

Protein production to reduce environmental impacts

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European agriculture faces numerous challenges

Productivity

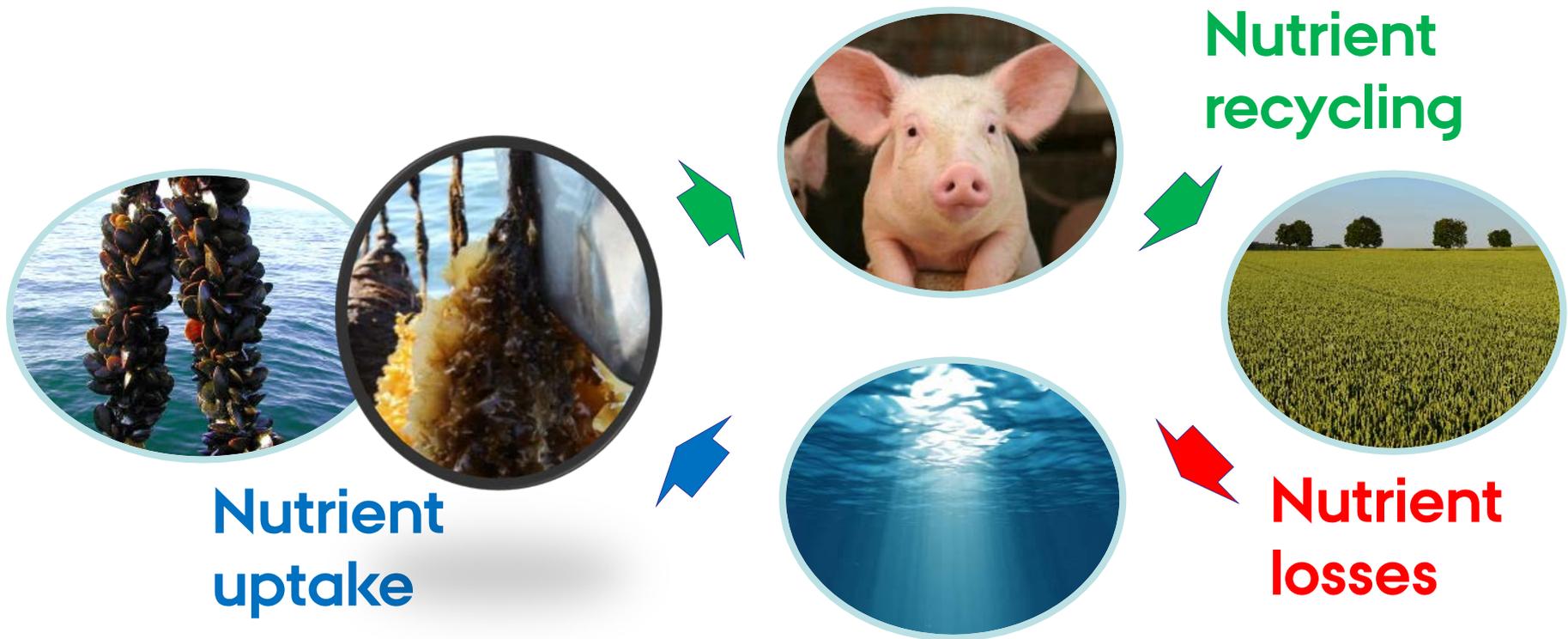
- Biomass for food, feed, material and energy
- Stagnating yields
- Large import of protein feed

Environment

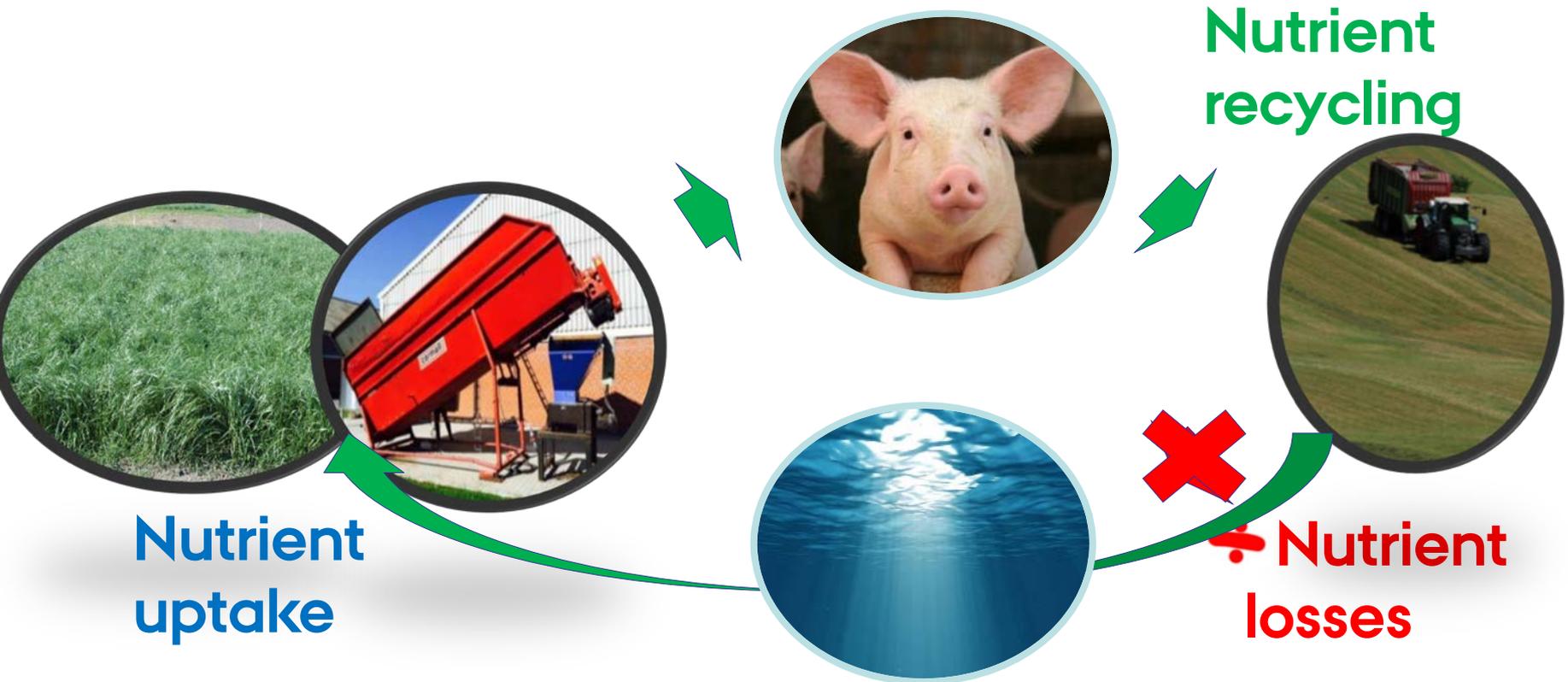
- High nutrient leaching (Nitrate and Water Framework Directives)
- High pesticide use
- Agriculture must contribute to EU climate goals (EU climate policy)

Time to look for radical innovation instead of incremental

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

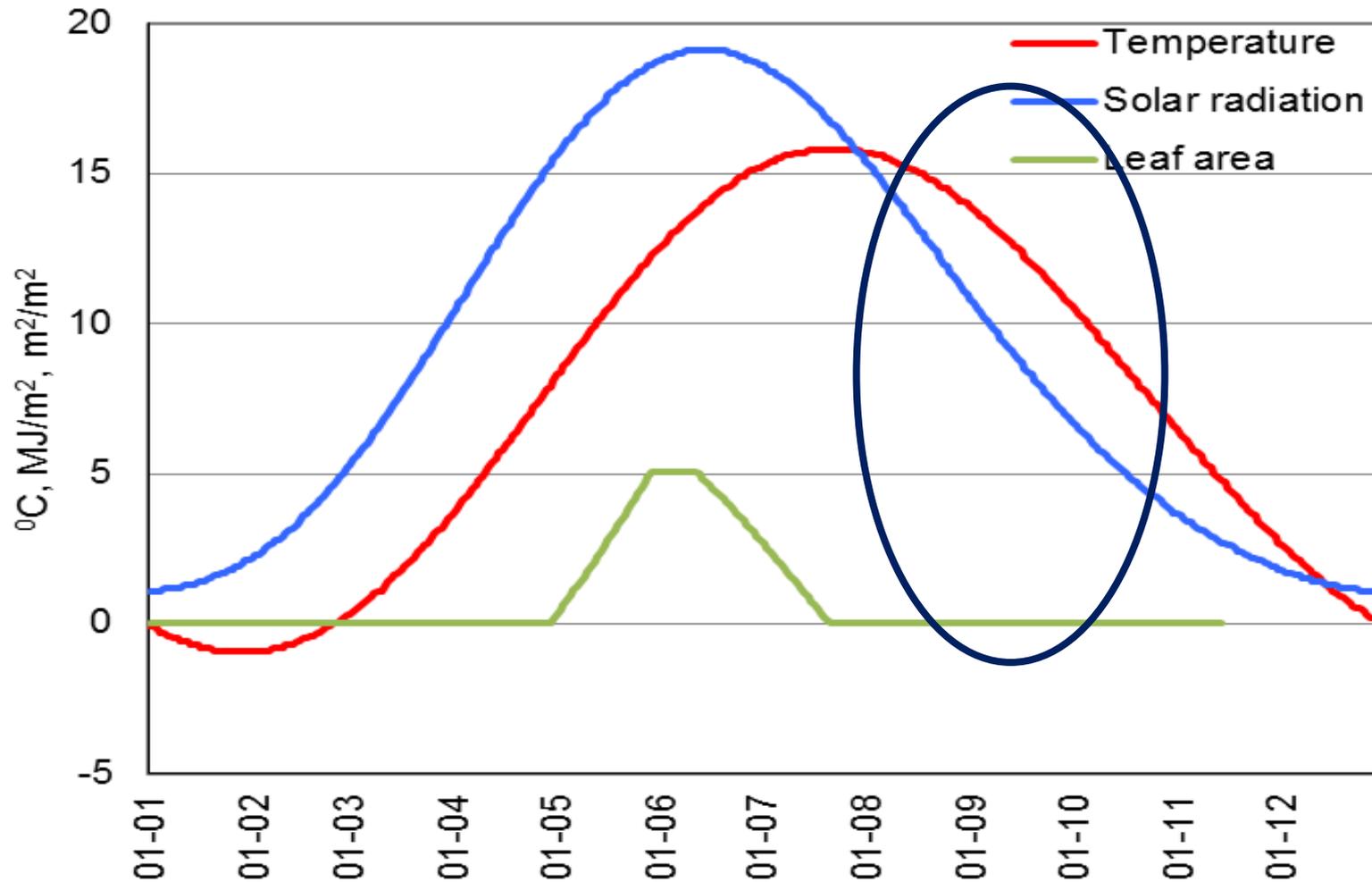


New land-based product chains can increase productivity & reduce N-losses significantly



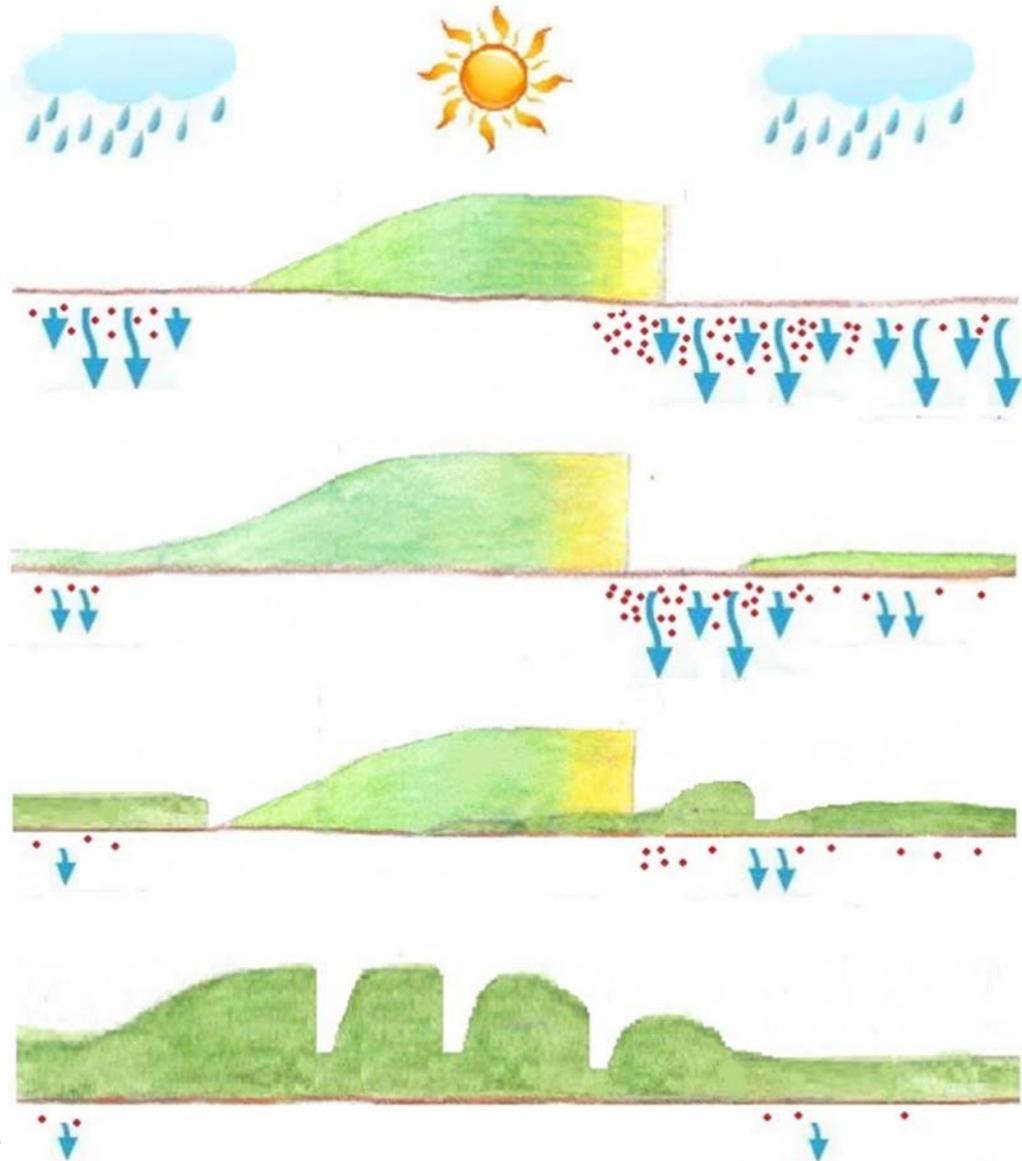
Grain crops utilize only part of the growing season

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

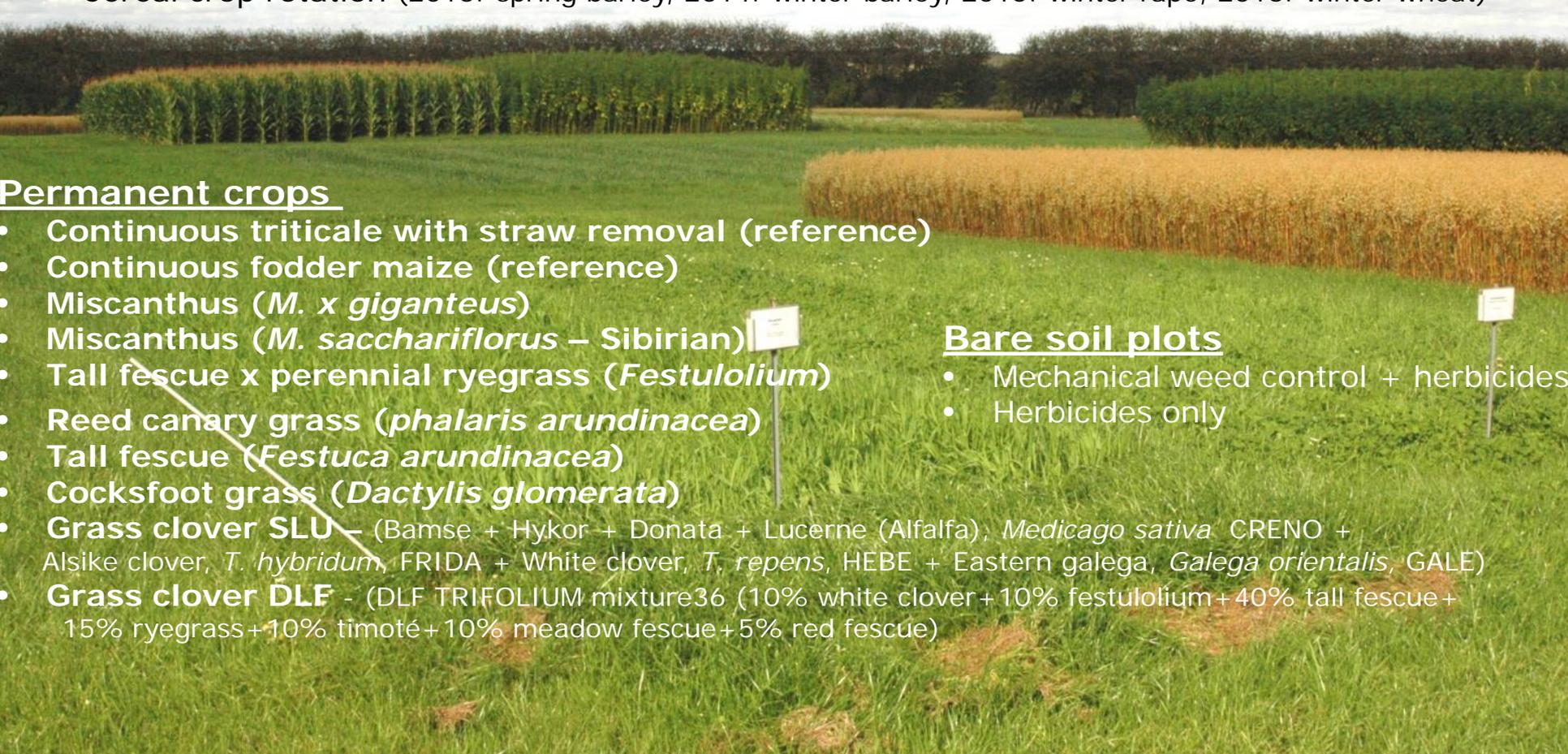
- Cereal crop rotation (2013: spring barley, 2014: winter barley, 2015: winter rape, 2016: winter wheat)

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

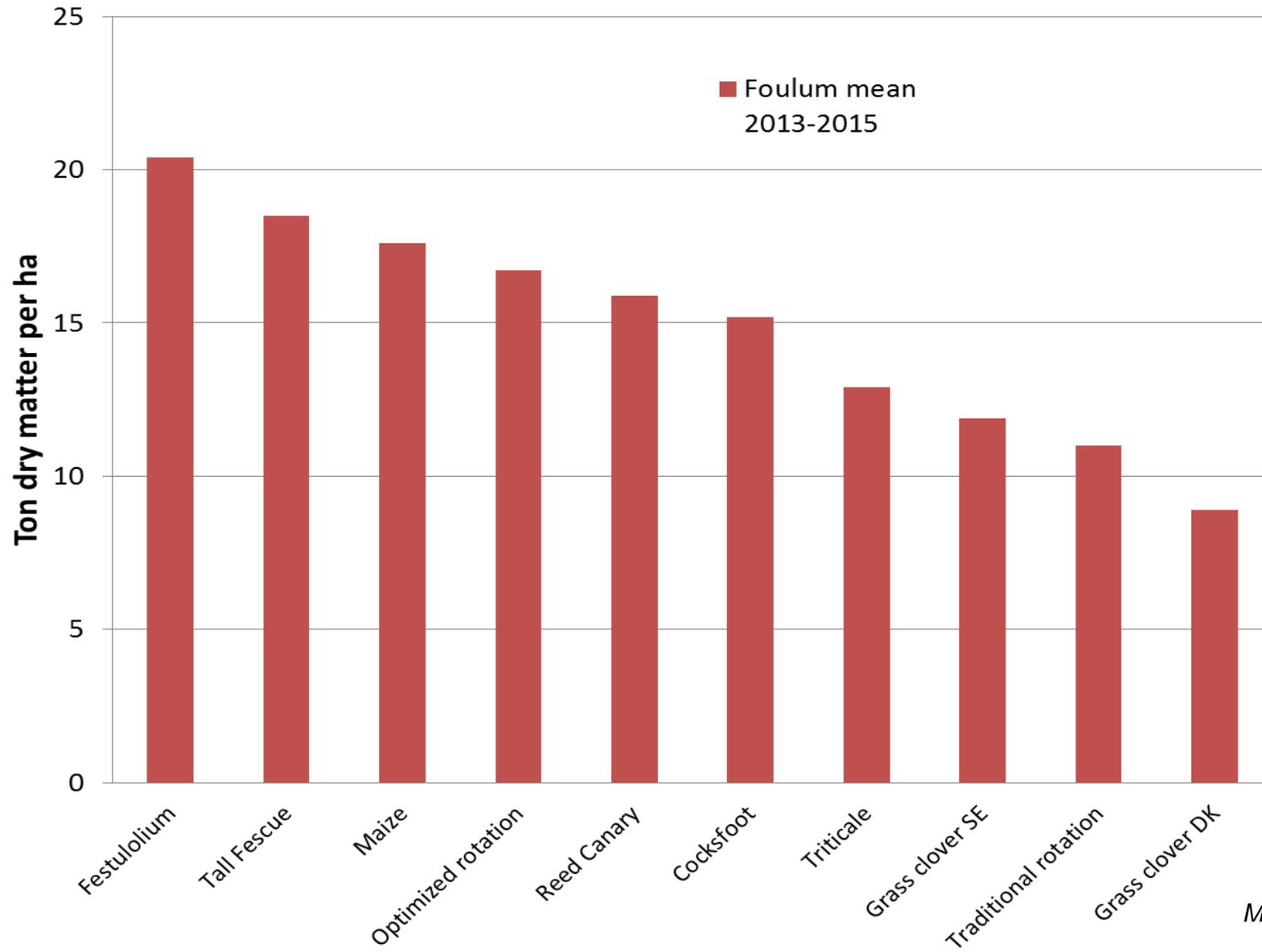
- Mechanical weed control + herbicides
- Herbicides only



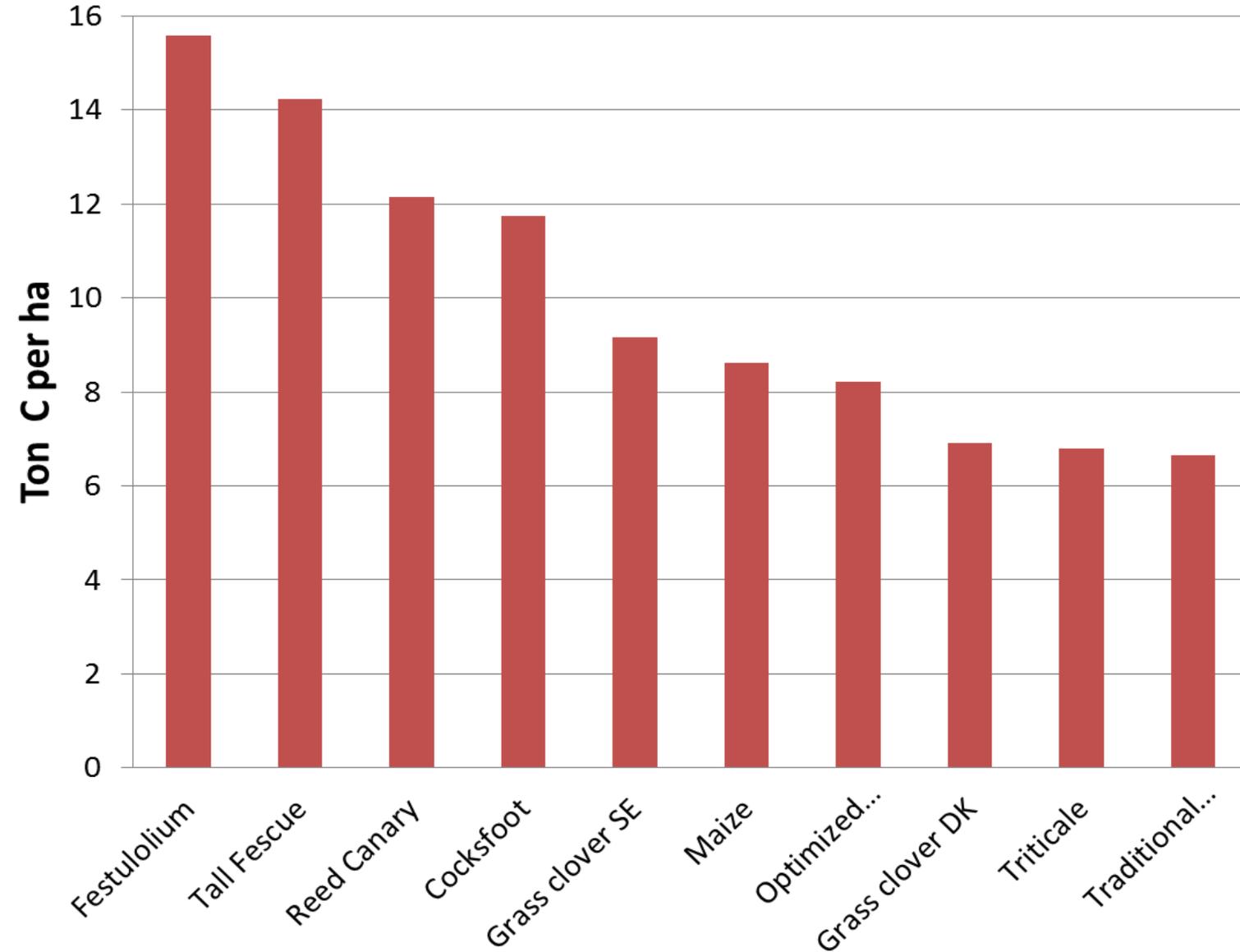




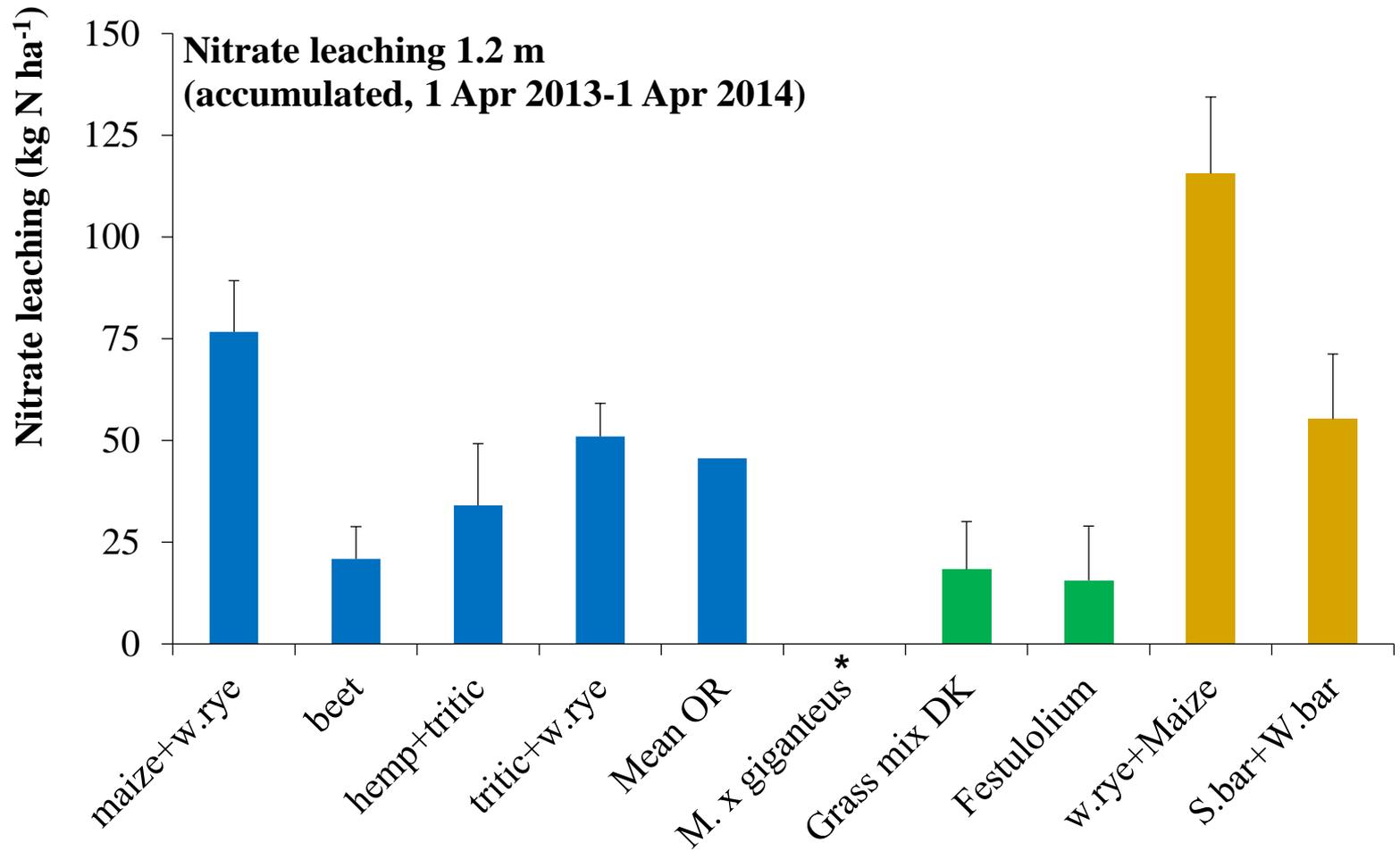
High variation in total biomass yield



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

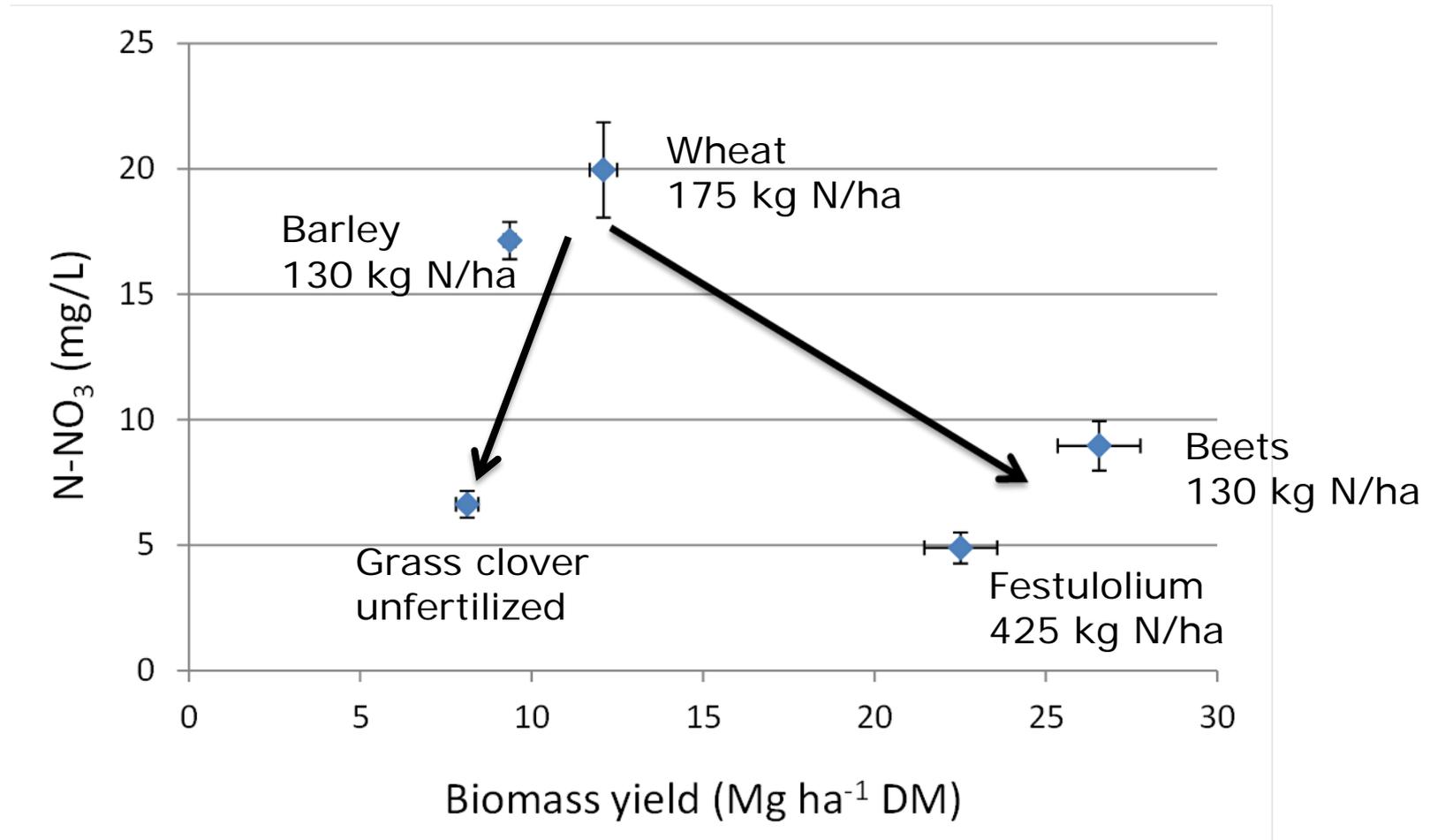


Cumulated leaching is up to six times higher in annual crops than in grasses



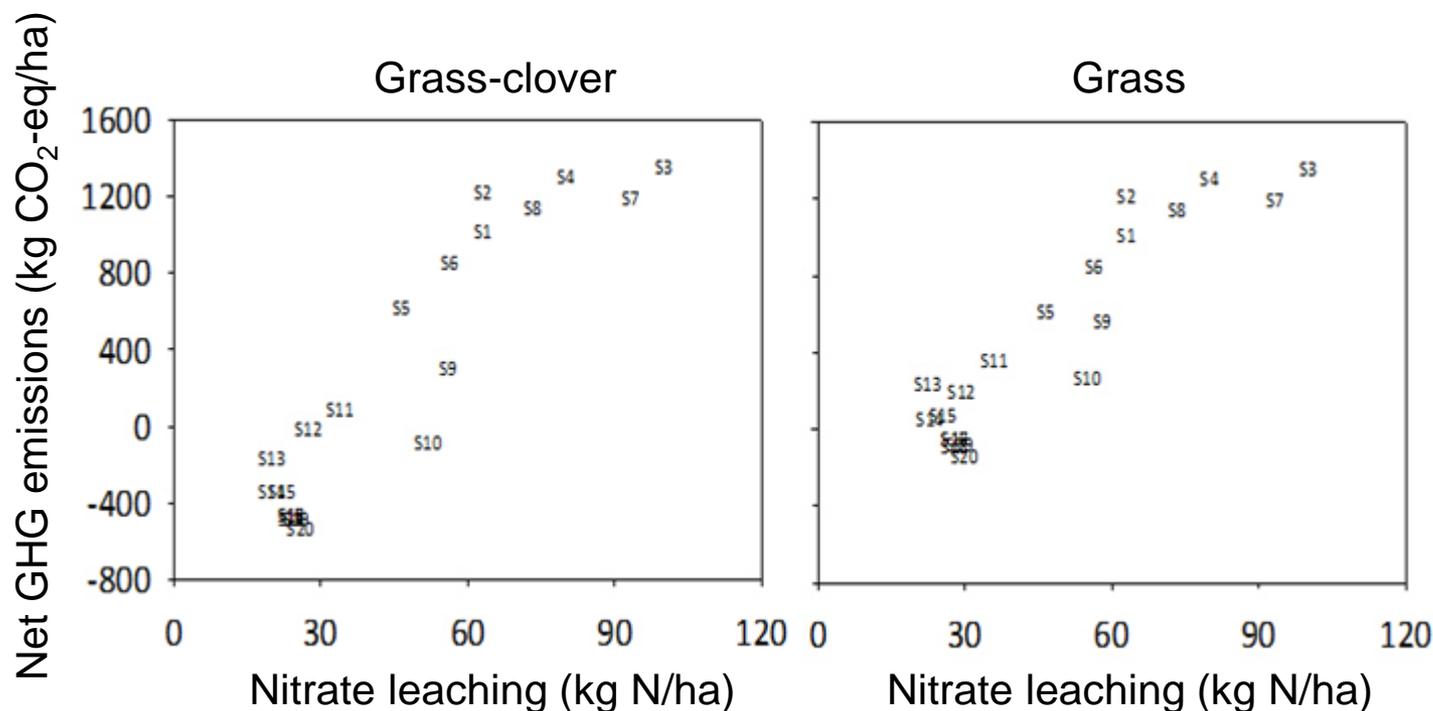
* Not calculated yet

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

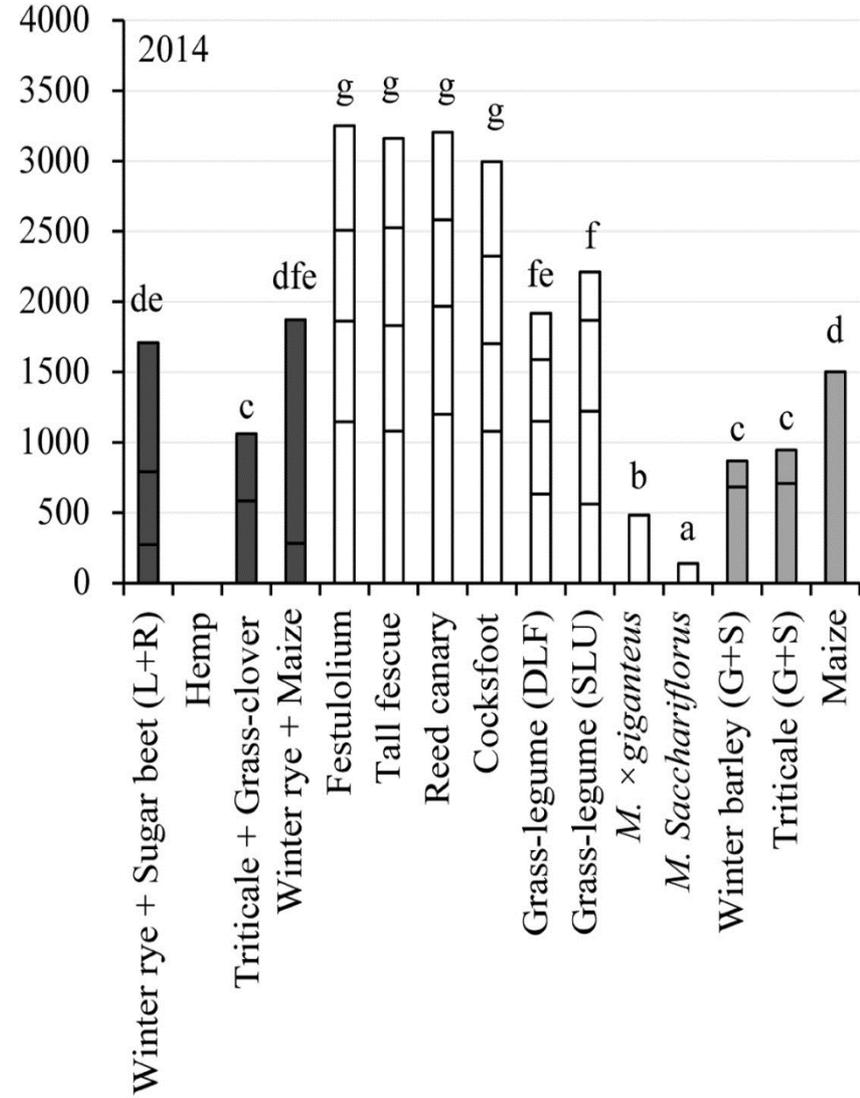
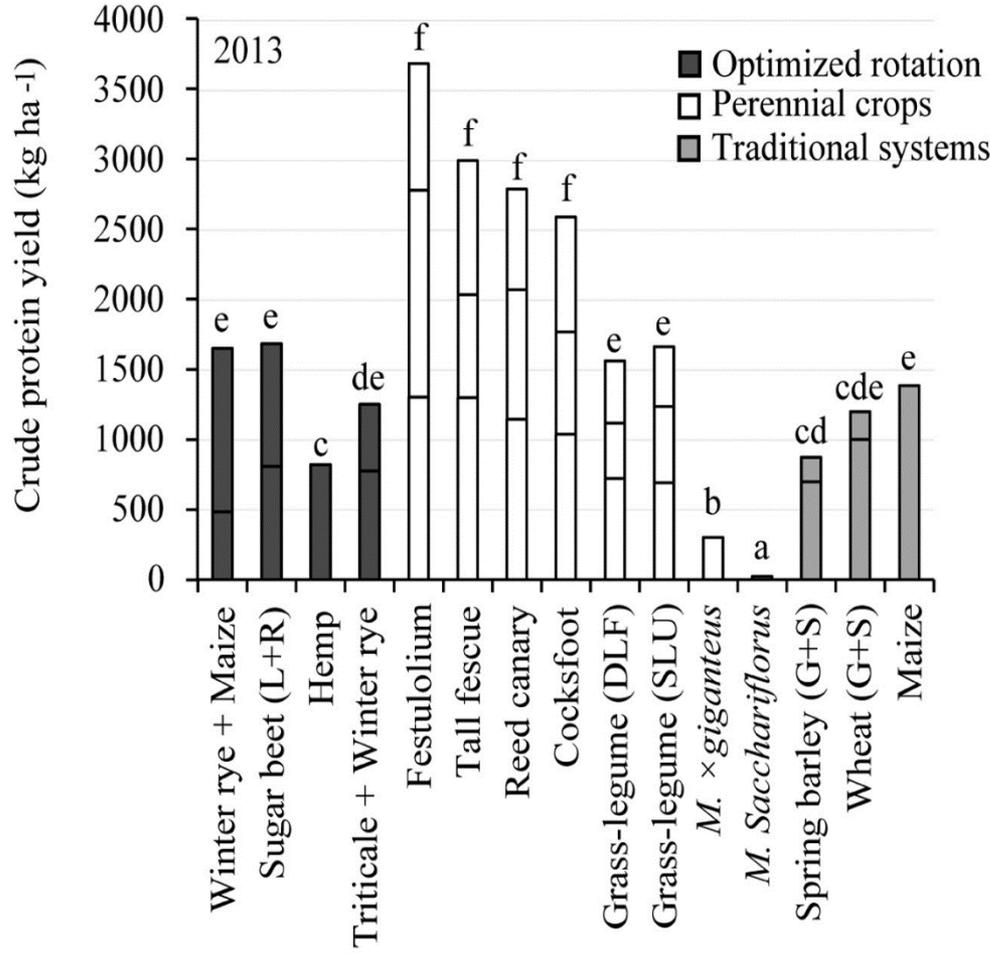


So, what to do with all that grass?



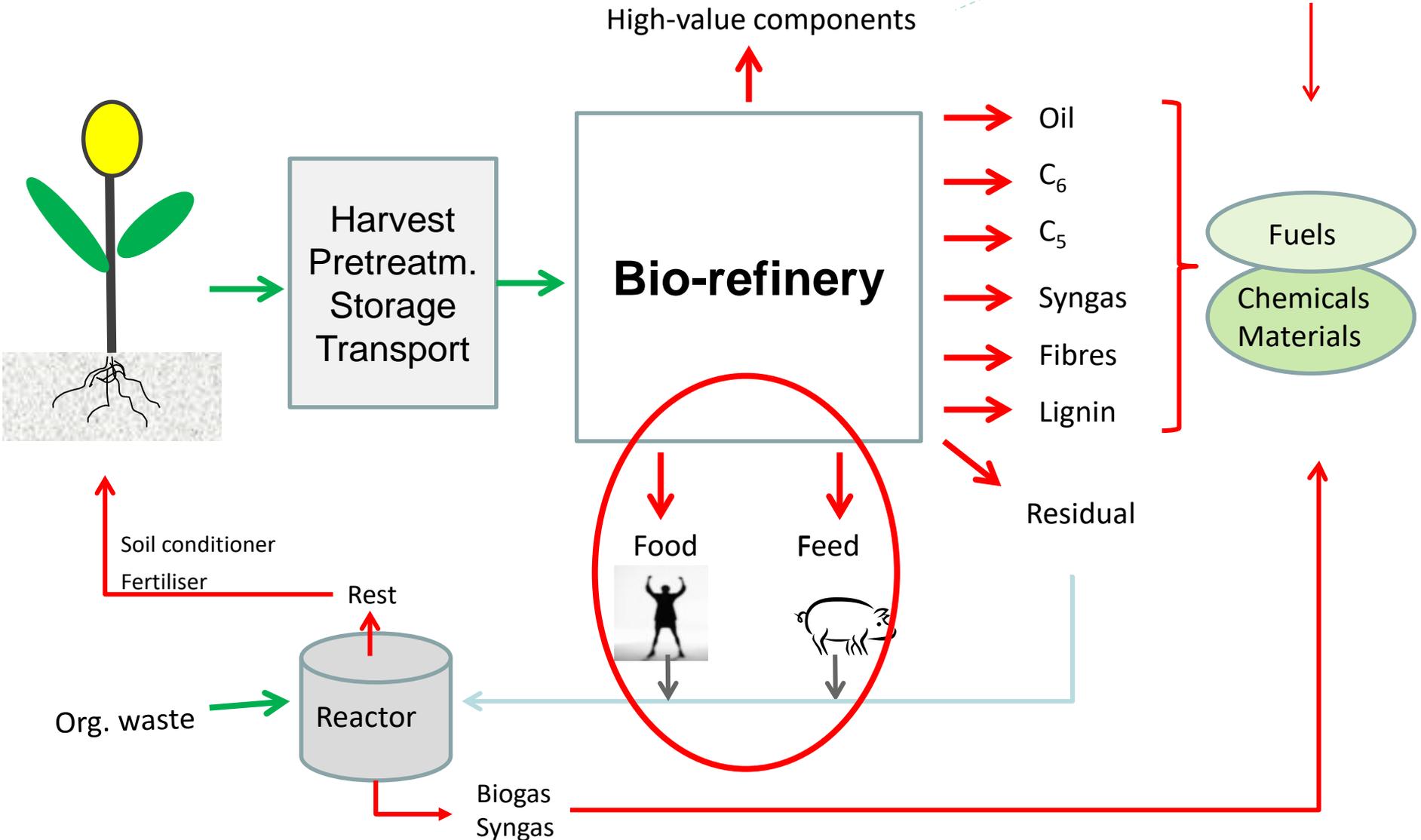
Total crude protein yield in Foulum biomass

Solati et al., 2018

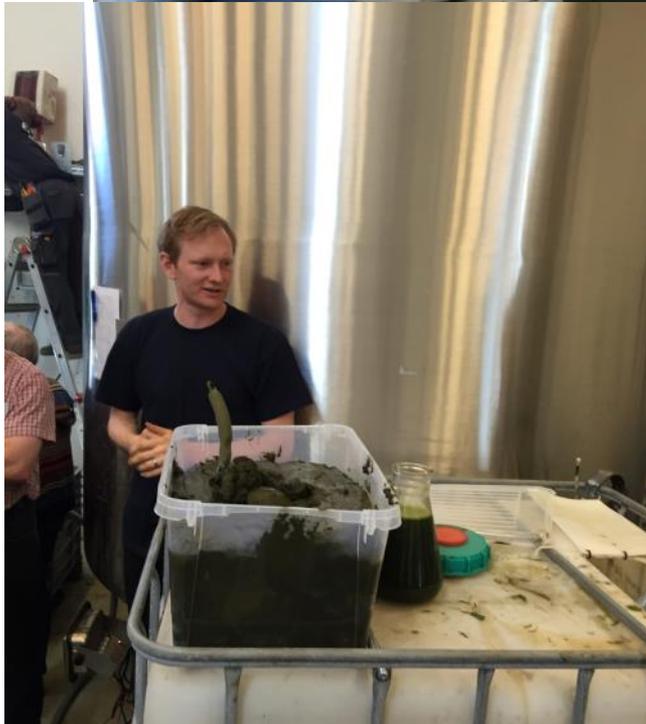
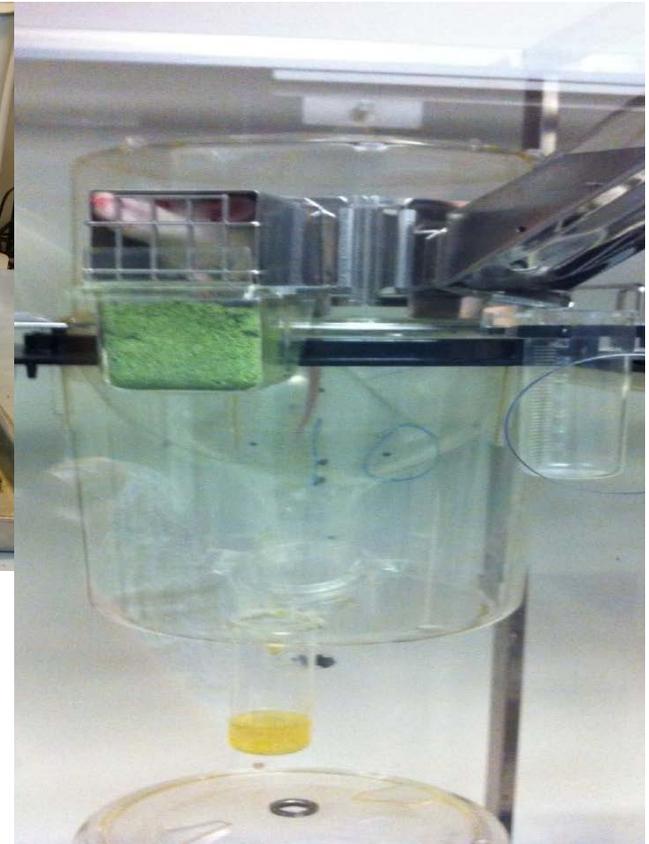


Implementation of a radical new crop production paradigm is conditional to development of green biorefineries

Colours
Flavors
Medicin
Other chemicals



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



BioValue (www.biovalue.dk)

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



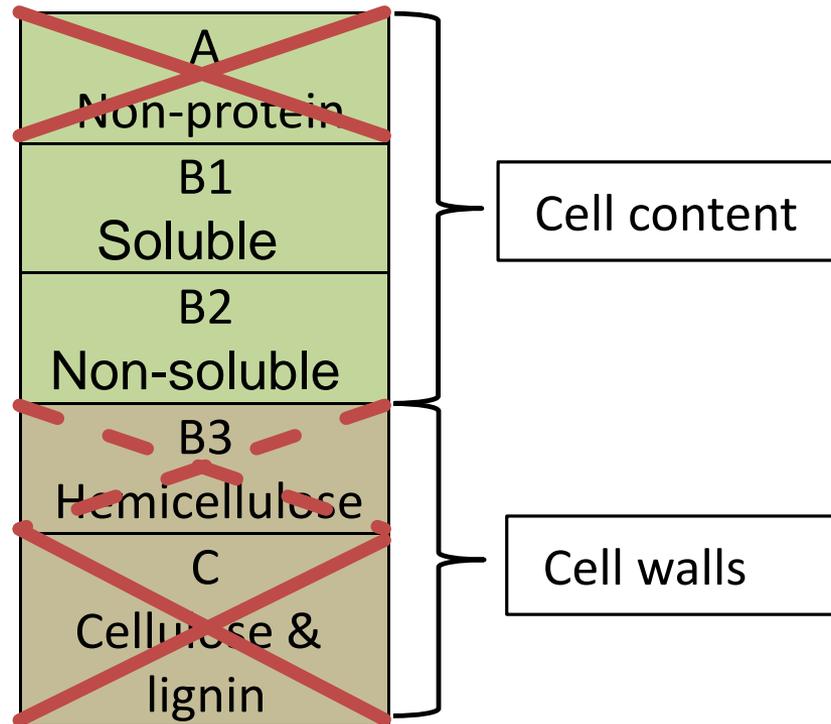
MULTIMIX

SERATA 6.0m



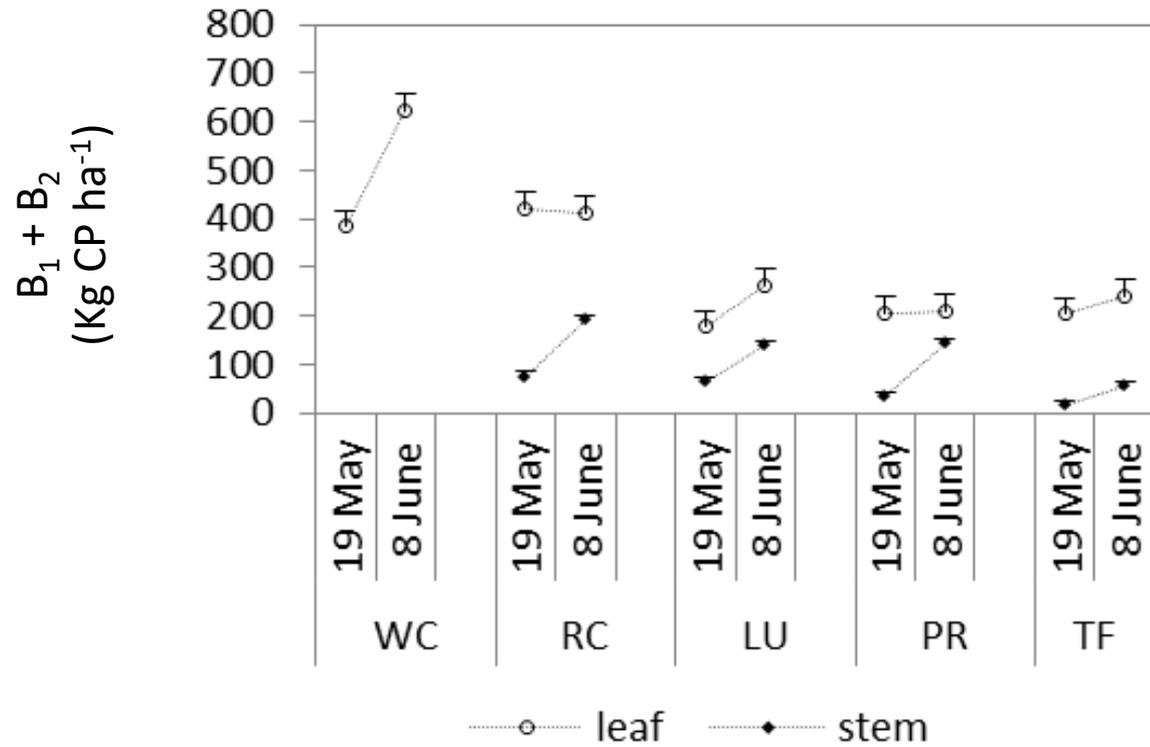


Protein-N in plant material





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

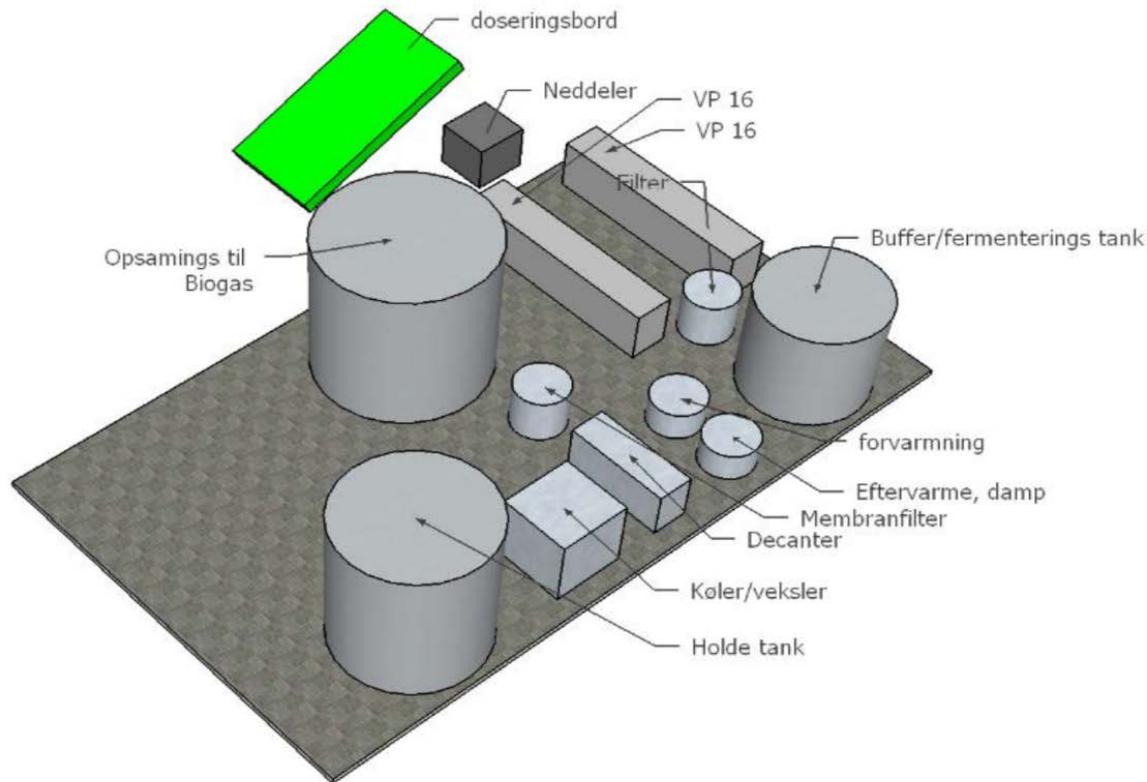
Source. Morten Ambye Jensen

Slide 4

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 |
| 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



General conclusions on grass protein

- 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 Gode Liv

The advertisement features a background image of four pigs in a lush green field with trees. A circular seal in the top left corner contains the text 'coop', 'SMAG FORSKELLEN', and five stars. The main text reads 'POPPELGRIS fra Hestbjerg'. At the bottom, the slogan 'Dyrevelfærd, der kan smages' is written in a cursive font. In the bottom right corner, there is a logo for 'DYREVELFÆRD Det Ekstra Gode Liv' featuring a green four-leaf clover.