Etiology, Impact and Control of Root Rot in Faba Bean

Annual Report
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Brief Project Description: Zero-tannin faba bean has the potential for use in human food and as a feedstock for aquaculture. However, tannin-free faba bean cultivars have thinner seed coats containing fewer saponins and alkaloids, which increase their susceptibility to Fusarium root rot. Faba bean production in Alberta could reach 25,000 acres by 2010 and has been increasing in northwest Manitoba (Dauphin). Faba bean is a good source of energy and protein (28-32%). Market demand is high and production costs are similar to that of field pea. Disease surveys of faba bean from 2004 to 2006 have shown that Fusarium root rot is an important soil-borne disease in Alberta. Approximately 30% of plants at the Lacombe Research Centre were infected in 2006 and several commercial fields had infected taproots and damaged fibrous roots, which resulted in stunting, wilting, and yield losses. To help stabilize faba bean yields and protein production, we are evaluating the interaction of fungicide seed treatments and pathogen inoculum levels to develop a model linking disease levels, nodulation and yield losses.

Root infection by Fusarium species is considered one of the major constraints to faba bean production. More than 13 species of Fusarium have been reported to cause root rot in faba bean, but the majority of symptoms were associated with infection by F. oxysporum, F. avenaceum and F. solani. A root disease survey in Saskatchewan in 1975 showed that Rhizoctonia solani (60%) was the most common cause of root disease in faba beans. However, a survey of faba bean fields in Alberta in 2006 showed that faba bean root rot samples were mostly infected by Fusarium species. The same survey also isolated R. solani and Pythium species at low frequencies.
Preliminary field trials of fungicide seed treatments to control Fusarium and Rhizoctonia root rot of faba bean were conducted at Lacombe in 2005. Seed treatments with Vitaflo 280 and Apron Maxx improved emergence compared to non-treated controls inoculated with either pathogen. Both fungicides also improved yield in plots inoculated with Fusarium species.

Materials and Methods:
In 2009, mycelial plugs of the root pathogen Fusarium avenaceum were grown for 2 weeks in polyethylene bags filled with 1.5L of sterilized wheat grains. Then, the infested wheat grain was air-dried, ground into powder, and stored at 4°C until it was used as inoculum. Field experiments were set up at Lacombe and Morden to examine the effect of inoculum concentration of F. avenaceum on seedling emergence, root rot severity and faba bean yield. At each field site, the treatments included three inoculum concentrations and a non-inoculated control. Field trials were arranged in a randomized complete block design (RCBD) with four replications. Each plot consisted of 4 rows, 6 m in length with 30 cm row spacings. The cultivars Snowbird and Earlibird were used at Lacombe, but only Snowbird was planted at the Morden site. At both field sites, the seed were inoculated with a granular Rhizobium inoculant. Seedling emergence, root rot severity, nodulation and yield and were recorded. Plant roots were collected and assessed for root rot severity (0-9 scale) (Fig. 1). Nodulation was assessed on a scale of 0-4, based on nodule number, size and distribution on the roots (0 = no nodules, 1 ≤ 5 nodules/plant, 2 ≤ 10 nodules/plant, 3 ≤ 20 nodules/plant and 4 > 20 nodules/plant. In September, the seed from each plot was harvested and yields were obtained.

At each location a second experiment was set up to examine the interaction between inoculum concentration and different fungicidal seed treatments. Seed of the faba bean cultivar Snowbird was treated with Apron Maxx (3.25 mL/kg seed), Trilex (3.7 mL/kg seed), Vitaflo 280 (3.3 mL/kg seed) or with the experimental fungicide SP102000019578 (3.7 mL/kg seed). An untreated check was also included among the treatments at both field sites. The trial was set up in a split-plot design with four replications. Main plot treatments consisted of the same inoculation concentrations of F. avenaceum that were used in the first experiment. The subplot treatments included the seed-treatment fungicides.

The experiments were sown on May 21st at Morden and on May 9th at Lacombe at a 5 cm depth and at the recommended seeding rate. Inoculum of the Rhizobium spp. and F. avenaceum were incorporated at the time of seeding. Seedling emergence was determined on June 17th at Morden and on June 6th at Lacombe. Root rot severity and root nodulation were assessed on August 3rd to August 5th at Morden and on August 11-12th at Lacombe. The experiments were harvested on September 15th in Morden and September 24th in Lacombe. The data on emergence, root rot, nodulation and yield from the experiments at both sites has been statistically analysed.

Root Rot Survey. In 2009, a joint root rot survey, in cooperation with Dr. D.L. McLaren of AAFC-Brandon, was conducted of commercial faba bean fields in Manitoba and Alberta. The survey for root diseases was conducted in late July to early August at Brandon, in mid August at Morden and in late August to early September in Alberta. Root rot severity was assessed at five
sites in each field and the plants were collected for isolation of the causal organisms in the laboratory in order to determine the most common cause of root rot. This winter, the pathogenicity of each of the fungal isolates will be determined.

**Project Goals:** The project will assess the impact of Fusarium root rot on emergence, root nodulation, root rot and yield of faba bean. This project will focus on *Fusarium* spp. as the putative pathogen causing root rot. Field trials will be conducted to study the effects of inoculum concentration and disease level on nodulation and yield loss and the interacting effects of fungicidal seed treatments and inoculum level on nodulation, disease severity and yield. In 2009, surveys of commercial faba bean fields in Manitoba and Alberta were conducted to evaluate the severity of the root diseases and identify the pathogens responsible for this disease.

**Results and Discussion:**

**Effect of inoculum concentration**
At Lacombe, seedling emergence in the faba bean cultivar Snowbird was significantly lower than that of the cultivar Earlibird. Emergence declined with increased inoculum concentration in Snowbird, but had no effect on seedling emergence in Earlibird. The two highest inoculum concentrations resulted in significant increases in root rot severity in both faba bean cultivars. The highest inoculum concentration significantly decreased root nodulation in the cultivar Earlibird, but inoculum concentration did not significantly affect root nodulation in the cultivar Snowbird. Fusarium inoculation also reduced seed yield at all levels of inoculum, but none of them reached a significant level.

At Morden, inoculum concentration did not have a significant effect on seedling emergence, root rot severity, root nodulation or yield. Only the cultivar Snowbird was grown at the Morden site.

**Interaction of inoculum concentration and fungicidal seed treatments**

**Alberta**
At Lacombe, seedling emergence declined as inoculum concentration increased. Emergence in all the fungicide seed treatments was similar to that of all the disease-free treatments. All fungicides significantly improved seedling emergence compared to the non-fungicide control treatment. The experimental seed-treatment fungicide SP102000019578 provided the greatest improvement in emergence, followed by Apron Maxx and Vitaflo 280. Seedling emergence in the Trilex treatment was greater than that of the untreated control, but was lower than the other seed treatments.

At the Lacombe site, root rot severity ratings ranged from 1.1 to 2.9 and increased with higher inoculum concentrations. At each of the three different inoculum concentrations, the untreated check had significantly higher root rot ratings than any of the seed treatments. Root nodulation was high, ranging from 3.0 to 3.8 and was not affected by seed treatment.
At Lacombe, the effectiveness of the fungicide seed-treatments in reducing yield losses was most evident at the highest inoculum concentration (45 mL/row). Yield was significantly greater compared to the inoculated control in all the fungicide seed treatments except Trilex at an inoculum concentration of 30 mL/row, and all treatments except Trilex and Apron Maxx at 45 mL/row. At lower inoculum concentrations, the seed treatments did not significantly differ from the untreated control with respect to yield. Differences in yield compared to the untreated check ranged as high as 18.6% at an inoculum concentration of 30 mL/row and 13.2% an inoculum concentration of 45 mL/row. There were also associated losses in the quality of seed.

Manitoba
At the Morden site, seed treatment was shown to significantly improve seedling emergence, but pathogen inoculum concentration and the inoculum concentration x fungicide treatment interaction had no effect on seedling emergence. Across inoculum concentrations, Vitaflo 280, SP102000019578 and Trilex increased seedling emergence in comparison to the untreated check. Seed treatment with Apron Maxx resulted in a slight improvement in seedling emergence, but was not significantly better than the untreated check.

Root rot severity ratings were generally low ranging from 2.1 to 3.3 at the Morden site. Even though variability within treatments was low, root rot severity was not significantly affected by fungicide seed treatment, inoculum rate or their interaction.

At the Morden site, root nodulation was good in all the seed treatments at each pathogen inoculum concentration rate and ranged from 2.2 to 2.8.

Yield was significantly affected by pathogen inoculum concentration and fungicide seed treatment. The yield at the highest inoculum concentration (45 mL/row) was 7% lower than the disease-free check. The yields in seed treatments with Apron Maxx, SP102000019578 and Vitaflo 280 were significantly better than that of the untreated check. Seed treatment with Trilex resulted in slightly higher yields than the untreated check, but the difference was not significant. Compared to the untreated check, Apron Maxx, SP102000019578 and Vitaflo 280 improved yield by 8.2%, 7.2% and 6.5%, respectively.

Root Rot Survey
In Alberta, growing conditions were generally dry throughout the summer. In most faba bean crops, root rot was unevenly distributed and severity ratings were low (Table 1). However, root rot was severe in one broad bean field near Edmonton. The affected plants in the broad bean crop were stunted with small, yellowing leaves and brown roots that had little or no nodulation. The majority of these diseased plants produced fewer pods and smaller seeds than the healthy plants from the same crop.

In the Alberta crops, the survey results showed that *Fusarium* spp. were the most prevalent root pathogens with isolation frequencies from the 18 faba bean crops that ranged from 29 to
90% and averaged 72% (Table 2). Although *Pythium* species were detected in 17 faba bean crops, they were isolated at low frequencies that averaged 22%, but ranged as high as 67%. A substantial number of *Rhizoctonia solani* isolates were collected from 12 crops, but only 18% of the roots from the affected crops were infected by this fungus.

In Manitoba, frequent showers occurred throughout the summer and daily temperatures were generally lower than normal. Three root diseases were observed (Table 1). *Fusarium* root rot (*Fusarium* spp.) was detected in all 16 crops surveyed, making it the most prevalent root disease of faba bean in Manitoba. Crops in which *Fusarium* spp. were isolated had root rot severity ratings that ranged from 2.2 to 5.3 with an average rating of 3.5. *Rhizoctonia* root rot (*Rhizoctonia solani*) was detected in eight of the 16 crops surveyed with severity ratings of 2.2 to 5.3 and an average of 3.8. *Pythium* species were detected in three of the 16 crops that had disease severity values that ranged from 4.2 to 5.3 and averaged 4.7. However, in the three faba bean crops from which *Pythium* spp. were isolated the pathogen was detected at low frequencies that ranged from 6 to 10% of the roots sampled (Table 2). Similarly in the eight fields in which *R. solani* was found, the pathogen was isolated from only 2 to 8% of the roots and averaged 5%. In contrast, the *Fusarium* species were detected on average in 72% of the roots with a range of 26 to 94% of the roots from individual crops.

Six crops in Manitoba had average root rot severity values above 4 (i.e., symptoms were present on 50% of the root system) and this would have had an adverse impact on yield.

Root nodulation ratings ranged from 1.0 to 4.0 with an average of 3.0 over all crops surveyed in Manitoba, and ranged from 0.0 to 4.0 with an average of 3.2 in the crops in Alberta. No obvious relationship was detected between root rot severity and root nodule formation in either province.

*Fusarium* species were the most prevalent pathogens associated with root rot in faba bean and occurred at similar frequencies in Alberta and Manitoba. *Pythium* species were more commonly isolated than *R. solani* and these pathogens were more frequently isolated in Alberta than in Manitoba. Pathogenicity tests are underway to clearly identify the species of pathogens that are most damaging to the faba bean root system.

**Conclusions:** This new research will improve root rot control in faba bean, which should encourage greater faba bean production, leading to increased crop diversification. More widespread faba bean cultivation will dampen supply fluctuations that currently inhibit the growth of the processing industry and will encourage development of new markets for both raw and value-added products. Improved seed quality also will make faba beans more attractive as a component in meal rations for livestock. This research will focus on prevention of seed and root infection in faba bean by fungicide application and will provide a database on yield losses resulting from *Fusarium* root rot of faba bean.

**Milestone Update:** The project is proceeding according to plan.
Budget Update: The total funding of $8,000 was evenly split between researchers at AAFC-Morden and Field Crop Development Centre of Alberta Agriculture and Rural Development in Lacombe, AB to support research on root rot control. This is the first year of this project and the funds were used to partially pay the salary of a summer student and cover the costs of materials and supplies as well as the project overhead (15%) costs. This winter, a research proposal based on this study will be submitted to Agri-Food Research & Development Initiative (ARDI) in order to obtain matching funds to support the last two years of this study. The Saskatchewan Pulse Growers Association agreed to fund this study at field sites located at Brandon (Dr. D.L. McLaren) and Saskatoon (Dr. B.D. Gossen).

Communication Update: The results from this study will be published when the project is completed. This research project will be highlighted at future Special Crop Field Days that will be held at AAFC-Morden. The results of the 2009 faba bean root rot survey will be published in the 2010 Canadian Plant Disease Survey.

Acknowledgements
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Fig. 1. Root rot severity rating (0-9).
### Table 1. Prevalence and severity of root diseases in 34 crops of faba bean in Alberta and Manitoba in 2009.

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. crops affected</th>
<th>Disease Severity</th>
<th>Nodulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Range</td>
</tr>
<tr>
<td><strong>Alberta</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusarium root rot</td>
<td>18</td>
<td>1.5</td>
<td>0.0-8.0</td>
</tr>
<tr>
<td>Rhizoctonia root rot</td>
<td>12</td>
<td>1.6</td>
<td>0.0-8.0</td>
</tr>
<tr>
<td>Pythium root rot</td>
<td>17</td>
<td>1.4</td>
<td>0.0-8.0</td>
</tr>
<tr>
<td><strong>Manitoba</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusarium root rot</td>
<td>16</td>
<td>3.5</td>
<td>2.2-5.3</td>
</tr>
<tr>
<td>Rhizoctonia root rot</td>
<td>8</td>
<td>3.8</td>
<td>2.2-5.3</td>
</tr>
<tr>
<td>Pythium root rot</td>
<td>3</td>
<td>4.7</td>
<td>4.2-5.3</td>
</tr>
</tbody>
</table>

<sup>1</sup>Means are based on an average of the crops in which the diseases were observed. Root diseases were rated on a scale of 0 (no disease) to 9 (death of plant, seedlings died back soon after emergence).

<sup>2</sup>Nodulation was rated on a scale of 0 (no nodules) to 4 (at least 20 nodules/plant).

### Table 2. Prevalence of different root pathogens in 34 crops of faba bean in Alberta and Manitoba in 2009.

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. crops affected</th>
<th>Isolation Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean&lt;sup&gt;1&lt;/sup&gt;</td>
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<tr>
<td><em>Fusarium</em> spp.</td>
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<td>72</td>
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<td><em>Rhizoctonia solani</em></td>
<td>12</td>
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</tr>
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<td><em>Pythium</em> spp.</td>
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</tr>
<tr>
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<td>8</td>
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<tr>
<td><em>Pythium</em> spp.</td>
<td>3</td>
<td>8</td>
</tr>
</tbody>
</table>

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