Black Stem Rust (BSR) Technical Meeting, May 20-21st, 2009, Riverdale, MD

Executive Summary: APHIS, EDP (Emergency and Domestic programs) and CPHST (Center for Plant Health Science and Technology) organized a technical meeting in Riverdale, Maryland to discuss the history and the current status of the Black Stem Rust program at APHIS and also the potential threat posed by Ug99, a highly virulent stem rust strain currently not present in the western hemisphere. Topics covered included modeling technology for anticipating and understanding incursions, early detection and mitigation, strategies for adopting currently available technologies to identify resistant cultivars of Barberry species and ways to harmonize BSR regulations between Canada and the United States. Ongoing research on black stem rust disease and barberry were presented during the two day meeting by a team of experts. Representatives from the National Plant Board, American Nursery Landscape Association, Washington State University, Pennsylvania State University, University of Connecticut, South Dakota State University, USAID, and the USDA, Animal and Plant Health Inspection Service (APHIS), Agricultural Research Service (ARS) as well as Cooperative State Research, Education, and Extension Service (CSREES) were in attendance. Most of the participants at the meeting were attending the small grains workshop (NCERA-EWW-SSGW) in Baltimore resulting cost-saving for the BSR Program. In addition to exchange of scientific information, and establishing networks the meeting was useful in aligning activities of several federal entities and universities working on BSR and barberry and several potential collaborative projects are in the offing.

Objectives: The primary purpose of the meeting was mainly to gain alignment among federal entities and universities working on and/or funding black stem rust/barberry research and discuss current status and technical issues such as, barberry resistance screening program at USDA-ARS; methods for identification of barberry varieties, status of research on identifying wheat stem rust pathogen race Ug99; status of early warning system in place/modeling/management of black stem rust disease

Background: There are numerous critical issues that impact the BSR Program at APHIS. These are,

- Methodology for **identification of ornamental barberry** varieties
- Understanding **mechanisms involved in resistance/susceptibility** in barberry and their **durability.**
- Predicting **invasiveness of barberry** species or their hybrids and their role in black **stem rust epidemics**
- Rapid methods for **identification of new races of black stem rust pathogen** and **predicting** their **spread** through **modeling**
- **Management** / Containment of new races of black stem rust pathogen Ug99 and their entry into US.

The summary of the presentations are given below.

Summary of Presentations:

Black Stem Rust and barberry eradication program:
Black stem rust is an important disease of wheat. It has a wide host range including wheat, oats, barley, rye, timothy, wild and grasses and barberry. It is caused by the fungus *Puccinia graminis.* The fungus is heteroecious, alternating from cereal to barberry or *Mahonia.* The common barberry was brought to North America by early settlers as hedge plants, source of dyes and also berries were harvested to make sauces, jellies, wines, and preserves. Thus, the barberry became established in areas where it was a close neighbor to the small grain cereals, and both were moved by farmers as agriculture spread west in the early 1800s. After the disastrous epidemic of 1916, laws against the growing of barberry were passed in the important wheat-producing states and a cooperative federal and state program on barberry eradication was started in these states in 1918. Barberry eradication breaks the rust cycle to prevent local outbreaks of stem rust. The Barberry Eradication program was supplemented in 1919 by the issuance of Federal Quarantine No. 38 to prevent the interstate movement and reestablishment of susceptible barberries. It is estimated that approximately 100 million barberry bushes were eradicated from wheat growing states.

A Federal program established in the early 1930's to test species and cultivars of *Berberis, Mahonia,* and *Mahoberberis* for reaction to *P. graminis* still continues with the support of USDA. At present, black stem resistant cultivars are allowed to be used as ornamentals after a rust screening test at the USDA-ARS, Cereal Disease Laboratory in St. Paul, Minnesota. So far almost 300 cultivars have been screened for rust resistance and a number of these are marketed by the nursery and landscaping industry.
For further information contact: David Long, USDA-ARS, Cereal Disease Laboratory, St. Paul, MN, david.long@ars.usda.gov.

Identification of Barberry Cultivars:
Cultivars of Japanese barberry (*Berberis thunbergii*) are popular ornamental garden shrubs. More than 40 cultivars of barberry with varied leaf color and plant habit are commercially available in the U.S. It can be very difficult to distinguish between cultivars based purely on morphological characteristics. Currently, researchers at the University of Connecticut are using molecular tools (Amplified Fragment Length Polymorphism-AFLP) to distinguish between various species and cultivars and several scientific papers have been published. Certain ornamental varieties introduced in 1878 have become invasive in certain New England states and are also crossing with the remnants of the common barberry present in the wild. The hybrids (*Berberis x ottawensis*) can also be distinguished using AFPL tests. The Canadian Food Inspection Agency (CFIA) routinely conducts molecular tests on barberry varieties imported into the country to ascertain their identity. Those that are found not to match the molecular profile of the 11 approved varieties or those which are identified as *x ottawensis* are rejected.

The current hypothesis is that the rust resistance of x*ottawensis* cultivars may be highly variable from being susceptible to completely resistant to rust. However, resistance in their progeny cannot be predicted. Research is underway at University of Connecticut to screen ornamental barberry plants in the market for their molecular profile and breed for sterile varieties. University of Connecticut also has the largest collection of

ornamental *B. thunbergii* cultivars, an important source of well characterized germplasm for nursery industry. As there is a renewed interest in barberry and its role in black stem rust epidemics the need for better molecular tools to identify various ornamental barberries in support of the nursery industry was highlighted. Morphological methods are not sufficient to distinguish the various cultivars of species of barberry.
For further information contact: Mark Brand, University of Connecticut, Storrs, CT, mark.brand@uconn.edu.

Black Stem Rust Pathogen Ug99 and modeling possible incursions:
Lessons learned from the recent soybean rust incursion into US has allowed the development and establishment of an early warning system. The setting up of Pest Information Platform for Extension and Education (PIPE) platform which combines information technology, dissemination, and Integrated Pest Management (IPM) has provided an excellent tool for monitoring possible incursions of new wheat rust pathogens such as Ug99 and their mitigation. The platform is simple in design, flexible and expandable, empowers extension specialists and enhances communication among stake holders. This provides a "one-stop" rapid access to information in easy-to-use formats. Pennsylvania State University is working with other stake holders through a USDA, NRI Bio-security Program Grant.

New races of WSR are not known to be present in Western Hemisphere and model simulations suggest that they will not likely survive aerial transport across the Atlantic or Pacific Oceans. Tropical western Africa is the most likely source area for aerobiota that are blown to the Western Hemisphere. However as far as we know, wheat/barley production is very low in this region. Integrated Aerobiology Modeling System (IAMS) simulations suggest that it is likely that spores from Mexican wheat production regions would be blown to U.S. wheat fields on a seasonal basis if Ug99 epidemics were present there. The current assessments concludes that if there is an incursion of Ug99 in the Western Hemisphere over the next few years, it would most likely be human mediated. Therefore the possible "human-mediated" incursion scenarios into, the American continent is needed urgently.
For further information contact: Scott Isard, Pennsylvania State University, State College, PA, sai10@psu.edu.

Molecular analysis of *Puccinia graminis*:
Puccinia graminis, the causal agent of stem rust, has a broad host range and has been subdivided into subspecies/varieties based on spore morphology or formae specialis (f.sp.) based on host range. *P. graminis* f.sp. *tritici* (*Pgt*) infects wheat, barley as well as several species of grasses. Strains of *Pgt* are characterized into races based on a standard set of wheat differential lines containing specific stem rust resistance genes (*Sr*). In 1998 a new virulent strain of *Pgt*, commonly referred to as Ug99 (race TTKSK), collected in Uganda, has spread through North East Africa, Arabian Peninsula and recently into Iran. The majority of wheat grown worldwide is susceptible to Ug99 and therefore this new race posses a significant threat to world food security. In last three years two variants of Ug99 have been found in Kenya and characterized as race TTKST (virulence to *Sr*24) and TTTSK (virulence to *Sr*36).

Molecular tools are being developed for the characterization of *P. graminis*. Simple sequence repeat (SSR) markers indicate that Ug99 (TTKSK) and the two variants (TTKST and TTTSK) are genetically very similar and likely represent mutants within an asexual lineage rather than progeny from sexual recombination. *Pgt* genomic resources are currently being used to develop molecular diagnostic assays for rapid identification and detection of Ug99 lineage.

For further information contact: Les J. Szabo, USDA ARS Cereal Disease Laboratory, St. Paul, MN, Les.Szabo@ars.usda.gov

A Case Study of Black Stem Rust in Washington State:

Black Stem Rust in Washington State provides an excellent opportunity for studying a number of aspects of the disease such as presence of susceptible hosts (wheat and barley) planted in a large area, presence of alternate host barberry. Washington State is 6th in U.S. wheat production with 5.4 M ha planted with soft white wheat and almost 75% of which is exported. Overall, weather conditions for BSR are not favorable, but epidemics have occurred, especially during years with cooler temperature in May and higher than average rainfall in June.

Barberry eradication was conducted from 1944-1978 in 21 different counties in the eastern part of the state and almost 194,000 bushes were destroyed from approximately 11,000 properties. However, a recent study (2002-2003) has shown that there are some bushes still present which may be re-growths. Discussions are under way to re-examine some of the older records of eradication.

Researchers at Washington State University are more concerned of the "home-grown" new races of rust developing in the Pacific North west and their possible movement into the great-plains. In an analysis of the rust pathogen in 2007, 17 races of the rust pathogen were discovered in a small area with one race exhibiting virulence to Sr24, an important rust resistance gene in wheat. This indicates the presence of “sexually reproducing” populations of the pathogen, possibly on alternate (barberry) hosts in close proximity to the wheat and barley fields. Pathways of some of the races moving to the central plains were also discussed and a need for developing models for the above pathway was stressed.

For further information contact: Tim Murray, Department of Plant Pathology, Washington State University, Pullman, WA, tim_murray@wsu.edu

Management of Black Stem Rust with Fungicides:

Excellent progress has been made in screening currently registered fungicides for management of rust in test plots planted with rust susceptible cultivar (Baart). The modern products tested significantly reduced symptoms, among which triazoles were best. Type of sprayer nozzles did not significantly affect the control. However, there are concerns (tolerance) on using only one class of fungicides. Currently four states (SD, MT, IN and KS) are participating in screening trials of 12 different fungicides. Examples are, Triazole: Alto, Caramba, Folicur, Proline, Prosaro, and Tilt; Strobilurin: Headline and Gem, and dual mode of action compounds, Quilt, Stratego & Stratego Pro, and Twinline.

For further information contact: Jeff Stein, Plant Science Department, South Dakota State University, SD, Jeff.stein@sdstate.edu