Stable water isotopes reveal agricultural co-cropping as a potential climate change adaptation practice

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Introduction

- Water stress occurrences are projected to increase by 50% by 2050 in some areas in Scotland and the UK[1].
- Nature-based solutions (NBS) such as co-cropping cereals and legumes could potentially provide soil water optimisation in agroecosystems[2].

Aim and Objectives of this Study

Aim: To explore water uptake dynamics of cereals in different cropping systems using stable water isotopes during water-stressed conditions.

Objectives are to:

1. Characterise isotopic values of precipitation.
2. Determine the sources of plant water uptake of monocultures.
3. Assess changes when co-cropped with legumes.

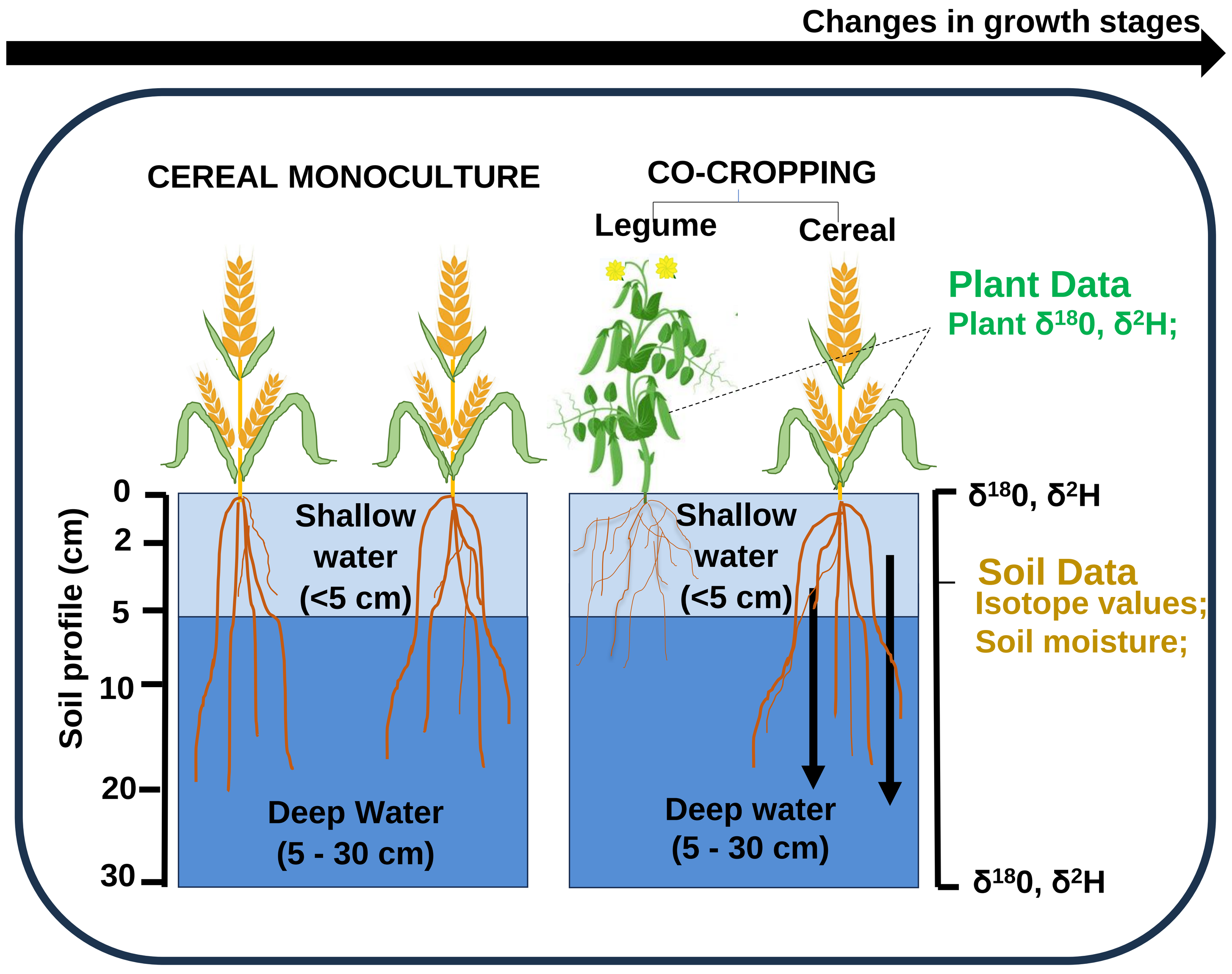

Fig. 1: Conceptual diagram of determining plant water uptake dynamics in cereal monoculture and co-cropping during different growth stages using stable water isotopes

Methods

- This study uses stable isotopes of soil and vegetation water (δ^2H and $\delta^{18}O$) to explore water uptake sources and patterns in agroecosystems[3] (Fig.1).
- Field experiments at Balruddery Farm, Dundee, UK in 2022 and 2023 (Fig.2).
- Treatments (4 monocultures and 5 co-cropping)

Monocultures	Co-cropping
Barley (3 genotypes)	Barley and Pea (**B&P**) Barley and Bean (**B&F**)
Wheat (1 genotype)	Wheat and Faba bean (***W&F***) Wheat and Pea (***W&P***)

Fig. 2: Study location

Results

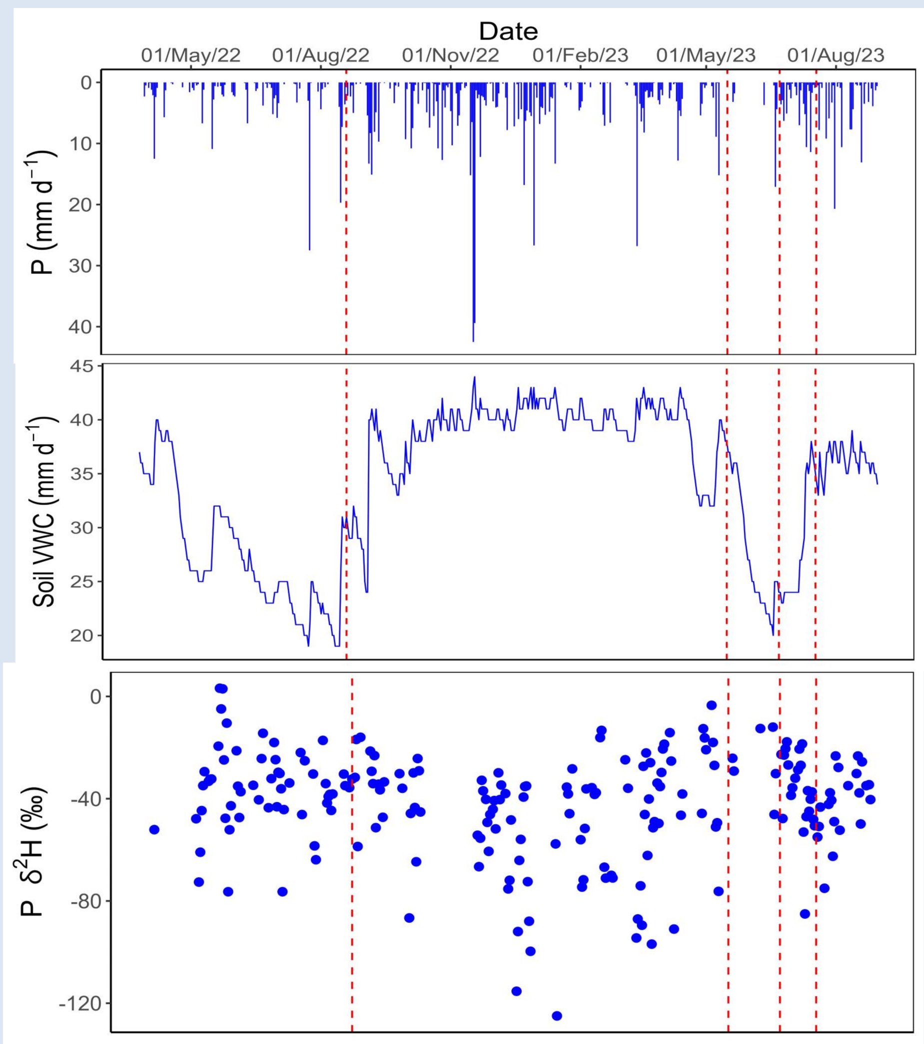

Fig. 3: Hydro-climatological data during the study period.

- Huge variation in precipitation patterns during the study period with wet winter and dry summers (Fig. 3).
- Dry conditions (low soil moisture content ~20%) prevailed during sampling in August 2022 and June 2023.
- Isotopic values of precipitation shows seasonal patterns with summer samples more enriched and winter samples more depleted.

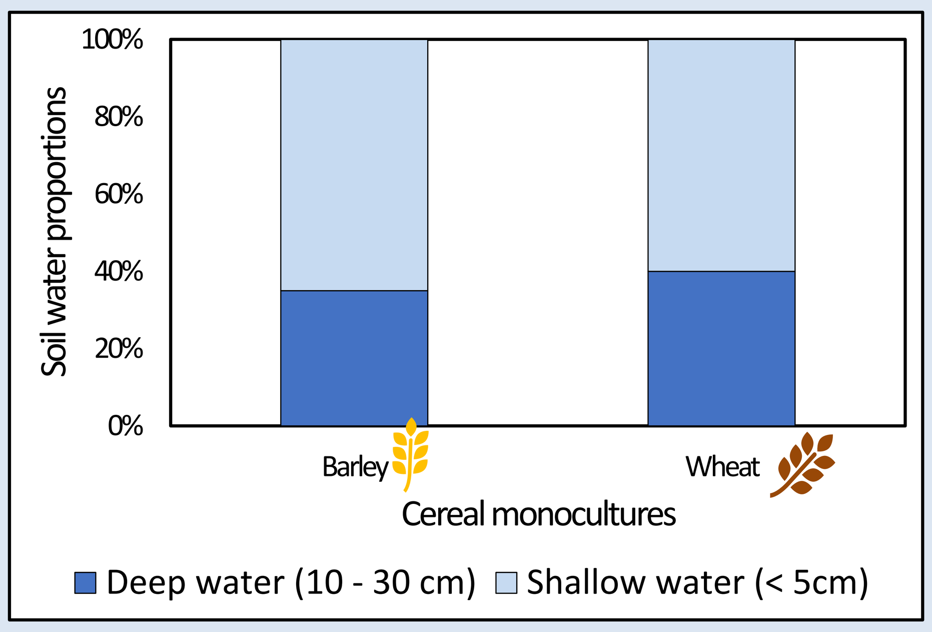

Fig. 4: Sources of plant water uptake of monocultures.

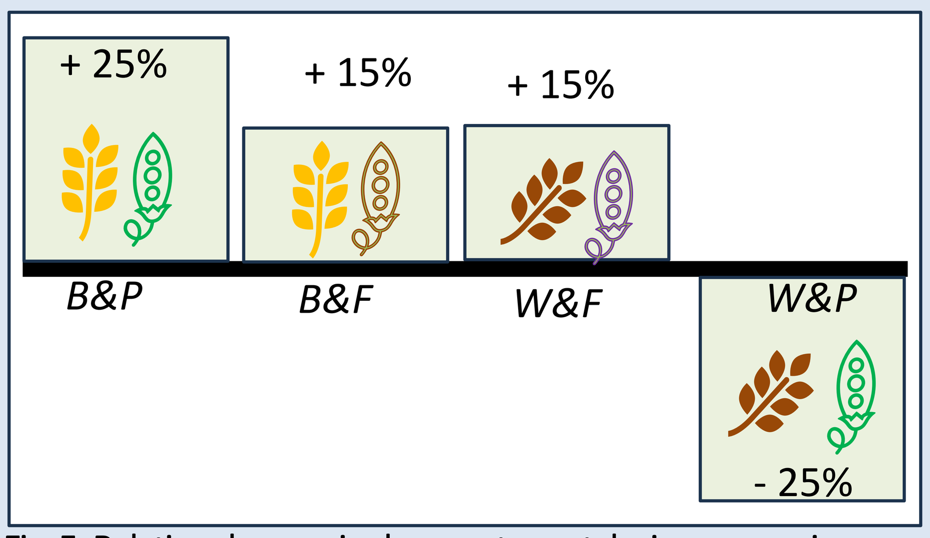

Fig. 5: Relative changes in deep water uptake in co-cropping compared to their monocultures.

- Plant cereals in monocultures predominantly used shallow soil water (upper 5 cm), regardless of growth stage and hydro-climatological conditions (Fig. 4).
- Overall, the cereals in co-cropping exhibited plasticity and increased plant uptake from deep soil water (5 - 30 cm) compared to their respective monocultures during dry periods (Fig. 5).
- The results show that only *W&P* is mostly dependent on shallow soil water.

Conclusions

- Successful novel study of water dynamics in Scottish agroecosystems using stable isotopes of water (δ^2H and $\delta^{18}O$).
- Cereal plants in Scotland mostly use shallow soil water (≤ 5 cm depth) during growth.
- Co-cropping cereals with legumes showed optimisation of soil water use, with the potential to grow more food under limited water availabilities.
- Co-cropping can provide climate resilience for cereals and improve productivity.
- Useful information and data for climate, water, and agricultural policies.

Future

- Modelling of carbon and water interlinkages in co-cropping systems under climate change.
- Model water use of different crop combinations under climate change scenarios.
- Develop a framework for selecting appropriate co-cropping systems in Scotland that would be beneficial for farmers, policymakers, and researchers.

References

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