Optimising water use and soil carbon sequestration

Can agricultural co-cropping systems provide multiple benefits to address climate change?

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1. Introduction

In Scotland, drought conditions are predicted to rise by 20 – 30 % by 2050 which is likely to cause water stress in agriculture, and other sectors[1].

Agricultural co-cropping is a measure that potentially increases system resilience to drought[2].

Co-cropping systems are already shown to have many benefits, such as higher yields, increased land productivity, improved soil health and biodiversity[2]

However, its potential in optimising water use (as a climate change adaptation strategy) and increasing soil carbon sequestration (for climate change mitigation) has not been fully explored.

Crop combinations that might be best in future Scottish climate conditions are unknown.

1.1 Co-cropping systems

Description of co-cropping systems

Co-cropping is the practice of growing two or more crop species simultaneously on the same field for a significant part of the growing cycle (Fig.1).

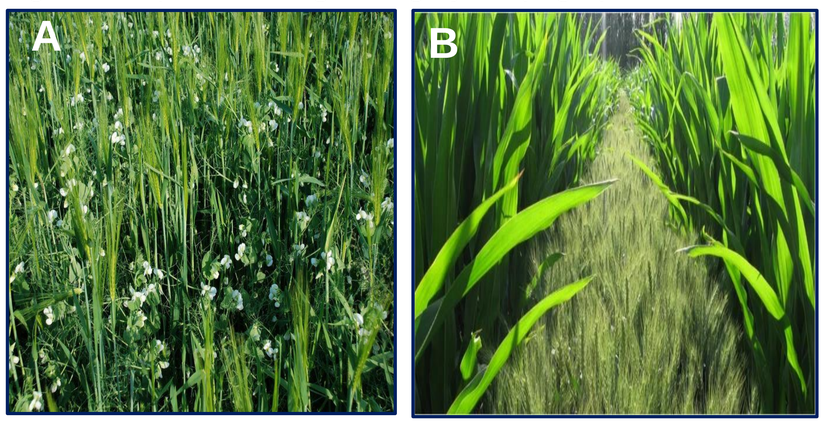

Fig 1a: Co-cropping of peas and barley. Source: FiBL, Hansueli Dieraue, DiverIMPACTS

Fig 1b: Co-cropping of maize and wheat. Source: J. Evers, Wageningen University and Research

1.2 Aim and objectives

Aim: Examine the role of agricultural co-cropping systems in sustainable **water use** and **carbon sequestration**.

Objectives

1) Identify viable co-cropping systems for Scotland based on trait complementarity.
2) Characterise the relationships between water and carbon cycling in co-cropping systems and how those change under water stressed conditions.
3) Examine the resilience and long-term sustainability of co-cropping systems under climate change.
4) Develop a theoretical framework to test hypotheses on water-carbon interlinkages and resource complementarity in co-cropping systems.

Acknowledgements

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2. Methodology

- The methodological approach of the research is described in Fig. 2.

WP 1: Development of a review-based matrix of crop traits and performance
Addressing Objective 1
- ❑ Analyse existing co-cropping datasets
- ❑ Develop a systematic approach for selecting potential co-cropping systems

WP 2: Experimental work to understand underlying mechanisms of co-cropping systems
Addressing Objective 2
- ❑ Field experiments: collecting plant, emission, meteorological and soil data (Fig. 3)
- ❑ Laboratory analysis: Detailed analysis of soil, water & plant from field experiments using stable water isotopes [3]

WP 3: Role of co-cropping systems in climate change adaptation and mitigation
Addressing Objective 3
- ❑ Modelling water and carbon cycling in co-cropping systems under climate change

WP 4: Development of theoretical framework and stakeholder engagement
Addressing Objective 4
- ❑ Develop a theoretical framework to test hypotheses on water-carbon interlinkages and resource complementarity in co-cropping systems useful for selecting appropriate co-cropping combinations and modelling
- ❑ Stakeholder engagement via Arable Scotland, also including SEPA and Scottish Water.

Figure 2: The methodological approach of the research. WP = Work Package

- Fig. 3 shows experimental approach while Fig. 4 describes interactions in co-cropping systems

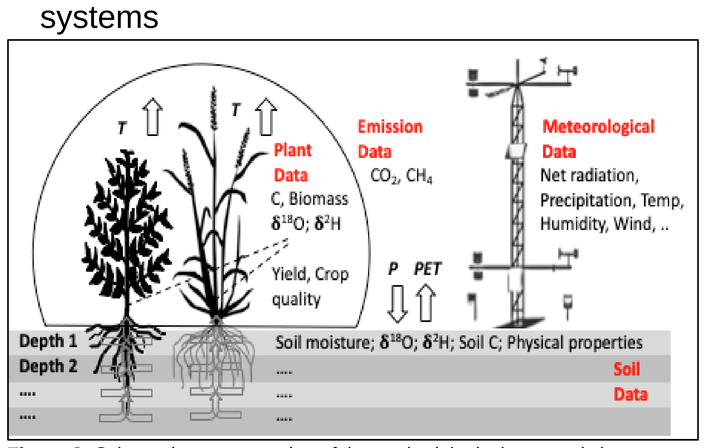

Figure 3: Schematic representation of the methodological approach (not to scale) to be implemented at field site. Arrows represent water fluxes. *T* = Transpiration, *P* = Precipitation, *PET* = Potential evapotranspiration.

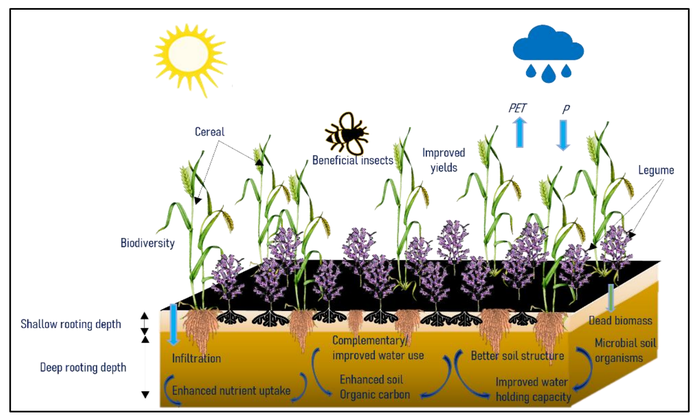

Figure 4: Above-and below-ground processes in a co-cropping system. P = Precipitation, PET = Potential evapotranspiration

3. First-year experimental design

- Field experiments to test **spring barley/pea** and **winter wheat/faba bean** combinations**.**
- Specific question: What is the water use strategy (competition, facilitation, complementarity, or compensation) and what quantity of carbon can be sequestered?
- The selected crop combinations have niche complementarity in terms of root traits (deep-rooted vs shallow-rooted) which are relevant for water use and carbon sequestration.

Table 1: Details of the first-year experimental setup

Growing season	Co-cropping system	Root traits	Treatments	Layout	Farm
Spring 2022	Spring barley and pea	Deep-rooted and shallow-rooted	1. Barley (Laureate) monoculture 2. Barley (Sassy) monoculture 3. Pea (LG Stallion) monoculture 4. Laureate / LG Stallion (70% /30%) 5. Sassy / LG Stallion (70% /30%	5 treatments x 5 replicates. Each plot is 1.5 m wide x 6.25 m long	Grieves House (Fig 5), Balruddery Farm Dundee
Winter 2022	Winter wheat and faba bean	Deep-rooted and shallow-rooted	1. Wheat (variety 1) monoculture 2. Wheat (variety 2) monoculture 3. Faba bean monoculture 4. Wheat variety 1 / Faba bean (70% /30%) 5. Wheat variety 2 / Faba bean (70% /30%)	5 treatments x 5 replicates. Each plot is 1.5 m wide x 6.25 m long	Grieves House (Fig 5), Dundee

Fig 5a: Aerial photo of Grieves House with the experimental plot layout shaded in blue

Fig 5b. Experimental plot layout. T = Treatment; Rep = Replicate; G = Guard

Eventually, this study will help to design appropriate co-cropping systems and support Scotland's actions and strategies for sustainable water use and to reach net zero carbon emissions by 2045.

4. References

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