Advanced Barley Agronomy

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Anything That Looks Easy is Hard to Do Right - This Includes Production of Malting Barley
Components of Yield

Yield =

# of plants/acre x # of spikes/plant x
# of kernels/spike x weight of kernels
Factors Impacting Yield and Quality of Grain

- Seeding rate
- Excessive temperatures
- Freezing temperatures
- Insufficient moisture for germination or plant growth.
- Water-logged soils
- Weed competition
- Insects
- Diseases
Growth Stages of Barley

Pre-jointing

Post-jointing

http://www.extension.umn.edu/distribution/cropsystems/DC2548.html#fig7
Kernel Development Stages

- Watery ripe
- Late milk
- Hard dough
- Ripe

http://www.extension.umn.edu/distribution/cropsystems/DC2548.html#fig7
Factors Impacting Yield Pre-jointing

- Excessive temperatures
- Freezing temperatures
- Insufficient moisture
- Variety selection
- Plant nutrition
- Diseases
- Insects
- Weed competition
Factors Impacting Yield Post-jointing

- Excessive temperatures at jointing
- Excessive temperatures at pollination
- Freezing temperatures at pollination
- Variety selection
- Plant nutrition
Factors Impacting Kernel Weight and Plumpness (post-spike emergence)

- Excessive temperatures
- Insufficient moisture
- Variety selection
- Plant nutrition
- Weed competition
- Diseases
- Insects
Recommended Seeding Rates

- 800,000 to 1,000,000 pure live seed
- 1.8 to 2.3 bu/ac
- 88 to 110 lb seed per acre
Plant Nutrition for Malting Barley

- Barley responds well to nutrients limiting in the soil, especially nitrogen (N).
- However, too much N can increase protein.
- The amount of fertilizer to apply is dependent on:
  - Intended end use of the barley
  - Residual soil N in the soil
  - Expected yield
Impacts of Excessive Nitrogen

• Excessive grain protein
  – Especially problematic under drought-like conditions.

• Lush plant growth
  – Susceptible to lodging and plant diseases.
  – Lodged plants often have thinner, low-weight kernels high in protein.
Determining Soil N Needed

• Growers should be encouraged to sample and test their soil for residual soil fertility (N, P, K).

• Testing can be done using soil core probes that sample to a depth of 2 feet.

• Growers need to be educated that malting barley has lower N requirements than wheat or feed barley.

• It is better to underestimate the amount of N to apply to malting barley.
### Nutrient recommendations for malt and feed barley in the Midwest United States

<table>
<thead>
<tr>
<th>Yield goal in Bu/Ac</th>
<th>Soil N plus fertilizer N required for malt barley in cooler, moister climates (lb/ac, 2’)</th>
<th>Soil N plus fertilizer N required for malt barley in warmer, drier climates (lb/ac, 2’)</th>
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<tbody>
<tr>
<td>40</td>
<td>60</td>
<td>48</td>
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<tr>
<td>60</td>
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<tr>
<td>80</td>
<td>120</td>
<td>96</td>
</tr>
<tr>
<td>100</td>
<td>150</td>
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</table>

Variety Selection

• Growers should be encouraged to grow cultivars desired by maltsters and brewers.
• Cultivars need to be adapted to the region where they are produced.
Breeding Improved Malting Barley Varieties

- Development of improved malting barley varieties takes a minimum of 10-12 years.
- Development is a cooperative effort between the breeding programs and the malting and brewing industry.
- End user dictates goals of the breeding program.
- Conventional breeding methods with use of molecular marker-assisted selection and genomic selection.
- No GMO breeding methods are used.
Breeding Programs in North America

• Began breeding specifically for malt quality after WW II.

• The quality profile of the barley varieties developed matched that for the production of adjunct beers.

• High enzymatic activity and protein ≤ 13.5%.
Location of Barley Breeding Programs for All Brewers
Location of Barley Breeding Programs for Adjunct Brewers
Needs for Eastern Barley

- Cultivars suitable for the craft industry
- Winter barley for areas south of Massachusetts.
- Cultivars able to handle warm nighttime temperatures.
- Cultivars with resistance to:
  - Fusarium head blight and DON accumulation
  - Net and spot blotch
  - Powdery mildew and leaf rust (southern area of region)
  - Pre-harvest sprouting
American Malting Barley Association (AMBA) Members (Before the Rise of Craft Beers)

<table>
<thead>
<tr>
<th>Malting Members</th>
<th>Brewing Members</th>
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<tbody>
<tr>
<td>Briess Malt &amp; Ingredients</td>
<td>Anheuser-Busch</td>
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<td>Cargill Malt</td>
<td>Boston Beer</td>
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<td>Great Western Malting</td>
<td>Miller Brewing</td>
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<tr>
<td>InteGrow Malt</td>
<td>Sierra Nevada Brewing</td>
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<td>Malteurop North America</td>
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<tr>
<td>Rahr Malting</td>
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American Malting Barley Association (AMBA) Members (After the Rise of Craft Beer)

**Malting Members**
- Briess Malt & Ingredients
- Cargill Malt
- Great Western Malting
- InteGrow Malt
- Malteurop North America
- Rahr Malting

**Brewing Members**
- AB-InBev
- Bell’s Brewery
- Boston Beer
- Brooklyn Brewery
- Brown-Forman (distiller)
- Craft Brew Alliance
- Deschutes Brewery
- Dogfish Head Craft Brewery
- Gambrinus Company
- MillerCoors
- New Belgium Brewing
- New Glarus Brewing
- Schell’s Brewing
- Sierra Nevada Brewing
- Summit Brewing
### 2017 AMBA Recommended Varieties

#### Recommended Six-rowed Malting Barley Varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>Year</th>
<th>Variety</th>
<th>Year</th>
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<tbody>
<tr>
<td>Celebration</td>
<td>2011</td>
<td>Stellar-ND</td>
<td>2006</td>
</tr>
<tr>
<td>Innovation</td>
<td>2014</td>
<td>Thoroughbred</td>
<td>2015</td>
</tr>
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<td>Lacey</td>
<td>2000</td>
<td>Tradition</td>
<td>2004</td>
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<tr>
<td>Legacy</td>
<td>2001</td>
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<td></td>
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<td>Quest</td>
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#### Recommended Two-rowed Malting Barley Varieties

<table>
<thead>
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<th>Variety</th>
<th>Year</th>
<th>Variety</th>
<th>Year</th>
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<tbody>
<tr>
<td>AAC Synergy</td>
<td>2015</td>
<td>Endeavor</td>
<td>2014</td>
</tr>
<tr>
<td>ABI Voyager</td>
<td>2014</td>
<td>Exhibition</td>
<td>2013</td>
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<tr>
<td>AC Metcalfe</td>
<td>2005</td>
<td>Harrington</td>
<td>1989</td>
</tr>
<tr>
<td>CDC Copeland</td>
<td>2007</td>
<td>Hockett</td>
<td>2010</td>
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<tr>
<td>CDC Meredith</td>
<td>2013</td>
<td>LCS Genie</td>
<td>2017</td>
</tr>
<tr>
<td>Charles</td>
<td>2009</td>
<td>Merit 57</td>
<td>2010</td>
</tr>
<tr>
<td>Conlon</td>
<td>2000</td>
<td>Moravian 37</td>
<td>2010</td>
</tr>
<tr>
<td>Conrad</td>
<td>2007</td>
<td>Moravian 69</td>
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<td></td>
<td></td>
<td>ND Genesis</td>
<td>2016</td>
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<td></td>
<td></td>
<td>Pinnacle</td>
<td>2011</td>
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<td></td>
<td></td>
<td>Scarlett</td>
<td>2008</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wintmalt</td>
<td>2014</td>
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Identifying Varieties for the Eastern Growing Region

• Established the Eastern Spring Barley Nursery (ESBN) in 2015.

• Common list of 20 varieties grown in ME, VT, MA, NY, PA, OH, IN, MI in the US and QB and PEI in Canada.

• Varieties selected based on input from craft industry personnel and university researchers in the region.

• Varieties included two- and six-rowed entries, and newer and “heritage” varieties.
ESBN Nursery Locations
Data Collected

Field Data

- Days to heading, plant height, lodging, foliar diseases, stem breakage, and yield

Barley Quality Data

- Grain moisture, test weight, protein, barley color, kernel plumpness, 1000-kernel weight, DON, DON (NDSU FHB nurseries), stirring number (RVA), and seed dormancy (NDSU)

Malt Data (3 locations + NDSU)

Extract, wort protein, wort color, S/T, DP, alpha-amylase, wort beta-glucan, wort viscosity, and FAN
## Mean Performance Across Entries for the Selected ESBN Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Yield (bu/ac)</th>
<th>Test weight (lb/bu)</th>
<th>Protein (%)</th>
<th>DON (ppm)</th>
<th>Plumps (%)</th>
<th>RVA† (SN)</th>
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<tbody>
<tr>
<td>Michigan State (Chatham)</td>
<td>71.5</td>
<td>48.2</td>
<td>13.6</td>
<td>0.0</td>
<td>93.7</td>
<td>73</td>
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<tr>
<td>Michigan State (Hickory Corners)</td>
<td>59.1</td>
<td>47.2</td>
<td>14.3</td>
<td>0.0</td>
<td>70.3</td>
<td>91</td>
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<tr>
<td>Michigan State (Posen, MI)</td>
<td>49.8</td>
<td>52.0</td>
<td>12.4</td>
<td>0.0</td>
<td>85.6</td>
<td>178</td>
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<td>Ohio State</td>
<td>19.2</td>
<td>46.0</td>
<td>11.8</td>
<td>0.0</td>
<td>75.3</td>
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<td>Penn State</td>
<td>87.3</td>
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<td>10.8</td>
<td>0.5</td>
<td>95.5</td>
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<tr>
<td>Univ. of Maine (Orono)</td>
<td>107.9</td>
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<td>9.9</td>
<td>0.0</td>
<td>95.0</td>
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<td>Univ. of Maine (Presque Isle)</td>
<td>93.8</td>
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<td>Univ. of Vermont</td>
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<td>11.4</td>
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<td>91.2</td>
<td>104</td>
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</table>

†RVA = Rapid Viscoanalyzer; SN = stirring number. SN<120 is indicative of kernels damaged by preharvest sprouting.
Preharvest Sprouting

http://1.bp.blogspot.com/-zby9anqMuJA/U5R6pbFJM9I/AAAAAAAAACho/OhScfnFT1go/s1600/IMG_3366.JPG
<table>
<thead>
<tr>
<th>Variety</th>
<th>Stirring Number</th>
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<tr>
<td>2ND28065</td>
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<td>AAC Synergy</td>
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<tr>
<td>Cervesa</td>
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<tr>
<td>Conlon</td>
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<td>Explorer</td>
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<tr>
<td>KWS Becky</td>
<td>153</td>
</tr>
<tr>
<td>LCS Genie</td>
<td>148</td>
</tr>
<tr>
<td>ND Genesis</td>
<td>97</td>
</tr>
<tr>
<td>Pinnacle</td>
<td>138</td>
</tr>
<tr>
<td>Tradition</td>
<td>146</td>
</tr>
</tbody>
</table>
• Plant diseases can affect three parts of the plants
  – Roots
  – Foliar components (stems and leaves)
  – Spike and kernels
• Both cultural and chemical (fungicides) methods are available for controlling diseases.
• Effects of root rot are especially noticed in dry years.

• Early in the barley life cycle, root rots can reduce the number of plants.

• Following pollination, root rots can reduce kernel weight and plumpness.
Symptoms of Root Diseases

http://cbarc.aes.oregonstate.edu/cbarc/RhizoctoniaRootRot.htm
Control Methods for Root Rots

- Treatment of seeds with fungicides prior to sowing.

- Crop rotation
  - Many pathogens causing root rots can also infect cereals such as wheat.
Use of Seed Treatments

- Depending on the product, you can control diseases and insects.
- Insects that can be controlled include wireworms, aphids (winter barley).
- Diseases that can be controlled include common and loose smut, common root rot, Fusarium crown rot, and net blotch.
Foliar Diseases

• Predominantly cause damage by reducing kernel weight and plumpness.

• The most important leaves to protect with fungicides are the top two leaves of each tiller.
Symptoms of Foliar Diseases

Spot form of net blotch

Powdery mildew

Photo courtesy of Dr. Robert Brueggeman, Dept. of Plant Pathology, NDSU.

http://www.mpiz-koeln.mpg.de/bildobjekte/research/schulzeLefert/panstruga1/Web_Zoom.jpg
Spike and Kernel Diseases

- These diseases often result in yield losses due to reduced kernel weight.
- Some fungi causing spike diseases can produce mycotoxins.
- Fungi are molds.
- Molds can cause problems during the malting process.
Symptoms of Spike and Kernel Diseases

Fusarium Head Blight on Barley

Black Point on Barley

Picture courtesy of Brian Steffenson, Univ. of Minn.

Control of Foliar and Kernel Diseases

- Fungicides such as propiconazole (Tilt), tebuconazole (Folicur), prothioconazole (Proline), prothioconazole + tebuconazole (Prosaro), and metconazole (Caramba).

- Sowing of resistant varieties.

- Don’t use strobilurin fungicides for controlling FHB.
Damage Due to Insects

- Damage due to insects can be grouped into two categories:
  - Damage due to consumption of plant parts during feeding.
  - Damage due to virus or toxins transferred during feeding.
Controlling Insects

• Insects can be controlled using chemicals specific for the species.

• Similar to controlling diseases, the top two leaves of the plant should be protected from damage.
Insect Pests of Barley


Viruses Affecting Barley

• Barley yellow dwarf virus
  – Transmitted by aphids.

• Barley stripe mosaic virus
  – Transmitted by infected seeds.

• Barley yellow mosaic virus
  – Transmitted by a fungus in the soil.
Symptoms of Plant Viruses

http://www.rothamsted.ac.uk/ffi/pics/patch_early.jpg

http://pubs.caes.uga.edu/caespubs/pubcd/B1190/B1190-30b.jpg
Effects of Crop Rotation on Barley Quality

- Proper crop rotation reduces the likelihood of diseases, insect, and weed pests.
- Favorable crops to follow include canola, sugarbeet, sunflower, and dry bean.
- Crops to avoid following include corn and wheat, soybean.
Harvesting Malting Barley

• Pre-harvest desiccants should not be used on malting barley because they can reduce germination.

• Barley harvested at moisture > 13.5% needs to be aerated and dried.

• Barley stored at moisture >13.5% can have mold growth during storage.
Threshing Malting Barley

• Threshing equipment needs to be set correctly to prevent breaking and skinning of barley.

• Skinned and broken kernels reduces germination.

• The husk on barley provides a protective covering to the developing sprout of the kernel during germination.
Kernels Damaged During Threshing

http://www.ambainc.org/pub/Production/Harvesting.pdf
Managing Stored Barley

- Stored grain should be kept cool, dry, and clean to maintain quality.

- Grain containing foreign material and skinned or broken kernels is susceptible to mold and insect damage.

- Grain moisture should be kept below 12% during summer months.

- The allowable storage time for barley is doubled for each 20 °F that the grain is cooled.
Importance of Education for Reducing Barley Quality Losses

• Providing outreach/education to growers and grain handlers is important in preventing or reducing barley quality losses.

• Educate the educators.
Summary

• Biotic and abiotic stresses throughout the growing season can impact barley and malting quality.

• Stresses early in the growing season can reduce yield due to fewer plants, tillers, and kernels per spike.

• Stresses following pollination can result in reduced kernel weight and plumpness.

• Improperly harvested and stored barley can quickly lose its quality and be unsuitable for malting.
Questions?