

# Protein production to reduce environmental impacts

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# European agriculture faces numerous challenges

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## **Productivity**

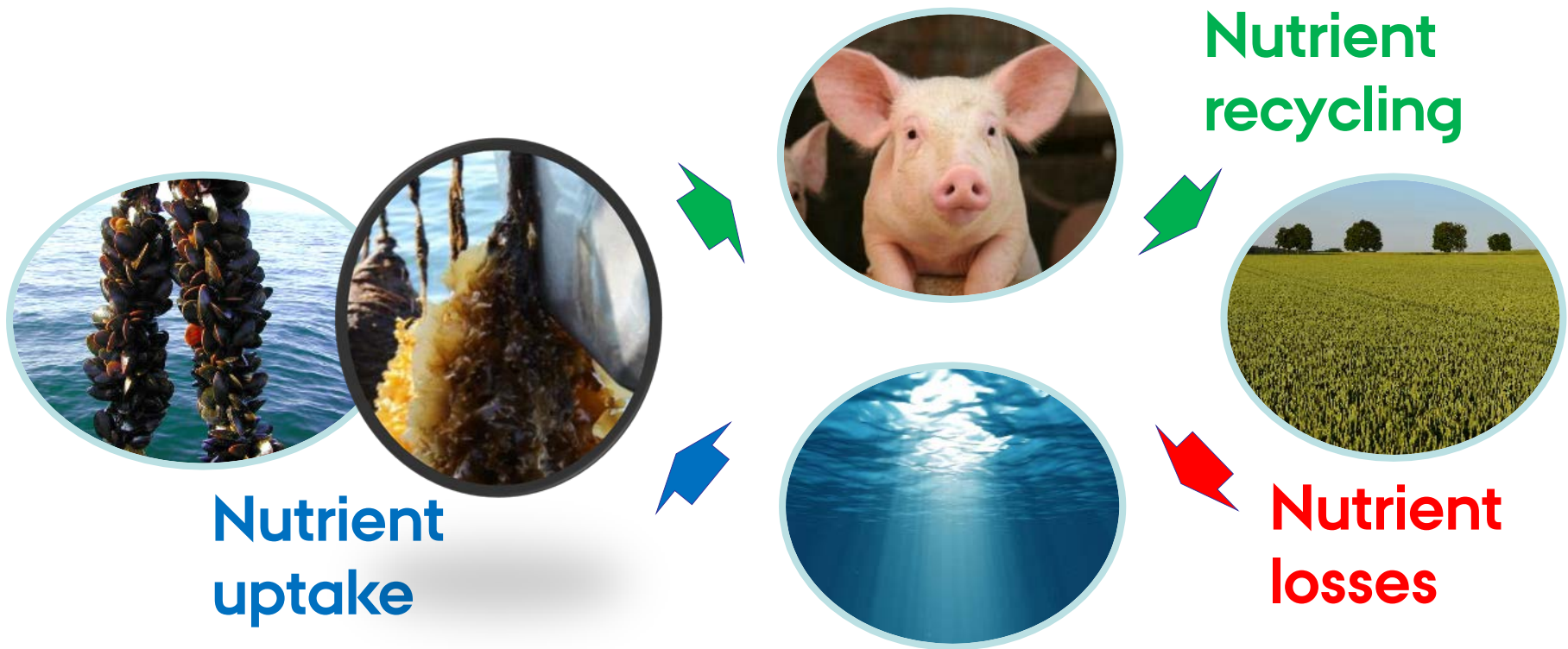
- Biomass for food, feed, material and energy
- Stagnating yields
- Large import of protein feed

## **Environment**

- High nutrient leaching (Nitrate and Water Framework Directives)
- High pesticide use
- Agriculture must contribute to EU climate goals (EU climate policy)

**Time to look for radical innovation instead of incremental**

# New business on mussels and starfish is trying to close the nutrient cycle

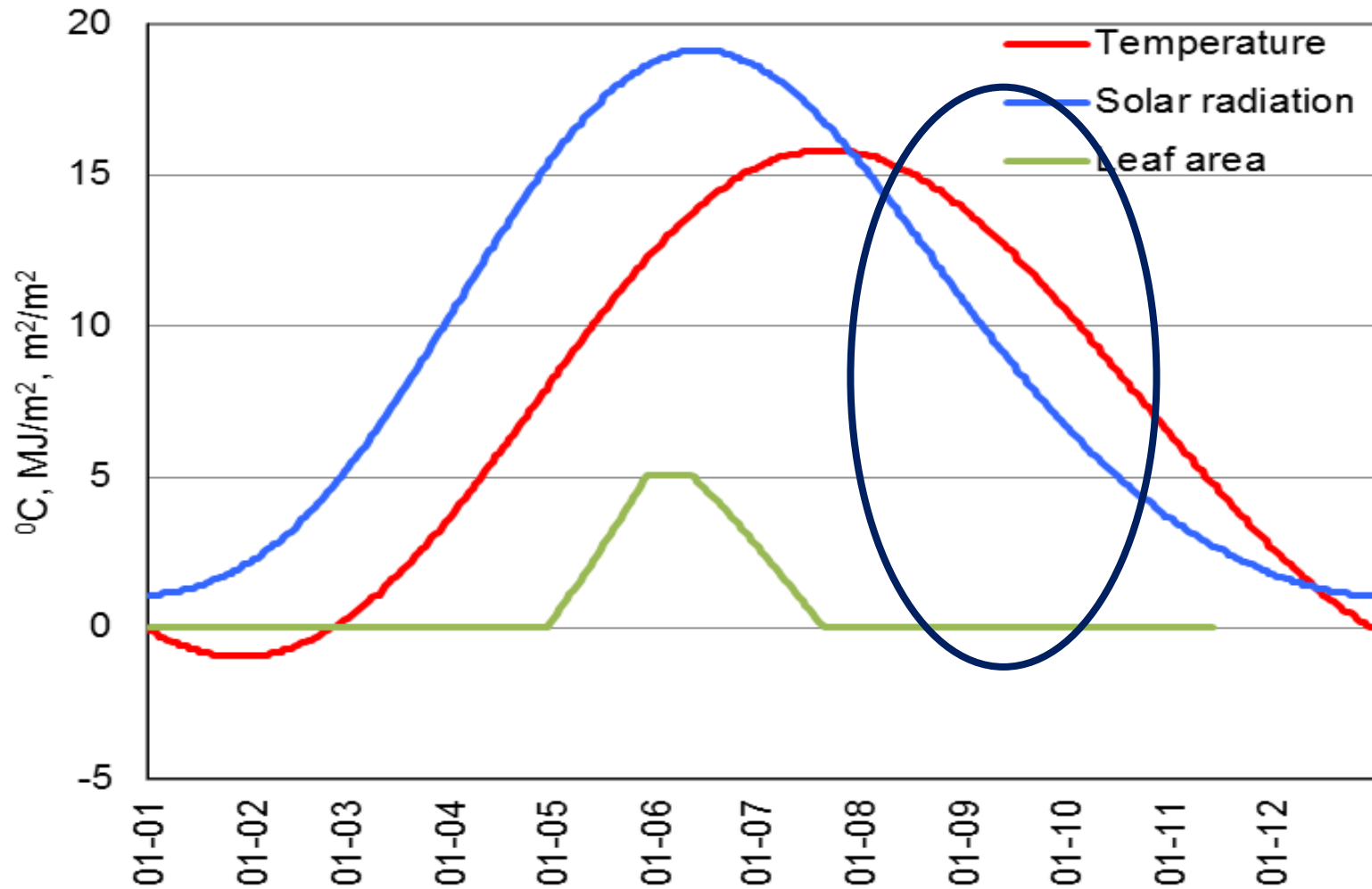


# New land-based product chains can increase productivity & reduce N-losses significantly



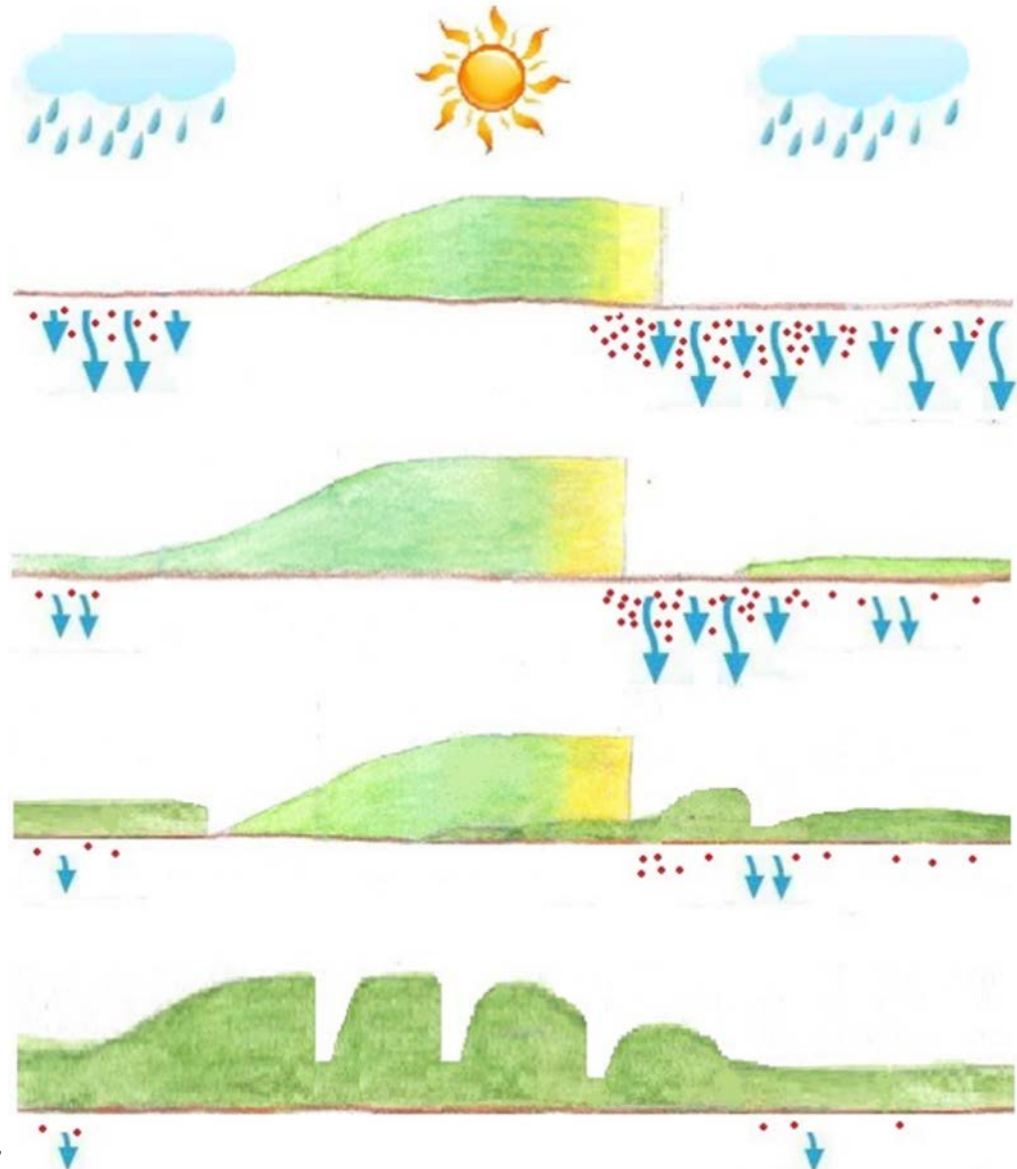
# Grain crops utilize only part of the growing season

Case: spring barley in Denmark



# Tightening the nitrogen (N) cycle

- ↓ Soil water (drainage)
- Soil nitrate (leaching)



# Production systems designed to cover the whole year investigated

## Optimized Crop Rotation

- Energy maize + Winter rye (direct sowing end October)
- Energy beets
- Hemp + Triticale
- Triticale early harvest (10-15 July) + undersown grass clover (two cuts: autumn and spring)

## Conventional crop rotation

- Cereal crop rotation (2013: spring barley, 2014: winter barley, 2015: winter rape, 2016: winter wheat)

## Permanent crops

- Continuous triticale with straw removal (reference)
- Continuous fodder maize (reference)
- Miscanthus (*M. x giganteus*)
- Miscanthus (*M. sacchariflorus* – Sibirian)
- Tall fescue x perennial ryegrass (*Festulolium*)
- Reed canary grass (*phalaris arundinacea*)
- Tall fescue (*Festuca arundinacea*)
- Cocksfoot grass (*Dactylis glomerata*)
- Grass clover SLU – (Bamse + Hykor + Donata + Lucerne (Alfalfa), *Medicago sativa* CRENO + Alsike clover, *T. hybridum*, FRIDA + White clover, *T. repens*, HEBE + Eastern galega, *Galega orientalis*, GALE)
- Grass clover DLF - (DLF TRIFOLIUM mixture36 (10% white clover+10% festulolium+40% tall fescue+15% ryegrass+10% timoté+10% meadow fescue+5% red fescue)

## Bare soil plots

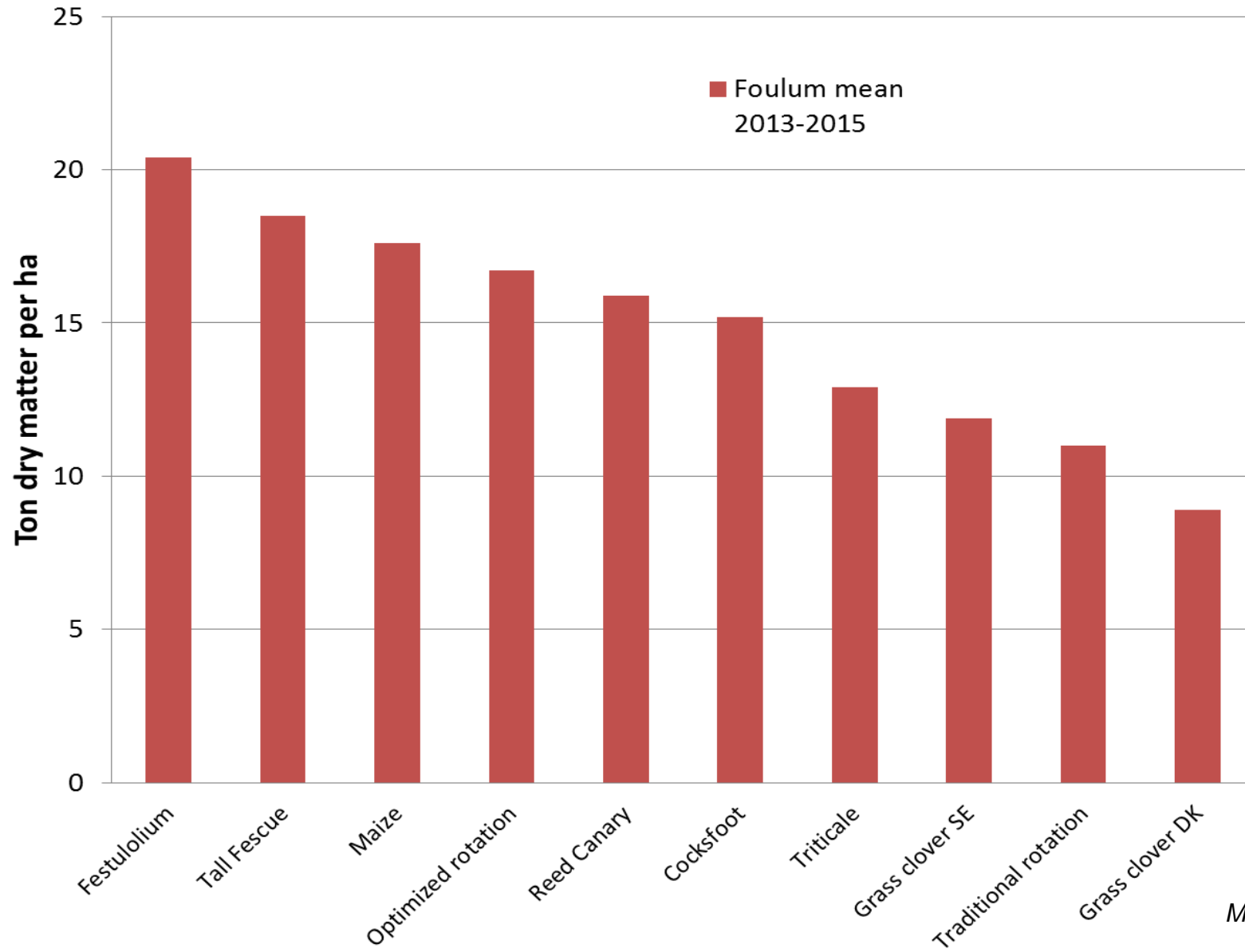
- Mechanical weed control + herbicides
- Herbicides only



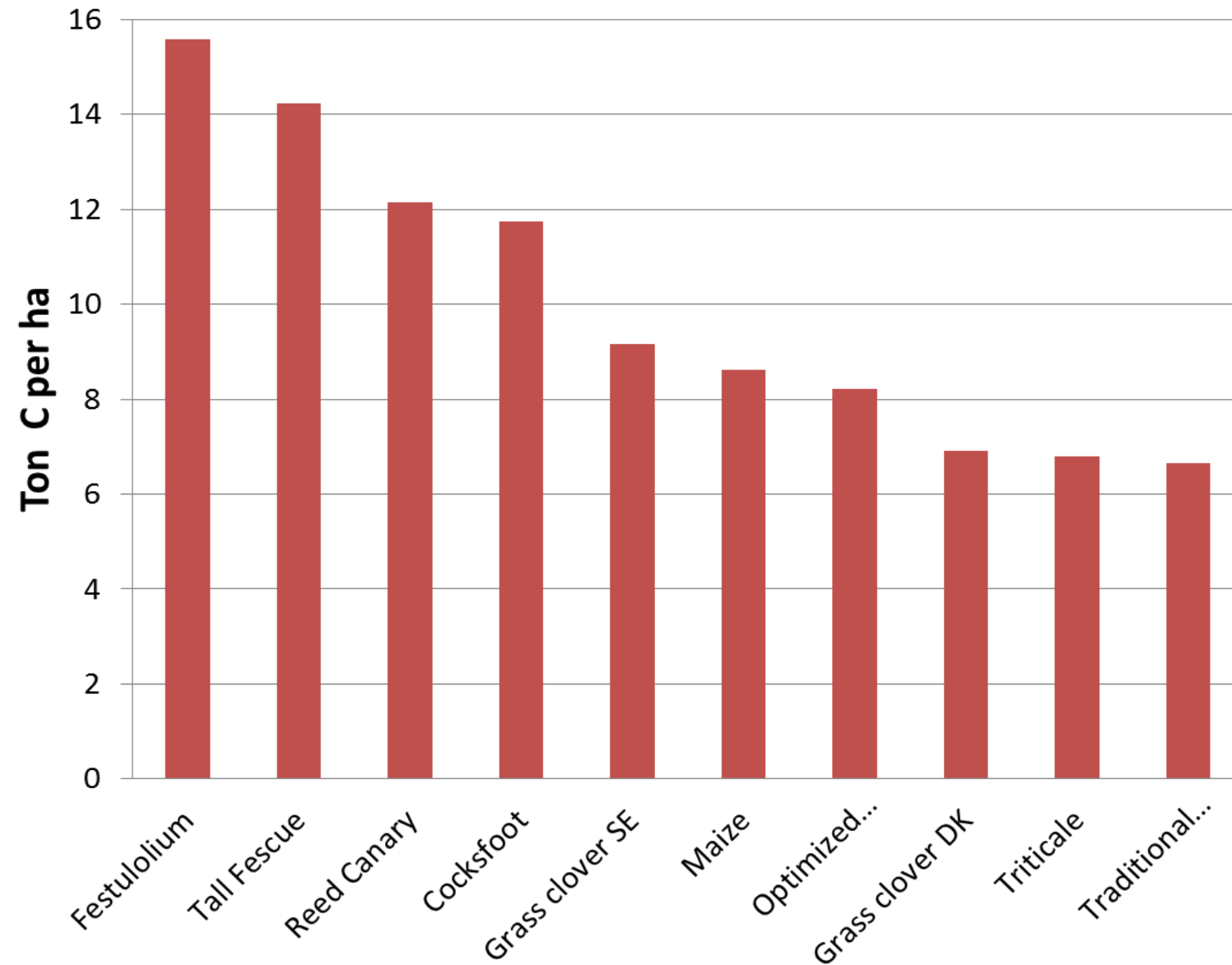




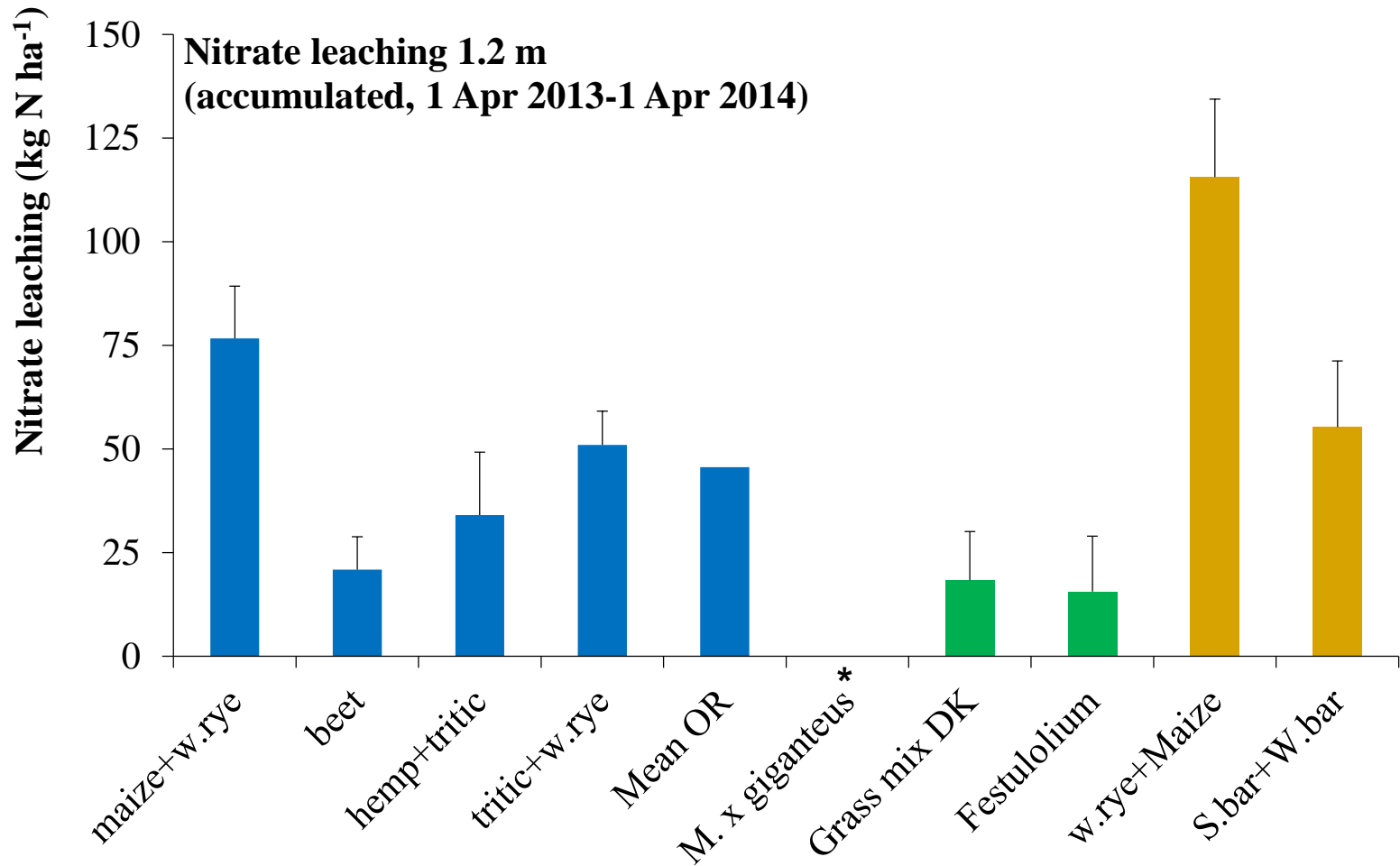
# High variation in total biomass yield



# Maize moves down the range of carbon uptake when roots are included (preliminary data)

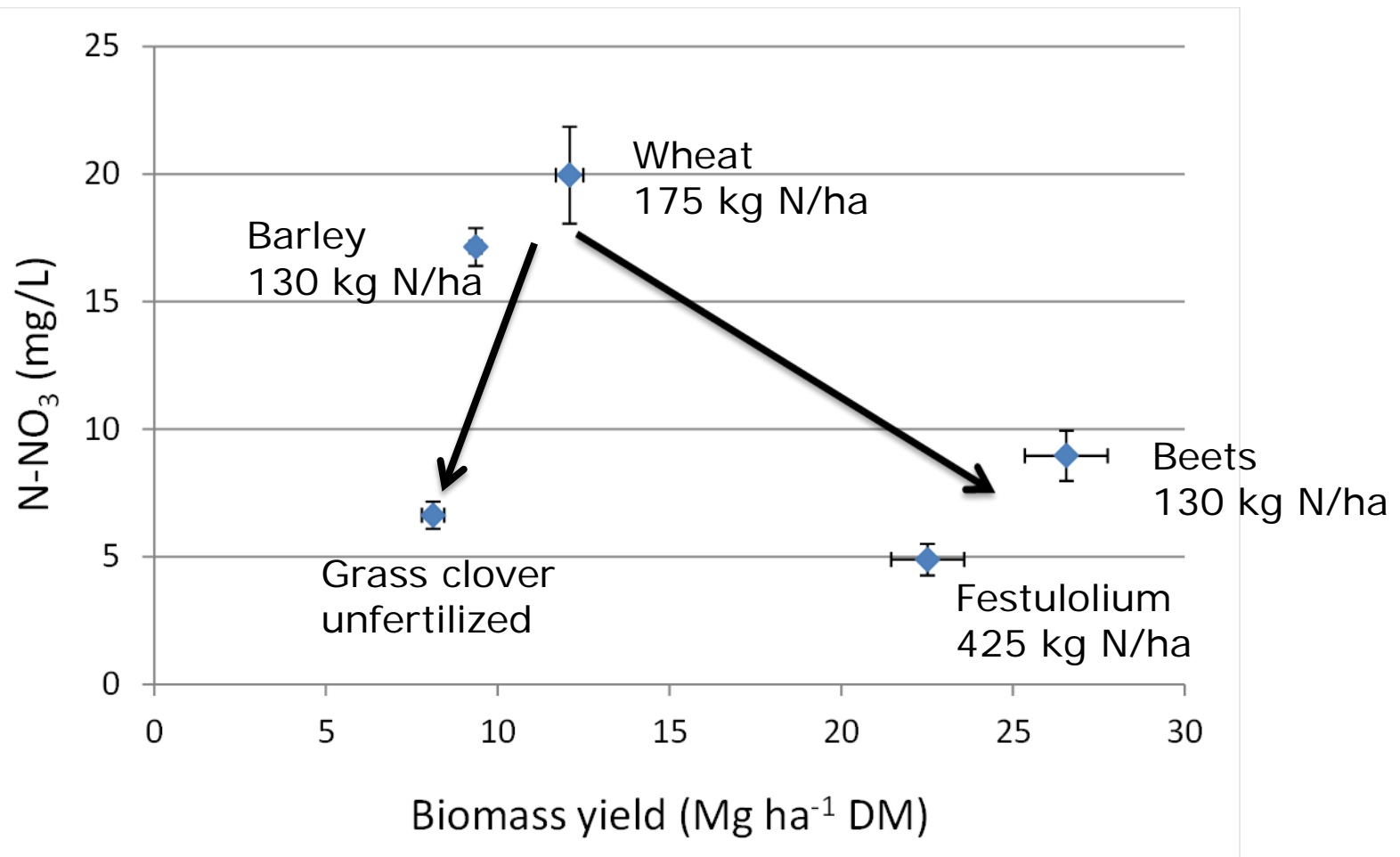


# Cumulated leaching is up to six times higher in annual crops than in grasses



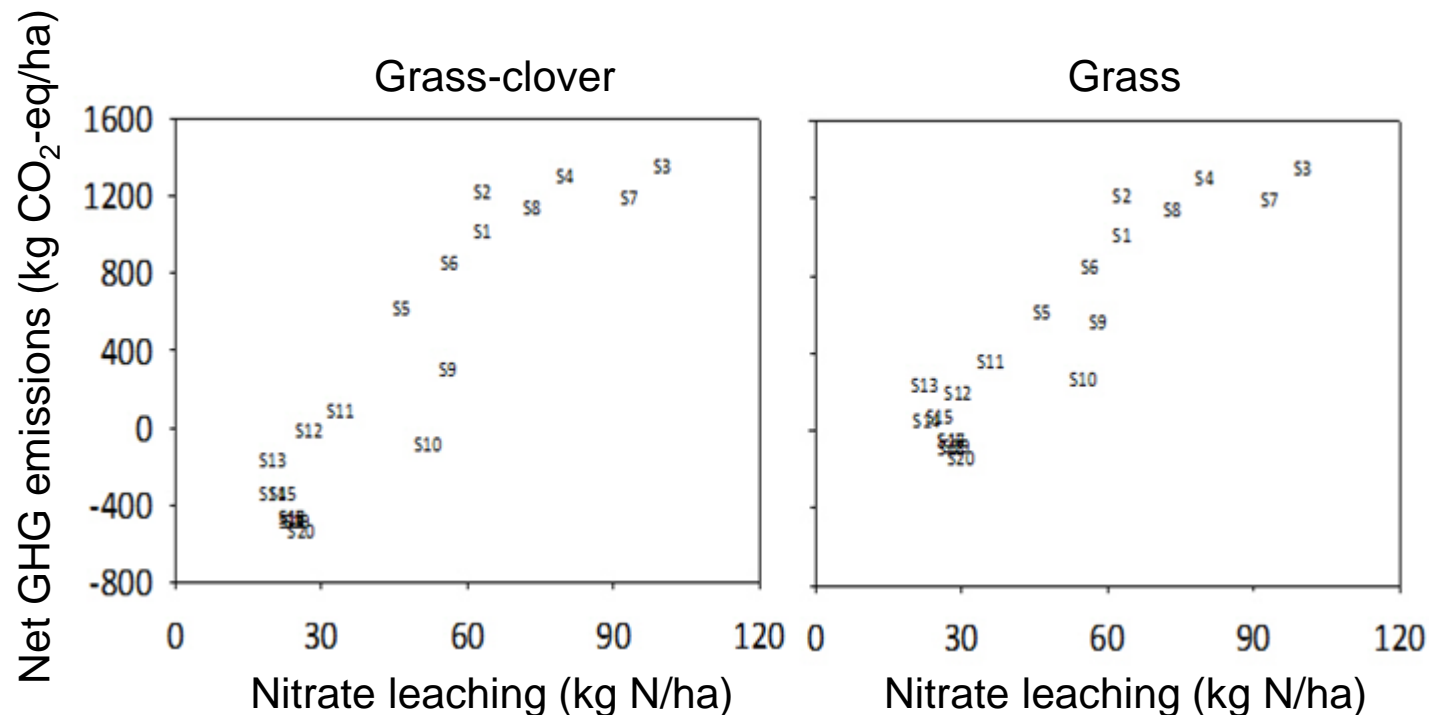
\* Not calculated yet

# It is possible to increase yield AND to decrease nitrate leaching



# Synergy between greenhouse gas emission reduction and nitrate leaching

Comparison of rotations with varying proportion of grass

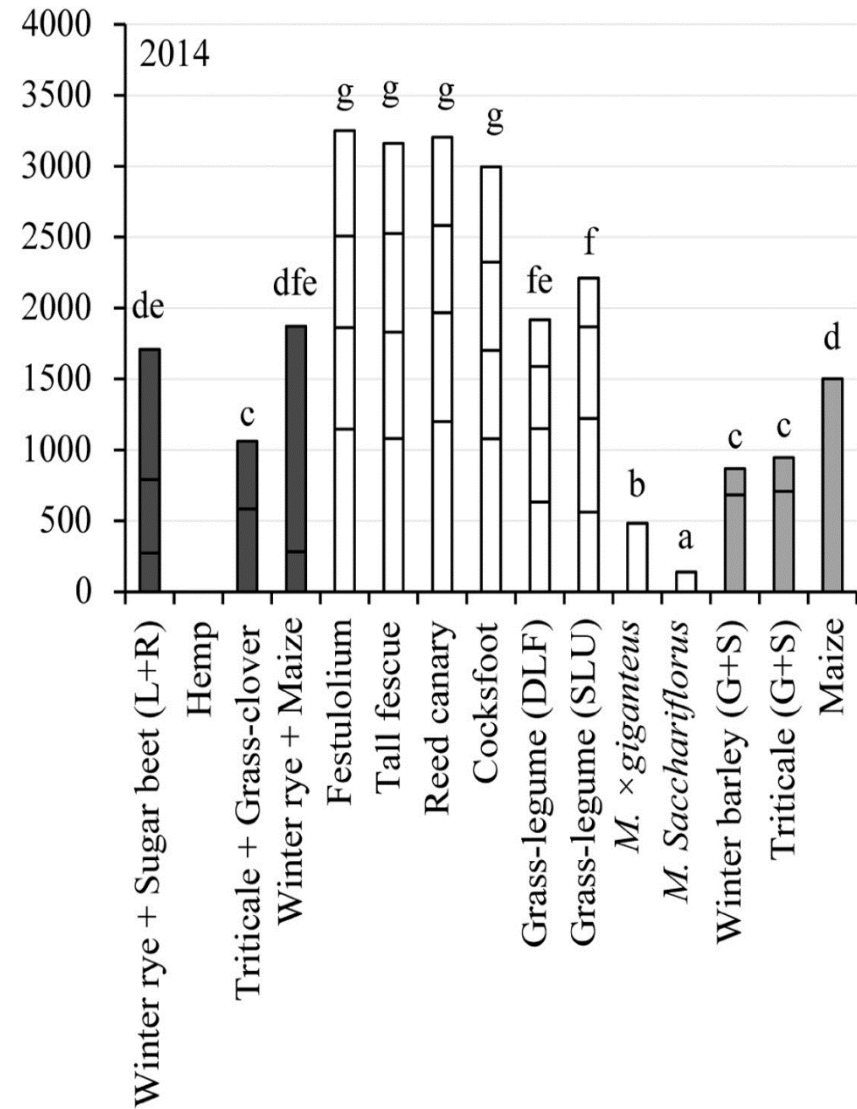
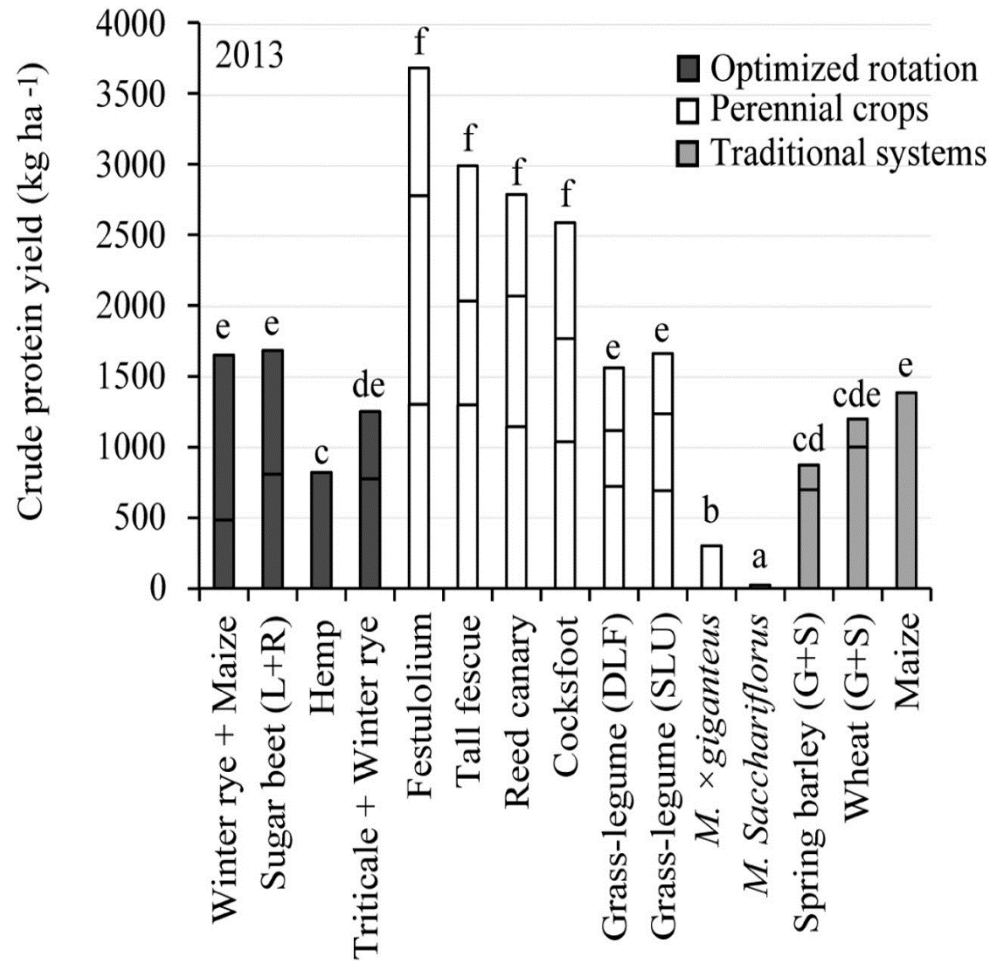


# So, what to do with all that grass?



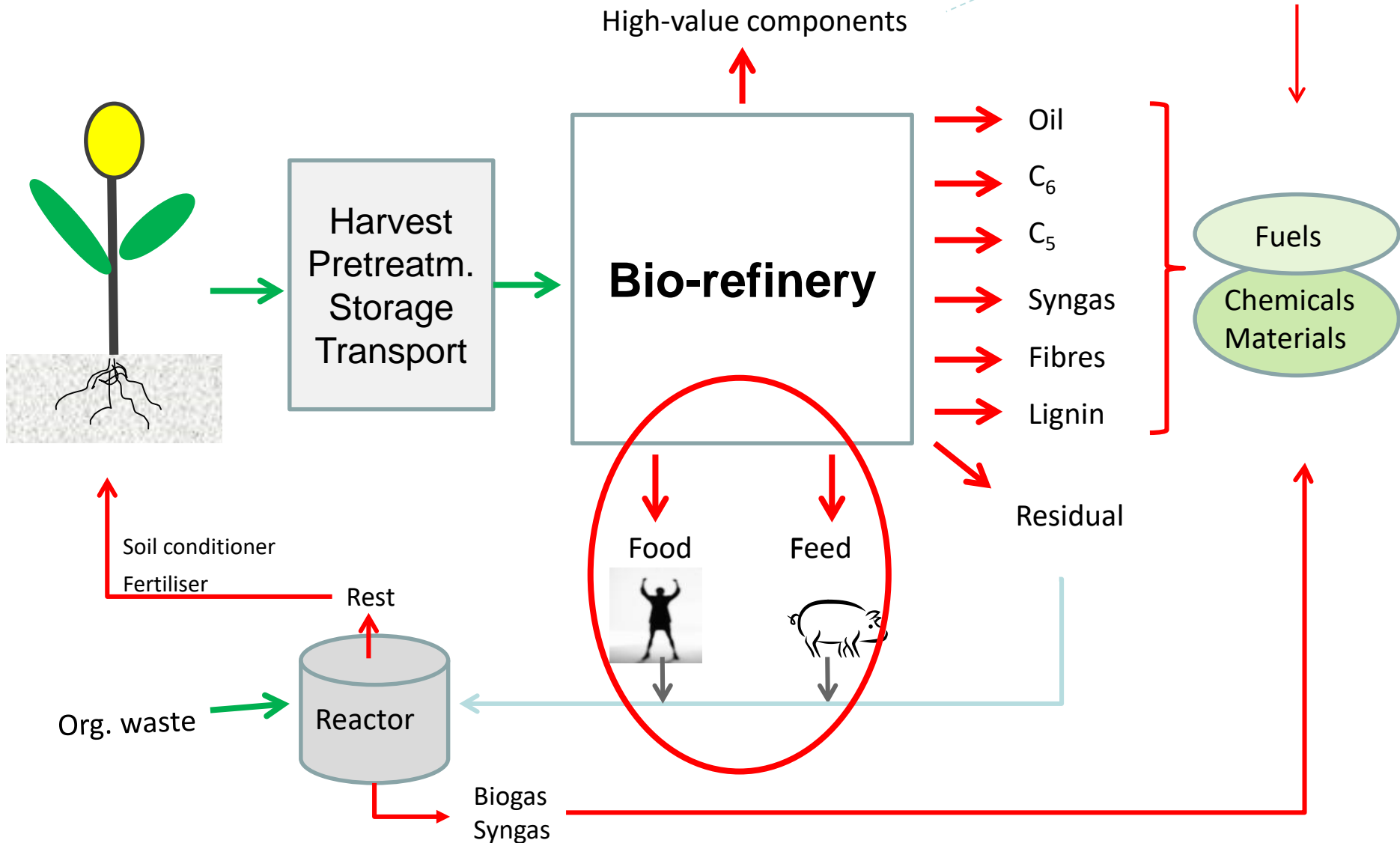
# Total crude protein yield in Foulum biomass

Solati et al., 2018

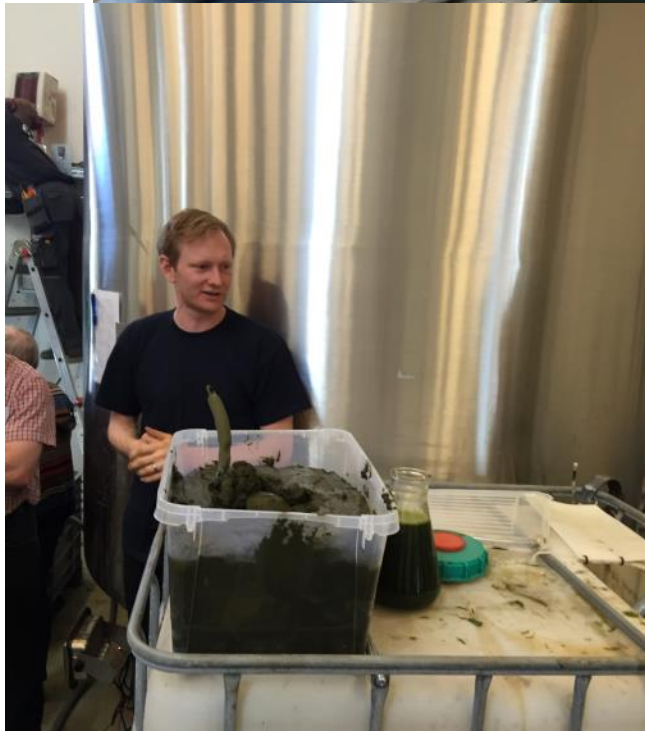
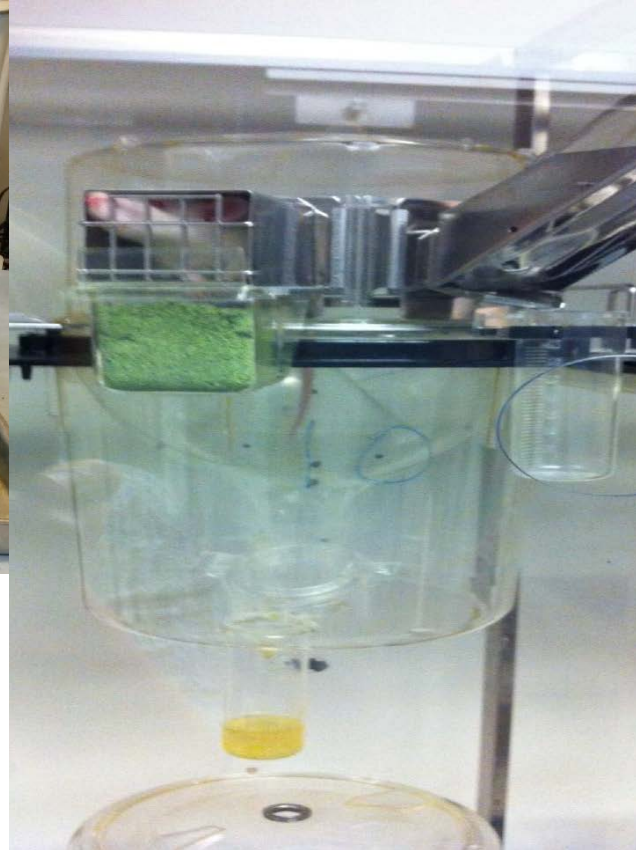


# Implementation of a radical new crop production paradigm is conditional to development of green biorefineries

Colours  
Flavors  
Medicin  
Other chemicals



# Crops are separated, protein precipitated and animals fed to determine feeding value in current projects



BioValue ([www.biovalue.dk](http://www.biovalue.dk))

Biobase ([www.dca.au.dk/en/research/bioeconomy-and-biobased-production/biobase](http://www.dca.au.dk/en/research/bioeconomy-and-biobased-production/biobase) )



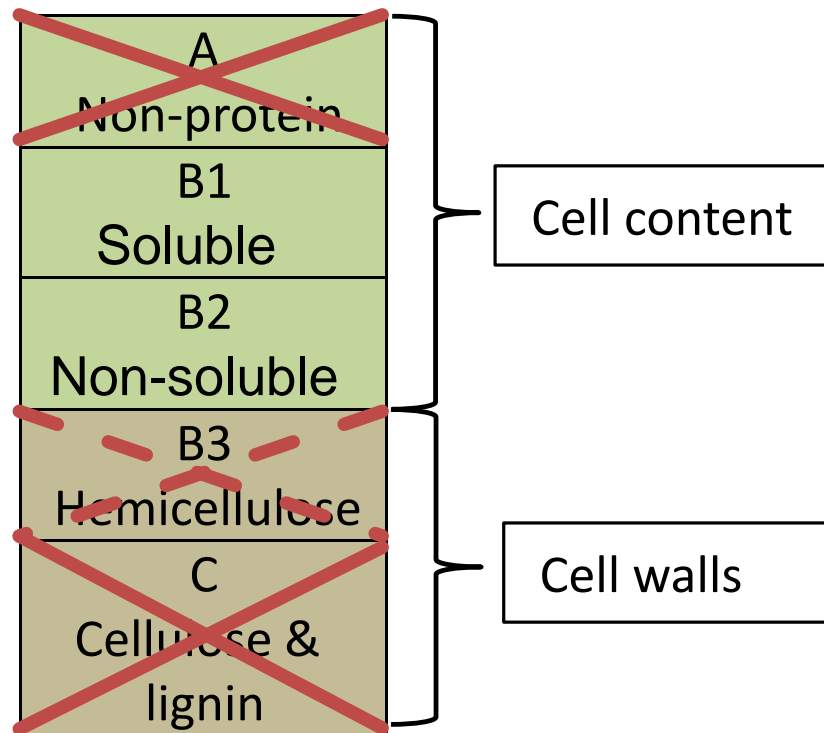
**MULTIMIX**

SCORATO 6.0m





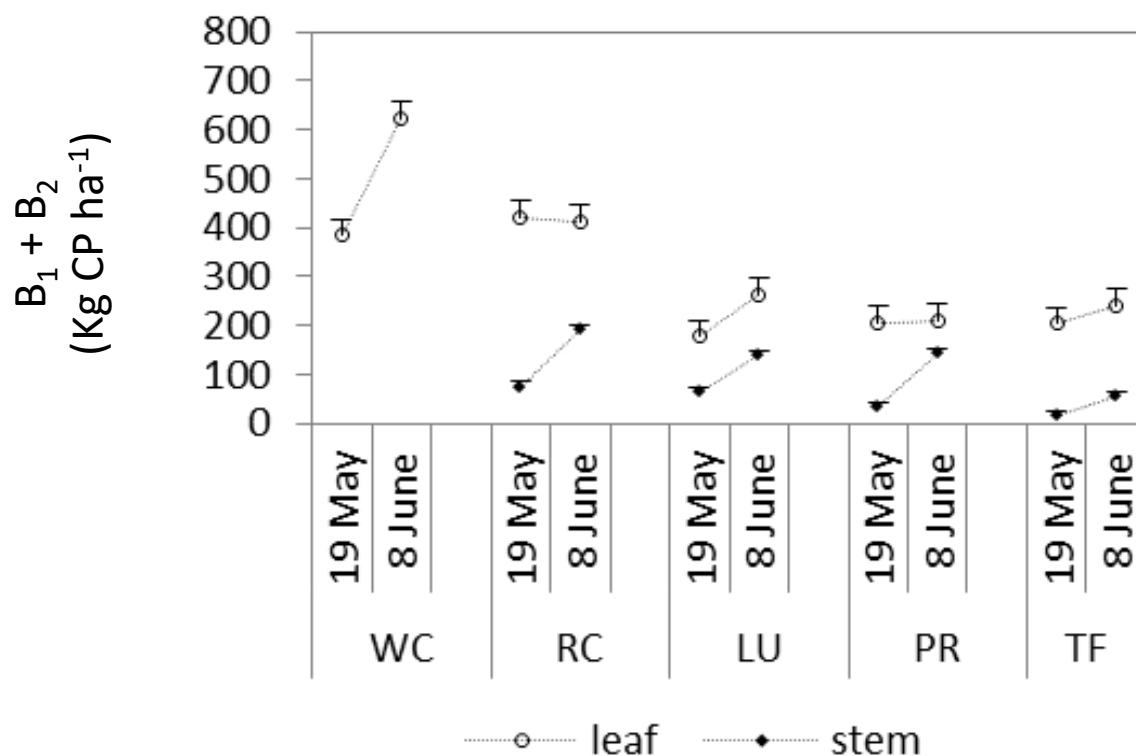
# Protein-N in plant material





Most of the soluble protein is found in leaves, so that a separation before extraction may be interesting for increasing process protein output

Solati et al., 2017





Faculty of Science

## **Decentralized facility–prerequisites**

*In:*

Capacity: 20.000 tonnes DM Clover grass  
(+/- 2.000 hectares)

Investment : 20.000.000 DKK

Maintenance : 5% of facility investments

Depreciation : 10 - 15 years

Operating time facility: 3.000 hours/year

*Out :*

3.600 ton DM Dried protein concentrate

14.000 ton DM Pulp

2.500 ton DM Brown juice

Source. Morten Ambye Jensen

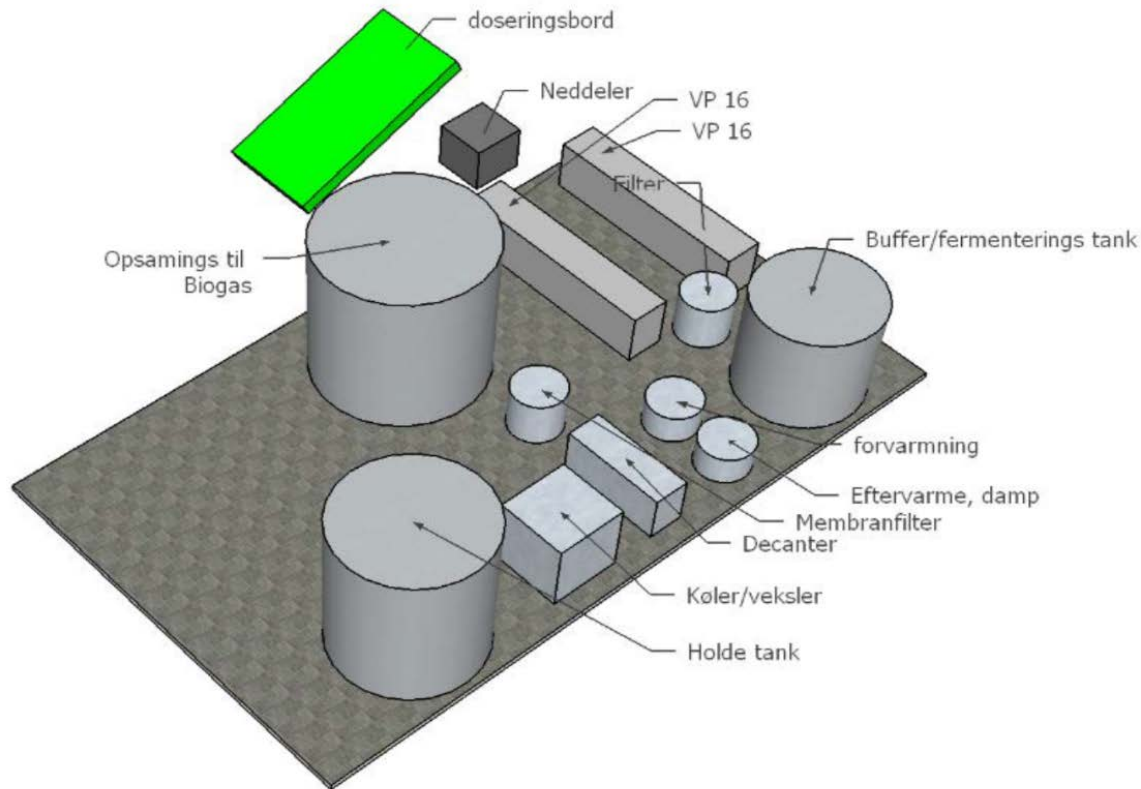
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## Economic result

	Conventional (k.DKK/year)	Non-GMO (k.DKK/ton)	Organic (k.DKK/ton)
Income			
Dried protein (Soy equivalent)	9.445,0	13.789,7	18.889,0
Pulp	12.633,0	12.633,0	12.206,0
Brown juice	0	0	0
Total income	22.078,0	26.422,7	31.095,0
Costs			
Biomass	22.601,0	22.602,0	22.551,0
Energy, auxiliary mat.	2.871,0	2.871,0	2.871,0
Labour	1.474,0	1.474,0	1.474,0
Cost of capital	2.834,0	2.834,0	2.834,0
Total costs	29.780,0	29.781,0	29.730,0
Result	-7.702,0	-3.358,3	1.365,0

# DEMO-PLANT FOR GREEN BIOREFINERY UNDER CONSTRUCTION FOR 2019

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# General conclusions on grass protein

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- Grass can double productivity and halve environmental impacts per ha
- Extract the high protein content in grass & legumes and feed the fibre to dairy cattle
- Processing of grass and legume biomass is optimised to ensure high protein contents
- Feeding trials on mono- and polygastric animals are promising
- Positive business case for organic production

Farmers are eager to produce grass – if there is a market



Now, environmental gains can also be  
used in marketing



coop

SMAG  
FORSKELLEN

★★★★★

POPPELGRIS

— fra —

Hestbjerg

*Dyrevelfærd, der kan smages*

DYREVELFÆRD  
Det Ekstra Godt Liv

The advertisement features a photograph of four pigs in a lush green field with trees in the background. The text is overlaid on the image. In the top left, there is a circular logo with the word 'coop' and the phrase 'SMAG FORSKELLEN' with five stars below it. The main title 'POPPELGRIS' is in large, bold, white capital letters, followed by '— fra —' and 'Hestbjerg' in a smaller, white serif font. At the bottom, the phrase 'Dyrevelfærd, der kan smages' is written in a white script font. In the bottom right corner, there is a white rectangular logo with a green four-leaf clover and the text 'DYREVELFÆRD' and 'Det Ekstra Godt Liv'.