Two-rowed and six-rowed malting barley germplasm development in California.

Lynn Gallagher, Department of Plant Sciences, University of California, Davis, CA

Executive Summary
This project will help meet the goals of AMBA when breeding objectives are met wherein a developmental pipeline is filled with six-rowed and two-rowed germplasm having favorable alleles (genes) conferring resistances to several diseases combined with superior malting characteristics in barley lines highly adapted to the Western growing region. The foliar disease resistances being incorporated are primarily those against Barley Yellow Dwarf Virus (BYDV), barley stripe rust, scald, net blotch and Cereal Yellow Dwarf Virus (CYDV). Resistance to leaf rust and powdery mildew are additional possibilities. Promising initial results for two-rowed barley are indicated for advanced lines selected from crosses of an ICARDA/CIMMYT line (developed in California) to Oregon St. material. These new lines will be available for distribution after harvest in late May ’07. Very few six-rowed malting barleys are sufficiently adapted to growing conditions found in the Central Valley of California to be of breeding value. The first six-rowed crosses for malting quality are in the F4 generation. Additionally six-rowed Oregon St. winter barleys were crossed to a small number of spring barleys from northern states to form base populations for improved advanced line creation.

Development of 2 and 6-row Spring and Winter Malting Barleys for the Intermountain West: Variety and Germplasm Development.

DE Obert
USDA-ARS
National Small Grains Research Facility
Aberdeen, ID 83210

Executive Summary
Major objectives and expected benefits:
Our project mission is two-fold: 1) develop and provide to industry and producers superior widely adapted malt barley cultivars, and 2) develop improved barley germplasm which can be used by other public and private barley breeding programs. In addition to variety development our work also provides valuable information to private industry, other breeders, and barley producers via multiple location testing of lines from other breeding programs. Therefore we assist in meeting the mission of AMBA by the development of improved varieties, assisting other breeding programs in their effort to release improved cultivars, and providing management advice to barley producers.

Our major objective is to develop malting barleys that can be grown over large and diverse production areas to provide a uniform supply of barley for the malting industry. This goal is being accomplished by testing all phases of our breeding lines at all
locations in Idaho that either currently grow malt barley or that have potential for expanded malting barley production. In addition, we also test our elite spring lines in Montana and our advanced and elite winter lines in Kansas, Oregon, and Washington. Expected benefits include 1) more widely adapted cultivars to irrigated and rain-fed areas of current production and 2) lines that expand the potential for malting barley production into under utilized cropping systems, such as winter production in environments currently used only for feed barley.

Objectives and Accomplishments in 2006:

A significant accomplishment was the production of 160 A of Charles, a winter two-rowed malt variety being grown for plant-scale evaluation. Sublette, a two-rowed spring cultivar was grown on 250 A for plant-scale production but has been eliminated from additional evaluation. In addition, 95Ab2299, a winter two-rowed type, was approved for plant-scale evaluation and seed increase has begun for plant-scale evaluation beginning the fall of 2009.

In addition, objectives from the 2006 grant proposal were met: 1) An additional year of evaluation was provided for our elite materials and selection for very diverse environments was practiced, 2) elite lines from Busch Agricultural Research (BARI) were evaluated allowing us to provide valuable information to area producers, and 3) testing locations were expanded to include a winter testing location in Hutchinson, KS. This location allows us to gain knowledge concerning the winterhardiness and heat and drought tolerance.

Before 2003 our winter lines were tested only at Aberdeen, ID. In 2004 we were also able to evaluate at Parma, ID. In the fall of 2004 our winter lines were planted at Aberdeen, Filer, and Parma, ID., Pendleton, OR, and Pullman, WA. In the fall of 2006 we also planted these trials at Colby and Hutchinson, KS. These expanded winter testing locations provide a thorough representation of literally hundreds of thousands of acres of highly productive winter small grain areas, giving us confidence we can continue to release improved winter malting barley cultivars which can be grown on large production areas. The additional locations in Kansas represent an area that is currently planted exclusively to winter wheat. We, at this point, don't propose that winter malting barley will soon become common in these areas, but these experimental plots should provide us some idea of the amount of heat and drought tolerance that exists in our germplasm. With continuing water restrictions in Idaho this may become a more pressing issue in the near future.

We evaluated six elite lines from BARI in exchange for their testing our elite malt test at two additional locations: Idaho Falls, ID and Fairfield, MT. In the past our program has focused almost exclusively on Idaho but with the expansion of testing our spring lines in Montana, and our winter lines in Oregon and Washington, we are now able to test for broader regional adaptation.
Executive Summary

The overall aim of this research is to develop new six-rowed barley varieties with acceptable malt quality, improved disease resistance, and high yield potential. This research will directly assist in AMBA’s mission to provide an adequate supply of high quality malting barley. Barley improvement at the University of Minnesota is a cooperative effort of the Department of Agronomy and Plant Genetics, the Department of Plant Pathology, and the Research and Outreach Centers of the University of Minnesota. Specific breeding goals include high yield, enhanced lodging resistance, resistance to Fusarium head blight (FHB), net blotch, spot blotch, stem rust, and Septoria speckled leaf blotch (SSLB), and favorable malting and brewing characteristics. To meet these objectives, we are conducting a comprehensive breeding and genetics research effort funded by state and federal grants. This AMBA project supports breeding activities (making crosses, population development, trait evaluation, breeding line selection) directed toward the development of new varieties. This past year one breeding line, M109, was entered into AMBA plant-scale brewing evaluation with the 2006 crop. Breeding line M115 was rated satisfactory for its second year in AMBA pilot-scale malting and will advance to plant-scale in 2008. Our first breeding line with enhanced FHB resistance was rated satisfactory in AMBA pilot malt testing (2005 crop) and entered into a second year of testing with the 2006 crop.

During the previous year, we made crosses, among elite parents, designed to combine desirable traits. We developed populations through single seed decent and successfully conducted our standard set of yield and disease trials in Minnesota to evaluate breeding lines. Growing conditions were generally dry during most of the season, however, we obtained good quality data from all of our planned trials and experiments at five locations in Minnesota. Specific expected outputs on a yearly basis are: 1) development of breeding populations segregating for useful genes; 2) barley germplasm with specific desirable traits; 3) a steady flow of variety candidates into the AMBA pilot malting and plant-scale brewing programs.

The following are some of the most significant accomplishments from the previous year:

- Variety candidate M109 was grown for AMBA plant scale brewing evaluation with the 2006 crop. Sufficient production was obtained from 3 locations in Minnesota and North Dakota to permit plant-scale brewing.

- Three of the four variety candidates (M115, M122, M124) we submitted to AMBA pilot malting evaluation were rated satisfactory with the 2005 crop. This is the second year M115 was rated satisfactory. We should have sufficient seed of M115 in 2008 to grow for plant-scale brewing evaluation. M122 is our first line with enhanced FHB resistance.
• We continue to make progress in developing breeding lines with resistance to FHB, net blotch and Septoria speckled leaf blotch and have crosses made in which we will be using SSR markers to select for resistance alleles.

• Graduate student, Federico Condon, successfully defended his PhD thesis in April, 2006. Using a historical set of varieties and breeding lines, he has estimated genetic gain for important traits in the breeding program, characterized genetic diversity in response to breeding using molecular markers, and conducted association mapping to identify desirable genes for agronomic, disease, and quality traits.

MANAGEMENT AND EPIDEMIOLOGY OF BARLEY DISEASES

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Executive Summary: This is an applied research program directed to the control of the plant disease issues of importance to the barley industry in Minnesota and the Upper Midwest. The emphasis of the research is directed to research on the foliar pathogens of barley. Fusarium head blight (FHB or scab) presents the greatest threat to the production of malt quality barley in Minnesota and research on FHB has been the principle focus of the program. The foliar diseases of importance in Minnesota include net blotch, spot blotch, Septoria leaf blotch, and the rusts (leaf and stem rust). Barley Pathology Research at the University of Minnesota is a cooperative effort of the Department of Plant Pathology, the Department of Agronomy and Plant Genetics and the experiment stations of the University of Minnesota. The joint efforts of these research programs have results directly in the development of new malting barley varieties suitable for production in the upper Midwest of the United States.

In 2006 this project was instrumental in the screening of over 14,350 field rows and 250 pots in the greenhouse for resistance to FHB. The program also conducted germplasm screening in the field and greenhouse to the foliar pathogens of barley. In 2006 the project was involved in the screening of 600 rows in the field and 1,300 pots in the greenhouse for response to Pyrenophora teres (net blotch).

Investigations on Barley Diseases and Their Control

Brian J. Steffenson

Department of Plant Pathology, University of Minnesota

Executive Summary

Plant diseases are one of the most important constraints to barley (Hordeum vulgare) production and quality in the United States. Our Cereal Disease Resistance
Project is part of the Minnesota Barley Improvement Program team that develops six-rowed malting barley cultivars for the Midwest. The primary mission of the Cereal Disease Resistance Project at the University of Minnesota is the control of economically important barley diseases. For many diseases, this goal is best achieved through the development of cultivars with genetic resistance. Thus, the long-term goal of this project is to develop the knowledge base, resources, and germplasm for achieving durable disease resistance in malting barley cultivars. In addition to these goals, it is also essential to conduct disease surveys and monitor pathogen populations for new virulence types. In 2006, breeding lines were sown for evaluation for resistance to spot blotch, Septoria speckled leaf blotch (SSLB), and net blotch. Durable resistance has been achieved for spot blotch. Our evaluations ensure that this resistance is not lost when exotic material is introgressed into the breeding program. Indeed, we identified several susceptible lines from Busch Agricultural Resources, Inc. (BARI) breeding program in this tests. These lines have now been discarded. We are also working on increasing the level of resistance to SSLB and net blotch in the Minnesota program. Toward this end, we have identified a number of agronomically advanced lines with high levels of resistance to both diseases. Our annual disease survey was conducted on July 12-14 in 2006. Fusarium head blight, net blotch, and SSLB continue to be common diseases on barley, but their severity was reduced due to dry weather in 2006. Bacterial blight also was found in a few fields in 2006. Additional pathogen isolates were collected from this survey and were stored in our pathogen collection. Pathogen isolates are an essential resource for resistance breeding efforts and the identification of novel sources of disease resistance. They are also useful as a historical record of virulence shifts in pathogen populations. Our research goals all directly address AMBA’s primary objective of developing malting barley cultivars with improved agronomic and quality characters. The deployment of superior malting cultivars with disease resistance will help ensure that an adequate supply of high quality malting barley is available to the malting and brewing industry.

Developing Improved Malt Barley Varieties for Montana and the Western US
Dr. Tom Blake, Professor, Montana State University

MISSION:
Our mission is to develop the next generation of malting barley varieties for barley growers in Western North Dakota, Montana, Idaho and the Pacific Northwest. The MSU barley improvement program has aggressively utilized agronomically superior parents for the past two breeding cycles, crossing them with excellent malt quality parents and selecting desirable recombinants. This use of high yield potential, exceptionally durable lines like Baronesse, Stark, MT851195 and MT860756 as parents has enabled us to select malt barley lines with agronomic performance nearly equal to the best feed barley varieties currently available (table 1,2). The continuing diversion of corn to ethanol production is likely to result in high feedgrain prices for the foreseeable future, making it even more important to demonstrate that our malt barley varieties are agronomically competitive with feed barley varieties.
The MSU barley improvement program is devoted to improving the farmgate value of the Montana and US barley crops. We seek to reverse the slide in barley acreage from 1986 (more than 12 million acres nationally) to 2006 (less than 3 million acres nationally). We will need to make barley economically more competitive with wheat to reverse this unfortunate trend. While increasing yield will help, increasing quality and the reliability of our dryland malt barley crop will be critical.

In the past year, we successfully won AMBA recommendation for ‘Craft’ (PI646158), our first malt barley release with obviously improved agronomic performance. Our objectives for the next two years are to guide Geraldine and Hockett successfully through the AMBA plant scale evaluation and recommendation process (tables 1 and 2).

Our project has taken the lead in moving $qGPC6H$, the ‘Karl’ low grain protein gene on chromosome 6, into all of our regionally adapted varieties. The primary action of this gene appears to be to extend grainfill duration, enabling greater starch storage and perhaps increasing grain yield and possibly malt extract (table 3). We recently purchased a used Phoenix micromalting unit, and will explore how $qGPC6H$ impacts quality and agronomic performance in a wide variety of genetic backgrounds and environments. Maximizing US barley’s potential as a starch production and storage system will improve our competitive position relative to corn, while also improving barley’s malting quality. Over the next five years we need to optimize barley straw as a substrate for cellulosic ethanol production, an objective the MSU program began working on two years ago.

**PRIMARY OBJECTIVE:**
The primary objective of the MSU barley improvement program is to improve the farmgate value and competitiveness of barley for Montana growers. Malt barley provides growers with added value, and Montana’s position as a malt barley provider has improved over the past decade. Enabling Montana’s dryland barley growers to reliably produce high quality malt barley is our project’s primary goal.

**Epidemiology and Control of Barley Leaf Diseases Caused by Fungal Pathogens**

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**EXECUTIVE SUMMARY**

Stripe rust *Puccinia striiformis* f. sp. hordei remains an important fungal disease of barley in some areas of North America. Resistant cultivars are considered an economical means of disease control.
Genes conferring broad based resistance to stripe rust have been mapped in a “Baronesse” background. The next logical step would be the transfer of these genes into lines/cultivars acceptable to the malting industry as well as to the grower. The (ongoing) project develops quantitative, more durable types of resistance in an agronomically desirable background. At the same time more information on the degree of dominance and possible background effects will be gathered.

Breeding and Genetics of Six-rowed Malting Barley
Richard D. Horsley
Department of Plant Sciences
North Dakota State University

Executive Summary

The objective of the project is to develop and release improved six-rowed malting barley varieties acceptable to barley producers in North Dakota and adjacent areas in the United States, and to those who use or process this barley. This objective is being accomplished using traditional breeding methodologies. Traits receiving top priorities are improved malt quality, resistance to Fusarium head blight (FHB) and foliar diseases, reduced deoxynivalenol (DON) accumulation, and improved agronomic performance. In the short-term, varieties with acceptable malt quality will be developed that accumulate 25% less DON than Robust. Long-term goals are to develop varieties that accumulate 75% less DON than Robust. Today’s growers have many choices of crops to produce. All new varieties with acceptable malting and brewing quality also must have sufficient agronomic performance to make them competitive with other barley varieties and other crops. Our improved varieties must consistently meet the quality needs of the malting and brewing industries and the demands of the growers.

For the first time, a line (ND20448) from our breeding project with improved FHB resistance and acceptable malt quality was found satisfactory in its first year of Pilot Scale Evaluation. ND20448 accumulates about 30% less DON than Robust, yields intermediate to Robust and Drummond, and appears to have acceptable malt quality. In 2006, 391 of the 729 experimental lines we evaluated in replicated yield trials came from our FHB-resistance breeding project.

The North Dakota Agricultural Experiment Station released Stellar-ND, tested as ND16301, in February 2005. Stellar-ND has a high yield potential across a wide range of growing conditions in the northern Great Plains, excellent straw strength during the growing season and at harvest, and excellent malt quality. Miller Brewing found Stellar-ND to be satisfactory in two years of Plant Scale evaluation and Anheuser-Busch found Stellar-ND to be satisfactory in one-year of testing. The second-year of Plant Scale testing by Anheuser-Busch will be done using grain produced in 2006.
EXECUTIVE SUMMARY
Diseases are the most important factor in limiting the yield and quality of malting barley production in the upper mid-west of the US. The objectives of the Barley Pathology Project at North Dakota State University are to maintain and enhance resistance to barley diseases and develop timely, practical methods for disease control to ensure that the quantity and quality of malting barley in the upper Midwest are not limited by disease. We will achieve this goal through the support of the development of cultivars with genetic resistance to current and emerging diseases, as well as through the development of cultural and chemical management strategies. To accomplish this goal we have an ongoing program of surveying and research as well as working closely with state and industry breeders throughout the region.

In 2006/07 we,
- Conducted field trials and or screened in China or several locations in North Dakota breeding material and elite selections for breeders and geneticists at NDSU, USDA and several mid-west breeding programs.
- Screened 872 lines in two separate tests in the greenhouse or in the field for resistance to spot blotch. Of the two-rowed lines tested in the winter of 2006/07, 31% were resistant and of the six-rowed lines 49% were resistant.
- Screened 494 lines in the greenhouse for resistance to net blotch, but due to low disease development we are currently repeating those tests.
- Surveyed 108 fields for 12 barley diseases and posted weekly graphics summarizing the disease progress with accompanying interpretation on the NDSU web site, which allowed farmers and industry to make more informed disease control decisions. Diseases were lower in 2006 than for the last 5 years, both for FHB, leaf spots and rust. Insect levels were moderate especially later in the season.
- Identified the chromosomal location of the leaf rust resistance gene $Rph13$ and identified a new leaf rust resistance gene. Leaf rust is a common late season disease of barley in the upper mid-west. The new gene is particularly interesting as it has a slow-rusting phenotype which is highly desirable. We have identified one microsatellite (SSR) marker closely linked to $Rph13$ which if combined with other markers may be useful for marker assisted selection.
- Identified that the septoria speckled leaf blotch pathogen is genetically diverse throughout ND and western MN and that although a sexual stage has not been identified it is likely to exist. This information is critical for making decisions about how to deploy resistance genes for this important disease.
• Our continued collaboration on leaf and head disease screening contributed to the development of a good disease resistance package in line ND20448, a line with less FHB than Robust and good malting characteristics. ND20448 was found acceptable in its first year of AMBA Pilot Scale Evaluation.
• Our continued collaboration on leaf and head disease screening contributed to the development of a good disease resistance package in Stellar-ND, which has been found satisfactory in one year of Anheuser-Busch plant scale testing and two years of Miller Brewing plant scale testing.

MALTING AND BREWING QUALITY OF BARLEY

Dr Paul Schwarz
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EXECUTIVE SUMMARY

The primary goals of the Barley Quality Program at NDSU are to provide individuals in the barley improvement program with barley and malt quality analytical services, 2.) to conduct applied research that addresses issues of immediate concern and improves the understanding of malting quality, 3.) to conduct the annual survey of regional barley crop quality, and 4.) to provide training in cereal chemistry with particular emphasis on the science of malting and brewing.

Major Objectives and Expected Benefits (goals 1 and 2: AMBA funded projects):

Barley and Malt Quality Analyses: Malt quality analyses provided to individuals in the NDSU barley variety development program (and others) directly assists AMBA in meeting its mission of providing the malting and brewing industries with an abundant supply of high quality malting barley. Early generation screening for malt quality is important in streamlining the overall malting barley variety development process. Elimination of undesirable materials at an early stage increases the overall quality of materials submitted for laboratory malting. Barley and malt quality analyses conducted for breeding research projects contribute to a more complete understanding of the genetics of malting quality. Likewise, quality analyses conducted for barley production studies help maintain barley as a competitive crop within the region.

Research Studies - Applied quality research directly addresses the AMBA mission to increase the understanding of malting barley. Projects which have addressed immediate issues have had major impact. Our past research work on pre-harvest sprouting and deoxynivalenol are important examples of immediate issues.

Objectives Met in the One-Year Funding period

Barley and Malt Quality Analyses
• Screened 3350 early generation samples for barley quality, and 130 variety plot samples for malt quality.
  o Data for the NDSU Variety Development Program was used to make decisions on lines submitted for advanced testing.
• Micro-malted and provided malt quality analyses (n=181) for a study on transgenic barley showing partial resistance to FHB.
• Micro-malted and provided malt quality analyses (n=98) for a study on adaptation of European germplasm in western ND and eastern MT.
  o These lines may prove of value under irrigation conditions, and may provide growers with a competitive crop (barley) until adapted domestic cultivars are released.

Research
• Identified significant interference from beta-amylase in the standard ASBC method for the determination of alpha-amylase in malt (method Malt-7)

Most Significant Accomplishment
• Provided value services to barley grower, industry and researcher stakeholders, while maintaining a good balance of applied barley research.

MISSION: The primary purpose of AMBA is to encourage and support an adequate supply of high quality malting barley for the malting and brewing industry and increase our understanding of malting barley.

PRIMARY OBJECTIVE: Develop malting barley varieties with improved agronomic and quality characters to keep malting barley competitive with other crops so that growers continue to plant and produce an adequate supply of suitable quality for improved utilization by the industry.

Net Blotch of Barley: Survey of Pathogen Virulence

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Northern Crop Science Laboratory
Cereal Crops Research Unit
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Executive Summary: Because net blotch on barley has the potential to cause severe yield loss as well as a reduction in quality and that most barley lines are moderately to highly susceptible, it is important that we have an understanding of host resistance and pathogen virulence in this important host-pathogen system. This proposal was aimed at identifying pathogen virulence present in the Pyrenophora teres field populations at Langdon and Fargo, ND in 2004 and 2005 in an attempt to characterize the variability of virulence of P. teres the causal agent of net blotch on barley. Successful progress in this research will help our understanding of the virulence as it relates to specific
resistance genes in the host with the ultimate goal of being able to effectively breed for durable net blotch resistance. Several good resistance sources have been identified that have not been overcome by any of the *P. teres* isolates collected to date. This research will be conducted each year to monitor changes in the pathogen population in order to provide important information on the effectiveness of various sources of resistance.

**What major objectives or issues are being resolved short and long term, how are you resolving them, and what are the expected benefits?**

In the present study we have identified what resistance genes are effective in the field population and at the same time identifying which genes are ineffective in combating net blotch of barley in the ND/MN region in the previous two growing seasons. We have also identified changes in virulence within the pathogen population over the two year period tested, showing that the pathogen population has the ability to change if selection pressures such as the introduction of single resistance genes were applied. Long term, it is our objective to monitor the change in the *P. teres* population to identify what resistance genes have been overcome or have the potential to be overcome. This monitoring will aid in choosing resistance genes for developing durably resistant barley cultivars.

**What objectives were met and/or outputs produced in the one-year funding period?**

Using a varied barley differential set with published differences we have identified which lines contain the most effective resistance. The most effective resistance sources in the year 2005 study are barley genotypes CI1179 (Algerian), CI5791, CI9214, PI552963 (Heartland), and NDB112. All other resistance sources were susceptible to at least one isolate collected in 2005.

**What were the most significant accomplishments?**

The most significant accomplishment in this work was the identification of which resistant sources are overcome and which ones contain potentially durable net blotch resistance that could be used in combating net blotch in this region as well as the identification of virulence changes within the pathogen population from year to year.

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**Germplasm Enhancement for RWA Resistance**

D.W. Mornhinweg, D.R. Porter, and G.J. Puterka

USDA-ARS Plant Science and Water Conservation Research Laboratory

Stillwater, Oklahoma

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**Executive Summary**

Whenever insect pests impact grain yield of barley they affect malting quality. The major cause of yield loss with RWA feeding is through head trapping which results in
reduced fertility and a severe decrease in plumpness of surviving seed. Not only is less grain available for malt, but the quality of that grain is greatly decreased. When RWAs feed on susceptible plants, the new leaves do not unroll and aphids build up in high numbers inside the unrolled leaves where they are protected from contact insecticides as well as natural parasites and predators, and wind and rain. In years of severe or early infestation, chemical control can only be accomplished with repeated applications of systemic insecticides. These chemicals are not only expensive for barley producers but could quite possibly end up in malt produced from treated fields. The solution to these problems is resistant varieties. 109 unadapted germplasm lines have been developed in previous years as a part of this project after screening the entire NSGC. Two lines have been officially released to breeders while the others were available upon request. Inheritance studies, also accomplished in previous years by this project, have given barley breeders valuable information on how to best utilize these germplasm lines in their breeding programs.

Negative affects on yield and malting quality are often associated with the use of unadapted germplasm in a breeding program, so a prebreeding program was instituted to bring resistant genes into good malting quality backgrounds adapted to all the barley growing areas of the US. Due to the common occurrence in aphid populations of biotype change after which the aphid can overcome resistance, all 109 resistant sources have been utilized in this prebreeding program in hopes of producing germplasm with genetic diversity for resistance which could protect barley from any future aphid biotype change. Such a biotype change occurred in the summer of 2003 when wheat varieties resistant to RWA1 were severely damaged and yields greatly reduced. This new biotype has since been named RWA2. Since that time yet another 3 biotypes (RWA3, RWA4, and RWA5) have been reported and more are suspected. We have tested potential RWA1 resistant barley germplasm releases against RWA2 and RWA3 and all highly resistant lines have maintained their resistance.

Seven, RWA-resistant, winter, feed barley germplasm lines in a Schuyler background were released in the fall of 2005. Nineteen, RWA resistant, 6-rowed, spring, barley germplasm lines in 6-rowed, malting barley backgrounds and 17, RWA resistant, 2-rowed, spring, barley germplasm lines in 2-rowed, malting barley backgrounds were released in 2006. Breeders should be able to utilize these germplasm lines directly in a breeding program with reduced detrimental affect on malting quality as well as grain yield. Seven, RWA-resistant, 2-rowed, spring, feed barley germplasm lines were also released in 2006. There are 34 different sources of resistance involved in these 50 germplasm lines. All 43 spring germplasm releases were tested against 5 biotypes of RWA in 2006. Resistance appears to be holding up to all biotypes. Analysis is ongoing.

Stoneham and Sidney, drought hardy, spring, 2-rowed, feed barley cultivars were also released in 2006. These barleys are not only RWA-resistant but also adapted to the high and dry production areas of eastern Colorado and Wyoming and western Nebraska and Kansas.

The Oregon Barley Improvement Program
Executive Summary

How the OSU program helps AMBA realize its mission and primary objective: The two principal goals of this project remain (1) to develop six-row winter malting barley varieties that will assist AMBA in meeting its mission of providing the malting and brewing industries with an abundant supply of high quality malting barley and (2) to develop molecular breeding tools that will benefit all barley breeders working to advance the AMBA cause. We are addressing AMBA’s primary objective – ensuring that barley is a competitive crop – by incorporating malting quality into high yielding winter habit varieties that provide growers with a profitable and productive cropping option.

Major issues, solutions, and expected benefits: We have developed a winter barley germplasm base suitable for making the elite x elite crosses from which most malting barley varieties derive. It has taken 20 years to reach this point due to necessity of combining malting quality, disease resistance, and winter hardiness. Our approach to solving these complex issues has been to develop molecular breeding tools based on knowledge of gene locations, effects, and interactions. We now have excellent parental stocks and two years ago embarked on a more extensive crossing program to generate the segregating generation progeny from which AMBA-approved varieties can be expected to come. The benefits will be high yielding malting barley varieties that represent a new, dependable, and alternative source of high quality malting barley.

One-year objectives and outcomes: We developed, tested, characterized, and selected winter germplasm at multiple locations. We have ceased all spring barely improvement efforts, except for specialized disease resistance stocks. We have advanced lines with excellent yields under irrigated and dryland conditions. These high yielding lines have good disease resistance and potentially acceptable malt profiles. We have developed perfect markers for target traits and implemented these in our breeding program. No malting quality data are available for the 2006 crop samples, due to the construction of a new facility for the CCRU.

Most significant accomplishments: Per the preceding section, we have developed some very exciting germplasm and we have developed molecular breeding tools to accelerate future gains. Three lines are in their first year of AMBA Pilot Scale testing. A new line is in increase for submission to the program in 2007. And the breeding pipeline is full.

Malting Quality Analysis of New Barley Selections
2006 CROP YEAR REPORT
Allen D. Budde, Chris Martens and Mark R. Schmitt.
Executive Summary:

The Malting Quality Analysis project at the Cereal Crops Research Unit (CCRU) in Madison is an on-going effort to provide information to a number of state and federally funded barley breeders on the malting quality of new barley selections. Upon receipt of seed from cooperating breeders, we micro-malt the samples of the various lines, and then analyze the resulting malt for a number of parameters used to assess the suitability of the line for development of commercial malting varieties. Our goal is to provide accurate and timely data on the malting quality of the submitted samples to assist barley breeders in making their breeding line selections. We also carry out investigations on the malting barley in order to better understand the biochemical basis for malt production and malting quality.

The QA lab completed the 2005 crop year analyses in August, 2006, in time to prepare for the move to a new facility. The 2005 crop year analyses represent the greatest number of samples that have ever been malted and analyzed in one year at the CCRU. The QA lab was moved in October of 2006. We encountered a number of expected and unexpected issues, which have delayed us from initiating malting of breeder’s submissions. Nearly all issues have been resolved and performance testing is nearly complete. If performance testing goes well, we hope to begin malting 2006 crop year submissions the week of March 12. We have plans in place to process an increased number of samples per week through to initiation of malting the 2007 crop year samples. Remaining submissions from the 2006 crop year will be malted and analyzed as time permits.

As a result of discussions at the 2007 Barley Improvement Conference, breeders are being provided with barley analytical data as the best alternative to our usual malt analyses. As of March 9, 2007, barley data on 2000 submissions have been reported back to the breeders.

We have prepared the AMBA pilot and plant scale malts using our Joe White micromalters and have completed malting 50% of the regional nursery submissions. Analyses of these malts will be completed prior to the Spring AMBA Technical Committee meeting.
Characterization of Novel Genes Encoding $\alpha$-Glucosidase in Malting Barley
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Executive Summary
How this project helps meet AMBA’s mission and primary objective: AMBA’s mission of encouraging and supporting an adequate supply of high quality malting barley is addressed by this project’s primary goal which is the development of knowledge of starch degrading enzymes and assays that measure their collective activity that will be useful in selecting germplasm with improved malting quality. The malting quality parameter this research addresses is the efficiency of starch conversion to fermentable sugars. It is widely accepted that four enzymes ($\alpha$-amylase, $\beta$-amylase, $\alpha$-glucosidase and limit dextrinase) work in concert to produce fermentable sugars from starch. The ability to consistently maximize production of fermentable sugars from raw products, both malt and adjunct grains, can only be obtained by having a thorough knowledge of the enzymes involved. This project is contributing to AMBA’s mission by building a more complete knowledge of starch degradation and measures of starch degradation during malting and mashing which supports basic and applied scientists involved in the development of malting quality barley.

The Primary Objective we are addressing is to remedy our lack of knowledge of the novel $\alpha$-glucosidase genes we discovered and reported on in the 2005-2006 progress report.