Nitrogen utilization by different management of digestates and manures

Session: **Slurry management for high N use & low N_2O**

Foto: Peter Sørensen

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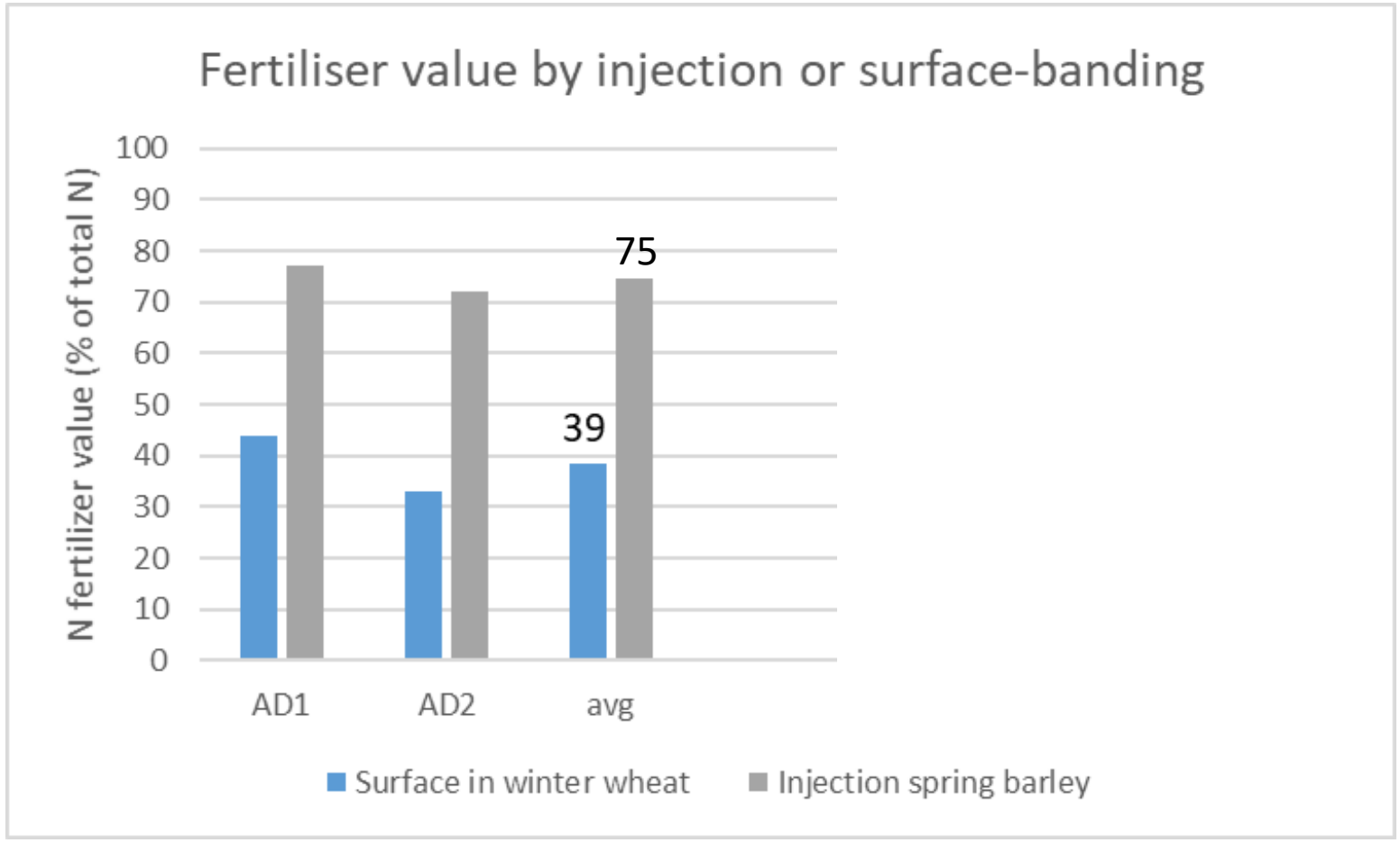
Intro

- 40% of manures in DK are digested in biogas plants
- Poor utilization by surface application of biogas digestates by surface application (winter cereals and grass)
- How can manure N utilization be improved?
  - By surface application
  - By injection
- Effects on nitrous oxide (N_2O) emission?

Surface application

Very low N fertiliser value of biogas digestates by surface application to winter wheat



- High dry matter content in biogas manure (digestates)
- High pH
- Acidification of digestates requires large amount of acid

AD1 and AD2: digested biomass from two biogas plants

(data from Nyang'au et al 2023)

Better utilization of liquid fraction on winter wheat crop (surface application)

Treatment	Winter wheat	Spring barley (injection)
	N value MFE	N value MFE
	%	%
Digestate untreated (52 % NH4-N)	44	77
Liquid fraction from digestate (62% NH4-N)	58	81

(unpublished results)

Liquid fraction from separation of digestates

Screwpress

Decantercentrifuge

Solid fraction

Application of liquid fraction and biochar to winter wheat

22. April 2024

Surface application in bands (150 kg total N/ha)
-all plots received 50 kg N/ha in mineral N earlier

Biochar (30 kg P/ha = 2,1 tons wet biochar/ha)
(Stiesdal Skyclean)

Biochar from pyrolysis of pelletized solid fraction

Treatments to winter wheat (2 years)

Treatment	Input kg N/ha
Liquid fraction	150
Liquid acidified pH7	150
Liquid acidified pH6	150
Liquid acidified pH5	150
Liquid + biochar	150
Liquid mixed with biochar	150
NS fertiliser + biochar	150
Sedicanter + extra digestion	150

+50 kg N/ha in NPK fertilizers

Liquid fraction from decantercentrifuge Nature Energy (Videbæk)

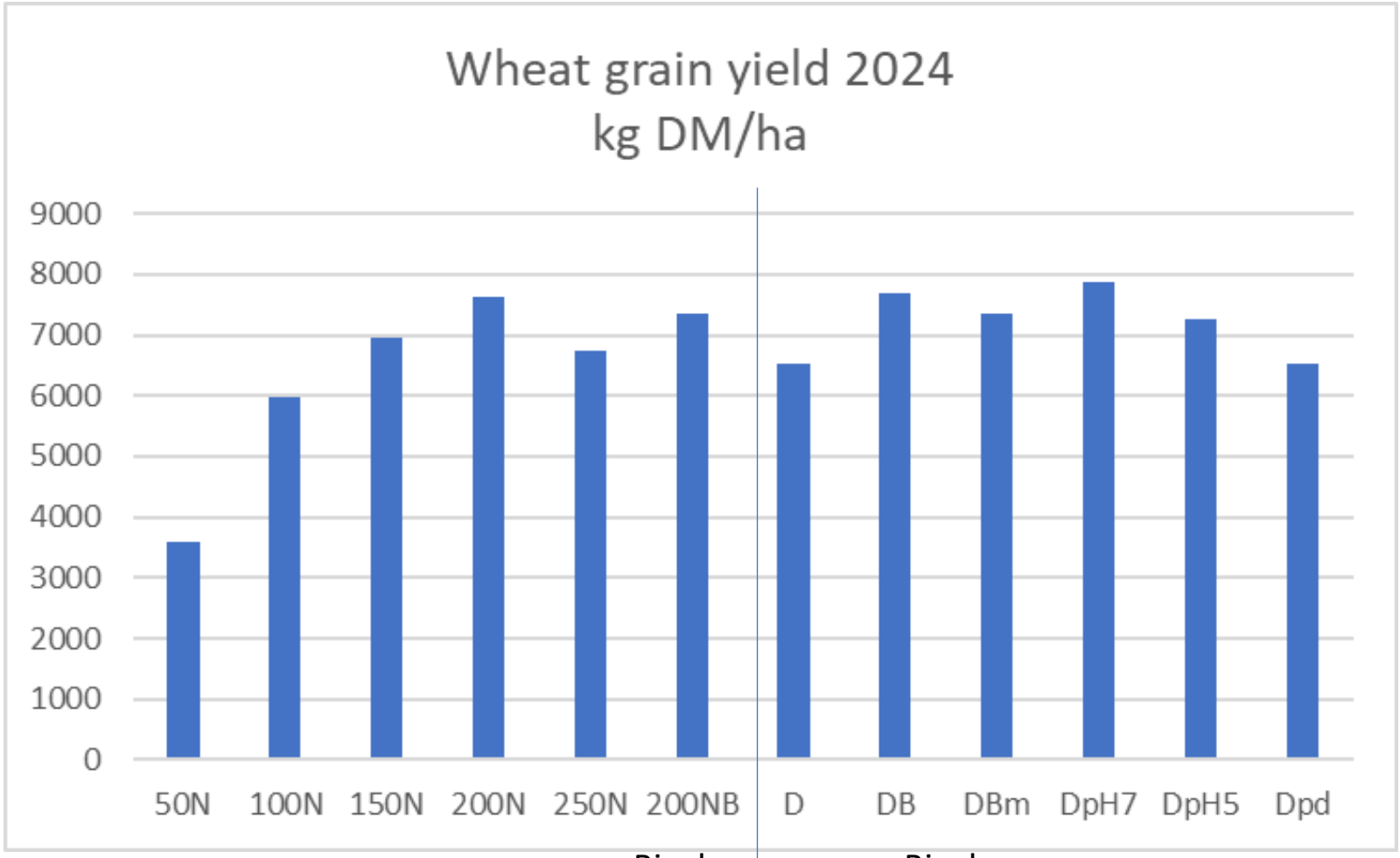
N fertilizer values measured in winter wheat - no clear effect of treatments

Treatment	Input	N value (%)	
	kg N/ha	2023	2024
Liquid fraction (untreated)	**150**	**56**	**57**
Liquid acidified pH7	150	77	60
Liquid acidified pH6	150	65	
Liquid acidified pH5	150	73	67
Liquid + biochar	150	56	65
Liquid mixed with biochar	150	60	66
NS fertiliser + biochar	150	91	83
Sedicanter + extra digestion	150		60

Acidification: +10-20% point

No statistical significant differences in N fertilizer value (mineral fertilizer replacement value)

Yields in winter wheat 2024
- same yields with mineral N and liquid fractions

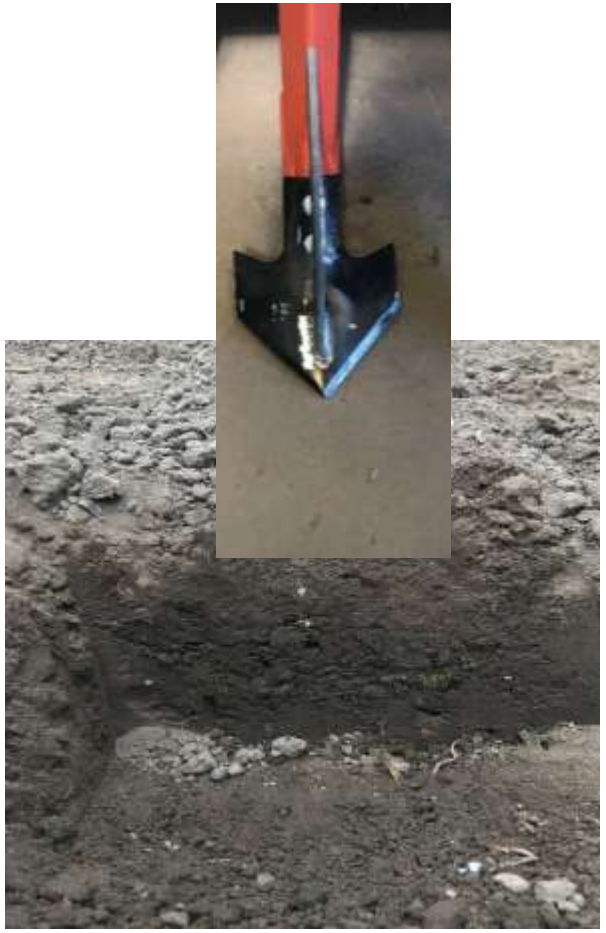


Same yields with 150 kg N/ha in liquid fraction and mineral N fertiliser (NS)

D = Untreated (NH4-N/total N: 67 %)
B = Biochar (m = mixed)
Dpd = Sedicanter + digest
(NH4-N/total N: 75 %)

Effects of injection method on N utilization and N_2O?

8 cm

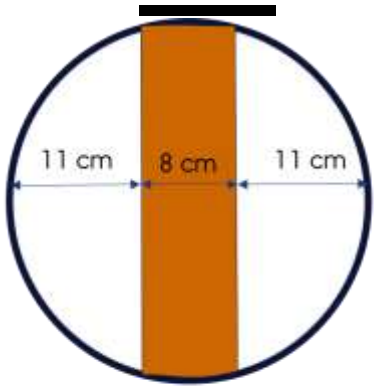


17 cm

26 cm tine

Foto: Peter S. Nielsen, AU

Injection of cattle slurry to spring barley- Treatments



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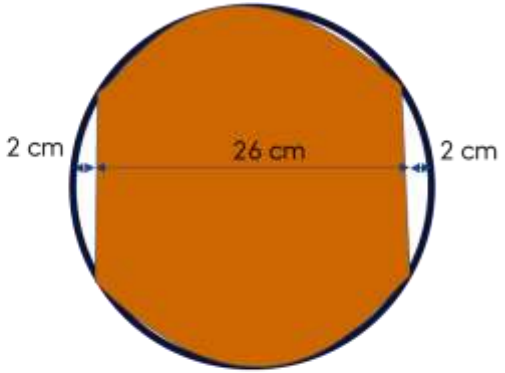

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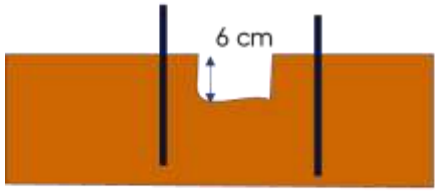
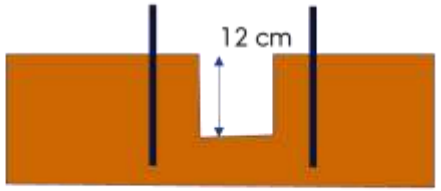
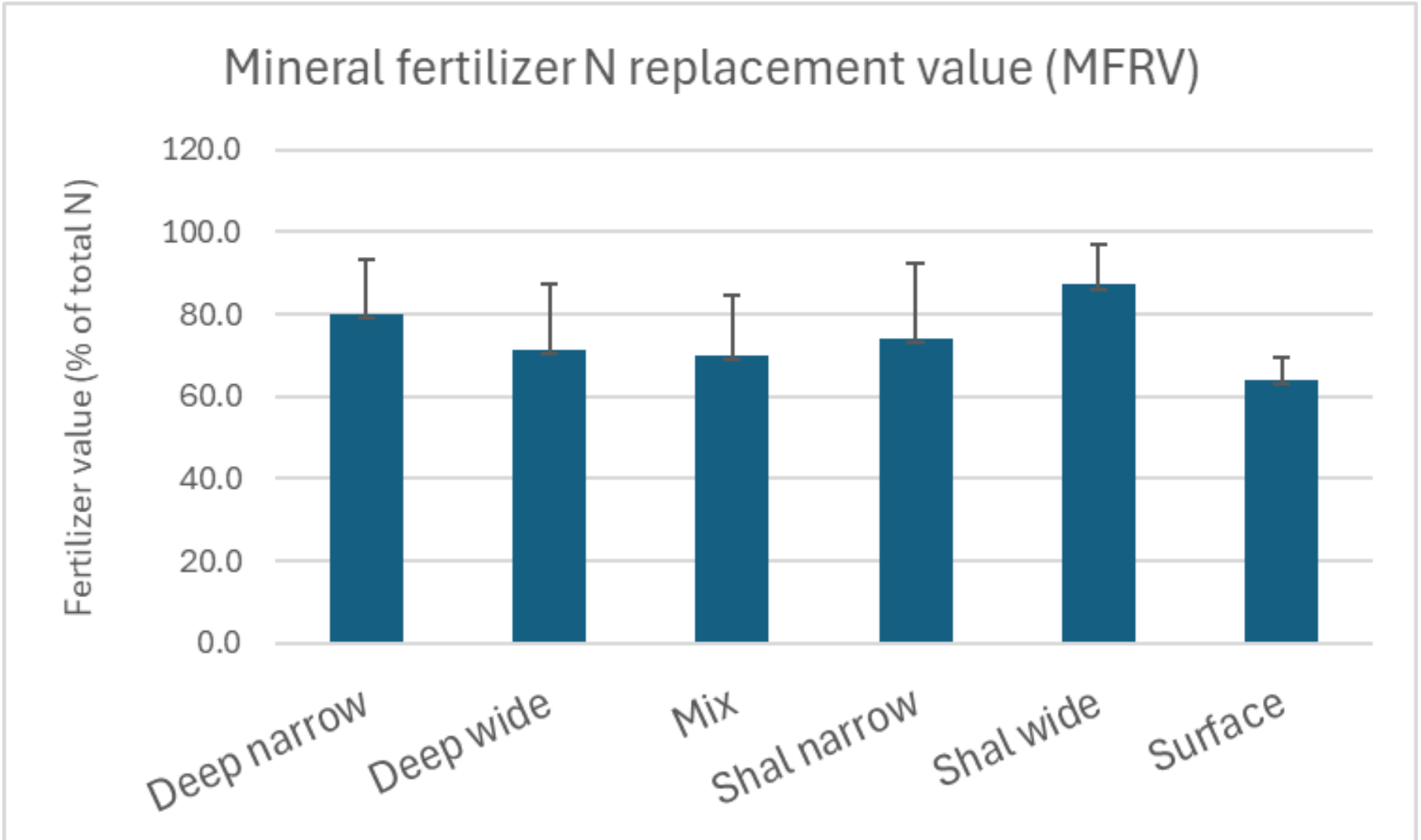


SHALLOW



DEEP

Effects of cattle slurry injection method on N utilization (2025)



Conclusions

- Better utilization of digestates by injection
- Improved fertilizer value in growing crops by separation of digestates
- Tendency of improved N utilization by acidification of liquid fractions.
- No clear effect of biochar addition on N utilization
- Wheat yields comparable to mineral N fertilizer (at similar total N)
- Injection to barley: Similar N utilization by injection with different distribution

Thank you for your attention

The LOWHIGH project was supported by Innomission/AgriFoodTure
The KUGA project by Planteafgiftsfonden

Slurry surface application

SLURRY MANAGEMENT FOR LOW N_2O EMISSIONS

DEPARTMENT OF AGROECOLOGY
AARHUS UNIVERSITY

PLANTEKONGRES 2026
8. JANUARY 2026

CHRISTIAN DOLD
TENURE TRACK ADJUNKT

INTRODUCTION

- Slurry and digestates are important organic fertilizer in Danish agriculture.
- However, they can lead to substantial N_2O emissions.
- This depends on the crop rotation, type and treatment of slurry/digestate, and application technique, among others.
- We present three different projects, where we test how to reduce N_2O emissions from slurry and digestate applications.

LOWHIGH PROJECT

To assess how treating liquid fractions of digestates can reduce N_2O emissions, including biochar application.

EXPERIMENTAL DESIGN

Field study:
2023 & 2024

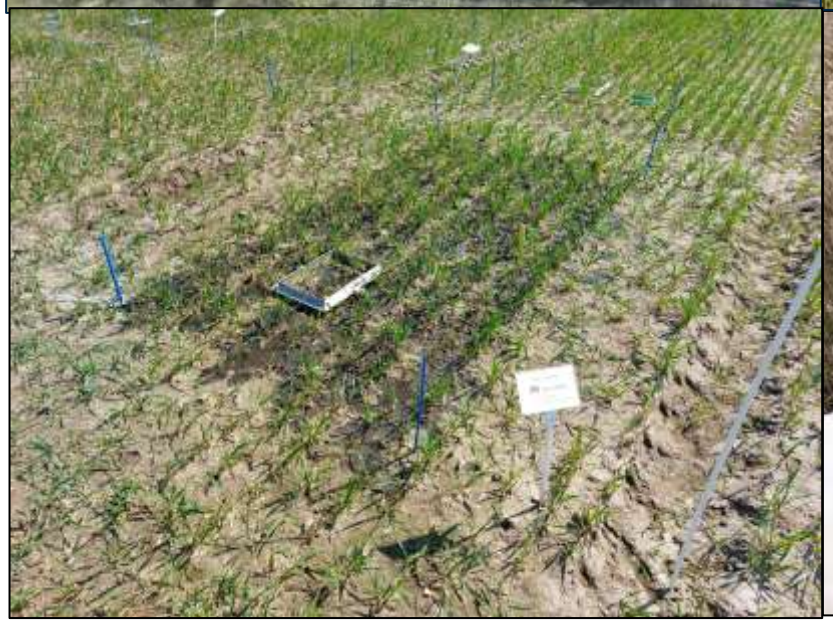
Crop: Winter wheat

Application rate:
150 kg N/ha

Plots: 1.44 x 2.5 m

12 N_2O measurements;
Apr – June

Soil mineral N, soil water content, yield



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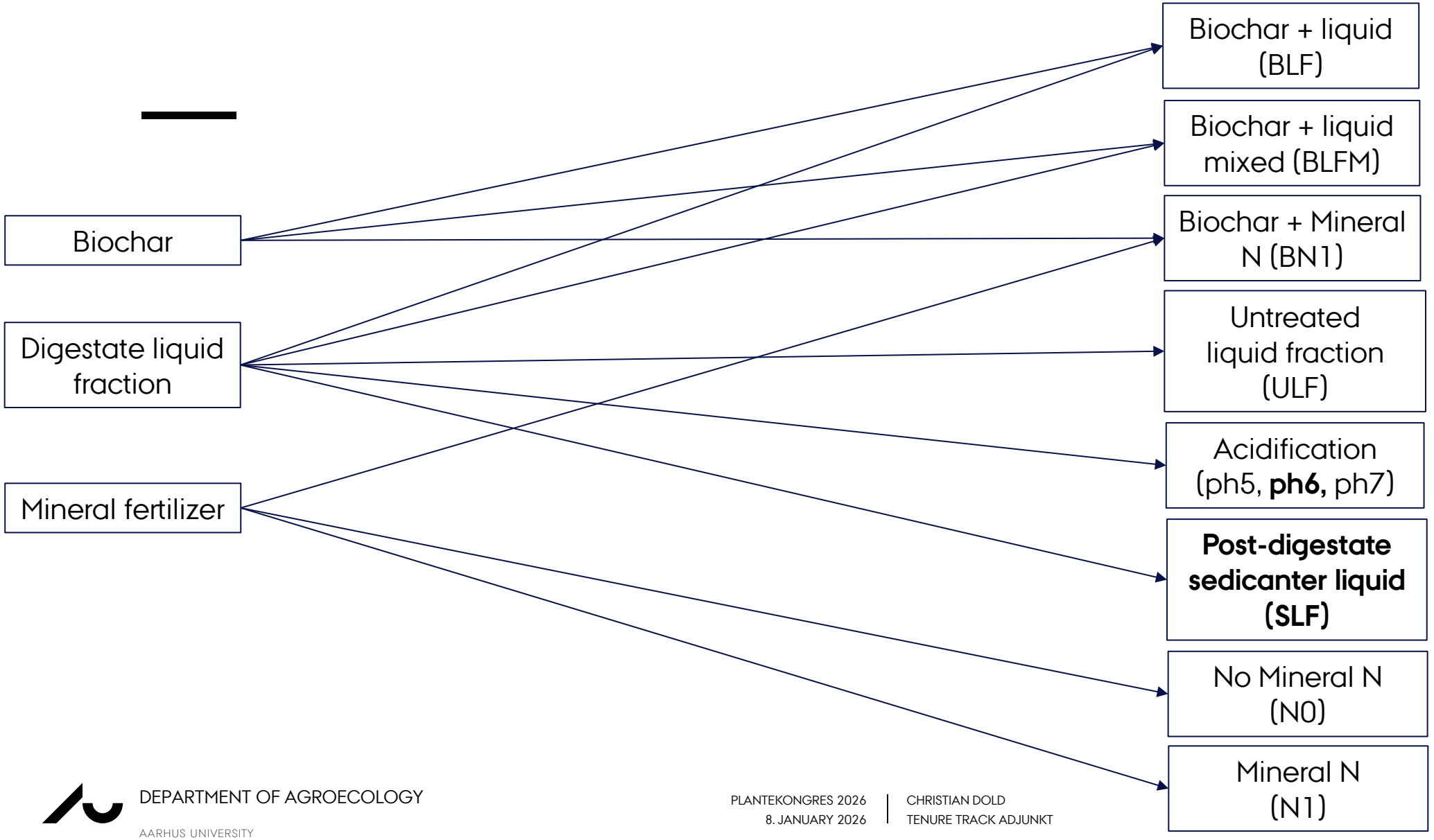
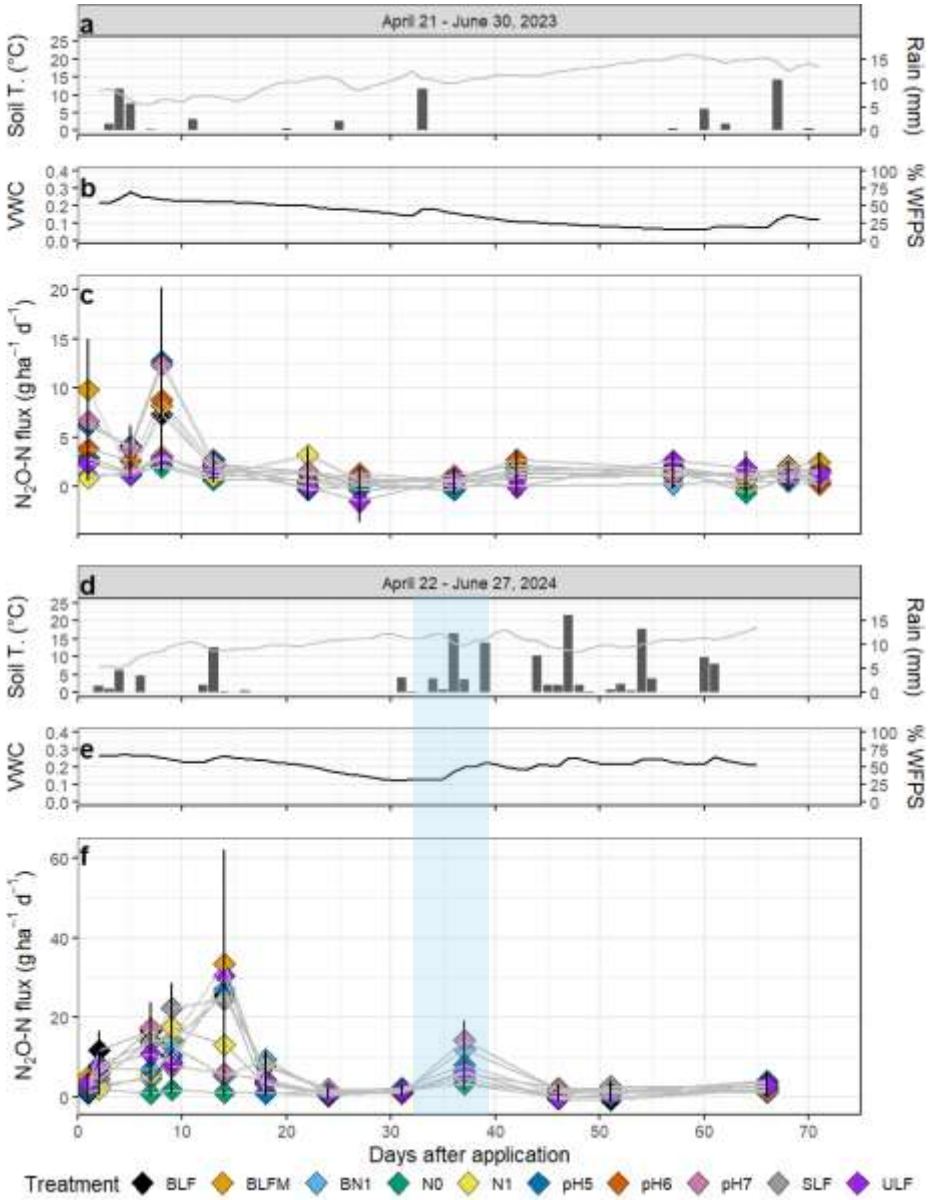
EXPERIMENTAL DESIGN - TREATMENTS

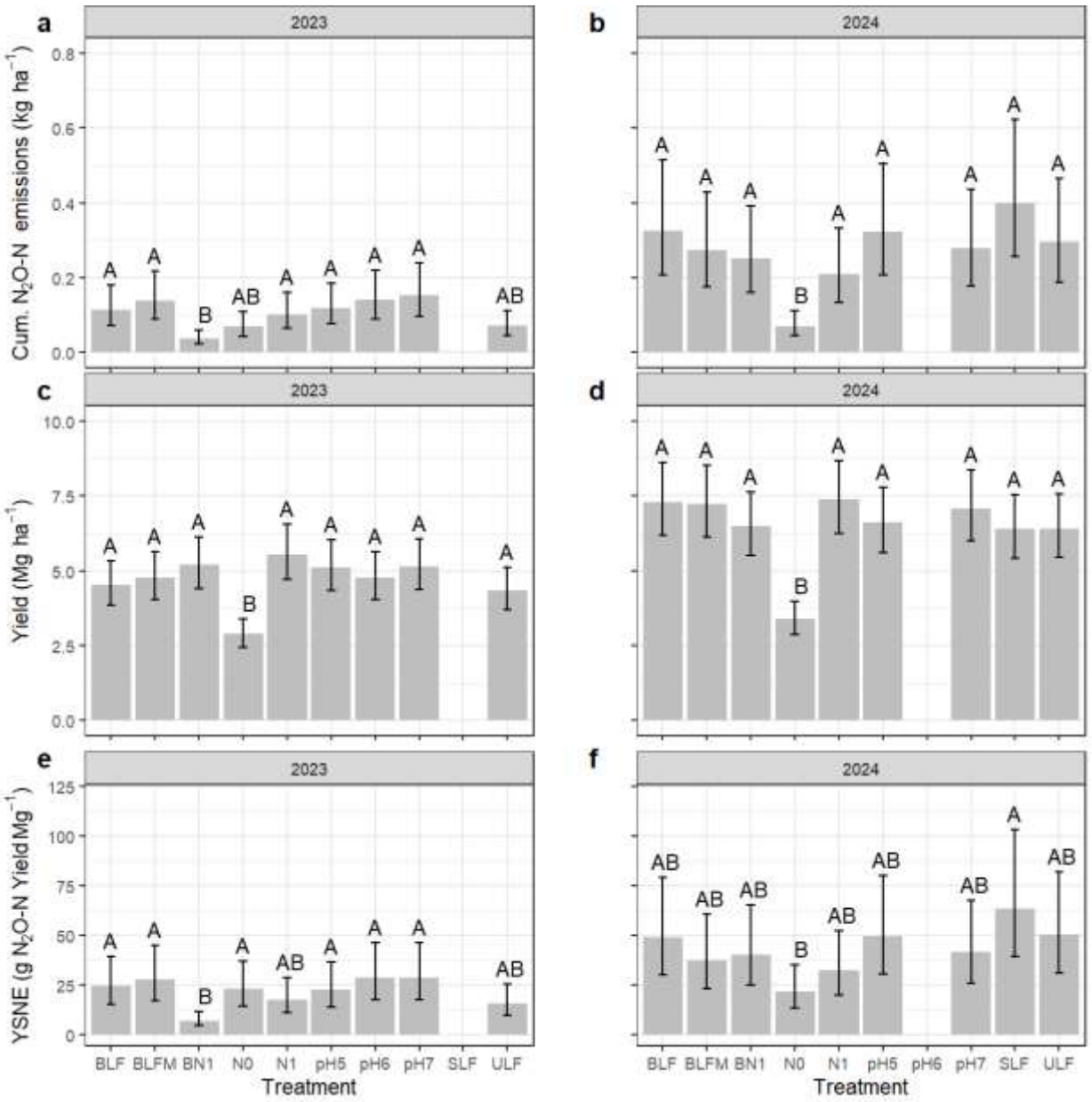


RESULTS



- 2023 was a dry year, while 2024 was a wet year, which significantly increased the N_2O emissions in 2024.
- Most N_2O emissions occurred during the first three weeks after application.
- Rainfall in 2024 triggered another peak event after three weeks.

RESULTS



- Neither biochar, acidification or post-treatment of liquid fraction of digestates significantly reduced cumulative or yield-scale N_2O emissions.
- Only biochar with mineral N reduced N_2O emissions in the dry year of 2023, but not in 2024.
- However, acidification had no negative effect on N_2O emissions, and a positive effect on NH_3 emissions is likely.

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KUGA PROJECT

To quantify the effect of slurry application technology on N_2O emissions

EXPERIMENTAL DESIGN

Field study:
2025 & 2026

Crop: Spring barley

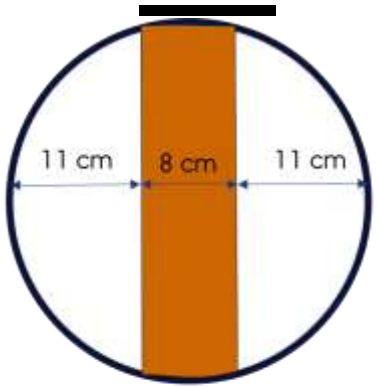
Application rate:
150 kg N/ha

Mini-plots: 1m^2 with
30 cm diameter rings

EXPERIMENTAL DESIGN - TREATMENTS

Treatment ID	N source	Application depth	Application width	Mixing	Function
1	None	None	None	unmixed	Control
2	Mineral N	Shallow	Narrow		Reference mineral N
3	Cattle slurry	Surface	Bands		Trailing hose
4		Shallow	Narrow		Injection, grubber tine
5		Deep	Wide		Injection, goosefoot
6		Shallow	Wide		Injection, goosefoot
7		Deep	Narrow		Injection, grubber tine
8		Deep	Narrow	mixed	Injection, grubber tine

EXPERIMENTAL DESIGN - TREATMENTS



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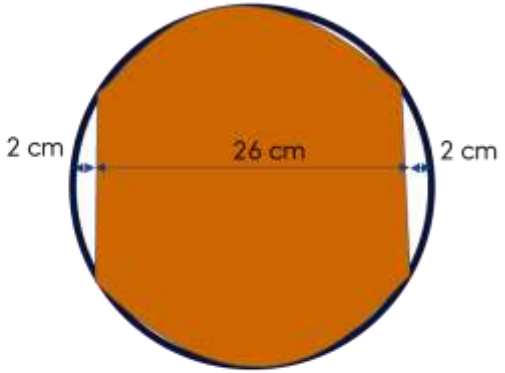

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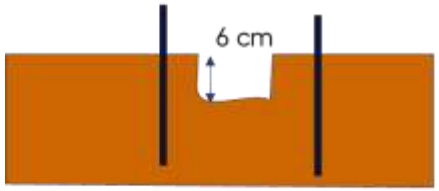
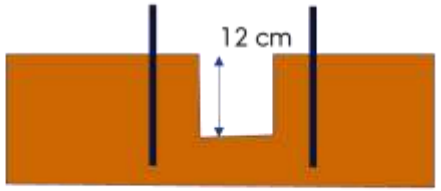


SHALLOW



DEEP

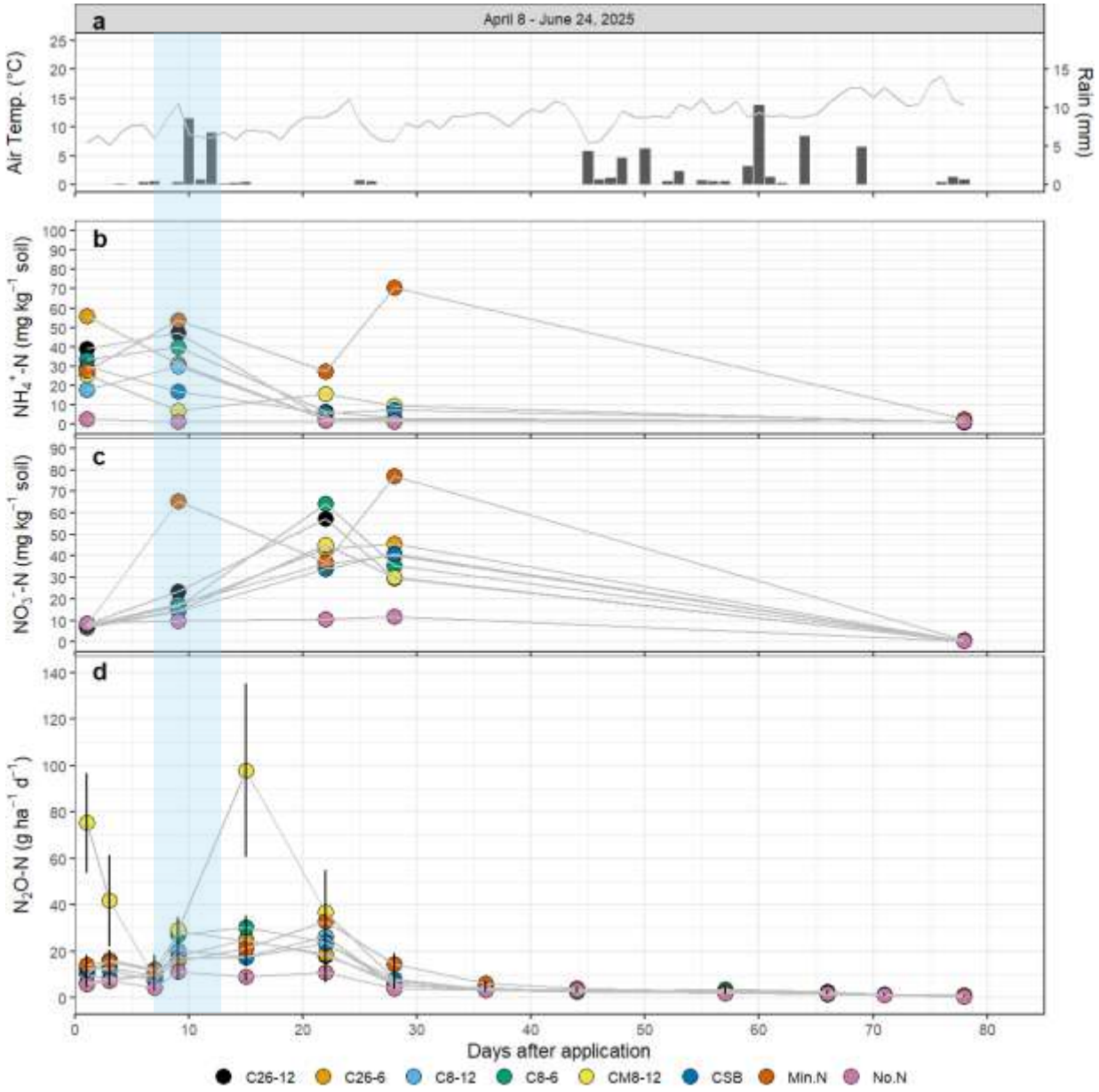
N_2O EMISSIONS & OTHER DATA

- 14 N_2O measurements; Apr 4 – June 24, 2025
- Six soil mineral N samples
- Continuous soil moisture and temperature
- Above-ground biomass at harvest

3 min measurement

From June 13 – 5 min measurement

PRELIMINARY RESULTS 2025



- Most N_2O emissions happened in the first three weeks after application.
- Cattle slurry increased NH_4^+ in soil, which was converted to NO_3^- over time.
- A few rain events together with increased temperature triggered N_2O emissions from cattle slurry N inputs.
- All cattle slurry treatments had similar emissions, other than in cattle slurry mixed with soil (CM8-12), with high emissions.

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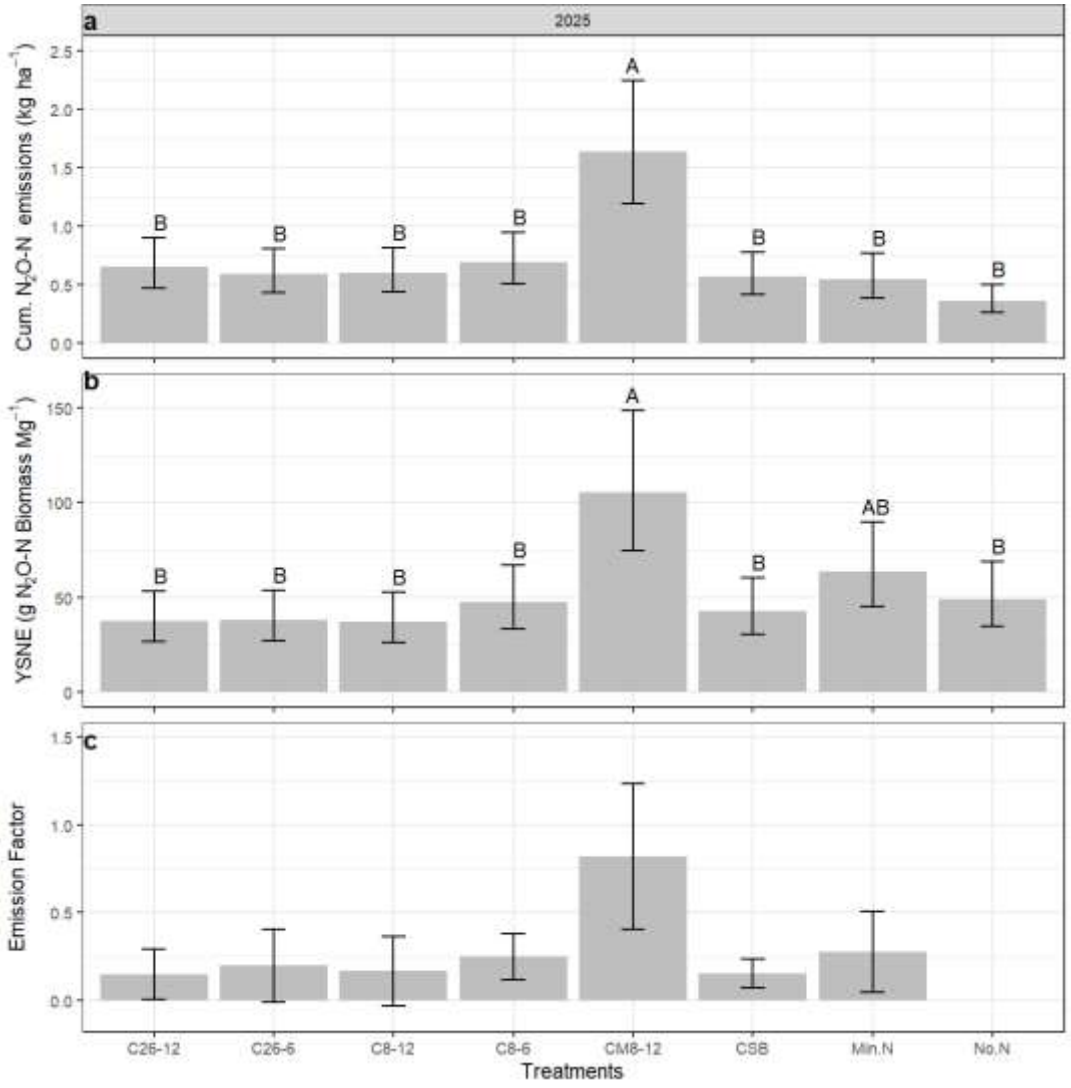
PRELIMINARY RESULTS 2025



- No effect of slurry application technique on cumulative or yield-scaled N_2O emissions, other than cattle slurry mixed with soil (CM8-12).
- Emission factor between 0.2% – 0.75%; no difference to mineral N (other than CM8-12)
- However, only a few measurements in the growing season for a year with relatively dry conditions.

➢ Need for more frequent measurements with contrasting weather conditions on different scales.

SMARTFIELD PROJECT

SmartField
Science Policy Practice

To quantify how much N_2O can be reduced while maintaining high yields and without N pollution

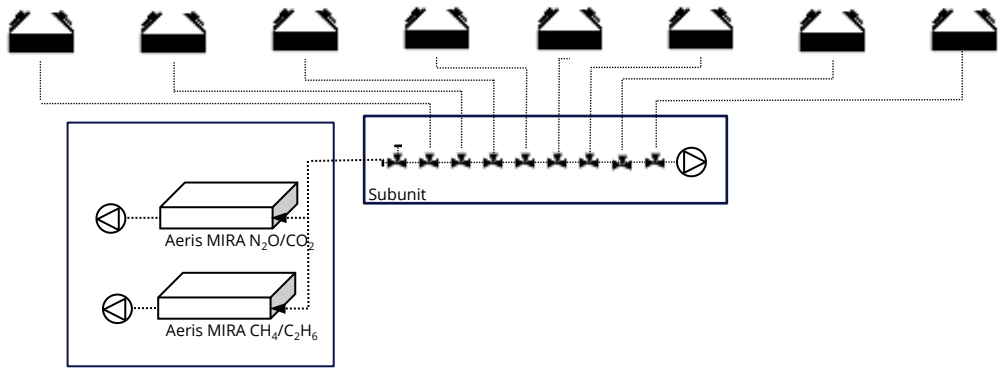
EXPERIMENTAL DESIGN

2024	2025	2026	2027	2028
Spring barley	Grass-clover	Maize	Spring barley	Winter rye

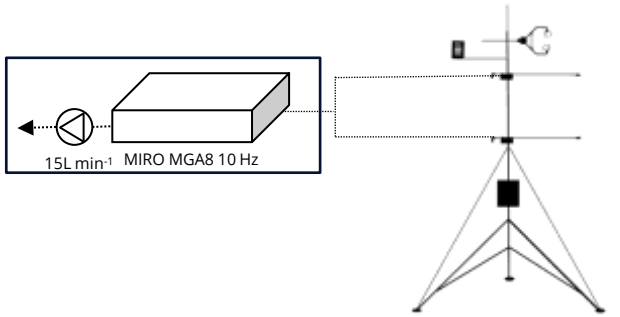
- 9 ha field on sandy loam soil (JB4)
- Feed production
- 5-year crop rotation
- Slurry and digestate application according to Danish standards

EXPERIMENTAL DESIGN

Plots: Chambers (N_2O, CH_4, CO_2)



Subfields: Flux Gradient (N_2O, CH_4, CO_2, NH_3, etc.)



Both:

- Initial conditions
- Suction Cup NO3-, DOC
- Soil Moisture Profile Probe VWC, Temp
- Drone: Vegetation Indices
- Weather station
- Yield & Field operations
- Soil samples: Nmin, BD

TREATMENTS ON PLOT-SCALE

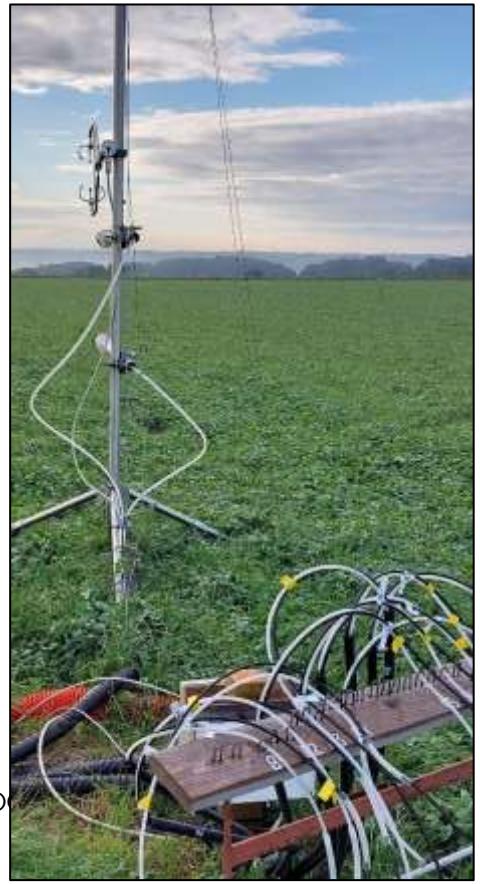
N source	Treatments	Rationale
None	Zero N	Emission factor
Cattle slurry	Business-as-usual	Control
	+Vizura	Benchmark
	+Vizura -20% N	N_2O Mitigation
	+Eminex	
Digestate	Business-as-usual	
	+Vizura	
	+Vizura -20% N	
Mineral N fertilizer	-50% N	N fertilizer replacement value
	Business-as-usual	
	+50% N	

TREATMENTS ON FIELD-SCALE

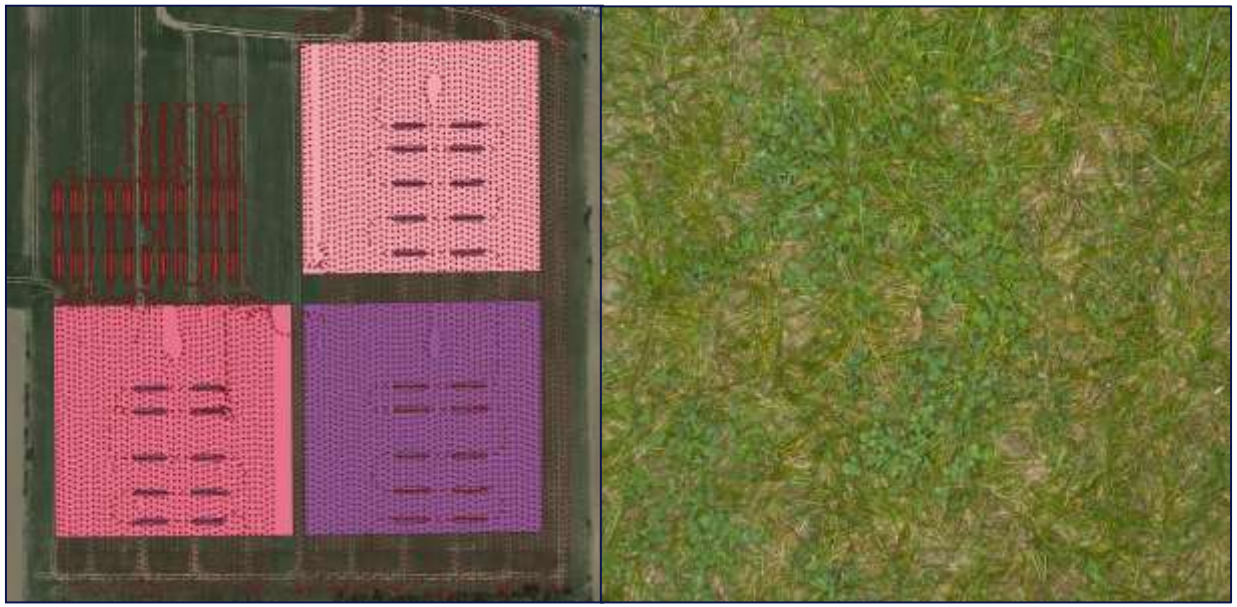
N source	Treatments	Rationale
Cattle Slurry	Business-as-usual	Control
	+Vizura -20% N	N_2O Mitigation
Digestate	+Vizura -20% N	

TREATMENTS ON FIELD-SCALE

N source	Treatments	Rationale
Cattle Slurry	Business-as-usual	Control
	+Vizura -20% N	N_2O Mitigation
Digestate	+Vizura -20% N	



GRASS-CLOVER COMPOSITION



SUMMARY

- Acidification of liquid fraction of digestates does not increase N_2O emissions.
- Biochar can reduce N_2O emissions from mineral N, but wet weather conditions may overshadow the effect.
- N_2O emissions are not affected by slurry application depth and width, other than when mixed with soil (for a dry year).
- However, more frequent measurements on plot and field-scale are required to identify the potential to reduce N_2O emissions from slurry and digestate application.

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