GROWING WINTER MALTING BARLEY WEST OF THE CASCADES

Introduction

Growing malting barley is increasingly being considered by farmers west of the Cascades to serve emerging craft brewing and distilling markets and to function as a rotation crop for horticultural crops, such as potatoes or vegetable and grass seed. Several publications provide information on growing barley generally (Meints et al. 2021; Robertson and Stark 2003) and the prospects for a malting barley industry in the region (Verhoeven et al. 2019). This publication provides a succinct resource for those preparing to grow winter malting barley.

Confirm Market Opportunity

The most critical consideration for prospective growers is to line up a market for malting barley prior to production. Malting operations often contract with producers far in advance of the actual harvest and often specify the variety to be grown. See *Growing Malting Barley in and around the Willamette Valley* (Verhoeven et al. 2019) for a regional review of opportunity and the Craft Maltsters Guild for a national map of craft malt operations. Other malt information and sales opportunities may be identified through the Washington Grain Commission, OSU Barley World, and the National Barley Growers Association.

Select a Field

Winter barley fields should be well drained and not prone to flooding or standing water, which can stunt or kill barley during the winter. Select a production field with uniform conditions including soil type, soil organic matter levels, pH, previous season cropping history, and nutrient levels. These will impact characteristics such as grain **protein** and malting quality, so within-field variability should be minimized. Barley lots of the same variety destined to be harvested from multiple fields or by multiple farmers can be tested separately and combined if the quality is similar enough.

Prepare the Seedbed

A well-worked seedbed should be established for barley. Consider an off-set disk or chisel plow followed by a spike tooth harrow for combined primary and secondary tillage. Firm up the soil after seeding with a cultipacker. See *Field Equipment for Grain Production on Modest Acreages and Diversified Farm Operations* (Bramwell and Brouwer 2019) for information on equipment selection and field operations.

Manage Soil Fertility

Information on fertility management for barley production is available in *Growing Barley in Western Washington* (Meints et al. 2021) and the *Idaho Spring Barley Production Guide* (Robertson and Stark 2003). Follow general recommendations for phosphorus (P), potassium (K), sulfur (S), and micronutrients, based on fall soil tests. Demand for these nutrients is generally similar for winter and spring barley and are independent of end use. Note that P is critical for winter survival and should be applied at planting to avoid deficiency. When making yield-based fertilizer calculations, note that the yield potential of winter barley is approximately 20% higher than that of spring barley. Refer to general barley production guidelines for managing soil pH, which should be between 6.2 and 7.0. If lime application is required, apply in the fall, prior to tillage and seeding, to allow integration into the soil.

Nitrogen (N) management is of primary importance in malting barley because of the strict grain protein specifications for malt. Ideally, grain protein levels should be 10–12% and should not exceed 13%. Elevated grain protein decreases the potential alcohol yield of malt (reported as percent **extract** on a malt quality test). High soil N levels can increase grain protein and decrease grain **plumpness** (reported as percent plump kernels on a 6/64-inch screen on a malt quality test) and should therefore be avoided. Additionally, high N rates may increase the potential for lodging in environments west of the Cascades. See the Glossary, below, and Table 1 for a summary of terms for grain and malt quality specifications.

To manage N, obtain a soil test in the fall prior to planting. Recommended soil sampling depth ranges from 6 to 12 inches, and deeper if samples are collected in increments (i.e., by the foot). A depth of 8 inches will be suitable, but the most important factor is sampling to the same depth for accurate year-to-year comparison.

On average, a total of 20 lb/acre of available N (nitrate + ammonium) is sufficient to maintain the crop throughout the fall and early spring. Do not apply excess N in the fall. High winter rainfall that is typical west of the Cascades will likely result in loss of excess soil N through leaching and runoff which creates both an environmental concern and an economic loss.

The following spring take a second soil test, and do not make assumptions about residual spring N based on the fall test. On average, a total of 80–100 lb/acre of available N is sufficient to maintain the crop until maturity. Target N application rates may need to be adjusted to account for specific scenarios. For example, lower rates will be needed if you expect a lower yield potential, are using slow-release fertilizers or frequent liquid applications, or are following a legume cover crop. In such cases, target 80 instead of 100 lb/acre. Additionally, nitrogen that can be expected (based on the spring soil test) to be released from organic matter should be subtracted from the target application rate.

Spring fertilizer applications are best made with a fertilizer wagon or other implements that minimize passes through an established crop. Apply spring N as soon as soil moisture allows field traffic. Delaying spring N application past full tillering stage is less effective at increasing yield and can contribute to an undesirable increase in grain protein.

See sidebar Example Fertility Scenarios and Recommendations for practical examples that illustrate winter N dynamics and provide some approaches to varying fertility scenarios that you may encounter.

Seed

Sourcing certified seed can help ensure that the variety is pure (not mixed with other varieties), meets germination targets, and is free of weed seed and seed-borne diseases. Grain that has been grown for feed or malt often will not meet these parameters and can negatively impact production from the start. Seed winter barley 1–1.5 inches deep with a seed drill. Plan to seed winter malting barley from early to mid-October. Seeding earlier increases the likelihood of barley yellow dwarf virus (BYDV), while seeding later may result in poor establishment.

Winter malting barley seeding rates from 90 to 120 lb/acre on a pure live basis are recommended (Meints et al. 2021; Roberts and Stark 2003). Figure 1, adapted from Roberts and Stark (2003), provides a calculation for taking germination rate and seed purity into consideration to determine an actual seeding rate. The example assumes a 95% germination rate and 95% purity rate. See *Growing Barley in Western Washington* (Meints et al. 2021) for more detail on selecting an appropriate seeding rate.

Example Fertility Scenarios and Recommendations

Example 1. A fall soil test (6-inch sampling depth) in the Willamette Valley, Oregon, indicated 119 lb/acre of available N. Such high available fall N indicates an over application to the previous crop, and, consequently, no fall N was applied. In the spring, only 39 lb N/acre remained and 60 lb/acre N was applied. Very little N is likely to remain in the spring in instances where fall available N is below 50–60 lb N/acre.

Example 2. In the Chehalis Basin, Washington, barley was fall seeded in a field with residual fertilizer from applications to a summer spinach crop. The soil test indicated approximately 20 lb/acre available N. No fall fertilizer was applied, and 100 lb/acre N (40-0-0-8) was applied in the spring.

Example 3: A fall soil test in the Chehalis Basin indicated less than 20 lb/acre available N and low phosphorus and sulfur values. A 16-20-0-8 fertilizer was applied in the fall at 125 lb/acre of actual product (20 lb N/acre). Spring applications of 100 lb N/acre of 40-0-0-8 and 50 lb/acre of muriate of potash (0-0-62) were made per soil test potassium recommendations.

$$\frac{Desired\ seeding\ rate\ (lb/acre)}{(\%\ germination/100)x\ (\%\ purity/100)} = Actual\ seeding\ rate\ (lb/acre)$$

$$\frac{100\ lb/acre}{(95/100)x\ (95/100)} = 110\ lb/acre$$

Figure 1. An equation and an example for calculating a seeding rate that takes germination and seed purity into consideration.

Variety Selection

Selecting an appropriate variety for winter malting barley production in western Washington is critical. The most important factor is the malting quality parameters desired by the buyer (see Table 1 and Glossary). These parameters can be influenced by malt end use, such as all-malt brewing, adjunct brewing or distilling, as well as a maltsters interest in marketing a unique product.

Quality must be balanced with important agronomic factors, including yield potential, winter hardiness, disease resistance, and susceptibility to lodging. It is possible for spring barley varieties to survive a mild winter west of the Cascades; however, it is not recommended as the risk of crop loss due to cold temperatures is too great. Due to poor agronomic traits, it may not be economically viable to produce certain varieties desired by malting companies, and it is important to review regional variety trial results and available barley publications to inform selection, like those found through OSU Barley World, WSU Bread Lab, and Meints et al., 2021. Finally, seed availability can be a limiting factor, and it is important to plan ahead to ensure that quality seed of a desired variety is available.

Scout for Pests and Disease

Foliar fungal pathogens generally spread rapidly in the spring (from late February through May, depending on the year), and it is often too wet to spray in midwinter. Seed treated with fungicides or insecticides is an option for some soilborne fungal pathogens (e.g., *Pythium* species and *Rhizoctonia* sp.) and insect-transmitted disease (such as BYDV) (Dyer and Johnston 2012; Kirby et al. 2017). Seed treatments will not protect against foliar diseases common to winter barley production. Inquire with seed companies or malting companies you may contract with regarding availability of fungicide and insecticide seed treatments.

Late winter and early spring (i.e., late February through March) scouting will help with early detection of foliar diseases such as scald (*Rhynchosporium commune*) (Figure 2). Scout fields in a large X, Y, or Z pattern looking at the tops and the bottoms of leaves every seven to ten days and more frequently after storms, as rust spores are wind-borne. The beginning of February, weather permitting, is a good time period to apply fungicide to keep scald and stripe rust (*Puccinia striiformis* f. sp. *hordei*) at bay. In wetter areas, late February to the first half of March may be more realistic for a first application (Figure 3).

Figure 2. Winter malting barley showing early signs of scald during a March 2nd field check. In this field, a foliar application was made just before mid-March when the soil was sufficiently dry. Photo credit: S. Bramwell.

Manage for Foliar Diseases

The best preventive approach to avoid barley diseases is to grow resistant varieties, in addition to employment of cultural controls such as minimizing volunteer host crops (i.e., green bridge control) and crop rotation, among others (Kirby et al. 2017). The first step in proper disease treatment is pathogen identification (Burrows et al. 2013). Pesticide applications, conventional or organic, should be selected based on identified pests or diseases. When varieties susceptible to scald or rusts are grown west of the Cascades, a treatment program must be considered (Mclean 2020). Refer to Disease Resources (WSU Wheat and Small Grains, n.d.[a]) and the *Pacific Northwest Disease Management Handbook* (Pscheidt and Ocamb 2019) for more disease management recommendations. Cereal pathologists are available at WSU and OSU to answer questions and make specific recommendations.

Figure 3. Typical wet and cool February and March conditions in the Boistfort Valley, western Washington. The knoll to the right is composed of heavier clay soils. As a result, barley at this higher point in the field shows somewhat higher moisture stress than elsewhere. No flooding occurred in this field, but flooding did kill barley elsewhere in the Chehalis Basin during this growing season. Photo credit: S. Bramwell.

General Spray Recommendations to Manage Foliar Diseases

Three main classes of active ingredients are currently available in fungicide products registered for use on barley: triazoles, strobilurins, and succinate dehydrogenase inhibitors (SDHIs). In addition, several fungicide products are available that contain more than one active ingredient; these mixed fungicides are often more expensive but are more effective and exhibit longer residual activity. Fungicides containing a strobilurin fungicide tend to be particularly effective against rust diseases.

Regardless of which fungicide is selected, two spring applications (first in February or March, and a second at flag leaf) are typical for winter production of susceptible varieties west of the Cascades. Larger spray rigs will reduce the number of field passes needed and minimize stops to refill (Figure 4).

Figure 4. A John Deere 650 with a 400-gallon capacity used in spray applications in southwest Washington. This equipment can apply fungicide on approximately 25 acres before needing to be refilled. Photo credit: S. Bramwell.

Category 1 Approach: Management for Average Yield and Quality

Barley growers west of the Cascades in low disease-pressure situations can either use no fungicide or a low-cost one, such as an inexpensive triazole, depending on presence of disease in a given year and variety being grown. Make sure the disease of interest is listed on the fungicide label. If both a fungicide and an herbicide are being used, consider mixing them together to reduce application costs. Subsequently, a fungicide with a mixed mode of action can be used for a flag leaf application, where the greatest response from fungicide application can be expected (Turkington et al. 2015). All pesticides must be labeled for use on barley.

Category 2 Approach: Management for Maximum Yield and Quality

In some situations, scald and leaf or stripe rust are expected to be ubiquitous and difficult, especially if incidence of one or the other begins early in the season. In these cases, use one of the mixed mode-of-action products for both the first application (February to March) and the flag leaf application, especially if one is expecting very high yields. Given the longer residual activity of these products, this is intended to keep disease pressure under control before the second (flag leaf) application.

A common scenario is an application as early as possible in the spring to keep scald from getting established and a second application targeting stripe rust and to hold scald in check. If both applications are employed, use different products to reduce selection for fungicide resistance.

Philosophies, yield objectives, environmental conditions, financial considerations, and so on will vary among seasons and across growers. As a result, there is likely no single recipe that will be best for everyone.

Specific Comments for Barley Yellow Dwarf Virus

Seed as late as possible to reduce chances of infection from barley yellow dwarf virus (BYDV), an aphid transmitted foliar disease. This disease is most likely to be a problem when aphids are active in the fall (early October or earlier), but you should inspect throughout the spring as well. Systemic insecticide seed treatment can help reduce spread of aphid populations, and malting companies that provide seed may have applied this treatment. See *Yellow Dwarf of Wheat, Barley, and Oats* (Wegulo and Hein 2013) for help recognizing and managing BYDV.

Scout fields to detect aphid populations after emergence. Greenbugs (*Schizaphis graminum*), the type of aphid most commonly known as vectors of BYDV, are thought to overwinter at the base of barley as eggs or live aphids (Robertson and Stark 2003). Growers can consider controlling these with an insecticide, such as malathion, permethrin, and acephate, or organically with horticultural oils, neem oil, PyGanic, or spinosad. All controls will be unreliable if coverage is incomplete, if aphids are already feeding widely on barley, or aphids carrying the virus migrate into the field after spraying.

Specific Comments for Stripe Rust, Leaf Rust, and Scald

Stripe rust and scald are two foliar diseases that need to be managed for winter barley either through resistance or a fungicide program. Leaf rust (*Puccinia hordei*) has been reputed to be a less frequent issue, but in recent western Washington trials, both leaf rust and scald have been destructive. Stripe rust can result in loss of up to two-thirds of the crop in highly susceptible varieties and one-third of moderately susceptible varieties.

Scald (*Rhynchosporium secalis*) infection occurs under wet and humid conditions (Figure 5). The pathogen can result in yield losses of up to 40% and is one of the most destructive barley diseases globally (Newton 2021). Infection is most common when barley comes into contact with barley stubble from a previous crop. However, alternate grass hosts infect the crop even in fields with no recent history of barley production. Crop rotation will reduce the risk of infection.

Figure 5. Winter malting barley growing through cool, wet conditions. This field received recent spring herbicide and fungicide applications. Photo credit: Clinton Waite.

For susceptible varieties in conventional systems, base fungicide (as well as insecticide) applications on positive disease identification by scouting. Apply fungicides when the number of leaves infected or the number of plants infected is greater than five percent (WSU Wheat and Small Grains, n.d.[b]). Effective control of foliar diseases depends on early detection. Scald is likely to start earlier (usually during cool, wet springs) and rust somewhat later (for example, during wet, early summer). However, if rust occurs early (e.g., February or March), a fungicide should be applied regardless of incidence level.

In organic production systems, varieties resistant to foliar diseases are the only option for producing winter malting barley.

Specific Comments for Fusarium Head Blight

On the west coast, scouting is recommended to determine whether a head spray to control Fusarium head blight (FHB) (*Fusarium graminearum*) is justified. This disease is not yet established in the region but is common farther inland in Idaho and Montana (Burrows et al. 2012). A good time to monitor is after precipitation or irrigation events at the time of flowering, as the disease flourishes in moist conditions. Controlling FHB is important because the pathogen produces a mycotoxin called DON (deoxynivalenol), which is typically restricted by malting companies to 1ppm in grain (Cornell CALS 2018). DON is sometimes often referred to as vomitoxin.

A specific spray program is not recommended for FHB at this time. The fungicide is an additional cost economically and ecologically, and a good deal of barley can be knocked down during application. Consult regional agronomists, cereal pathologists, and the *Pacific Northwest Disease Management Handbook* (Pscheidt and Ocamb 2019) for management recommendations. Regional cereal pathologists tend to recommend combination products with long-lasting control of several cereal diseases. The same active ingredients can be found in name-brand and generic products.

Manage Weeds

Weed seed or excess green material at harvest can reduce the quality of malting barley, so considering weed control methods prior to, at, and after planting is extremely important. Weed pressure in any grain crop is determined by the annual weed seed bank and vegetative propagules of perennial weeds. In an Integrated Pest Management approach to weed management, cultural and biological approaches are used before deploying chemical measures. For example, weeds can be managed through crop rotation, alternating production of early and late season crops, stale seedbeds, conventional or chemical fallow, the use of cover crops, and periodic perennial cover (especially if grazed). See *Ecological Management of Agricultural Weeds* (Liebman et al. 2001) for more information.

Weed Management in Conventional Systems

In conventional systems, and in cases where the above cultural and biological practices were either not used or were insufficient, the following steps should result in a relatively weed free crop (Figure 6 and Figure 7).

Figure 6. A field of winter malting barley ('Thunder') in May that is being grown on contract in southwest Washington. The field is relatively free of weeds except for some grass weeds in field margins (out of frame). This field received preemergent and post-emergent herbicide applications. Photo credit: Mike Peroni.

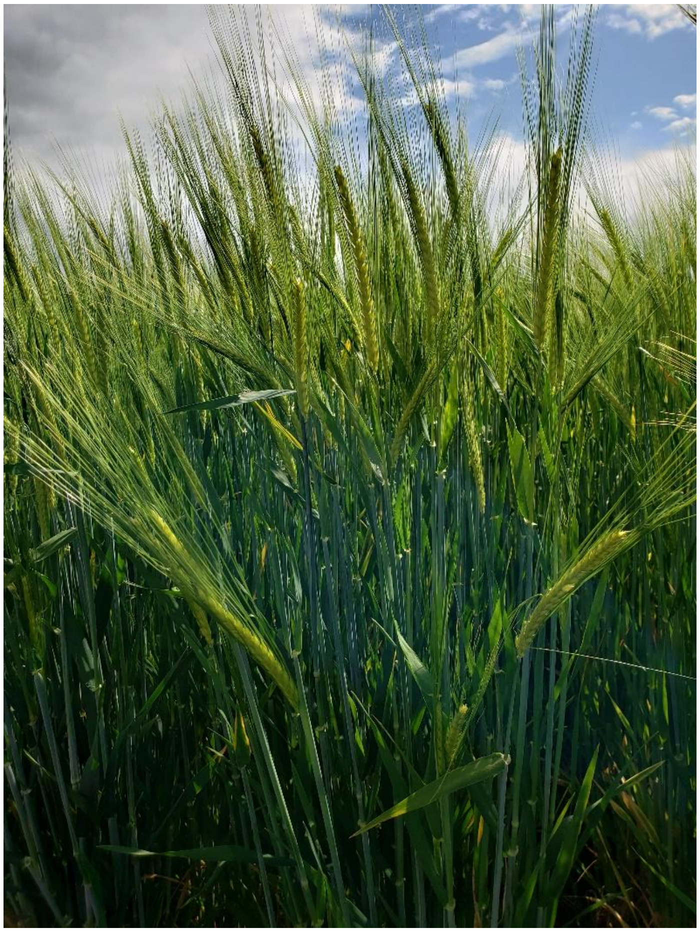

Figure 7. Winter malting barley beginning to fill, relatively unimpeded by competing weeds. This field received preemergent and post-emergent herbicide applications. Photo credit: Mike Peroni.

Till the production area prior to planting or apply a burndown herbicide. Avoid planting barley in fields with a history of grass weeds resistant to Group 1 herbicides if possible (Campbell et al. 2015). Make a preemergence diuron herbicide application following seeding and prior to emergence. This application will reduce grass weed issues in the winter and spring and provide moderate broadleaf weed control. This is a unique “west of the Cascades” label that should be utilized. Refer to herbicide labels regarding recommended barley seeding depth (if noted) to avoid damaging the growing tip.

There are many post-emergence options for broadleaf weed control in barley that can be used as needed throughout the fall, winter, and spring. A standard recommendation for winter barley is to combine applications of herbicides with different modes of action, such as a combination of a bromoxynil + pyrasulfotole product that disrupts photosynthesis (e.g., Huskie at 13 oz/acre) with an MCPA product (0.25–0.5 lb ai/acre), which is an auxin growth regulator that interferes with protein synthesis at the growth points (meristematic tissue) of weeds. This approach is broad spectrum and safe on the crop. Some herbicides should not be tank mixed with fungicides (such as Huskie and tebuconazole).

Spring herbicide application should occur as soon as field conditions permit and when weeds are young and most susceptible. Consult the section titled Barley of the Cereal Grain Crops chapter of the *Pacific Northwest Weed Management Handbook* and other Extension publications, like *Herbicide Mode-of-Action Summary* (Ross and Childs 2020) and *Weed Control in Small Grains* (Marshall 2017), for specific guidance regarding production selection, application rates, and herbicide mode of action.

Post-emergence grass weed control options in barley are quite limited. Among the best typical options is pinoxaden (e.g., Axial XL at 16.4 oz/acre). This provides control of such species as wild oats and annual ryegrass that is not Group 1 resistant. It will not control some species such as annual or roughstalk bluegrasses or brome species, thus reinforcing the importance of the preemergence weed management application to suppress those species.

Herbicide and fungicide applications can be combined where labels permit and if the products are listed for barley. Some growers prefer this combination while others withhold fungicide application until disease is detected during fall or spring scouting.

Regarding broadleaf or grass weed management, regional weed specialists are available at Oregon State University and Washington State University if more or different options are needed, or if there is a need to tailor a more specific grass weed management program to a particular grass species in your fields.

Preharvest Weed Management

It is important for growers to know that the use of preharvest weed management options (such as the use of 2,4-D, glyphosate, Aim) are very restricted or prohibited by maltsters and malt buyers. Direct questions to the malting operation, and carefully observe AMBA guidelines. AMBA opposes post-heading herbicide treatments, and AMBA members do not purchase malt that received post-heading treatment, known as desiccants, as a preharvest aid.

Weed Management in Organic Systems

Both cultural and mechanical practices can help control weeds in organic systems. Tine weeders and rotary hoes are both examples of blind cultivation that can be very effective at killing weeds, but timing and conditions must be ideal to achieve maximum control (Lötjönen and Mikkola 2000). Both of these methods work best to control small annual broadleaf weeds. They uproot the weeds and bring them to the surface to dry out. It is recommended to increase seeding rate by 10% to account for potential loss after cultivation.

A typical regime would be to use the tine weeder or rotary hoe a few days before emergence (approximately five days after seeding) and again when the barley has reached the three-tofour-leaf stage. There will be some crop injury, but the goal is to remove newly germinated and emerging weeds and let the barley compensate over time. See [*Field Equipment for Grain Production on Modest Acreages and Diversified Farm Operations*] (Bramwell and Brouwer 2019) for more information. Mechanical cultivation will be most effective if the soil is dry and crumbly and the weeds are in the “white thread” stage. Given the frequent rains that occur after fall planting west of the Cascades, growers should not rely on mechanical weeding as their only method of control.

There are a number of cultural methods that can be employed prior to planting that can also contribute to weed control. Establishing a good rotation system that includes different types of crops can help reduce weed pressure. Adding a vigorous growing legume cover crop into the rotation will provide the double benefits of adding some nitrogen to the soil while also suppressing weeds.

Rotations can reduce weed pressure by breaking weed life cycles. For example, continuous small grain production can lead to an abundance of weeds that have a similar ecological niche, including winter annual grass weeds (Sullivan 2003). Winter grains are often better at competing against annual weeds because of their rapid establishment and canopy growth in the fall, but it is recommended to increase the seeding rate by 25–50% to increase competitiveness against weeds (Tallman 2011).

Increasing seeding rate is one of the most effective strategies for controlling weeds in organic systems. Additionally, using a narrower row spacing (4–5 in) or cross-drilling at a 45-degree angle may help reduce weed pressure by limiting sunlight to weed seedlings (Mallory and Kersbergen 2013).

Grain Moisture

Growers should not harvest when the grain is too wet. In general barley should be harvested at 13.5% moisture or lower if possible (Figure 8 and Figure 9). Otherwise, the grain will need to be dried before storage. However, it is also important to minimize rain damage prior to harvesting, which can reduce germination. If the crop is mature and rain is expected, it may be necessary to harvest and dry it to avoid loss of quality. Examples of acceptable moisture levels identified by malt houses can be seen in Table 1. Check with your local Extension office for availability of grain moisture meters.

Harvest the Grain

Germination is critical for malting barley so care must be taken to minimize damage during harvest. Skinned and broken kernels should be kept to less than 5%. The acceptable rate may vary so check with your buyer. Barley is considered “skinned” when one-third or more of the husk has been removed or the husk is loosened or removed over the germ (Robertson and Stark 2003). A small amount of awn is preferred to skinned or broken kernels. During harvest take a handful of grain and if there are more than a few skinned or broken kernels adjustments should

Figure 8. Moisture meters are helpful to ensure grain is ready for harvest. Daytime humidity will greatly affect grain moisture content. Photo credit: S. Bramwell.

Figure 9. Grain that is ready for harvest at approximately 11.5% moisture content. Boistfort Valley, WA. Photo credit: S. Bramwell.

be made (AMBA, n.d.[a]). Most kernel damage usually comes from the cylinder speed being set too high.

Consult your combine operating manual for barley harvesting settings, being aware that threshing adjustments during the day may be needed in response to temperature, grain and straw moisture, or change in barley variety (Figure 10). Detailed information on harvesting, drying, and storing malting barley is available from the American Malting Barley Association (AMBA, n.d.[a]). Practical advice on how to identify specific types of combine losses and damage is described in *Idaho Spring Barley Production Guide* (Robertson and Stark 2003).

Figure 10. Inspect grain during harvest to ensure combine settings are correct. Photo credit: S. Bramwell.

Minimize Foreign Material, Weeds, and Other Substances

Adjust combine settings and inspect grain to minimize dockage (or "foreign material") which includes matter other than barley, such as stones, chaff, stems, etc. (Ash and Leath 1996). Buyers will limit dockage to a maximum percentage, such as 0.5% or 1.0%. Any dockage in excess of the limit can lead to a deduction off the value of the lot. Specific maximum limits are established by some buyers. For example, Great Western Malting has the following limits: wheat (1.0%), wild oats (1.0%), other barley varieties (2.0%), peas (0.5%), lentils (1.0%), and Foreign Material (1.0%). Malt companies often will not want to set a limit lower than 1.0% for dockage, because it can lead to skinning the kernels due to overcleaning.

Ask malting company buyers directly for these and other limits, including for sprouted and damaged kernels, crop desiccants, mold, blight, live insects, postharvest insecticides, and DON (see comments on Fusarium head blight, above). There is typically no latitude for the presence of grain boring insects in malting barley. See the American Malting Barley Association Malting Barley Requirements for additional information (AMBA, n.d.[b]).

Pull Samples for Quality Testing

Grain samples for malting barley grown under contract will often be required by the malting company. In these instances, samples are sent directly to the company laboratory. For barley grown for small malt houses, an independent testing facility may be identified. The Hartwick College Center for Craft Food and Beverage also provides testing services. Typically, a sample is collected running a combine diagonally across the field. Information on malt quality provided to the malting company as early as possible helps them to understand what quality they can anticipate from the field.

The most important part of grain sampling is getting a representative sample. This is not possible by digging a hand into the top of a railcar or grain truck because grain quality can vary within or between fields, and grain stratifies (is layered or otherwise sorted by location) throughout the grain handling process. A careful approach to sampling will prevent a load of barley from being rejected at the malt house due to unexpected variations in quality.

Use a Grain Probe

Hand grain probes come in two types: compartmented and open throat. Compartmented probes use segmented compartments to collect grain evenly from multiple depths while open throat probes tend to collect more grain from the top of the load (Figure 11). Probes come in lengths from 6 to 12 feet and are typically brass. Select a grain probe that is long enough to reach the bottom of the lot being sampled. Cooperatives may have mechanical probes available.

See American Malting Barley Association Production and Quality Information resource pages for specific information on quality parameters for malting barley or talk to your buyer.

Figure 11. A typical 6 ft compartmented brass grain probe. Select a grain probe that can reach to the bottom of the grain truck or railcar. Photo credit: S. Bramwell.

Steps to Obtain a Composite Sampling Method

Grain sampling consists of three steps: (1) collect multiple probe samples directly from the harvester, railcars, or trucks, (2) combine and mix these based on desired lot separation, and (3) obtain a one-pound subsample (composite) from each lot to send for quality testing.

Step 1: Take Multiple Samples with a Grain Probe

Depending on the size of your operation and size of the lot, sampling may be as simple as a single probe from the center of your carrier (e.g., from a grain truck). However, multiple probe samples taken from different places within the lot will typically be necessary. According to the Canadian Grain Commission, eight probes should be taken from a single truck, and ten from a partitioned truck or truck and trailer. Sampling patterns and more extensive information on sampling is available on their website (CGC 2019).

The scale of your operation will help determine your sampling approach. The actual number of samples you send will be determined by your capacity to separate lots of different quality (see Step 2, below).

- For large combined lots, take three probe samples per railcar (one per compartment on a three-compartment car; Figure 12). Alternately, large lots may be sampled at binning (transfer of grain into upright storage bins) to determine the overall quality per bin.
- For a mid-scale operation in which barley from multiple trucks will be combined in a single bin or railcar, consider collecting two or three probe samples per truck.
- If sampling a single field on a smaller scale, run your combine diagonally across it and take one probe sample directly from the harvester or from the truck after offloading from the combine (Figure 13).

Step 2: Evaluate, Combine and Mix Probe Samples

Once sampled, empty the contents of the grain probe onto a clean sampling canvas or a section of sufficiently long rain gutter that will prevent grain spilling out the ends. Look for any differences in contaminants, kernel plumpness, general condition, or other variations (Figure 14). Where obvious differences occur, consider sending separate samples for testing.

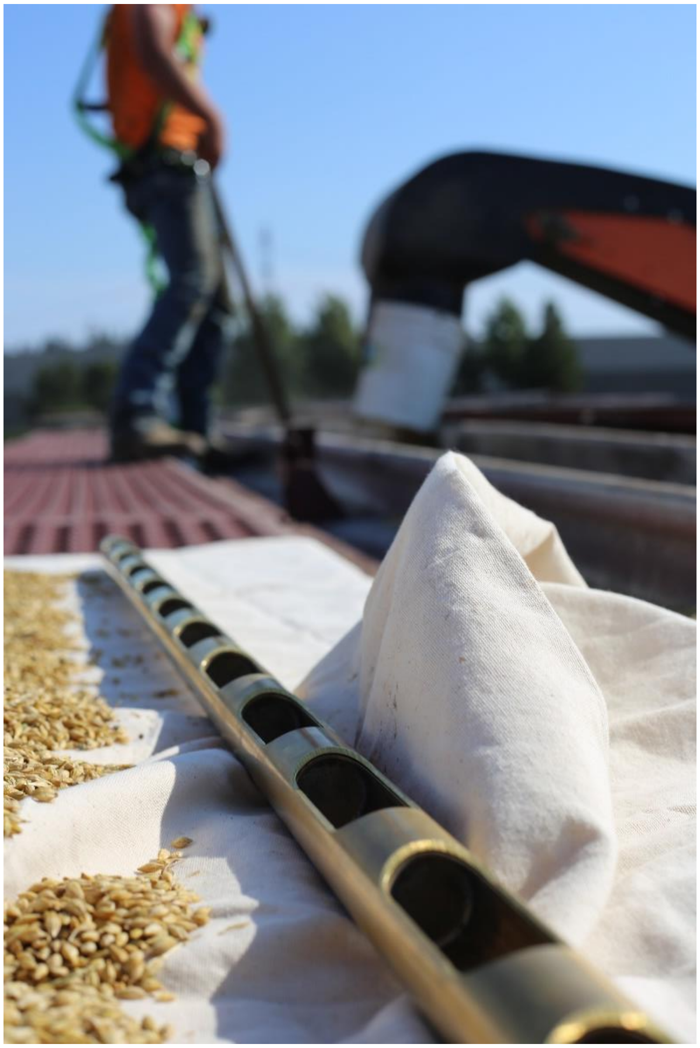

Figure 12. Sample pulled from a railcar compartment. Photo credit: S. Bramwell.

Figure 13. A randomly selected combine path cut through a field to collect a sample for a preharvest laboratory test. Photo credit: S. Bramwell.

If no obvious differences are apparent, combine probe samples in a bucket or other container as appropriate based on your lot separation plans. Those samples destined for the same lot are combined, and those destined for separate lots are combined separately to ensure homogenous barley bins for malting.

Step 3. Take a Composite Subsample from Each Lot

Once mixed, collect approximately one pound of grain (500 grams) from each lot for quality testing. Package the resulting sample in a plastic bag and label thoroughly. This will be sent to a testing laboratory for preharvest malt quality analysis. The malt company will interpret the results or may help you interpret them. See your local county Extension office to locate an appropriate testing laboratory and for help with interpreting test results.

Figure 14. Compartments allow inspection of grain harvested from different locations in the field. A sample pulled from a combine that harvested a single swath across a field will help you see any differences in the barley as they were stratified in the grain bin during transit across the field. Photo credit: S. Bramwell.

Table 1. Malting barley breeding guidelines: ideal commercial malt criteria.

	Adjunct brewing two-row	All malt brewing and distilling two-row	Grain distillers' two-row
Barley factors			
Plump kernels (on 6/64)	> 90%	> 90%	> 70%
Thin kernels (through 5/64)	< 3%	< 3%	< 5%
Germination Energy (4 ml 72 hr GE)	> 98%	> 98%	> 98%
Protein	≤ 13.0%	≤ 12.0%	11.5–14.0%
Skinned and broken kernels	< 5%	< 5%	< 5%
Malt factors			
Total protein	≤ 12.8%	≤ 11.8%	11–13.5%
On 7/64 screen	> 70%	> 75%	> 50%
Glycosidic nitrile (g/mt)[2]		< 0.5%	< 1.5%
Predicted Spirit Yield (LPA*/mt)[2]		≥ 400	
Measures of malt modification			
Beta-glucan (ppm)	< 100	< 100	
Soluble/total protein	40–47%	38–45%	> 48%
Turbidity (NTU)	< 10	< 10	
Viscosity (absolute cP†)	< 1.50	< 1.50	
Congress wort			
Soluble protein	4.8–5.6%	< 5.3%	< 6.0%
Extract (FG db)	> 81.0%	> 81.0%	> 79.0%
Color (ASBC)	1.6–2.5	1.6–2.8	< 4.0
Free amino nitrogen	> 210	140–190	> 250
Malt enzymes			
Diastatic power	> 140	110–150	> 200
Alpha amylase	> 50	40–70	> 75

Source: reprinted and adapted with permission from the American Malting Barley Association (AMBA 2019).
*LPA = liters pure alcohol per metric ton.
†cP = centipoise, a unit of dynamic viscosity.

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Glossary of Malt Barley Terms

alpha amylase: An enzyme in malt that is responsible for the rapid breakdown of starch during mashing. Alpha amylase is synthesized by the germinating grain during the malting process and is influenced by the variety and the degree of modification. Low levels of alpha amylase in the malt lead to long conversion times and poor extract yields in the brewery.

beta-glucan: High molecular weight polymers which form the cell wall components of the barley grain. Wort beta-glucan is a measure of the extent of endosperm modification, with low values (less than 100 ppm) indicating greater modification of the barley endosperm. High beta-glucan content in wort is associated with many difficulties in brewing, such as long run-off times, difficult beer filtration, and hazes.

diastatic power (DP): A measure of the total starch degrading enzymatic activity of a malt. DP levels in malt are influenced by the variety and protein content of the grain. Higher grain protein content produces higher DP levels in the malt. Malts with high DP produce more fermentable worts.

extract: The extract content indicates the maximum soluble yield of the malt. The soluble material is primarily carbohydrates, which provide the source of fermentable sugars, but also include proteins, amino acids, minerals, etc. Extract is calculated by measuring the specific gravity of the wort and is reported as a percentage of the original malt weight on either a “dry matter” or “as is” basis.

free amino nitrogen (FAN): A measurement of the amount of free amino acids available in the wort which is an important source of nutrients for the yeast during fermentation. FAN is reported as parts per million (mg/L) in the wort. Levels over 150 ppm are usually considered adequate. Higher levels of FAN are necessary in high gravity and high adjunct brewing.

friability: Friability is the measure of a malt’s readiness to crumble when subjected to crushing. It is an estimation of the physical modification of the malt grains. A sample of malt is put into a steel mesh drum. For a fixed time of eight minutes, the grains are pressed against the rotating sieve by means of the pressure force of a rubber roller. The friable malt (easily crushed parts) falls through the sieve, while the hard parts remain inside the drum. The friability is reported as the percentage of the malt by weight which passes through the sieve. High protein levels can also significantly reduce the friability of the resulting malt.

germination energy: Barley must have high germination ability in order to be successfully malted. Germination ability for malting is assessed using standardized tests developed by the malting industry. Germination energy is determined by placing 100 kernels of barley on filter paper in a petri dish and adding 4 mL of distilled water. Samples are kept in a germination chamber under controlled conditions of 20°C and 90% relative humidity. Germination is expressed as the total number of kernels which germinate after 72 hours.

glycosidic nitrile (GN): A precursor compound to ethyl carbamate formation during the distilling process which is present in some malting barley varieties. Low or non-GN producing varieties are desirable for all-malt whisky production.

plumpness: Plump barley is the material retained on a 6/64 in. slotted sieve. Thin barley is the fraction of the kernels which pass through the 5/64 in. sieve. These kernels are generally removed prior to malting. Plumper kernels contain more starch and give a higher percentage of extract which in turn produces a greater amount of beer from a given weight of malt. Kernel size uniformity promotes uniform germination and a higher quality malt.

predicted spirit yield (PSY): An estimate of the total amount of alcohol that can be obtained from a given weight of malt upon distillation, expressed in liters of absolute alcohol (200 Proof) per metric tonne of grain.

protein: The desirable range for protein content in malting barley is 9.5%–12.0%. High protein is limiting to the extract content of malt which results in less alcohol in the beer. Low protein is limiting to the enzyme content of malt. Protein content of barley is measured using whole grain analyzers or by combustion, calculated as the percentage of nitrogen multiplied by 6.25 and reported on a “dry basis.”

soluble protein: The amount of protein in soluble form in the wort, expressed as a percentage of malt weight. Soluble protein is determined on diluted wort using a spectrophotometric method based on the absorbance of proteins in the ultraviolet range. The ratio of soluble to total protein (S/T) calculated by dividing the soluble protein value by the percent total malt protein is an indicator of the extent of protein modification in the malt.

References

AMBA (American Malting Barley Association). 2019. Malting Barley Breeding Guidelines Ideal Commercial Malt Criteria.

AMBA (American Malting Barley Association). n.d.(a). Harvest, Drying, and Storing Malting Barley to Get Market Premiums.

AMBA (American Malting Barley Association). n.d.(b). Malting Barley Quality Requirements.

Ash, M.S., and M.N. Leath. 1996. Economic Implications of Cleaning Malting Barley in the United States. USDA-ERS Report 745.

Bramwell, S., and B. Brouwer. 2019. Field Equipment for Grain Production on Modest Acreages and Diversified Farm Operations. *Washington State University Extension Publication* EM116E. Washington State University.

Burrows, M., W. Grey, and A. Dyer. 2012. Fusarium Head Blight (Scab) of Wheat and Barley. *Montana State University Extension Publication* MT200806AG. Montana State University.

Burrows, M., J. Olmstead, and W. Grey. 2013. Fungal, Bacterial, and Physiological Leaf Diseases of Cereal Crops (Wheat, Durum, Barley). *Montana State University Extension Publication* MT200913AG. Montana State University.

Campbell, J., C. Mallory-Smith, A.G. Hulting, and C.E. Weber. 2015. Herbicide-Resistant Weeds and Their Management. *Oregon State University Extension Publication* PNW 437. Oregon State University.

CGC (Cascadia Grains Commission). 2019. Guide to Taking a Representative Sample.

Cornell CALS (College of Agriculture and Life Sciences). 2018. Malting Barley: Keys to Successful Production in New York State. Cornell Cooperative Extension.

Dyer, A., and J. Johnston. 2012. Small Grain Seed Treatment Guide. *Montana State University Extension Publication* MT199608AG. Montana State University.

Kirby, E., T. Paulitz, T. Murray, K. Schroeder, and X. Chen. 2017. Disease Management for Wheat and Barley. In *Advances in Dryland Farming in the Inland Pacific Northwest (PNW)*, G. Yorgey and C. Kruger, eds., chapter 10, 399–468. *Washington State University Extension Publication* EM108. Washington State University.

Liebman, M., C.L. Mohler, and C. Staver. 2001. Ecological Management of Agricultural Weeds. Cambridge: Cambridge University Press.

Lötjönen, T., and H.J. Mikkola. 2000. Three Mechanical Weed Control Techniques in Spring Cereals. *Agriculture and Food Science Finland* 9:269.

Mallory, E., and R. Kersbergen. 2013. Growing Organic Barley in Maine. *University of Maine Cooperative Extension* Bulletin #1027. University of Maine.

Marshall, M. 2017. Weed Control in Small Grains. In *South Carolina Pest Management Handbook for Field Crops—2017*, 203–211. Clemson Cooperative Extension. Clemson University.

McLean, M. 2020. Scald of Barley. Agriculture Victoria.

Meints, B., C. Carrijo, B. Verhoeven, S. Fisk, and P. Hayes. 2021. Growing Barley in Western Washington. *Washington State University Extension Publication* EM122E. Washington State University.

Newton, A. 2021. Rhynchosporium on Barley. The James Hutton Institute.

Pscheidt, J.W., and C.M. Ocamb, eds. 2019. Pacific Northwest Disease Management Handbook. Oregon State University.

Robertson, L.D., and J.C. Stark, eds. 2003. Idaho Spring Barley Production Guide. *University of Idaho College of Agricultural and Life Sciences* Bulletin 742. University of Idaho.

Ross, M.A., and D.J. Childs. 2020. Herbicide Mode-Of-Action Summary. *Purdue University Cooperative Extension Service Publication* WS-23-W. Purdue University.

Sullivan, P. 2003. Organic Small Grain Production. ATTRA Sustainable Agriculture.

Tallman, S. 2011. Weed Management in Organic Small Grains. ATTRA Sustainable Agriculture.

Turkington, T.K., J.T. O'Donovan, K.N. Harker, K. Xi, R.E. Blackshaw, E.N. Johnson, G. Peng, et al. 2015. The Impact of Fungicide and Herbicide Timing on Foliar Disease Severity, and Barley Productivity and Quality. *Canadian Journal of Plant Science* 95:525–537.

Verhoeven, B., S. Fisk, R. Graebner, L. Helgerson, B. Meints, and P. Hayes. 2019. Growing Malting Barley in and around the Willamette Valley. *Oregon State University Extension Publication* EM 9233. Oregon State University.

Wegulo, S.N., and G.L. Hein. 2013. Yellow Dwarf of Wheat, Barley, and Oats. *University of Nebraska-Lincoln Extension Publication* G1823. University of Nebraska-Lincoln.

WSU Wheat and Small Grains. n.d.(a). Disease Resources. Washington State University.

WSU Wheat and Small Grains. n.d.(b). Stripe Rust. Washington State University.

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