DZine

honoring the illustrious career of the infamous Mike Davis

Vol. 38 | 2021

There was a king of barley into Wisconsin,
A Davis king both great and high,
He hae sworn a solemn oath
John Barleycorn must malt and brew.

He took a malthouse and malted him down,
Put water upon his head,
And he hae sworn a solemn oath
John Barleycorn shall be steeped.

But the cheerful cycles came kindly on,
And show'rs both fell and ceased;
John Barleycorn got up again,
And sore surpris'd them all.

The sultry suns of germ came,
And he grew thick and strong;
His acrospire weel arm'd wi' a pointed
spear, that no one should undermodify him.

The sober Kiln enter'd mild,
Where he grew from gold and onward;
His modbending crease and husk intact
Only show'd the rootlet to fail.

His colour mellowed and
He was cleaned and sorted;
And then the analysts began
Their eager congressing and mashing.

They've taen machines, spendy and
complex, and assessed his extract, his S/T;
His enzymes, FAN and all revealed in the
COA, all for the brewers' contemplatie.

They found him satisfactory, the brewers did
And cudgell'd him full sore;
In mills they ground him into grist
Whilst the water boiled for the mash.

They filled up a darksome pit
With water to the brim;
They heaved in John Barleycorn,
There let him sink with hops so bitter to
work him farther woe;

They wasted, o'er a scorching flame,
The marrow of his bones;
But the brewers us'd him worst of yet,
Adding hops and pitching yeast before the
ferment.

And they hae taen his very heart's blood,
And drank it round and round;
And still the more and more they drank,
Their joy did more abound.

John Barleycorn was a hero bold,
Of noble enterprise;
For if you do but taste his blood,
'Twill make your courage rise.

'Twill make a man forget his woe;
'Twill heighten all his joy;
'Twill make the widow's heart to sing,
Tho' the tear were in her eye.

Then let us toast John Barleycorn,
Each man a glass in hand;
And may his great posterity
Ne'er fail in the land ' o AMBA!

John Barleycorn: A Ballad

Robert Burns, 1782 – with liberties taken in 2021

To: Mike Davis, Barley Research Catalyst

From: Ashley, Harmonie, Pat, and Scott

Subject: The DZine

This D (for Davis) Zine is dedicated to you and your heroic efforts to support, nurture, and catalyze barley research in the US. Barley researchers from across the country have contributed short narratives and posters describing the outcomes of their research - research that was undertaken as a direct result of your untiring efforts via AMBA and the NBIC.

Thanks millions!

California

The Malting Barley Program at UC Davis is very young, starting at the beginning of this millennial, less than twenty years ago. One of the key supports to its survival has been Mike Davis with the American Malting Barley Association (AMBA). We have enjoyed his collaboration, and guidance, through all these years, as well as his assistance to secure funding for our Program. Mike contributions, through AMBA, resulted in tree new malting barley cultivars adapted to California.

His lobby efforts during the last years lead to the funding for the USDA Pest Initiative, a global effort involving the entire US Barley community of researchers and growers to improve disease resistance/tolerance to pests through the whole country.

Mike, it has been a privilege to work all these past years with you, and now it is an honor to help you to celebrate your deserved retirement.

Idaho

Mike:

On behalf of the USDA-ARS Barley Breeding Project at Aberdeen, I deeply thank you for your strong and enduring support of our barley research - and for barley research everywhere. AMBA, under your leadership, has become a most critical organization smoothing the link between researchers and end-users. Barley improvement meetings have been an effective platform for barley researchers and malting industry representatives to exchange information and discuss forward thinking issues related to the improvement of malting barley varieties. The malting quality testing system coordinated by AMBA is a valuable tool for breeding programs. With your help and efforts, the Aberdeen breeding program successfully released the popular spring variety of “Klages” and the winter varieties of “Charles” and “Endeavor” which greatly served and continue to serve the growers and malting industry. With changes in barley growing conditions, FHB has surfaced as a potential problem in Idaho. You helped our program join the US Scab initiative. We have received funding and information from the US Scab program and continue to test our breeding lines. Fortunately, we identified quite a few lines with good FHB resistance and lower DON content. These lines are widely used in our breeding development. I must mention that our agency base funding has been improved because of the lobbying effort from you with our stakeholders. You have worked so closely with the Aberdeen station, people here may not be very clear who are our national leaders, but certainly know Mike Davis!

Many Thanks,

Gongshe

Iowa

Mike Davis -

Roger P. Wise[a,b,c,d] 1989-2021

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I met Mike midway through my career, but I had heard of his impact long before that. "The barley stakeholders are very good at protecting positions" is what then ARS National Program leader, Chuck Murphy, told me at the time I mentioned changing my official status from oat to barley.

I earned my Ph.D. at Michigan State University working on the genetic fine structure of the barley *Mla* powdery mildew resistance locus (Wise & Ellingboe 1985), then followed with a postdoc where I cloned the *T-urf13* (Southern corn leaf blight) susceptibility gene from T-cytoplasm maize mitochondria (Wise et al. 1987; Schnable & Wise 1999). After that, it was back to barley at the Max Planck Institute in Köln, Germany prior to taking a position on oat crown rust with USDA-ARS at Iowa State University (Rayapati et al. 1994; Yu et al. 2001).

Being focused on the molecular mechanisms of host-pathogen interactions in cereals, I was not on the radar screen of breeding for malting quality and/or yield. But, along the way we helped to build up resources for the community such as the Barley1 GeneChip genome array (Close et al. 2004; Caldo et al. 2004; Wise et al. 2007), the PLEXdb database for gene expression of plants and plant pathogens (Dash et al. 2012), and The Hordeum Toolbox (THT) Barley CAP database (Blake et al. 2012).

I also kept reiterating that without resistance to pathogens, there would be nothing left to malt (I used the same argument with the oat stakeholders). In some way, over the years, I like to think that constant nudging eventually helped Mike along to his last big push, the Barley Pest Initiative or "BPI". This $5+ million effort to Congress brings together over 30 barley scientists at nine ARS locations, and ten University extramural collaborators in 15 states to target the top 20 fungi, viruses, bacteria, insects and nematodes that parasitize barley, devastating quality and yield.

The first $1 million was funded in FY21, with another $1 million+ in FY22. That was welcome and needed support for our project. As we learn more about the conservation of resistance signaling pathways in plants, it is clear that going forward, this effort will positively impact not only barley, but other small grain cereals, as well as more distantly related crops.

All organisms respond to stimuli through networks of interacting proteins and other biomolecules. The barley MLA nucleotide-binding, leucine-rich-repeat (NLR) receptor (Wei et al. 2002) and its orthologs confer recognition specificity to many cereal diseases, including powdery mildew, stem and stripe rust, Victoria blight, and rice blast. In this new age of genomics-assisted breeding, application of genome-scale approaches (Moscou et al. 2011; Surana et al. 2017; Velásquez-Zapata et al. 2021) will enable scientists to quickly put together relevant biological networks to model disease resistance responses. This will promote new investigations from lab to fields, critical to breeders and growers that use disease resistance to produce better crops.

Thus, as we push on with the Barley Pest Initiative, Mike's efforts will promote critical infrastructure for further research into the complex molecular components that control disease resistance in crops.

Thank you Mike!

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Michigan

Mike Davis: Servant Leader

Some in the barley community might have thought we were a bit crazy, and we probably were, but Mike and AMBA were willing to take a chance on us. Chris Kapp, Jim Isleib, and myself - all researchers associated with the Michigan State University Upper Peninsula Research and Extension Center - wanted to support the revival of malting barley in the Upper Peninsula (U.P.) of Michigan. Only problem was, malting barley had not been grown in that region for decades. Not to mention, we did not have the most hospitable growing conditions or well-defined markets. Nonetheless, the modest funding each year helped us get seeds in the ground, which we were able to leverage for additional funding to test more varieties, across multiple locations, and begin to investigate cultural practices. Funding through AMBA opened the door for us to the prominent barley researchers who were gracious with their time and expertise to help out our fledgling program. Trips to the National Barley Improvement Conference and participation on the National Barley Improvement Committee further broadened our network, thanks to Mike. Although we never quite got malting barley to the level of prominence in the U.P. we were hoping for, malting barley certainly is a recognized crop in other parts of Michigan now - feeding multiple craft-scale malthouses and enjoyed in many of the nearly 400 breweries in the state. The research program at Michigan State University, which now also includes Dr. Brook Wilke, Dean Baas, and James DeDecker owe a debt of gratitude to Mike and AMBA for taking a chance on us.

Submitted by Ashley McFarland

I first met Mike in 2016. I was working at a Michigan craft malting start up and I wanted to become more involved with the broader national and international barley community. The International Barley Genetics Symposium was being held in Minneapolis in June and I was able to secure a student registration.

I knew I was going to be out of my depth already, so when Mike extended an invitation to attend the concurrent AMBA board meeting as an associate member, I thought… why not?

Mike immediately made me feel welcome and respected, as he always does, and the experience was enlightening to say the least. As predicted, most of the symposium speakers' topics and posters were over my head, but the folks I met and conversed with that week remain in my heart.

Those experiences were critically important to me as an early-career agricultural researcher, though I wouldn't fully realize that until some years later. At the time, I had no grasp of just how influential Mike would be in my professional growth. His tireless enthusiasm, warmth, and dedication to public service are exemplary and without his support, barley research in Michigan may have withered in the field.

Submitted by Ryan Hamilton
Graduate Research Assistant
Field Crop Pathology Lab
Michigan State University

Mike Davis: Servant Leader

During my initial ventures into research in 2014 at Michigan State University's Kellogg Biological Station (KBS), I was fortunate to be introduced to the malting barley research community through relationships with Ashley McFarland and subsequent introductions to Mike Davis and the AMBA community. Subsequently, I was overwhelmed with commitment by Mike and colleagues in the research and industry communities in supporting our malting barley work, both through funding and cheering us on. Mike leveraged support from Michigan industry partners to help us in our effort and opened connections to the premier barley researchers across the country and internationally, and I will forever cherish the opportunity to engage in this community. One of the highlights of my career in this work is when Mike and team organized an AMBA meeting at Bell's Brewery, invited us at MSU to attend, and brought the whole group out to KBS for a tour of our barley research plots. Through all of these connections and funding, we've been able to learn so much about growing barley in Michigan, and also have been able to contribute to several regional and national projects evaluating barley varieties. Thanks Mike for your great leadership!

Submitted by Brook Wilke

2017-2021 WINTER BARLEY VARIETY TRIAL TRENDS

Rachel Drobnak, Brook Wilke, Dean Baas

With support from: MSU Project GREEEN, American Malting Barley Association, Michigan Craft Beverage Council

Background

The craft beverage industry is increasingly becoming an important part of Michigan's economy; in fact, the craft beer value chain in 2016 was estimated to contribute over $500 million to the Gross State Product (Miller et al., 2019). Currently, a goal in the sector is to provide local sources of malting barley to craft brewers and maltsters. Understanding winter barley varietal performance is important for Michigan producers, since varieties can differ widely in yield, disease resistance, phenology, and quality measurements.

MSU Extension, in collaboration with MSU AgBioResearch and the LTAR (Long-Term Agroecosystem Research) Project at W.K. Kellogg Biological Station, has conducted a Winter Barley Variety Trial since 2017 at Hickory Corners (Kalamazoo County) and Kawkawlin (Bay County). Over the course of five years, 85 varieties of winter barley have been tested for agronomic and malting quality data, and about 40 have been tested for at least two years. This long-term research is valuable because it is difficult to conduct multi-year, multi-location varietal studies and gather quality data. These data are crucial in helping producers, maltsters and brewers make decisions about varieties that produce optimal yields and quality in Michigan's climate.

Above. 2021 Winter Barley Variety Trial at KBS

Below, 2-row (left image) and 6-row (right image) winter barley

Methods

In this analysis, we investigated which varieties are best performing (i.e., highest yield, highest quality metrics), how varieties differ in phenology (i.e., heading and maturity date), and which varieties are most susceptible to disease and extreme weather. We used quality data thresholds provided by the American Malting Barley Association to judge performance. To organize the data, we referenced tables from the MSU Wheat and Soybean Variety Trial publications to formulate methods for multi-year comparisons.

AMBA Quality Metrics	
RVA (>120)	Rapid Visco Analysis; degree of pre-harvest sprout damage
CP (<12.5%)	Crude Protein; impacts ability to produce malt extract
Plump (>90%)	Size and uniformity of kernel; ensures water is absorbed evenly when steeped
DON (<1 ppm)	Deoxynivalenol; indicates presence of Fusarium, a mycotoxin

Background & Management: Hickory Corners

	2017	2018	2019	2020
Planting date	9/27/16	9/26/17 @ 120 lbs/A	10/16/18	10/10/19
Fertility	9/27/16 – 20 lbs N/acre, 100 lbs P/ acre, 50 lbs K/acre 4/12/17 – 12 S/acre, 102.5 lbs N/acre (50 lbs AMS + 200 lbs urea/acre)	9/26/17 – 20 lbs N/acre, 65 lbs K/acre 4/5/18 – 12 S/acre, 102.5 lbs N/acre (50 lbs AMS + 200 lbs urea/acre)	10/16/2018 – 20 lbs N/acre, 45 lbs P/ acre, 65 lbs K/acre, 6.3 lbs S/acre. 4/10/2019 100 lbs N/ acre (urea)	10/8/2018 – 32 lbs N/acre, 52 lbs P/ acre, 12 lbs S/acre. 3/27/2020 60 lbs K/ acre, 100 lbs N/acre, 10 lbs S/ acre.
Fungicide	5/26/17 – 8 oz./acre Prosaro®	5/29/18 – 8 oz/acre Prosaro®	5/31/2019 8.2 oz/A Prosaro	5/27/2020 13.7 oz/acre Miravis Ace
Harvest	6/30/17	7/2/18	7/17/19	6/30/20
Growing season conditions	Fall and winter were much warmer than usual, with tempera- tures becoming more normal into summer. Over-winter, the site received more rain than snow, however, spring and summer were a bit dryer than normal.	September was warm and very dry, but a switch to wet and cool conditions oc- curred mid-October, and cool conditions persisted through April delaying crop development. Temperatures turned warm in May with adequate rainfall un- til mid-June when conditions turned dry	An unusually cold wet spring delayed devel- opment. There was also some winter kill.	A cool and wet peri- od in April and early May was followed by intermittent dry peri- ods until harvest.
Previous crop	-	Soybeans	Soybeans	Soybeans
Soil type	-	Kalamazoo Sandy Loam	Kalamazoo Sandy Loam	Kalamazoo Sandy Loam

2021 Winter Barley Variety Trial at KBS.

Background & Management: Kawkawlin

	2018	2019	2020
Planting date	10/3/17 @ 120 lbs/A	10/17/2018	10/26/19
Fertility	Fall of 2017- 150 lbs./ac of 10-10-30 was broadcast and then incorporated. Spring of 2018- 35 gals/ac of 28% N plus 9 lbs./ac S.	Fall – 10 lbs N/acre, 10 lbs P/acre, 30 lbs K/acre 4/25/2019 – 100 lbs N/acre (28%)	10/26/2019 – 15 lbs N/acre, 15 lbs P/acre, 45lbs K/acre. 5/16/2020 100 lbs N/acre (urea)
Fungicide	8.2 oz./acre of Prosaro® at heading.	5/18/2019 – 10 oz./acre Nexicor	None
Harvest	7/6/18	7/26/19	7/17/20
Growing season conditions	Similar to Hickory Corners, cooler than average temperatures persisted from planting through April. Subsequently, this site experienced drought conditions during grain fill. Crop height was short and lodging was not present at harvest.	An unusually cold wet spring delayed development. There was also some winter kill.	Late planting led to limited fall growth, including no fall emergence for a few varieties. A portion of the plot area was removed from analysis due to winter injury from ponding.
Previous crop	Dry beans	Dry beans	Dry beans
Soil type	Wixom Sandy Loam	Wixom Sandy Loam	Wixom Sandy Loam

Harvesting the 2021 Winter Barley Variety Trial in Kawkawlin.

Grain Yield

Variety	HC 2-Yr Avg	KK 2-Yr Avg	HC 3-Yr Avg	KK 3-Yr Avg	HC 4-Yr Avg
08ARS509-1	106.95	90.20	-	-	-
08ARS632-5	98.20	81.35	-	-	-
13ARS537-13	97.50	79.50	-	-	-
13ARS537-19	71.00	79.75	-	-	-
AC13/028/53*	109.75	96.15	-	-	-
Charles	74.20	63.50	72.10	61.73	81.33
DH130910	80.10	83.00	85.80	77.73	102.85
DH140088	100.20	83.95	96.73	82.30	-
DH140963	109.00	85.05	-	-	-
Endeavor	75.70	64.30	79.83	61.00	88.63
Flavia	104.05	93.45	101.27	84.77	113.70
Hirondella*	102.20	91.30	98.00	76.90	112.50
KWS Scala	93.15	97.50	-	-	-
LCS Calypso	91.10	86.40	-	-	-
LCS Casanova	108.80	69.10	-	-	-
LCS Nenea	101.65	74.55	-	-	-
LCS Puffin	101.05	73.45	-	-	-
LCS Violetta	73.65	53.40	-	-	-
Lyberac	100.10	85.00	102.17	78.60	-
Nomini*	85.00	73.20	-	-	-
Rossignola*	116.05	89.45	-	-	-
Secretariat	89.55	81.30	-	-	-
Thoroughbred*	86.65	75.05	84.93	64.60	103.95
Wintmalt	85.90	73.70	82.83	65.83	94.13

Top 33% of varieties, by column

Table 1. Yield averages over 2-,3-, and 4- consecutive years, by site (HC: Hickory Corners, KK: Kawkawlin). "*" indicates 6-row varieties

Winter barley at KBS.

Malting Quality

Variety	Site Years AMBA Quality			
	RVA	CP	Plump	DON
Wintmalt	6/6	5/6	5/6	4/5
LCS Calypso	4/4	3/4	3/4	3/3
LCS Puffin	4/4	3/4	4/4	3/3
Flavia	3/6	6/6	6/6	4/5
Lyberac	3/3	3/3	4/5	2/3
Hirondella*	3/6	4/6	4/6	2/5
DH130910	4/4	2/4	4/6	2/3
LCS Violetta	3/4	2/4	3/4	2/3
KWS Scala	3/3	3/3	3/3	2/3
LCS Casanova	3/3	2/3	3/3	2/3
LCS Nenea	3/3	2/3	2/3	2/3
08ARS632-5	2/3	2/3	3/3	2/3
DH140963	3/3	3/3	3/3	1/3
Thoroughbred*	6/6	5/6	0/6	3/5
MW12_4007-001*	2/2	2/2	0/4	1/1
Charles	0/6	4/6	4/6	4/5
DH140088	1/3	2/3	4/5	2/3
Endeavor	1/6	5/6	2/6	4/5
Rossignola*	2/3	3/3	3/3	1/3
13ARS537-13	1/3	3/3	3/3	2/3
13ARS537-19	1/3	3/3	3/3	2/3
SU_Mateo	2/3	3/3	1/3	2/2
AC13/028/53*	0/2	2/2	2/2	0/2
Nomini*	3/3	2/3	0/3	1/3
Secretariat	3/3	2/3	1/3	1/3
08ARS509-1	1/3	3/3	1/3	2/3
VA11B-141LA	2/2	2/2	0/2	0/2
Amaze 10*	0/2	1/2	0/2	2/2

Achieves standard >67% of site years sampled
Achieves standard 33%-67% of site years sampled
Achieves standard <33% of site years sampled

Table 2. Frequencies of passing AMBA quality standards for RVA, CP, Plump, and DON. "*" indicates 6-row varieties

Phenology

Variety	Heading Date			Maturity Date	
	2021	2020	2019	2021	2020
Nomini*	15-May	21-May	21-May	28-Jun	25-Jun
Secretariat	16-May	21-May	26-May	29-Jun	28-Jun
Thoroughbred*	17-May	23-May	26-May	28-Jun	28-Jun
13ARS537-19	18-May	24-May	26-May	21-Jun	25-Jun
13ARS537-13	18-May	24-May	30-May	25-Jun	25-Jun
Visuel*	19-May	25-May	-	21-Jun	27-Jun
Thunder	19-May	25-May	-	23-Jun	25-Jun
KWS Faro*	20-May	23-May	-	25-Jun	28-Jun
Pixel*	20-May	25-May	-	28-Jun	28-Jun
Amaze 10*	20-May	-	27-May	28-Jun	-
VA16M-84	21-May	26-May	-	25-Jun	27-Jun
VA16M-81	21-May	25-May	-	28-Jun	28-Jun
Charles	23-May	24-May	1-Jun	21-Jun	25-Jun
Flavia	23-May	26-May	27-May	21-Jun	26-Jun
LCS Violetta	23-May	27-May	29-May	21-Jun	27-Jun
KWS Scala	23-May	27-May	1-Jun	23-Jun	26-Jun
OMU19	23-May	26-May	-	24-Jun	27-Jun
Hirondella*	24-May	27-May	31-May	24-Jun	28-Jun
Endeavor	25-May	27-May	3-Jun	26-Jun	27-Jun
Wintmalt	26-May	28-May	9-Jun	27-Jun	27-Jun
DH140963	26-May	27-May	31-May	28-Jun	26-Jun
KWS Somerset*	26-May	27-May	-	28-Jun	28-Jun
OMR19	27-May	27-May	-	26-Jun	26-Jun
LCS Calypso	29-May	25-May	27-May	23-Jun	25-Jun
DH141132	30-May	28-May	-	28-Jun	27-Jun
OMZ19	30-May	28-May	-	28-Jun	27-Jun
LCS Puffin	1-Jun	25-May	31-May	26-Jun	25-Jun

Earliest 1/3rd heading/maturing, by year
Middle 1/3rd heading/maturing, by year
Latest 1/3rd heading/maturing, by year

Table 3. Average heading and maturity dates. Phenology data was only collected at Hickory Corners. "*" indicates 6-row varieties

Discussion

Grain Yield

- Yield averages vary by year and location due to external factors, including weather and management
- Flavia and Hirondella had consistently high yields (and generally produce high quality grain), but are more susceptible to pre-harvest sprout
- Charles and Endeavor had consistently low yields as well as lower quality grain
- Higher yielding varieties do not necessarily relate to higher malting quality (ex: Rossignola, AC13/028/53)

Malting Quality

- Varieties tend to achieve high quality scores in some metrics and low scores in others, across multiple years and locations. One example, Thoroughbred (a six-row variety), has high quality except in Plump
- CP is consistent among varieties and is more influenced by management and other factors than variety

Varieties susceptible to pre-harvest sprout

- Charles
- Endeavor
- Hirondella

Pre-harvest sprout in winter barley

Phenology

- There is no visible relationship between heading and maturity date
- 6-row varieties tend to have earlier heading dates and later maturity dates
- Most varieties trend in the same heading/maturity date range over multiple years
- Earlier maturing varieties (ex: LCS Calypso) allow more flexibility for double cropping systems
- Varieties with consistent heading date ranges (ex: Secretariat) allow for optimal fungicide applications to protect against Fusarium head blight

Overall Recommendations

Best performing (highest yield & malting quality)

- *Flavia*
- *Hirondella*
- *Wintmalt*
- *Lyberac*

Worst performing (highest yield & malting quality)

- Charles
- Endeavor

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Acknowledgments

Thank you to the following for your support: Karen Beaubien, James DeDecker, Josh Dykstra, Ryan Hamilton, Aaron MacLeod, Christian Kapp, Ashley McFarland, Dr. Luke Reese, Allison Smith, Kevin Smith & 2017-2020 Kellogg Farm interns

Funding for this research comes from:

American Malting Barley Association, Inc.

Michigan Brewers Guild

Project GREEEN

Learn more

For more information about small grains for brewing and distilling visit the MSU Extension Malting Barley website. Questions regarding the event can be directed to Brook Wilke (wilkebro@msu.edu) or Dean Baas (baasdean@msu.edu).

Minnesota

Mike has been an indefatigable champion for increasing investment in barley research across the US. At the University of Minnesota, his efforts resulted in expanding the barley breeding program to include two-rowed and winter barley, developing new breeding tools to improve agronomic and quality performance, and enhancing our ability to combat important diseases in the region. These important research efforts were supported not only by direct investment through AMBA, but also through his deft lobbying skills with Congress to gain additional dollars to support the USDA-ARS labs and NIFA and ARS research projects. The Cereal Disease Laboratory in St. Paul, Cereal Crops Research Unit in Madison, and the Small Grains Genotyping Center in Fargo are just a few of the key elements of the national barley research infrastructure that Mike helped build and have supported the UM barley research team. Perhaps as important as improving the research infrastructure for barley was Mike's role in fostering strong collaboration between researchers and the malting and brewing industries. Communicating a clear picture of the current and future needs of these industries helped to insure that the science we were doing at the University of Minnesota would have an impact in the real world. We are all indebted to Mike for his tireless efforts to advance barley research and the end uses for the crop. Think Barley! Drink Beer! Skol!

Brian J. Steffenson
Distinguished Global Professor
Lieberman-Okinow Endowed Chair
Department of Plant Pathology
University of Minnesota

International Barley
Genetics Symposium

U of MN Varieties

Manchuria	1918
Minsturdi	1922
Svansota	1926
Velvet	1926
Peatland	1926
Glabron	1929
Regal	1931
Mars	1945
Forrest	1957
Cree	1957
Manker	1974
Morex	1978
Robust	1983
Excel	1990
Stander	1993
Royal	1994
MNBrite	1998
Lacey	2000
Rasmusson	2008
Quest	2010

BARLEY IMPROVEMENT

Advanced Yield Trials are evaluated by barley breeder Kevin Smith at the NW Research and Outreach Center, Crookston, MN

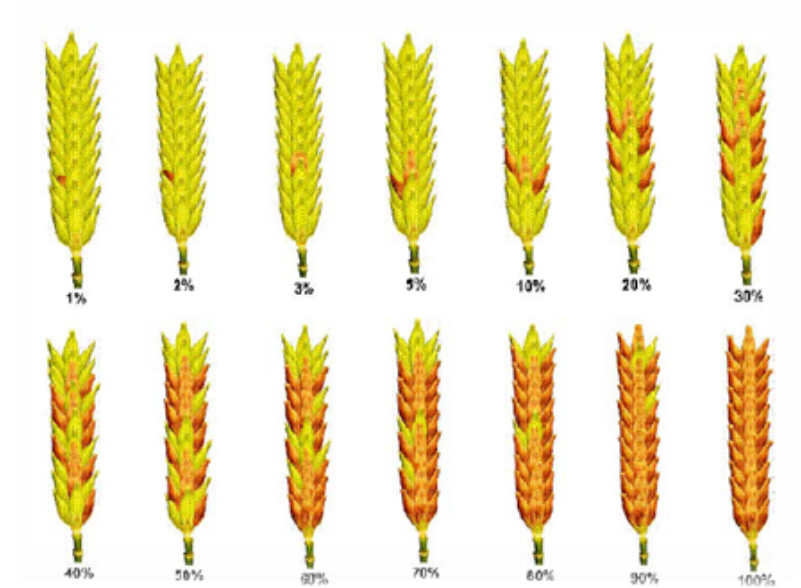
UNIVERSITY OF MINNESOTA
Driven to Discover℠

The Fusarium Head Blight Experience

Research Update from the US Wheat and Barley Scab Initiative

Kevin Smith - University of Minnesota

2003 Barley Improvement Conference, January 8, 2003
Sir Francis Drake Hotel, 450 Powell Street, San Francisco, California



Breeding for Fusarium Head Blight Resistance

ROW THE BOAT
MINNESOTA
Paul Bunyan
FOOTBALL TROPHY
NATIONAL W CLUB
1948
WISCONSIN
MINNESOTA

Montana

Research | Service | Education

~MSU BARLEY BREEDING~

THANKS MIKE DAVIS FOR YOUR SUPPORT OF MSU'S

~Spring and winter breeding

~In house malting & brewing capabilities

~Malt quality analysis from early generations, F5s on

~Hockett release, dryland stable

~Buzz barley release, low protein dryland stable

~Undergrad, Masters & PhD training

~Collaborative & innovative research

~Cutting edge drone technology

~Genetic techniques for high throughput selection

~Public resource for the full barley value chain

Nebraska

Helping Barley in the Wilderness:

Though the Great Plains once had a large winter barley community, in the late 20th and early 21st centuries, it dwindled to programs at the University of Nebraska and USDA-ARS at Stillwater OK. Every year I would be asked do you want to keep winter barley research going? Fortunately, Mike Davis, with limited resources, provided small grants from AMBA, enough to document that winter barley still had an interest and a place in the Great Plains. Equally importantly, he opened doors at the Brewers Association and at the federal agencies to continue barley research. Through these funds, the winter barley projects will continue at the University of Nebraska and the USDA-ARS for the foreseeable future. What really makes Mike so important is that he took the time to help researchers develop compelling grants and methods to lobby Congress and federal agencies so that barley always had a "voice at the table". He was the spokesperson and the face of barley at the national level. Mike was that needed honest broker of what needs to be done, what could be done, and then how to get it done. In summary, he was the researcher's and the industry's best friend. ***Thank you!***

P. Stephen Baenziger
University of Nebraska-Lincoln

North Dakota

The activities of Mike Davis played instrumental roles in the growth and development of the USDA-ARS Cereal Crops Unit and its scientists at Fargo. Probably the most significant achievement was the acquisition of funds to establish the small grains genotyping lab (also the other three labs at Pullman, Manhattan, and Raleigh). This along with strong and continuous support of the barley and wheat research projects by Mike over the last 20 years played a substantial role in getting the Fargo Cereal Crops Unit and its research scientists recognized on an international level. The careers of numerous smalls grains scientists including Justin Faris, Timothy Friesen, Steven Xu, Shiaoman Chao, Shunwen Lu, Linda Dykes, Jae-Bom Ohm, Lynn Dahleen, Prem Jahuar, and Mike Edwards all benefited directly from Mike's efforts, and recent new hires including Shengming Yang, Jason, Fiedler, Raj Nandety, Craig Carlson and other positions yet to be filled also greatly benefited indirectly from the notoriety of the unit obtained through research achievements that would not have been possible without the support of Mike and his efforts through AMBA. The scientists at the USDA-ARS Cereal Crops Research Unit in Fargo, both past and present, are truly grateful to Mike for all his years of hard work, dedication, and support.

Justin Faris, Tim Friesen, Shengming Yang, Jason Fiedler

USDA-ARS Cereal Crops Research Unit, Fargo, ND

Ohio

Sometime late 2012 I received an invitation to present a talk at the 2013 Barley Improvement Conference. It would be my first BIC meeting and I was extremely nervous.

The talk was titled “Insight into the genetic basis of winter-hardiness and the potential this has to alter US malting-quality barley.” It connected recent discoveries partially explaining winter-hardiness, to work done nearly 50 years earlier funded by Anheuser-Busch Inc. and the Malting Barley Improvement Association for development of two-row winter-hardy malting barley for Missouri.

Mike welcomed me into the group without hesitation. The following year several key things happened that had critical and lasting effects. Firstly, Mike encouraged me to submit a proposal to the American Malting Barley Association grants program. What happened next was mind-blowing. The 2013–14 winter morphed into a true test winter – nearly every barley plant in my field was winterkilled – except for those old Missouri lines and a few offspring I developed from them. Then that spring Mike suggested to Andy Tveekrem, craft brewing pioneer, that he should come visit my field plots.

Mike has been a unifier of the barley community, working to support those in it, and made it fun to be part of.

Eric J. Stockinger
The Ohio State University
Department of Horticulture and Crop Science
Wooster OH 44691
stockinger.4@osu.edu
https://stockingerlab.osu.edu/

Oregon

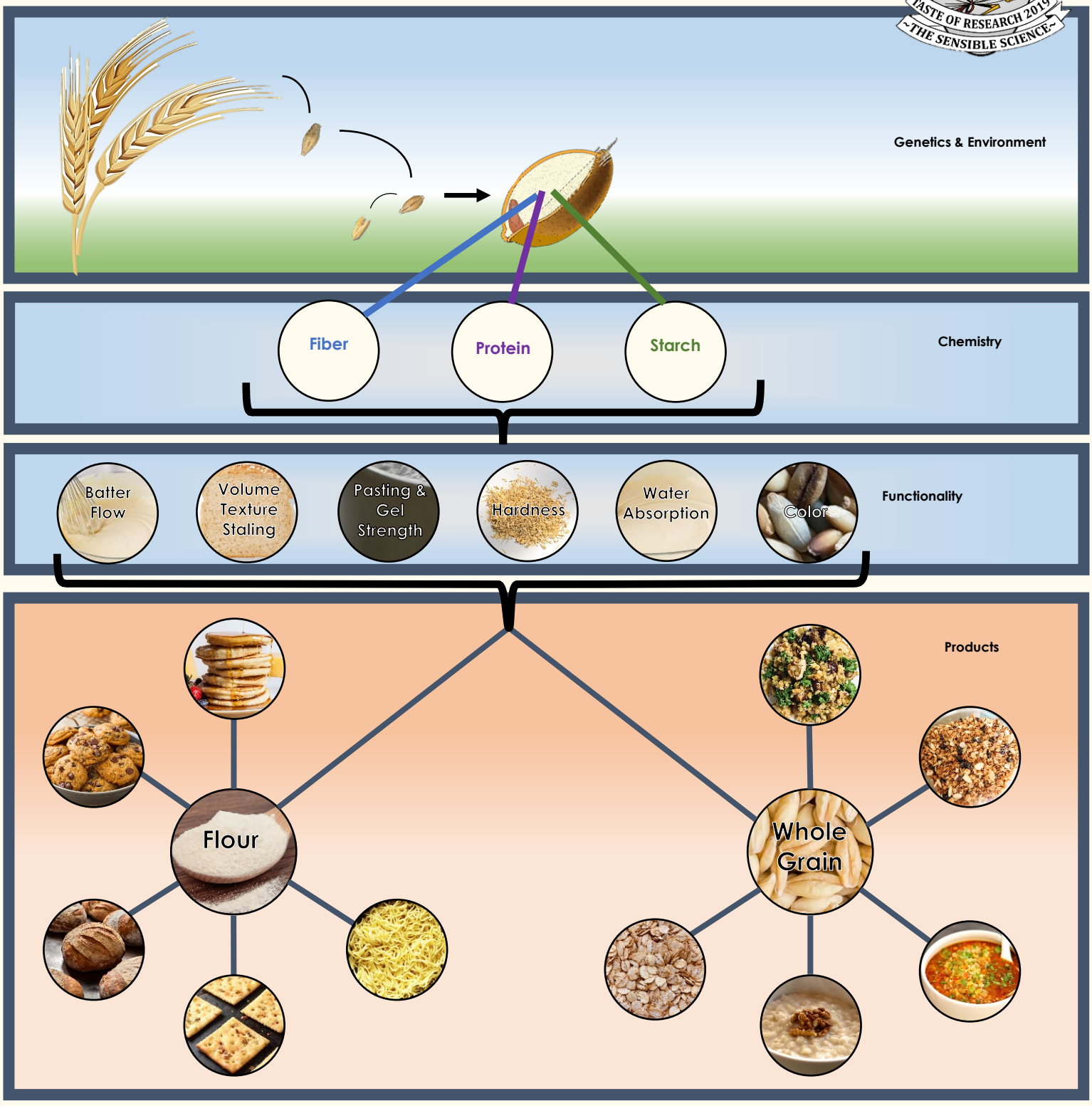
Mike:

Personally, and on behalf of the Oregon State University Barley Project, our deepest thanks for championing our barley research - and barley research everywhere. As I recall, it all started when you came out to personally convey the news that AMBA would no longer fund the OSU Barley Program. I was new on the job and was all about doubled haploids and international barley improvement. Your one wee whiff of *Hordeum bulbosum* pollen changed everything! AMBA funding for our program continued, and grew. AMBA funding led to other direct industry funding and – most importantly – recurring Federal funding. First came the North American Barley Genome Mapping Project, and later its successor the Barley Genome Mapping Project. When special grants were no longer the route to go, you helped to ensure NACAs – stripe rust, stem rust, and now scald (via the BPI). You also ensured we got on board with doubled haploid production for the USWBSI. This recurring funding for fundamental research resulted in a steady stream of publications and spin-off competitive grants. The core funding, however, was always from AMBA - and that ensured a continual focus on developing malting barley varieties. Your support and patience as we worked through 6-rows, off-beat spring 2-rows was essential. And then we all saw the light: 2 rows!!!! First out the chute was Thunder: on the AMBA recommended list and quite possibly in a bottle in your fridge. Thanks millions.

Pat

Jordyn Bunting | Graduate Research Assistant | M.S. | Advisor: Dr. Andrew Ross

Food Quality and Functionality of Naked Barley

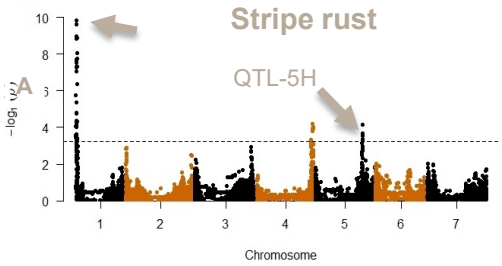


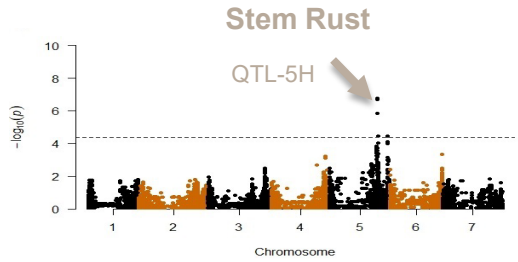
Oregon State University

Developing a framework for making fiber-rich foods delicious

Barley Disease Resistance Research

Premise: Stripe rust, stem rust, and scald are actual and/or potential threats to sustainable barley production. Climate change will exacerbate the impact of these diseases. Mapping, characterization and introgression of resistance genes into 2-row winter/facultative malting backgrounds will help to ensure a reliable supply of quality malting barley.





Milestones, since 2016

Population	#DH	Genotyping	Phenotyping	Output
Cycle I	123	9K	Stripe, Stem Rust	Hernandez et al 2019
Cycle II	384	50K	Stripe, Stem rust and Scald	Hernandez et al 2020a,b
Cycle III	384	50K	Stripe and Stem Rust	In prep
Cycle IV	661	50K	Stripe, Stem rust, Scald	Ongoing
AMBA-LTT	384	50K	Stripe rust and Scald	In prep
Bi-parental		GMS	Stripe and Stem Rust 5H	On going

Barley Doubled Haploid Production and the USWBSI

Rationale: Doubled haploids – completely homozygous – facilitate gene discovery, variety selection, and expansion of genetics knowledge.

2017-2020 Milestones

238 F1 Donors Planted

2,653 Tillers Collected

79,590 Anthers to Tissue Culture

7,597 Plantlets Regenerated

4,184 Doubled Haploids Produced

Oregon State University

Barley Genotype & Beer Flavor

Research has shown that barley genotype contributes to malt and beer flavor. Over the last decade an experimental pipeline has been developed to assess this impact using current varieties and novel germplasm.

Using this pipeline we are embarking on new experiments to assess the interaction of genotype with malting parameters and brewing process on beer flavor. As well as investigating the contribution of heirloom variety genetics to flavorful barley.

Milestones

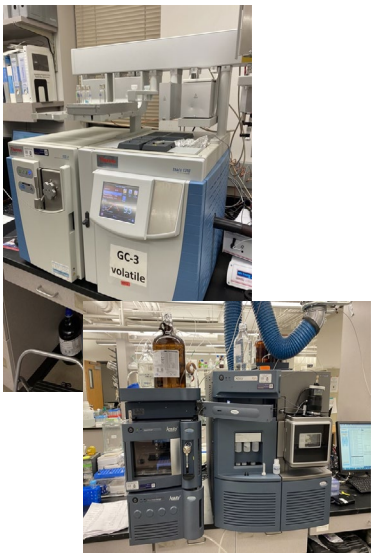
- **Herb et al. 2017** – Sensory panels can detect differences between beers brewed with different barley genotypes and from different growing environments
- **Bettenhausen et al. 2018** – Similar base malts malted at different locations have distinct chemical profiles
- **Bettenhausen et al. 2020** – Metabolomics and beer sensory can detect differences in beers made with similar malts of different genotypes
- **Windes et al. 2020** – Chemical and sensory analysis of malt hot steeps can be used in order to better trace barley genotype contributions to malt and beer flavor
- **Morrissy et al. 2021** – Reaffirms that barley genotype contributes to beer flavor, but the specific contributions of heirloom varieties remain a mystery.

The Flavor Pipeline

Malting

Hot Steep & Beer Sensory

Metabolomics



Oregon State University

Malting and Brewing with Naked Barley

Barley is the optimum substrate for malting and brewing/distilling

Most malting barley varieties are covered: the adhering hulls provide a natural filtration system

Advances in brewing technology, including mash filters, can replace the hull

Naked barley (free-threshing) has the potential to have significantly higher levels of malt extract and improved beer quality

Adjustments may be needed to optimize the malting of naked barley

Potential advantages in brewing:

- Lower transportation and storage costs
- Higher extract levels
- Lower astringency
- Improved stability in finished beer

Our study:

- Two naked selections + covered check malted in the OSU Mini-malter
- Three malts x two brewing methods (lauter tun + rice hulls and mash filter) brewed by OSU Fermentation Science
- Trained and consumer panel sensory assessments

Barley germplasm and variety development

The development of malting barley varieties has been the central mission of the OSU program since 1986. Key synergistic elements are doubled haploids, extensive phenotyping and genotyping, constant communication with growers and industry, and dedication to the goals of the Land Grant system: stimulating economic development, contributing to the body of knowledge, and educating.

Genetic stocks, populations and arrays
From Steptoe x Morex
To Multi-rust Cycle 5

Knowledge
From quality QTLs to flavor

Germplasm development and characterization

Varieties
Winter/facultative focus
Occasional springs
From 6-row to 2-row
Maja to Thunder
More on tap!

Education and Outreach
BarleyWorld and beyond!

Oregon State University

Washington

I first met Mike in the late 90s as an undergraduate student at WSU over a beer of course. I had no idea of his impact on barley research, but across my 25 year career working with barley I've come to know Mike as the most influential advocate for barley research in the US. After joining NDSU I had the pleasure of joining Mike in DC as a member of the National Barley Improvement Committee. During the lobbying trips I was deeply impressed by his influence on the hill and amazed by the voice he gave the barley research community. I won't forget a meeting where Mike became so impassioned by what was being said across the table that he blew a vein in his eyeball, which instantly turned bright red making some of those opposing his view on the opposite side of the table visually squeamish. I'm grateful that I got a taste for the work he does and the power of a leader when they go up to bat for something they believe in. The barley community will miss his voice and tenacity in his retirement, but I'm still not convinced that he has really retired.

Bob Brueggeman, WSU barley breeder

Strategic malting barley improvement for craft brewers through consumer sensory evaluation of malt and beer

Evan B. Craine[1], Stephen Bramwell[2], Carolyn F. Ross[3], Scott Fisk[4], Kevin M. Murphy[1]

[1]Department of Crop and Soil Sciences, Washington State University; [2]Thurston County Extension, Washington State University; [3]School of Food Science, Washington State University; [4]Deparment of Crop and Soil Science, Oregon State University

Objective

Can insights into beer liking and sensory attributes be gained through hot steep malt sensory using an untrained panel of craft beer consumers ($n = 95$)?

Results

- Washington State University barley breeding lines had higher consumer acceptance than the control variety, CDC Copeland
- Each genotype had a distinctive beer flavor profile, such as 12WA_120.14 (fruity and sweet aromatic), which had the highest consumer acceptance ratings, and 10WA_107.43 (citrus), which has been released as the variety "Palmer"
- Different barley genotypes present varied sensory properties in the final beer and particular malt and beer sensory attributes may influence consumer acceptance, such as chemical and fruity

Acknowledgments

Full article DOI: 10.1111/1750-3841.15786
(Journal of Food Science)

Towards Identification of Stem Rust Pathogenicity Loci Evolved for Virulence against Major Barley R-genes

Arjun Upadhaya and Robert S. Brueggeman
Dept. of Crop and Soil Science, Washington State University, Pullman, WA, USA

Introduction

- Stem rust caused by *Puccinia graminis* f. sp. *tritici* is a devastating disease of barley and wheat, worldwide.
- Recently, we identified highly virulent isolates of stem rust from the PNW region that overcame the major barley R-genes *Rpg1* and *rpg4/5*.
- We believe that identification and characterization of pathogenicity loci is crucial for the deployment of durable and effective sources of resistance in barley against this population.

Hypothesis

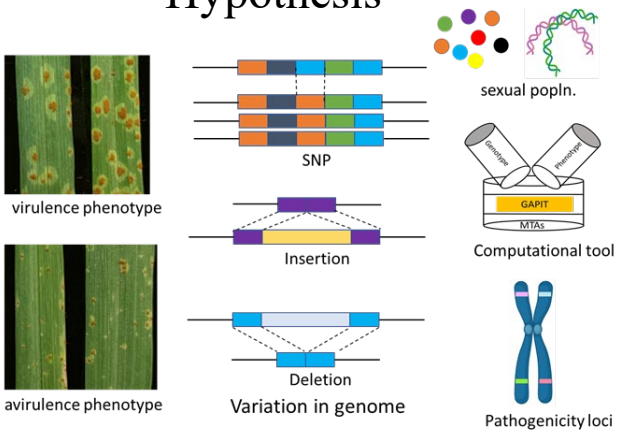


Fig.1 Pictorial form of hypothesis

1. Sexual recombination during sexual phase in native Mahonia plants can rapidly generate diverse virulent isolates in the PNW region.
2. Pathogen phenotype is associated with variation in the pathogen's genomes. Observed phenotype and the pathogen genotype data together can be used to identify pathogenicity genes with the aid of bioinformatics tools and association mapping.

Methodology

- Collect pathogen phenotype data through screening of five barley and twenty wheat differentials.
- Generate genotype data through whole genome sequencing of 96 diverse isolates.
- Use association mapping approach to identify pathogen loci/genes interacting with corresponding R-genes in the cereal hosts.

Results

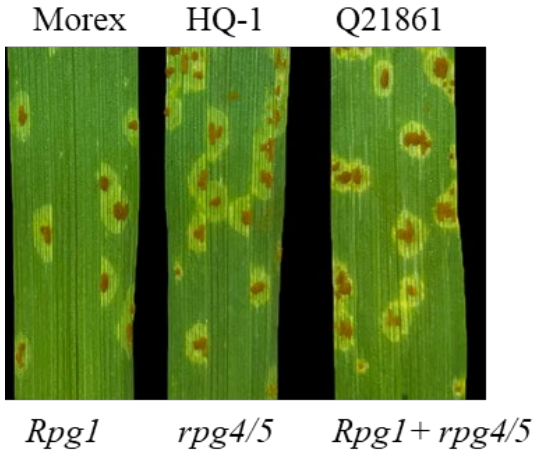


Fig.2 PNW isolate, Lsp21 virulent on major barley R-genes, *Rpg1* and *rpg4/5* when stacked together in barley line, Q21861.

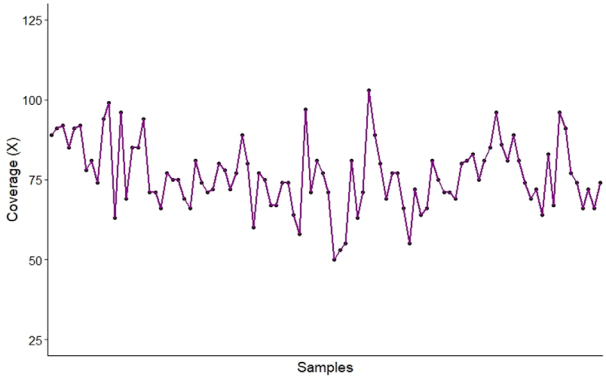


Fig.3. Average genome coverage of 96, stem rust isolates obtained through whole genome sequencing.

Conclusion

Identification of pathogenicity loci will help to unravel the genetic cause of virulence gain in the PNW stem rust population.

WASHINGTON STATE UNIVERSITY
USDA Agricultural Research Service
Barley Pest Initiative (BPI)

Unravelling the *Rpt5/Spt1* net blotch resistance hub on barley chromosome 6H

Karl Effertz and Robert S. Brueggeman
Department of Crop and Soil Science, Washington State University, Pullman, WA 99164, USA

Introduction

A locus on barley chromosome 6H harbors both broad spectrum resistance and isolate specific susceptibility to the destructive necrotrophic pathogen *Pyrenophora teres* f. *teres (Ptt)*, the causal agent of net blotch of barley. Analysis of this locus revealed an unprecedented level of polymorphism coupled with non-canonical recombination surrounding the locus, leading us to believe that the locus is under extreme diversifying pressure by the pathogen. We present high resolution mapping results and preliminary validation of one of the genes underlying this important locus.

Methodology

- High resolution mapping using 1,920 CI5791(r) x Tifang (s) F_2 recombinant gametes delimited the Rpt5/Spt1 locus to ~3Mb containing two strong candidate genes
- Barley stable transformants harboring a candidate receptor like protein (Rpt5/Spt1) from resistant line CI5791 displayed a shift towards resistance (~6.5 → ~3.5)

Results

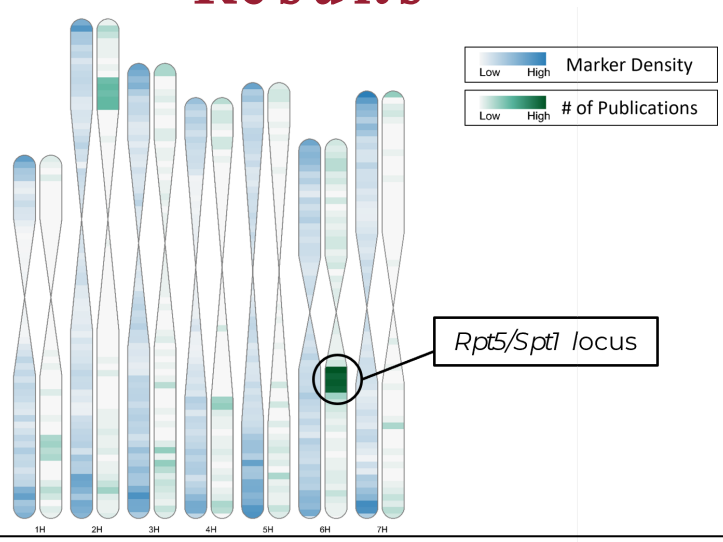


Figure 1 – Map of marker density and publication frequency of all reported loci in the barley-net blotch pathosystem. The *Rpt5/Spt1* locus is the most reported locus in this pathosystem, harboring both resistances and susceptibilities (modified from our book chapter summarizing this pathosystem -Effertz et al. 2021).

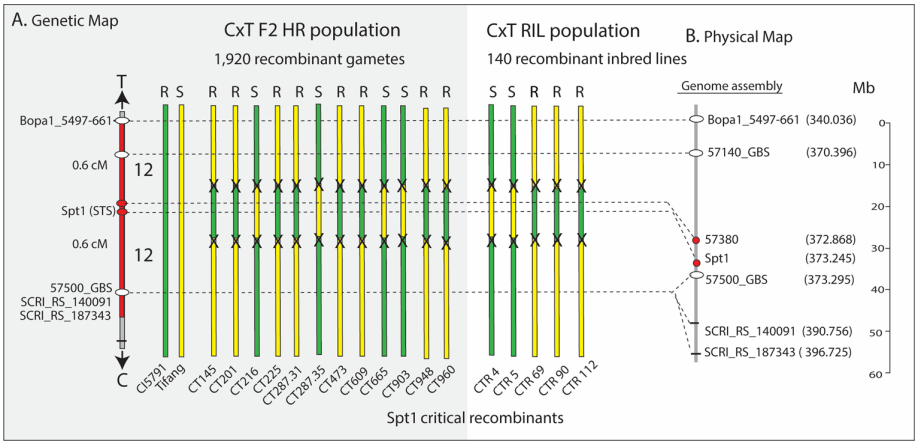


Figure 2 – Genetic map showing the results of our high-resolution mapping efforts. The high rate of double recombination observed surrounding this locus in ~5% of individuals was confirmed in a CxT RIL population (right) and a Steptoe x Morex DH population (not pictured) leading us the hypothesize that this may be a conserved evolutionary mechanism to retain the function of this important locus.

Future Direction

- Expression analysis in natural and *Spt1.C* transgenic lines to determine the role of *Spt1.C* allele
- Validate additional gene(s) within this locus responsible for robust resistance observed in landrace CI5791

WASHINGTON GRAIN COMMISSION
WASHINGTON STATE UNIVERSITY

From SNP to Sip; Improving Barley Malt Quality at Washington State University

Matthew J. Brooke and Robert S. Brueggeman
Department of Crop and Soil Science, Washington State University, Pullman, WA 99164, USA

Introduction

The purpose of this research is to utilize marker assisted selection (MAS) to identify lines with elite malt quality characteristics during the early generation selection process. A 526 SNP marker, panel spread evenly across the barley genome, was designed to provide marker data with malt quality traits including low b-glucan, low protein, high α-amylase, and enzyme extract. This marker panel coupled with a new state of the art inhouse malt quality testing lab (**Figure 1**) will accelerate the 2-row spring and winter malt barley breeding programs to meet AMBA quality with wide adaptability to the diverse Pacific Northwest growing regions.

Methodology

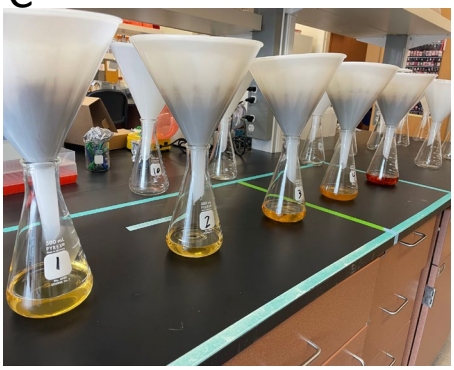
- Develop association mapping panel of 300 experimental lines from WSU
- Genotype population using 526 SNPs
- Collect Malting data from 2021 and 2022 growing season
- Malting data and genotyping data will be used to run association mapping to identify malt quality QTL within the WSU breeding program

New WSU Malt Lab

A

B

C



D

Figure 1 A: Curio micro malter and kiln to achieve experimental levels of germination and modification for malt quality analysis. **B**: WSU elite lines from the germination tanks to be kilned. **C**: Congress wart extraction. **D**: Robotic ThermoScientific Gallery analyzer for high throughput analysis of Beta glucan, Alpha Amylase, Extract and Diastatic power.

Future Direction

- Select and develop elite WSU spring and winter malt barley varieties that meet AMBA quality standards adapted to the PNW
- Establish service lab to support growers, maltsters and breweries in the region

Pinpointing the region of the barley genome contributing to hybrid disease susceptibility

Shaun J. Clare and Robert S. Brueggeman
Department of Crop and Soil Science, Washington State University, Pullman, WA 99164, USA

Introduction

Hybrid barley production is on the rise as hybrid vigor/heterosis can boost yield, however this can also lead to unexcepted consequences. Using two populations generated from crosses between resistant parents have exhibited hyper susceptibility to the disease spot form net blotch in all F_1 progeny and approximately half of F_2 progeny (**Figure 1**) which was designated the susceptibility to *Pyrenophora teres* 2 (*Spt2*) gene. This extreme transgressive segregation in a deleterious manner has previously not been documented and warrants further investigation.

Methodology

- Three rounds of phenotypic and genotypic screening of over 1000 F_2 progeny from CI5791×Tifang delimited *Spt2* to ?Mb (**Figure 2**).
- Markers were developed for PCR-GBS using the barley 9K, 50K and exome capture.
- QTL mapping was performed using MapDisto 2.1 and Qgene 4.4.0.

Results

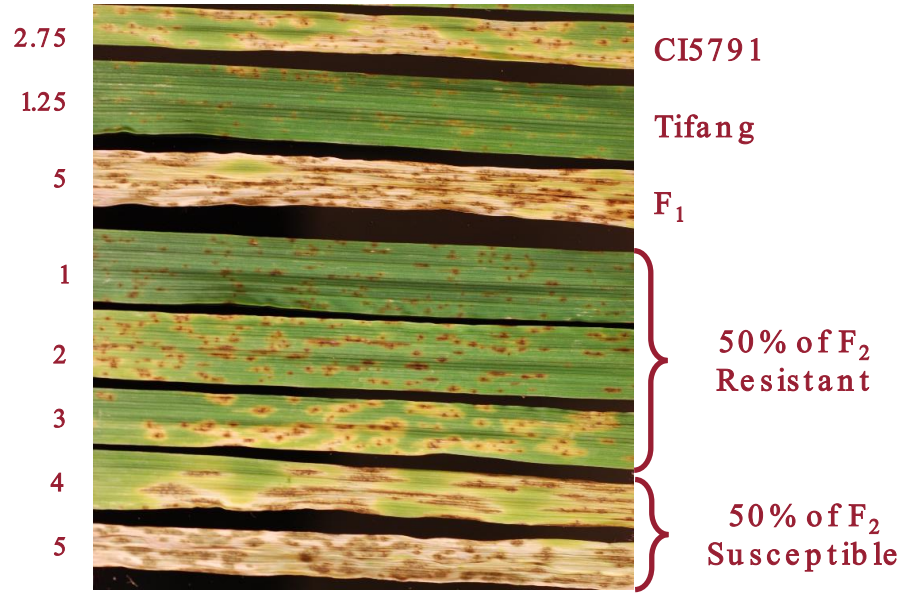


Figure 1. Representative photographs of exhibiting spot form net blotch symptoms.

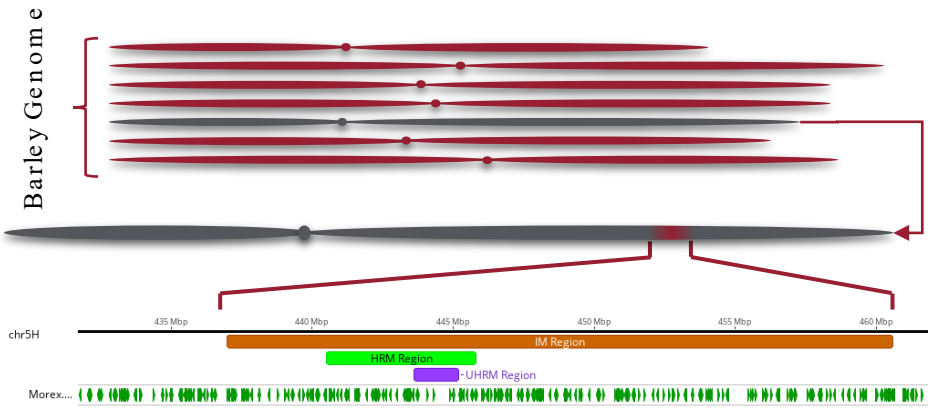


Figure 2. Barley genome ordered from chromosome 1H to 7H to scale using the Morex V2 reference assembly. Chromosome 5H is highlighted in grey with initial, high and ultra high-resolution mapping of the hybrid susceptibility locus are shown as orange, green and purple blocks, respectively. Gene annotations within the respective regions are shown as green arrows.

Future Direction

- Map hybrid susceptibility in CI5791 × Golden Promise
- Validate the *Spt2* gene responsible for hybrid susceptibility

WASHINGTON GRAIN COMMISSION
WASHINGTON STATE UNIVERSITY
Triticeae CAP
Coordinated Agricultural Project

Wisconsin

Mike Davis has been instrumental in the growth of barley research community in terms of his commitment to recruit the best scientific talent and also for ensuring continued financial support. For the past six years Mike has supported our research on abiotic stress tolerance through grants from AMBA. Two of the most wonderful attributes of Mike Davis are his great sense of humor and his uncanny ability to network at the highest levels. To just give an example, when I met Mike at the IBGS2016, Minneapolis, a few months after I joined the USDA, he introduced me to some of the barley researchers and said, "We decided to recruit Mali for the scientist position because at the dinner after his interview he ordered beer while the other candidate had ordered wine!". At the USDA retreat in the tri-societies meeting in 2017, when I introduced myself to our ARS administrator Dr. Chavanda Jacobs-Young, she immediately quipped "You folks are very lucky to have such a strong and persistent stakeholder working for you". A testament to his outstanding ability as a lobbyist reaching the highest echelons of the USDA! You will be greatly missed Mike! Wishing you a very happy retired life!!

-Ramamurthy 'Mali' Mahalingam

Mike Davis been an instrumental force for the malt and barley research community throughout his years as the president of AMBA. The industry won't be the same without him. I first met Mike as a graduate student at the retirement of the former Cereal Crops Research Unit's Research Leader, Dave Peterson. Since then, I've been lucky to call Mike a colleague and friend. The power of Mike's lobbying ability is impressive to say the least! Rumor has it that the job that I currently hold at the CCRU was opened after Mike spoke with Herb Kohl, the U.S. senator from Wisconsin at the time. The first BIC I attended in San Diego the weather was colder than back in Wisconsin and I remember freezing at dinner with Mike and other colleagues since they didn't have heaters in the restaurant! Thank you, Mike, for all the work you've done for the industry. You'll be thoroughly missed by all. Enjoy retirement☺

-Marcus Vinje

The Malt Quality Lab at the Cereal Crops Research Unit has driven the advancement of malting barley lines developed by public sector researchers for over 70 years. For about 38 years, the lab has been generously supported by AMBA and at the heart of this effort was the unwavering support of Mike Davis. Mike was instrumental in relocating the Barley and Malt lab from an outdated building to a state-of-the-art facility. Mike has been a staunch advocate of our research initiatives and his lobbying efforts have not only resulted in our unit being one of the most fiscally stable labs in the ARS, but also resulted in our increase in both scientific and support staff hired at the CCRU. The service work team went up in staff positions as a result of his sustained efforts, as did the staff of the non-service work mission-oriented activities of the CCRU. Mike has brought leadership, enthusiasm, and direction to our endeavors and we will miss his support both professionally and personally. We wish him the very best in his retirement.
Thank you Mike!

-Cynthia Henson, Stan Duke, Jason Walling, Chris Martens, & staff of the Malt Quality Lab

Agronomy Department Chairman and Professor Stan Duke presenting the UW-Madison 'Friend of Agronomy' award to Dr. Michael P. Davis, President of the American Malting Barley Association, Inc. for his sustained interest and support of malting barley research at UW-Madison. 1998.

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