2015 BREWERS ASSOCIATION FUNDED RESEARCH GRANTS

ALL-MALT BEER - BARLEY DEVELOPMENT PROJECT

- Partner(s): Brewers Association, North Dakota State University, United States Department of Agriculture Agricultural Research Service, ID (USDA-ARS Aberdeen), Briess Malt & Ingredients Co.
- Primary goal(s): Identify and commercialize malting barley varieties better suited to all-malt brewing for cultivation in the U.S.
- Background: Craft brewers represent a 33% customer for U.S. malt consumption as of 2015. And yet, there are currently no malting barley varieties specifically bred for all-malt brewing in production in the U.S. Craft brewers currently use malt made from barley varieties bred for adjunct brewing, with negative stability outcomes in packaged beer.
- Additional Information: Study will continue development of test plots of spring and winter lines at Aberdeen; micro malting at North Dakota State University with Paul Schwarz group; 2016 seed increase of varieties of promise from 2015; pilot malting at Briess of varieties which were involved in the seed increase; brewery trials with participating breweries.

RESPONDING TO A NEW THREAT TO THE VARIETY CASCADE FROM POWDERY MILDEW

- Partner(s): USDA Agricultural Research Service, OR
- Researcher: David Gent
- Primary goal(s): Conduct a final year of surveys to determine the geographic extent and severity of powdery mildew on Cascade in Oregon and Washington. Characterize powdery mildew reaction of cultivars to Cascade-virulent strains of the pathogen. Work with public breeding programs to evaluate critical male germplasm for its reaction to Cascade-virulent strains of the powdery mildew fungus. Communicate and disseminate results to the hop industry and the craft brewing community.
- Background: Powdery mildew of hop (caused by *Podosphaera macularis*) is the most costly disease to the U.S. hop industry and, by extension, brewers. The disease is managed largely by repeated application of fungicides, with susceptible cultivars receiving on average 8.3 fungicide applications per acre per year (Gent et al., 2012). Economic losses from powdery mildew and its management have been estimated at about 15% of total crop revenue (Mahaffee et al., 2003), in addition to unmeasured costs due to greater supply instability and reduced brewing quality.
- Additional Information: Management of powdery mildew is accomplished most efficiently with genetic host resistance. Grand funds were used to conduct a systematic evaluation of male germplasm for its reaction to widely prevalent strains of *P. macularis*, including strains virulent on plants possessing the resistance gene R6. This work is foundational for identifying potential sources of new resistance in existing public breeding lines and accelerating development of new varieties with broad-spectrum resistance to virulent strains of the powdery mildew fungus.

NITRATE RESIDUES IN AND ON HOPS

- Partner(s): Washington State University
- Researcher: Douglas Walsh
- Primary goal(s): Evaluate the interactions of plant nutrition with arthropod pest abundance and disease severity on the brewing qualities and nitrate levels in Cascade hops.
- Background: Craft brewers have been innovative in enhancing the methods used to incorporate hops into the brewing process. Methods have included dry-hopping after the boil, wet hopping with fresh hops, adding hops later in the boil, and dry-hopping with whole cones or pelletized hops. Additionally, most craft brewers use a substantially greater quantity of hops per barrel than the large brewers of traditional American Pilsner-type adjunct lager beers.
- Additional Information: The primary impact for hop growers will be providing some knowledge of optimal fertilization rates that maximize yields of hops that do not contribute to the nitrate loads in beer. These hops in turn should provide craft brewers with the brewing properties they seek.

AROMA AND FLAVOR DECIDERS IN CASCADE, CENTENNIAL, CHINOOK HOP VARIETIES

- Partner(s): Oregon State University
- Researcher: Thomas Shellhammer
- Primary goal(s): Characterizing the aroma of Cascade, Centennial and Chinook hop varieties using advanced instrumental techniques to identify the hop aroma compounds important to each variety and gain insight into the potential synergy of mixtures/blends of the three varieties.
- Background: Dry-hopping is a technique whereby maximal extraction of hop oils may occur relative to traditional hopping techniques, and many craft brewers use it to create intense hop aroma in finished beer. The aroma profile supplied by Cascade, Chinook, and Centennial hops is characteristic of many American craft brands. These hops are used ubiquitously across the American craft beer sector; this research project studied the unique synergy of these varieties in a dry-hopping regime.
- Additional Information: Understanding the key drivers to hop aroma in the individual platforms, as well as the combined hopping regime provided insight into markers of hop aroma quality for each variety. We anticipated that brewers could adjust blends of these hops to hit targets of particularly important aroma compounds. Additionally, deep understanding on a chemical level of what compounds are characteristic of the total "C" hop aroma will aid in hop breeding. Understanding potential hop blends to create an aroma that represents the combination serves as a practical output for brewers dealing with shortening supply and rising costs of important hop supplies.

OREGON STATE UNIVERSITY MALT LAB

- Partner(s): Oregon State University
- Researcher: Pay Hayes
- Primary goal(s): Development of a pilot malting facility at Oregon State University (OSU). The facility will meet the current need for generating sufficient malt to assess beer flavor and other attributes in classic, new, and future barley varieties.
- Background: There is increasing appreciation for the impacts of different barley varieties and growing environments on beer flavor. Clearly, barley production practices, the malting process, the maltster, and the brewer all make critical contributions to beer flavor. If the genetic architecture of a barley variety, and the interactions of this architecture with the environment, can make important contributions to flavor, this presents opportunities to create new beers with new markets. In addition, there is interest in developing malting protocols and new beer styles from other grains and pseudo-cereals – e.g. quinoa, sorghum, rice, etc.
- Additional Information: Contributors included Dr. Patrick Hayes, Professor of Barley Breeding and Genetics, Oregon State University; Dr. Tom Shellhammer, Professor of Fermentation Science, Oregon State University; Dr. Paul Schwarz, Professor - Malting Barley Quality, North Dakota State University; Jeff Clawson, Pilot Brewer and Pilot Plant Manager, Oregon State University; Scott Fisk, Pilot Maltster and Barley Field Program Manager, Oregon State University.

BARLEY AND MALT METABOLITES THAT CONTRIBUTE TO BEER FLAVOR QUALITY

- Partner(s): Colorado State University
- Researcher: Adam Heuberger
- Primary goal(s): This investigation characterized barley grain and/or malt metabolites that contribute to beer flavor, and served as the foundation for developing new methods to evaluate malting barley varieties for flavor.
- Background: Current investigations have identified that barley varieties contain distinct profiles of volatile and non-volatile metabolites. However, the overall effect of this metabolite variation on beer quality is largely unknown. We hypothesize that metabolite variation in the barley grain and/or malt influence beer quality traits such as flavor, aroma, and flavor stability. The long-term goal of our research is to develop methods that evaluate metabolite variation in barley grain and malt to inform on downstream beer quality.
- Additional Information: 5 Barley lines were malted and brewed using a malt-forward, low-hop procedure at John I. Haas Innovations Center (Yakima, WA). Varieties of barley were chosen that have similar quality characteristics (e.g. FAN, alpha-amylase, diastatic power). Samples of the barley grain and malt were sent to Colorado State University for non-volatile metabolite analysis, and the malt was used for brewing n=5 beers at John. I. Haas Innovations Center. Volatile metabolite analysis of the barley grain, malt, and beer was conducted at New Belgium Brewing. Sensory analysis was performed on malt and beer at New Belgium using a standard quality assessment procedure that evaluates appearance, aroma, taste, mouthfeel, and body. Malt chew tests were performed utilizing quantitative descriptive analysis of malt attributes based on a modified-version of the Weyermann Malt Aroma Wheel. Beer evaluation followed a similar procedure of quantitative descriptive analysis on the finished product.

SUSTAINABLE GROWER PRODUCTION PRACTICES: 2-ROW BARLEY AND NITROGEN USE

- Partner(s): University of Idaho
- Researcher: Christopher Rogers
- Primary goal(s): Develop nitrogen management strategies for winter and spring barley tailored to meet grain quality standards of the Brewers Association for all-malt beer production. Screen cultivars and breeding lines for selection of traits in winter and spring barley specifically for all-malt beer production.
- Background: Screening of breeding lines from the USDA-ARS and University of Idaho research groups in Aberdeen, Idaho was undertaken in previous years. These lines potentially have unique agronomic trait profiles that are desirable for all-malt brewing. In particular, grain protein requirements for all-malt two-row barley varieties are typically lower than those for adjunct two-row malt barley. While breeding and genetics play an important role in determining the range of these factors, fertilizer nitrogen management strategies also play a critical role in determining the percent plump kernels, the final grain protein concentration, and thus the suitability of particular barleys in all-malt brewing. By providing optimal nitrogen to meet grain needs and malting specifications, we can decrease environmental impacts associated with nitrogen loss and improve the overall sustainability of barley production.
- Additional Information: A combined effort to investigate agronomic management practices in combination with the evaluation of appropriate breeding lines led to an improved understanding of production practices to provide malt barley that meets the need of all-malt beer producers while improving the overall sustainability of barley production. Additionally, focus on winter malt barley provided added opportunities for barley production specifically in regions outside current dominant growing regions.

FIELD GUIDE FOR INTEGRATED PEST MANAGEMENT IN HOPS

- Partner(s): Hop Growers of America
- Principal: Ann George
- Primary goal(s): Produce Field Guide for Integrated Pest Management in Hops, to provide growers, consultants, extension personnel, and other pest managers with the most current science-based information.
- Background: We expanded the scope of this third edition beyond the Pacific Northwest to encompass several new regions where hop production is increasing, making the scope of this book national and attempting to address the needs of both large and small hop producers in established, emerging, and reemerging hop-producing regions. Craft brewers are seeking local sources of hops to appeal to their consumers. In expanding the scope of this handbook, we hope to assist new hop growers in their efforts to control pests as they learn to produce hops in the microclimates associated with their geographic locations.
- Additional Information: Production of high quality hops requires careful attention to numerous arthropod, disease and weed pests, as well as horticultural practices that may exacerbate or suppress these pests. Multiple plant pathogens and arthropods have been documented as hop pests, and many plants common to hop-producing regions can become weeds in hop yards in certain circumstances. The damage pests and diseases cause ranges from insignificant to complete economic loss due to direct reduction in yield or diminished cone quality.

DEVELOPING QUALITY ANALYSIS INFRASTRUCTURE TO SUPPORT LOCAL MALTING BARLEY PRODUCTION

- Partner(s): Michigan State University Upper Peninsula Research and Extension Center (MSU UPREC)
- Principal: Ashley McFarland
- Primary goal(s): Procure equipment necessary to test the various quality specifications outlined in the American Malting Barley Association standards. Train staff at the MSU UPREC on use of equipment and best handling instructions for processing grain samples. Develop a fee schedule that will allow MSU UPREC to recover operating expenses, while maintaining a low-cost option for producers and maltsters to test their grain.
- Background: There is increasing interest from consumers in products that incorporate locally sourced ingredients. Brewers are therefore looking to source ingredients grown outside of current growing regions. Malting barley varieties must be selected and tested to ensure success in different growing regions, and those varieties must be tested for their malting performance and ultimately brewing properties and flavor contributions before being viable in the market.
- Additional Information: This grant answered a significant gap in lab testing capacity in the Upper Midwest and the entire U.S. There were very few economically viable options for lab analysis throughout the U.S. and none in Michigan that would handle quality analysis of malting barley grain according to the American Malting Barley Association (AMBA) standards. In addition, MSU's barley research program produced a great number of barley samples each year that were sent out of state for analysis at a cost that limited the breadth of research possible. Grant funds were used to establish a malting barley grain analysis laboratory at the Michigan State University Upper Peninsula Research and Extension Center to serve both farmers and maltsters throughout the Upper Midwest region.