Leaf and tree water-use efficiencies of *Populus deltoides* × *P. nigra* in mixed forest and agroforestry plantations

Anaïs Thomas, Nicolas Marron, Damien Bonal,

Séverine Piutti, Erwin Dallé and Pierrick Priault

arbre

UNIVERSITÉ DE LORRAINE

INRAe

➤ Water becomes a scarce resource under temperate latitudes

➤ Mixture plantations have the potential to optimize
the quantitative use of this resource

➤ Water may be used more efficiently by the trees (to produce biomass)
as compared to a monoculture because of niche complementarity

➤ This potential has seldom been demonstrated

To determine if species mixing has an impact on poplar WUE and if the potentially highlighted differences could be found independently of scale, spatial (leaf and tree level) and temporal (instantaneous, leaf lifetime, growing season)

Hypotheses

The species interactions will allow the poplars in the mixtures to increase WUE compared to the poplars in monoculture thanks to:
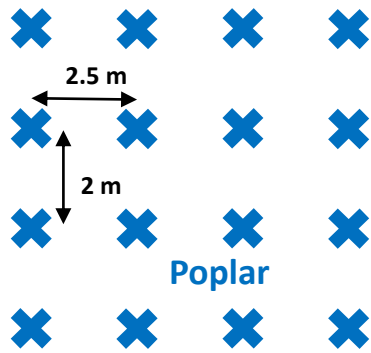
(1) a reduction in competition

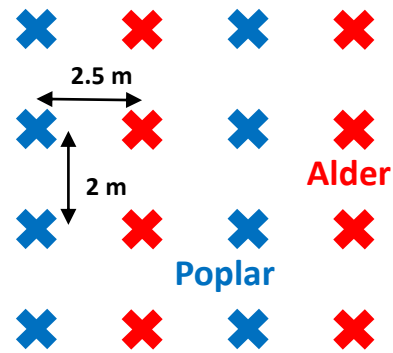(2) and / or a facilitation effect due to the presence of the N_2-fixing species in mixtures

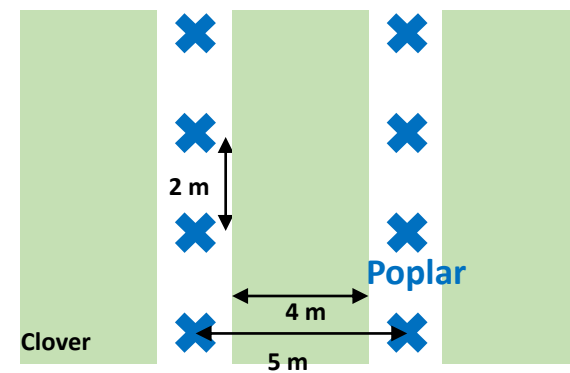➢ Three ha plantation in northeastern France, installed in 2014

➢ Three treatments:

Monoculture plot detail

Forest mixture plot detail

Agroforestry plot detail

➢ Twelve poplar trees per treatment

Instantaneous

Leaf gas exchanges

Intrinsic water-use efficiency (WUE$_i$) $= \dfrac{\text{Light-saturated net } CO_2 \text{ assimilation}}{\text{Stomatal conductance}}$

Leaf life span

Mass spectrometry

Carbon isotope discrimination (Δ, ‰)

Known to be inversely proportional to WUE$_i$

Growing season 2020

Allometric equations

$$\text{Transpiration water-use efficiency (WUE}_T) = \frac{\text{Biomass increment}}{\text{Transpiration}}$$

Sap flow measurements

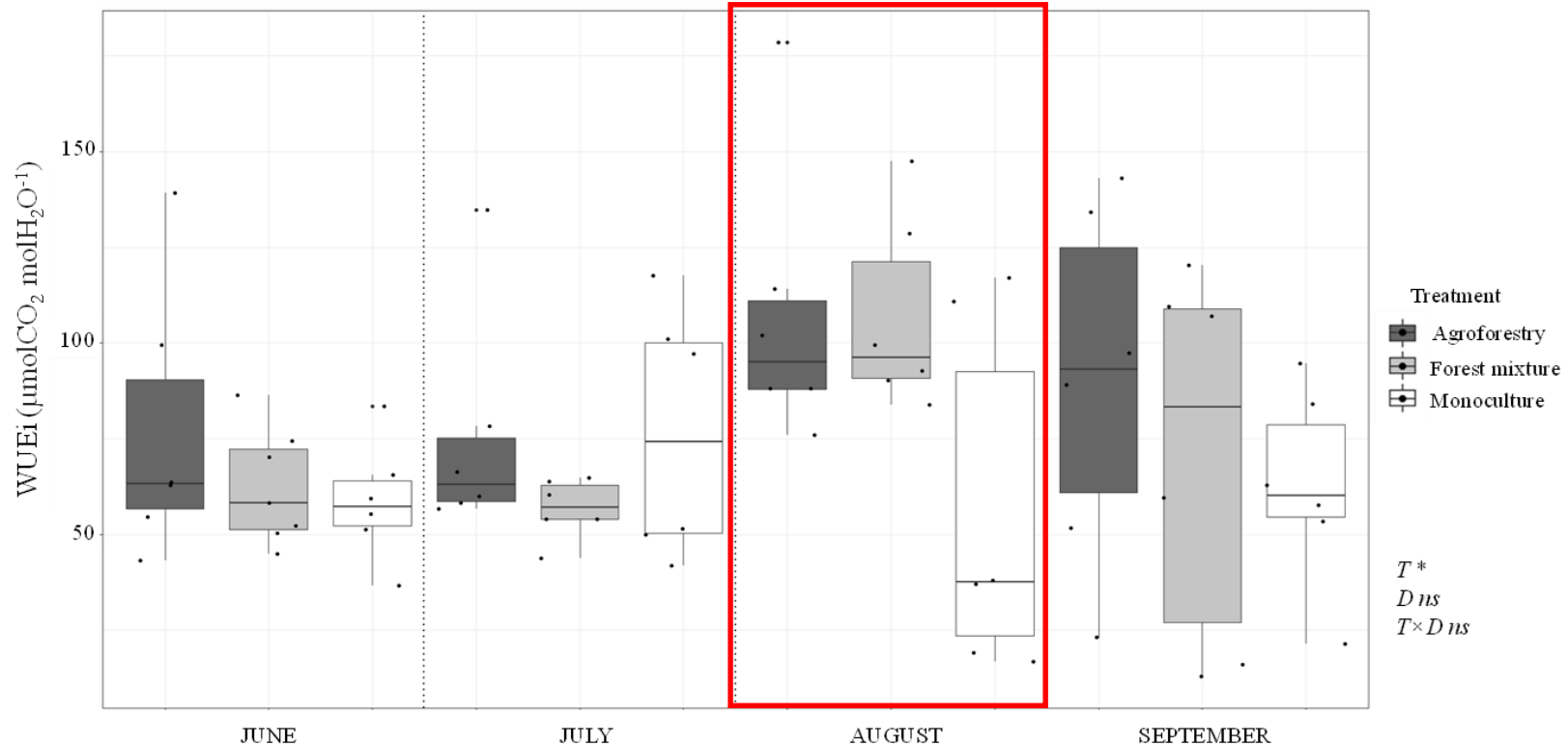Stem microcores ➜ Mass spectrometry

Ring carbon isotope discrimination (Δ_{wood}, ‰)

Known to be inversely proportional to WUE$_T$

Growing season 2020

Introduction	Methods	**Results**	Discussion

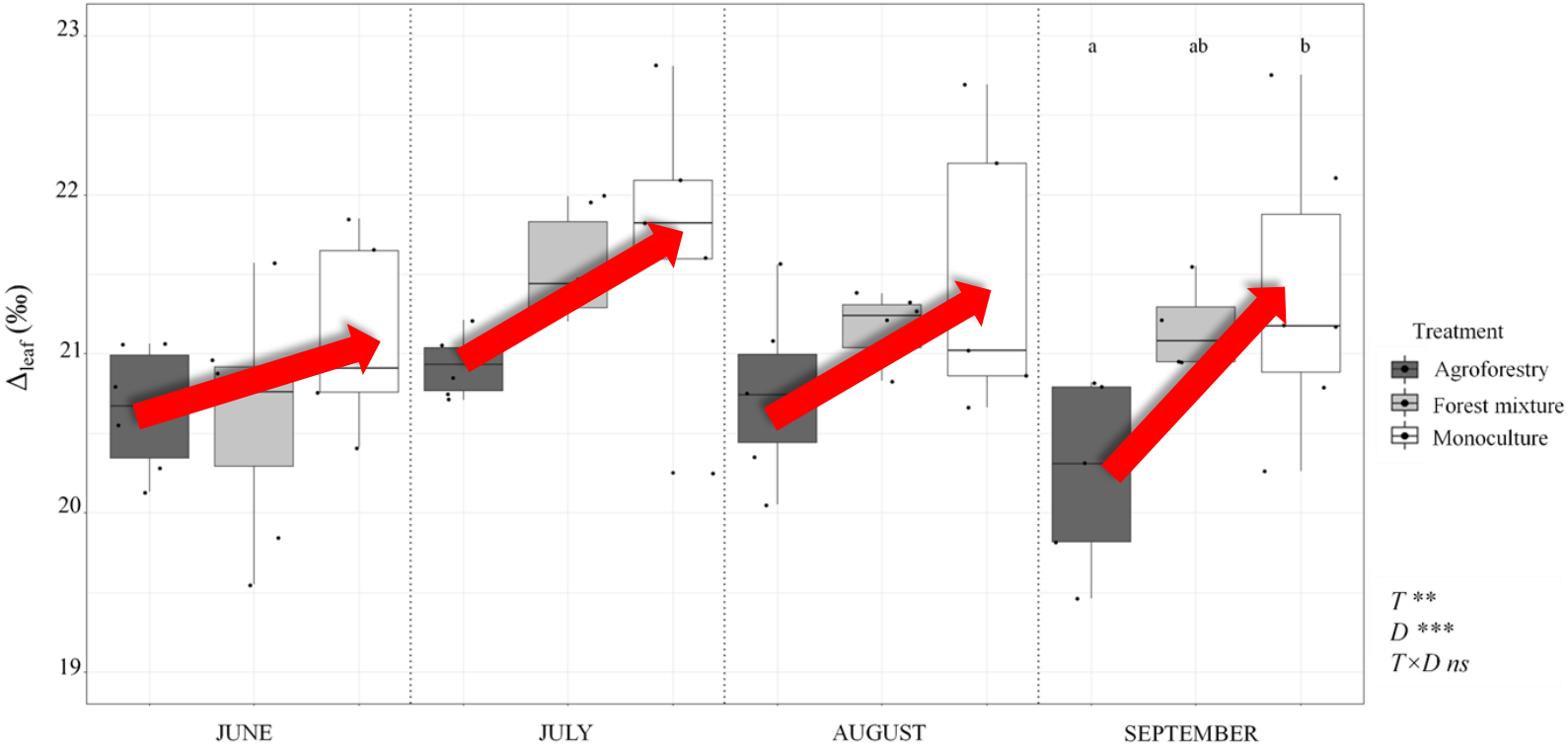| Context	Objective	Site	Leaf	Tree	**Leaf**	Tree	Factors	Drivers

Thomas et al. 2022

➢ WUE$_i$ higher in the agroforestry than in the monoculture

➢ August: WUE$_i$ ↗ in the mixtures and ↘ in the monoculture (gap increase)
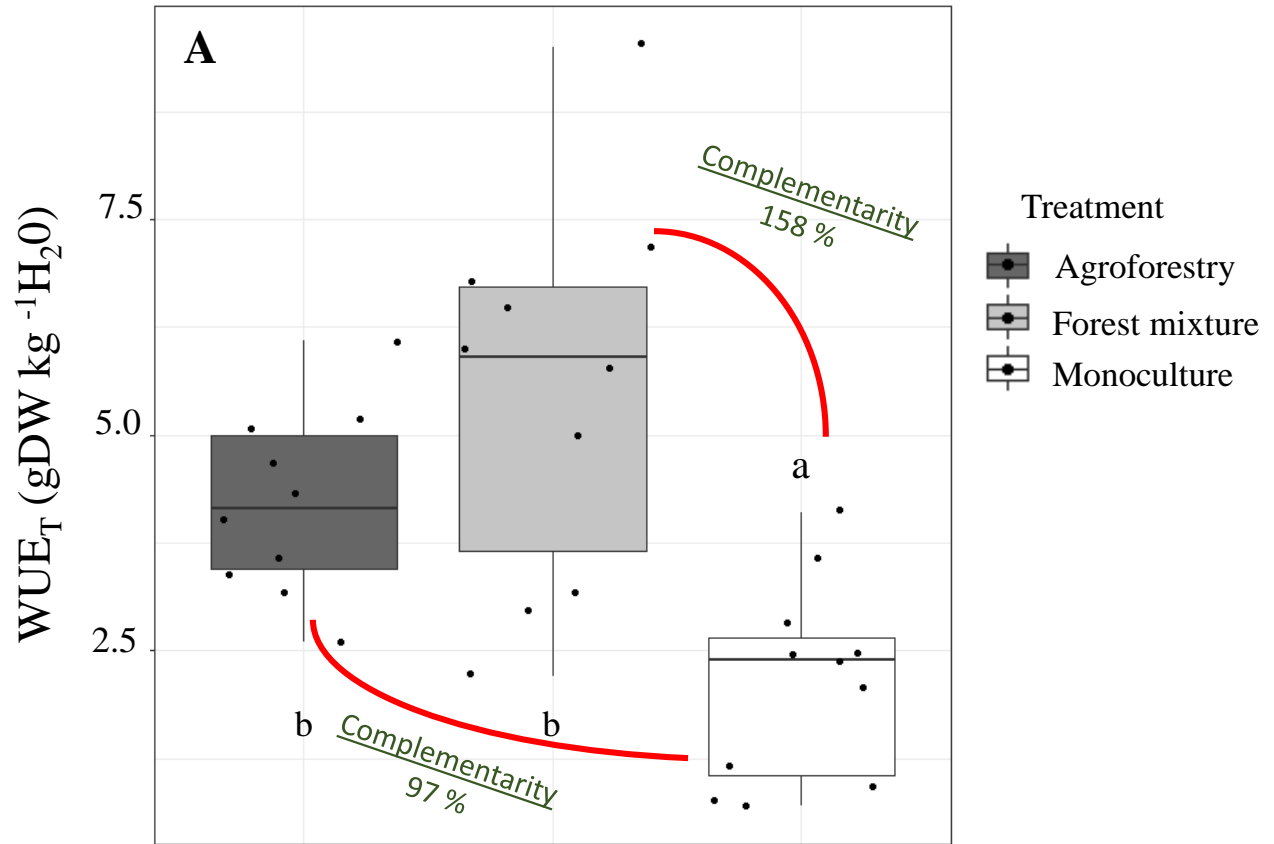
Thomas et al. 2022

> ➤ Identical trends as for WUE$_i$: Lower values in the agroforestry (higher WUE)
> Gap increase at the end of the season

Introduction	Methods	**Results**	Discussion

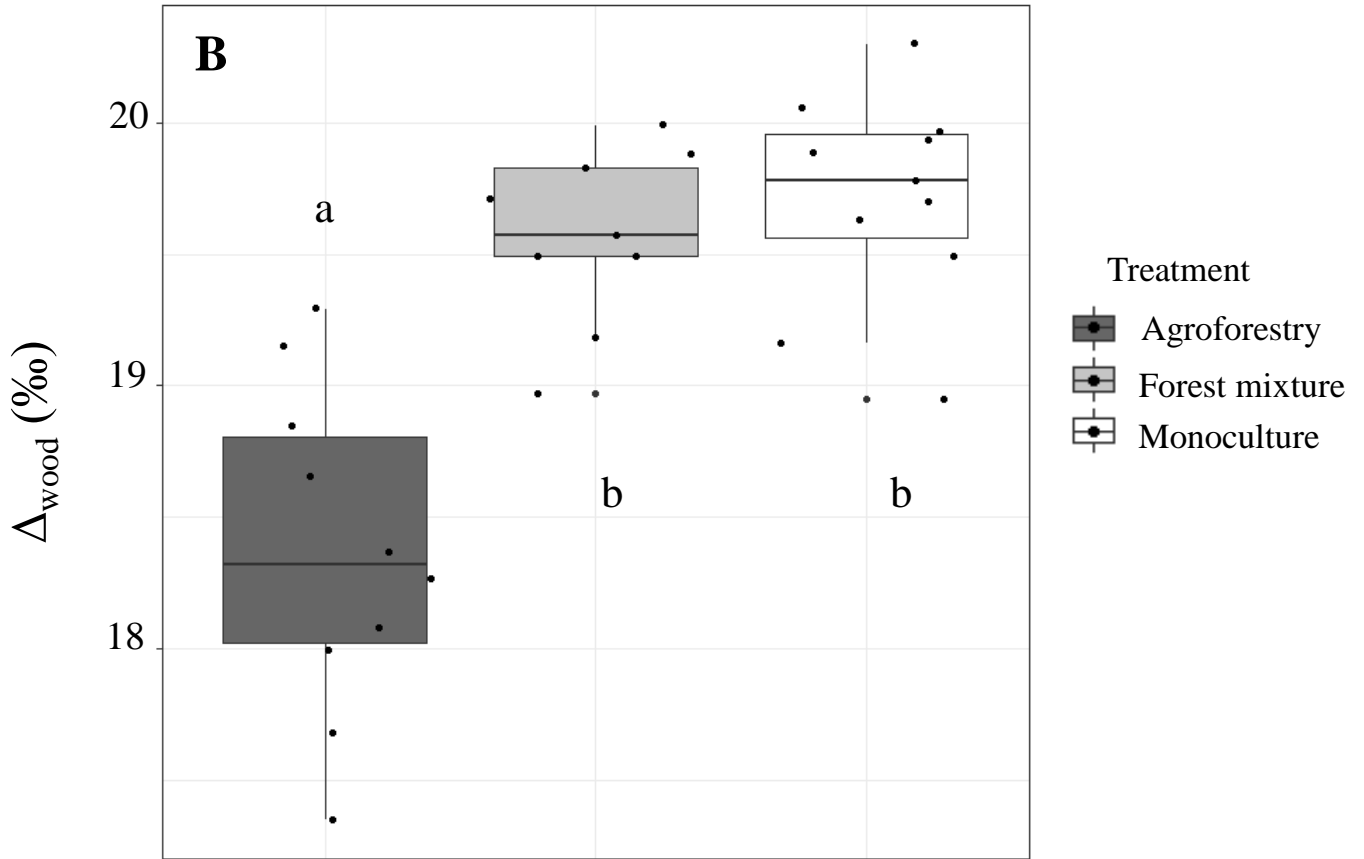| Context	Objective	Site	Leaf	Tree	Leaf	**Tree**	Factors	Drivers

Thomas et al. 2022

➢ WUE$_T$ forest mixture > WUE$_T$ agroforestry > WUE$_T$ monoculture

Thomas et al. 2022

> Similar trend as for WUE_T: Agroforestry > Forest mixture = Monoculture

➤ Poplars in both mixture types showed higher WUE compared to the monoculture

➤ An ↗ of WUE has been commonly observed in response to a decrease in water availability

Bonhomme et al. 2008, Fichot et al. 2009, 2010, Cocozza et al. 2011

	JUNE			JULY			AUGUST		
	AF	FM	Mono	AF	FM	Mono	AF	FM	Mono
$\Psi_{predawn}$ (MPa)	-0.15 [a] ± 0.01	-0.19 ± 0.01 [ab]	-0.25 ± 0.02 [b]	-0.18 ± 0.02 [a]	-0.15 ± 0.01 [a]	-0.35 ± 0.02 [b]	-0.29 ± 0.02 [a]	-0.32 ± 0.01 [a]	-0.34 ± 0.01 [a]

… but there was not water limitation

➤ A higher N supply in mixtures than in monoculture can ↗ increase WUE in poplars

Ripullone et al. 2004

… but there was no difference in leaf [N] between poplars in mixtures and monoculture

➤ Difference in agroforestry probably associated to higher light availability due to lower tree planting density than in the forest plots

➤ Agroforestry *vs.* Monoculture:

     differences were associated to differences in g_{400} and A_{sat} ...

          and transpiration

➤ Forest mixture *vs.* Monoculture:

     differences were associated to differences in g_{400} ...

          and both transpiration and biomass accumulation

Poplar trees are more productive (Thomas et al. 2021) and use water more efficiently (Thomas et al. 2022) in agroforestry than in monoculture !

👍

Thank you!

For more details:

Anaïs Thomas[1], Nicolas Marron[1], Damien Bonal[1], Séverine Piutti[2], Erwin Dallé[1] and Pierrick Priault [1,3]

[1]AgroParisTech, INRAE, UMR Silva, Université de Lorraine, 54000 Nancy, France; [2]INRAE, UMR Laboratoire Agronomie et Environnement (LAE), Université de Lorraine, 54518 Vandœuvre-lès-Nancy, France; [3]Corresponding author (pierrick.priault@univ-lorraine.fr)