

Among-provenance diversity and phenotypic plasticity of water-use efficiency in sessile oak populations growing in a mesic common garden

Arivoara Rabarijaona¹, Stéphane Ponton¹, Didier Bert², Alexis Ducousso²,
Béatrice Richard¹, Joseph Levillain¹, and Oliver Brendel¹

¹ Université de Lorraine, AgroParisTech, INRAE, Silva, Champenoux, France

² Université de Bordeaux, INRAE, BioGeCo, Cestas, France

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✉ stephane.ponton@inrae.fr, arivoara.rabarijaona@inrae.fr

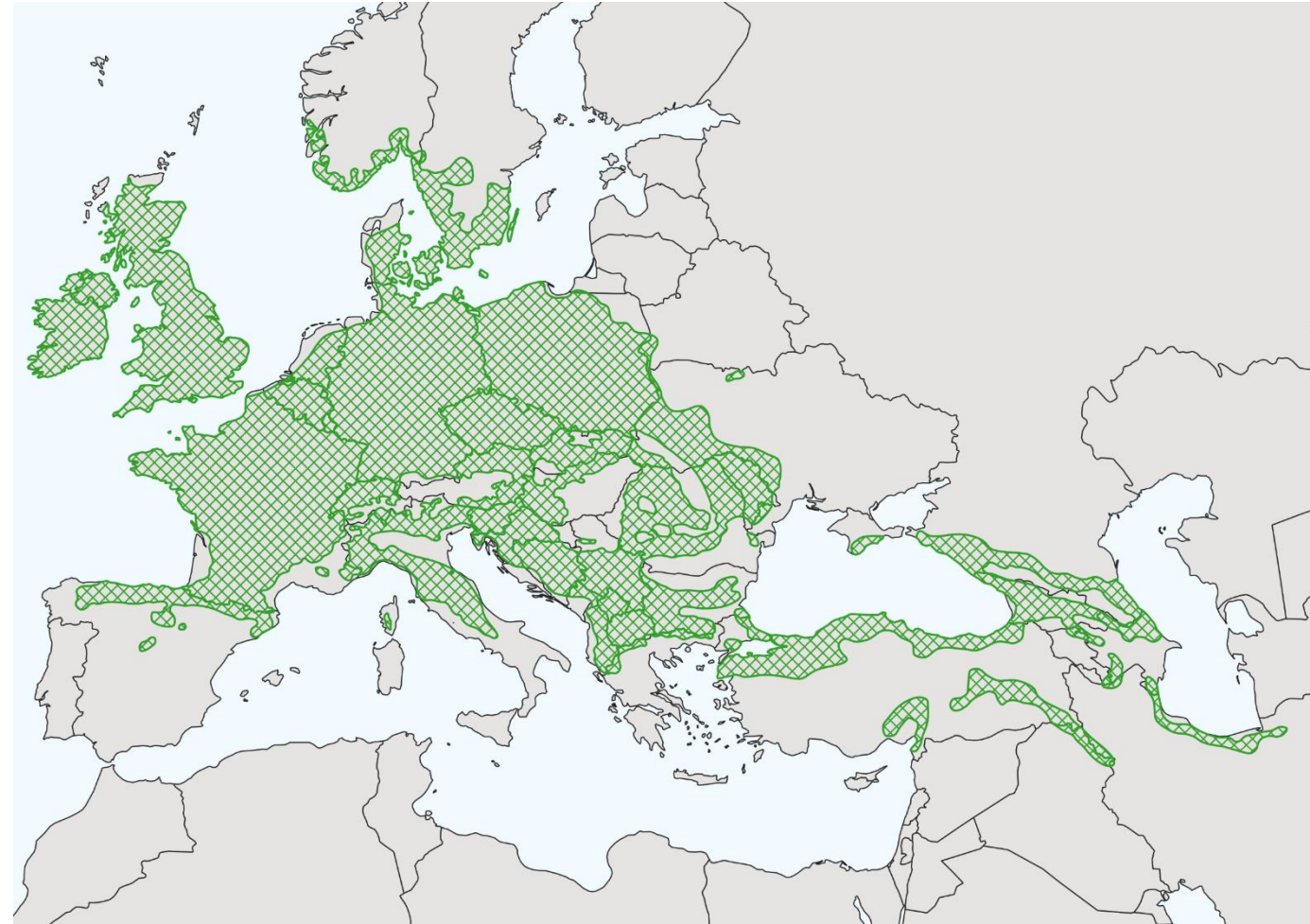


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Sessile oak is a widespread species



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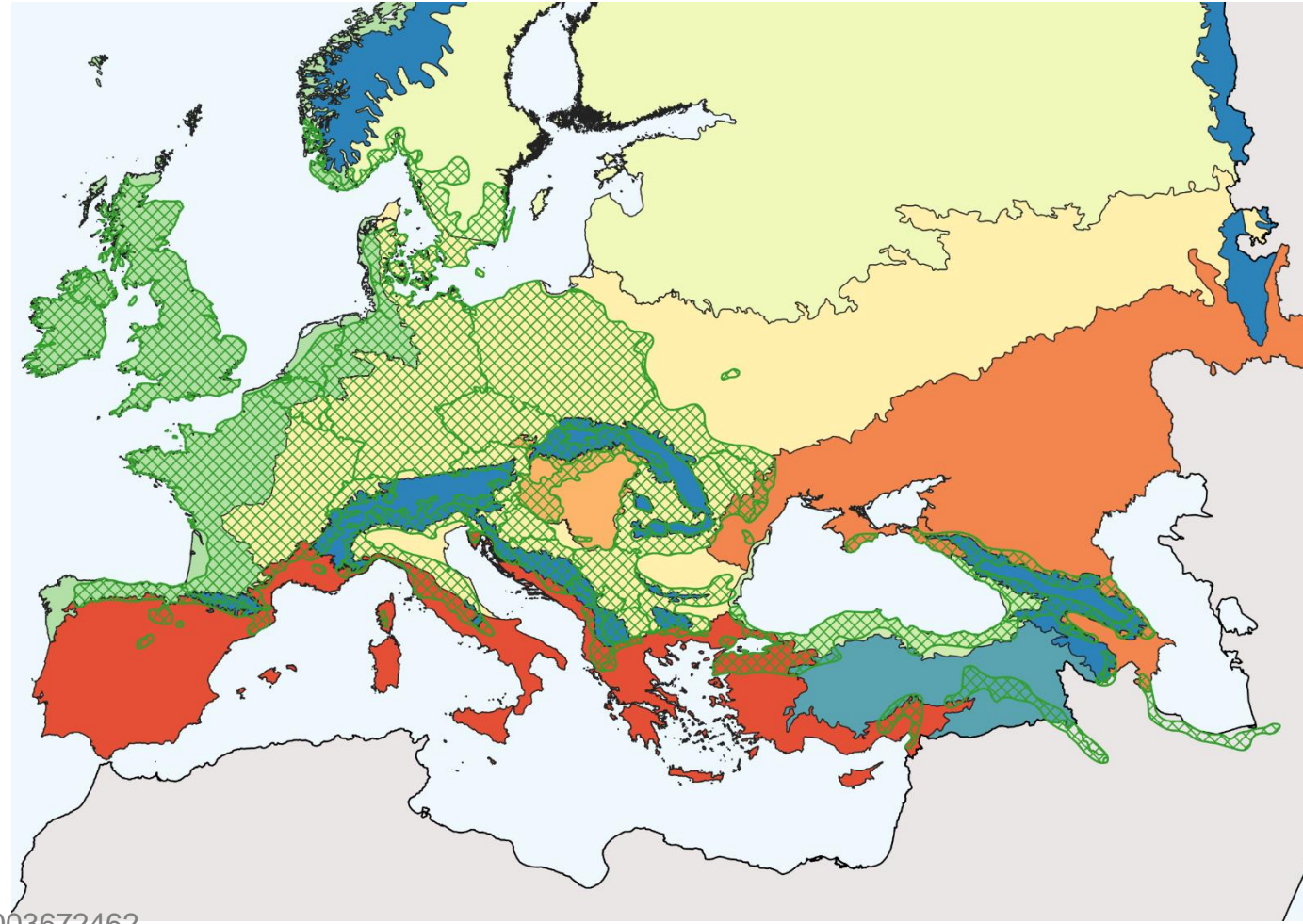
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Sessile oak is a widespread species

- Sessile oak occupy a wide range of ecological conditions → **local adaptation**
- Correlation between among-population differences in some traits measured in a common garden and provenance conditions [1;2]



[1] Vitasse et al. 2009; <https://doi.org/10.1139/X09-054>

[2] Bruschi et al. 2010; <https://doi.org/10.1080/11263501003672462>

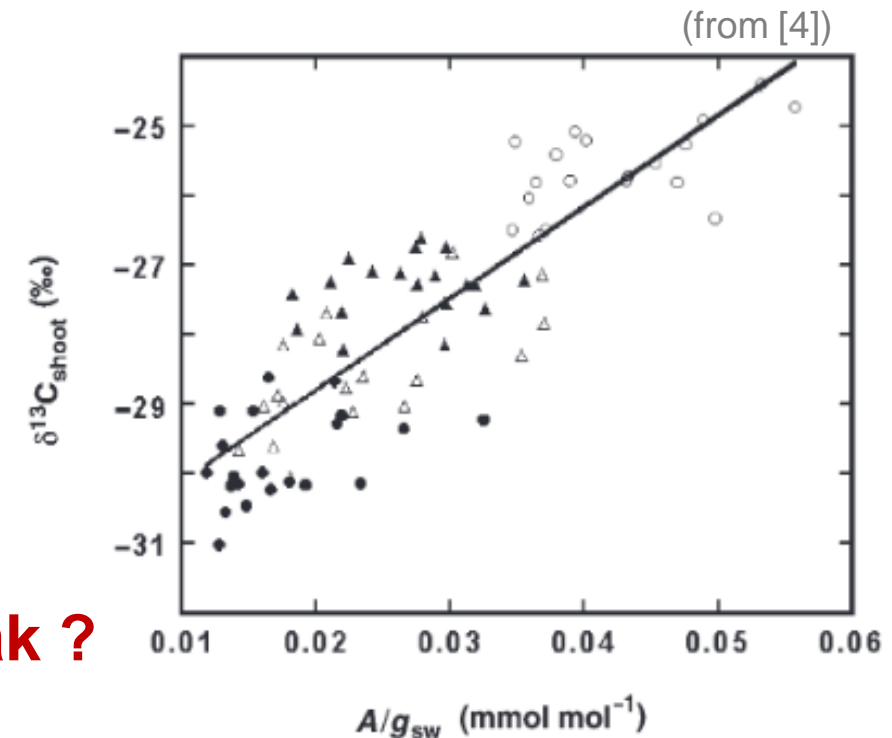
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What is intrinsic Water-Use Efficiency (iWUE)?

$$\text{iWUE} = \frac{\text{net CO}_2 \text{ assimilation rate (A)}}{\text{stomatal conductance for water vapor (g}_{\text{sw}})}$$

- iWUE is **positively related** to the carbon isotope composition ($\delta^{13}\text{C}$, ‰) of the photosynthetic products [3], and in white oak wood $\delta^{13}\text{C}$ [4].
- Relationship between population differences in iWUE and water deficit gradient in different species [5,6]
→ **iWUE is a drought-adaptive trait.**



→ **Is iWUE an adaptive trait to drought for sessile oak ?**

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[3] Farquhar & Richards. 1984; <https://doi.org/10.1071/PP9840539>

[5] Li et al., 2000; <https://doi.org/10.1071/PP99056>

[4] Ponton et al. 2002; <https://doi.org/10.1093/treephys/22.6.413>

[6] Lauteri et al. 2004; <https://doi.org/10.1111/j.1420-9101.2004.00765.x>

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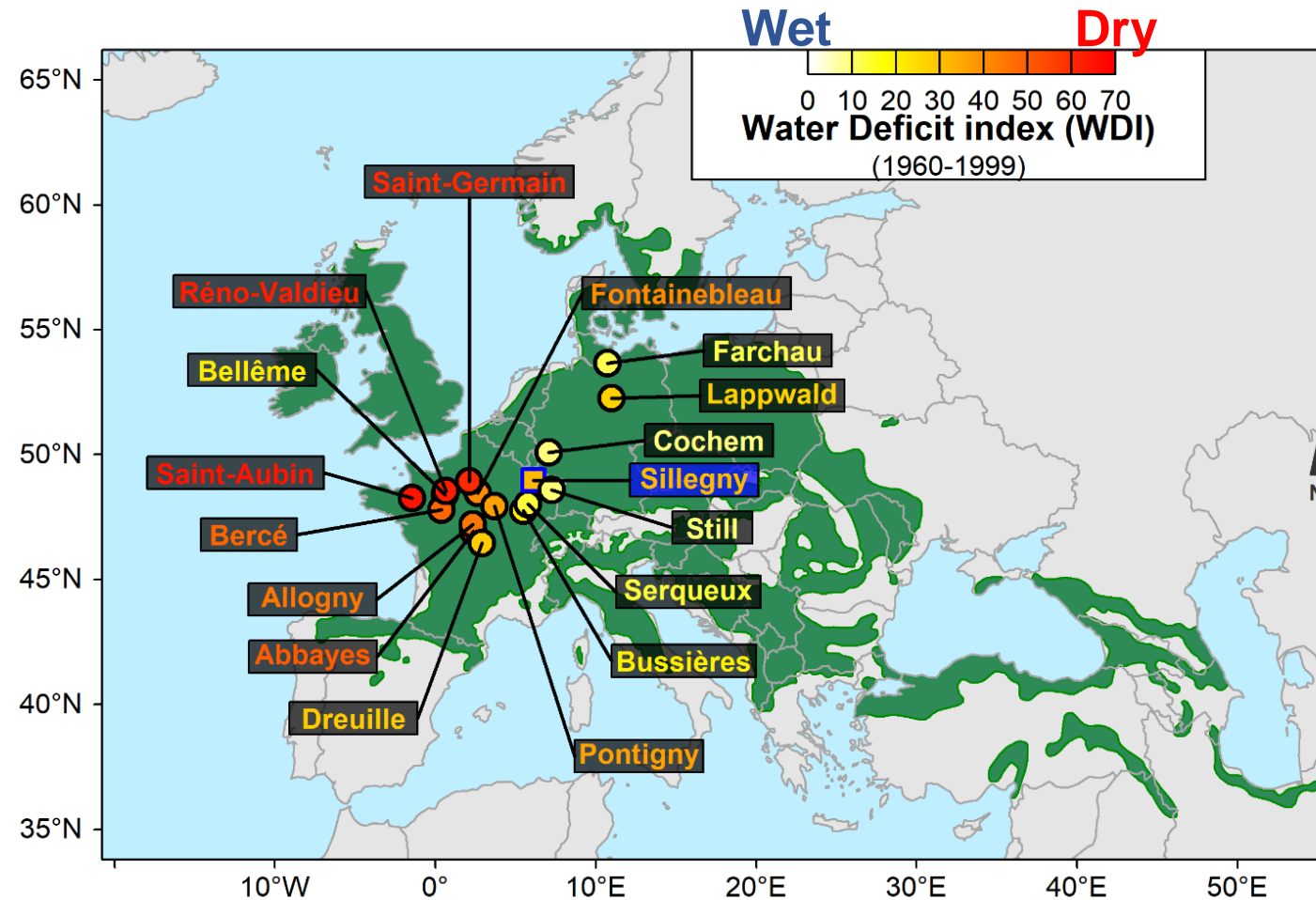
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Comparison of $\delta^{13}\text{C}$ among 16 sessile oak populations

- Estimation of iWUE with **tree-ring $\delta^{13}\text{C}$**



- 16 populations from 16 provenances with contrasted mean water deficit index
- Planted in a **mesic common garden** in France (Sillegny) in 1993.



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$\delta^{13}\text{C}$ measured in 3 contrasted years

- Tree-ring $\delta^{13}\text{C}$ measurements:

- 2000: wet year

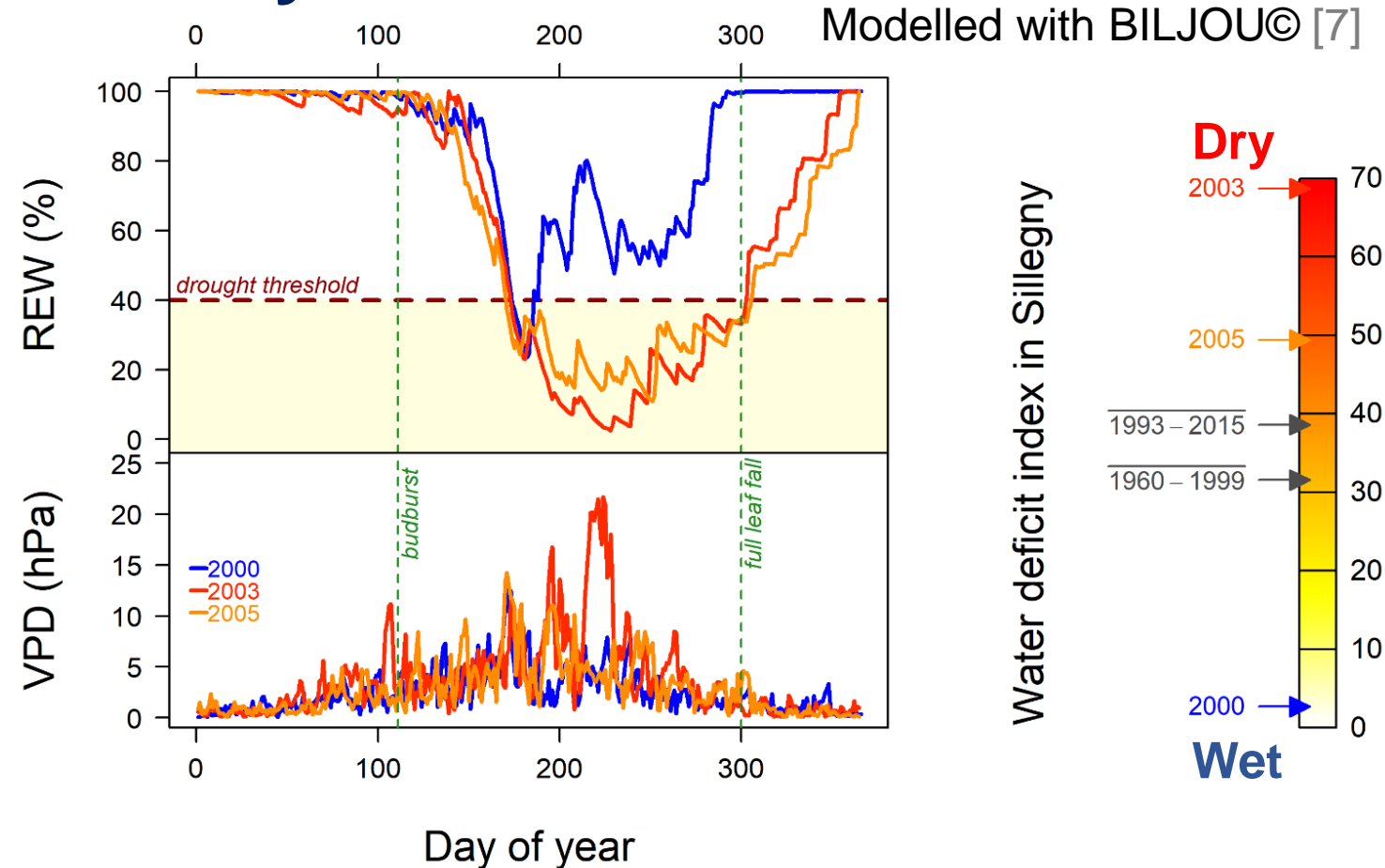
- 2003: severely dry year**

- 2005: moderately dry year

- 2 plasticity indices to drought:

- $\delta^{13}\text{C}_{2003-2000} = \delta^{13}\text{C}_{2003} - \delta^{13}\text{C}_{2000}$
(response to severe drought)

- $\delta^{13}\text{C}_{2005-2000} = \delta^{13}\text{C}_{2005} - \delta^{13}\text{C}_{2000}$
(response to moderate drought)



[7] Granier et al. 1999; [https://doi.org/10.1016/S0304-3800\(98\)00205-1](https://doi.org/10.1016/S0304-3800(98)00205-1)

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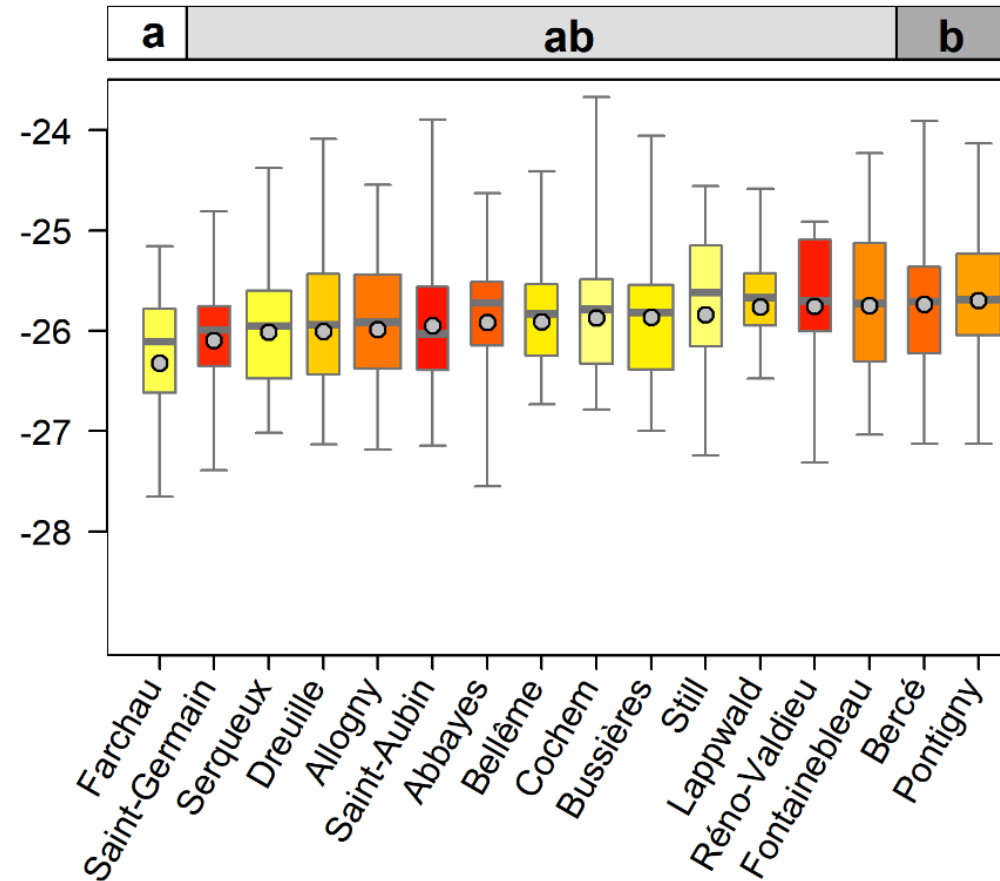


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Differences in $\delta^{13}\text{C}$ among sessile oak populations

- **Significant population effect** on $\delta^{13}\text{C}$
- among population $\Delta\delta^{13}\text{C}$: **0.6‰** (seen in other oak species[8,9])
- among population $\Delta\delta^{13}\text{C}$ < within population $\Delta\delta^{13}\text{C}$
- No significant relationship between population $\delta^{13}\text{C}$ and provenance water deficit index

High iWUE
↑
 $\delta^{13}\text{C}$ 2003(‰)
Low iWUE

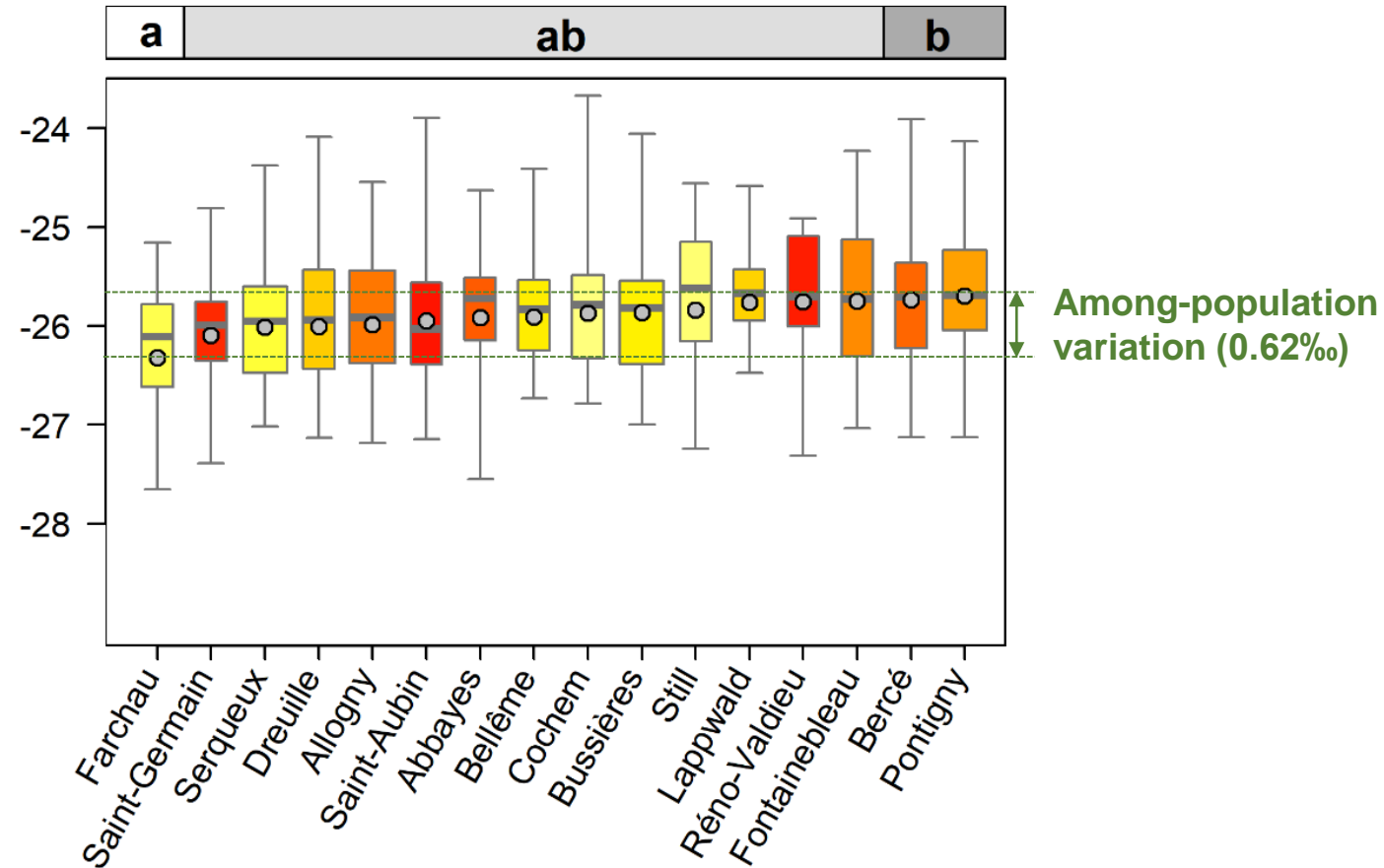


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High iWUE
↑
Low iWUE

$\delta^{13}\text{C}$ 2003(‰)



[8] Rice et al. 1993; <https://doi.org/10.1007/BF00320511>

[9] Sun et al. 2016; <https://doi.org/10.1007/s00468-016-1380-y>

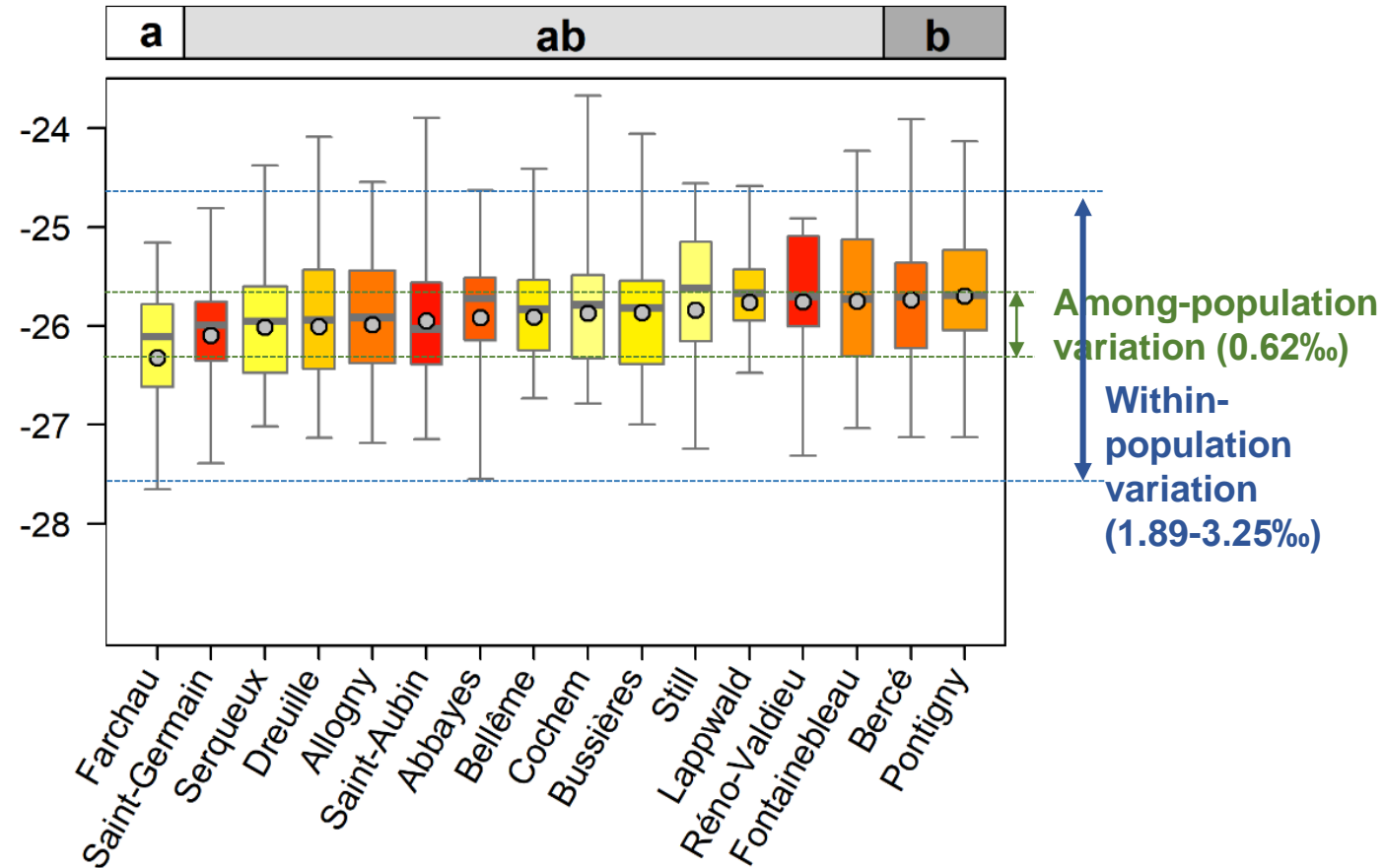
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High iWUE
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Low iWUE



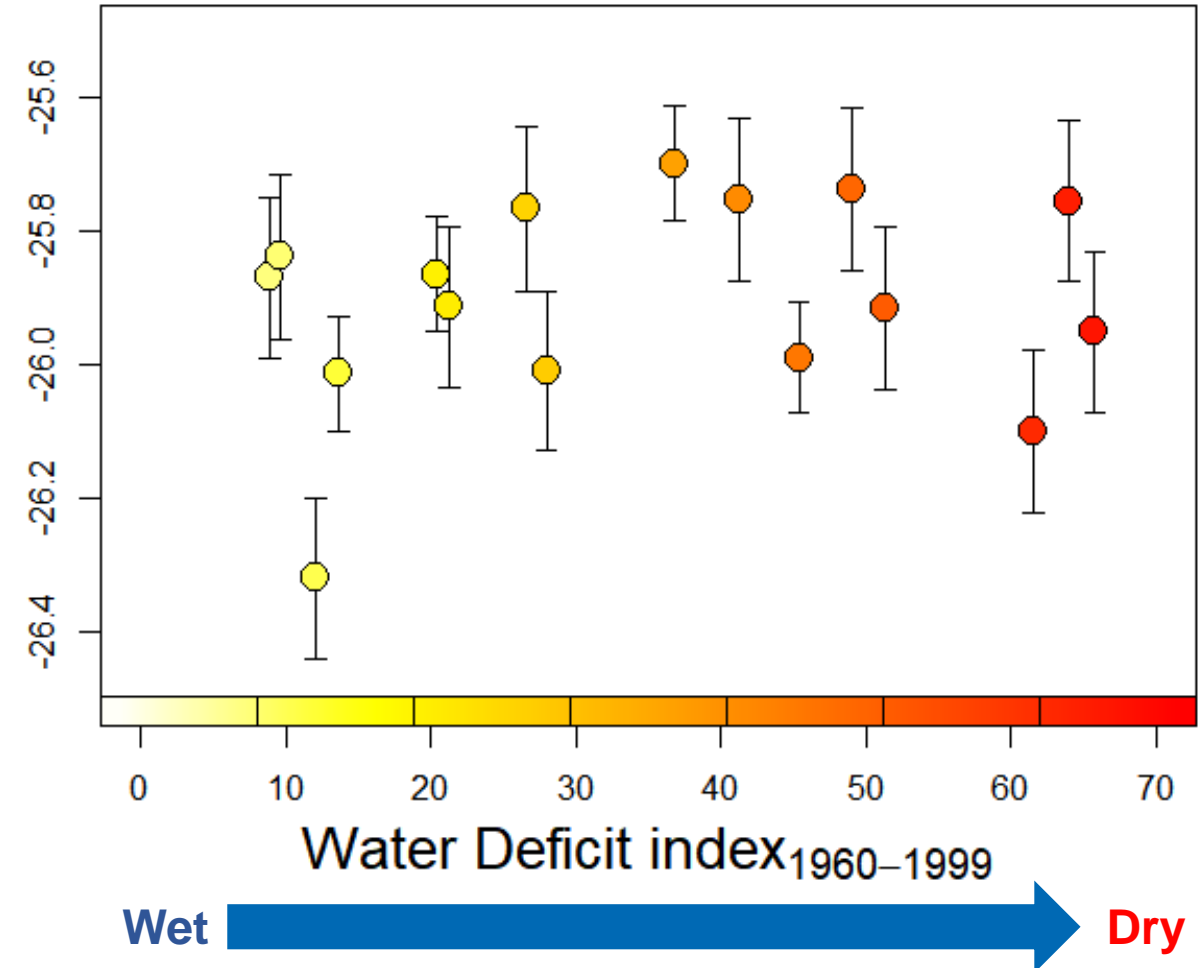
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High iWUE



Low iWUE

 $\delta^{13}\text{C}$ 2003(‰)

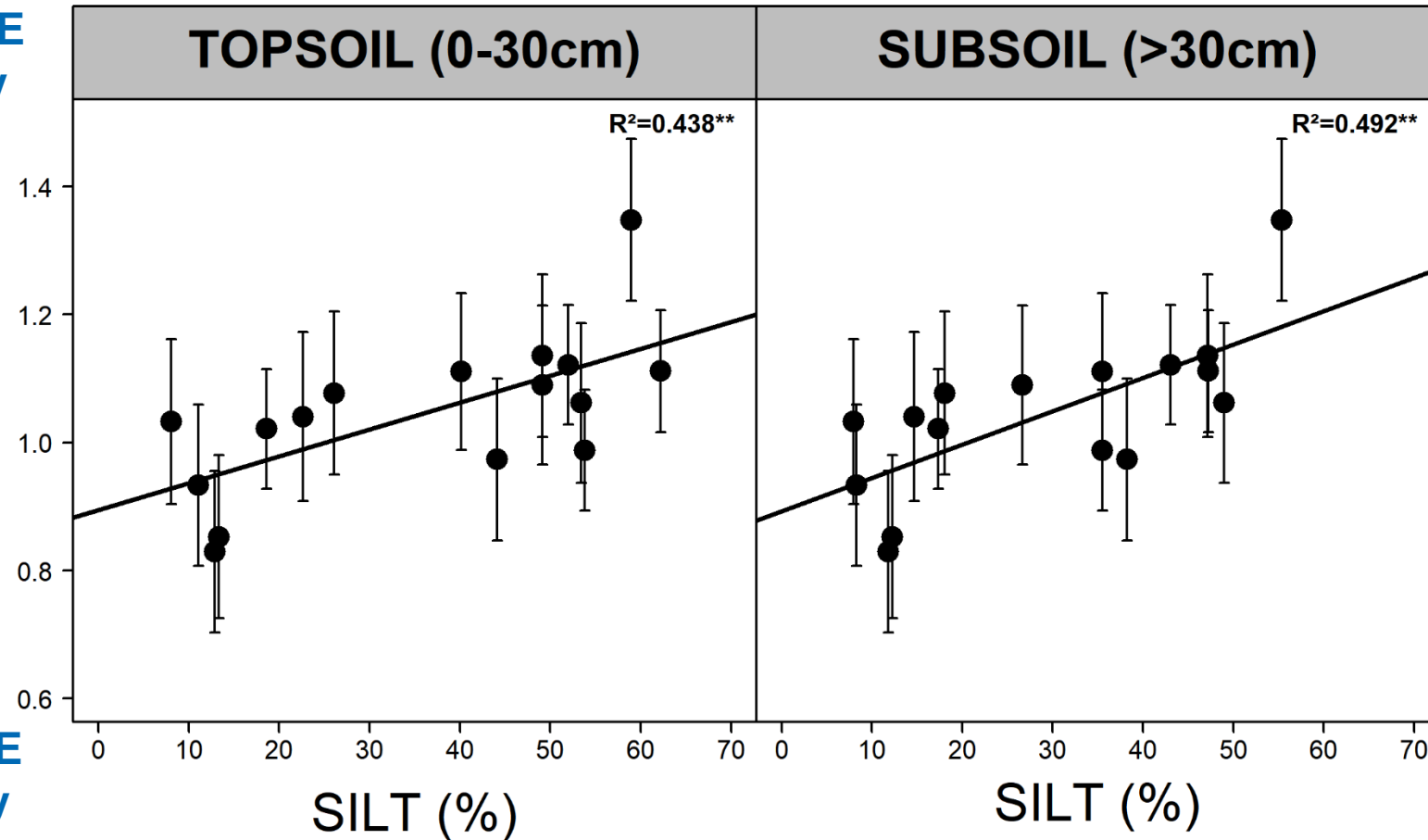
Differences in $\delta^{13}\text{C}$ plasticity to severe drought

- The population means of $\delta^{13}\text{C}_{2003-2000}$ plasticity were correlated to soil texture (%silt, %sand) of the provenance site

High iWUE
plasticity

$\delta^{13}\text{C}$ 2003–2000

Low iWUE
plasticity



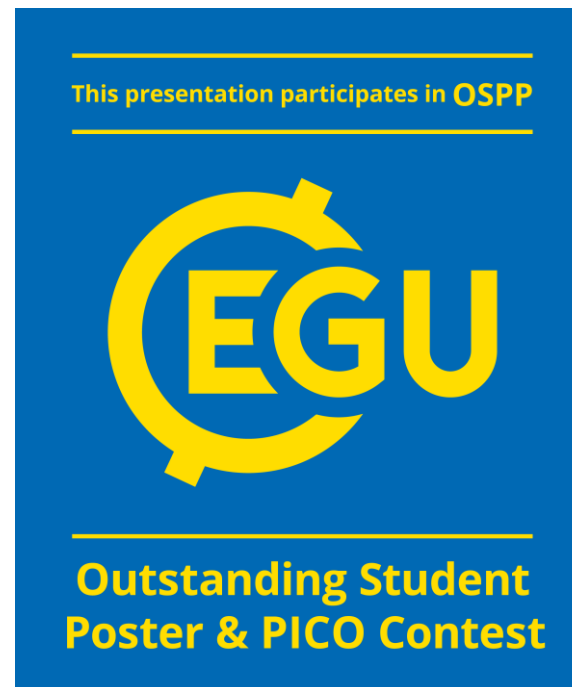
In the common garden of Sillegny,
where the pedoclimatic conditions are in average mesic:
Is iWUE an adaptive trait to drought for sessile oak ?

- **Among-population variation in iWUE:**
 - Was lower than the within-population variation in iWUE
 - Was not correlated to the environment of the provenance sites
- **Among-population variation in iWUE plasticity to severe drought:**
 - Populations from silty soil were more responsive to severe drought by increasing WUE
→ **Difference in drought response strategies [10] among populations from different soil texture**

[10] Brendel & Epron, 2022; <https://doi.org/10.1093/treephys/tpab143>

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submitted to Frontiers in Forests and Global Change*

For questions :

arivoara.rabarijaona@inrae.fr

stephane.ponton@inrae.fr

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