Integrated Management Of Wheat Diseases

Principle Investigator:

Jeffrey Stein, Assistant Professor, Small Grains Pathology, SDSU, Brookings

Collaborators:

Lawrence Osborne, Assistant Professor, Extension Plant Pathologist, SDSU, Brookings
Karl Glover, Spring Wheat Breeder, Plant Science Dept., SDSU, Brookings
Bill Berzonsky, Winter Wheat Breeder , Plant Science Dept., SDSU, Brookings
Dennis Todey, SDSU Climatologist

Progress Report for FY08

Develop a Wheat Disease Management System for South Dakota:

Weather-driven disease modeling. In 2007, we continued our multi-state collaborative studies on the epidemiology and modeling of Fusarium Head Blight (FHB) in wheat. The effort is partially supported by the U.S. Wheat and Barley Scab Initiative (USWBSI) and has resulted in the development of a web-based risk advisory tool that provides coverage for 24 states, including South Dakota. The data generated by our efforts was integral in the refinement and implementation of a third-generation spring wheat model that has a higher level of accuracy than those previously available.

Greenhouse and field studies have confirmed our previous hypothesis that there is a strong relationship between the quantity of spores present on a wheat head during the week of flowering and the resulting disease severity, and more importantly, the final concentration of deoxynivalenol (DON, a.k.a. vomitoxin) in the grain. This is an extremely important discovery because one of our collaborators in the aforementioned FHB forecasting effort developed an algorithm that estimates the number of Fusarium propagules (spores) on a wheat head based on historical weather data. The combination of our results and this algorithm has the potential to greatly advance the development of a mycotoxin-forecasting model for FHB.

In January of 2008, Vivek Gupta began working on his Ph.D. in the program and is developing integrated management strategies for wheat stem rust. Specifically, he is working on infection risk forecast models that could be deployed in the event that a highly virulent race of stem rust (such as Ug99) were to become established in the region. This project is partially funded by a USDA-CSREES ‘seed’ grant.

Varietal susceptibility screening. See objective below.

Fungicide efficacy and deployment of the system. Progress for these sub-objectives has been minimal; although my hope is that these efforts will accelerate now that Dr. Larry Osborne has begun serving as the Extension Plant Pathologist. It should also be noted that part of Gupta’s project is to determine the effectiveness and optimal application methodology for modern fungicides in order to control stem rust of wheat. There is a large void of information in this topic area and we need to understand how stem rust can be managed in an emergency situation.

Germplasm development and varietal screening:

During 2007, members of the Small Grains Pathology (SGP) program assisted both the spring and winter wheat breeding programs with the assessment of disease susceptibility at multiple locations in the state. We also supported the efforts of these programs to screen germplasm in the greenhouse (e.g. stem rust on winter wheat). The multi-disease germplasm evaluation effort noted last year is continuing and we now have a set of leaf rust isolates that can screen for the presence of ~20 key leaf rust resistance genes.

Significant advances have occurred in the project relative to germplasm improvement effort. First, we obtained a series of wheat lines that are novel sources of resistance to FHB. This material is different than the Sumai3-based resistance that is now common in the spring wheat and winter wheat germplasm at SDSU. One of these lines, MULT757, is currently being used in the resistance mapping/germplasm improvement project that Jose Gonzalez is undertaking with Karl Glover and me as collaborators. Our program has also been crossing the remainder of the resistance sources with elite spring wheat, and soon winter wheat, germplasm in order to introduce additional sources of resistance in those programs.

Fungal diseases continue to be a limiting factor for wheat production in South Dakota as well as throughout the region. Significant diseases include scab, the rusts, the leaf spot complex, and the root rot complex. Many of these diseases occur annually in South Dakota, although severity varies by location and year. Of note is Fusarium head blight, which caused an estimated $34 million in crop losses for 2005 alone.

Our research objectives include two main collaborative efforts that represent multi-year projects. We propose to:
1) develop a wheat disease management system for SD (expanded collaboration that includes SDSU Extension Plant Pathologist, L. Osborne, and Climatologist, (D. Todey) and
2) continue germplasm development and varietal screening (collaborations with the SDSU wheat breeders, K. Glover and B Berzonsky).

Proposed Projects

Develop a Wheat Disease Management System for South Dakota:

Objective – To produce a wheat disease risk prediction system that utilizes a combination of weather data (historical and forecasted), known level of varietal resistance, and fungicide efficacy information to provide real-time, site-specific disease risk information and management recommendations.

Justification – The wheat crop in South Dakota is complex because multiple classes (winter and spring) are grown over a range of ecological zones and different cropping practices. This results in different diseases being prevalent in each region. For example, FHB is usually most important in the spring wheat crop grown in the relatively wet northeastern region of the state whereas common root rot is usually most important in winter wheat crop grown under drier conditions in the west. Breeding for resistance to multiple diseases while maintaining a high yield potential is difficult and active disease management with fungicides is often practiced. By combining weather-based disease risk models, level of varietal resistance to a specific disease, and optimal fungicide recommendations one could potentially reduce the need for unnecessary applications while maintaining high yield and quality.

Materials and Methods:

i) *Weather-driven disease modeling*: Most fungal diseases are highly dependent on weather and mathematical models can be created that explain this dependence. For example, we have been involved with a project that is attempting to model FHB in spring wheat. Essentially, FHB can be predicted to have highest disease severity when the temperature is between 20-30oC (68-86oF) and the average relative humidity is >70% during heading. Many of the other major diseases of wheat (e.g. leaf rust) have been modeled elsewhere and we propose to evaluate the ability of these models to predict disease risk using local pathogen isolates on the spring and winter wheat varieties grown in South Dakota. Models will initially be examined through inoculations of select varieties with a mixed-isolate inoculum under controlled conditions (growth chamber and greenhouse) and later in the field. Modifications of existing models or the development of novel ones will be performed as necessary.

ii) *Varietal susceptibility screening*: Understanding the susceptibility of a wheat variety to a specific pathogen can impact management recommendations. For example, certain varieties are extremely susceptible to tan spot and planting such varieties into wheat stubble will greatly increase the risk of yield-reducing tan spot infections. We will evaluate the common spring and winter wheat varieties for susceptibility to FHB, tan spot, Septoria and Stagonospora leaf spots, and common leaf and stripe rust races. Advanced breeding lines will also be included in the screenings. Varieties will be evaluated using South Dakota pathogen isolates and initially tested under controlled conditions (greenhouse). Data collected from breeder's nurseries and Crop Performance Testing locations will also be utilized.

iii) *Fungicide efficacy:* Fungicide efficacy trials have been conducted under the direction of Marty Draper for several years. This data includes different application timings, fungicide actives, and often multiple varieties. This data will be mined to determine optimal management strategies for the various diseases. Eventually, inoculated trials will be conducted in the field for more specific examinations and model validation.

iv) *Deployment of the system*: We have been working with Dennis Todey, SDSU Climatologist, to develop a gridded data weather system for South Dakota. The goal of this system is to combine data from ground weather stations (SDSU, airport, etc) with advanced NWS models in order to cover the entire state. This project is in its infancy but shows good potential and additional funding is being sought elsewhere. Once this system is established, we will be able to develop a web-based interface where a producer can log in, provide some basic information on the crop of interest (variety, crop stage, etc), and be given a relative disease risk for a variety of wheat pathogens. Information on the potential for yield losses and fungicide recommendations will also be made available.

Germplasm development and varietal screening

Objective – We plan to screen released varieties, advanced breeding material, germplasm, and other sources for multiple disease resistance. Participate in the generation of adapted germplasm with novel sources of resistance that can be used by the SDSU wheat breeders in their varietal improvement efforts.

Justification – Breeding for resistance or tolerance to plant pathogens is one of the most effective ways to reduce crop losses due to disease. However, this can be a difficult process as incorporation of resistance to one disease (e.g. scab) may introduce susceptibility to another (e.g. tan spot), agronomic characteristics notwithstanding. Additionally, varieties that do have resistance to a specific disease can become susceptible following the adaptation and/or migration of a virulent race or strain of a pathogen. Thus, the process of identifying and introducing new sources of disease resistance into crops is an active one and breeders and plant pathologists must remain vigilant.

Materials and Methods – Spring and winter wheat nurseries will be visited on a regular basis during the growing season. The disease severity for the pathogens present on select varieties will be noted and isolates will be collected. Samples of any rust present will be sent to the USDA-ARS Cereal Disease Laboratory (St. Paul, MN) for race typing. Greenhouse studies examining specific diseases will be conducted as previously described. In addition, we will also perform crosses in an attempt to introduce additional disease resistance into regionally adapted lines that can then be used by the SDSU wheat breeders in varietal development.