Bilateral Danish-USA networking to increase yields and resource efficiency in organic crop production
Symposium: 11 June 2018, 08:30-18:00

ABSTRACT

Title of presentation:
Digestates from cover crop, straw and cattle slurry mixtures as nutrient source in organic cropping system

Name of presenter, title, affiliation:
Doline Fontaine, PhD student, Department of Agroecology, Aarhus University

Research focus incl. research questions and the starting point (state-of-the-art):
The aim of the current study is to quantify the influence of main crop harvest time and straw management and the inclusion of anaerobic digestion of cover crops and straw on N and S utilization and on potential biogas production. A comparison between mono- and co-digestion of cover crops, straw and cattle slurry is also included.

Results and on-going work:
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.

Conclusions (incl. research gaps and major research questions for future research related to 'improved nutrient supply/resource efficiency and efficient implementation in practice'):
Can early harvest of barley/cereals be implemented in practice in any type of organic farming (economical reasons)?
Long term effect of digestate application as fertilizer (residual organic matter and organic nutrients in soil)
Can the use of digestate as N organic fertilizer be sufficient to supply other nutrients (P, K, micronutrients…)?

DIGESTATES FROM COVER CROP, STRAW AND CATTLE SLURRY MIXTURES AS NUTRIENT SOURCE IN ORGANIC CROPPING SYSTEM

DOLINE FONTAINE
PHD STUDENT

PETER SØRENSEN &
JØRGEN ERIKSEN
SUPERVISORS

AARHUS
UNIVERSITY
DEPARTMENT OF AGROECOLOGY

EXPERIMENTAL SCHEME

N ressources and utilization
- Different management strategies of harvest
- Cereal and cover crop
- N residual effect in the 2nd year

Anaerobic digestion
- Silage of cover crop and straw mixtures
- Mono- and co-digestion with cattle manure
- Transformation of N and S

N fertilizer value
- Fertilization from organic digestates and raw manure/silages
- Crop yield and N uptake

Transformation N and S in soil
- Net mineralisation turnover of N and S in soil
- Incubation at 10º C

I. EFFECT OF DIFFERENT MANAGEMENT STRATEGIES OF CROP AND COVER CROPS ON N UTILIZATION IN AN ARABLE ORGANIC CROPPING SYSTEM

- → Strategies: Harvest time of the main crop, cutting height of the straw, straw removal, harvest of the cover crop
- → Residues for biogas production
- → Nutrients removal/reallocation
- → Residual N fertilization value

Photo: September 2017, Peter Sørensen

	2017				2018
Treatment	**Harvest condition of spring barley**	**Date of harvest**	**Catch crops: clover and chicory**	**Harvest of catch crops**	**Spring fertilization**
1	Early harvest	25 July	Yes	13 October	CC residues
2	Early harvest with high cutting table. High stubble	25 July	Yes	13 October	CC residues
3	Harvest. Straw removed	10 August	Yes	13 October	CC residues
4	Harvest. Straw left	10 August	Yes	13 October	CC residues

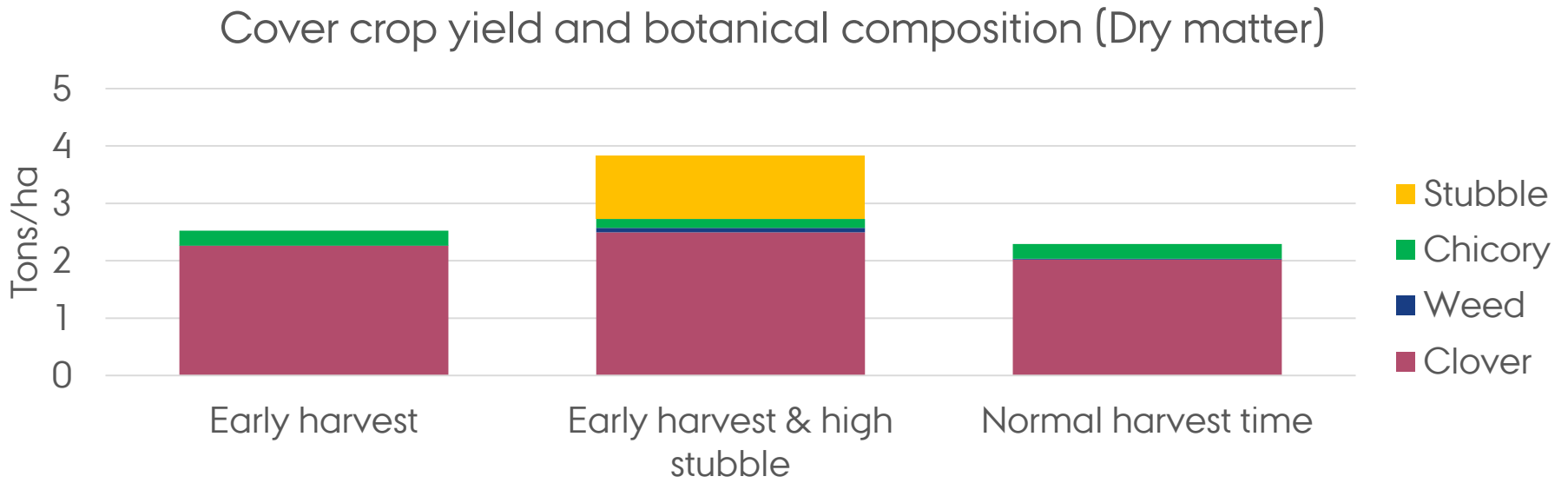
HYPOTHESIS

- The residual effect is proportional to the N content of the residues left in the field. The more cover crops left on to the field in 2017, the greater the N residual effect for the following crop

- Early harvest time of the main crop will increase the vegetative period of the cover crop and its dry matter yield and N content

- The straw left has a low or negative N residual effect due to the N consumption by the decomposer microorganisms

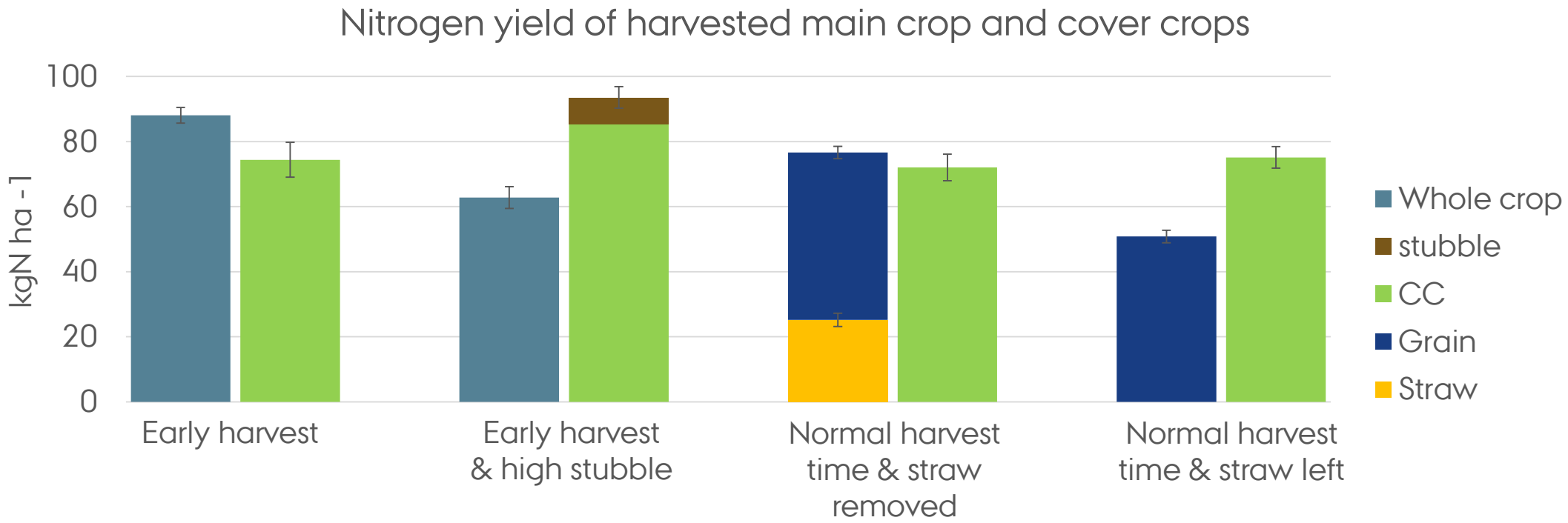
PRELIMINARY RESULTS



- Early harvest of Spring Barley (2 weeks earlier): ~0.2 tonDM/ha of additionnal biomass for biogas production
- High stubble left (28% DM-1.3 tonsDM/ha)

	Harvested separately	Harvested together
CC (tons FM/ha)	18.0	19.6
Straw (tons FM/ha)	5.0	1.8
Ratio CC:straw	**3.6**	**11.0**

PRELIMINARY RESULTS



- High N content in CC (75 kgN ha $^{-1}$)
- No effect of harvest time on N yield in CC
- Increase of 10kgN/ha from CC in treament 2

II. INFLUENCE OF ANAEROBIC DIGESTION OF COVER CROPS AND STRAW MIXTURES IN PILOT DIGESTERS ON N AND S CHEMICAL COMPOSITION

→Transformations of N and S
→Mass balances of N and S (losses during process)

Hypothesis

- Mineralization of N and S is expected to happen during the anaerobic digestion process as well as losses of N and S compounds in the biogas stream
- Digestates have a higher N fertilizer value than undigested materials
- The first year fertilizer value of digestates is equal to the ammonium content of the digestates

MATERIALS

CC & straw harvested in experiment 1
Silage of CC and Straw with ratio 1:0, 3:1, 10:1

Photos: Yolanda Perschke

7 reactors CSTR
15L working capacity
HRT: 25 days

Photo: Doline Fontaine

METHODS

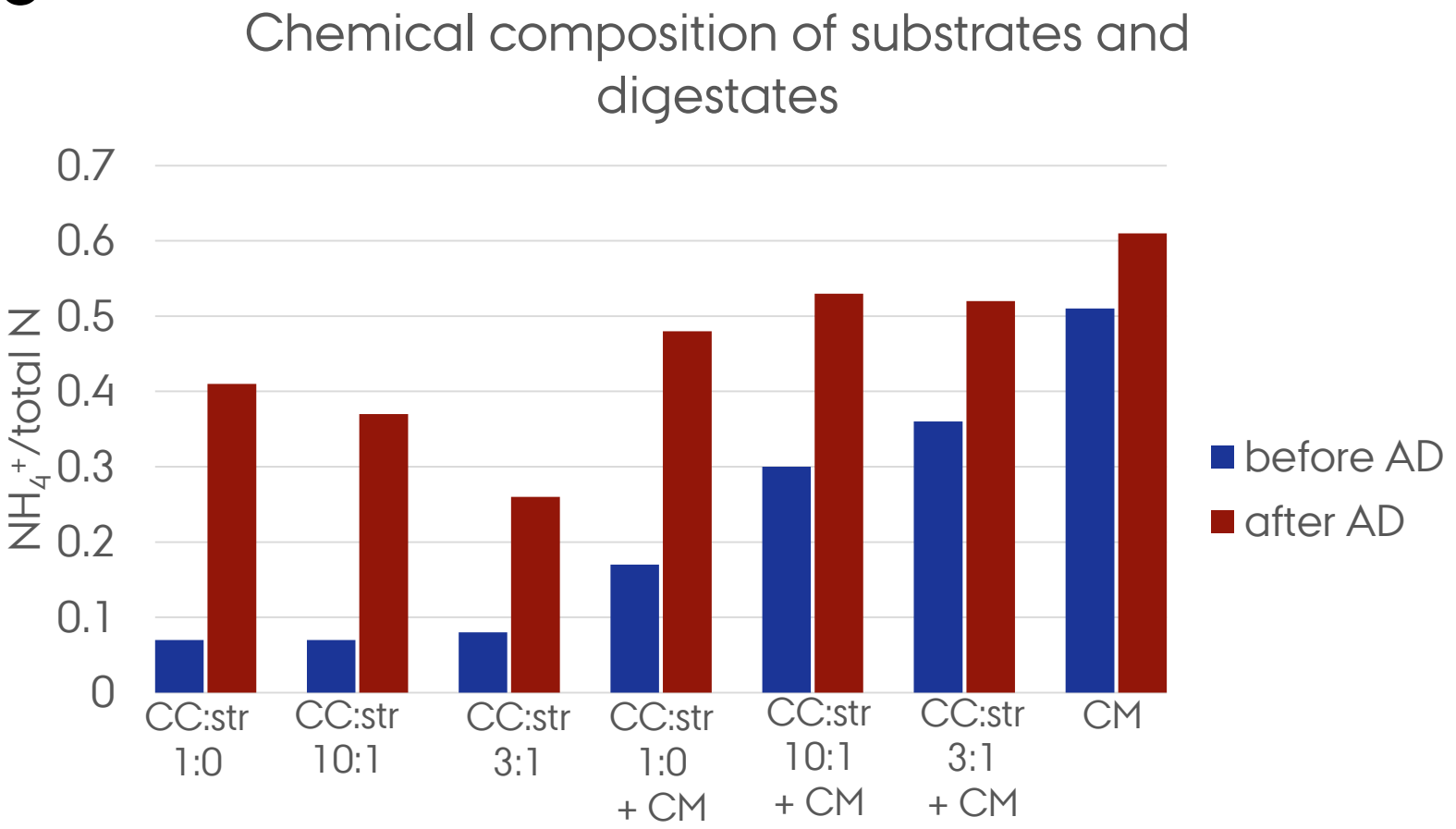
R1	• Mono-digestion • CC: Straw 1:0
R2	• Mono-digestion • CC:Straw 3:1
R3	• Mono-digestion • CC:Straw 10:1
R4	• Co-digestion with CM • CC:Straw 1:0
R5	• Co-digestion with CM • CC:Straw 3:1
R6	• Co-digestion with CM • CC:Straw 10:1
R7	• Control CM

DM feeding: 9%

CM: cattle manure

PRELIMINARY RESULTS

Photo: Doline Fontaine



- 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

III. N FERTILIZER REPLACEMENT VALUE OF DIGESTATES AND RAW MANURE/SILAGES

Microplots experiment

→ Crop yields and N uptake

Same level of total N

Photos: Doline Fontaine & Betina Nørgaard Pedersen

April 2018

- Application of digestates or manure
- Sowing Spring Barley

- Manure weeding

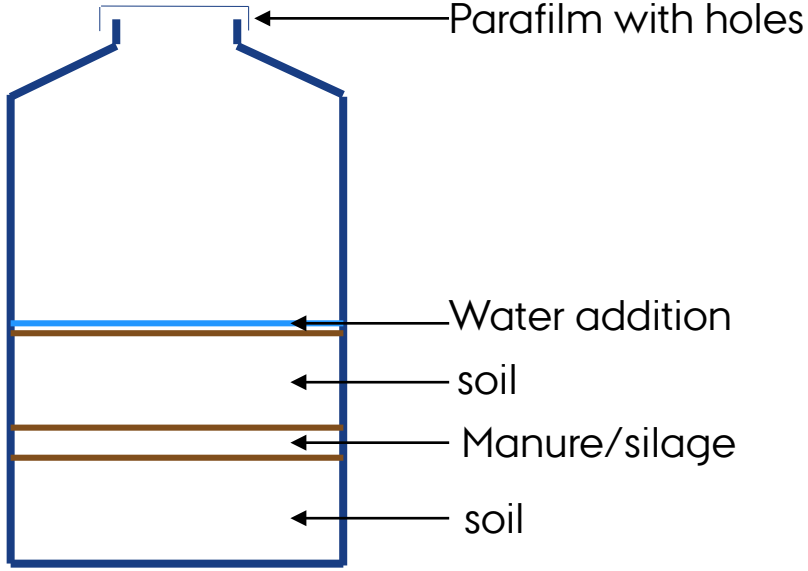
August 2018

- Harvest
- Yield response + N uptake

IV. EFFECT OF ANAEROBIC DIGESTION OF CATCH CROP AND STRAW MIXTURES ON NUTRIENTS N AND S AVAILABILITY IN SOIL

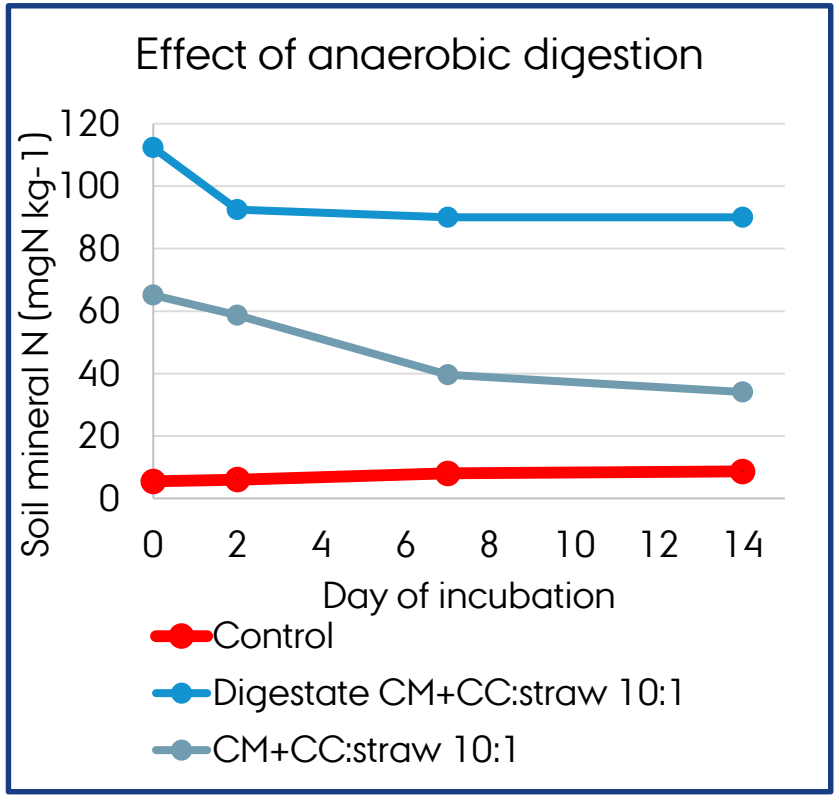
Soil incubation study

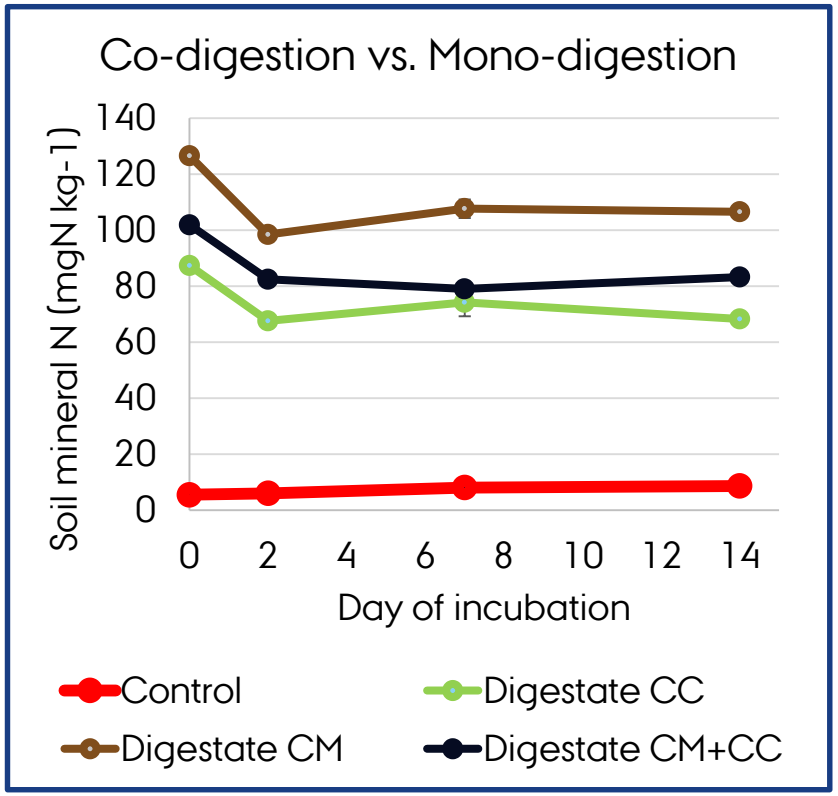
→Net N and S mineralisation turnovers of soil amended with digestates and raw manure/silages

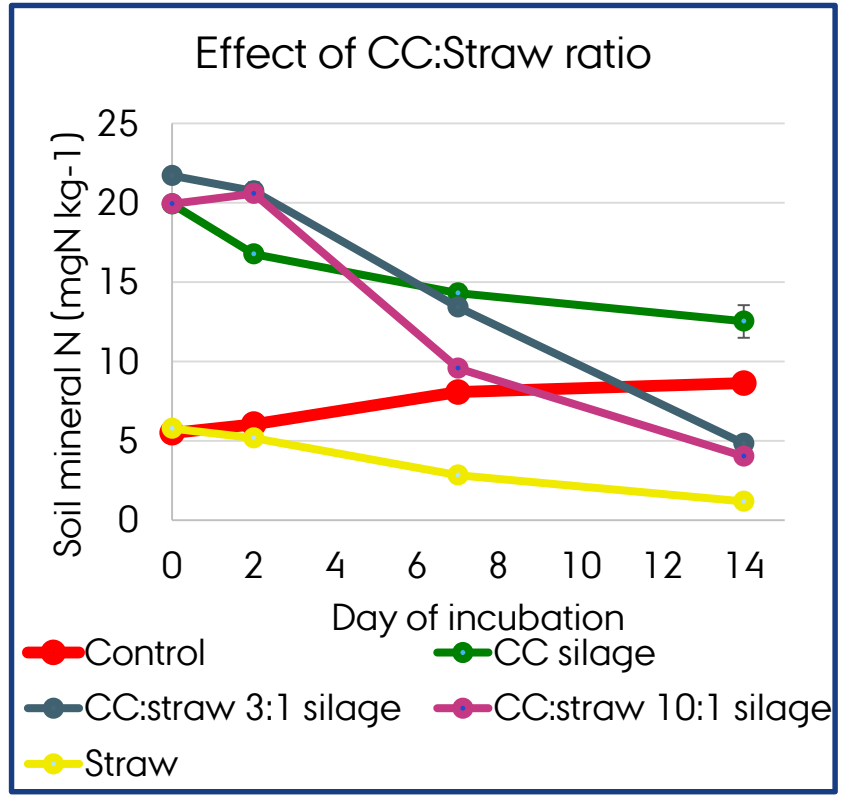


PRELIMINARY RESULTS (FIRST 14 DAYS)

Incubation with similar Total N (200mgN kg^{-1}soil)







- Net immobilisation of mineral N applied during the first 14 days
- Lower immobilisation in digestates than raw substrates
- Significant immobilisation of mineral N for the degradation of straw by microorganisms (higher C:N content)

CONCLUSION

- Promising results for the harvest of high stubble and cover crops
  - Increase DM yield
  - Increase N yield → N residual effect
  - CC:straw ratio 11:1
- Combining with anaerobic digestion
  - Additional biogas yield?
  - Increase fraction of NH_4^+ in total N
  - Reallocation of nutrients
- N fertilizer values
- N transformations in soil
  - Net immobilisation of mineral N during the first 14 days at low temperature

THANK YOU FOR YOUR ATTENTION

DOLINE FONTAINE
PHD STUDENT