# Evidence of xylem hydraulic sectoring in apple trees from a deuterium tracing experiment in a split-root system

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1. Evaluate xylem sectoriality in apple trees







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(adapted)

1. Evaluate xylem sectoriality in apple trees

2. Verify if sectoriality is affected by water availability at root level









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#### Methodology

#### Experimental design







#### **Methodology**

#### Experimental design



#### Split-root system







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#### Methodology

Labelled irrigation (<sup>2</sup>H)  $\longrightarrow$  Sampling  $\longrightarrow$  Extraction (CVD)  $\longrightarrow$  Analysis (IRMS)









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#### **Results: average F<sub>sw</sub> in different sampling positions**







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• F<sub>SW</sub> in soil coincides with percentage of

sectors receiving labelled water





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• F<sub>SW</sub> in soil coincides with percentage of

sectors receiving labelled water

when all soil is wet, F<sub>SW</sub> in the tree is

similar to that in the soil







- $F_{SW}$  in soil coincides with percentage of sectors receiving labelled water
- when all soil is **wet**, F<sub>sw</sub> in the tree is

similar to that in the soil

 when part of the soil is dry, F<sub>SW</sub> in the tree is larger than in the soil









- $F_{SW}$  in soil coincides with percentage of sectors receiving labelled water
- when all soil is wet, F<sub>SW</sub> in the tree is

similar to that in the soil

- when part of the soil is dry,  $F_{\rm SW}$  in the tree is larger than in the soil
  - → most of the water uptake occurs from the wet side







F<sub>sw</sub> in rootstock (5 cm height)

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water





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#### F<sub>sw</sub> in rootstock (5 cm height)

homogeneous values in 100

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water





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#### F<sub>sw</sub> in rootstock (5 cm height)

- homogeneous values in 100
- high F<sub>SW</sub> only in sectors that received labelled water in

**50\_W** and **25\_W** 

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water





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#### F<sub>sw</sub> in rootstock (5 cm height)

- homogeneous values in 100
- high  $\mathrm{F}_{\mathrm{SW}}$  only in sectors that received labelled water in

**50\_W** and **25\_W** 

• enrichment also in non-labelled

sectors in **50\_D** and **25\_D** 

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water







F<sub>sw</sub> in shoots (90 cm height)

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water





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#### F<sub>sw</sub> in shoots (90 cm height)

strong heterogeneity between  $\rightarrow$ 

sectors within each tree

mixing of water is limited  $\rightarrow$ 

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water





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#### F<sub>sw</sub> in shoots (90 cm height)

→ strong heterogeneity between

sectors within each tree

→ mixing of water is limited

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water







#### F<sub>sw</sub> in shoots (90 cm height)

→ strong heterogeneity between

sectors within each tree

→ mixing of water is limited

→ mixing enhanced when other
sectors are dry

frame = individual tree; radius of circle =  $F_{SW}$ ; color = irrigation water





#### Conclusions

- Apple tree xylem exhibits sectored behaviour if soil is homogeneously wet
- Lateral movement is enhanced if part of the soil is dry
  - strong water potential gradients can overcome resistance to lateral flux
- Water and nutrient distibution in the canopy may be heterogenous







#### Conclusions

- Apple tree xylem exhibits sectored behaviour if soil is homogeneously wet
- Lateral movement is enhanced if part of the soil is dry
  - strong water potential gradients can overcome resistance to lateral flux
- Water and nutrient distibution in the canopy may be heterogenous
- Implications for ecohydrology
  - → in <u>sectored</u> trees that access different water sources, composition of plant water could be spatially variable within the tree
  - → collecting multiple samples per tree could be advisable







### Thank you!



Scan the QR code for additional material and to discuss further!





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#### Why was F<sub>sw</sub> in shoots higher in non-labelled than in labelled sectors?







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#### Why was $F_{sw}$ in shoots higher in non-labelled than in labelled sectors?

• difficulty in exactly identifying sectors along the trunk









#### Why was $F_{sw}$ in shoots higher in non-labelled than in labelled sectors?

- difficulty in exactly identifying sectors along the trunk
- inaccuracy during sampling









#### Why was $F_{\text{sw}}$ in shoots higher in non-labelled than in labelled sectors?

- difficulty in exactly identifying sectors along the trunk
- inaccuracy during sampling
- twisting of xylem vessels around the trunk









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#### Can we better visualize the flow of water in the tree?

• planned experiment with dye as tracer



McElrone et al. (2021) Functional hydraulic sectoring in grapevines as evidenced by sap flow, dye infusion, leaf removal and micro-computed tomography, *AoB PLANTS*, 13 (2), 2021. <u>https://doi.org/10.1093/aobpla/plab003</u>





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