IMPROVING N RECOVERY FROM GREEN MANURE

ON CONTRASTING SOIL TYPES UNDER COLD CLIMATE CONDITIONS

NIBIO
NORSK INSTITUTT FOR BIOØKONOMI

Randi Berland Frøseth[a], Sissel Hansen[b], Kristian Thorup-Kristensen[c], Marina Azzaroli Bleken[d]

[a] Norwegian Institute of Bioeconomy Research, Dep. of Grain and Forage Seed Agronomy, NO-6630 Tingvoll
[b] Norwegian Centre for Organic Agriculture, Gunnars veg 6, NO-6630 Tingvoll
[c] University of Copenhagen, Dep. of Plant and Environmental Sciences, Højbakkegård Allé 13, DK-2630 Taastrup
[d] Norwegian University of Life Sciences, Dep. of Environmental Sciences, Fougnerbakken 3, NO-1432 Ås

BACKGROUND

In northern temperate regions, grass-clover green manure is used as a one-year break crop in stockless organic cereal rotations in order to provide soil fertility and reduce the pressure of weeds, pests and diseases.

The green manure is mown repeatedly and the herbage is left as mulch. The herbage contains a substantial amount of nitrogen (N), which is at risk of being lost when it decomposes in the field.

Mulching of green manure Photo: A.K. Bakken

OBJECTIVES

To improve the N recovery from grass-clover green manure on contrasting soil types under cold climate conditions by

A. evaluating the effects of various strategies for green manure management* on the yield and N recovery of a subsequent spring barley crop.

*including anaerobically digested herbage as fertilizer

B. estimating effects of low temperature and soil type on N and C mineralization of N-rich plant residue.

MATERIALS AND METHODS

A. Field experiment - green manure management

A 3-year field trial at 4 sites in Norway with contrasting soil types.

Table 1 Overview of the treatments in the 3-year crop rotation.

2008	2009		2010	Term
Barley + green manure undersown	Green manure ley 3 cuts – herbage:	Mulched	Barley	G-3M
		2 removed, 3rd mulched	Barley	G-1M
		Removed	Barley	G-0M
		Removed	Barley + digestate (110 kg N/ha)	G-0M-D
Barley (no fertilizer)	Oats (no fertilizer)		Barley + digestate (110 kg N/ha)	C-D
			Barley + fertilizer (80 kg N/ha)	C-I

The harvested green manure herbage was anaerobically digested in a biogas plant. The digestate applied in spring 2010 contained 110 kg N/ha, equivalent to 40% of N in the harvested herbage.

B. Incubation experiment - mineralization

- Soil or soil + clover leaves (4g/kg dry soil)
- At 0, 4, 8.5 and 15°C

C mineralization

x 3 replicates
= 48 airtight chambers with CO_2 trap

Sampling on days 0, 3, 8, 15, 30, 52, 80, 134 and 142

Kept aerobic by monitoring and adding O_2

N mineralization

x 4 replicates

Destructive sampling on days 0, 3, 8, 15, 30, 52 and 80

Analysed for **NH_4-N and NO_3-N**

Table 2 Soil properties for the two soil types from the field trial that was used in the incubation. trial. The silty clay loam was from Kvithamar and the sandy loam was from Værnes.

Soil type	Sand (%)	Clay (%)	pH	Total C (%)	C/N
Silty clay loam	3	27	6.0	4.45	11.4
Sandy loam	51	6	6.2	1.30	11.8

RESULTS

A. Effects of green manure management

Yield of a subsequent spring barley crop

Ranking of barley grain yields after:

herbage removal ≤ digestate without green manure ≤ herbage mulched ≤ herbage removal and digestate ≤ inorganic fertilizer without green manure

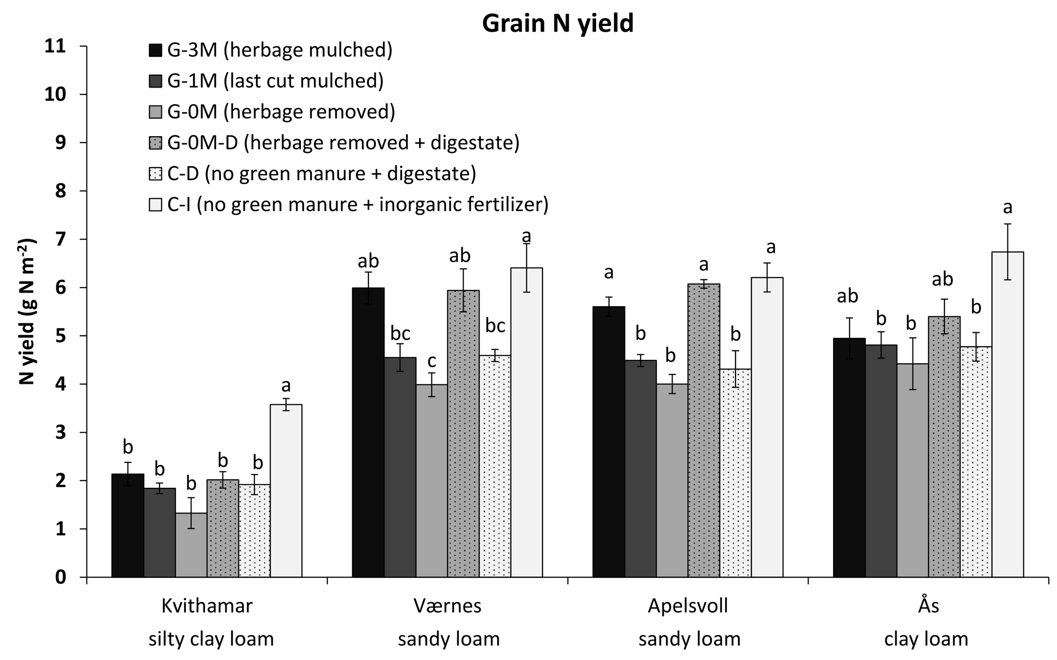

Fig 1 Barley grain N yield at the different sites in 2010. Abbreviations for the treatments are explained in Table 1. Bars (± S.E) within each site which do not have any letter in common are significantly different ($P < 0.05$) by Tukey HSD.

Relative to the early growth stages, at harvest the ranking of the mulching and use of digestate improved.

Low yields at Kvithamar was an effect of soil type and cold weather conditions.

N recovery

Digestate increased N recovery with 9% point compared to mulching.

Table 3 Apparent recovery (%) of N applied as mulched herbage (G-3M or G-1M) or digestate (G-0M-D): 100 x ((*N yield – N yield*$_{G\text{-}0M}$)/*N applied*).

	G-3M	G-1M	G-0M-D
Grain	6 b	10 ab	13 a
Above-ground biomass	7 b	8 ab	16 a

B. N and C mineralization of N-rich plant residue

Substantial N mineralization unaffected by low temperature

Net N immobilization in clay, similar tendencies in sand, more severe at higher temperatures

Net N mineralization increased, positively related to temperature

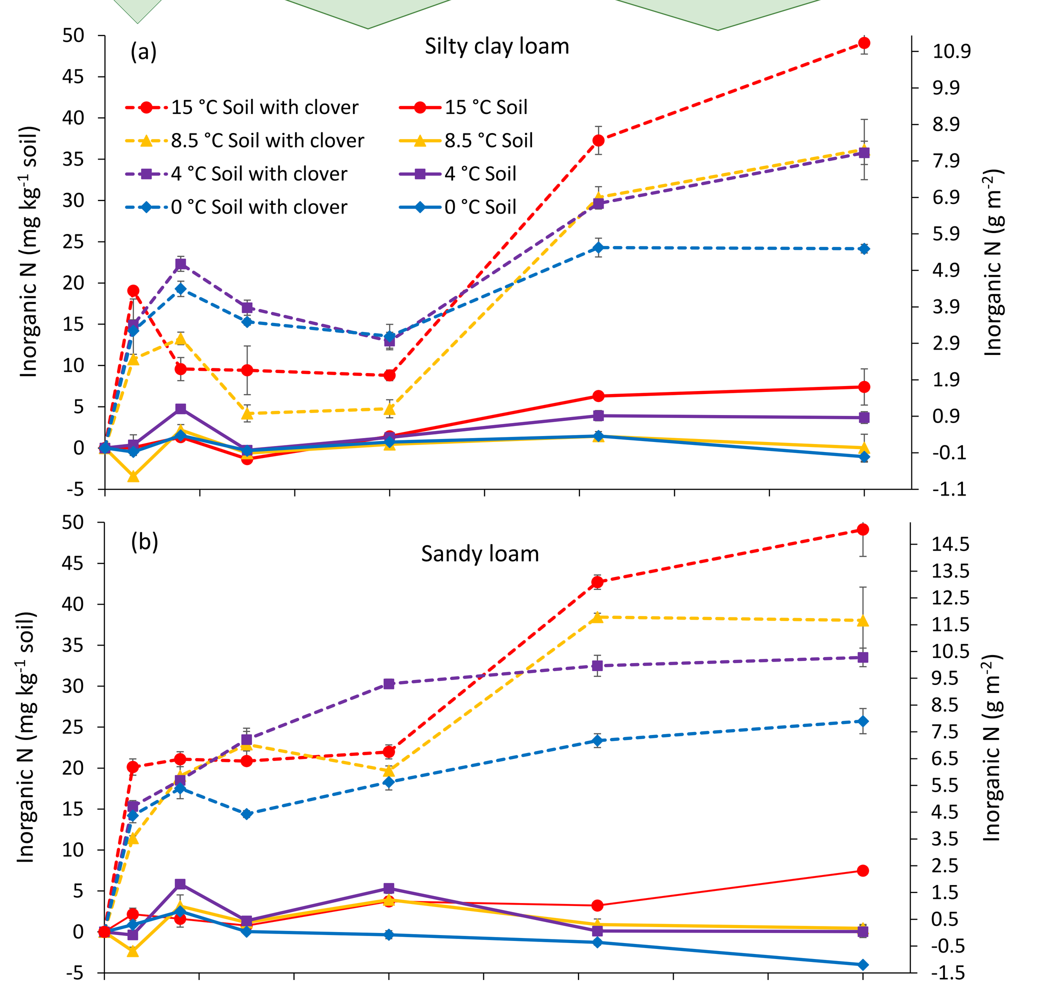

Fig 2 Net inorganic N (NH_4-N and NO_3-N) during 80 days of incubation at 0, 4, 8.5 and 15 °C in (a) a silty clay loam and (b) a sandy loam with clover leaves (dotted lines) and without (lines). Inorganic N at the start of the experiment is subtracted. Line bars indicate standard error for mg kg^{-1} soil. The right vertical axis shows the N content in a 20 cm soil layer assuming the soil bulk density in situ.

Only 13-22% of clover N was mineralized after 80 days. Almost half of it was mineralized after 3 days.

The ratio between mineralized N and C was higher at low temperatures than at high temperatures during the first weeks of decomposition.

CONCLUSION

A. Green manure management

The digestate strategy was the most promising option:

- improved N recovery by a subsequent crop
- reduced risk of N losses
- additional fertilizer (digestate) available
- but improvement of farm-scale biogas systems is needed

Removal of the herbage:

- reduced the barley grain yield by 0-33%
- reduced the risk of N losses
- only recommended if fertilizer applied to the subsequent crop or the soil is very fertile

B. Mineralization at low temperatures

Soil type

- ➢ The clay soil responded less to the green manure treatments than the sandy soil
- ➢ Lower decay rate and net N immobilization in the clay soil when N-rich plant residue was added

Temperature

- ➢ Initial rapid net N mineralization of N-rich plant material, even at 0 °C
- ➢ The initial N mineralization was less affected by low temperature than C mineralization

FUTURE PERSPECTIVES

A. Cost-efficient and practical solutions are needed for running small herbage-based biogas plants under cold climate conditions.

B. Innovative modelling approaches are needed for simulating the effects of low temperatures on N mineralization from fresh plant material.

References

Frøseth R B, Bakken A K, Bleken M A, Riley H, Pommeresche R, Thorup-Kristensen K, Hansen S. 2014. Effects of green manure herbage management and its digestate from biogas production on barley yield, N recovery, soil structure and earthworm populations. European Journal of Agronomy. 56: 90–102

Frøseth R B, Bleken M A. 2015. Effect of low temperature and soil type on the decomposition rate of soil organic carbon and clover leaves, and related priming effect. Soil Biology and Biochemistry. 80: 156–166

Frøseth R B, Thorup-Kristensen K, Hansen S, Bleken M A. Mineralization of clover leaves at low temperatures in contrasting soil types. Submitted

nibio.no
randi.froseth@nibio.no
phone: +4790662714

Pb 115,1431 Ås
+47 406 04 100

NORSØK Norwegian Centre for Organic Agriculture

NMBU Norwegian University of Life Sciences

UNIVERSITY OF COPENHAGEN