Initiative Aids Progress in Development of Barley Varieties with Improved Scab Resistance

By Don Lilleboe*

One of the world's oldest cultivated grains, barley currently is the fourth most important global cereal crop after wheat, rice and corn. Within the United States, 3.0 million acres of barley were harvested in 2013, with more than 215 million bushels produced. The crop is utilized in three primary ways: as malt for the making of beer and other beverages; for human consumption; and for animal feed.

Like wheat, however, barley production faces threats from a myriad of diseases – one of the most important being Fusarium Head Blight (FHB), or scab. Since the early 1990s, scab has inflicted billions of dollars in damages to U.S. wheat and barley crops by causing lower yields and test weights and by triggering formation of a mycotoxin known as DON (short for deoxynivalenol). Above a certain level, DON can make barley unhealthy for direct human or animal consumption and likewise can make it unsuitable for malting and brewing purposes.

That's why barley has been part and parcel of the U.S. Wheat & Barley Scab Initiative (USWBSI) since the group's establishment in the latter 1990s. Through funding support and information exchange venues, the USWBSI provides substantial assistance to barley researchers as they strive to combat scab via the development of cultivars with higher levels of resistance to this disease, as well as improved crop management practices.

While there are, as yet, no barley varieties that can be considered "highly resistant" to scab, progress definitely has been – and is being –

made. In 2010, for instance, the University of Minnesota released a new six-rowed barley variety called "Quest," which is significantly more resistant to scab and DON accumulation, compared to most other Upper Midwest barley varieties.

Kevin Smith, barley breeder for the University of Minnesota, says one of his program's main priorities is to develop and test methods that improve the efficiency of breeding barley with lower DON, high yield and acceptable malting quality. His work is intertwined with research conducted by other scientists in the U.S. Wheat & Barley Scab Initiative, Smith emphasizes. For example:

• He works closely with the laboratory of UM cereal plant pathologist Brian Steffenson to screen for new genetic sources of resistance and conduct genetic mapping studies. "This results in new lines and potentially new genetic marker information that can be used in our breeding program," Smith explains.

• He also develops and shares genetic stocks that are used by UM molecular geneticist Gary Muehlbauer's lab to conduct experiments to illuminate the genetics of resistance and identify important genes.

• Smith collaborates with Richard Horsley, North Dakota State University barley breeder, in field disease and yield screening to identify superior breeding lines and potential new varieties.

• In another North Dakota collaboration, Smith works with Shiaoman Chao, research molecular geneticist with the USDA-Agricultural Research Service in Fargo, to develop and implement marker-based breeding strategies for FHB resistance and lower DON.

The Minnesota barley breeder says that the financial support provided by the U.S. Wheat & Barley Scab Initiative has been integral to the progress

made by his program – and those with which he cooperates – in the development of enhanced scab resistance. "We have invested a lot of resources into FHB/DON breeding because this is an important disease in our region," Smith states. "The large field-based disease screening effort, multiple genetic studies and marker-based selection approaches would not be possible (or only on a very small scale) without the USWBSI."

Gary Muehlbauer says that the Scab Initiative is the source of all his lab's funding for their work on barley and wheat resistance gene identification and resistant-line development. "Our work has already benefited stakeholders through the more-efficient selection of FHB-resistant barley varieties," Muehlbauer points out, adding that those benefits are expected to accumulate significantly as the efficiency increases.

Brian Steffenson explains that controlling scab takes on added importance considering that "even low amounts of mycotoxins can render the grain useless to end users." His lab focuses on enhancing FHB resistance of barley cultivars from "more-distant sources" (i.e., landraces and wild species) outside the regular gene pools. "These sources have more diverse alleles than do advanced breeding lines," Steffenson notes. The lab engages in "pre-breeding" - taking the original sources of resistance and then backcrossing them several times to produce more agronomically advanced lines. Selected lines are then provided to Kevin Smith for his breeding program.

Support provided by the U.S. Wheat & Barley Scab Initiative is "absolutely vital" to his laboratory's work, Steffenson stresses. "The work simply would not be done without the funding," he states.

North Dakota State University breeder Richard Horsley, who develops both six-rowed and two-rowed barley varieties, notes that the NDSU two-

rowed variety “Conlon” actually leads the list of all Upper Midwest barley varieties when it comes to lower accumulation of DON. (Conlon is on the list of American Malting Barley Association-recommended malting barley varieties.)

A key challenge when developing a malting barley variety with improved FHB resistance, Horsley explains, is “making sure that the variety also has agronomics acceptable to the producer and the malt quality acceptable to the maltster.” Much of the resistance used by the NDSU and Minnesota breeding programs originates from Chinese sources of resistance that are unsuitable for this region (e.g., too tall, very weak straw and very late in maturity; also of very poor malting quality). That reality can add several years to the already-long process of developing a new malting barley variety acceptable for release to producers.

While the Upper Midwest traditionally has been a primary source of six-rowed barley for the malting and brewing industries, there now is increased interest in two-rowed varieties for this end use, according to Horsley. He says there are two main reasons: First, two-rowed barley has an advantage in its percent malt extract compared to six-rowed. Second, barley breeders have been very successful in developing new two-rowed varieties and advanced lines with agronomic performance and disease resistance at par with, or better than, six-rowed barley – as well as enzyme levels approaching those of six-rowed varieties. “Two-rowed barley has a much plumper kernel, as well as lower protein and DON accumulation, [compared to] six-rowed barley,” Horsley says. That lowers the likelihood of producers having their barley rejected due to being unable to meet the market specifications for those factors.

The NDSU barley breeding program has been among those benefiting from the U.S. Wheat & Barley Scab Initiative's support, Horsley reports. "Finding the potential variety that has improved FHB resistance – and acceptable agronomic performance and malt quality – is a 'numbers game,' " he observes. "To identify variety candidates, we had to increase the size of our breeding program, which would have been extremely difficult without the USWBSI funding."

USWBSI funding also has been critical to the screening of more than 3,000 samples from Horsley's program for DON content each year. The NDSU malt barley quality laboratory, directed by Dr. Paul Schwarz, conducts those analyses.

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