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FROM WINTER BARLEY TO COLD BEER

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Summary

Winter malting barley is a new crop opportunity for Pacific Northwest growers, based on new varieties of the world's oldest crop. In this report, we summarize a number of issues pertinent to winter malting barley variety development, including a brief review of the genetics of malting quality and winter hardiness, our breeding strategy, management issues, and economic issues.

Background

Winter malting barley offers the U.S. barley industry a new source of supply and Pacific Northwest (PNW) growers an alternative crop. Winter malting barley is an option to the weather- and disease-related risks of spring barley in the upper Midwest, weather-related risks and variable quality in western dryland spring barley, and the cost of western irrigated spring barley. In the PNW, we have a range of highly productive farming systems, ranging from dryland to irrigated. The winter rainfall pattern means that yields of winter barley on dryland can be as good, or better, than yields of spring barley under irrigation.

Water is a key resource in much of the West, and as a result optimum dryland production is an economically attractive option. Where winter cereals can be irrigated, as in parts of the Columbia Basin and the Snake River Plain, yields are phenomenal. Agronomic data on winter barley varieties and selections under dryland (Pendleton, Oregon and Pullman, Washington) and irrigation (Aberdeen, Idaho) are shown in Table 1. In the PNW, there are existing storage and transportation networks for malting barley, and these could be used for winter malting barley, which is harvested by mid-July, well before most of the U.S. spring barley crop.

Table 1. Agronomic and malting quality data for winter barley selections and check varieties; 1989-2001; average of data from Pendleton, OR, Pullman, WA, and Aberdeen, ID.

Variety/selection	Grain yield (lbs/ac)	Test weight (lbs/bu)	Grain protein (%)	Malt extract (%)	Diastatic power	Alpha amylase
88Ab536	5278	52	11.3	79.2	160	52.4
STAB 7	5920	52	10.9	79.9	140	56.5
STAB 47	5187	52	11.9	78.1	140	57.9
STAB 113	6419	53	10.0	80.1	130	51.1
KAB47	5532	52	11.0	79.8	120	62.3
KAB 51	5686	53	10.9	79.4	120	53.4
Strider	7408	51	NA[1]			
Kold	6764	52				
Hundred	6666	50				
Scio	6793	51				

[1]Strider, Kold, Hundred, and Scio are known to have unacceptable malting quality.

There are no winter barley varieties approved for malting by the American Malting Barley Association (AMBA) in commercial production in the United States. The variety '88Ab536', a winter six-row developed by Darrell Wesenberg (USDA/ARS, Idaho) was the first winter variety to meet AMBA quality specifications, but it is not in commercial production. This variety was a real breakthrough in terms of combining malting quality and winter hardiness. As detailed in the following sections on genetics and breeding, '88Ab536' is a cornerstone of our winter malting barley program. There are many winter malting varieties in commercial production in Europe (mostly two-row), although most of the barley acreage in Europe is spring two-row. The North American malting and brewing industries are rather unique in their preference for six-row. There are genetic, agronomic, and economic/political issues that need to be addressed in order to make winter malting barley an American reality. The key genetic issues are malting quality and winter hardiness. The key production issues are managing protein and tillage. The key economic/political issue is Federal crop insurance.

Genetics of malting quality and winter hardiness

Both winter hardiness and malting quality are complex traits that have been problematic for traditional breeding. New tools for working with these traits, which capitalize on DNA-based technologies, are quantitative trait locus (QTL) analysis, marker-assisted selection (MAS), and gene isolation. These biotechnology tools will allow plant breeders to more rapidly develop experimental lines for assessment as potential varieties. These tools are distinct from those used for introducing foreign genes into crop plants using transgenic technologies to produce genetically modified organisms (GMOs). At this time, there are no GMO barleys in commercial production in the U.S.

Malting quality is the most important value–added trait in barley. On the one hand, a number of genes are known that are important determinants of malting quality. Examples of such genes are alpha amylases and beta amylases. However, most of the genes determining malting quality are still unknown. Over the past 10 years, tremendous progress has been made in characterizing malting quality at the QTL level. The North American Barley Genome Project (NABGP) has devoted significant resources to describing malting quality genes and QTL in the variety 'Morex' -- the North American six-row malting quality standard. 'Morex' also happens to be one of the parents of '88Ab536', which puts us a step ahead in the winter malting barley game. We now have the opportunity to validate 'Morex' malting quality QTL alleles in a new genetic background and to use this information for developing superior winter malting varieties.

The focus of our genetics efforts is the 'Strider' x '88Ab536' (STAB) doubled haploid (DH) population. 'Strider' is an agronomically attractive winter six-row feed barley. Two lines in the STAB mapping population-- STAB 7 and STAB 113--have shown a malting quality profile that is in accordance with the industry guidelines and are candidates for a second year of testing in the AMBA program (Table 1). We are now genetically "dissecting" these

selections in order to understand which genes they have inherited from '88Ab536' and which from 'Strider', since our goal is to combine '88Ab536' quality and 'Strider' yield.

Winter hardiness includes characters such as low temperature tolerance, vernalization requirement, and photoperiod response. It is a pretty fair generalization to say that rye and triticale are the most winter hardy cereals, followed by winter wheat, winter barley, and winter oats. There are overlaps, so that the most winter hardy barleys are superior to some of the less winter hardy wheats, etc. Over the years, we've been systematically unraveling the complexity of these winter hardiness traits in barley using QTL tools. We have identified a region on chromosome 7 of barley that harbors genes controlling all components of winter hardiness. In '88Ab536' this same region traces to its Nebraska winter-feed barley parent. '88Ab536' is unique in that it has low temperature tolerance but it does not require vernalization nor does it have strong photoperiod requirement. This attribute--winter hardiness with no growth habit "baggage"--has some exciting implications for developing facultative varieties, as will be described below in the section on management.

Breeding strategies

When we first heard about the malting quality and cold tolerance of '88Ab536', we immediately crossed it to our two best winter feed barley varieties--'Kold' and 'Strider'--in order to combine malting quality, yield, and stripe rust resistance. The first results were the 'Strider' x '88Ab536' (STAB) and 'Kold' x '88Ab536' (KAB) mapping populations. Two lines--STAB 7 and STAB 113--are candidates for a second year of AMBA quality testing and we are planning on submitting two KAB lines --KAB 47 and KAB 51--for their first year of AMBA evaluation in 2002. All of these selections have agronomic and disease resistance advantages over '88Ab536' and they have shown acceptable quality profiles in micro malting tests. All of these selections can be spring-sown, an attribute that is discussed further in the following section on management. However, none of these selections has the yield potential of the best feed barley varieties, and all have minor deficiencies in their malting profile. To remedy these defects, we are taking two strategies. One is to inter cross the best STAB and KAB selections and to rapidly advance progeny to homozygosity (true breeding lines) via a breeding technique called single seed descent. This technique involves running several generations per year through the greenhouse, using one seed to represent the initial sample of genetic combinations that were generated in the original cross. The first of these selections, together with progeny from other winter crosses, will be grown in head rows at Hyslop Farm this winter. Our second strategy is to use molecular markers to rapidly transfer cold tolerance and disease resistance genes and QTL alleles into the best contemporary spring six-row malting varieties. We will start this project in the greenhouse this winter.

Management

Genetics are clearly a critical aspect of winter malting barley, but once the overall genetics package is in place, management comes into play. In the 2000-2001 crop year, we started a series of experiments at the Columbia Basin

Agricultural Research Center, Pendleton. The key production issues we are studying are fertility management, rate and date of seeding, tillage regimes, and options for managing winter injury. We have generated 1 year of data on nitrogen management and dormant seeding and are putting in trials this year to address the other considerations. Please see the report in this publication by Petrie et al., "Nitrogen Management for Winter Malting Barley." Grain protein is a key "gateway" character for malting barley. Malting barley growers producing a specified variety will likely be required to meet specific targets, including a grain protein specification. For six-row barley, the current AMBA specification is 11.5 – 13.5 percent. In many PNW environments we are in the position of needing to raise grain protein; in much of the rest of the world, the challenge is to keep proteins below critical thresholds. In 2000-2001, we started a series of fertility management trials to manage grain protein in winter malting barley.

Genetic improvement of winter hardiness is a key objective of the breeding program goal, but based on past experience, gains will be modest and incremental. One option for PNW environments, where winter kill is not an annual event, is to maintain existing levels of cold tolerance but "breed out" a physiological trait often found in winter varieties--vernalization requirement. The other physiological trait often found in winter varieties, photoperiod sensitivity, may be quite convenient to retain and manipulateA variety that is cold tolerant and remains in a vegetative state due to sensitivity to short days will remain vegetative over the winter and re-grow in the spring. The same variety can also be dormant-seeded or spring planted and will grow and develop normally, once day length reaches a critical threshold. Accordingly, in 2000 we launched a series of experiments with the same varieties sown under different sowing dates (from October to April) and cropping systems. These trials will be repeated this season, and we added a study in which we will simulate winter injury and re-seed into the remaining stand with the same variety in the spring. We have also planted experiments to examine the effects of chloride and zinc on agronomic and malting quality traits.

Economics

Crop insurance availability can be an important factor in the decision to produce an alternative crop such as winter malting barley. Insurance is available for barley but it will not at this time provide coverage for winterkill of fall-sown barley. Winter barley can be insured if, upon inspection in the spring, the stand is considered adequate to produce a yield equal to the Actual Production History (APH). If the stand is determined to be adequate, the winter barley is then eligible for the feed grain portion of the insurance. If the barley variety is an AMBA - approved malting variety and is under contract with an end user, it is also eligible for the malt barley price and quality endorsement. Efforts are underway to make crop insurance available for winter barley.

Contacts

There are no winter malting varieties in commercial production and the best experimental varieties are still several years away from commercialization. We do have limited seed available for on-farm trials; please contact Pat Hayes (541-737-5878) if you are interested in

looking at these selections in the 2002-2003 crop year. Great Western Malting is a key player in Pacific Northwest spring malting barley, and will play a key role in winter malting barley when varieties are available. For information on spring malting barley opportunities for the 2002 crop year, please contact the following Great Western Malting Co. representatives: Kevin Anderson (360-696-5493) or Greg Friberg (360-696-5482).

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