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Verticillium wilt (VW), caused by the fungus, *Verticillium albo-atrum*, is one of the most damaging alfalfa diseases in temperate regions of the world. This disease has been destructive to alfalfa throughout Europe since the early 1900s. VW was first identified in the Yakima Valley of Washington state in 1976. It is now established in most northern alfalfa-growing states in the U.S.A. and in several southern provinces of Canada. It was first reported in Wyoming in 1981 and is now established in most of the irrigated alfalfa growing areas in the state (see Figure 1).

A study completed in 1989 showed that Wyoming growers were losing approximately \$2 million annually due to VW's presence in irrigated fields planted with susceptible varieties.

Symptoms

Symptoms of VW appear in alfalfa fields during the fall of the second year or the spring of the third year following planting. Symptoms consist of wilted plants scattered throughout the field (see Figure 2) and generally occur following periods of cool, rainy weather that favor disease development. When symptoms first appear, upper leaves become wilted and turn slightly blue-gray (see Figure 3). Initially, one or more stems on a given plant may be affected. The upper leaves twist, eventually turning tan with a light pink color (see Figure 4). All of the lower leaves on affected stems ultimately develop symptoms. Stems stay erect and affected leaves remain attached. Eventually the entire plant wilts, dies, and turns brown (see Figure 5). Plants may die throughout the growing season, as well as during winter; however, most plants die during mid-summer from the combined stress associated with the disease and high temperatures.

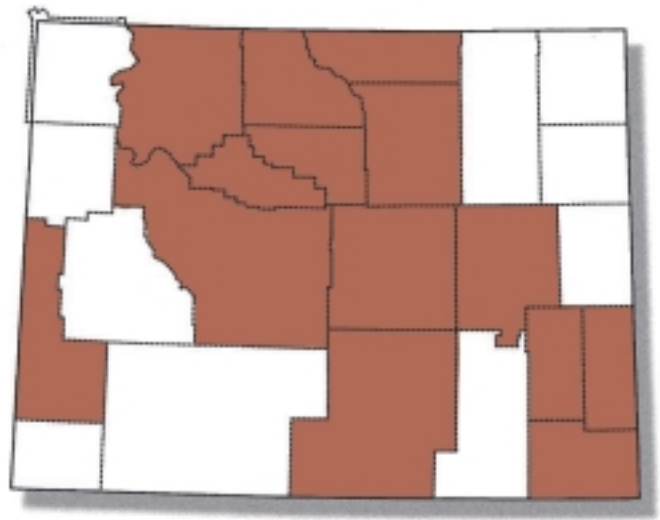


Figure 1. Shaded counties indicate where *Verticillium wilt* has been identified in Wyoming.



Figure 2. The yellow to brown plants in this three-year-old alfalfa field show typical symptoms of VW.



Figure 3. An alfalfa plant showing early symptoms of VW. Upper leaves are blue-gray in appearance.



Figure 4. Alfalfa plants having mid-stage symptoms of VW. Leaves are dead and twisted, with a slight pink color.



Figure 5. As plants move into the advanced stage of VW, they severely wilt and eventually collapse and die.

Symptoms and plant deaths result from the fungus invading and plugging the water-conducting xylem vessels in plant roots and stems. Also, the fungus releases a toxic chemical (toxin) that spreads throughout the plant. The inner vascular tissue in the root becomes discolored and, when cross-sectioned, appears to have a circular, yellow-brown stain (see Figure 6).

Disease cycle

The initial, long distance spread of *Verticillium albo-atrum* to Wyoming and many other alfalfa-growing states can be traced to infected seed grown in the Pacific Northwest during the mid 1970s. Knowing this has resulted in close inspection of seed fields by state seed certification agencies in an attempt to reduce further spread. This fungus also can be spread in baled hay, where it can survive up to nine months. It is not known to survive in silage.

Once VW is introduced into a field, secondary spread within a field may occur through wind-blown spores, as well as transmission from insects, grazing livestock, or haying equipment. Fungus spores develop excessively during periods of extended cool weather (68 to 76 degrees Fahrenheit) and rain. Spores formed on infected tissue are spread by wind during either spring or fall. The swather is responsible for spreading the fungus between fields because infected stems and leaves, which collect behind the cutting bar during haying operations, slowly fall into the mowed field during harvest (see Figure 7). If environmental conditions are optimum, the fungus infects freshly cut stems of actively growing plants resulting in the infection of many alfalfa plants. Because infected plant material is often carried in animal hooves, grazing livestock may spread the fungus between alfalfa fields. The fungus may survive the passage through sheep's digestive systems but not through those of cows. Therefore, movement of grazing sheep may also result in the spread of the fungus.

VW appears to be worse where fields are sprinkler irrigated as compared to fields having furrow irrigation. VW has not been detected in dryland alfalfa in Wyoming. Also, cool, rainy weather followed by sprinkler irrigation, or vice versa, immediately following harvest in fields three or more years old, may result in severe plant infection.

Management

The following management practices are suggested to prevent VW from being introduced into new plantings and slow down the spread of the disease in older fields. These steps will prolong the life of the plant stand and reduce alfalfa production losses.

Harvesting and sanitation of equipment

When the disease is confined to one or more fields, growers should harvest the healthy fields first. Equipment should be cleaned thoroughly after harvesting diseased fields and after finishing fall harvest. Thorough and rapid cleaning can be accomplished using a

high-pressure hose. After cleaning, the cutter bar should be disinfected using either steam or a 1 part household bleach with 9 parts water solution. If bleach is used, the equipment must be rinsed with water shortly after treatment, as bleach is very corrosive to metal.

Fall management of VW-infested fields

Research conducted at the Padlock Ranch near Dayton, Wyoming, has shown that increased disease and decreased stand and yield may have occurred when the third regrowth was cut in VW-infested fields, compared with a two-cut treatment. Managing the field for two cuts and grazing the frosted-down third regrowth was less detrimental to stands than three cuttings. Because the fungus only infects fresh, green stems, cutting green alfalfa increased VW, while grazing the frosted-down alfalfa did not.

To help ensure winter survival, alfalfa plants should not be cut or grazed within four to six weeks of the first killing frost (24 degrees Fahrenheit) unless there is at least 10 to 12 inches of growth. This will provide sufficient time to ensure adequate energy storage needed for overwintering and initiation of growth in the spring. Irrigating to fill the soil profile during this time period reduces overwintering stress due to dryness. Short-term alfalfa grazing after frost appears to have no adverse effect on stand life; however, one should avoid grazing stands when the soil's surface is wet. Extended grazing of alfalfa fields even when the soil's surface is not wet can cause damage to the crowns and shorten the stand's life.

Irrigation management of VW-infested fields

Because the infection of freshly cut stems is increased during rain or sprinkler irrigation, VW-infested alfalfa fields should not be irrigated after harvest until new stems are 4 to 6 inches tall. This growth period allows sufficient time for the water-conducting vessels in the old stems to close, preventing infection. Waiting to irrigate also will reduce stem bud infection if the alfalfa stem nematode is in the soil. Under hot, dry conditions, alfalfa fields with VW should be irrigated before harvesting to provide sufficient soil moisture to ensure maximum regrowth.

Using VW-infected hay

Hay harvested from fields with VW should not be placed in healthy fields for livestock feed since the fungus can survive in hay and may cause plant infection in healthy plants. Also, moving livestock from VW-infested fields to healthy fields should be avoided as transmission of the fungus may occur.

Crop rotation

Once a stand has declined to the point of being uneconomical, the field should be rotated out of alfalfa for three to five years. To prevent fields from becoming heavily infested with weeds during rotation, crops such as wheat, barley, oats or corn should be planted.



Figure 6. The yellow-brown discoloration of the vascular root tissue in this plant is another symptom of VW.



Figure 7. The accumulation of VW-infected leaves and stems on this swather header is a common way of spreading the VW fungus within and between alfalfa fields.



Figure 8. Planting VW-resistant alfalfa varieties decreases the percentage of infected plants and prolongs the life of the stand. Flags separate the VW-resistant variety, Arrow, (left), from the VW-susceptible variety, Apollo (right).

The only other crop grown in Wyoming that is susceptible to VW is sainfoin (*Onobrychis viciifolia* Scop.). Several other forage legume crops have been tested at the University of Wyoming greenhouse and appear to be unaffected. Plants tested include point vetch (*Oxytropis riparia* Litv.), cicer milkvetch (*Astragalus cicer* L.), red clover (*Trifolium pratense* L.), yellow sweet clover (*Melilotus officinalis* L.), and hairy vetch (*Vicia villosa* Roth).

Planting resistant varieties

Planting certified VW-resistant alfalfa varieties is the most important and least expensive management practice available (see Figure 8). In Wyoming, the average annual yield increase of 0.4 tons per acre was obtained in the second year of production by planting a resistant variety over a susceptible variety. Over 70 certified alfalfa varieties are currently available with an "R" or higher disease rating to VW, alfalfa stem nematode (SN) and Phytophthora root rot (PRR), with sufficient winter hardiness (fall dormancy categories of 2-5) for Wyoming's harsh growing conditions. All three of these stand-decline diseases should be considered when selecting a variety for growing in Wyoming. Information about multiple disease-resistant varieties and appropriate selection processes for particular areas in the state is provided in the UW Agricultural Experiment Station Bulletin B-919R, *Guide for Selecting Alfalfa Varieties with Disease Resistance for Wyoming*. This and other extension publications are available for purchase through the University of Wyoming College of Agriculture Resource Room and UW Cooperative Extension Service county offices.

Summary

Verticillium wilt has been in Wyoming for over 19 years and now is established in most of the major-irrigated areas in the state. The disease first appears in two- to three-year-old irrigated stands of alfalfa. Symptoms are more noticeable in spring or fall, following cool, rainy weather. Infected plants die rapidly during mid-summer and are quickly replaced by weeds.

The integration of certified VW-resistant varieties, along with recommended sanitation of harvesting equipment

and fall harvesting management practices, should reduce the introduction, spread, and loss attributed to this destructive disease.

Available publications of similar interest

1. *Impact of Verticillium wilt on Wyoming alfalfa hay production*. Page, M.S., F.A. Gray, W.G. Kearl, and R.L. Hossfeld. (1990). Agricultural Experiment Station Bulletin, B-935, University of Wyoming, College of Agriculture.
2. *Guide for selecting alfalfa varieties with disease resistance for Wyoming*. Gray, F.A. and D.W. Koch. (1998). Agricultural Experiment Station Bulletin, B-919R, University of Wyoming, College of Agriculture.
3. *A guide for selecting alfalfa varieties for irrigated stands in Wyoming*. Gray, A.M. and C.R. Anderson. (1995). Cooperative Extension Service Bulletin, B-1009, University of Wyoming, College of Agriculture.
4. *Fall dormancy & pest resistant ratings for alfalfa varieties, 2000/2001 ed.* Alfalfa Council, 10920 Ambassador Drive, Suite 302, Kansas City, MO 61453.
5. "1999 Alfalfa variety yield trials." Gray, A.M. (2000). In *Agricultural Experiment Station Progress Report*, pp. 159-165. University of Wyoming, College of Agriculture. (published yearly)
6. *Alfalfa analyst*. (1997). Alfalfa Council, Inc., P.O. Box 1017, Davis, CA, 95617-1017.
7. *Alfalfa stem nematode biology and management*. Gray, F.A. and G.D. Franc. (1993). Agricultural Experiment Station Bulletin, B-761R, University of Wyoming, College of Agriculture.
8. *Biology and management of Phytophthora root rot of alfalfa*. Gray, F.A. and D.W. Koch. (1996). Agricultural Experiment Station Bulletin, B-791R, University of Wyoming, College of Agriculture.
9. *A guide for identification of Verticillium wilt in alfalfa*. Peadar, R.N. and A.A. Christen. 1984. USDA-ARS, Ag. Info. Bulletin No. 456.

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