AGRICULTURAL RESEARCH FOUNDATION
Final Report
Funding Cycle 2013-2015

TITLE: **Soilborne Plant Pathogens in Long-term Experiments and Fields at Pendleton**

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SUMMARY:

Root and crown diseases are common on field crops in the low-rainfall, non-irrigated areas of eastern Oregon, where wheat is the dominant crop. Production efficiency for wheat and other field crops depends upon healthy root systems that are capable of extracting water and nutrients from deep within the soil profile. Some pathogens that reside in soil or in plant residues degrade root hairs and root branches and thereby reduce the plant's efficiency for extracting soil water and nutrients. Other pathogens degrade the crown or lower stem tissue and thereby reduce or prevent transmission of water and nutrients from the root to the shoot. Several of the same pathogens also attack food-legume (pea, lentil and chickpea) and brassica (camelina, canola and mustard) crops that are of importance in the region.

Effects of some pathogens are influenced by crop residue management practices, crop rotations, nitrogen rates, planting dates, and other variables in cropping systems. The research center at Pendleton is the home of the oldest continuous agronomic experiments in the western USA. The trials are briefly described in the Procedure Section, and at http://cbarc.aes.oregonstate.edu/Research_at_Pendleton. These experiments are widely acclaimed at the local, national and international levels for their importance to science and to the practice of agriculture. Research results have been published as book chapters, journal papers, meeting proceedings and presentations at grower field days and at wheat industry educational seminars. USDA-Agricultural Research Service scientists are co-located with OSU scientists at Pendleton and they manage additional long-term trials. Many or most of these trials contain the diversity of fungal and nematode pathogens that are representative of production systems throughout the region.

Molecular methods were recently developed for use in agricultural research. These DNA-based tests make it possible to quickly and accurately determine the identity and quantity of pathogenic fungi and nematodes in soil by extracting all DNA from soil and then conducting highly specific quantitative PCR tests to identify and quantify DNA of pathogens against an immense background of beneficial organisms. The Root Disease Testing Service (RDTS) at the South Australian Research and Development Institute (Adelaide, Australia) began offering a DNA-based commercial service in 1999 to screen fields for the presence of soilborne pathogens (Ophel-Keller et al. 2008. Australasian Plant Pathology 37:243-253). The RDTS has now processed more than 20,000 samples from dryland fields used to produce small grains and other field crops across the Australian continent. Each of their reports include the inoculum density for 15 pathogens plus one pathogen group, each of which are of potential importance to production of wheat, barley, legumes and brassica crops in Oregon. The RDTS tests have also been used for

two studies in the USA, including OSU's long-term experiment at Moro (Smiley et al. 2013. Plant Disease 97:537-546 and 97:547-555). Results of the DNA testing at Moro were astounding. We gained insights into pathogen dynamics that would have never been detected using standard disease diagnostic procedures. For instance, we learned that the two main species of *Fusarium* that attack small grains in our region were being differentially selected by different cropping practices. That finding will guide future breeding efforts to develop resistant wheat varieties. We also found that DNA of *Rhizoctonia* and *Pythium* species were relatively uniform across all cropping practices, meaning that crop management is unlikely to be very productive as we search for ways to control those diseases. We discovered that a previously unsuspected pathogen is involved in the root rot complex of winter pea. We also learned that winter wheat and spring wheat were selecting for greater prevalence of different species of the root-lesion nematode. We had no idea that was happening. Since each wheat variety has a different level of resistance to these nematode species, and it varies with each variety, it is important to know which species is most important in individual fields.

This grant provided funding to examine DNA extractions for the identities and quantities of pathogenic fungi and nematodes in long-term experiments at Pendleton. We sampled 85 plots in the long-term experiments and 20 other experimental fields at the Columbia Basin Agricultural Experiment Station. Funding from the ARF led our colleagues in the USDA-ARS, at Pendleton, to join into and thereby expand this effort by sampling 31 additional treatments from their long-term experiments. The USDA paid for their proportional component of the expense for the sampling, shipping and DNA testing.

OBJECTIVES:

1. Collect and process soils to identify and quantify key plant pathogen species in experiments and fields at the Columbia Basin Agricultural Research Center.
2. Examine relationships between pathogen density and soil physical, soil chemical, and soil microbial properties monitored at 5- to 10-year intervals in these long-term experiments.

PROCEDURES:

Eighty five samples were evaluated from six long-term experiments.

1. Crop residue management; since 1931. (24 samples) A winter wheat-summer fallow rotation with 5 N variables (inorganic, pea vine, or manure) and burning or not burning stubble. There are 9 treatments, 2 replicates, and 2 phases (wheat is planted on alternate blocks every year). We sampled each end of 6 treatments in both reps to make 4 'reps'.
2. Winter wheat-spring pea rotation; since 1963. (12 samples) There are 4 tillage variables and 8 replicates, with 4 reps planted to wheat and 4 to pea each year. We sampled 2 contrasting tillage systems for 3 reps of each crop.
3. Tillage-Fertility; since 1940. (27 samples) This is a winter wheat-summer fallow rotation with 3 tillage and 6 N variables, with 3 reps. Wheat is harvested every other year, and was 'in-crop' when sampled during 2013. We sampled 3 N rates in each tillage and rep.
4. Continuous cereals with conventional tillage; since 1931. (9 samples) Winter wheat was planted annually from 1931 to 1982 and then split into spring barley, spring wheat and winter wheat. We sampled 3 'reps' within the 3 plots.
5. Continuous cereals without tillage; since 1997. (11 samples) Annual spring barley, spring wheat and winter wheat are planted with 2 N rates and 2 types of grain drill. We sampled 3

'reps' from one grain drill 'treatment' and one N rate within each crop. Additionally, a small portion of the annual winter wheat with conventional tillage experiment (#4 above) was split off and maintained without tillage since 1998. Two samples were collected from this no-till annual winter wheat experiment to compare results with the no-till winter wheat experiment initiated during 1997.

6. Perennial grassland; since 1931. (2 samples) This pasture is a proxy for native grassland.

Fifty one samples were evaluated from shorter-term experiments.

1. Three-year rotations; since 2004. (12 samples) Rotations of winter wheat, spring barley and fallow are maintained either with or without tillage. There are 2 reps of each rotational phase. We sampled each rep of each phase in the no-till and in the conventional tillage trials.
2. Organic agricultural systems, since 2005. (4 samples) Samples were collected from a 192-plot experiment managed under certification standards for organic agriculture. We chose samples to contrast the 'organic cover crop' with the 'organic intercrop'. Sampling followed the spring wheat phase of the sequences, and for this study, our samples were composites of replicate plots that included mixtures of clovers and medics.
3. Inoculum depth in no-till experiments. (4 samples) Samples from two no-till experiments were collected to evaluate the distribution of inoculum density at depths 0 to 6 inches and 6 to 12 inches.
4. Two-year no-till sequences, since 1982. (16 samples) A factorial experiment with a 2-year rotation of winter wheat and spring wheat, with 5 N and 2 residue management levels, was initiated by the USDA-ARS in 1982. Since 1982 the trial area has been altered to include various other crop sequences and seeding date variables. A parallel sequence of experimental variables was established in 1997 to evaluate wheat responses and changes in soil properties during the first several years after initiating a no-till system, compared to the established 15-year no-till experiment. In 2010 the fallow phase of the sequence was replaced by Austrian winter peas.
5. Fallow tillage systems. (15 samples) Many fields are maintained as a winter wheat-summer fallow rotation using either no tillage (chemical fallow) or conventional tillage. We sampled USDA-ARS experiments to compare these tillage systems at multiple sites.

SIGNIFICANT ACCOMPLISHMENTS:

Soil samples were collected from 136 plots in experiments and small fields during mid-March 2013. Each sample consisted of a composite of 20 soil cores (1-in. diameter × 12-in. deep) from an individual plots or small fields. Most samples were from OSU's Columbia Basin Agricultural Research Center (CBARC; 105 samples) and the USDA-ARS's Columbia Plateau Conservation Research Center (CPCRC; 31 samples). DNA extracted from the soil samples was evaluated at an Australian laboratory to quantify the inoculum density of 15 potential pathogens. Fungal inoculum concentration in picograms DNA/g of soil was reported for *Bipolaris sorokiniana, Fusarium culmorum, Fusarium pseudograminearum, Gaeumannomyces graminis* var. *avenae, Gaeumannomyces graminis* var. *tritici, Phoma koolunga, Phoma medicaginis* var. *pinodella,* Clade F (a group) of *Pythium* species, and *Rhizoctonia solani* AG-8. Two tests were performed to differentiate between two clusters (haplotypes) of *Fusarium pseudograminearum* that are known to occur in Australia. For nematodes, DNA concentrations were converted to nematodes/g of soil based on standard curves for the following five species; *Ditylenchus dipsaci, Heterodera avenae, Pratylenchus neglectus, Pratylenchus thornei* and *Pratylenchus teres*.

Ten of 15 of these potential pathogen species were detected in the soil samples we submitted to the Australian laboratory. Two well-known pathogens known to be involved in the Fusarium crown rot complex in the PNW were detected. Inoculum of *Fusarium pseudograminearum* was generally higher following winter wheat than after spring wheat and the opposite occurred for *F. culmorum*. The apparent selection of different Fusarium species by different wheat varieties or wheat growth habits provided support for our earlier finding, in 2012, that this was apparently also occurring in the long-term experiments at Moro. There is an urgent need to gain a better understanding of this phenomenon because genetic resistances that are being developed in winter wheat are specific and not necessarily equally applicable to each of these *Fusarium* species.

Inoculum of the root-lesion nematode *Pratylenchus neglectus* was also higher after winter wheat than after spring wheat and the opposite occurred for the species *P. thornei*. Again, this supports a finding from testing conducted in the long-term experiments at Moro during 2012. We also reported that these species of root-lesion nematodes could be shifted in species dominance over just a few years of change from using winter wheat to spring wheat or spring barley. As with the Fusarium crown rot pathogens, there is an urgent need to gain a better understanding of this phenomenon because genetic resistances that are being developed in wheat are specific to each of these nematode species. The need for dual-species resistance will be required to address the highly variable cropping systems being used by wheat producers in eastern Oregon.

As we found at Moro in 2012, the legume pathogen *Phoma medicaginis* var. *pinodella* was mostly restricted to treatments that included a pulse crop. We didn't even know that this pathogen was occurring in low-rainfall environments of the PNW until it was detected by the DNA-based tests at Moro during 2012. The occurrence and potential importance of this additional pathogen's involvement in the legume root rot complex in low rainfall environments will require additional examination, particularly in view of progress being made in overseas pulse crop breeding programs to introduce genetic resistance to this pathogen.

Inoculum of *Pythium* spp. (Clade F) was very common and often also at a high density in the various cropping systems we examined. We also found that detection of DNA of *Rhizoctonia solani* AG-8 and *Gaeumannomyces graminis* var. *tritici* were often contrary to that which we anticipated from observations of disease symptoms in these experiments. Testing during a second season will be required to determine if that observation may have been skewed by local weather conditions prior to the sampling of these experiments during 2013.

DNA of the root rot pathogen *Bipolaris sorokiniana* was detected in a few spring grain cropping systems, confirming earlier findings during surveys of crown rot and root rot pathogens of small grains in the PNW. It can be expected that any change to a greater frequency of spring cereals in what is currently a predominantly winter wheat producing regions could lead to an increasing importance of this pathogen in our region, just as is the case in other spring cereals producing regions of North America and overseas.

This survey of multiple pathogens in multiple cropping systems provided guidance for future investigations. We submitted a manuscript for publication in the journal *Plant Disease* but our paper was rejected mostly because we had not repeated the sampling over time. The survey is therefore being repeated to provide greater confidence in the results and to determine if seasonal variability in weather may have created any anomalies in pathogen dynamics during 2013. Our samplings during March 2015 will be taken mostly from the same experiments and treatments that were sampled during 2013. Funding for the repeated survey during 2015 is being derived from a USDA-ARS specific cooperative agreement for OSU research on pathogens and pathogen dynamics in wheat and barley.

BENEFITS & IMPACTS:

1. Reset the base of knowledge needed to refocus research objectives into the future.
2. Compare results of long-term experiments at Pendleton with those already available at Moro (17 vs. 11 inch precipitation) and in that way evaluate similarities or contrasts in pathogen dynamics across the region.
3. Establish a knowledge base that can be used to justify proposals for Federal competitive grants in the future.
4. Communicate results to growers and their advisors during field days and educational forums.
3. Communicate results to the statewide, regional, national and global scientific communities.

ADDITIONAL FUNDING RECEIVED: A USDA-ARS specific cooperative agreement for OSU research on soilborne pathogens affecting wheat and barley production in the PNW; $90,000 for the fiscal year 2014-2015 fiscal.

FUTURE FUNDING: None has been identified or requested as of this time.