Crop Profile for Alfalfa in Washington

Prepared: March 2006

General Production Information

- Hay is the sixth most valuable commodity produced in Washington, with 790,000 acres harvested in 2004. Alfalfa hay makes up about 65% of the total hay grown in the state. The value of alfalfa hay alone approached $252M in 2004 (1).
- Washington ranks 21st in the nation in production of alfalfa, with 2.3% of the nation’s production.
- In 2004, the average yield per acre was 5 tons. Alfalfa yields in Franklin County and lower Grant County have reached up to 10 tons per acre.
- Average annual production costs for alfalfa in Washington are $85/ton.
- Average price received for baled hay is approximately $110/ton.
- In 2004, the value per harvested acre of alfalfa was $525.

PRODUCTION REGIONS

The majority of alfalfa hay, 356,000 acres or 73% of the state’s total, is produced in Spokane, Stevens, Grant, Adams, Benton, Franklin, western Walla Walla, and Yakima counties.

GENERAL INFORMATION

Alfalfa (Medicago sativa), also known as lucerne, is a perennial leguminous plant. It is the most important hay and pasture plant in North America.
Alfalfa is the principal roughage for ruminants as well as being a source of protein. When protein supplements such as soybean meal are high-priced, producers use alfalfa to provide the protein in animal diets.

Alfalfa is a cross-pollinated species. It relies on insects, primarily domesticated leafcutting bees, honey bees, alkali bees, and various wild bees for pollination. Wind pollination does not occur because the flower is structured in a way that physical “tripping” to expose the stigma to the anthers is required. Bees manipulate the flower when foraging for pollen and in doing so “trip” the flower. High quality alfalfa is normally harvested before or at first bloom. Because pollinators are often present in forage alfalfa fields, care is taken when selecting insecticide options to avoid products that are highly toxic to bees.

Alfalfa is rotated with other crops for reasons that include breaking disease and insect infestation cycles and weed management. Normal rotations in the Columbia Basin range from 2 to 7 years depending on whether the land is suitable for rotation crops like potatoes, dry onions, sweet corn, or other fresh vegetables.

Principal markets for Washington alfalfa include 245,000 dairy cows on 675 dairies in the state. About 20% of Washington alfalfa is compressed and shipped in sealed containers to the Pacific Rim countries of Japan, Korea, and Taiwan. Lower-quality alfalfa, affected by rain or contaminated by weeds, is often fed to beef cattle as-is or blended with concentrates in feedlot operations. A few growers will contract a year’s production with a broker or dairy with the price based on forage quality tests. Usually, the grower must farm several hundred acres of hay in order to meet these contracts.
The Columbia Basin (Grant, Adams, Benton, Franklin, western Walla Walla, and Yakima counties) lies in the rain shadow of the Cascade Mountains. This area normally receives from 8 to 10 inches of precipitation annually, mostly falling as rain or snow in the winter months. It is not uncommon for the months of July and August to be nearly free of measurable precipitation. Alfalfa normally dries down to baling moisture (12-17%) within about 8 days in May and June, and 5 to 7 days during the hotter summer months. The Columbia Basin environment is uniquely qualified for producing high-quality hay.

The growing season of the Columbia Basin allows from three harvests in the northern areas to five and sometimes six harvests in the extreme southern parts. Moving from north to south, the number of frost-free (>32° F) days ranges from 160 days in Omak to 176 at Quincy to 209 at the Tri-Cities. Average Accumulated Growing Degree Days (Base 50) at Prosser is 2550 units. The range of growing degree days for Prosser during the last five years was 2441 in 1999 (a cool year) to 2909 in 2003 (a warm year)(2).

Cultural Practices

**Land Selection and Seedbed Preparation**

Alfalfa grows best on well-drained loam or loamy-sand soils with pH ranging from 6.5 to 8.5. Alfalfa cannot tolerate extended periods of flooding. When possible, growers avoid soils that are saline or sodic in nature, have hard pans, or have high water tables. However, successful alfalfa production has been accomplished under circle irrigation in areas of 12-18 inches of sandy soils overlaying caliches.

**Fertility Requirements**

Columbia Basin alfalfa requires applications of phosphorous, potassium, sulfur, zinc, and boron, and in older stands, small amounts of nitrogen. Fertilizer application decisions are based on soil tests.

When properly inoculated with symbiotic *Rhizobia* bacteria, alfalfa utilizes nitrogen from the air. On sandy soils or in rotations following a grain crop such as wheat, starter fertilizers containing 30 to 50 pounds of nitrogen are commonly used to aid stand establishment.

**Variety Selection**

Varieties in the fall-dormancy (FD) classes 3 through 6 are used in the Columbia Basin. The higher the fall-dormancy class, the less fall-dormant is the variety. From Othello northward, growers plant FD 3-4. From Othello southward, varieties with FD 4-5 are planted. Some FD 6s are grown in the border areas near Boardman, Oregon. Winter hardiness (WH) of alfalfa is correlated with fall dormancy. In general, less fall-dormant varieties have higher yields than their more fall-dormant counterparts. However, the chance for injury is greater with the less fall-dormant types. Persistence, the real measure of a variety’s life span, is conditioned by many factors, including pest resistance, response to frequent cutting, fall dormancy, and winter hardiness. Varieties also differ in their forage quality, resistance to (irrigation) wheel traffic, tolerance to excessive soil moisture, and standability (resistance to lodging). Growers take all of these characteristics into account when choosing a variety (5). Planting blends rather than named varieties, such as those listed in the *Alfalfa Variety Yield Trials* publication (6), gives rise to problems with genetic purity, fall dormancy, or pest resistance.
Seedbed Preparation

Optimal stands of alfalfa result from seedbeds that are moist, firm, uniform, and free from excessive amounts of material from the previous crops. If alfalfa follows a cereal grain such as wheat, the straw must be removed prior to soil tillage. Plowing may be necessary to bury large amounts of crop residues. Frequently, late summer-planted alfalfa seedlings are stunted and unthrifty in the chaff rows but healthy and robust between chaff rows. Growers add 30 to 50 pounds of nitrogen prior to planting to aid the microbial breakdown of straw and chaff in these situations. Ideal soil firmness is characterized by a ½- to ¾-inch depression of a person’s footprint in the seedbed. The optimum seedbed preparation sequence, and the one practiced by most growers except those on very sandy soils, is 1) pre-irrigation, 2) final seedbed preparation as soon as the soil can be tilled, and 3) immediate planting. This sequence allows seed germination and emergence without the challenge of a soil crust formed by subsequent irrigations, and without the accompanying wet conditions favoring “damping off” (seedling rotting complex described in the disease management section).

Proper firmness of alfalfa seedbed. Footprint depresses soil about ½ to ¾ inches. Photo by John Kugler.

Planting

Seeding rates of 15 to 20 pounds per acre are commonly used in the Columbia Basin. Recent research from central Oregon showed that with ideal conditions, optimal stands can be attained with as little as 8 pounds per acre. Some seed is coated with lime, which lowers the amount of actual seed per pound in the bag by 30%. Seeding rates are often adjusted accordingly. The 15- to 20-pound seeding rate allows for less-than-perfect establishment conditions as a result of soil crusts, disease and insect attacks, improper seed placement, drought during germination, weed competition, and wind damage.

Growers utilize several methods of planting. One common method, especially for fields under center-pivot irrigation systems, is to apply seed from the air with aerial application (a.k.a. “crop-dusting”) aircraft. Another method employed by some fertilizer companies is to mix seed with fertilizer and spread the mixture with large spreaders (Air Seeders) with 70-foot booms. Immediately after seeding, ganged harrows are pulled over the seedbed to lightly cover the seed. Irrigation is applied immediately with rapid revolutions of the circle. These operations allow seeding, covering the seed, and initial irrigation within several hours. These methods are often successful, but can result in variation of seed distribution and variation in seed depth/covering, which in turn can result in less-than-desirable stands. The most successful and reliable seeding method is the use of drills, with or without press wheels, that place seed ¼ to ½ inch deep (¾ to 1 inch for very sandy soils), with an attached corrugated or smooth ring packer.

An optimal seedling stand can be assessed when seedlings have developed 3 to 4 trifoliate leaves.

Optimal seedling populations range from 50 to 75 per square foot. Fifteen to twenty-five plants per square foot are needed in the first year following seeding to attain maximum forage yields. If uniformly distributed, four to six plants per square foot may be adequate for maximum yields in mature stands.
Companion Crops

The use of companion crops, also called “nurse” crops, is not currently a popular practice. While companion crops, usually small grains, may protect small seedlings in areas with strong winds, they also compete with seedling alfalfa for fertilizer, space, and water in a manner similar to weeds. Where a companion crop is used, it is typically killed with a grass-specific herbicide when it has reached 4 to 5 inches in height. The resulting dead grass provides shelter for the alfalfa seedlings from wind and blowing sand. Oats are a common choice for a companion crop. They are seeded at 15 to 25 pounds per acre. If allowed to develop for harvest, oats are cut in the early heading stage while stems and leaves are still green. If allowed to develop past the soft dough stage, some oat seeds will mature, shatter, and volunteer in the subsequent alfalfa cuttings.

Irrigation Management During Establishment

Proper irrigation is vital to establishing a healthy stand of alfalfa. It is preferable to plant seed in soil containing sufficient moisture to germinate and sustain healthy seedlings to the one-trifoliate-leaf stage. If this is not possible due to extreme high heat or low water-holding capacity of soil (as in very sandy soils), irrigation is employed. Until the germinating seeds emerge from the soil, the surface ½ inch is moistened either by frequent overhead irrigation (daily or every other day) or by short-duration but frequent surface irrigations (as in rill-irrigated fields). Once young roots grow 1 to 2 inches down into the soil, irrigation is scaled back so that the newly reached root zone is moist but the surface is allowed to dry. In areas where water is allowed to pool and then dry, alfalfa seedlings often become stunted and suffer reduced growth as the soil becomes compacted.

Irrigation Management

Alfalfa consumes about 30 to 36 inches of water per season depending on the soil type and irrigation system employed. Center-pivot irrigation systems are more efficient and make it easier to farm than surface (rill) irrigation. The first irrigation date for rill-irrigated alfalfa occurs during late April or early May. Some rill-irrigated fields with deep soil and good water-holding capacity may not need irrigation until the first crop is harvested in May. Fields under center-pivot systems, however, must start irrigation as soon as water is available, usually the last week in March, to begin filling the soil profile. Center-pivot systems apply less water per irrigation, but apply it over a greater time period. Wheel-line and hand line irrigation schedules are similar to rill irrigation. Commonly, rill irrigated fields are watered twice between harvests, whereas center-pivot systems are rarely turned off between cuttings except to harvest. In heavier soils, irrigation is discontinued about 7 days prior to harvest to allow the surface of the soil to dry and firm up in order to support harvest equipment. In sandy soil, irrigation is discontinued about 5 days pre-harvest and restarted immediately after the hay is removed from the field.

Soil Moisture Monitoring

Soil moisture monitoring technology is becoming more popular with growers as a management tool. Sensors that record the available moisture in the upper, middle, and lower root zone are placed in several locations within a field. Some units are tied to transmitters that relay data electronically to central computers owned by consulting businesses or growers themselves. These time-saving tools allow more precise irrigation scheduling.
Harvesting

Harvest frequency depends on the nutritional quality desired in the hay product, the desired stand life, and the target market. High-quality dairy hay, which brings the highest price, is harvested during the late bud stage of growth before any sign of bloom. Growers can discern bud stage by simply walking through the field and feeling the terminals of the tallest stems. Buds about to open have a hard lump inside the terminal growth point. Dairy-quality hay is harvested on an average of every 30 days, starting in late May or early June and continuing through September. Alfalfa hay for the horse market requires lower protein and higher fiber. More mature hay with up to 50% bloom can be desirable for this market. This growth stage is attained by delaying harvest to 35- to 37-day intervals. In the southern growing areas, 4 to 5 harvests are taken, while in the northern areas 3 to 4 harvests are taken each year.

At least 95% of the alfalfa grown in the Columbia Basin is harvested as dry hay. Bale sizes range from:

- 14” x 18” x 48” two-twine bales weighing 90 to 100 pounds, to
- 14” x 24” x 48” three-twine bales weighing 110 to 140 pounds, to
- mid-size bales measuring 3’ x 3’ x 8’ weighing 850 pounds, to
- 3’ x 4’ weighing 1250 pounds, to
- big bales measuring 4’ x 4’ x 8’ weighing about 1600 pounds.
A small portion (less than 1%) of the alfalfa harvested in Washington is green-chopped and ensiled. Alfalfa is cut primarily with self-propelled swathers that cut at a stubble height of about 3 inches, pass the cut hay through corrugated rollers to crush the stems (which aids in drying time), and leave it in windrows from 4 to 8 feet wide to sun-cure. Baling occurs when the overall moisture of the hay is from 13 to 18% for smaller bales and from 11 to 16% for big bales. The process of drying is called “curing.” Properly cured hay at the appropriate moisture levels will keep the leaves attached to the stem during the baling process and the stems will have the right amount of moisture to bend without snapping under baling pressure. Such hay is said to have good leaf retention with soft stems. Windrow drying is aided with machines (rakes, hay fluffers, hay lifters, and tedders), that turn the windrow over to expose the damp underneath part of the windrow, or simply lift the windrow off the damp ground and move it laterally to a drier area next to the existing windrow. Chemical drying agents (usually acids such as propionic acid) can be used during swathing to alter the surface of the stems to hasten moisture loss. Hay inoculants, which allow baling at a slightly elevated moisture level (up to 20% moisture), are sometimes used, especially during cool, humid weather when curing is slow.
Forage Quality

Forage quality terms, parameters, and characteristics differ for dairy, feeder, and export alfalfa. Dairy hay is defined primarily by the feeding value, i.e., the potential to produce milk. Currently, the primary predictor of price is how the forage performs in tests for nutrients as part of the dairy ration. Alfalfa is the main source of digestible fiber for the ruminant and also is a source of phosphorus, calcium, and, less importantly, protein. Currently, an index called Relative Feed Value (RFV), a predictor of fiber digestibility, is used to value alfalfa. It combines the estimation of Acid Detergent Fiber (ADF), a predictor of digestibility, and Neutral Detergent Fiber (NDF), a predictor of intake, into an RFV index. Most dairymen prefer alfalfa with an RFV between 160 and 170. Alfalfa rated in this range provides the highest-digestibility fiber with sufficient roughage to promote good rumen function. A newer index called Relative Forage Quality (RFQ) is being used in some parts of the country. RFQ adds to the cost of wet chemistry analysis. It is better suited for Near-Infrared Spectroscopy (NIRS) analysis. RFQ analysis is especially advantageous in that it estimates the digestibility of the fiber. RFQ takes into account morning vs. afternoon harvesting, the leafiness of the hay (fiber in leaves is more digestible than stem fiber), and the impacts of heat damage. More discussion of RFQ and how it compares to RFV can be found at [http://www.uwex.edu/ces/crops/uwforage/RFOvsRFV.htm](http://www.uwex.edu/ces/crops/uwforage/RFOvsRFV.htm).

In export hay, aesthetic characteristics are of primary importance. Export alfalfa hay should be green, stems should be large and preferably hollow, leaves should be intact on the stems and evenly distributed in the bale and no alfalfa flowers or foreign material should be present. Forage quality, although very important, is secondary to visual characteristics in the export market.

Product Packages and Marketing

Bale size somewhat determines the market for the product. Small bales may go to an exporter who compresses the bales by 50%, re-ties, and shrink-wraps them onto pallets for shipment by container to foreign markets. Small bales are also consumed domestically by the horse, dairy, or feeder market. Big bales may be used by mechanized dairies or by exporters who slice, compress, and wrap them into smaller palletized units for shipment. Most cubing operations prefer big bales for ease in mechanized handling.

Storage

Hay left exposed to the weather can suffer considerable spoilage. A ¼-inch rain can soak into and ruin the top 3 to 4 tiers of bales in a stack as well as the bottom bales. This can result in greater than 40% loss. Export hay is wrapped. A high percentage of export hay is protected by wrapping the top, sides, and bottom of stacks. This costs from $4 to $10/
ton depending on the width and height of the stack. Hay barn storage costs more initially, but amortized over 15 to 20 years average about $8 to $10/ton. Stackyards are kept smooth, free of weeds and trash, and elevated so that water will drain away from the stack.

Double stack of small bales, peaked and wrapped. Photo by Glenn Knopp.

Hay shed with side protection. Photo by Glenn Knopp.

The balance of the document addresses pest management. Pest categories are listed in order of importance, with weeds having the greatest impact on the industry, followed by insects, diseases, nematodes, and vertebrate pests. Within each category, an attempt has been made to list the pests in order of importance to the industry’s overall pest management system, in terms of pesticide use, control efforts, and actual or potential damage to the crop.

**Weeds**

Weeds are the primary production pests of alfalfa. They can compete either directly or indirectly by serving as hosts for insect, disease, and nematode pests. Annual herbicide costs average $46.00/A. Because alfalfa is a perennial, some weeds
are problems only during stand establishment and pose little threat during the subsequent production years. For example, in
a full, healthy stand, alfalfa will out-compete or prevent establishment of common lambsquarters (*Chenopodium album*
L.), redroot pigweed (*Amaranthus retroflexus* L.), foxtail barley (*Hordeum jubatum* L.), dandelion (*Taraxacum officinale*),
and kochia (*Kochia scoparia*). Other weeds, both annual and perennial, including flxweed (*Descurainia sophia* L.),
tumble mustard (*Sisymbrium altissimum* L.), shepherd’s purse (*Capsella bursa-pastoris* L.), white campion (*Silene latifolia* Poir. or *Silene alba*), and quackgrass (*Elytrigia repens* L.) may be present every year and must be managed.

Grasses such as quackgrass, barnyardgrass (*Echinochloa crus-galli* L.), cheatgrass (*Bromus tectorum* L.), and wild oats
(*Avena fatua* L.), and broadleaf weeds such as white campion, common groundsel (*Senecio vulgaris* L.), redroot
pigweed, lambsquarters, dodder (*Cuscuta* spp.), and various mustards including shepherd’s purse compete for
nutrient resources and damage the marketability of hay, reducing the crop value by 20 to 50%. Certain noxious weeds
including quackgrass, yellow nutsedge (*Cyperus esculentus* L.), white campion, Canada thistle (*Cirsium arvense* L.),
and common groundsel must be addressed as required by state and local noxious weed control boards. Furthermore,
noxious weeds present in hay prevent export to foreign markets.

While glyphosate-resistant alfalfa was available in most parts of the U.S. in the fall of 2005, sales were delayed in
Washington State because of concerns in the export market. As in other glyphosate-resistant crops, alfalfa with this trait
may assist the alfalfa industry in managing weed pests.
Controls

Cultural

Almost all Washington alfalfa growers practice crop rotation, except those with fields on rocky ground where cultivation is very difficult and/or alternative crops are limited. Rotation partners include potatoes, cereal grains, dry beans, grass hay, and dry peas. Rotating to different crops enables a wider range of weed control options. Chemical fallow is seldom used pre-plant.

Growers reduce weed pressure (primarily from broadleaf weeds such as lambsquarters, pigweed, barnyardgrass, foxtail barley, and mustards) for the seedling crop by pre-germinating weeds and then using tillage during the final stages of seedbed preparation.

Some growers schedule planting in late summer (early August), which takes advantage of winterkill of annual weeds and allows the emerging crop to better compete against weeds, thereby reducing the need for herbicides.

Chemical: Post-emergence Herbicides

Bromoxynil (Buctril) is normally applied at 0.25 to 0.375 lb ai/A in a tank mix with 2,4-DB or imazamox for broadleaf weed control. The bromoxynil/imazamox tank mix can be effective in controlling common groundsel if applied before cold fall weather begins.

2,4-DB (Butyrac or Butoxone) applied at 0.5 to 1.5 lb ae/A is often mixed with bromoxynil for a wider spectrum of broadleaf weed control.

Imazethapyr (Pursuit) applied at 0.047 to 0.094 lb ae/A for broadleaf weed control is being used less as it is being replaced by imazamox, which has a shorter soil residual. With a 30-day pre-harvest interval, it can be applied between cuttings.

Imazamox (Raptor) applied at 0.03125 to 0.047 lb ae/A controls many broadleaf weeds and also has some activity on certain grasses. Raptor can also be applied between cuttings.

Clethodim (Select) applied at 0.157 to 0.25 lb ai/A is used on almost all plantings following a rotation of cereal grains. Its main use is for control of volunteer wheat. Both sethoxydim and clethodim can be used on established alfalfa for grass control. Most grass weeds are controlled with dormant-applied herbicides. However, in-season grass herbicides are very important when dormant-applied herbicides are not used, usually in the final production year where residual herbicides could interfere with subsequent crops.
Sethoxydim (Poast or Poast Plus) applied at 0.19 to 0.47 lb ai/A is used for grass weed control on very few acres, as growers prefer the greater efficacy of clethodim.

Pronamide (Kerb) applied at 1.0 to 2.0 lb ai/A controls grasses while alfalfa is in the seedling (at least one trifoliate leaf expanded) stage, but is seldom used because of its high cost compared to clethodim. It is used in late-summer seedings where growers expect most annual broadleaf weeds to die from winterkill.

Chemical: Established Stands

The majority of herbicide applications on established stands of alfalfa occur in late fall or early spring, during the time when alfalfa is dormant. Normally, only one application is necessary for season-long weed control. However, under moderate weed pressure, some in-season herbicide applications may be necessary.

Hexazinone (Velpar) at 0.5 to 1.0 lb ai/A is used on 50% of the acreage in the first and second years of the stand as a dormant application tank-mixed with paraquat (Gramoxone Max) at 0.26 to 0.48 lb ai/A. This combination simultaneously burns down germinating weeds and burns the alfalfa tops to prevent foliar take-up of metribuzin or other partner herbicides.

Metribuzin (Sencor) is applied at 0.25 to 1.0 lb ai/A in the late fall or early spring before any significant growth on alfalfa occurs (dormancy). The re-cropping interval is shorter for Sencor than for Velpar and it is often tank-mixed with paraquat as described above.

Terbacil (Sinbar) applied at 0.4 to 1.2 lb ai/A, is another dormant-applied material but is seldom used on alfalfa. Issues of phytotoxicity on sandy soils and tolerance of common groundsel limits its usefulness.

Diuron (Karmex, Direx) is applied at 1.2 to 2.4 lb ai/A and is used where the stand is expected to remain for several years. It is a dormant-applied material with a 2-year plantback restriction. It is not very effective on cheatgrass or volunteer cereals. It appears to be one of the most effective formulations, however, in killing white campion when used in combination with metribuzin or hexazinone.

Hexazinone + diuron (Velpar AlfaMax MP) is a twin-pack product with its respective ingredients applied at 0.5 lb ai/A and 0.6 lb ai/A. Newly released in 2004, this is likely to replace hexazinone-diuron tank mixes because this formulation is less expensive. It is one of two products that provide partial control of white campion.

Glyphosate (Roundup and others) is applied at a 2% solution for spot treatment of dodder (Cuscuta spp.). Preplant treatment for quackgrass is applied at 0.75 to 1.5 lb ae/A. About 10% of growers use glyphosate at rates up to 0.75 lb ae/A to actively growing alfalfa to destroy the crop at the end of the rotation.

Norflurazon (Zorial) applied at 1.0 to 2.0 lb ai/A can be used on alfalfa 5 months old, to dormant alfalfa, or in-season after a harvest to prevent germination of certain broadleaf and grass weeds.

MCPA (several trade names) applied at 0.46 lb ae/A is registered for use in winter to control annual broadleaf weeds when alfalfa growth has stopped, however, it is seldom used as the dormant-applied products control most annual broadleaf weeds. Alfalfa must be completely dormant or crop damage is likely. If the stand is to be removed after first cutting, MCPA may be used as it has no plantback restrictions.

Trifluralin (Treflan TR-10 or Treflan HFP) applied at 2.0 lb ai/A is occasionally used in-season between cuttings for control of summer annual grasses, particularly barnyardgrass that infests alfalfa when the stand is not vigorous.

Insect Pests (8)

Insects are second to weeds as the most troublesome pests of alfalfa. As a group, insects can reduce harvests directly through feeding or indirectly by creating opportunities for secondary pests or causing delayed regrowth, which affects the number and date of subsequent cuttings. Insect pest problems are generally worse after a mild winter. During mild years, some insects overwinter as adults as well as eggs. When this happens, populations can increase rapidly in the spring and require control measures prior to first cutting.

Alfalfa Weevil, Hypera postica
Alfalfa weevil is an annually occurring pest of alfalfa in certain areas of the state, particularly in Klickitat County (near Goldendale), Walla Walla County (along the Snake River), and Grant County (between Quincy and Ephrata). Untreated severe infestations can reduce first-harvest yields by 50%.

Both adults and larvae cause damage. However, larvae do the most frequent damage by chewing on the plant terminals. Depending on larvae population, damage can range from terminal leaf skeletonization to complete defoliation of the season's first growth, leaving fields with a grayish cast. When weevil populations are high in the first harvest, delay in regrowth can occur in subsequent harvests.

In Washington, alfalfa weevils overwinter as adults in protected sites adjacent to alfalfa fields. They become active as spring temperatures exceed 60º F, moving into the alfalfa and laying eggs in stems of new growth. Adults measure about 3/8 of an inch in length. They are light brown with a darker brown stripe in the middle of the back. An adult will lay 2 to 15 eggs within an alfalfa stem. A single adult is capable of laying 600 to 800 eggs.

Upon hatching, the larvae move up the stem to the plant terminal where they feed on newly initiated leaves. As the larvae get older they will move out from the terminal and feed on the more exposed alfalfa foliage. Larvae are pale yellow to light green when small and turn bright green with a white stripe down the middle of their back. A characteristic black head is evident.

Once the larvae have finished feeding they drop to the ground and form a cocoon. After pupation (10 to 14 days), they emerge as adults, feed briefly on alfalfa foliage and leave the field to hibernate for the rest of the summer and following winter.

![Alfalfa weevil life cycle](image)

**Alfalfa weevil life cycle. Graphic by Tim Woodward.**

**Controls**

**Cultural**

Growers mow weeds, brush, and other vegetation near alfalfa fields to reduce overwintering habitat. If the field is within two weeks of harvest and alfalfa weevils are present at damaging levels, early harvest of first-cutting growth is practiced, as it is more cost-effective than insecticide application. Young larvae shaken from plants during harvesting may succumb to dehydration by sunlight when not protected by foliage. Some may remain healthy under the windrow and continue to feed on regrowth. Growers examine under the windrows for alfalfa regrowth and larvae numbers. No regrowth, damaged regrowth of 50% of the plants, and/or a count of 8 or more larvae per square foot triggers chemical treatment.

No alfalfa varieties are considered resistant to alfalfa weevil. However, the recent introduction of glandular-haired alfalfa varieties bred for tolerance to the potato leafhopper (*Empoasca fabae*) may provide some tolerance to small
Biological

Weevil parasites (*Bathyplectes curculionis*) and fungal pathogens are sometimes responsible for reducing weevil populations but none of these are commercially available.

Chemical

Five percent of the state’s acreage is treated annually for alfalfa weevil. If there is a history of weevil damage, fields are monitored on a weekly basis beginning in the spring. Stems no more than 8 inches long are collected and vigorously shaken within a container. An economic threshold has been established at 1.5 to 2 larvae per stem. Damaged terminals are also counted. Twenty damaged terminals out of a random sample of 50 (or 40%) indicate an economic threshold. When the alfalfa plants are 8 to 10 inches tall, a standard 15-inch sweep net is used to determine larval populations. Sweep nets may underestimate the true population, as small larvae are difficult to dislodge from the plant terminals.

Methomyl (Lannate) applied at 0.9 lb ai/A is widely used because of its additional efficacy on pea aphid and because it has no pre-harvest interval. In addition, it is one of the least detrimental insecticides to pollinators.

Phosmet (Imidan 2.5 EC) at 1.0 lb ai/A can be applied through chemigation and has a 7-day PHI. Cancellation of registration of this product is under consideration by EPA.

Lambda-cyhalothrin (Warrior) and cyfluthrin (Baythroid 2E) are synthetic pyrethroids applied at 0.02 to 0.03 lb ai/A and 0.044 lb ai/A, respectively. Each has a 7-day PHI. These are replacing Imidan as a preferred product. Application while bees are foraging is avoided by applying during the early morning or evening hours.

Malathion applied at 1.5 lb ai/A is often used later in the first growth period because it is inexpensive, can be used through chemigation, and has no pre-harvest interval.

Permethrin (Pounce 3.2 EC, Ambush 25W) at 0.1 to 0.2 lb ai/A can be applied through sprinkler irrigation. There is no PHI if 0.1 lb ai/A or less is used but there is a 14-day PHI if over 0.1 lb ai/A is used. A buffer of 100 yd for aerial application and 20 yd for ground application is required to protect aquatic habitats.

Carbofuran (Furadan 4F) at 0.25 to 1.0 lb ai/A is occasionally applied early in the first growth. It gives extended protection and is taken up through the soil as well as through the foliage. The PHI at the higher rate is 28 days.

Carbaryl (Sevin XLR Plus) is rarely if ever used as the cost per acre is almost double that of other effective products and it has high toxicity to pollinators. If used, it is applied at 1.0 to 1.5 lb ai/A.

Chlorpyrifos (Lorsban 4E) is seldom used since Japanese hay importers have a low residue tolerance. When used, it is applied at 0.5 to 1.0 lb ai/A.

Indoxacarb (Steward) applied at 0.065 fl oz ai/A is used early on young larvae and may require a second application.

Aphids

Four aphid species attack alfalfa in Washington. These include **pea aphid** (*Acyrthosiphon pisum*), **blue alfalfa aphid** (*Acyrthosiphon kondoi*), **spotted alfalfa aphid** (*Theroaaphis maculata*), and **cowpea aphid** (*Aphis craccavora*) (9). Aphids damage alfalfa by sucking juices from the plant, causing stunting and yield loss. They also inject toxins while feeding that further stunt and sicken plants. The toxin levels injected vary among species. Those secreted by the spotted alfalfa aphid, the blue alfalfa aphid, and the cowpea aphid are the most damaging. Aphids secrete a sticky substance called honeydew that, during heavy infestations, can host sooty molds that turn the stems and leaves black. In extreme cases, the honeydew can interfere with harvesting by gumming up machinery. Molds growing on honeydew reduce palatability, hold soil and dust on the forage, and may be toxic.
Pea aphids are the larger, light-green aphids. The smaller, blue-green ones are blue aphids. (The out-of-focus black insect is a cowpea aphid.) Photo by Tim Woodward.

Alternate hosts of pea aphid include clovers, peas, and other legumes. Cowpea aphids infest many hosts including common weeds such as shepherd’s purse, lambsquarters, and curly dock. Threshold levels in seedling alfalfa are about 5 per stem for pea aphid and 1 for spotted aphid. Threshold levels for established alfalfa (less than 10 inches tall) are 40 per stem for pea aphid and 10 for spotted aphid. In established alfalfa more than 10 inches tall, the threshold level is 75 per stem for pea aphid and 30 for spotted aphid.

Spotted alfalfa aphid. Photo by Tim Woodward.

The cowpea aphid has been observed in the lower Columbia Basin but populations have been mixed with pea aphid and blue alfalfa aphid. The Columbia Basin has experienced annual spring populations of blue aphid, fall populations of spotted and blue alfalfa aphid and season-long populations of pea aphid. Most treatable infestations on established alfalfa occur during the first growth in the spring and include either pea aphid or mixed populations of pea aphid and blue alfalfa aphid. Spotted alfalfa aphid control treatments usually occur during August seeding.
**Controls**

**Cultural**

Many commercially available varieties have genetic resistance to pea aphid and spotted alfalfa aphid, and a few have resistance to the blue alfalfa aphid. No released varieties are resistant to the cowpea aphid. Weed management in field edges, borders, ditch banks, and adjacent non-crop areas is practiced to reduce habitat for source populations of aphid. If crop harvest occurs within 10 days of meeting aphid thresholds, early harvesting is practiced, as it is more economical than the cost of chemical treatment.

**Biological**

Naturally occurring wasp parasites *Lysiphlebus* spp. and *Diaeretiella* spp. and predators such as lady beetles, lacewings, big-eyed bugs, damsel bugs, and syrphid flies help in managing aphid populations. However, under rapid aphid build-ups, parasite and predator populations generally lag too far behind to provide sufficient protection against crop damage.

**Chemical**

Ten percent of the alfalfa acreage is treated annually for aphids, either single or multiple species.

**Dimethoate** applied at 0.25 to 0.5 lb. ai/A and **malathion** applied at 1.0 to 1.5 lb ai/A are the chemicals of choice for pea aphid and blue aphid control because of cost. Malathion can also control alfalfa weevil.

**Permethrin (Pounce 3.2EC, Ambush 25W)** applied at 0.05 to 0.2 lb ai/A has been effective for spotted alfalfa aphid, with the rate used depending on the time remaining before harvest. There is a 14-day PHI when the rate is above 0.1 lb ai/A and no PHI for rates of 0.1 lb ai/A or less.

**Cyfluthrin (Baythroid 2E), lambda-cyhalothrin (Warrior) and zeta-cypermethrin (Mustang)** are also being used in place of **chlorpyrifos (Lorsban)** because of the export market’s low tolerance for chlorpyrifos residues.

**Cutworms, Loopers, Armyworms**

Several lepidopterans occasionally cause damage to alfalfa. Annual treatment for these pests occurs on less than 5% of alfalfa acreage. The **alfalfa caterpillar** (*Colias eurytheme*), the common yellow butterfly, occurs annually but rarely requires control. Likewise, the **alfalfa looper** (*Autographa californica*) and three species of armyworms, the **western yellowstriped armyworm** (*Spodoptera praeftica*), the **bertha armyworm** (*Mamestra configurata*), and the **beet armyworm** (*Spodoptera exigua*) seldom require control. They appear in sporadic occurrences, perhaps only in one of every 15 years. Several cutworms, primarily the **variegated cutworm** (*Peridroma saucia*), are occasionally troublesome in the early spring.

**Controls**
**Cultural**

No varieties resistant to lepidopteran pests are available.

**Biological**

None available.

**Chemical**

*Bacillus thuringiensis* (BT) (*Deliver*) applied at 0.25 to 1.5 lb product/A, is effective on immature armyworms only. The cost per acre is 4 to 5 times that of conventional insecticides. For this reason, growers use less expensive alternatives.

*Lambda-cyhalothrin* (Warrior) applied at 0.015 to 0.025 lb ai/A or *zeta-cypermethrin* (Mustang) applied at 0.028 to 0.05 lb ai/A are the products of choice (at current prices, Warrior is about $2.00/A less costly).

*Carbaryl* (Sevin XLR Plus) applied at 1.5 lb ai/A is available, but because of its toxicity to bees is seldom used.

**Clover Root Curculio, *Sitona hispidulus***

The clover root curculio adult is a small (1/8-inch) grayish weevil. It occurs in almost all alfalfa acreage in Washington. The adult weevil may chew notches in leaves, but the larvae do greater damage. Overwintered adults lay eggs in trash and soil. Eggs hatch and the larvae migrate to the plant roots to feed. They chew cavities in roots, which become sites of fungal and bacterial infections that can result in death of the plant. First- and second-instar larvae feed on nitrogen-fixing rhizobia nodules and small secondary roots. As they grow, larvae move to the larger branch roots and tap root, which they girdle. Research has shown a positive relationship between clover root curculio feeding and increased infection with *Fusarium* species. Growers, crop consultants, and Extension personnel have noticed reduced plant health and stand loss as a result of secondary infections of roots at curculio feeding sites. No research has been done to quantify economic damage.

Controls

**Cultural**

Crop rotations of at least one year to non-host crops are practiced when possible to reduce the soil populations of immature larvae.

**Biological**

There are no biological controls known.

**Chemical**

There are no products registered for control of this insect.

Clover Leaf Weevil, *Hypera punctata*

Pea Leaf Weevil, *Sitona lineata*

Blister Beetle, *Epicauta* spp.

Meadow Spittlebug, *Philaenus spumarius*

Slugs

Western Spotted Cucumber Beetle, *Diabrotica undecimpunctata*

These minor insects impact less than 1% of alfalfa in any year.

**Grasshopper** infestations occasionally occur in dryland alfalfa. Irrigated alfalfa is not impacted.

**Controls**

**Cultural**

Growers manage weeds along edges of fields, ditch banks, and waste areas to reduce habitat for these insects.

**Biological**

*Nosema locustae* is a naturally occurring fungus that parasitizes grasshoppers during wet springs and often keeps grasshopper populations low.

**Chemical**

*Nosema locustae* (*NoLo Bait*) applied at 1.0 to 2.0 lb product/A early in the season when the grasshoppers are in the 3rd and 4th instars has been successful in holding down populations.

Carbaryl (*Sevin XLR Plus*) applied at 0.5 to 1.5 lb ai/A is most often used to treat fields where bees are not present.

Dimethoate applied at 0.25 to 0.5 lb ai/A is used prior to bloom period and often chosen because of its relatively low cost.

Lambda-cyhalothrin (*Warrior*) applied at 0.02 to 0.03 lb ai/A or *zeta-cypermethrin* (*Mustang*) applied at 0.035 to 0.05 lb ai/A is less toxic to bees and other beneficials. These compounds are gaining use because of pollinator safety.

Carbofuran (*Furadan 4F*) applied at 0.12 to 0.5 lb ai/A, *chlorpyrifos* (*Lorsban 4E*) applied at a rate of 0.5 to 1.0 lb ai/A, or *malathion* applied at 1.5 lb ai/A can also be used. However, some exporters of hay are sensitive to the use of chlorpyrifos because of Japan's lower residue tolerance levels.

Methyl parathion is registered but seldom used because of liability issues. Some agricultural chemical vendors no longer market methyl parathion.

**Clover leaf weevils** are problematic during the spring when larvae feed on leaves. Cool moist weather conditions allow a natural fungus parasite to mitigate populations.

**Chemical**

Carbaryl (*Sevin XLR Plus*) applied at 0.5 to 1.0 lb ai/A or *malathion* applied at 1.0 lb ai/A is an effective control.

**Pea leaf weevil** adults sometimes damage seedlings planted in the spring by chewing off cotyledons.
Cultural

Damaging infestations seem to migrate into the field from borders, where the weevils overwintered as adults. Elimination of weeds and vegetation on field edges and borders is practiced.

Chemical

There are no materials currently registered for use on hay.

Blister beetles and meadow spittlebugs occur in Washington but are seldom seen.

Chemical

Carbaryl (Sevin XLR Plus) applied at 0.5 to 1.5 lb ai/A, lambda-cyhalothrin (Warrior) applied at 0.02 to 0.03 lb ai/A, or zeta-cypermethrin (Mustang) applied at 0.035 to 0.05 lb ai/A, is used as a control for blister beetles.

For the meadow spittlebug, lambda-cyhalothrin (Warrior) applied at 0.02 to 0.03 lb ai/A, zeta-cypermethrin (Mustang) applied at 0.028 to 0.05 lb ai/A, permethrin (Pounce 3.2 EC) applied at 0.1 to 0.2 lb ai/A, or cyfluthrin (Baythroid 2E) applied at 0.0125 to 0.025 lb ai/A is used.

Slugs and the western spotted cucumber beetle are problems only on seedlings on the west side of the Cascade Mountains.

Chemical

Metaldehyde baits (Durham Metaldehyde Granules 7.5) used at a rate of 0.75 lb ai/A broadcast over hotspots are used for slug control, but baits are deactivated by rainfall.

The western spotted cucumber beetle is controlled with carbaryl (Sevin XLR Plus) used at a rate of 1.0 lb ai/A, lambda-cyhalothrin (Warrior) used at a rate of 0.02 to 0.03 lb ai/A, or permethrin (Pounce 3.2 EC) used at a rate of 0.1 to 0.2 lb ai/A.

Diseases (10)

Alfalfa is susceptible to a wide range of bacterial, fungal, and viral diseases. If it were not for the release of resistant varieties, diseases would be the primary pests of alfalfa. Diseases of alfalfa attack foliage, crowns, or roots and may substantially reduce yield, stand life, and forage quality. Many diseases of mature alfalfa are difficult to control due to a lack of registered fungicides. Fortunately, many of the diseases that occur on alfalfa are not as economically damaging in Washington as in other areas of the United States.

Planting varieties with genetic resistance to the most prevalent diseases is the primary method of disease management for alfalfa. A variety that is classified as having resistance to a disease must meet the standard requirement that at least 31 to 50 percent of the plants in the population must show resistance in standard tests. This implies that the remaining plants are susceptible. In reality, some of the remaining plants in the population may have moderate resistance and others low resistance. A few of the plants in the population will be susceptible to the disease. A variety classified as having high resistance would have a very low number of plants that are actually susceptible. Furthermore, most testing laboratories use several isolates of the disease and apply the inocula at a much higher rate than would be found in nature when field-testing the variety. Although a resistant variety may show diseased plants in the field, rarely do they suffer economic yield loss. This is because the healthier plants produce more stems.

Planting resistant varieties does not supplant or negate the importance of good production practices.

DAMPING-OFF DISEASES

Damping-off, the early wilting and death of young seedlings either pre- or post-emergence, is caused by a number of soil-borne fungi. Seedlings older than 1 to 2 weeks old are less susceptible to damping-off. Pythium, Phytophthora, Rhizoctonia, Aphanomyces and Fusarium are the primary pathogens responsible for damping-off. These fungi are usually active during cool, wet conditions in the spring, and less often in the fall. They occur most often in over-
irrigated alfalfa.

Controls

Cultural

Growers plant at a higher seeding rate and at a time of year conducive to faster emergence and faster seedling development, which aids in escaping the disease. They avoid over-irrigation and improve drainage where feasible.

Chemical

Approximately 90% of all commercial alfalfa seed is treated at the seed plant with a fungicide. Mefenoxam (Apron XL), applied at 0.64 fl oz product/100 lb seed, or 0.015 lb ai/100 lb seed, is the product of choice, although some seed plants alternate with metalaxyl (Allegiance FL) applied at 0.75 to 1.5 fl oz product/100 lb seed, or 0.015 lb to 0.03 lb ai/100 lb seed. Other fungicides registered for use include captan and fludioxonil (Maxim) but these are seldom used unless requested by the seed customer. As an alternative to seed treatment, mefenoxam (Ridomil Gold EC) may be surface applied at 0.25 to 0.5 pint/A as a soil treatment prior to planting. Mefenoxam will not control Aphanomyces.

ROOT AND CROWN ROTS

Root and crown rots are common and can be the most damaging diseases. The complex of fungi that can cause these rots include: Phytophthora megasperma, Stagonospora meliloti, Rhizoctonia spp., Aphanomyces euteiches, and Colletotrichum trifolii. With the exception of Phytophthora root rot and Rhizoctonia infections, stand decline usually begins in the second year. Phytophthora and Rhizoctonia can ruin a stand soon after planting.

Phytophthora Root Rot

One of the major organisms responsible for root rot is Phytophthora. It is present in all alfalfa-growing areas in Washington and causes its greatest damage under flood irrigation on poorly drained soils. It can be severe in over-irrigated conditions even on well-drained soils using sprinklers. The disease can be a problem in mature stands but in Washington, seedling stands have been found with severe problems.

Although Phytophthora primarily infects roots, all parts of the plant can express symptoms. Leaves will wilt, turn yellow to reddish-brown, and drop off. Tan to brown lesions will appear and eventually turn black with the center of the root turning yellow. Reddish orange to yellow streaks spread from the tip of the rotted end of the root and can eventually rot the entire root. If the disease enters the crown, the plant will soon die.

Rotted roots caused by Phytophthora root rot appear dark brown to black. Photo by Tim Woodward.
Controls

Cultural

Soil and water management are the most important cultural controls. Resistant cultivars are available and growers use them.

Biological and Chemical

Growers choose resistant varieties as the most economical strategy for control.

Rhizoctonia Root and Crown Rot

*Rhizoctonia* fungi can affect mature plants as well as seedling alfalfa. The species survives in the soil as sclerotia or it can survive living on dead organic matter when a living host is not present. High temperature and excessive soil moisture promote Rhizoctonia rot.

Controls

Cultural

Avoidance of over-irrigation during high heat will limit severity of this disease. No resistant varieties are available.

Biological and Chemical

None.

*Anthracnose, Colletotrichum trifolii*

*Anthracnose* has occurred in Washington but is fairly rare. Anthracnose can affect leaves, stems, and crowns of the plant. Once it reaches the crown, the fungus can kill the plant or make it more susceptible to winter loss. Symptoms include a bluish-black rot that can be seen on the crown when dead stems are removed. Diamond shaped lesions form on the stem, enlarge, kill the stem, and leave the characteristic “shepherd’s crook,” a stem that has wilted and was unable to recover its upright growth habit.

Anthracnose spreads rapidly during warm and humid weather. Splashing rain and irrigation water disperse spores onto growing stems.

![Diamond-shaped lesions on alfalfa stems typical of Anthracnose.](image)

Controls

Cultural

Resistant cultivars are available and used by growers.
Biological and Chemical

Growers choose resistant varieties as the most economical strategy for control.

FOLIAR DISEASES

Several leaf diseases occur on alfalfa. The most common in Washington are common leaf spot caused by *Pseudopeziza medicaginis*, spring black stem caused by *Phoma medicaginis*, Stempheylium leaf spot caused by *Stemphylium spp.*, Stagonospora leaf spot caused by *Stagonospora meliloti*, rust caused by *Uromyces striatus*, downy mildew caused by *Peronospora trifoliorum*, and alfalfa mosaic virus (AMV). Of these, downy mildew and alfalfa mosaic virus appear to be the only foliar diseases of concern, as the others rarely cause economical damage.

**Downy Mildew**

Downy mildew expresses itself in cool, wet, or humid conditions and in Washington is more prevalent under sprinkler irrigation. Damage can be most serious in seedling alfalfa fields or in spring cuttings within established fields. Downy mildew is easy to distinguish: a grayish growth of spores is apparent on the underside of leaflets and the upper side of infected leaves takes on a light green to yellow color. On infected stems, the internodes are shorter and thicker than those of normal stems. Plant growth can be stunted.

Downy mildew infection is indicated by light blotches on upper side of leaves corresponding to gray spores on underside. Photo by Tim Woodward.

**Controls**

**Cultural**

In sprinkler-irrigated fields, growers reduce symptoms by allowing longer intervals between irrigations, with more water applied per irrigation. In cases where the disease is severe, growers schedule early cutting in order to avoid further damage to foliage. The removal of spores by initiating harvest and the seasonal increase in temperature reduce downy mildew re-infection for the remainder of the year.

**Alfalfa Mosaic Virus**

Alfalfa mosaic virus occurs worldwide and is a seed-borne disease. Eighty percent of the plants in alfalfa stands over 2 years old may contain AMV. Breeding for resistance to the disease is difficult as more than 200 strains are known to exist. However, breeders have selected against the disease by avoiding plants in the field exhibiting AMV symptoms. Symptoms can range from light green or yellow leaf mottle, stunting, and leaf distortion to long-term decline in plant vigor, root necrosis, and plant death. The virus may have no visible symptom, although present in the plant. AMV is transmissible by aphids and machinery. Studies have shown that an initial incidence of 11% AMV-infected plants
increases to 91% in less than a year after nine cuttings have taken place.

Although greenhouse studies have shown that yield reductions occur on individual plants infected with the virus, it is difficult to show yield declines in the field, probably due to compensation by healthy or tolerant plants in the remaining field population.

Chlorotic streaks caused by AMV infection. Photo by Tim Woodward.

Controls

*Cultural*

Because aphids vector the virus, growers passively manage against AMV by controlling aphids with insecticides and by selecting varieties with high resistance to aphids.

WILT DISEASES

Three primary wilt diseases impact alfalfa in Washington: bacterial wilt, caused by the bacterium *Clavibacter insidiosum*; fusarium wilt, caused by the fungus *Fusarium oxysporum*; and verticillium wilt, caused by the fungus *Verticillium albo-atrum*.

*Bacterial wilt* is present wherever alfalfa is grown, with the exception of hot desert areas of the southwestern United States and areas of low rainfall that are not under irrigation.
Stunted plant infected with bacterial wilt, left. Healthy plant, right.

Symptoms include leaf mottling, slight cupping of leaflets, and reduction in plant height. Severely infected plants are stunted and yellow-green, with spindly stems and small, distorted leaflets. The disease is most obvious on regrowth after cutting. Cross sections of taproots show a yellowish brown discoloration of the outer vascular tissue. As the disease progresses, the entire stele discolors.

**Controls**

**Cultural**

The use of resistant cultivars is the primary method for management of this disease. Most resistant varieties are available in dormancy classes 2-5. Although there has been progress in breeding for bacterial wilt resistance in other dormancy classes, Washington growers expecting longer stand life avoid their use due to lower levels of resistance and the potential for winterkill.

**Biological and Chemical**

Growers choose resistant varieties as the most economical strategy for control.

**Fusarium wilt** is another disease that can be found wherever alfalfa is grown. Fusarium wilt can be identified by a dark reddish-brown discoloration in the center of the taproot. The disease can be more severe when plants are infested with root-knot nematodes. Thus, cultivars with resistance to both Fusarium wilt and root-knot nematodes are preferred by growers in Washington as both organisms can occur readily.

**Controls**

**Cultural**

High levels of resistance to Fusarium wilt can be found in all dormancy classes.

**Biological and Chemical**

Growers choose resistant varieties as the most economical strategy for control.

**Verticillium wilt** was first found in the United States in 1976 on alfalfa growing in the Yakima Valley and in the Columbia Basin of central Washington. Since then, it has spread across the U.S. and Canada primarily through infested seed of susceptible varieties. Most of the dormant seed marketed in the U.S. is produced in the Pacific Northwest.

Verticillium wilt can be a serious problem in Washington if a susceptible variety is planted. It can reduce yields by 50% and shorten stand life severely. Verticillium wilt symptoms are distinctive, with diseased plants usually scattered throughout the field. A V-shaped yellowing occurs on leaflet tips. Leaves on individual stems dry and turn brown or copper. Individual leaflets may fall off. Infected stems do not wilt and often retain their green color until all the leaves are
dead. Internodes are shortened toward the end of a stem and eventually the pathogen spreads to the crown, affects all the stems, and kills the plant.

Roots may show discoloration in the vascular region similar to that induced by bacterial wilt. Root symptoms may be evident even when foliar symptoms are absent.

Green stem with dead leaves unique to Verticillium wilt. Photo by Tim Woodward.

Cross-section of root showing Verticillium wilt (creamy-orange color) plugging vascular tissue. Photo by Tim Woodward.

Controls

**Cultural**

Varieties having either resistance or high resistance to the disease are available and used by growers.

**Biological and Chemical**

Growers choose resistant varieties as the most economical strategy for control.

Nematodes (3, 4)

Parasitic nematodes occur in Washington and damage alfalfa every year. Plant-parasitic nematodes are microscopic worms
that have piercing mouthparts that they use to penetrate plant cells and feed. They also vector plant viruses. Nematodes rank equal to diseases in importance. The four species of most concern in Washington are two root-knot nematodes, the **northern root-knot nematode** (*Meloidogyne hapla*) and the **Columbia root-knot nematode** (*M. chitwoodi Race 2*), the **stem nematode** (*Ditylenchus dipsaci*), and a **lesion nematode** (*Pratylenchus penetrans*).

The **stem nematode** is the most destructive nematode on alfalfa. Some infected stands of susceptible varieties may become unproductive within two years. These nematodes feed and reproduce in the lower stems and crown portion of the plant, primarily on new stem buds. Infected buds swell and become distorted and stunted and sometimes die due to secondary infection. Occasionally a stem will grow as much as 12 inches in length but be completely white (devoid of chlorophyll). This sign of infection is termed “white flagging.” In flood-irrigated fields or fields with overhead irrigation, large patches of infected plants will enlarge down-slope as nematodes leave plant tissue when abundant moisture is present and are carried with flowing water, thus infecting additional plants. Infected seedlings often fail to mature into established plants. Stem nematode occurs in loam and silt loam soils, but seldom in sandy soils.

![White flagging caused by stem nematode. Photo by Tim Woodward.](image)

**Controls**

**Cultural**

Many varieties are available with resistance to stem nematode. Those rated as resistant or highly resistant will persist well in locations where stem nematode occurs. Crop rotation with a non-leguminous crop for two years is practiced to lower soil populations. Harvesting when plant tissue is dry helps prevent spread of nematodes within the field.
Biological and Chemical

Growers choose resistant varieties as the most economical strategy for control.

Severe stunting in seedling stands of alfalfa has been observed in soils north of Pasco. Seedling death has been observed with susceptible varieties in controlled experiments with northern root-knot nematodes. In the Columbia Basin area, mixed populations of northern and Columbia root-knot nematode have been documented. Columbia root-knot nematode Race 1 does not increase on alfalfa, but Race 2 does. Columbia root-knot nematode is the more damaging of the two species to potatoes, a common rotation crop with alfalfa.

Controls

Cultural

A limited number of resistant varieties are available. When feasible, growers practice crop rotations to non-host crops to help reduce soil populations. Good weed control helps reduce soil populations. Rotations with potatoes where fumigants are used dramatically lower soil populations, however in some cases, irrigation water from irrigation projects, especially recycled water from upstream fields, contains large amounts of nematode larvae and serves to re-inoculate soils. Larvae of root-knot nematodes have been shown not to enter the roots of rye and oats.

Biological and Chemical

A nematicidal substance, believed to be butyric acid, forms during the decomposition of crop aftermath such as with rye and timothy used in rotation.

Growers choose resistant varieties as the most economical strategy for control.

Lesion nematode is a relatively minor pest in Washington. Lesion nematodes attack root hairs and small secondary
roots, causing necrosis. Damaged roots are susceptible to secondary infections. Occasionally a fall-planted stand will become infected, resulting in establishment failure. Root lesion nematodes prefer heavier soils but can occur in sandy locations under irrigation.

**Controls**

**Cultural**

There are only a few varieties with documented tolerance to lesion nematode.

**Biological and Chemical**

Growers choose resistant varieties as the most economical strategy for control.

**Vertebrates**

Rodents are minor pests compared to insects, diseases, and weeds. The *pocket gopher* (*Thomomys talpoides*)(11) and the *meadow vole* (*Microtus spp.*)(12) are the principal rodent pests of alfalfa. Once established in a field or adjoining areas, pocket gophers are difficult to control and almost impossible to eliminate. Populations vary from year to year or between spans of years depending on activity of raptors, coyotes, and other predators. Pocket gophers will become more prevalent when hay is grown in an extended stand. Shorter rotations that involve deep tillage will destroy tunnel systems and kill some gophers. Some, however, always survive to rebuild the infestation. Pocket gophers prefer irrigated cropland where food sources are more plentiful, but they will inhabit field edges, ditch banks, and waste areas adjacent to fields. These areas become a source of migrating juveniles. Gophers remain active during the winter months.

Pocket gophers damage alfalfa by feeding on taproots and secondary roots, sometimes killing mature plants. They attack roots in the top 24 inches of soil. They have been known to consume top growth in aboveground excursions, but the animals spend very little time on the surface. Mounds of soil, sometimes over 12 inches high, brought to the surface by pocket gophers during tunneling, can damage harvest machinery and when mixed with hay, reduces the marketability. Pacific Rim importers will reject containers of compressed hay that show signs of excess soil. Export lots of compressed hay often consist of 5 to 10 containers. If port inspectors find contamination in one container, the whole lot may be rejected and shipped back to the U.S. at the expense of the exporter. This can cost up to $10,000 for that export lot.

Voles feed both above and below ground, although they rarely burrow below 6 inches. They make runs above ground for short distances from their nest and will decimate large patches (6 feet in diameter) of alfalfa by feeding on crown and surface root tissue. Meadow vole populations vary over years and between spans of years. They remain active during the winter months and are adept at tunneling under snow cover and dead plant growth. Much of the vole damage to alfalfa stands takes place during the winter months while there is little or no human field activity.
Controls

Biological

Predators, including skunks, coyotes, hawks, and especially owls, eat gophers and voles. Providing nesting habitat and perches may encourage raptors to take up residence near the field.

Cultural

Trapping has historically been effective but is time consuming. Given the choice, many growers would rather trap than
use poison bait because they can be assured of control. Another procedure, called the Varmit Getter Pest Control System® (13) uses a mixture of propane and oxygen, which when injected into a burrow and ignited, effectively destroys the tunnel and any living animal within. This system is expensive and is probably employed only in the most severe infestations.

**Chemical**

Baits are very effective in controlling both pocket gophers and meadow voles. Deploying baits, either mechanically or manually, is the primary method of control, since trapping with standard gopher traps is illegal. Mechanical deployment involves tractor-drawn “gopher machines” that pull a shank through the ground then drop poisoned bait into the resulting machine-made burrow. Gophers explore the newly made burrows if the burrows cross or connect to their tunnel system, thereby contacting and consuming the bait. Hand baiting is more reliable than mechanized baiting as the poison bait is placed directly into existing burrows and runs.

**Strychnine alkaloid (Gopher Getter, Gopher-Go)** at 1.0 to 3.0 lb/A using 0.005 to 0.015 lb ai/A (1.0 to 3.0 lbs/A treated milo or wheat grain) is an effective below-ground treatment. **Milo Pocket Gopher Bait** is used at 1.0 to 2.5 lb/A. Many growers use a maintenance approach, treating fields in the spring with gopher machines. Depending on the infestation, growers may treat the entire field. However, most try to prevent populations from taking up residence in the field by simply treating the perimeter.

For voles, **zinc phosphide (Prozap Zinc Phosphide)** pellets are broadcast by air or ground at rates up to 10 lb product (0.2 lb ai)/A before plants reach two inches of first growth or regrowth (30-day PHI). A second application can be made after 10 days but the total rate per year cannot exceed 20 lb product/A or 0.4 lb ai/A. Alfalfa forage from treated areas is not harvested until the alfalfa reaches maturity. Treated alfalfa cannot be grazed. For gophers, this bait is placed directly in burrows at a rate of 2.0 to 3.0 lb/A.

**ADDITIONAL/Critical Needs**

Research to quantify the economic damage caused by feeding of the clover root curculio and interim chemical control options are critical needs of the industry.

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509-545-3511 (p)
509-545-2130 (f)
woodward@wsu.edu

**INDUSTRY CONTACT**

**National Alfalfa Alliance**
100 N. Fruitland, Suite B
Kennewick, WA 99336
### References


### ACTIVITY TABLE FOR FALL-SEEDED AND ESTABLISHED ALFALFA CROPS

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* Dormant-applied herbicides (for control of summer/winter annuals and perennials) can be applied on established alfalfa in the fall after alfalfa growth stops or in the early spring before growth begins.

** Irrigation occurs throughout the season except one week prior to cutting and resumes immediately after each cutting.

S = Southern WA, N = Northern WA, 1 = first cutting, 2 = second cutting, 3 = third cutting, 4 = fourth cutting, 5 = fifth cutting

### ACTIVITY TABLE FOR SPRING-SEEDED ALFALFA CROP

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* Irrigation occurs throughout the growing season except one week prior to cutting and resumes immediately after cutting.
P = Pre-irrigation. R = Refilling soil profile for winter.

S = Southern WA, N = Northern WA, 1 = first cutting, 2 = second cutting, 3 = third cutting, 4 = fourth cutting