Sugar beet fertilization practices in Germany  
- N, P, K -

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Sugar beet cultivation in Germany

Characteristics
- ~400,000 ha p.a. (out of 11.7 mio ha arable land)
- ~25,000 sb growers (Ø ~12 ha/grower)
- 20 sugar factories
- 4 companies
- Growers associations
- Contracts

www.zuckerverbaende.de Jahresbericht IfZ 2016/2017
Farm survey about cropping techniques in sugar beet cultivation in Germany

2.984 farms since 2010
sugar factories
sugar beet area
Timetable

Pre-crop    Catch crop   Winter
Sowing: end of march
(20.03. – 15.04.)
resowing: 1 % (main reason: erosion)

Harvest:
Sept. – Nov.

Herbicides
Fungicides
(Insecticides)
mineral / organic fertilizer
(additional mineral fertilizer)
application of \( P_2O_5, K_2O, \) lime
or organic fertilizers
Results from a survey among experts from sugar companies (1994-2010; estimated percent of beet growing area) joint with results from a survey among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field).

- 20% straw mulch
- 34% catch crop mulch
Influences of soil tillage on N mineralisation during the growing season

- results from unfertilized plots in a tillage trial in Göttingen 1995 after 4 years of different tillage applied, in situ-incubation of soil cores in the field -

Hoffmann et al., 1997
Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
Catch crops - development

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
Catch crops help to prevent nitrate leaching

Hauer et al. 2016

Sites/years

Soil mineral N (kg N/ha) in November

White mustard
Catch crop mixture
straw mulch

A/2013
A/2014
B/2013
B/2014
Crop rotations and tillage

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
Background

1. **Adequate nutrient supply** is fundamental for high yielding crops
2. **Fertilizer application** is essential for adequate nutrient supply, but can contribute to negative environmental effects
   - pollution of ground (N) and surface water (N, P)
   - $\text{N}_2\text{O}$ and $\text{NH}_4$ emissions
3. **Fertilizer application** has to meet either goals:
   - optimum nutrient supply of sugar beet crops
   - minimize environmental risks
Use of mineral and organic fertilizers

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
Time of fertilizer application

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
Applied N fertilizer
- including fertilizer application to the catch crops -

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
Applied N fertilizer
- including fertilizer application to the catch crops -

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
### Types of N fertilizers used

<table>
<thead>
<tr>
<th>fertilizer type</th>
<th>number of fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium ammonium nitrate</td>
<td>1475</td>
</tr>
<tr>
<td>Urea</td>
<td>853</td>
</tr>
<tr>
<td>NP</td>
<td>793</td>
</tr>
<tr>
<td>Urea ammonium nitrate solution</td>
<td>660</td>
</tr>
<tr>
<td>Ammonium sulphate nitrate</td>
<td>153</td>
</tr>
<tr>
<td>Ammonium sulphate</td>
<td>121</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>fertilizer type</th>
<th>number of fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas digestate</td>
<td>507</td>
</tr>
<tr>
<td>Pig slurry</td>
<td>369</td>
</tr>
<tr>
<td>Dairy slurry</td>
<td>227</td>
</tr>
<tr>
<td>Cattle manure</td>
<td>189</td>
</tr>
<tr>
<td>Poultry manure</td>
<td>139</td>
</tr>
<tr>
<td>Dried chicken faeces</td>
<td>121</td>
</tr>
<tr>
<td>Compost</td>
<td>101</td>
</tr>
</tbody>
</table>

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field) total number of fields = 2984, 2010-2017, includes multiple entries
Nitrogen surpluses of field balances in Germany (Mean 2009 – 2011)

Geupel & Frommer, 2014; http://www.umweltbundesamt.de/publikationen/reactive-nitrogen-in-germany

Chemical status of groundwater in Germany 2015

BMU/UBA (Hrsg.), 2017; http://www.umweltbundesamt.de/publikationen
The fertilizer N dose is calculated by accounting for the nutrient requirement of the crop minus the amount of available N from the soil (Nmin; mineralization, immobilization during the season; manure; catch crops)

N-target value (adapted to yield level)
+ basic soil N mineralization
= crop N requirement (estimated from N uptake in autumn)
  - spring soil Nmin - basic soil N mineralization
  - extra N release (manure, catch crop)
= fertilizer N dose

German fertilizer application ordinance (DüV), 2017

up to 300 kg N/ha
20 – 100 kg N/ha
German fertilizer use ordinance (DüV), 2017

Nutrient balance for N

- Each farm has to calculate an annual nutrient balance:
  \[ \text{N input (fertilizers, manures)} - \text{N removal (crops)} = \text{N surplus} \]
- Farm-scale level, 3-year moving-average
- The maximum tolerable surplus is: 50 kg N/ha and year

Influence of N fertilizer dose on N removal and N surplus

(leaves/tops left in the field)
Amount of nitrogen fertilizer rules the N-surplus

\[ \text{N balance} = \text{kg N fertilizer}_{(\text{org + min})} - (\text{root yield} \times 1.8 \text{ kg N/t beet}) \]

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms each year, answers given for the largest sugar beet field)
## Nutrient uptake of sugar beet crops in Germany

### Field trial data 1994 – 2013 (N=114)

Bürcky et al. 2017 and 2018

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Beet Mean (min - max) in kg/ha</th>
<th>Leaves and tops Mean (min - max) in kg/ha</th>
<th>Total plant Mean (min - max) in kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>110 (72-169)</td>
<td>114 (51-199)</td>
<td>224 (133-328)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>20 (9-28)</td>
<td>14 (6-23)</td>
<td>34 (16-49)</td>
</tr>
<tr>
<td>Potassium</td>
<td>136 (79-214)</td>
<td>245 (94-439)</td>
<td>381 (186-617)</td>
</tr>
</tbody>
</table>
Nutrient uptake of sugar beet crops in Germany
Field trial data 1994 – 2013 (N=114)

Beet N uptake

Beet N concentration
Effects of N fertilizer dose on sugar yield and beet quality - dose-response curves from two contrasting fields -

- Beet yield
- Sugar yield
- Sugar content
- Amino-N content

Laufer et al. 2016, adopted
Nutrient uptake of sugar beet crops in Germany
Field trial data 1994 – 2013 (N=114)

Beet N uptake (kg N/ha)

Beet N concentration (kg N/ha)

Beet P uptake (kg P/ha)

Beet K uptake (kg P/ha)

Bürcky et al. 2018
Effects of $K_2O$ fertilizer combined with liming

10 field trials in the middle and in the south of Germany, 2011-2012

Fischer et al. 2013
Organic fertilizers: nutrient composition differs

Ratio of applied and removed nutrients;
only organic fertilizers taken into account;
2010 – 2013, n=768

...mostly P$_2$O$_5$ rules the amount

Survey about sugar beet cultivation among farms (since 2010, more than 300 farms, answers given for the largest sugar beet field)
Fertilizer recommendation based on a crop rotation

Target: to replace the removal of P and K for the whole crop rotation with one application, mostly in fall

<table>
<thead>
<tr>
<th>Crop rotation</th>
<th>Yield (t/ha)</th>
<th>Removal P (kg P$_2$O$_5$/ha)</th>
<th>Removal K (kg K$_2$O/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugar beet</td>
<td>65</td>
<td>65</td>
<td>163</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>9.0</td>
<td>72</td>
<td>54</td>
</tr>
<tr>
<td>Winter barley</td>
<td>8.5</td>
<td>68</td>
<td>51</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>205</strong></td>
<td><strong>205</strong></td>
<td><strong>268</strong></td>
</tr>
</tbody>
</table>
Organic fertilizers: losses along the way

plant available N during growing season = effective fertilizer

soil organic matter, partly later available N

= total N input
Influence of N fertilizer on GHG emissions

N fertilizer: mineral and organic including applications to the catch crop, 2010 – 2013 (n = 1181)
mean N amount was 141 kg N ha\(^{-1}\) for all 3 years

Greenhouse gas emissions, analysis by source sector, EU-28, 1990 and 2015
http://ec.europa.eu/eurostat/statistics-explained
GHG emissions from sugar beet cultivation

Results from a survey among farms (2010 - 2012, more than 350 farms each year)

Other production factors:
- P₂O₅
- K₂O
- Pesticides
- Seeds

according to Trimpler et al., 2016; adopted
Nitrogen and phosphorus balance of Finland, kg/ha

Source: Natural Resources Institute Finland.
Nitrogen balance of Germany, kg/ha

Source: Natural Resources Institute Finland.
Thank you!