Effect of anaerobic digestion of cover crops and straw on N and S availability in the digestate

Doline Fontaine[1], Yolanda Maria Lemes Perschke[2], Lu Feng[2], Henrik B. Møller[2], Jørgen Eriksen[1], Peter Sørensen[1]

[1] Department of Agroecology, University of Aarhus (AU), Blichers Allé 20, 8830 Tjele, Denmark
[2] Department of Engineering, University of Aarhus (AU), Blichers Allé 20, 8830 Tjele, Denmark
(E-mail: doline.fontaine@agro.au.dk)

Abstract

Lack of nutrients and poor synchrony between nutrient availability and crop demand are often reasons for low yields in organic farming. A field experiment conducted in Denmark aims to use cover crops (CC) to produce extra biomass for biogas production and afterwards utilize the digestate as nitrogen (N) and sulfur (S) fertilizer. The influence of the main crop harvest time and the straw management on biomass production of cover crops is investigated. A spring barley crop and an under-sown CC (clover and chicory mixture) were established to compare early and late barley harvest time and different straw management, including a treatment with high stubble. The dry matter (DM) yield of CC in October was 2.5 t/ha for early barley harvest and 2.3 t/ha for late harvest. At early barley harvest with high stubble treatment, an extra DM yield of 1.3 t/ha was obtained. The harvested CC was ensiled and used as substrates for mono- and co-digestion with cattle manure in 15L digesters. The silages contained mixtures of CC and straw at ratios 1:0, 3:1 and 10:1 (fresh weight basis). Anaerobic digestion (AD) increased the fraction of NH_4^+ in total N from 0.07 to 0.41 in a reactor fed with CC silage only, for example. This increase was lower for reactors fed with higher ratio of straw in the silage mixture.

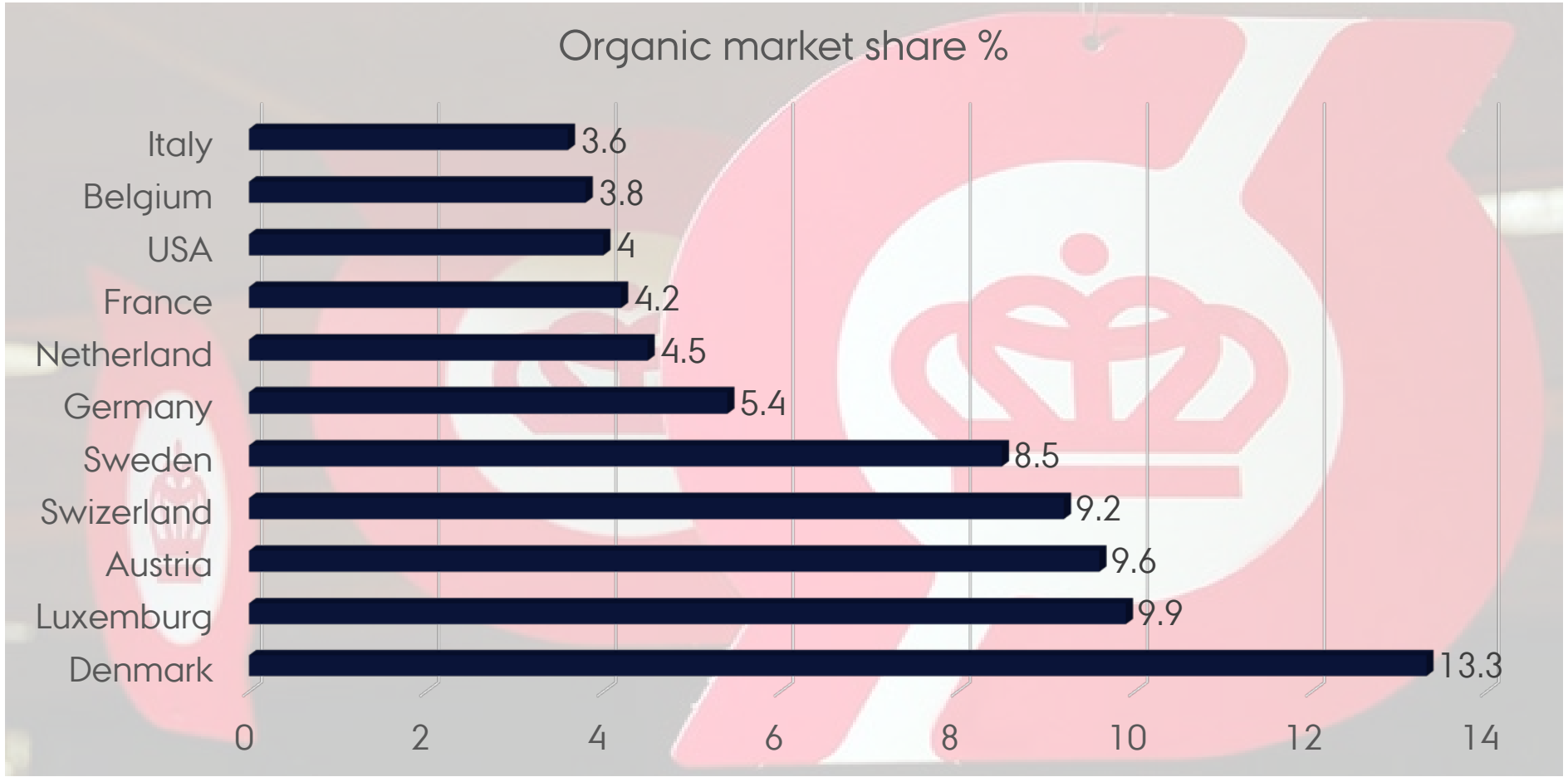
In 2018, the N fertilizer value of cattle manure and different digestates and raw silages are tested in a new spring barley crop in confined microplots. Yields and N uptake of spring barley will be measured and the fertilizer value of digested materials will be compared with corresponding undigested cover crops. In addition, the fate of N and S in the soil with different cover crop-straw mixtures and digestion management will be investigated.

Effect of anaerobic digestion of cover crops and straw on N availability in the digestate

Doline Fontaine[1], Yolanda Maria Lemes Perschke[2], Lu Feng[2], Henrik B. Møller[2], Jørgen Eriksen[1], Peter Sørensen[1]
[1] *Aarhus University, department of agroecology*
[2] *Aarhus University, department of engineering*

Project

NUTHY : NUTrients for Higher organic crop Yields



Source: 2017 estimate by Organic Denmark, USDA

Nutrient N limitation in organic farming

Lack of

of N supply

Digestate from AD

- Organic ressources
- Higher mineral N content

Poor synch
between nutrient availability and plant demand

Improvement of N utilization

Substrates

		Harvested separately : Barley straw in Summer CC in Autumn	Harvested together : Barley straw + CC in autumn
Barley straw	(tons FM/ha)	5.0	1.8
Cover Crop (CC)	(tons FM/ha)	18.0	19.6
Ratio CC:Straw		3.6	11.0

Substrates

Barley straw

Cover crop (CC)

(88% red clover, 11% chicory, 0.5% weeds)

Silage of CC + straw with ratios 1:0, 3:1, 10:1 (w/w)

Lab-scale reactors

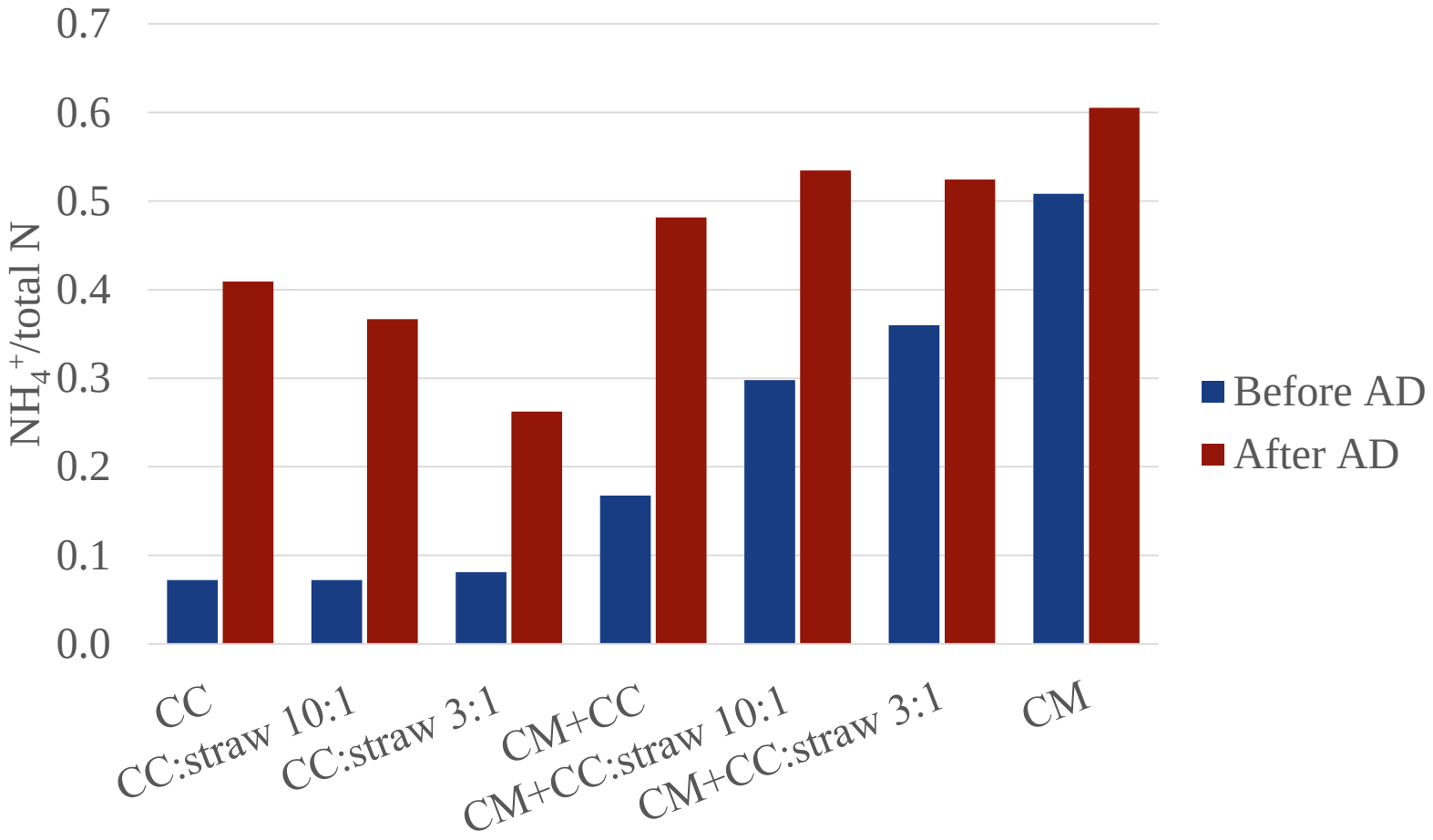
Reactor	Substrates feeding				Digestion management
	Mixtures	% silage	% CM	% water added	
R1	CC:straw 1:0	75	-	25	Mono-digestion
R2	CC:straw 10:1	39	-	61	Mono-digestion
R3	CC:straw 3:1	31	-	69	Mono-digestion
R4	CC:straw 1:0 + CM	63	17	20	Co-digestion
R5	CC:straw 10:1 + CM	30	33	37	Co-digestion
R6	CC:straw 3:1 + CM	20	38	42	Co-digestion
R7	CM	-	100	-	-

CM: Cattle manure

Substrates and digestates composition and methane yields

Feeding mixtures	VS (%)		pH	Total N (kg N/ton DM)	CH_4 yield (ml CH_4/gVS)
	before AD	after AD	after AD	After AD	
CC:straw 1:0	7.8	4.3	7.9	57.3±0.3	323
CC:straw 10:1	6.5	4.4	7.7	38.4±0.3	216
CC:straw 3:1	8.9	5.0	7.4	24.5±0.3	184
CC:straw 1:0 + CM	7.8	4.6	8.1	60.5±0.9	317
CC:straw 10:1 + CM	7.4	4.4	8.0	57.8±0.5	243
CC:straw 3:1 + CM	8.4	5.6	8.0	41.5±0.3	228
CM	7.0	4.3	8.4	77.4±0.2	159
Average reduction (-) or increase (+) between before and after AD	- 39 %		+ 0.9	0	-

Mineral N transformation



- AD increases fraction of NH_4^+ in total N
- Lowest increase for reactor fed with higher ratio of straw
- No effect on the proportion of NH_4^+ in digestates from co-digestion with manure

Field experiment in microplots

- N fertilizer response
- 15 treatments
- 1 control
- 4 references of N

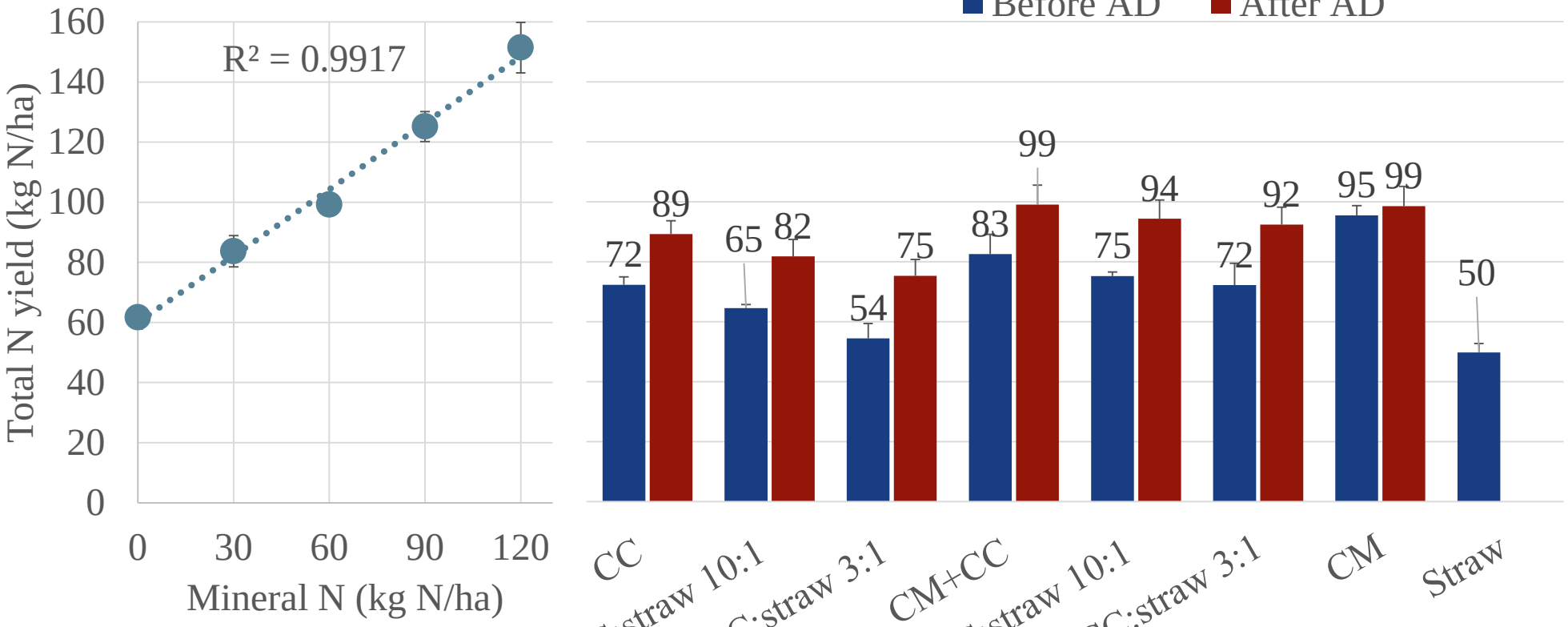
April 2018

- Injection of digestates/manure
- Sowing Spring Barley

August 2018

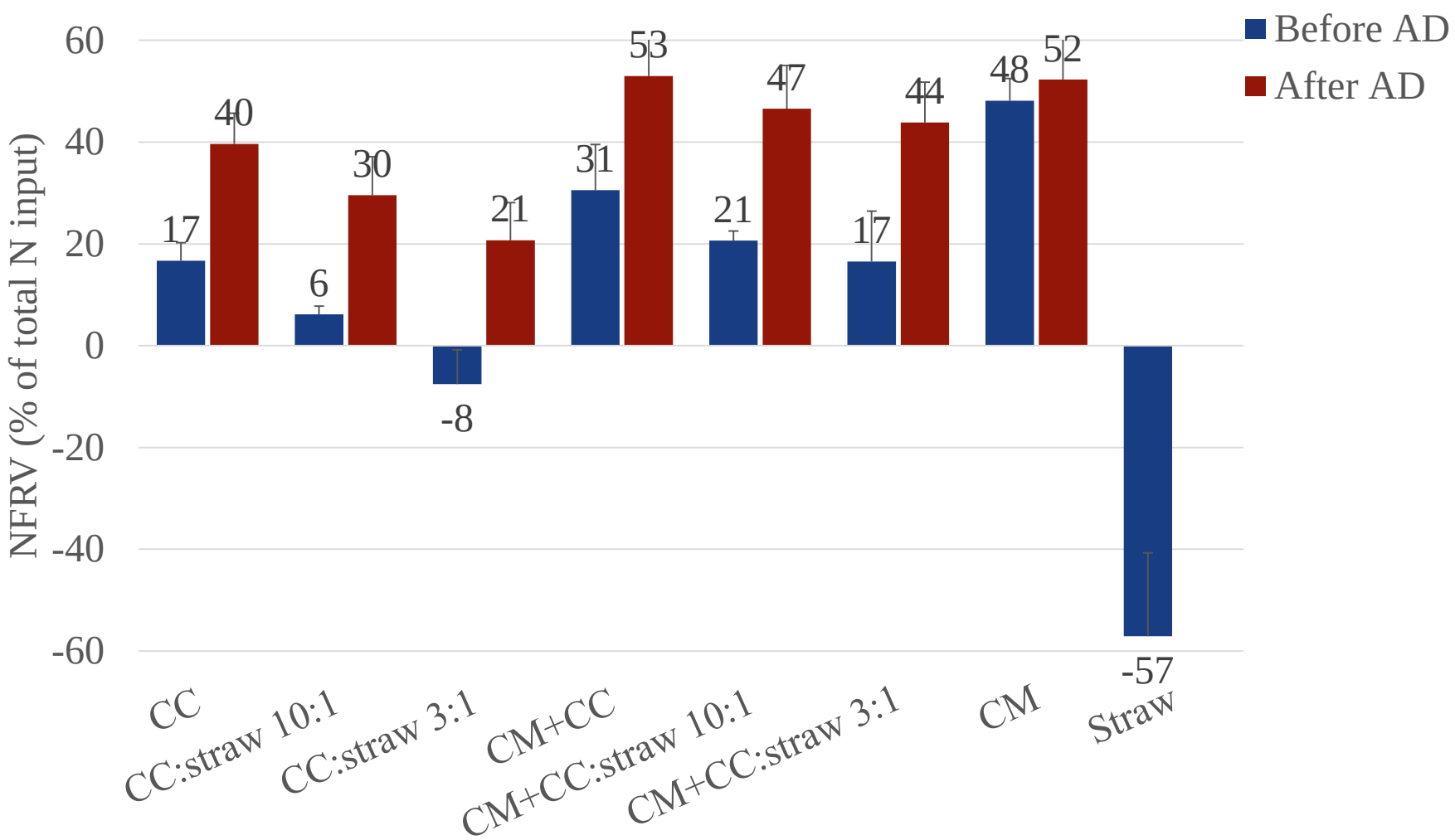
- Harvest
- Yield response & N uptake

Crop N uptake



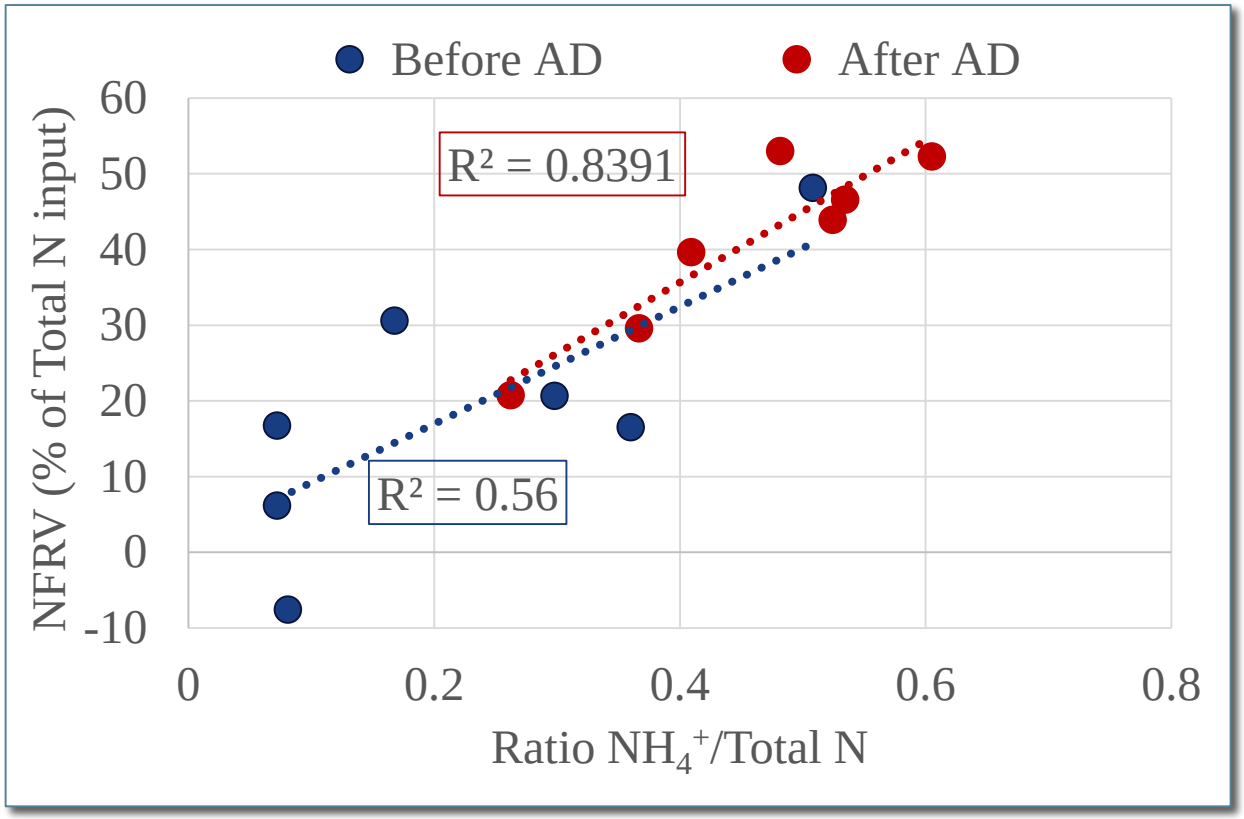
- Higher crop N uptake after application of digestates
- Average increase: 16 kg N/ha between before AD (74) and after AD (90)

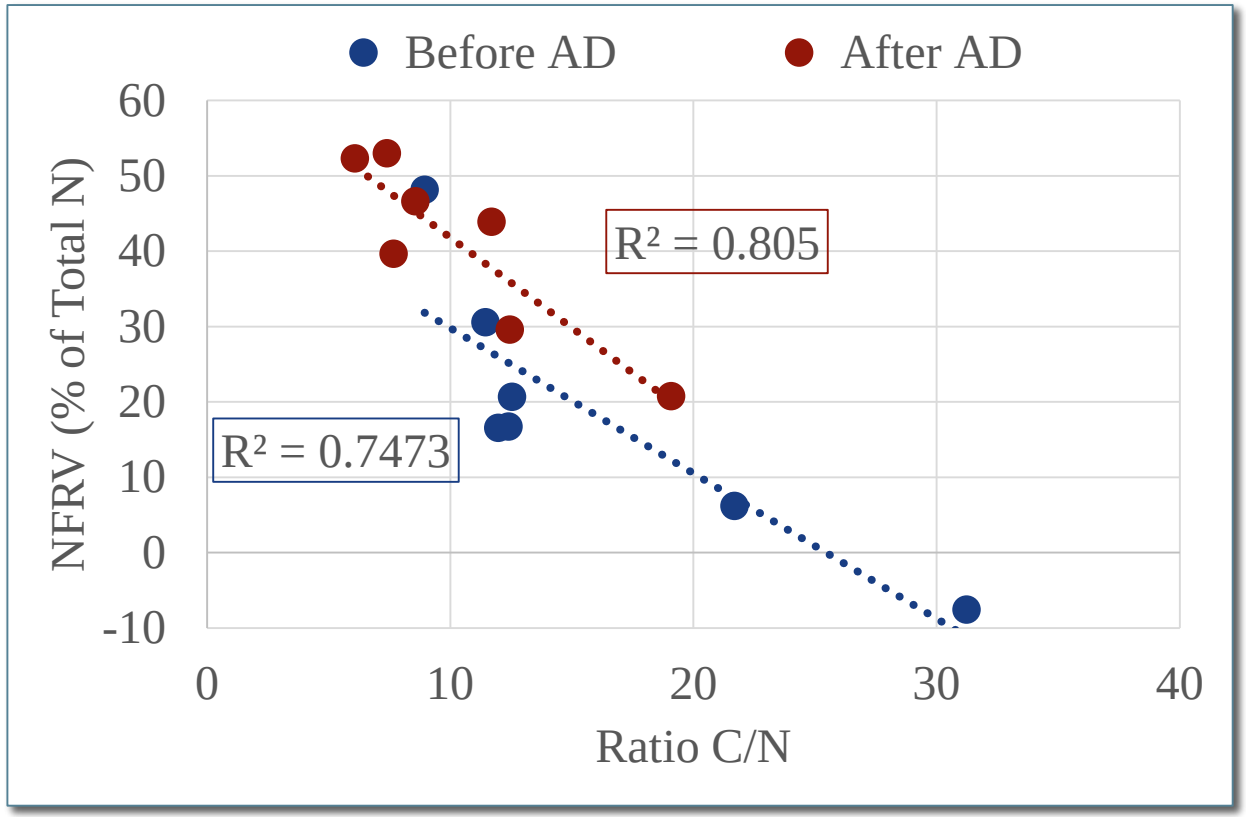
Nitrogen fertilizer replacement value



- Negative NFRV of substrates with high straw contents
- Average NFRV increase from 14% (before AD) to 39% (after AD)

Nitrogen fertilizer replacement value





- Increase NH_4^+/total N ratio → higher crop N uptake
- Lower C/N ratio → reduction of potential for immobilisation

Conclusion

Anaerobic digestion improves the use of crop residues and cover crops in organic farming systems :

- Increase fraction of NH_4^+ in total N
  - Increase N fertilizer replacement value from 14% to 39%
- Reduction of C/N ratio
  - Less immobilisation, improve synchrony with crop demand

- Additional biogas yields

- Other benefits:
  - Mobile manure → Spatio-temporal application
  - Less residual N in soil → reduce risk of N leaching

Thank you for your attention

Funded by

ICROFS
International Centre for Research in Organic Food Systems