

Merproduktion og mindre udledning i græsmarken

Sustainable intensification of agricultural systems in combination with biorefinery processing can produce more food & biomass for energy while reducing emissions

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European agriculture faces numerous challenges

Productivity

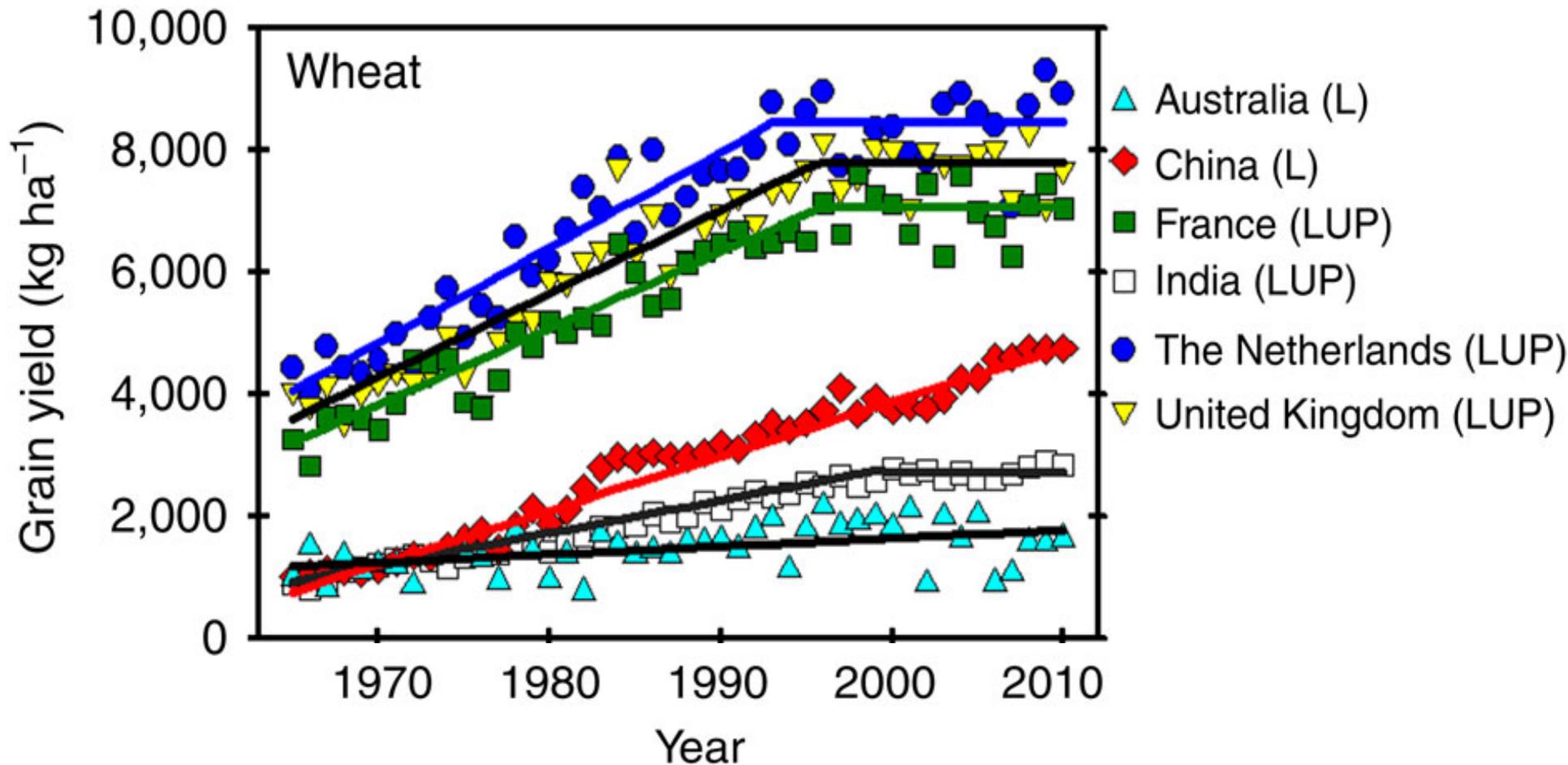
- Biomass for food, feed, material and energy
- Stagnating yields
- Large import of feed especially soy bean products (97% imported)

Environment

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

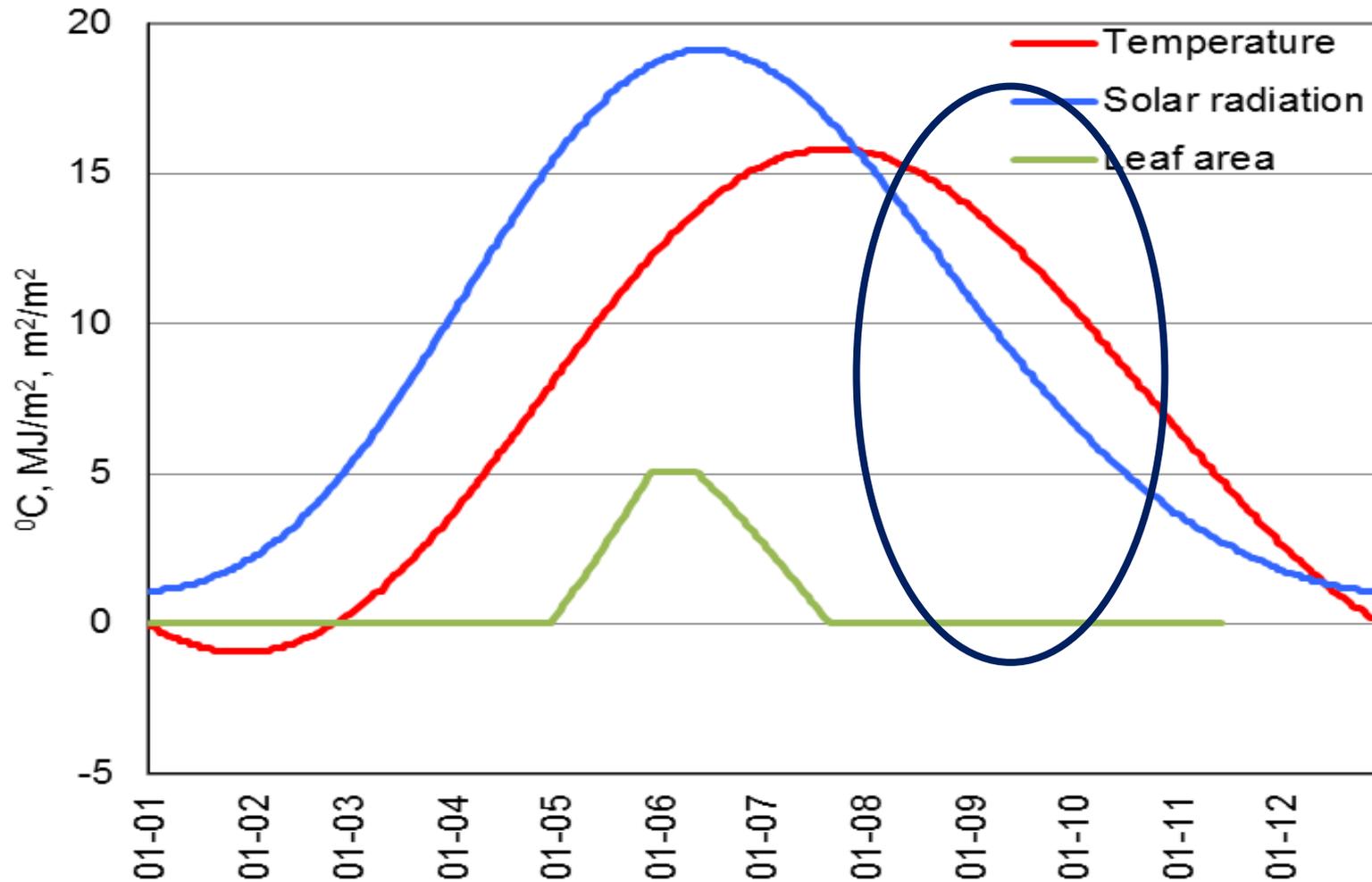
The answer may be sustainable intensification – more with less!

However, it seems to be hard to increase yields (sustainably) in existing crops in Europe



Grain crops utilize only part of the growing season

Case: spring barley in Denmark





Innovative production systems investigated at AU

Crop Rotation – large plots (all crops every year)

- 1) Energy maize (Amagrano) + Winter rye (direct sowing 31/10 – one cut spring)
- 2) Energy beets (Debby)
- 3) Hemp (Felina – harvest 12/9) + Triticale (sowing 10/10)
- 4) Triticale early harvest (10-15 July) + undersown grass clover (two cuts: autumn and spring)

Crop Rotation – large plots (one crop per year)

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

Permanent crops – large plots

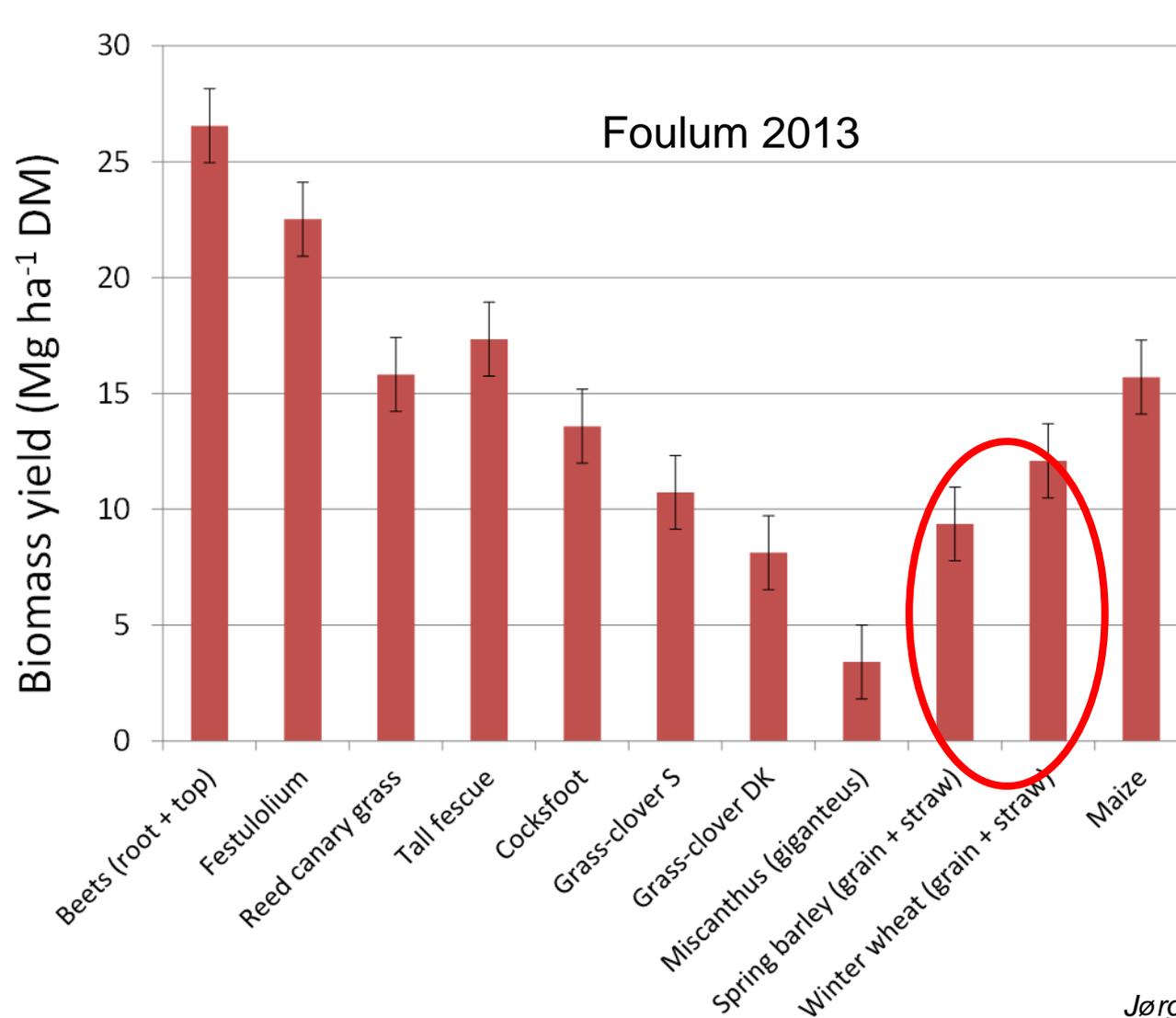
- 5) Miscanthus (*M. x giganteus*)
- 6) Miscanthus (*M. sinensis* – Sibirian)
- 7) Tall fescue x perennial ryegrass (*Festulolium*, HYKOR)
- 8) Continuous wheat/triticale with straw removal (reference)
- 14) Continuous maize (reference)

Permanent crops – small plots

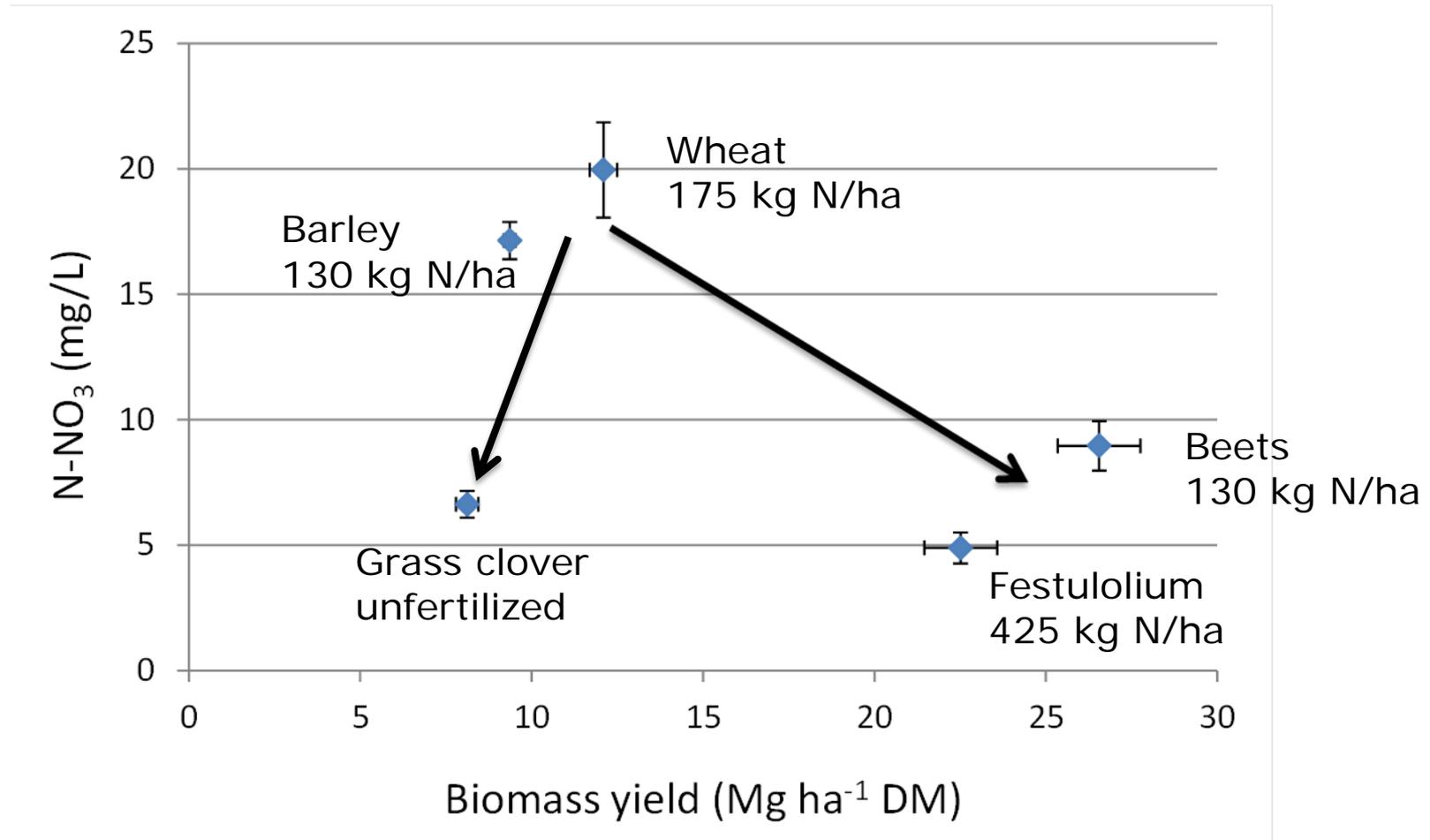
- | | | |
|---|---------|---|
| 9) Reed canary grass (<i>phalaris arundinacea</i>) | BAMSE) | <u>Bare soil plots</u> |
| 10) Tall fescue (<i>Festuca arundinacea</i>) | KORA) | 16) Mechanical weed control + herbicide |
| 11) Cocksfoot grass (<i>Dactylis glomerata</i>) | DONATA) | 17) Herbicides only |
| 12) Grass clover Swedish – (Bamse + Hykor + Donata + Lucerne (Alfalfa), <i>Medicago sativa</i> CRENO + Alsike clover, <i>T. hybridum</i> , FRIDA + White clover, <i>T. repens</i> , HEBE + Eastern galega, <i>Galega orientalis</i> , GALE) | | |
| 13) Grass clover Danish - (DLF TRIFOLIUM mixture36 (10% white clover+10% festulolium+40% tall fescue+15% ryegrass+10% timoté+10% meadow fescue+5% red fescue) | | |



Total yields of selected crops show potential for a doubling

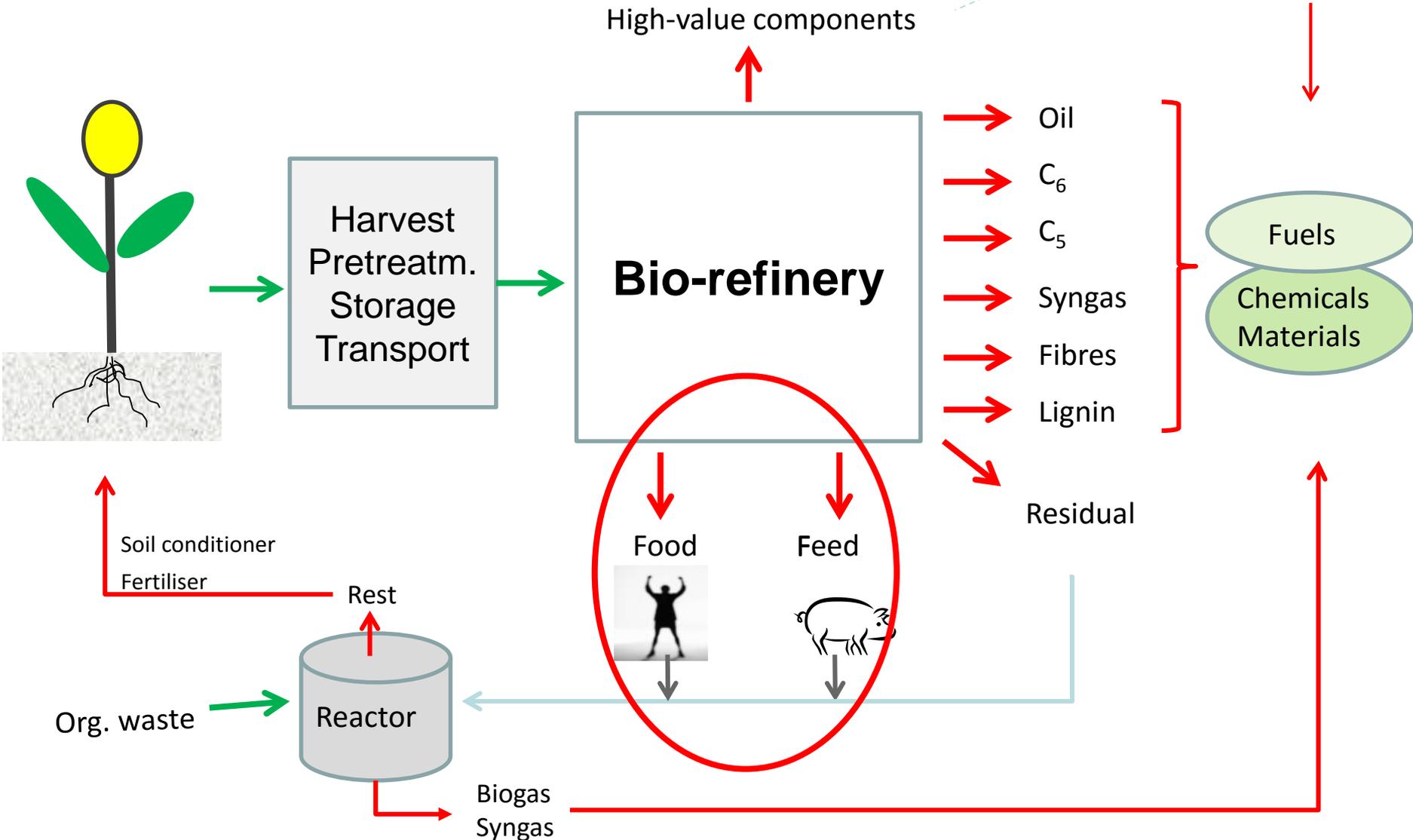


It is possible to increase yield and decrease nitrate leaching

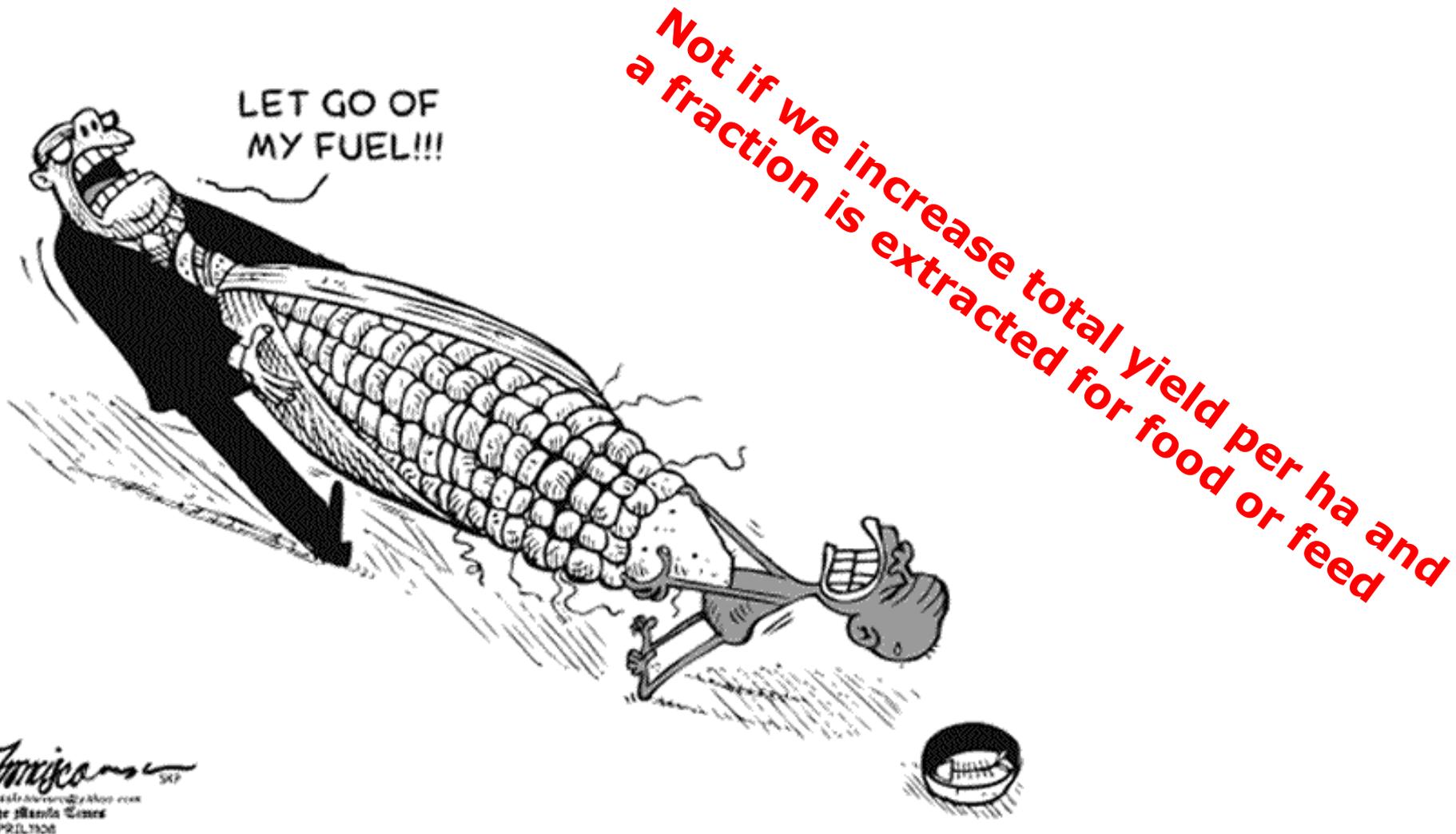


Implementation of a radical new crop production paradigm is conditional to development of green biorefineries

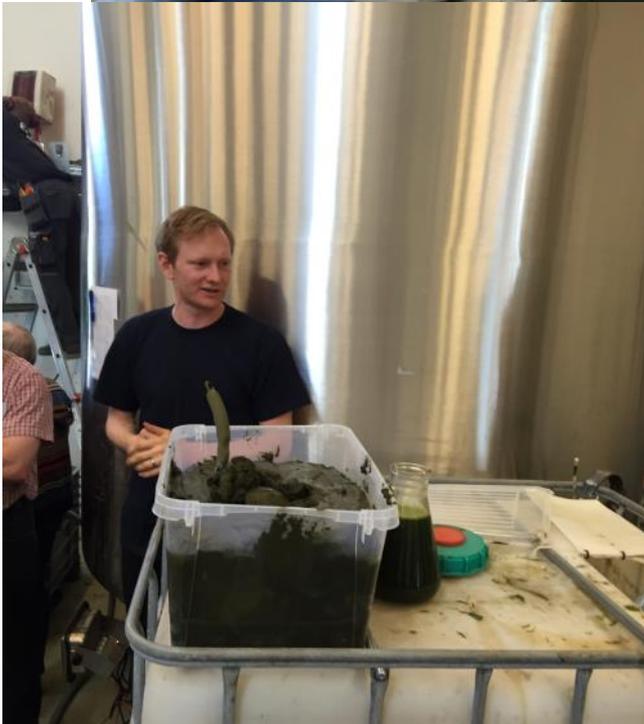
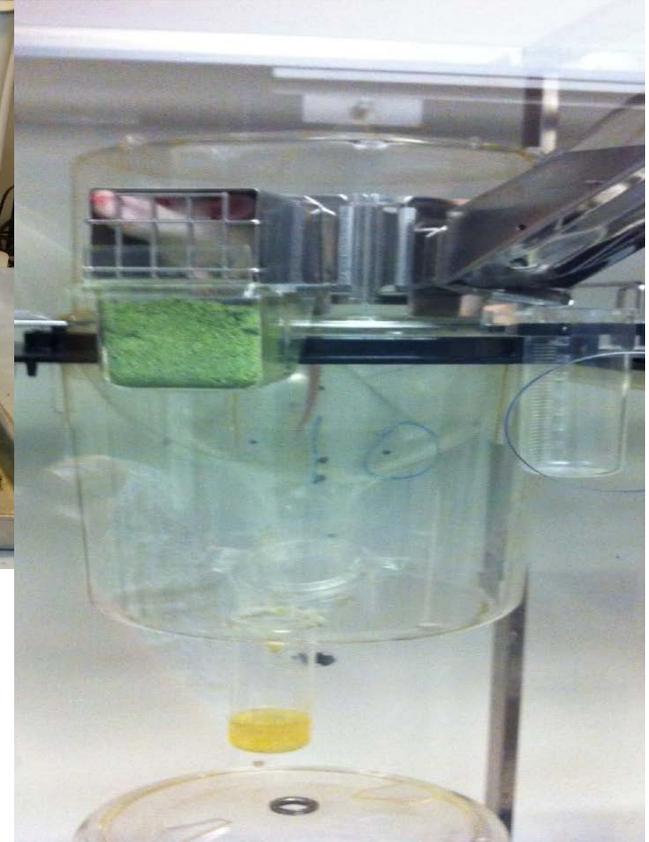
Colours
Flavors
Medicin
Other chemicals



Will production of biomass crops reduce food availability?



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



Biovalue (www.biovalue.dk)

Biobase (www.dca.au.dk/en/research/biobase)

The bioindustry (e.g. DONG Energy & Novozymes) are concerned about the bio-resource

Will there be enough biomass for establishing a significant biorefinery industry?

- Will it be sustainable (soil C, pesticides, GHG, nutrient leaching, biodiversity.....) ?
- What about iLUC?
- What types of biomass can be available for which technologies?

This was answered by a scenario analysis
(*Gylling et al., 2013 + 2016*)

Prerequisite: No change in Danish food production

See more in

<http://curis.ku.dk/ws/files/47425822/TimioplanUKnet.pdf>



THE + 10 MILLION TONNES STUDY

Increasing the sustainable production of biomass for biorefineries



Three Danish biomass scenarios for 2020

Business as usual:

- No changes in crops or technologies
- Existing resources (straw, manure, rape oil etc.)

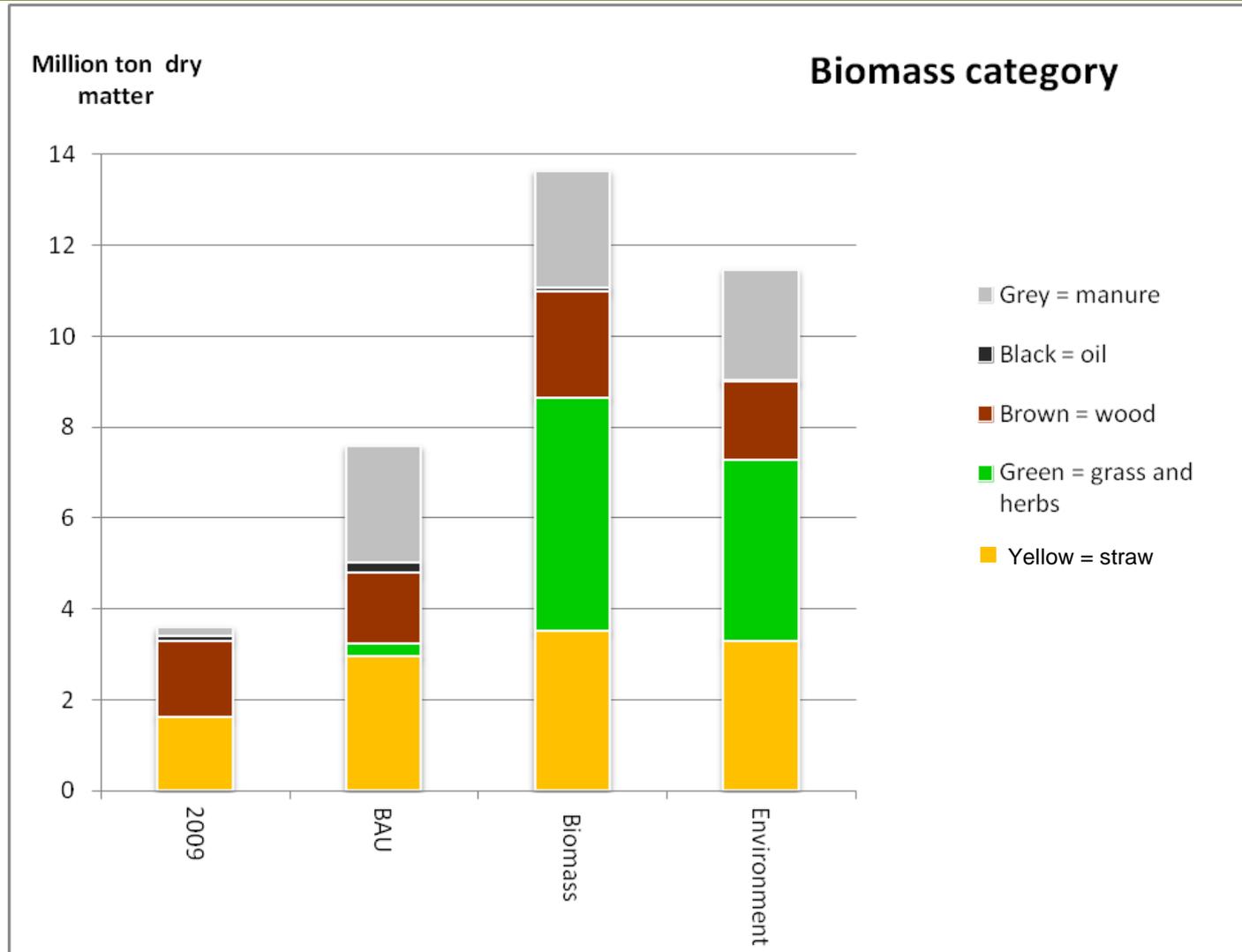
Biomass optimised:

- Straw rich grain varieties
- Increased straw harvest
- Less grain and rape → high productive biomass crops (beets 19 t ha⁻¹ DM)
- Fertilization of natural grasslands
- Road sides, aquatic weeds, catch crops etc.

Environmentally optimised:

- No straw removal from land with critical low carbon content
- Perennial biomass crops (grass 15 t ha⁻¹ DM)
- No grain crop production in nitrate sensitive areas
- No fertilization of natural grasslands
- Increased afforestation

Different biomass types for different conversion technologies

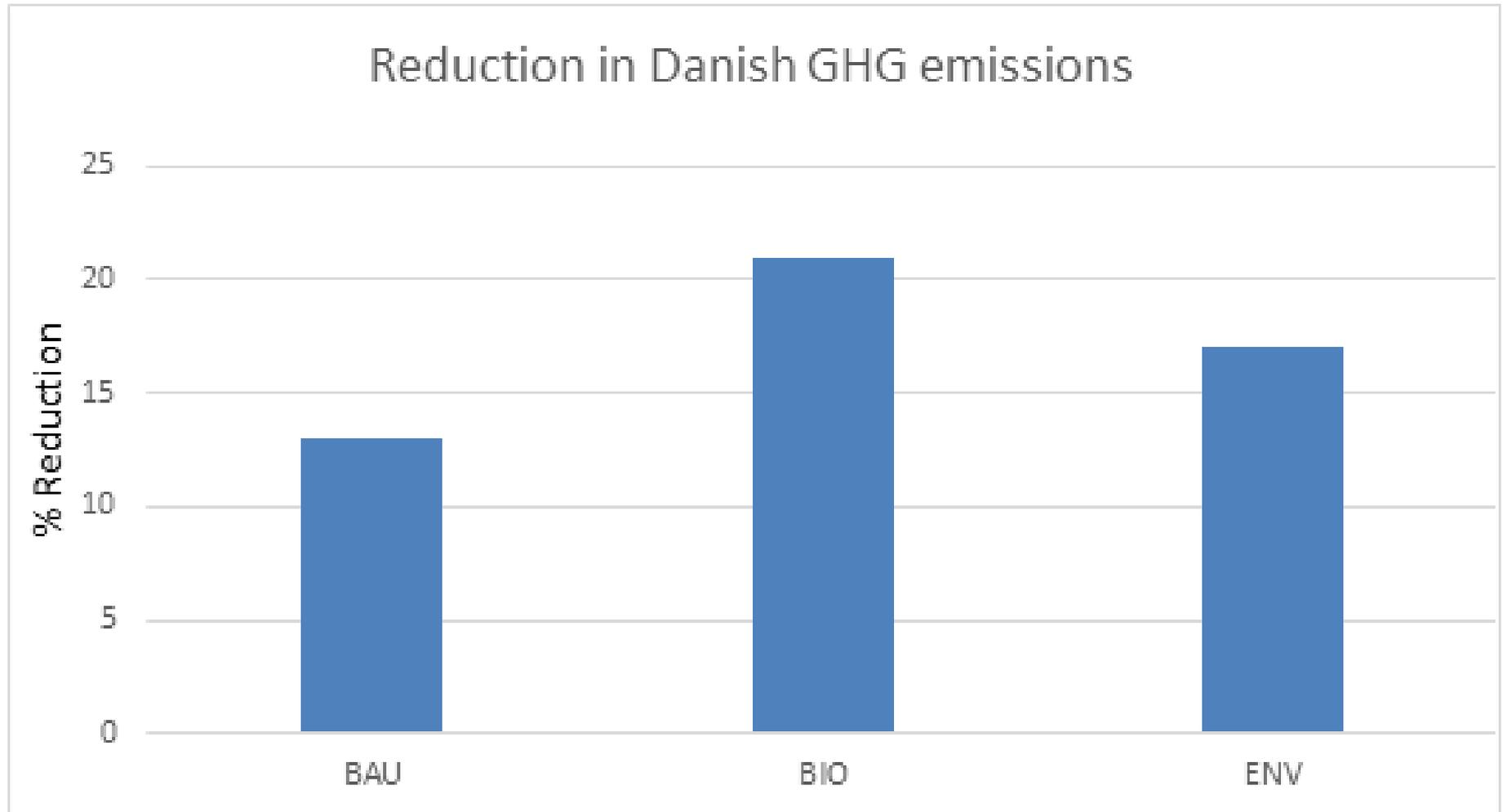


Increased biomass utilisation can reduce nitrate leaching

	Change in root zone nitrate leaching for Denmark (ton N y ⁻¹)		
	BAU	Biomass	Environment
Animal manure	-5.752	-5.752	-5.487
SRC	-248	-248	-248
New biomass crops substituting rape		-3.142	-6.085
New biomass crops substituting grain crops		775	-5.040
Afforestation	-847	-847	-2.005
Additional catch crops			-4.598
Total	-6.846	-9.214	-23.463

Will fulfil the demands of the EU Water Framework Directive

Energy system scenarios were defined to analyse the effect on TOTAL Danish GreenHouse Gas emissions



We can sustainably increase productivity by combining the best from agronomy with the best from industry!

