

RESEARCH PROJECT TITLE: Improving genetic resistance to *Cephalosporium* stripe of wheat through field and toxin screening and molecular mapping with novel genetic stocks

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INTERIM REPORT

PROJECT OBJECTIVES:

1. Characterize response of select winter wheat populations, parents, and progeny to *Cephalosporium gramineum*. Utilize both fungal toxin(s) and field screening methods to identify materials with superior disease resistance.
2. Identify and use molecular markers to determine the inheritance of resistance to *Cephalosporium* stripe

KEY WORDS: *Cephalosporium* stripe, resistance, wheat

STATEMENT OF PROBLEM: *Cephalosporium* stripe of wheat is a limiting factor for many Pacific Northwest wheat growers in erosion-prone areas, especially when early planting and/or trashy fallow are practiced. Burning or plowing stubble and delayed seeding can provide substantial control of *Cephalosporium* stripe. However these cultural control methods conflict strongly with attempts to control soil erosion. No soft white winter wheat cultivars show complete resistance to *Cephalosporium* stripe, although there are variations in the degree of tolerance among cultivars. Genetic tolerance identified to-date may be adequate to reduce inoculum levels and control the disease in the long-term. However, characterizing varieties and breeding lines remains problematic and superior levels of disease resistance are needed. Expression of resistance is incomplete and environmentally dependent. Further, the disease tends to be aggregated within fields, thus making useful comparisons difficult in early generations of cultivar development.

ZONE OF INTEREST: low and intermediate rainfall

ABSTRACT OF RESEARCH FINDINGS: We successfully evaluated populations of progeny resulting from four different crosses of a resistance source from Europe with PNW varieties. These populations were found to segregate as expected for a quantitatively-inherited trait, and indicate that it should be possible to select genotypes with higher levels of resistance to *Cephalosporium* stripe than is present in currently available varieties in the PNW. Results show that populations derived from some crosses may be better sources of resistance than others. Additional trials included two evaluations of alternative sources of resistance, two elite yield trials, and a barley trial. Five highly promising lines from among the four cross populations have been advanced to multi-location yield trials for 2005-06, and another 15 lines have been placed in preliminary yield trials. Two lines identified from the Oregon Winter Elite Yield Trial show high levels of resistance to *Cephalosporium* stripe and are being considered for production of Breeder's Seed. The third year of field plots has been established. These studies include 11 trials and encompass over 1400 plots. Marker-based studies will receive intense emphasis in the final year

of the project so as to determine the inheritance of resistance and to evaluate the potential for marker-assisted selection.

RESULTS AND INTERPRETATION:

Background - The OSU Wheat Breeding project has established a unique germplasm exchange agreement with Nickerson Seeds, a European breeding company with programs in France, England, Germany, and Spain. In screening the Nickerson germplasm, we identified several lines that have superior resistance to *Cephalosporium* stripe (Table 1). These lines are of different genetic background from current PNW varieties and are mostly soft red grain types. It is likely the resistance(s) also are unique, or at least complementary, to that in our own breeding materials. In Oregon field evaluations from 2000 to 2002, the Nickerson lines showed high yield potential, superior resistance to foliar diseases, and favorable adaptation to the PNW region. As such, we have an exciting opportunity to introgress novel disease resistance genes into PNW materials without sacrificing yield potential, plant architecture, grain quality, or adaptation. The most immediate challenge is, through crossing and selection, to recapture soft white wheat end-use quality as needed for PNW export markets.

Because of the superior performance and disease resistance of the Nickerson lines, we initiated crosses in 1999 and fast-tracked a number of segregating populations. Additional materials for our investigations include populations from single and 3-way crosses with other NSA lines as listed in Table 1. These crosses were made in spring 2002 and are being advanced via single-seed descent in the greenhouse and sufficient quantities of seed will be available for field evaluation in the 2006-07 season.

Table 1. Reactions of cultivars to field infestations of *Cephalosporium* stripe.

Cultivar	2002 Pendleton % White heads	2001 Pendleton % White heads
Stephens	32.5	57.5
Madsen	11.5	13.5
Weatherford	5.5	21.5
Tubbs	21.0	30
Rossini	2.0	3.5
<i>Rossini/Ysatis//Oracle (9800919)</i>	1.3	3
<i>Rossini/Ysatis//Oracle (9800924)</i>	1.5	2
<i>NSA 99-0626</i>	5.3	.
<i>NSA 99-0248</i>	4.0	.
<i>NSA 99-2104</i>	3.0	.
<i>NSA 98-0995</i>	0.7	.
<i>NSL 99-7743</i>	3.0	.

2004-05 field season - Four populations, based on single or 3-way crosses of OSU varieties ‘Tubbs’ and ‘Weatherford’ with ‘Rossini’ or ‘Rossini’ derivatives (Table 2) were planted in the field in fall 2004 with seedstocks that were F3-derived F5 lines with white seed. 236 lines were included in the 2004-05 field evaluation, with two replications per line. Plots were planted into stubble mulch in Pendleton, OR using an early seeding date (September 10, 2004). Though the field was previously used for *Cephalosporium* studies, we also inoculated to ensure high and uniform disease levels. This was done by adding *Cephalosporium*-infested oat kernels to each

seed packet at a rate equal to the weight of wheat seed. Each plot was two rows by 10 ft.

Table 2. Cross populations planted for *Cephalosporium* investigations in fall 2004.

Pedigree	Number of progeny tested
Tubbs//OR951431/(Rossini/Ysatis//Oracle)	67
Tubbs//(Rossini/Ysatis//Oracle)/Weatherford	51
Tubbs//(Rossini/Ysatis//Oracle)/OR9900553	78
(Rossini/Ysatis//Oracle)/Weatherford	40

Near-perfect stands were attained and disease pressure was strong, with whitehead levels as high as 70% (Table 3). Results were consistent with those of 2003-04, when seed quantities were more limited, and showed frequency distributions of the type expected for a quantitative trait (Fig. 1). A large number of progeny were substantially more resistant than 'Madsen', and many had resistance levels equal to or greater than that of the resistance sources (Fig. 1). Frequency distributions differed among the four crosses. The single cross not including 'Tubbs' showed the most resistance, with 50% of progeny showing less than 10% whiteheads (Fig. 1). Five lines with highly favorable agronomic characteristics and resistance greater than Madsen have been entered in multi-location yield trials for 2005-06. Whitehead ratings of these lines in 2005 were 0.75, 2.0, 2.2, 12.2, and 15.0%. Another 15 promising lines from these crosses have been advanced to preliminary yield trials.

In addition to evaluation of the progeny described above, we added several other trials. Evaluation of the Oregon Winter Elite Yield Trial (Fig. 2) for the past two years allowed us to identify two highly promising lines that were already within the OSU Wheat Breeding Program. In 2005, these lines showed only 1.5 and 1.0% whiteheads, while Stephens had 35%. These two lines are now being considered for advance to Breeder's Seed. In the Nickerson Elite Yield Trial, more than 50% of the lines showed less than 10% whiteheads (Fig. 2), indicating a rich source of resistance yet to be utilized. An additional trial of 17 entries included alien sources for high levels of resistance to *Cephalosporium* stripe. We obtained repeatable whitehead ratings between reps that were consistent with the expected reactions of these lines based on genetic background. Though barley is not usually considered to be strongly impacted by *Cephalosporium* stripe, casual observations in the field indicate that this disease may sometimes be more of a problem on barley than we realized. We confirmed results from the previous season by demonstrating differences between two sources of malt quality. One of these sources shows good resistance to *Cephalosporium* stripe (as did the 4 winter feed varieties we evaluated), while the other source was highly susceptible.

Table 3. Trials planted in 2004 and rated for whiteheads caused by *Cephalosporium stripe* in 2005. Whitehead ratings are the average of two assessment dates (June 15 and 22). For segregating populations, bold letters indicate the resistance source for each cross.

Trial or Pedigree	# of entries (including checks)	(% White Heads)
Tubbs//OR951431/(Rossini/Ysatis//Oracle = 920)* = Pop A	77	2.25 – 70.00
Tubbs//(Rossini/Ysatis//Oracle = 924)/Weatherford = Pop B	61	2.50 – 58.80
Tubbs//(Rossini/Ysatis//Oracle = 920)/OR9900553 = Pop C	88	3.30 – 69.00
(Rossini/Ysatis//Oracle = 924)/Weatherford = Pop D	50	0.80 - 40.80
Oregon Winter Elite Yield Trial	40	0.40 – 40.00
Nickerson Elite Yield Trial	40	0.90 – 50.30
Alien Resistance Sources	17	0.25 - 42.50
Advanced Barley Lines	10	5.00 - 82.50

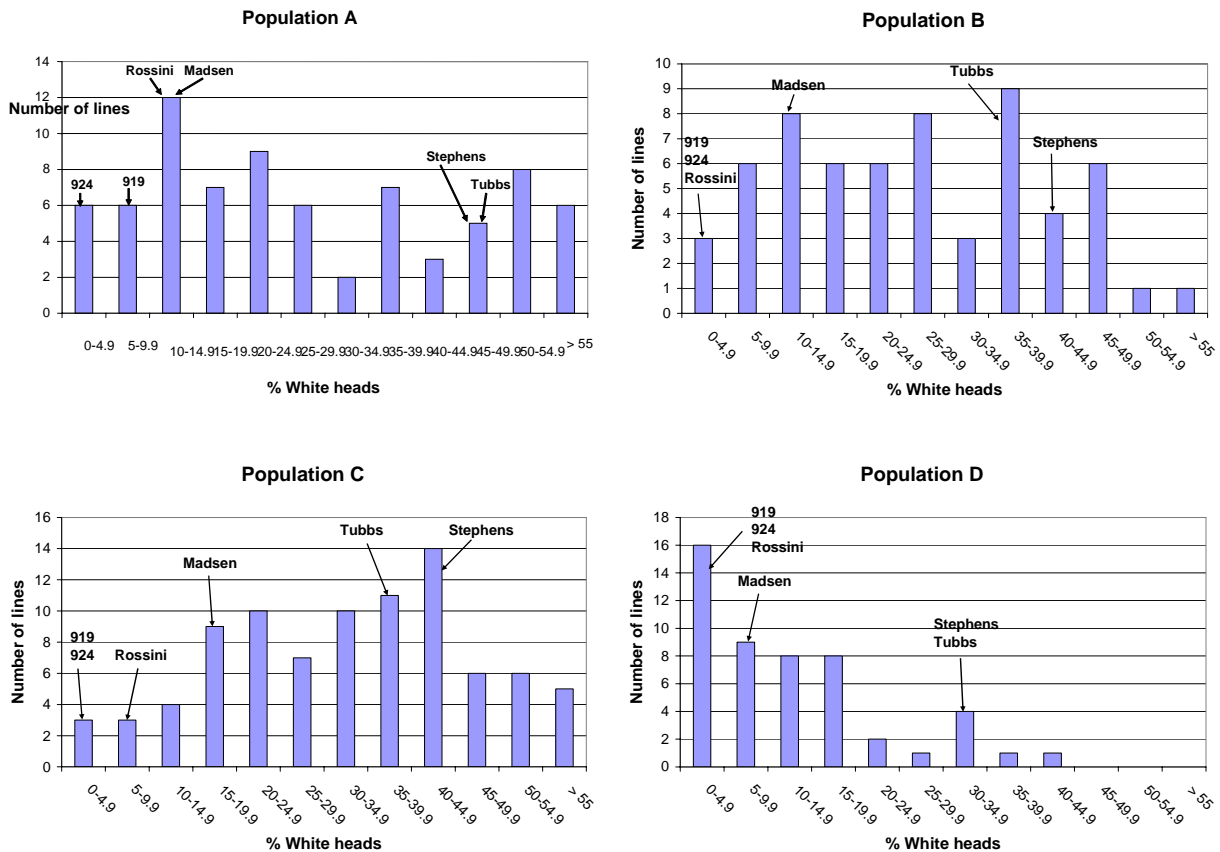


Fig. 1. Frequency distribution of lines for four segregating populations evaluated for % whiteheads caused by *Cephalosporium gramineum* in artificially inoculated field trials, Pendleton 2004.

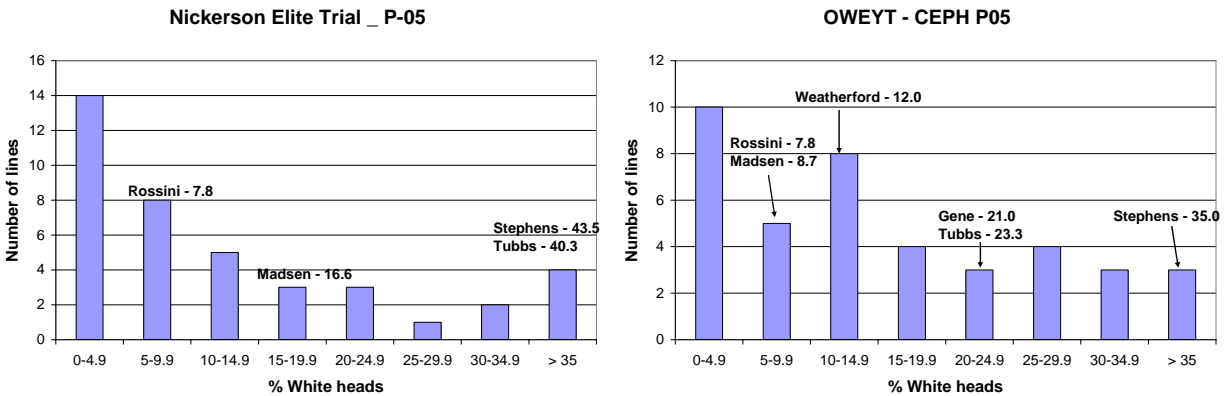


Figure 2. Whitehead ratings of entries and checks in The Nickerson Elite and Oregon Winter Elite Yield Trials in 2005.

Toxin screening - Considerable effort has been devoted to the toxin screening assay. This assay has been less repeatable and has required more time than initially anticipated. In contrast, field studies have been more repeatable and more discriminating than originally expected. We thus are placing more emphasis on field assays, including 7 additional field studies in 2005-06 (Table 4) beyond the Nickerson populations that were originally proposed.

Molecular markers. The USDA-ARS Western Regional Small Grain Genotyping Laboratory in Pullman has kindly agreed to provide markers for parents of the Nickerson A-D populations described above. The goal is to identify SSR and other markers to find polymorphic markers that are most useful for these studying these populations. Parental materials were supplied to this Laboratory last spring, and two-thousand data points have been allocated to the project. Once the markers are available, we will begin intense efforts to study the inheritance of resistance based on QTL analyses, and to identify markers that can be readily used for marker-assisted selection in the breeding program.

2005-06 season - Plots for the third field season were planted into stubble mulch on September 12, 2005 at the Columbia Basin Agricultural Research Center in Pendleton. Each plot is two rows x 10 ft. Eleven different trials were established (Table 4). In addition to the four Nickerson populations originally proposed for study, we have added seven additional trials that have potential to help evaluate germplasm with increased resistance to *Cephalosporium* stripe. The yield loss trial includes wheat genotypes with a large range of resistance, and will help us determine the level of resistance required to avoid significant yield loss to this disease. Also new for 2005-2006 are screening nurseries for the USDA-ARS winter wheat Breeding Program in Pullman and the Idaho Winter Wheat Breeding Program. In total, the 2005-06 trials include over 1400 plots.

Table 4. Trials planted in fall 2005 for *Cephalosporium* stripe investigations.

Trial	Number of entries (including checks)	Number of replications
Tubbs//OR951431/(Rossini/Ysatis//Oracle) = Pop A	77	3
Tubbs//(Rossini/Ysatis//Oracle)/Weatherford = Pop B	61	3
Tubbs//(Rossini/Ysatis//Oracle)/OR9900553 = Pop C	88	3
(Rossini/Ysatis//Oracle)/Weatherford = Pop D	50	3
Oregon Winter Elite Yield Trial	40	3
Nickerson Elite Yield Trial	40	2
Advanced Barley Lines	20	3
Wheat Yield Loss Trial (10 varieties, inoculated and non-inoculated)	20	4
Barley Yield Loss Trial (4 varieties, inoculated and non-inoculated)	8	4
USDA-ARS (Pullman) Wheat Breeding Program	42	4
Idaho Winter Wheat Breeding Program	13	3

INTERACTION (COOPERATION) WITH OTHERS CONDUCTING RELATED ACTIVITIES: Knowledge and germplasm is routinely shared with all other wheat breeding programs in the Pacific Northwest. We are currently evaluating material provided by Kim Campbell (USDA-ARS, Pullman) and Bob Zemetra (University of Idaho). Approaches to working with *Cephalosporium gramineum* are shared with Tim Murray at Washington State University. Dick Smiley (OSU, Pendleton) evaluates germplasm for resistance to Fusarium foot and root rot, a disease complex of high importance in conservation tillage systems.

PUBLICATIONS AND PRESENTATIONS:

Dryland Extension/Researcher Post-Harvest Meeting, Pendleton, OR, September 2005. "Update on pathology activities".

Nickerson - PNW Wheat Meeting, Portland, OR, April 2005. "Summary of pathology efforts".

CBARC Pendleton Station Field Day, Pendleton, OR, June 2005. "Cephalosporium stripe tolerance: breeding and genetics".