Small Grains Genotyping Labs Help Breeders Develop & Release Improved Cultivars Faster

By Don Lilleboe*

Ask most people what a "genotyping lab" is and why its work is important, and you'll be rewarded with a blank stare. Ask a wheat or barley breeder the same question, and you'll receive a succinct reply — and one delivered with conviction.

The USDA Agricultural Research Service (ARS) operates four regional small grains genotyping laboratories. Though their work is highly technical, the core mission of these labs, in layman's terms, is to: (1) develop new molecular marker technologies; (2) implement effective strategies for their application in the breeding of small grain crops; (3) provide breeders with access to state-of-the-art molecular technologies; and (4) help maximize the efficiency of small grain breeding programs by speeding up the process of new cultivar release.

Plant breeders, both public and private, annually submit thousands of samples from their research programs to these labs. The labs then employ their sophisticated gene marker technology to analyze the samples for traits of interest and to interpret the generated data. This information, back in the hands of the breeders, is of great value as they focus on incorporating the desired trait(s) into their breeding populations much more quickly than they could have otherwise.

"We provide breeders with marker data in three broad categories," explains Gina Brown-Guedira, director of the Eastern Regional Small Grains Genotyping Laboratory in Raleigh, NC. The first category is the "evaluation of breeding lines and cultivars with marker diagnostics for major genes that confer resistance to disease or affect adaptation and end-use quality." The second is to identify markers for selection in segregating generations to enrich populations for desirable genes. And the third service category, Brown-Guedira relates, is "genome-wide marker analysis for mapping in bi-parental populations, association mapping and genomic selection."

All four ARS small grains genotyping labs serve breeders who are working directly on resistance to Fusarium Head Blight (scab). The North Carolina lab primarily serves breeders in the soft red winter, soft white winter and hard red winter wheat market classes, plus barley and oat breeders. The ARS small grains genotyping lab at Fargo, ND, works with hard red spring, durum and hard red winter wheat breeders, as well as spring barley, primarily from Minnesota and the two Dakotas. The ARS lab in Manhattan, KS, mainly serves the genotyping needs of hard winter wheat breeders from Texas, Oklahoma, Kansas, Colorado, Nebraska, Montana and the Dakotas. The Pullman, WA, lab works with Pacific Northwest breeders, including Idaho and Montana for purposes of Fusarium Head Blight.

Molecular geneticist Shiaoman Chao, who oversees the Fargo lab, says her group on average receives 2,000 samples per year, per breeder, for marker genotyping. About 30% of their research and service work pertains directly to Fusarium Head Blight (FHB). (That percentage is similar for the Raleigh lab; at Manhattan, it's closer to 50%.) "In wheat, generally we genotype the breeding lines using the markers that are known to be associated with disease resistance," Chao says. "Depending on the breeding program, the number of markers used [ranges] from three associated with a specific resistance source, to seven targeting multiple resistance sources." For barley, to date, "the genotyping has been done by using a selected set of 400 markers covering the entire genome, including the regions important for FHB and DON." Next-generation sequencing methods are being introduced for barley, and Chao expects their use to soon be employed for wheat as well.

Guihua Bai, director of the USDA Central Small Grain Genotyping Center at Manhattan, points out that in concert with their core mission, the ARS labs also conduct collaborative research projects with breeders and geneticists to identify QTL* for important traits, including FHB resistance; develop markers for the QTL; and transfer the QTL to locally adapted breeding lines using marker-assisted backcross and double-haploid technology to quickly improve wheat (or barley) resistance to FHB and other traits. They additionally train students and technical

personnel from various institutes and breeding programs in high-throughput genotyping.

*(*QTL stands for "quantitative trait loci." QTL are stretches of DNA that are linked to, or contain, the genes that underlie a particular quantitative trait, such as FHB resistance.)*

With demand for their services continually expanding — and with ARS operating budgets under increased pressure — the genotyping labs rely strongly upon support from stakeholder entities like the U.S. Wheat and Barley Scab Initiative (USWBSI). "Support of the USWBSI was key to the establishment of the regional genotyping labs," Brown-Guedira affirms. "Ongoing support has allowed our lab to provide genotyping data for large multi-institutional projects, integrating MAS (marker-assisted selection) for FHB resistance with doubled-haploid (DH) production."

In North Dakota, "we have been using funds from the Initiative to develop and optimize lab protocols to generate genotype data, and to carry out pilot studies in assisting breeders using the marker data for their programs," Chao reports. "USWBSI backing likewise helps the genotyping labs to support the students and/or post-doctoral personnel who comprise an integral part of their workforce," Bai adds.

Their work is highly technical and specialized. It's cutting-edge technology immersed within the complex world of DNA, chromosomes, genetic mapping and sequencing — a world that's basic to plant and animal life, but simultaneously one that's foreign to most laymen. But the core reason for these small grains genotyping labs' existence — and the motivation behind all their endeavors — is pretty straightforward: It's all about helping breeders find and utilize important traits — like stronger resistance to Fusarium Head Blight — more quickly than they could strictly through phenotypic evaluations. The ultimate result is the faster development and release of improved cultivars to the farmer.

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