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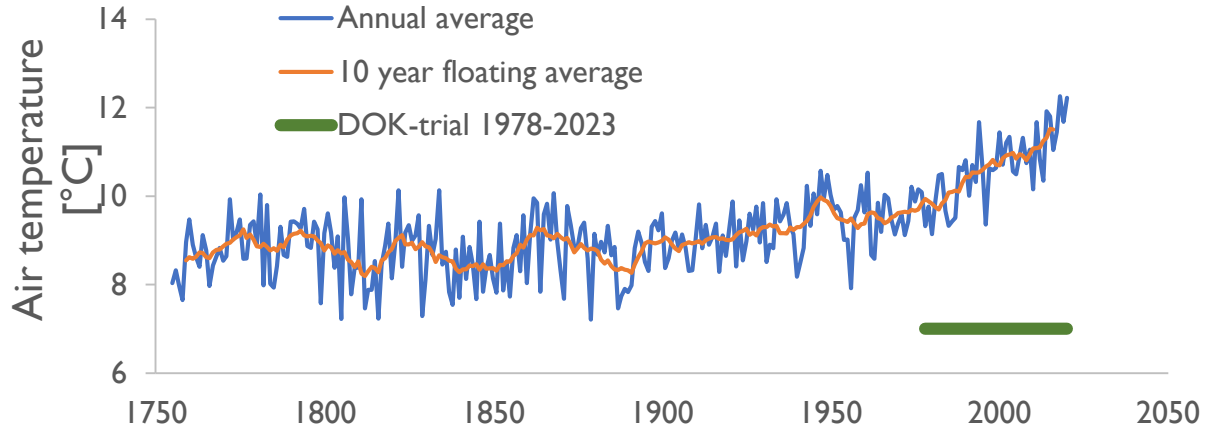
Organic farming for long-term food security

Evidence from 45 years research in the DOK trial

Andreas Fliessbach - Organic Innovation Days, 23.10.2024, Organic House, Brussels

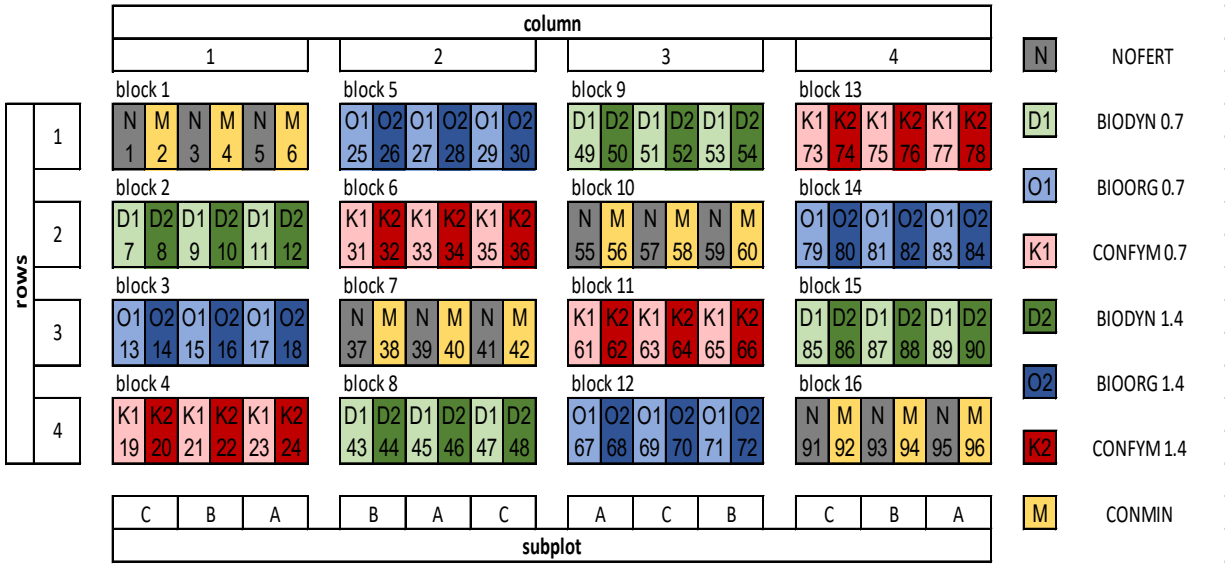
The DOK field experiment

- Long-term study since 1978
- System comparison „Is organic feasible?“
- Farmer groups as a reality control
- Today the trial serves as a research platform
- Scientific publications



Experimental design

- Haplic luvisol on deep alluvial loess
- 791 mm and 10.9°C MAT
- 8 Treatments – 3 subplots – 4 replicates
- 96 plots
- Soil tillage and crop rotation identical
- **BIODYN** – biodynamisch (demeter)
- **BIOORG** – bioorganisch (Bio Suisse)
- **CONFYM** – conventional (IP Suisse)
- **CONMIN** – conventional, no manure, industrial NPK



	NOFERT	BIODYN 0.7	BIOORG 0.7	CONFYM 0.7	CONMIN	0.7 DGVE
		BIODYN 1.4	BIOORG 1.4	CONFYM 1.4		1.4 DGVE
Fertilization	-	composted manure, slurry	rotted manure, slurry	stacked manure, slurry, industrial	industrial	
Plant protection	mechanical	preparations	copper sulphate	insecticides, fungicides, herbicides (thresholds)		
		mechanical, indirect				

Crop rotation changes

- Same 7-year crop rotation in all systems
- Adapted after each crop rotation period (CRP)
- 7. CRP (2020-2026) similar to 6. CRP

Year	1. CRP 1978–1984	2. CRP 1985–1991	3. CRP 1992–1998	4. CRP 1999–2005	5. CRP 2006–2012	6. CRP 2013–2019
1	Potato	Potato	Potato	Potato	Silage maize	Silage maize
	Green manure	Green manure	Green manure			Green manure
2	Winter wheat 1	Winter wheat 1	Winter wheat 1	Winter wheat 1	Winter wheat 2	Soya
	Winter forage	Winter forage	Winter forage	Green manure	Green manure	
3	White cabbage	Beetroot	Beetroot	Soya	Soya	Winter wheat 1
				Green manure	Green manure	Green manure
4	Winter wheat 2	Winter wheat 2	Winter wheat 2	Silage maize	Potato	Potato
5	Barley	Barley	Grass clover 1	Winter wheat 2	Winter wheat 2	Winter wheat 2
6	Grass clover 1	Grass clover 1	Grass clover 2	Grass clover 1	Grass clover 1	Grass clover 1
7	Grass clover 2	Grass clover 2	Grass clover 3	Grass clover 2	Grass clover 2	Grass clover 2

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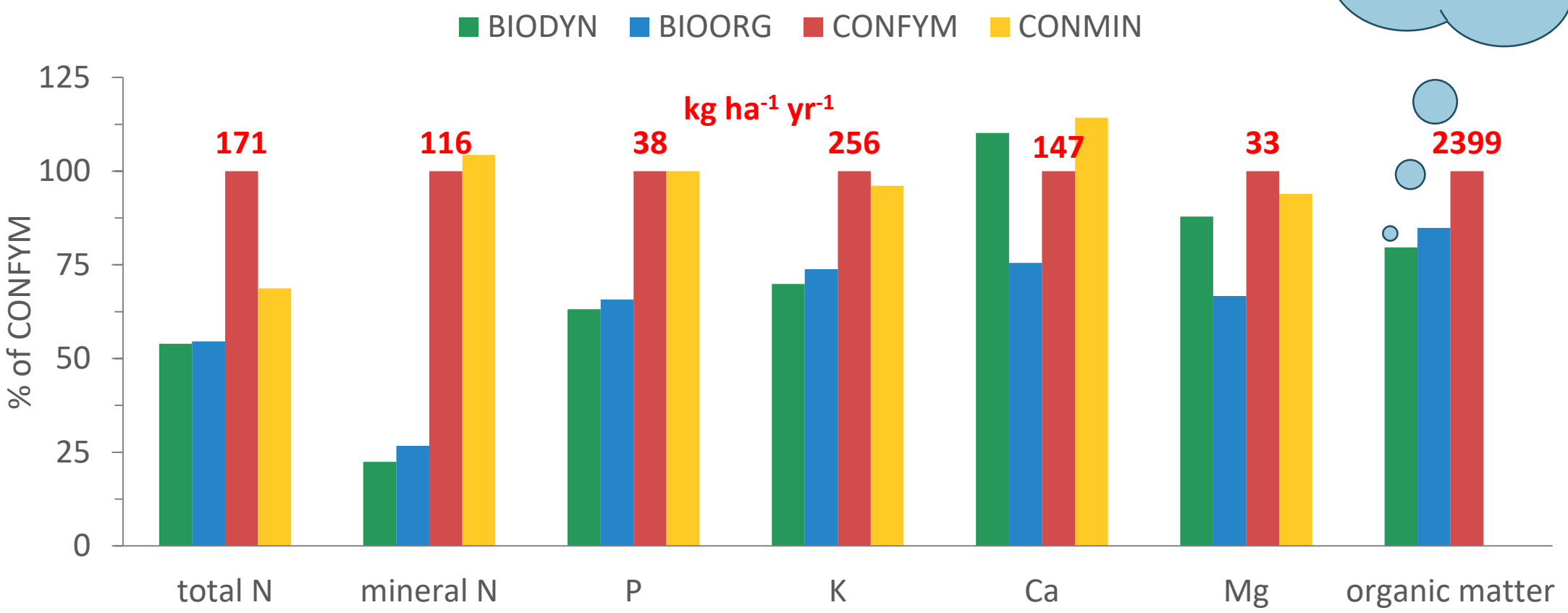
Fertilizer inputs (mean annual inputs over CRP 2-6)

Losses from manure storage and composting



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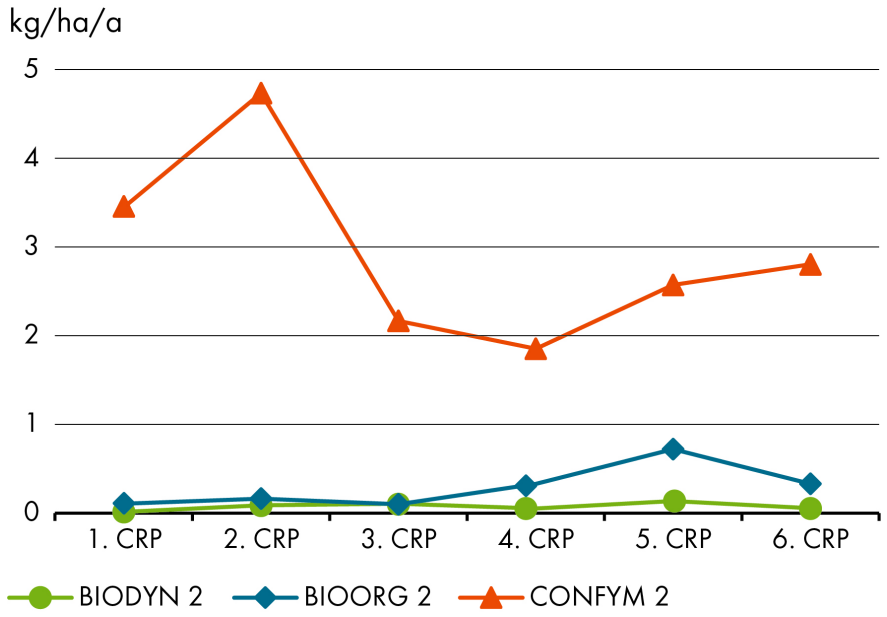
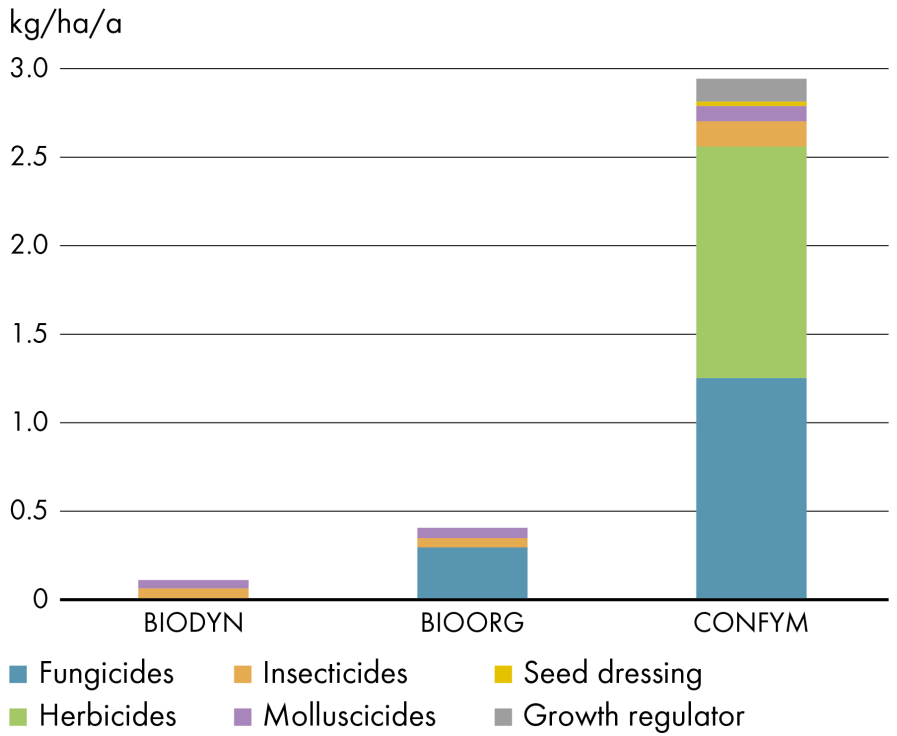
Plant protection





- In kg active substance per hectare as an average over all crops of a CRP
- Reduced pesticide inputs in CONFYM/CONMIN from 3rd CRP, but increasing numbers of applications
- 92 % less pesticides in BIODYN/BIOORG compared to CONFYM/CONMIN

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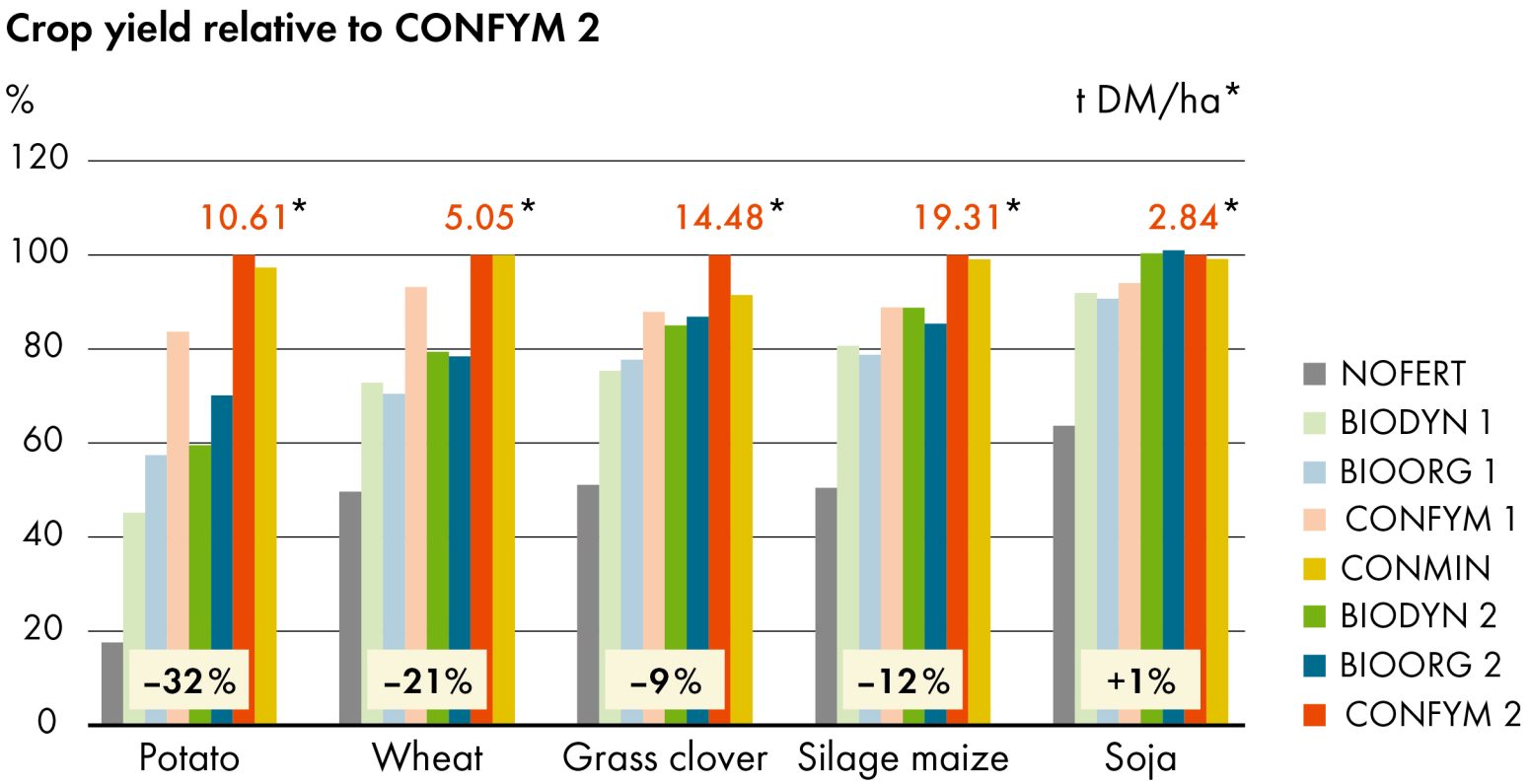
Yields

- Yield gap decreased in dependency of crop: potato>wheat>silage maize> grass clover>soybean
- 15% yield gap for organic systems at 1.4 LU across all crops
- Yield gap decreased from 20% based on results of the first three crop rotation periods



Knapp et al. (2023): Field Crops Research

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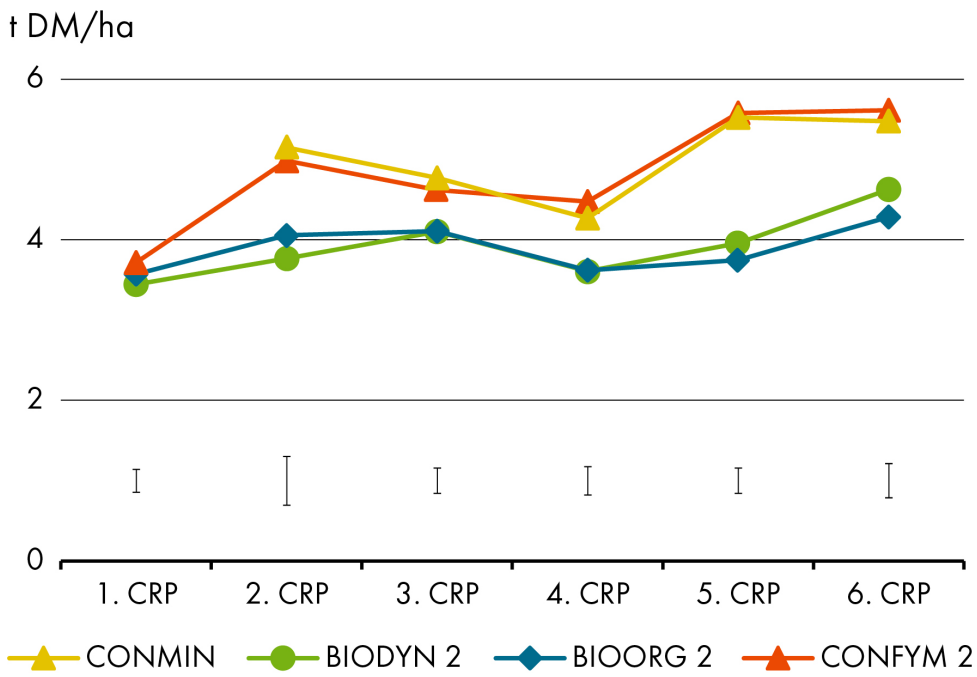
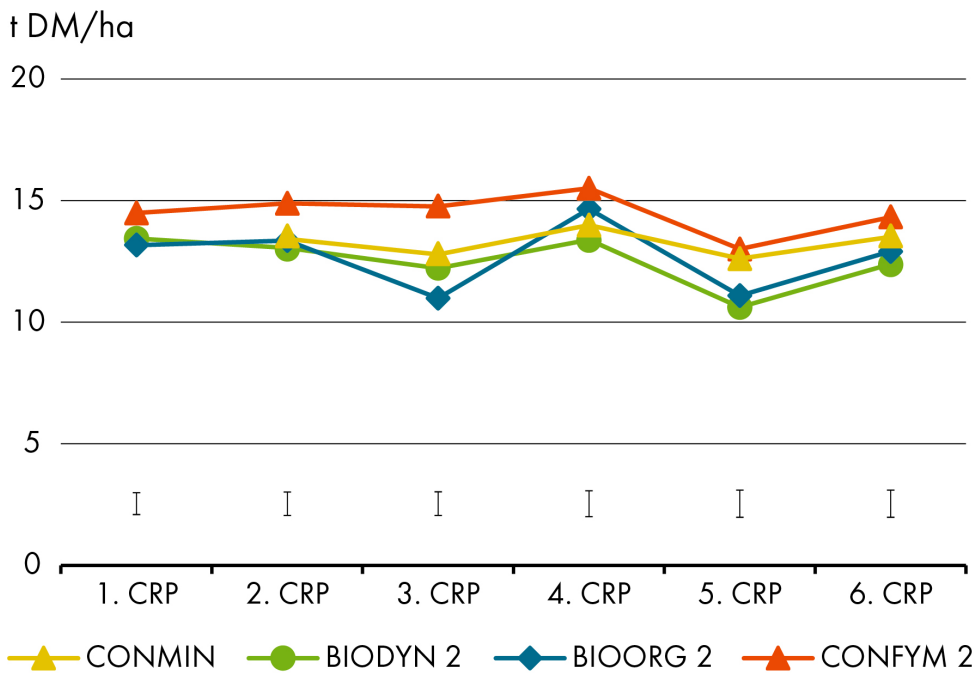
Yields

Mean wheat and grass clover yields per crop rotation period (CRP)

Winter wheat yield



Grass clover yield



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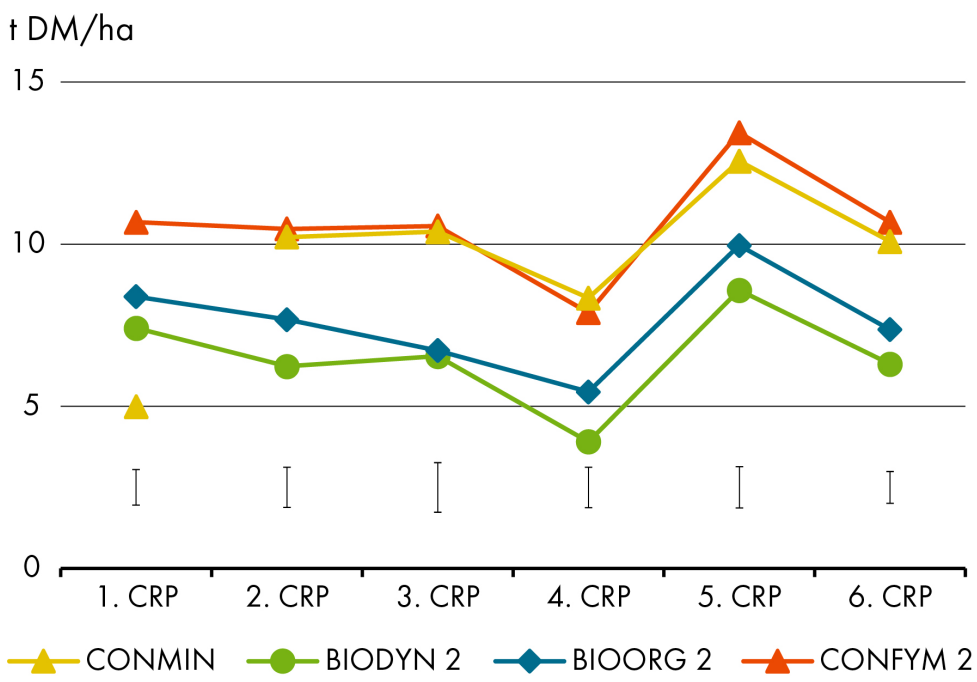
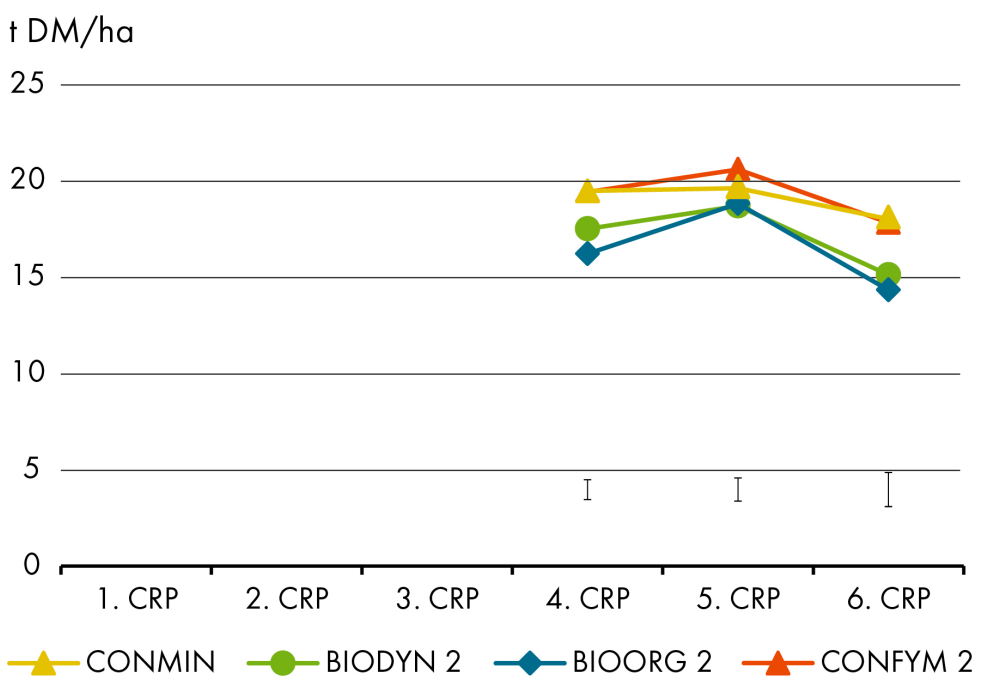
Yields

Mean potato and silage maize yields per crop rotation period (CRP)

Potato Yield



Silage maize yield



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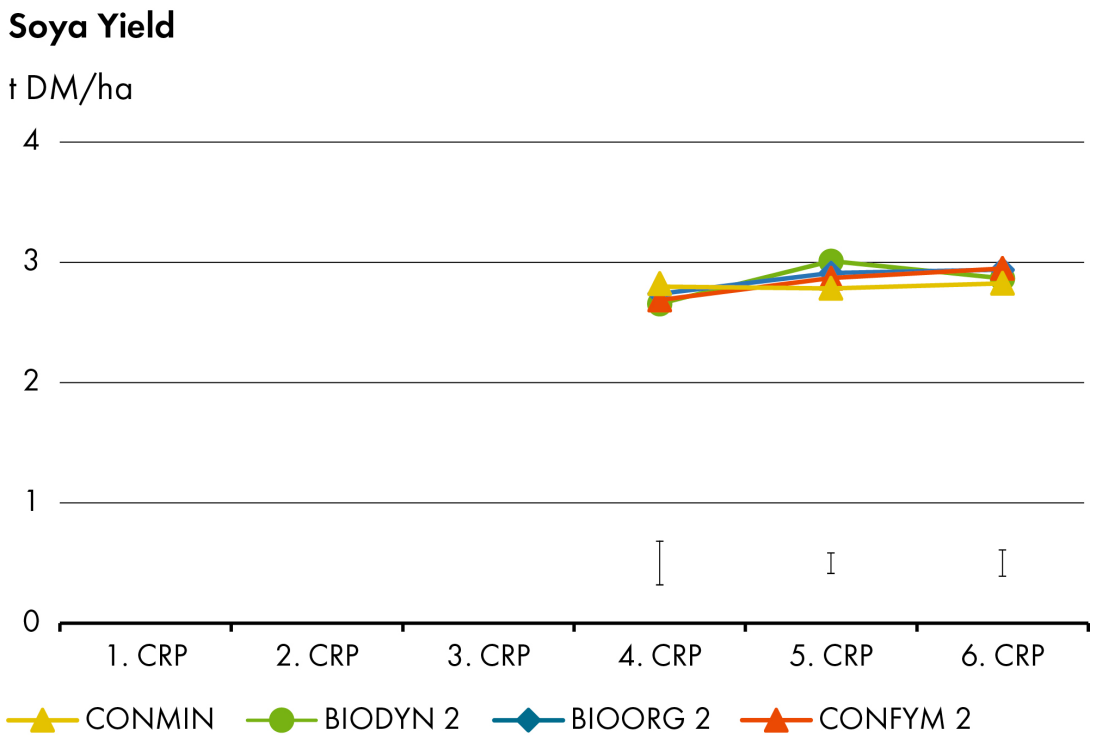
Yields

Mean yields per crop rotation period (CRP)



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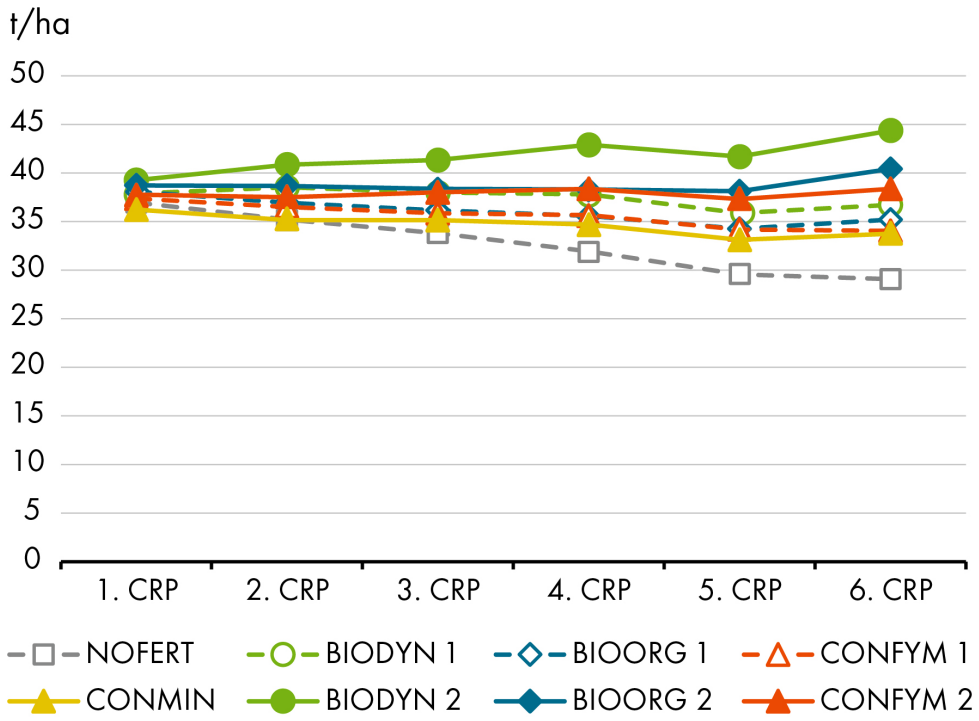
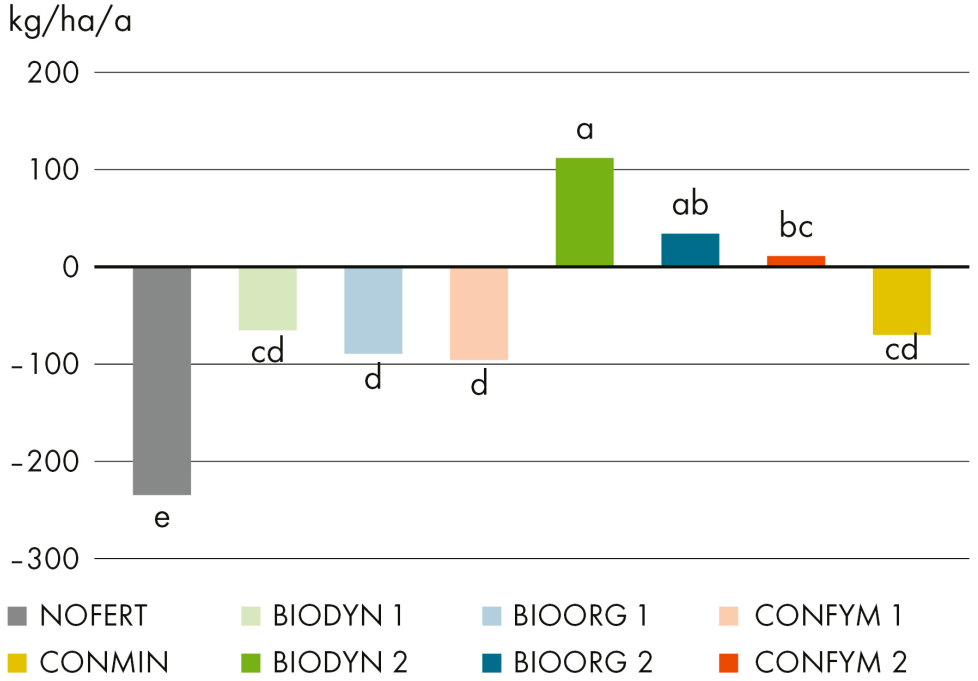
Soil organic carbon (SOC)

SOC-stock (0-20cm)



SOC-stock change



- All system fertilized at 0.7 LU, CONMIN and NOFERT loose SOC
- Mixed farming with 1.4 LU can sustain SOC stocks
- Increased SOC stocks in BIODYN presumably due to input quality

Krause et al. (2022): Agronomy for Sustainable Development

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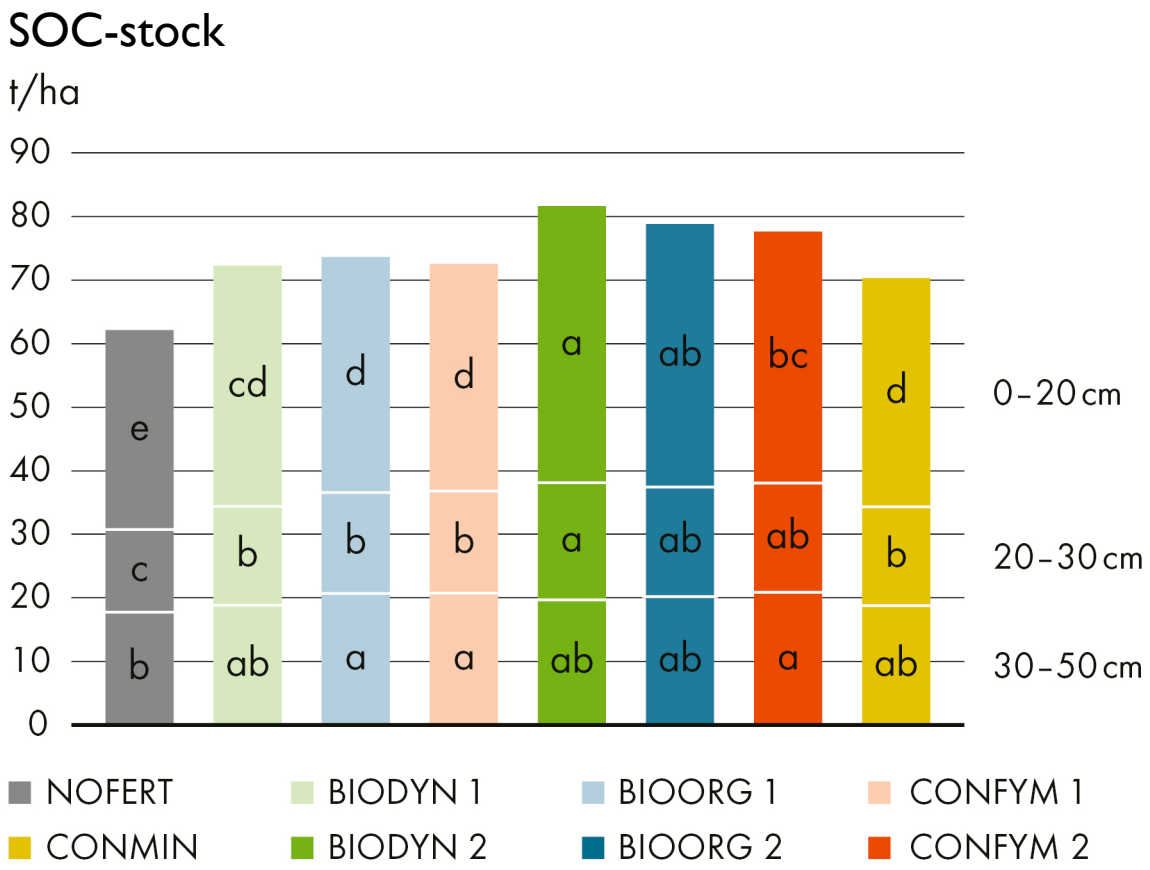
Soil organic carbon

- Stratified soil sampling in 2019-2020
- Main differences in soil carbon stock occur in topsoil



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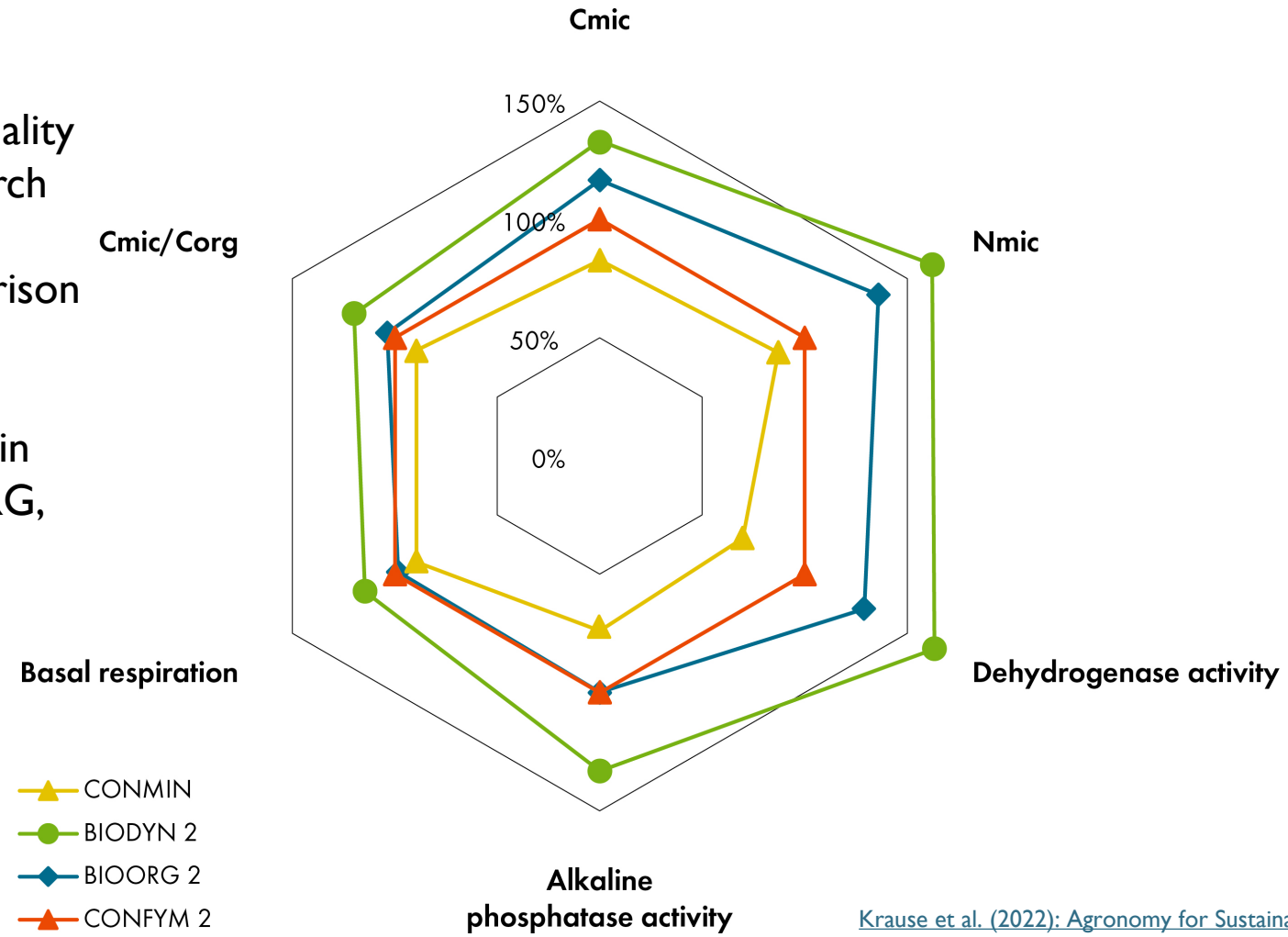
Biological soil quality

- Indicators of soil biological quality analysed within specific research projects
- Data are presented in comparison to CONFYM, representing "business as usual"
- Highest biological soil quality in BIODYN, followed by BIOORG, CONFYM and CONMIN



Krause et al. (2022): Agronomy for Sustainable Development

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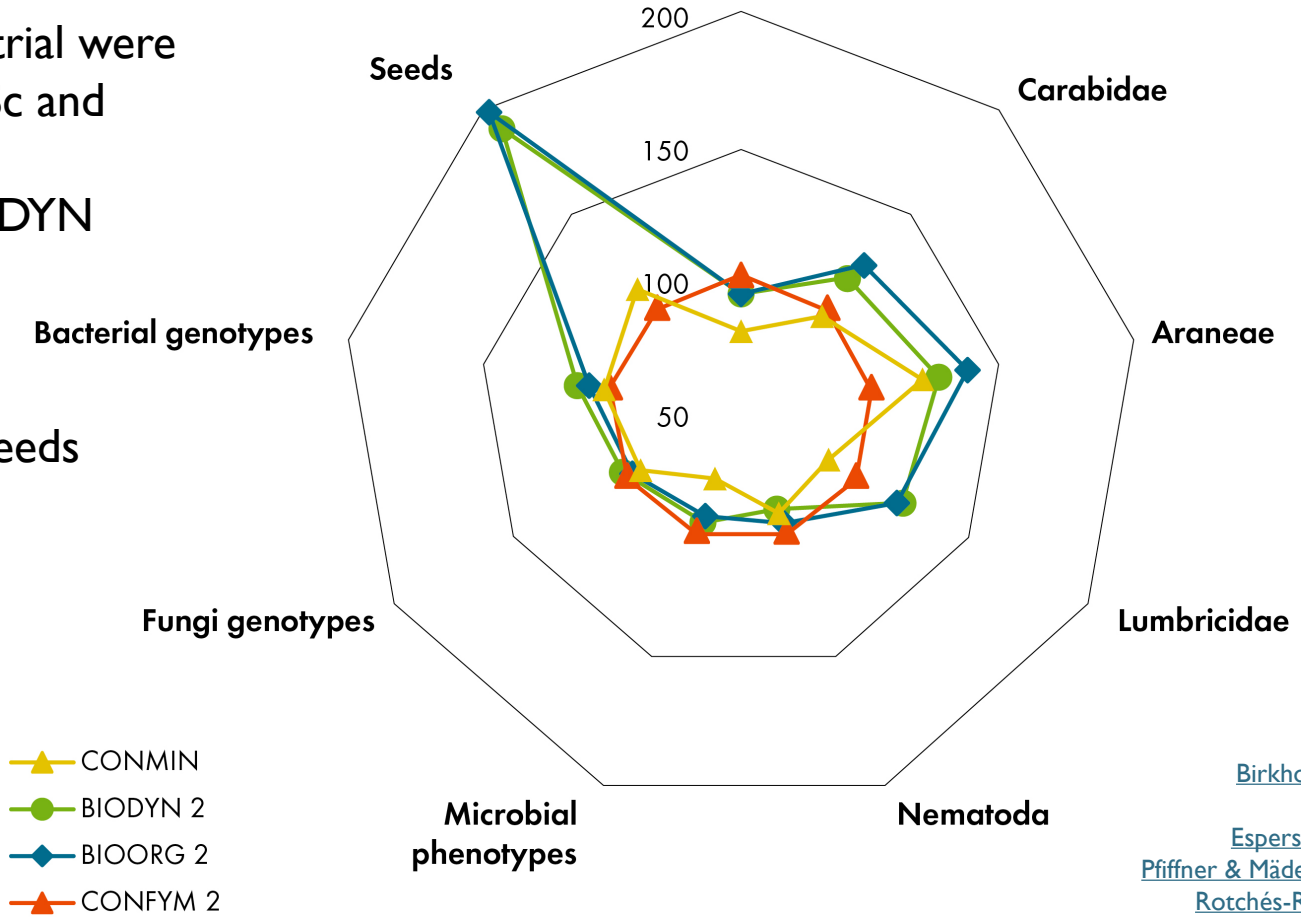
Species diversity

- Soils of the DOK trial were used in various MSc and PhD studies
- BIOORG and BIODYN showed increased diversity for microflora, macrofauna and weeds



Birkhofer et al. (2008): Soil Biology and Biochemistry
Hartmann et al. (2015): ISME Journal
Esperschütz et al. (2007): FEMS Microbiology Ecology
Pfiffner & Mäder (1997): Biological Agriculture & Horticulture
Rotchés-Ribalta et al. (2020): Applied Vegetation Science

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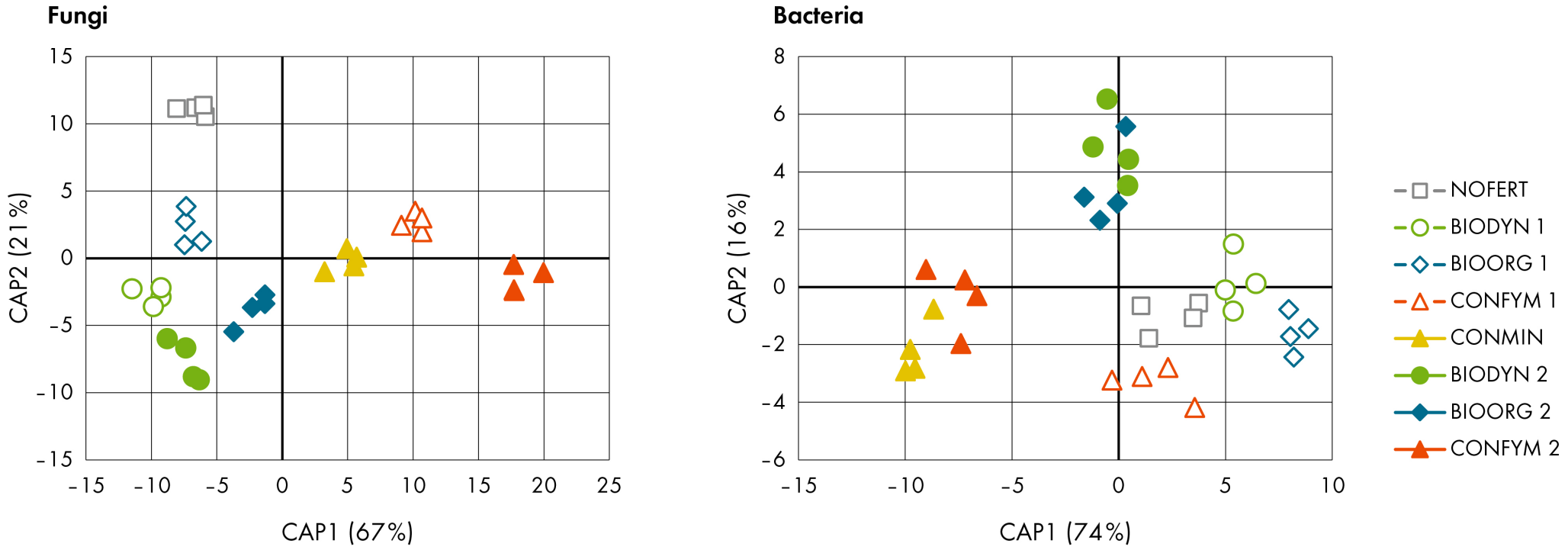
Soil microbial diversity



- Amplicon approach targeting 16S rRNA and ITS marker genes
- Stronger influence of the cropping system on fungi
- Stronger influence of organic fertiliser intensity on bacteria

Lori et al. (2023): FEMS Microbiology Ecology

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Energy consumption and global warming potential in the DOK trial (1985-1998) from a life cycle assessment

System	Energy use		Global warming potential	
	GJ ha^{-1} yr^{-1}	MJ kg^{-1} yield DM	kg CO_2-eq ha^{-1} yr^{-1}	kg CO_2-eq kg^{-1} yield DM
BIODYN	13.6 (65 %)	1.6 (80 %)	2804 (63 %)	0.35 (81 %)
BIOORG	14.5 (69 %)	1.8 (90 %)	2920 (65 %)	0.36 (84 %)
CONFYM	21.0 (100 %)	2.0 (100 %)	4474 (100 %)	0.43 (100 %)
CONMIN	26.9 (128 %)	2.8 (140 %)	4121 (92 %)	0.44 (102 %)

Nemecek et al. (2011)

- Energy savings: Organic farming does not use synthetic chemical fertilisers and pesticides. Compared to conventional farming, energy consumption is therefore 30 per cent lower.
- This advantage is reduced to 10-20 % per yield unit.

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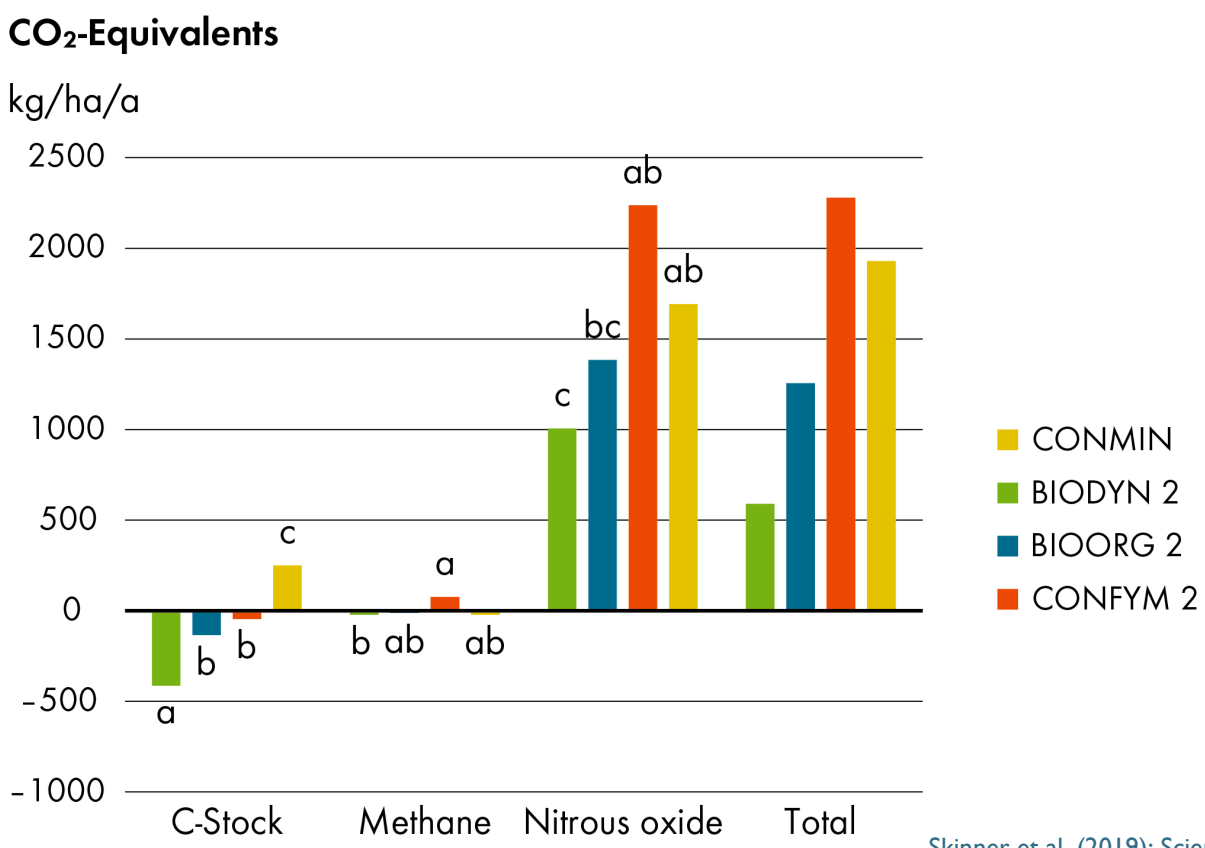
Soil borne greenhouse gas emissions

- C-stock changes assuming constant bulk density for each plot
- N_2O measurement campaign for 571 days (grass clover - maize - cover crop)
- Field site as system boundary
- N_2O emissions drive climate impact
- SOC increases, especially in BIODYN, did not enhance N_2O emissions
- 56 % lower soil borne GHG in BIODYN/BIOORG vs CONFYM/CONMIN



Skinner et al. (2019): Scientific Report

Krause et al. (2022): Agronomy for Sustainable Development

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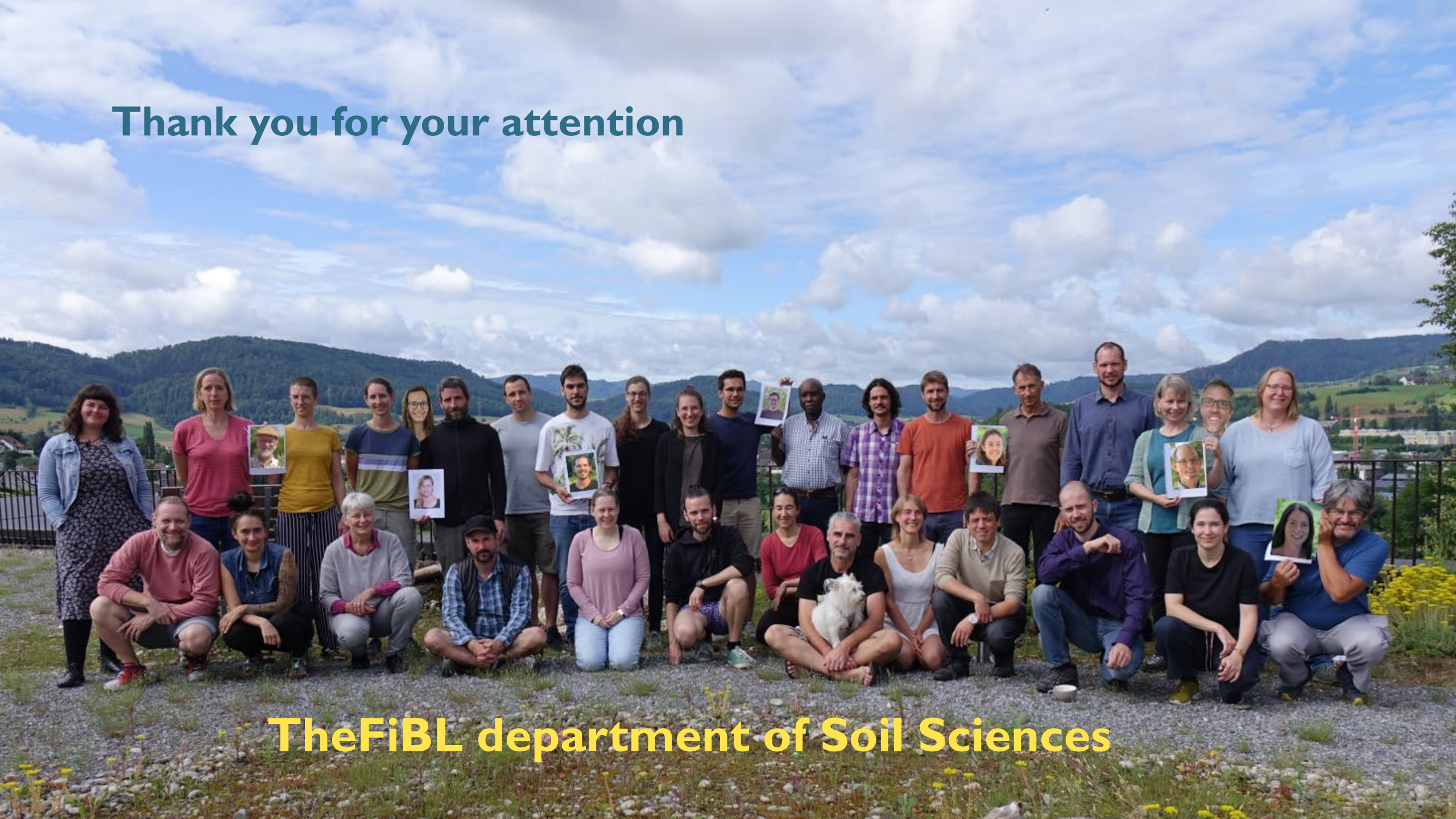
Conclusions drawn from DOK trial results

- Crop yields were 20% lower in organic *vs.* conventional over the first three CRP but the yield gap went down to 15% over six CRP.
- The two organic systems build on recycling manure and nutrients from livestock.
- The additional yield in conventional systems comes with costs for industrial inputs that reduce the economic outcome and increase the energy use, with negative environmental consequences.
- Organic farming systems show improved soil quality and biological processes compared to conventional.
- Climate impact is reduced.
- More species are found in organic farming systems

Thank you for your attention



TheFiBL department of Soil Sciences