Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Evaluating phloem sap $\delta^{13}C$ as a short-term indicator of drought stress in banana

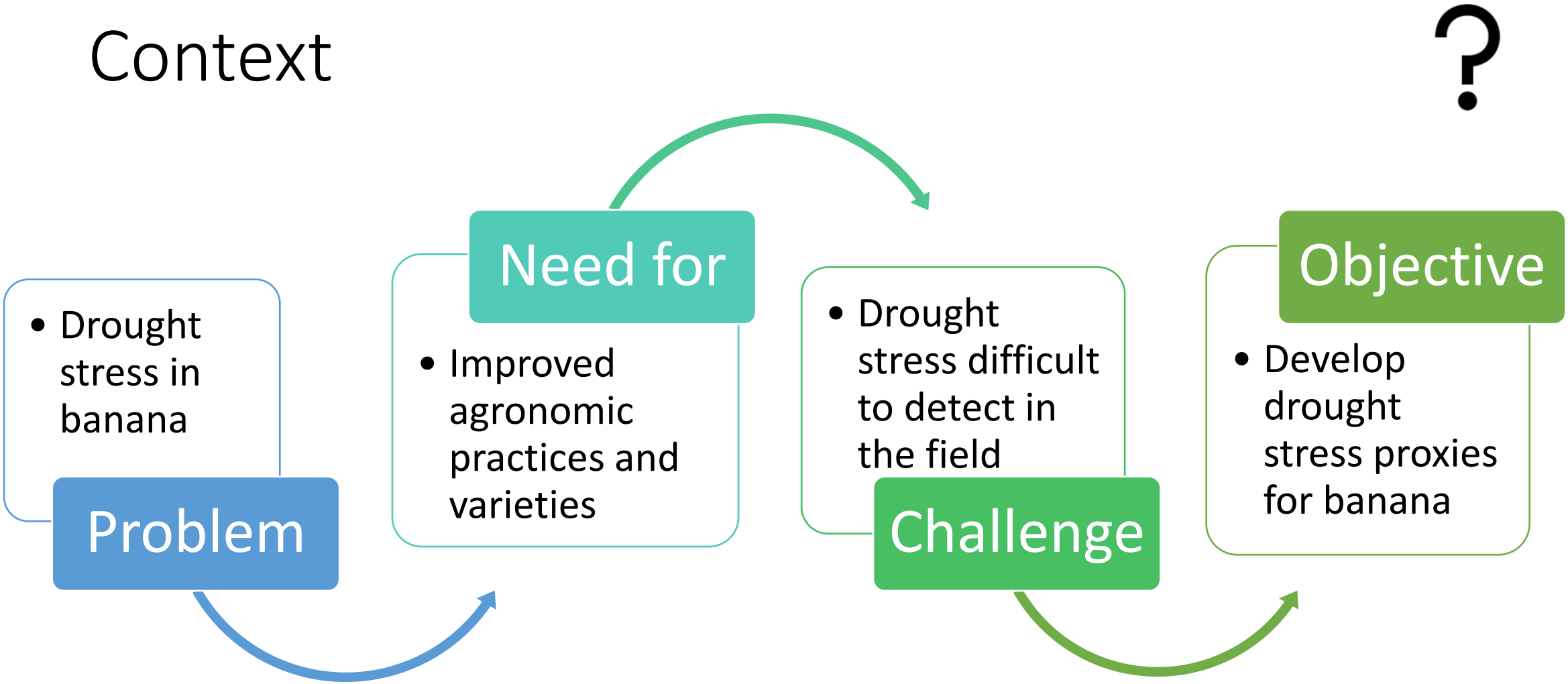
Vantyghem, M., Merckx, R., Hood-Nowotny, R., Swennen, R., Heiling, M., Resch, C., Dercon, G.

Contact: *mathilde.vantyghem@kuleuven.be*

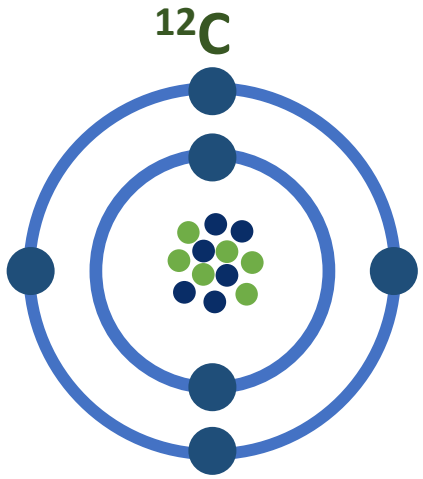
IHC 2022
HORTICULTURE FOR A WORLD IN TRANSITION
ANGERS – FRANCE

Why do we need such indicators

Context

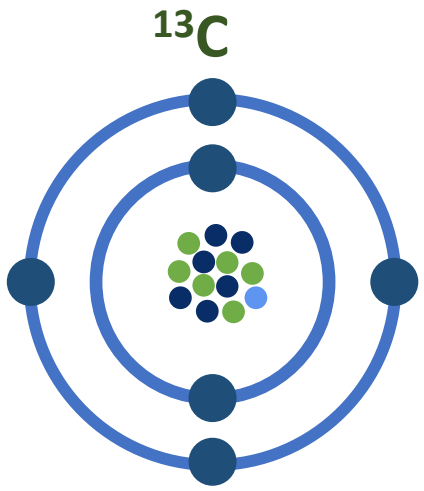

?
Problem
• Drought stress in banana
Need for
• Improved agronomic practices and varieties
Challenge
• Drought stress difficult to detect in the field
Objective
• Develop drought stress proxies for banana

Stable carbon isotope values ($\delta^{13}C$)



- 6 protons
- 6 neutrons

98,9 %



- 6 protons
- 7 neutrons

1,1 %

$$\delta^{13}C\ (‰) = \frac{{C^{13}}/{C^{12}}_{sample} - {C^{13}}/{C^{12}}_{standard}}{{C^{13}}/{C^{12}}_{standard}} * 1000$$

Stable carbon isotope values ($\delta^{13}C$)

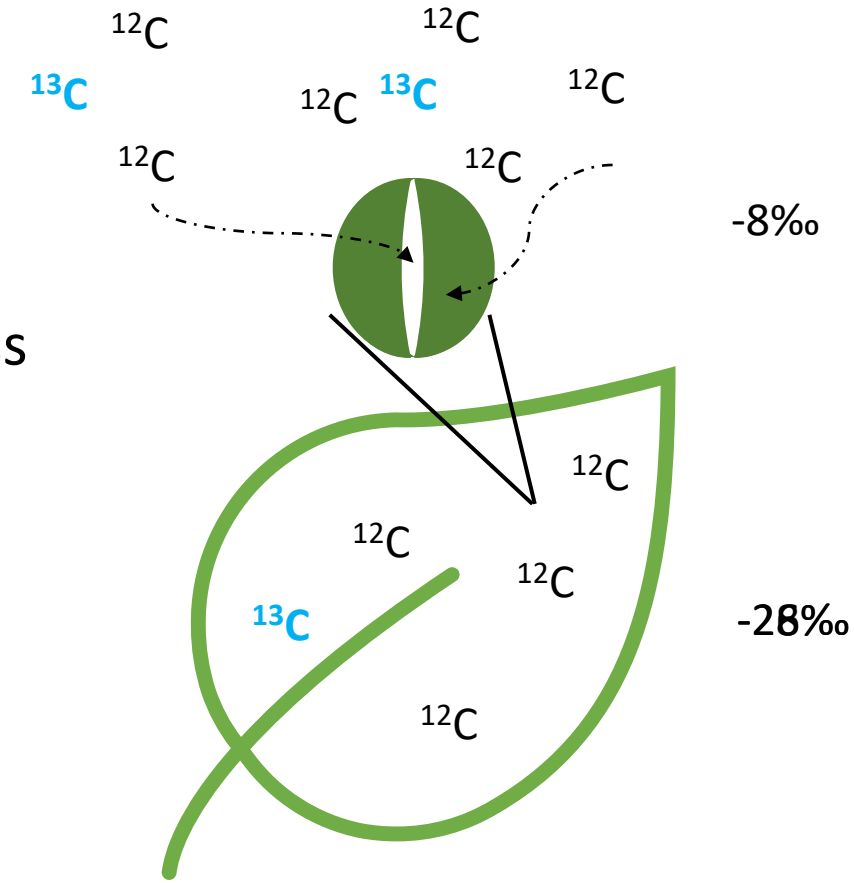
Principle

- C3 plants: ^{13}C discrimination during photosynthesis
- Stomatal closure decreases discrimination
- $\delta^{13}C$ in plant material indicator for drought stress

Bulk leaf $\delta^{13}C$

- Confirmed use for banana (*Vantyghem et. al, 2022*)
- Stable & time-integrated

…what about instantaneous stress?



$\delta^{13}C_{phloem}$

- Phloem sap contains recent photo-assimilates
- Information on instantaneous stress?
- Sampling?

Objective

- Develop phloem sampling method banana
- Evaluate $\delta^{13}C_{phloem}$ as an indicator for short-term changes in stress
- Compare with $\delta^{13}C_{bulk}$

Approach

Experimental set-up

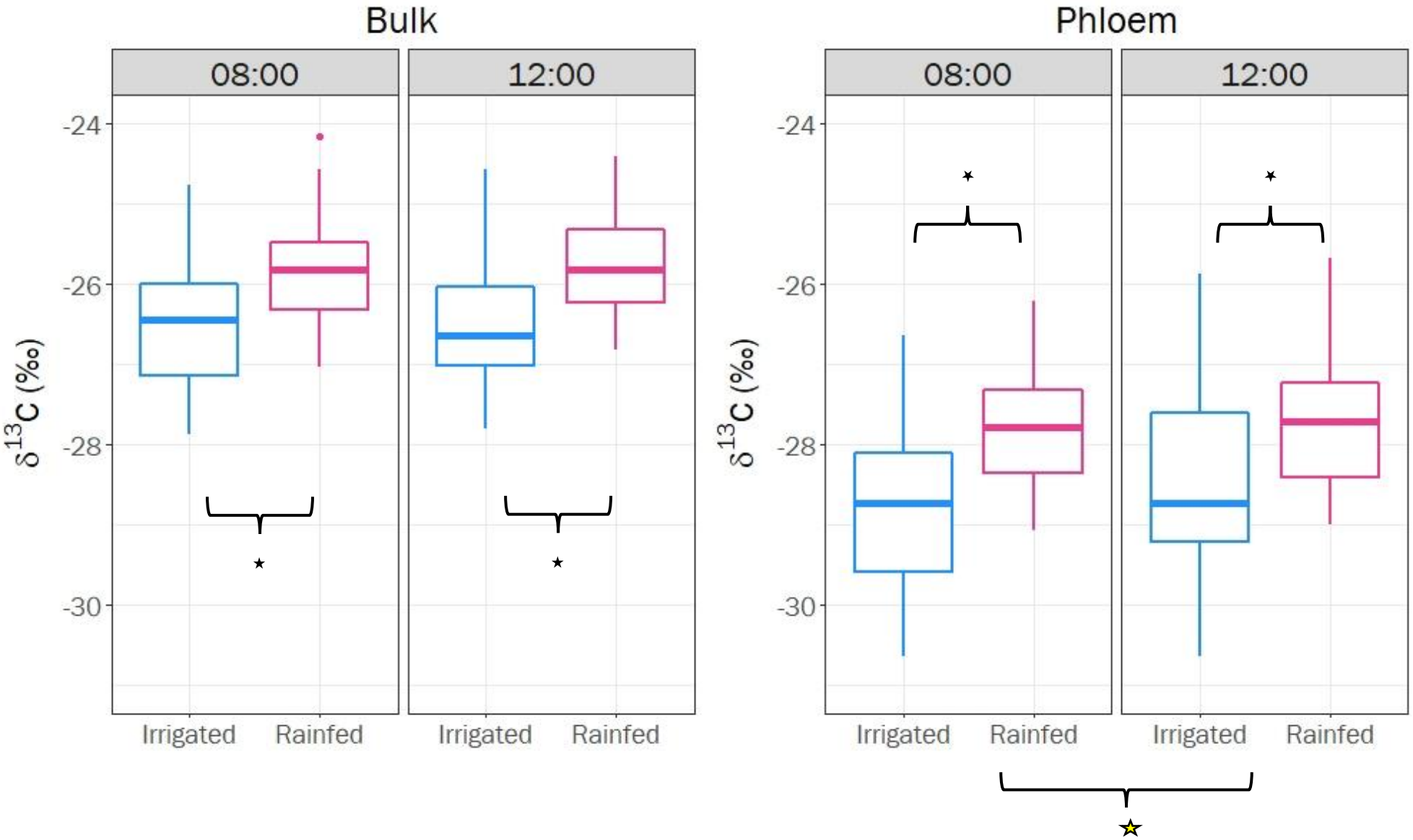
- Experimental farm NM-AIST/IITA, Arusha, Tanzania
- Long-term drought trial (planted 2017) – **irrigated/rainfed**
- Sampling in January, 2021 (**dry season**)
- Grand Nain, 4th cycle
- **Bulk** leaf samples - **phloem sap** samples
- **Morning** (8am) – **noon** (12am)
- 24 plants
- 2nd – 4th fully open leaves

Phloem sap sampling

- Adapted from trees (*Gessler et. al, 2004*)
- Excise 0.5 cm^3 from **petiole**
- Place in 1 mL distilled H_20
- Rest 5h (**extract WSOM**), remove tissue
- Wash with non-polar solvent to remove latex
- 100 µL aliquot of aqueous phase
- Place in tin capsule, oven-dry (70°C)
- Isotope Ratio Mass Spectrometry (**IRMS**)

Results

Results

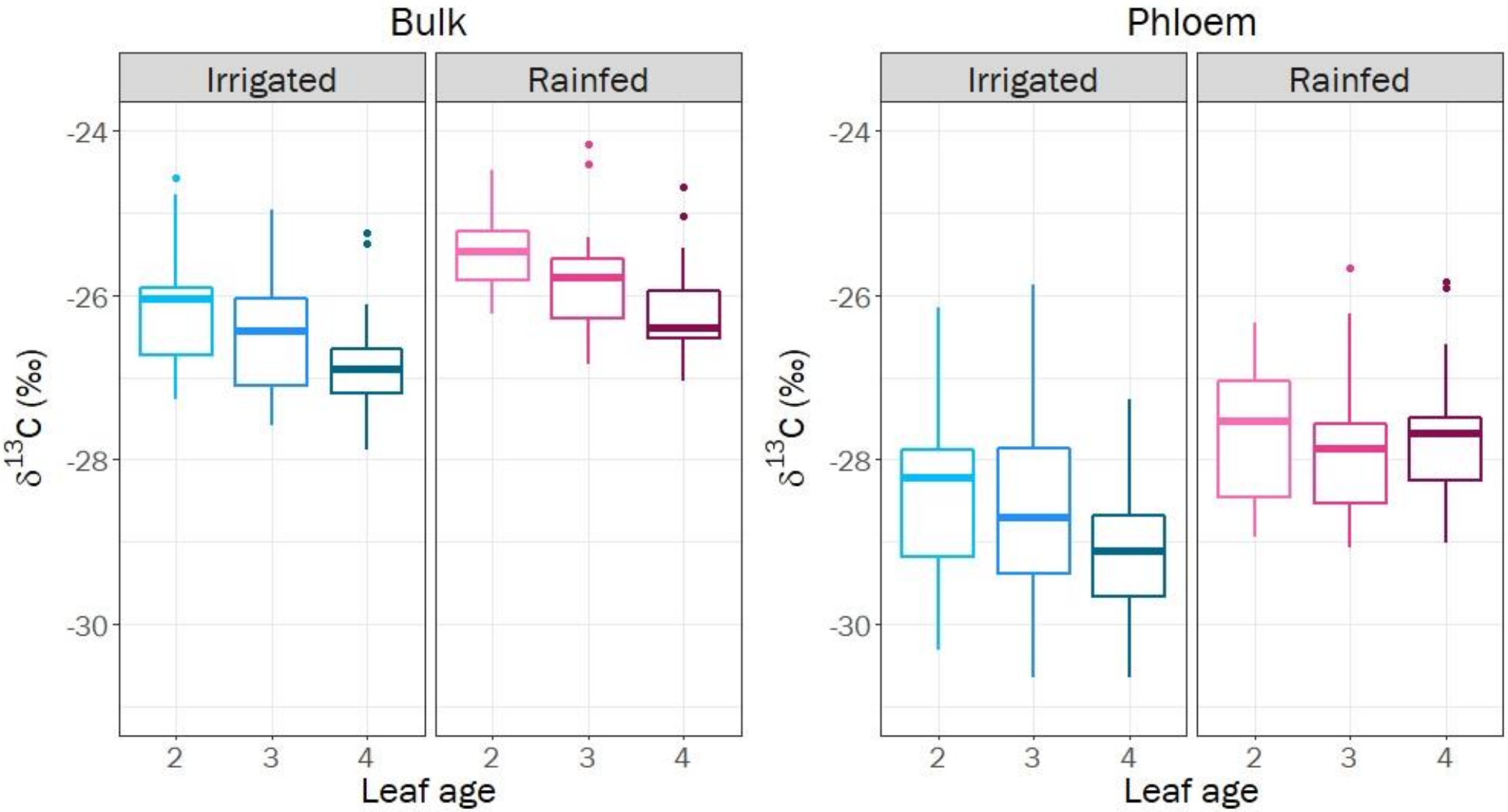


Results

Phloem recovery rate (mg WSOM/cm³)

		Time**	
		8:00	**12:00**
Treatment	**Irrigated**	7.45 ± 0.53	5.72 ± 0.38
	rainfed	7.07 ± 0.51	5.09 ± 0.31

Results


Bulk
Irrigated
Rainfed
-24
-26
-28
-30
$\delta^{13}C$ (‰)
2
3
4
Leaf age
Phloem
Irrigated
Rainfed
-24
-26
-28
-30
$\delta^{13}C$ (‰)
2
3
4
Leaf age

Conclusion

Conclusion

- $\delta^{13}C_{phloem}$ is a **sensitive** indicator for drought stress
  - ✓Strong treatment effect
  - ✓Diurnal variation
  - ✓Light exposure variation?

- Sampling method works
  - ✓Easily applicable **in-field**
  - ✓**Sufficient** amounts of sample for analysis
  - ✓**Qualitative**

Thank you!

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

KU LEUVEN

BOKU

KINGDOM OF BELGIUM
Foreign Affairs,
Foreign Trade and
Development Cooperation

IITA
Research to Nourish Africa

Nelson Mandela African Institute of Science and Technology
Arusha
Academia for Society and Industry