Fusarium species and mycotoxins in oats: effect of cropping factors and health promoting compounds

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Outline

• Aims and challenge
• Project description
• Preliminary results
• Conclusions and upcoming work
Aims & challenge

• Promotion of cereal production for food

Graubünden Barley Soup

All Swiss barley is used for feed!

http://www.myswitzerland.com/
Aims & challenge

• Promotion of cereal production for **food**
  Swiss barley and oats for food, less for feed
Aims & challenge

- Promotion of cereal production for **food**
  Swiss barley and oats for food, less for feed

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**Recipe for Bircher Müesli**

Original recipe by Dr. Bircher

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Oats: 86% import! The little amount of oats produced in Switzerland is used for feed.

[http://www.about.ch/culture/food/](http://www.about.ch/culture/food/)
Aims & challenge

• Promotion of cereal production for food
  Swiss barley and oats for food, less for feed

• Improved health
  Elevated content of health promoting compounds (HPCs) in certain cereal varieties, e.g. phenolic acids, anthocyanins, arabinoxylans, carotenoids, β-glucans

• Fusaria and mycotoxins
  → severe yield losses
  → threat to human health

• Improved safety
  HPCs could reduce growth of toxigenic *Fusarium* species

→ Healthy & Safe (start: December 2013)
Occurrence - Epidemiology - Resistance - Forecasting

WP 1

- Monitoring of growers’ samples throughout Switzerland (cropping factors)
- Agroscope variety trials in S, W & E Switzerland (cropping & environmental factors)

F. graminearum  F. equiseti  F. crookwellense
Very small country but with large climatic differences between regions
Occurrence - **Epidemiology** - Resistance - Forecasting

WP 2

- Climate chamber
  Variety, temperature
  & leaf wetness duration
Occurrence - Epidemiology - Resistance - Forecasting

WP 2

- Climate chambers
  Variety, temperature
  & leaf wetness duration

- Field conditions
  Weather & inoculum

Inoculation during anthesis
WP 3

- Resistance experiments at three sites in Switzerland
- HPC enhanced genotypes
- Artificial infections
Sites of resistance experiments
Sites of resistance experiments

Sites of resistance experiments:
- Zurich-Reckenholz
- Changins
- Cadenazzo

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Occurrence - Epidemiology - Resistance - Forecasting

WP 3

- Resistance experiments at three sites in Switzerland
  - HPC enhanced genotypes
  - Artificial infections

- Toronit x 211.12014 mapping population
  Role of carotenoids

- Wheat isolines
  Anthocyanin spectrum

- HPCs on in vitro growth and toxin production
Information system for risk assessment of FHB and DON contamination in wheat
FusaProg for wheat, oats, barley and their mycotoxins

Information system for risk assessment of FHB and DON contamination in wheat  WP 4
FusaProg for wheat, oats, barley and their mycotoxins

Information system for risk assessment of FHB and DON contamination in wheat

© H.R. Forrer, Agroscope ART

WebApp for FusaProg: as of now available for wheat only

Kontakt: Tomke.Mus@art.admin.ch
Idee und Konzept: Hans-Rudolf Forrer ART
powered by widas*
© 2006 Forschungsanstalt ART
WP 5 Implementation partners

Industry & marketing

Extension

Research

Konferenz der kantonalen Pflanzenschutzdienste (KPSD)
Conférence des services phytosanitaires cantonaux (CSP)
Conferenza degli servizi fitosanitari cantonali (CSF)

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1. Workshop with partners, January 2014
1. Workshop with partners, January 2014
WP 1: Occurrence - monitoring 2013

• 280 barley samples from 17 cantons
WP 1: Occurrence - monitoring 2013

- 280 barley samples from 17 cantons
- 93 oat samples from 11 cantons
WP 1: Questionnaire on cropping factors

Variety

Previous crop

Tillage / Residue management

Production system
Results oat monitoring 2013 (n = 93)

*Fusarium* species distribution

**FP:** Ø 4% (0-18%)

**FG:** Ø 1% (0-22%)

**FL:** Ø 1% (0-11%)

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. poae</td>
<td>55%</td>
</tr>
<tr>
<td>F. graminearum</td>
<td>17%</td>
</tr>
<tr>
<td>F. langsethiae</td>
<td>16%</td>
</tr>
<tr>
<td>F. avenaceum</td>
<td>7%</td>
</tr>
<tr>
<td>F. culmorum</td>
<td>3%</td>
</tr>
<tr>
<td>F. triticinctum</td>
<td>1%</td>
</tr>
<tr>
<td>F. crookwellense</td>
<td>7%</td>
</tr>
<tr>
<td>F. equiseti</td>
<td>1%</td>
</tr>
<tr>
<td>F. spp.</td>
<td>1%</td>
</tr>
</tbody>
</table>
Results oat monitoring 2013

Fusarium species distribution

FP: Ø 4% (0-18%)

FG: Ø 1% (0-22%)

FL: Ø 1% (0-11%)

Barley (n=280)

- F. poae
- F. graminearum
- F. langsethiae
- F. avenaceum
- F. culmorum
- F. tritcinctum
- F. crookwellense
- F. equiseti
- F. spp.

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Oat monitoring: average toxin contents

Toxin content (µg kg$^{-1}$)

$\sum$ sum T-2 & HT-2 toxins: 450 µg kg$^{-1}$

F. poae

F. graminearum

F. langsethiae

n = 93
Effect of oat varieties on incidence of *Fusarium* species

Grains infected by *Fusarium* spp. (%)

- *F. poae* $P < 0.001$
- *F. langsethia* $P = 0.007$

Wieland (n=34) Triton (n=32) Gaillette (n=7) Expander (n=6) Ebène (n=4) President (n=3)

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Effect of oat varieties on incidence of *Fusarium* species

- *F. poae*  \( P < 0.001 \)
- *F. langsethiae*  \( P = 0.007 \)
- *F. graminearum*  n.s.

**FL ↑ FG ↓ and vice versa: Different ecological niches?**

Grains infected by *Fusarium* spp. (%)
Effect of oat varieties on **HT-2/T-2**
toxin content & correlation

- **F. poae**
  - $R = 0.11$, n.s.
- **F. langsethiae**
  - $R = 0.53$, $P < 0.001$
- **sum HT-2/T-2**

Grains infected by **F. poae** / **F. langsethiae** (%)

- Wieland (n=34)
- Triton (n=32)
- Gaillette (n=7)
- Expander (n=6)
- Ebène (n=4)
- President (n=3)
Effect of oat varieties on FG, DON content and correlation

*F. graminearum*  
\[ R = 0.47, \ P < 0.001 \]

In monitoring few samples of «black oats»
Effect of previous crops on *F. poae* incidence in oats

<table>
<thead>
<tr>
<th>Grains infected by <em>F. poae</em> (%)</th>
<th>wheat</th>
<th>maize</th>
<th>barley</th>
<th>oats</th>
<th>spelt wheat</th>
<th>potatoes</th>
<th>triticale</th>
</tr>
</thead>
<tbody>
<tr>
<td>P = 0.002</td>
<td>34</td>
<td>24</td>
<td>15</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Effect from spelt wheat probably coincidence (n=3) → more data needed.
Effect of previous crops on incidence of *F. graminearum* / *F. langsethiae*

Grains infected by *F. graminearum* / *F. langsethiae* (%)

- **F. graminearum** n.s.
- **F. langsethiae** \( P = 0.049 \)

Different ecological niches?
Effect of previous crops on toxins

Toxin content (µg kg⁻¹)

- nivalenol
- deoxynivalenol
- T-2 toxin
- HT-2 toxin

n.s.
-″-
P < 0.001
-″-

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Resistance experiments with artificial infections - symptoms in wheat varieties

P < 0.001
n = 27

Symptom rating in oats not possible

already ranked as «less susceptible»

very high carotenoid content

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Conclusions

- Growers’ oat samples were contaminated with T-2 & HT-2 content somewhat scary.

- Pronounced effect between varieties - different for individual *Fusarium* species.

- True variety effect, or weather or HPC related?

- Effect of cropping factors not clear yet.

Dataset for oats - in contrast to wheat and barley - still very small; more samples and in-depth analyses needed.
Ongoing experiments and outlook

• Oat and barley **monitoring** 2014 running

• **Resistance** experiments at 3 sites (oat, barley, wheat)
  Harvest has started, followed by seed health test (incidence), qPCR, toxin content

• **Epidemiology**: climate chamber experiments running, field in 2015
  Effect of temperature, leaf wetness duration on infection, contamination and spore deposition
Health threatening mycotoxins

Value added, healthy & safe cereals

Economic & social benefits:
• reduced toxin risks and less fungicide use
• increased attractiveness of Swiss food products
Thank you

Support in the lab & field:
• Andreas Kägi
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• Irene Bänziger
• Eveline Jenny
• Phillip Streckeisen
• Felix Wettstein
• Field workers group

Oat & barley samples:
• Cantonal plant protection officers
• Participating growers

Inspiration for research in plant pathology
Hans-Rudolf Forrer

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