Analysis of correlation between soil moisture and late blight occurrence

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Structure

• Introduction

• Hypotheses

• Results
  – Field Experiments
    • 2010
    • 2011
  – Analysis of “Monitoring-Data”

• Discussion
Introduction

- **ADLER (2000):**
  - latent infected potato tubers became more important on primary infections in years with wet springs
  - research has to focus on soil borne infections between planting and emergence

- **BÄßLER (2005):**
  - influence of soil type and soil moisture on primary infections
  - he recommended a soil module for prediction models

<table>
<thead>
<tr>
<th>Latent infected sprouts [%]</th>
<th>2 days</th>
<th>4 days</th>
<th>8 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>sandy loam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>silty loam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>loamy sand</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Introduction

• The correlation between infected tubers and infected sprouts on the surface is controversially discussed in literature:

  – MELHUS (1915), MURPHY and McKAY (1927): correlation between the volume of covered soil and infected sprouts on surface

  – HÄNNI (1949): infected sprouts cannot reach the surface

  – BOYD (1980): primary infections are not caused from soil borne infected sprouts but spores are directly splashed from contaminated soil to leaves

The ZEPP prediction model SIMBLIGHT1 calculates the first occurrence of late blight. It predicts an earlier outbreak, if there has been a four day period of totally saturated soil between planting and 7 days after emergence.
Hypotheses

- The influence of soil moisture on the first occurrence of late blight was analysed
- The analyses were focused on the incubation period of *Phytophthora infestans*
- Soil borne infections from infected tubers to healthy sprouts should now be taken into account

**Diagram:**
- Spore landing
- Germination
- Penetration
- Infection
- Incubation
- Latency
- Infection time
- First symptoms
- Spore release
- Sporulation
- Colonisation
- Dying off the plant

*Source: LfL Bayern*
Hypotheses

spore-formation on an infected tuber

germination (indirect germination/zoospores are required)

spore-landing on a healthy sprout

infection supported by soil water

germination

penetration

infection

incubation

first symptoms

spore-release

infection time

Water potential:

0-60 hPa 60-300 hPa 15000 hPa

Processes:

indirect germination (MACDONALD and DUNIWAY (1978))

Sporangia formation (MACDONALD and DUNIWAY (1978))

zoospore transport (STOLZY et al. (1965) and PORTER (2005))

(Bellingham 2009)
Field Experiment – planting
Field Experiment 2010/2011

- **2010**
  - **1. April**
  - **15. April**
  - **1. May**
  - **15. May**
  - **1. June**
  - **15. June**
  - **1. July**

- **2011**
  - **1. April**
  - **15. April**
  - **1. May**
  - **15. May**
  - **1. June**
  - **15. June**
  - **1. July**

- planting
- irrigation before emergence
- irrigation after emergence
- sampling sprouts for PCR-detection

- **planting**
- irrigation before emergence
- irrigation after emergence
- sampling sprouts for PCR-detection
Field Experiment 2010 – Irrigation

before emergence

after emergence
Field Experiment 2010 – Results

days above field capacity

- between planting and 7 days after emergence
- in total

[number of days]

without irrigation
- uncovered
- covered

irrigation before emergence
- uncovered
- covered

irrigation after emergence
- uncovered
- covered

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Field Experiment 2010 – Situation 21.06.

No late blight symptoms until harvesting

Sampling of 20 Agria sprouts per plot on 28. June for PCR-detection of latent infected sprouts
Field Experiment 2010 – Results

- Percentage of latent infected sprouts is positively correlated with days above field capacity.
- No visual late blight symptoms in field.
Field Experiment 2011 – Results

- Very dry weather conditions throughout April until June – field capacity only due to irrigation
- No statistical analysis because of only one latent infected sprout
- No visual late blight symptoms

- Conditions seemed not to be suitable for sporangia formation on the surface of the infected tubers
- Complex correlation between the processes for soil borne infections
Field Experiment 2010 and 2011 – Results

<table>
<thead>
<tr>
<th>processes</th>
<th>conditions</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>sporangia formation on the tubers surface</td>
<td>![Field Capacity B_{fc}]</td>
<td>✔</td>
<td>✗</td>
</tr>
<tr>
<td>indirect germination (zoospore release)</td>
<td>![Soil Saturation B_{sat}]</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>zoospore transport through soil water</td>
<td>![Soil Saturation B_{sat}]</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
Analysis of monitoring data

- In the *Phytophthora* monitoring in Germany the parameters crop prevalence (high/low) and soil moisture (high/low) were assessed.
- Analysis concerning the variability of first occurrence according to the four groups:

<table>
<thead>
<tr>
<th>soil moisture</th>
<th>low</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>crop prevalence</td>
<td>low</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>high</td>
<td>2</td>
</tr>
</tbody>
</table>

Soil moisture has no significant influence on the date of the first occurrence of late blight.

Significant influences are given by crop prevalence.

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 versus 3</td>
<td>no</td>
</tr>
<tr>
<td>2 versus 4</td>
<td>no</td>
</tr>
<tr>
<td>3 versus 4</td>
<td>yes</td>
</tr>
<tr>
<td>3 versus 2</td>
<td>no</td>
</tr>
<tr>
<td>1 versus 4</td>
<td>yes</td>
</tr>
<tr>
<td>1 versus 2</td>
<td>no</td>
</tr>
</tbody>
</table>

Tukey-Test (confidence interval 95%)
### Discussion

<table>
<thead>
<tr>
<th></th>
<th>monitoring data 2006 to 2010</th>
<th>field experiment 2010</th>
<th>field experiment 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>correlation between high soil moisture and latent infected sprouts</td>
<td>🟣</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>correlation between high soil moisture and date of first late blight occurrence</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
</tr>
<tr>
<td>correlation between high crop prevalence and date of first late blight occurrence</td>
<td>✓</td>
<td>✗</td>
<td>✗</td>
</tr>
</tbody>
</table>

- This leads to the question…
Is the effect of soil moisture on the date of first occurrence of late blight considerably overestimated?

- Also discussed in literature

- Analyses which lead to a high effect of soil moisture on first occurrence are often related to latent infections

- The correlation between soil moisture and latent infections could be proved in the field in 2010

- Latent infections are not correlated to an earlier outbreak of late blight

- It seems that the outbreak is related to other environmental conditions for the fungus
Discussion

- High soil moisture could lead to an intense distribution of zoospores in soil resulting in a high percentage of latent infections.

- High soil moisture has no influence on the date of first occurrence of late blight in the field.

- The integration of soil moisture in prediction models for the first occurrence of late blight has no practical use.
Thanks for your attention!