Crop Profile for Barley in Washington

Prepared: April 2001

General Production Information

- Washington ranked fourth during 1999 in the US in barley production with 10.3% of the US crop (1).
- 500,000 acres were planted and 490,000 acres were harvested yielding 28,910,000 bushels in 1999 with an estimated value of $51 million (1).
- Crop value per harvested acre was $104 in 1998 (1).
- While production costs vary considerably with rainfall and other factors, a ten-year study shows a per acre average of $187 ($116 variable, $71 fixed); this study showed a value per acre of $113 (3).
- Barley's value to Washington growers is primarily in its function as a useful rotation tool between more profitable crops. The economics of growing barley make affordable pest control extremely important.
- 92% of the 1999 planting was made up of feed barley varieties and 8% were malting varieties (1).
- End use for Washington barley is primarily feed (beef and dairy cattle, swine and poultry production) at 92% and malting (food, beer, beverages) at 8% (4).

Production Regions

Barley is grown in every county in Washington, but concentrated production is located in eastern Washington in Adams, Garfield, Lincoln, Spokane, and Whitman counties.
Barley is a cool-weather cereal grain primarily produced on dryland farms in Washington (a small portion--less than 5%--is grown under irrigation). Over 95% of the barley grown in Washington is spring barley, which is planted in early spring (generally April) and harvested in late July or August of the same year. Washington's winter barley is seeded in September or October and harvested in late July or August of the following year.

The preponderance of spring barley can be attributed to two factors: it is a less risky crop than winter barley and it primary functions as a rotation crop with winter wheat. None of the barley varieties grown in Washington are extremely winter-hardy; a harsh winter can dramatically reduce or even obliterate yield. Traditionally, winter barley had higher yields (due in large part to a longer growing period), but the newer varieties of spring barley introduced in the early 1990s yield just as well. Because barley functions as a rotation crop with winter wheat, the spring barley cycle is a good fit. Barley matures early, uses less water than wheat, and has a short life cycle, allowing rotation to the more profitable winter wheat or even, in high rainfall areas, a triple rotation following wheat and preceding a legume (pea/lentil) crop.

Both two-row and six-row barley varieties are grown in Washington. A six-row variety called Steptoe, developed in the 1970s, was the state standard for years, but has been largely replaced by a high-performing, two-row imported variety called Baronesse. A grower's choice of two-row or six-row depends upon environment, climate, and available varieties; either can be used for the three primary markets: animal feed, malting, or human food.
Animal feed is by far the dominant market for Washington barley. Two-row barley varieties tend to result in higher "test weight," an important factor in the feed market. Malting, a market with very specific product standards and specifications, comprises about 12% of Washington barley sales. Less than one percent of Washington's barley is grown for human consumption. A number of different types, such as hulless, awnless, and waxy allow growers different niche markets.

**Cultural Practices**

Washington barley is generally grown in rotation with wheat, with the typical rotation being (more profitable) winter wheat followed by (less profitable) spring barley. In higher rainfall areas, a legume crop may follow spring barley. Other crops including potatoes may be part of some rotations.

Seedbed preparation for barley is minimal. Residues of the previous crop are usually partially incorporated but not totally plowed under; a pristine seedbed is not necessary. Direct seeding is practiced on some acreages, in which case there is no seedbed preparation. Barley's own residue breaks
down very well compared to other cereal crops; it is very rarely burned but may be disked or otherwise plowed under.

Barley has low moisture requirements. It can be grown in as few as 11 to 12 inches of annual rainfall and can tolerate less moisture under "no-till" (direct seeding) systems. A summer fallow system (land left idle during a growing season) conserves enough moisture in the soil to enable production in some situations where rainfall is as low as 6 to 7 inches annually.

Washington barley growers use registered, certified seed, some of which is grown in the state. Most barley is produced for the open market. Malting barley is the exception, it is grown under contract.

Because of narrow profit margins and low returns on barley, chemicals are not used extensively for pest control. In some cases, chemical use could be effective, but is precluded by simple economics. New, cost-effective pest control options are needed for barley.

Pests are listed in the order of importance, with weeds being the most important followed by diseases, then insects.

### Weeds

Weeds are the most important class of barley pests in Washington State. Costs of control and losses due to weeds are greater than with any other pests. Herbicides represent the greatest amount of pesticides applied to Washington barley in terms of amount of active ingredient applied and percentage of treated acres.

Generally, herbicide application timings can be categorized as pre-plant, pre-emergence, post-emergence, or harvest aid.

Pre-plant applications often include the use of nonselective herbicides designed to control weeds or volunteer grains present prior to planting barley. Pre-plant applications of nonselective herbicides may replace the use of a tillage operation to kill vegetation, thereby reducing moisture loss from the soil and soil erosion due to tillage operations. Other types of pre-plant herbicides will selectively control weeds as they emerge. Usually these herbicides will require mechanical incorporation with a disk, cultivator, or some other tillage tool to activate the herbicide.

Pre-emergence herbicides are applied after the crop is planted, but prior to emergence of crops and weeds. Usually, the herbicides are applied to the soil surface, but may be incorporated into the soil above the seeded crop using a light harrow.

Post-emergence herbicides are applied following emergence of the crop and weeds. Most selective herbicide applications in barley are made at this timing. The products that are most effective for weed
management and cause the least amount of injury to the crop will vary depending upon the development stage of the barley crop.

Harvest aid herbicide applications are made approximately two weeks prior to harvest. These applications have two purposes. They are designed to kill weeds so that by the time of harvest the weeds have dried out and will not interfere with the harvest operation and to ensure that weed parts do not affect the quality of harvested grain. While a harvest aid application will not increase yield of that year's barley crop, it can reduce or prevent seed production of the target weed, resulting in a net decrease of the soil weed seed bank. Ultimately, most of the annual weeds in a field originate from seed that was produced in that field rather than immigrating from outside the field.

Generally, weed management strategies are devised for specific annual grasses and annual broadleaf weeds. The annual grass weed causing the greatest problem in Washington barley is wild oat (*Avena fatua*). The particular annual broadleaf species of importance vary greatly throughout the state, determined by the local climate and production practices, such as tillage systems and crop rotations. Problems besides wild oat may include Russian thistle (*Salsola* spp.), mayweed chamomile (*Matricaria* spp.), common lambsquarters (*Chenopodium album*), dog fennel (var. *Matricaria* and *Anthemis* spp.), Italian ryegrass (*Lolium multiflorum*), and prickly lettuce (*Lactuca serriola*). Green and yellow foxtails (*Setaria viridis* and *Setaria glauca*) are common barley pests in the Great Plains, but, while present in Washington, have not posed a pest problem to date.

Perennial weeds, considered a long-term problem, are managed throughout the crop rotation by combinations of tillage and herbicide treatments. Those most pestiferous in barley are field bindweed (*Convolvulus arvensis*), Canada thistle (*Cirsium arvense*), and quackgrass (*Elymus repens*). Barley is considered the greatest competitive crop of most rotations and is included in rotations for this reason.

### Controls

**Biological**

Biological control has not effectively and consistently controlled any of the species of weeds known to be chronic problems in barley.

**Integrated Weed Management**

Barley is used as a rotational weed management tool in eastern Washington. Integrating the competitive abilities of barley along with mechanical and chemical control effectively reduces the overall chemical use in barley and in the other rotational crops. Specifically, barley in the rotation tends to reduce populations of annual grasses such as wild oat and Italian ryegrass in a subsequent rotation to wheat (or another cereal). Cultural controls such as crop rotation are widely practiced among growers to reduce the amount of weeds. Mechanical weed control such as tilling the fields to control weeds prior to planting controls nearly all annual weeds present and greatly reduces the growth of perennial weeds. Growers
balance this benefit against the detriment of excessive tillage that results in soil erosion.

Chemical

**Triallate (Far-Go, Buckle)** is used on 26% of barley acreage in eastern Washington for pre-emergence control of wild oat. The emulsifiable concentrate (EC) must be mechanically incorporated into the soil, therefore is not effective in "no-till" (direct-seeded) cropping systems. Resistant populations of weeds may develop. Far-Go is generally used at 1.25 lbs. a.i./A. The granular formulation is applied at 1.0-1.5 lbs. a.i./A. Buckle, which combines triallate with trifluralin, is used at a rate of 10 to 12.5 lbs. product/A.

**Thifensulfuron (Harmony)** is an amino-acid-synthesis inhibitor effective on broadleaf weeds. It is used on 24% of barley acreage in eastern Washington. It may be applied when barley is in the two-leaf stage of growth until the flag leaf is visible. Harmony GT (75% thifensulfuron) is applied at 0.225-0.375 oz. a.i./A. Due to potential for resistance development, growers apply thifensulfuron in combination with broadleaf herbicides with different modes of action. Optimal performance requires adequate soil moistures and temperatures of 60°F or greater before, during, and immediately following application. When tank-mixed with thifensulfuron, most graminicide activity is not reduced. (Graminicides are herbicides active on graminoid, or grass-like vascular plants.) Thifensulfuron is packaged in formulation with many other ingredients (e.g., Canvas when in combination with both metsulfuron and tribenuron methyl, Harmony Extra when in combination with tribenuron), so rate of application can vary significantly, but never exceeds the equivalent of 0.45 oz. a.i./A.

**2,4-D and MCPA (amine and ester formulations)** are effective for post-emergence control of many species of broadleaf weeds; they do not control grass weeds. They also may be used as a pre-harvest aid to desiccate broadleaf weeds that could interfere with the harvest operation or as a spot treatment for perennial weeds. Fifteen percent of barley acreage in eastern Washington received applications of 2,4-D and 22% received applications of MCPA. Application rate varies from 0.125 to 1.0 lbs. a.i./A. There is no information available on the usage of specific formulations (amine or ester). MCPA and 2,4-D are often mixed with herbicides with other modes of action in an attempt to prevent or slow development of resistance. Applications of 2,4-D or MCPA must be delayed until the crop is well developed to avoid damaging the crop. This delay can increase infestations of weeds causing reduced barley stand and ultimately yield. Tank mixing 2,4-D or MCPA with certain graminicides may reduce the activity of the graminicide.

**Bromoxynil (Buctril or Bronate)**, a photosynthetic disrupter used on approximately 16% of barley acreage in eastern Washington, is effective for post-emergence control of many broadleaf weeds. It may be applied to barley from emergence to the boot stage of the crop. Bromoxynil is very effective on small weeds, but larger weeds may escape control. Weeds emerging after a bromoxynil application will not be controlled by the herbicide. Bromoxynil is most commonly used as the Bronate formulation (premixed with MCPA) or tank-mixed with other broadleaf herbicides. Bronate is typically applied at 0.25 to 0.375 lbs. a.i./A for both bromoxynil and MCPA, while Buctril is typically applied at 0.5 lbs. a.i./A. When tank-mixed with bromoxynil, graminicide activity is not reduced.
Tribenuron (Express, Harmony Extra) is an amino-acid-synthesis inhibitor effective on broadleaf weeds. Used on 12% of barley acreage in eastern Washington, it may be applied when barley is in the two-leaf stage of growth until the flag leaf is visible. Due to potential for resistance development, growers apply tribenuron in combination with broadleaf herbicides with different modes of action. Optimal performance requires adequate soil moisture and temperatures of 60°F or greater before, during, and immediately following application. Express is applied at 0.125 to 0.25 lbs. a.i./A. More often, Harmony Extra is used, which is premixed with thifensulfuron and results in less a.i./A.

Clopyralid (Stinger) is effective on certain broadleaf weeds in the Asteraceae family including thistles, prickly lettuce, and mayweed chamomile; particularly effective as a spot treatment for Canada thistle. Used on less than 1% of the barley acreage in eastern Washington. Use of this product may prevent planting susceptible crops such as canola or mustard for a period of twelve months. Other clopyralid products that may be used include Curtail (premixed with 2,4-D amine) and Curtail M (premixed with MCPA).

Dicamba (Banvel, Clarity) is effective on many broadleaf weeds. Percentage use pattern not established on barley in eastern Washington. Potential for injury to barley is relatively great with this product, therefore rate and application timing is restricted. Applications are generally 2 to 4 oz. product/ A or 0.0625 lbs. a.i./A from emergence up to the four-leaf stage of the crop. Dicamba is typically used in combination with other broadleaf herbicides such as MCPA to increase the control spectrum or as a potential herbicide-resistance management tool.

Picloram (Tordon 22K) is effective on many broadleaf weeds and may be applied from the three-leaf until the jointing stage of the crop, but is used very little in Washington as it restricts rotation crop options. Tordon 22K is restricted to 1.5 oz./A annually, but applications using 0.5 to 1.0 oz. product or 0.023 lbs. a.i./A would be more likely. It is most commonly used as a spot treatment on perennial weeds either pre- or post-harvest.

Diuron (Karmex DF) is effective for grass and broadleaf control when applied pre-emergence at 1.2 to 1.6 lbs. a.i./A. This photosynthetic disrupter may only be used on winter barley in western Washington.

Metribuzin (Lexone, Sencor) is a photosynthetic disrupter used infrequently for broadleaf and grassy weed control in Washington barley. Application would be limited 3 to 3.75 oz. a.i./A. May be applied to barley from the two-leaf to jointing stage of growth. May injure certain varieties of barley.

Paraquat (Gramoxone Extra) is a nonselective, restricted-use herbicide applied at about 0.5 to 0.75 lbs. a.i./A as a preplant or pre-emergence herbicide for control of weeds in no-tillage or reduced tillage production systems. It is a photosynthetic disrupter.

Chlorsulfuron (Glean) is an amino-acid-synthesis inhibitor used infrequently for broadleaf weed control on winter or spring barley. Glean is limited to 0.23 lbs. a.i./A, and Finesse, which is premixed with metsulfuron, is applied at 0.15-0.3 lbs. a.i./A. May be applied from the two-leaf through the second-
joint stage of barley growth. Due to potential for resistance development, growers apply chlorsulfuron in combination with broadleaf herbicides with different modes of action. Persistence of chlorsulfuron in the soil, particularly with increasing pH, may restrict crop rotation options, including rotating back to barley.

**Metsulfuron (Ally)** is an amino-acid-synthesis inhibitor effective primarily for broadleaf weed control. Percentage use pattern not established in the state. May be applied from the two-leaf through the boot stage of barley growth. Due to potential for resistance development, growers apply metsulfuron in combination with broadleaf herbicides with different modes of action. Persistence of metsulfuron in the soil, particularly with increasing pH, may restrict crop rotation options. Rates range from 0.06 to 0.18 lbs. a.i./A. Sold as **Finesse** when premixed with chlorsulfuron and **Canvas** when premixed with thifensulfuron.

**Prosulfuron (Peak)** Used at 0.22 to 0.29 lbs. a.i./A, this amino-acid-synthesis inhibitor is effective primarily for broadleaf weed control. Percentage use pattern not established in the state. May be applied from the three-leaf through the second-joint stage of barley growth. Due to potential for resistance development, growers apply prosulfuron in combination with broadleaf herbicides with different modes of action. Persistence of prosulfuron in the soil, particularly with increasing pH, may restrict crop rotation options.

**Triasulfuron (Amber)** Used at standard rates of 0.21 to 0.35 lbs. a.i./A, this amino-acid-synthesis inhibitor is effective primarily for broadleaf weed control. Percentage use pattern not established in the state. May be applied when barley is in the two-leaf through the preboot stage of growth. Due to potential for resistance development, growers apply triasulfuron in combination with broadleaf herbicides with different modes of action. Persistence of triasulfuron in the soil, particularly with increasing pH, may restrict crop rotation options, including rotating back to barley.

**Glyphosate (Roundup Ultra)** is a non-selective systemic herbicide used at 0.375 to 0.5625 oz. a.i./A for control of annual and perennial weeds. An amino-acid-synthesis inhibitor, it may be used as a preplant or pre-emergence herbicide for control of weeds in no-tillage or reduced tillage production systems. Also may be used as a preharvest aid to desiccate weeds that could interfere with the harvest operation or as a spot treatment for perennial weeds.

**Diclofop (Hoelon)** this restricted-use herbicide is used at 0.75 lbs. a.i./A for post-emergence control of several species of annual grasses. Percentage use pattern not established in the state. May be applied to barley at the one- to four-leaf stage of growth. Resistant populations of weeds may develop. Applying diclofop within five days of the application of certain broadleaf herbicides may reduce grass control.

**Difenzoquat (Avenge)** Used at rates of 0.625 to 1 lb. a.i./A. Post-emergence control of wild oat. Percentage use pattern not established in the state. May be applied to wild oat at the three- to five-leaf stage of growth. Some loss of barley yield may have already occurred by waiting until weeds are in the proper stage for application. Resistant populations of weeds may develop.
**Imazamethabenz (Assert)** Used at a rate of 0.41-0.47 lbs. a.i./A. Post-emergence control of wild oat. Percentage use pattern not established in the state. May be applied to wild oat at the one- to four-leaf stage of growth. Subsequent emergence of weeds may result in reinfestation. Resistant populations of weeds may develop. Soil persistance may restrict crop rotation options.

**Trifluralin (Treflan)** Used at 0.5 to 0.75 lbs. a.i./A. Post-plant incorporation control of certain annual grass and broadleaf weeds in barley. Percentage use pattern not established in the state. Required mechanical incorporation precludes use in no-tillage and direct seeding systems. Not effective against wild oat.

**Metam-Sodium (Vapam or Soil-Prep)** is a soil fumigant sometimes used as a preplant treatment for crops in rotation with barley. Besides controlling weeds, it manages certain nematodes and diseases. With Washington barley being a low or negative cash crop, no fumigation takes place solely for barley (or for its primary rotation crop, wheat), but it might be used for a higher value crop in the rotation such as potato.

### Diseases

**Stripe Rust, *Puccinia striiformis hordei***

Stripe rust is primarily a disease of cool climates. It has caused widespread, devastating losses in each region where it has occurred. Barley stripe rust, which was first detected in the United States in 1991, has become the most widely destructive disease of barley in the West. It is known to reduce yields by 30 to 100% and to reduce grain quality. Damage to barley depends on its stage of growth relative to rust development. Rust development at an early stage of growth causes the most damage.
Barley heavily infected with stripe rust
Photo courtesy of University of Oregon and Jay Pscheidt

Controls

Cultural

Stripe rust can be controlled by resistant cultivars; some newly released barley cultivars in the West are resistant to stripe rust.

Chemical

Seed treatment with Baytan (Triadimenol) at 1.5 oz. product/cwt. or 0.031 lbs. a.i./cwt. can protect barley seedlings from infections in the event of early onset of disease, and thus delay disease development. Foliar application of Tilt (Propiconazole) or Folicur (Tebuconazole) at 4 fl. oz. product/A or 1.8 oz. a.i./A will control stripe rust. Tilt is currently registered for use. Folicur has had an emergency exemption from registration from 1996 to 2000 (Section 18 numbers for 1998 through 2000 are 98-WA-18, 99-WA-16, and 00-WA-19).

Barley Yellow Dwarf (BYDV)
Barley yellow dwarf, caused by barley yellow dwarf virus (BYDV), is the most important and widespread virus disease of barley in the world. In Washington, vectors that transmit BYDV include corn leaf aphid, bird-cherry oat aphid, English grain aphid, and, to a lesser extent, other aphids such as rose-grass aphid. Losses from barley yellow dwarf can approach 100% when plants are infected early. Losses of 40% are not uncommon in commercial fields and are usually highest with early infections. Losses vary among cultivars, isolates of BYDV, and environmental conditions. Yield losses result from fewer heads per plant, fewer seeds per head, partial sterility, and reduced kernel size and weight.

**Controls**

**Cultural**

Avoidance of early fall and late spring planting allows the plants to develop at a time when aphid populations are lowest. Resistant or tolerant cultivars have potential for control. The aphid vectors have a wide variety of alternate hosts. Corn leaf aphid favors wild grasses, oat, millet, timothy, fescue, and, occasionally, corn, while the bird-cherry oat aphid favors almost any grass, including bluegrass lawn types as well as corn. Proximity to alternate hosts could enhance vectors' ability to spread barley yellow dwarf.

**Chemical**

Use of systemic insecticides such as **Gaucho (Imidacloprid)** at 2 oz. product/cwt. or 0.0625 lbs. a.i./cwt. will prevent transmission of BYDV by aphids. Use of foliar insecticide **Di-Syston (Disulfoton)** will reduce aphid population and therefore reduce the spread of BYDV.

**Scald, Rhyncosporium secalis**

Scald is a common disease of barley in cool, semi-humid growing regions. Yield losses as high as 35-40% have been reported. However, losses of 1-10% are common.
Scald can be recognized by oval to elongate spots with light centers and dark brown to black edges

Photo courtesy of OSU Extension Plant Pathology

Controls

Cultural

Barley scald is reduced by destruction of the sources of primary inoculum (infected seed or residue). Some cultivars are resistant to scald.

Chemical

Seed treatment has not been established for disease control. Foliar spray with Tilt at the rate of 4 fl. oz. product/A has been shown to control the disease.

Net Blotch, *Pyrenophora teres*

Net blotch is most important in areas of high humidity and high rainfall. The severity of net blotch is also related to the susceptibility of cultivars. There has been an increase in the incidence of net blotch in recent years, particularly because of growing continuous barley, minimum tillage, and irrigation. Yield losses can approach 100% in severely affected fields of highly susceptible cultivars, but more typical
losses range from 10 to 40%.

Net blotch symptoms: note the narrow, dark brown stripes extending across and down the leaf
Photo courtesy of University of Oregon and Paul Koepsell

Controls

Cultural/Chemical

Destruction of primary inoculum is the first step for control of net blotch. Use of pathogen-free seed or seed treated with fungicides like Vitavax will prevent introduction of the pathogen into clean fields. Rotation with non-susceptible crops for at least two growing seasons reduces net blotch. Resistant cultivars are an effective means of control.

Stem Rust, *Puccinia graminis*

Like stripe rust and leaf rust, specialized strains of stem rust fungus are adapted to specific crops (wheat, rye, oats, and certain grasses). However, the strains that infect barley may come from wheat, rye, or other grasses. Damage to barley depends on its stage of growth relative to rust development. Epidemics that occur before the dough stage of plant growth are most damaging. Losses caused by stem rust
depend upon type of resistance and/or conditions favorable for rust development. Warm and wet late spring conditions are extremely favorable for stem rust development.

Controls

Cultural/Chemical

Stem rust is best controlled by resistant cultivars and application of foliar fungicides. Foliar application of **Tilt** or **Folicur** (4 fl. oz. product/A or 1.8 oz. a.i./A) will control stem rust. Spray should be timed between boot to milk stage. Tilt will control stem rust but cannot be used past flag leaf emergence.

**Leaf Rust, Puccinia hordei**

Leaf rust is important in some regions where the crop matures late. In Washington, it is more of a problem west of the Cascade Mountains than east of the mountains. Damage to barley depends on the stage of growth relative to when rust begins to develop. Severe early infection causes shriveled kernels and a decrease in grain number. Epidemics that occur before or during flowering are most damaging.

Controls

Cultural/Chemical

Leaf rust can be controlled through resistance and cultivars that are slower to express rust and through foliar applications of systemic fungicides. Seed treatment with **Baytan (Triadimenol)** at 1.5 fl. oz. product/cwt. or 0.03 lbs. a.i./cwt. will control early development of leaf rust on spring barley. Foliar application of **Tilt (Propiconazole)** or **Folicur (Tebuconazole)** at 4 fl. oz. product/A or 1.8 oz. a.i./A will control leaf rust. Because leaf rust is not a big problem in most barley production areas in the State of Washington, there have been almost no fungicide applications that are specifically for control of barley leaf rust.

**Bare Patch, Rhizoctonia spp.**

Bare patch is a disease of barley in many parts of the world. The disease is a problem in Washington State, but seldom causes serious losses. The disease has been associated with minimum tillage and planting too soon after use of herbicides to kill previous cereal crops.

Controls

Cultural
Tillage to break the continuous crop is highly effective in controlling the disease. Vigorous plants growing in well-fertilized soil are less likely to become severely diseased. Resistant cultivars are not available.

**Chemical**

Seed treatment with **PCNB** at the rate of 3 fl. oz. product/cwt. or 0.05 lbs. a.i./cwt. may provide some control. Chemical fallow or mechanical tillage can significantly reduce the disease severity.

**Seedling Blight and Common Root Rot,\n\n*Fusarium culmorum, F. graminearum***

Several fungi cause seedling blight and common root rot or dryland root rot, but the two species listed above are the most common pathogens in the Pacific Northwest. These fungi can attack seedlings, foliage, heads, and grain. Losses from common root rot are severe in years of below normal soil moisture when plants are drought stressed.

**Controls**

**Cultural**

Using clean seed may reduce seedling infection. Planting in cool soil can reduce seedling infection. Root rot is usually less severe on barley that has been optimally fertilized. Over-fertilization, especially with nitrogen, can make root rot more severe by promoting excessive use of water. Using resistant or tolerant cultivars may reduce common root rot.

**Chemical**

Seed treatment with broad-spectrum fungicides can control seedborne infections. **Imazalil** used as seed treatment at 0.25 to 0.5 fl. oz. product/cwt. may reduce Fusarium root rot (dryland root rot), but it has seldom been used in Washington for this purpose.

**Powdery Mildew, Erysiphe graminis hordei**

Powdery mildew is most damaging in high humidity climates. Powdery mildew of barley is restricted to wild and cultivated barley and does not attack other cereals. Yield losses are greatest when plants are infected as seedlings and disease development continue through flowering.

**Control**
Cultural

Resistant cultivars are effective until the virulent races of the fungus become prevalent, which usually occurs about three to four years after the release of the resistant cultivars. The pathogen thrives on lush, nitrogen-rich plants and is less damaging when correct proportions of nitrogen, potassium, and phosphorus are used.

Chemical

Foliar application of Tilt or Folicur at 4 fl. oz. product/A or 1.8 oz. a.i./A will control powdery mildew. In the Pacific Northwest, spraying for control of powdery mildew is usually not necessary because it seldom causes severe yield losses in this region, but if the fungicides are used for rust control, they will also control powdery mildew.

Covered Smut, *Ustilago hordei*

Covered smut occurs in the state of Washington, but losses from the disease are rare because the environments are not conducive and major barley production areas do not have a history of the disease. In addition, seed treatments have reduced incidence of the disease. However, because heads infected with covered smut are harvested with healthy grain, losses can arise from lowered grade due to smutty grain.
Covered smut symptoms
Photo courtesy of OSU Extension Plant Pathology

Controls

Cultural/Chemical

Covered smut is controlled effectively in Washington State by using seeds treated with Baytan at 0.75-1.5 fl. oz. product/cwt.; Vitavax at the rate of 9-12 fl. oz. product/cwt.; or Dividend XL at 1-2 fl. oz. product/cwt. Resistant cultivars would likely work, but because of the success of seed treatment, little effort has been placed on developing resistant cultivars.

Loose Smut, Ustilago nuda

Loose smut is most common in areas of high humidity and rainfall at anthesis (open-flower period). In most regions, losses from loose smut are minor. Occasionally, highly susceptible cultivars sustain some loss. Quality of harvested grain is not affected, because the smut spores are dispersed long before harvest. In Washington State, the disease is generally not a problem because of unfavorable weather conditions. Infection occurs only during flowering and is favored by wet and cloudy weather and moderate temperatures.

Controls

Cultural

Resistant cultivars control loose smut, but resistance to loose smut is not a priority in barley breeding programs in Washington State because the disease is not economically important.

Chemical

Seed treated with Vitavax or Baytan at the rate of 9-12 fl. oz. product/cwt. or Dividend XL at 1-2 fl. oz. product/cwt. will control loose smut.

Black Chaff and Bacterial Leaf Streak, Xanthomonas translucens pv. translucens

These diseases almost disappeared during the use of organic mercury seed treatments. With elimination of the organic mercury seed treatments, the diseases have again become widespread, especially where sprinkler irrigation is used. Yield losses can be 10-15%. The diseases may persist from one season to the next on barley seed, barley straw, winter barley, or grass hosts. It does not survive in soil for very long.
The fungus can spread from plant to plant by wind and rain, insects, or mechanical contact. The seed may become infected when heads are infected, but effective transmission to seedlings is usually 5% or less. Major spread occurs under sprinkler irrigation.

**Controls**

**Cultural**

Use of pathogen-free seed produced under dry conditions, coupled with crop rotation to destroy infested plant debris, is the best control measure. No resistant cultivars are known.

**Chemical**

Seed treatments containing copper reduce seedborne inoculum but do not prevent spread from infested plant debris.

**Snow Molds, Fusarium and Typhula Species**

Snow molds are diseases of the plant tissue near the soil surface under the snow. Snow cover provides an insulating blanket that keeps soil temperature near 0°C even though air temperatures may be much lower. Beneath deep snow, barley plants slowly deplete their carbohydrate and then their protein reserves. In this weakened state, they are predisposed to snow mold. Since this is a potential problem only for winter barley, which represents a very small portion of Washington barley, and since winters severe enough to cause snow mold (deep, long-standing snow) would produce conditions too risky for winter barley anyway, snow mold is not a concern at this time in Washington.

**Controls**

**Cultural**

Growers avoid planting in areas of long, persistent snow cover. No barley cultivars are known to have high resistance to snow mold.

**Chemical**

**Baytan (Triadimenol)** used as seed treatment at the rate of 9-12 fl. oz. per 100 lbs. will control speckled snow mold caused by *Typhula* spp.

**Pythium Root Rot, Pythium spp.**
Phythium root rot is most common where soils remain wet for long periods. *Pythium* species can attack a broad range of hosts, including barley. Pythium root rot is associated with direct-seeded (no-till) barley in the Pacific Northwest.

**Controls**

**Cultural**

The standard management practices including tillage used by most barley producers are effective for preventing Pythium root rot. Draining low spots to prevent excessive soil moisture reduces the disease.

**Chemical**

*Apron* (mefenoxam) is used as a seed treatment at a rate of 0.32 to 0.64 fl. oz. product/cwt.

**Scab (Head Blight), *Fusarium* spp.**

Scab on barley, also called Fusarium head blight, is caused by the same *Fusarium* spp. that cause scab on wheat and other small grains and cause stalk rot on corn. It can also cause seedling blight and root rot. Since 1993, the disease has been very destructive in many regions where barley is grown in rotation with corn and in acreage with reduced tillage. Scab has not been a big concern historically in Washington because the weather conditions and cropping systems are generally unfavorable for scab development. Absence of heavy rain at heading to anthesis and post-anthesis and dry late-spring conditions are not conducive for scab development. Scab causes losses by reducing yield and quality and by producing toxins that affect animals and humans. The toxins also affect the taste qualities of beer.

**Controls**

**Cultural**

Crop rotation with at least a one-year break in cereal and grass cultivation is practiced for control of scab. Barley is generally not planted following corn, or crop residues of corn (particularly irrigated corn) may be plowed under. Because spores of the scab fungus can be airborne for some distance, barley growing is also avoided near fields with abundant corn residue. In irrigated barley, growers reduce irrigation during heading to maturity to reduce scab. Resistant cultivars are being developed for regions where scab is an important disease of barley.

**Chemical**

Treatment of seed with an effective fungicide like *Imazalil* and *Dividend XL* (mefenoxam and difenoconazole) may protect seedlings from seedborne inoculum. Dividend XL (24c, WA-990014) is
used at a rate of 2 fl. oz. product/cwt. on spring barley only. Foliar fungicides like **Folicur** have potential for reducing head blight.

**Spot Blotch, Cochliobolus sativus**

Spot blotch causes losses only in regions with a warm, humid climate and is rarely a problem in barley grown under semiarid conditions. The severity of spot blotch varies greatly from year to year. Spot blotch has reduced yields by 36% in highly susceptible cultivars. In Washington State, it is a minor disease.

![Image of barley with spot blotch symptoms](image)

**Spot blotch symptoms: dark, circular brown spots forming blotches over large areas of the leaf**

Photo courtesy of University of Oregon and Paul Koepsell

**Controls**

**Cultural**

The use of pathogen-free or fungicide-treated seed is suggested for control of the disease. Rotation with non-susceptible crops aids in the destruction of infested residue, which reduces the level of primary inoculum. However, soilborne inoculum may negate the value of residue destruction. Cultivars with an
acceptable level of resistance to spot blotch have not been developed.

**Chemical**

Foliar applications of fungicides, such as **Tilt** at 4 fl. oz. product/A or 1.8 oz. a.i./A will control spot blotch.

---

**Insect Pests**

At least thirty insect species attack, or have the potential to attack, barley grown in Washington. Most are considered insignificant or minor pests. Their importance is often local and may vary depending upon season and other conditions. The most commonly encountered pests include cereal aphids, grasshoppers, wireworms, cutworms and armyworms, and Hessian fly. A pest new to Washington wheat, the cereal leaf beetle, has the potential to be a pest for Washington barley.

Because of the low economic return on barley, chemicals are not used extensively for insect control. Simple economics precludes many growers' use of seed or foliar treatments. Insecticide applications are often limited to outbreak conditions or in response to threats of insect-vectored diseases like barley yellow dwarf virus (see Disease section). New, cost-effective pest control options are needed for barley.

No statistics on chemical use in barley are available in Washington. Insecticides used in barley production can be grouped into three categories: 1) pre-planting; 2) pre-emergence; and 3) post-emergence materials. Pre-planting chemicals involve seed treatments prior to planting (e.g., imidacloprid, lindane). Pre-emergence chemicals are primarily soil treatment substances injected or applied at time of planting (e.g., disulfoton). Post-emergence chemicals are used as foliar sprays applied after the plants have emerged; these include disulfoton, and malathion. Although barley and wheat share many insect pests and diseases, the chemicals used to control these insects may differ. For example, compounds recommended for use on wheat such as Lorsban, Phorate, Thimet, and Dimethoate are not registered on barley. Washington entomologists are working with barley growers and the Washington Barley Commission to develop and institute stable, long-lasting biological control programs for barley.

**Cereal Aphid**

Various spp. including Corn Leaf Aphid, *Rhopalosiphum maidis* (Fitch);
Bird Cherry-Oat Aphid, *Rhopalosiphum padi* (Linnaeus);
English Grain Aphid, *Sitobion avenae* (Fabricius);
Rose-Grass Aphid, *Metopolophium dirhodum* (Walker);
Russian Wheat Aphid, *Diuraphis noxia*

Aphids are the most important insect pests of barley in Washington. Occasionally, aphids are
sufficiently abundant to cause localized direct damage by feeding on the plants, generating toxins that stunt or deform the barley, but for the most part they are a concern in barley for the indirect damage they bring about by vectoring barley yellow dwarf virus (BYDV, see Disease section). Russian wheat aphid is not known to vector BYDV, but is a potential direct pest of barley in Washington.

Aphids may occur in colonies of 300 to 500+ individuals. Colonies develop in protected areas near the bases of leaves, in leaf whorls, or on stems inside leaf bases. Some occur within tightly rolled leaves or in trapped seed heads caused by toxic secretions produced during feeding. Cereal aphids often occur in mixed colonies of different species. They are often held in check by natural enemies.

Aphids are cyclic pests and can become problematic when conditions favor overwintering survival or rapid buildup during spring. When winters are warm, aphids overwinter on grasses and fall-seeded small grains, then re-invade fields from adjacent or distant overwintering sites in southcentral Washington during the spring. Aphids reproduce quickly and populations can increase dramatically once colonies are established, if environmental constraints are limited. Early detection is difficult as aphids occur initially in low numbers and hide in protected areas on plants. Late-planted barley is especially susceptible to aphid attack. Under normal conditions, plants can usually withstand late season infestations and produce seed without significant reductions.

**Controls**

**Cultural**

The timing of barley planting does a great deal to discourage aphids' developing to problem levels. The majority of Washington barley is spring barley; that which is planted relatively early (February through April) is less at-risk for aphid infestation. Barley planted in May, especially mid- to late-May, is at great risk for aphid infestation. (Such late plantings tend to perform poorly agronomically anyway.) The barley planted earlier in the spring tends to be well enough established to withstand the impacts of the later arrival and development of the aphid populations.

Winter barley comprises a very small part of Washington's barley crop; it would be much more susceptible to BYDV and timing the plantings for late in the season might help diminish the impact of aphids.

Plants that harbor non-economic aphids may serve as hosts for natural enemies or provide nectar and pollen resources for predatory beneficials. When located adjacent to cropping systems, a diversity of plant types may offer refuge and/or food for overwintering agents. Tillage methods that leave undisturbed marginal strips along fence rows and at field edges may also enhance conservation of overwintering sites for natural enemies.

**Biological**
Cereal aphids are attacked and usually checked by an array of natural and introduced enemies. Most of these agents are established in the field, but there is a need in some cases (e.g. bird cherry-oat aphid) to strengthen and enhance the pool of natural enemies. Among beneficial predators found in eastern Washington are parasitoid wasps, predatory ladybird beetles, lacewings, and aphid-attacking flies. Selected pathogenic fungi are also known to control aphid populations. Many of these natural enemies are adapted to enter rolled leaves or confined areas to attack aphids in all life stages. Several of the natural enemies respond quickly to match increasing aphid numbers. This is an interactive complex of enemies that has been responsible for maintaining most cereal aphids in low numbers and reducing the impact of the Russian wheat aphid (RWA) since its arrival in the Pacific Northwest in 1989.

**Chemical**

Post-emergence insecticide treatments to control aphids may become necessary when post-emergence infestation levels average 10% per tiller, stem, or head. Some scouting is practiced to determine actionable levels.

**Disulfoton (Di-Syston 8E)** is recommended for use as either a soil treatment at 1 lb. a.i./A or a post-emergence foliar spray at 0.5 to 1 lb. a.i./A for control of Russian wheat aphid. It has a 30-day pre-harvest restriction. Russian wheat aphid has not caused problems in Washington in more than four years due to the success of biocontrol. If trends hold, chemical pest management will be needed seldom.

**Methyl Parathion (Penncap-M)** at 0.25 to 0.75 lb. a.i./A is a foliar spray for use against Russian wheat aphid and is effective against aphids in general.

**Malathion (Malathion** at 1 lb. a.i./A) is another post-emergence foliar spray. It has not proven very effective at aphid control, but works against grasshopper.

**Methomyl (Lannate** at 0.23 to 0.45 lb. a.i./A) is a foliar spray.

**Endosulfan (Thiodan 3EC** at 0.5 lb. a.i./A) is a foliar spray.

**Carbofuran (Furadan** 4F at 0.125 to 0.25 lb. a.i./A) is a foliar spray used for grasshoppers on barley which also seems to be effective against aphids, but would be cost-prohibitive to use for the chief purpose of aphid protection.

**Grasshoppers, various spp.**

Adults and nymphs of several species are not usually considered pests unless their populations reach outbreak numbers. High populations in certain years can be devastating to all available forage, including heads, stems and foliage of barley. Typically residents of non-crop, rangeland areas, grasshoppers will move into adjacent crops, including cereal grains.
Controls

Biological

The microsporidian protozoan Nosema locustae, labeled for use on croplands, is a slow-acting pathogen effective when used as a grasshopper bait around areas of infestation. Label suggests no less than 1 lb. product/A per application.

Chemical

Disulfoton (Di-Syston 15G at 1 lb. a.i./A, 24c WA-850036) is a granular systemic registered for use in Washington against aphids, grasshoppers, and Hessian fly. It is used at planting time and has a 30-day preharvest restriction. There are reports of phytotoxic activity on barley with this compound. Limited to one application per season.

Malathion at 1 lb. a.i./A is a post-emergence foliar spray effective against grasshoppers.

Carbofuran (Furadan 4F at 0.125-0.25 lb. a.i./A) is applied as a foliar spray prior to heading. This compound is limited to two applications per year.

Wireworms, various spp.

These minor barley pests have multiple-year life cycles. Sporadic, localized outbreaks can cause economic damage. Damage occurs when larvae burrow into kernels and leaf whorls above seed (fall-planted) or kernels and underground parts of plants after sprouting (spring-sown). Damage is most severe during cool, wet spring weather.

Controls

Cultural

Wireworms may not be a problem if land is treated with a soil fumigant or chemicals before grains are planted. Soil fumigants are not likely to be used for barley alone because of cost.

Chemical

Imidacloprid (Gaucho 480 at 3 fl. oz. product/100 lbs. seed) is used as pre-planting seed treatment. It has a 45-day pre-harvest restriction.

Lindane (Lindane at 0.135 fl. oz. product /100 lbs. seed) is another seed treatment. Certified seed may
be already treated with this material. It is moderately effective against low populations of wireworms.

**Telone II or C17** can be used as pre-planting soil fumigant, but is not cost-effective to use solely for reducing wireworm in barley.

**Cutworms and Armyworms**

Various spp. including Variegated Cutworm, *Peridroma saucia*; Armyworm, *Podoptera frugiperda* or *Pseudaletia unipuncta*; Bertha Armyworm, *Mamestra configurata*; and Zebra Caterpillar, *Ceramica picta*

These and other species of larval moths are considered minor pests that may damage young barley plants early in spring. Caterpillar forms live in the soil or near the base of plants.

**Controls**

Certain controls are available for cutworms and armyworms, but are rarely used due to cost and margins.

**Chemical**

**Endosulfan (Thiodan 3EC** at 0.5 lb. a.i./A) is a foliar spray that can be applied before heads form. Not widely used.

**Methomyl (Lannate** at 0.23-0.45 lb. a.i./A) is a foliar spray registered on armyworms but not cutworms. Works best when applied when worms are smaller and younger.

**Hessian Fly, Mayetiola destructor**

Traditionally a pest on wheat, Hessian fly has caused some damage in southeastern Washington barley, notably in Asotin, Garfield, and Columbia counties. Larvae feed at or near the plant crown, or at the leaf bases. There are two to three generations per year. Feeding damage stunts plants, kills upper portions, and reduces yield. Stems are weakened and tillers break off at harvest.

**Controls**

**Cultural**

Tillage helps control Hessian fly. It is more of a problem in direct-seeded ("no-till") situations. Studies suggest that certain varieties, including Baronesse, may be resistant to Hessian fly. Breeding programs are underway to develop greater resistance.

**Biological**
At least six species of parasitoid wasps attack Hessian fly. Unfortunately, these parasites destroy later developmental stages, which comes too late in the life cycle to affect the damaging larval population.

**Chemical**

**Imidacloprid** *(Gaucho 480 at 1-3 fl. oz. product/100 lb. seed)* is a seed treatment effective against first generation fly, and possibly some second generation. Also used as an aphid control.

**Disulfoton** *(Di-Syston 15G at 1 lb. a.i./A, 24c WA-850036)* is a granular systemic registered for use in Washington for grasshoppers, and Hessian fly. It is used at planting time and has a 30-day pre-harvest restriction. There are reports of phytotoxic activity on barley with this compound. Limited to one application per season.

**Cereal Leaf Beetle, Oulema melanopus**

This pest has recently been seen on wheat in the Spokane area. While it is not yet a pest to Washington barley, it has the potential to become one. Carbofuran is proven to be effective against cereal leaf beetle; **lambda-cyhalothrin** should also be effective but at present is not registered for use on barley. Based on other states' experience, biocontrol (both disease- and insect-based) holds promise in managing this pest.

**PEST CONTROL ISSUES**

Additional, cost-effective chemical controls are needed in barley, especially for wireworms.

**Contacts**

**AUTHORS**

Dr. William J. Turner  
Washington State University  
P.O. Box 646420  
Pullman, WA 99164-6420  
Phone (509) 335-3720  
Fax (509) 335-1009  
E-mail: turnerwj@wsu.edu

Dr. Joseph Yenish  
Washington State University  
P.O. Box 646420  
Pullman, WA 99164-6420
Dr. Roland F. Line, emeritus  
Washington State University  
P.O. Box 646430  
Pullman, WA 99164-6430  
Phone (509) 335-3755  
FAX (509) 335-7674  
E-mail: rline@wsu.edu

Dr. Xianming Chen  
USDA-ARS/Washington State University  
P.O. Box 646430  
Pullman, WA 99164-6430  
Phone (509) 335-8086  
FAX (509) 335-9581  
E-mail: xianming@mail.wsu.edu

TECHNICAL CONTACTS

Extension Weed Scientist  
Dr. Joseph Yenish  
Washington State University  
P.O. Box 646420  
Pullman, WA 99164-6420  
Phone (509) 335-2961  
Fax (509) 335-1758  
E-mail: yenish@wsu.edu

Entomologist  
Dr. Keith S. Pike  
Washington State University  
Irrigated Agriculture Research and Extension Center  
24106 N. Bunn Road  
Prosser, WA 99350-9687  
Phone (509) 786-9269  
Fax (509) 786-9370  
E-mail: kpike@tricity.wsu.edu

Plant Pathologist
Dr. Timothy Murray
Washington State University
P.O. Box 646420
Pullman, WA 99164-6430
Phone (509) 335-9541
Fax (509) 335-9581
E-mail: tim_murray@wsu.edu

Agronomist
Dr. Steven E. Ullrich
Washington State University
P.O. Box 646420
Pullman, WA 99164-6430
Phone (509) 335-4936
Fax (509) 335-8674
E-mail: ullrich@wsu.edu

INDUSTRY CONTACT

Mary Palmer-Sullivan
Administrator
Washington Barley Commission
905 W. Riverside Suite 501
Spokane, Washington 99201
Phone (509) 456-4400
Fax (509) 456-2807
Email: mpsulli@foxinternet.com
URL: www.washingtonbarley.org

References

