Improving the management of Fusarium and Aphanomyces root rots in field peas

Collaborative research:  
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Audrey Kalil, NDSU Williston Research Extension Center  
Julie Pasche, NDSU Department of Plant Pathology  
Michael Wunsch, NDSU Carrington Research Extension Center
Fusarium & Aphanomyces root rots of field peas: Impact of crop rotation

Carrington, ND 2018
Field with a history of severe field pea root rot

<table>
<thead>
<tr>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 nodes plants/acre</td>
<td>10 nodes % severity</td>
<td>13.5% moisture bushels/acre</td>
</tr>
<tr>
<td><strong>Two-year rotation peas/wheat</strong></td>
<td>223,076 ab</td>
<td>53 b</td>
</tr>
<tr>
<td><strong>Four-year rotation peas/wheat/wheat/wheat</strong></td>
<td>240,209 a</td>
<td>44 ab</td>
</tr>
<tr>
<td><strong>Four-year rotation peas/wheat/canola/wheat</strong></td>
<td>219,901 b</td>
<td>39 b</td>
</tr>
<tr>
<td><strong>Four-year rotation peas/wheat/flax/wheat</strong></td>
<td>222,930 ab</td>
<td>44 ab</td>
</tr>
</tbody>
</table>

*Variety: ‘Salamanca’ (yellow-cotyledon type)  Seeding rate: 300,000 pure live seeds/acre*

Within-column means followed by different letters are significantly different: $P < 0.05$ (plant population, root rot), $P < 0.10$ (yield), Tukey multiple comparison procedure.
Fusarium & Aphanomyces root rots of field peas: Impact of fungicide seed treatment across crop rotation treatments

Field with a history of severe field pea root rot

Carrington, ND
2018

<table>
<thead>
<tr>
<th>Seed Treatment</th>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>metalaxyl + imidacloprid</td>
<td>220,868</td>
<td>46</td>
<td>32</td>
</tr>
<tr>
<td>Allegiance 0.2 fl oz/cwt + Gauch 1.6 fl oz/cwt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>target: Pythium, insect pests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P&gt;F: 0.1297 CV: 8.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>metalaxyl + imidacloprid + prothioconazole + penflufen</td>
<td>228,726</td>
<td>45</td>
<td>34</td>
</tr>
<tr>
<td>Allegiance 0.2 fl oz/cwt + Gauch 1.6 fl oz/cwt + Evergl Energy 1.0 fl oz/cwt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>target: Pythium, Rhizoctonia, Fusarium, insect pests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P&gt;F: 0.2900 CV: 16.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>metalaxyl + imidacloprid + prothioconazole + penflufen + ethaboxam</td>
<td>230,033</td>
<td>43</td>
<td>38</td>
</tr>
<tr>
<td>Allegiance 0.2 fl oz/cwt + Gauch 1.6 fl oz/cwt + Evergl Energy 1.0 fl oz/cwt + Intego Solo 0.2 fl oz/cwt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>target: Pythium, Rhizoctonia, Fusarium, Aphanomyces, insects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P&gt;F: 0.0803 CV: 18.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Variety: ‘DS Admiral’ (yellow-cotyledon type)
Seeding rate: 300,000 pure live seeds/acre
Within-column means followed by different letters are significantly different (P< 0.10; Tukey multiple comparison procedure)
### Fusarium & Aphanomyces root rots of field peas: Impact of crop rotation

**Hettinger, ND**  
**2018**

Field with no previous field pea production

<table>
<thead>
<tr>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4-5 nodes plants/acre</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Two-year rotation peas/wheat</strong></td>
<td>143,264</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Four-year rotation peas/wheat/wheat/wheat</strong></td>
<td>141,715</td>
<td>1.2</td>
</tr>
<tr>
<td><strong>Four-year rotation peas/wheat/canola/wheat</strong></td>
<td>143,070</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Four-year rotation peas/wheat/flax/wheat</strong></td>
<td>148,878</td>
<td>1.7</td>
</tr>
</tbody>
</table>

- **Root rot severity** (bloom initiation % severity):

  - Two-year rotation: 1.7
  - Four-year rotation peas/wheat/wheat/wheat: 1.2
  - Four-year rotation peas/wheat/canola/wheat: 1.9
  - Four-year rotation peas/wheat/flax/wheat: 1.7

- **Yield (13.5% moisture bushels/acre):**

  - Two-year rotation: 32
  - Four-year rotation peas/wheat/wheat/wheat: 36
  - Four-year rotation peas/wheat/canola/wheat: 32
  - Four-year rotation peas/wheat/flax/wheat: 33

---

**Variety:** ‘Bridger’ (yellow-cotyledon type)  
**Seeding rate:** 300,000 pure live seeds/acre

Within-column means followed by different letters are significantly different: \( P < 0.05 \), Tukey multiple comparison procedure.  

\( P>F: 0.7888 \)  
\( CV: 9.1 \)  

\( P>F: 0.1230 \)  
\( CV: 30.3 \)  

\( P>F: 0.1409 \)  
\( CV: 10.7 \)
Aphanomyces root rot of field peas:

Biology

Causal pathogen: *Aphanomyces euteiches* (an oomycete; “water mold”)

Conditions that favor infection:
- **Soil moisture:** high
- **Soil temperature:** high

Pfender and Hagedorn 1982
Phytopathology 72:306-310
Aphanomyces root rot of field peas: Impact of planting date
No-till production – Carrington, ND

2018 Field with history of severe field pea root rot (Aphanomyces & Fusarium, Aphanomyces predominant)

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Wilted Plants</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 30</td>
<td>365,468</td>
<td>36</td>
<td>10</td>
<td>55</td>
</tr>
<tr>
<td>May 10</td>
<td>343,137</td>
<td>65</td>
<td>20</td>
<td>39</td>
</tr>
<tr>
<td>May 21</td>
<td>361,025</td>
<td>65</td>
<td>31</td>
<td>27</td>
</tr>
</tbody>
</table>

Variety: ‘DS Admiral’ (yellow-cotyledon type)
Seeding rate: 385,000 pure live seeds/acre

Within-column means followed by different letters are significantly different (P< 0.05; Tukey multiple comparison procedure)
Aphanomyces root rot of field peas: Planting date studies (2018)
Impact of soil temperature on root rot severity

2018 Field with history of severe field pea root rot (Aphanomyces & Fusarium, Aphanomyces predominant) Carrington, ND. Data from study conducted under no-till production.
**Aphanomyces root rot of field peas: Impact of planting date**

**Conventional tillage – Carrington, ND**

2018 Field with history of severe field pea root rot (Aphanomyces & Fusarium, Aphanomyces predominant)

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Wilted Plants</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 30</td>
<td>320,353</td>
<td>42</td>
<td>a</td>
<td>52</td>
</tr>
<tr>
<td>May 10</td>
<td>327,455</td>
<td>62</td>
<td>a</td>
<td>41</td>
</tr>
<tr>
<td>May 21</td>
<td>346,447</td>
<td>62</td>
<td>b</td>
<td>20</td>
</tr>
</tbody>
</table>

*P>F: 0.0787 CV: 7.5  P>F: 0.0011 CV: 11.9  P>F: 0.0002 CV: 7.3  P>F: < 0.0001 CV: 12.5*

**Variety:** ‘DS Admiral’ (yellow-cotyledon type) **Seeding rate:** 385,000 pure live seeds/acre

Within-column means followed by different letters are significantly different (P< 0.05; Tukey multiple comparison procedure)
Aphanomyces root rot of field peas: Planting date studies (2018)
Relationship between soil temperature and root rot severity

2018 Field with history of severe field pea root rot (Aphanomyces & Fusarium, Aphanomyces predominant) Carrington, ND. Data from no-till and conventional-till production.

- **Graph:**
  - **Equation:** $y = 1.0976x - 5.5612$
  - **$R^2$:** 0.4563

- **Axes:**
  - **Y-axis:** Root rot severity (%) mid-vegetative growth
  - **X-axis:** Soil Temperature ($^\circ$F)

- **Conditions:**
  - 2 inches deep; average temperature, 7-day period after planting
Aphanomyces root rot of field peas: Planting date studies (2018)

Relationship between soil temperature and wilt symptom development

2018 Field with history of severe field pea root rot (Aphanomyces & Fusarium, Aphanomyces predominant) Carrington, ND. Data from no-till and conventional-till production.

![Graph showing the relationship between soil temperature and wilt symptom development. The equation of the line is y = 1.4586x - 58.369 with R² = 0.794.](image)

- Wilted plants (%) late pod-fill vs. Soil Temperature (°F)
- 2 inches deep; average temperature, 7-day period after planting
Aphanomyces root rot of field peas: Planting date studies (2018)
Relationship between soil temperature and yield

2018 Field with history of severe field pea root rot (Aphanomyces & Fusarium, Aphanomyces predominant) Carrington, ND. Data from no-till and conventional-till production.
### Aphanomyces root rot of field peas: Impact of planting date
No-till production – Carrington, ND

#### 2017 Field with history of severe field pea root rot (Aphanomyces & Fusarium, Aphanomyces predominant)

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population (plants/acre)</th>
<th>Root Rot % severity</th>
<th>Wilted Plants % incidence</th>
<th>Field Pea Yield (bushels/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 17</td>
<td>223,027</td>
<td>52</td>
<td>a</td>
<td>33</td>
</tr>
<tr>
<td>May 2</td>
<td>223,318</td>
<td>66</td>
<td>a</td>
<td>31</td>
</tr>
<tr>
<td>May 15</td>
<td>204,442</td>
<td>88</td>
<td>b</td>
<td>13</td>
</tr>
</tbody>
</table>

#### Statistical Significance
- **P>F:** 0.2954 CV: 18.8
- **P>F:** 0.0005 CV: 12.7
- **P>F:** 0.0031 CV: 26.3
- **P>F:** < 0.0001 CV: 14.4

#### Notes
- **Variety:** ‘DS Admiral’ (yellow-cotyledon type)
- **Seeding rate:** 300,000 pure live seeds/acre
- Within-column means followed by different letters are significantly different (P< 0.05; Tukey multiple comparison procedure)
Aphanomyces root rot of field peas: Efficacy of seed treatments

Seed treatments:

- **Metalayxl** and **mefenoxam**: ineffective.
- **Ethaboxam** (Intego Solo): registered on lentils and chickpeas.

Control of Aphanomyces with seed treatments is difficult:

- Aphanomyces root rot develops during vegetative growth and bloom, when the concentration of fungicide active ingredients in the target tissues (tap root, epicotyl) is low.
# Aphanomyces root rot of field peas:

**Efficacy of seed treatments**

**Intego Solo**

combined analysis across nine field pea studies

*active ingredient*: ethaboxam

<table>
<thead>
<tr>
<th></th>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BASE SEED TREATMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evergol Energy 1.0 fl oz/cwt +</td>
<td>327,300</td>
<td>59</td>
<td>39</td>
</tr>
<tr>
<td>Gaucho 1.6 fl oz/cwt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intego Solo 0.2 fl oz/cwt +</strong></td>
<td>327,339</td>
<td>60</td>
<td>41</td>
</tr>
<tr>
<td>BASE SEED TREATMENT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intego Solo 0.3 fl oz/cwt +</strong></td>
<td>330,398</td>
<td>61</td>
<td>42</td>
</tr>
</tbody>
</table>

**BASE SEED TREATMENT**

Evergol Energy 1.0 fl oz/cwt +
Gaucho 1.6 fl oz/cwt

**Intego Solo 0.2 fl oz/cwt + BASE SEED TREATMENT**

**Intego Solo 0.3 fl oz/cwt + BASE SEED TREATMENT**

**CV**:

- Plant Population: 3.9
- Root Rot: 5.9
- Yield: 5.6
Fusarium root rot: Biology

Causal pathogens:
• *Fusarium* spp. (fungal pathogens)

Conditions that favor infection:
• Soil moisture: low to high
• Soil temperatures: high
Symptoms:

- *When soil temperatures are high prior to emergence:* **Poor stand establishment** due to seed decay and damping-off
- **Root rot:** lesions that are initially brick-red to brown and later necrotic
- **Wilt:** plants yellowing from the bottom up
Fusarium root rot of field peas: Impact of planting date
Direct-seeded – Carrington, ND

2018 Inoculated with *Fusarium solani, F. avenaceum*. Symptoms suggest Aphanomyces pressure was low.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Wilted Plants</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 29</td>
<td>273,775</td>
<td>15</td>
<td>1</td>
<td>49</td>
</tr>
<tr>
<td>May 10</td>
<td>272,831</td>
<td>19</td>
<td>1</td>
<td>45</td>
</tr>
<tr>
<td>May 21</td>
<td>266,369</td>
<td>41</td>
<td>3</td>
<td>39</td>
</tr>
</tbody>
</table>

| P>F: 0.7105 CV: 7.5 | P>F: <0.0001 CV: 21.1 | P>F: 0.0002 CV: 51.0 | P>F: 0.0016 CV: 8.5 |

Variety: ‘DS Admiral’ (yellow-cotyledon type)  Seeding rate: 308,000 pure live seeds/acre
Within-column means followed by different letters are significantly different (P< 0.05; Tukey multiple comparison procedure)
Fusarium root rot of field peas: Impact of planting date
Direct-seeded – Carrington, ND

2018 Inoculated with *Fusarium solani*, *F. avenaceum*. Symptoms suggest Aphanomyces pressure was low.
**Fusarium root rot of field peas: Impact of planting date**

Conventional tillage – Carrington, ND

2018  Inoculated with *Fusarium solani, F. avenaceum.* Symptoms: *Aphanomyces* pressure likely moderate.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population (5-8 nodes plants/acre)</th>
<th>Root Rot % severity</th>
<th>Wilted Plants % incidence</th>
<th>Yield (13.5% moisture bushels/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 29</td>
<td>272,323</td>
<td>20</td>
<td>3</td>
<td>42</td>
</tr>
<tr>
<td>May 10</td>
<td>332,798</td>
<td>43</td>
<td>4</td>
<td>41</td>
</tr>
<tr>
<td>May 21</td>
<td>330,112</td>
<td>50</td>
<td>7</td>
<td>34</td>
</tr>
</tbody>
</table>

*P>F:* 0.0047  *CV:* 10.7  
*P>F:* 0.0067  *CV:* 28.3  
*P>F:* 0.0012  *CV:* 28.6  
*P>F:* 0.0230  *CV:* 8.0

**Variety:** ‘DS Admiral’ (yellow-cotyledon type)  
**Seeding rate:** 308,000 pure live seeds/acre  
Within-column means followed by different letters are significantly different (*P* < 0.05; Tukey multiple comparison procedure).
**Fusarium root rot of field peas**: Impact of planting date  
No-till production – Williston, ND

2018  Inoculated with *Fusarium solani, F. avenaceum*. Aphanomyces pressure unknown.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population</th>
<th>Root Rot</th>
<th>Wilted Plants</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 26</td>
<td>211,605</td>
<td>31</td>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>May 7</td>
<td>192,051</td>
<td>44</td>
<td>4</td>
<td>26</td>
</tr>
<tr>
<td>May 16</td>
<td>210,250</td>
<td>41</td>
<td>2</td>
<td>23</td>
</tr>
</tbody>
</table>

*Variety: ‘DS Admiral’ (yellow-cotyledon type)  Seeding rate: 330,000 pure live seeds/acre*  
Within-column means followed by different letters are significantly different (*P* < 0.05; Tukey multiple comparison procedure)
Fusarium root rot of field peas: Planting date studies (2018)

Relationship between soil temperature and root rot severity

2018 Field peas inoculated with *Fusarium solani, F. avenaceum*. Aphanomyces pressure low to moderate. Carrington and Williston, ND. Data from no-till and conventional-till production.

![Graph showing the relationship between soil temperature and root rot severity. The graph includes data points for Carrington and Williston, with Carrington represented by blue data points and Williston by brown data points. The equation of the line is given as $y = 1.3439x - 44.669$ with an $R^2$ value of 0.6057.]

2 inches deep; average temperature, 7-day period after planting.
Aphanomyces root rot of field peas: Planting date studies (2018)
Relationship between soil temperature and wilt symptom development

2018 Field peas inoculated with *Fusarium solani, F. avenaceum*. Aphanomyces pressure low to moderate. Carrington and Williston, ND. Data from no-till and conventional-till production.

![Graph showing relationship between soil temperature and wilt symptom development.](image-url)
Aphanomyces root rot of field peas: Planting date studies (2018)
Relationship between soil temperature and yield

2018 Field peas inoculated with *Fusarium solani, F. avenaceum*. Aphanomyces pressure low to moderate. Carrington and Williston, ND. Data from no-till and conventional-till production.

![Graph showing relationship between soil temperature and field pea yield](image_url)

- **Williston:** Brown data points
- **Carrington:** Blue data points

- **Equation for Williston:** $y = -0.4568x + 68.64$, $R^2 = 0.6592$
- **Equation for Carrington:** $y = -0.5288x + 56.088$, $R^2 = 0.9994$

2 inches deep; average temperature, 7-day period after planting
**Fusarium root rot of field peas:** Impact of planting date
Direct-seeded – Carrington, ND

2017 Inoculated with *Fusarium* spp. Symptoms suggest *Aphanomyces* pressure was low.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population (4-6 nodes plants/acre)</th>
<th>Root Rot % severity</th>
<th>Wilted Plants % incidence</th>
<th>Yield (13.5% moisture bushels/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 17</td>
<td>285,608</td>
<td>7</td>
<td>1</td>
<td>51</td>
</tr>
<tr>
<td>May 2</td>
<td>320,456</td>
<td>24</td>
<td>2</td>
<td>51</td>
</tr>
<tr>
<td>May 15</td>
<td>334,686</td>
<td>42</td>
<td>1</td>
<td>51</td>
</tr>
</tbody>
</table>

*P > F*:
- April 17: 0.0415 (CV: 6.8)
- May 2: <0.0001 (CV: 13.9)
- May 15: 0.2624 (CV: 45.8)
- Yield: 0.9979 (CV: 6.7)

**Variety:** ‘Abarth’ (yellow-cotyledon type)

**Seeding rate:** 330,000 pure live seeds/acre

Within-column means followed by different letters are significantly different (*P* < 0.05; Tukey multiple comparison procedure)
## LENTILS - Impact of planting date on Fusarium root rot

**Direct-seeded – Carrington, ND**

2018

Inoculated with *Fusarium* spp. Symptoms suggest Aphanomyces pressure was low.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population (plants/acre)</th>
<th>Root Rot (bloom initiation % severity)</th>
<th>Wilted Plants (late bloom % incidence)</th>
<th>Yield (13.5% moisture pounds/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 29</td>
<td>400,825</td>
<td>5</td>
<td>0</td>
<td>2270</td>
</tr>
<tr>
<td>May 10</td>
<td>366,049</td>
<td>8</td>
<td>0</td>
<td>2120</td>
</tr>
<tr>
<td>May 21</td>
<td>407,867</td>
<td>9</td>
<td>3</td>
<td>1242</td>
</tr>
</tbody>
</table>

*P>F: 0.1882 CV: 11.0*  
*P>F: 0.0004 CV: 26.2*  
*P>F: <0.0001 CV: 56.9*  
*P>F: <0.0001 CV: 11.6*

**Variety:** CDC ‘Impress’ (medium-green type)  
**Seeding rate:** 488,000 pure live seeds/acre

Within-column means followed by different letters are significantly different (*P< 0.05; Tukey multiple comparison procedure*)
LENTILS: Impact of planting date on Fusarium and Aphanomyces root rots
Conventional tillage – Carrington, ND

Inoculated with *Fusarium* spp. Significant *Aphanomyces* pressure impacted portions of the study.

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Plant Population (plants/acre)</th>
<th>Root Rot Bloom Initiation % Severity</th>
<th>Wilted Plants Late Bloom % Incidence</th>
<th>Yield 13.5% moisture pounds/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 28</td>
<td>358,592</td>
<td>20</td>
<td>7</td>
<td>2370</td>
</tr>
<tr>
<td>May 10</td>
<td>335,993</td>
<td>18</td>
<td>13</td>
<td>1781</td>
</tr>
<tr>
<td>May 21</td>
<td>323,433</td>
<td>15</td>
<td>7</td>
<td>788</td>
</tr>
</tbody>
</table>

*P>F* values: 0.7212 CV: 15.4, 0.6975 CV: 16.3, 0.6983 CV: 98.9, 0.0092 CV: 15.4

Variety: CDC ‘Impress’ (medium-green type)  Seeding rate: 488,000 pure live seeds/acre

Within-column means followed by different letters are significantly different (*P* < 0.05; Tukey multiple comparison procedure)
Thank you!

Research funded by:
Northern Pulse Growers Association
North Dakota Crop Protection Product Harmonization Board & Registration Board
North Dakota Department of Agriculture USDA Specialty Crop Block Grant Program