



Agronomy Facts 77

Malting Barley in Pennsylvania

HISTORY

Malting barley was introduced to the United States by the Dutch, English, and French during the time of European settlement and became an important crop for both animal feed and its use in the production of beer. Barley production and malt houses were common in colonial Pennsylvania.

Its use in beer production drove malting barley from the East Coast farther west. At one time, malting barley was grown in much of the Corn Belt region; yet, as the prices of corn and soybean rose, malting and feed barley was phased out of production. In Pennsylvania, feed barley production has continued to the present.

Currently, malting barley is predominantly grown in the western United States, Canada, and Europe. In the United States, malting barley is grown from the Dakotas to Washington, with North Dakota having the most acres. With the rapid growth of craft beer production, a demand for locally sourced malted barley has led to the development of malt

houses in Pennsylvania and other states in our region. In some states, such as New York and Maryland, legislation has provided some incentives to use locally produced barley for craft beer. Because of these factors, interest in malting barley production is increasing. In this fact sheet we will review some of the key practices involved in successful malting barley production in Pennsylvania.

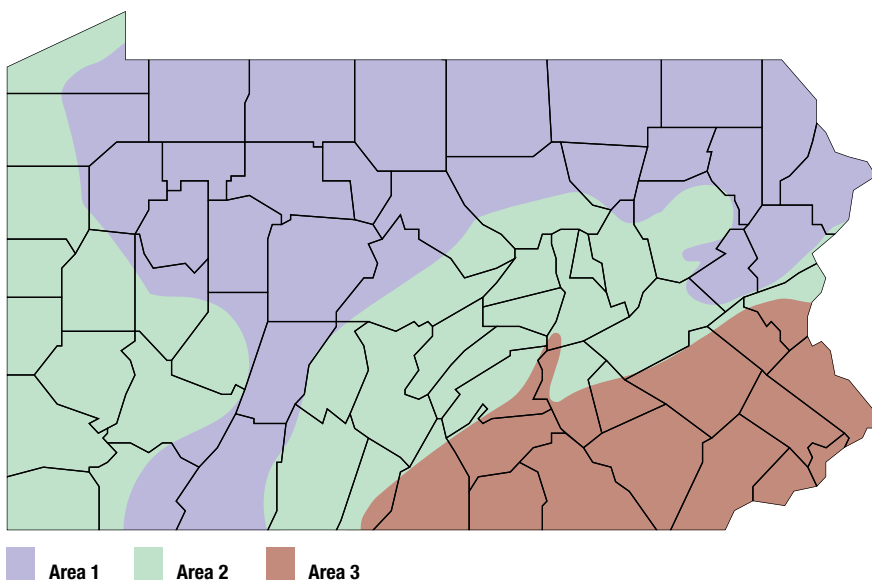
DESCRIPTION AND ADAPTATION

Barley is a cool-season annual grass and cereal grain that grows best in well-drained soils that have a pH ranging from 6.5 to 7.0. Barley lines are available in both winter and spring types. Spring types are best adapted to shorter-season areas in Area 1 in Figure 1. Winter types are best adapted to the longer season areas in Areas 2 and 3. Barley is less winter hardy than wheat or rye, so timely planting, selection of winter-hardy lines, and good soil fertility management are keys for consistent success.

Malting barley is a specific type of barley that differs from the feed barley commonly grown in the state. Typically, malting barley lines produce higher levels of amylase enzymes, which convert starch to sugars during the brewing process and have lower protein levels.

Malting is a process in which the grain is soaked in water, or “steeped,” and then partially germinated before being dried. During this germination process, the barley seeds release enzymes that break down the starch in the endosperm of the seed to provide nutrition to the developing seedling. When the germination process is suspended, these enzymes are available to be used to convert the starches into sugars in barley and other grains used in the brewing process. The amount of enzymes in the malt is rated using

Figure 1. Small grain management areas in Pennsylvania.



an indicator called diastatic power. The diastatic power is especially important when other grains, called adjunct grains (grains lacking converting enzymes), are used in the brewing process. Most craft beers use only malted barley, but some can contain oats, wheat, unmalted barley, and rye as adjunct grains.

Malting barley has other characteristics that are important to the brewer. Plump, uniform kernels are important to produce a good, evenly germinating malt in order to maximize the malt extract potential (i.e., fermentable sugar concentration). Flavor characteristics of different malting barley varieties is a new area of interest by some brewers—different malting barley varieties can produce different flavors when malted, thus increasing the importance of variety selection in the brewing and malting industry. Dormancy, a trait that keeps the barley from sprouting in the head, has been avoided in many malting barley lines but could be important in our region in the future. For example, many feed barleys will not germinate well for 30 to 60 days following harvest.

Malting barley varieties are available in either two- or six-row head types (Figure 2). Historically, the six-row types have higher yields and smaller, less uniform kernels. The two-row types have been grown more in Europe and tend to have larger, more uniform kernels. The six-row types tend to have higher enzyme levels and are better adapted to the noncraft brewers that use a lot of adjunct grains such as corn or rice. As breeders have worked to develop modern varieties, the differences between six-row and two-row types have been minimized; however, there are still some strong preferences among maltsters and brewers based on head type, so it is best to know what your market preferences are before growing a particular variety.

As with feed barleys, malting barleys are available in both spring and winter types. Yields of malting barley will likely be similar to or slightly less (maybe 10 percent or

Figure 2. Six-row (top) and two-row (bottom) barley types.



so) than the best adapted feed barleys. This would be due to a combination of less-adapted lines and perhaps slightly lower nitrogen rates. For winter barley in areas where it is best adapted, yields of 60 to 90 bushels per acre should be possible. For spring barley in northern Pennsylvania, yields of 40 to 80 bushels per acre should be feasible.

VARIETIES

Most of the available malting barley varieties have been developed in other regions (western states, western Canadian provinces, or Europe). Seedsmen and universities like Penn State have been working to try to identify adapted lines that meet the quality specifications of the malting industry and yield well.

Winter varieties are available from the western United States and European companies. Current public lines from the western United States have been ‘Charles’, ‘Endeavor’, and ‘Maja’. Examples of some European winter varieties are ‘Wintmalt’, ‘Scala’, and ‘SY Tepee’. Another winter alternative is the variety ‘Thoroughbred’. This popular feed variety has some malting barley in its pedigree and some malt houses have found it to be a good variety for malting. In longer-season areas where winter barley is adapted, winter barley will often yield about 40 to 50 percent higher than spring barley.

Spring varieties that have done well in New York and Pennsylvania include ‘Conlon’, ‘Newdale’, ‘AC Synergy’, and ‘Quest’. ‘Conlon’ is an especially early two-row variety that might have some potential when grown in longer season areas to escape heat and disease pressure. ‘Newdale’ and ‘AC Synergy’ are two-row lines, while ‘Quest’ is a six-row type.

As the best varieties can change, it’s best to keep abreast of current variety evaluations. Variety performance data at Penn State is available at extension.psu.edu/plants/crops/grains/small/trial-reports. Cornell’s performance data is posted on their small grain site at plbrgen.cals.cornell.edu/research-extension/small-grains/cultivar-testing.

For larger breweries, varieties for malting are provided on the American Malting Barley Association list at ambainc.org/content/64/recommended. This website also shows recommended two-row and six-row winter and spring varieties and lists the varieties recommended for the current year and the amount of each variety that has been planted.

SEEDING

Winter malting barley should be seeded between September 10 and 20 in Area 1, between September 15 and 25 in Area 2, and between September 30 and October 5 in Area 3 (see Figure 1). Do not delay seeding because of dry soil. Seed 1 to 1.5 inches deep. Maintain a uniform seeding depth. Shallow seedings can cause poor stands and be subject to winterkill. Since winter barley is less winter hardy than winter wheat, winter survival is poor in most locations in Area 1. In Area 2, winter survival may be poor in approximately one year out of six, whereas winter survival should be adequate most years in Area 3.

The desired population for winter barley is 1.2 to 1.5 million per acre (28 to 34 plants per square foot). A common recommendation is for 2 bushels per acre (96 pounds per acre). The seeding rate should be based on the number of seeds per acre rather than pounds per acre since malting barley often has plumper (larger) seeds. For example, a seed lot with large seeds at 9,000 seeds per pound would require 144 pounds (1.3 million / 9,000) or 3 bushels per acre to achieve the rate of 1.3 million seeds per acre.

For spring barley, seed should be sown similar to oats in late March or April or as early as possible. Try not to seed late. Delaying seeding can result in more insect and disease pressure and heat stress during grain fill. Seeding rates are similar to those for winter barley. Using no-till can help facilitate early planting and avoid delays caused by tillage in the spring.

CROP ROTATIONS

Crop rotations are an important consideration in malting barley production. With winter barley, following a crop that is harvested early enough in Pennsylvania is often a challenge. Ideal crops are corn harvested for silage, early varieties of soybeans, and sweet corn or green beans. Avoid planting barley following a small grain such as winter wheat, winter rye, or winter barley. Volunteer plants from the preceding small grain crop can contaminate the malting barley and lead to rejection. Following these crops can also lead to disease issues. Barley can be planted following spring oats, as any volunteers will be winter killed and the disease issues are not as much of a concern between oats and barley. Check on herbicides used in the prior crop, especially corn or soybeans, to make sure there will not be any herbicide carryover issues.

Winter malting barley can provide some opportunity to diversify traditional crop rotations and double crop with soybeans, sorghum sudangrass, or various cover crop species. These should be included in the economic analysis when considering growing malting barley.

For spring barley, there are fewer issues with crop rotation. The ideal situation would be to follow a low-residue crop like soybeans where an early no-till planting might be an option. If planting into a cover crop, make sure the crop was killed with herbicides at least two weeks prior to seeding to avoid any transmission of diseases or aphids to the emerging barley seedlings. This can also occur from adjacent cover crops that are killed for corn or soybean production.

FERTILITY

The basis for a sound fertility program is a soil test. For optimum barley production, strive for pH values of 6.5 to 7.0. Ideally, phosphate (P) and potassium (K) levels should be in the optimum range as well. Typically, P and K needs are applied in the fall at planting. In some situations, adding 20 pounds of fall nitrogen (N) can be beneficial. This is particularly true following corn or oats where soil residual N levels may be low. Manure can be used to supply some or all of the P and K needs, but be careful to avoid overapplication since excessive N can cause lodging.

Spring N requirements are similar or slightly less than those for feed barley. Excessive N rates can cause the grain protein levels to rise. If they get above 12 to 13 percent, this could cause problems with the malting and brewing process and lead to rejection. On the other hand, it is not ideal to compromise yield due to N deficiency, which can occur with lower N rates. We are still evaluating N rates on malting barley.

For feed barley, spring N recommendations are 0.8 pound of N per bushel of expected yield goal. For an 80-bushel-per-acre crop, the recommendation would be about 64 pounds per acre. This is probably a good starting point for malting barley in our region. Higher rates can also cause the crop to lodge and be slow to mature. If plants did not tiller well, apply N by mid-March; otherwise, apply any time up to Feekes growth stage 5 (see Figure 3 on page 4). Adjust this recommendation for any residual N from previous manure applications (see extension.psu.edu/agronomy-guide/cm/tables/table-manure-nitrogen-availability-factors-for-use-in-determining-manure-application-rates-based-on-planning-conditions). When applying N to malting barley and other small grains, strive for uniform applications since skips can have a negative impact on yield and overlaps can result in lodged areas in the field.

WEED AND INSECT CONTROL

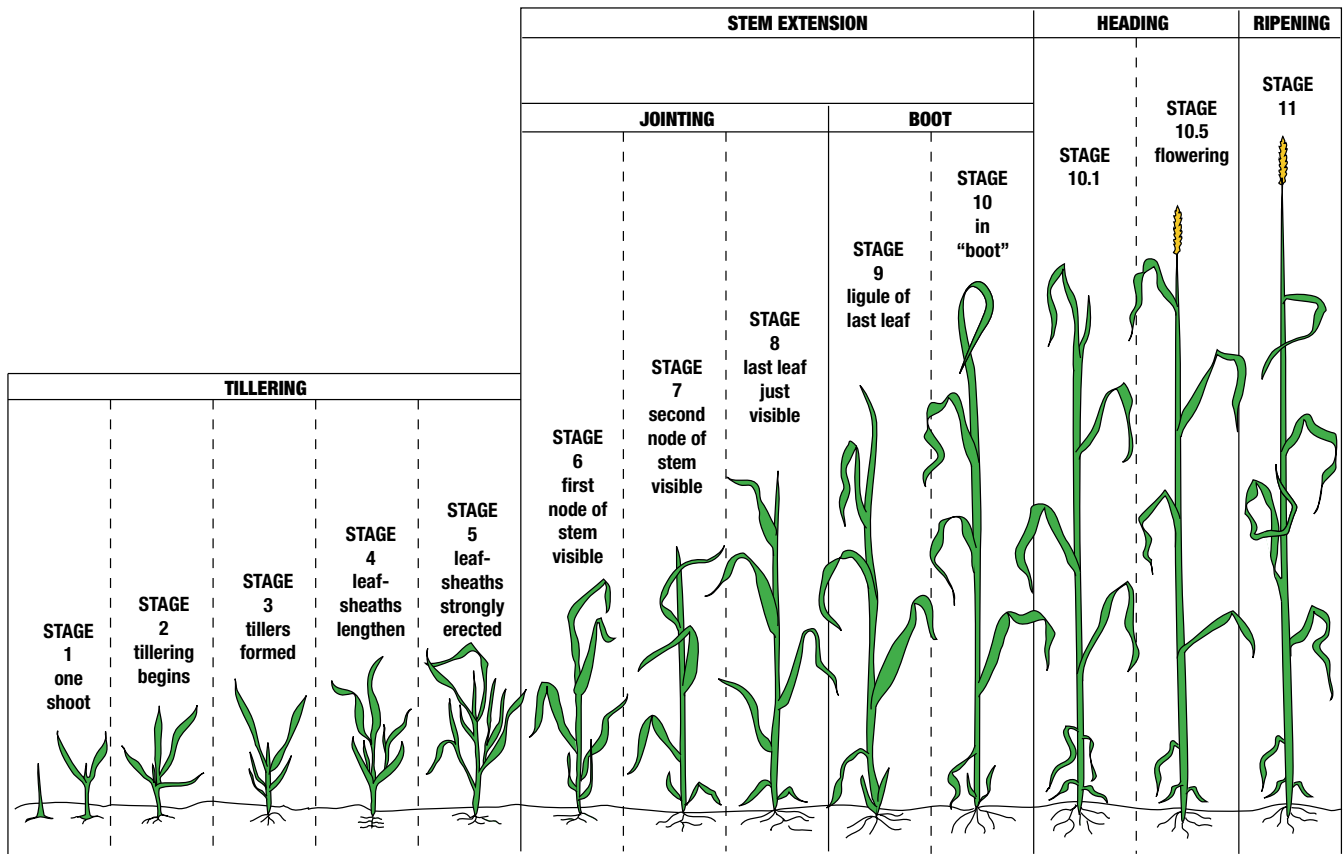
Weed control for malting barley is similar to that of feed barley. Tillage or burndown herbicides in the fall can be used to destroy any significant weeds prior to planting, and then in early spring the field can be treated for winter annuals or broadleaf weeds with common small grain herbicides. Make sure the product is labeled for barley since some herbicides are labeled only for wheat and can cause injury to barley. For spring barley, a similar approach can be used as in oats, with an herbicide or tillage early in the spring followed by an herbicide if necessary while the crop is in the vegetative stages. Detailed herbicide recommendations can be found in the *Penn State Agronomy Guide*.

DISEASES

The most common malting barley diseases are foliar pathogens, which affect the leaves; viruses, which affect the entire plant; and head diseases.

A common foliar pathogen is powdery mildew, which is a white cottony fungus that appears on the leaves during the vegetative growth. If infection progresses to the uppermost leaf, called the flag leaf, it can cause reductions in yield and grain quality. Varieties differ dramatically in their resistance to powdery mildew. It's important to know the level of resistance of the variety you are growing and then treat with a fungicide if necessary. Ideally, using a resistant variety is the first step to managing this disease. Treating with a strobilurin fungicide near Feekes growth stage 7 is a management option for powdery mildew. Other foliar diseases of malting barley include net blotch, scald, and leaf rust. In our environment, they don't often reach threshold levels needed for control.

Figure 3. Small grain growth stages.



The main virus disease is barley yellow dwarf virus. This is a virus transmitted by aphids from nearby grass or cover crops to the barley seedlings. The virus causes patches of discoloration and stunted growth. It can be an issue on early planted winter barley or spring barley planted adjacent to other small grains or cover crops that are burned down for corn production. While incidence of this disease is irregular, the best management option is to use a resistant variety. When an aphid infestation is identified early in the crop, control with an insecticide may limit the spread of the disease. Once plants show symptoms, no control measures are available.

The main head disease in malting barley is *Fusarium* head blight or head scab. Scab can cause the barley grain to have high levels of vomitoxin produced by the fungus. The malting industry is very sensitive to this contamination, and levels over 1 ppm are a cause for rejection. Symptoms of scab in barley are different from those in wheat. In barley, the kernels have a darkened appearance and often don't show the blighted white head sections like they do in wheat (Figure 4). There are also fewer shriveled "tombstone" kernels, so it can be harder to clean contaminated grain to reduce the vomitoxin levels. Advanced infections may show light pink or orange mold on the heads (Figure 5).

Head scab is caused when *Fusarium* spores land on the emerging head near or after the plant is flowering during wet or humid weather. These spores may already be in your field in residue from previous crops like corn or wheat, or they can blow in from other fields in the area. Unlike wheat, which flowers after the heads emerge, barley flowers as the head is emerging from the boot, making visualization of this stage difficult. While the flowers may be infected, barley glumes are the most frequently affected plant part. Barley varieties have some differences in resistance, but resistance to head scab is not as well developed as in wheat.

Fungicide applications are one of the management tactics that can be used to partially control the fungus and reduce vomitoxin levels in the grain. The optimal timing for an application is when the head is fully emerged from the boot on 50 percent of the primary tillers. Only nonstrobilurin fungicides should be used to protect against scab, and currently Prosaro and Caramba are the most effective products for this use. An application like this will also give protection against several flag leaf and other head diseases. Further work is being conducted to identify additional management options for this disease.

HARVESTING AND STORAGE

Malting barley should be harvested as soon as possible following physiological maturity when grain moisture drops below 18 percent. Rain on mature heads can have a big negative impact on grain quality. Since many malting varieties have low dormancy, rain can cause preharvest sprouting and make the grain unsuitable for malting due to low germination rates after harvest and drying. Rain on mature heads can also negatively impact the color and freshness of the grain, which can reduce the quality of the malt.

Slow ground speed and reel speed as much as possible to avoid skinned or broken kernels. Skinned and broken kernels can cause distorted and nonuniform germination during the malting process. Some of these can be removed by cleaning the grain prior to malting. Preharvest desiccants should never be used on malting barley. To measure harvest loss, finding 12.5 average-sized barley kernels per square foot equates to a yield loss of 1 bushel per acre.

Once the barley is harvested, it should be dried to about 12 percent moisture for long-term storage. Unlike most other grains, malting barley must be kept viable during the storage phase since the grain needs to germinate during malting. Because of this, natural air or low-temperature systems (less than 100°F) are preferred for drying malting barley in order to avoid reducing grain quality. If the harvested grain contains foreign material or broken or small kernels, consider cleaning it prior to storage. This will improve the storability and grade of the grain.

For an excellent summary on harvesting and drying malting barley, see the “Harvesting, Drying, and Storing Malting Barley” publication from the American Malting Barley Association available at ambainc.org/media/AMBA_PDFs/Pubs/Harvesting_Drying_and_Storing_Barley.pdf.

QUALITY ISSUES AND MEASUREMENT

One of the key differences in producing malting barley is that the quality of the crop is scrutinized more carefully and subjected to rejection more than most other grains. First, the maltsters often specify the varieties that are acceptable. The overall basic goals of malting barley production are to produce a clean grain that has high germination, plump kernels, low vomitoxin, and suitable protein levels and is free of mold and insects. The rationale for these and more quality traits are discussed in the brochure from the American Malting Barley Association available at ambainc.org/media/AMBA_PDFs/Pubs/Production/Quality_Brochure.pdf.

Some of the basic criteria for acceptable malting barley are listed below. These are estimates and specific values may vary depending on the buyer.

- Pure lot of an acceptable variety
- Germination of 90 to 95 percent or higher
- Protein content of 10 to 12.5 percent
- Moisture content of 13.5 percent or below
- Vomitoxin levels at or less than 1 ppm
- Free of insect and weed seeds
- Free of chemical residues (fungicides and desiccants)
- Less than 5 percent peeled and broken kernels
- Plump kernels (more than 90 percent on a 6/64 screen)

More detailed quality guidelines are available for plant breeders that specify some of the enzymatic levels and malting characteristics at ambainc.org/media/AMBA_PDFs/News/Guidelines_for_Breeders.pdf. If you are growing an accepted malt variety, then most of these traits should be in the acceptable range when managed appropriately.

Figure 4. Fusarium head blight symptoms on barley showing darkened kernels.



Figure 5. Advanced symptoms of Fusarium head blight on barley with salmon and white fuzzy growth on grain.



MARKETING AND PRICES

As with many specialty grains, it is best to have a market for your crop before you grow it. Contact and contract with maltsters *before* planting malting barley. Have specifications and quality requirements in place beforehand. In our region, there will likely be a higher risk of rejection than in western states due to a higher risk of vomitoxin contamination and preharvest sprouting. Prices are a function of the cost of production and the local demand for the crop. In general, it is best for producers to look at potential returns from an alternative, more common crop and use that to estimate the price necessary to get into malting barley production. In the Mid-Atlantic, one alternative crop might be winter wheat. To compare winter wheat with malting barley, you would need to consider input costs like seed, nitrogen, straw yields, and the yield of any succeeding crop such as soybeans. In this example, straw yields with barley might be reduced by 25 percent, N rates lower than wheat, and double-crop soybean yields might be 10 bushels per acre higher.

If you can, plan ahead for an alternative market for rejected barley. This can help minimize economic losses if the crop is rejected based on grain quality. Using barley as a portion of finishing rations for beef cattle is a good option—the barley is a good substitute for corn, and beef cattle are fairly tolerant of low to moderate mycotoxin levels in the grain. Also, barley is often only a portion of the ration, so the mycotoxins can be diluted in the feed as well. Barley can also be used in dairy rations, but mycotoxin levels will need to be monitored more carefully.

ORGANIC MALTING BARLEY PRODUCTION

Malting barley can be produced using organic methods, but there are several issues to consider. First, the price of organic feed barley is much higher than that of conventional barley, and this can provide a good alternative for malting barley that doesn't meet the standards for malting. At the same time, the premium for malt-grade organic barley may not be as much on a percentage basis as it is for conventional barley due to the high price. From a production standpoint, organic production can be riskier from two perspectives. First, there are no effective fungicides available to control head scab, so alternative methods of managing head scab are needed. One tactic could be to plant different maturities and use planting dates to create some variation in heading dates, reducing the chance of an unfavorable weather period increasing scab and vomitoxin levels for the entire crop. Then harvest each separately, monitor vomitoxin, and use accordingly. The second challenging pest could be annual weeds in spring crops. In lieu of herbicides, selecting fields with low annual weed pressure and then using a tine weeding program can be one approach to minimize weeds in spring-planted crops. In winter crops, weeds are usually much less of a problem in organic systems.

SUMMARY

Successful malting barley production requires some attention to detail to be profitable. Developing a good understanding of the market and the quantity and quality needed

is key. Then following up with a careful crop production plan to produce quality grain is critical. Finally, monitoring the quality of the grain produced and having some alternative markets are important as well.

RESOURCES

American Malting Barley Association
ambainc.org

Brewers Association
www.brewersassociation.org

Craft Maltsters Guild
www.craftmalting.com/grower-resources

Penn State Extension Small Grains Performance Data
extension.psu.edu/plants/crops/grains/small/trial-reports

Penns Mault Raw Barley Testing Procedures and Considerations for Micro-Malthouses
pennsmault.com/agronomic-resources

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