

Estimating uptake and internal transport dynamics of irrigation water in apple trees using deuterium-enriched water

Nicola Giuliani¹, Agnese Aguzzoni², Francesco Comiti¹, Daniele Penna³, and Massimo Tagliavini¹

¹Faculty of Agricultural, Environmental and Food Sciences, Free University of Bozen-Bolzano, Italy – nicola.giuliani@student.unibz.it

²Eco Research, Bozen-Bolzano, Italy

³Department of Agriculture, Food, Environment and Forestry, University of Florence, Italy



Fakultät für Agrar-, Umwelt- und Lebensmittelwissenschaften
 Facoltà di Scienze agrarie, ambientali e alimentari
 Faculty of Agricultural, Environmental and Food Sciences

1 – Research questions

1. What is the time interval between irrigation and the arrival of irrigation water at different tree heights?
2. To which extent can irrigation water uptake and transport be accelerated by increasing the portion of soil volume receiving drip irrigation water?

2 – Materials and Methods

Field experiment

- mature apple orchard (sandy loam soil) located in Auer-Ora (Bolzano, Italy), September 2021, in two sunny days
- CRBD with 4 blocks, 3 irrigation levels (n = 12)
- drip irrigation (3 L per dripper in one hour) with deuterium-enriched water ($\delta^2\text{H} = 12050 \text{‰}$), with irrigation levels differing by the number of drippers per tree (1, 2 and 4 in SL1, SL2, and DL4, respectively)
- soil sampling in different positions and depths around drippers (1 and 32 h)
- shoot sampling at 1.5 and 3.0 m each tree (1, 2, 4, 6, 8, and 32 hours after irrigation)
- estimation of tracer arrival time basing on 10% of the maximum value (Meinzer *et al.*, 2006) and with an approach based on the first sampling time at which the isotopic composition was different from pre-irrigation values

Pot experiment

- transparent shelter in Laimburg (Bolzano, Italy), July 2021, in a typical summer day
- CRD with 4 sampling times (n = 12)
- irrigation with labelled water ($\delta^2\text{H} = 1631 \text{‰}$)
- 5 cm stem sections at 0, 50, 100, and 150 cm height, after 1, 2, 4, and 8 h from irrigation

Water extraction and isotopic analysis

- CVD (cryogenic vacuum distillation) followed by IRMS

3 – Results

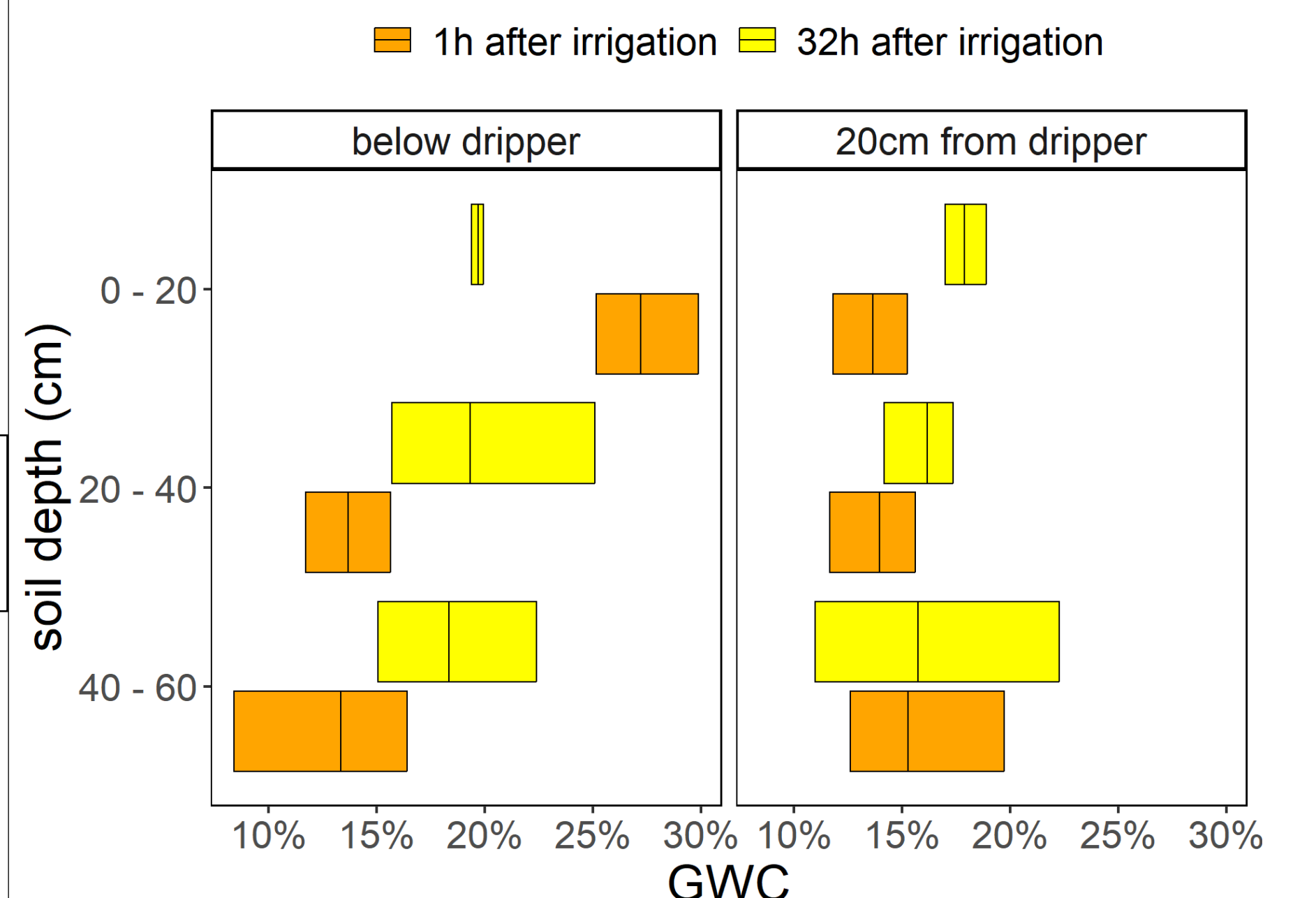


Figure 1. Soil gravimetric water content at different positions and depths around the dripper, at different times after irrigation.

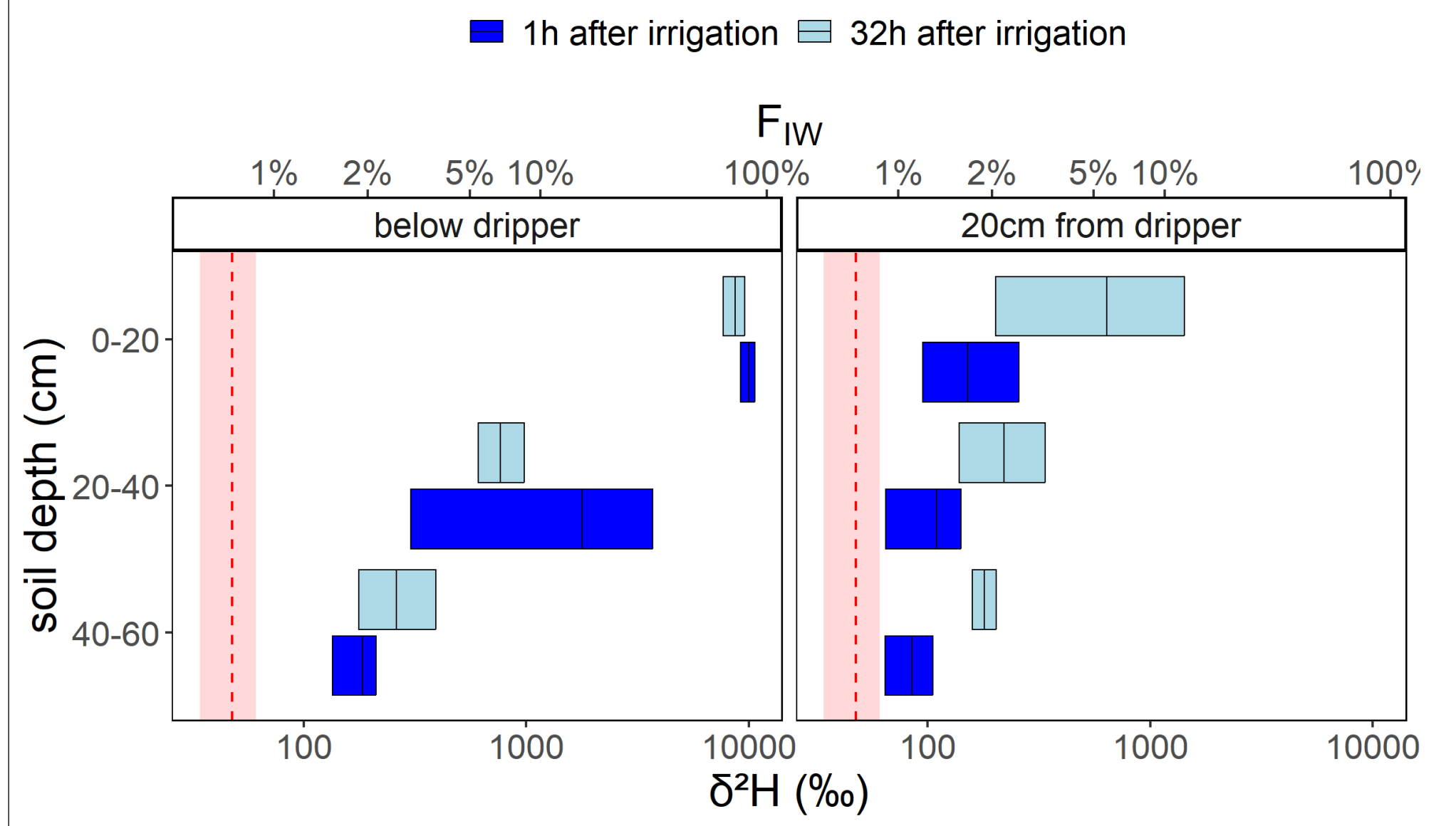


Figure 2. Soil isotopic composition and fraction of irrigation water at different depths and positions around the dripper, at different times after irrigation. Red line and shaded area represent isotopic composition before irrigation (mean \pm SD)

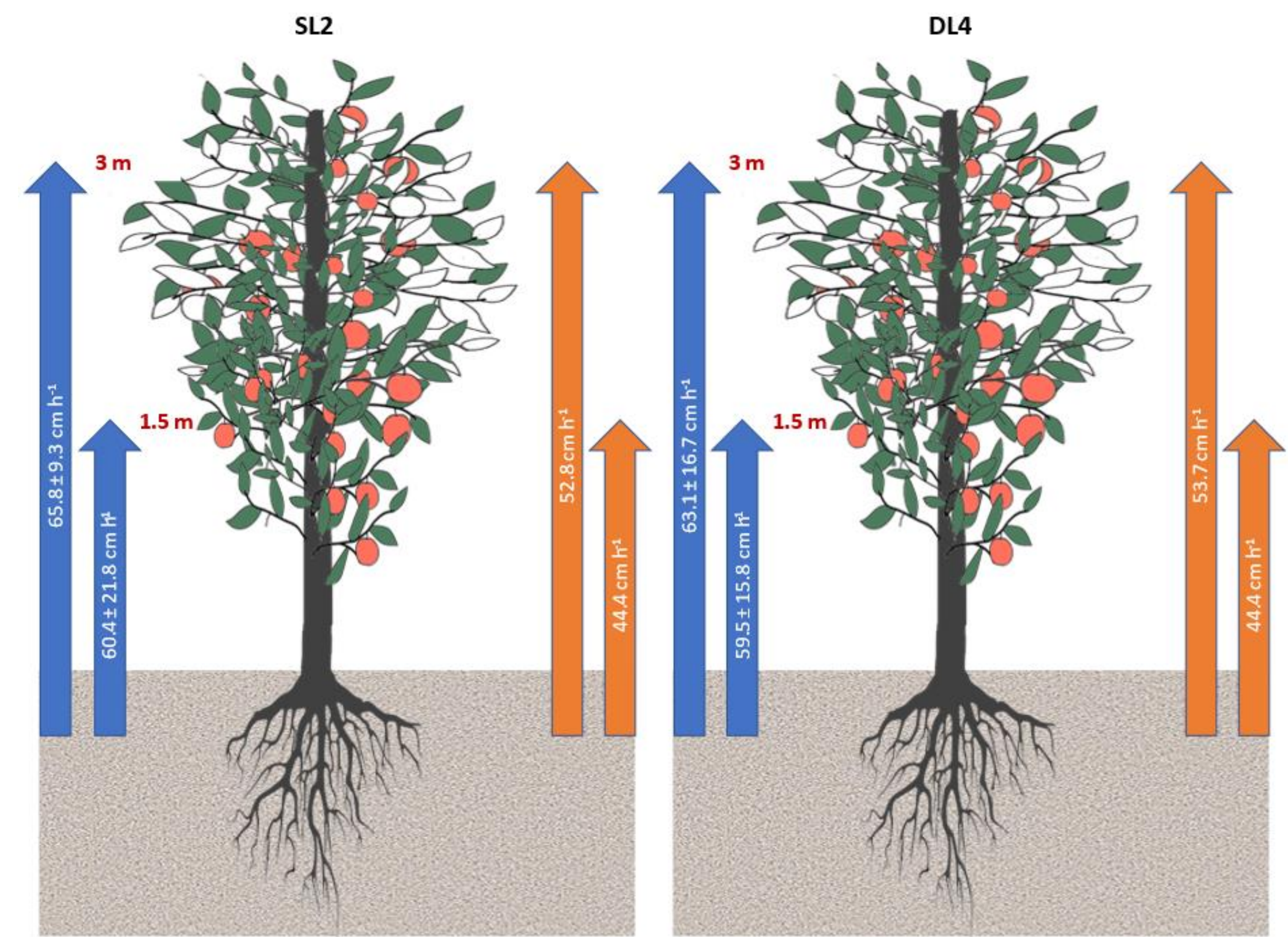


Figure 4. Field experiment. Sap flow velocity for different heights calculated according to Meinzer *et al.* 2006 (blue arrows) and based on the first sampling time at which the isotopic composition was different from control values (orange arrows). Values are mean \pm SD.

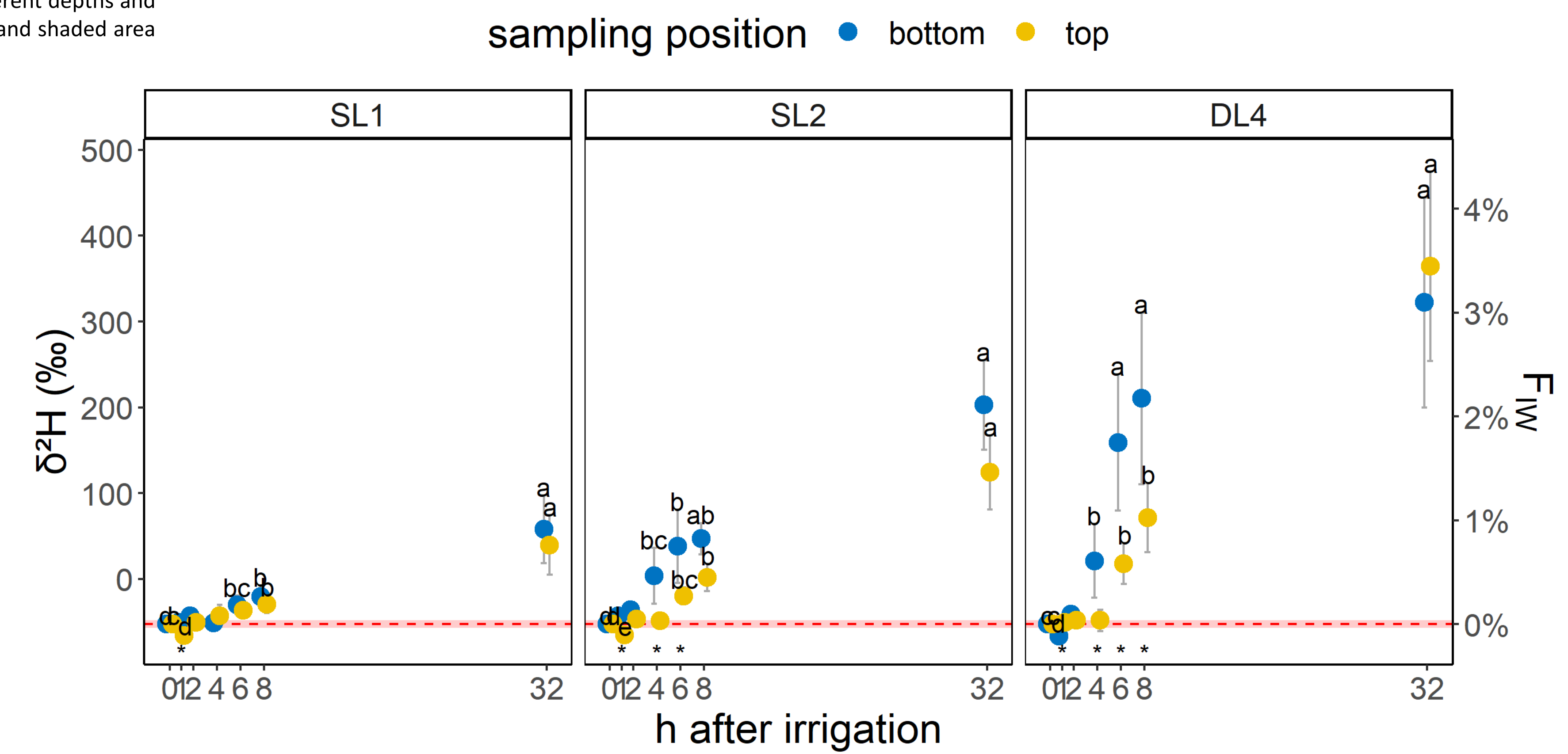


Figure 3. Field experiment. Isotopic composition and fraction of irrigation water in shoots. Points and error bars are mean \pm SE. Letters indicate differences among sampling times within each treatment and height, asterisks indicate differences between sampling heights within each treatment and sampling time ($\alpha=0.05$). Red line and shaded area represent isotopic composition before irrigation (mean \pm SD).

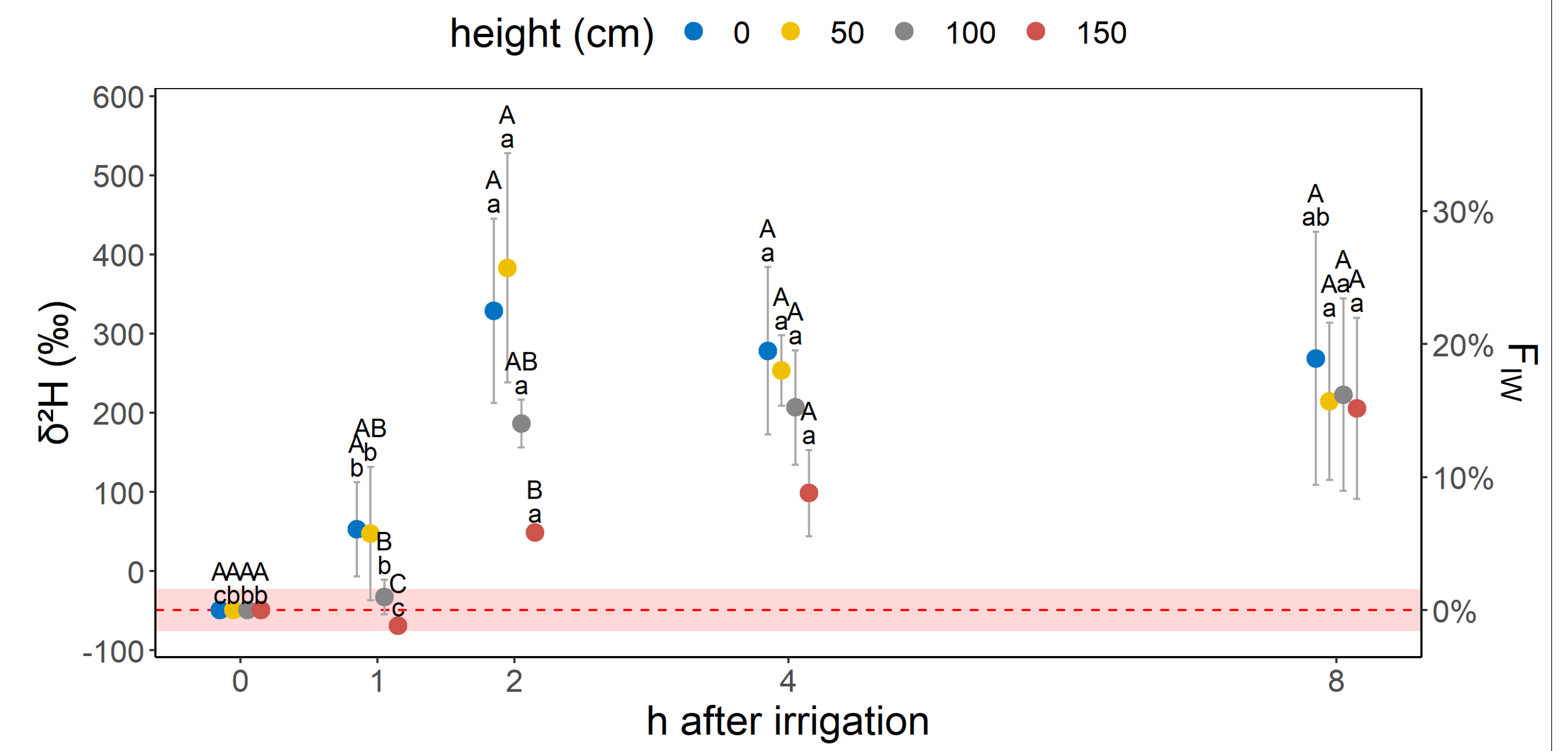


Figure 5. Pot experiment. Isotopic composition and fraction of irrigation water in stem. Points and error bars are mean \pm SE. Uppercase letters indicate differences among heights within each sampling time, lowercase letters indicate differences among sampling times within each sampling height ($\alpha=0.05$). Red line and shaded area represent isotopic composition before irrigation (mean \pm SD).

4 – Conclusions

- Irrigation water remains localized close to the dripper
- Irrigation water is taken up by apple trees soon after the irrigation event as it can be detected in shoots at 1.5 m height already after 4 h from irrigation
- The fraction of irrigation water in shoots increases by increasing the number of drippers per tree (and amount of water per tree)
- The velocity of water transport inside the trees is not affected by the irrigation treatment
- Further research is needed to understand the effect of the localization of irrigation water on the extent of water uptake by trees

Acknowledgements

Data collection was carried out under the TIOMI project funded by the Autonomous Province of Bolzano-Bozen; data analysis and elaboration was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022).

