

# Kvælstof-flow i økologisk, biodynamisk og konventionelle dyrkningssystemer

Hvad siger DOK-forsøgene, om N-flow i forhold til udbytter, udvaskning og emissioner i de tre dyrkningssystemer.

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## The DOK Trial

A 45-year comparative study of organic and conventional cropping systems



## Hvad er DOK forsøg?

Dossier DOK trial

Langvarig forsøg med sammenligning af systemer

- **Biodynamisk (D)**
- **Økologisk (O)**
- **Konventionel (K)**

Siden 1978

Klima:

- Ø 872mm nedbør
- 10-årlig gennemsnitstemperatur:
  - 1978: 9,9 °C
  - 2020: 11,2 °C

Jord:

- 12% sand
- 72% silt
- 16% ler

## CONMIN

Konventionel med mineralisk gødning

- Kun mineralisk gødning
- Pesticider og vækstregulator

## CONFYM 1

Konventionel med husdyrgødning

- Mineralisk og husdyrgødning
- Pesticider og vækstregulator
- 2 gødningsniveauer

## CONFYM 2

## BIOORG 1

Økologisk

- Kun husdyrgødning + patentkali og stenmel
- 2 gødningsniveauer
- Ingen pesticider

## BIOORG 2

## BIODYM 1

Biodynamisk

- Kun husdyrgødning + patentkali og stenmel + biodynamik preparations
- 2 gødningsniveauer
- Ingen pesticider

## BIODYM 2

## UFERT

Ugødnet

- Biodynamiks preparations
- Ingen Pesticider

## DOK forsøg design

7 års sædskifte

→ år 6&7 kløvergræs

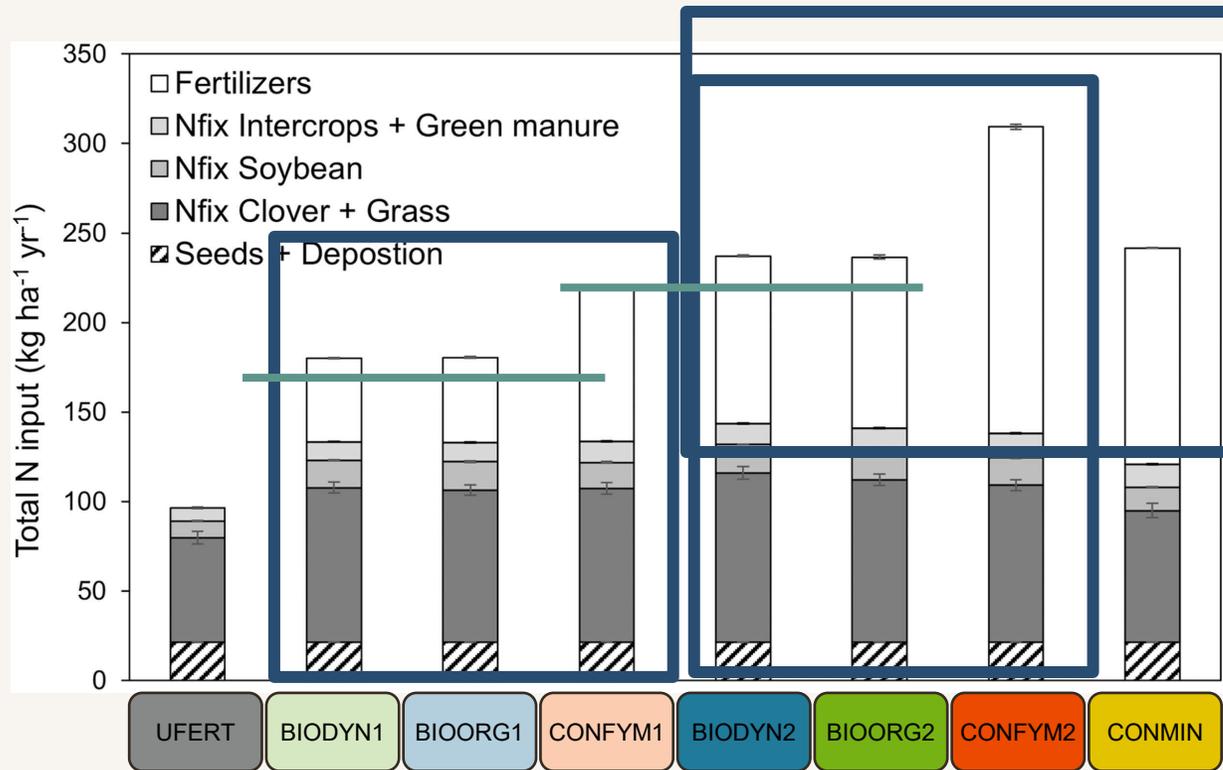
År	Afgrøder
1	Majs (silage)
	Efterafgrøder
2	Soja
3	Vinterhvede
	Efterafgrøder
4	Kartofler
5	Vinterhvede
6	Kløvergræs
7	Kløvergræs

pløjning inden  
rodfrugter og korn sås

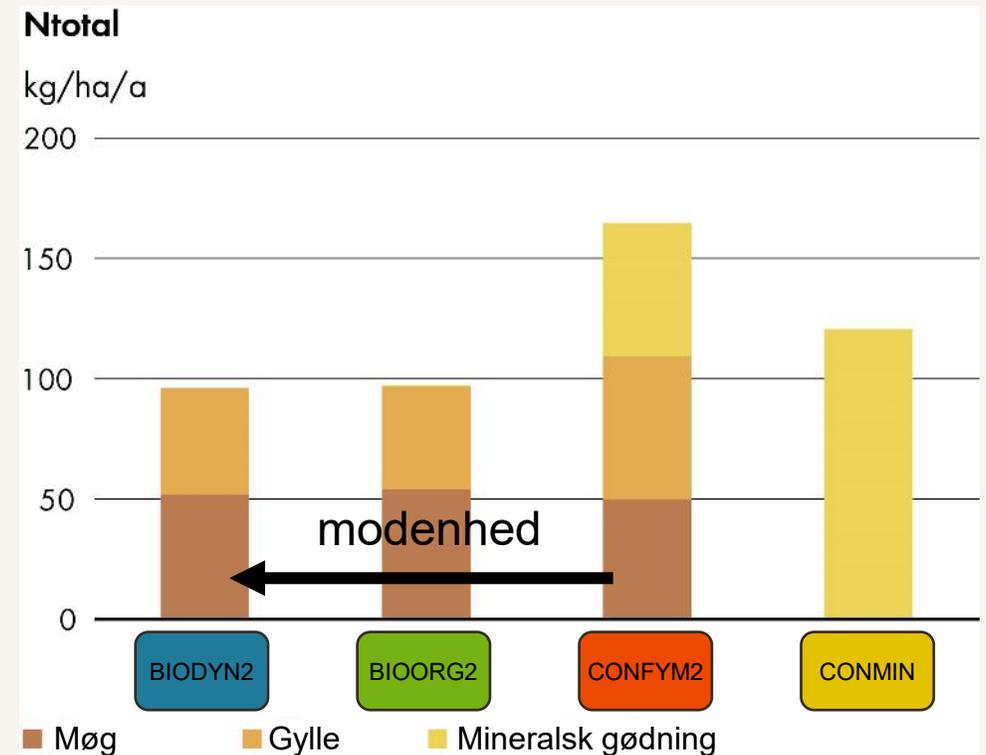


[Dossier DOK trial](#)

# Gødning - Kvælstofinput



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



## Hvordan ser det forskellige mæg ud?

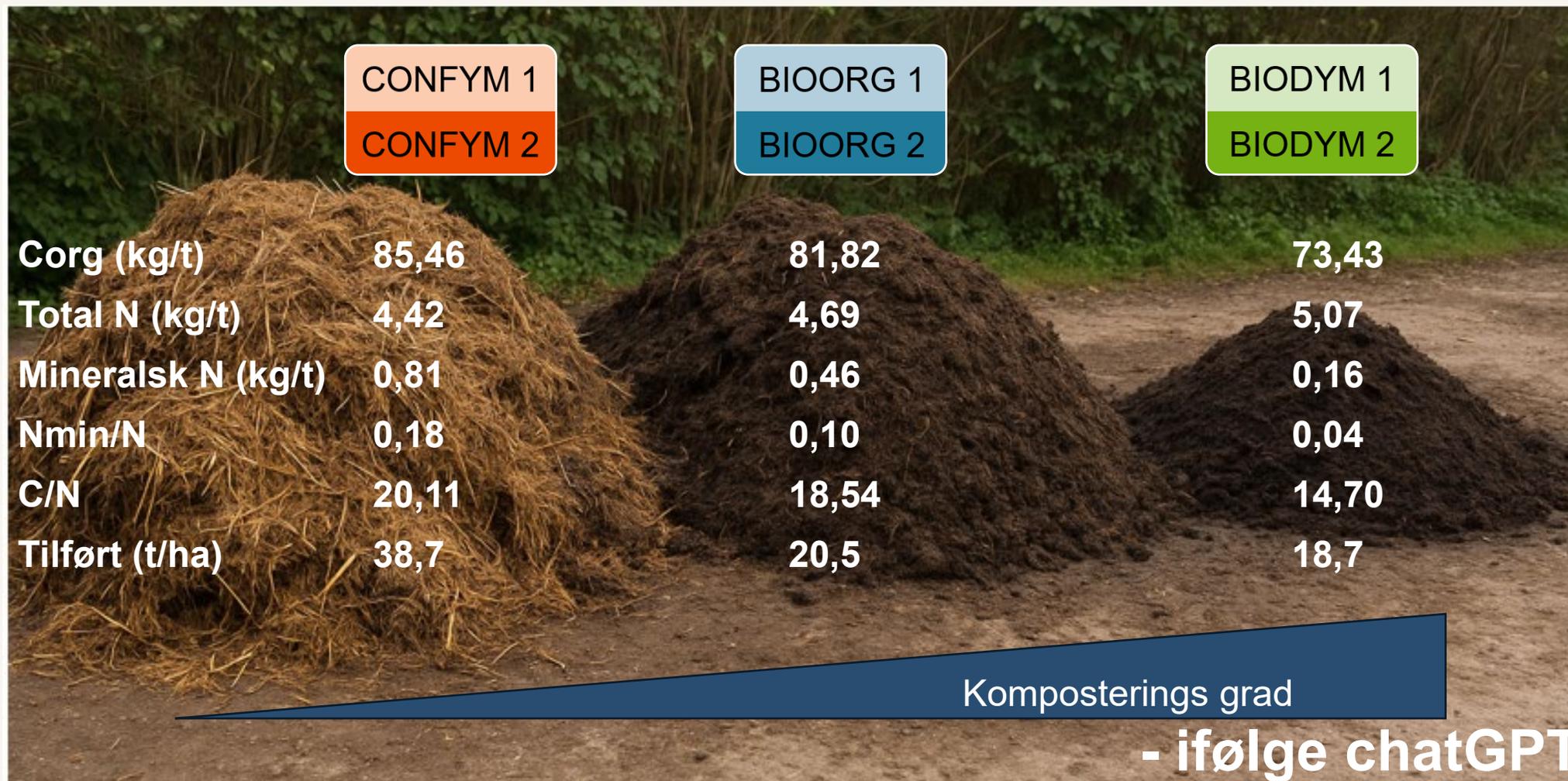
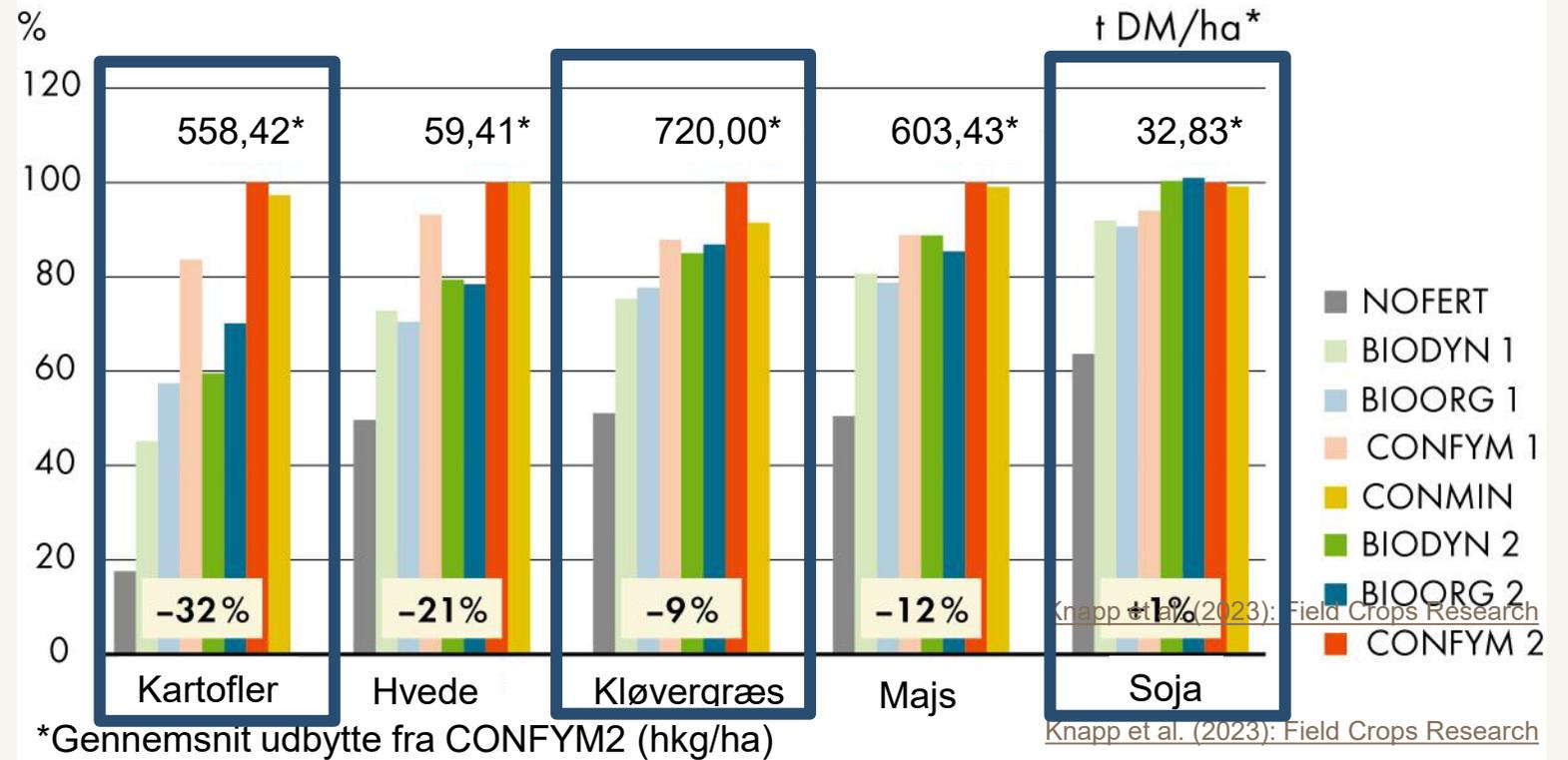


Bild: ChatGTP generet af Aline Dallo, FiBL

# Udbytte i de forskellige systemer

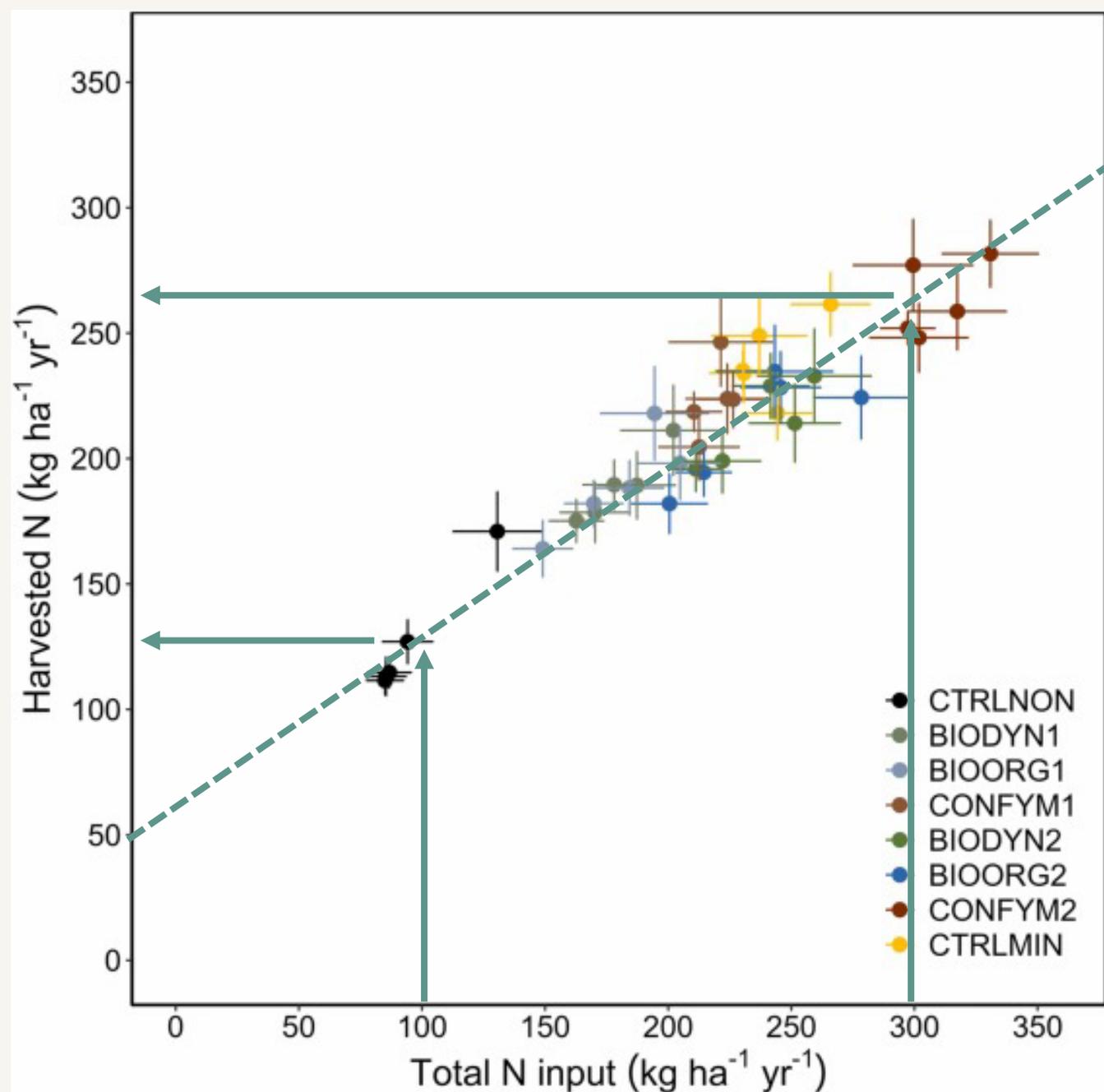
- Soja og græskløver kun små forskelle
- Kartofler større reaktion på systemerne
- CONFYM 1 højre udbytte end BIODYM 2 og BIOORG 2  
→ Indikation af indflydelsen af pesticider og **let opløselige næringsstoffer** på udbyttet

Crop yield relative to CONFYM 2



## Forholdet mellem kvælstof input og udbytte

- Tilført N bestemmer høstede N

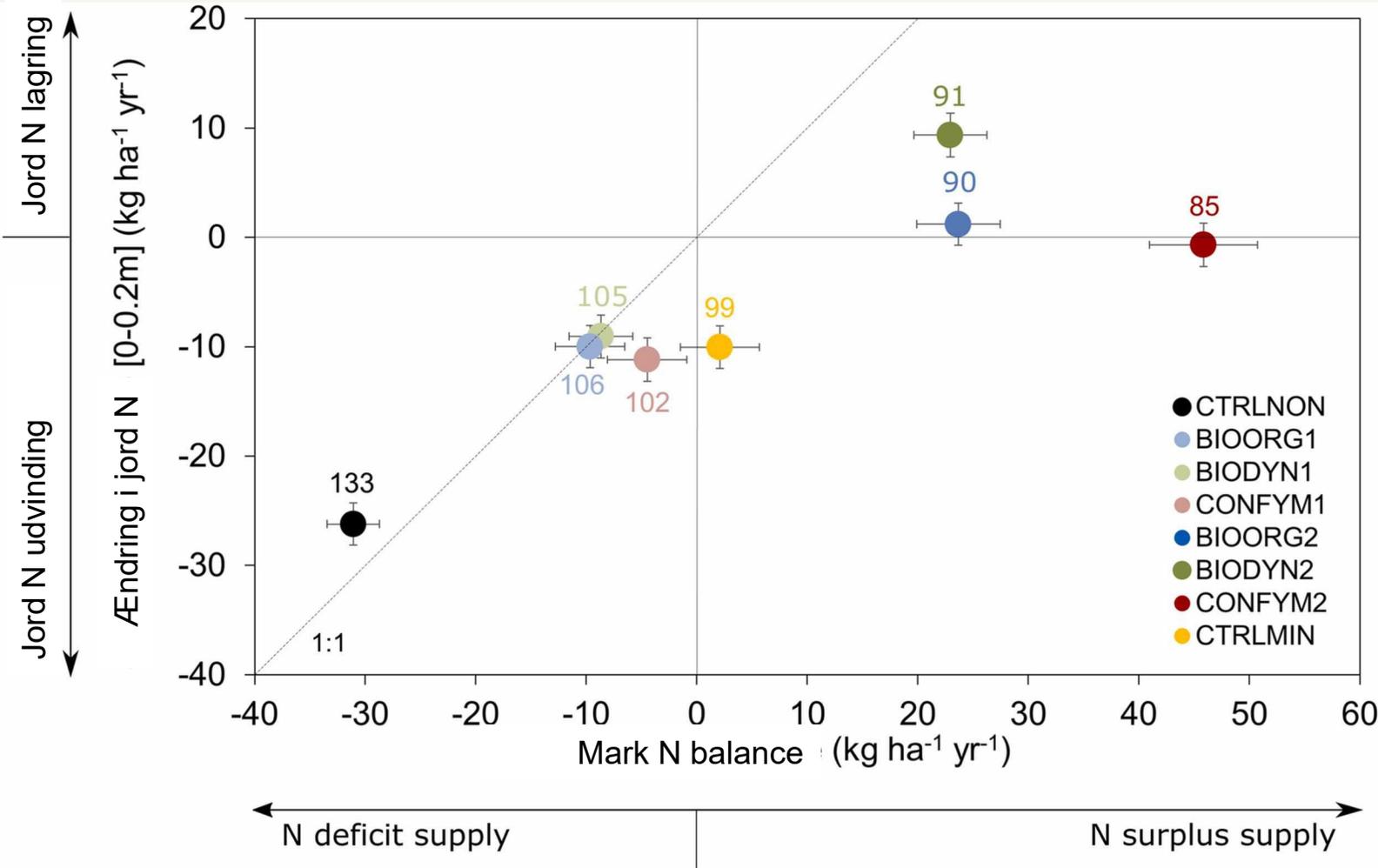


## Kvælstofbalance

<b>Kg N per ha &amp; år</b>	<b>Gødning</b>	<b>Kvælstof fiksering</b>	<b>Deposition og frø</b>	<b>Høstede</b>
<b>NOFERT</b>	0	75	21	128
<b>BIODYN 1</b>	47	112	21	189
<b>BIOORG 1</b>	48	111	21	190
<b>CONFYM 1</b>	85	112	21	223
<b>BIODYN 2</b>	93	122	21	214
<b>BIOORG 2</b>	96	119	21	213
<b>CONFYM 2</b>	171	117	21	264
<b>CONMIN</b>	121	99	21	240



# Kvælstofbalance vs jord kvælstof indhold



Negative kvælstofbalancer resulterer i udvinding af kvælstof fra jorden og dermed også udvinding af kulstof.

Kvælstoftilførsel uden kulstofftilførsel øger ikke jordens kvælstoflagre, men øger tabene.

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

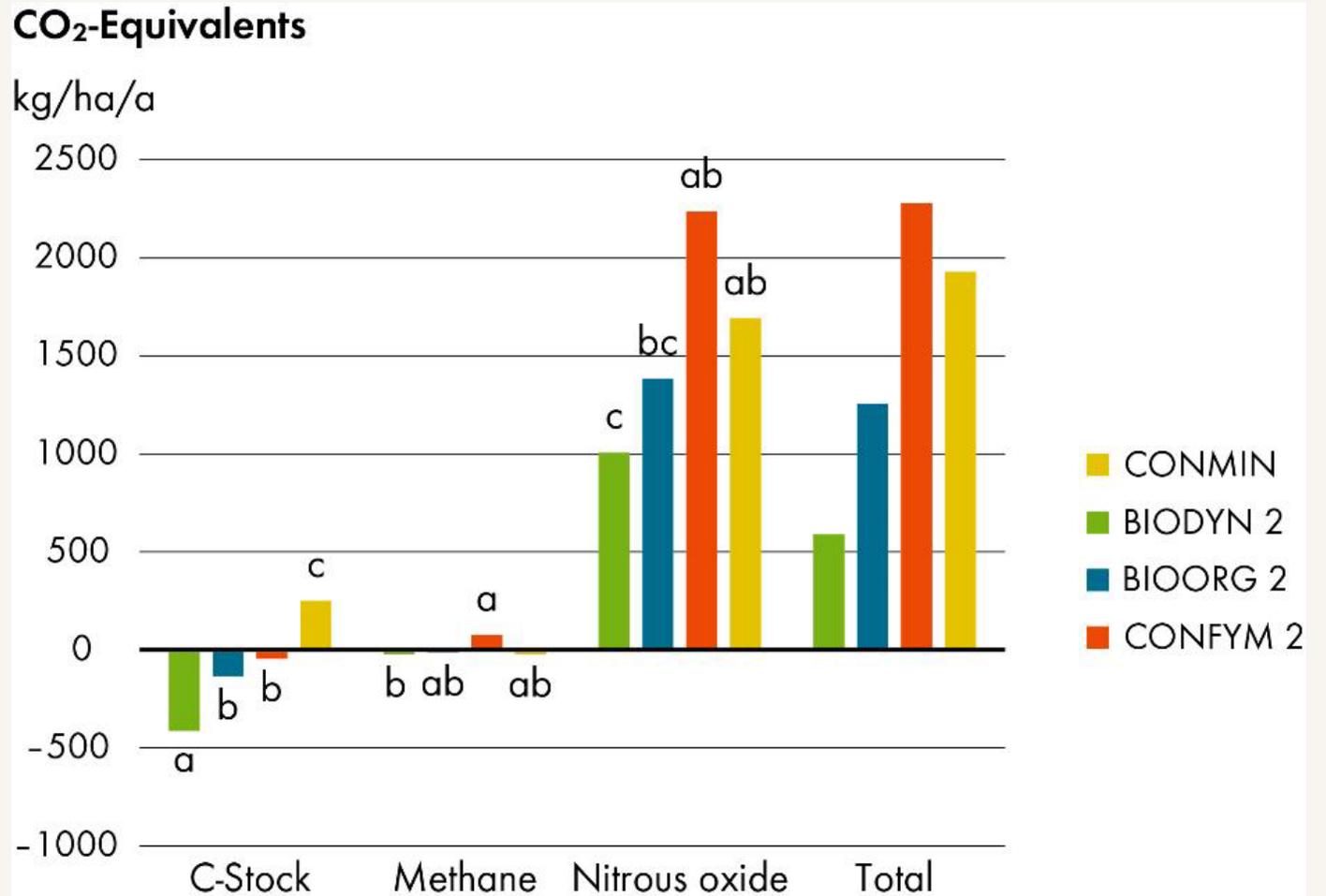
# Klimaaftryk

Nitrousoxid er den afgørende emission

tilført kvælstof er den afgørende faktor for N<sub>2</sub>O

tilgængeligt kulstof fører til højere N<sub>2</sub>O-emissioner

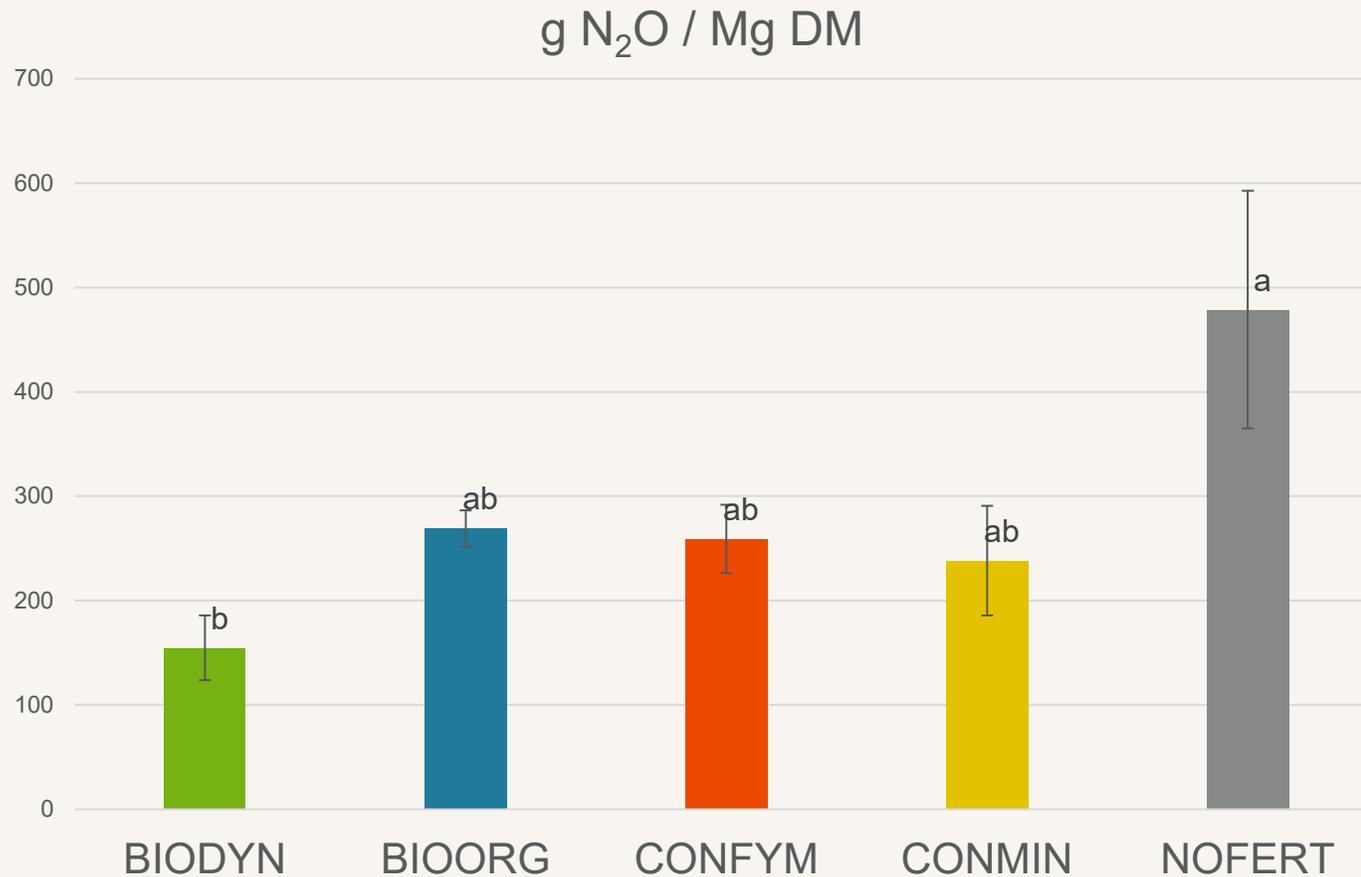
forsøget viser kun markemissioner, ikke emissioner og tab under kompostering



[Krause et al. \(2022\): Agronomy for Sustainable Development](#)

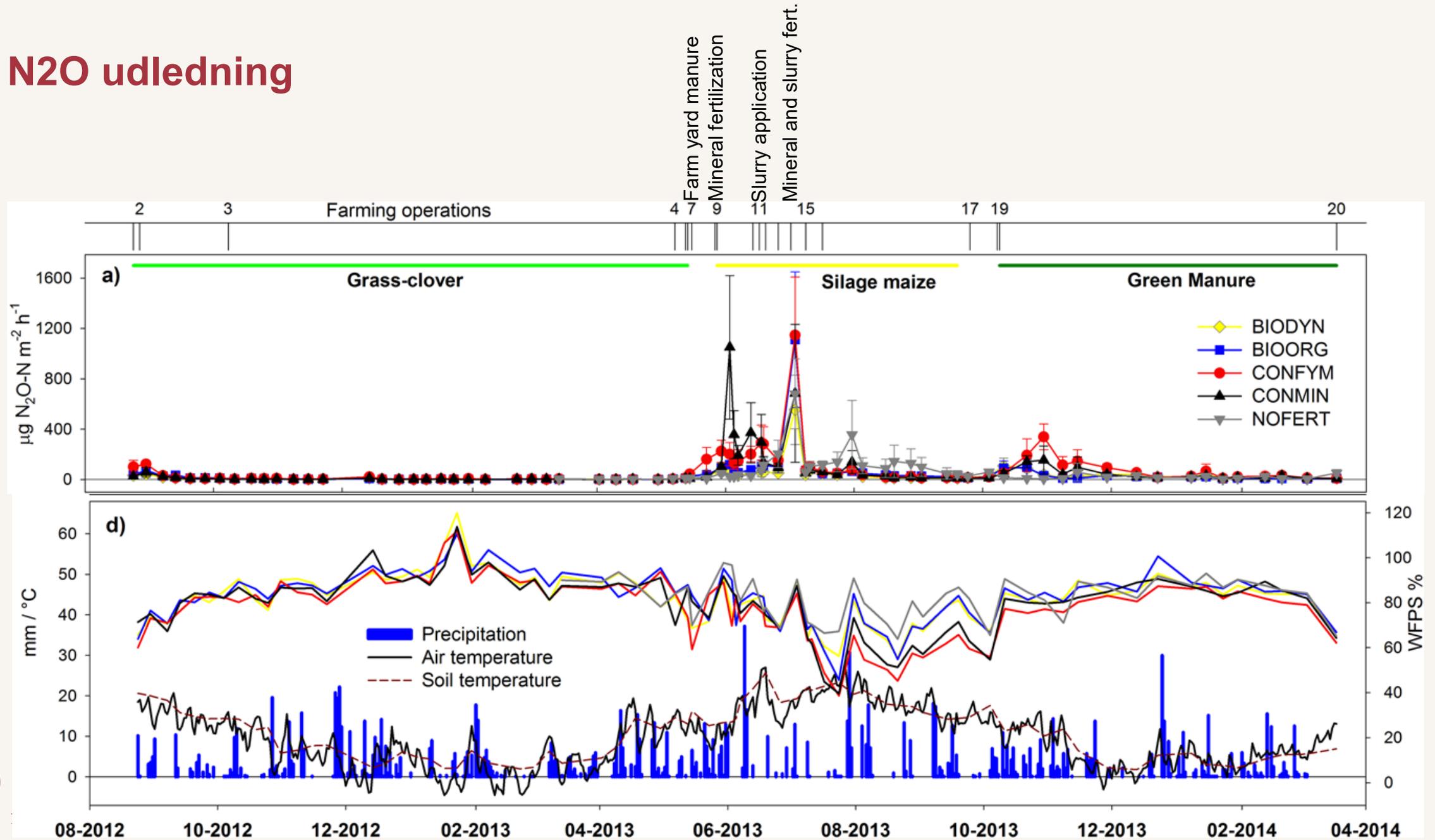
[Skinner et al. \(2019\): Scientific Report](#)

# Lattergas i sammenhæng med udbytte



Produktiviteten i CONFYM og CONMIN er højere, hvilket betyder færre emissioner pr. høstet ton af afgrøder.

# N<sub>2</sub>O udledning



# Opsamling

Jordforandringer tager tid → 45 år forsøg

Udbytte er drevet af tilført kvælstof mængde

Der er behov for at tilføre tilstrækkelige mængder gødning for at opretholde jordens N- (og C-)lagre

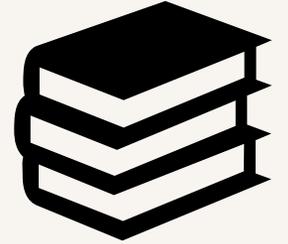
Klimaaftryk er drevet af N<sub>2</sub>O

N<sub>2</sub>O er drevet af tilgængelige kvælstof og kulstof



[Dossier DOK trial](#)

## Kilde



Fliessbach, A., Krause, H.-M., Jarosch, K., Mayer, J., Oberson, A., & Mäder, P. (2024). The DOK Trial - A 45-year comparative study of organic and conventional cropping systems. <https://doi.org/10.528/zenodo.10568719>

Fliessbach, A., Oberson, A., Jarosch, K., Mayer, J., Krause, H.-M., & Mäder, P. (2023). The DOK trial - 42 years of organic and conventional cropping systems. In FiBL (pp. 1–36). FiBL. <https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.fibl.org%2Ffileadmin%2Fdocuments%2Fshop%2F1783-powerpoint-dok-en.pptx&wdOrigin=BROWSELINK>

Knapp, S., Gunst, L., Mäder, P., Ghiasi, S., & Mayer, J. (2023). Organic cropping systems maintain yields but have lower yield levels and yield stability than conventional systems – Results from the DOK trial in Switzerland. *Field Crops Research*, 302, 109072. <https://doi.org/10.1016/J.FCR.2023.109072>

Krause, H. M., Stehle, B., Mayer, J., Mayer, M., Steffens, M., Mäder, P., & Fliessbach, A. (2022). Biological soil quality and soil organic carbon change in biodynamic, organic, and conventional farming systems after 42 years. *Agronomy for Sustainable Development* 2022 42:6, 42(6), 1–14. <https://doi.org/10.1007/S13593-022-00843-Y>

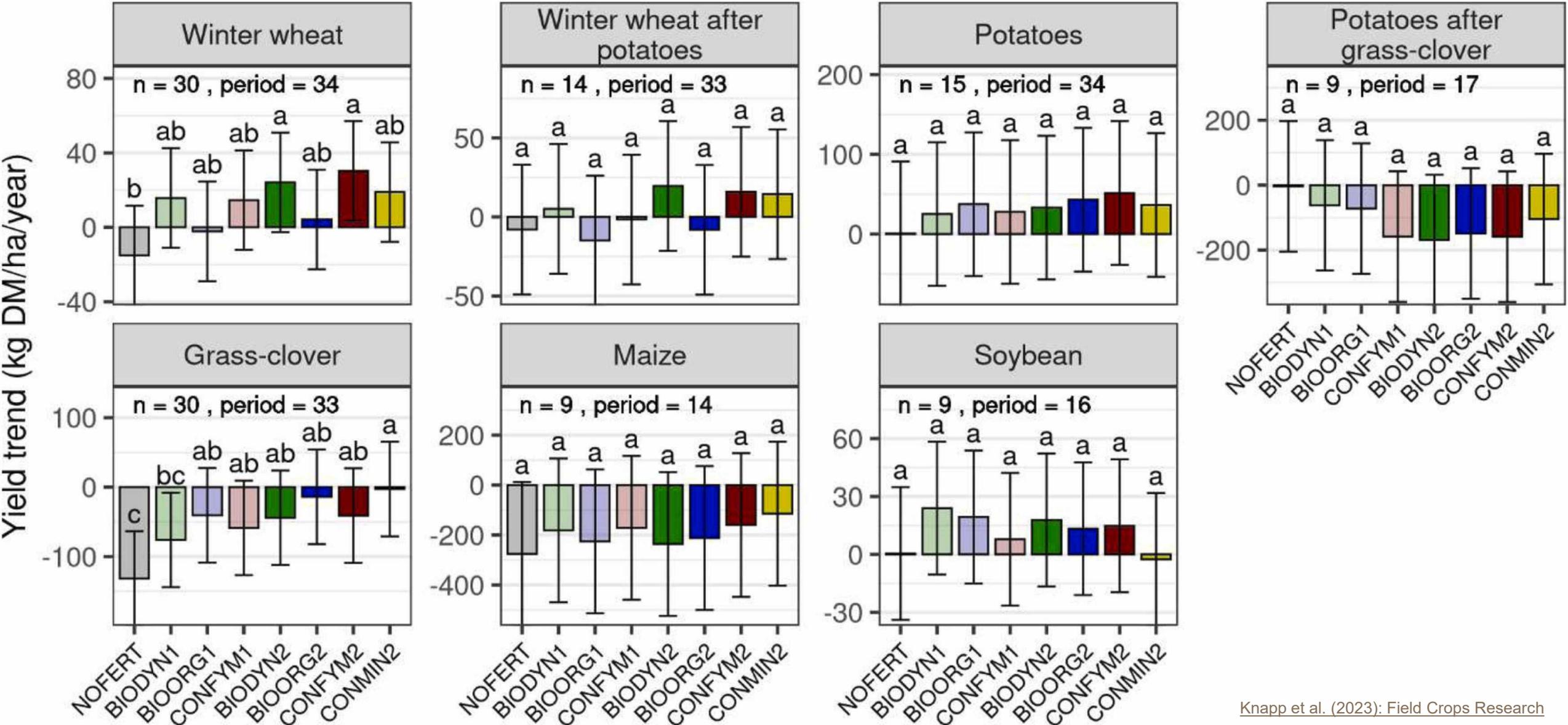
Oberson, A., Jarosch, K. A., Frossard, E., Hammelehle, A., Fliessbach, A., Mäder, P., & Mayer, J. (2024). Higher than expected: Nitrogen flows, budgets, and use efficiencies over 35 years of organic and conventional cropping. *Agriculture, Ecosystems & Environment*, 362, 108802. <https://doi.org/10.1016/J.AGEE.2023.108802>

Skinner, C., Gattinger, A., Krauss, M., Krause, H. M., Mayer, J., van der Heijden, M. G. A., & Mäder, P. (2019). The impact of long-term organic farming on soil-derived greenhouse gas emissions. *Scientific Reports* 2019 9:1, 9(1), 1–10. <https://doi.org/10.1038/s41598-018-38207-w>

**Table 2: Development of the seven-crop rotation since the start of the trial**

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

Winter forage is harvested, while green manure remains on the field and is worked in.



Knapp et al. (2023): Field Crops Research

Figure: Estimated yield trends per crop and treatment. As preceding crops have changed during the experiment, the yield trends were additionally analyzed in winter wheat only after potatoes and in potatoes only after grass-clover. Values greater than zero denote yield increase, and smaller than zero yield decrease. n indicates the number of field x year combinations, and period shows the number of years between first and last year of observations. Error bars indicate the 95% confidence interval of the estimated trend and trends are significantly different from zero at P < 0.05 if error bars do not overlap zero. Treatments that do not carry the same letters are significantly different at P < 0.05. (Knapp et al. (2023))

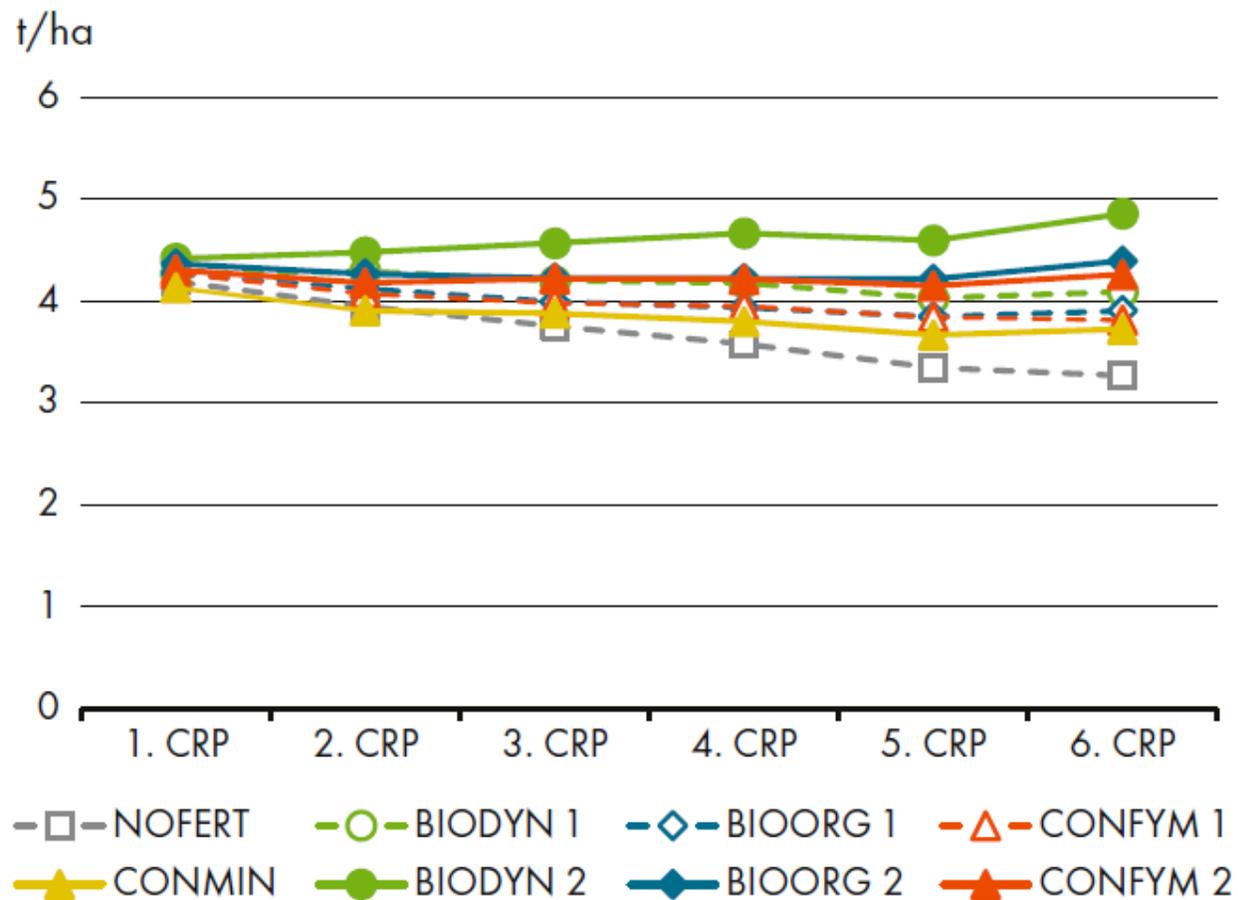
Table: Characterization of the organic fertilizers. ([Knapp et al. \(2023\): Field Crops Research](#))

Product	Manure (kg/t)			Slurry (kg/m <sup>3</sup> )		
	BIODYN	BIOORG	CONFYM	BIODYN	BIOORG	CONFYM
<b>Total N</b>	5.07	4.69	4.42	1.08	0.96	1.40
<b>Mineral N</b>	0.17	0.46	0.81	0.68	0.59	1.05
<b>P</b>	1.80	1.64	1.13	0.15	0.13	0.16
<b>K</b>	5.00	6.11	4.34	2.82	1.94	2.48
<b>Ca</b>	12.92	5.42	2.96	0.59	0.42	0.51
<b>Mg</b>	1.77	1.12	0.89	0.19	0.12	0.15
<b>Corg</b>	73.43	81.82	85.46	7.29	5.61	7.14
<b>Dry matter</b>	234.50	230.47	188.07	21.88	15.62	20.54
<b>Nmin/N Ratio</b>	0.04	0.10	0.18	0.63	0.62	0.75
<b>C/N Ratio</b>	14.70	18.54	20.11	6.72	5.68	5.06
<b>Samples</b>	90	79	48	202	211	160

Table: Applied nutrients through fertilizers (kg/ha/year) over the duration of the experiment excluding the first crop rotation cycle and averaged by year. Values in parentheses indicate the amounts, which were applied through manure, slurry, and mineral and other fertilizers combined, respectively. ([Knapp et al. \(2023\)](#))

Treatment	Total <sup>1</sup> nitrogen (TotN)	Mineral nitrogen (MinN)	Phos- phorus (P)	Potassium (K)	Calcium (Ca)	Magne- sium (Mg)	Organic matter (OM)
<b>NOFERT</b>	0 (0,0,0)	0 (0,0,0)	0 (0,0,0)	0 (0,0,0)	0 (0,0,0)	0 (0,0,0)	0 (0,0,0)
<b>BIODYN1</b>	48 (26,21,0)	13 (0,13,0)	12 (9,3,0)	89 (29,61,0)	80 (64,13,4)	14 (9,4,1)	957 (686,271,0)
<b>BIOORG1</b>	48 (25,22,1)	15 (2,13,0)	12 (9,3,1)	92 (35,46,14)	52 (30,10,15)	11 (6,3,3)	1016 (784,224,10)
<b>CONFYM1</b>	86 (26,34,28)	57 (5,26,28)	19 (7,4,9)	124 (26,60,42)	87 (18,13,58)	16 (5,4,7)	1157 (906,294,0)
<b>BIODYN2</b>	95 (52,43,0)	26 (1,25,0)	24 (18,6,0)	179 (58,121,0)	160 (128,26,8)	28 (18,9,2)	1911 (1368,543,0)
<b>BIOORG2</b>	96 (51,44,1)	30 (4,27,0)	24 (17,6,2)	184 (70,92,27)	104 (60,20,31)	22 (12,5,5)	2032 (1568,448,19)
<b>CONFYM2</b>	171 (52,69,55)	113 (9,52,55)	37 (13,7,18)	248 (52,121,83)	144 (36,25,86)	32 (11,7,15)	2314 (1812,587,0)
<b>CONMIN2</b>	121 (0,0,121)	121 (0,0,121)	38 (0,0,38)	246 (0,0,246)	168 (0,0,168)	31 (0,0,31)	0 (0,0,0)

**Figure 18: Total nitrogen stock in the soil**



N supply in the top 20 cm of the soil. Mean value of the measurements during each crop rotation period. The data were calculated from the total N content, taking into account the bulk density of the soil, measured in the first CRP.

## Kvælstof i jord

The C/N ratio of the soil organic matter hardly

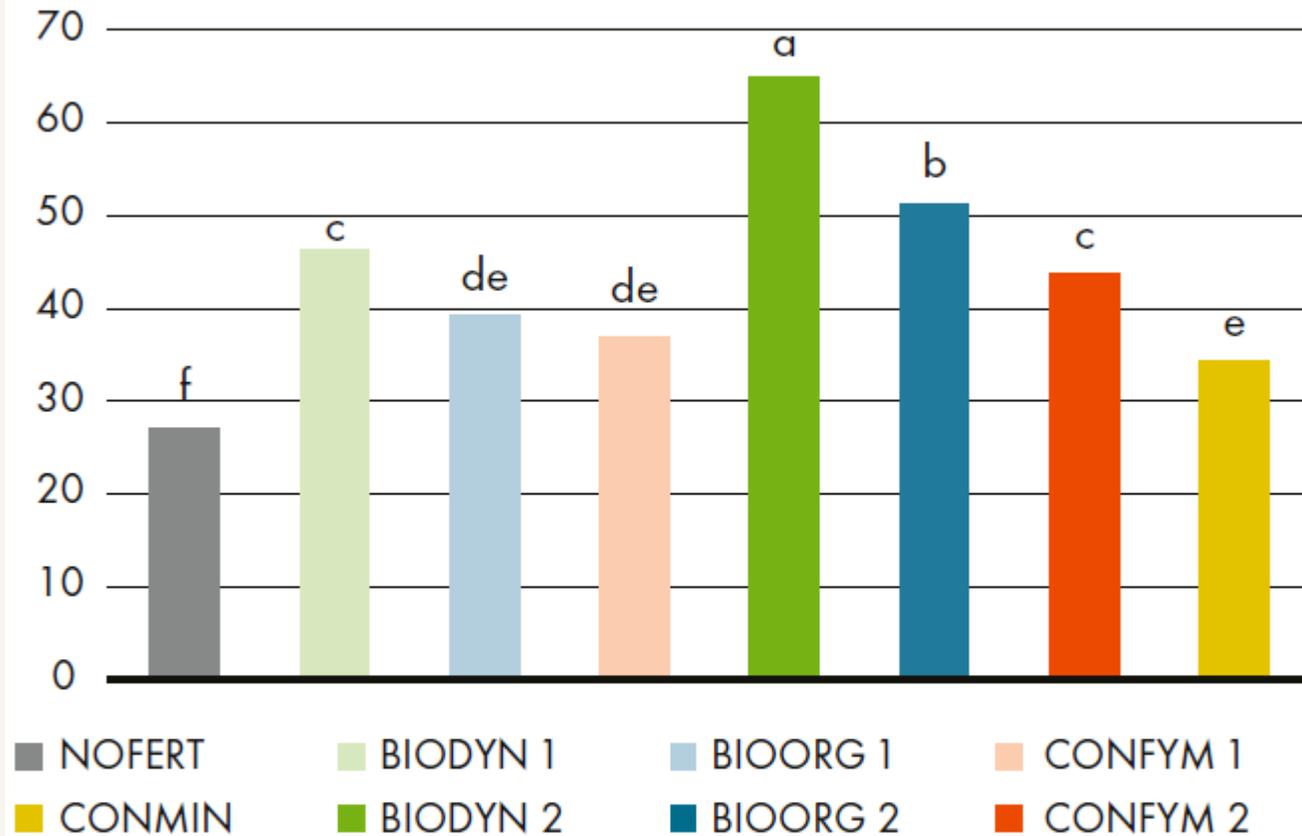
changed over the DOK trial period. The mean value

was constant at  $9 \pm 0.11$  and showed no effects related

to the cropping system.

## Nmic

mg/kg soil



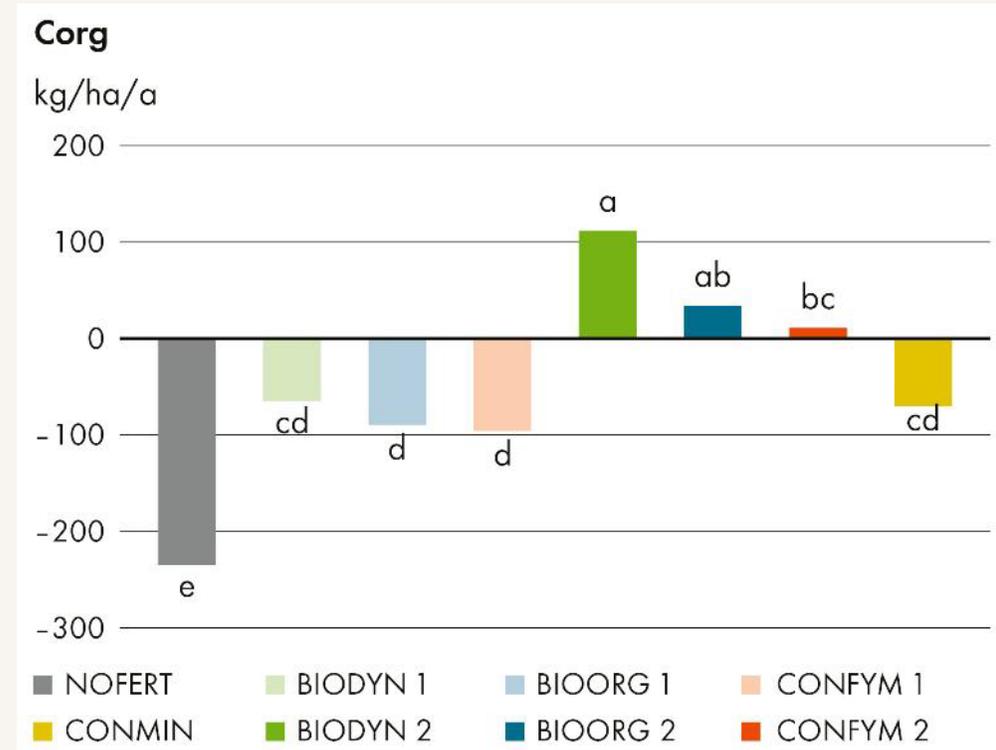
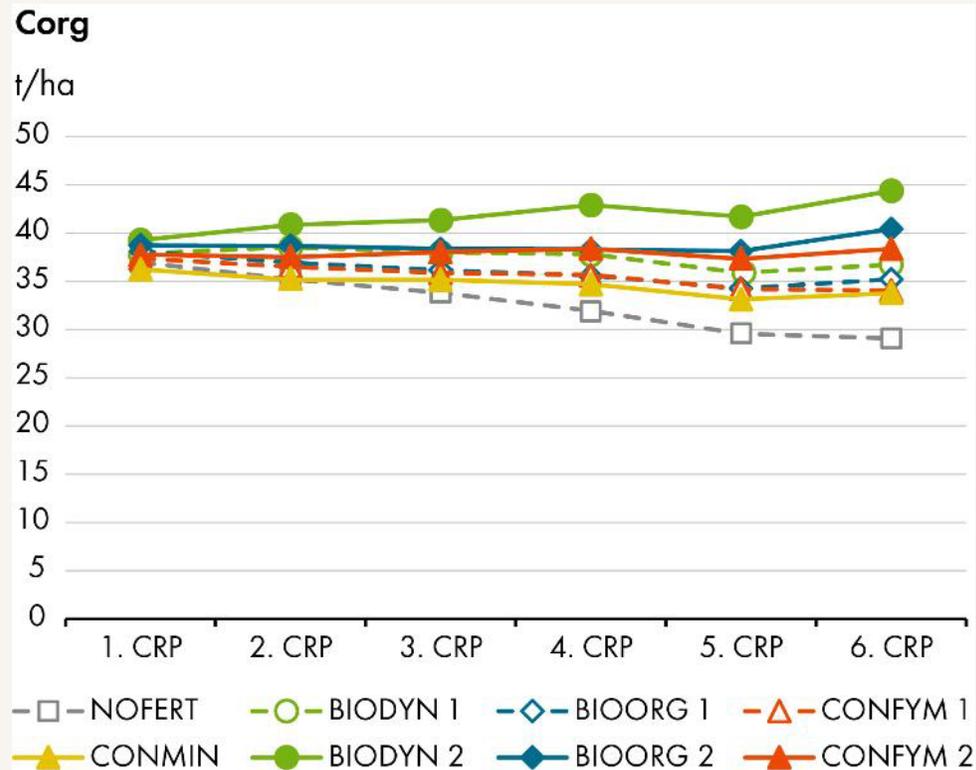
Microbially bound nitrogen in the eight systems of the DOK trial. Mean value from analyses of all plots in spring in 1998, 2006, 2012 and 2019.

## Mikrobielle kvælstof

Kvælstoffet i mikroorganismer fungerer som et midlertidigt lager for N i jorden, som frigives igen efter mikroorganismernes død.

Organisk gødning øger den mikrobielle biomasse

# Jord kulstof



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

- 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