Innovative biomass production systems, harvest, and conservation technologies

In P1
grass production, grass protein, wheat protein, and wheat straw
are in focus

Intensification of biomass production
Quality of biomass for protein extraction
Straw & grain quality
Amino acid profil of wheat protein
Separat harvest of grain and straw
Ensiling of fiber after protein extraction
Optimization of biomass production chain
Determination of available biomass

Intensification of biomass production

- Sustainable intensification of biomass production on current agricultural land - feeding future biorefineries
- Crops producing **large biomass yield** - **main criteria**
- Moreover:
  - *IPAR* = amount of captured sunlight by the plants
  - *RUE* = “conversion efficiency” of *IPAR* into biomass
- Crops with **high *IPAR* and high *RUE*** - **another criteria**

Industrial use

- Direct industrial use:
  - Biorefinery: variety of plant material with large supply (13-17 Mg ha^{-1}) of biomass
  - Farming: diversified cropping systems with high biomass yield per hectare; soil fertility
  - Plant breeding: increased seed production and selling (for some crops)

- Perennial crops have high *IPAR*, but overall low *RUE*:
  - Genetic improvement for higher *RUE*, thus higher biomass yield per hectare – plant breeding industry

Candidate crops / cropping systems for intensification of biomass production

Optimised (4-year) rotation	
Foulum	W. rye-maize-w. rye-beet-hemp-triticale-grass/clover ✓
Jyndevad	W. rape-hemp-w. rye-maize-w. rye ✓
Perennial crops Foulum/Jyndevad	*Fertilised:* Reed canary Tall fescue ✓ Cocksfoot Festulolium (only at Foulum) ✓ *Low-fertilised:* *Miscanthus spp.* *Unfertilized:* Grass-legume mixtures ✓

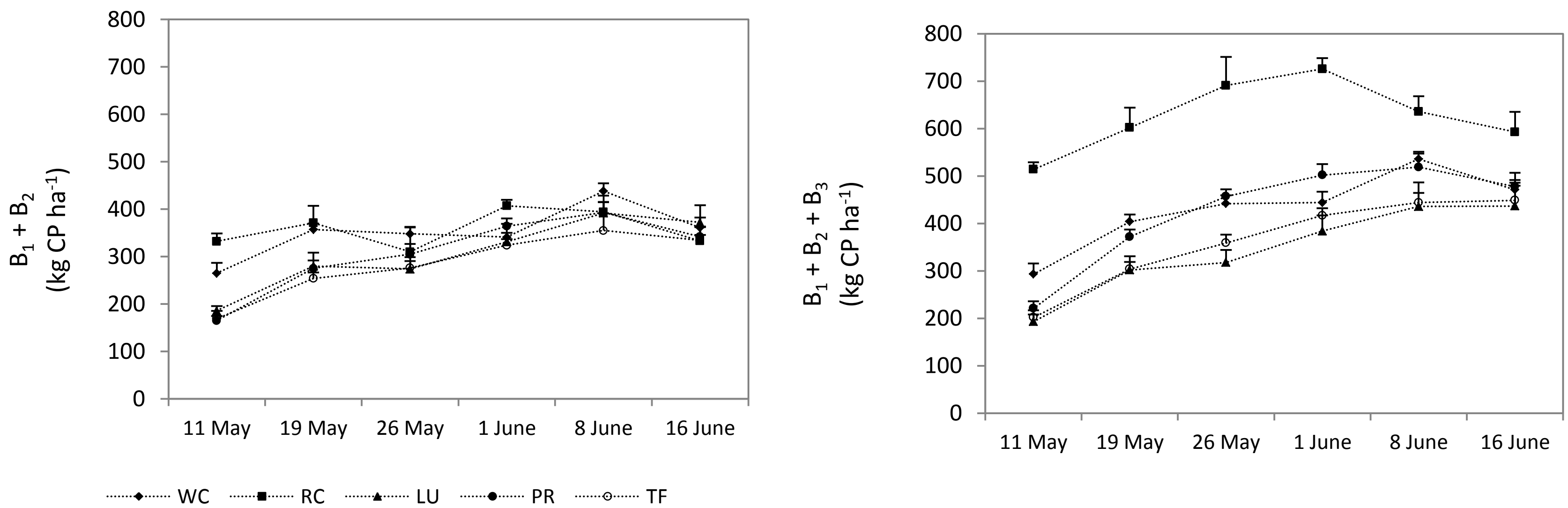
✓ Similar or larger biomass than traditional systems*,
and also larger nitrogen content (indication for protein content)
and lower soil nitrate leaching.

* Traditional systems represented mainly by maize monoculture as one of the most productive in terms of biomass yield.

Quality of biomass for protein extraction

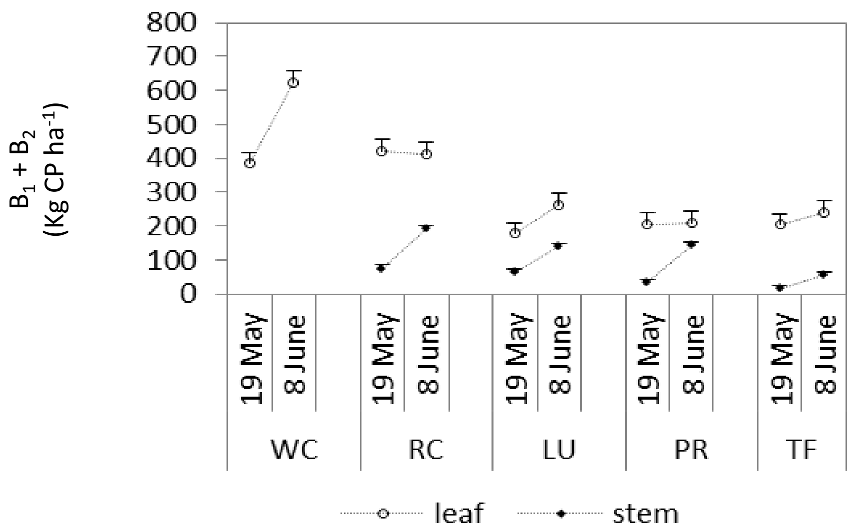
- Extracted protein from plants can be divided in A, B, and C fractions, depending on extractability. Only B fractions are of industrial interest

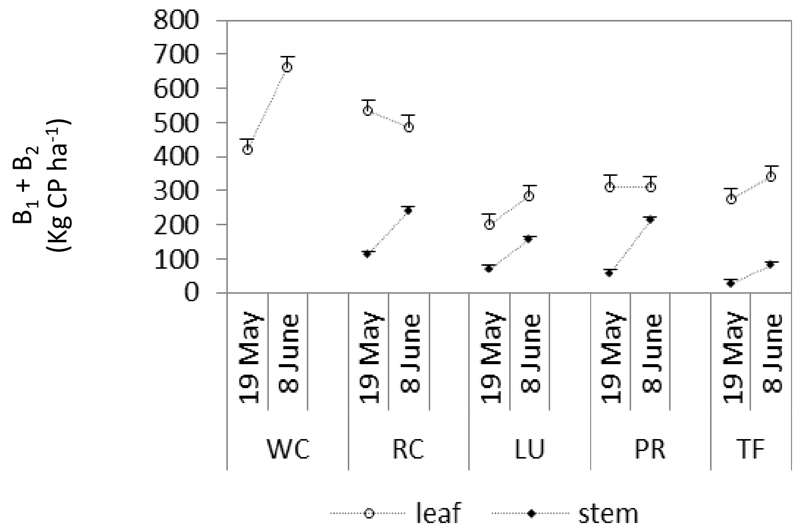
- Screening of plants for protein extractability
  - If only soluble B_1+B_2 fractions can be extracted: little difference btw crops
  - If also B_3 can be extracted red clover is clearly the most productive



Quality of biomass for protein extraction

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





Quality of biomass for straw production

Main Goal: To identify molecular markers for straw yield and for grain quality parameters to obtain both a good grain quality and straw quality.

Traits analyzed:

Straw traits: straw yield, height, Septoria, lodging, sugar yields and C/N content

Grain traits: grain yield, width, and length, specific weight, protein, gluten, starch, water, aNDF, and TGW.

The research is therefore primarily aimed at Plant Breeding companies, Biorefineries, and the Chemical industry

- In house genotyping with KASP markers for straw and grain yield parameters
- Breeding: Faster establishment of new breeding lines, because genotyping is faster than phenotyping
- Farmer & breeding: New cultivars with improved grain and straw yield and quality.
- Biorefinery: Provide information on how to increase the sugar yields and minimize differences between cultivars for enzymatic saccharification of wheat straw.

Investigating Nitrogen composition in winter wheat for possible use in bio-refineries

- Proteins represent the major N-constituent in plants throughout their development
- Various wheat samples are hydrolyzed to investigate their Amino Acid (AA) profile

- Industrial value of AA profile in integrated bio-refinery approaches
  - Indication on nutritional value of plant material for feed
  - Value of using AA's as precursor for chemical production

The main goal is to analyze N-containing substances in dependence of N-status and growth stages in different plant organs to find optimal wheat for bio-refinery applications

BIOVALUE SPIR

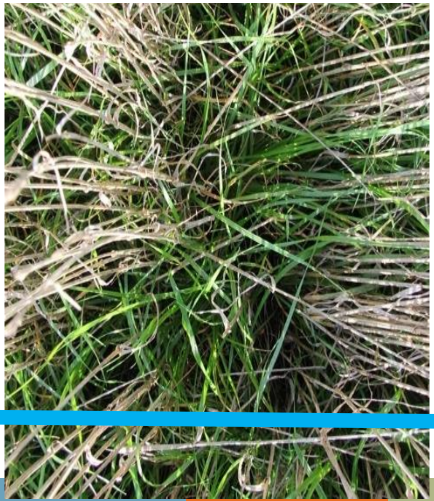
TEKNOLOGISK INSTITUT

Strip harvesting of cereals – two streams

Strip harvest of spikes

Grain/spike mixture for cattle feed

Under-sown catch-crops



Combined harvest of straw and catch-crops

Straw/catch-crop mixture for biogas

Strip harvesting of cereals

Relevance for the agricultural industry:

- Cheaper harvest of grain fraction compared to conventional grain harvest
- Higher yield of grain feed for e.g. calves
- Potentially higher yield of catch-crops
- Rational, combined harvest of straw+catch-crops
- Higher methane yield from straw after co-ensiling with catch-crop?

Ensiling of fiber after protein extraction

Studies of effluent run-off, mass loss, quality change etc.

Relevance for the agricultural industry:

- Optimization of the handling and use of the fiber fraction
- Input to economic evaluation and optimization of the green protein value-chain

Modelling & Economy

- The model calculates
  - Total cost for acquisition of biomass
  - Harvest cost on different soil types and nutrient supply
  - Storage cost & storage loss for different storage options
  - Cost depending on transport form, loading equipment, and distance

- Through multiple choices of yield per hectare, harvest methods, transport means, pretreatment, storage options, the total cost for biomass acquisition can be calculated

Commercial use of the model

- Counselling
  - In order to get the cheapest biomass; How should the biomass be stored?
  - If I choose a cheaper storage form, what is then the impact on storage loss?
  - Given a certain yield, harvest, and storage; How far can the biomass be transported?

    This distance can later be used to calculate available biomass for a biorefinery within a certain prize limit

- Biomass suppliers:
  - Before production of new type of biomass: Calculation of cost and revenue

- Biorefinery:
  - Determination of storage cost, storage loss, transport costs, maximum transport distance. Approximation of cost of biomass
  - Use of maximum transport distance for calculation of available biomass

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