Co-cropping improves soil carbon and productivity for environmental sustainability of crops grown without agrochemicals

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Introduction

- Cereal production covers approximately 410, 000 hectares in Scotland[1].
- Due to the climate crisis, there is an urgent need to grow more food with less land and resources globally[2].
- Nature-based solutions (NBS) such as co-cropping cereals (e.g., barley) and legumes (e.g., peas) could potentially help meet these goals, increasing soil carbon and improving crop production, alongside other agricultural and environmental benefits[3].

Aim and Objectives of this Study

Aim: To explore the impacts of different barley-pea co-cropping systems on soil carbon and crop productivity in crops grown without agrochemicals.

Objectives are to:

1. Examine soil carbon, yields, and crop productivity in co-cropping compared with monocultures.
2. Compare two barley cultivars with contrasting traits.

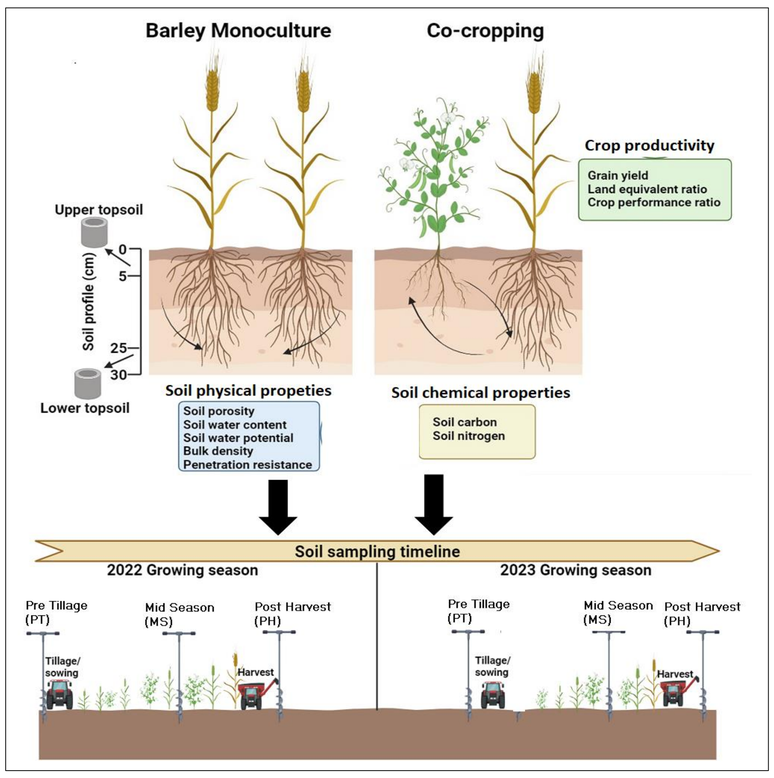

Fig. 2: Schematic representation of the crop productivity and soil properties examined in the mono- and co-cropping systems. The lower schematic indicates the 6 sampling occasions.

Methods

- Field study at Balruddery Farm, Dundee, UK in 2022 and 2023 (Fig. 1) designed in 5 cropping systems with 5 replicates each.

Monocultures	Co-cropping
Barley (Laureate) (**BL**) Barley (KWS Sassy) (**BS**)	Barley (Laureate) and Pea (***BL&PS***); 70:30 mix
Pea (LG Stallion) (**PS**)	Barley (KWS Sassy) and Pea (***BS&PS***);70:30 mix

- Key soil property were examined at 0-5cm (upper topsoil) and 25-30cm (lower topsoil) depths (Fig 2).
- No agrochemicals (fertilizers, pesticides or herbicides) were used.
- Crop performance ratio (CPR) was used as an indicator for crop productivity; Land equivalent ratio (LER) was used to indicate land productivity.

Fig. 1: Study site at Balruderry Farm, Dundee

Results

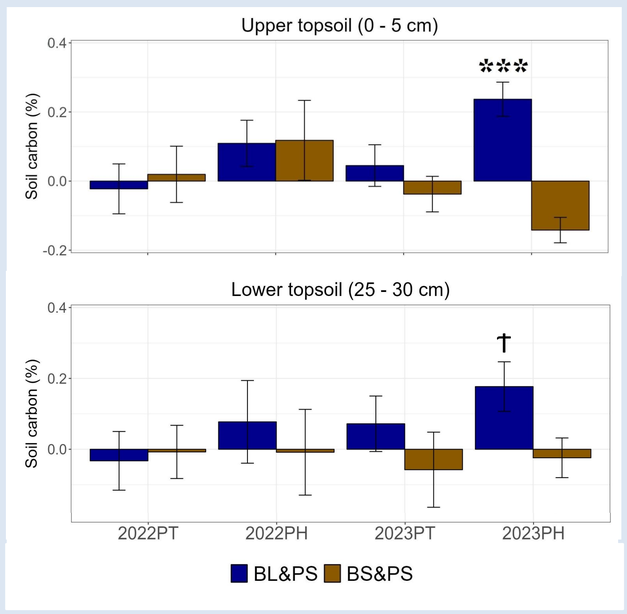

Fig. 3: Comparative differences in total carbon (%) of co-cropping systems and their respective monocultures during all sampling occasions. *BL&PS* = Barley (Laureate) and pea; *BS&PS* = Barley (KWS Sassy) and with pea. PT = Pre-treatment; PH = Post-harvest. ***indicates significant ($p<0.05$) and † indicates marginal ($p<0.1$) difference.

- In the upper topsoil (<5cm soil depth), total soil carbon significantly increased under barley (Laureate) co-cropping compared with the monoculture in 2023 (Fig. 3).
- A trend towards increased total soil carbon was also observed in the lower topsoil of barley (Laureate) co-cropping, suggesting potential long-term benefits (Fig. 3).
- Cultivar-specific responses to soil carbon were observed in co-cropping.

Table 1: Barley grain yields (Mean ± standard deviation) of the cropping systems. Barley sowing rate in co-cropping is 70% of monocultures (w/w).

	2022	2023
Cropping systems	**Yield** ($g\ m^{-2}$)	**Yield** ($g\ m^{-2}$)
Barley (Laureate) Monoculture	440 ± 40	320 ± 60
Barley (Laureate) and Pea	440 ± 50	350 ± 60
Barley (KWS Sassy) Monoculture	410 ± 50	300 ± 60
Barley (KWS Sassy) and Pea	380 ± 60	300 ± 40

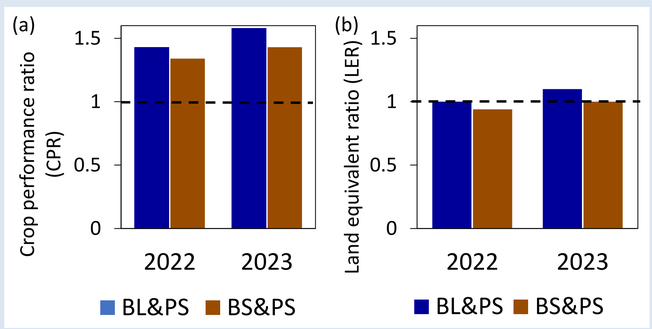

Fig. 4: Productivity of co-cropping systems. (a) Crop performance ratio (CPR) and (b) Land equivalent ratio (LER). *BL&PS* = Barley (Laureate) and pea; *BS&PS* = Barley (KWS Sassy) and with pea. No. of replicates (n= 5). The dashed line at 1 indicates monoculture performance.

- Co-cropped barley maintained yield despite lower seed rate (70% of monocrop) (Table 1).
- Despite the lower sowing rate, co-cropped Laureate yield was 100 - 110% of monocrop yield; Co-cropped Sassy yield was 94 - 100% of monocrop yield.
- Peas senesced in co-crop and monoculture before harvesting.
- Co-cropped barley showed higher crop productivity (34 – 58%) and up to 10% higher land productivity than the barley monoculture (Fig. 4).
- Different responses of the barley cultivars were due to phenotypic plasticity in the absence of competition from the peas.

Conclusions

- Co-cropping increased soil carbon and produced higher yields and productivity than monoculture crops grown without agrochemicals .
- Co-cropping could enhance soil health and crop productivity, offering resilience under a changing climate.
- Co-cropping can provide risk reduction and insurance against complete crop failure for barley.
- Results can be used to inform agricultural, environmental and net zero government policies.

Future

- Modelling of carbon and water interlinkages in co-cropping systems under climate change will be used to predict long-term impacts .
- Insights will be used to 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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