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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

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Julien Toillon, Bénédicte Rollin, Erwin Dallé, Jean-Charles Bastien, Franck F. Brignolas, et al.. Optimization of wood production in bioenergy plantations: 1. through the use of adequate plant material in terms of resource use efficiencies. Poplars and Willows on the Prairies. Joint Conference of Poplar Council of Canada, IPC Environmental Applications Working Party, and Poplar Council of the United States, Sep 2011, Edmonton, Canada. hal-02748842

HAL Id: hal-02748842

<https://hal.inrae.fr/hal-02748842>

Submitted on 3 Jun 2020

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Optimization of wood production in bioenergy plantations

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

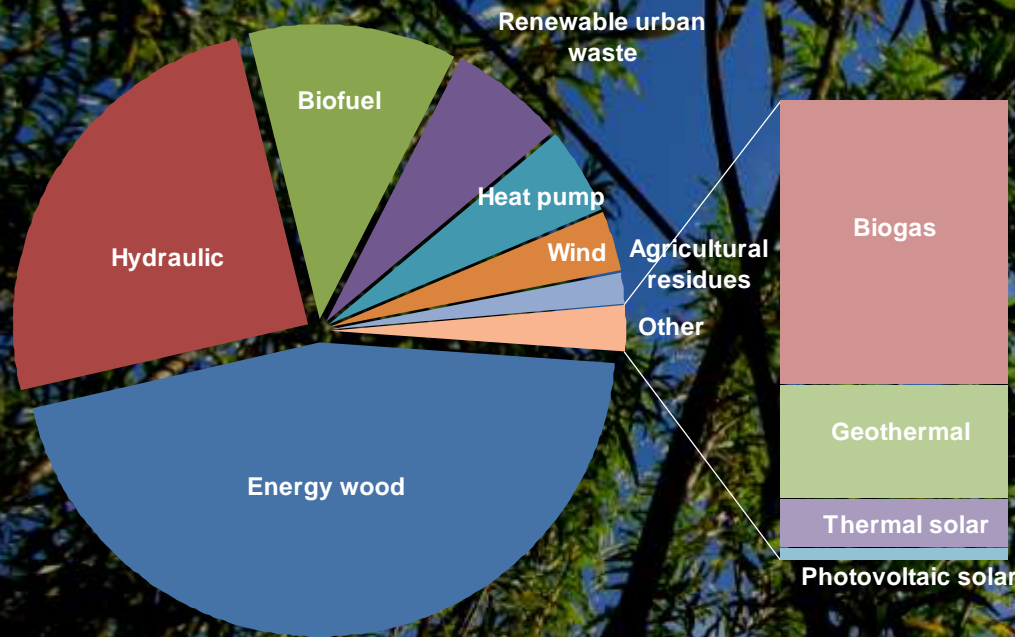
Julien TOILLON, Bénédicte ROLLIN, Erwin DALLÉ
Jean-Charles BASTIEN, Franck BRIGNOLAS & Nicolas MARRON

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

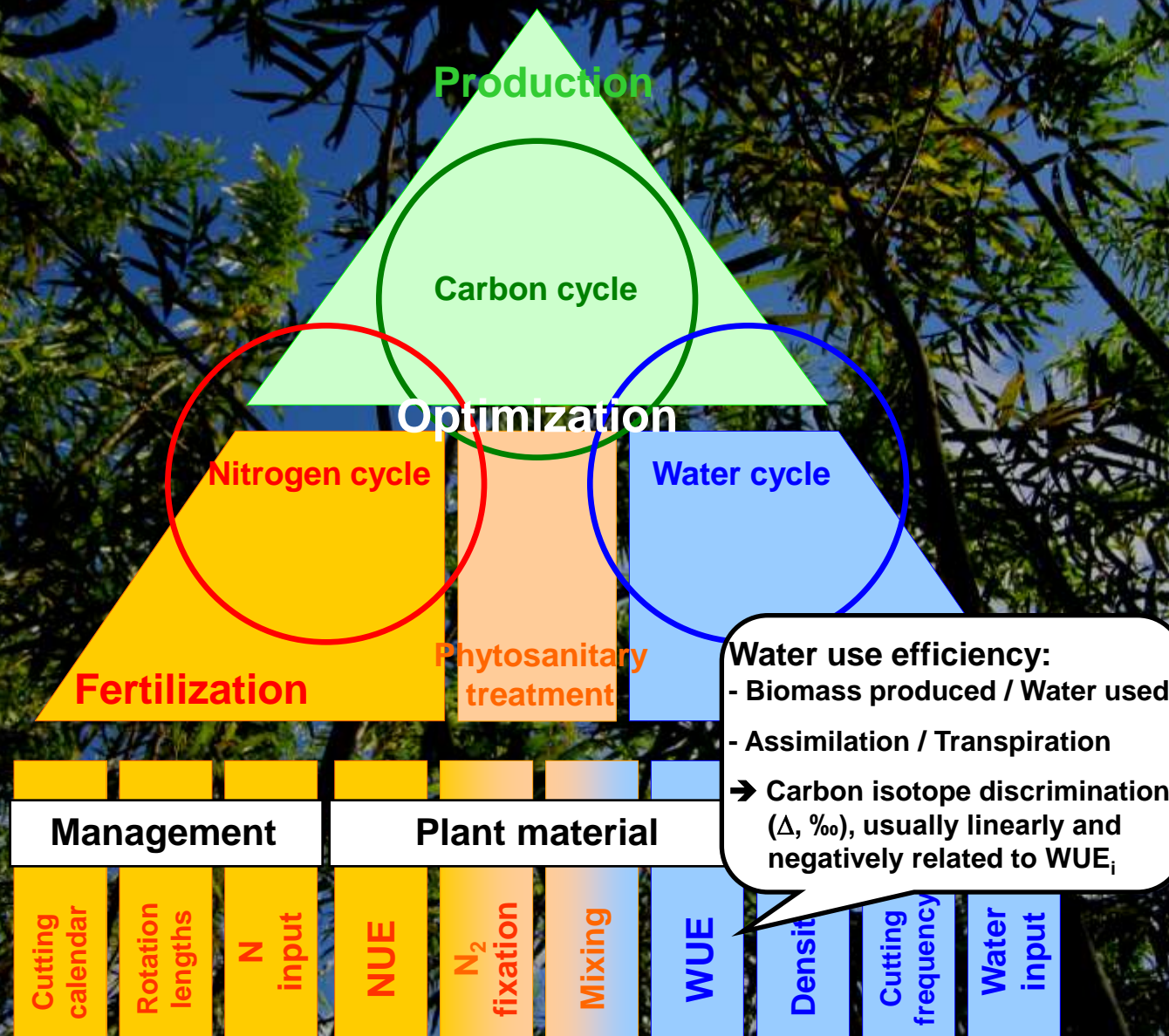
→ 2 to 8 year rotations

Why?

How?

Where?

What?



Water use efficiency:

- Biomass produced / Water used
- Assimilation / Transpiration

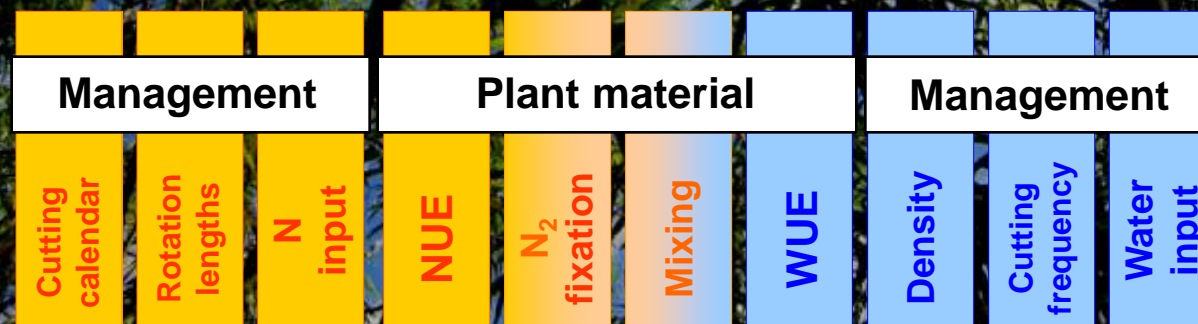
→ Carbon isotope discrimination (Δ , ‰), usually linearly and negatively related to WUE_i

Why?

How?

Where?

What?



Why?




How?

Where?

What?



Intens&Fix

- ERA-Net Bioenergy
- Franco-German cooperation
- "Cost optimization of short rotation forestry adapted plantations"
- www.creff.eu
- French National Research Agency Call "ANR Bioenergies"
- Technical and scientific consortium
- "New concepts of sustainable energy crops with woody species"

				Cutting calendar	Management
				...	
				...	
				N ₂ fixation	Plant material
				Mixing	
X	X			WUE	Management
X	X			Density	
X				Cutting frequency	
X				Water input	

See poster

See poster

Why?

How?

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What?

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

Institut National de la Recherche Agronomique

Forêt, Cellulose, Bois-construction, Ameublement

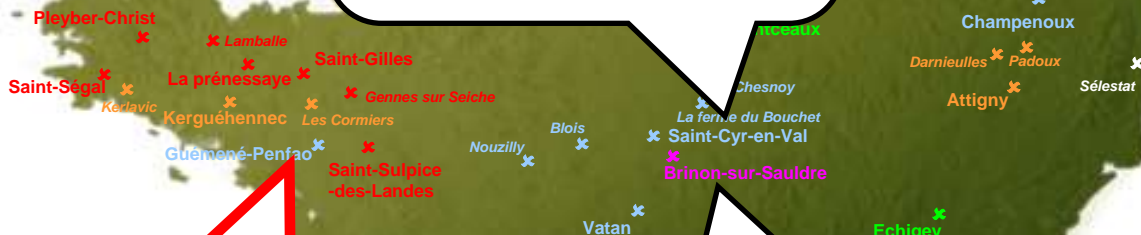
Chambres d'Agriculture

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⁻¹
N : 1.7 g kg⁻¹

Brittany

8 willow clones



T°C : 17.0°C
Rainfall : 257 mm
OM : 9.9 g kg⁻¹
N : 0.6 g kg⁻¹

Centre

Poplar clonal test (60 clones) + 6 willow clones



T°C : 17.4°C
Rainfall : 382 mm
OM : 62.1 g kg⁻¹
N : 3.2 g kg⁻¹

Bourgogne

Growing conditions

Why?

How?

Where?

What?



Poplar
'Dorskamp'



Robinia
2 provenances



Willow
8 clones

The 3 species at the same site

Close Δ / WUE values for leaves and wood

Close Δ / 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



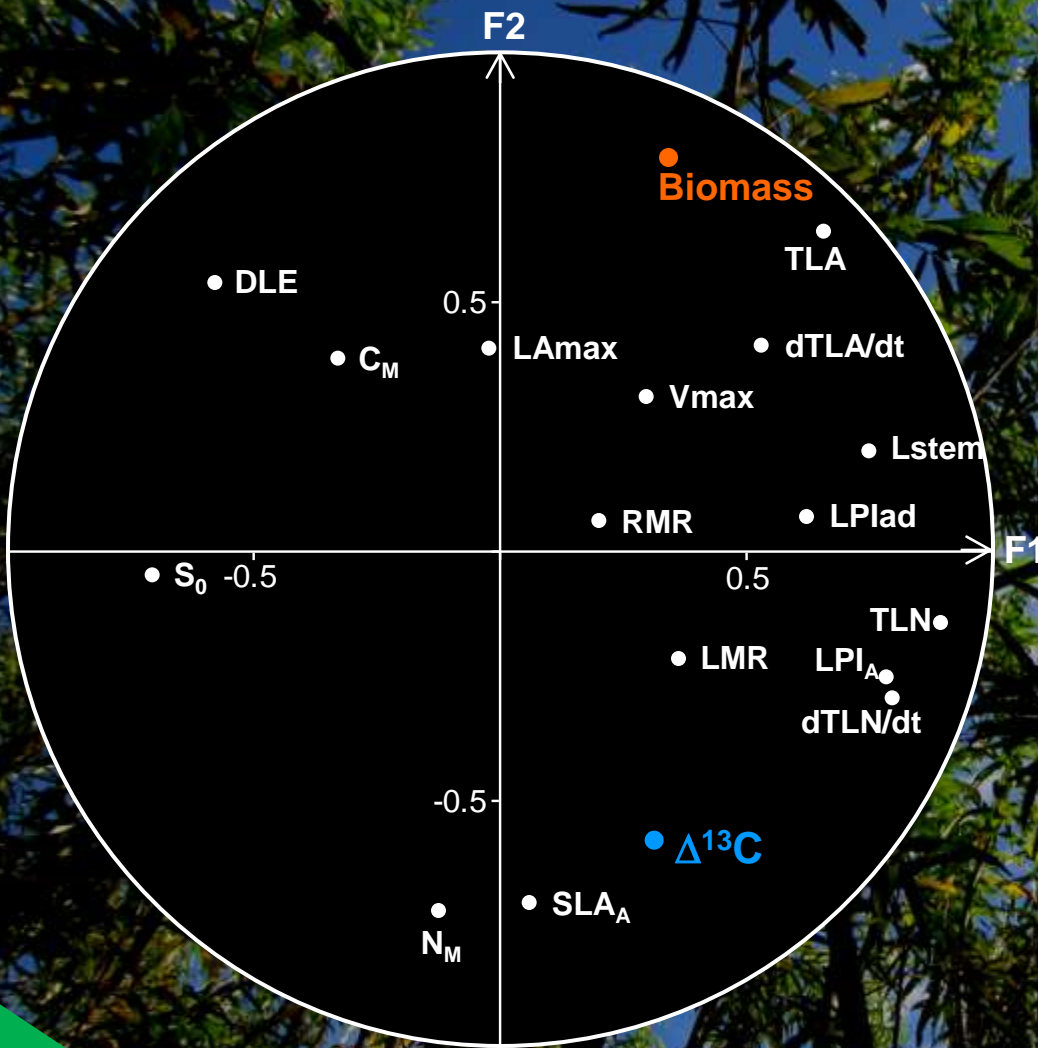
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Rainfall : 148 mm

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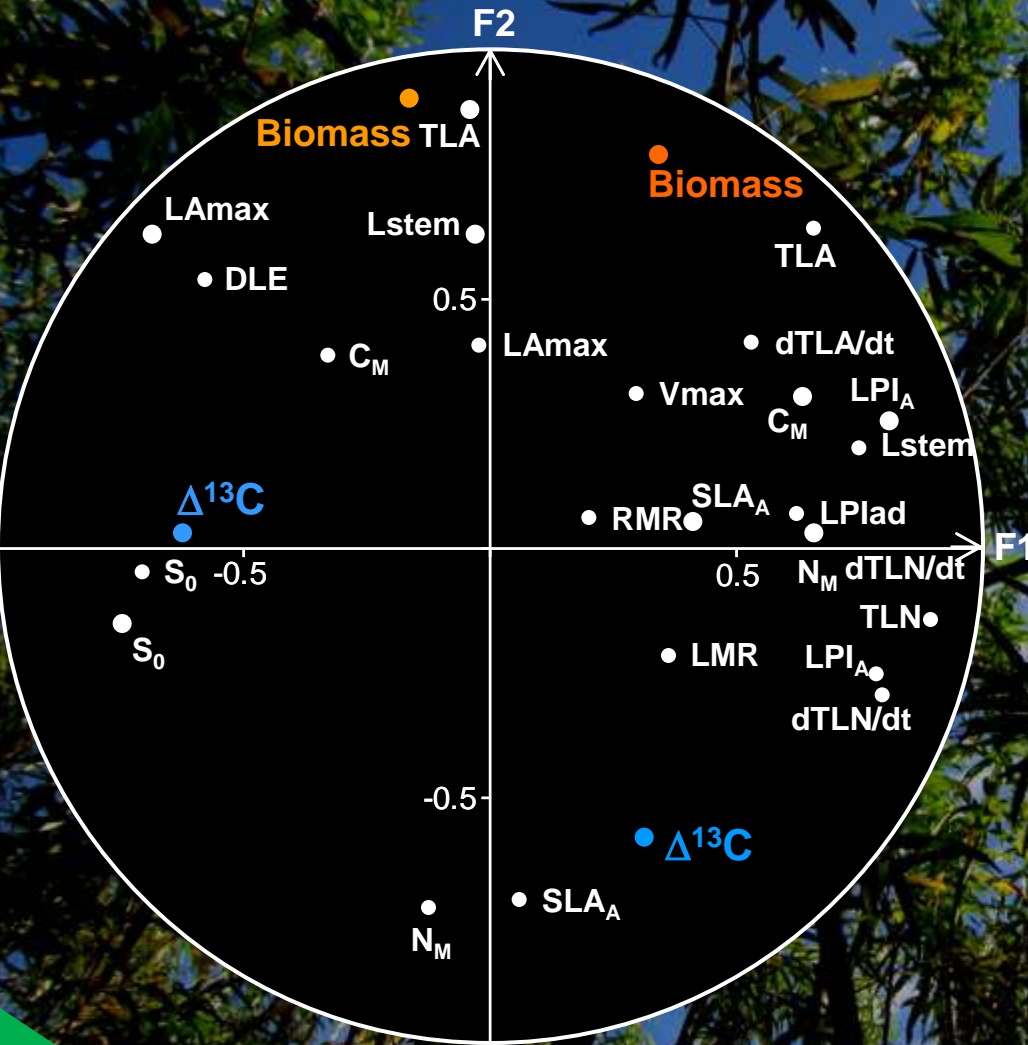
N : 1.7 g kg⁻¹

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



Marron et al. 2005

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

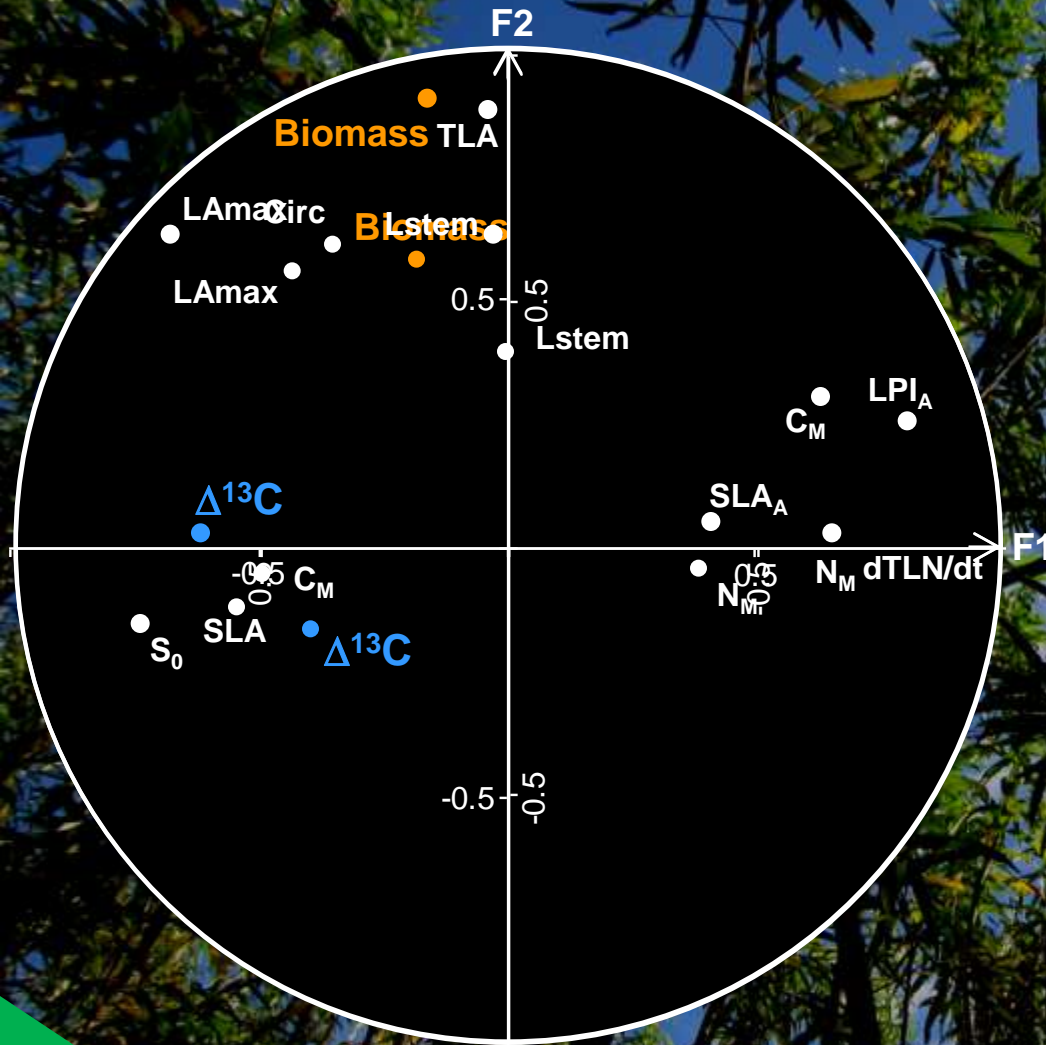


Marron et al. 2005

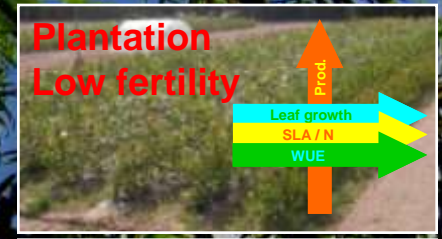


Monclus et al. 2005

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



Marron et al. 2005



Monclus et al. 2005



Monclus et al. 2006

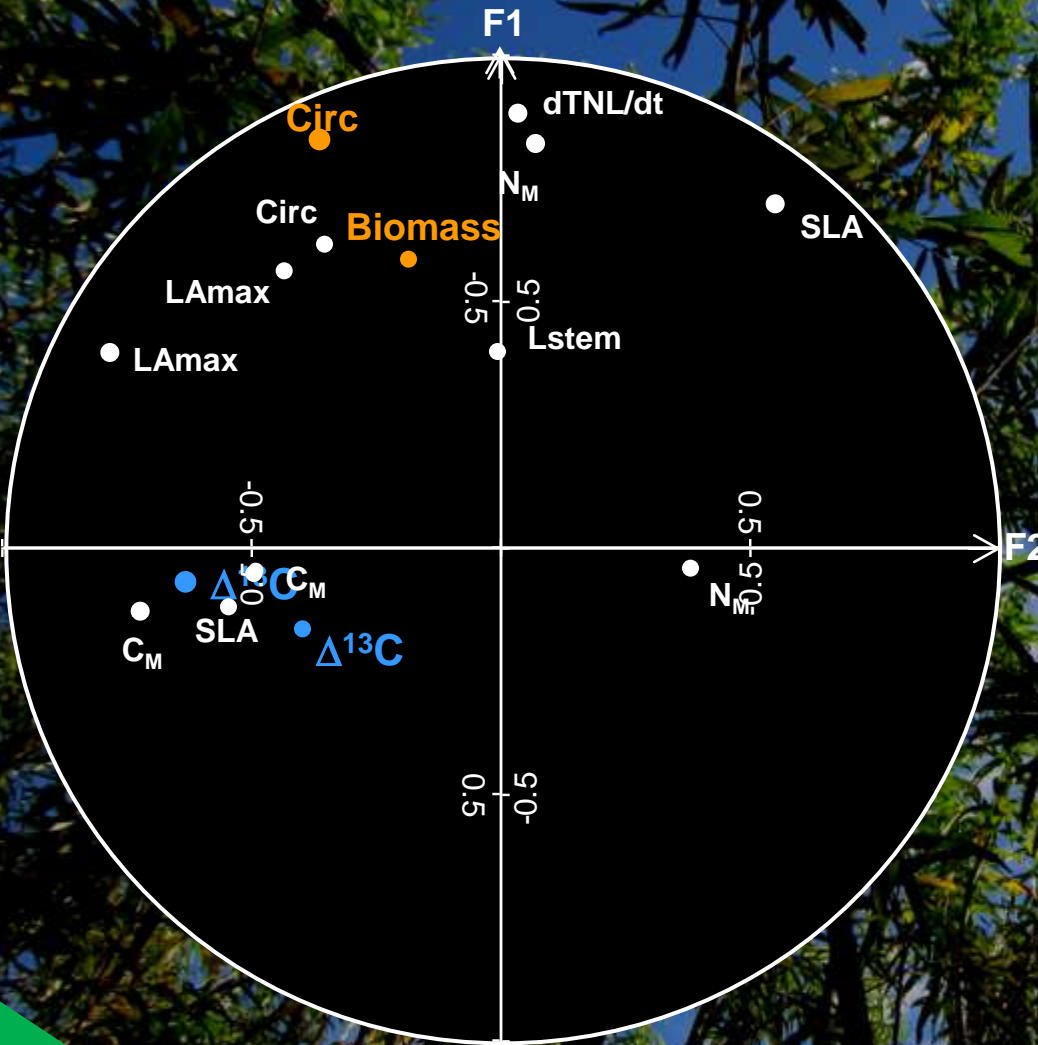
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European poplar clones (Belgian F1)



Marron *et al.* 2005



Monclus *et al.* 2005



Monclus *et al.* 2006



Marron and Ceulemans 2006

Dillen *et al.* 2011

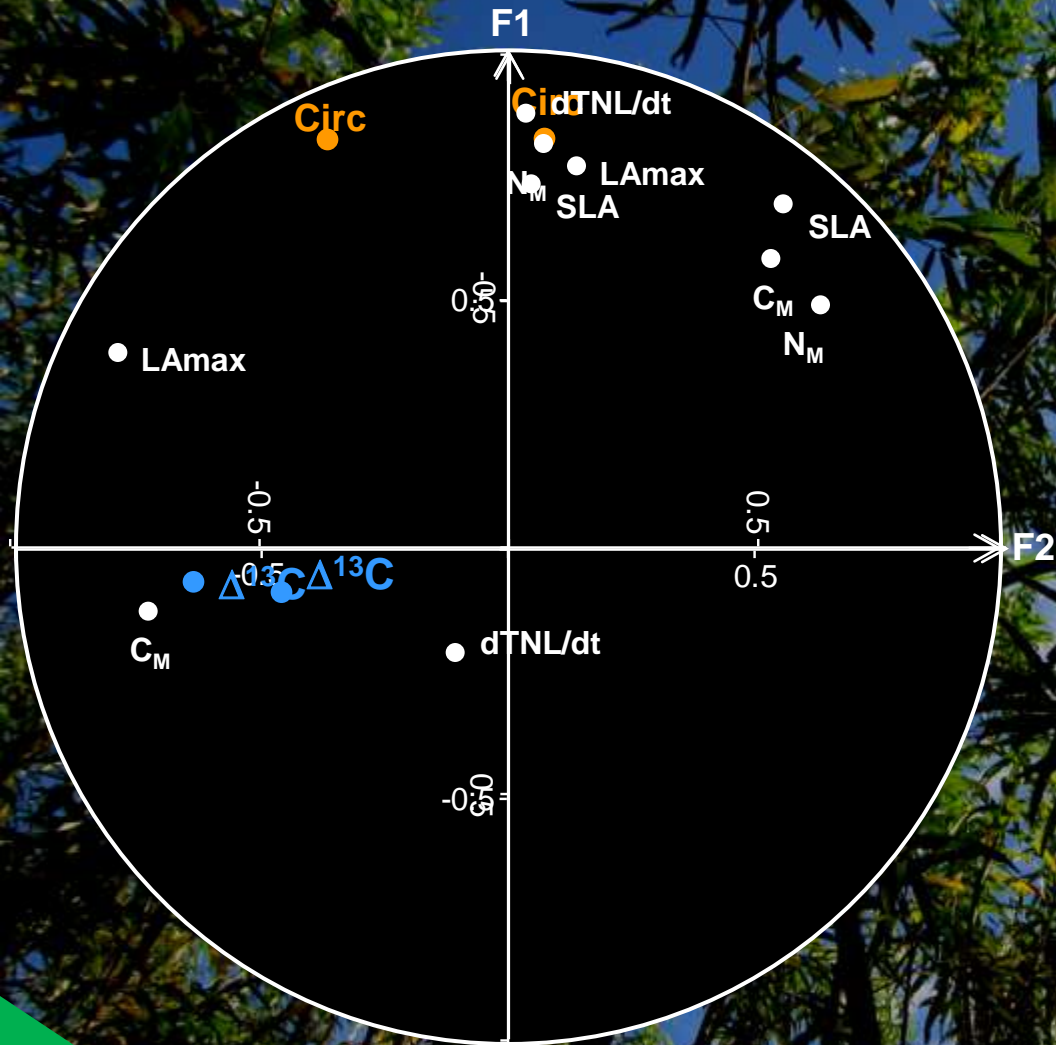
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European poplar clones (Belgian F1)



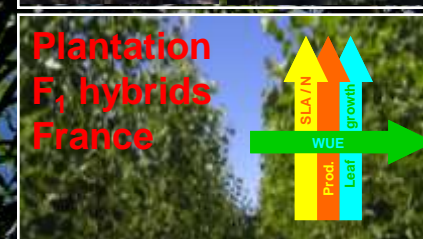
Marron *et al.* 2005



Monclus *et al.* 2005

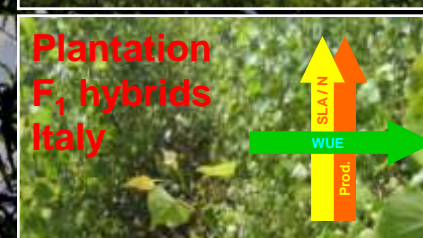


Monclus *et al.* 2006



Marron and Ceulemans 2006

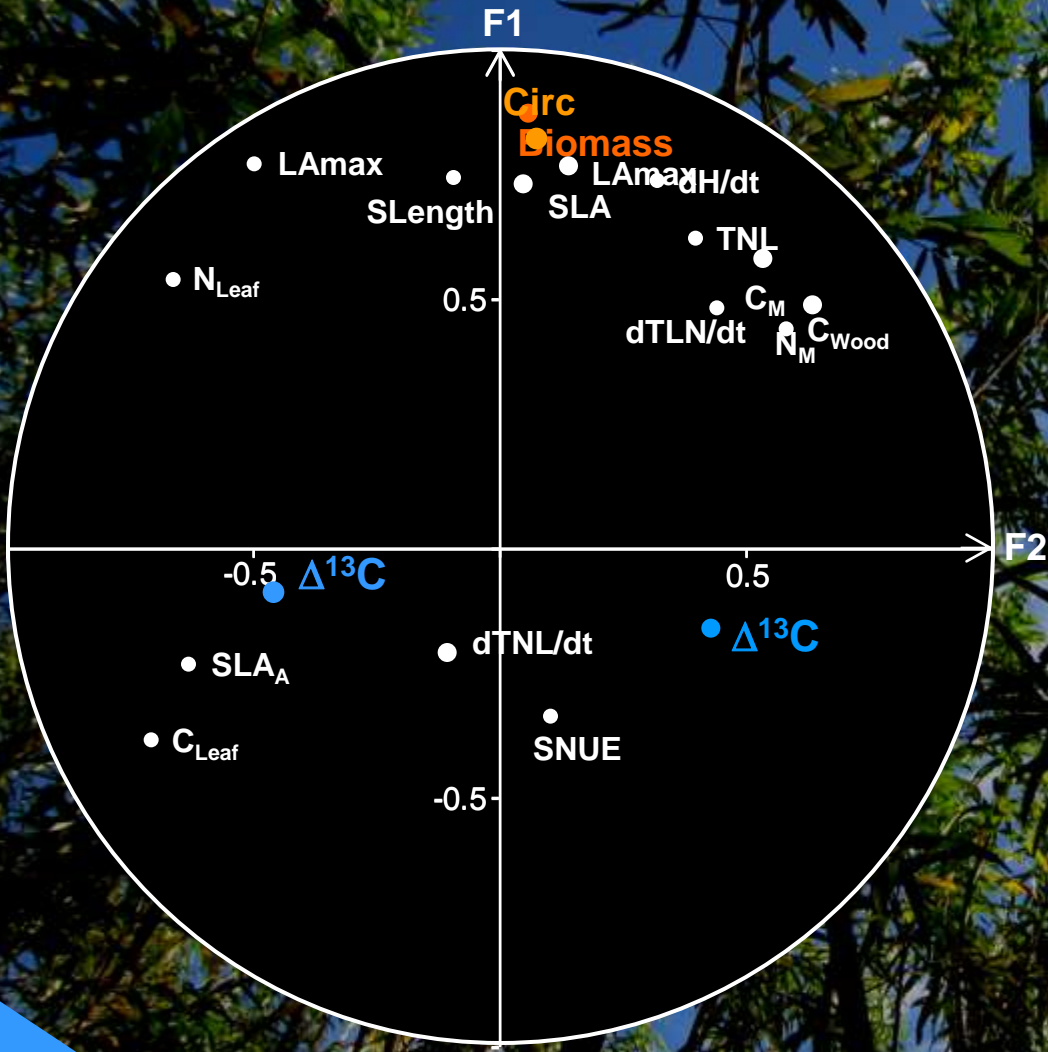
Dillen *et al.* 2011



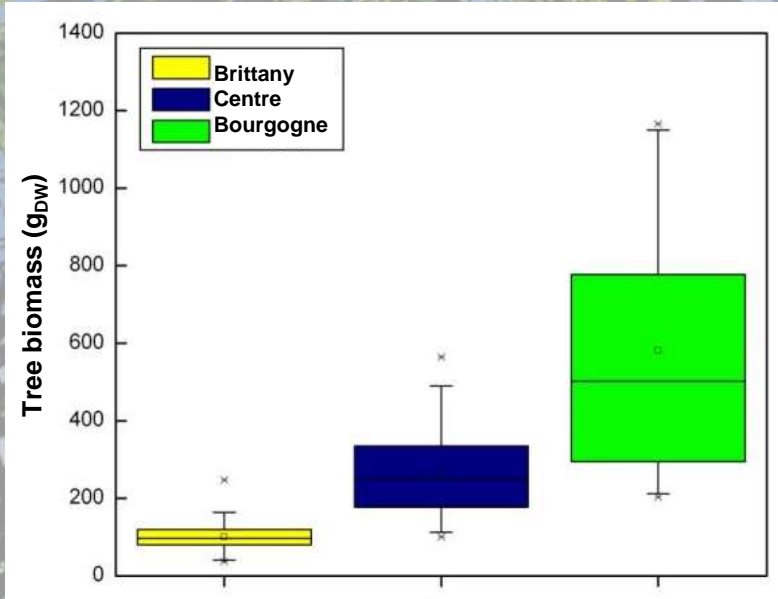
Marron *et al.* 2007

Dilleff *et al.* 2011

European willow clones (Sweden / Ireland)

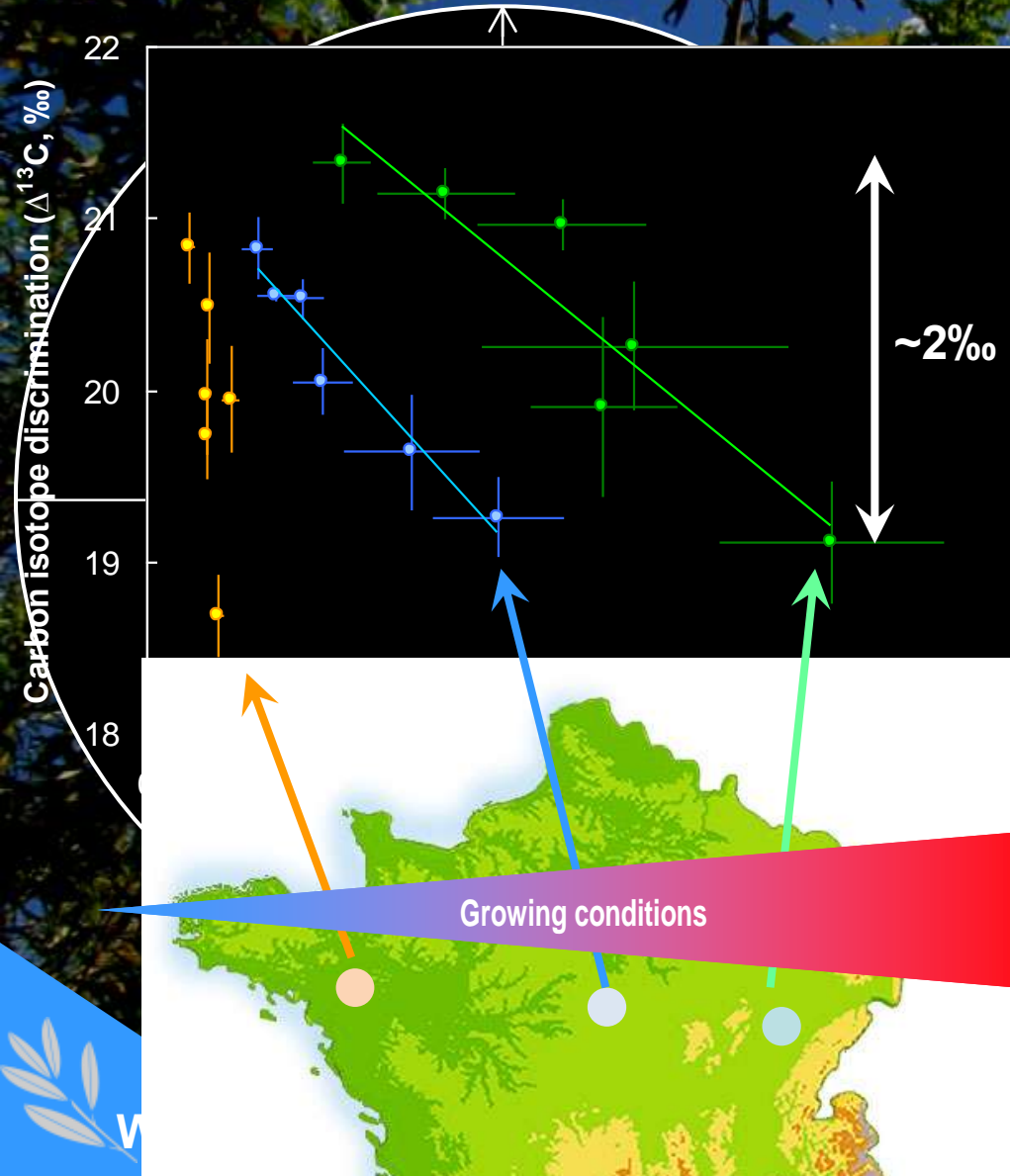


Six willow clones at 3 contrasting sites



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

European willow clones (Sweden / Ireland)



... when studied site by site...

Around 30% variation in Δ among willow clones

Clone ranking stable among sites

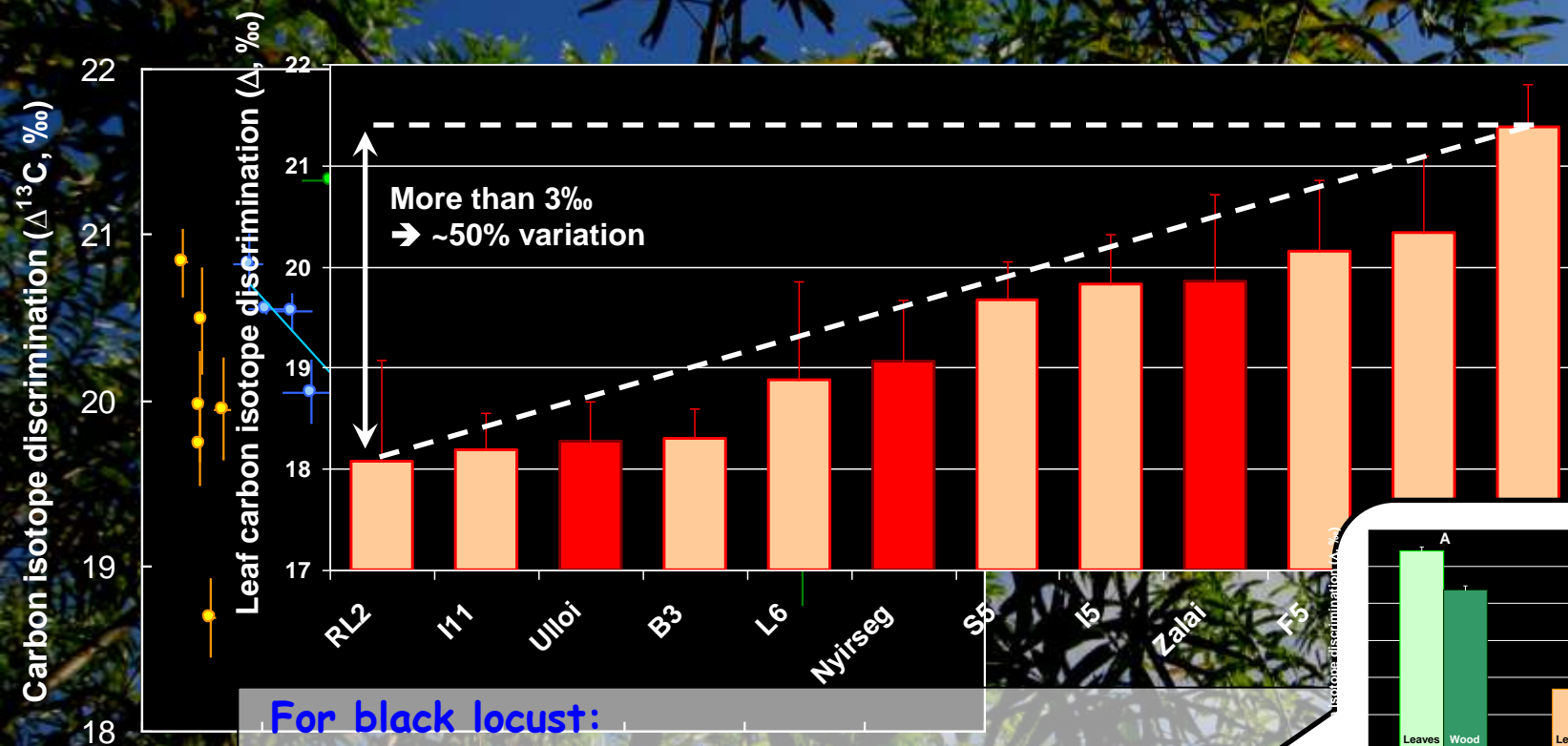
→ Quite wide variation enabling selection

Relation Δ / biomass stronger when conditions are favorable

→ Δ driven by assimilation at the "good" sites

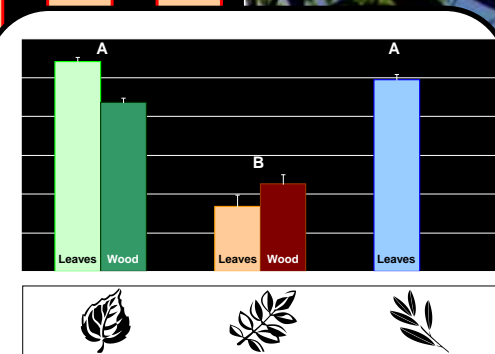
→ Δ driven by stomatal conductance at the "bad" site

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 Δ (17.2‰) and cutting Δ (19.5‰)
- Need to describe in more details this promising species for bioenergy



Why?

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In summary:

Variation

- Large Δ / 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 Δ and production has been shown

Willow: negative link Δ / 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

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

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

Farquhar *et al.* 1984

Source: atmospheric CO_2
 $\delta^{13}\text{C}_{air}$ c_a

