The green biorefinery seen from the organic farmers perspectives

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Aalborg University Copenhagen
Outline

• The farmers role
• The grass clover as engine for organic rotations and environmental protection
• Practical challenges in the grass harvest
• Biomass logistics
• Feeding with grass protein
• Economics – competition with other sources of protein feed
• Outlook and new projects
The farmer is decisive for green biorefining

- He deliver the grass.
- He use the protein products.
- He use the residues as fertilizer.
- Should he build the biorefinery?
Benefits of grass clover

- In organic farming: The engine of the crop rotation
  - 200 kg nitrogen per hectare + 30 kg N as pre crop value.
  - 20 to 25 % grass clover in the rotation.
  - The nitrogen must be utilized to generate the value.

- In general: Soil improvement and environmental benefits
  - Soil improvement is important – but difficult to put an economic value on.
  - New targeted environmental regulation looks at extended grassland in water catchment areas.
Grass harvest - Yields in trials

Yields (OrganoFinery – project)

- Research trials – Copenhagen Universitet

<table>
<thead>
<tr>
<th>Yield (ton ha(^{-1}))</th>
<th>Crop DM</th>
<th>Crop protein</th>
<th>Protein in concentrate(^*))</th>
</tr>
</thead>
<tbody>
<tr>
<td>White clover / Ryegrass</td>
<td>6.26</td>
<td>0.88</td>
<td>0.31</td>
</tr>
<tr>
<td>Red clover</td>
<td>8.82</td>
<td>1.47</td>
<td>0.51</td>
</tr>
<tr>
<td>Red clover / Cock’s foot</td>
<td>9.50</td>
<td>1.36</td>
<td>0.48</td>
</tr>
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</table>

- Field trials - SEGES

<table>
<thead>
<tr>
<th>Yield (ton ha(^{-1}))</th>
<th>Crop DM</th>
<th>Crop protein</th>
<th>Protein in concentrate(^*))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>13.31</td>
<td>2.53</td>
<td>0.89</td>
</tr>
<tr>
<td>Red clover</td>
<td>16.45</td>
<td>2.86</td>
<td>1.00</td>
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<tr>
<td>Grass clover mixture</td>
<td>19.23</td>
<td>2.95</td>
<td>1.03</td>
</tr>
</tbody>
</table>

\(^*)\) Protein in concentrate estimated to 35% of crop protein

Kilde: Fog et al. 2017
Grass harvest – Estimated weekly yields (3,000 ha)

- Green mass (ton)
- Dry matter (ton)
- Protein (ton)
Harvest methods

- The grass has to be processed quickly after harvest in the field.
- Maxigrass (Grasstech.ie) – no soil contact – uncrushed grass - little capacity.
Harvest methods

• Broad mover followed by a self-loading forage wagon
  • High capacity
  • Grass not crushed
  • Light wagons
  • Few tracks

Foto: Pöttinger AT
Biomass logistics

• Transport costs are serious for the economy.

• Trade off between short distances and economy of scale.

• Can local pressing units combined with regional refineries be a solution (cattle feed from press cake)?

Photo: P. Kiel- Biotest
Feeding with grass protein – wet or dry?

• Most farmers prefer dry feed from the feed company.

• Drying of protein paste – also a processing cost.

• Trials with protein paste in dry feed production showed technical difficulties even at low volume of grass protein paste (5 %)

Photo: M. Ambye-Jensen
Norwegian trials with grass juice

- Grass juice as protein feed for pigs.
- Good acceptance from the pigs – lower feed value than control feed.
- Storage can be a challenge – conservation with formic acid.
- Danish test of lactic fermented protein paste in project SuperGrassPork.
### Economics

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<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Income, protein sale</strong></td>
<td>5,640</td>
<td>8,000</td>
</tr>
<tr>
<td><strong>Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bought grass crop</td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>Juice pressing</td>
<td>1,300</td>
<td>800</td>
</tr>
<tr>
<td>Transport</td>
<td>1,900</td>
<td>1,500</td>
</tr>
<tr>
<td>Biorefining</td>
<td>3,300</td>
<td>1,500</td>
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<tr>
<td>Energy</td>
<td>1,100</td>
<td>200</td>
</tr>
<tr>
<td>Disposal of reject water</td>
<td>1,800</td>
<td>0</td>
</tr>
<tr>
<td><strong>Result</strong></td>
<td>-5,260</td>
<td>2,500</td>
</tr>
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#### Necessary price of protein concentrate DKK / kg

The price must be able to compete with e.g. soy protein. Current price for organic soy cake: 4.60 DKK / kg. (conventional 2.30 DKK / kg)

Depending on the digestibility of the grass protein some animals can pay a good price (e.g. piglets)

Ref: Niels Tvedegaard, KU-IFRO
Synergy with biogas production

- Share transport costs of grass and reject water.
- Waste heat from the biogas plant can be used for drying of protein paste.
- Reject water from the biorefinery can be used to make plant biomass fluid in the biogas plant.
Outlook and new projects

• Big interest among organic farmers for the concept – both for growing more grass and for exchanging soy protein with grass protein.

• Implementation of green biorefinery for protein feed depend first of all on product quality and price. Must be documented before the farmers will involve themselves in grass protein production.

• The projects SuperGrassPork and Green Eggs will document the feed value and further develop the biorefining technique. (Green Development Program / ICROFS)

• Green Bioraf (Grøn Bioraf) at AU Foulum and SUBLEEM 2.0 at Danish Technological Institute will develop an document optimized biorefining processes. (2019 - )

• Central Denmark Region has funded two innovation projects for planning og commercial biorefinery plants.

• Green Development Program has launched 14 mil. DKK as investment subsidy for the first full scale pilot plants.

• SEGES run Bioraf-Business project to show business opportunities for organic farmers.
Green proteins are future farming

• At SEGES we believe there are future possibilities for Danish farmers in growing green crops for biorefining.

• We have recently published two whitepapers on green biorefining and plant proteins for human consumption (in Danish).