Legumes as mix partners make a perfect organic crop

Herwart Böhm
Thünen Institute of Organic Farming
Structure

I. Introduction
- Thünen Institute – Federal Research Institute
- Thünen Institute of Organic Farming

II. Diversity of grain legumes
- Agony of choice

III. Why cultivating mixed crops?
- weed suppression
- diseases and pests
- harvest conditions
- yield
- yield stability
- higher nutrient levels

IV. Alternative / new mixed cropping systems
I. Introduction

Thünen-Institute – Federal Research Institute

Herwart Böhm
Thünen-Institute of Organic Farming
# German agricultural research at a glance...

### 100 % province (state) financed

<table>
<thead>
<tr>
<th>Universities with Agricultural Faculties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kiel</td>
</tr>
<tr>
<td>Göttingen</td>
</tr>
<tr>
<td>Bonn</td>
</tr>
<tr>
<td>Kassel</td>
</tr>
<tr>
<td>Gießen</td>
</tr>
<tr>
<td>Hohenheim</td>
</tr>
<tr>
<td>Weihe[nstephan</td>
</tr>
<tr>
<td>Halle</td>
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<tr>
<td>Rostock</td>
</tr>
<tr>
<td>Berlin</td>
</tr>
</tbody>
</table>

### 50 % federal, 50 % host state

<table>
<thead>
<tr>
<th>6 Leibniz-Institutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZALF - Agricultural Landscape</td>
</tr>
<tr>
<td>IAMO - Eastern Europe</td>
</tr>
<tr>
<td>FBN - Livestock</td>
</tr>
<tr>
<td>ATB - Agricultural Engineering</td>
</tr>
<tr>
<td>IGZ - Horticulture</td>
</tr>
<tr>
<td>DFA - Food Chemistry</td>
</tr>
</tbody>
</table>

### 100 % federal

<table>
<thead>
<tr>
<th>5 Federal Institutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thünen - Rural Areas, Forestry and Fisheries</td>
</tr>
<tr>
<td>JKI - Cultivated Plants</td>
</tr>
<tr>
<td>FLI - Animal Health</td>
</tr>
<tr>
<td>MRI - Nutrition and Food</td>
</tr>
<tr>
<td>BfR - Consumer Protection</td>
</tr>
</tbody>
</table>

Universities of Applied Sciences:

- Kiel
- Osnabrück
- Soest
- Bingen
- Dresden
- Bernburg
- Weihenstephan
- Nürtingen
- Eberswalde
- Neubrandenburg

Agr. Research Institutes of the Provinces (States) in almost every state.
Thünen Institute with 14 specialized Institutes

3 main areas:

- Fisheries
- Forestry
- Agriculture

Fisheries
- Baltic Sea Fisheries
- Fisheries Ecology

Forestry
- Forest Genetics
- Forest Ecosystems
- International Forestry and Forest Economics
- Wood Research

Agriculture
- Rural Studies
- Farm Economics
- Market Analysis
- Agricultural Technology
- Biodiversity
- Climate-Smart Agriculture
- Organic Farming
Thünen Institute of Organic Farming
- *Trenthorst*

**Director:**
Dr. Hans Marten Paulsen

[Prof. Dr. Gerold Rahmann]

**Staff:** ~ 90 (thereof 29 scientists)

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**Research fields**

- Organic plant and fodder production
- Organic animal husbandry (cows, sows, pigs, hens and broilers)
- Animal health and animal welfare
- Environmental protection and resource efficiency
II. Diversity of grain legumes
- Agony of choice

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Grain legumes species

- Faba bean
- Pea
- Blue lupin
- White lupin
- Yellow lupin
- Soy-bean
- Common vetch

- Susceptibility to anthracnose 
  \[ \text{Colletotrichum lupini} \]

- Spring- and winter forms

- only in mixed cropping
Decision tree
- Which grain legume is suitable for my site

more than 50 soil points

pH-value
5,8-6,0
> 6,0

rainfall during flowering
less than 100 mm
more than 100 mm

Temperature during the seed formation
low
high

suitable
faba bean
pea
soybean
white lupin
blue lupin

of limited suitability
common vetch

suitable
faba bean
pea
lens
soybean

of limited suitability
white lupin
blue lupin
common vetch

of limited suitability
soybean
faba bean

suitable
faba bean
pea
soybean

of limited suitability
common vetch

of limited suitability
pea
lens

suitable
faba bean
pea

of limited suitability
common vetch

of limited suitability
soybean

suitable
faba bean
pea
lens
soybean

of limited suitability
white lupin

source: adapted from Völkel and Vogt-Kaute (2013) in KTBL-Heft 100
Thünen Institute of Organic Farming in Trenthorst

- Northern Germany, Eastern hill country of Schleswig-Holstein,

Site and weather:
- Climate: moderate maritime
- Precipitation: 705 mm mostly < 100 mm during flowering
- Mean temperature: 8.8° C
- Lower temperatures during seed formation
- Altitude: 40 m
Soil characterisation of the Experimental Farm Trenthorst

- Stagnic cambisol / Gleyic cambisol
- Soil type: Ls3
- 50 – 55 soil points
- pH: 6.0-6.5

<table>
<thead>
<tr>
<th>Depth</th>
<th>Sand [%]</th>
<th>Silt [%]</th>
<th>Clay [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-30 cm</td>
<td>45.6</td>
<td>34.7</td>
<td>17.4</td>
</tr>
<tr>
<td>30-60 cm</td>
<td>45.3</td>
<td>33.1</td>
<td>20.3</td>
</tr>
<tr>
<td>60-90 cm</td>
<td>43.2</td>
<td>33.8</td>
<td>21.8</td>
</tr>
</tbody>
</table>
Decision tree

- Which grain legume is suitable for my site

**pH-value**
- 5.8-6.0
- > 6.0

**rainfall during flowering**
- less than 100 mm
- more than 100 mm

**Temperature during the seed formation**
- low
- high

**suitable**
- faba bean
- pea
- soybean
- white lupin
- blue lupin

**of limited suitability**
- common vetch

**source:** adapted from Völkel and Vogt-Kaute (2013) in KTBL-Heft 100
Field experiments at the Thünen Institute of Organic Farming
- Comparison of different grain legumes (2011 – 2013)

Field experiments
- 4 replicated blocks / plot size von 15 x 1.75 m = 26.25 m

Grain legumes as sole crop
1. Pea (Respect, 70 kernels m⁻²)
2. Faba bean (Divine, 36 kernels m⁻²)
3. Blue lupin (Boruta, 130 kernels m⁻²)
4. White lupin (Feodora, 70 kernels m⁻²)

Common vetch [Vicia sativa]
(seed ratios)
1. Berninova
2. Toplesa
3. Slovena
4. Jaga
5. Ina

1. Sole crop vetch (SC-V, 120 kernel m⁻²)
2. Sole crop oat (SC-O, 350 kernels m⁻²)
3. 75% SC-V + 25% SC-O
4. 50% SC-V + 50% SC-O
5. 25% SC-V I + 75% SC-O
Grain yield of sole crops (2011 - 2013)
Grain legume species in comparison to different varieties of common vetch

<table>
<thead>
<tr>
<th>Crop</th>
<th>Grain yield [t ha⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oat</td>
<td>3.73</td>
</tr>
<tr>
<td>Pea</td>
<td>1.50</td>
</tr>
<tr>
<td>Faba bean</td>
<td>3.40</td>
</tr>
<tr>
<td>Blue lupin</td>
<td>2.42</td>
</tr>
<tr>
<td>White lupin</td>
<td>3.93</td>
</tr>
<tr>
<td>Vetch: Berninova</td>
<td>2.61</td>
</tr>
<tr>
<td>Vetch: Ina</td>
<td>2.00</td>
</tr>
<tr>
<td>Vetch: Jaga</td>
<td>2.82</td>
</tr>
<tr>
<td>Vetch: Slovenia</td>
<td>3.75</td>
</tr>
<tr>
<td>Vetch: Toplesa</td>
<td>2.47</td>
</tr>
</tbody>
</table>
Crude protein content (2011 - 2013)

Grain legume species in comparison to different varieties of common vetch
Crude protein yield (2011 - 2013)
Grain legume species in comparison to different varieties of common vetch
Conclusion: Comparison of different grain legumes

✓ White lupins have the highest yields, CP-contents and CP-yields; But the cultivation can not be recommended due to the susceptibility against anthracnose

✓ Faba bean are characterized by high yields, CP-contents and CP-yields

✓ Peas and blue lupins decline under these site conditions in comparison to the other grain legumes. But blue lupins are characterized by high protein contents and a high protein quality.

✓ Common vetches showed a moderate - high yield level with high protein contents. Variety Slovena realized the second highest crude protein yield. Vetches can be fed well to ruminants. Cultivation as a sole crop can not be recommended – mixed cropping systems are necessary!
III. Why cultivating grain legumes as mixed crops?
Effective weed suppression:
Example: pea and oat - sole crop vs mixed cropping

Pea: sole crop
Pea-oat-mixture
Oat: sole crop
How much light is available for the weeds?

(Gronle et al., 2015)
Is light the only factor?

➢ In pots following plants were grown:
  - pea as sole crop
  - pea and oat in mixture
  - oat as sole crop

➢ Cultivation together with weeds (chickweed [Stellaria media])

➢ Pots were divided in the underground between the agricultural crops and weeds (above) or free development of roots were possible (below)

⇒ Release of growth-inhibiting substances via the oat roots reduces the weed growth.

(Gronle et al., 2015)
Summary of the reasons for the effective weed suppression in mixed cropping systems

1. Less light (photoactive radiation) is responsible for lower weed growth
2. Release of growth-inhibiting substances by the roots of oat reduces the weed growth
3. Lower nitrogen levels (plant available nitrate) in the soil due to the nitrogen demand and uptake of the cereals

In subsequence: lower nitrate leaching in the following autumn-winter-period
Reduced tillage intensity with the help of weed suppression of mixed cropping systems?

**Ploughing**

1. operation → precision cultivator

Tillage depth: 8-10 cm

2. operation → mouldboard plough

Tillage depth: 25-27 cm

**Tillage by Stoppelhobel (shallow plough)**

1. operation → Stoppelhobel

Tillage depth: 4-6 cm

2. operation → Stoppelhobel

Tillage depth: 8-12 cm
Weed coverage with regard to the tillage and cultivation system (Trenthorst, 2009)
Weed biomass with regard to site, tillage and cultivation system

Weed biomass [g d.m. per m²] for pea and oat in 2009 and 2010 at Köllitsch and Trenthorst. The graphs show the mean values of the different tillage methods: plough and Stoppelhobel. Significant differences are indicated by letters and asterisks. Adapted from Gronle et al. (2015).
Preventive defence against pests:
- less aphids in mixed cropping?

**Pea aphids [Acyrthosiphum pisum]:**
- losses of yield and quality by suction damages
- transmission of viruses (PEMV, nano viruses)

[source: Gronle et al. (2014); Gronle & Böhm (2016)]
Harvest conditions:
- Stand high at harvest

Mixed cropping increases the lodging resistance in grain legumes with a low lodging resistance (e.g. peas) and a high biomass production (winter peas, common vetches)

The higher stand height of the mixed crops facilitates the harvest operations
Higher yields:
Assessment of yield by using the RYT-method

source: Böhm (2006)
Higher yield stability:
Boxplots of sole and mixed crops (2003 – 2005)

\[ \text{cv\%} = 26.1 \quad 22.2 \quad 28.7 \quad 13.5 \quad 17.4 \quad 31.7 \quad 19.6 \quad 34.1 \quad 29.3 \quad 42.8 \quad 20.6 \quad 22.1 \]

**mixed cropping**

- BL/SB
- BL/PE
- BL/FB
- PE/SB
- FB/OA
- FB/PE

**sole crops**

- BL
- FB
- PEA
- WL
- SB
- OAT
Higher crude protein content: spring barley, spring wheat and oat in sole and mixed cropping

Source: Bramm and Böhm (unpublished)
Conclusion: Mixed cropping systems

✓ Mixed cropping systems show a significant better weed suppression compared to sole crops (light, nitrogen, root-exsudates)

✓ The better weed suppression of mixed cropping systems offers the possibility to integrate tillage systems with a reduced intensity

✓ Mixed cropping reduces the level of aphids

✓ Mixed cropping increases the lodging resistance in crops with a high biomass production (winter peas, common vetches)

✓ Mixtures of faba bean and oat as well as pea and barley show a high yield stability and the highest RYT-values

✓ Protein content of the cereal partners is increased in mixed cropping

✓ Optimal seed densities are 80-100% grain legumes and 20% cereals of the respective seed density of each sole crop (except vetches and winter peas)
IV: Alternative mixed cropping systems:

- Winter peas
- Common vetches
- Intercropping of maize and climbing beans

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Which advantages offer the cultivation of winter peas?

✓ Soil cultivation and seed bed preparation in autumn with a lower risk of soil compaction
✓ Good utilization of the winter soil moisture
✓ Earlier flowering reduces the infestation with aphids
✓ Advantages of the mixed cropping systems are useable
✓ Higher yields compared to spring peas

Requirement:
✓ An excellent winter hardiness of the varieties
### Available varieties of winter peas

<table>
<thead>
<tr>
<th>Variety</th>
<th>Breeder</th>
<th>Sellers/distribution</th>
<th>Habit</th>
<th>Flower colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Szarvasi Andrea</td>
<td>Szarvasi Medicago Kft. [HU]</td>
<td>Ceressaaten [DE]</td>
<td>sl / lg</td>
<td>white</td>
</tr>
<tr>
<td>James</td>
<td>RAGT [FR]</td>
<td>NPZ [DE]</td>
<td>sl / sh</td>
<td>white</td>
</tr>
<tr>
<td>Comanche</td>
<td>RAGT [FR]</td>
<td>NPZ [DE]</td>
<td>sl / sh</td>
<td>white</td>
</tr>
<tr>
<td>Isard</td>
<td>Agri Obtentions [FR]</td>
<td>ZG Raiffeisen eG [DE]</td>
<td>sl / sh</td>
<td>white</td>
</tr>
<tr>
<td>Gangster</td>
<td>RAGT [FR]</td>
<td>NPZ [DE]</td>
<td>sl / sh</td>
<td>white</td>
</tr>
<tr>
<td>Arkta</td>
<td>Selgen A.S. [CZ]</td>
<td>Bayrische Futtersaatbau GmbH [DE]</td>
<td>nl / lg</td>
<td>purple</td>
</tr>
<tr>
<td>Karolina</td>
<td>Szarvasi Medicago Kft. [HU]</td>
<td>Ceressaaten [DE]</td>
<td>nl / lg</td>
<td>white</td>
</tr>
<tr>
<td>E.F.B. 33</td>
<td>Marktgesellschaft mbH der Naturland Betriebe [DE]</td>
<td></td>
<td>nl / lg</td>
<td>purple</td>
</tr>
<tr>
<td>Szarvasi Aliz</td>
<td>Szarvasi Medicago Kft. [HU]</td>
<td>Ceressaaten [DE]</td>
<td>nl / lg</td>
<td>purple</td>
</tr>
<tr>
<td>Pandora</td>
<td>Marktgesellschaft mbH der Naturland Betriebe [DE]</td>
<td></td>
<td>nl / sh</td>
<td>white</td>
</tr>
</tbody>
</table>

sl: semi-leafless  
nl: normal-leafed  
lg: long  
sh: short
Impressions of winter peas

Sole crop: Isard
Sole crop: James
mixture: E.F.B. 33 with triticale
mixture: Karolina with triticale
Overwintering rates of winter peas

(source: Böhm (2015))
Mixed cropping of common vetches:
Grain yield (mean of 2014 and 2015)

Values behind the name of the variety is the seed density

source: Böhm (unpublished)
Mixed cropping of common vetches: crude protein yield (2014)

source: Böhm (unpublished)
Intercropping of maize and runner beans

Aim: Improvement of the protein supply in animal nutrition

- Silage maize: high energy content with a good digestibility; a good silability
  silage quality – BUT: a low crude protein content
  => Intercropping of maize with runner and scarlet runner beans

- Traditional cropping system in South America and Africa, but also in Austria and France
  => Use of beans and corn for human nutrition

- EU-Projekt „Legume Futures‘: Establishment of maize-bean-intercropping in organic farming
  • Comparable yields
  • CP-content of the maize-bean-mixtures were up to 30% higher
  => Maize-bean-silage (MBS) in animal nutrition?

- BÖLN-projekt „Maize-Bean“ started in April 2014
  => Project deals with complex topics along the production chain
Intercropping of maize with climbing beans
Thank you for your attention!

Questions?
Field experiments in the years 2014 - 2016

<table>
<thead>
<tr>
<th>Year</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silage maize</td>
<td>Fabregas (S210)</td>
<td></td>
<td>Saludo (S210)</td>
</tr>
<tr>
<td>Sowing:</td>
<td>27. May</td>
<td>15. May</td>
<td>09. May</td>
</tr>
<tr>
<td>Seed density:</td>
<td></td>
<td>Sole crop: 11 kernels m⁻² / Mixture : 8 kernels m⁻²</td>
<td></td>
</tr>
<tr>
<td>Weeding:</td>
<td></td>
<td>Harrowing (EC 12-13) / Hoeing (EC 13-14)</td>
<td></td>
</tr>
<tr>
<td>Beans</td>
<td></td>
<td>Runner and scarlet runner beans</td>
<td></td>
</tr>
<tr>
<td>Distance:</td>
<td></td>
<td>~ 15 cm beside the maize row (double row)</td>
<td></td>
</tr>
<tr>
<td>Seed density:</td>
<td></td>
<td>6 kernels m⁻²</td>
<td></td>
</tr>
</tbody>
</table>
Impressions of the cultivation
Field experiments with different runner and scarlet runner beans, 2014

**Runner beans [Phaseolus vulgaris]**

- **Tarbais (TA)**
  - TSW [g]: 620
  - Flower colour: white
  - Seed colour: white

- **Gr. Posthörnchen (GP)**
  - TSW [g]: 450
  - Flower colour: light-violet
  - Seed colour: russet

- **Terli (TE)**
  - TSW [g]: 360
  - Flower colour: white
  - Seed colour: white

**Scarlet runner beans [P. coccineus]**

- **Preisgewinner (PG)**
  - TSW [g]: 1200
  - Flower colour: red
  - Seed colour: Red-black

- **Cobra (CO)**
  - TSW [g]: 350
  - Flower colour: purple
  - Seed colour: black

- **Weiße Riesen (WR)**
  - TSW [g]: 1200
  - Flower colour: white
  - Seed colour: white
### Field experiments with different runner and scarlet runner beans, 2015

#### Runner beans \( \text{[Phaseolus vulgaris]} \)

<table>
<thead>
<tr>
<th>Variety</th>
<th>TSW [g]</th>
<th>Flower Colour</th>
<th>Seed Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarbais (TA)</td>
<td>620</td>
<td>white</td>
<td>white</td>
</tr>
<tr>
<td>Cobra (CO)</td>
<td>450</td>
<td>light-violet</td>
<td>russet</td>
</tr>
<tr>
<td>Preisgewinner (PG)</td>
<td>1200</td>
<td>red</td>
<td>Red-black</td>
</tr>
<tr>
<td>Anellino verde (AV)</td>
<td>310</td>
<td>violet</td>
<td>beige</td>
</tr>
</tbody>
</table>

#### Scarlet runner beans \( \text{[P. coccineus]} \)

<table>
<thead>
<tr>
<th>Variety</th>
<th>TSW [g]</th>
<th>Flower Colour</th>
<th>Seed Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gr. Posthörnchen (GP)</td>
<td>450</td>
<td>purple</td>
<td>black</td>
</tr>
<tr>
<td>Weiße Riesen (WR)</td>
<td>1200</td>
<td>white</td>
<td>white</td>
</tr>
</tbody>
</table>
Dry matter total yield in 2014 and 2015

controls:
[Silomais, Reinsaat]
M11 = Maize [11 kernels m⁻²]
M8 = Maize [8 kernels m⁻²]

Runner beans:
[P. vulgaris, 6 kernels m⁻²]
CO = M8 + Cobra
GP = M8 + Grünes Posthörnchen
TA = M8 + Tarbais
TE/AV = M8 + Terli/ Anellino verde

Scarlet runner beans
[P. coccineus, 6 kernels m⁻²]
PG = M8 + Preisgewinner
WR = M8 + Weiße Riesen

Source: Böhm et al (2016)
Dry matter bean yield in 2014 and 2015

- Higher yields of beans resp. Yield percentages in 2015 in comparison to 2014
- Runner bean 'Tarbais' in both years with the highest yields and yield percentages (8.1 resp. 14.2% of total yield)

Runner beans:
- [P. vulgaris, 6 kernels m\(^{-2}\)]
  - CO = M8 + Cobra
  - GP = M8 + Grünes Posthörnchen
  - TA = M8 + Tarbais
  - TE/AV = M8 + Terli/Anellino verde

Scarlet runner beans
- [P. coccineus, 6 kernels m\(^{-2}\)]
  - PG = M8 + Preisgewinner
  - WR = M8 + Weiße Riesen

source: Böhm et al (2016)
Crude protein content (XP) of maize and maize-bean mixtures in 2015 and 2015

- Significant increase of the crude protein content in the mixtures with runner and scarlet runner beans
- Crude protein content in 2015 on a higher level compared to 2014
- Mixture with runner bean ‚Tarbais‘ with the highest XP-increase: 1.3 resp. 1.6 %-points (+25 resp. +21%)

source: Böhm et al (2016)
## Material & Methoden
- geprüfte Sorten und Anbauformen

<table>
<thead>
<tr>
<th>Sorte</th>
<th>Wuchstyp</th>
<th>Aussaatstärke [kf Kö m⁻²]</th>
<th>Anbauform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Szarvazi Andrea [Szarvasi Afila]</td>
<td>hb / lg</td>
<td>80 EF</td>
<td>Reinsaat</td>
</tr>
<tr>
<td>James</td>
<td>hb / kz</td>
<td>80 EF</td>
<td>Reinsaat</td>
</tr>
<tr>
<td>Comanche</td>
<td>hb / kz</td>
<td>80 EF</td>
<td>Reinsaat</td>
</tr>
<tr>
<td>Isard</td>
<td>hb / kz</td>
<td>80 EF</td>
<td>Reinsaat</td>
</tr>
<tr>
<td>Gangster</td>
<td>hb / kz</td>
<td>80 EF</td>
<td>Reinsaat</td>
</tr>
<tr>
<td>Szarvazi Andrea</td>
<td>hb / lg</td>
<td>40 EF + 100 TIW</td>
<td>Gemenge</td>
</tr>
<tr>
<td>James</td>
<td>hb / kz</td>
<td>60 EF + 100 TIW</td>
<td>Gemenge</td>
</tr>
<tr>
<td>Arkta</td>
<td>nb / lg</td>
<td>40 EF + 100 TIW</td>
<td>Gemenge</td>
</tr>
<tr>
<td>Karolina</td>
<td>nb / lg</td>
<td>40 EF + 100 TIW</td>
<td>Gemenge</td>
</tr>
<tr>
<td>E.F.B. 33</td>
<td>nb / lg</td>
<td>40 EF + 100 TIW</td>
<td>Gemenge</td>
</tr>
<tr>
<td>Szarvasi Aliz</td>
<td>nb / lg</td>
<td>40 EF + 100 TIW</td>
<td>Gemenge</td>
</tr>
<tr>
<td>Pandora</td>
<td>nb / kz</td>
<td>40 EF + 100 TIW</td>
<td>Gemenge</td>
</tr>
</tbody>
</table>

Grain yield with regard to site, tillage and cultivation system

(Gronle et al., 2015)
Comparison of spring and winter pea yield

Quelle: Gronle et al. (2014)
Bioassay test:
Weed suppression in mixed cropping systems with oat

Unkrautbiomasse [mg per plant]

<table>
<thead>
<tr>
<th></th>
<th>shoot</th>
<th>root</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with root exsudates of oat</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Gronle et al., 2015)
Preventive defence against pests:  
- Effect on pea moth

**Pea moth** [*Cydia nigricana*]:  
- losses of yield and quality by feeding damages of the larvae  
- loss of germination capacity

<table>
<thead>
<tr>
<th>Crop stand</th>
<th>Pea moth larvae damaged peas (%) 2009/10</th>
<th>2010/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFB SC</td>
<td>32.3 ± 3.2 a</td>
<td>32.4 ± 1.1 b</td>
</tr>
<tr>
<td>EFB-TR IC</td>
<td>37.6 ± 2.3 a</td>
<td>37.4 ± 1.6 a</td>
</tr>
<tr>
<td>James SC</td>
<td>7.4 ± 1.7 b</td>
<td>18.2 ± 1.0 d</td>
</tr>
<tr>
<td>James-TR IC</td>
<td>4.3 ± 0.9 b</td>
<td>23.0 ± 1.2 c</td>
</tr>
</tbody>
</table>

Means within each column with different letters are significantly different (P < 0.05)

*source: Gronle et al. (2014)*
Mixed cropping of common vetches: weed suppression (mean of 2014 and 2015)

source: Böhm (unpublished)
The Thünen Topics:

**Natural Resources and Protected Assets**
- Soil
- Water
- Climate and Air
- Biological Diversity
- Forests
- Seas

**Production and Utilization**
- Plant Production
- Renewable Resources
- Forest Management and Wood Use
- Livestock Farming and Aquaculture
- Fisheries
- Land Use and Wild Animal Management

**Economy, Society and Policy**
- Competitiveness and Structural Change
- Income and Employment
- Rural Living Conditions
- Markets, Trade, Certification
- Global Food Security
- Consumer and Society
- Long-term Policy Concepts

*Organic Farming*
Research topics of the Thünen Institute of Organic Farming

On-Station Research (focuses)

- Intercropping and mixed cropping systems
- Legumes (production, quality, environmental aspects)
- Soil: Nutrients, carbon and soil biodiversity
- 100 % organic feed for pigs
- Organic piglet production and boar fattening
- Ethological aspects of animal welfare (pigs, cattle, goats)
- Environmental and animal welfare effects of outdoor access areas
- Product quality of feed, milk and meat

On-Farm Research (examples)

- Stable schools to improve animal health und management in organic dairy farming
- Climate effects and sustainability in a network of organic and conventional farms