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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=

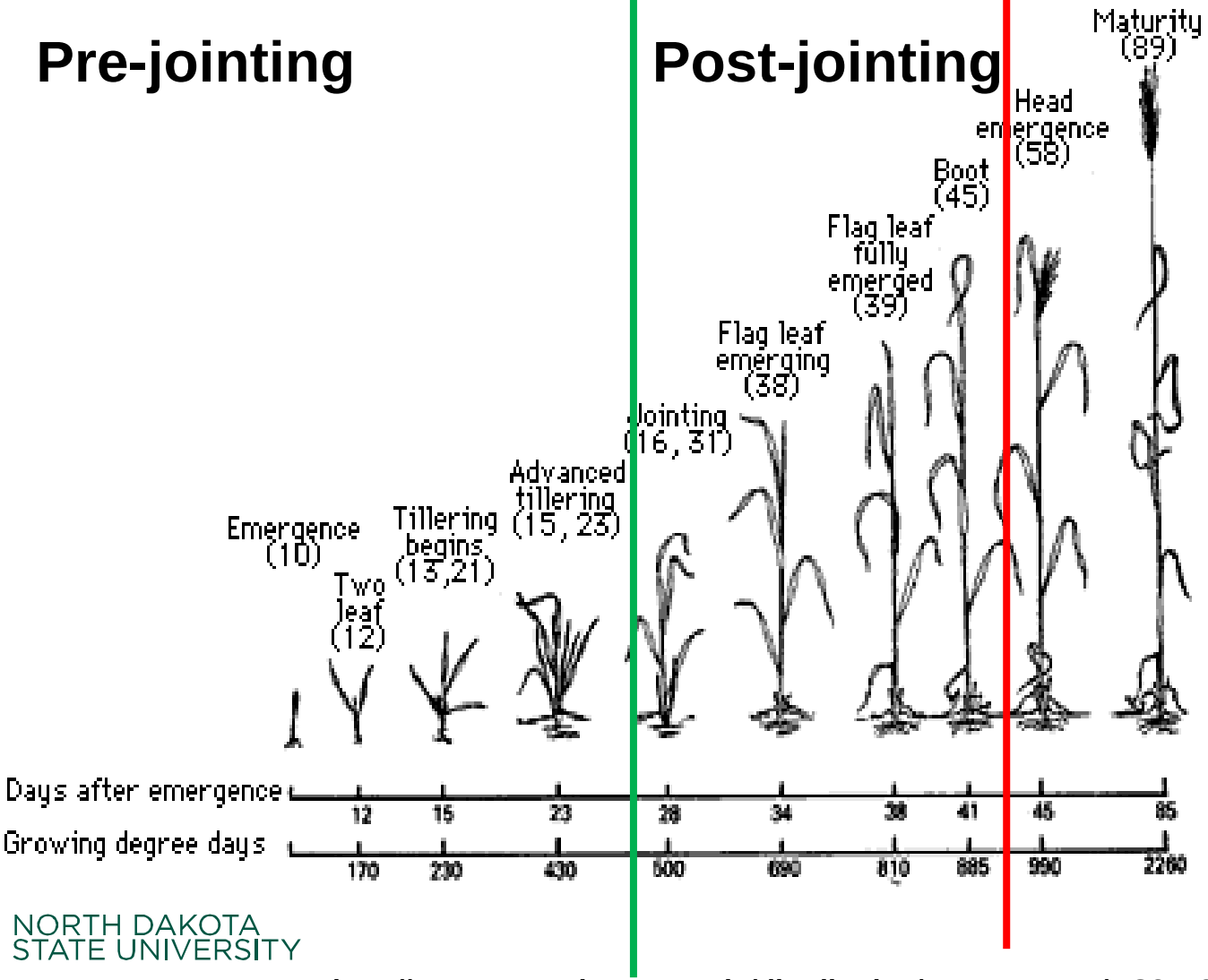
# of plants/acre x # of spikes/plant x

#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



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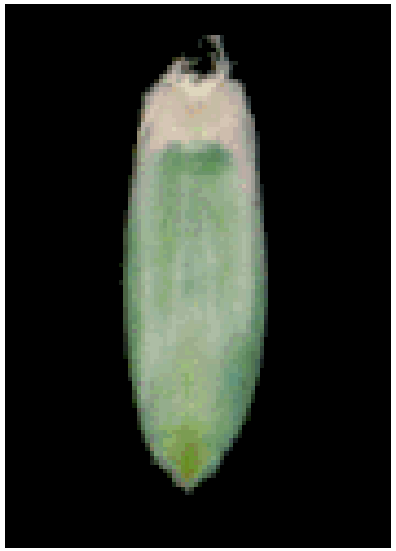
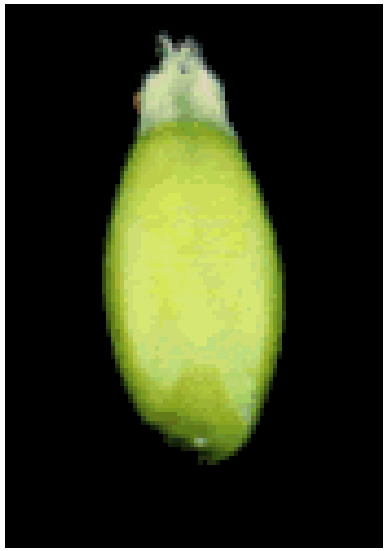
http://www.extension.umn.edu/distribution/cropsystems/DC2548.html#fig7

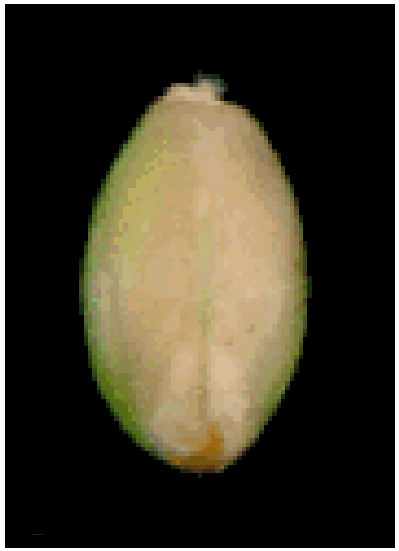
Kernel Development Stages



Watery ripe



Late milk



Hard dough

Ripe

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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

Yield goal Bu/Ac	Soil N plus fertilizer N required for malt barley in cooler, moister climates in eastern ND (lb/ac, 2')	Soil N plus fertilizer N required for malt barley in warmer, drier climates in western ND(lb/ac, 2')
40	60	48
60	90	72
80	120	96
100	150	120

Reproduced with minor modifications from D.W.Franzen and R.J. Goos. (2015) *Fertilizing Malting and Feed Barley,* Fargo, ND: North Dakota State University Extension Service, with permission.

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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

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Location of Barley Breeding Programs for Adjunct Brewers

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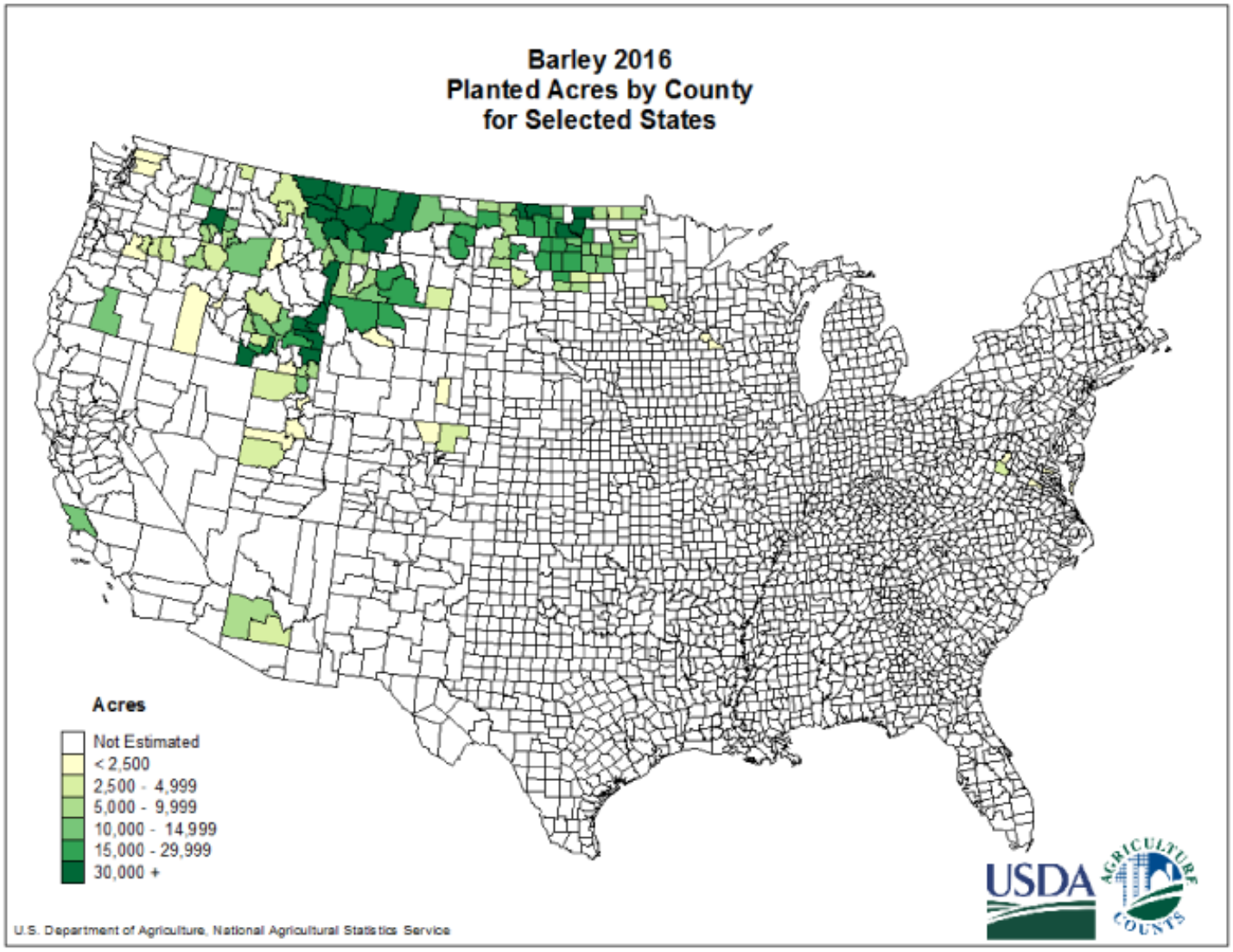

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Needs for Eastern Barley

- 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)

Malting Members

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

Brewing Members

- Anheuser-Busch
- Boston Beer
- Miller Brewing
- Sierra Nevada Brewing

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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

Variety	Year	Variety	Year
Celebration	2011	Stellar-ND	2006
Innovation	2014	Thoroughbred	2015
Lacey	2000	Tradition	2004
Legacy	2001		
Quest	2011		

Recommended Two-rowed Malting Barley Varieties

Variety	Year	Variety	Year
AAC Synergy	2015	Endeavor	2014
ABI Voyager	2014	Exhibition	2013
AC Metcalfe	2005	Harrington	1989
CDC Copeland	2007	Hockett	2010
CDC Meredith	2013	LCS Genie	2017
Charles	2009	Merit 57	2010
Conlon	2000	Moravian 37	2010
Conrad	2007	Moravian 69	2010
		ND Genesis	2016
		Pinnacle	2011
		Scarlett	2008
		Wintmalt	2014

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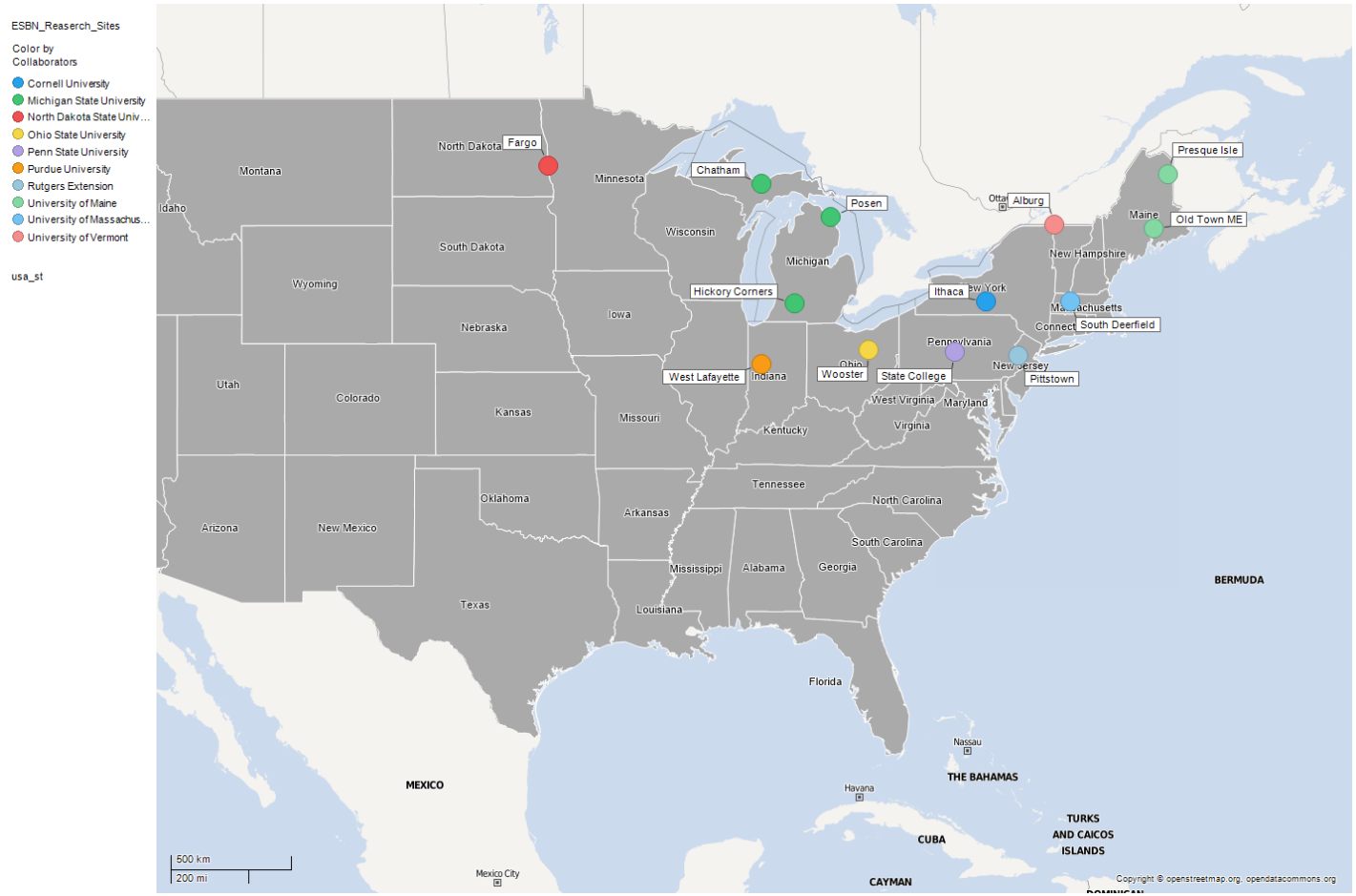
Identifying Varieties for the Eastern Growing Region

- 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



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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

Location	Yield	Test weight	Protein	DON	Plumps	RVA†
	(bu/ac)	(lb/bu)	(%)	(ppm)	(%)	(SN)
Michigan State (Chatham)	71.5	48.2	13.6	0.0	93.7	73
Michigan State (Hickory Corners)	59.1	47.2	14.3	0.0	70.3	91
Michigan State (Posen, MI)	49.8	52.0	12.4	0.0	85.6	178
Ohio State	19.2	46.0	11.8	0.0	75.3	121
Penn State	87.3	53.1	10.8	0.5	95.5	161
Univ. of Maine (Orono)	107.9	50.4	9.9	0.0	95.0	175
Univ. of Maine (Presque Isle)	93.8	45.6	10.0	2.0	96.3	72
Univ. of Vermont	66.6	45.9	12.0	0.0	95.4	139
North Dakota State Univ.	80.1	49.4	11.4	0.0	91.2	104

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

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Preharvest Sprouting

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http://1.bp.blogspot.com/-zby9anqMuJA/U5R6pbFJM9I/AAAAAAAACho/OhScfnFT1go/s1600/IMG_3366.JPG

Mean Stirring Number Across Locations of Selected Varieties in the 2016 ESBN

Variety	Stirring Number
2ND28065	112
AAC Synergy	76
AC Metcalfe	76
Cervesa	64
Conlon	89
Explorer	128
KWS Becky	153
LCS Genie	148
ND Genesis	97
Pinnacle	138
Tradition	146

Plant Diseases

- 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.

Root 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

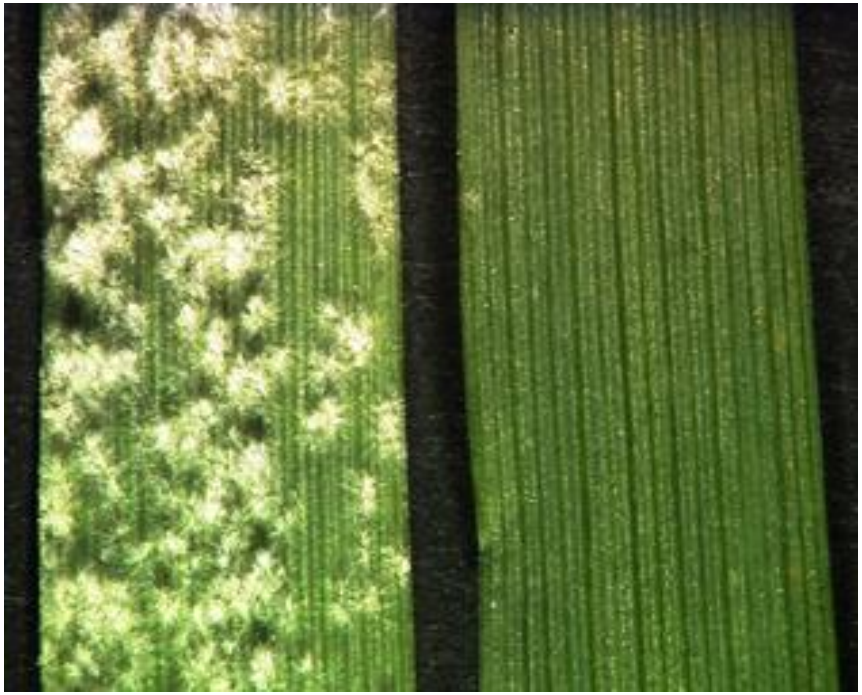
- Predominantly cause damage by reducing kernel weight and plumpness.
- The most important leaves to protect with fungicides are the top two leaves of each tiller.

Symptoms of Foliar Diseases

Spot form of net blotch

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

Powdery mildew



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

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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

Picture courtesy of Brian Steffenson, Univ. of Minn.

Black Point on Barley

http://www.agwine.adelaide.edu.au/images/plant/research/black_point.jpg

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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

http://www.vtaide.com/png/images/cricket-f3.jpg

http://www.dpi.qld.gov.au/images/Biosecurity_GeneralPlantHealthPestsDiseaseAndWeeds/Insects-RoseGrainAphid-AdultAndNymphs-500.JPG

http://www.idratherbewriting.com/wp-content/uploads/2007/07/grasshopper.jpg

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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/ppi/pics/patch_early.jpg

http://pubs.caes.uga.edu/caespubs/pubcd/B1190/B1190-30b.jpg

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Effects of Crop Rotation on Barley Quality

- Proper crop rotation reduces the likelihood 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 ^{o}F that the grain is cooled.

Summarized from information provided by the American Malting Barley Association

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?

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