Greenhouse gas emissions from organic farming systems in Denmark

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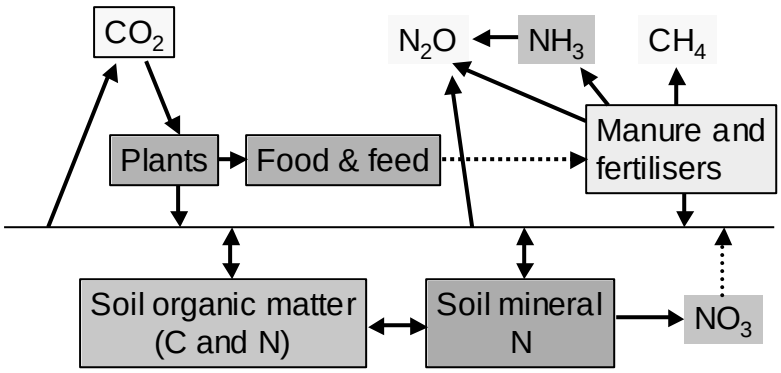
Characteristics of farming systems

- ✓ **Conventional**
  - ✓ Crop rotation: Cash crops
  - ✓ N inputs: Mineral N fertiliser (possibly manure)
  - ✓ Crop protection: pesticides to control weeds, pests, diseases
- ✓ **Organic**
  - ✓ Crop rotation: Cash crops in combination with green manures and N-fixing cover/catch crops
  - ✓ N inputs: Manure and N-fixation
  - ✓ Crop protection: mechanical weed control

Greenhouse gas emissions



Crop rotation experiment at Foulum

Experimental factors

Experimental factors (1997-2004):

- Production system (organic with and without grass-clover as green manure)
- Catch crops (with: +CC, without: -CC)
- Manure (with: +M, without: -M)

Experimental factors (2005-2008):

- Production system (conventional, organic with and without green manure)
- Catch crops (with: +CC, without: -CC)
- Manure/fertiliser (with: +M, without: -M)

Experimental treatment combinations

Crop rotation	Production system	-CC +M	+CC -M	+CC +M
Org-GM	Green manure-cash crop-organic	X	X	X
Org-Cash	Cash crop-organic	X	X	X
Conv	Cash crop-conventional	X		X

M: animal manure (organic) or mineral fertilizer (conventional).
CC: catch crop, '+' is with catch crop and '-' is without catch crop.

Crop rotations

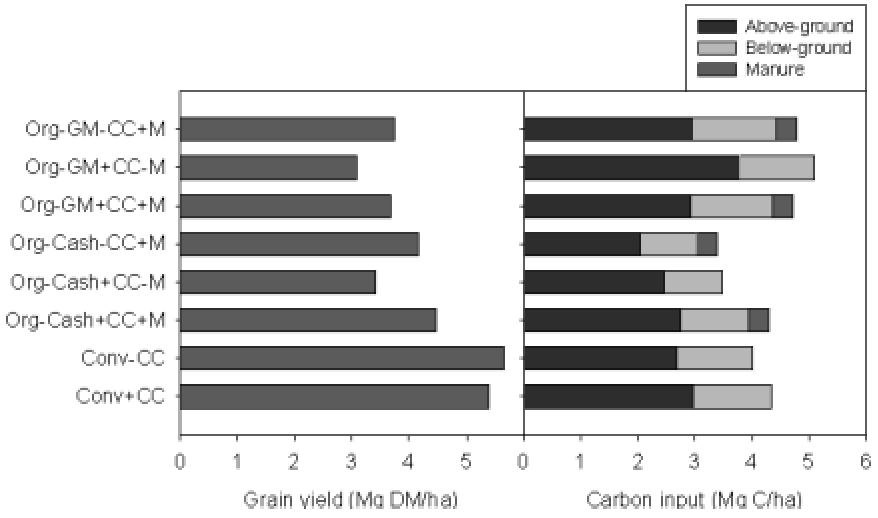
	Field	Org-GM	Org-Cash	Conv
1st course 1997-2000	1	S. barley:ley	Spring oat[CC]	
	2	Grass-clover	Winter wheat[CC]	
	3	Winter wheat[CC]	Winter cereal[CC,1]	
	4	Pea/barley[CC]	Pea/barley[CC]	
2nd course 2001-2004	1	S. barley:ley	Winter wheat[CC]	
	2	Grass-clover	Spring oat[CC]	
	3	Winter wheat[CC]	S. barley[CC]	
	4	Lupin/barley[CC]	Lupin	
3rd course 2005-2008	1	S. barley:ley	S. barley[CC]	S. barley[CC]
	2	Grass-clover	Faba bean[CC,2]	Faba bean[CC,2]
	3	Potato	Potato	Potato
	4	Winter wheat[CC,3]	Winter wheat[CC,3]	Winter wheat[CC,3]

N-fixing catch crops in organic crop rotations (Org-GM and Org-Cash)
Non N-fixing catch crops in the conventional rotation (Conv)

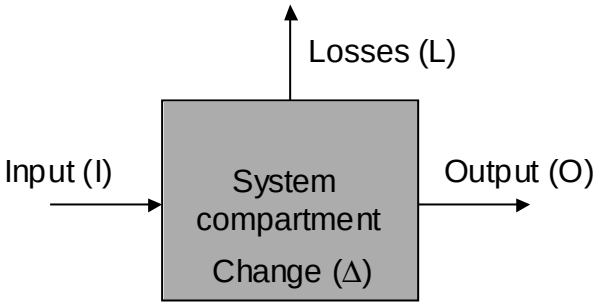
Measurements

- ✓ **C and N input**
  - ✓ Manure (rate and contents)
  - ✓ Mineral fertiliser (rate and contents)
  - ✓ N-fixation estimated from measured N in legume biomass (Høgh Jensen et al., 2004)
  - ✓ Deposition (standard site value for wet and dry deposition)
- ✓ **C and N off-take**
  - ✓ Cash crops (yield and contents)
  - ✓ Grassland cuts (yield and contents)
- ✓ **N losses**
  - ✓ N leaching (suction cells at Foulum)
  - ✓ Nitrous oxide (static chamber measurements + IPCC methodology)

Grain yield and carbon input

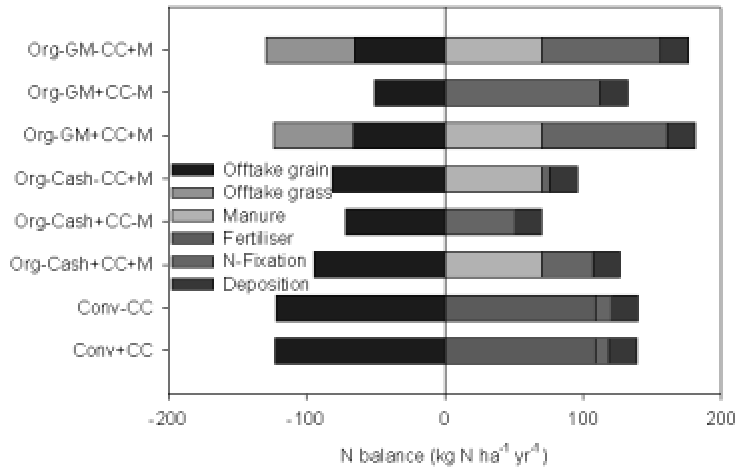


Nitrogen balances

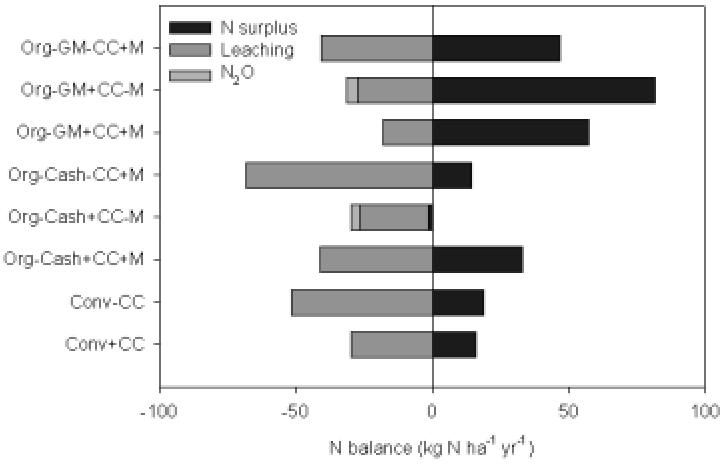


Surplus: $S = I - O = \Delta + L$
Efficiency: O/I
Losses: $L = S - \Delta$

Nitrogen balance



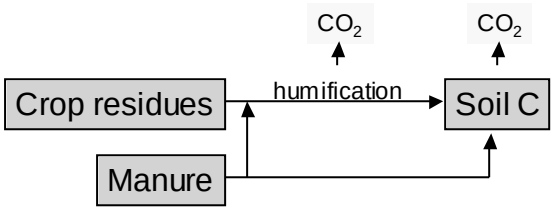
N balance and measured losses



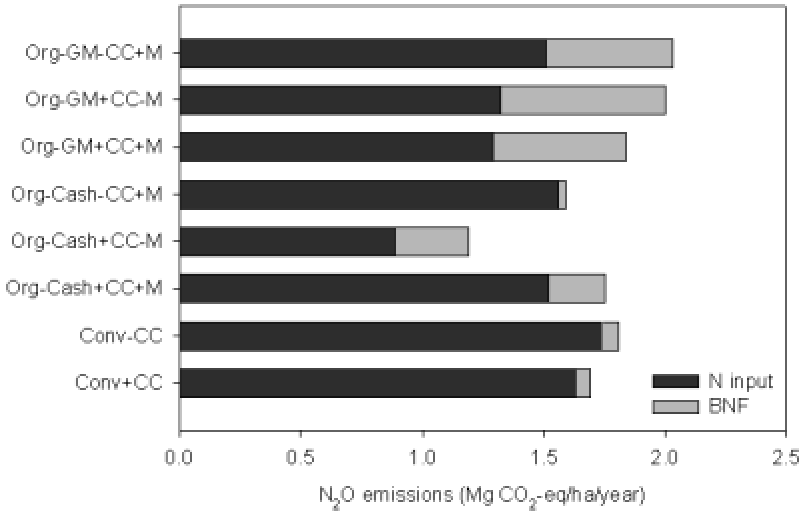
Simple soil carbon model

$$\frac{dC}{dt} = hA - kC$$

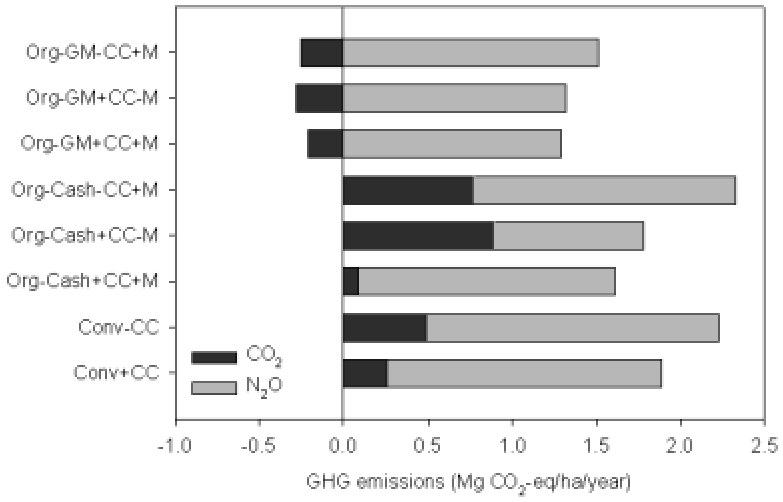
C is the content of carbon in soil (t C ha^{-1})
t is time (year)
k is the turnover rate (yr^{-1})
h is the humification constant (0.20 for residues, 0.35 for manure)
A is the amount of crop residues (t C ha yr^{-1})



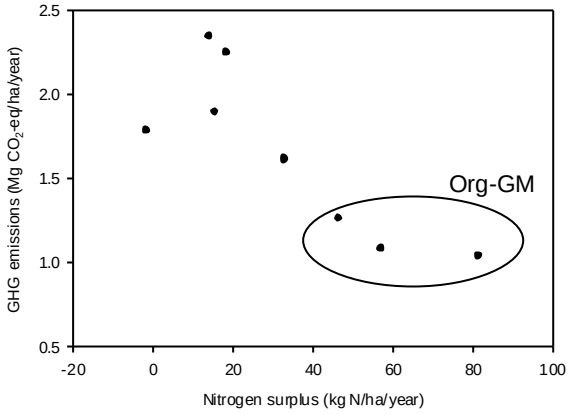
N_2O emissions without and with BNF



GHG emissions (net CO_2 and N_2O)

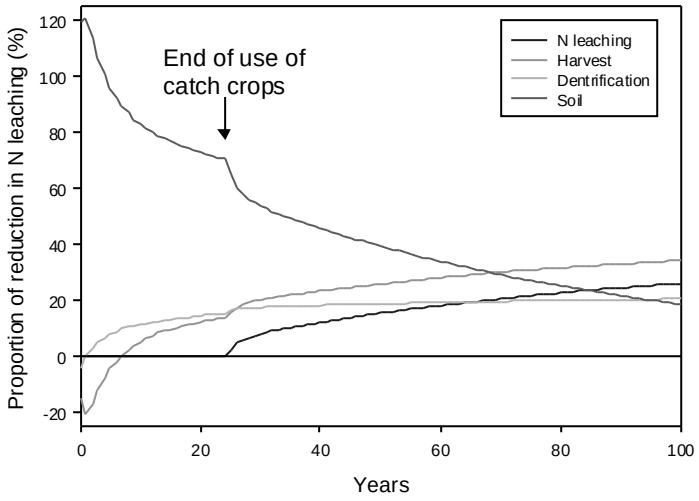


GHG emissions decline with increasing N surplus



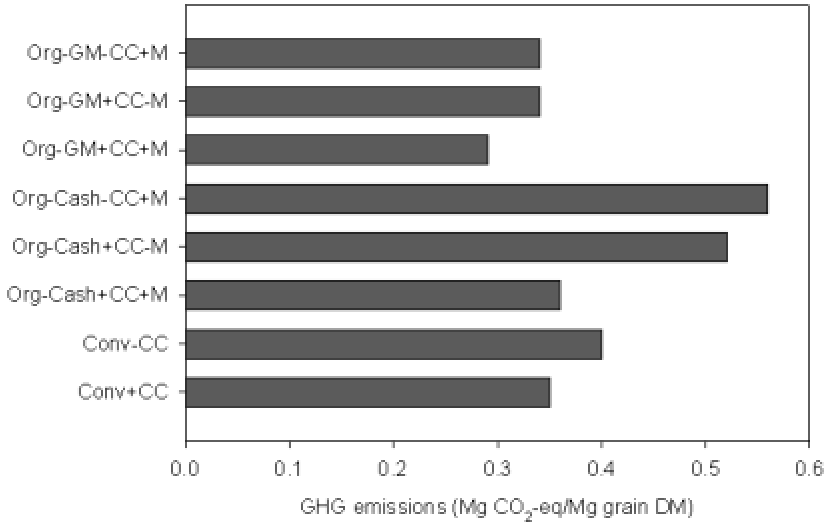
Increasing N surplus in this systems generally mean higher C storage

Fate of reduced N leaching from use of catch crops



Simulation study using the FASSET model

GHG emissions per unit product (grain)



Conclusions

- ✓ **Components of GHG emissions**
  - ✓ Soil carbon storage is important in organic systems with catch crops, green manure crops (grasslands) and animal manure
  - ✓ Important to consider whether BNF itself contributes to N_2O
  - ✓ What is the long-term effect of increasing soil organic matter (C+N) storage?
- ✓ **GHG emissions per unit area**
  - ✓ Smallest emissions from organic systems with green manure
  - ✓ Use of catch crops reduces emissions in systems without green manure
- ✓ **GHG emissions per unit product**
  - ✓ Little difference between systems, except for the organic cash crop systems, which have high emissions, unless both manure and catch crops are used