Final Progress Report

Project #: 3682

Progress Report Year: 3 of 3

Title: Control of Strawbreaker Foot Rot (Eyespot) and Cephalosporium Stripe in Winter Wheat

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A. Carter, Crop & Soil Sciences, WSU
K. Garland-Campbell, USDA-ARS

Executive summary: Variety trials for eyespot and Cephalosporium stripe were not conducted in 2016-17 due to staff and funding limitations; however, the trials were completed in 2015-16 and 2017-18, and are in progress for 2018-19. A total of 83 new varieties and advanced lines were evaluated for resistance to eyespot and tolerance to Cephalosporium stripe. Data from these plots were used to update disease ratings in the Washington State Crop Improvement Association Seed Buyers Guide and the WSU Extension Small Grains variety selection tool. We streamlined the process used to test varieties by collaborating with the WSU Variety Testing program to identify and test lines that were in their 2nd year of Variety Testing plots and planting head-row plots instead of yield trials. We also solicit advanced lines from WSU Winter Wheat Breeding (including ARS Club-Wheat Breeding) for testing. This approach greatly reduces the space needed for testing, which allows us to test more lines, and reduces labor needed for harvest, but still requires significant labor for destructive sampling and disease rating.

Studies to map disease resistance genes to the eyespot fungi in a population derived from Madsen were conducted to determine whether the same genes control resistance to both pathogens. Although Madsen is one of the first two eyespot resistant varieties released in WA and has been grown for almost 30 years, its resistance to the eyespot pathogens was never mapped because it was not known that there were two different fungal species that caused the disease at the time of Madsen’s release. In addition, we know there are differences in the effectiveness of resistance to these fungi in Madsen and other eyespot-resistant varieties. In collaboration with colleagues in China, we also mapped resistance to cereal cyst nematode (CCN) in the same Madsen population and demonstrated that it carries two different genes, one each to H. avenae and H. filipjevi, both derived from VPM-1, the source of eyespot resistance. Phenotyping and genotyping have been completed and we plan to complete the mapping analysis for eyespot in spring 2019.

Field studies to determine the effectiveness of variety mixtures on eyespot and Cephalosporium stripe were conducted over the past 3 years; the final experiment was planted in September 2018 for disease evaluation and harvest in summer 2019. Disease severity data were collected from all six experiments, but yield data were collected from 4 of 6 experiments due to severe lodging. Data from the first three years (six locations) are being analyzed and conclusions will be presented when all data have been collected and analyzed.
Seed treatment trials for eyespot and Cephalosporium stripe were conducted in 2015-16 and 2016-17; there were no yield or disease control benefits in either year, so the work was not continued. Plots to evaluate foliar fungicides for eyespot were established in 2016 and 2018, but not completed due to a lack of disease and poor stand. We are planning to conduct a trial in spring 2019 in conjunction with a private company if a location with enough disease pressure can be located.

Chemical control of eyespot remains an important option for control and several new products have been registered in the past few years. Some of these contain active ingredients for which we have already screened the eyespot fungi for resistance, but others need to be tested because resistance to them occurs in other plant pathogenic fungi. Due to limitations in funding and labor, we did not make progress on this objective during this funding cycle.

Spore-trapping for the eyespot fungi was conducted over the past three years at the Plant Pathology Farm, Palouse Conservation Field Station, and Spillman Farm to understand the seasonal dynamics of ascospore release, which may contribute to pathogen genetic variation. This study represents more fundamental research to understand the biology of eyespot disease and insure that we have effective control measures going forward, both for stable disease resistance and fungicide sensitivity. Data will be collected through May 2019, summarized and analyzed to conclude this phase of the research.

Impact: Cephalosporium stripe and eyespot continue to be significant yield-limiting diseases for winter wheat production. Nearly all public and private breeding programs in the PNW are addressing these diseases because resistant/tolerant varieties are the most effective way to limit their impact. This project is the only place where all new varieties and advanced breeding lines are evaluated side-by-side for their reaction to eyespot and Cephalosporium stripe. The data we generate are shared with wheat breeders to support variety release and growers at variety testing field tours, online at the WSU Extension Small Grains website, and is used to provide ratings in the WSCIA seed buyer’s guide and the WSU Small Grains Variety Selection tool for use by growers in making variety selection decisions.

Currently, the gene present in Madsen is the primary source of resistance in all PNW eyespot-resistant varieties and understanding its genetic control will insure it remains effective. Not all eyespot-resistant varieties are equally effective in limiting disease development. We suspect this may be the result of minor genes that have not been previously identified and/or differences in genes involved in resistance to the two eyespot fungi. Identifying minor genes affecting eyespot resistance and molecular markers for them will allow breeders to develop new varieties with more effective eyespot resistance. Because of the focus on mapping genes in Madsen, we did not screen wild relatives of wheat for eyespot resistance during this grant cycle but continue to believe new sources of resistance are important in the long-run and plan to resume screening in the next cycle.

Publications:


Presentations:

Stripe rust and other diseases in small grains. WSU Extension, Western Whitman County Field Tour, Dusty, WA, June 7, 2018.


Overview of Winter Wheat Disease Research in Washington State, Jilin Agricultural University, Changchun, China, September 20, 2017.


Outlook for stripe rust and other diseases in small grains. WSU Extension, Western Whitman County Field Tour, Farmington, WA, June 13, 2016.

Outlook for stripe rust and other diseases in small grains. WSU Extension, Western Whitman County Field Tour, Dusty, WA, June 9, 2016.

Outlook for stripe rust and other diseases in small grains. WSU Extension, Variety Testing Field Tour, Ritzville, WA, June 8, 2016.
### Objective

1. Evaluate mixtures of resistant/tolerant and susceptible varieties in field plots for their impact on eyespot and Cephalosporium stripe.

2. Screen wild wheat relatives for potential new sources of resistance genes.

### Deliverable

- The potential effectiveness of variety mixtures in controlling eyespot and Cephalosporium stripe will be determined. This is particularly important for Cephalosporium stripe where varieties with highly effective resistance are not available.

- Identify potential new eyespot resistance genes for use by breeders to improve effectiveness of resistant varieties.

### Progress

**2016:** Field plots were established in Fall 2015 on the Plant Pathology Farm (eyespot) and Palouse Conservation Field Station (Cephalosporium stripe) to determine the effect of mixtures on each disease. Each plot contains two resistant/tolerant and two susceptible varieties planted separately and in all possible combinations. Plots were inoculated in November and disease severity and yield determined in summer 2016. Unfortunately, yield data were not obtained from the eyespot plot due to spring flooding. Data are being analyzed now.

**2017:** Data were collected from field plots planted in 2016 and are being analyzed. Field plots were planted again in fall 2017 for data collection in 2018.

**2018:** Data for disease severity and yield were collected again and are being analyzed together with data from previous years. Field plots were planted in fall 2018 to complete this study in 2019.

**2016:** No activity in 2016. Inoculum is being produced now to screen a Madsen population being mapped for cereal cyst nematode resistance to determine the relationship between these genes. Repeat tests of some wild species is anticipated during 2017 to confirm previous results and identify potential donors for genetic studies.

**2017:** A Madsen population was screened for resistance to one (Oy) of the two eyespot pathogens to determine whether the same genes are involved in resistance to both pathogens. This population is also being screened for cereal cyst nematode resistance by colleagues in China.

**2018:** Screening of the Madsen population with the second eyespot pathogen (Oa) was completed and data have been summarized. Genotyping data were obtained and mapping of genes involved with resistance will be completed during winter 2019.

### Timeline

- **Multiple years of data are needed to confirm the responses of the mixtures being tested, so this work continue each year of the project. Field plots were planted in fall 2018; data from these studies will be analyzed following harvest in 2019 and not be continued.**

- **2016:** This work will begin in fall 2016 or spring 2017, but not completed until the end of the project.

- **2017:** Screening of the Madsen population will continue during the first half of 2018, after which we plan to complete screening some wheat relatives through 2018 into 2019.

- **2018:** Screening of the Madsen population for resistance reaction was completed. Data are being analyzed to identify QTL associated with resistance to both pathogens and should be completed by June 2019. Screening of a Cappelle-Desprez x Whetstone population will begin during winter 2019 instead of screening wild relatives.

### Communication

- Results from these plots are presented at field days, variety testing plot tours, and other talks to grower and industry groups, and available online at the Extension Small Grains Team website. Data will be published in appropriate scientific journals when analysis is complete and presented at scientific meetings.

- Results of this research will be shared with breeders, presented at field days, variety testing plot tours, and other talks to grower and industry groups. Data also will be published in appropriate scientific journals.
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<thead>
<tr>
<th>Objective</th>
<th>2016</th>
<th>2017</th>
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<th>Notes</th>
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<td>3. Evaluate eyespot pathogen populations for resistance to new fungicide active ingredients.</td>
<td>Provide data that will help growers and field consultants make decisions about whether and which fungicide to use in controlling eyespot by testing fungicides registered for eyespot control in multiple locations in eastern WA.</td>
<td>2016: A field plot was established near Ritzville, WA in spring 2016, but later abandoned due to inadequate eyespot disease and too much dryland foot rot to provide meaningful results. A seed treatment trial was planted in fall 2015, disease evaluated and yield determined in summer 2016.</td>
<td>2017: No activity on this objective during 2017.</td>
<td>2016: This is the last year of fungicide testing in this funding cycle unless the agchem industry provides support.</td>
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<td>Results from these plots will be presented at field days, variety testing plot tours, and other talks to grower and industry groups, and available online at the Extension Small Grains Team website. Results also will be published in Plant Disease Management Reports so they are available to the larger small grains pathology community.</td>
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<td>2016: A field plot was planted in fall 2018 to test fungicides in conjunction with a private company; however, dry conditions resulted in uneven emergence and the plot will not be used. Testing may still occur if a commercial field with eyespot is located in spring 2019.</td>
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<td>4. Determine impact of pathogen genetic variation on disease epidemiology, especially the eyespot pathogens, to insure resistance genes remain effective</td>
<td>Develop molecular and microbiological data describing genetic variation in the eyespot and Cephalosporium stripe pathogens and its potential effect on disease control using resistant varieties.</td>
<td>2016: Molecular markers were developed for one of the eyespot fungi during 2015. Marker development for the other eyespot fungus and <em>Cephalosporium gramineum</em> are in progress, but limited progress was made in the second half of 2016 due to personnel turnover. Spore traps were established at the Palouse Conservation Field Station and Spillman Farm to understand the seasonal dynamics of ascospore release, which may contribute to pathogen genetic variation. Traps are sampled weekly and evaluated using microscopy and real-time PCR to determine when and relatively how many spores were released.</td>
<td>2017: Aerial spore-traps were deployed from September through May, with samples collected weekly. Samples from spring have been analyzed; data from fall collections are still being collected and summarized to determine when ascospores of the eyespot fungi are present. No progress was made on development of molecular markers for the eyespot/Cephalosporium stripe fungi.</td>
<td>This was a long-term objective and spore-trapping work was conducted each year of the project. Data collection on spore-trapping will end in spring 2019; all data will be combined for analysis and publication.</td>
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<td>Results of this research will be shared with breeders, presented at field days, variety testing plot tours, and other talks to grower and industry groups. Results also will be presented at scientific meetings and published in appropriate scientific journals.</td>
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<td>Prepare an article for <em>Wheat Life</em> during the three-year project summarizing results.</td>
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5. Evaluate advanced breeding lines and new varieties for resistance to eyespot and Cephalosporium in field plots

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<th>Year</th>
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<td>2016</td>
<td>Forty-four breeding lines and advanced selections were established in field plots and inoculated in fall 2015. Disease evaluation was conducted on both plots in June 2016. Yield data were not taken due to extensive lodging in both plots that was not related to disease resistance and would have led to misleading results.</td>
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<td>2017</td>
<td>Variety screening was not conducted in 2017. Thirty-nine lines were planted and inoculated for both eyespot and Cephalosporium stripe rating in 2018. Data from previous trials was used to provide and update ratings for the WSCIA Seed Buyer's Guide and WSU Small Grains variety selection tool.</td>
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<td>2018</td>
<td>Thirty-nine winter wheat cultivars and breeding lines were evaluated for their resistance/tolerance to eyespot and Cephalosporium in June 2018. Another 39 lines were planted in September for evaluation in 2019.</td>
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2016: Testing did not occur due to staff and funding limitations.  
2017: Disease testing plots for new varieties were planted in collaboration with the WSU Variety Testing program in fall 2017 for rating in 2018.  
2018: This was the second year of testing in collaboration with the WSU Variety Testing program and first year with WSU Winter Wheat Breeding. This activity will continue given the nature of variety development.  

Results from these plots are presented at field days, variety testing plot tours, and other talks to grower and industry groups, and available online at the Extension Small Grains Team website. Data are used to update variety ratings in the Washington State Crop Improvement Seed Buyer's Guide, the WSU Extension Small Grains Variety Selection tool, and published online in Plant Disease Management Reports so they are available to the larger wheat research community.