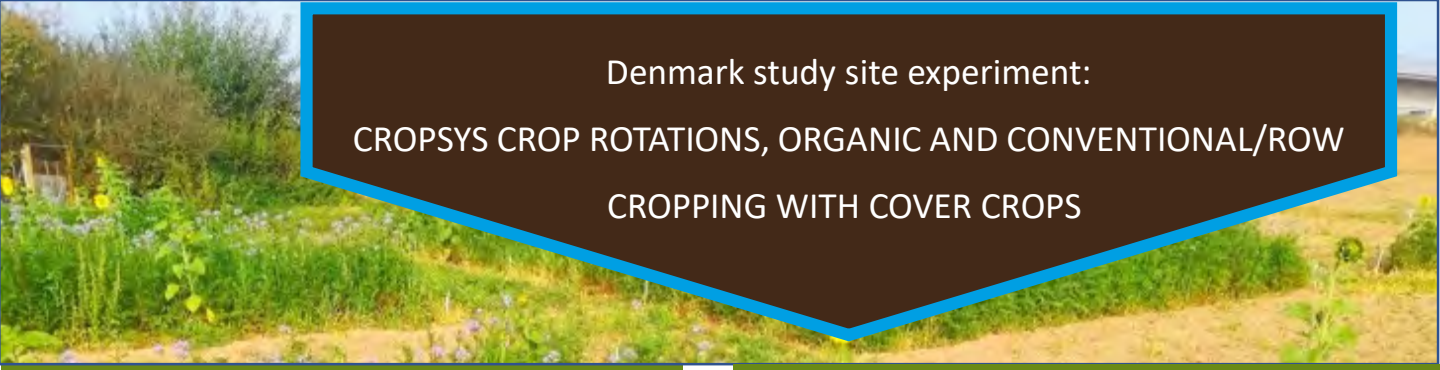

Denmark study site experiment:

CROPSYS CROP ROTATIONS, ORGANIC AND CONVENTIONAL/ROW CROPPING WITH COVER CROPS

The problem

Agricultural practices can affect soil health by altering soil chemical, physical and biological properties, with some effects being visible only in the long-term. The choice of crops to be grown in rotation, the use of organic amendments and the management of unproductive periods (fallow vs cover crops) can greatly affect the availability of nutrients in the system, as well as the build up of soil organic matter, the abundance of soil micro- and macro organisms and soil physical properties, such as bulk density. In the context of organic arable production, these aspects are of crucial importance to reduce the yield gap and increase the stability of the system.

The proposed solution

This experiment aimed at exploring whether the addition of animal manure, the use of cover crops and/or the inclusion of legume-based ley in the crop rotation would improve soil chemical, physical and biological properties for improved soil health in the long-term. These properties were assessed in 2019, and the treatments investigated had been performed since 2005.

This field site used a long-term crop rotation experiment that started in 1997 with focus on organic arable systems, with the aim of improving crop yield and nutrient availability while reducing nitrate leaching and weed problems. The field experiment is located at Foulum, in the central part of Denmark, and the soil is a sandy loam with a good content of soil organic carbon at the start of the experiment.

Experimental design

Crop rotation	Cover crop (CC) (+/-)	Animal manure (M) (+/-)
Organic 2 (O2) (Spring barley, ley, grass-clover, Spring wheat, Spring oats)	-	+
Organic 2 (O2)	+	-
Organic 2 (O2)	+	+
Organic 4 (O4) (Spring barley, Faba bean, Spring wheat, Spring oats)	-	+
Organic 4 (O4)	+	-
Organic 4 (O4)	+	+
Conventional 4* (C4) (Spring barley, Faba bean, Spring wheat, Spring oats)	+	-
Conventional 4* (C4)	-	-

* With mineral fertiliser (F).

Measurements taken: Relative crop yield change (compared to the control, i.e. conventional without cover crops), Bulk density, Earthworm counts, Water stable aggregates, Nutrient availability (P, K, Mg)

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Results

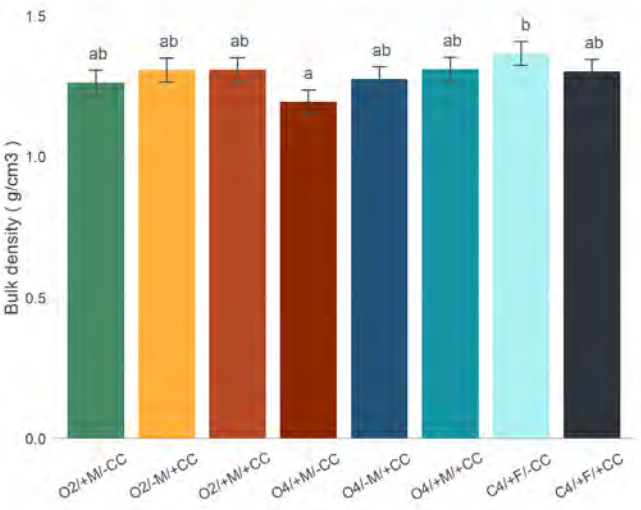

Figure 1. Bulk density versus treatments. There were significant differences found, with conventional without cover crops having the greatest bulk density.

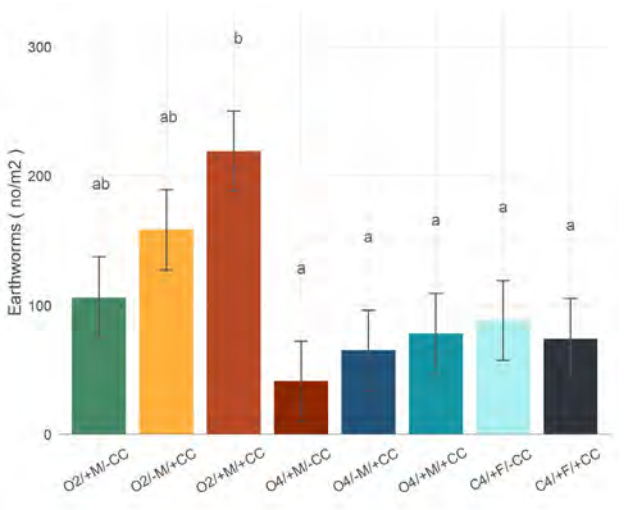

Figure 2. Earthworm counts versus treatment. O2 (organic with legume-based ley) with manure and cover crops resulted in significantly higher worm counts.

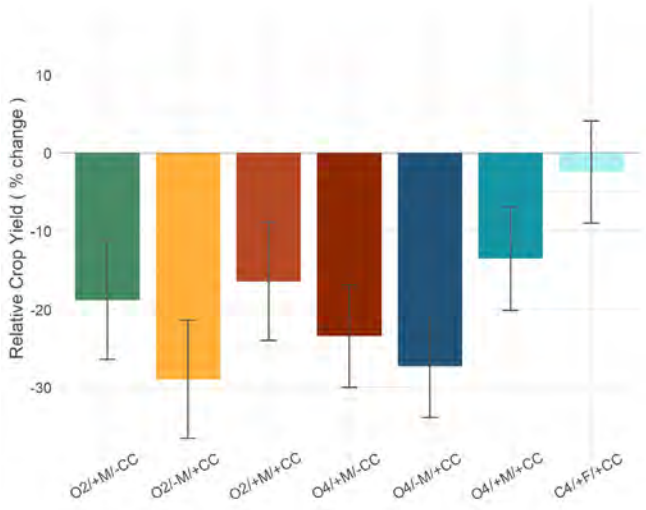

Figure 3. Relative crop yields (conventional without cover crops used as baseline) versus treatment. Organic treatments without animal manure resulted in the lowest yield, while use of cover crops and manure reduced the yield gap.

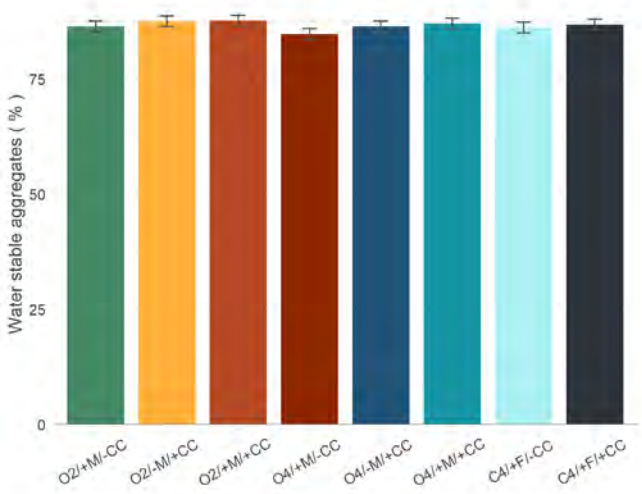

Figure 4. Water stable aggregates versus treatment. The high stability across treatments indicate good conditions irrespective of treatment.

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Results

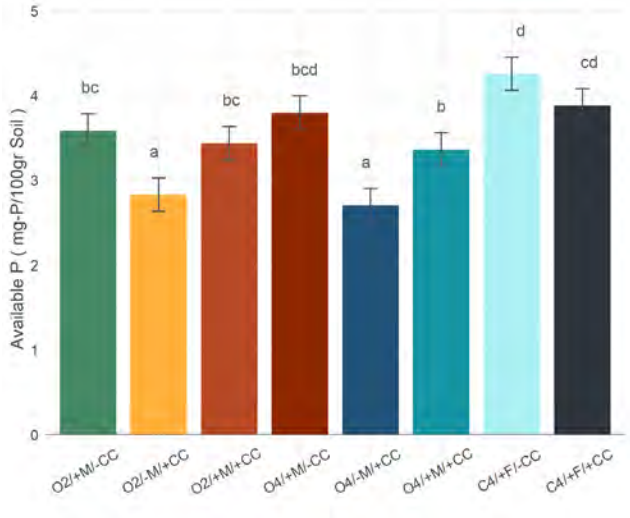

Figure 5. Available phosphate (P) versus treatment. The use of cover crops reduced P availability in the soil at time of sampling.

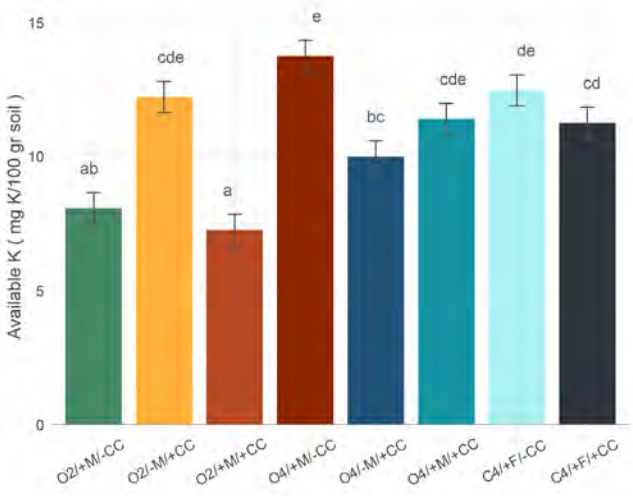

Figure 6. Available potassium (K) versus treatment. O2 with catch crops and O4 with manure resulted in significantly higher K availability.

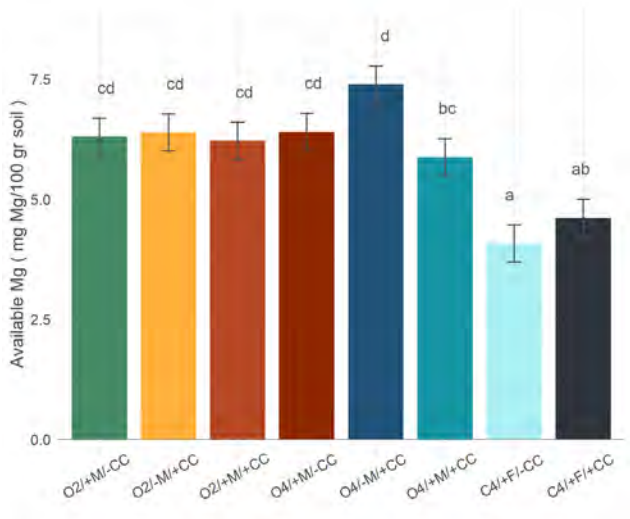

Figure 7. Available magnesium (Mg) versus treatments. There was significantly more availability under O4 with cover crops.

Rotation	Fertilizer	Cover crop	SOC (%) 2005	SOC (%) 2019
O2	+M	+CC	2.3	2.4
		-CC	2.0	2.1
	-M	+CC	2.0	2.1
O4	+M	+CC	1.9	2.1
		-CC	2.2	2.3
	-M	+CC	2.1	2.3
C4	+F	+CC	2.2	2.2
		-CC	1.9	2.0

Table 1. Soil organic carbon (SOC) versus treatments. SOC measured in 2019 reflected the same variation as at the start of the treatments in 2005, with only small changes.

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Economic analysis

- The costs of the cover crops used in this experiment were low as the ryegrass was under-sown alongside cereal seeds, with 6kg applied per hectare (equating to approximately 300 DKK per ha).

- Cover crops reduce N leaching. The economic savings of reducing N leaching was estimated at 5 DKK per kilogram of N

Stakeholder feedback

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Key findings

In this field experiment, small differences in soil physical properties and soil organic carbon were observed between treatments. This could be explained by the high initial quality of the soil and because no “extreme” treatments were included in the study. However, use of cover crops and animal manure affected the availability of nutrients in the soil at time of sampling, due to both short and long-term processes (e.g., temporary immobilization of P in cover crop biomass and depletion of P in organic treatments without animal manure). Compared to the control (conventional without cover crops), organic treatments had lower yields, but the yield gap was alleviated by the use of cover crops and animal manure. The inclusion of one year of legume-based ley in the rotation (O2) had a positive effect on earthworm abundance, which was particularly high in treatments with cover crops. This points to a joint effect of good quality litter availability and reduced soil disturbance by cultivation.

Conclusions

Use of cover crops, animal manure and legume-based leys can maintain or improve soil physical, chemical and biological properties, while reducing the yield gap between organic and conventional production. This is particularly relevant in organic arable systems, where the availability of nutrients may be limited.

Top right: earthworm count; top left: legume-based cover crops (undersown) growing after harvest of the main crop; bottom: plots in the field experiment.

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