Research Institute of Organic Agriculture FiBL
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The DOK Trial

42 years of organic and conventional cropping systems

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History and background

- Since 1978
- System comparison approach
- Accompanied by farmers advisory board
- **Initial aim:** test feasibility of organic agriculture
- **Today:** research platform for farming system functioning

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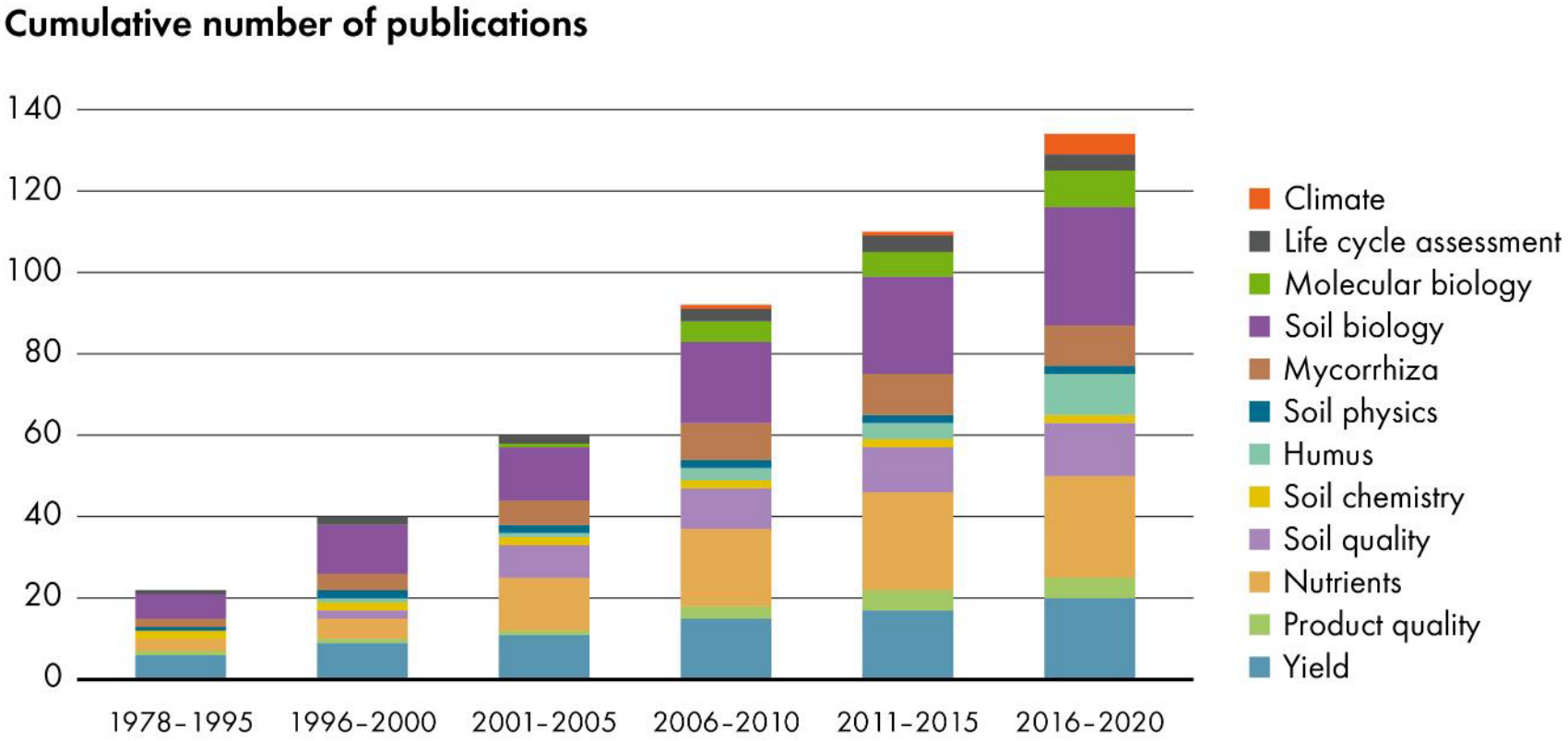
Publications



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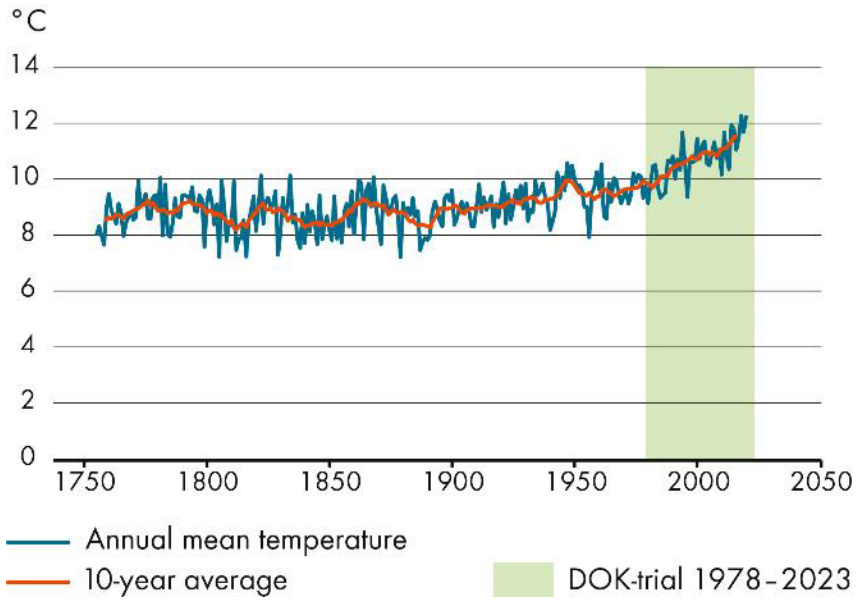
Location and climate

- Located south of Basel between Therwil and Biel-Benken
- Annual mean precipitation of 872 mm
- Increasing temperatures during the course of the experiment
- Annual mean temperature: (10-year average)
  1978: **9.9 °C**
  2016: **11.5 °C**



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Field setup

- Soil type: haplic luvisol
- Soil type:
  - Sand 12 %
  - Silt 72 %
  - Clay 16 %
- Same crop rotation and tillage in all systems
- Mimicking certified farming systems

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Cropping systems

BIODYN (D)
biodynamic (Demeter)

BIOORG (O)
organic (Bio Suisse)

CONFYM (K)
conventional (IP Suisse)

CONMIN (M)
conventional, purely mineral fertilised

Cropping system	NOFERT	BIODYN		BIOORG		CONFYM		CONMIN
Livestock units per hectare	-	0.7	1.4	0.7	1.4	0.7	1.4	-
Fertilisation								
Farmyard manure	-	Manure compost and slurry		Rotted manure and slurry		Stacked manure and slurry		-
Mineral fertiliser	-	Rock dust		Rock dust Potash magnesia		Urea, ammonium nitrate, calcium ammonium nitrate, triple superphosphate, potassium chloride		
Plant protection								
Weed control	Mechanical, by harrowing and hoeing					Mechanical and with herbicides		
Plant diseases	-	Indirect measures		Indirect measures, copper sulfate for potatoes		Fungicides		
Pests	Biological control *(Bacillus thuringiensis)*, plant extracts, preventive measures					Insecticides, biological control, slug pellets and preventive measures		
Special features	Biodynamic preparations			-		Growth regulators		

Mäder et al. (2002): Science

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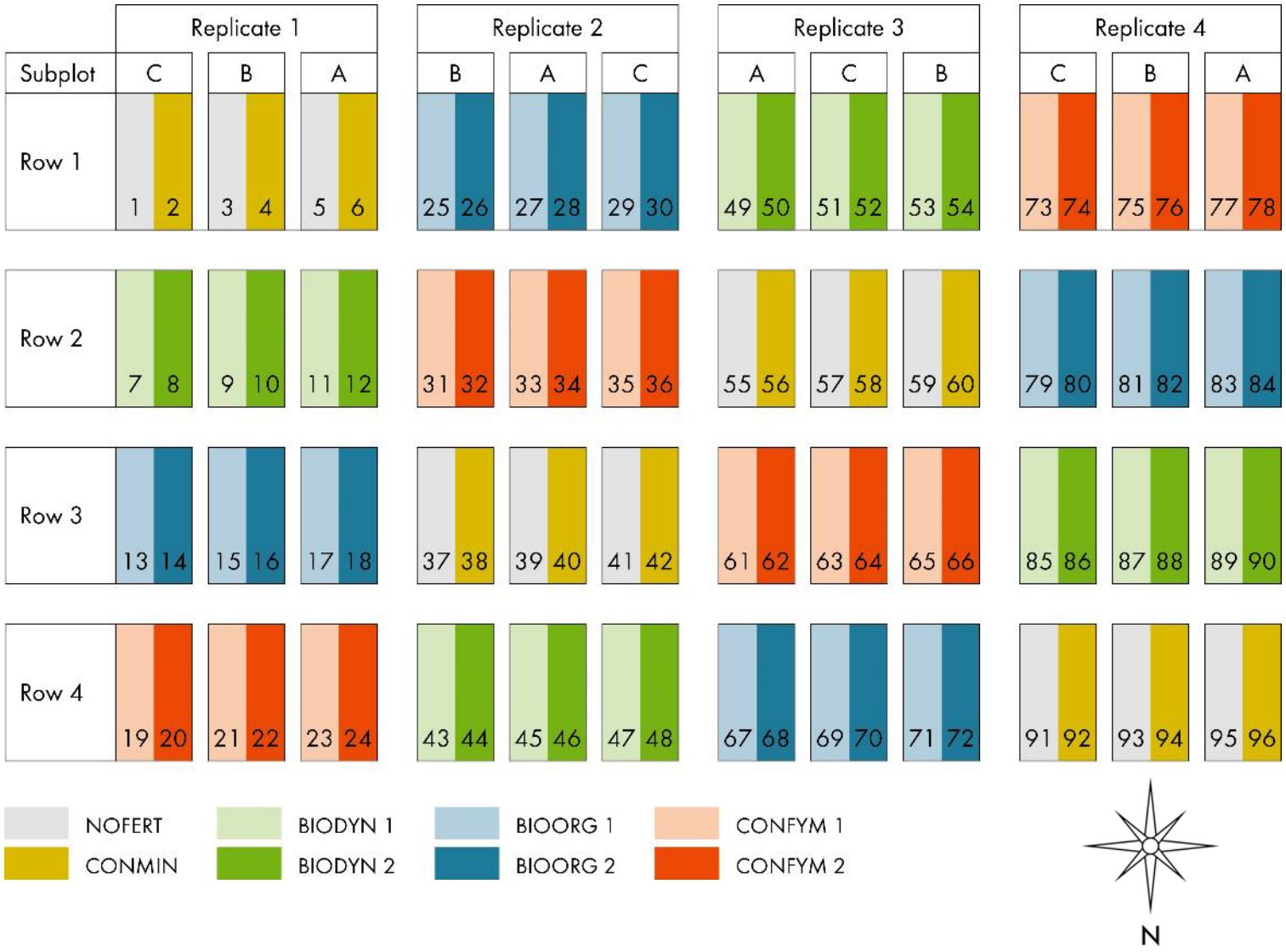
Plot plan

- 8 Treatments on 3 subplots (A, B, C)
- Subdivided into 4 rows and 4 replicates
- 96 experimental plots (5x20m)
- Fertilisation intensity

0.7 LU, 1.4 LU
(1 = half, 2 = customary)

LU= Livestock unit



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Crop rotation

- Same 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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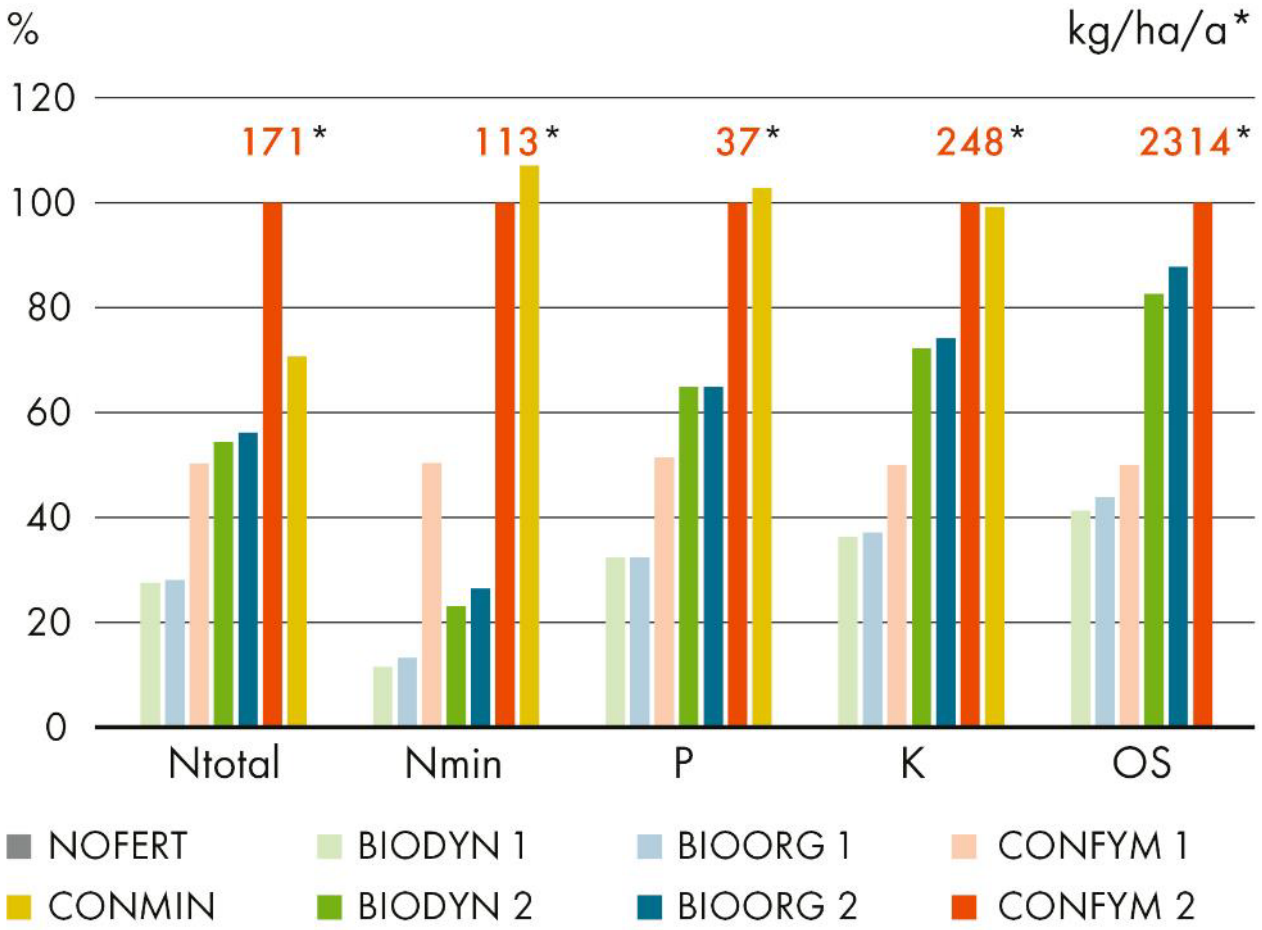
Fertilisation

- Treatment-specific manures differ in composting duration and aeration
- Organic systems at 0.7 LU receive half of nutrient inputs

Annual mean nutrient inputs (CRP 2-6)



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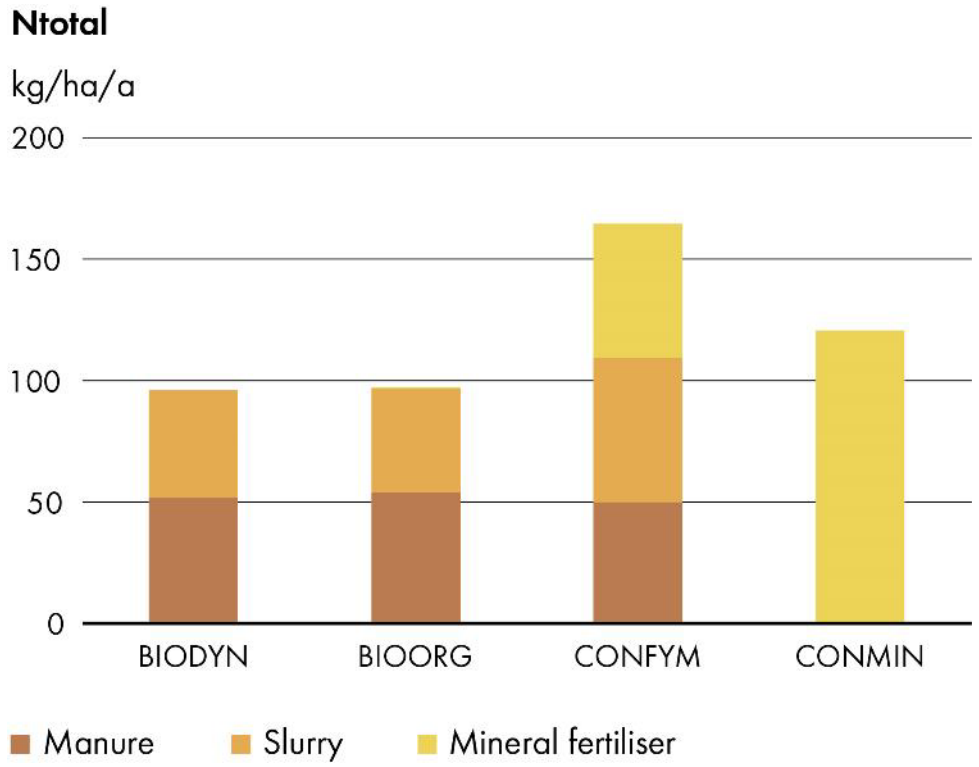
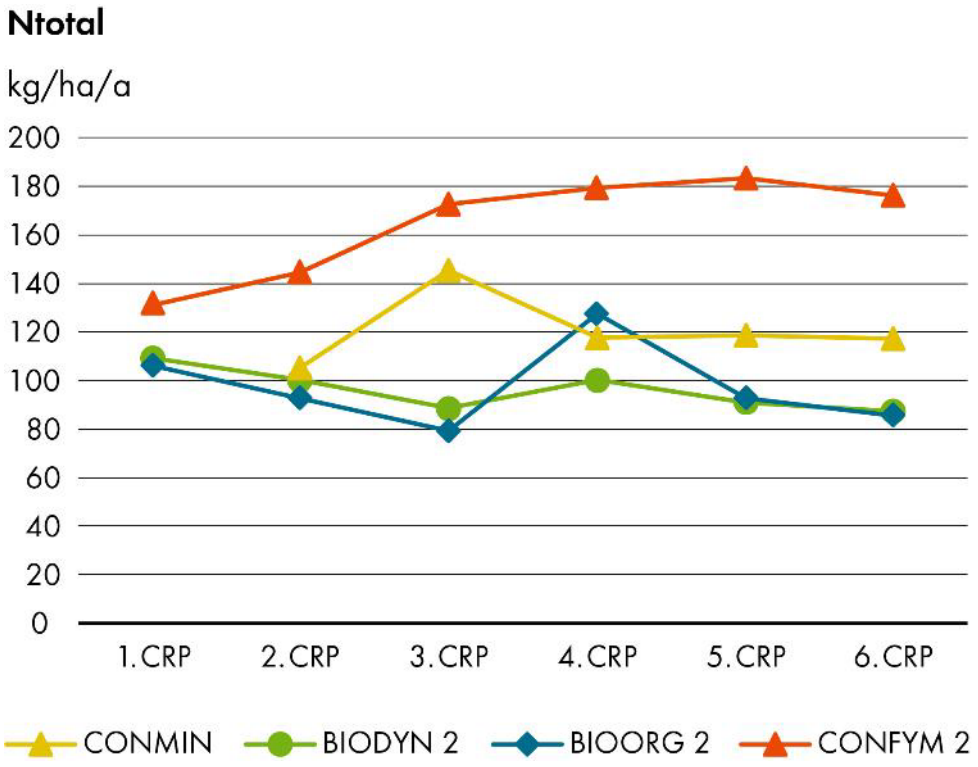
Nitrogen fertilisation

Sources and development of total nitrogen input in manure, slurry and mineral fertilisers





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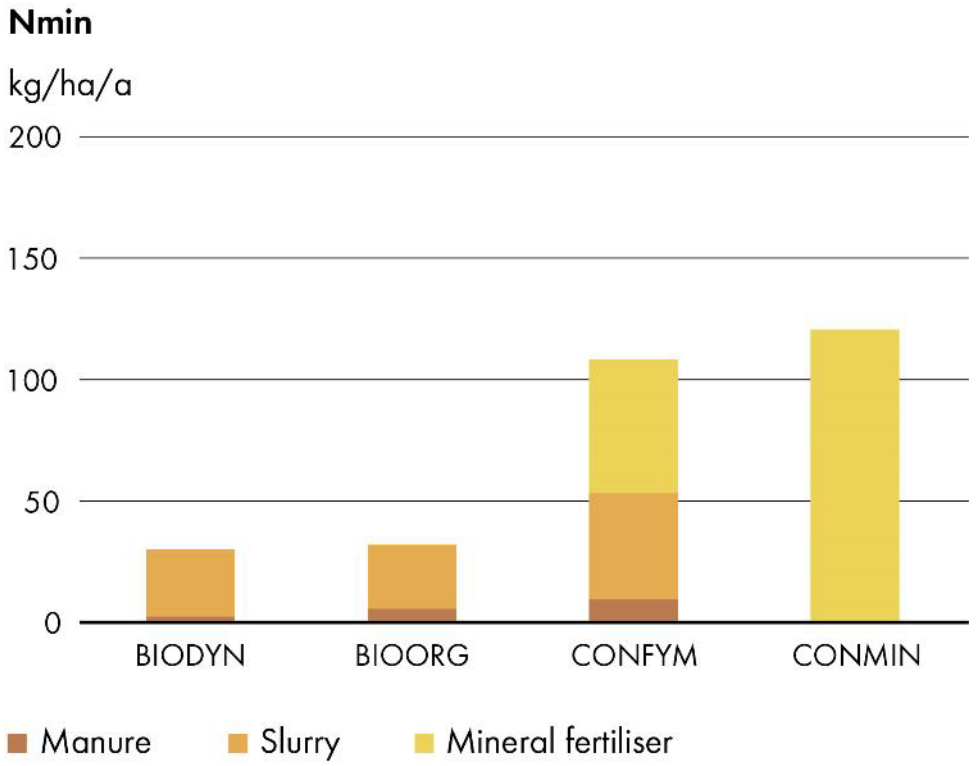
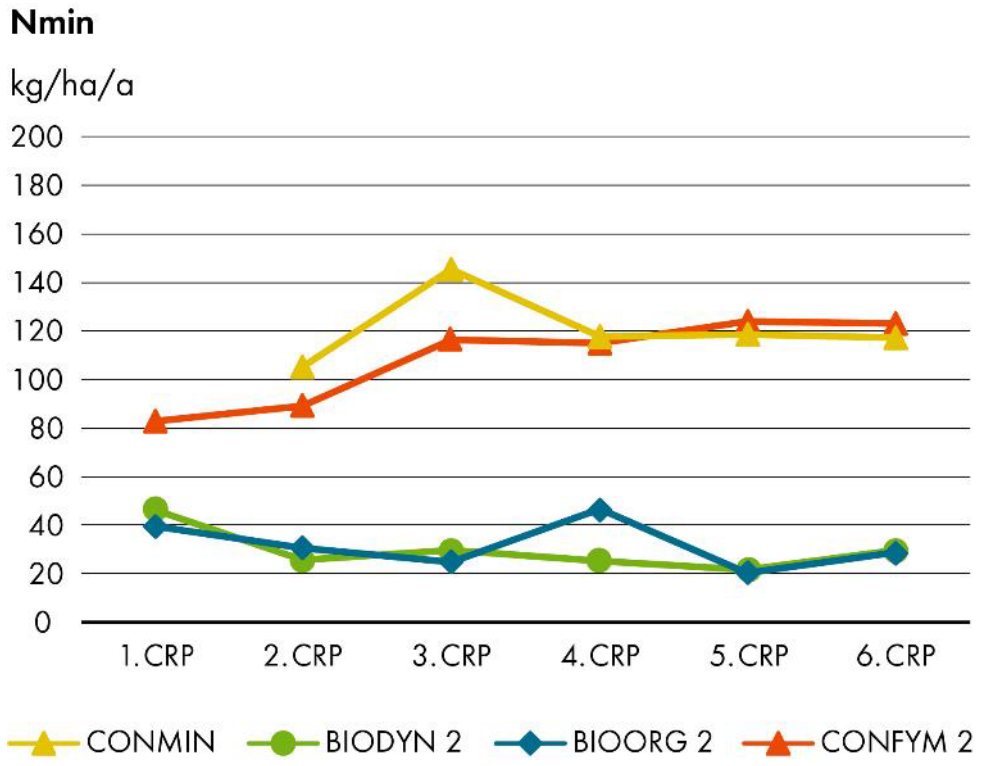
Nitrogen fertilisation

Sources and development of mineral nitrogen input in manure, slurry and mineral fertilisers





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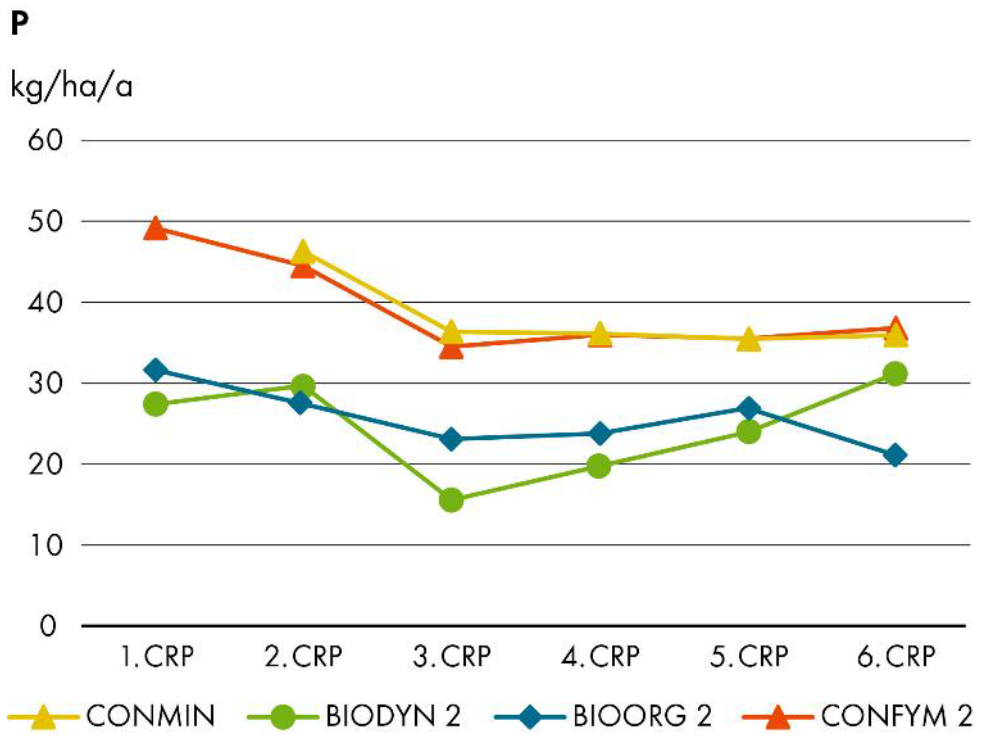
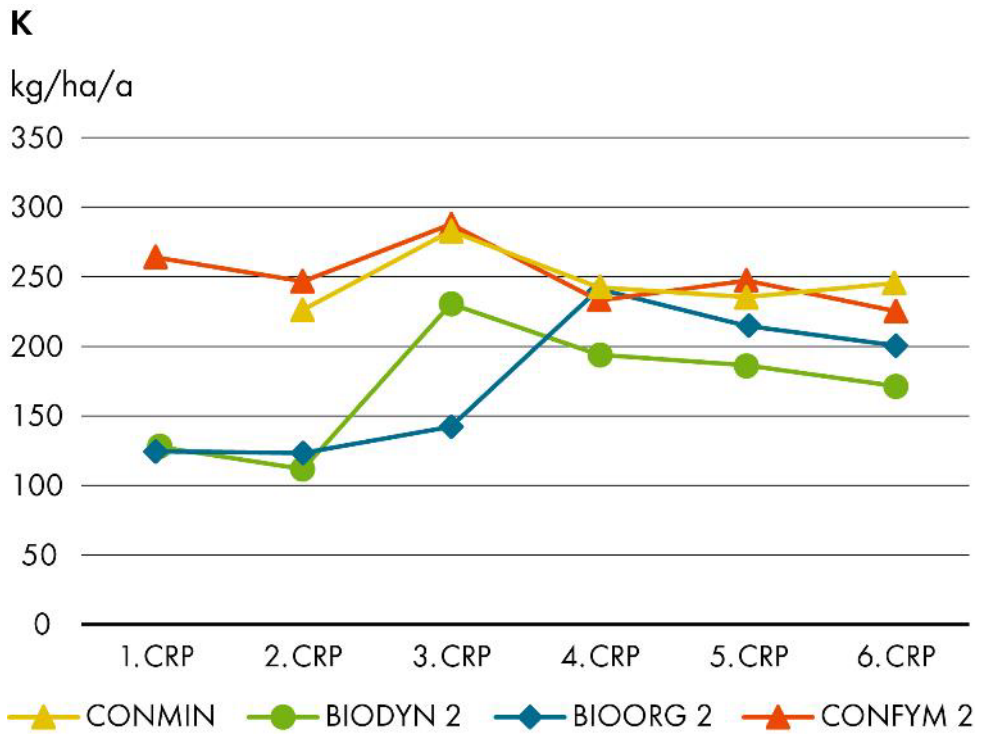
Phosphorous and potassium fertilisation

Evolution of phosphorous and potassium inputs





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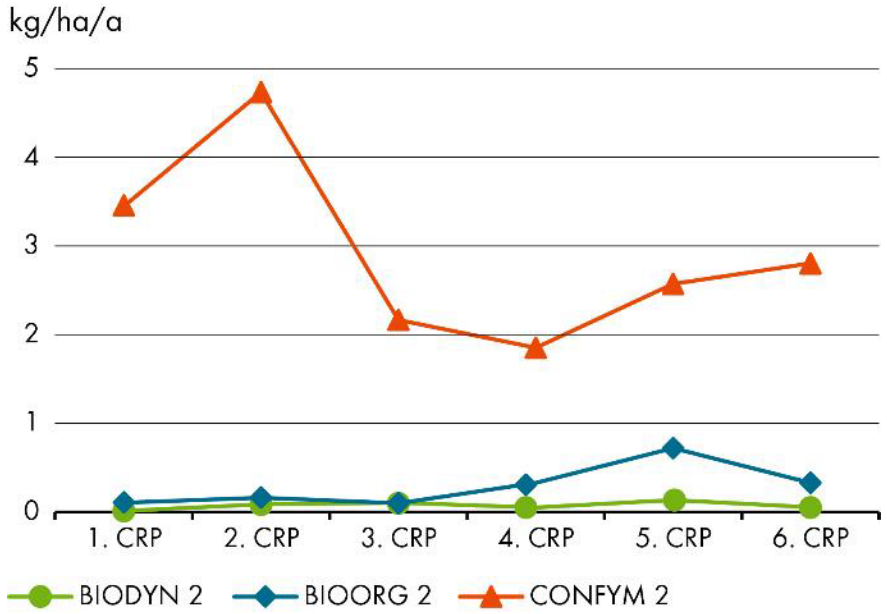
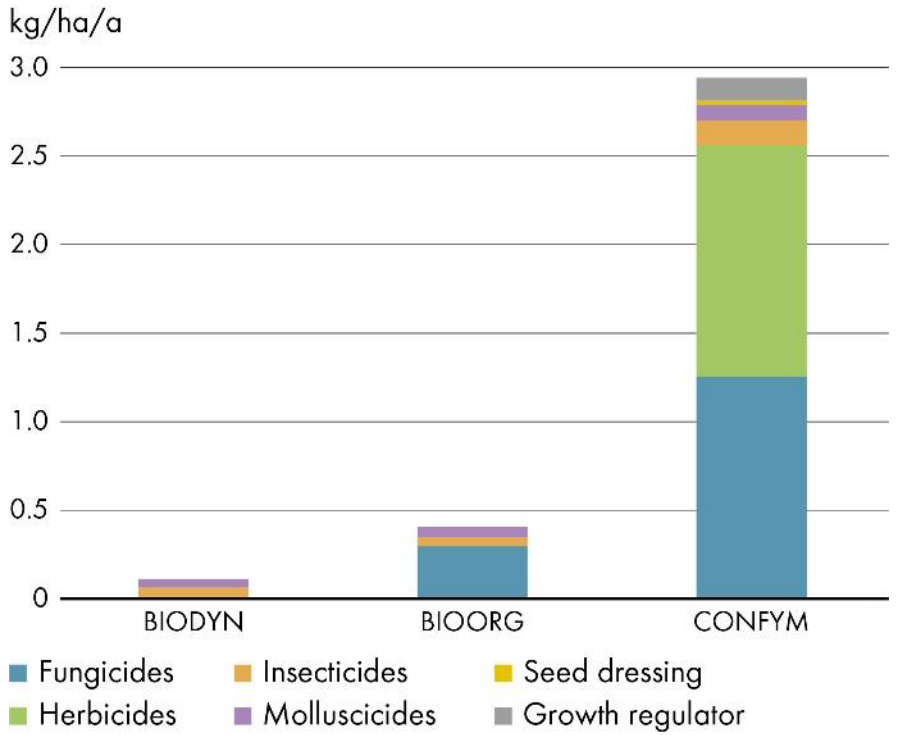
Plant protection





- In kg active substance per hectare
- Reduced pesticides 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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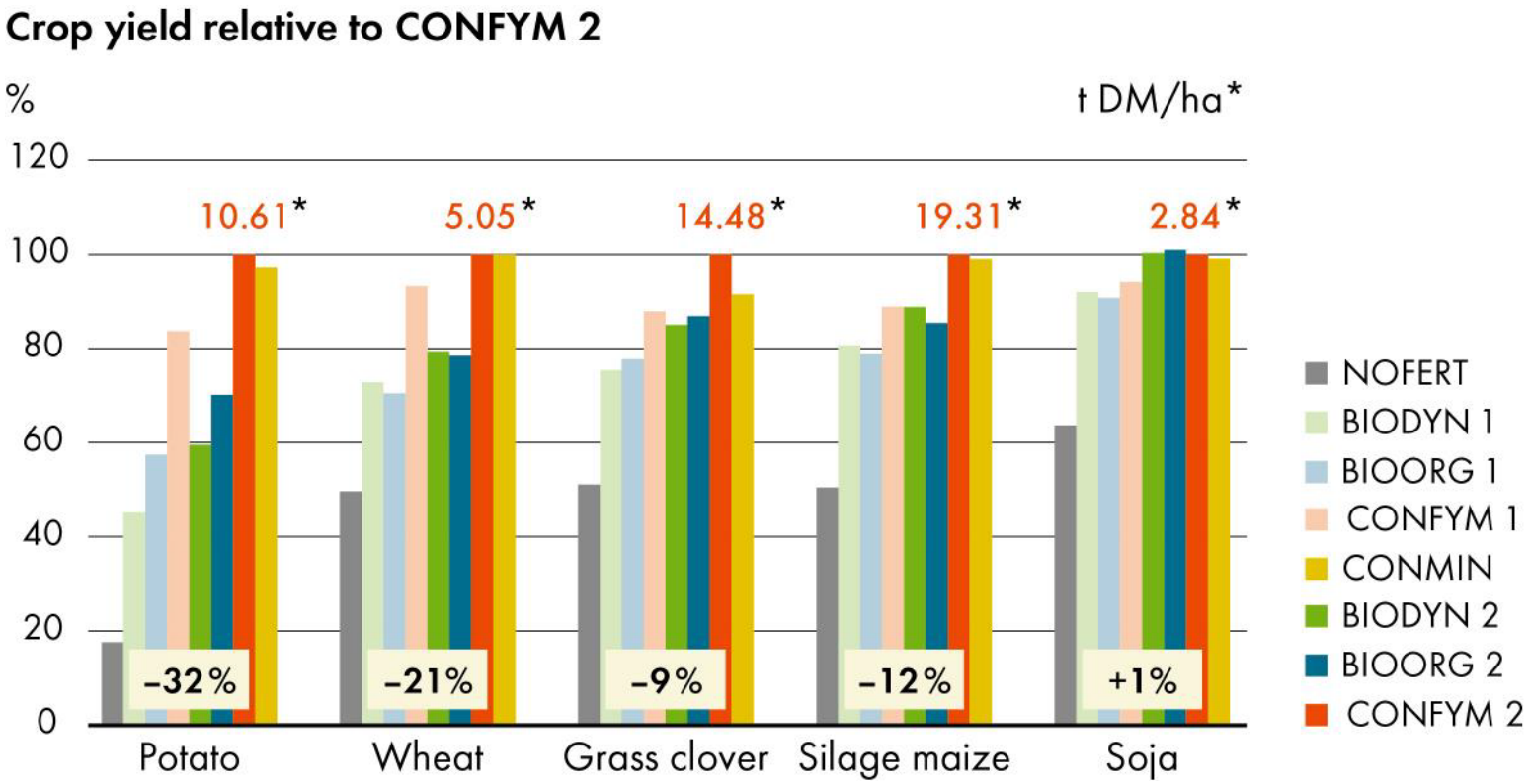
Yields

- Yield gap decreases in dependency of crop: potato>wheat>silage maize> grass clover>soybean
- 15 % yield gap for organic systems at 1.4 LU across all crops (CRP 1-6)



Knapp et al. (2023): Field Crops Research

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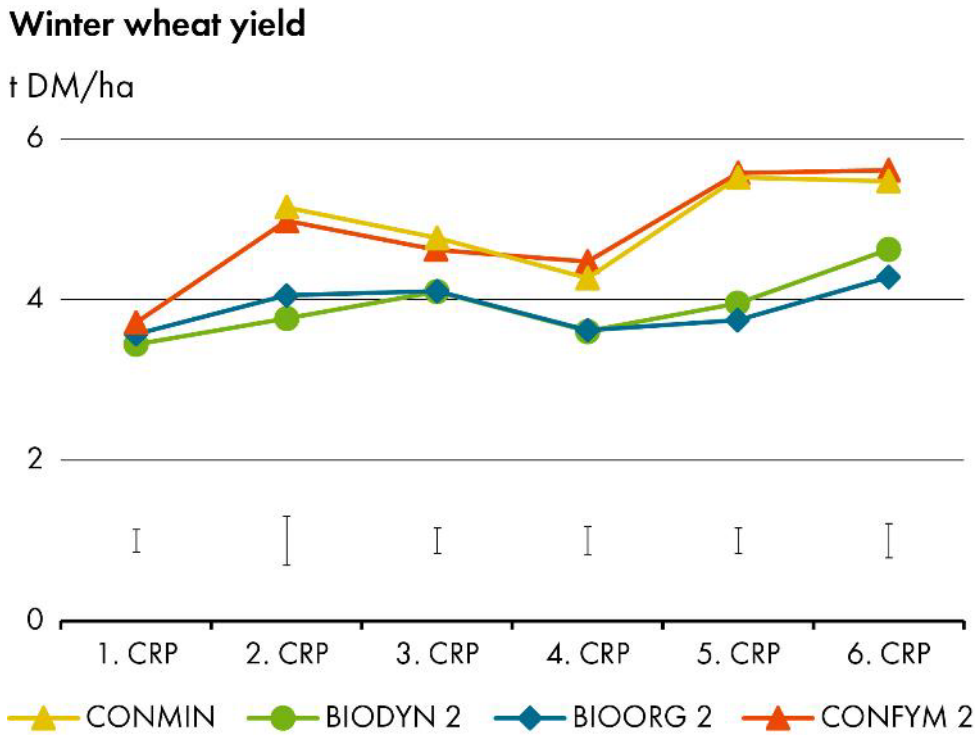
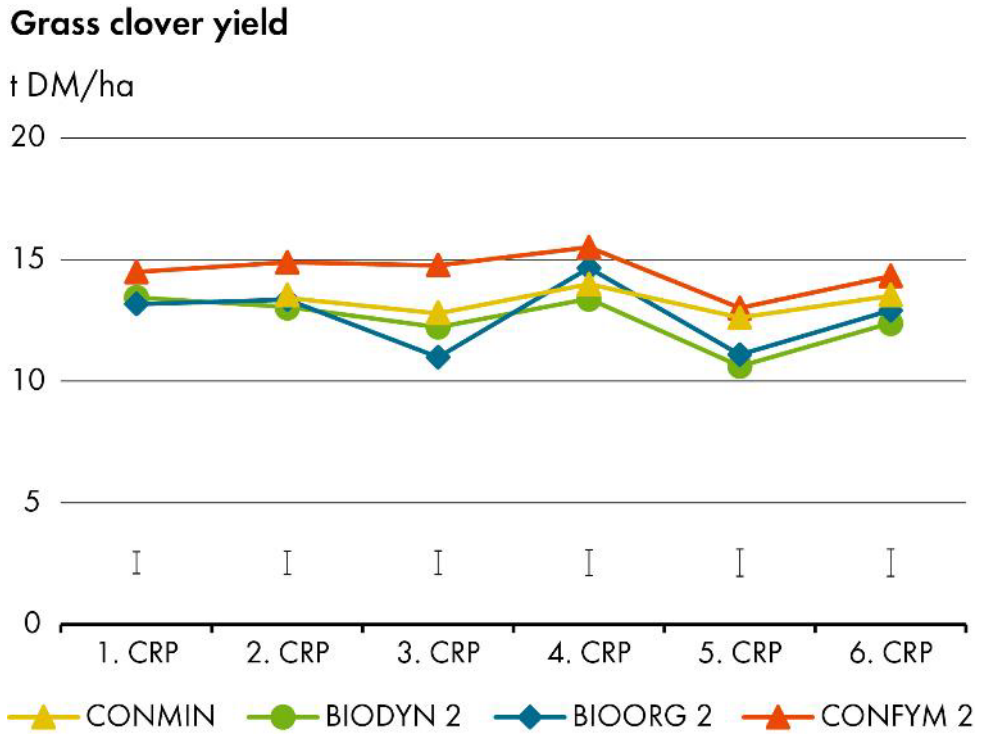
Yields

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





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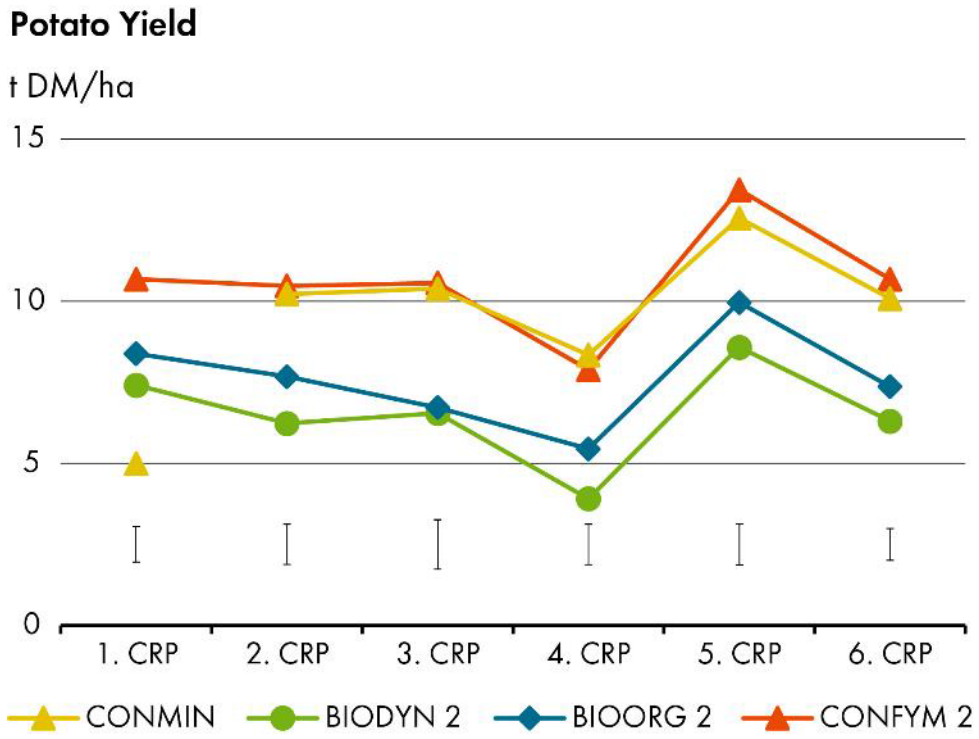
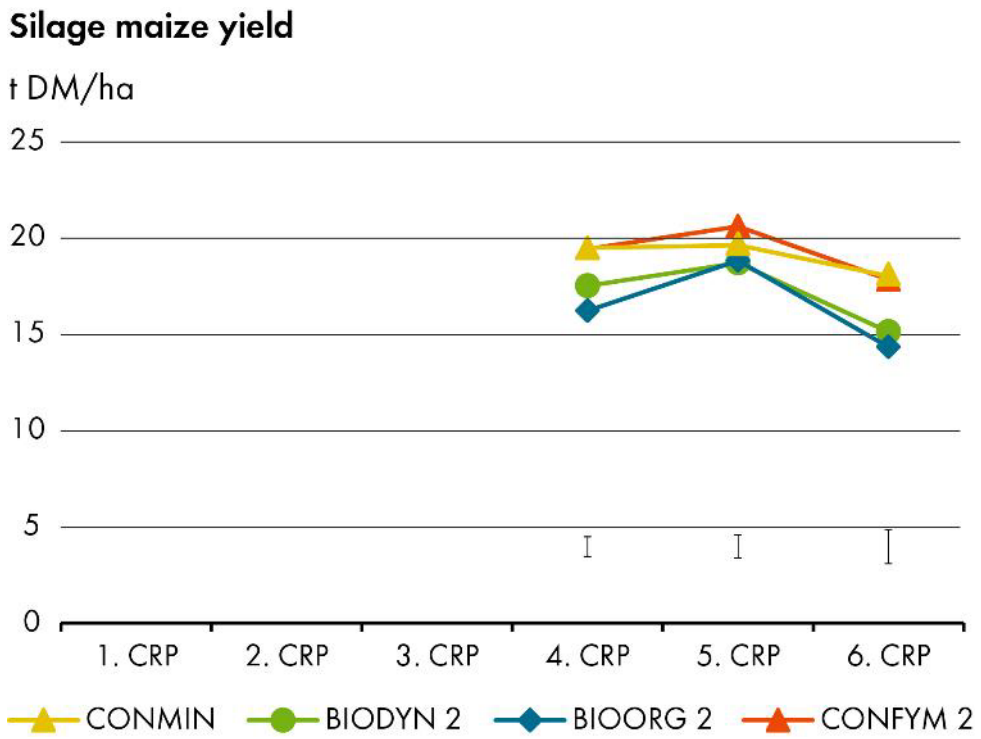
Yields

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





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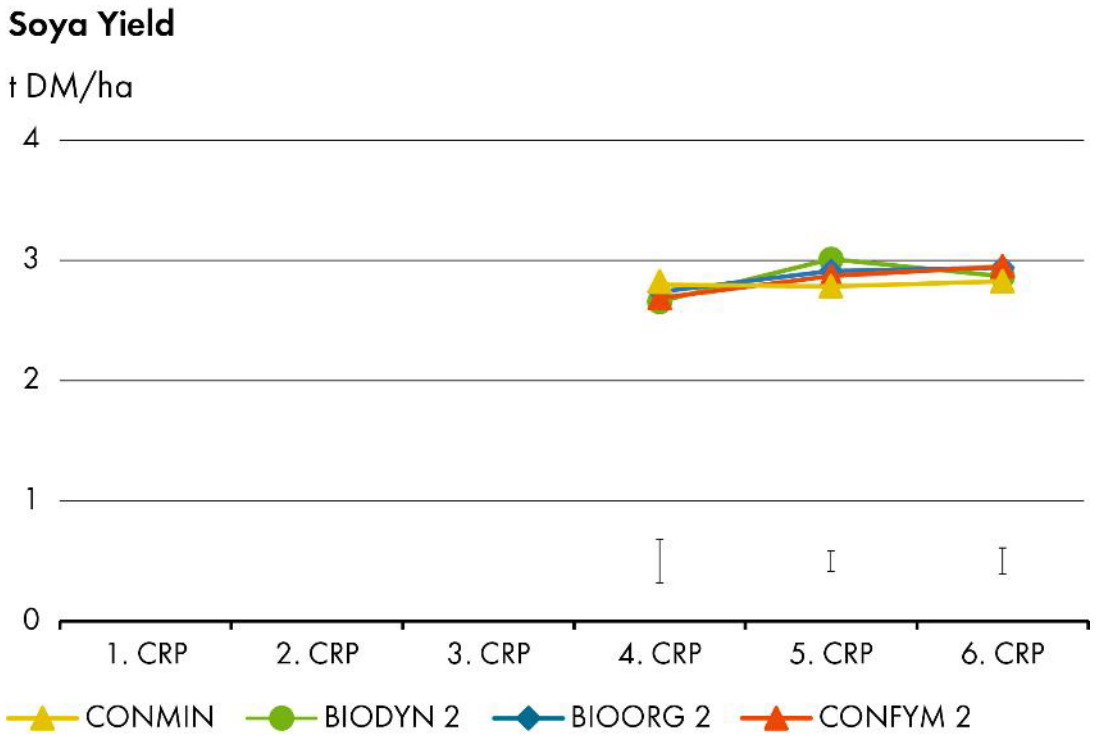
Yields

Mean yields per crop rotation period (CRP)



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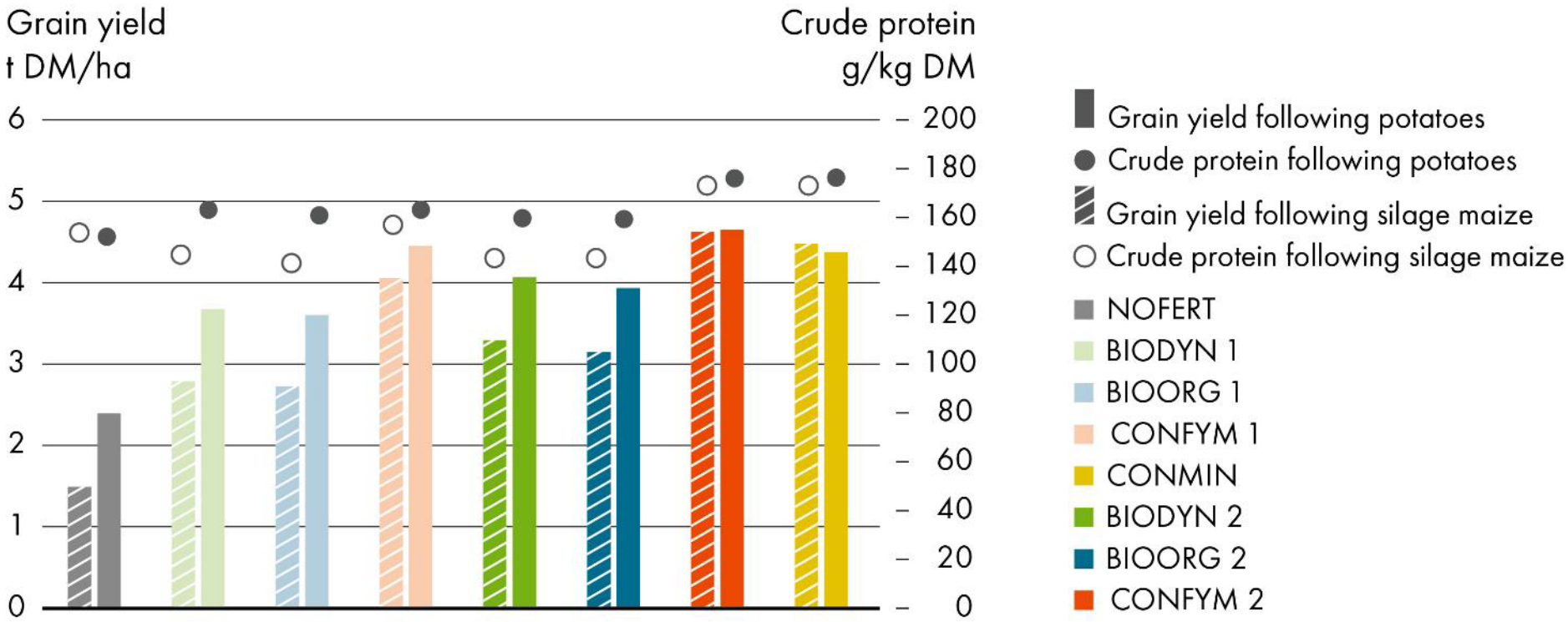
Winter wheat yields and crude protein content



Mayer et al. (2015): European Journal of Agronomy

- Lower protein content in organic winter wheat especially after precrop maize

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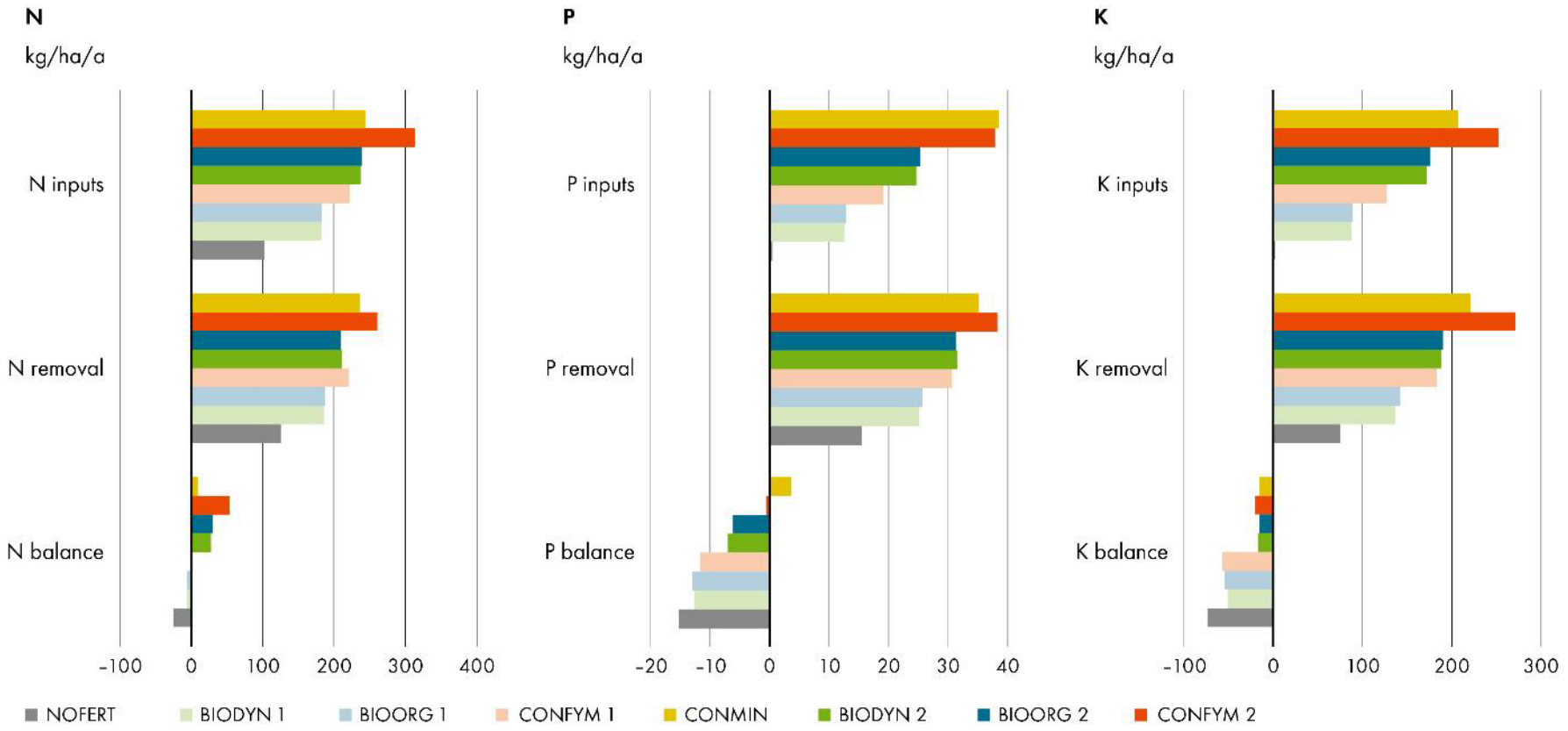
Nutrient balances

- Removal via harvest, Input via fertilisation, symbiotic nitrogen fixation and deposition
- Positive N balance in all organically fertilised systems at 1.4 LU
- Negative P and K balance in almost all systems



Oberson et al. (2024): Agriculture, Ecosystems and Environment

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Nutrient balances

Details in kg/ha/a	Fertiliser	Symbiotic fixation	Deposition and seed	Harvest	Balance	Change in soil stock	Utilisation efficiency
NOFERT	0	75	21	128	-31.1	-26.2	133 %
BIODYN 1	47	112	21	189	-8.7	-9.1	105 %
BIOORG 1	48	111	21	190	-9.6	-10.0	106 %
CONFYM 1	85	112	21	223	-4.5	-11.2	102 %
BIODYN 2	93	122	21	214	22.9	9.3	91 %
BIOORG 2	96	119	21	213	23.7	1.2	90 %
CONFYM 2	171	117	21	264	45.9	-0.7	85 %
CONMIN	121	99	21	240	2.1	-10.0	99 %

Oberson et al. (2024): Agriculture, Ecosystems and Environment

- High nitrogen use efficiency in all systems
- Risk for P depletion in all systems

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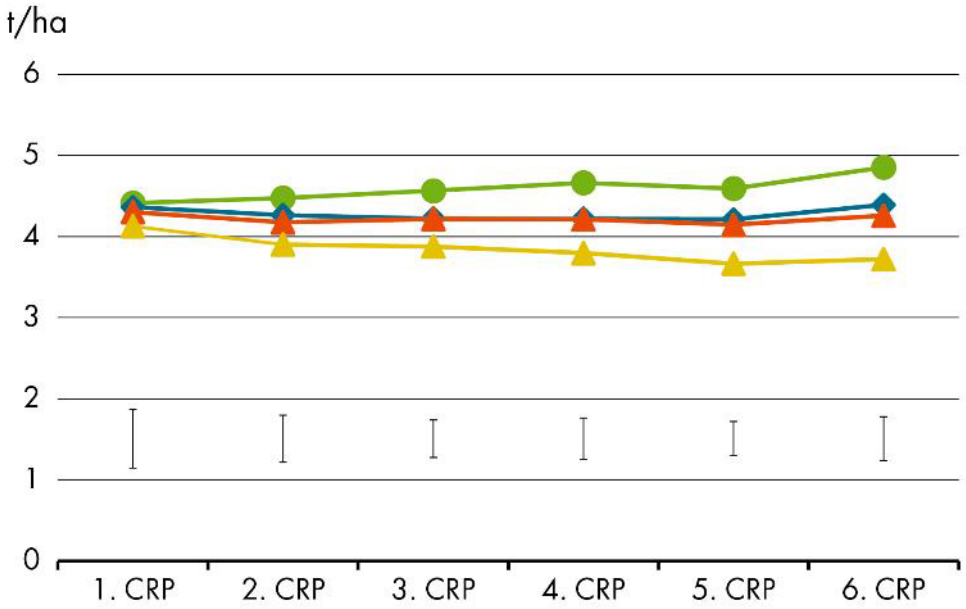
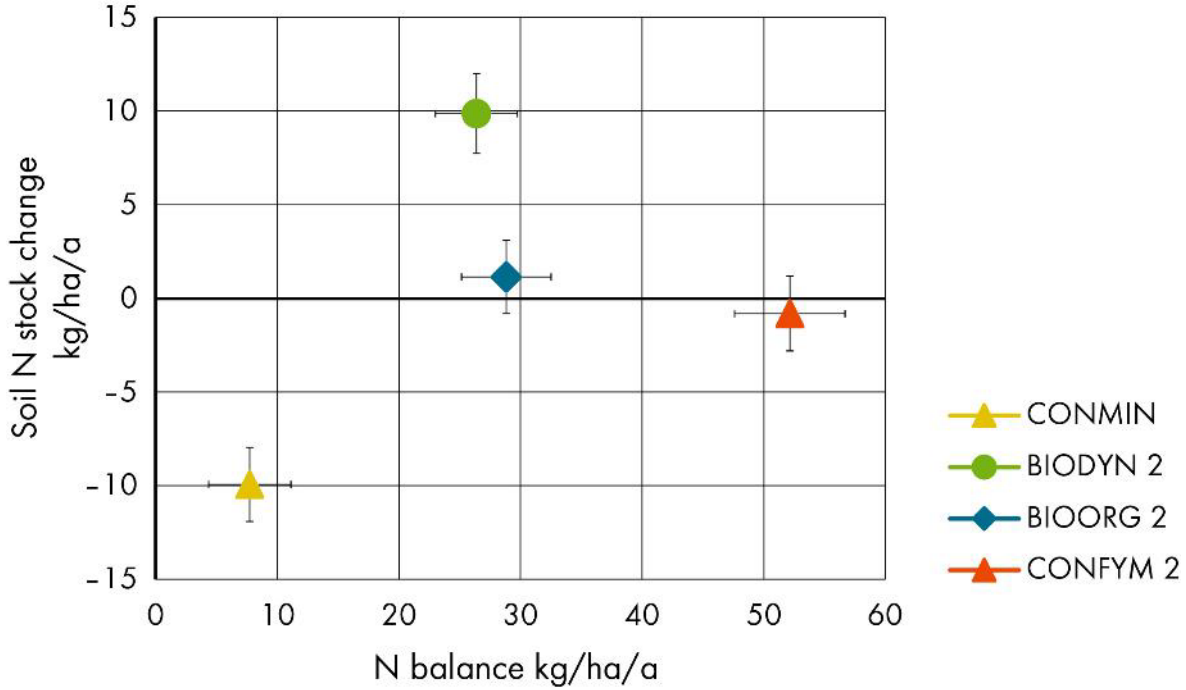
Soil nitrogen stocks and nitrogen balance





- N balance across CRP 2-6 includes inputs via fertilisation, deposition, seeds and nitrogen fixation and outputs via harvest
- CONFYM needs 50 kg ha^{-1} yr^{-1}excess nitrogen to maintain soil N stocks
- CONMIN looses soil N despite positive N balance, BIODYN gains soil N

Oberson et al. (2024): Agriculture, Ecosystems and Environment

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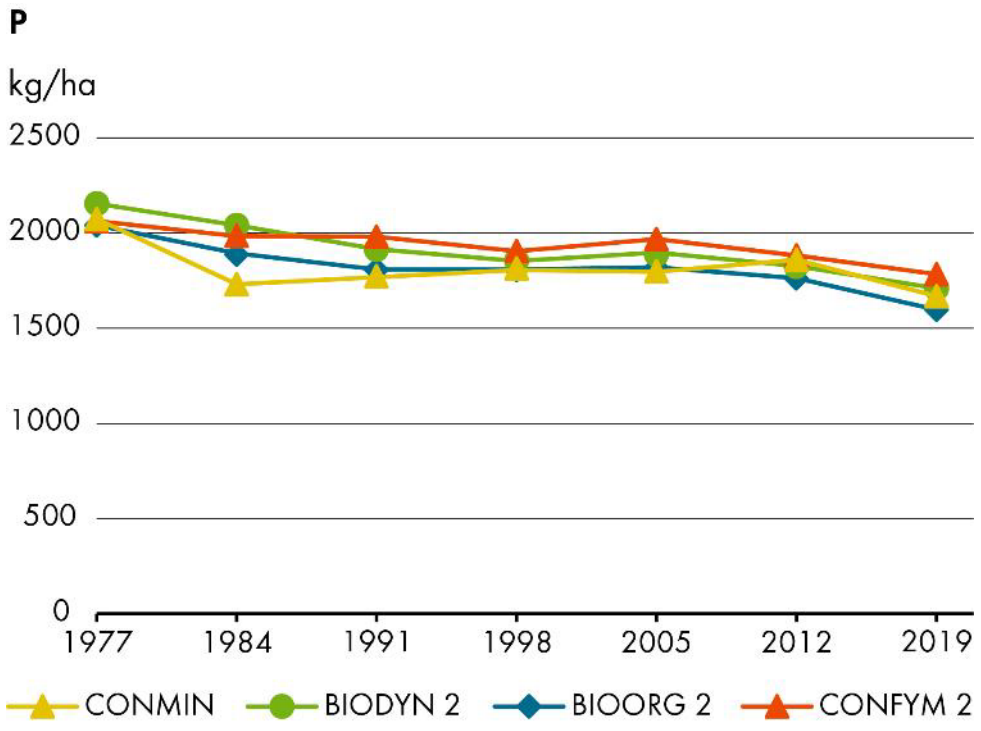
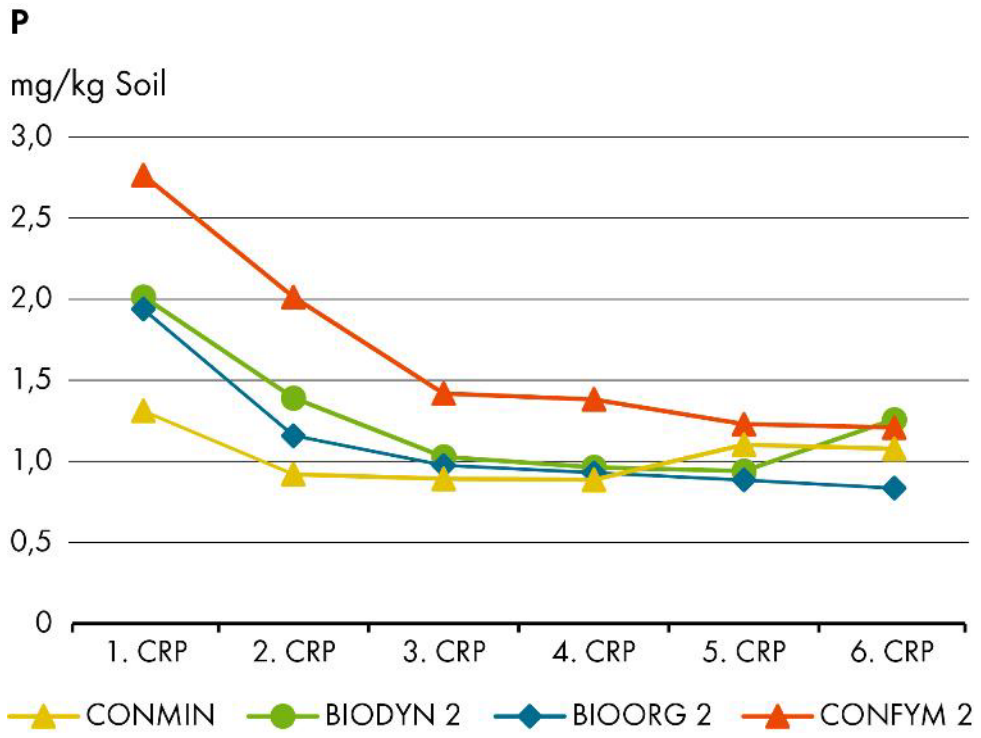
Soil phosphorus





- Soil P stocks (n=4) and available soil P concentrations (n=32) across CRP1-6
- CONMIN was left unfertilised in CRP1 and starts with low available P in CRP2
- P depletion in all systems but slower decrease in CONFYM

Krause et al. (2024): Scientific Reports

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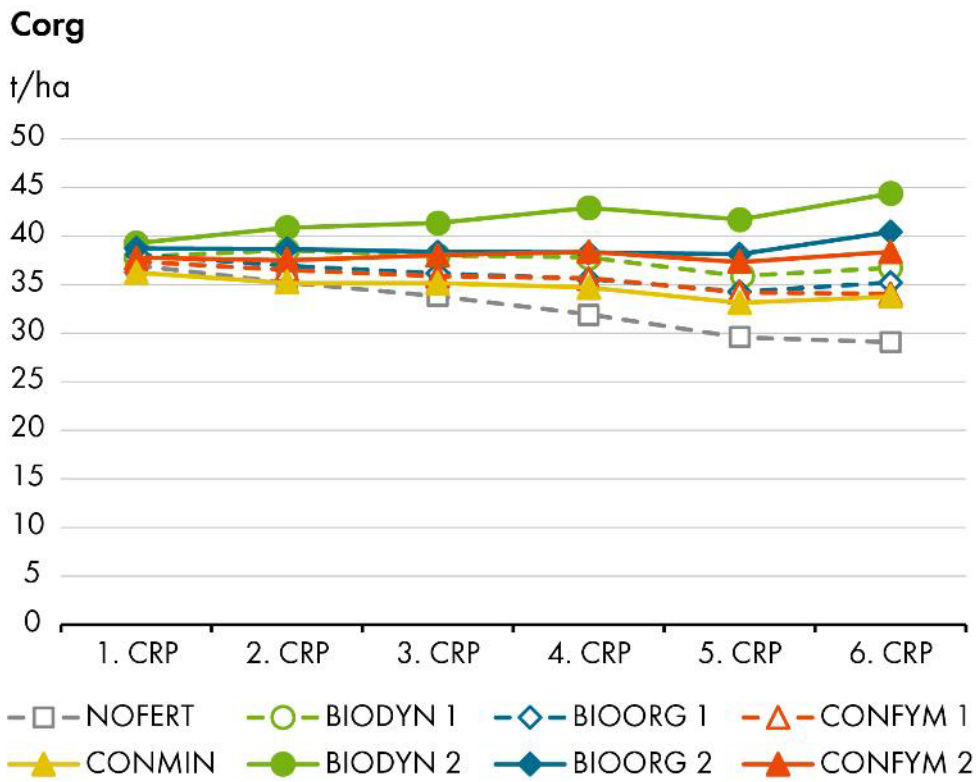
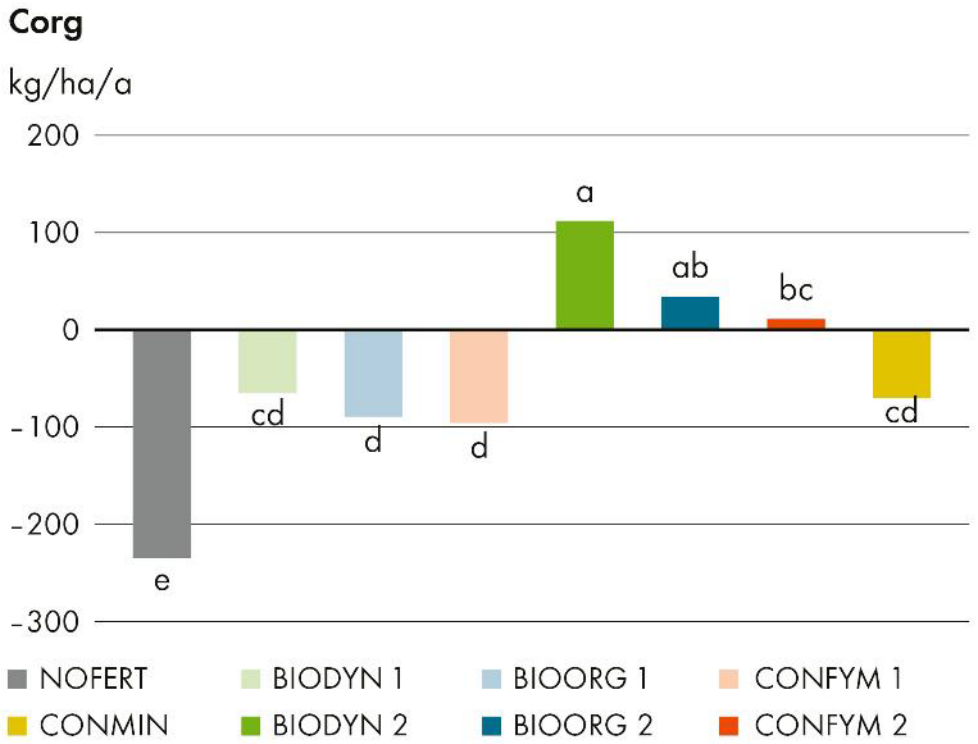
Soil organic carbon





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

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

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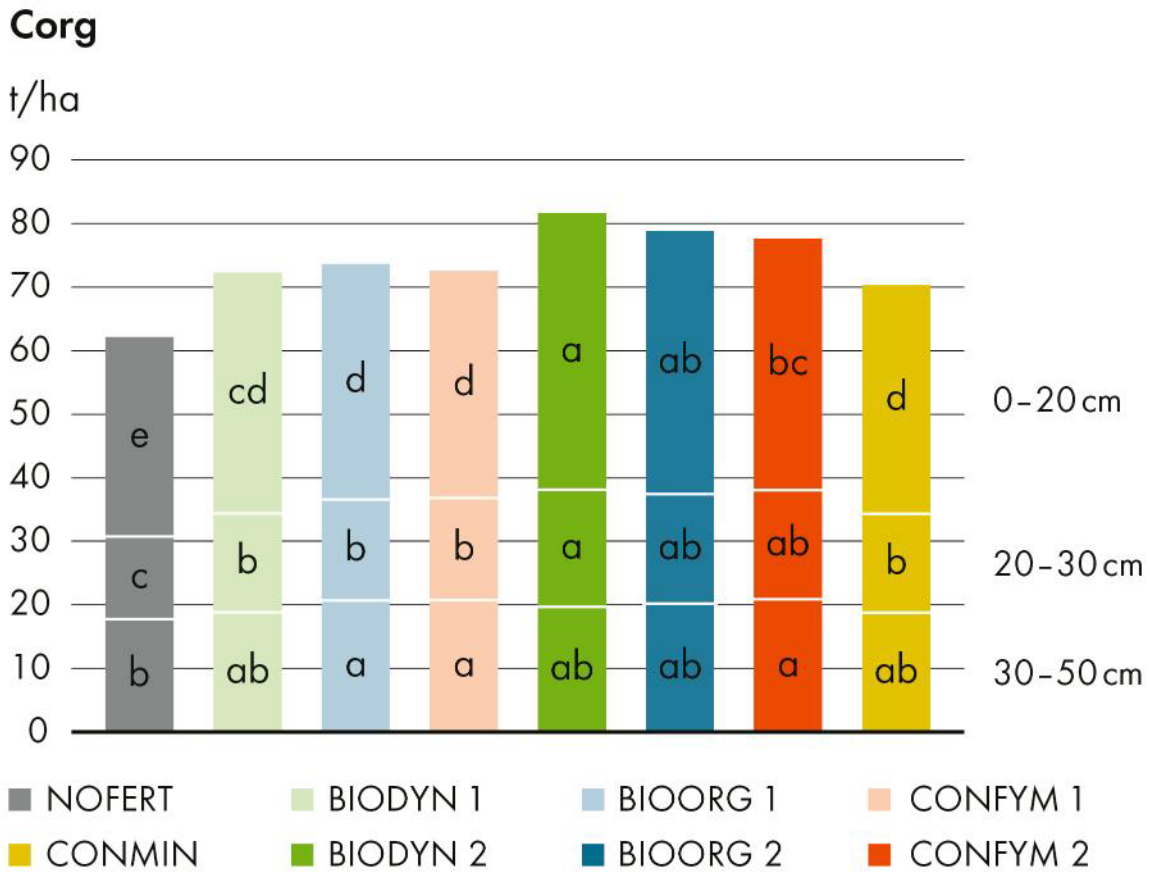
Soil organic carbon

- Main differences in soil carbon stock occur in topsoil



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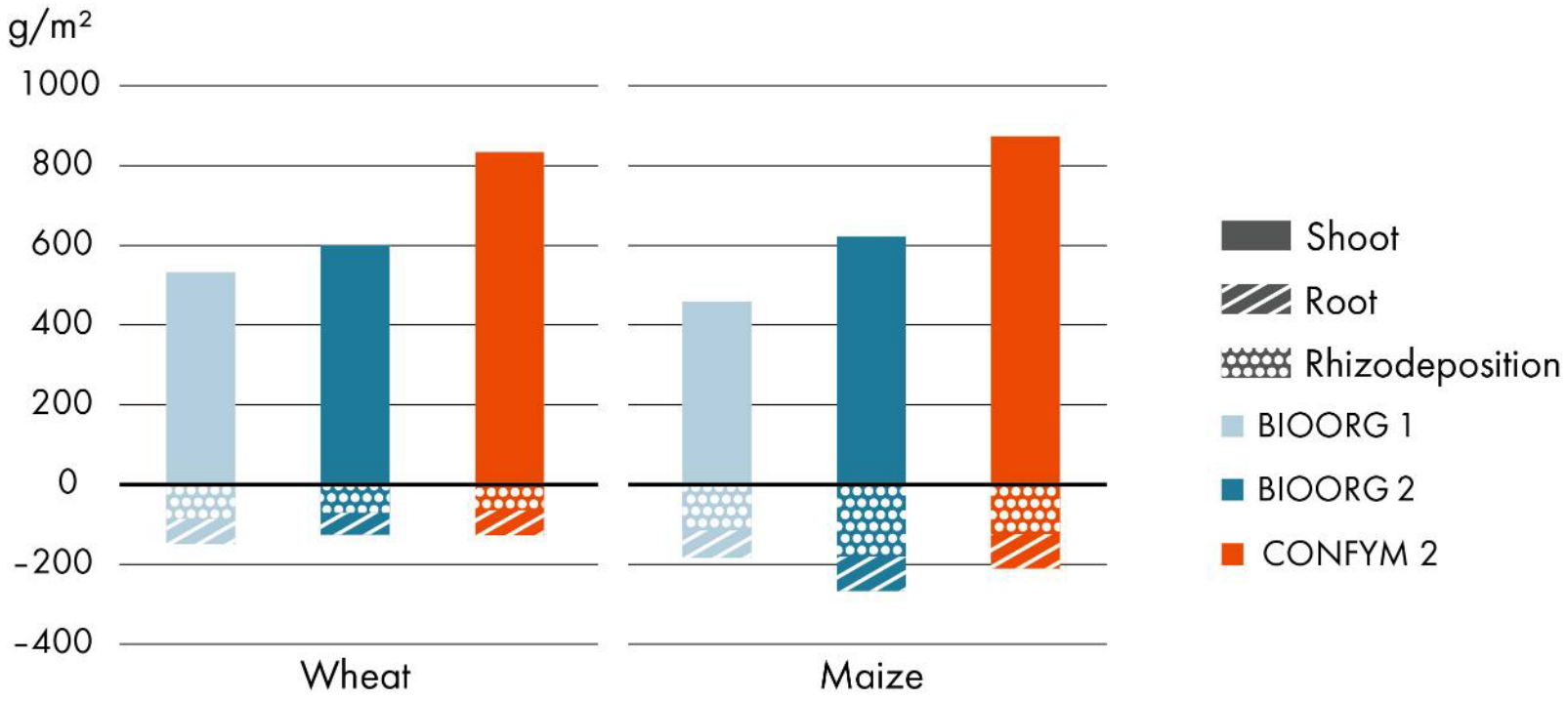
Soil organic carbon inputs via Rhizodeposition



Hirte et al. (2017): Frontiers in Plant Science

- Aboveground biomass does not correspond to belowground carbon inputs.
- Higher roots and rhizodeposition input in BIOORG under maize only

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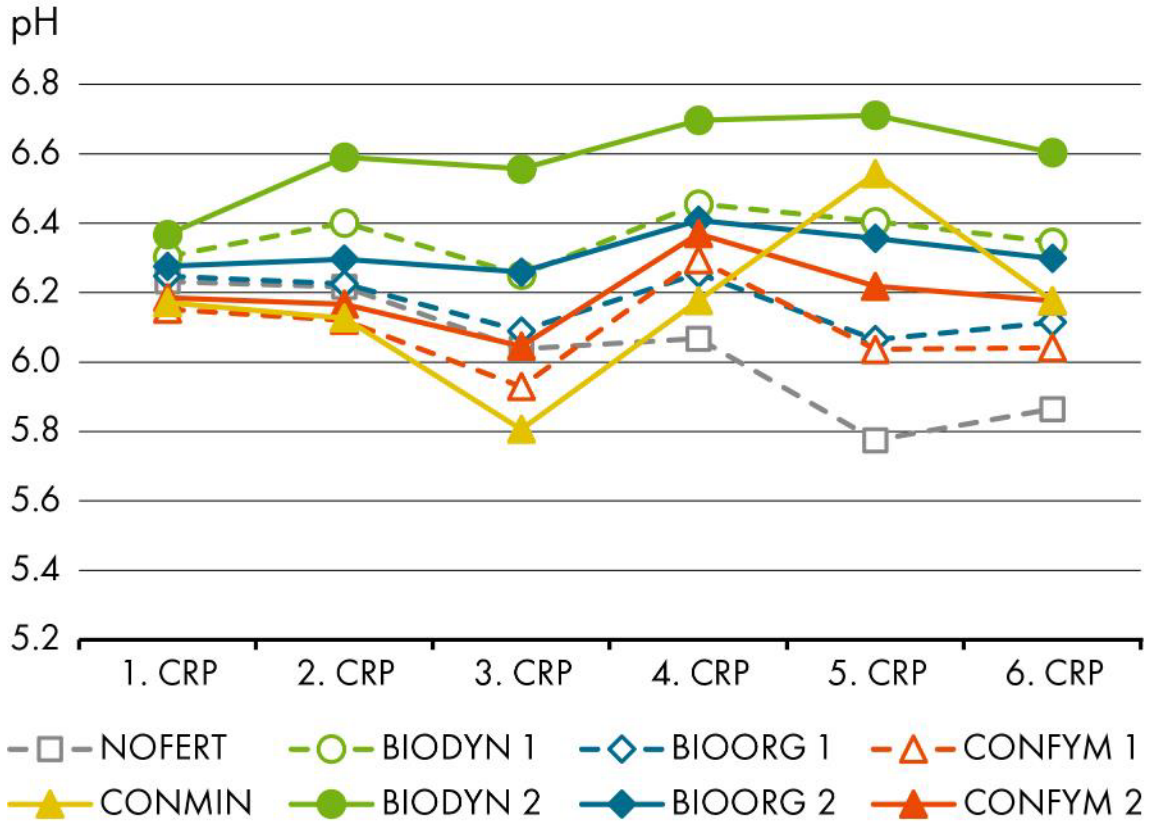
Soil pH (H_2O)

- Highest soil pH in BIODYN
- Liming in CONFYM and CONMIN in CRP3



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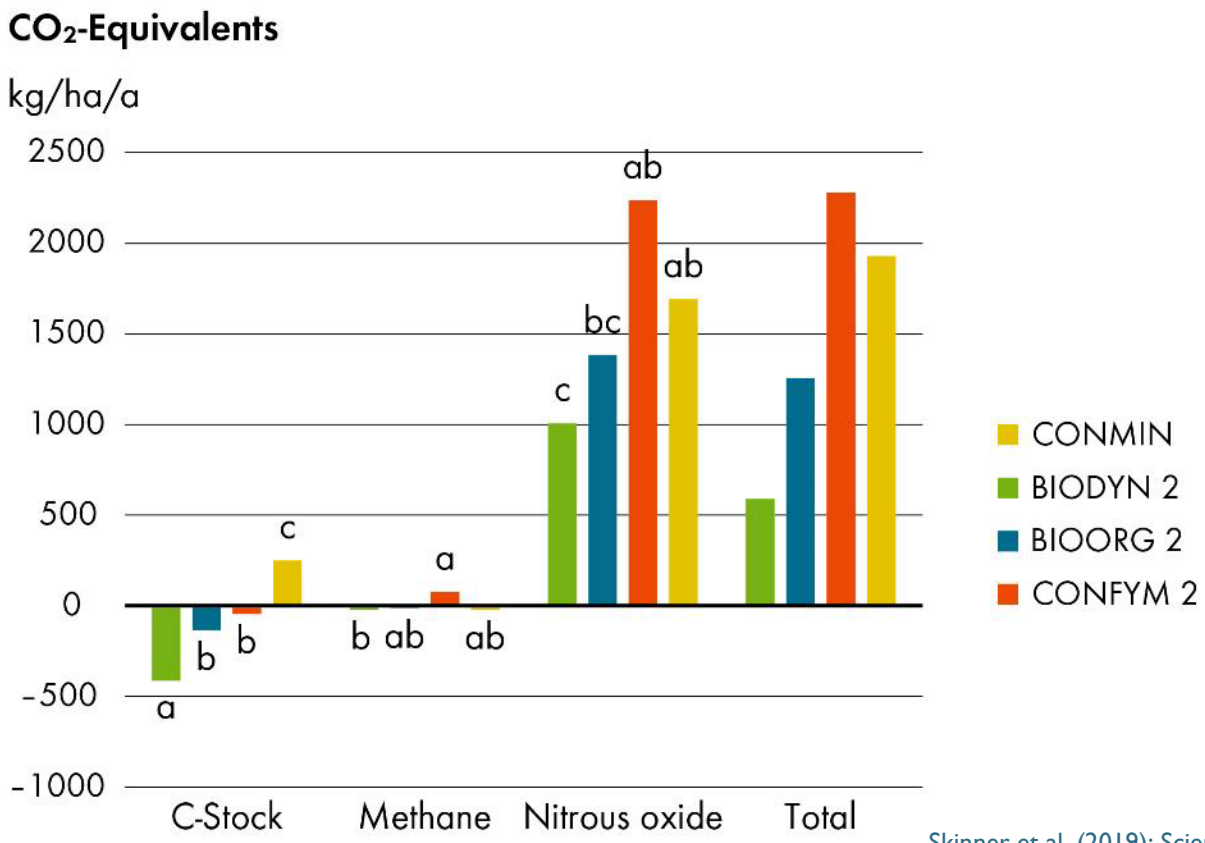
Soil borne greenhouse gas emissions

- C-stock changes assuming constant bulk density for each parcel
- 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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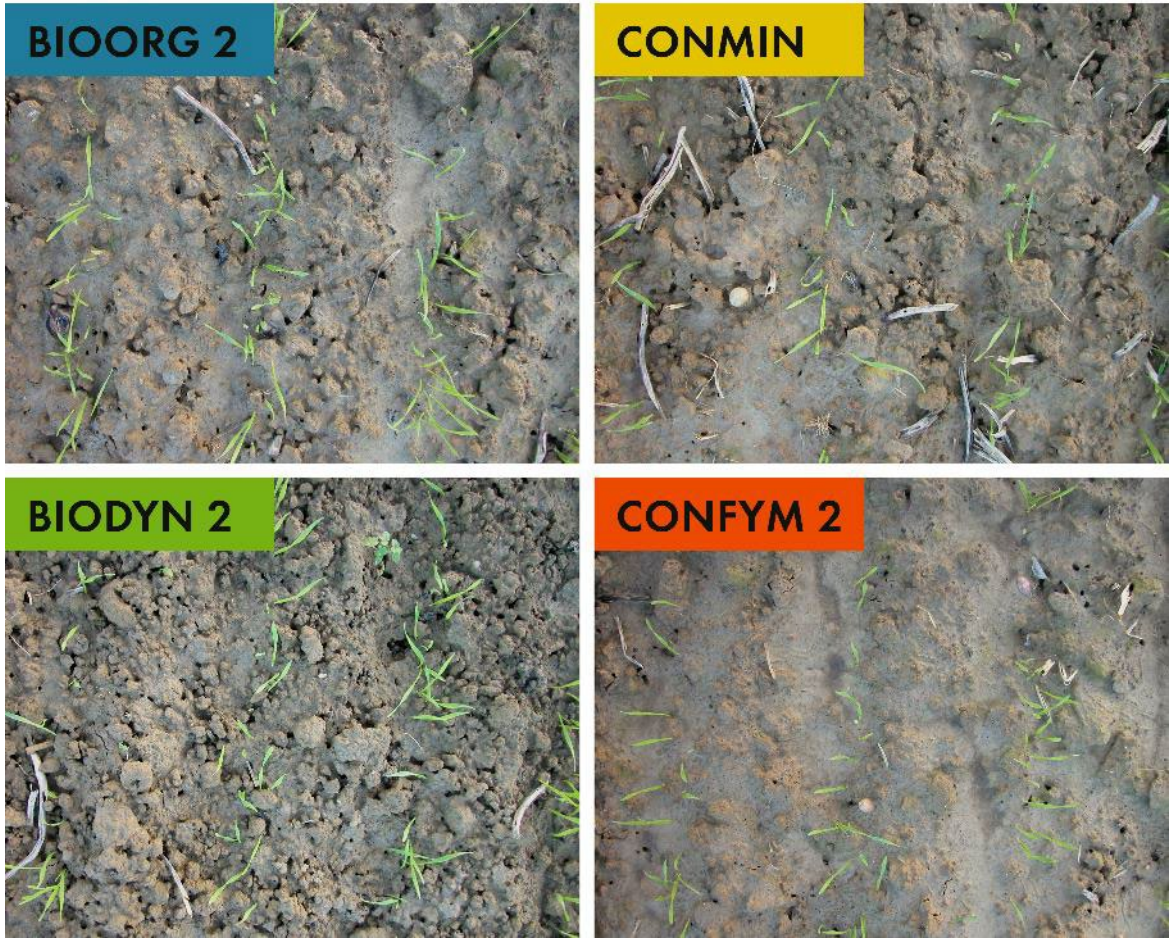
Soil structure



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Soil aggregate stability

	Proportion of stable aggregates	Significance
BIODYN 2	50.1 %	a
BIOORG 2	44.2 %	ab
CONFYM 2	38.4 %	b
CONMIN	38.4 %	b
Overall average across all systems		
March 2000	55.3 %	a
March 2003	48.2 %	b
July 2003	24.8 %	c

Fliessbach et al. (2000): Konferenzbeitrag

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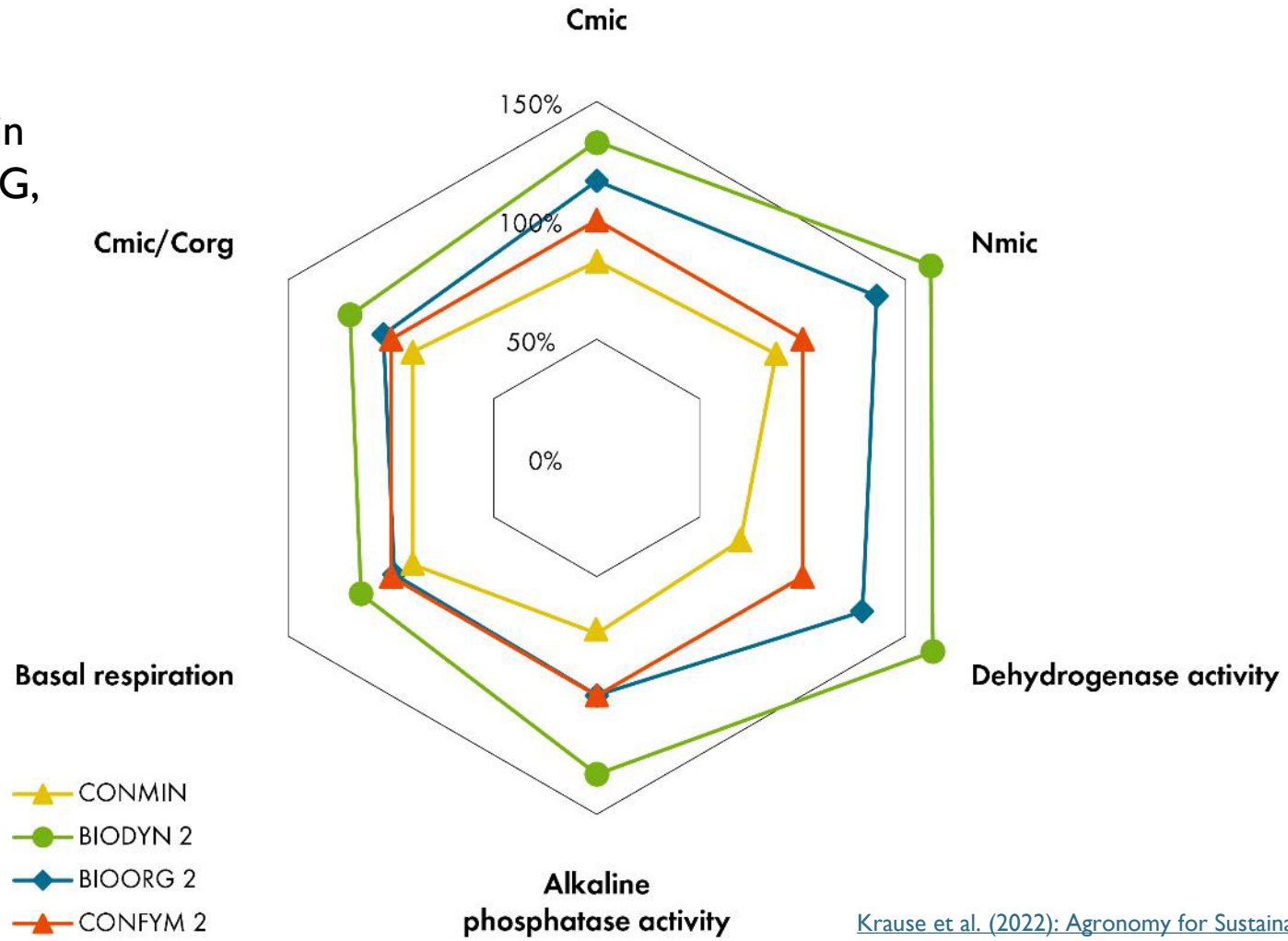
Biological soil quality

- Highest biological soil quality in BIODYN, followed by BIOORG, CONFYM and CONMIN



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

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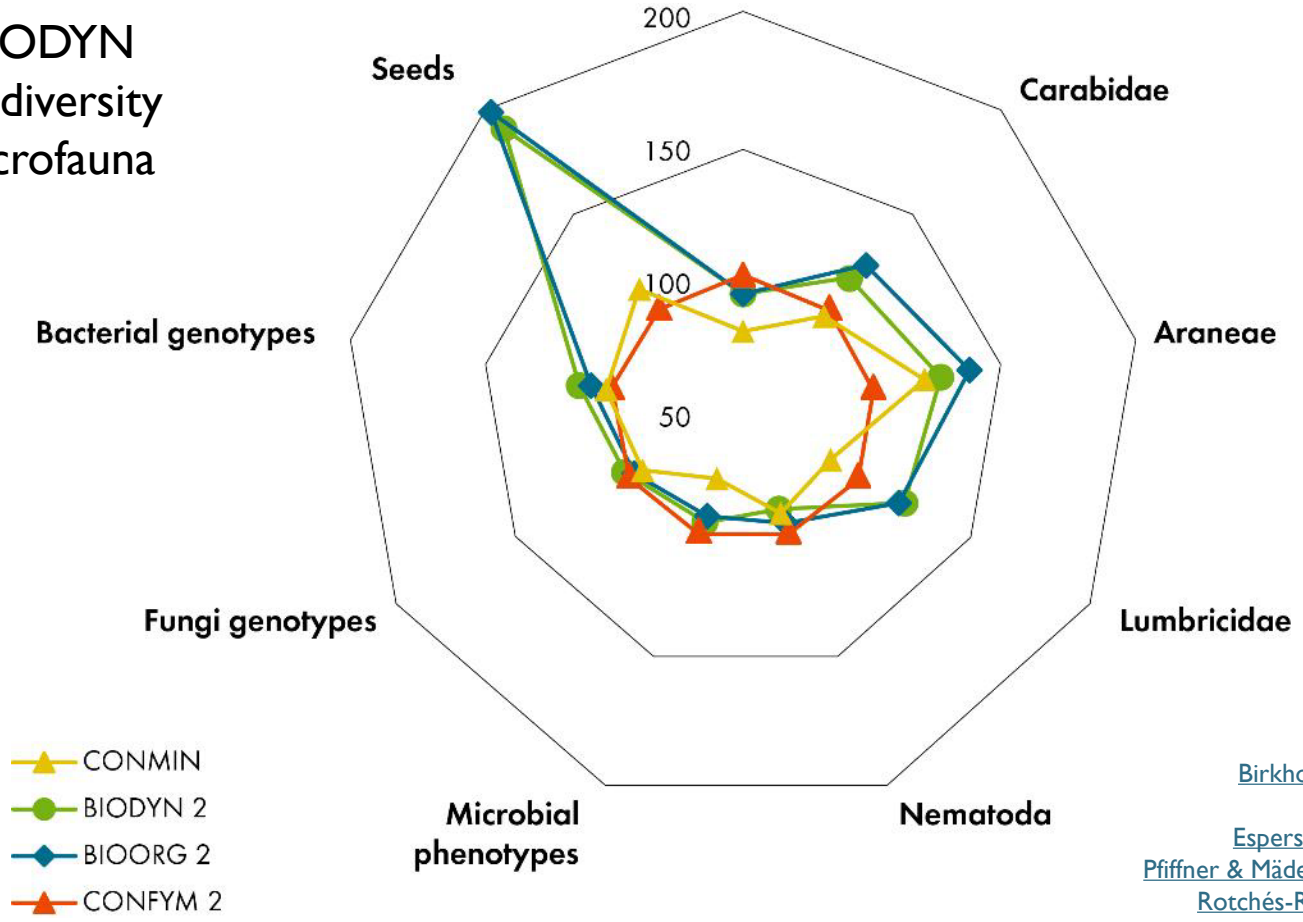
Species diversity

- BIOORG and BIOODYN 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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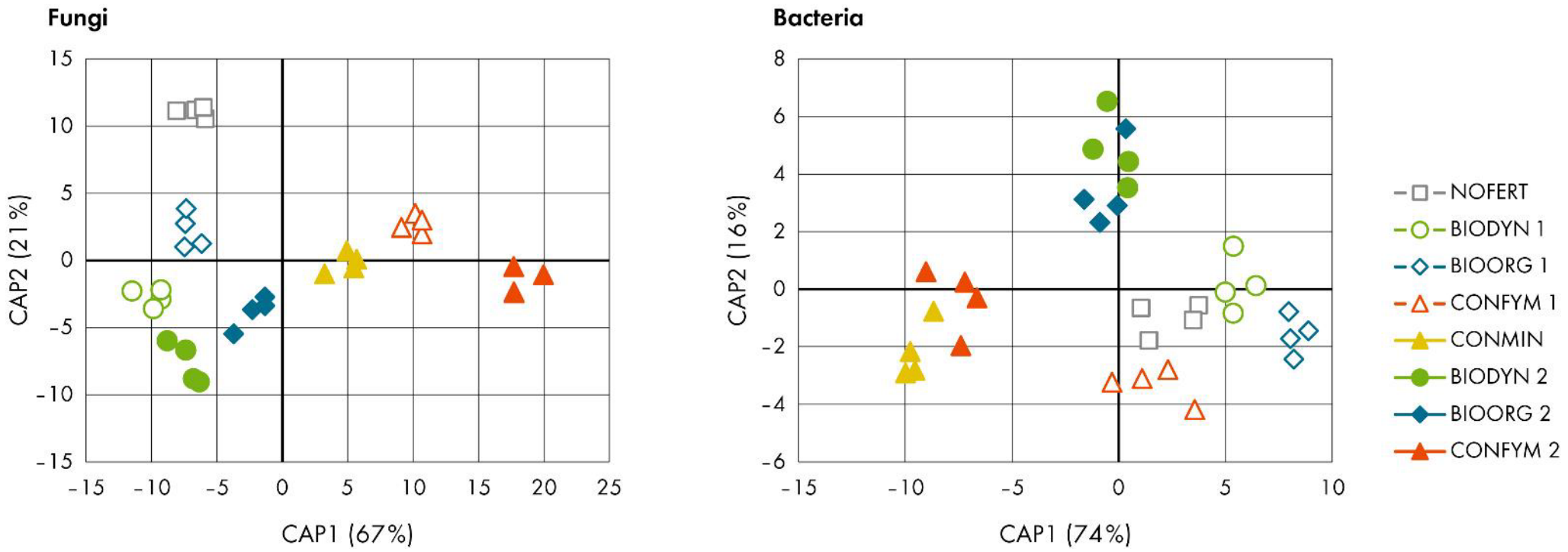
Soil microbial diversity



- 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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Thanks to

Financing

- Federal Office for Agriculture FOAG
- Federal Office for the Environment FOEN
- Swiss National Science Foundation
- Coop Fund for Sustainability
- European Commission

Lease of study areas Therwil

- Agrico Cooperative, Birsmattehof, Therwil
- Stamm family, Oberwil

Partner institutions

Field teams

Consulting farmers

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