Legumes - the fuel for organic farming: chances, problems & solutions for crop rotations
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Our family farm(s):

My father’s farm:
• conventional farming
• egg production
• feed mill and soybean processing

My farm:
• organic farming
• sheep and cattle for meat production
• cultivation of all kind of crops
My Sheep and Cows
Science

Soybean Processing for animal feed

Soybean Breeding for human consumption
On-Farm research:

• Legumes in organic farming
• Direct seeding
• Weed management
• Variety testing

• Soybeans, lupins, peas...
Structure

1. Characteristics of Legumes
2. Planning of crop rotations with legumes
3. Problems in grain legume cultivation and solutions
4. Farm circulations
5. Legumes as intercrops
1. Characteristics of legumes
N is the fuel for the growth of plants

- in organic farming, no mineral „artificial“ N fertilizers are allowed
- artificial N fertilizers contribute to the problems of salinization, pH- and humus reduction in the long term
- organic farmers can only use the dung of their animals or several kind of composts
  → the only way to get N in organic farm circulations is through legumes!
N$_2$-fixation of legumes

1. rhizobia-bacteria
2. roothair
3. root
4. root nodules
5. bacteroids
6. infection hose
Important legumes for organic farming

Grassland legumes:
- Clover (white, red, crimson, subterranean, persian...)
- alfalfa
- vetch

Grain legumes
- peas
- lupins
- faba beans
- soybeans
- lentils

feed only for ruminant animals or biogas or mulching

for human consumption or all kind of animals
Development of cultivation of grain legumes in Germany

source: Stockinger, Lfl 2008
## Characteristics of grain legumes


<table>
<thead>
<tr>
<th></th>
<th>faba beans</th>
<th>peas</th>
<th>yellow lupins</th>
<th>blue lupins</th>
<th>white lupins</th>
<th>soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil</strong></td>
<td>deep medium to heavy soils, high water demand</td>
<td>Light to medium soils, good water regimen, stones are unfavorable</td>
<td>Light and sandy soils</td>
<td>Light to medium soils</td>
<td>Medium to heavy soils, good water regimen</td>
<td>Soils which easily warm up, good water regimen, stones unfavorable</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td>6,5-7</td>
<td>5,5-7</td>
<td>4-6; lime sensitive</td>
<td>5,0-6,8</td>
<td>5,5-6,8</td>
<td>6,5-7</td>
</tr>
<tr>
<td><strong>TSW in g</strong></td>
<td>300 - 500</td>
<td>200 - 300</td>
<td>110-150</td>
<td>130-180</td>
<td>300-500</td>
<td>150-200</td>
</tr>
<tr>
<td><strong>Date of seeding</strong></td>
<td>15.3.–15.4.</td>
<td>15.3.–15.4.</td>
<td>15.3.-15.4.</td>
<td>1.3.-31.3.</td>
<td>1.4.-30.4.</td>
<td>15.4.-15.5.</td>
</tr>
<tr>
<td><strong>Seeding depth</strong></td>
<td>6-10 cm</td>
<td>4-6 cm</td>
<td>2-4 cm</td>
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</tr>
<tr>
<td><strong>Stand density</strong></td>
<td>30-50 Grains/m²</td>
<td>70-90 Grains/m²</td>
<td>90-100 Grains/m²; 120 Grains/m²</td>
<td>90-100 Grains/m²; 120 Grains/m²</td>
<td>90-100 Grains/m²; 120 Grains/m²</td>
<td>40-60 Grains/m²</td>
</tr>
<tr>
<td><strong>Temp. ∑ (° C)</strong></td>
<td>1900</td>
<td>1750</td>
<td>n.s.</td>
<td>n.s.</td>
<td>1900</td>
<td>2800</td>
</tr>
<tr>
<td><strong>Thersing (av.)</strong></td>
<td>1.9.-30.9.</td>
<td>1.8.-15.8.</td>
<td>1.9.-30.9.</td>
<td>15.8.-15.9..</td>
<td>1.9.-30.9.</td>
<td>15.9.-15.10..</td>
</tr>
</tbody>
</table>
2. Planning of crop rotations with legumes
## Legumes: planning of crop rotations

<table>
<thead>
<tr>
<th>crop</th>
<th>Karalus 2003</th>
<th>other sources</th>
<th>problem</th>
<th>solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>faba bean</td>
<td>3 - 5</td>
<td>6-7 (Arvalis 2011)</td>
<td>fungus, viroses, nematodes</td>
<td>crop rotation</td>
</tr>
<tr>
<td>peas</td>
<td>6 - 8</td>
<td>6 - 9 (Bioforschung Austria 2011)</td>
<td>fungus, lices, beetles</td>
<td>Aphano-mycies test, winterpeas, crop rotation</td>
</tr>
<tr>
<td>lupins</td>
<td>3 - 5</td>
<td>4 - 6 (Ufop 2009)</td>
<td>fungus, viroses, nematodes</td>
<td>seed testing</td>
</tr>
<tr>
<td>soybeans</td>
<td>2 -3</td>
<td>4</td>
<td>sclerotina, rhizoctonia</td>
<td>temporal distance to sunflower, rapeseed...</td>
</tr>
</tbody>
</table>

*source: Sojaförderring 2011*
## Legumes: planning of crop rotations

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<th>problem</th>
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</tr>
</thead>
<tbody>
<tr>
<td>lentils</td>
<td>5</td>
<td>5</td>
<td>fungus</td>
<td>crop rotation, temporal distance also to peas</td>
</tr>
<tr>
<td>vetches</td>
<td>4 - 6 (Bioforschung Austria 2011)</td>
<td>fungus</td>
<td>not in crop rotations with peas!</td>
<td></td>
</tr>
<tr>
<td>red clover</td>
<td>6 - 7 (LfL 2010)</td>
<td>diseases, pests</td>
<td>crop rotation, also temporal distance to faba beans and peas</td>
<td></td>
</tr>
</tbody>
</table>

**source:** Sojaförderring 2011
Crop rotation

Option 1:
- 2 years clover grass
- winter wheat
- intercrop faba beans
- corn
- soybean
- winter wheat/triticale

Option 2:
- 2 years clover grass
- winter wheat
- spelt
- faba beans/peas/lupins
- corn
- soybean
- 2 years clover grass? triticale?
3. Problems in grain legume cultivation and solutions
Behavior of pests in the field corridor (FREYER 2003)

- Specific field pests (a)
- Migratory pests from field to field (b)
- Migratory pests from boundary structures (c)
Cultivation of peas in Kissing (2011)

extreme lice damage
Cultivation of peas – summer- vs. winterpeas

source: Gronle & Böhm
cultivation of peas – mixture vs. pure seed

Mixed cropping: triticale and winter peas

source: Gronle & Böhm
Cultivation of peas – mixed cropping/singel cropping

Grain yields of two winter pea varieties in single and mixed (with triticale) cropping
Mixture seed: faba beans and oat
Differential Diagnosis for fungus diseases of soils

control + nutrient solution + activated carbon + gamma radiation

Fatigue of legumes has biological causes!

source: Dr. J. Fuchs
Compost and health of legumes

Suppression of pests through compost?

feet diseases of peas

source: Bruns & Finckh
Compost and health of legumes

Composts have significant effect!

Phoma medicaginis

Biotest with 30vol. % compost; basis substratum is steril

Note 7

Note 6

Note 5

Note 4

Note 3

Note 2

Note 1

Infektion (% Pilz)

Substrat Sand-Kontrolle Sand + Kompost 30 vol.%

50 60 70 80 90 100

Anzahl Pflanzen (%)

0 10 20 30 40 50 60 70 80 90 100

0,1 0,5 1,5 2 2,5 3

Kruskal-Wallis-Test bei unabhängigen Stichproben

source: Bruns & Finckh
Compost and health of legumes

application of compost in rows

machine for row-application of compost

furrow puller

mix teeths
coulter
pressure roller

Source: Hensel, Bruns & Heß
organic fertilizers

control
(without fertilizers)

green waste chaff

15.05.2009

source: Lux & Schmidtke
Use of fertilizers in faba beans

Abb. 9: Effect of carbon rich, organic fertilizers on the grain yield of faba beans

source: Lux & Schmidtke
Chances for winter forms of grain legumes

- Advantages in yield at sites with dry summers (climate change)
- Reduced danger of N-leaching during winter
- Efficient weed suppression
- Advanced when lice pressure is high
- Low seeding density in mixed cropping
- 2-3 weeks earlier harvesting
- Soil covered throughout the year, protection from erosion
- When early harvested for silage, two crops per year possible
4. Farm circulations
Flow of nutrients, Energy and carbon
Use of clover grass

Collection of 75 - 200 kg N after 2 years

Collection of 180 - 360 kg N after 2 years

The use of clover grass/lucerne is beneficial!
Biogas production could substitute ruminants
Biogas Plant
Greenhouse
5. Legumes as intercrops
### N₂ Fixation power

<table>
<thead>
<tr>
<th>Kind of Legume and its use</th>
<th>kg N/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>several years of clover grass; green fallow</td>
<td>75 - 200</td>
</tr>
<tr>
<td>several years of clover grass; use for ruminants or biogas</td>
<td>170 - 340</td>
</tr>
<tr>
<td>peas for grain production</td>
<td>80 - 220</td>
</tr>
<tr>
<td>peas - barley mixture for grain production</td>
<td>60 - 150</td>
</tr>
<tr>
<td>peas - barley mixture for silage</td>
<td>60 - 150</td>
</tr>
<tr>
<td>undersown clover cereals</td>
<td>20 - 70</td>
</tr>
</tbody>
</table>

*source: Loges et al.(2002) bioland 14 - 15*
Faba bean intercropping

source: Josef Niedermaier
Effect on Corn

source: Josef Niedermaier
Transfer of clover to potatoes

source: Weller, Bioland 2011
Thanks for your attention!