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Using stable water isotopes to trace cereal water use in agricultural co-cropping systems under contrasting hydro-climatological conditions

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Agricultural co-cropping, which is the cultivation of two or more crops simultaneously on the same field, is gaining rapid attention in temperate agroecosystems as a viable nature-based solution to improve agricultural productivity. However, relatively little is known about plant water use patterns in temperate agricultural co-cropping systems. Specifically, the functioning and resilience of these systems compared to their equivalent monocultures is likely to depend on whether water use is complementary for the different crops and how this might change during the growing season and under different hydro-climatological conditions.

This study focused on addressing these knowledge gaps by using water stable isotopes to trace the sources of vegetation water uptake (shallow or deep soil water) in 5 different cereal-legume co-cropping systems and 4 of their respective cereal monocultures under field conditions in North-East Scotland. For each treatment, we extracted vegetation water, and soil water from 5 different depths for analysis of isotopic composition. We then performed MixSIAR end-member mixing modelling to explore proportional water uptake patterns for cereal vegetation throughout the growing season and under wet and dry conditions.

The results showed that cereals in all the monocultures and co-cropping systems predominantly used shallow soil water (upper 5 cm), regardless of growth stage and hydro-climatological conditions. Cereal water uptake patterns in monocultures and co-cropping systems were comparable during wet hydrological conditions. However, the analyses revealed that cereals in co-cropping systems exhibited plasticity and increased their water uptake up from deeper soil water (5 – 30 cm) compared to cereals in monocultures during dry conditions. Furthermore, during dry conditions, we found different seasonal responses in the co-cropping systems between cereal genotypes traits. Understanding of plant water use patterns for different cropping systems could inform the design of resilient and sustainable water management practices and agricultural policies. The plasticity observed in co-cropping systems could potentially contribute to optimised

water use under climate change.