Research Proposal for the Agricultural Research Foundation
Oregon Wheat Commission

TITLE: Screening for Resistance to Major Wheat Diseases in Oregon

INVESTIGATOR: Chris Mundt, Botany and Plant Pathology, Oregon State University (OSU), Corvallis

COOPERATORS: Jim Peterson, Crop and Soil Science, OSU, Corvallis – wheat breeding
Oscar Riera-Lizarazu, Crop and Soil Science, OSU, Corvallis – marker analysis

FUNDING HISTORY: New request - $40,006 for 2010-2011

ABSTRACT:
A combination of locations, production practices, and inoculation techniques will be used to provide high levels of disease pressure in separate trials of Cephalosporium stripe, Fusarium crown rot, strawbreaker foot rot, Septoria tritici blotch, and stripe rust. Resistance levels of entries in elite and advanced yield trials will be determined to evaluate potential varietal releases and to allow growers to make the best varietal decisions when new varieties are first available to them. Evaluation of disease resistance in two mapping populations with high yield potential and resistance to multiple diseases will contribute to the next generation of disease resistant, higher yielding winter wheat varieties for Oregon growers. Approximately 10,000 plots will be evaluated in the course of the proposed research. The studies are crucial to continued progress in the OSU Wheat Breeding Program, increased profitability for Oregon wheat growers, and ability to adopt conservation tillage practices.

OBJECTIVE: Evaluate elite and advanced wheat lines and mapping populations for resistance to Cephalosporium stripe, Fusarium crown rot, Septoria tritici blotch, strawbreaker foot rot, and stripe rust.

PROCEDURES:
Material to be evaluated. The proposed work will focus on two categories of germplasm:

1) Entries in the 2010 Oregon Winter Wheat Elite Yield Trial (OWEYT). The OWEYT typically contains 40 entries incorporating winter wheat varieties that are currently grown in Oregon, recently released winter wheat varieties, and elite lines most likely to be released from the Oregon, Washington, and Idaho programs within the next few years.

2) Two mapping populations developed via germplasm exchange with Nickerson Seeds, a European plant breeding company. The Nickerson lines have provided very impressive yield potential and a rich source of resistance to several disease of importance in Oregon, including soil-borne diseases for which we have lacked high levels of resistance in the past. The first population is from a cross of Tubbs x Einstein. Einstein was developed and released by Nickerson UK and is a leading variety in the UK market. The second population is Tubbs x NSA98-0995. NSA98-0995 is an elite breeding line from the Nickerson-France breeding program. All three parent varieties are well adapted to the growing environments of the PNW,

but with very different genetic backgrounds. Each population is comprised of 268 randomly derived F5 progeny. Parents and check varieties are repeated within each replication of the populations to provide a total of 300 plots per replication of each population. Extensive molecular marker analyses have already been conducted on these two populations and are continuing. Disease reactions from the field studies described below will be used to develop associations between disease resistance and molecular markers that can be used to increase the speed and efficiency of selection. In addition, trials will identify valuable progeny to be used as parents in crosses.

Evaluating OWEYT will help to provide a direct comparison of established varieties to evaluate potential new releases and to allow growers to make the best varietal decisions when new varieties are first available to them. Evaluation of disease resistance in the two mapping populations will contribute to the next generation of disease resistant, higher yielding winter wheat varieties for Oregon growers.

Cephalosprium stripe, Fusarium crown rot, and strawbreaker foot rot. Trials will include three replications of OWEYT and two replications of the Einstein and 0995 populations at each of two locations for Cephalosporium stripe and Fusarium crown rot and one location for strawbreaker foot rot. Lines will be evaluated in 2-row x 10 ft. plots established with an H&N plot drill fitted with dual seed cones and hoe openers on a 14" spacing. The procedures described below have proven to be very reliable for both Cephalosporium stripe and strawbreaker foot rot over several years. We established dedicated Fusarium crown rot trials in growers' fields for the first time in fall 2009 and will adjust the procedures described below, if necessary, based on experience gained from the 2009-10 season.

Cephalosporium stripe – Plots will be planted at the Columbia Basin Agricultural Research Center stations in both Pendleton and Moro as Cephalosporium reactions of wheat lines do vary somewhat by location. Early seeding is crucial to attain sufficient Cephalosporium pressure for optimum resistance screening. The Pendleton site provides sufficient soil moisture for early seeding (~September 10) on a consistent basis. In Moro, irrigation will be used to provide sufficient moisture for early seeding. To inoculate field plots, the pathogen will be grown on autoclaved oat kernels that will be dried and added to the wheat seed envelopes at a rate equal to the volume of wheat seed.

Percent whiteheads, a good indicator of yield loss, will be rated for each plot at a time when there is sufficient expression on later maturing lines, but before earlier lines are completely ripe (usually late June). Plots will be treated with fungicide to avoid infection by strawbreaker foot rot, which can also cause whitehead symptoms. Though Fusarium crown rot could be present in Moro, it is likely that artificial inoculation with Cephalsoporium stripe will dominate over Fusarium crown rot. At both locations, control varieties with known reaction to Cephalosporium stripe will be examined carefully to ensure that whiteheads are caused primarily by Cephalosorium stripe.

At Pendleton, we will continue our tradition of responding to requests for testing additional lines in support of the overall cereal breeding efforts in the PNW. This often includes entries from the Washington State University and University of Idaho wheat breeding programs, the OSU Barley

Breeding Program, as well as hard white and hard red wheat lines from the OSU Wheat Breeding Program. The numbers of entries and replications vary among years, but typically require approximately 200-300 additional plots.

Fusarium crown rot – Plots will be planted in two commercial fields with a history of severe Fusarium crown rot. The fields will be located at least 50 miles apart in the region where Fusarium crown rot has traditionally been a problem commercially (Wasco, Sherman, Gilliam, and Morrow counties) and will rely entirely on naturally occurring inoculum in an attempt to represent the diversity of *Fusarium* species and genotypes present in commercial fields. Plots will be seeded as early in the fall as moisture conditions allow. Sites will be chosen such that Fusarium crown rot is likely to be the dominant disease causing whiteheads, and plants will be examined carefully to ensure that whiteheads are caused primarily by this disease. Data from these trials will complement information provided by Dick Smiley based on controlled inoculations, which has been highly useful but can only be used to evaluate a limited number of wheat lines and a small number of *Fusarium* species/isolates.

Strawbreaker foot rot – This disease will be evaluated at the OSU Botany and Plant Pathology Farm in Corvallis. We have found rankings for strawbreaker resistance to be highly similar on both sides of the Cascades and conducting trials in Corvallis reduces time and travel expenses considerably. Because cereals are a very minor component of the crop rotation on this farm, we can effectively work with strawbreaker foot rot without interference from other soil-borne pathogens of wheat. Strawbreaker foot rot will be established by spraying a spore suspension of the pathogen to the point of run-off on crowns of plants in all rows of each plot in early-to-mid December.

Plots will be rated for lodging, a good measure of disease severity, in June. Known check varieties and lines of specific interest will be examined to confirm a strong correlation between % lodging and degree of lower stem damage caused by strawbreaker foot rot. If lodging does not approach 100% in the susceptible checks, we instead will use a composite 1-5 score based on lodging, whiteheads, stunting, and foliar senescence.

Septoria tritici blotch. Notes will be taken on Septoria tritici blotch (STB) severity in three replications of the OWEYT, which will be available as part of the statewide wheat yield trial program. These plots will be planted in standard yield trial plots (5 x 20 ft.) in a randomized complete block design with three replications at both the Hyslop Farm near Corvallis and at a second site in the northern part of the Willamette Valley. STB severity also will be recorded in two replications of the Einstein and 0995 populations established in 5 x 20 ft. plots at the Hyslop Farm. High and uniform levels of STB typically occur throughout the Willamette Valley each year. Thus, artificial inoculations will be unnecessary. STB will be quantified by examining plots in June and estimating the percentage of total leaf area covered by lesions on a whole canopy basis.

Stripe rust. Responses of wheat lines to stripe rust are obtained from multiple sites in the PNW when natural infections occur. However, there can be runs of years in which natural infection is insufficient for adequate screening. Artificial inoculations thus will be conducted to obtain more consistent results on this important disease. Evaluations will focus on varieties and germplasm

in the crossing block at Hyslop, which includes essentially all advanced OSU lines and regional and international germplasm currently being used as parents in the breeding program. The crossing block consists of 2-row x 6 ft. plots, with one replication planted in October and a second in November so as to stagger flowering times for crosses to be made the following spring. Single rows containing a mixture of lines known to be highly susceptible to wheat stripe rust are typically planted at 30-40 ft. intervals throughout the crossing block to "trap" naturally occurring inoculum and spread disease to the plots. We propose to artificially inoculate these spreader rows with a stripe rust race of broad virulence that has been common in both the Willamette Valley and eastern Oregon in recent years so as to increase disease pressure. Spores will be increased on live plants in growth chambers and stored in liquid nitrogen to maintain viability. In March, 1-2 ft. sections of the spreader rows will be sprayed with water, spores applied, and covered with plastic over night to maintain moisture required for infection. Inoculated sections will be approximately 40 ft. apart along the spreader rows. In June, stripe rust severity will be quantified by estimating the percentage of total leaf area covered by lesions on a whole canopy basis. The Einstein and 0995 populations will be planted at several locations throughout Oregon for other purposes, and stripe rust severity will be collected at any location in which stripe rust occurs naturally.

TIMELINES:
Prepare seeds for planting – August/September 2010
Plant plots – September/October 2010
Maintenance of pathogen cultures – continuous
Prepare inocula for artificial inoculations – Cephalosporium stripe (July/August 2010), strawbreaker foot rot (November/December 2010), stripe rust (October 2009-March 2011)
Artificial inoculations – Cephalosporium stripe (September 2010), strawbreaker foot rot (December 2010), stripe rust (March 2011)
Disease readings – June 2011
Data analyses – June-August 2011
Final report – November 2011

JUSTIFICATION: Varietal resistance is the most effective and economical method to reduce losses caused by the many diseases that impact wheat productivity in Oregon. In addition, resistant wheat varieties are required to adopt conservation practices that reduce soil erosion, as these practices often increase the severity of wheat diseases. Obtaining accurate evaluations of the resistance of wheat lines on a yearly basis is thus crucial to breeding progress and to ensure that growers are provided with an adequate evaluation of resistance levels against multiple diseases at the time of variety release.

Though many diseases impact wheat production in Oregon, several currently deserve particular attention. Increased levels of resistance to Cephalosporium stripe and Fusarium crown rot are required to reduce chronic losses being experienced by growers in eastern Oregon. Septoria tritici blotch is currently the most important disease of wheat in the Willamette Valley, the highly variable pathogen is constantly adapting to resistance in commercial varieties, and severity of the disease is very likely to increase owing to expanded wheat acreage in the Valley. Approximately 2 million acres of wheat in the PNW would require fungicide application annually to control strawbreaker foot rot in absence of genetic resistance. At present, PNW breeders rely almost

entirely on a single source of resistance to strawbreaker foot rot (the 'VPM' gene), and new sources of resistance are required to protect against potential adaptation of the pathogen to this resistance. Stripe rust continues to be potentially the most important wheat disease because of favorable weather conditions in the PNW and the high reproductive capacity and variability of the pathogen. Though controlled effectively for decades by high temperature adult plant resistance, increasing virulence of new races are of great concern. With the exception of strawbreaker foot rot, resistance being used to control the above mentioned diseases is quantitative in nature, i.e., there are multiple genes involved and levels of resistance can vary continuously from very high to very low. Quantitative resistance usually is very stable over time. To effectively breed for such resistance, however, requires diligent efforts to obtain accurate and repeatable disease ratings in the field. Mapping of molecular markers associated with resistance to disease can increase both the speed and accuracy of selection, but field ratings still are required both for initial discovery of appropriate markers and to confirm resistance levels before new lines are released as varieties.

Collaborations between the OSU Wheat Breeding and Cereal Pathology Programs have greatly increased as we attempt to take full advantage of our resources and opportunities to make progress in disease resistance. Among the many positive outputs from this collaboration have been early identification of the variety Skiles in Cephalosporium stripe trials, confirmation of moderate resistance to Septoria tritici blotch in the variety Goetze, clarification of resistance levels to strawbreaker foot rot in new wheat releases, and preliminary identification of molecular markers for resistance to several diseases. Funding sources for the Cereal Pathology have been either eliminated (USDA STEEP program) or reduced through state budget cuts (Oregon Agricultural Experiment Station funds). We thus are approaching the OWC for consideration of funding these collaborative efforts.

BUDGET:

Salary:	
Faculty Research Assistant (0.50 FTE)	$20,160
OPE (53.8%)	10,846
Travel:	
In-State Domestic	4,000
Supplies and Materials:	5,000
Total:	$40,006

RELATION TO OTHER RESEARCH: The proposed trials are crucial to the overall OSU wheat breeding efforts and molecular marker discovery. The work also complements basic research studies of epidemiology and pathogen population genetics in the OSU Cereal Pathology Program.

SIGNATURE PAGE

PROPOSAL TITLE: Screening for Resistance to Major Wheat Diseases in Oregon

SUBMITTED TO: AGRICULTURAL RESEARCH FOUNDATION FOR THE OREGON WHEAT COMMISSION

SUBMITTED BY:

_____ Date: _____
Christopher C. Mundt, Principal Investigator

APPROVED BY:

_____ Date: _____
Lynda M. Ciuffetti, Department Head, Botany and Plant Pathology

_____ Date: _____
College of Agricultural Sciences

_____ Date: _____
Agricultural Research Foundation

CURRENT AND PENDING SUPPORT

NAME	SUPPORTING AGENCY	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITTED	TITLE OF PROJECT
Current: C.C. Mundt	National Science Foundation	519,000	9/15/05 - 9/14/10	15	Collaborative Research: Epidemic Waves, Landscape Heterogeneity, and Spatial Scale - Plant Disease Models
Pending: C.C. Mundt	National Science Foundation	**905,640**	**10/01/10 – 09/30/15**	15	Initial Epidemic Conditions as Primary Determinants of Epidemic Spread: A Plant Disease Model