Agricultural feedstocks: current status and the path to improvement

Dr. agr. Christine von Buttlar (Ref.)

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Title: „Cultivation of Biomass Crops for Biofuels: potential climate impact and other environmental effects“

Authors: F. Eulenstein, W. Merbach, C. von Buttlar, J. Augustin, A. Werner

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Topics

- Germany's renewable resources
- Yields and potentials
- Climate balance for biofuels
- Further environmental requirements
- Conclusions
1,96 Mio hectares used for bioenergy-crops (in 2011), of that area:
- 910,000 hectares of rape seed for biodiesel,
- 250,000 hectares of sugar beets & starch for ethanol,
- 800,000 hectares of crops for biogas (mostly for electricity & heat)
Germany’s political targets for the biofuel development

- Political target by the year 2020: (percentage of renewable sources of energy)
  - 17% biofuels,
  - 14% of bio-heat
  - 27% of bio-electricity

- Free potential for all bioenergy crops in Germany: 3,5 mio hectares (29% of the arable land)

- For the 17% aim of biofuels we need about 2,4 Mio hectares (~ 70%)

  ⇒

- Competition between renewables for biofuels, biogas and industrial use
- Only small parts of our fuel-consumption can be supplied by German biomass
Agricultural feedstocks used

Wet biomass (~30% dry matter)
- fermentation in biogasplant (Gas, electricity, head)

Dry biomass (~85% dry matter)
- Biofuel - Ethanol

Dry biomass (~85% dry matter)
- Biofuel - Biodiesel, Oil

Biomass, straw, wood, biowaste...
- Biofuel 2nd generation (BTL)
### Yields and Oil-equivalents (under German conditions)

<table>
<thead>
<tr>
<th>Ethanol</th>
<th>maize seed</th>
<th>cereal seed</th>
<th>sugar beet</th>
</tr>
</thead>
<tbody>
<tr>
<td>yield (dt fm/hectare)</td>
<td>100</td>
<td>80</td>
<td>500</td>
</tr>
<tr>
<td>equivalent of ethanol (l/hectare)</td>
<td>2500</td>
<td>1900</td>
<td>3500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plant oil/ Biodiesel</th>
<th>rape seed</th>
<th>Biogas/ (BTL)</th>
<th>maizeplant</th>
</tr>
</thead>
<tbody>
<tr>
<td>yield (dt/hectare)</td>
<td>35</td>
<td>yield (dt/hectare)</td>
<td>500</td>
</tr>
<tr>
<td>equivalent of diesel (l/hectare)</td>
<td>1100</td>
<td>equivalent of diesel (l/hectare)</td>
<td>4300-5000</td>
</tr>
</tbody>
</table>

Source: Eulenstein, F. et.a. 2011: Cultivation of biomass crops for fuels

- New technology BTL promises higher energy-yields per hectare for the future
Climate balance of biofuel (1st generation)

Relevant greenhouse gases in agricultural cultivation processes:

- **N₂O (nitrous oxide)**
  - Source: Soil (90%), cultivation, organic manures, changes in land use
  - Importance: **high**
  - Risk of leaching: N₀₃, NH₄⁺, Norg.

- **CO₂ (carbon dioxide)**
  - Source: fossil fuels for engineering
  - Importance: **high**

- **CH₄ (methane)**
  - Sources: application of manures, organic soils
    - others: Animals (75%), storage of organic manure
  - Importance: **low**
## Greenhouse gases and climate balance

<table>
<thead>
<tr>
<th>Fuels</th>
<th>Results</th>
<th>Default- value for cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\text{kg CO}_2$- equivalents/ GJ fuel</td>
<td>(BioNachVer 2007), VOGT u. FEHRENBACH, 2010</td>
</tr>
<tr>
<td>fossil diesel</td>
<td>$\text{brutto (bevor production)}$ = 73,61</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\text{netto (after production)}$ = 91,7</td>
<td></td>
</tr>
<tr>
<td>biomass</td>
<td>$\text{brutto (after cultivation)}$ = 15 - 35</td>
<td>$11-35$ (dependent on the crop)</td>
</tr>
<tr>
<td>difference fossil -</td>
<td>$\text{free for conversion from biomass to fuel}$</td>
<td>$55-75$</td>
</tr>
<tr>
<td>renewable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Eulenstein, F. et.a. 2011: Cultivation of biomass crops for fuels

- **Biomass values:** **without** change of land use from extensive to intensive
- The difference between $\text{CO}_2$-equivalent of the biomass production and fossil fuels is $55 – 75 \text{ kg CO}_2$/ GJ fuel.
- A reduction of greenhouse gases is possible, if the conversion from biomass to biofuel consumes less than this range!
Climate balance of biomass production for biofuels

"Under condition of cultivation WITHOUT change from extensiv to intensive landuse systems and belong official fertilizing recommendations"

<table>
<thead>
<tr>
<th>culture</th>
<th>results (kg CO₂-equ./GJ fuel)</th>
<th>Default- Value for cultivation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO₂</td>
<td>N₂O</td>
</tr>
<tr>
<td>rape</td>
<td>20,5</td>
<td>W 4,68</td>
</tr>
<tr>
<td></td>
<td>20,5</td>
<td>FK 6,76</td>
</tr>
<tr>
<td>weat</td>
<td>13,3</td>
<td>W 17,1</td>
</tr>
<tr>
<td></td>
<td>13,3</td>
<td>FK 49,5</td>
</tr>
<tr>
<td>rye</td>
<td>13,3</td>
<td>W 8,9</td>
</tr>
<tr>
<td></td>
<td>13,3</td>
<td>FK 18,3</td>
</tr>
<tr>
<td>maize-corn</td>
<td>13,3</td>
<td>W 7,2</td>
</tr>
<tr>
<td></td>
<td>13,3</td>
<td>FK 22,7</td>
</tr>
<tr>
<td>maize-biomass</td>
<td>5,4</td>
<td>W 3,8</td>
</tr>
<tr>
<td></td>
<td>5,4</td>
<td>FK 11,9</td>
</tr>
<tr>
<td>maize-biomass on organic soils</td>
<td>23,6</td>
<td>14,5</td>
</tr>
<tr>
<td>sugar beat</td>
<td>10,4</td>
<td>14,5</td>
</tr>
</tbody>
</table>

w = warm- dry; FK = humid- cold
Climate balance of biomass production für biofuels

Results:

- In comparison to fossil fuels, greenhouse gases can be reduced!
- The main sources are nitrogen oxide ($N_2O$) and carbon dioxide ($CO_2$).
- Lower values in North-Germany (warm) as in Southern Germany (weat and cold).
- Current guideline values can be kept for rape, rye and maize-biomass.
- Necessary adjustments for wheat, sugar beets and organic soils.
- Change from grasland to arable land should be avoided.
- Crop Growing with reduced nitrogen surplus is recommended.
Further environmental requirements to biomass production

Biodiversity
- Crop-rotation
- High diversity of species
- Low pesticides
- Ecological balance

Water protection
- Critical value 50 mg nitrate/ liter
- Nitrate-balance

Soil protection
- Federal Soil Protection Act
- Erosion prevention
- Stable humus-balance

Land use
- No change extensive – intensive
- No losses of grasslands
- No losses of forests
Conclusions

Results:

- Germany will supply **17% of biofuels** by 2020. Therefore ~ 70% of the free area for bioenergy crops is needed.
- The biomass- yield potential is high. Future **raises** are expected **moderately**.
- **Default values** for greenhouse gases are **approved** under certain conditions (no change of land use, moderate cultivation intensity).

Research is required in following areas:

- Adaption of **default values** for wheat and sugar beets.
- Other factors like **soil** and **climate** conditions have to be considered.
- Production of agricultural feedstocks should respect principles of **sustainability** for climate, water, soil and biodiversity.
Thank you for the attention!