Washington Grain Commission
Barley Research Report

Project #: 3019-3200

Progress Report Year: 2 of 3

Title: Improving Spring and Winter Barley Varieties for Malt, Feed and Food

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Cooperators: Clark Neely, Max Wood

Executive Summary: During the second year of this grant excellent progress was made towards improving WSU barley varieties for malt quality. The Washington Grains Commission (WGC) funds were integral in transitioning the WSU breeding program into a spring and winter malt barley breeding program. With the infrastructure now in place for malt quality analysis the bar is set to develop both spring and winter adjunct, all malt and distilling barley varieties with consistent quality and agronomics to make the American Malting Barley Association (AMBA) recommended list.

We are currently malting and analyzing elite 2022 field season material from both the spring and winter yield trials. The spring lines are being prioritized by high yielding experimental lines derived from elite-by-elite malt barley parental crosses. The winter material is being prioritized by yield, malt quality and winter survival data from the 2021 and 2022 growing seasons. We are developing a molecular marker panel specific to the WSU breeding program targeting genetic loci associated with malt quality traits to expedite early generation selection and advancement of superior genotypes through the breeding cycle. The combination of early generation marker assisted, genomic selection and speed breeding techniques in the greenhouse will optimize early generation selection for efficient movement of F5 generation material into the field enriched for malt quality, broad adaptability, and yield. Thus, the early generation spring head rows (~12,000/year), advanced single rep yield trials (~600/year) and multi rep yield trials (~60/year) will be enriched for malt quality so we can concentrate on selecting for farmer traits including yield, height, standability and disease resistance in the field utilizing traditional selection strategies. This will provide much more efficient use of the WGC funds and will allow for greater capacity to analyze later generation material that have already been screened for quality in the WMQL and via marker and genomic selection.

We have transitioned the program to a fully integrated malt barley breeding program with the genetics and phenotyping capabilities in place to develop both spring and winter classes of malt barley varieties that meet AMBA quality parameters. We identified several promising advanced spring and winter malt barley lines with excellent agronomics and malt quality data that met all AMBA parameters. The spring lines will be entered into the WSU variety testing program in spring 2023 and the winter lines were planted in the fall of 2023 in the inaugural year of the WSU winter barley variety testing trials planted at eight locations across high and medium rainfall zones. Three of the spring and three winter lines will be entered into the AMBA pilot evaluation program in 2023. If the data allows, we would like to release the best performing all malt (craft) and adjunct malt lines as varieties then pursue AMBA recommendation if they make it through the AMBA testing program.
Impact: In our efforts to maintain the spring malt barley development pipeline we made 83 new crosses focused on malt quality, targeted agronomic traits, and disease resistance. Individuals from 33 elite-by-elite crosses were selected and progeny advanced to plant an additional 12,000 F\textsubscript{3-4} head rows in the field for evaluation in the 2023 field season. In the 2022 field season we screened approximately 10,000 single head plots from our 2021 crossing block and selected 511 candidate malt barley progeny lines for single rep yield trials for the 2023 field season. All lines have been harvested and processing to collect data for selection and advancement of elite material. In the 2023 greenhouse the third spring malt barley crossing block was planted. The parental lines were selected based on quality, yield and disease resistance and additional crosses are underway. This season through the utilization of field and greenhouse crossing blocks we have now advanced our crossing such that we are ahead of schedule on progeny advancement and marker assisted and genomic selection such that we can put F\textsubscript{5} advanced and prescreened materials into the single head rows in 2024.

In the Fall 2020 and 2021 we planted 633 winter elite malting, advanced malting, and elite distilling lines from the Oregon State University winter barley breeding program (kindly provided by Dr. Pat Hayes; the Oregon State University barley breeder) in replicated trials at Spillman farm to determine yield potential, winter hardiness, lodging resistance, and malt quality performance. In collaboration with Dr. Pat Hayes, we have access to these materials to utilize as parental lines and an agreement for joint release of varieties coming from his material that perform well in Eastern Washington dryland production. Lastly, we have made 77 crosses with selected elite winter lines and are advancing these winter malt barley experimental lines including those containing winter hardiness introgressed from the lines 2MW18_4462-008 (University of Minnesota, provided by Dr. Kevin Smith) and RIL02WI-013 (Ohio State University, provided by Dr. Eric Stockinger). These lines contain Russian sources of extreme winter hardiness that survived the winters of the upper Midwest and have malt quality. These crosses along with winter hardy material provided by Dr. Gazala Ameen, South Dakota State University, are currently being advanced and utilized for additional crosses in the 2023 greenhouse.

Advanced spring malting lines will be entered into the WSU variety testing program in spring 2023 and the winter lines were planted in the fall of 2023 in the inaugural year of the WSU winter barley variety testing trials planted at eight locations across high and medium rainfall zones. Three of the spring and three winter lines will be entered into the AMBA pilot evaluation program in 2023. If the data allows, we would like to release the best performing all malt (craft) and adjunct malt lines as varieties then pursue AMBA recommendation if they make it through the AMBA testing program.

To aid rapid early generation selection, last season 288 elite WSU malting lines were selected and sequenced with the 50k Illumina bead express chip with an additional 288 selected from the 2022 field trials, which will also be genotyped with the 50K chip and additionally via genotype-by-sequencing. As this marker panel resolves positive malting loci in our breeding program utilizing genome wide association mapping (GWAS), Oxford Nanopore MinION DNA sequencing technology will be developed and utilized to genotype early generation material for genomic selection. The combination of early generation marker assisted, genomic selection and speed breeding techniques in the greenhouse will optimize early generation selection for efficient movement of F\textsubscript{5} generation material into the field enriched for malt quality, broad adaptability and yield. We have two MinION DNA sequencing instruments and experience utilizing the technology. This technology will be utilized for an adapted amplicon sequencing strategy to
generate genotyping data of over 2,000 experimental lines each year for early generation malt quality selection. Once this research is completed, we can begin utilizing the marker panel for marker assisted and genomic selection strategies early in our selection process with the markers associated with low grain protein, increasing malt extract, high alpha amylase and reduced wort ß-glucan.

We are continuing to introgress resistance to the virulent population of *Puccinia graminis* f. *sp tritici* (stem rust) identified in Washington state from the World Barley Core Collection (WBCC) and the OSU barley breeding program. Because these novel stem rust resistance genes identified from the WBCC, and OSU did not consistently translate to adult plant resistance in the field in 2021 and 2022 we continued to screen the barley primary germplasm pool for effective resistances. We identified the *Rpg7* resistance gene from the wild barley diversity panel as a very effective resistance gene against these virulent isolates. We recently crossed this source of resistance into our materials in the 2023 greenhouse crossing block.

As we further optimize and streamline selection utilizing high throughput genotyping and phenotyping the infrastructure put into place early in the development of my program will have a measurable impact on optimizing the return on the WGC’s investments. This investment in time and resources will expedite the development of AMBA recommended malt barley varieties in the future. As we move the breeding program forward these investments will have an impact on the ability to make more precise selections from intensive hybridization and screening of larger numbers of recombinant individuals. Our major focus will be on fixing malt quality in the program while increasing agronomic traits such as water use efficiency, heat tolerance, stature and lodging resistance, disease resistance and ultimately yield.

The most measurable impact(s) this project has had in this funding cycle was that we have now identified high yielding spring and winter malt barley lines that meet AMBA malt barley specifications. These lines have been submitted to WSU variety testing and will be entered into the AMBA pilot malting evaluation program in 2023. Although, it may take a few years before I can report on the release of AMBA varieties, with the tools in hand it is only a matter of hard work to achieve this goal. We will focus on the goal of transforming the program into a top malt barley breeding program releasing varieties that will someday dominate Washington malt barley acreage to feed the domestic supply of quality malting barley as well as international markets.

### Outputs and Outcomes:

<table>
<thead>
<tr>
<th>Objective</th>
<th>Deliverable</th>
<th>Progress</th>
<th>Timeline</th>
<th>Communication</th>
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<tr>
<td>1</td>
<td>Release of a craft and adjunct malting barley cultivars suited to brewing</td>
<td>Several of the advanced malting barley breeding lines have met AMBA standards and outperformed our modern malt variety checks for yield. These lines will be entered into Variety Testing and AMBA</td>
<td>2025-2026</td>
<td>Talks and presentations at field days; distribution of informative variety rack cards; Wheat Life articles; Pod Casts</td>
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<td>Event Description</td>
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<td>2</td>
<td>Release of a WSU winter malting barley variety suited to adjunct and or all malt craft brewing</td>
<td>Several elite winter malting lines provided by OSU met AMBA standards and outperformed our modern malt variety checks for yield. These lines were planted in the first winter barley Variety Testing trials in Fall of 2022 and will be entered into AMBA pilot testing in fall 2023.</td>
<td>2024-2025</td>
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<td>3</td>
<td>Release of a second IMI-tolerant barley variety with high yield and excellent disease resistance to complement Survivor. This could also be in the food or malt market class</td>
<td>We have thousands of known IMI-tolerant barley lines in our breeding pipeline. These have and will continue to undergo greenhouse and field trials as well as multi-location yield trials to identify the superior breeding lines available.</td>
<td>2024</td>
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<td>4</td>
<td>Hulless, waxy food barley variety release to support non-waxy high beta glucan varieties Havener and Meg's Song</td>
<td>Our hulless, high Beta-glucan breeding lines are performing well in the advanced breeder trials and will be included in variety testing trials.</td>
<td>2024-2025</td>
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Communications continued
Publications are listed here as the block above was too small.

Peer-Reviewed Publications (13 total):
Published, Accepted or Submitted from January 1, 2022 – December 31, 2022

Peer-Reviewed Publications:


