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Malting Barley Production in Michigan

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Because of the increasing demand for locally sourced ingredients in everything from the salads we eat to the beer we drink, barley, produced for malt, is being revisited as a potential crop for Michigan growers. This publication explores that potential and outlines best production practices for Michigan-grown malting barley.

Introduction

Barley – the most widely adapted cereal grain in the world – is an ancient crop that has been used for thousands of years for feed, food and production of beer. Its ability to thrive in adverse conditions makes it a suitable crop where other high-valued commodities such as corn, rice and wheat fail to yield. Although there is a wide spectrum of barley types, this text will focus on Hordeum vulagre L., the commonly cultivated species that dominates global production (Figure 1). The cultivation of barley, the fifth most-produced crop in the world, is widespread throughout North America and occurs on every other continent outside of Antarctica.

Oregon State University Barley Project, 2011

Figure 1. Barley is the fifth most produced crop in the world.

Worldwide, 125 million acres of barley were harvested in 2013. Only 3 million of those acres were harvested in the United States, which was nearly half of the 30-year national average (1984-2013, 5.9 million acres). U.S. acreage has steadily declined over this time period as barley competed for agricultural land with other high-value crops. Because of increased yields, however, domestic production of barley (in bushels) is down only 36 percent since 1984. In Michigan, only 10,000 acres of barley were harvested in 2013, with nearly all production going to feed markets. Nationally, 55 percent to 60 percent of barley goes to feed and is cracked, ground or rolled before being fed to livestock (Figure 2). Protein levels in barley grain range from 10 percent to 15 percent and are heavily affected by crop management. Aside from feed uses, 30 percent to 40 percent of U.S. barley is malted for brewing, 2 percent to 3 percent is used in other foods, and 5 percent is harvested for seed. Unique varieties of barley have been developed to

Bell's Brewery, Inc., 2013

Figure 2. The 8,000 acres of barley harvested in Michigan last year, primarily went to animal feed. As interest in local malt grows, we can anticipate seeing a shift in that barley usage.

support these end uses, although many characteristics of the grain remain consistent throughout the species. This publication will focus on specific varieties and cultural practices relating to barley produced for malt, or malting barley.

Barley's wide geographic range and adaptability have led to consistent use of the grain in brewing for at least 5,000 years. Barley destined to become beer is put through a process called malting, which essentially germinates and then dries the grain to prevent further development. The germination process produces two enzymes – alpha-amylase and beta-amylase – which hydrolyze starches to dextrins and fermentable sugars, necessary components of the brewing process.

A recent national trend toward sourcing food locally has impacted many sectors of food and agriculture, including beer production. The Michigan craft brewing industry has seen tremendous growth, with more than 150 craft breweries now operating in the state and more slated to open in the future (Figure 4). To meet consumer demand for a pure Michigan beer, brewers would like to procure grains and flavorings in-state but have difficulty sourcing quality malting barley. This need has prompted a reevaluation of barley production and malting in Michigan, with a specific focus on sustainable production practices and economic viability for Michigan farmers.

Oregon State University Barley Project, 2011

Figure 3. Sprouted barley.

The process by which barley is converted into a usable form for brewing is called malting (Figure 3.). Malting originated nearly 6,000 years ago, and although the process has not changed, the technology to carry out that process has advanced drastically over the years. When barley is malted, it is steeped or intermittently immersed in water for two to three days, which allows the grain to sprout. Sprouting the grain generates the enzymes necessary to convert starches into sugars during brewing. Once the grain has reached the optimum moisture level, it is transferred to the malting or germination floor, where it is constantly turned over a four to five-day period to ensure consistent germination. Automated malting facilities will use a pneumatic plant in lieu of a germination floor for this stage. The product, at this point known as green malt, is then kiln-dried, which ends germination. The length of the kilning period depends on the desired flavor and color of the malt product.

Options for malting in Michigan are limited but are expected to expand as the demand for local ingredients increases throughout the craft brewing industry. Access to high-quality barley is a major limiting factor to malthouse growth in-state. Quality barley grain is necessary to ensure quality malt. Following best management practices for controlling both disease and fertility in your stand is critical.

C. McKinney, 2014

Figure 4. Michigan is home to over 150 breweries, many of which bottle and can their product for retail sales.

History

Barley has long been recognized as the first cultivated and domesticated grain in the world, dating back more than 10,000 years. It originated in the Fertile Crescent, a crescent-shaped region located in the present-day Middle East. Although barley likely arrived in America with the first settlers, its main introduction from Europe was along the eastern seaboard in the early 17th century. Production was predominantly focused in New York state until the mid-19th century, but as the population moved west, barley moved with it, eventually reaching Wisconsin, Minnesota and North Dakota. As new varieties were introduced from regions throughout the globe, barley production also sprouted in the American Southwest, California and the Pacific Northwest. Currently, North Dakota, Montana and Idaho boast the greatest number of planted acres, ranking first, second and third, respectively.

Throughout the first half of the 20th century, it was not uncommon for Michigan to harvest more than 100,000 acres of barley annually, and at times upwards of 300,000 acres were harvested (Figure 5). Since the 1950s, however, barley acreage has steadily declined. A brief resurgence in the 1980s did not reverse this general trend, and over the past 10 years, Michigan barley production has averaged just 10,000 acres. The fact that a substantial barley crop was once realized in our state provides hope for the future.

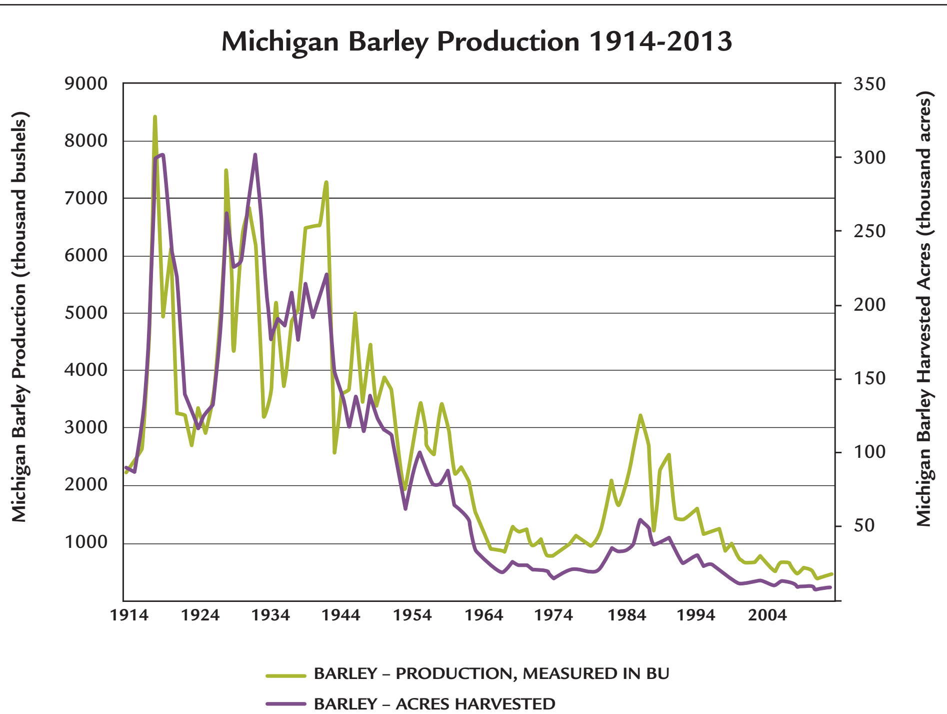

Figure 5. Over the last century, barley production in Michigan has declined greatly. Data from National Agricultural Statistics Service, Chart by A. McFarland

One significant factor motivating the reduction in barley acreage over the past half century was the closure of malting facilities in Michigan. Access to these processors, which took raw grain and converted it to malt for brewing, has diminished because of industrywide consolidation. With the closure of Stroh's Brewery in 1985, in-state markets for malting barley all but dried up (Figure 6). Currently, outside of a few small micromaltsters, no commercial malting facility exists in the state. Although some barley is grown every

Wikipedia, public domain

Figure 6. The closure of Stroh's Brewery in 1985 had a major impact on malting barley infrastructure in the state of Michigan.

USDA-NRCS PLANTS Database / Hitchcock, A.S. (rev. A. Chase). 1950. Manual of the grasses of the United States. USDA Miscellaneous Publication No. 200. Washington, DC.

Figure 7. *Hordeum vulgare* L.

year, the dominant market is now for feed, and many farmers find it more profitable to produce other crops, such as corn and soybeans.

Characteristics and Growth Habits

Both spring and winter types of barley exist. Winter barley is planted in the fall, and resumes growth early in the spring and generally matures one to two weeks before spring-planted barleys. Winter barley will usually fare better than spring barley in drought years, but it can also suffer significant winter injury. Winter barleys should be planted only in the southern half of Michigan, where winter temperatures are less extreme.

The barley plant (Figure 7) goes through three main growth stages: tillering, stem elongation and heading. Each of these stages varies in length depending on variety, climatic conditions, fertility, competition, pests, planting date, soil type and water availability. The Feekes scale is a system to describe the growth stages of cereals (Figure 8).

(http://extension.psu.edu/agronomy-guide/cm/images/figure-1-7-2.jpg)

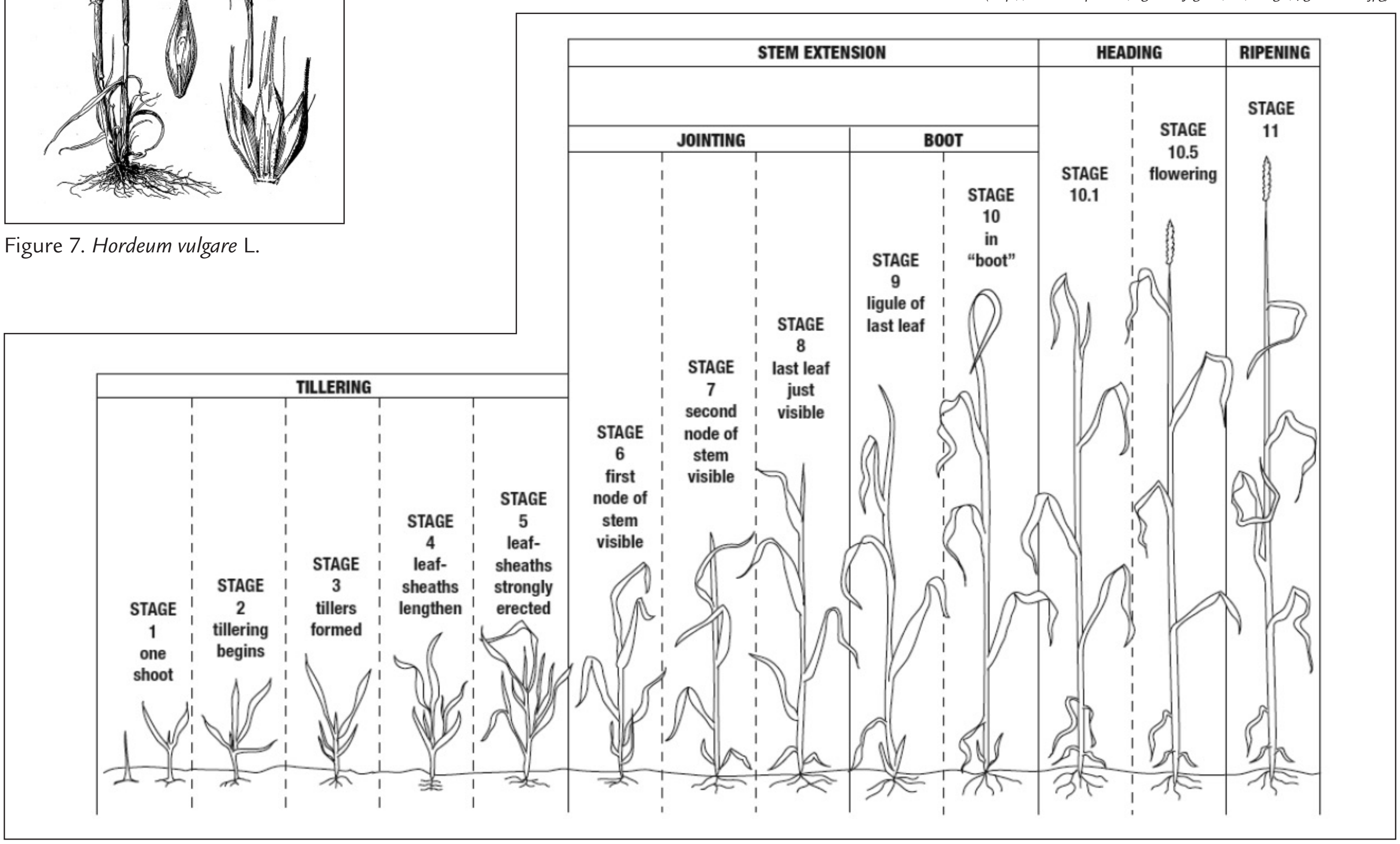

Figure 8. The Feekes Scale is used to describe growth stages in small grains, including barley.

The barley seed will germinate after it imbibes water and expands. Good seed-to-soil contact will increase water imbibition and promote germination. Barley will germinate when soil temperatures are above 36 degrees. The coleorhiza is the first structure to emerge through the caryopsis, followed by the seminal roots. In addition to the main stem, tillers will arise until stem elongation, which is initiated after several days of warm temperatures. Planting date, as well as water and nutrient availability, play important roles in determining tiller number. Barley can compensate for low stand density by increasing tiller number. An adventitious root system is developed during the tillering stage.

During stem elongation, the internodes of the stem stretch (Figure 9). As the plant gains height, the growing point moves up the stem until the plant reaches the boot stage. There are six-row (six rows of kernels/seedhead) and two-row (two rows of kernels/seedhead) barleys, with a predominance of six-row types in Michigan (Figure 10). Preference of two-row versus six-row is entirely up to the end user, and both types are favored in certain applications. Large breweries throughout the nation tend to favor six-row varieties, and craft brewers primarily use two-row varieties for their base malt.

A. Babb, 2014

Figure 9. Barley at the Feekes stage 8, flag leaves are just becoming visible.

B. Steffenson, University of Minnesota

Figure 10. Historically, craft brewers have primarily used two row (left) barley varieties and large breweries have favored six row (right) barley varieties.

Temperature, water and nutrients play an important role in determining spikelet size and floret number. Barley is a long-day species, so the extended days of summer trigger flowering. Pollination usually occurs when the head emerges from the boot, but pollination is possible before the head surfaces. The first flowers to open are often in the upper-middle portion of the head, and flowering proceeds up and down from the initial blossoms. Pollen can be sterilized by high temperatures. Seed development proceeds through several recognizable stages, including watery ripe, milk, soft dough, hard dough, grain hard and ripe. The period from pollination to maturity can range from 40 to 60 days, depending on climatic conditions and variety. The grain can be harvested when it reaches 14 percent moisture. In many varieties, the heads will bend down when they are ready to harvest, becoming very susceptible to breakage and loss.

Production and Growing Requirements

Adaptation

Barley's ability to adapt to diverse growing conditions has led to its successful establishment throughout the world. Nonetheless, great yield differences exist among growing regions, differences that are highly attributable to climate. Barley prefers a consistent, cool and moderately dry climate; it performs poorest in hot and humid conditions. The fact that barley matures earlier than other cereals, oftentimes escaping drought periods, makes barley the most drought-tolerant of all the cereal grains. This is critical because prolonged drought stress severely affects performance—consistent moisture throughout an extended growing season is preferred.

Barley is the only cereal that can be grown at extreme latitudes, including Alaska (64 degrees N), Finland (67 degrees N) and Norway (70 degrees N). It can also be grown at high elevations and will be found higher up on mountains than any other small grain. This versatility allows successful barley production in regions where other cereal crops frequently fail.

Soil requirements

Soil texture is very important to the performance of barley. It prefers well-drained, fertile loam or clay loam soils. Soils heavy in clay may become waterlogged, which limits root growth and results in poor- yielding, low-quality barley crops. If soil texture is too sandy, soil water supply may become inconsistent. This leads to a decrease in plant growth and reduced grain fill. Barley is very tolerant of alkalinity and salinity. It is less tolerant of acidic soils, preferring a soil pH of 6.0 to 8.5. Barley responds negatively to soil pH levels of 5.5 or lower, and fields should be limed according to soil analysis results.

Crop rotations

A well-planned crop sequence is an effective method of breaking disease and pest cycles and maintaining long-term soil health. The fibrous root systems that characterize small grains such as barley can enhance nutrient cycling, improve the physical structure of soil and add organic matter. Factors that may affect placement of barley within an existing crop rotation are the previous crop grown, previous herbicide used and pest history – weed, disease and insect pressure. Barley does best in a long rotation following a legume crop because of the availability of residual nitrogen. Productivity is often lowest when following barley or another small grain. Continuous small grain production is not recommended because of the increased incidence of plant disease, insects and certain weeds. Growing malting barley after corn can lead to an increase in Fusarium head blight, more commonly known as head scab (explained later in this text) because corn stover hosts Fusarium spores and so increases the likelihood of barley contracting this fungal disease.

Date of planting and seeding rate

Date of planting has a significant impact on the development and yield potential of barley. Generally speaking, earlier planting (planted by mid-September – winter varieties, as soon as possible, but before May 20 – spring varieties) leads to higher yields and lower crude protein levels; later planting leads to lower yields and higher crude protein. Earlier planting allows spring barley to take advantage of the cool and moist spring season. Spikelet number per head is determined by the six-leaf stage (refer to Feekes scale), and high temperatures during this physiological process will reduce yield.

Barley should be planted at a depth of 1 to 1.5 inches as soon as soil is dry enough to allow fieldwork (spring varieties). Seeding rate in Michigan has not been adequately researched to date, but a general guideline is to plant between 96 and 120 pounds per acre (Figure 11). A higher seeding rate may result in higher yields if

A. McFarland, 2014

Figure 11. Variety trial plots at the UPREC are planted at 96 pounds/acre.

conditions are optimum. It may also result in increased incidence of disease because dense leaf canopies inhibit air movement across the leaf surface, increase leaf wetness and provide a climate conducive for plant disease.

Fertility recommendations

A well-balanced fertility program is essential in achieving a high-quality, high-yielding barley crop. Soil sampling is always recommended to determine soil nutrient levels in your field and fertilizer needs. (See Extension bulletin E2904, "Nutrient Recommendations for Field Crops in Michigan," for further information.)

Nitrogen

Nitrogen is the most limiting nutrient in barley production, however, care must be taken when the grain intended for the production of malt (Figure 12). Crude protein levels are directly related to the nitrogen content of the grain, and low grain protein levels are desired by the brewing industry. If grain protein is too high, the amount of available extract is lower. Extract is defined as the amount of wort, or grain sugars, extracted from the mash. Higher extract percentages are favorable to brewers because it is the extract that gives the final product its flavor, foam and color. According to American Malting Barley Association standards, acceptable protein levels for two-row barley are less than 13 percent, and for six-row varieties, less than 13.5 percent. The difference between a sufficient amount of nitrogen for barley yield and growth and a nitrogen rate that leads to high crude protein levels within the grain is quite minute. Research by the Upper Peninsula Research and Extension Center (UPREC) in Chatham, Michigan, has shown that 60 to 80 pounds of available nitrogen per acre is a reasonable amount to apply when barley follows corn (Table 1). If barley is to follow a legume crop, the nitrogen rate needs to be lowered to account for nitrogen fixation by the legume. The most commonly used N fertilizers include urea and liquid urea/ammonium nitrate (UAN 28 percent). It is advisable to be conservative on nitrogen application rather than risk over application. Factors including late planting, low soil moisture and high temperatures often affect yield potential much more than soil fertility. Below are results from a barley fertility trial conducted in 2013 at the UPREC. Nitrogen sources used were urea and Environmentally Smart Nitrogen (ESN). The previous crop was corn grain (to induce heavy disease pressure).

A. Moore, 2012 *A. Moore, 2012*

Figure 12. Nitrogen deficiency (left) in barley is evidenced by yellowing of the vegetation. Barley sufficient in Nitrogen (right) is evidenced by consistent, deep green vegetation.

Table 1. UPREC Fertility Trial Results, 2013

Amount of nitrogen applied per acre (pounds) and type (grade)	Crude protein percentage	Yield (bushels per acre)
0 lb	12.4	37.2
60 lb Urea (46-0-0)	12.2	44.3
90 lb Urea (46-0-0)	12.2	50.1
120 lb Urea (46-0-0)	12.3	51.6
60 lb ESN (42-0-0)	12.1	39.9
90 lb ESN (42-0-0)	12.3	41.1
120 lb ESN (42-0-0)	12.0	45.7

Phosphorus and Potassium

Generally, Michigan soils will contain adequate levels of phosphorus and potassium for malting barley production. Once again, refer to your soil test results and amend the soil as needed. (See Extension bulletin E2904, "Nutrient Recommendations for Field Crops in Michigan," for further information on acceptable levels of soil phosphorus and potassium.)

Weed management

Effective weed control in barley is vital to optimize yield potential. Weeds compete with the barley crop for water, light and nutrients (Figure 13). Weed seed may also

C. Kapp, 2014

Figure 13. Weeds should be managed to minimize growth competition and potential weed seed contamination at harvest.

contaminate the grain at harvest and decrease the crop's value. Weed pressure will depend on several factors – the weed history of the field, weed seed infestation levels and the efficacy of fall control measures. Planting clean, certified seed free of weeds is a must to help reduce weed pressure within the stand. Fields that have a history of problematic perennial weeds such as milkweed (*Asclepias syriac*) or quackgrass (*Elytrigia repens*) should be treated the previous year with appropriate methods according to the species present. Early planting is also instrumental in successful weed control – it allows the barley to germinate earlier than many annual weeds and compete more effectively. Several cost-effective post-emergent herbicides are available for use in barley today. (See the MSU Extension "Weed Control Guide for Field Crops" (E-434) for specific information on herbicides labeled for use in barley.)

Insect management

Insect damage to barley is typically not a problem, but growers should always be prepared to scout fields and control insects if economic thresholds are reached. The economic threshold is defined as the number of insects or extent of damage at which some sort of control action should be taken to prevent an economic loss.

One insect that may prove to be a severe problem is the cereal leaf beetle (CLB) (Figure 14). This beetle was discovered in Michigan in 1962. Releases of beneficial parasitoids in the '60s and '70s helped reduce the severity of damage to crops, but severe CLB feeding was found in 2013 at UPREC. Both the adult beetles and their larvae feed on barley leaves, with larvae causing the more serious damage. The larvae feed on vegetative material between the veins of the leaf, down to the outer cuticle. This is often called window-paning (Figure 15), and severe injury can leave the field looking white or frosted. Economic thresholds vary depending on growth stage of the barley plant (Table 2). It is very important to protect the flag leaf. Energy produced by the flag leaf powers grain fill within the seedhead. Any damage done to the flag leaf during boot stage or beyond will have a dramatic negative impact on yield.

C. Kapp, 2014

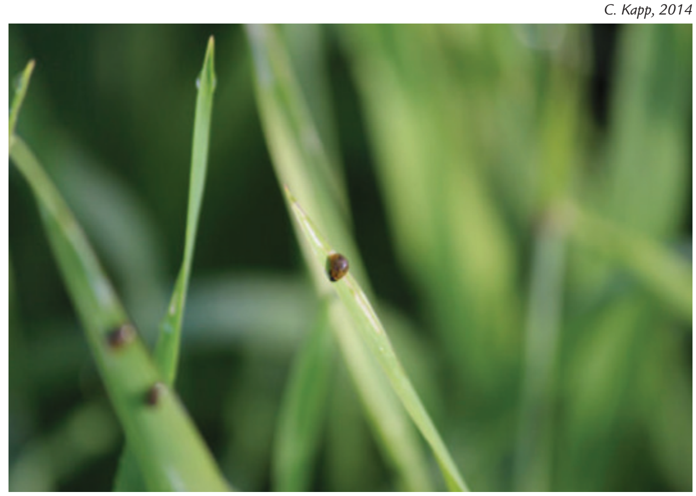

Figure 14. Cereal leaf beetle is the most prevalent insect issue in the production of barley.

J. Isleib, 2013

Figure 15. Cereal Leaf Beetle causes a "window paning" type damage to barley vegetation.

Purdue Entomology photo, John Obermeyer, 2012

Figure 16. Armyworms are another potential source of insect damage to barley.

Armyworm is another insect pest that may be of concern (Figure 16). True armyworm does not overwinter in Michigan. Adult moths are blown into the region on storm fronts from the South during the spring and early summer. The adults are attracted to dense green areas such as small grain and grass hay fields, where they lay their eggs. After the larvae hatch, they proceed to feed on the foliage of nearby plants and, in severe cases, may clip leaves from the main stem. Larvae hide at the base of the stem during the day and are most active during the evening and on cloudy days. Economic thresholds for this pest are once again based on plant maturity (Table 2). Smaller larvae are easier to control than large larvae, and it is large larvae that will do the most extensive damage, such as head clipping and quick defoliation of the crop.

For more specific insect information, please visit **www.msuent.com**.

Table 2. Economic thresholds for common pests in barley

Cereal leaf beetle (CLB)	Before boot stage	At boot stage
	3 larvae or eggs/plant	1 larvae or more/flag leaf
Armyworm	**Before heading stage**	**After heading stage**
	4 or more larvae/square foot	2 or more larvae/square foot

Disease control

Several plant diseases are detrimental to barley yield and quality. Important management considerations for disease control are crop rotation, residue management, fungicide seed treatment and selection of disease-resistant varieties. Scouting barley fields throughout the growing season allows early identification of disease and subsequent timely control.

The most severe disease in barley is Fusarium head blight (FHB), also known as scab (Figure 17). FHB is a fungal disease that infects the plant's flowers. It reduces yield by causing sterile florets and shriveled kernels. FHB can also lead to the development of mycotoxins in the kernels – most importantly, deoxynivalenol (DON),

P. Schwarz, 2014 P. Schwarz, 2014 P. Schwarz, 2014

Figure 17. Fusarium head blight (FHB) is the most devastating disease in barley produced for malt though decreases in yield and quality.
a. The first noticeable symptom of FHB is bleaching of some or all of the grain spikelets while the remaining head is healthy and green.
b. Infected grain kernels are commonly called tombstones and can appear shriveled, discolored, and will have a low test weight.
c. FHB infected grain is likely to contain the mycotoxin, deoxynivalenon (DON), also known as vomitoxin, which at certain levels can be toxic to humans and livestock.

which makes the grain unsuitable for both human and animal consumption. DON levels over 1 part per million (ppm) will lead to rejection of the barley for malt purposes if it is being marketed to a large-scale malthouse such as Cargill Malt or Anheuser-Busch InBev. Even minute DON levels can lead to excessive foaming of beer and other quality issues. FHB is spread by spores from hosts containing inoculum, such as infected small grain or corn residue. The spores are either carried by the wind or splashed onto the barley seed head by rain. Environmental conditions favorable for disease development are extended periods of hot (75 to 85 degrees F), humid weather. Infection can occur after the seed head clears the boot all the way through the hard dough stage. FHB cannot be completely avoided if weather conditions are favorable, but management practices can lessen the risk of infection. Helpful practices include selecting a variety that has some resistance to FHB, avoiding planting barley after corn or other small grains, and using a recommended fungicide. Tillage to bury residues from FHB-susceptible crops reduces Fusarium inoculum to some extent. Applications of labeled fungicide directly to the seed head immediately following head emergence usually reduces FHB and the creation of DON. Research at the UPREC has shown that certain fungicides sprayed at heading effectively reduce FHB (Table 3). Fungicides used to control FHB are usually sprayed during heading, and care must be taken to direct the spray onto the target surface of the seed head. Be sure always to follow label instructions.

Barley is also susceptible to various other diseases that may attack the roots, stems or leaves, including:

- Root rots – Pythium, Rhizoctonia.
- Rust – stem rust, leaf rust.
- Leaf diseases – bacterial blight, Septoria blotch, powdery mildew.
- Head disease – ergot, smut.
- Virus – barley yellow dwarf.

The use of a fungicide at heading has the added benefit of providing protection against the fungal leaf diseases, including the rust and leaf spot diseases.

For photos of other barley diseases, reference the Barley Disease Handbook by North Dakota State University: **http://www.ag.ndsu.nodak.edu/aginfo/barleypath/barleydiseases/**.

Table 3. Fungicide trial at the UPREC, 2013

Fungicide and amount applied	DON level (ppm)	Yield (bushels/acre)
Control (no fungicide applied)	1.05	47.2
Prosaro - 8.2 oz/ac, applied in Feekes stage 10.5	0.66	60.5
Caramba - 14 oz/ac, applied in Feekes stage 10.5	0.79	55.4

Economics

Establishment costs

Establishment costs will vary from farm to farm. Certified seed of desirable malting barley varieties is not currently being produced in Michigan (Figure 18). Shipping costs from outside the state will add to seed costs. The example budget on page 12 (Table 5) includes selected costs for establishing a crop of malting barley. Machinery and other input costs are based on 2014 MSU Extension estimates. Use your estimated expenses to prepare a budget tailored to your farm, not all inputs are needed in every operation.

Economics

Malting barley will need to meet minimum quality/protein requirements and be within acceptable limits of contamination from fungal diseases. If barley does not meet standards for malting, the grain harvested will need to be sold as feed grain, with a substantial reduction in value. Currently, elevator prices for feed-grade barley are around $3/bushel.

A. McFarland, 2014

Figure 18. Certified seed is not currently being produced in Michigan, but there are sources in other Midwest states. Planting certified seed is the first step in producing quality malting barley.

Table 4. Potential value of barley crop based on crop yield and price received.

Yield (bu/a)	Price received per bushel ($)										
	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00
35	105.00	122.50	140.00	157.50	175.00	192.50	210.00	227.50	245.00	262.50	280.00
40	120.00	140.00	160.00	180.00	200.00	220.00	240.00	260.00	280.00	300.00	320.00
45	135.00	157.50	180.00	202.50	225.00	247.50	270.00	292.50	315.00	337.50	360.00
50	150.00	175.00	200.00	225.00	250.00	275.00	300.00	325.00	350.00	375.00	400.00
55	165.00	192.50	220.00	247.50	275.00	302.50	330.00	357.50	385.00	412.50	440.00
60	180.00	210.00	240.00	270.00	300.00	330.00	360.00	390.00	420.00	450.00	480.00
65	195.00	227.50	260.00	292.50	325.00	357.50	390.00	422.50	455.00	487.50	520.00
70	210.00	245.00	280.00	315.00	350.00	385.00	420.00	455.00	490.00	525.00	560.00
75	225.00	262.50	300.00	337.50	375.00	412.50	450.00	487.50	525.00	562.50	600.00

Using average yields of barley variety trials conducted at the Michigan State University Research and Extension Center in Michigan's central Upper Peninsula, the following examples can be calculated using the establishment costs in Table 1:

1. Average yield of spring barley variety trials conducted from 2008 to 2011 (four years), including malting and feed barley varieties – 56 bushels per acre (high - 80 bu/acre; low - 40 bu/acre).

   Production costs using estimates above (adjusted grain hauling costs): $369.02. Therefore, a producer would have to receive a price of $6.50 to $7 per bushel to break even.

2. Average yield of 2013 malting barley variety trial – 50 bushels per acre.

   Production costs using estimates above (adjusted grain hauling costs): $367.46. Therefore, a producer would have to receive a price of $7 to $7.50 per bushel to break even.

Markets, demand and prices

Demand for malting barley from large-scale international breweries has been steady but not increasing significantly in recent years (Figure 19). Typically, growers enter into contracts with malting barley grain purchasers, setting a price and volume of delivery before planting. Industry contract prices were in the range of $6.30 to $6.90 per bushel in 2013. Minnesota cash elevator prices for open market malting barley were in the neighborhood of $4.50 per bushel in December 2013. Producers may need on-farm storage facilities for their crop because small brewers will normally spread their deliveries over most of the year.

Oregon State University Barley Project, 2009

Figure 19. Large-scale malting facilities have automated much of the malting process.

States with the largest acreages of malting barley are Montana, Idaho, North Dakota and Washington. Michigan ranks last (tied with Kansas) for 2014 prospective acreage

Table 5. Malting barley establishment costs in Michigan

Description	Expense per acre ($)	Subtotal ($)	Your farm
Pre-harvest machinery work			
Spray herbicide	6.69	6.69	
Tandem disc w/harrow (2X)	14.42	28.84	
Spread fertilizer	6.99	6.99	
Seed drill	10.17	10.17	
Spray fungicide	6.69	6.69	
SUBTOTAL		52.69	
Seed and fertilizer			
Certified seed ($18.20/bu)	36.40	36.40	
Ship seed to farm ($0.80/bu)	1.60	1.60	
Nitrogen (50 lb @ $0.40/lb)	20.00	20.00	
Lime (estimated annual cost)	15.00	15.00	
Phosphorus(40 lb @ $0.43/lb)	17.20	17.20	
Potassium (40 lb @ $0.35/lb)	14.00	14.00	
SUBTOTAL		104.20	
Herbicide and fungicide			
Herbicide	13.15	13.15	
Fungicide	34.00	34.00	
SUBTOTAL		47.15	
Labor			
Seeding and harvesting (3 hrs @ $13.17/hr)	39.51	39.51	
SUBTOTAL		39.51	
Land			
Cash rent equivalent	50.00	50.00	
SUBTOTAL		50.00	
Harvesting costs			
Combine	28.95	28.95	
Haul grain from field to farmstead (45 bu/acre X $0.09/bu)	4.05	4.05	
Haul grain to market (45 bu/acre X $0.17/bu)	7.65	7.65	
Bale straw (.75 tons/a, 37 small square bales/a, $.075/bale)	27.75	27.75	
Haul straw	4.00	4.00	
SUBTOTAL		72.40	
Total costs per acre (based on 45 bu/acre yield)		**366.16**	

in a listing of 22 barley-producing states, with virtually all of Michigan's 10,000 acres grown as feed-grade barley. The lack of infrastructure and experience in marketing malting barley in Michigan explains this statistic.

A listing of large-scale purchasers of malting barley can be found on the American Malting Barley Association, Inc., website at **http://ambainc.org/**. At least one of these purchasers, Busch Agricultural Resources, LLC, uses an E-auction process. Growers are given a password to get on the website, then offer their bid for lots of a designated bushel size. The lowest farmer-bidder gets the contract. Most of Busch's contracts are filled this way; the remainder through the traditional contract program.

Given the prices in traditional markets and distance of trucking required, malting barley has not been an attractive option for Michigan farmers. However, the rapid growth of the craft brewing industry in Michigan may provide a new potential market for locally produced malt. The craft brewing industry has expressed strong interest in sourcing local inputs for locally crafted beers (Figure 20). Currently, the main obstacle to development of this new market is the lack of Michigan malthouses, which are needed to process malting barley grain into a malt product suitable to craft brewers.

Outlook for potential

Overall, the potential acreage of malting barley needed to supply part of the demand from the craft brewing industry is small compared with acreage of major commodity crops such as corn, soybeans and wheat. This new market for Michigan farmers will very likely be driven by the development of local malting houses seeking locally produced barley grain of acceptable quality. The profitability of the crop will depend on contractual or open market prices offered. To be competitive with other common grains and commodity crops, price premiums must be high enough to make malting barley attractive to farmers.

A. McFarland 2014

Figure 20. Malt bagged and ready for brewing at the Pilot Malthouse in Jenison, MI.

Perspective from the Michigan Brewers Guild

Currently, large-scale international breweries located in the United States, which account for approximately 80 percent of beer sold in the country, are experiencing flat or steadily declining sales. Small, domestic craft brewers have seen a dramatic reemergence in the past 30 years, with the number of these breweries growing from virtually none to more than 2700 in 2013. While the major domestic brewers have seen steady declines, American craft breweries have realized continued growth – including 18 percent in 2013 – averaging more than 10 percent over the past decade nationally. Indeed, the craft beer industry is now a primary driver of growth in the nation's beer industry, accounting for nearly 8 percent of U.S. beer sales in 2013.

Craft brewers have become significant users of brewing raw materials such as hops and malted barley, and they typically use much larger quantities per barrel of beer produced than the large domestic brewers (Figure 21). Craft beer volume in 2013 accounted for 7.8 percent of the total market share but consumed over 25 percent of the malt. At a 10 percent market share, which is attainable in the near future, craft brewers will then use 31 percent of all malt consumed by U.S. brewers. Finally, if craft beer captures 20 percent of U.S. beer consumption, it is estimated that those brewers will use over 51 percent of the malt supply. These consumption ratios support the craft beer industry's impact on both the malting barley and malt market.

Michigan currently ranks fifth in the United States in number of breweries per state, and all Michigan breweries are craft brewers. The growth of Michigan's breweries reflects the national trend but is even more dramatic, with growth rates in excess of 20 percent

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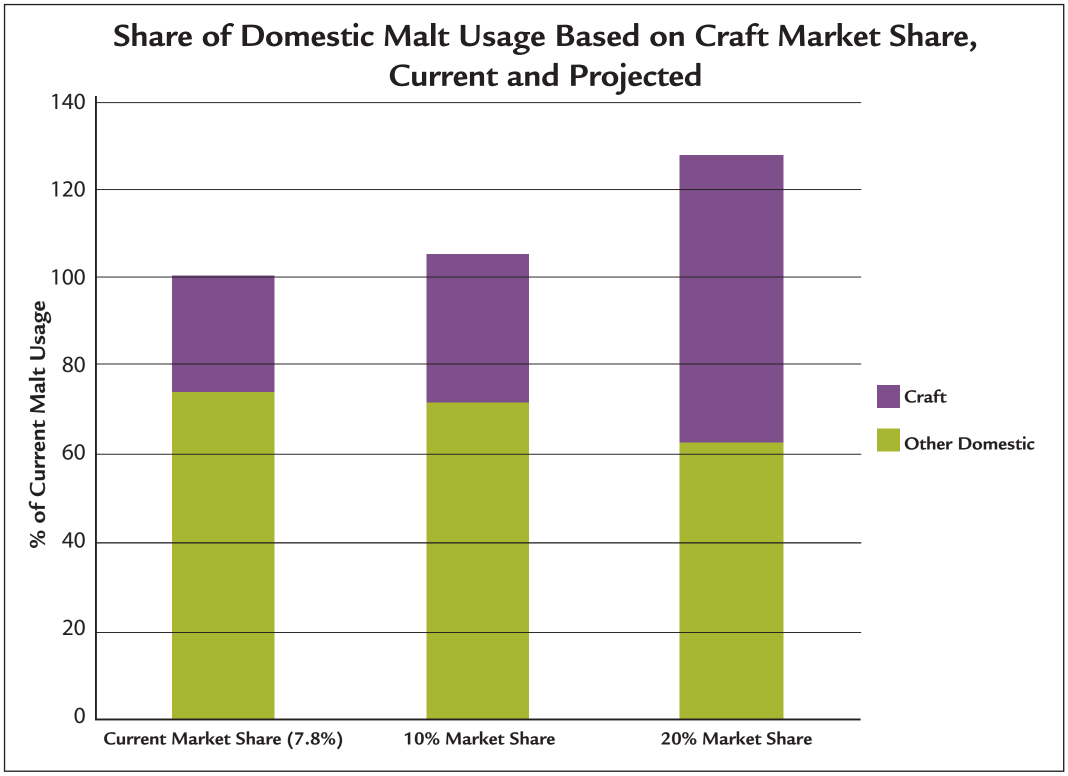

Figure 21. In 2013, although craft brewers only held 7.8% of the market share of beer purchased, they used over 25% of the total malt used for all beer production.

in recent years and more breweries planning to open. Currently, Michigan-brewed beer sold in Michigan accounts for 4.75 percent of all beer sold in the state. That share is expected to grow well beyond 10 percent in the future, and a 25 percent or larger share in 25 years is not out of the question. Michigan brewers produced and sold more than 296,900 barrels (31 gallons each) of beer in Michigan in 2013, which does not include the significant volume of beer sold outside of Michigan by Michigan brewers. Michigan's craft brewers are very interested in sourcing local products to use in brewing, as evidenced by the establishment of a significant hop industry locally as well as the use of many other locally produced agricultural products such as fruits, herbs, vegetables, honey and sugar. Malted barley is the largest single product used (aside from water) in the production of craft beer, and quality local malt would be of great interest to the state's growing breweries (Figure 22).

R. Hamilton, 2014

Figure 22. Quality malt is a major ingredient in craft brews.

Demand within the craft brewing industry for a robust and diverse flavor profile will undoubtedly shape the future of malting barley and malt production. Over time, as large-scale industrial breweries and their products have become more homogeneous, so, too, has malt, supplying the demand for a more consistent flavor. The Brewers Association has identified this as a mismatch for the craft brewing industry and potentially an impediment for growth. To produce all-malt brands, craft brewers seek barley malts with:

- Distinctive flavors and aromas.
- Lower free amino nitrogen.
- Lower total protein.
- Lower diastatic power (DP).
- Lower Kolbac index (ratio of soluble protein to total protein, or S/T).

To learn more about the demand for malting barley and a diverse malt market by the craft brewing industry refer to "Malting Barley Characteristics for Craft Brewers," created by the Brewers Association, at **https://www.brewersassociation.org/attachments/0001/4752/Malting_Barley_Characteristics_For_Craft_Brewers.pdf**.

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United States Department of Agriculture, National Agricultural Statistics Service. **www.nass.usda.gov**.

Resources

American Malting Barley Association Website: **www.ambainc.org**

Brewers Association Website: **www.brewersassociation.org**

Michigan Brewers Guild: **www.mibeer.com**

Michigan State University Farm Management, Dennis Stein: **www.msu.edu/~steind**

North Dakota State University, Institute of Barley and Malt Sciences: **www.ag.ndsu.edu/ibms**

M. Judge, 2014

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