Phenotyping Fusarium Head Blight resistance of oat by analysis of morphological and biochemical properties of grains

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Introduction

- Fusarium Head Blight (FHB) on oats
  - Little or no evidence of symptoms
    - On panicle
    - Necrotic infected grains
      → Difficult to assess the degree of infection
      → But accumulation of mycotoxins

- Various *Fusarium* species
  - *F. graminearum*, *F. poae*, *F. langsethiae*, *F. avenaceum*

- Infections are favored by high moisture and temperature.

- Infection of the florets at anthesis
- Propagation slowed down by panicle form conferring effective resistance (Bjørnstad and Skinnes, 2008).


Symptoms of natural infection in Chancy (GE) Switzerland – June 2016
Introduction

Oat grains contain
- Protein
- Health Promoting Compound (1,3;1,4)-\( \beta \)-D-glucans
- Fatty acids …

Decompose the impact of *Fusarium* infection on oat grains
- Morphological aspect
- Grain quality
  - Grain constituents
  - *Fusarium* toxins

→ Define resistance of oat grains
→ Find indicators of resistance

1. Comparisons between oat genotypes
2. Comparisons between different environments
1. FHB impact on oat grains

Experimental design

- 9 modern varieties
  - Canyon
  - Ebene
  - Expander
  - Gaillette
  - Husky
  - Melody
  - Poseidon
  - Samuel
  - Triton

- 6 Swiss landraces conserved in Vavilov Institute
  - Brune de Mont Calme
  - Hative des Alpes
  - Précoce jaune
  - Rosegghafer Adliker
  - S’Hafer Adliker

→ High genetic variability

Distribution of β-glucan content in grains

![Distribution of β-glucan content in grains](image)
1. FHB impact on oat grains

Experimental design

• Artificial inoculations with FG strain at anthesis.
• Observations of symptoms on plant.
• Analyses of grains
  • Morphological aspect → Damaged grains, Thousand Kernel Weight (TKW), huskiness (%).
  • β-glucan content → McCleary Method (Megazyme)
  • Protein content → Near-infrared spectroscopy (NIRS)
  • DON content → ELISA

Aerial view of the field test

Photo: M. Bertossa
1. FHB impact on oat grains

Results

Morphological aspects
- No visual symptoms on panicle nor on grains.
- Slight increases of TKW.
- No changes in the proportion of glumes.

Comparisons of TKW

TKW (g)

- Landrace Control
- Modern Control
- Landrace Infected
- Modern Infected

Photo: F. Combremont
1. FHB impact on oat grains

Results

Principal Component Analysis of non infected grains

Principal Component Analysis of infected grains
1. FHB impact on oat grains

Results

- But also differences between genotypes.
2. Impact of *Fusarium* infection on oats across environments

Experimental design

- 8 modern oat varieties
- 3 different environmental conditions
- Analyses of grains

Environmental conditions in field tests from 1st of June to 31st July

<table>
<thead>
<tr>
<th>Environment</th>
<th>Temperature (°C)</th>
<th>Total rainfalls (mm)</th>
<th>Relative humidity (%)</th>
<th>Evapotranspiration (mm/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changins 2014</td>
<td>18.4</td>
<td>245.6</td>
<td>70.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Changins 2015</td>
<td>21.6</td>
<td><strong>Irrigation at anthesis</strong></td>
<td>57.6</td>
<td>4.7</td>
</tr>
<tr>
<td>Cadenazzo 2015</td>
<td>22.8</td>
<td>193.1</td>
<td>68.1</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Environmental data: meteoswiss.ch
2. Impact of *Fusarium* infection on oats across environments

Results

Morphological aspects

- No visual differences between infected and non-infected grains.
- But visual differences between environments.

- Analyses of TKW:
  - TKW mostly affected by environmental conditions.
  - Environment x Infection
    - Decreases in Changins 2014
    - Increases in Changins 2015

Photo: F. Combremont
2. Impact of *Fusarium* infection on oats across environment

Results - Biochemical aspects

- β-glucan contents are affected by environmental conditions. (Peterson, 1991)

- Impact of the infection depends on environmental conditions:
  - Increases of β-glucan content in Changins 2014
  - Decreases in Cadenazzo 2015

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β-glucan contents in infected and non-infected oat grains from different environments.
2. Impact of *Fusarium* infection on oats across environments

Results - Biochemical aspects

**Decomposition of variances of β-glucan and protein content in grains**

<table>
<thead>
<tr>
<th></th>
<th>β-glucan content</th>
<th>Protein content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Genotype</strong></td>
<td>16% ***</td>
<td>48% ***</td>
</tr>
<tr>
<td><strong>Infection</strong></td>
<td>2% **</td>
<td>1% **</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td>32% ***</td>
<td>13% ***</td>
</tr>
<tr>
<td><strong>Interactions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G x I</td>
<td>ns</td>
<td>7% ***</td>
</tr>
<tr>
<td>G x E</td>
<td>7% **</td>
<td>10% ***</td>
</tr>
<tr>
<td>I x E</td>
<td>14% ***</td>
<td>4% ***</td>
</tr>
<tr>
<td>G x I x E</td>
<td>13% ***</td>
<td>8% ***</td>
</tr>
</tbody>
</table>

- Environmental conditions explain major of grain variability.
- Impact of the environment is higher than the impact of infections.
- Complex interactions → G x E + E x I
Results - Biochemical aspects

Impact of infection in Changins 2014 and Cadenazzo 2015

→ All genotypes are not affected to the same extent to G x E x I

→ Gaillette, Husky, Melody

β-glucan contents in infected and non-infected oat grains from different environments.
2. Impact of *Fusarium* infection on oats across environments

Results – Toxin analyses

- No DON detected in Changins 2015.
- Significant differences between genotypes.

![DON content in grains from Changins 2014](image)
Phenotyping FHB resistance in oats

→ FHB infection causes changes in grain quality parameters
  → Thousand kernel weight may increase or decrease with infection.
  → Infection can increase or decrease β-glucan and protein content in grains.
  → Modifications of quality parameters are not correlated among the genotypes.
  → Yet strong environmental impact on all parameters.
→ However, not all genotypes are affected to the same extent.

How to define grain resistance of oats?

→ Low accumulation of mycotoxins
→ Stability of grain properties
  • Normal development of grains and good filling.
  • Composition of HPC and protein not affected.

= Stability of grain quality despite pathogen presence.

How to phenotype for grain resistance of oats?

→ Toxin analyses.
→ Assess stability of grains properties in different environments with and without FHB infections.
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Steffen Beuch

Healthy and Safe team
Thank you for your attention
2. Impact of *Fusarium* infection on oat across different environments

Results - Biochemical aspects

- Negative but significant correlation between protein and β-glucan contents in non-infected grains
- Non significant in infected grains
  → Impact of infection on grain composition