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Crop rotation and crop management effects on cereal yields in arable organic farming in Denmark

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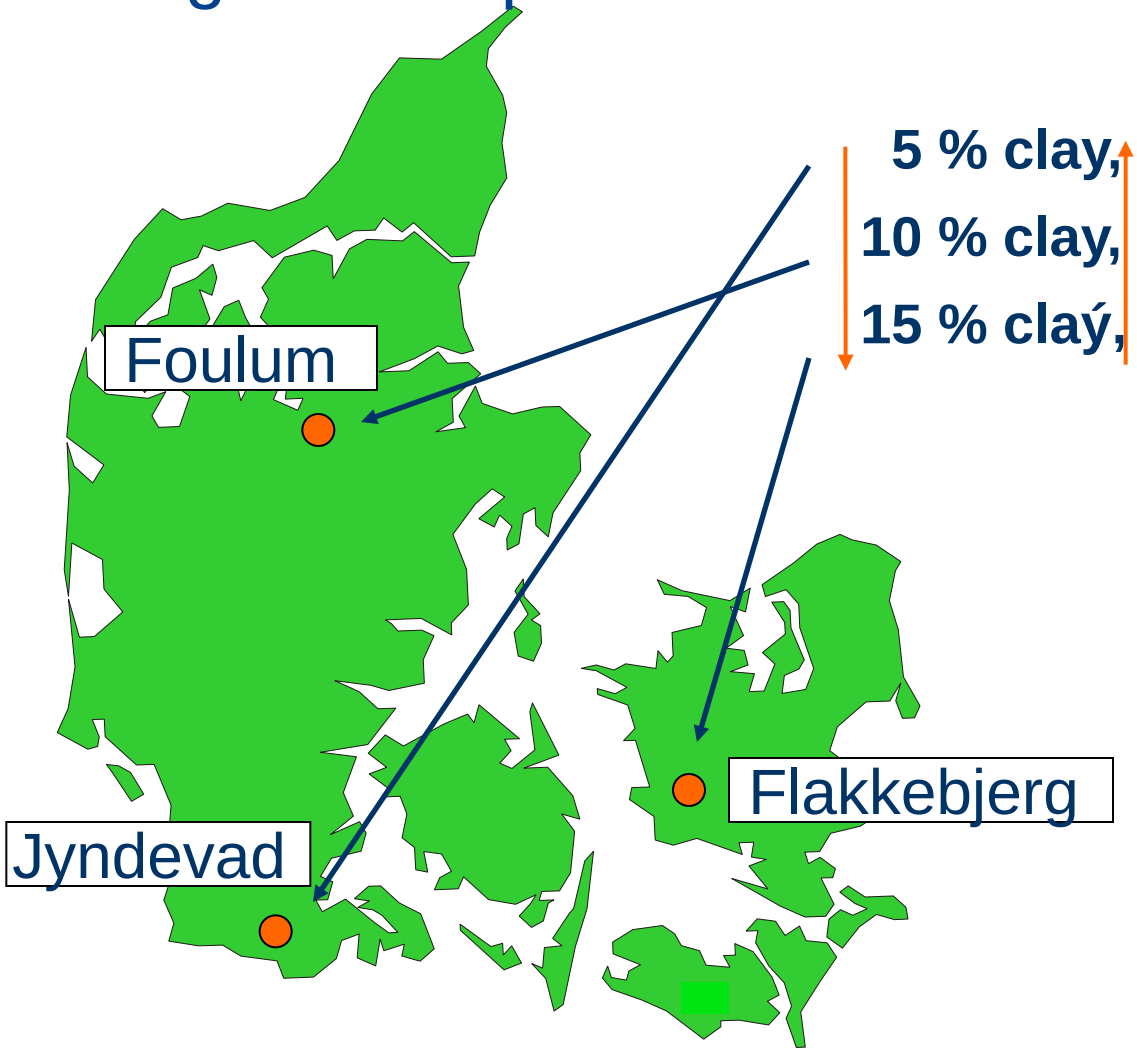
Long-term experiments with arable crop rotations



5 % clay, 950 mm

10 % clay, 700 mm

15 % claý, 600 mm

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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)

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Experimental treatment combinations (since 2005)

Crop rotation	Production system	-CC +M	+CC -M	+CC +M
O2	Green manure-cash crop-organic	X	X	X
O4	Cash crop-organic	X	X	X
C4	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.

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Crop rotations

	Field	O2	O4	C4
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 (O2 and O4)
Non N-fixing catch crops in the conventional rotation (C4)

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Nitrogen input in the O2 rotation

Source	S. barley	Grass-clover	Potato	W. wheat	Mean
Without manure (-M)					
Manure	0	0	0	0	0
Crop residues	33	343	70	40	122
Catch crop	0	0	0	78	20
Total input	33	343	70	118	141
With manure (+M)					
Manure	61	0	112	107	70
Crop residues	53	38	90	33	54
Catch crop	0	0	0	63	16
Total input	114	38	203	202	139

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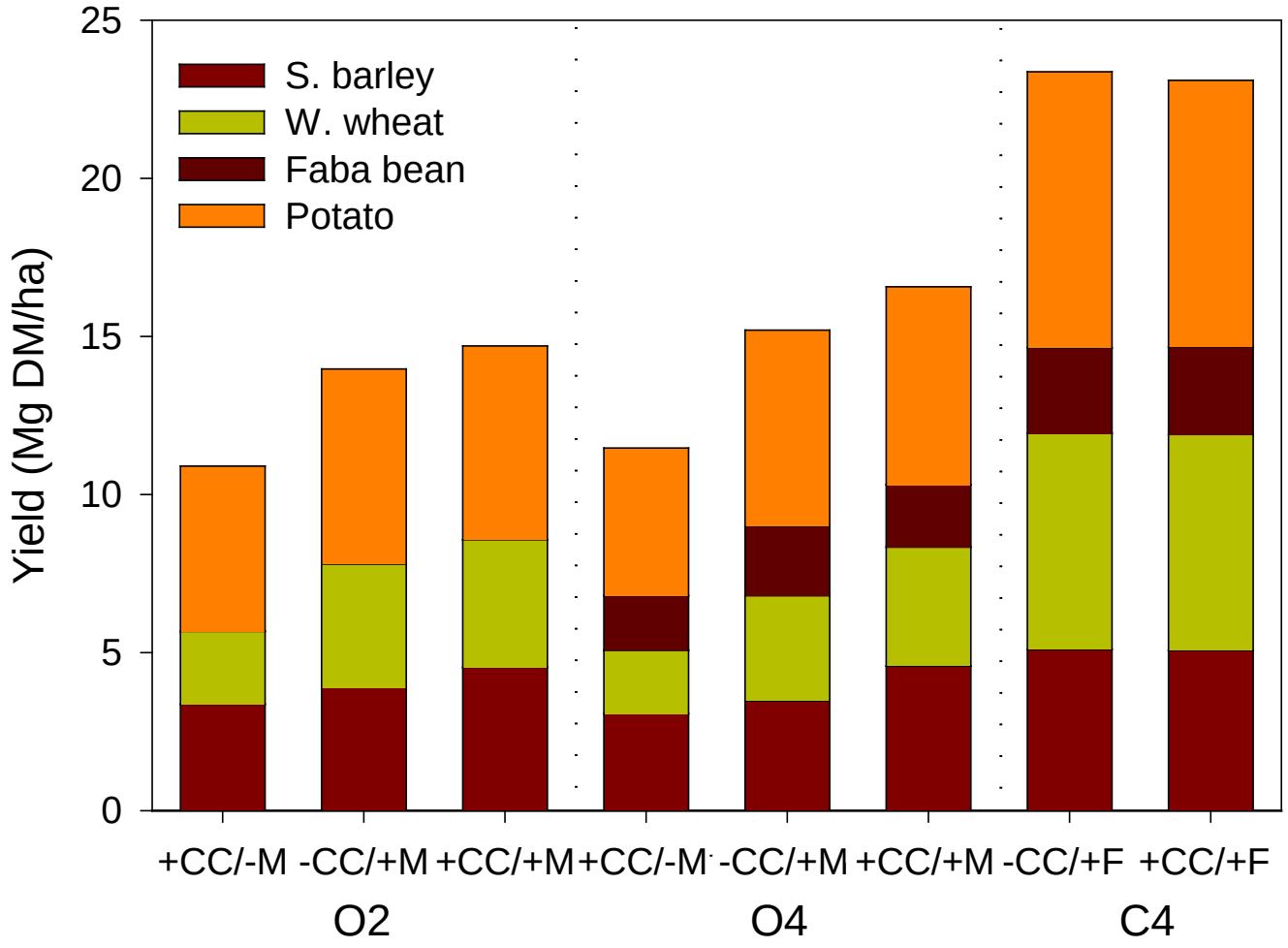
Yields (2006-08)



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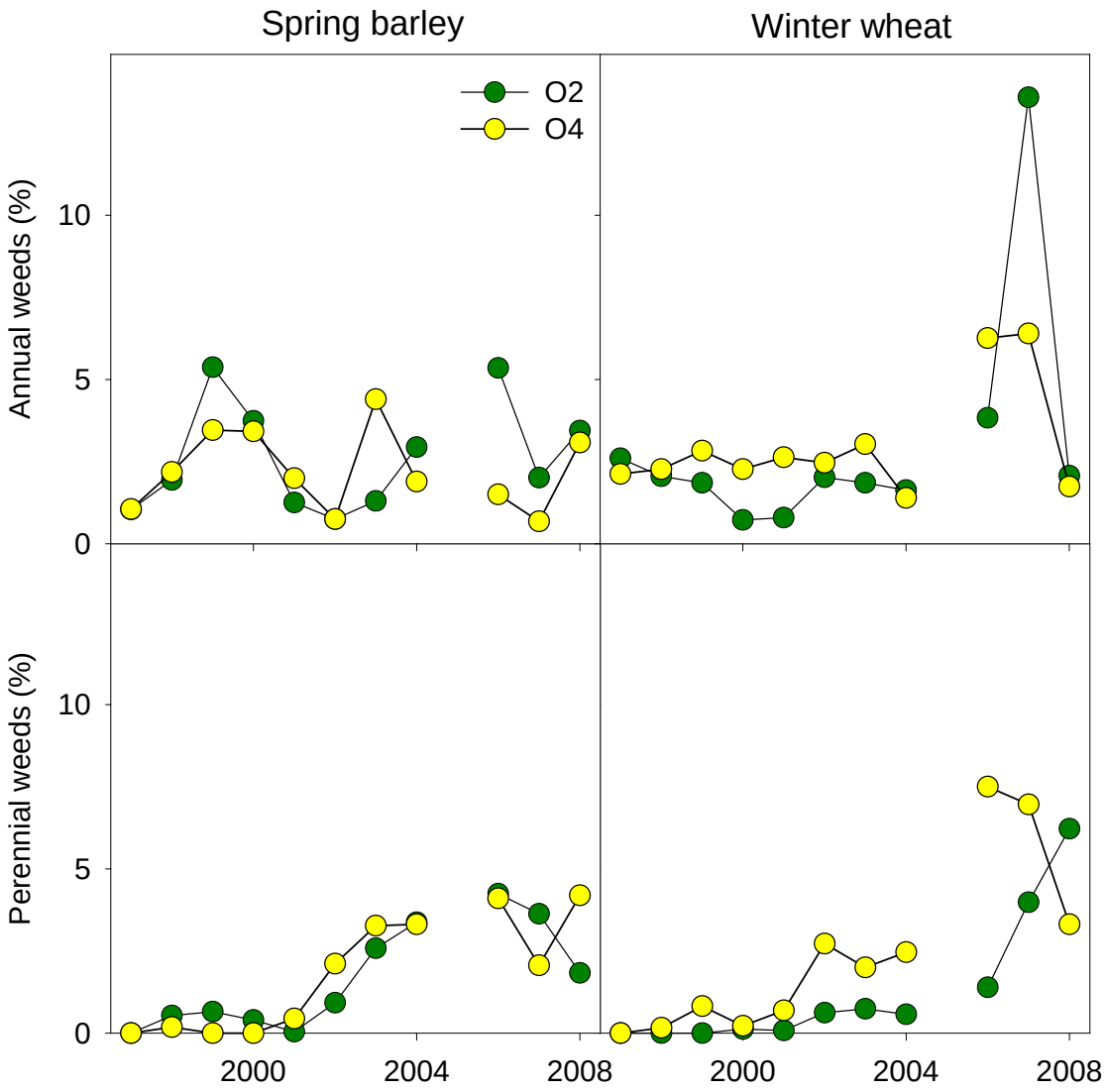
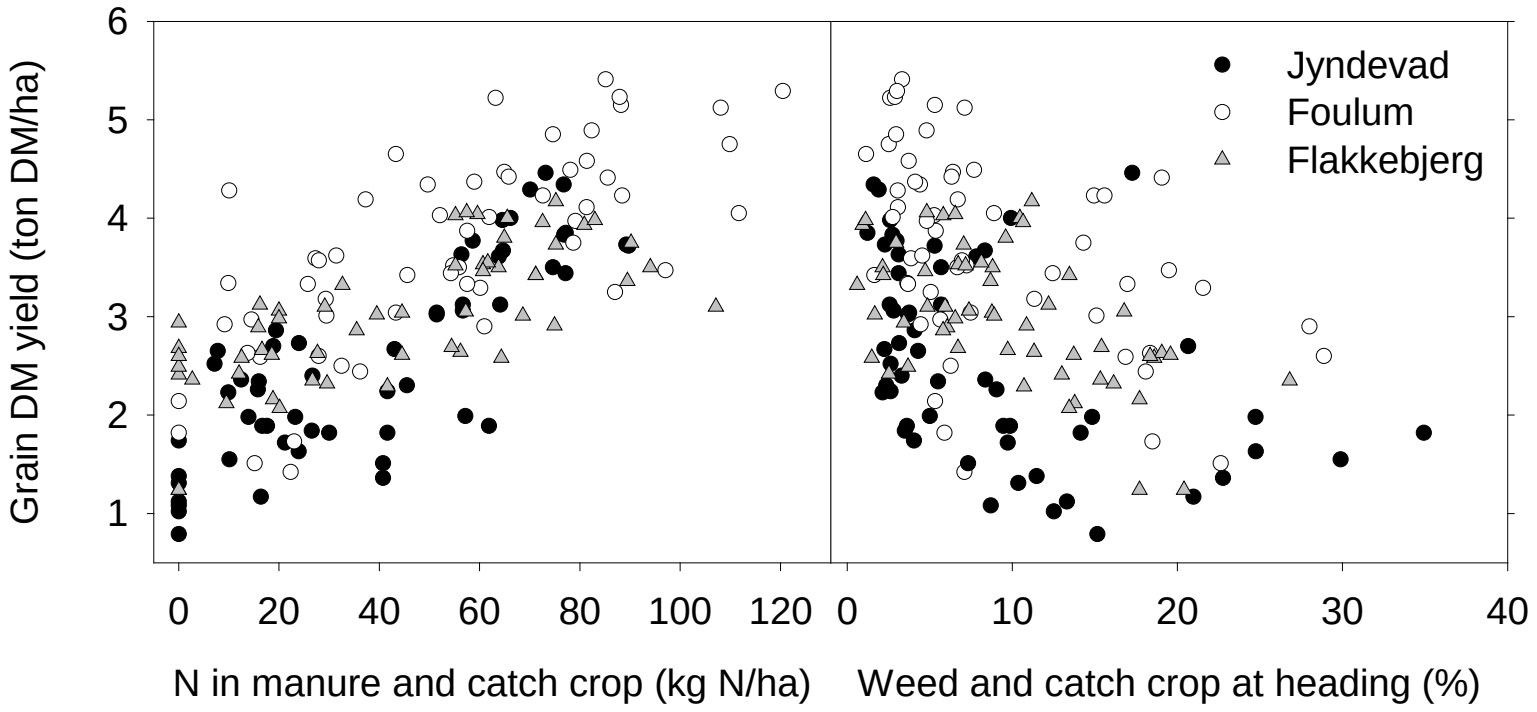
Weeds (% of total biomass at anthesis)



S. barley yield depends on N supply and weeds



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Estimates of yield effects from the experimental data

- Statistical analysis of data:
  - Effect of ammonium-N in manure on cereal yields
  - Effect of catch crops (in the rotation)
  - Effect of grass-clover (as precrop or in the rotation)
  - Effect of weeds (percent of biomass at anthesis)

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Yield responses for winter cereals

	Jyndevad		Foulum		Flakkebjerg	
Manure (kg DM/kg NH_4-N)	19	***	28	***	17	***
Grass-clover pre-crop (kg DM/ha)	1312	**	626	***	858	***
Grass-clover in rotation (kg DM/ha)	162	NS	600	***	778	***
Catch crop in rotation (kg DM/ha)	37	NS	60	NS	105	NS
Weeds (kg DM/% weed)	-14	**	-66	***	-37	**

Levels of significance: NS: P>0.05, *: 0.05>P>0.01, **: 0.01>P>0.001, ***:0.001>P.

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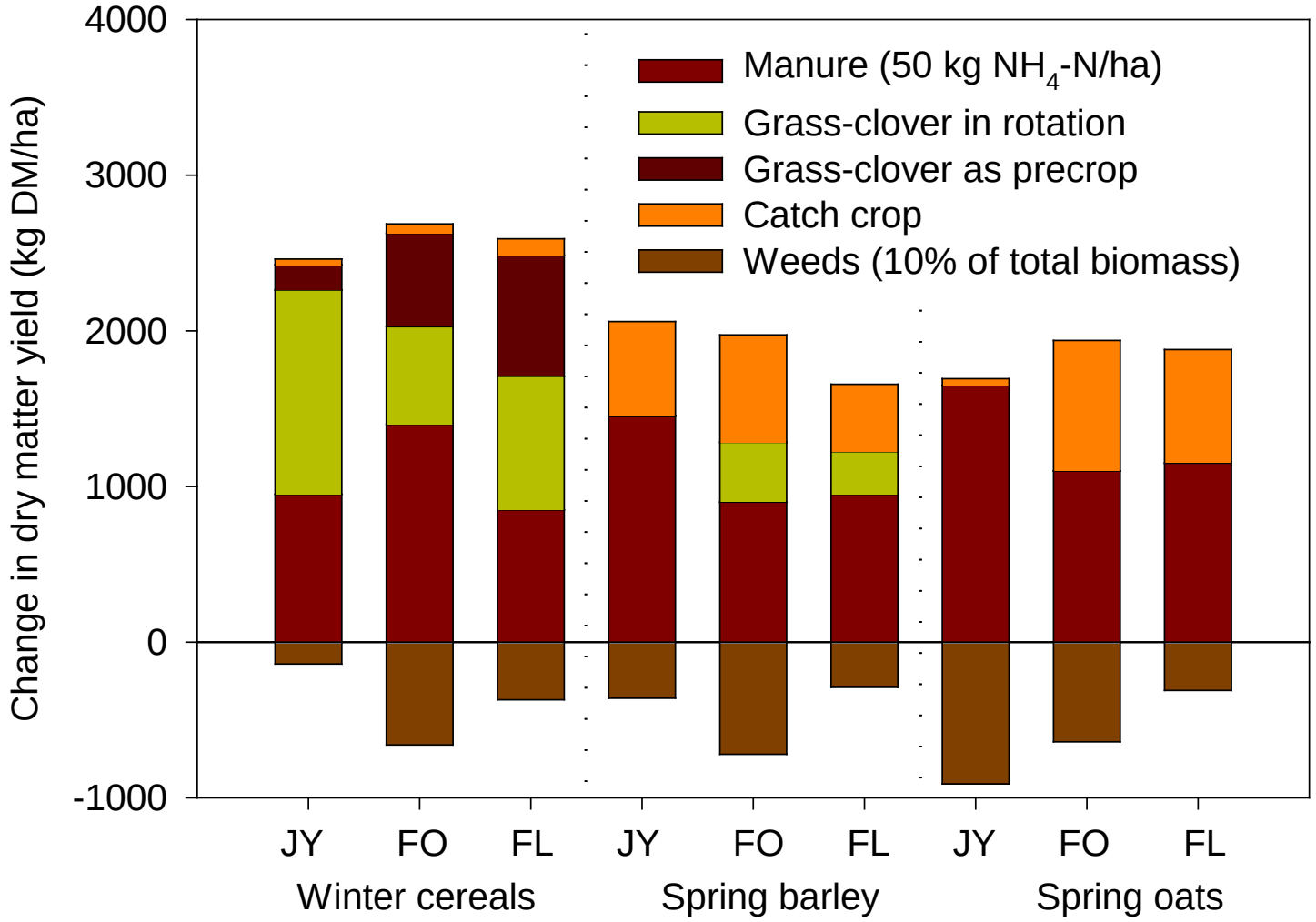
Yield effects of crop rotation and management



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Conclusions

- Manure application is the most important factor for enhancing yields in organic crop production
- Grass-clover and catch crops have both short- and long-term effects on cereal grain yields. This appears higher for grass-clover.
- Weeds provide a long-term challenge to control in cereal systems
- Yields may be further increased by increase the amount of nitrogen available in manure, e.g. through recycling of grass-clover and catch crops for biogas – and such measures may also provide weed control.

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