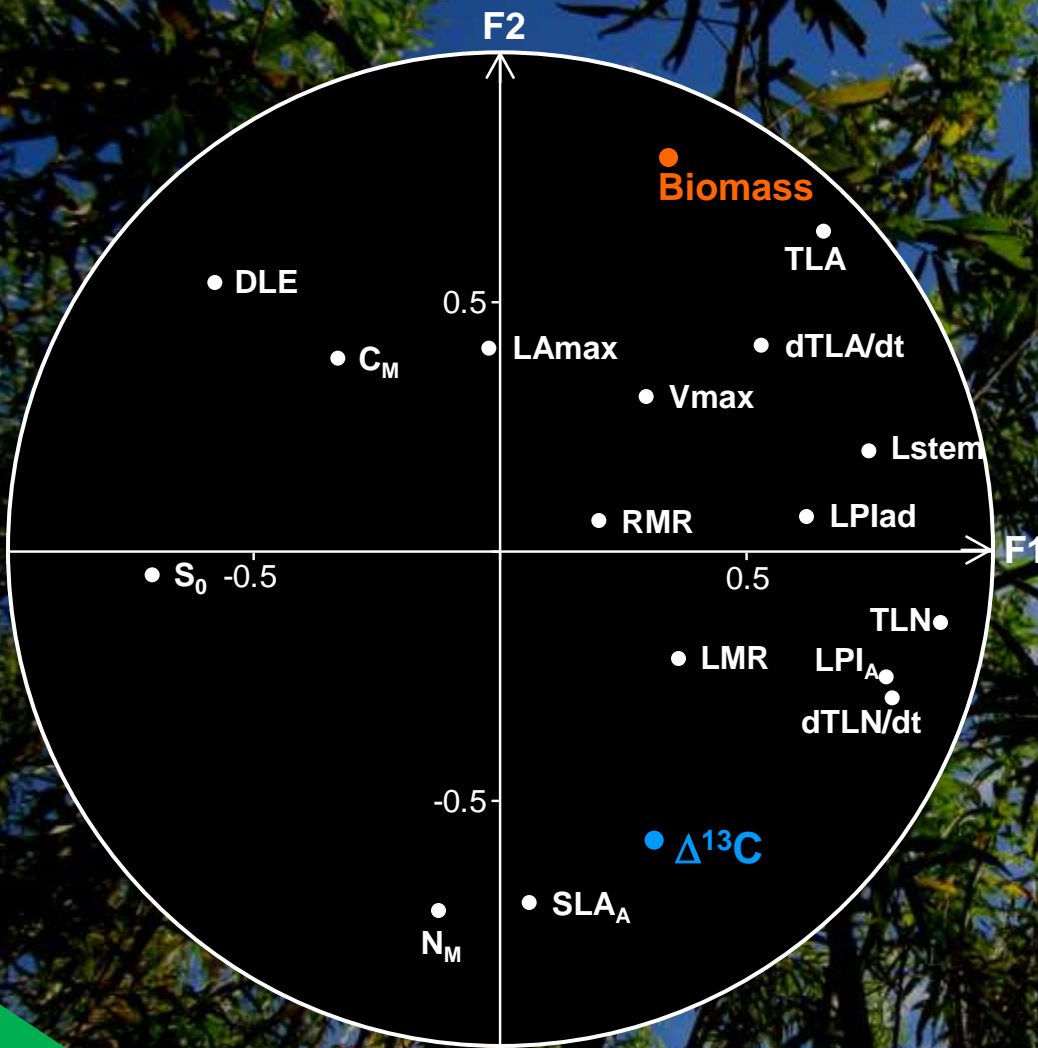
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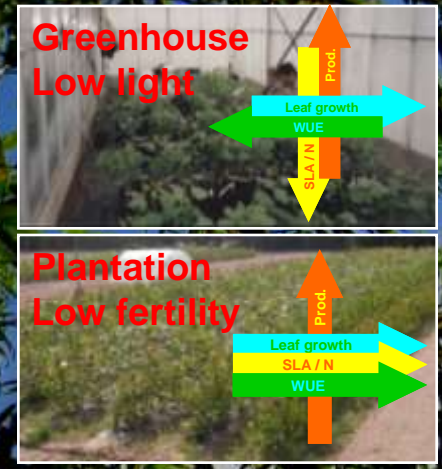
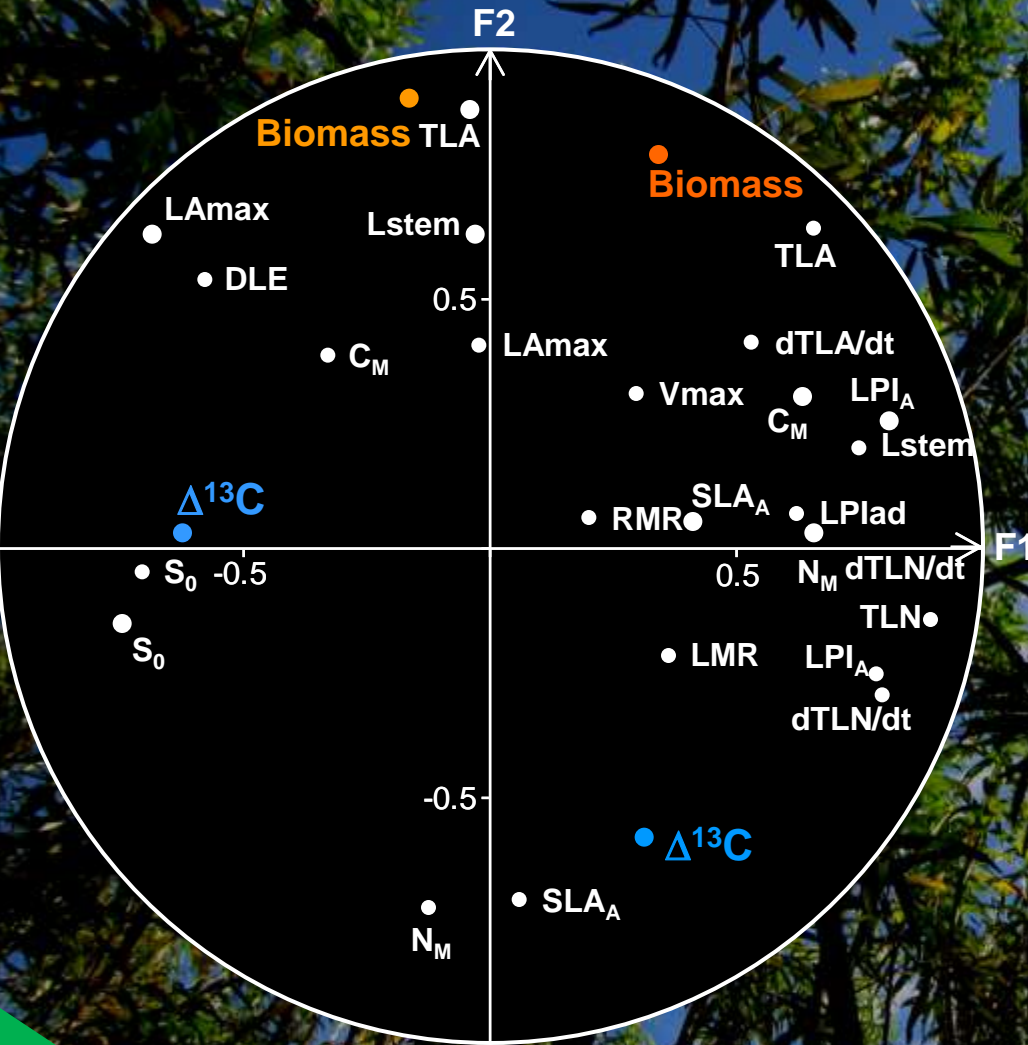
N : 1.7 g kg<sup>-1</sup>

# European poplar clones (Italy / Netherland / Belgium / France / Hungary)



Marron et al. 2005

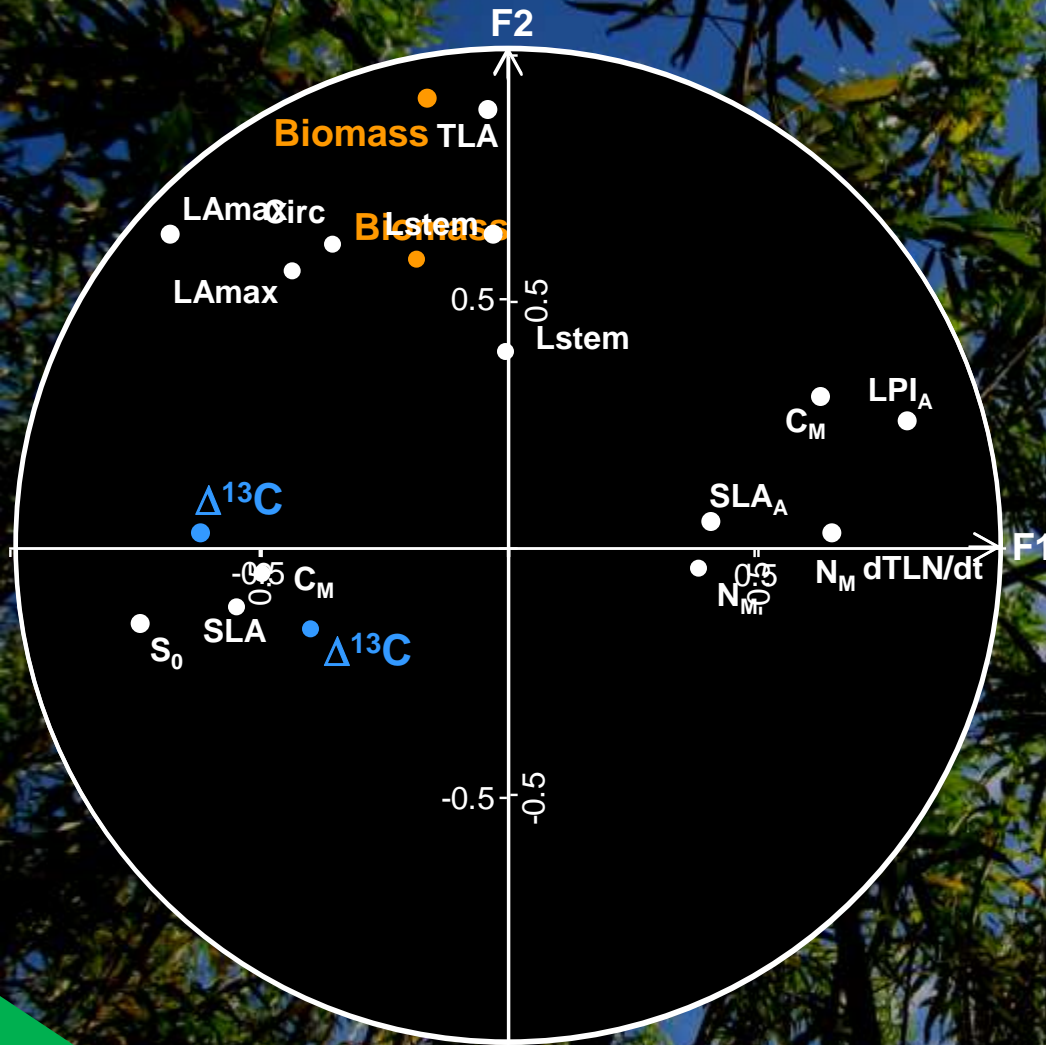
European poplar clones (Italy / Netherland / Belgium / France / Hungary)



Marron *et al.* 2005

Monclus *et al.* 2005

# European poplar clones (Italy / Netherland / Belgium / France / Hungary)



Marron et al. 2005



Monclus et al. 2005



Monclus et al. 2006

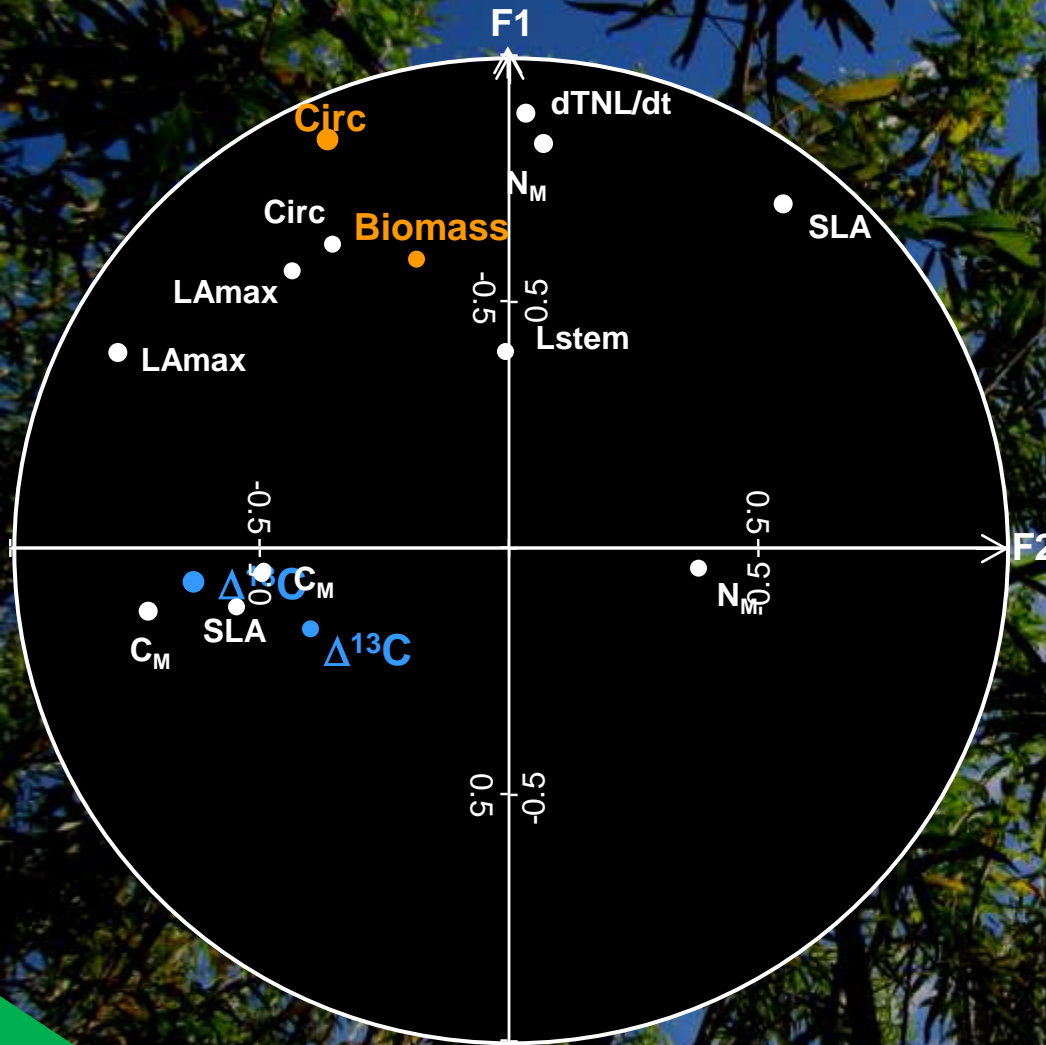
Why?

How?

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What?

### European poplar clones (Belgian F1)



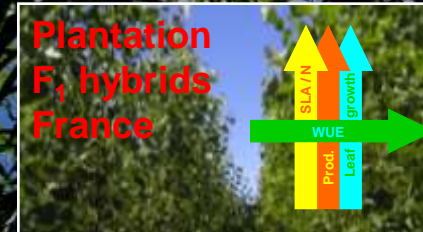
Marron *et al.* 2005



Monclus *et al.* 2005



Monclus *et al.* 2006



Marron and Ceulemans 2006

Dillen *et al.* 2011

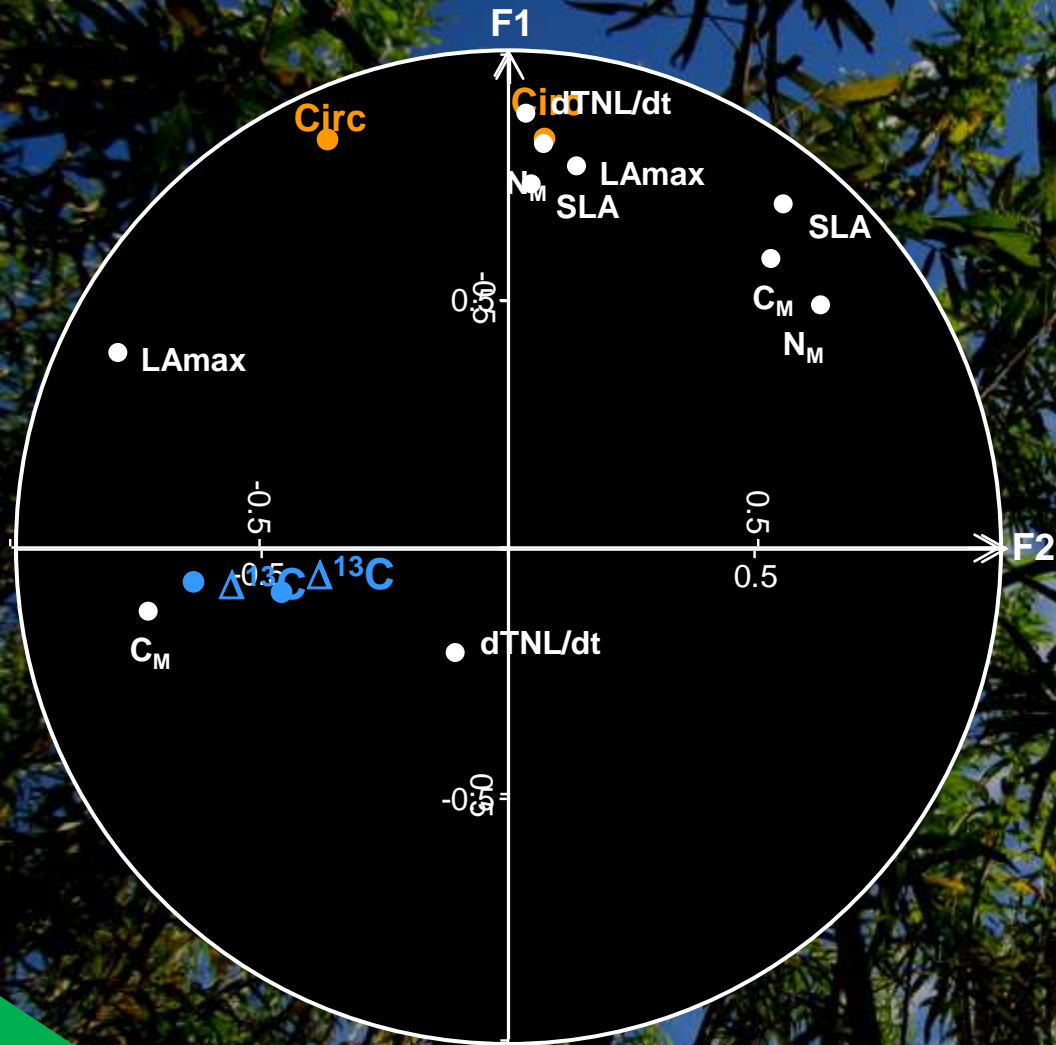
Why?

How?

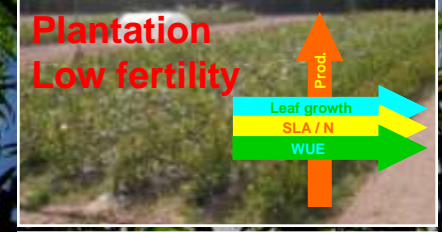
Where?

What?

### European poplar clones (Belgian F1)



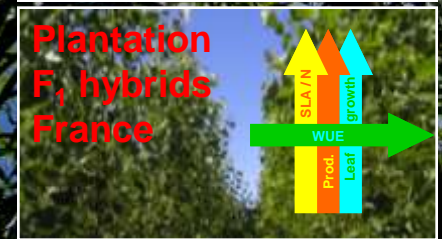
Marron *et al.* 2005



Monclus *et al.* 2005

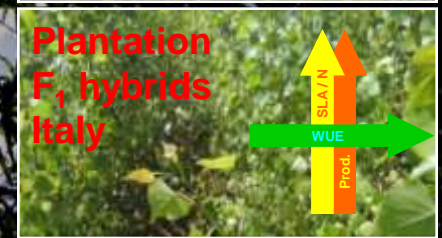


Monclus *et al.* 2006



Marron and Ceulemans 2006

Dillen *et al.* 2011

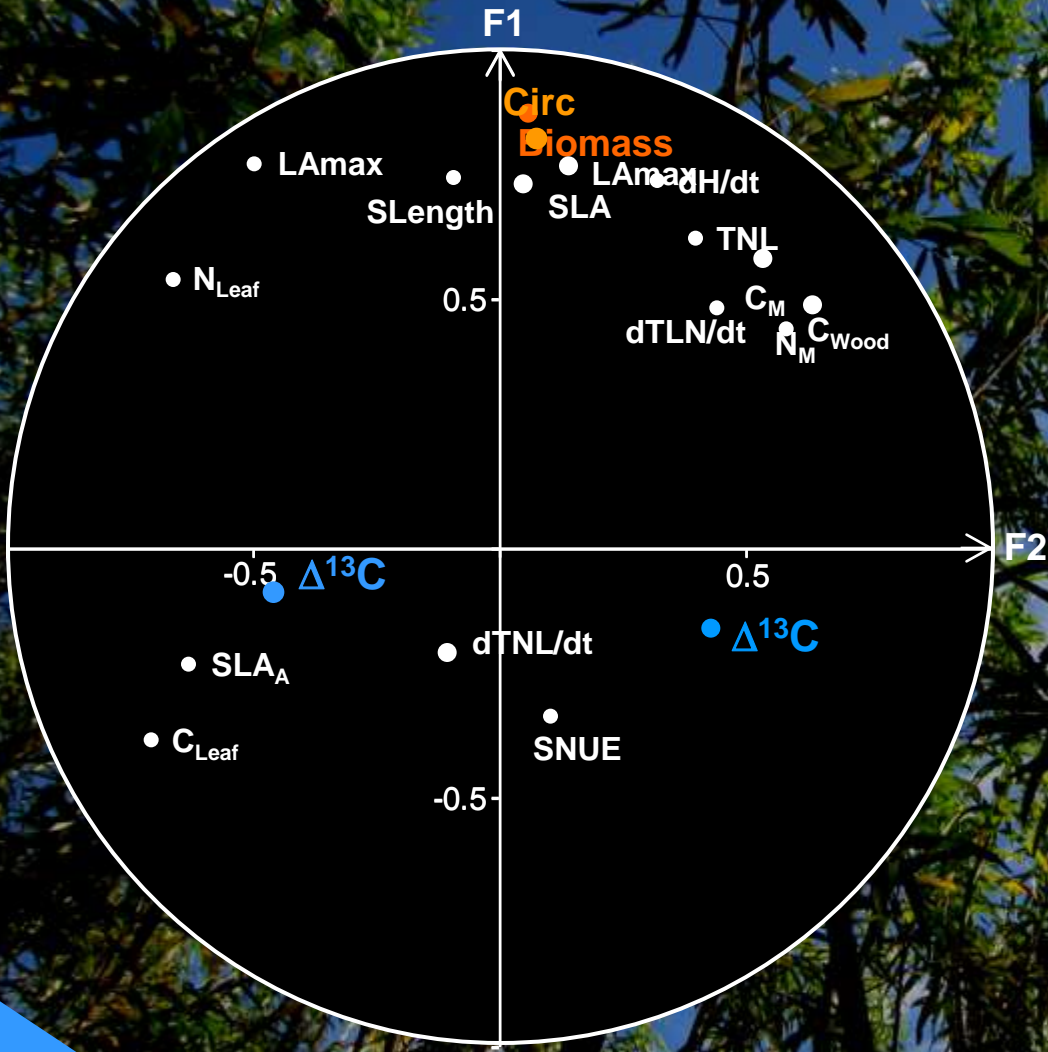


Marron *et al.* 2007

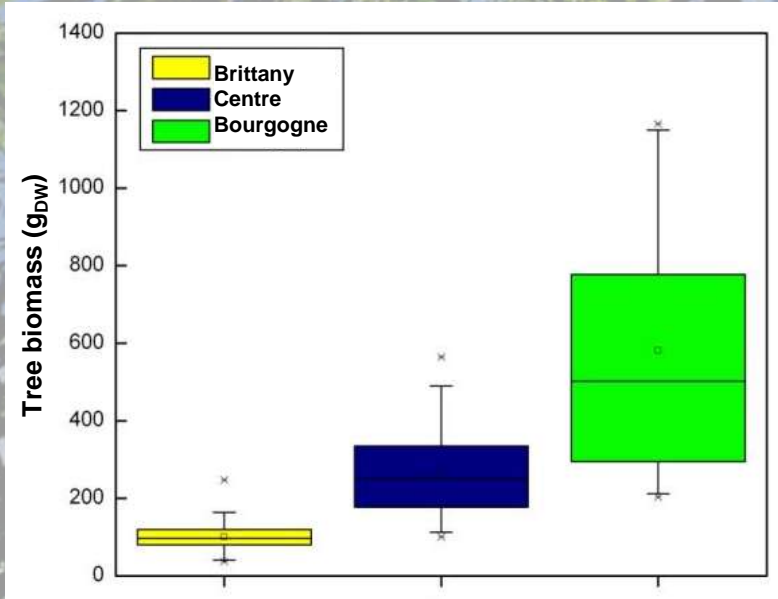
Dilleff *et al.* 2011



### European willow clones (Sweden / Ireland)



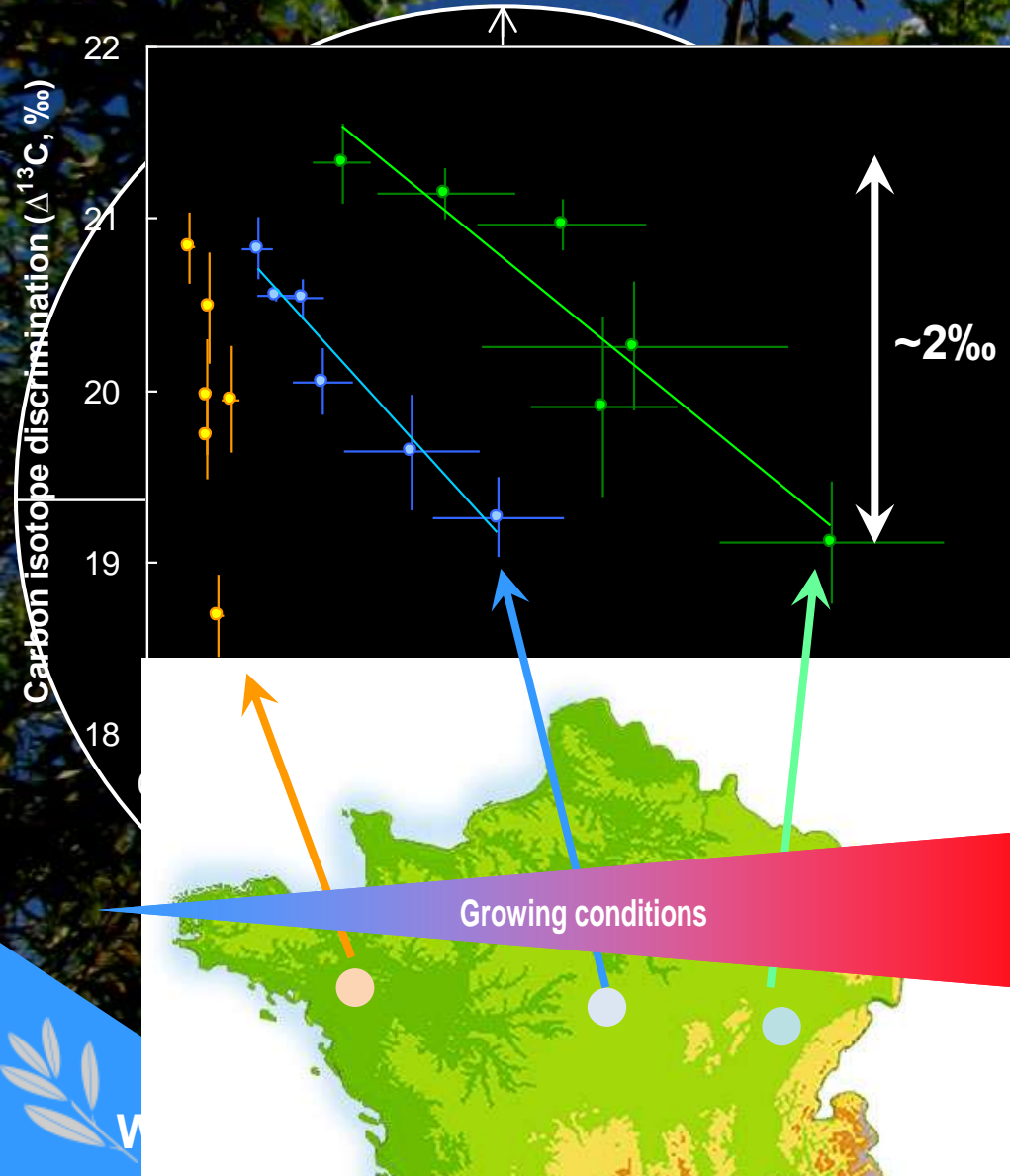
### Six willow clones at 3 contrasting sites



For willow as well, it seems that there is no relationship between productivity and  $\Delta$  / WUE  
 But...



## European willow clones (Sweden / Ireland)



... when studied site by site...

Around 30% variation in  $\Delta$  among willow clones

Clone ranking stable among sites

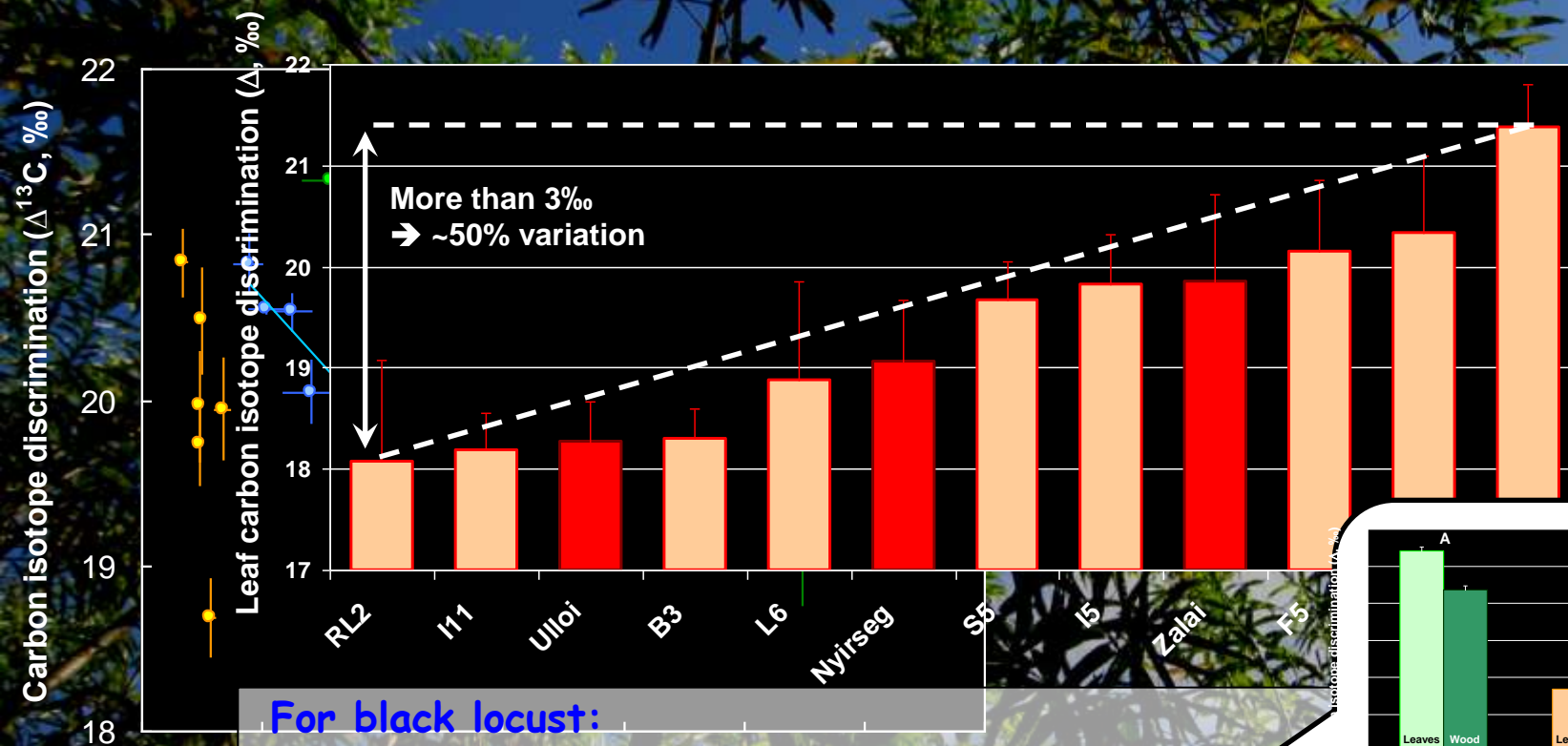
→ Quite wide variation enabling selection

Relation  $\Delta$  / biomass stronger when conditions are favorable

→  $\Delta$  driven by assimilation at the "good" sites

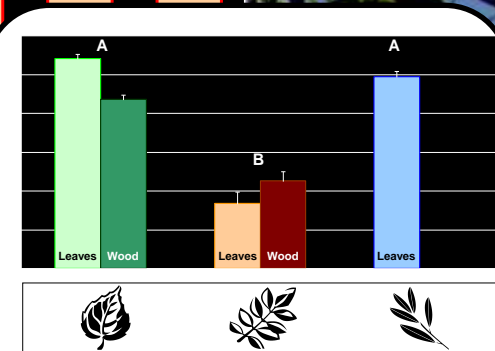
→  $\Delta$  driven by stomatal conductance at the "bad" site

European black locust clones (Hungary / France)



For black locust:

- Large clonal variation available in French and Hungary
- But difficulties to propagate it clonally
- Contradiction between seedling  $\Delta$  (17.2‰) and cutting  $\Delta$  (19.5‰)
- ➔ Need to describe in more details this promising species for bioenergy



Why?

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In summary:

### Variation

- Large  $\Delta$  / WUE variation for the three species...

... but highly dependant on growth conditions

Clonal rankings usually stable whatever conditions

### Relation with productivity

Poplar / Robinia: no link between  $\Delta$  and production has been shown

Willow: negative link  $\Delta$  / production (positive WUE / prod.)

→ In any case, possibility to select for both traits together

→ To be completed...



**Thank you...  
... and to the people  
contributing to these projects**

# Carbon isotope discrimination during photosynthesis and $W_i$ : simple model

$$\Delta^{13}\text{C} \approx \delta^{13}\text{C}_{\text{air}} - \delta^{13}\text{C}_p$$

$$W_i = \frac{c_a}{1.6} \left( \frac{b - \Delta^{13}\text{C}}{b - a} \right)$$

Farquhar *et al.* 1984

Source: atmospheric  $\text{CO}_2$   
 $\delta^{13}\text{C}_{\text{air}}$   $c_a$

