

Future of Malting Barley In North America

Keeping Barley Competitive
With Other Crops



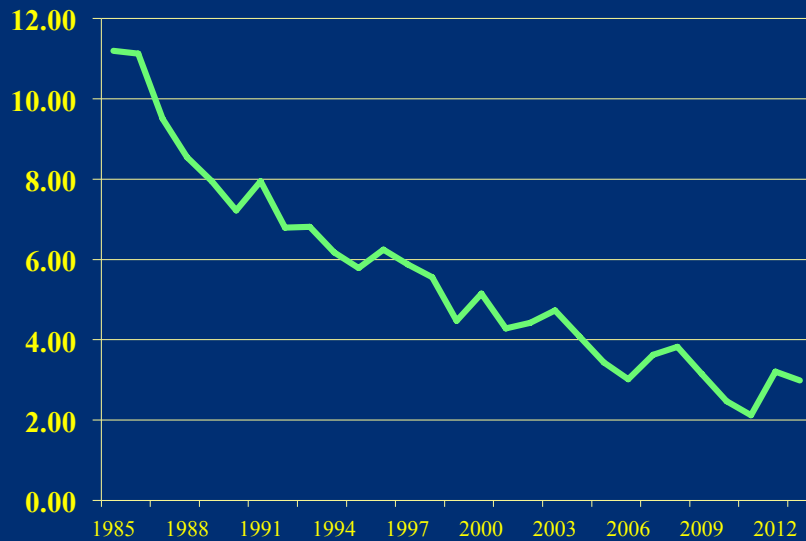
NO BARLEY

NO BEER!

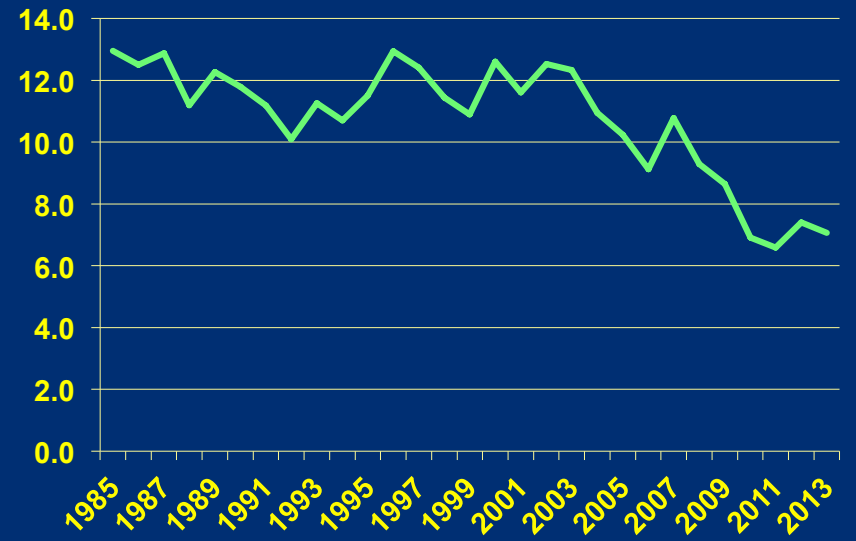


Million Acres

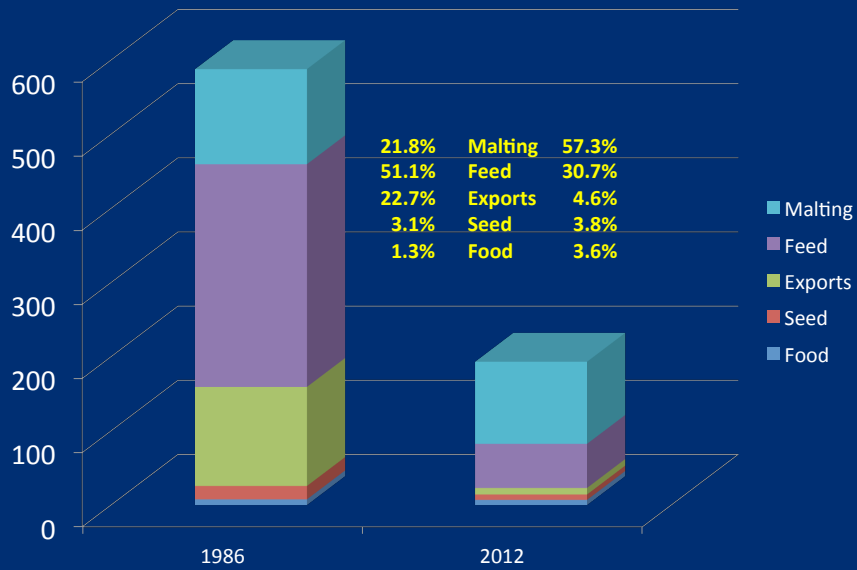
US Barley Acreage



Canadian Barley Acreage

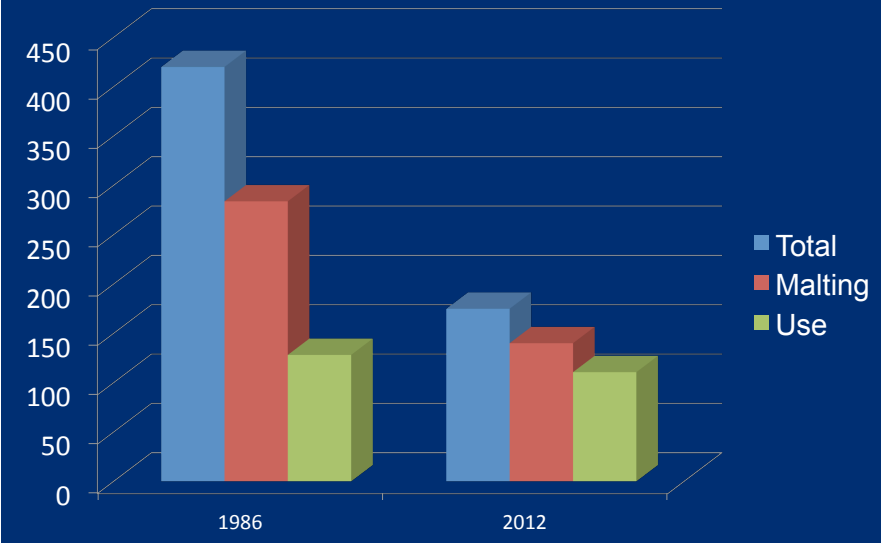


US Barley Use



US Barley Production & Malt Use

CO, ID, MN, MT, ND, WY



Why Has Barley Acreage Declined?

Static domestic malt use, limited barley & malt exports

Decline in use for feed = primary secondary use

Competition from abundant supplies of corn and dried distillers grain (DDGs)

Static & limited food use – although has FDA Healthy Heart Claim

USDA Barley Health Benefits Project – AMBA/NBIC lobbying

High risk crop – many chances for failure in making malting grade

Good return as malting, low or no return as feed

Risks: - Fusarium head blight (scab), other diseases, drought & heat stress, quality requirements

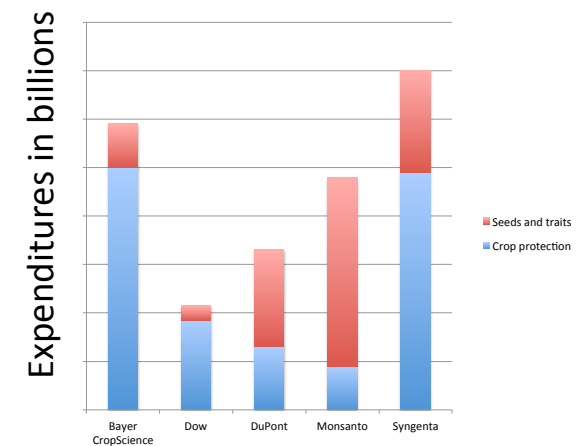
Competition with other crops – GROWERS HAVE OTHER OPTIONS

Corn, soybeans, canola = large and growing markets

Substantial investment by biotech seed companies, including GM variety development, in these crops and now wheat

Expenditures: Crop Protection and Seeds and Traits 1990-2008

- Bayer, Syngenta, BASF, DOW and DuPont were the firms that spent the most on Crop Protection R&D.
- Monsanto dominates the “seeds and traits” sector
- Comparative R&D Expenditures
 - Wheat—about 70c/acre/year
 - GM Row crops: \$10/acre/year



Slide courtesy Dr. Bill Wilson, NDSU

Why Has Barley Acreage Declined?

Biotech Crops with improved traits, including GM, have pushed barley out of higher rainfall areas into more marginal, dry ones

What happens to barley when it faces competition from GM drought tolerant corn, wheat and other crops that are being developed ?

Barley research & variety development primarily in public sector

State and provincial universities; USDA-ARS and Agriculture & Agri-Food Canada

Limited and declining public sector investment

Limited variety development by companies

US = Two brewers, one maltster, one private sector company – all traditional breeding

- minor part of their business, driven to meet needs, not profit
- depend on public sector for other research needs

Little or no interest by biotech seed companies in barley

Low acreage compared to other major crops

Substantial cost to commercialize a GM variety

Discovery, Development and Deregulation Costs of a GM Trait

Category		Cost (\$ million)	Number of responses
Discovery	Early discovery	17.6	5
	Late discovery	13.4	5
	Total cost	31.0	5
Construct optimization		28.3	5
Commercial event production & selection		13.6	6
Introgression breeding and wide-area testing		28.0	6
Regulatory science		17.9	6
Deregulation and regulatory affairs		17.2	6
Total		\$136.0	\$105 w/o Discovery

Phillips McDougall, September 2011

GM Barley?

Current Status & Considerations

Experimental GM barley lines have been developed

Lines with various genes for resistance to Fusarium head blight (scab)

USDA-ARS US Wheat & Barley Scab Initiative funded researchers

High beta-glucanase lines to improve chicken feed

Washington State University

None commercialized

GM lines grown in hydroponic cultivation in geothermal greenhouses in Iceland for commercial production of pure proteins for research (Cell Sciences)

No commercial field production of GM barley

Strong support for development of GM barley by barley grower

organizations - Growers are experienced in growing GM crops and feel GM barley is needed to keep barley competitive with other crops

GM Barley?

Current Status & Considerations

Growing consumer resistance and concerns about GM

Mixed views of malting, brewing, distilling, and food end-users

Strongly opposed - to neutral - to supportive

Thus no clear signal to biotech seed companies to pursue

Developmental costs of GM barley too high to recover investment

Low acreage compared to major crops and thus limited seed sale potential

A unique trait, with exclusive IP rights, and substantial economic benefits (e.g. drought tolerance, major disease resistance) that could be used worldwide, may provide viable market

American Malting Barley Association, Inc. Biotechnology Policy Statement

June, 2008

The American Malting Barley Association, Inc. (AMBA) provides funding for basic barley research in plant physiology, biochemistry and fundamental genomics as well as for more applied research in barley variety development. In addition, AMBA is involved in various federal programs funding barley biotechnology research to ensure access to current science and to keep barley competitive with other crops. At this time, there are no commercially available GM barley varieties in North America. AMBA is opposed to the commercial release of GM barley varieties.

JUNE, 2009

The American Malting Barley Association, Inc. (AMBA) provides funding for basic barley research in plant physiology, biochemistry and fundamental genomics as well as for more applied research in barley variety development. In addition, AMBA is supportive of various federal and state programs funding barley biotechnology research to ensure scientific advancement and to keep barley competitive with other crops.

GM Barley Conclusions

No commercial GM barley expected in foreseeable future

Cost of commercialization precludes public sector university or federal research agency commercialization

Would require Biotech seed company to commercialize – none appear interested at this time

If work was initiated now, and gene discovery & construction, gene transfer, and utility already demonstrated, it would still take an estimated 10 years+ to complete the process to a commercially approved GM barley

GM WHEAT

Strong grower support combined with change of view of many end-users (e.g. millers, bakers, food companies) from opposition to support due to concerns about declining wheat acreage and competition with GM crops

Accordingly, biotech seed companies are now working on wheat, often in collaboration with the public sector universities that have the varieties needed for gene trait introgression

Current estimate for first commercial GM wheat = 6 Years

Considerations for malting, brewing, and distilling industries

Production of wheat products if you want to be non-GM

Comingling of GM wheat with non-GM barley

Most barley farmers also grown wheat

Wheat & barley grown in same area move through same elevator & transportation systems

Barley Biotechnology Tool Box

X - No GM variety development

Targeted genetic improvements without being transgenic (GM)

Induce base pair gene changes by the plant not through gene transformation technology

Rapid Trait Development system (RTDS) - *Cibus*
(considered mutagenesis technology by USDA)

Doubled Haploid (DH) Barley Line Development

Rapid development of genetically homozygous varieties

Barley Biotechnology Toolbox

Gene tracking Technology (genotyping)

Initial methodology = one gene
Current technology = tens of thousands of genes at one time

Current major genotyping technology

Based on Single Nucleotide Polymorphisms (SNPs)
Illumina BeadXpress system (old) – Illumina iSelect system (new)
Exome capture sequencing

Next generation technology for genotyping

Genotyping by Sequencing (GBS)

Gene tracking applications

Marker Assisted Selection (MAS)
Track introgression of one or a few genes
Genomic Selection (GS)
Track thousands of genes to develop lines with desired agronomic & quality traits

Barley Biotechnology Challenge

\$\$\$ - Most all funding from limited public sector sources

vs billions being invested by biotech seed companies in other crops

State universities & USDA-ARS research locations

USDA-ARS Small Grains Genotyping Laboratories (4)

Fargo, ND; Manhattan, KS; Raleigh, NC; Pullman, WA
Created through earmarks – AMBA/NBIC & wheat stakeholder lobbying

USDA-ARS US Wheat & Barley Scab Initiative grant program

USDA-NIFA Agriculture & Food Research Initiative (AFRI) Competitive Grant Program

Grants to individual scientists
Large grants to multi-researcher, discipline, and institution coordinated projects
Triticeae (barley & wheat) Agricultural Coordinated Project (TCAP)
\$25 million (\$5M/year): 2011-2015

Keeping Barley Competitive With Other Crops

Barley biotechnology research in of itself is not enough to keep barley competitive with biotech seed crops

Coordinated research in many disciplines is needed

Breeding, genetics, molecular biology, biochemistry, physiology, pathology, management

Adequate & effective national public sector barley research infrastructure

Stakeholder funding, direction, and collaboration

American Malting Barley Association (AMBA)
Brewing & Malting Barley Research Institute (BMBRI, Canada)
Brewers Association (BA)
Individual malting & brewing companies
State barley grower organizations

AMBA National Coordinator of US Malting Barley Research



AMBA lobbies Congress, Federal Agencies, and State Universities to positively impact all these research infrastructure components

AMBA also lobbies with barley growers for favorable federal farm program provisions (e.g. crop insurance)



American Malting Barley Association, Inc.

(Founded in 1938 as the Malt Research Institute)

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

VISION: To be the leader in improvement, development, and understanding of malting barley in the US.

PRIMARY OBJECTIVE: Develop six-row and two-row malting barley varieties broadly adapted for the barley production areas of North America with suitable agronomic, malting, and brewing performance.

US Malting Barley Variety Development Programs

(breeding, genetics, supporting and other research)

Montana State University
North Dakota State University
Oregon State University
University of California – Davis
University of Minnesota
University of Nebraska
USDA-ARS, Aberdeen, ID
USDA-ARS, Raleigh, NC
Utah State University
Virginia Polytech & State University
Washington State University

AB-InBev
Malteurop
MillerCoors
Limagrain

AMBA member
Funded by AMBA

Other US Malting Barley Research

*Biochemistry, Genomics, Molecular Biology, Physiology
Diseases, Insects, Quality, Management, Variety Trials*

Programs listed for malting barley variety development plus:

Colorado State University	University of Vermont
Cornell University (NY)	University of Wisconsin
Michigan State University	University of Wyoming
North Carolina State University	USDA-ARS, Fargo, ND
Ohio State University	USDA-ARS, Madison, WI
Pennsylvania State University	USDA-ARS, Manhattan, KS
Texas A&M University	USDA-ARS, Pullman, WA
University of Idaho	USDA-ARS, Stillwater, OK
University of Maryland	USDA-ARS, St. Paul, MN

AMBA funding

Canadian Malting Barley Variety Development Programs

Primary

AAFC, Brandon, MB
University of Saskatchewan
Alberta Agriculture and Rural Development

Secondary

Sapporo Breweries Ltd.
Syngenta

US Varieties are entered into Canadian testing system for potential registration and production

Brewing & Malting Barley Research Institute (BMBRI) – AMBA's Canadian Counterpart

AMBA Quality Evaluation Program

Step 1 - Micro malting evaluations @ USDA-ARS Cereal Crops Research Unit, Madison, WI – 5,000 to 6,000 lines/year – AMBA provides supporting funds

Step 2 - AMBA pilot scale malting evaluations by collaborating members - Average of 35+ lines/year

Step 3 – AMBA Plant Scale Evaluation Program

VARIETY/LINE	PROGRAM	BREWER TESTING
<u>Western Winter Two-Row</u>		
Endeavor	USDA-ARS, ID	AB-InBev, MillerCoors
02Ab669	USDA-ARS, ID	AB-InBev, New Glarus
<u>Western Spring Two-Row</u>		
2Ab04-X01084-27	USDA-ARS, ID	New Belgium, Sierra Nevada
2Ab17271	USDA-ARS, ID	Briess, New Glarus
<u>Midwest Spring Two-Row</u>		
2ND25276	ND State University	AB-InBev, Bell's, MillerCoors
<u>Midwest Spring Six-Row</u>		
ND22421	ND State University	MillerCoors
ND26891	ND State University	AB-InBev, MillerCoors

AMBA 2014 Recommended Varieties

Two-Row

<i>ABI Voyager (2014)</i>	<i>AB-InBev</i>
<i>AC Metcalfe (2005)</i>	<i>Agriculture & Agrifood Canada</i>
<i>CDC Copeland (2007)</i>	<i>University of Saskatchewan</i>
<i>CDC Meredith (2013)</i>	<i>University of Saskatchewan</i>
<i>Charles* (2009)</i>	<i>USDA ARS, Aberdeen, ID</i>
<i>Conlon (2000)</i>	<i>North Dakota State University</i>
<i>Conrad (2007)</i>	<i>AB-InBev</i>
<i>Expedition (2013)</i>	<i>Malteurop</i>
<i>Harrington (1989)</i>	<i>University of Saskatchewan</i>
<i>Hockett (2010)</i>	<i>Montana State University</i>
<i>Merit (2000)</i>	<i>AB-InBev</i>
<i>Merit 57 (2010)</i>	<i>AB-InBev</i>
<i>Moravian 37 (2010)</i>	<i>MillerCoors</i>
<i>Moravian 69 (2010)</i>	<i>MillerCoors</i>
<i>Pinnacle (2011)</i>	<i>North Dakota State University</i>
<i>Scarlett (2008)</i>	<i>Saatzucht Joseph Breun GdBH, Germany</i>
<i>Wintmalt* (2013)</i>	<i>KWS Lochow, Germany</i>
<i>* Winter barley (year added)</i>	

AMBA 2014 Recommended Varieties

Six-Row

<i>Celebration (2011)</i>	<i>AB-InBev</i>
<i>Innovation (2014)</i>	<i>AB-InBev</i>
<i>Lacey (2000)</i>	<i>University of Minnesota</i>
<i>Legacy (2001)</i>	<i>AB-InBev</i>
<i>Quest (2011)</i>	<i>University of Minnesota</i>
<i>Robust (1984)</i>	<i>University of Minnesota</i>
<i>Stellar-ND (2006)</i>	<i>North Dakota State University</i>
<i>Tradition (2004)</i>	<i>AB-InBev</i>

American Malting Barley Association, Inc.						AMBA 2014
Malting Variety Development Funding Allocation Goals*						Funding
April, 2014						
1994	2004	2012	2014*		2014	Variety & Supporting
%	%	%	%		Regional %	Research
				MIDWEST		\$194,418
7.1	10.2	14.0	32.7	Spring 2-Row	59.8%	
59.5	49.6	34.3	14.3	Spring 6-Row	26.1%	
		6.9	7.1	Winter 2-Row	13.0%	
		1.4	0.6	Winter 6-Row	1.1%	
66.6	59.8	56.6	54.7	Subtotal	100.0%	54.9%
				WEST		\$152,000
13.1	26.7	26.3	26.9	Spring 2-Row	63.7%	
14.3	7.8	2.1	0.1	Spring 6-Row	0.2%	
		11.2	15.1	Winter 2-Row	35.8%	
		3.8	0.1	Winter 6-Row	0.2%	
6.0	5.7			Winter (2&6)		
33.4	40.2	43.4	42.2	Subtotal	100.0%	42.9%
				East		\$7,500
			2.3	Winter 2-Row	74.2%	
			0.8	Winter 6-Row	25.8%	
0.0	0.0	0.0	3.1	Subtotal	100.0%	2.1%
100.0	100.0	100.0	100.0	TOTAL		\$353,918 Variety
* 96.8% Weighted dues reported						\$139,932 National/Other
						\$493,850 Total Funding

National Barley Research Program

AMBA Strategic Goals

- **Technology to accelerate variety development**
 - e.g. latest DNA tracking technology
 - NOT GM
- **Management practices**
- **Increased Yields**
- **Winter Varieties**
- **Resistance to Abiotic Stress**
 - drought, heat, cold
- **Lodging resistance**
- **High Test Weight**
- **Improved Quality**
 - **Quality evaluation for breeding programs**
 - **Preharvest sprouting**
 - **Fermentability prediction**
 - **Glucanase assays**
 - **Flavor screening of barley**

National Barley Research Program

AMBA Strategic Goals

- **Food Safety**
- **Increased secondary uses**
 - Food, Feed, Straw for biofuels
- **Insects (RWA, Bird cherry oat aphid)**
- **Disease Resistance**
 - **Ug99 Stem Rust**
 - **Fusarium head blight (scab)**
 - **Barley yellow dwarf virus**
 - **Cereal yellow dwarf virus**
 - **Bacterial leaf streak**
 - **Stripe rust**
 - **Root diseases**
 - **Net blotch**
 - **Septoria speckled leaf blotch**
 - **Spot blotch**
 - **Powdery mildew (winter barley)**



Fusarium Head Blight
aka Scab = DON (vomitoxin)



Ug99 (African) Stem Rust



American Malting Barley Association, Inc. REGULAR MEMBERS (21)

- | | |
|----------------------------|-----------------------|
| AB-InBev | Gambrinus Company |
| Bell's Brewery | Great Western Malting |
| Boston Beer | InteGrow Malt |
| Briess Malt & Ingredients | Malteurop |
| Brooklyn Brewery | MillerCoors |
| Brown-Forman | New Belgium Brewing |
| Cargill Malt | New Glarus Brewing |
| Craft Brew Alliance | Rahr Malting |
| Deschutes Brewery | Schell's Brewing |
| Dogfish Head Craft Brewery | Sierra Nevada Brewing |
| | Summit Brewing |



American Malting Barley Association, Inc.

ASSOCIATE MEMBERS (45)

Abita Brewing	Deer Creek Malthouse
Alaskan Brewing	Farm Boy Farms
Allagash Brewing	Firestone Walker Brewing
Anchor Brewing	Flying Dog Brewery
Avery Brewing	Founders Brewing
Bear Republic Brewing	Full Sail Brewing
Blacklands Malt	Gold Rush Malt
Blue Ox Malthouse	Harpoon Brewery
Boulevard Brewing	Langunitas Brewing
Cold Spring Brewing	Lakefront Brewery
Colorado Malting	Left Hand Brewing
Corsair Artisan Distillery	Leopold Bros Distillery



American Malting Barley Association, Inc.

ASSOCIATE MEMBERS (45)

Long Trail Brewing	Saint Arnold Brewing
Lost Coast Brewery	Schlafly Beer
Malterie Frontenac	Smuttynose Brewing
Matt Brewing	Storz Brewing
Odell Brewing	Stone Brewing
Oskar Blues Brewery	Troegs Brewing
Rahr & Sons Brewing	Urban Chestnut Brewing
Real Ale Brewing	Valley Malt
Riverbend Malt House	Victory Brewing
Rogue Ales	Wachusett Brewing
Russian River Brewing	