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To cite this version:

Marion Zapater, Nathalie Bréda, Guillaume Storchi, André A. Granier. Inter and intra-specific variability of carbon isotope composition (δ13C) and water use efficiency in 5 deciduous tree species growing a mixed stand in North-Eastern France. AGU Fall Meeting, Dec 2005, San Francisco, États-Unis. 1 p., 2005. hal-02830208

HAL Id: hal-02830208

https://hal.inrae.fr/hal-02830208v1

Submitted on 7 Jun 2020

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Paper Number : B11A-0999

Inter and intra-specific variability of carbon isotope composition ($\delta^{13}C$) and Water Use Efficiency in 5 deciduous tree species growing in a mixed stand in North Eastern France.

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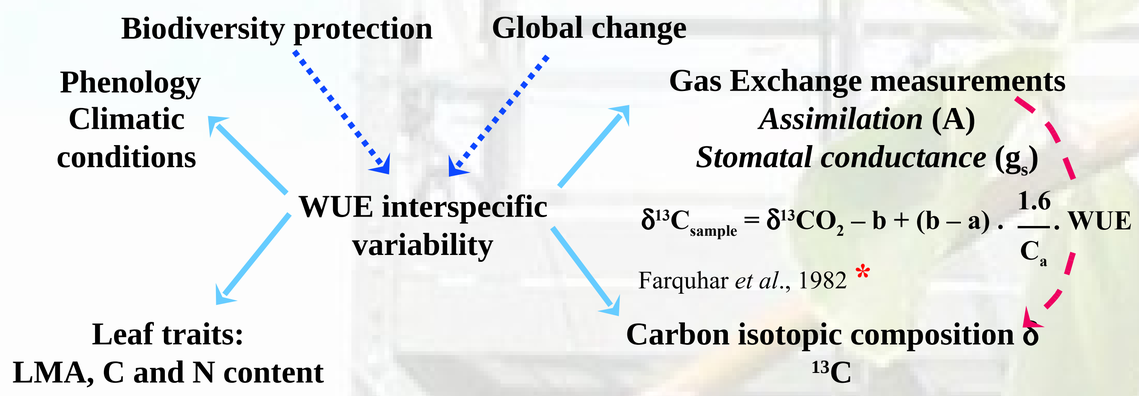
Introduction

• Little information is yet available on **response of mixed stands to climate change**

• **Intrinsic Water Use Efficiency** (**WUE**), *i.e.* the ratio between assimilation rate (A) and stomatal conductance (g_s), is a trait that reflects tree functioning, especially at the leaf level

• WUE can be estimated indirectly at leaf level, using **carbon isotopic composition ($\delta^{13}C$)** of leaf material (Farquhar *et al.*, 1982)

• We analysed WUE, phenology and other foliar traits on **five deciduous european tree species** to
*** compare variability of these traits among species**
*** link trait differences to functional ecological groups (shade tolerance)**



* where
a: discrimination coefficient during stomatal diffusion
b: discrimination coefficient during carboxylation (*via* PEP_C and Rubisco)
C_a: atmospheric concentration in CO_2.
WUE_{int}: Intrinsic Water Use Efficiency (*i.e.* A/g_s)

Material and Methods

✓Experimental site : Hesse forest, a 15-25 years old broad-leaved mixed stand in North Eastern France (N 48°40'27"; E7°03'53"; Elevation 305m), belonging to the international networks CARBOEUROPE and FLUXNET.

✓A portable photosynthesis system (LI-6200, Licor, Lincoln, USA) was used to measure leaf gas exchange (A, g_s, WUE).

✓Foliar and soluble sugar $\delta^{13}C$, carbon (%C: $gC/g_{dry\ matter}$) and nitrogen (%N) leaf content were determined using a continuous flow isotope ratio mass spectrometer (Delta S; Thermofinnigan, Bremen, Germany) coupled with a nitrogen-carbon elementary analyser (Na 1500 Carlo Erba, Italie).

✓Measurements were performed during late spring-early summer (2005).

✓Measurements were carried out at 2 levels in the canopy, in sun and shade leaves.

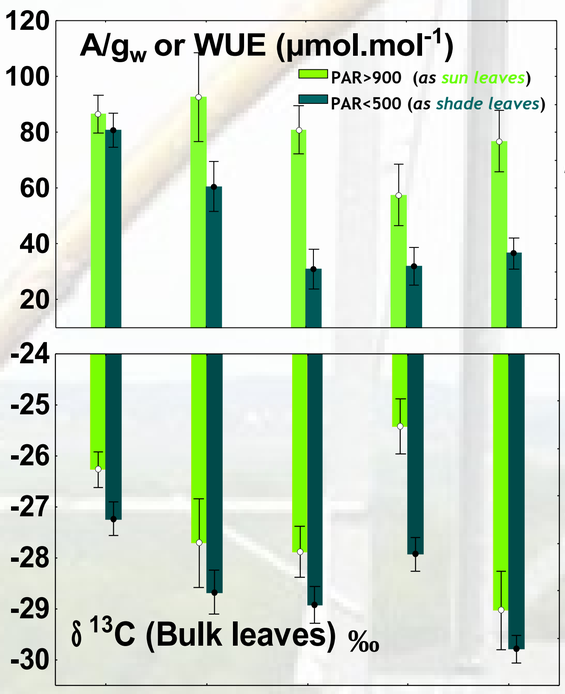
✓Phenology was followed during spring bud break;

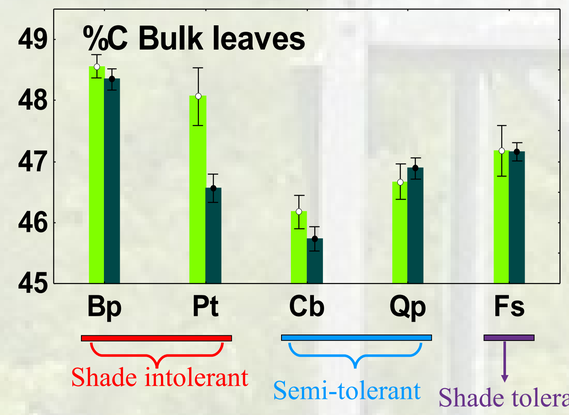
✓LMA (Leaf Mass Area) is the ratio between foliar dry mass and leaf area

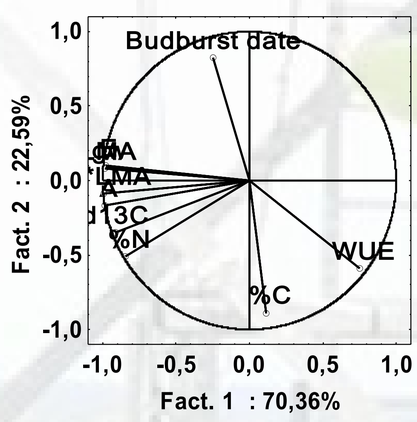
✓The studied species belong to contrasted functional types of light tolerance:

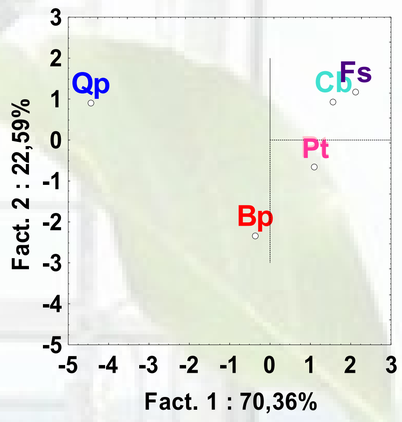
3 Silver birches	Bp	*Betula pendula*	Pioneer	shade intolerant
1 European Aspen	Pt	*Populus tremula*	Pioneer	shade intolerant
3 Hornbeams	Cb	*Carpinus betula*	Post pioneer	semitolérant
3 Sessile oaks	Qp	*Quercus petraea*	Post pioneer	semitolérant
3 European Beeches	Fs	*Fagus sylvatica*	late successionnal	shade tolerant

Results





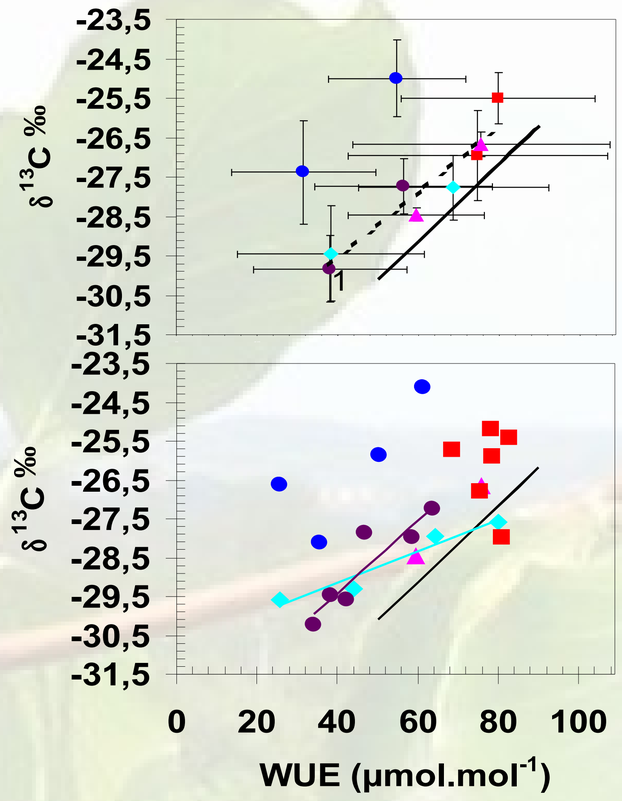




Clustering of species using Principal Components Analysis :
Quercus largely separated on the first axis : A, gs, $\delta^{13}C$, % N, LMA
Betula separated on second axis : phenology, % C

Interspecific variability and difference between lower canopy (shade leaves); and **upper canopy** (sun leaves) **of δ13C, WUE and bulk leaves %C**

Confidence Interval



Relationship between WUE and $\delta^{13}C$, pooling the two canopy levels: interspecific (upper figure) and intraspecific (lower figure). (bars represent standard deviation)

Theoritical relationship Farquhar *et al.*, 1982	y= -35 + 0.0979*x		
Interspecific Relationship w/o Quercus data	y= -32.89+0.08*x	r^2= 0.89	p<0.05
Carpinus betula	y= -30.76 + 0.04*x	r^2= 0.94	P< 0.05
Fagus sylvatica	y= -33.17 + 0.09*x	r^2= 0.84	P< 0.05

Relatioships are non-significant for the three others species

Discussion and conclusions

• **Clear differences in soluble sugar $\delta^{13}C$ and WUE were found among the investigated species, independently of the leaf location in the canopy**

• Within each tree species:
i) **shade leaves had lower WUE, and more negative $\delta^{13}C$ than sun leaves**;
ii) variability among trees was low compared to among species

• No trait alone clustered the functional types, except %C and phenology,
This was mainly due to the Birch trees, which had a higher carbon content and an earlier bud break compared to the other species

• linear relationships were found between WUE and $\delta^{13}C$

* At the **intra-specific level** for ***Fagus sylvatica*** and ***Carpinus betula***.
* At the **inter-specific level**, when omitting the ***Quercus*** data
The ***Quercus*** leaves were non-mature (only 30 days when measurements occured) (Morecroft and Roberts, 1999), while in the ***Fagus*** species the full maturity time is shorter (about 30 days, Granier *et al.*, 2000)

* Difference to theoretical relationship (**Farquhar *et al.*, 1982) mainly due to differences in intercept**

Differences among the species' WUE/$\delta^{13}C$-relationships might be species-specific and could be caused by differences in:

*** Isotopic composition of air within the canopy (here -8‰ was used)**

*** dark respiration, photorespiration and leaf internal resistance to CO_2 transfert**

* the proportion of PEPc in total CO_2 fixation (**b**)

Aknowlegment

We are grateful to Claude Bréchet, Oliver Brendel, Bernard Clerc, Sylvain Mathieu, Pierre Montpied, Didier Le Thiec and François Willm for their help.
This work was supported by GIP ECOFOR and CARBOEUROPE-IP (505 572).

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