March 4, 2011
ASSBT Biennial Meeting, Albuquerque, NM

Analysis of Breeding Progress
of Sugarbeet

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Corrected Sugar Yield (CSY) and White Sugar Yield (WSY) of New Varieties on National Scale


- CSY, official variety trials
- WSY, national scale

\[ y = 8.27 + 0.15x \]
\[ r^2 = 0.73 \]

\[ y = 6.04 + 0.11x \]
\[ r^2 = 0.78 \]

Source: IfZ 2010
## Increase of Sugar Yield in EU Member States

<table>
<thead>
<tr>
<th>Country</th>
<th>Sugar Yield (t ha$^{-1}$) 2001-2005</th>
<th>Increase (% p.a.)</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>11.88</td>
<td>&gt;1,5</td>
<td>1983-2004</td>
</tr>
<tr>
<td>B</td>
<td>10.74</td>
<td>2,2</td>
<td>1985-2004</td>
</tr>
<tr>
<td>NL</td>
<td>10.66</td>
<td>1,4</td>
<td>1950-2004</td>
</tr>
<tr>
<td>E</td>
<td>10.58</td>
<td>5</td>
<td>1990-2005</td>
</tr>
<tr>
<td>GB</td>
<td>10.35</td>
<td>2</td>
<td>1970-2004</td>
</tr>
<tr>
<td>DK</td>
<td>9.96</td>
<td>&lt;1,3</td>
<td>1984-2004</td>
</tr>
<tr>
<td>D West</td>
<td>9.50</td>
<td>1,6</td>
<td>1970-2005</td>
</tr>
<tr>
<td>S</td>
<td>8.41</td>
<td>&gt;1</td>
<td>1985-2004</td>
</tr>
<tr>
<td>D East</td>
<td>8.08</td>
<td>3,5</td>
<td>1990-2005</td>
</tr>
<tr>
<td>PL</td>
<td>7.05</td>
<td>7</td>
<td>1994-2004</td>
</tr>
<tr>
<td>H</td>
<td>6.78</td>
<td>4</td>
<td>1999-2004</td>
</tr>
<tr>
<td>I</td>
<td>6.43</td>
<td>&lt;1</td>
<td>1960-2004</td>
</tr>
<tr>
<td>SK</td>
<td>6.26</td>
<td>&gt;5</td>
<td>1999-2005</td>
</tr>
<tr>
<td>FIN</td>
<td>5.70</td>
<td>&gt;1</td>
<td>1955-2004</td>
</tr>
</tbody>
</table>

Source: Fuchs et al. 2008
Trials with Sugarbeet Varieties Registered 1964 to 2003

Field Trials near Göttingen, Germany 2008
  • completely randomized block design
  • 11 varieties of different registration years

Greenhouse Trials in Göttingen, Germany 2008
  • completely randomized block design
  • 17 varieties of different registration years
Technical Progress in yield

- New variety
  - + Breeding
  - + Agronomy & Climate
- Old variety

Source: Loel et al. 2010, modified
Mean Chemical Composition of Sugarbeet
Germany, 2007

- Water 76.6%
- Dry matter 23.4%
- Sucrose 17.4%
- Non sugar 2.0%
- Marc 4.0%

Source: Kenter and Hoffmann 2008
Development of Sugar Content and Root Yield of Sugarbeet


\[ y = 17.32 - 0.02x \]
\[ r^2 = 0.1 \]

\[ y = 57.25 - 0.75x \]
\[ r^2 = 0.67 \]

Source: IfZ 2010
Development of the Potassium, Sodium and Amino-N Content of Sugarbeet


![Graph showing the development of Potassium, Sodium, and Amino-N content in sugarbeet from 1975 to 2010, with trend lines and equations for each nutrient.]

- Potassium: $y = 58.24 - 0.71x$, $r^2 = 0.89$
- Amino-N: $y = 23.21 - 0.33x$, $r^2 = 0.59$
- Sodium: $y = 8.12 - 0.14x$, $r^2 = 0.42$

Source: IfZ 2010
Relative Chlorophyll Content of Sugarbeet Varieties of Different Registration Years (1964 bis 2003)

Reference variety registered in 1964 = 100%
Field trials and greenhouse (GWH) trials, IfZ, Germany 2008

Source: Loel et al. 2010
Photosynthesis depending on the Chlorophyll Content of Sugarbeet Varieties of Different Registration Years (1964 bis 2003)

Reference variety registered in 1964 = 100 %, greenhouse (GWH) trials, IfZ, Germany 2008

**Photosynthesis Rate [%]**

**Chlorophyll Content [%]**

- **a**
- **b**
- **r²**

- **GWH** 96 n.s. 0.81* 0.78*

**Source:** Loel et al. 2010

**p<0.01** n.s. not signifikant
Root Yield depending on the Chlorophyll Content of the leaves of Sugarbeet Varieties of Different Registration Years (1964 bis 2003)

Reference variety registered in 1964 = 100%
Field trials and greenhouse (GWH) trials, IfZ, Germany 2008

** p<0.05  n.s. not signifikant
Content of Marc in the Fresh Matter (FM) of Old and New Sugarbeet Varieties

Germany 2006

Marc, fresh matter [%]

<table>
<thead>
<tr>
<th>Year</th>
<th>1964</th>
<th>1987</th>
<th>2002 (E-Typ)</th>
<th>2003 (Z-Typ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marc, %</td>
<td>5.0</td>
<td>5.5</td>
<td>4.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

p<0.05

Source: Kenter and Hoffmann 2008
Composition of Marc Dry Matter of Old and New Sugarbeet Varieties

Germany 2007

Source: Kenter and Hoffmann 2008
Changes in Total Dry Matter Yield and Quality Parameters of Sugarbeet by Breeding Progress

Comparison of different references

<table>
<thead>
<tr>
<th></th>
<th>Technical progress per year</th>
<th>Breeding progress per year</th>
<th>Breeding progress in relation to technical progress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>field</td>
<td>greenhouse</td>
</tr>
<tr>
<td>White sugar yield</td>
<td>1.0-2.0%</td>
<td>0.9%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Total dry matter yield</td>
<td>0.10-0.17 t ha⁻¹</td>
<td>0.11 t ha⁻¹</td>
<td>0.08 t ha⁻¹</td>
</tr>
<tr>
<td>Technical quality</td>
<td>1.21-2.27%</td>
<td>0.46%</td>
<td>0.38%</td>
</tr>
</tbody>
</table>

Source: Loel et al. 2010, modified
Summary

Higher technical quality → lower standard molasses loss → increased white sugar yield

\[
\text{Dry Matter} = \sum_{\text{Sowing}}^{\text{Harvest}} \text{PAR} \times \text{LAI} \times \text{RUE} \times \text{HI}
\]

- Increased assimilation by
  - increased chlorophyll content
  - increased photosynthesisrate

unmodified unmodified unmodified

increased beet/leave relation increased sugar/marc relation

Source: Hoffmann 2006, modified
Conclusion

• Breeding progress resulted in a crop well adapted to the demands of sugar manufacturing.
• This was achieved by a decrease of the impurities and a more beneficial relation of short-chain carbohydrates (sugar) to long-chain (cell wall) carbohydrates.
• It has to be tested whether this is a result of higher internal energy efficiency of the plant.
• It is expected that variety improvement in terms of physiological processes will continue further.
• This change of carbohydrate partitioning will hopefully not result in a higher susceptibility against pests and diseases.
Thank you very much for your attention!
Estimation of Variance Components of the Effect of Genotype, Year, Region and Field Site on White Sugar Yield

New sugarbeet varieties, Federal Plant Variety Office, Germany 1981-2005

<table>
<thead>
<tr>
<th>Source of the variance</th>
<th>Variance components</th>
<th>%</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>variety</td>
<td>0.0889</td>
<td>3.5</td>
<td>0.015</td>
</tr>
<tr>
<td>year</td>
<td>0.5651</td>
<td>22.1</td>
<td>0.228</td>
</tr>
<tr>
<td>variety*region</td>
<td>0.0098</td>
<td>0.4</td>
<td>0.005</td>
</tr>
<tr>
<td>year*region</td>
<td>0.1180</td>
<td>4.6</td>
<td>0.115</td>
</tr>
<tr>
<td>site*region</td>
<td>0.3411</td>
<td>13.3</td>
<td>0.159</td>
</tr>
<tr>
<td>year<em>site</em>region</td>
<td>1.3022</td>
<td>50.8</td>
<td>0.150</td>
</tr>
<tr>
<td>residual error</td>
<td>0.1369</td>
<td>5.3</td>
<td>0.007</td>
</tr>
</tbody>
</table>

Source: Fuchs et al. 2008