Research Institute of Organic Agriculture FiBL
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Crop production and environmental impact of organic and conventional farming systems

Results from a 42 year old field trial

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13.01.2024

FiBL Switzerland with sites in Frick & Lausanne

- Founded in 1973
- 290 employees
- Research, consulting, continuing education and development cooperation
- Research in modern infrastructure at the Frick site and on over 150 Swiss organic farms

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Departments of FiBL Switzerland

- Soil Sciences
- Crop Sciences
- Livestock Sciences
- Food System Sciences
- International Cooperation
- Extension, Training & Communication
- Suisse Romande
- Finances, Resources & Administration

FiBL group

- **FiBL Switzerland**
  Founded 1973
  290 employees
- **FiBL Germany**
  Founded 2000
  65 employees
- **FiBL Austria**
  Founded 2004
  36 employees
- **ÖMKI Hungary**
  Founded 2011
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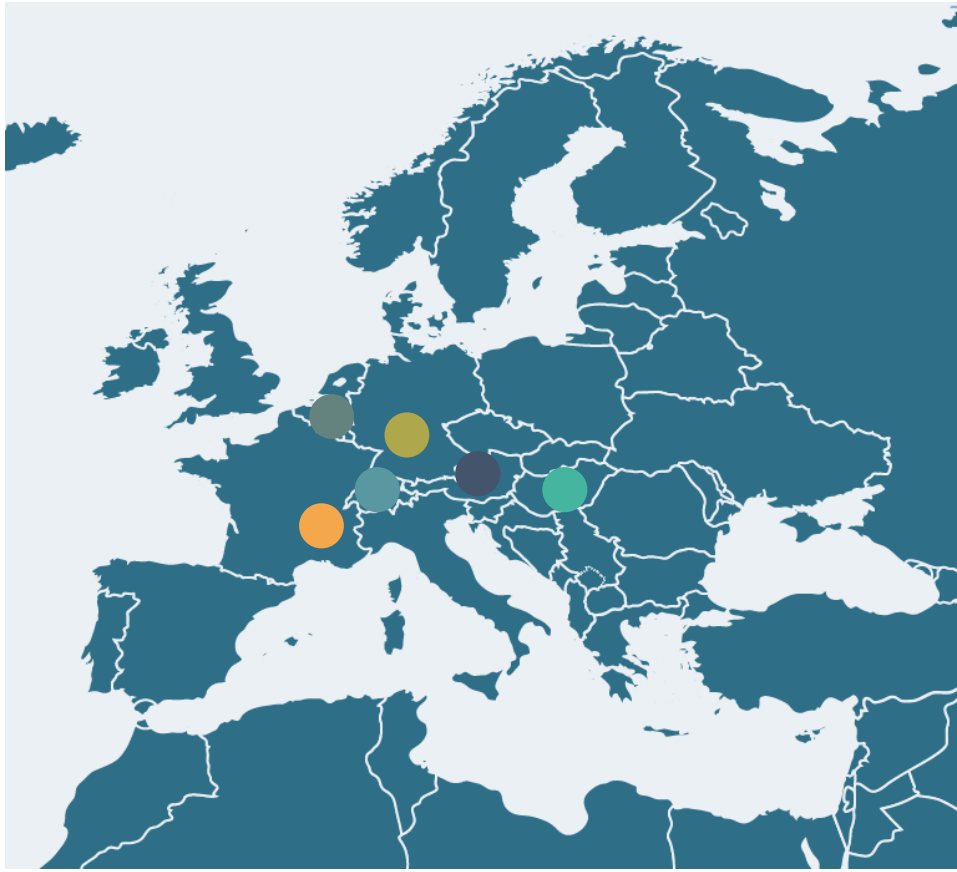
  7 employees



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Department of Soil Sciences

Working groups

- Soil fertility & climate
- Nutrient management & symbioses
- Cultivation techniques in arable farming

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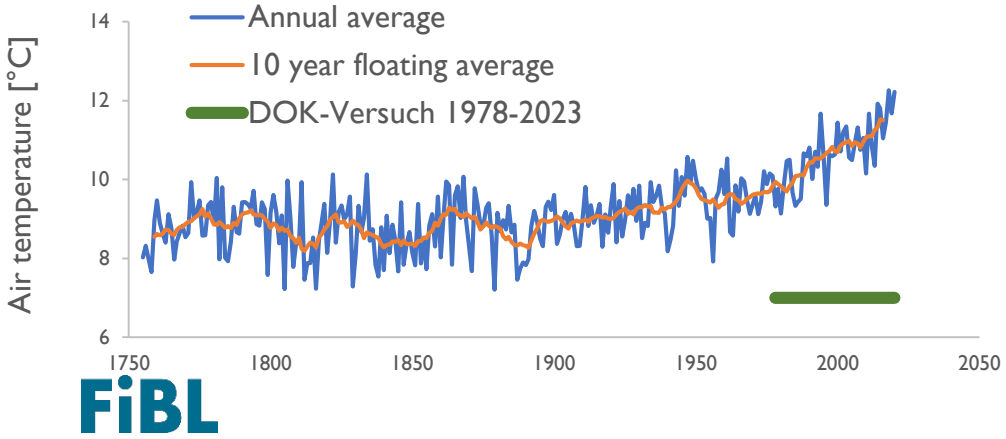
The DOK trial

- Since 1978
- System-comparison approach
- accompanied by farmers advisory board
- Initial aim: "test feasibility of organic agriculture"



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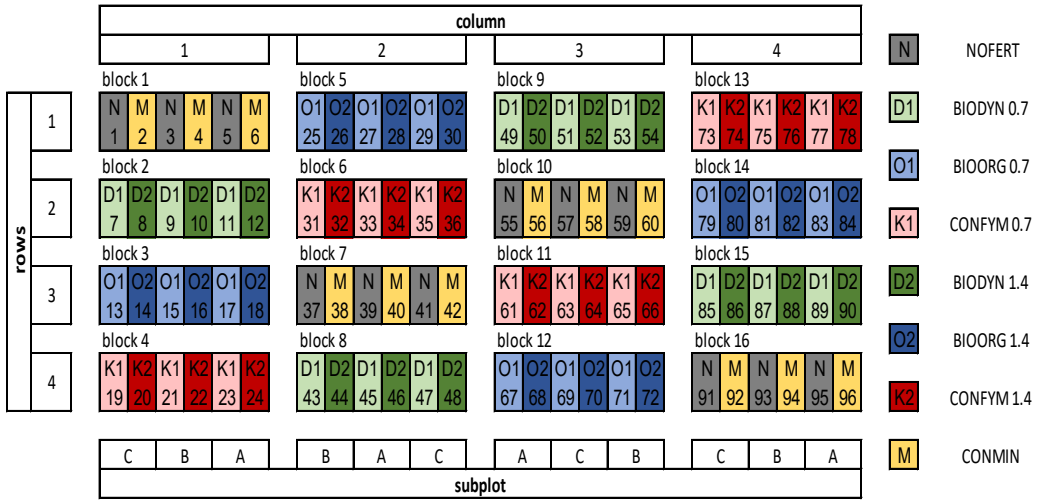
Field setup

- Haplic luvisol
- 791 mm and 10.9°C MAT
- 8 Treatments – 3 crops – 4 replicates
- 96 parcels
- Similar tillage in all farming systems



BIODYN – biodynamic (demeter)
BIOORG – bioorganic (Bio Suisse)
CONFYM – conventionel (IP Suisse)
CONMIN – conventionel, mineral control

Farming system	NOFERT	BIODYN 0.7 / BIODYN 1.4	BIOORG 0.7 / BIOORG 1.4	CONFYM 0.7 / CONFYM 1.4	CONMIN	0.7 LU / 1.4 LU
Fertilization	-	composted manure, slurry	rotted manure, slurry	stacked manure, slurry, mineral	mineral	
Crop protection	mechanical	preparations / mechanical, indirect, beneficials	copper-sulfate	insecticides, fungicides, herbicides (thresholds)		

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Crop rotation

Same crop rotation in all systems

	1978-1984	1985-1991	1992-1998	1999-2005	2006-2012	2013-2019
	1. CRP	2. CRP	3. CRP	4. CRP	5. CRP	6. CRP
1	potato	potato	potato	potato	sillage maize	sillage maize
2	winter wheat 1	winter wheat 1	winter wheat 1	winter wheat 1	winter wheat 1	soya bean
3	cabagge	beetroot	beetroot	soya bean	soya bean	winter wheat 1
4	winter wheat 2	winter wheat 2	winter wheat 2	sillage 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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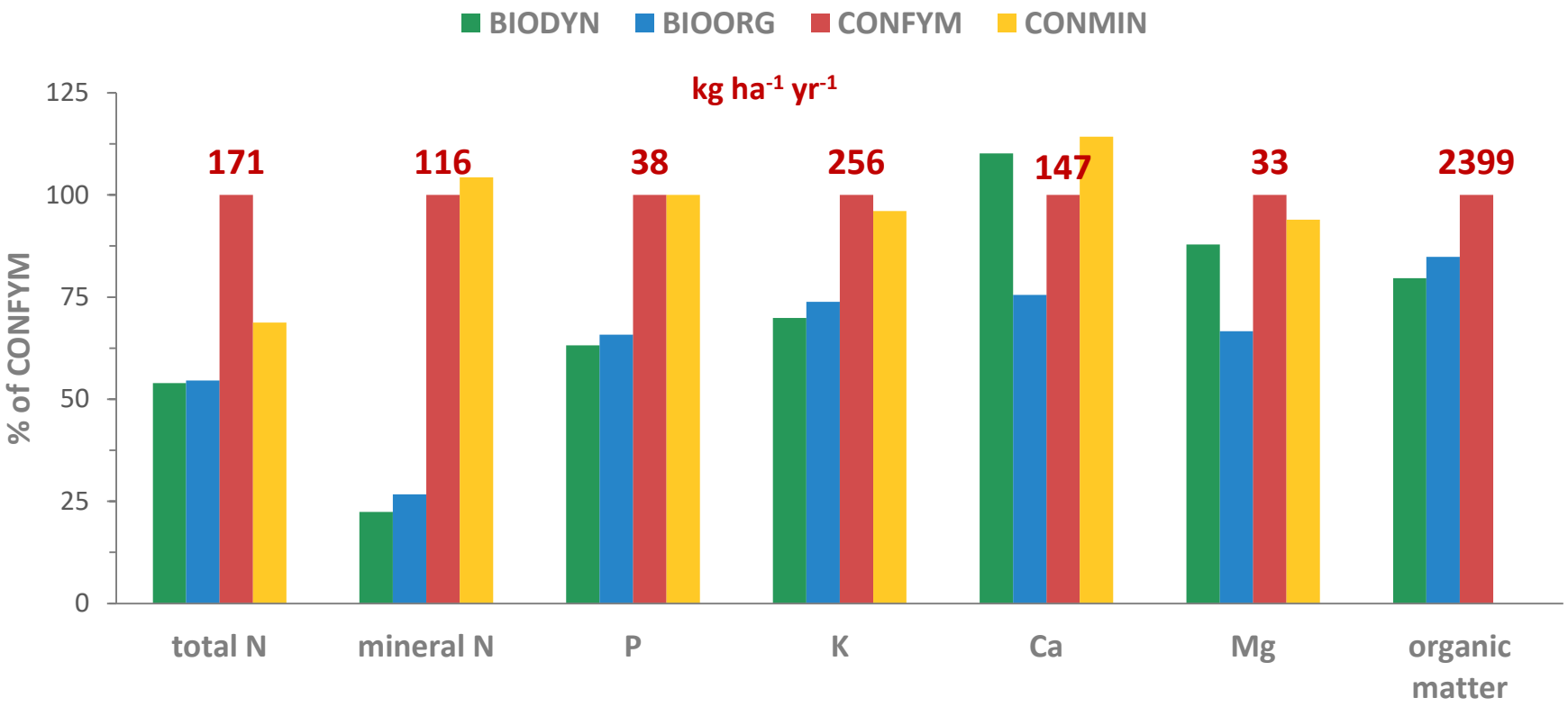
- Two-year grass-clover in all systems
- Maize and soja beans as emerging crops from 4. CRP onwards

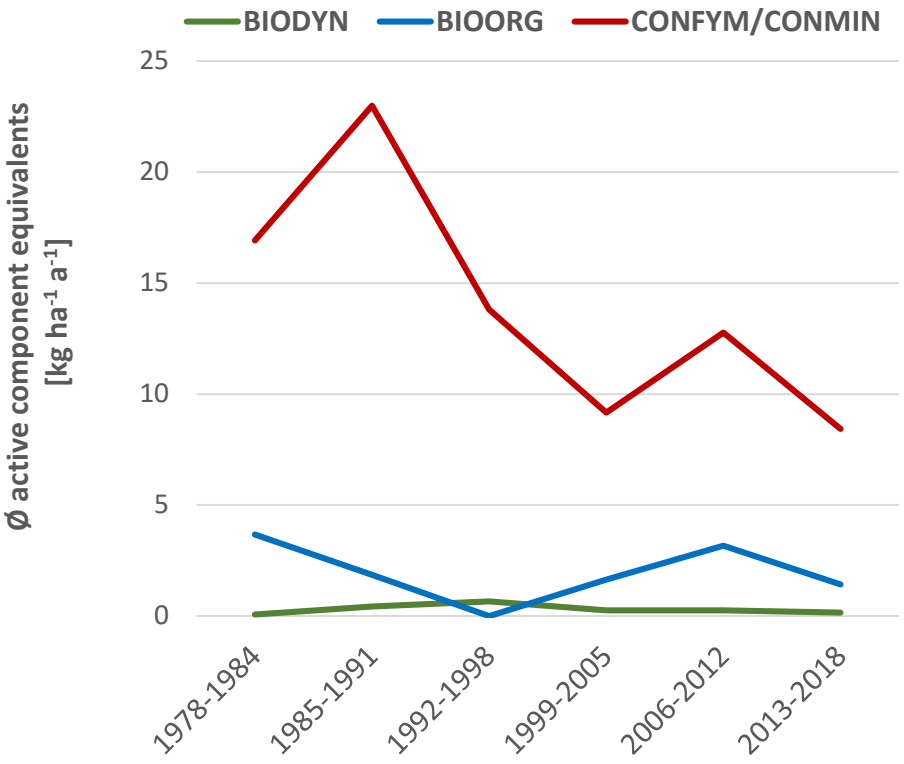
Plant nutrition

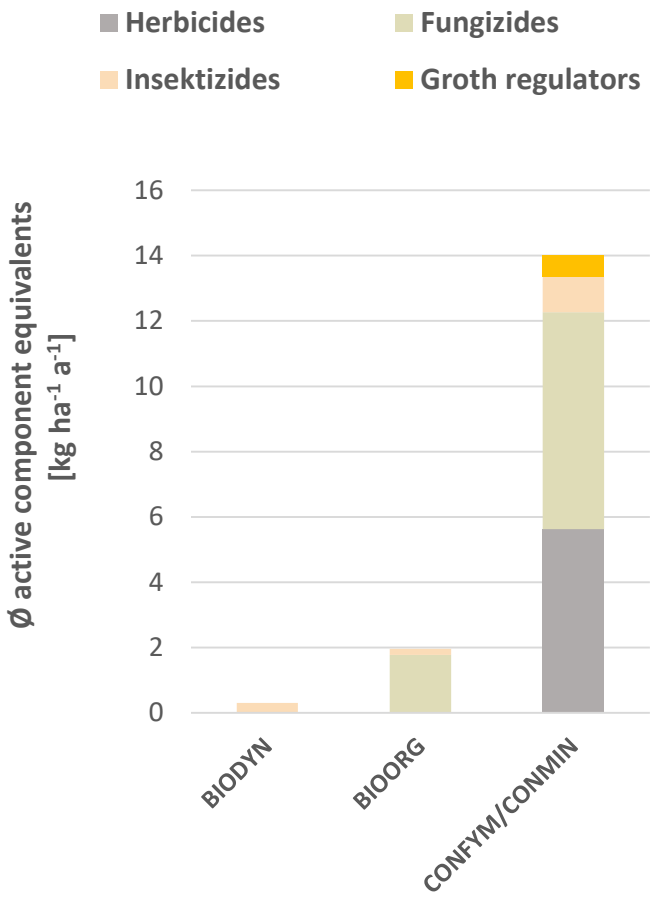
Mean annual nutrient inputs (CRP 2-6)



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

Plant protection inputs





- Similar plant protection in CONMIN and CONFYM
- Reduced chemical pesticides inputs in CONFYM/CONMIN from 3rd CRP
- 92% less pesticides in BIODYN/BIOORG compared to CONFYM/CONMIN

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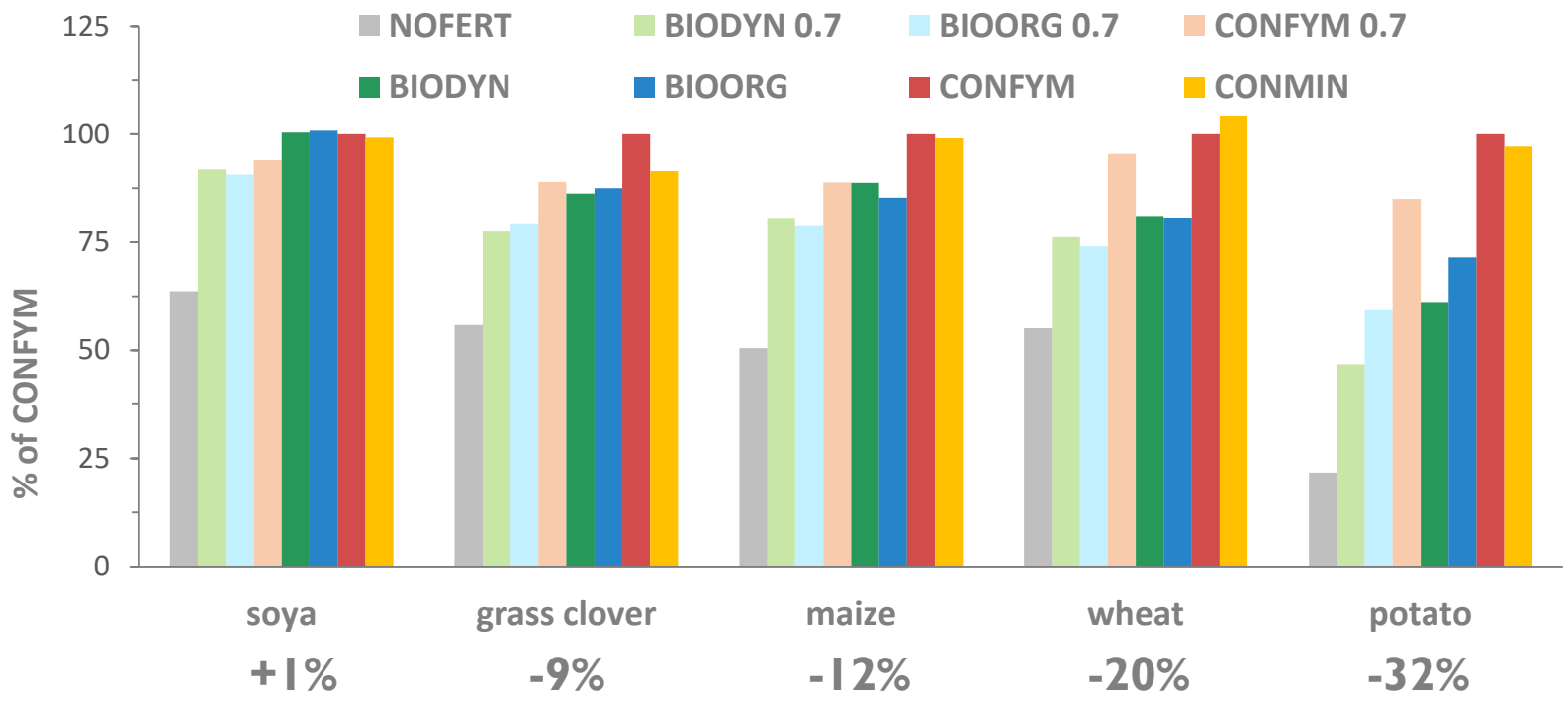
Impressions from the DOK trial

Impressions from the DOK trial

Yields

Mean yields of CRP 1-6 (grass clover, wheat, potato) and CRP 4-6 (soya, maize)



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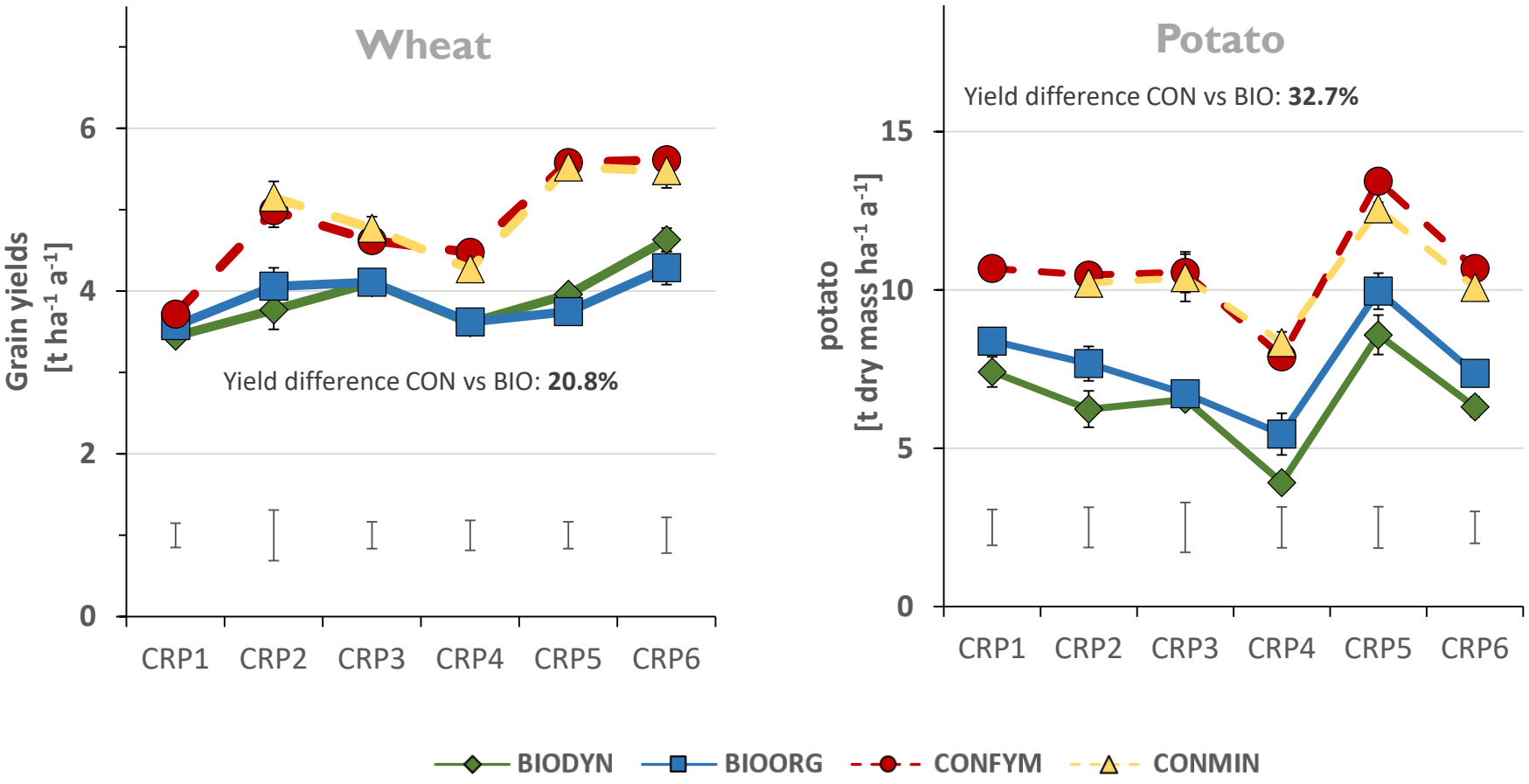
Knapp et al. (2024)

- Stable yields in all systems
- 15% yield gap for BIO compared to CON at 1.4 LU across all crops

Temporal development of yields



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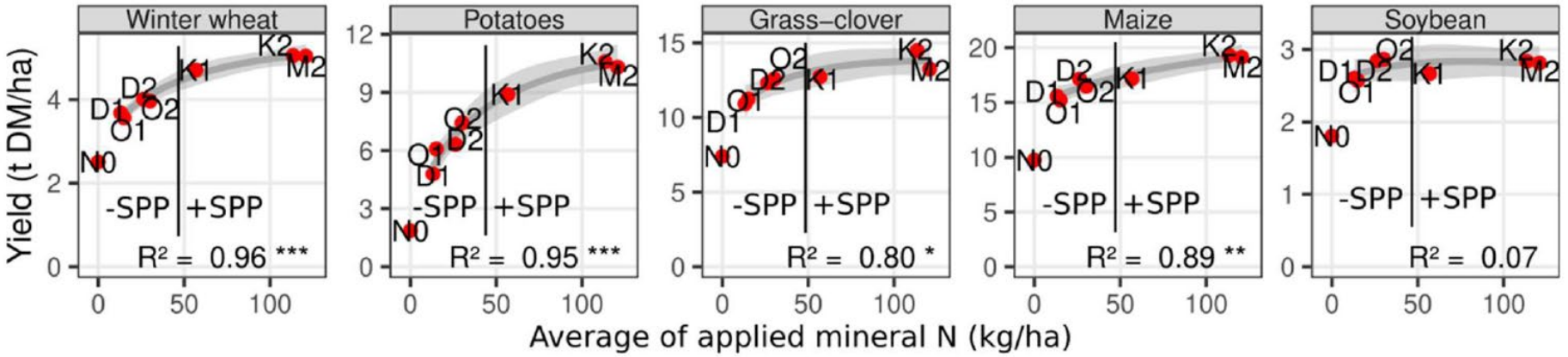
Yields

Relationship between yields and nitrogen fertilization



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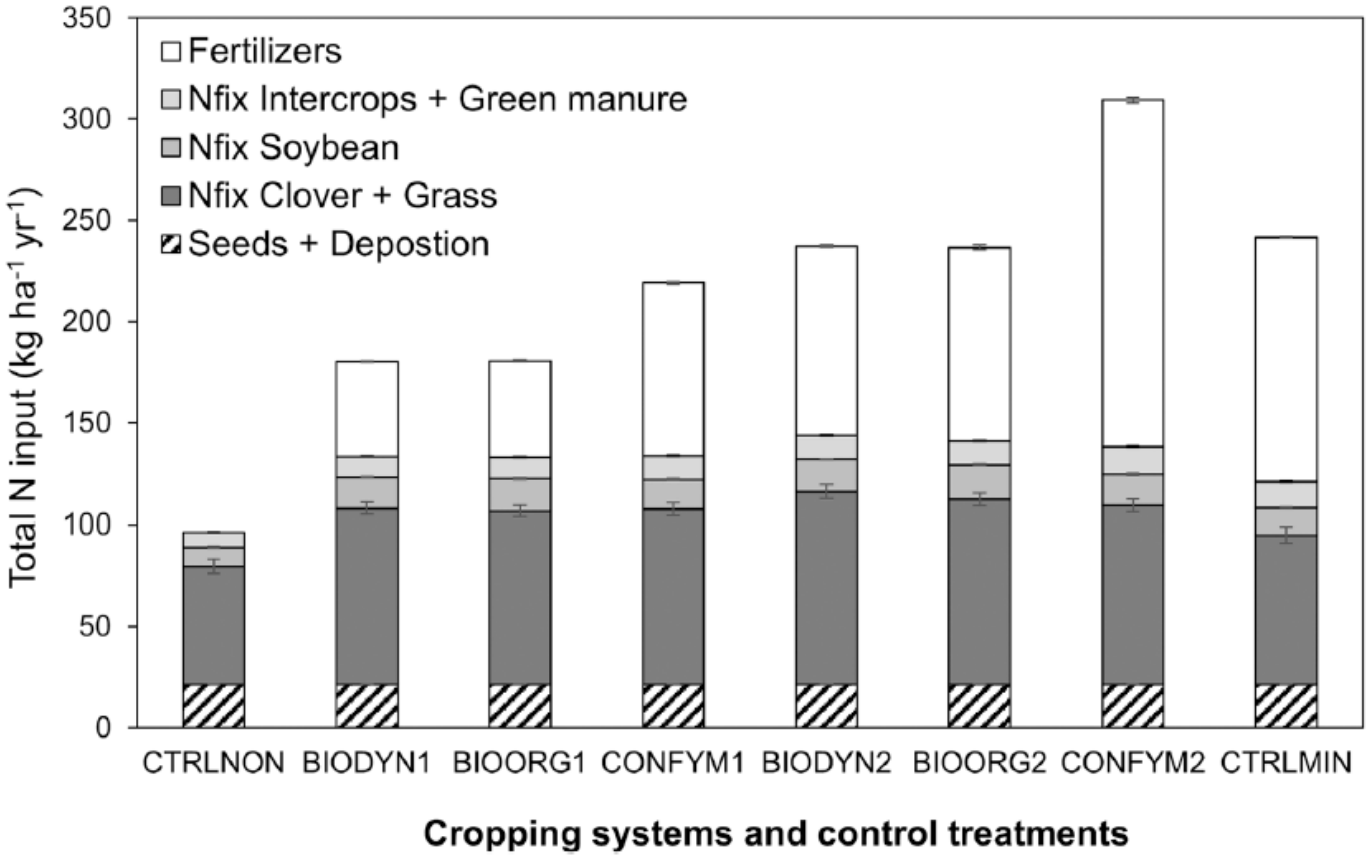
Knapp et al. (2024)

- Legumes vs non legumes
- Highest yields reduce nitrogen use efficiency

Fertilizer nitrogen inputs and symbiotic nitrogen fixation

- Nitrogen fixation was followed ^{15}N tracing in grassclover and soya
- Balance across 5 crop rotation periods

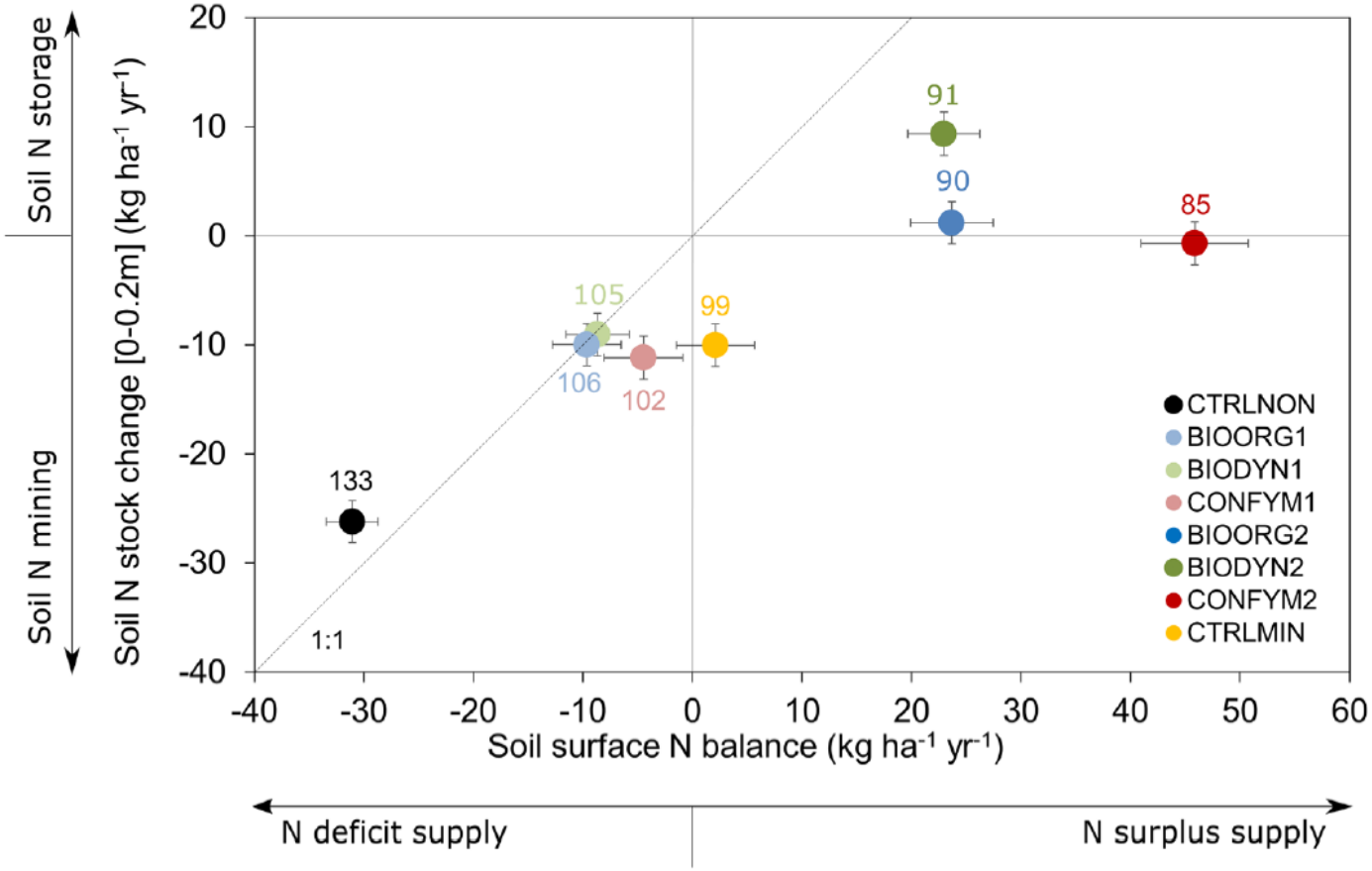


Oberson et al (2024)
doi: 10.1016/j.agee.2023.108802

- Fixed nitrogen exceeds fertilizer nitrogen inputs for all system except CONFYM2 and CONMIN

Soil nitrogen and nitrogen balances

N balances include inputs via fertilization, deposition, seeds and nitrogen fixation and outputs via harvest across CRP 2-6



- CONFYM needs ~45 kg ha^{-1} yr^{-1}excess nitrogen to maintain soil N stocks
- CONMIN looses soil N despite positive N balance
- BIODYN builds soil N, but still shows unavoidable losses

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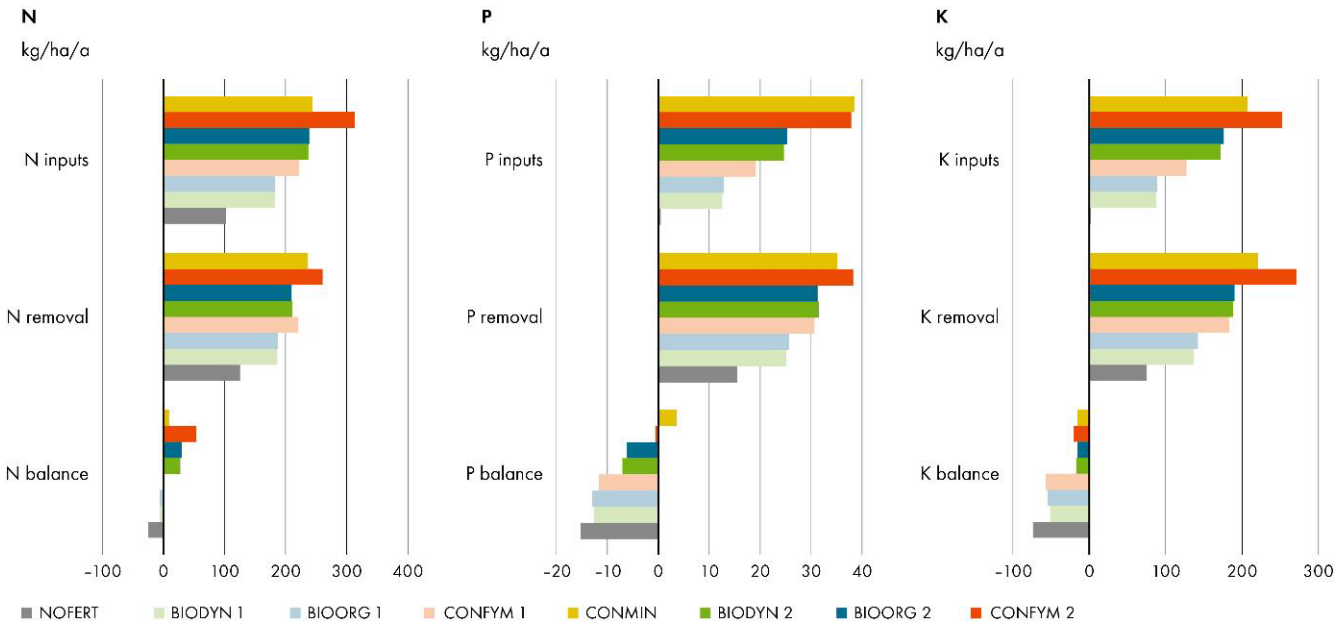
Oberson et al (2024)
doi: 10.1016/j.agee.2023.108802

N, P and K 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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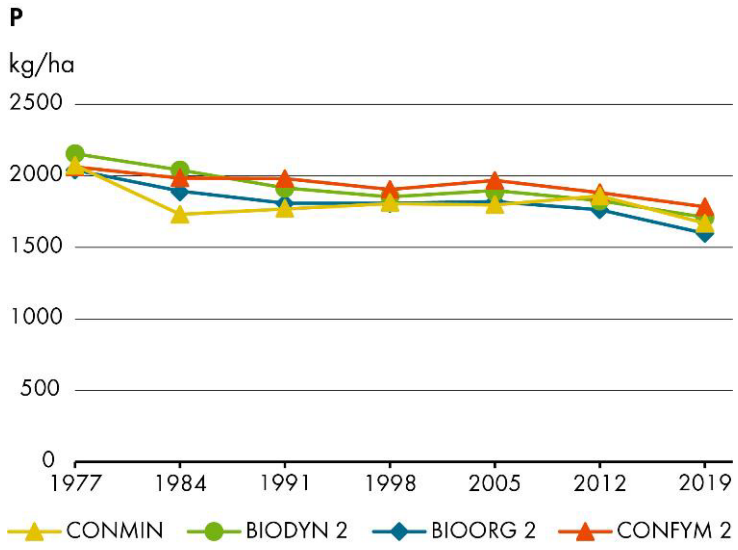
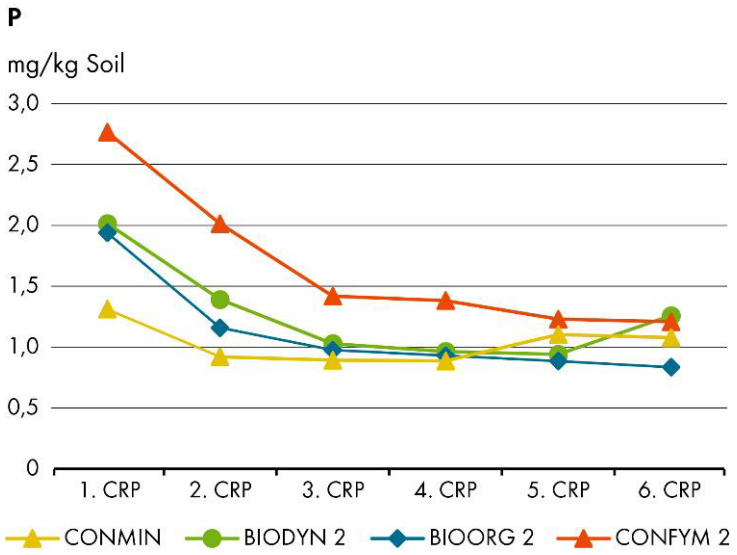
Soil phosphorus





- 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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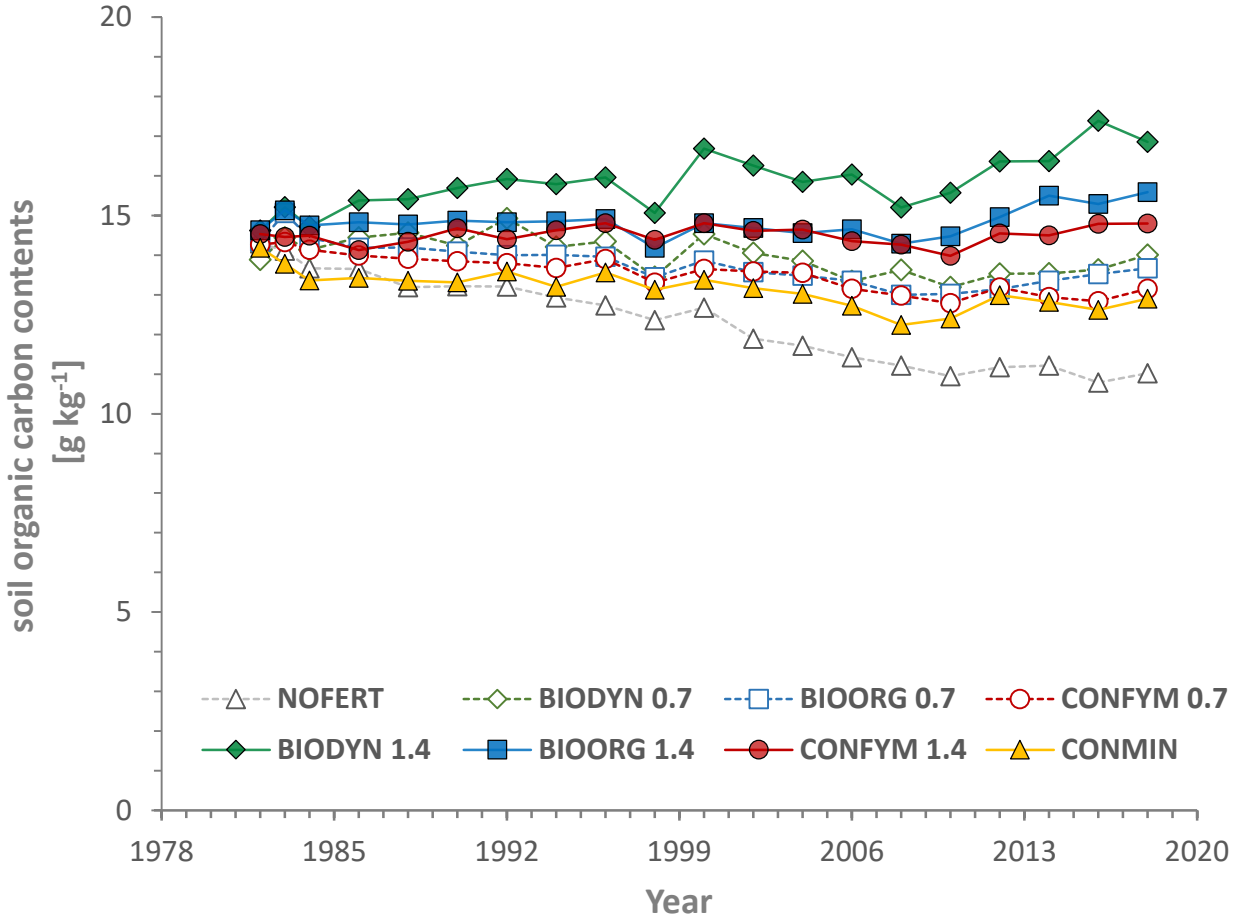
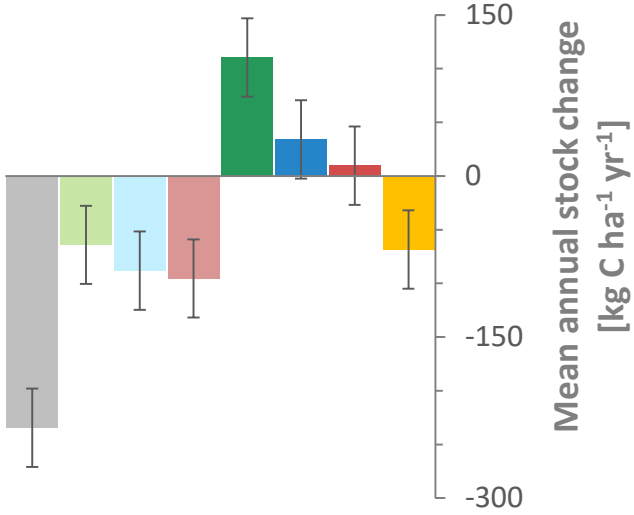
Soil organic carbon

Elemental analysis of archived soil samples (0-20 cm)



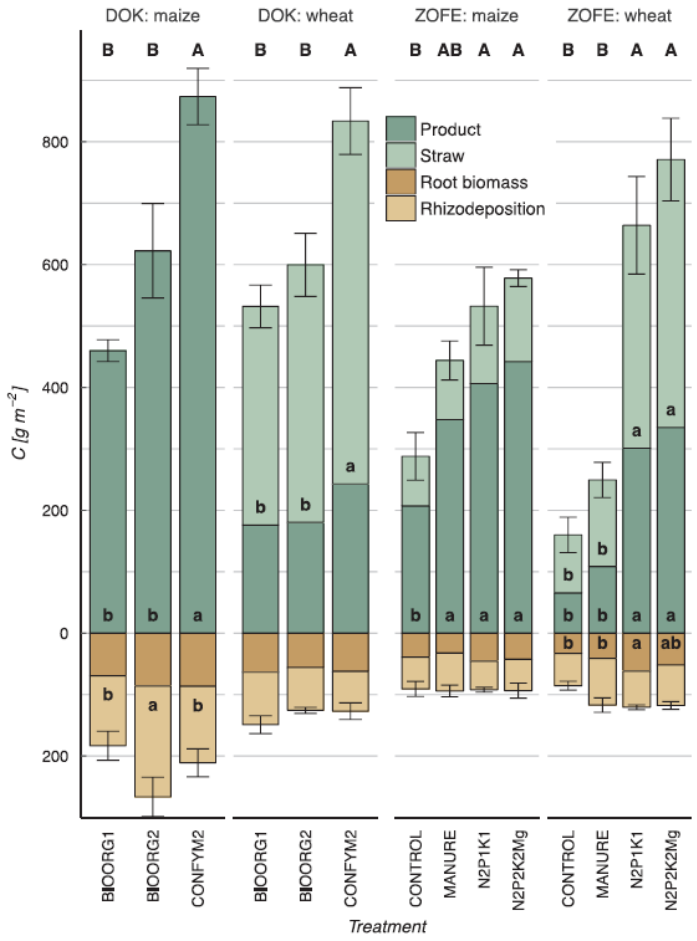


FiBL Krause et. al (2022)

- All system at 0.7 LU, CONMIN and NOFERT loose soil organic carbon
- Mixed farming with 1.4 LU can sustain soil organic carbon
- Increased SOC contents in BIODYN due to composting of manures

Rhizodeposition

$^{13}CO_2$ pulse labeling



- Soil carbon inputs via roots and rhizodeposition is independent from primary production

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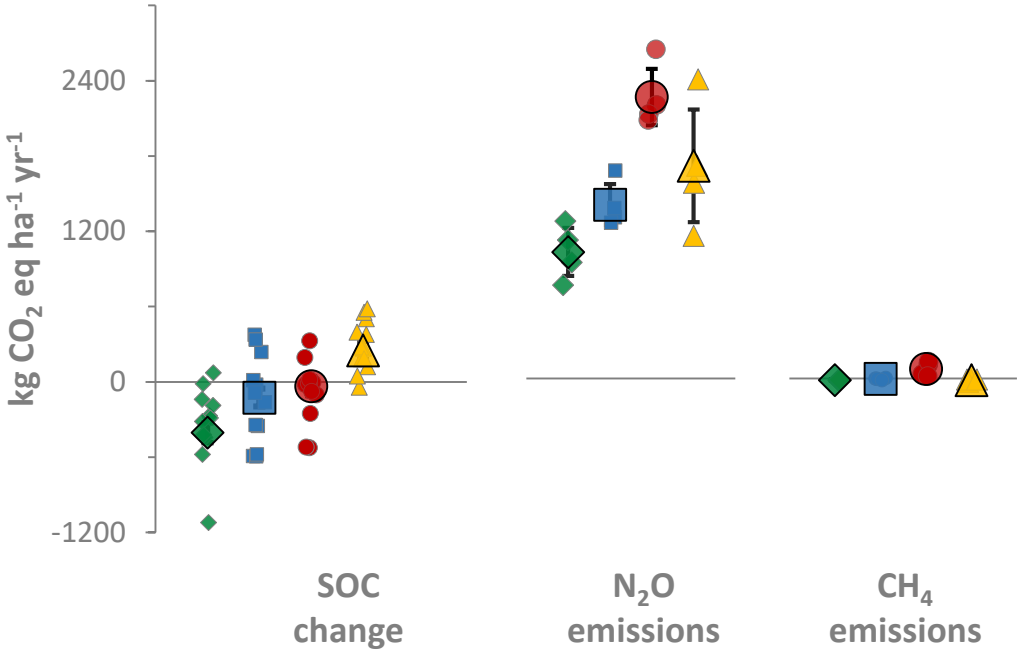
Hirte et al. 2018:
https://doi.org/10.1016/j.agee.2018.07.010

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)



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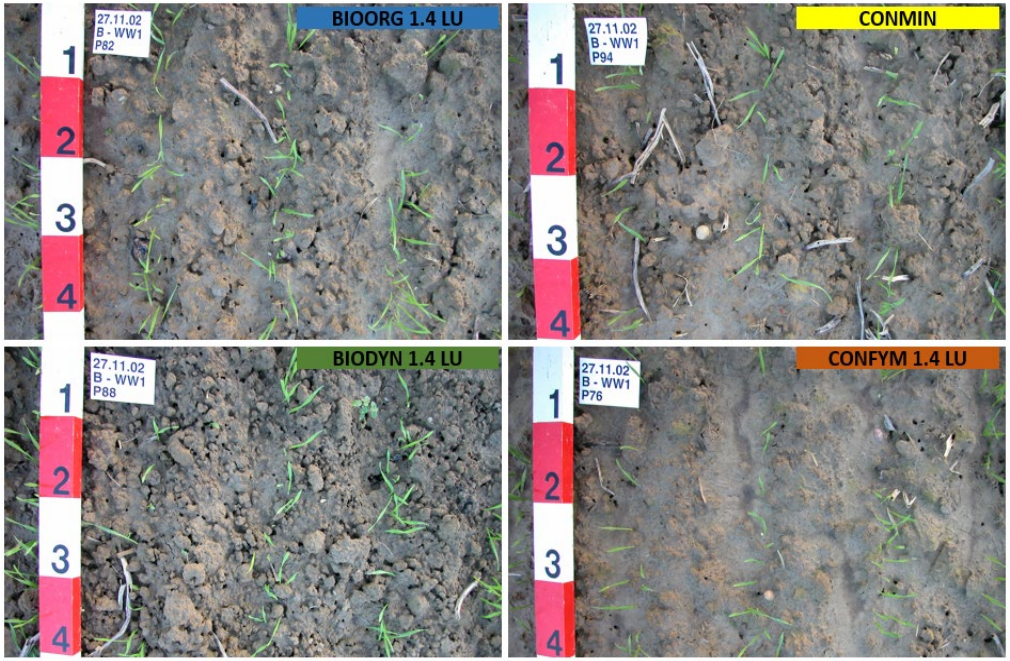
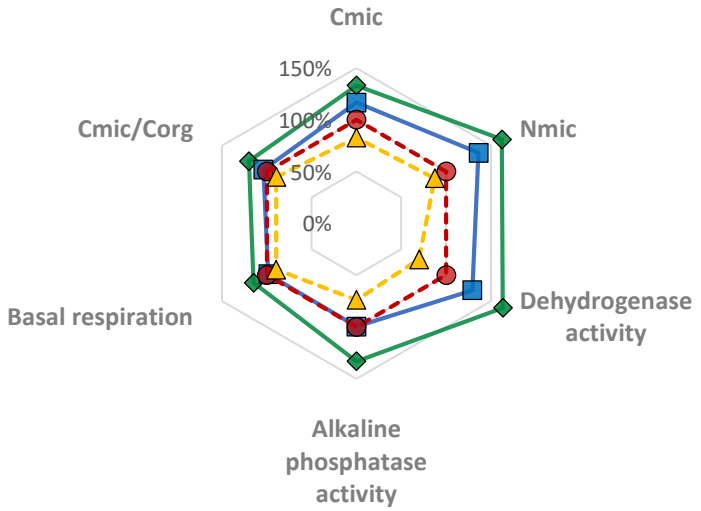
Skinner et al., (2019),
Krause et al. (in prep.)

- Field site as system boundary
- N_2O emissions drive climate impact
- Raising SOC contents in BIODYN did not enhance N_2O emissions

Soil biology

Soil structure, microbial biomass and activity





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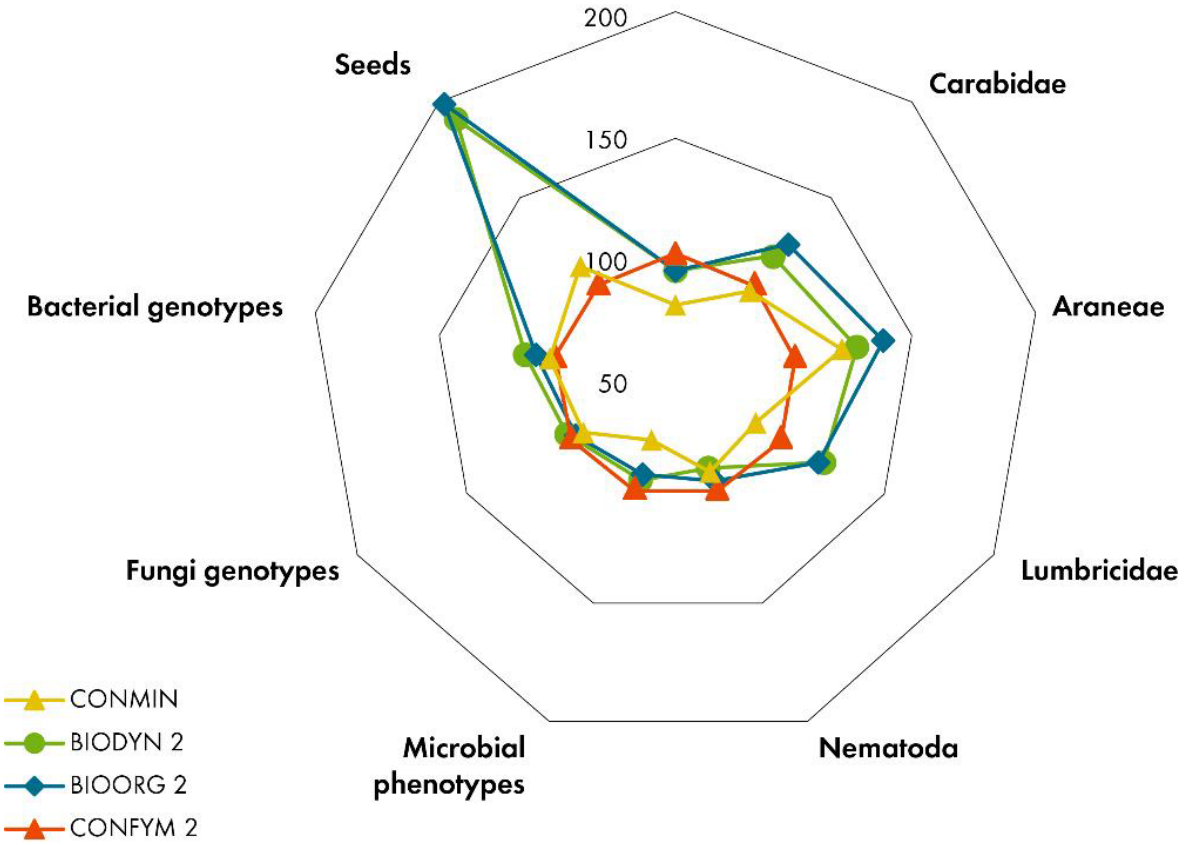
- Visible differences in soil structure
- Highest biological soil quality in BIODYN

Species diversity

- BIOORG and BIOODYN showed increased diversity for microflora, macrofauna and weeds



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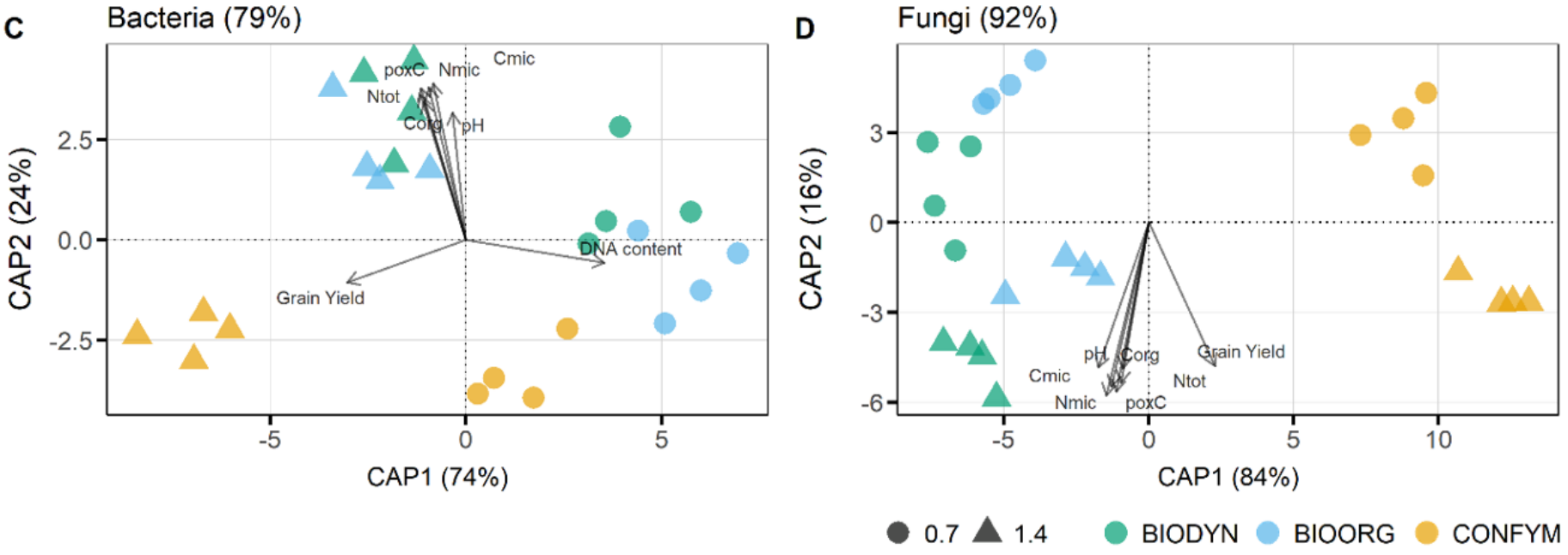
Birkhofer et al. (2008): Soil Biology and Biochemistry
Hartmann et al. (2015): ISME Journal
Esperschütz et al. (2007): FEMS Microbiology Ecology
Pfiffner & Mäder (1997): Biological Agriculture & Horticulture
Rotchés-Ribalta et al. (2020): Applied Vegetation Science

Soil biology

Soil microbial diversity - Amplicon sequencing of bacterial 16S rRNA gene and fungal ITS in organically fertilized systems at 0.7 and 1.4 LU input intensity



- Bacterial community structure mainly affected by fertilization intensity
- Farming system as main driver for fungal diversity

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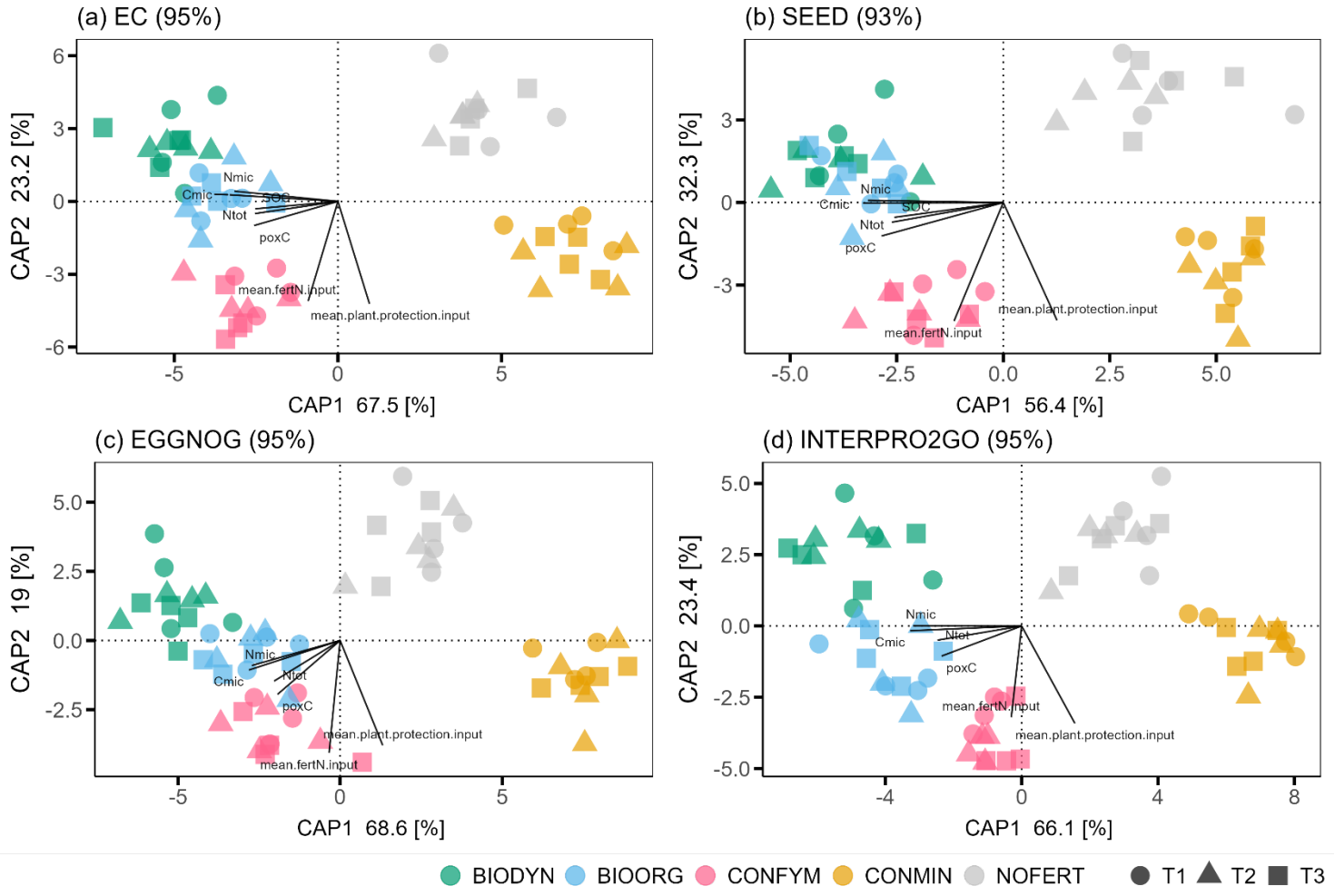
Lori et al (2023)

Soil metabolic potential

Shotgun approach with 11.5 billion reads, 3 samplings in spring 2019



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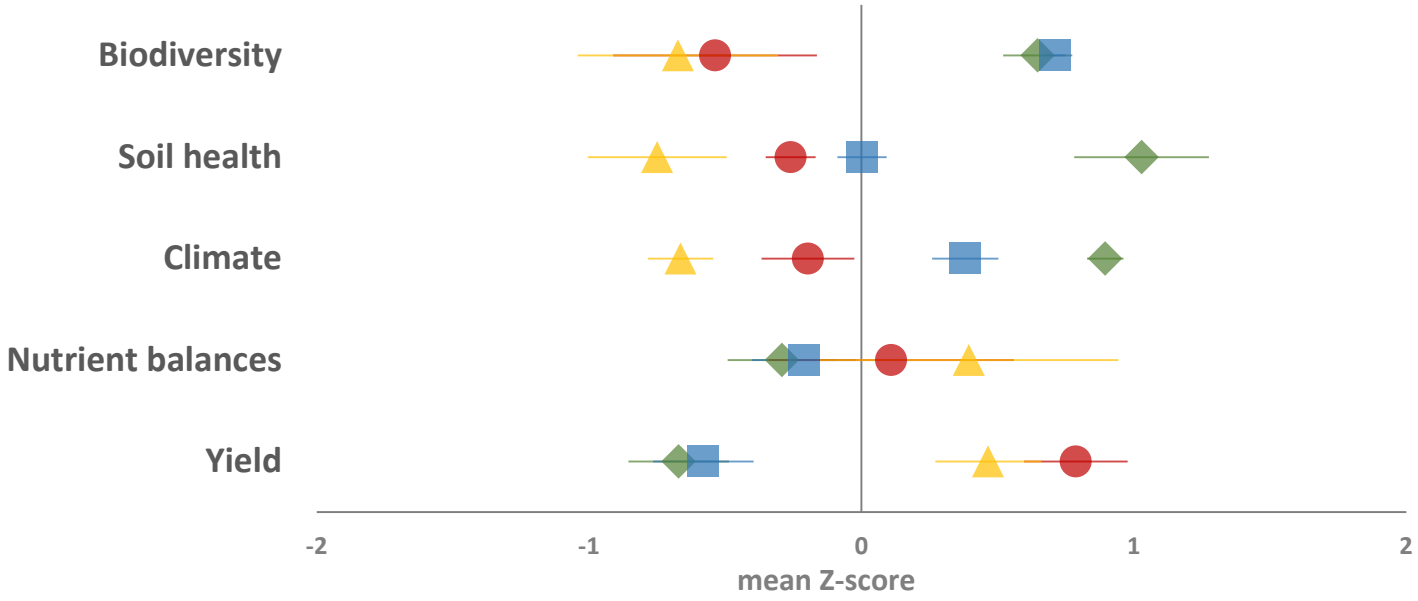
Krause et al. (under revision)

- Distinct soil metabolic potential across farming systems
- Fertilization, organic management and manure preparation as driving management practices

System multifunctionality

Indicator approach, relative change between systems

Biodiversity: Bacteria, fungi, nematodes, carabidae, araneae, enchytreidae, lumbricidae, seed bank
Soil health: Dehydrogenase, phosphatase, soil respiration, soil N and P, soil pH, Cmic, Nmic,
Climate: Soil C stock change, N_2O and CH_4 emissions
Nutrient balances: P, N and K balances, nitrogen use efficiency
Yields: Maize, soja, wheat, potato and grassclover



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Krause et al. (2024)

- Trade off between biodiversity and yields for organic and conventional systems
- Benefits for biodynamic for soil health and climate

Current research questions

- Resilience of cropping systems to drought
- Nitrogen losses (NH_3, N_2, NO_3) and complete N balance
- Contribution of soil mesofauna and macrofauna to soil quality

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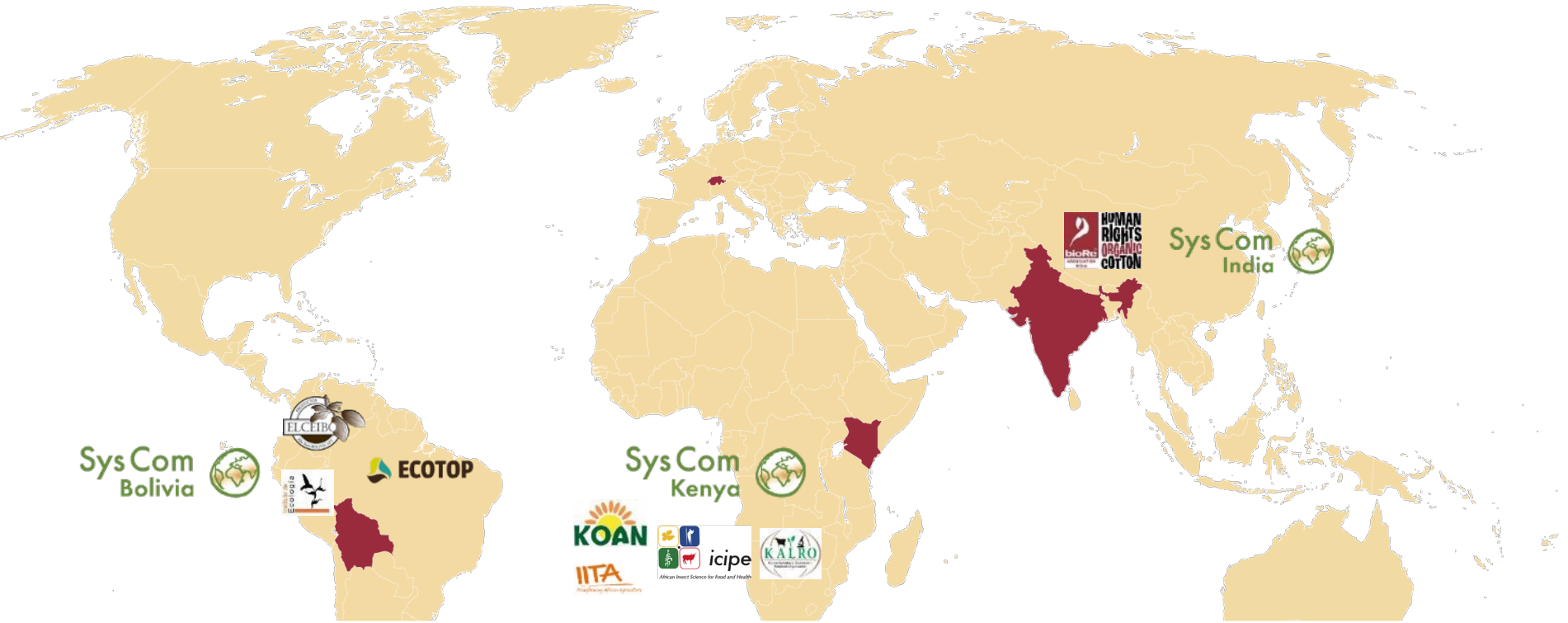
Tropical system comparison experiments

Since 2007



Organic vs conventional as monoculture or agroforestry Focus Crop: Cocoa	Organic vs conventional at low and high input level Focus Crop: Maize	Organic and biodynamic vs conventional with/without GMO Focus Crop: Cotton

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Thank you for your attention!!!

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