AARHUS
UNIVERSITET

Flows of nitrogen and climate relevant gases in experimental rotations on three soil types

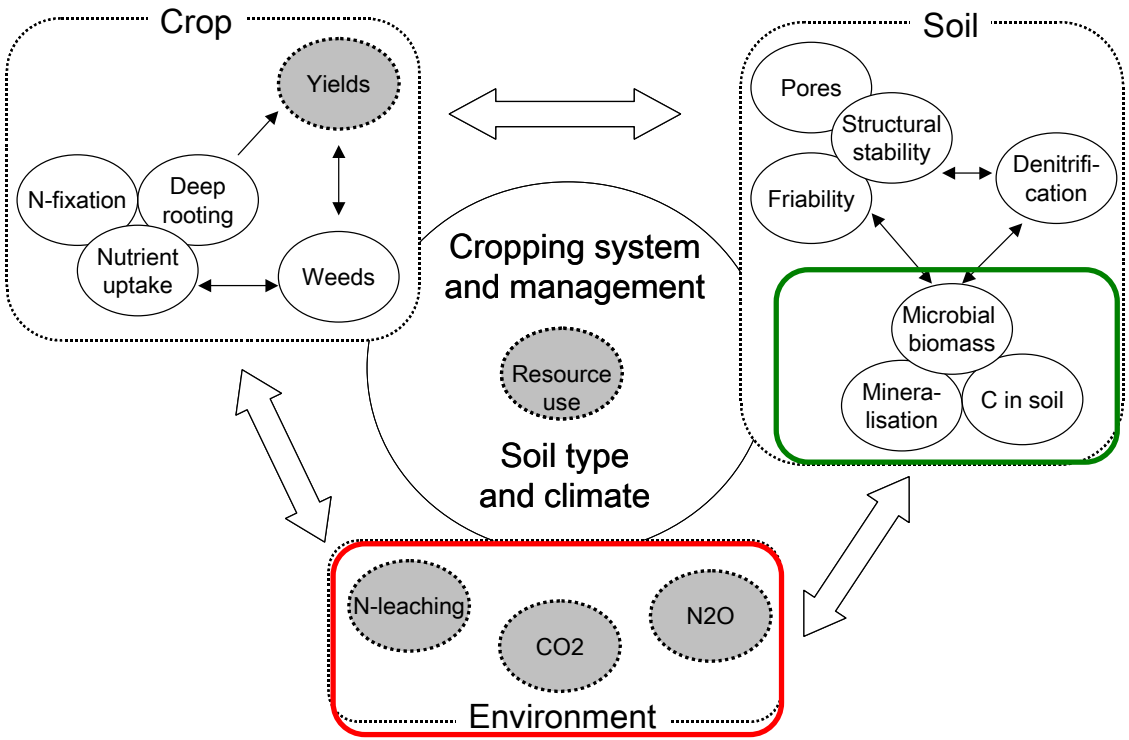
Results from studies within organic and conventional cropping systems

Søren O. Petersen, Dept. Agroecology and Environment, Aarhus University

Overview

- N cycling and GHG balance of arable cropping systems
- Experimental crop rotations in three locations
- ”Active” N
- N_2O: Seasonal trends
- N_2O emission potentials
- Green manure management and N_2O
- GHG balance of cropping systems
- Conclusions

A system approach

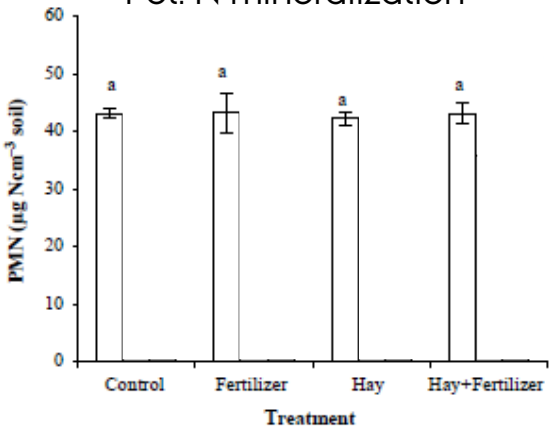


(Cookson et al., 2005)

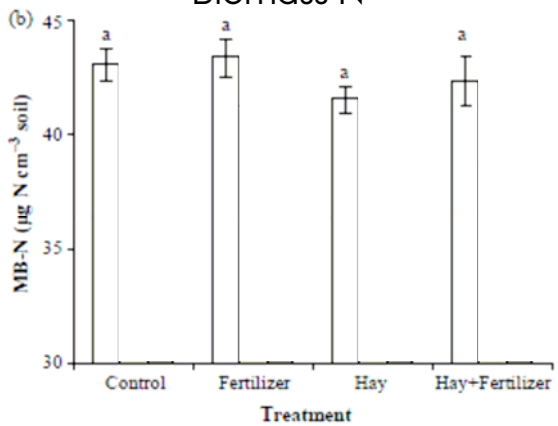
"Active" pools of N

- Pools represent a potential for N transformations
- … but pool size does not reveal N flows

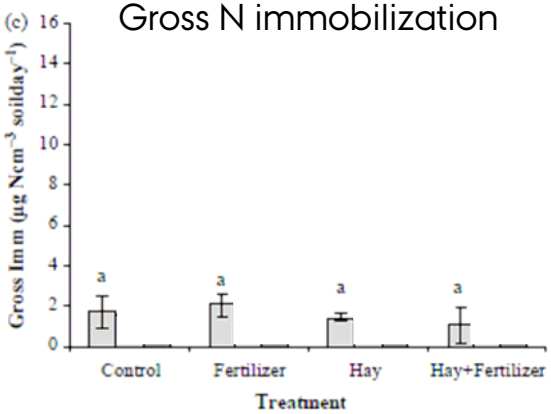
Pot. N mineralization



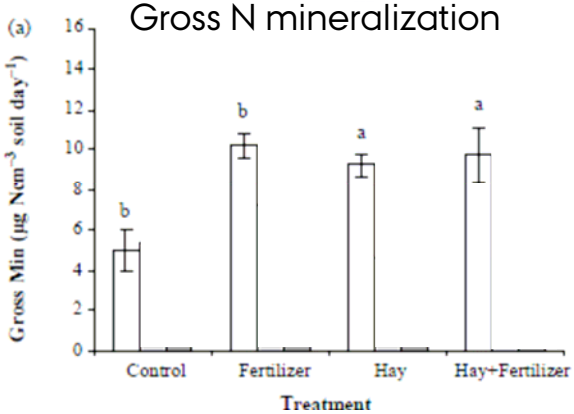
Biomass N



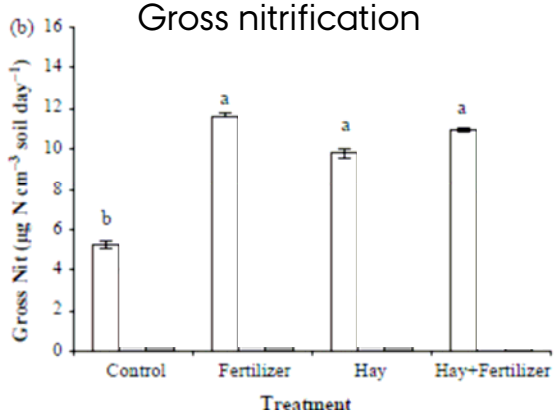
Gross N immobilization



Gross N mineralization

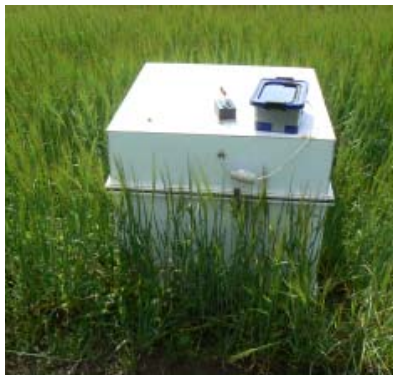


Gross nitrification

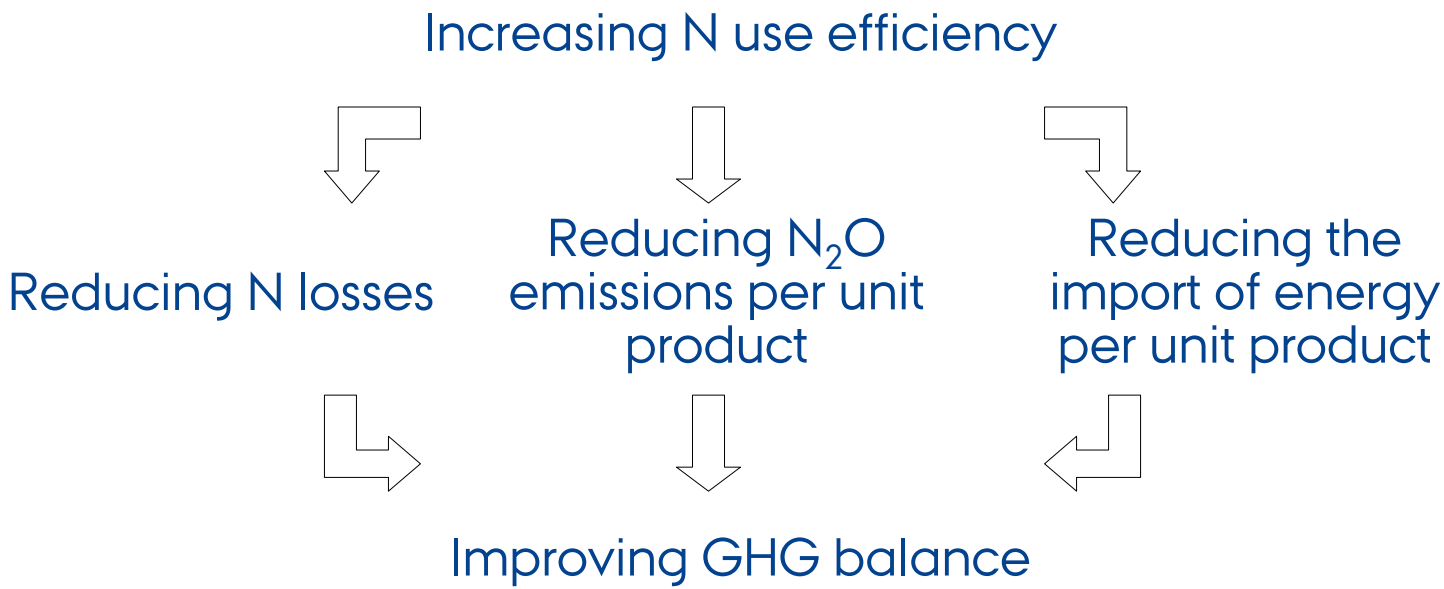


Greenhouse gas balance of arable cropping systems

- Nitrous oxide: Fertilizer/manure, biological N fixation, crop residues, N leaching, ammonia losses
- C stocks: Crop sequence, management
- Methane: Bioenergy production
- Energy use: Machinery, fertilizer production

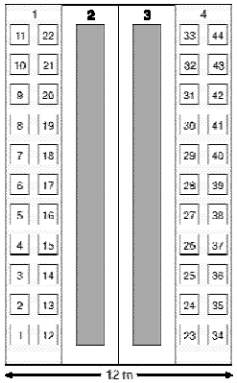


N cycling and GHG balance

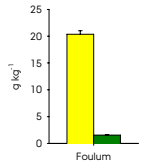


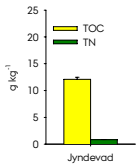
AARHUS
UNIVERSITET

3 locations

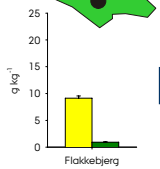


Foulum
9% clay
700 mm





Jyndevad
5% clay, 950 mm



Flakkebjerg
16% clay, 600 mm rain

Experimental rotations

	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course	1	S. barley:ley	S. barley[CC]	S. barley	S. barley
2005-2008	2	Grass-clover*	Pea/barley[CC]	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat[CC]	Winter wheat[CC]	Winter wheat	Winter wheat

[CC]Catch crop

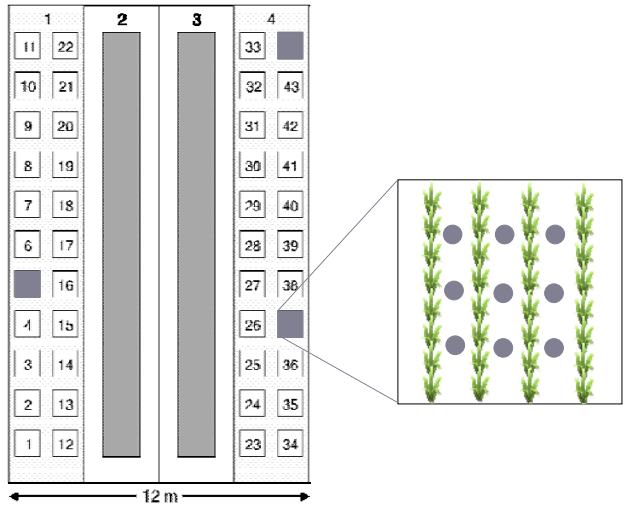
* Grass-clover green manure - cut or retained

AARHUS
UNIVERSITET

	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course	1	S. barley:ley	S. barley[CC]	S. barley	S. barley
2005-2008	2	Grass-clover	Pea/barley[CC]	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat[CC]	Winter wheat[CC]	Winter wheat	Winter wheat

[CC]Catch crop

"Active" N pools



› 3 sites (Jyndevad, Foulum, Flakkebjerg)
› 3 microplots per field plot

› 9 100-cm^3 rings installed in November
› Sampling of 2 rings per micro-plot April, May, June, August




AARHUS
UNIVERSITET

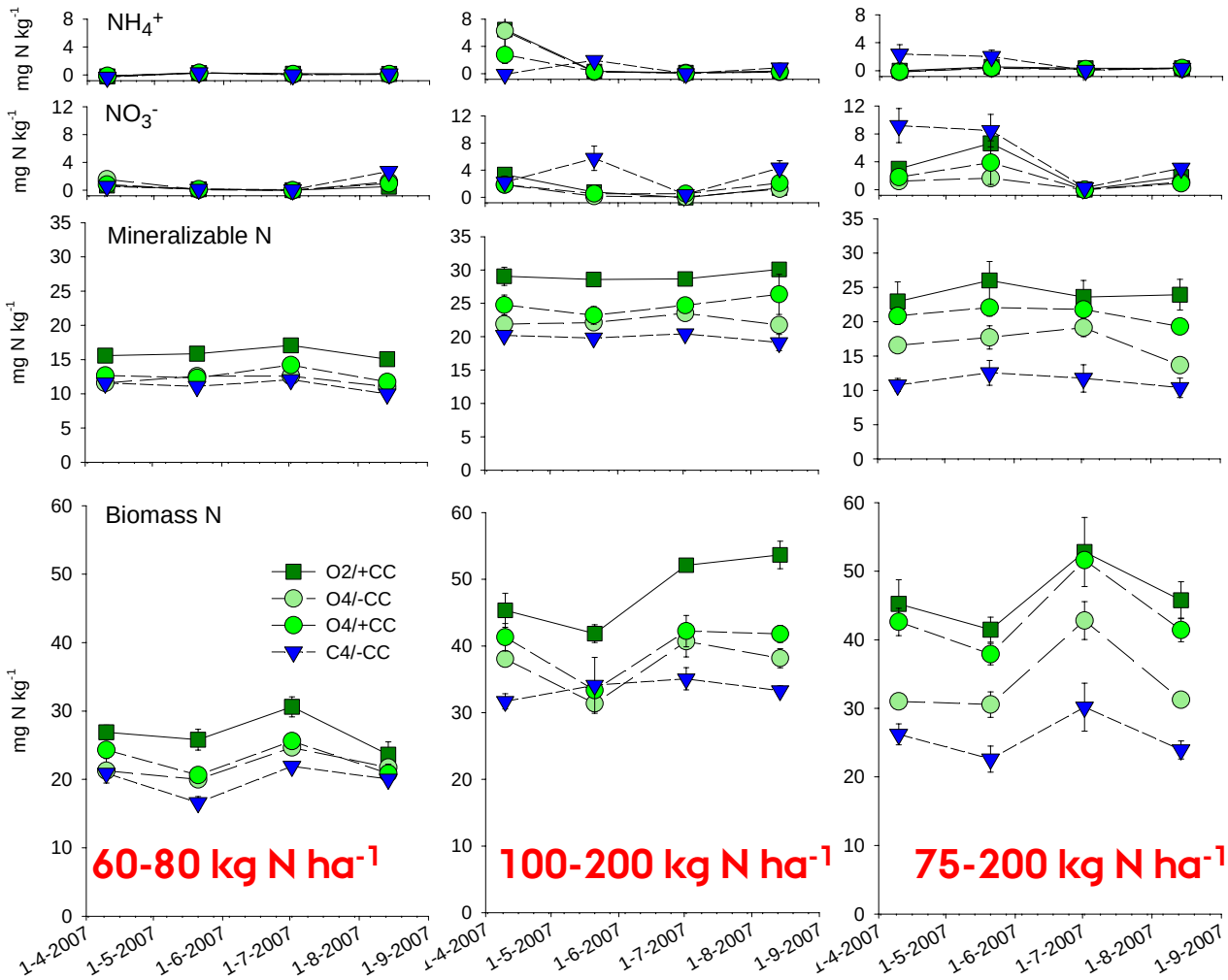
	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course	1	S. barley:ley	S. barley[CC]	S. barley	S. barley
2005-2008	2	Grass-clover	Pea/barley[CC]	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat[CC]	Winter wheat[CC]	Winter wheat	Winter wheat

[CC]Catch crop

"Active" N

- Ammonium
- Nitrate
- Mineralizable N
- Biomass N

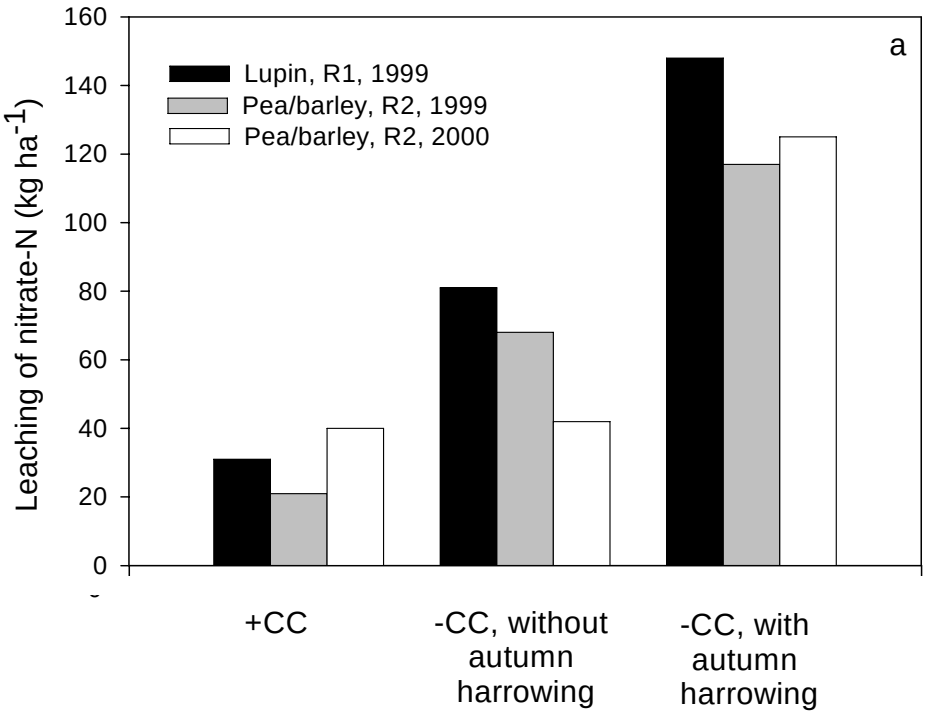
10 mg N kg^{-1} ~
30-40 kg N ha^{-1}
in plough layer



(data: J.E. Olesen et al., 2005)

Management and N dynamics

- Tillage in autumn can increase N leaching
- Catch crops can reduce N leaching
- Fate of N in catch crops?

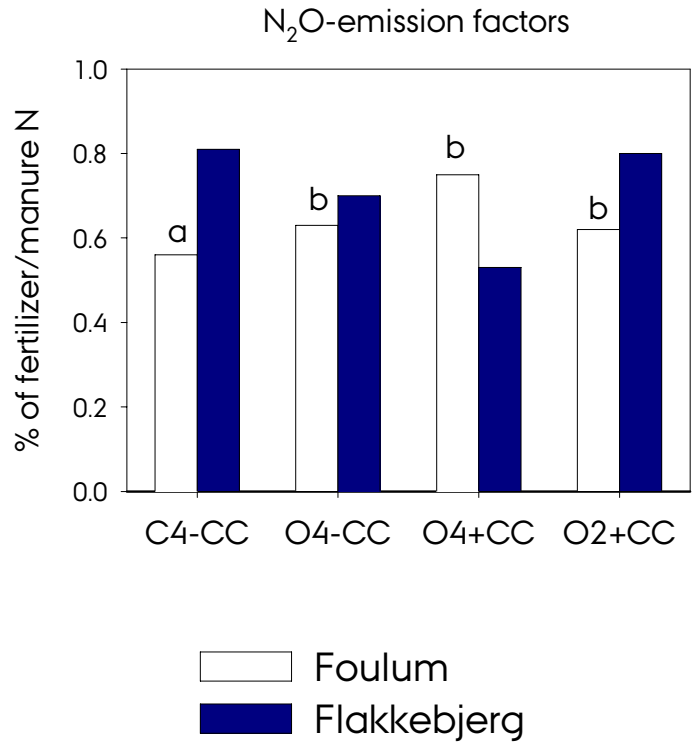


AARHUS
UNIVERSITET

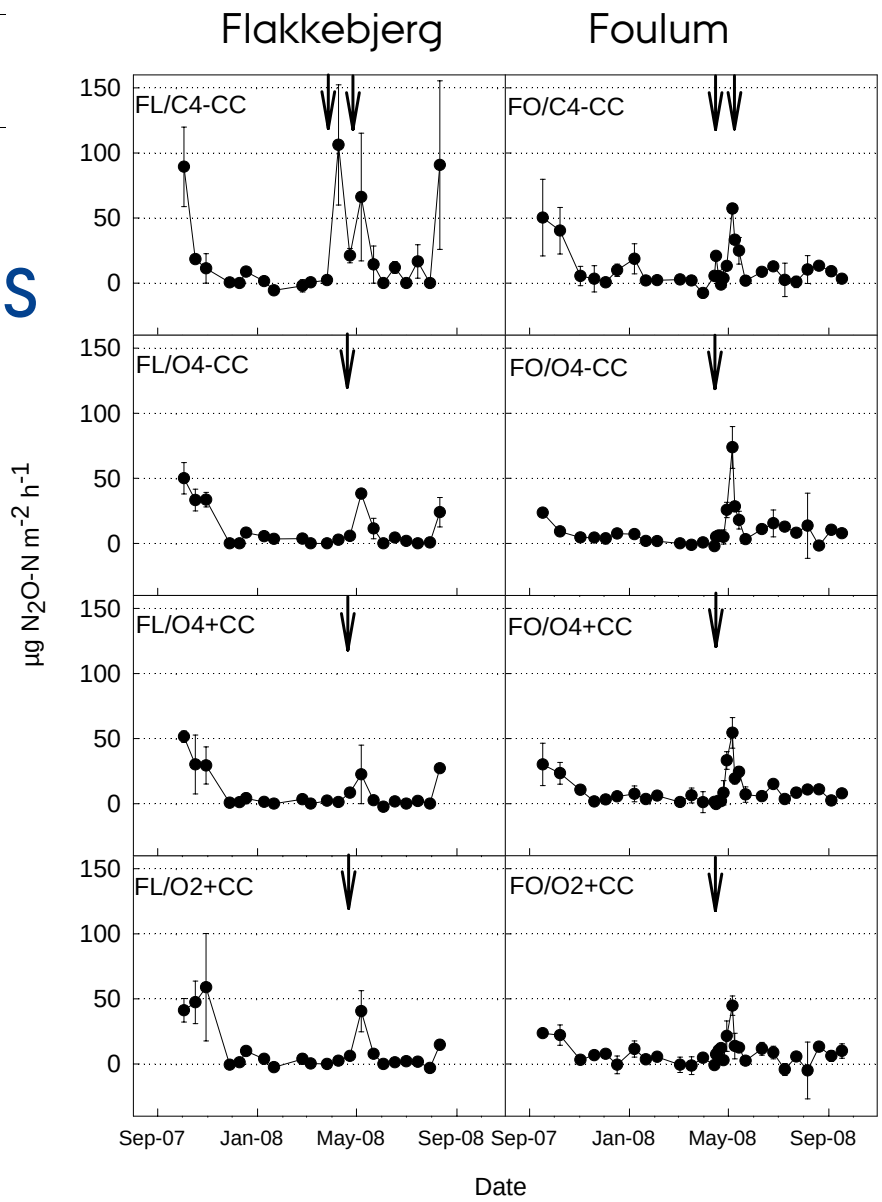
	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course	1	S. barley:ley	S. barley[CC]	S. barley	S. barley
2005-2008	2	Grass-clover	Pea/barley[CC]	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat[CC]	Winter wheat[CC]	Winter wheat	Winter wheat

[CC]Catch crop

N_2O: Seasonal trends



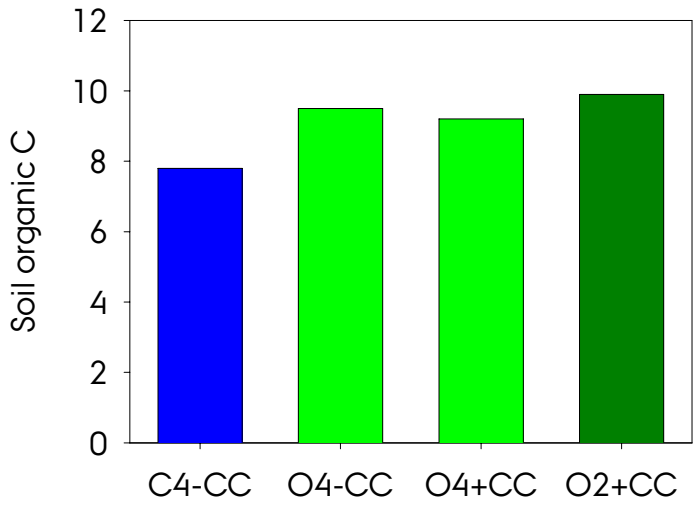
(data: Chirinda et al.)



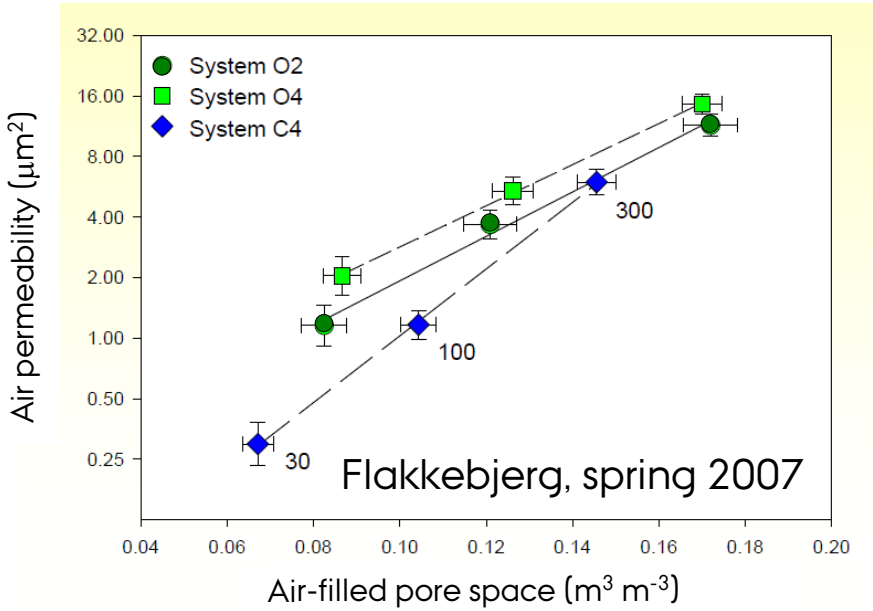
(data: P. Schjønning)

N_2O emission potential

SOM (amount, quality, distribution)



Soil-atmosphere gas exchange



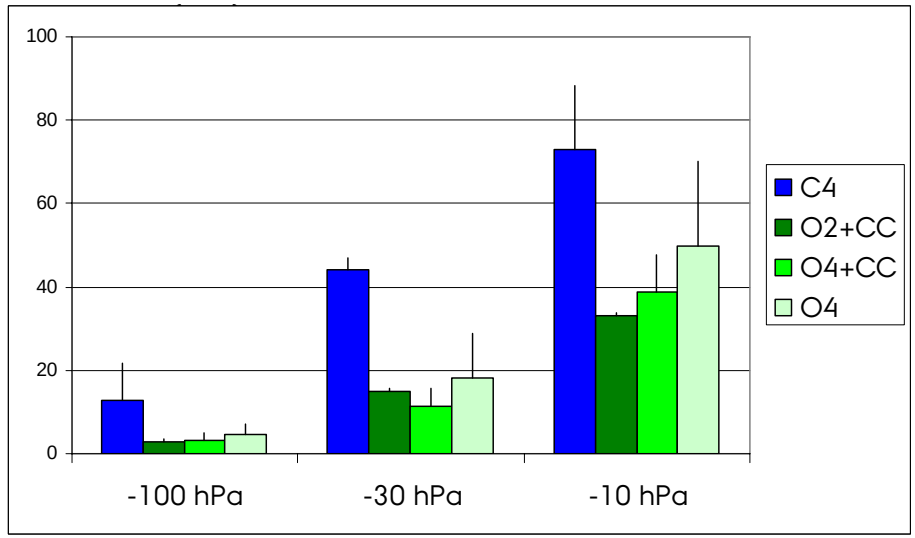
N_2O emission potentials (Flakkebjerg)

O2 +CC

O4 -CC

O4 +CC

C4 -CC



O2^{CC} - Forage crop rotation with grass-clover as green manure

	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course	1	S. barley:ley	S. barley^{CC}	S. barley	S. barley
2005-2008	2	Grass-clover*	Pea/barley^{CC}	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat^{CC}	Winter wheat^{CC}	Winter wheat	Winter wheat

^{CC}Catch crop

* Grass-clover green manure - cut or retained

AARHUS
UNIVERSITET

	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course 2005-2008	1	S. barley:ley *	S. barley[CC]	S. barley	S. barley
	2	Grass-clover	Pea/barley[CC]	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat[CC]	Winter wheat[CC]	Winter wheat	Winter wheat

[CC]Catch crop
* Grass-clover green manure - cut or retained

Grass-clover management

- Strategy 1: Cuts exported for biogas treatment and use in other crops (+M)
- Strategy 2: Cuts left for in-field decomposition (-M)

AARHUS
UNIVERSITET

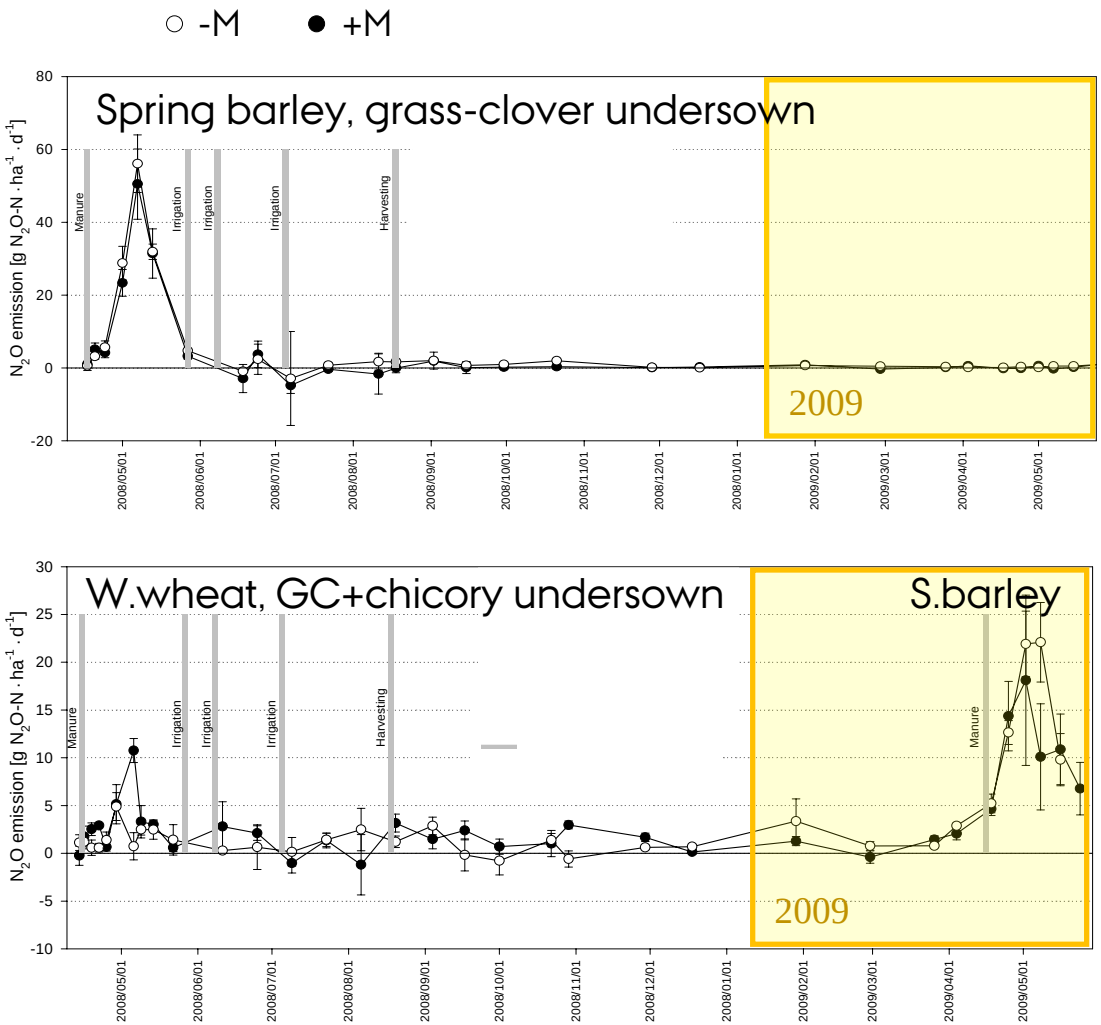
	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course 2005-2008	1	S. barley:ley *	S. barley[CC]	S. barley	S. barley
	2	Grass-clover	Pea/barley[CC]	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat[CC]	Winter wheat[CC]	Winter wheat	Winter wheat

[CC]Catch crop
* Grass-clover green manure - cut or retained

Grass-clover green manure

- No effect of digested slurry on N_2O
- High N_2O emissions due to green-manure decomposition?

(data: M.A. Brozyna et al.)



AARHUS
UNIVERSITET

	Field	O2 organic	O4 organic	O4 organic	C4 conventional
3rd course 2005-2008	1	S. barley:ley *	S. barley[CC]	S. barley	S. barley
	2	Grass-clover	Pea/barley[CC]	Pea/barley	Pea/barley
	3	Potato	Potato	Potato	Potato
	4	Winter wheat[CC]	Winter wheat[CC]	Winter wheat	Winter wheat

[CC]Catch crop
* Grass-clover green manure - cut or retained

(data: M.A. Brozyna et al.)

Grass-clover management

› Grass-clover green manure treatment in biogas digester tends to:

- enable targeted application
- increase N availability of green manure
- Improve crop yields

	N2O emissions [gN_2O-N * ha^{-1} * yr^{-1}]		Yields 2008 [kgN * ha^{-1}]	
	+ M	- M	+ M	- M
W.wheat	538.6	451.9	94.9 (1.0)	60.4 (0.7)
S.barley	849.1	1157.7	99.5 (5.3)	89.9 (4.7)
Grass-clover	272.9	468.1	273.0 (24.4)	-
Potato	1205.6	1447.1	134.9 (2.2)	119.3 (17.6)

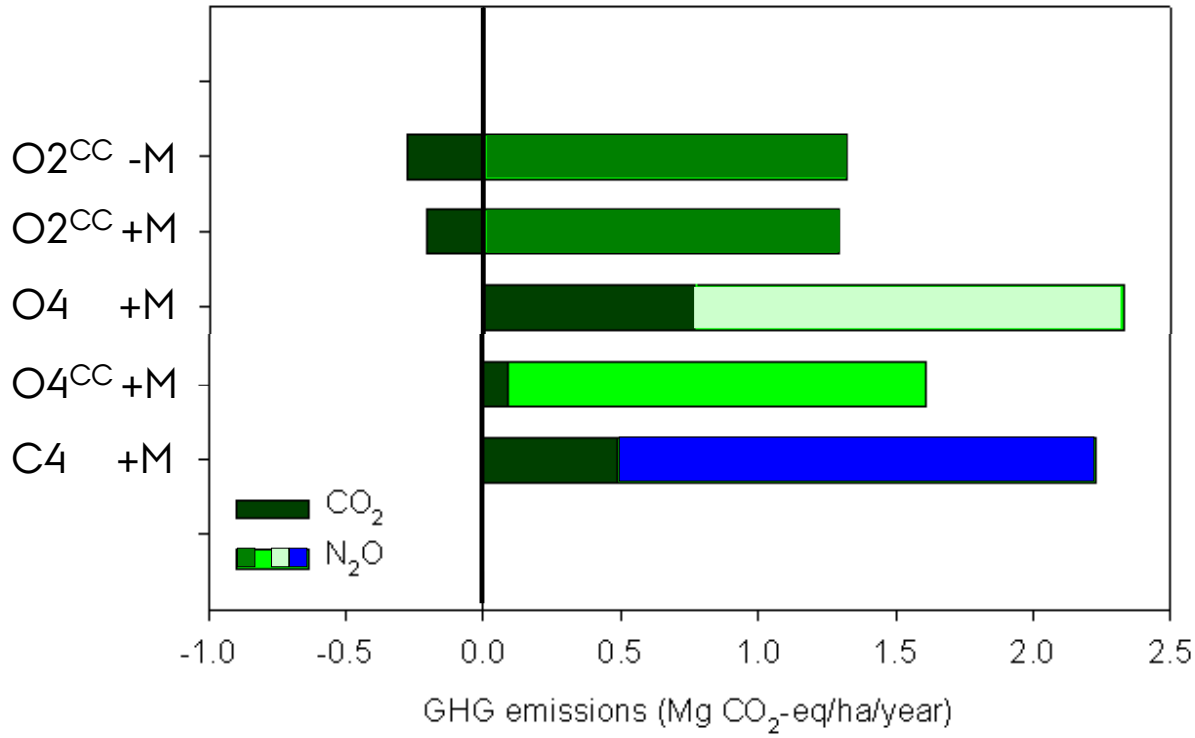
(data: J.E. Olesen)

GHG balance of cropping systems (calculated)

Org. forage crop rot.

Org. cash crop rot.

Conv. cash crop rot.



Conclusions

- N use efficiency and GHG balance closely linked
- Consistent effects of cropping system across soil types
- The potential of soils to accumulate ”active” N very different
- Limited effect of catch crops on N_2O emissions, but tends to improve C storage
- Reallocation of N in grass-clover green manure improves N use efficiency

Acknowledgements

› Ngonidzasche Chirinda
› Mette Sustmann Carter
› Michal A. Brozyna
› Per Schjønning
› Per Ambus
› Margrethe Askegaard
› Jørgen E. Olesen