HAL
open science

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

To cite this version:

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-02748842v1

Submitted on 3 Jun 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

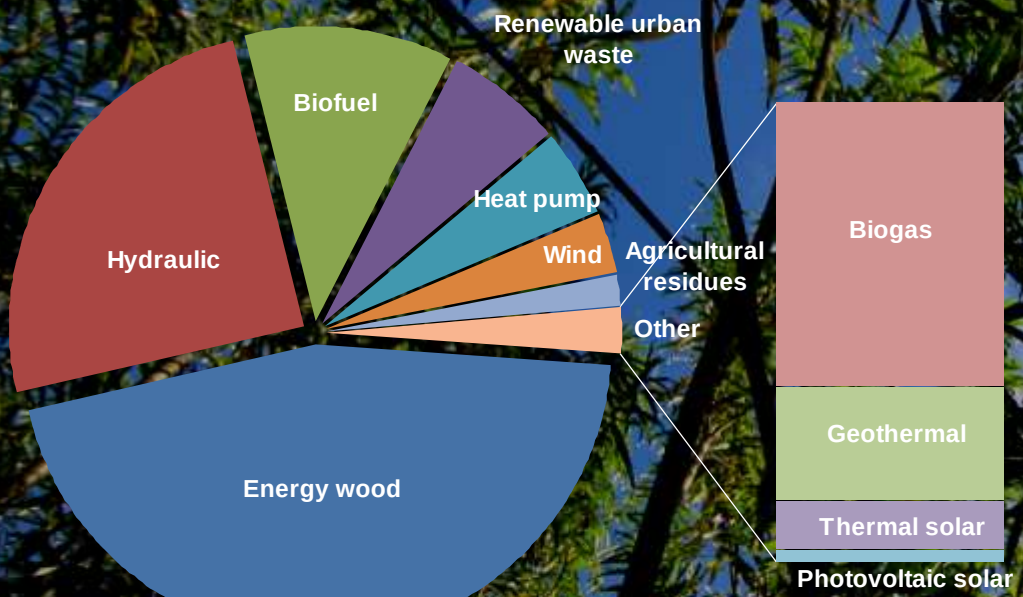
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

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

IPC – Edmonton
September 18-22, 2011



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

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

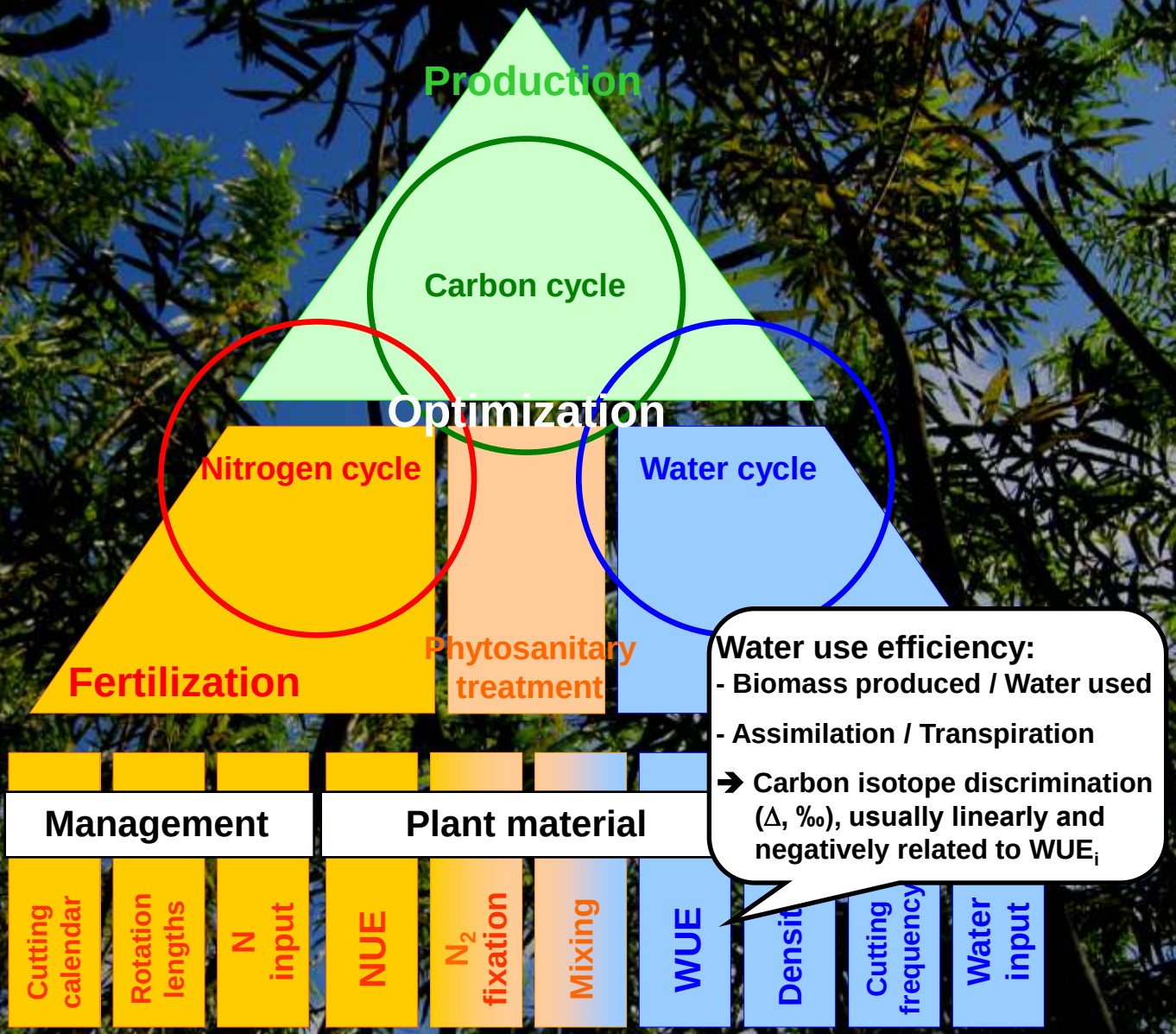
Most frequently used tree species in Europe:

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

➔ 1500 to 12 000 trees / ha

➔ 2 to 8 year rotations

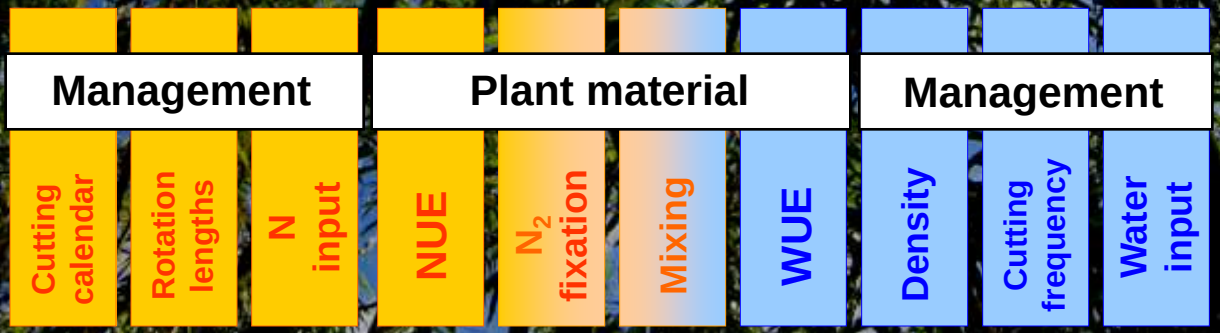
Why? **How?** Where? What?



Water use efficiency:

- Biomass produced / Water used
- Assimilation / Transpiration

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


Management
Plant material
Management
Cutting calendar
Rotation lengths
N input
NUE
N_2 fixation
Mixing
WUE
Density
Cutting frequency
Water input

Why? | **How?** | Where? | What?

CREFF — Cost Reduction and Efficiency Improvement of Short Rotation Coppice

SYLVABIOM

Intens&Fix

- ERA-Net Bi
- Franco-Ger
- "*Cost optim adapted pl*
- www.creff.e

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

Research Agency
ra"
m + Congo / Brazil
sification
st ecosystems"
rad.fr

			Cutting calendar	Management
			on hs	
			ut	
			E	Plant material
		×	N_2 fixation	
		×	Mixing	
×	×		WUE	
×	×		Density	Management
×			Cutting frequency	
×			Water input	

See poster

See poster

Why? | How? | **Where?** | What?

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

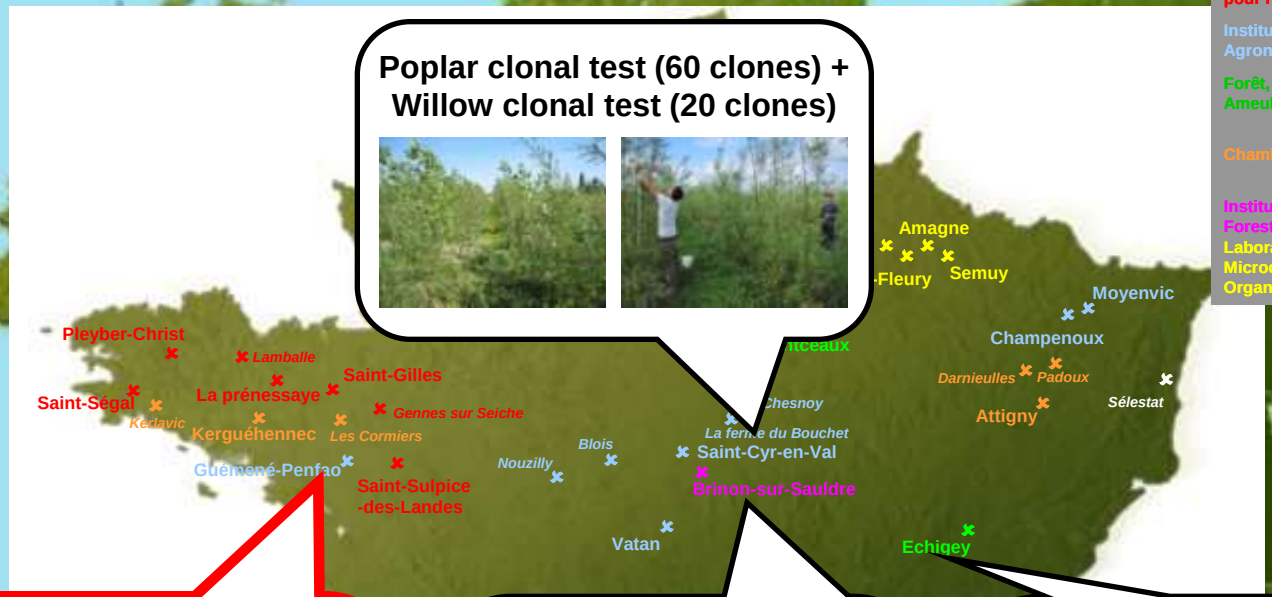
Institut National de la Recherche Agronomique

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

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?

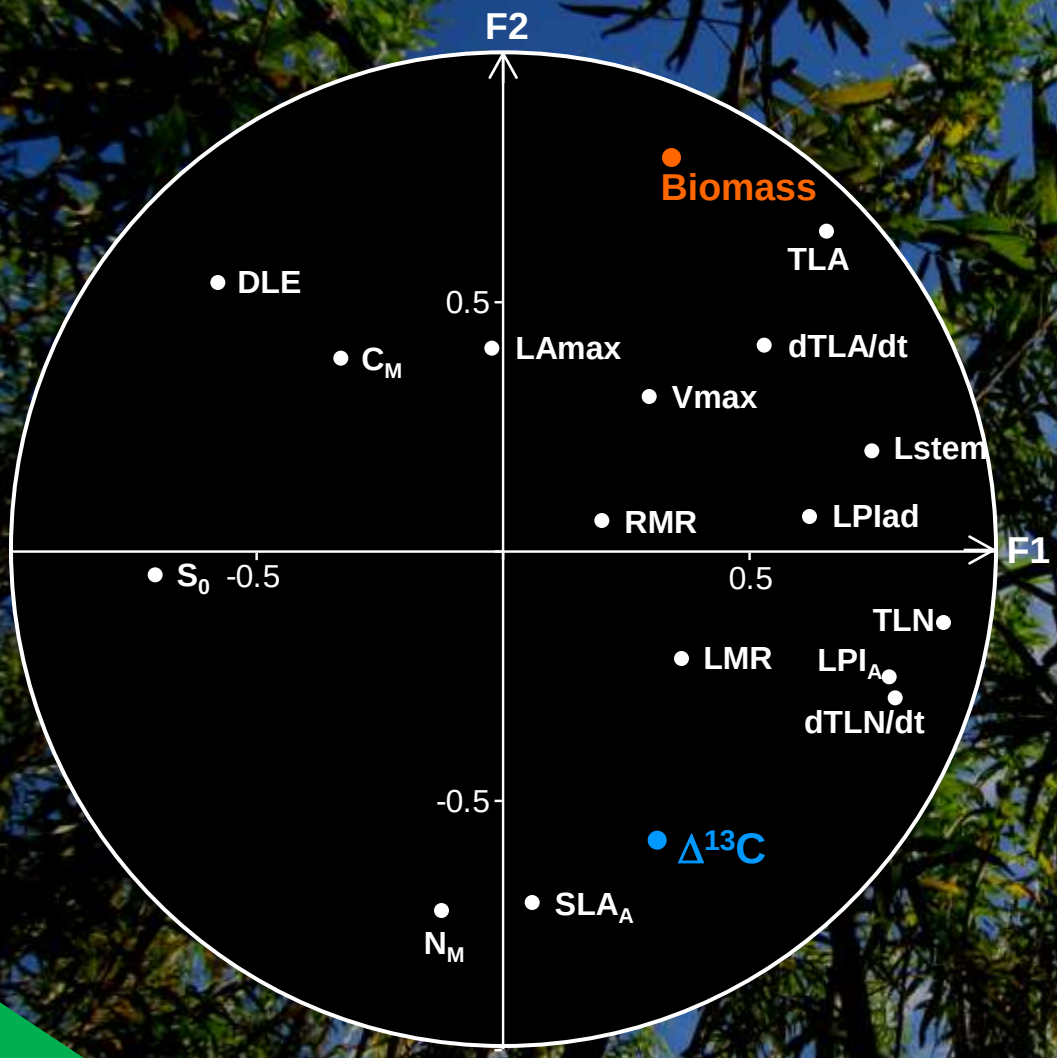
➔ Or due to extreme conditions at this site in 2010?

More precisely for each species…

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

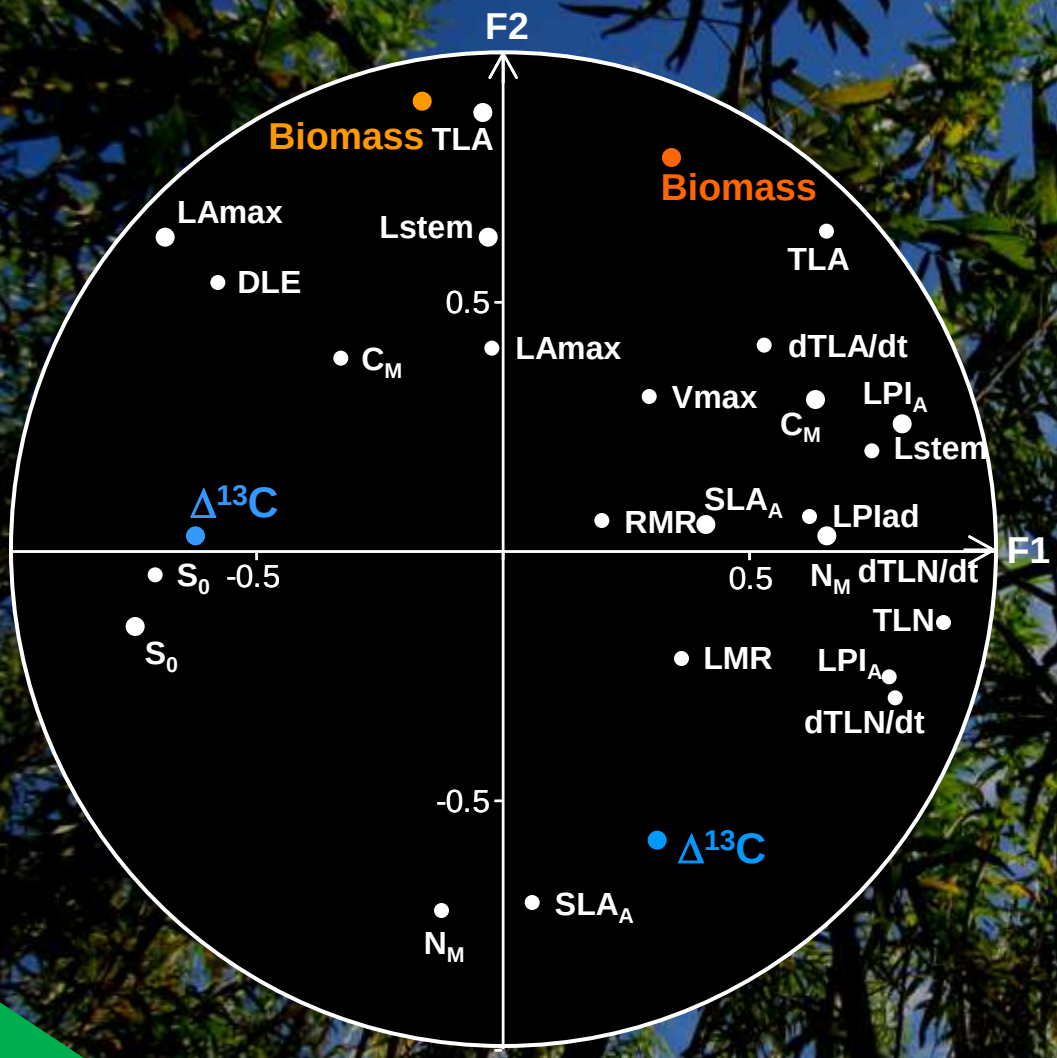
T°C : 16.7°C
Rainfall : 148 mm
OM : 39.5 g kg^{-1}
N : 1.7 g kg^{-1}

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



Marron *et al.* 2005

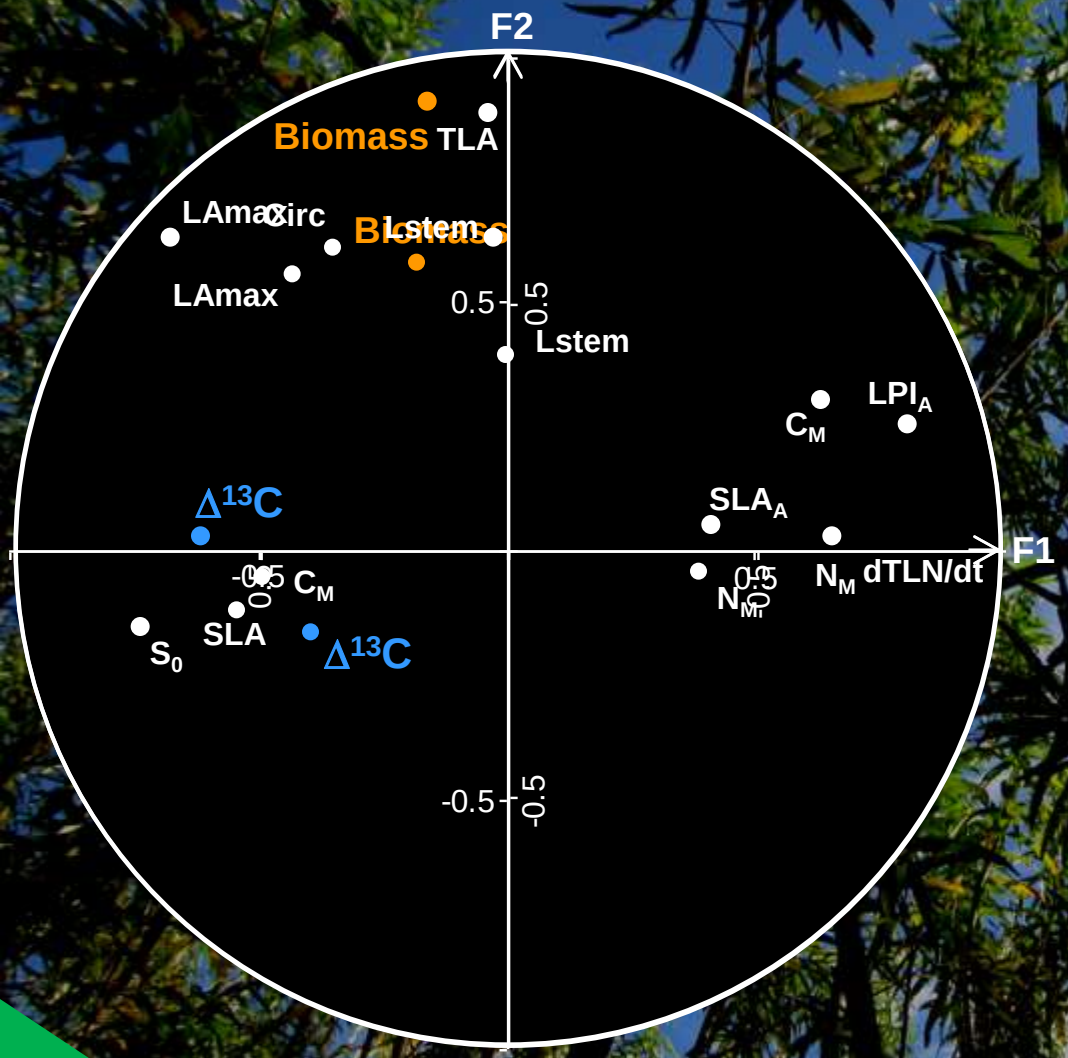
European poplar clones (Italy / Netherland / Belgium / France / Hungary)



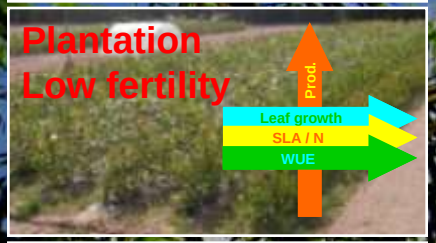
Marron *et al.* 2005

Monclus *et al.* 2005

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



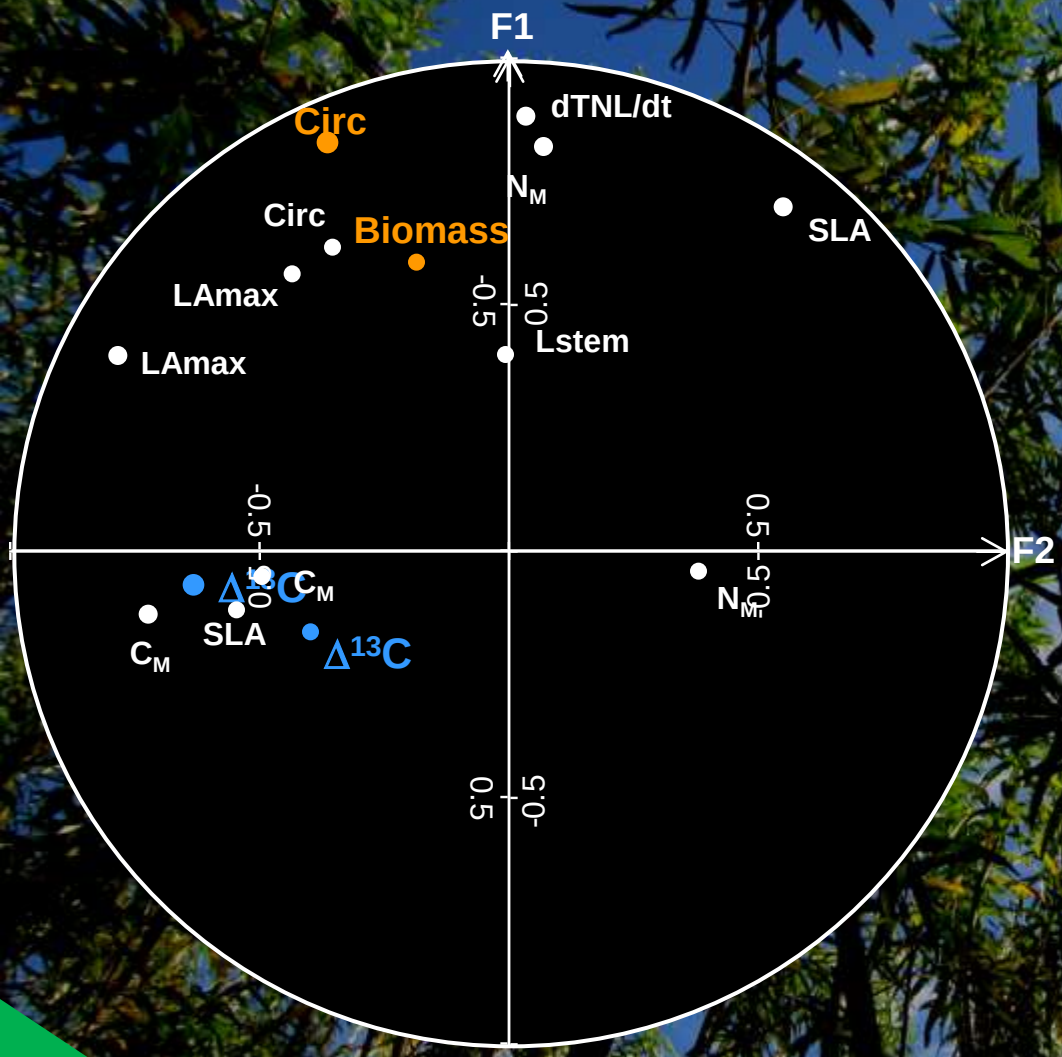
Marron *et al.* 2005



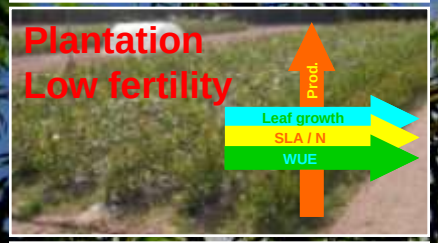
Monclus *et al.* 2005

Monclus *et al.* 2006

European poplar clones (Belgian F1)

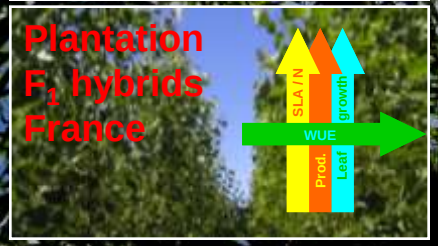


Marron *et al.* 2005



Monclus *et al.* 2005

Monclus *et al.* 2006

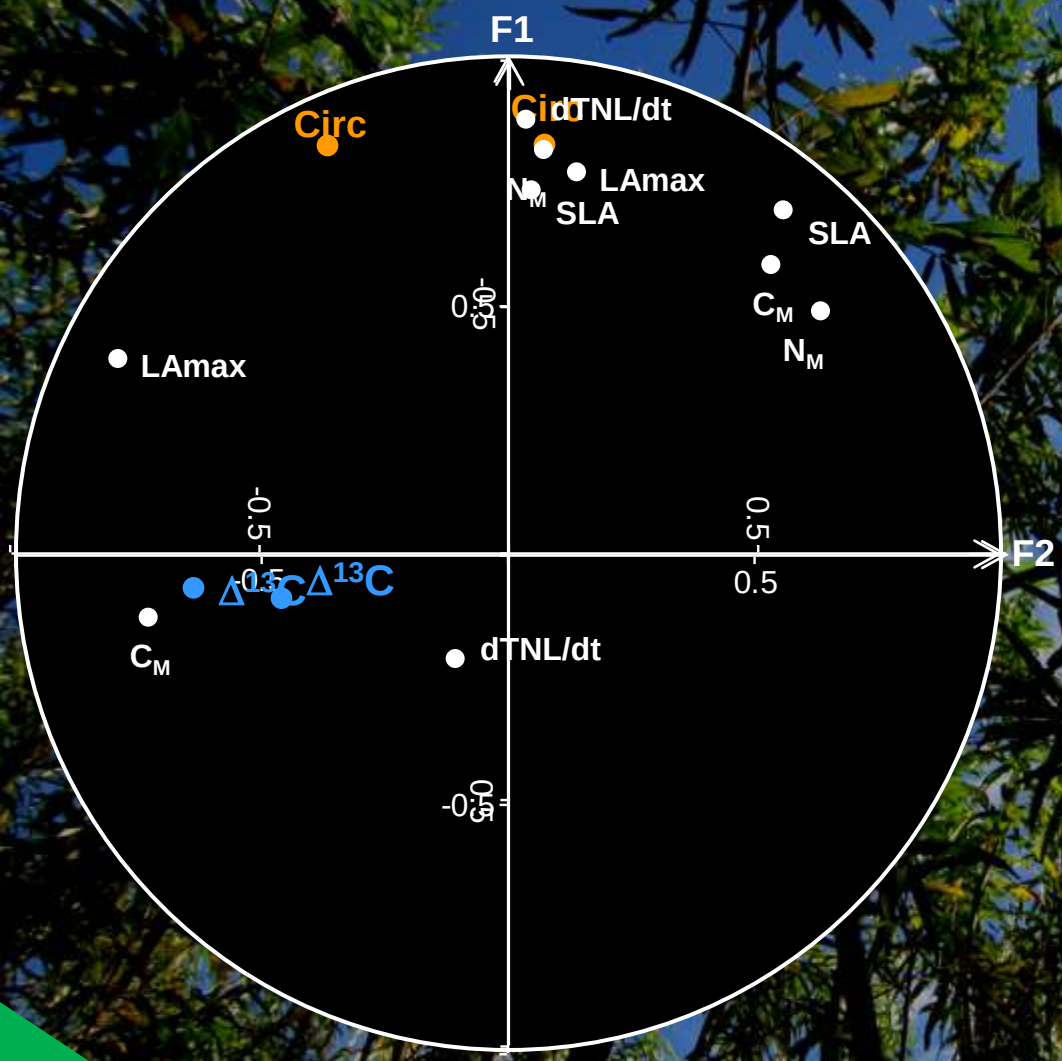


Marron and Ceulemans 2006

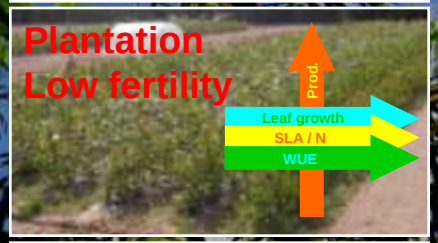
Dillen *et al.* 2011

Poplar

European poplar clones (Belgian F1)

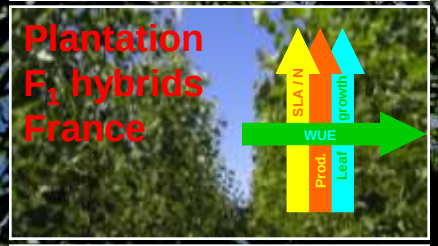


Marron *et al.* 2005



Monclus *et al.* 2005

Monclus *et al.* 2006



Marron and Ceulemans 2006

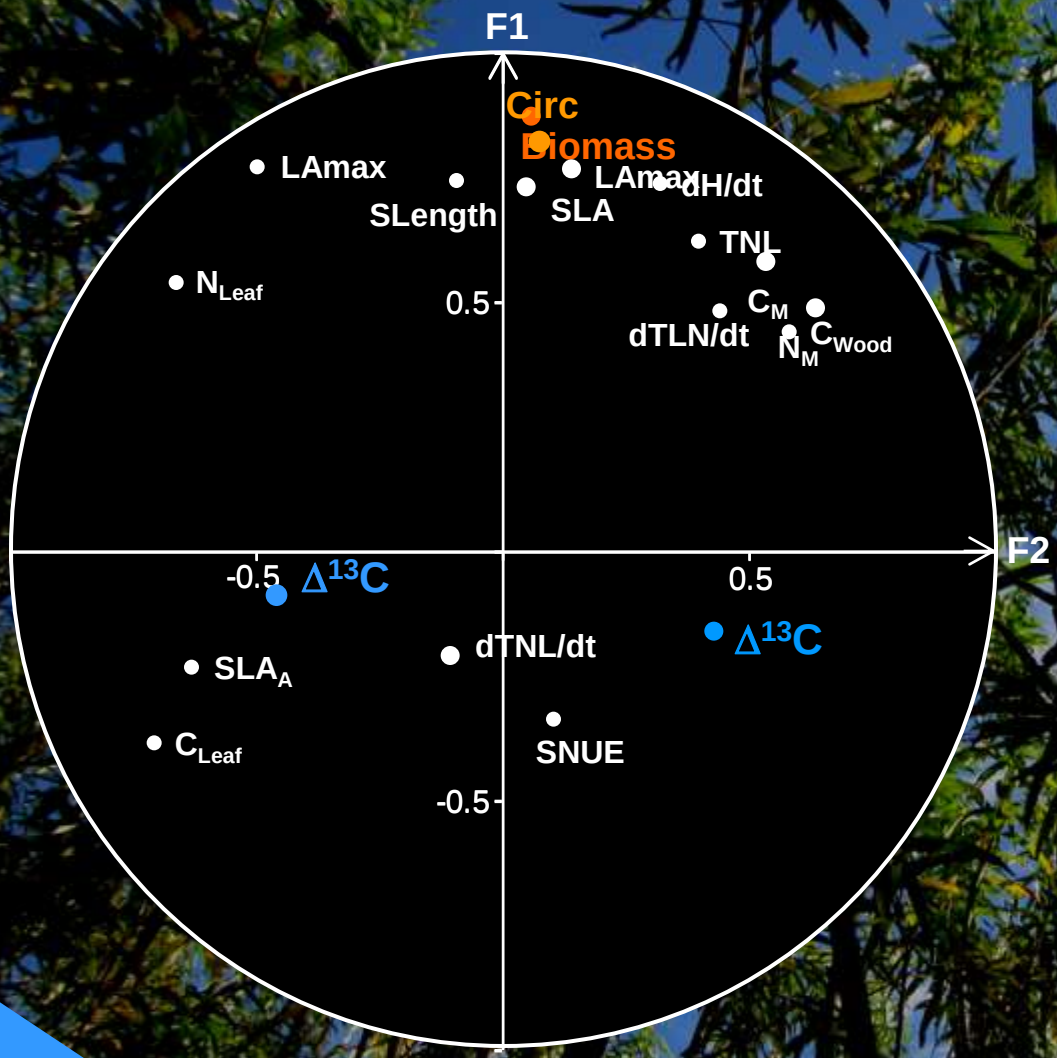
Dillen *et al.* 2011

Marron *et al.* 2007

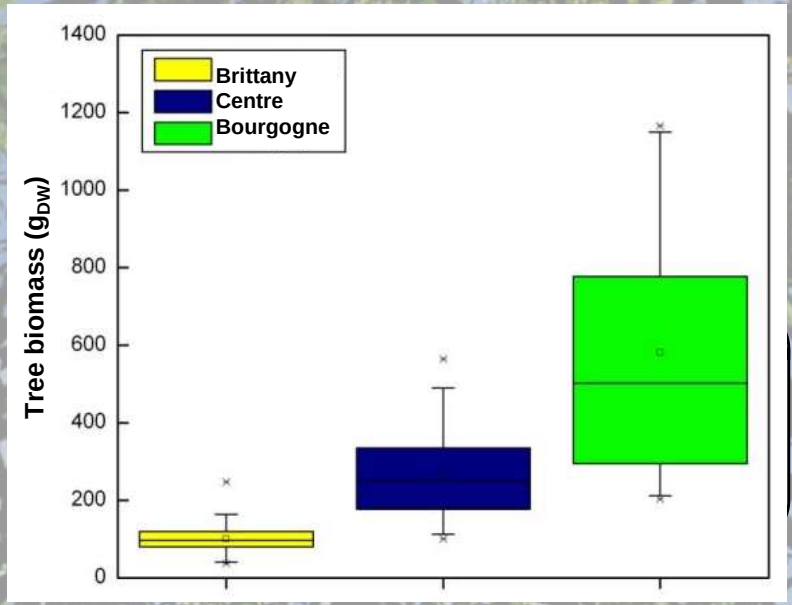
Dillen *et al.* 2011

Poplar

European willow clones (Sweden / Ireland)



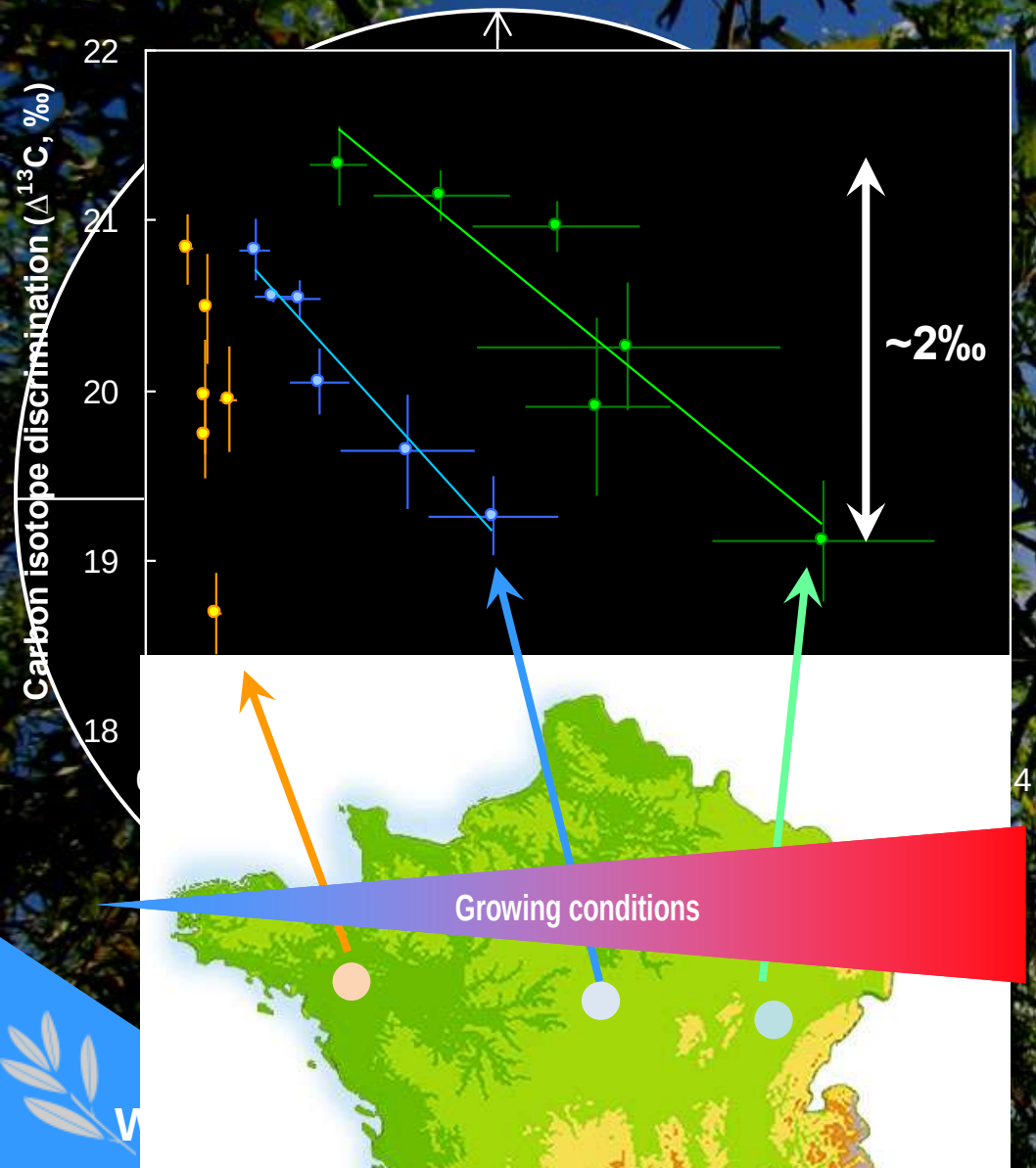
Six willow clones at 3 contrasting sites



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

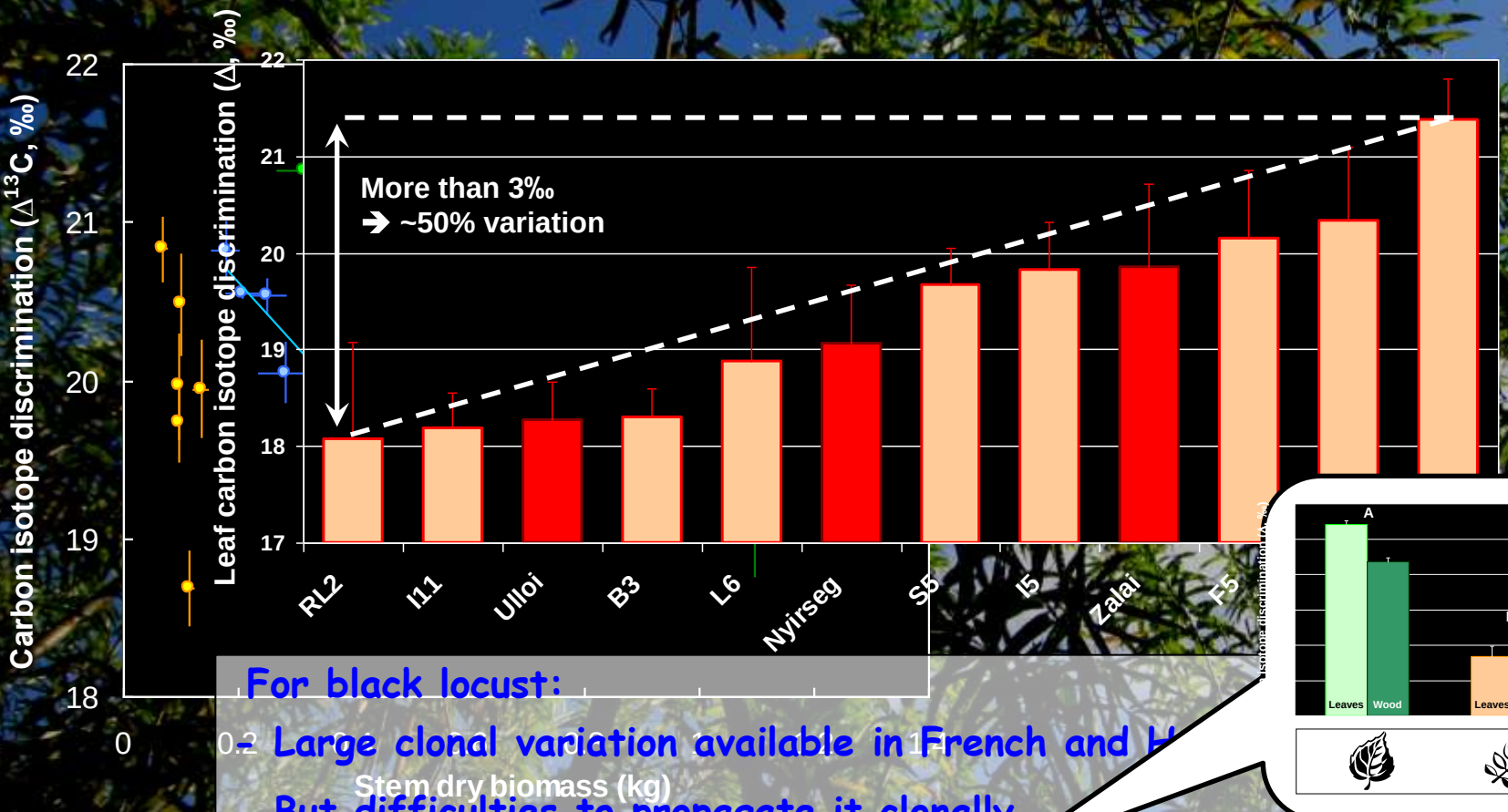
➔ Quite wide variation enabling selection

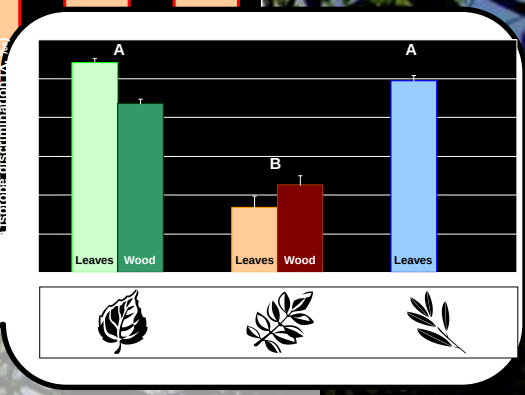
Relation Δ / biomass stronger when conditions are favorable

➔ 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 H
- 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

Black locust

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

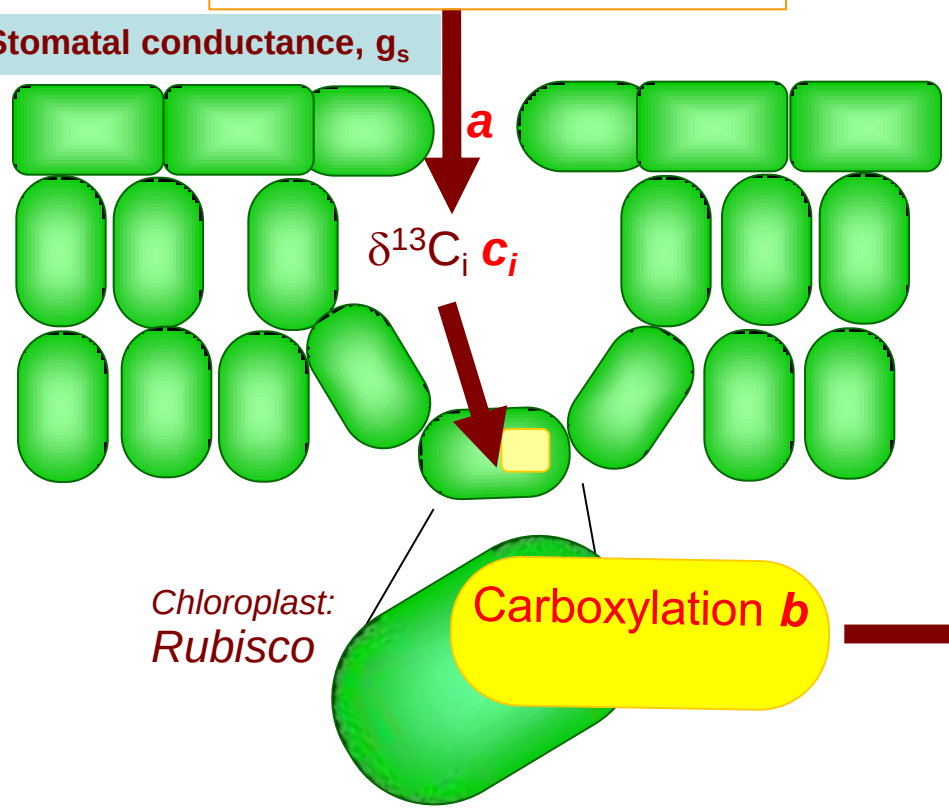
$$\Delta^{13}C \approx \delta^{13}C_{air} - \delta^{13}C_p$$

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

Farquhar *et al.* 1984

Source: atmospheric CO_2
$\delta^{13}C_{air}$ c_a

Stomatal conductance, g_s



Product: photosynthates $\delta^{13}C_p$

C_a : atmospheric CO_2 concentration

C_i : intercellular CO_2 concentration

C_c : chloroplastic CO_2 concentration

Discrimination factors:

a : 4.4‰

b : 27‰

$\delta^{13}C_{air}$: carbon isotope composition of atmospheric CO_2 (≈-8‰)

$\delta^{13}C_p$: carbon isotope composition of photosynthates