Activity 16

Sustainable Control of Wheat Diseases Through Marker-assisted Pre-breeding and Resistance Gene Discovery

Lead Researcher
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This research activity, led by Colin Hiebert of Agriculture and Agri-Food Canada (AAFC) in Morden, MB., will provide wheat breeders with new tools to diversify and strengthen the genetic resistance of new wheat varieties to important yield limiting diseases in Western Canada.

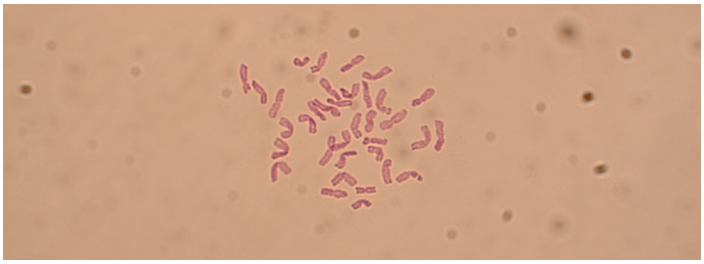
This research builds on prior research funded by a past Canadian Agricultural Partnership (CAP) using previously developed varieties as a foundation for the current research activity. Notably, a new stem rust resistance gene identified in the earlier CAP-funded work will play an important role in this project. Additionally, the research leverages information and experience from past initiatives, including Genome Canada-funded projects that developed new DNA markers.

Farmers in Western Canada continuously require new wheat varieties with updated genetic resistance and high yield. Disease resistance protects yield potential, improves seed and end-use processing quality, and reduces the use of crop protection products thereby slowing the development of pest resistance. This research aims to develop new tools that wheat breeders can use to improve, diversify, and strengthen disease resistance in new wheat varieties. These tools include several new disease resistance genes and DNA markers that allow key disease resistance genes to be selected in breeding populations and during parent selection. To maintain pace with the fast-developing pathogen populations in Western Canada and the threat of new disease strains, the discovery of new and improved genetic resistance ensures that Canadian wheat breeding programs will have valuable and effective resources needed for the challenge.

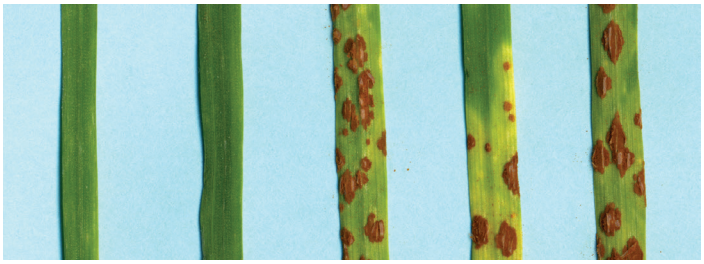
KEY TAKEAWAYS

- **Builds on older research using previously developed varieties as a foundation**
- **This research aims to develop new tools that wheat breeders can use to improve, diversify, and strengthen disease resistance in new wheat varieties**
  - Tools developed include several new disease resistance genes and DNA markers
- **New wheat varieties will be evaluated for their resistance to five diseases including FHB, leaf rust, stripe rust, stem rust, and common bunt**
- **Researchers have identified important genes for leaf, stem, and stripe rust resistance as well common bunt resistance and are developing new lines that will combine this resistance in a modern variety that already has a desired level of FHB resistance**
- **Researchers are working to improve DNA markers for the resistance genes that are based on old technology**
- **Researchers are working to discover new resistance genes**
- **Over 150 wheat lines for leaf stem rust resistance have been tested in field trials**
- **In pre-breeding activity, there has been backcrossing of an elite variety with good FHB resistance using two breeding streams**

Advanced breeding material in wheat breeding programs that are candidates for registration as new varieties are evaluated for five important dis-



A chromosome spread under a microscope of genes being transferred between bread wheat and durum. They are being checked to confirm the chromosome number is correct.



Wheat seedlings that were inoculated with stem rust. The two plants on the left were highly resistant to stem rust while the two plants on the right were susceptible. PHOTOS: COLIN HIEBERT

eases in Western Canada including Fusarium head blight (FHB), leaf rust, stripe rust, stem rust and common bunt. Developing new varieties that have updated and better genetic resistance to these key diseases is an economical and sustainable method of disease control, however, the pathogens that cause these diseases change over time and the genetic resistance of a variety becomes increasingly ineffective. To address this, resistance genes that have yet to be used, and newly discovered ones can be incorporated into wheat breeding programs, but these genes are often found in wheat lines that are not adapted for Western Canada.

These researchers have three objectives in their research. First, they have identified important genes for leaf, stem and stripe rust resistance as well common bunt resistance and are developing new lines that will combine this resistance in a modern variety that already has a desired level of FHB resistance. This will be achieved by backcrossing a combination of genes and selecting the resistance genes in each generation using DNA markers, a test that allows the researchers to track the inheritance of a specific gene. This is important because combinations of resistance genes are often impossible to visually select for by researchers.

The second objective is to improve DNA markers for the resistance genes included in this research that are currently based on old technology. By developing new DNA markers that are better for use in modern breeding programs, they will provide important tools that wheat breeders require to select these important genes in their breeding programs.

The third objective of this research is to discover new resistance genes. These researchers have access to global wheat collections that have been tested for disease resistance and they have selected wheat lines that have high potential to be carrying new resistance. This initiative will allow them to determine if new resistance genes are present and then they can begin to cross these genes into modern wheat varieties.

All three of these objectives address the need for improved and diversified resistance to diseases that can cause yield loss and reduced seed and end-use quality.

To date, this research has tested over 150 wheat lines from several international wheat collections for leaf and stem rust resistance in field trials that were previously selected for their resistance to stripe rust. These field experiments went as planned with optimal testing levels of disease for both rusts. The data generated from these field experiments confirmed parent selection to develop populations for genetic experiments with the goal of finding new resistance genes.

In pre-breeding activity, the researchers are backcrossing an elite variety with good FHB resistance using two breeding streams. In the first stream, they have selected and backcrossed leaf and stripe rust resistance genes and in the second they have selected and backcrossed stem rust and common bunt resistance genes.

During the 2024–25 winter the researchers plan to complete a backcross for each stream and then combine the two streams to select for all the resistance genes. This is being accomplished by using DNA markers to select the targeted genes. The work for DNA marker development will continue while testing these markers on the pre-breeding material. Finally, crosses to create populations for genetic experiments to look for new resistance genes will be completed and the process to generate doubled haploid populations will begin by using the hybrids from these crosses.