Evaluation of water use and carbon interactions in different agricultural co-cropping systems

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Introduction

- Rising water-stressed conditions in early spring and drier summers in some areas of Scotland and the UK[1, 2].
- Agricultural co-cropping systems have multiple benefits[3].
- Mechanisms for successful co-cropping systems are not fully understood.

Agricultural co-cropping

- Agroecological practice of growing two or more crop species simultaneously in the same field.
- ❖Co-cropping barley with pea may improve barley productivity and resource use due to nitrogen fixation by the pea.

Aim and Objectives

Project Aim: To examine the role of agricultural co-cropping systems in sustainable water use and carbon sequestration in a temperate system.

❖ Here we present results from an initial field experiment which aimed to characterise water use and carbon sequestration in barley-pea co-cropping systems.

Objectives of phase one were to:

1. Quantify crop productivity, water use and soil carbon
2. Compare two crop genotype traits
3. Determine seasonal changes in water use

Methodology

❖Trial from 18 April 2022 to 16 September 2022.

❖Soil and plant samples collected for analysis.

❖Land equivalent ratio (LER) >1 signifies higher land productivity.

Table 1: Two contrasting barley varieties and one pea variety designed in 5 treatments

S/N	Treatments	Shortened name
1	Barley (Laureate) monoculture	Barley1_mono
2	Barley (Sassy) monoculture	Barley2_mono
3	Pea (LG Stallion) monoculture	Pea_ mono
4	Laureate and LG Stallion	Barley1+ Pea
5	Sassy and LG Stallion	Barley2+Pea

Co-crops:
❖ Deep + shallow root traits
❖ Cereal + legume
❖ Mix ratio: 70 % - 30%

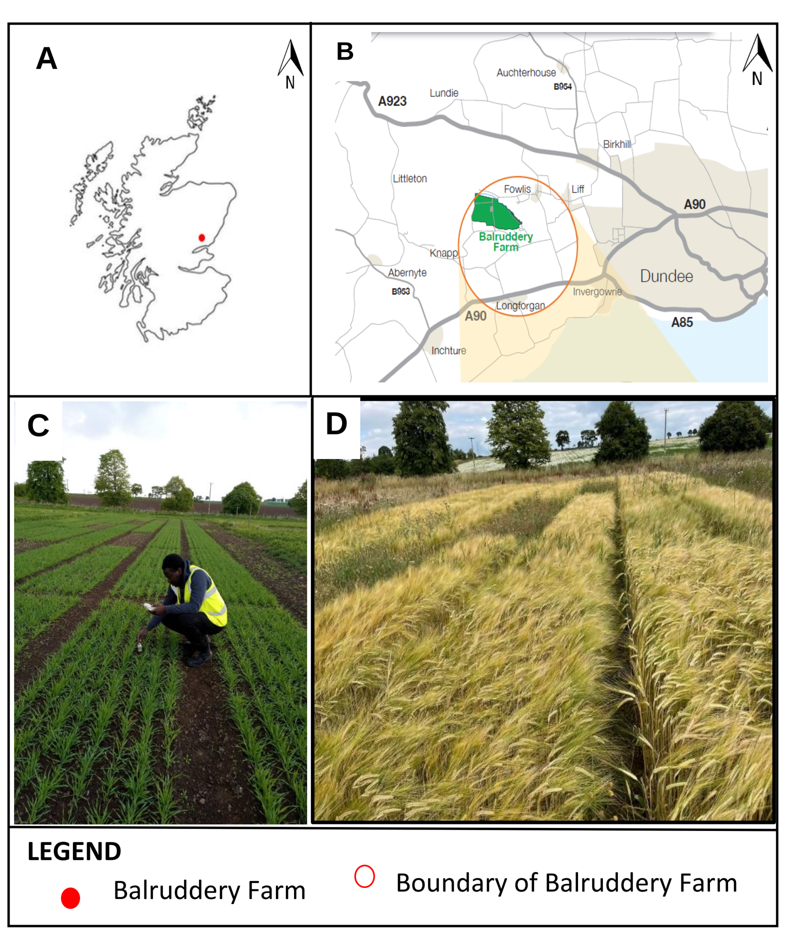

Figure 1: Trial at Balruddery Farm, Invergowrie, Dundee, UK

Preliminary Results of First Field Season

Hydroclimatological conditions during the study period

❖ Higher air temperatures and lower precipitation compared with 1960 – 2021 (Fig.2).

❖ Decline in soil moisture (Fig. 3).

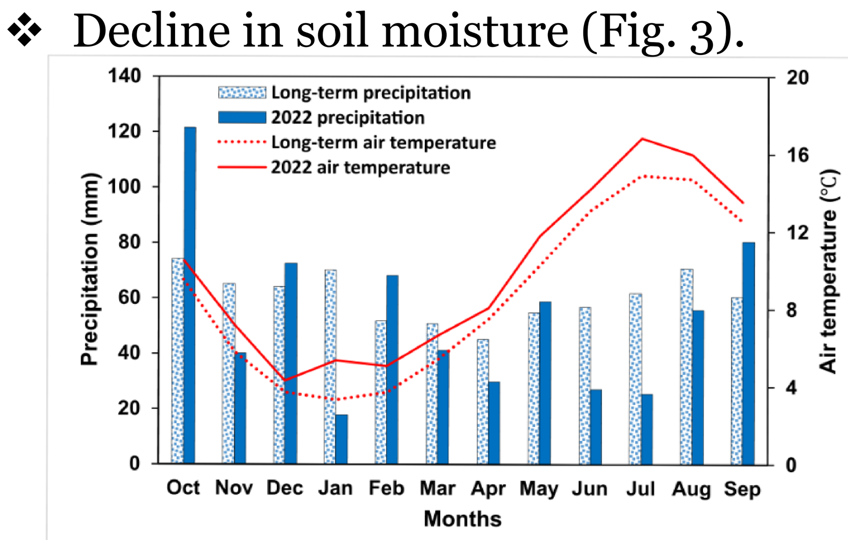

Figure 2: Monthly precipitation totals (mm) and average air temperature (℃) of 2022 hydrological year compared with the long-term (1960 - 2021) for Mylnefield-Invergowrie catchment. Source: UK Met Office

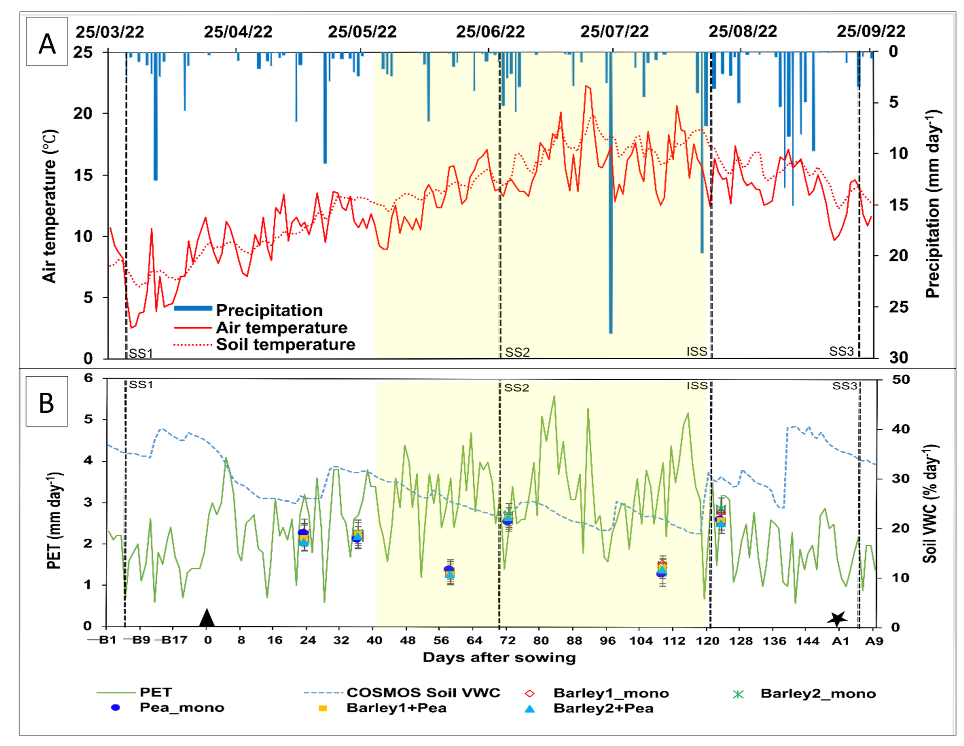

Figure 3: A - B) Hydroclimatological data during the trial. Source: COSMOS UK. ***The yellow band is the dry period based on 1- and 3-month Standardised Precipitation Index (SPI)****. Dash lines : SS1 = pre-sowing, SS2 = mid-growing, SS3 = post-harvest and ISS = isotopic sampling. The triangle is day of sowing, star is day of harvest; -B1 to -B24 are days before sowing; A1 to A9 are days after harvest.*

Grain yield , LER , WUE, and soil carbon

❖Pea failed due to the dry spell [4].

❖Laureate compensated for lower seed rate (100% of monocrop yield) (Table 2).

❖Sassy showed less plasticity in co-crop plots (94% of monocrop yield).

❖Soil carbon was unaffected (Fig. 4).

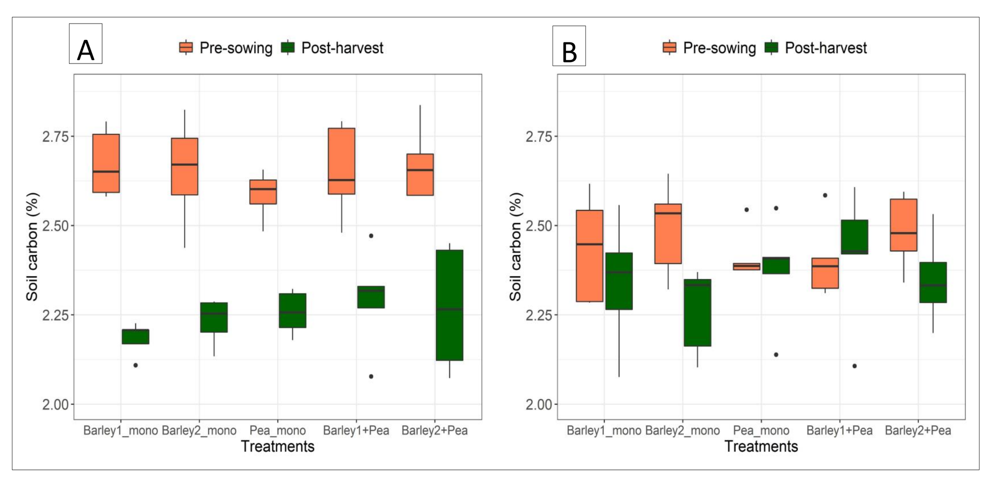

Figure 4: Soil carbon (%) of A) topsoil (0 - 5 cm) and B) deep soil (25 - 30 cm) at pre-sowing and post-harvest. n = 10 for each treatment.

Table 2: Average grain yields, land equivalent ratio (LER), and water use efficiency (WUE) of the treatments (n = 5).

Treatment	Crop	Grain yield ($g\ m^{-2}$)	LER	WUE ($kg\ m^{-3}$)
Barley (Laureate) monoculture	Laureate	439	-	1.15
Barley (Sassy) monoculture	Sassy	409	-	1.07
Pea (LG Stallion) monoculture	LG Stallion	15	-	0.03
Laureate and LG Stallion	Laureate	439	1.00	1.15
Sassy and LG Stallion	Sassy	383	0.94	1.00

Summary of preliminary results

❖This study is among the first few studies to examine agricultural co-cropping water use, and carbon cycling under a natural water-stressed condition in a temperate climate.

❖Under a dry period, barley maintained productivity and water use where pea failed.

❖Different responses of the barley genotypes were due to phenotypic plasticity in the absence of competition.

❖Barley – pea co-cropping could provide insurance against complete crop failure even under a water-stressed condition.

Future work

❖Analysis of soil water and plant xylem using stable water isotopes (δ^2H and $\delta^{18}O$) to determine water sources utilised by the crops.

❖This initial experiment will be developed further as described in Figure 5.

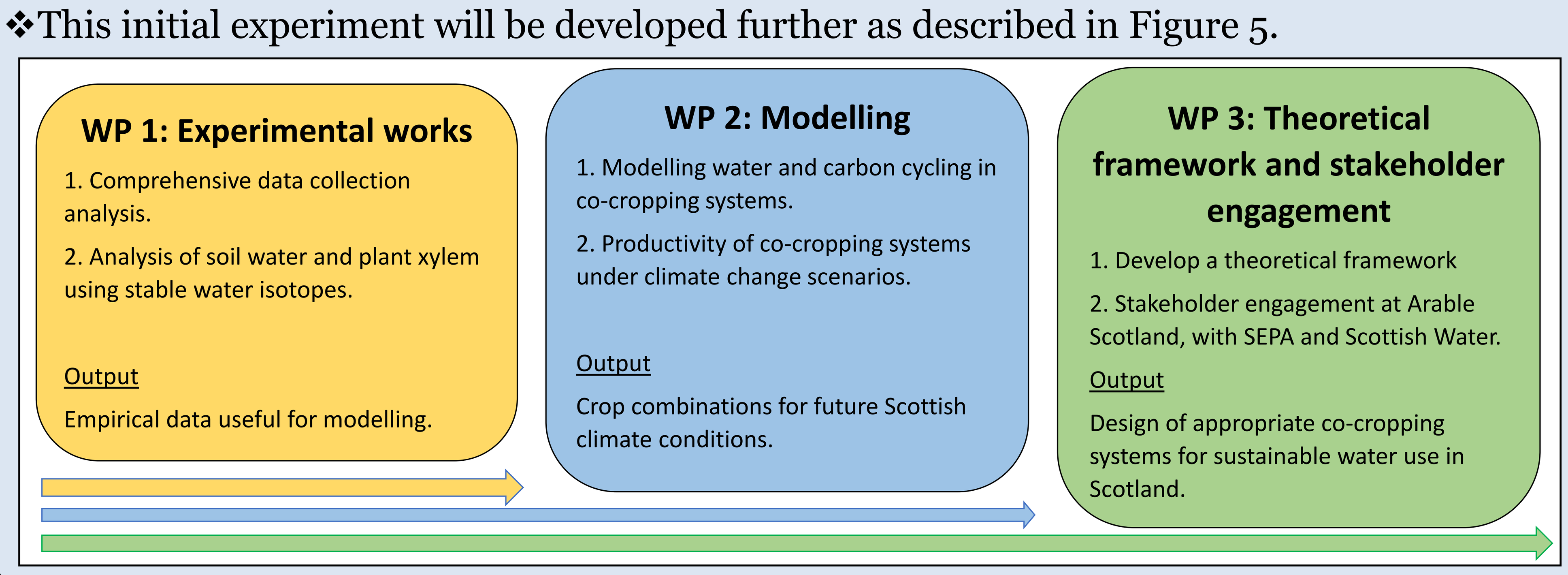

Figure 5: Future work and knowledge outputs from project work packages (WP).

Acknowledgements

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References

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