CHAPTER NINE

DISEASES

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Alfalfa is susceptible to a wide range of bacterial, fungal, and viral diseases. These diseases can attack foliage, crowns, or roots and may substantially reduce yield, stand life, and forage quality. Some diseases can be difficult to control because, except for seed treatment, no fungicides are registered for use on alfalfa. Fortunately, alfalfa diseases are not as economically damaging in the Intermountain Region as in other parts of the state; the cold winters, short growing season, and relatively dry conditions that prevail over most of the region are not conducive to them.

Planting varieties with genetic resistance to the most prevalent diseases is the primary method of disease management in alfalfa. Most diseases can be effectively managed using this approach. However, a field planted to a variety classified as resistant may contain diseased plants. Alfalfa is genetically diverse (heterogeneous), and there will always be some plants susceptible to disease even in a resistant population. For example, in a variety rated as having resistance to a particular disease, only 31 to 50 percent of the plants are resistant (Table 9.1). Resistance ratings represent the results of standardized tests performed on seedling plants. Such tests do not take into account various growth stages and environmental stresses that may influence diseases in the field. Therefore, genetic resistance should not be the only method used to control diseases in alfalfa. Crop management, such as irrigation and harvesting practices, plays an important role in preventing or minimizing losses caused by disease.

VERN MARBLE

This chapter outlines the most predominant or potentially threatening diseases in the Intermountain Region. They are grouped into four categories: damping-off diseases, root and crown rots, foliar diseases, and wilt diseases.

DAMPING-OFF DISEASES

Several soilborne fungi cause early wilting and death of young seedlings pre- or postemergence, a scenario commonly referred to as damping-off. The causes of damping-off are species of *Pythium, Phytophthora, Rhizoctonia,* and *Fusarium.* These fungi are most com-

***Phytophthora* root rot is only important where soil-water is excessive.**

mon in wet soils where drainage is poor or during periods of heavy rain or overirrigation. Damping-off typically occurs during cool, wet conditions in the spring, and less often in the fall. Control measures include planting at a rate that will allow for thinning due to seedling diseases and planting at a time of year when growing conditions favor rapid seedling development. Fortunately, seedlings more than 1 to 2 weeks old rarely become infected with these diseases.

Damping-Off Caused by Pythium

Pythium species are the most common cause of seed rotting and damping-off in seedlings. These fungi can greatly reduce a stand of alfalfa, especially in wet areas. *Pythium* survives in the soil or on crop residue. Swimming spores, called zoospores, infect seed or seedlings during periods of free moisture in the soil. Alfalfa seedlings become resistant to *Pythium* damping-off about 5 days after emergence, but infection of feeder roots can occur at any stage. Low temperatures and high soil moisture are favorable for disease development. The disease tends to be more severe in acidic soils.

Seeds infected by *Pythium* during germination turn into a soft brown mass, or the seedling root and cotyledon leaves become brown and soft soon after emergence. Infection at later stages causes lesions on the shoot and root. The lesions eventually collapse, causing damping-off or stunting and small dark green cotyledons. The root appears pinched off (color photo 9.1). Infected seedlings may fall over and die within a few days. Under optimal growing conditions, a seedling with a diseased primary root may survive by producing secondary roots above the lesions.

To compensate for seed loss due to *Pythium* fungi, seed at a higher-than-normal rate. Also, see the discussion of fungicides in the next section, about *Phytophthora.*

Table 9.1. Plant resistance ratings.

PERCENTAGE OF RESISTANT PLANTS	RESISTANCE CLASS
0–5	Susceptible
6–14	Low resistance
15–30	Moderate resistance
31–50	Resistance
>50	High resistance

Damping-Off Caused by *Phytophthora*

Symptoms of damping-off caused by *Phytophthora* fungi on seedling alfalfa are similar to those caused by *Pythium* fungi. The area below the cotyledons (hypocotyl) becomes water-soaked and limp, then collapses and withers. Seedlings are stunted and have small, dark green cotyledons and die within a few days.

A seed treatment fungicide, such as metalaxyl (Apron), can be used as a seed dressing to protect against seedling diseases caused by *Pythium* and *Phytophthora* species. However, use has not been found to be beneficial in tests in California; seed treatment fungicides are recommended only where seedling damping-off is known to be a problem. The preferred method for controlling this disease in the field is to optimize seedling growth by preparing a firm seedbed and adjusting soil pH and fertility to levels optimum for alfalfa growth. Avoid overirrigation. Also, plant when soil conditions favor rapid emergence and early seedling growth, such as in late summer (see chapter 2).

Damping-Off Caused by *Rhizoctonia*

Rhizoctonia fungi are another cause of seedling damping-off. Symptoms of this seedling disease include reddish brown, shrunken lower stems and roots. These fungi require a food base before infecting a plant; thus, excessive organic residue in the soil encourages them. Excessive soil moisture also favors them. However, unlike the seedling damping-off diseases already mentioned, infection by *Rhizoctonia* generally occurs during periods of high temperature and can affect seedlings at any growth stage.

No control measures are generally taken against *Rhizoctonia.* Ensuring decomposition of organic matter by adequately incorporating plant residue prior to planting alfalfa seed may reduce seedling infection.

ROOT AND CROWN ROTS

Root and crown rots are the most common and possibly most devastating diseases of alfalfa. They can be caused by a complex of fungi, including *Phytophthora* spp., *Stagonospora meliloti, Rhizoctonia* spp., and *Colletotrichum trifolii.* Stand decline is the most noticeable symptom. Decline usually begins during the 2nd year after planting and gradually becomes more severe. Early symptoms include yellowing and wilting of stem tips or entire shoots, which eventually die. Plants may be stunted and have an increased number of small, shortened stems and small leaves. Crowns of infected plants always exhibit some degree of rot. Control is difficult. This disease complex is a major factor contributing to early stand decline.

Phytophthora Root and Crown Rot

One of the primary organisms responsible for root and crown rot is *Phytophthora megasperma.* It is soilborne and occurs wherever alfalfa is grown. The greatest damage occurs under flood irrigation and with poorly leveled and poorly drained soils. Phytophthora root and crown rot can be injurious to seedling stands, but it is more commonly a problem in established fields.

Although *Phytophthora* fungi primarily infect roots, symptoms are expressed in all parts of the plant. Leaves wilt, turn yellow to reddish brown, and drop. Plants grow slowly after cutting and may wilt and die. Root symptoms are diagnostic for this disease. Tan to brown lesions on taproots usually appear where a lateral root emerges. Lesions eventually turn black; the center of the root is yellow. Taproots can be affected at any depth where water drainage is impeded. Red-orange to yellow streaks spread up several inches from the rotted end of the root (color photo 9.2). This disease can devastate large areas of a field, but frequently only individual plants are affected.

Phytophthora root rot is only important where soil-water is excessive. The fungi can survive for long periods in an inactive state in soil or in plant debris and become active when there is too much water. Rot caused by *Phytophthora* is most common at the tail end of flood-irrigated alfalfa fields. Spores of these fungi can be carried in irrigation water. Thus, if tail water is channeled from an infected field back to an irrigation canal, the disease can spread. The most frequent points of infection are the tips of small roots and the bases of fine lateral roots. The disease may be limited to a portion of the root or may spread up the taproot to the crown. If the crown becomes infected, the plant will likely die as soon as 1 week after infection. If infection is limited, the plant may continue growing at a reduced rate, but it will be far more susceptible to winter injury.

Alfalfa is genetically diverse and there will always be some plants susceptible to disease even in a resistant population.

Soil and water management is the most important cultural control. Reduce the amount of time that soil is saturated by reducing soil compaction with deep tillage (see chapter 2). Reducing the length of flood irrigation runs, shortening irrigation time, and leveling land all help alleviate disease severity. Cultivars resistant to phytophthora root rot are available; use them along with sound cultural practices in fields known to have problems with *Phytophthora* fungi.

Stagonospora Root and Crown Rot

Crown and root rot caused by the fungus *Stagonospora meliloti* is widespread in California but is not a major problem in the Intermountain Region. It can be one of the primary reasons for early stand decline, however. The vigor of an alfalfa stand decreases because of a slow necrosis, or dying, of crowns. Bark tissue on infected

roots and crowns is often cracked. A diagnostic symptom is the presence of red flecks in root tissue. Fine red streaks also occur in the xylem (the water-conducting tissue) in the center of the root, below rotted portions of the crown. The pathogen may also infect leaves, causing irregular tan lesions and defoliation.

Spores of *S. meliloti* are spread by water that splashes on infected leaves, stems, or plant debris. The fungus enters the crown through stems and grows slowly downward into the taproot. Although the infection can take 6 months to 2 years to kill a plant, it reduces plant vigor and yield. Leaves and stems are generally infected during spring rains, but crown infections can occur anytime. The disease is most damaging when alfalfa is not actively growing.

No resistant cultivars are available. Rotation out of alfalfa for 2 or 3 years eliminates sources of inoculum within a field.

Rhizoctonia Root and Crown Rot

This disease, caused by *Rhizoctonia* fungi, attacks established as well as seedling alfalfa. It occurs wherever alfalfa is grown and at any stage of plant growth. Root cankers are tan or buff elliptical, sunken lesions. When the pathogen is inactive during cool months, cankers heal and turn black. If the lesions girdle the taproot, the plant may die; otherwise, new roots will emerge and the plant will survive.

Rhizoctonia species persist in soil as sclerotia (an inactive stage of fungal development) associated with plant residue. They can also survive saprophytically—that is, living on dead organic matter—in the absence of a living host. These fungi require a food base before infecting a plant; thus, excessive organic matter in the soil favors the disease. After entering through wounds, the fungi travel from lateral roots to taproots and from crowns to crown buds. High temperatures and excessive soil moisture promote rhizoctonia rot.

No control measures are generally practiced. To reduce seedling infection, ensure decomposition of organic matter by adequately incorporating it before planting.

Anthracnose

Anthracnose, caused by the fungus *Colletotricum trifolii,* is a sporadic and relatively rare problem in the Intermountain Region, but, when it occurs, losses can be significant. Anthracnose can affect leaves, stems, and crowns of alfalfa, but crown rot has been the most significant symptom in the Intermountain Region. The most apparent symptom of anthracnose is the bluish black, V-shaped rot that can be observed on the crown when dead stems are removed. On stems, anthracnose causes small irregularly shaped blackened areas that may become large, sunken oval or diamond-shaped straw-colored lesions with black borders (color photo 9.3). Black fruiting bodies, which under a hand lens look like small dots, develop in the lesion. As lesions enlarge, they may coalesce, girdle, and kill one to several stems on a plant. In summer and fall, dead shoots (straw to pearly white in color) are scattered throughout the field.

The fungus persists in alfalfa debris and crowns. The disease reaches maximum severity during late summer and early fall. During the growing season, spores on stem lesions are a source of inoculum. Spores may also be spread with seed contaminated during the threshing process.

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

To control anthracnose, grow resistant cultivars. Clean debris off all harvesting equipment before the first spring harvest and also during the growing season when moving from an infected to a noninfected field. Cut infected alfalfa before losses become too severe. Rotating with crops other than clover and alfalfa for 2 years or more will eliminate sources of inoculum in the field.

FOLIAR DISEASES

Several foliar diseases attack alfalfa, including common leaf spot, stemphylium leaf spot, spring black stem, and downy mildew. Of these, downy mildew is generally the only foliar disease of concern in the Intermountain Region.

Downy Mildew

Downy mildew, caused by the fungus *Pernospora trifoliorum,* occurs in cool, wet, or humid conditions and is favored by sprinkler irrigation. It can be found anytime during the growing season in the Intermountain Region but is most common in spring. Damage is most serious in seedling alfalfa fields. Loss from downy mildew in established stands is usually restricted to the first cutting.

Downy mildew is easy to distinguish from other foliar diseases; the symptoms it causes are unique. During cool moist weather or when humidity is high, a fine grayish growth of spores is usually apparent on the underside of leaflets. The upper side of infected leaves is light green to yellow (color photo 9.4). Symptoms are usually restricted to portions of leaflets, but, if the infection is systemic, they may appear on entire leaves or shoots. Infected leaves are twisted and curled. On infected stems the internodes (the stem areas between leaves) are shorter and thicker than those of normal stems. Plant growth is stunted.

Pernospora trifoliorum overwinters as resting spores in the crown of surviving plants and in plant debris. Spores are produced during periods of near-100-percent relative humidity. They are fragile and survive for several hours to a few days, depending on environmental conditions. Dispersal is primarily by wind and splashing rain. Spores fall on young, susceptible leaves and germinate in free water. Germination of spores occurs from 39° to 84°F (4° to 29°C), with optimum germination at 65°F (18°C). The fungus produces large numbers of spores during periods of abundant moisture.

Cultivars resistant to downy mildew have been developed and are the most economical means of control. However, varietal resistance is not well documented, so choosing a resistant cultivar is difficult. Fortunately, downy mildew is rarely of economic importance in the Intermountain Region, and growers can manage it with cultural practices. Allowing longer intervals between irrigations, with more water per irrigation, can help reduce symptoms if fields are sprinkler irrigated. In rare cases when mildew is severe, cut alfalfa early to save foliage. Harvesting removes the inoculum source of the short-lived spores, removes young susceptible leaves, and reduces the relative humidity of the plant canopy. Normal increases in seasonal temperatures reduce the chance of downy mildew reinfection.

WILT DISEASES

Bacterial Wilt

Bacterial wilt, caused by the bacterium *Clavibacter insidiosum,* is present wherever alfalfa is grown, but it is rarely seen today due to the development of wilt-resistant cultivars. Infected plants are easily detected by their yellow-green color and stunted growth. Diseased plants may be scattered throughout the field. Mildly affected plants are short. They have mottled leaves and slightly cupped leaflets or leaflets that curl upward. Severely diseased plants are stunted, are yellow-green in color, and have spindly stems and small, distorted leaflets (color photo 9.5). Disease symptoms are most evident in regrowth after clipping. A cross section of an infected taproot reveals a yellowish tan color in the center. Often, small areas or pockets on the inside of the bark tissue turn brown.

The bacterium survives in plant residue in soil and enters plants through wounds in the roots and crown or through the cut ends of freshly mowed stems. Once a susceptible plant is infected, it usually does not recover. Disease symptoms rarely appear before the 2nd or 3rd year. Plants die within 5 to 8 months after showing symptoms. Disease severity and incidence increase with the presence of nematodes. The bacterium can survive in dry plant tissue or seed for at least 10 years and can be disseminated over long distances in seed and dry hay. However, populations of the organism in the soil decline quickly when infected plant residue decomposes. Bacterial wilt can be spread by surface water, tillage, mowing, and harvesting equipment. Plants with bacterial wilt are prone to winter kill. The greatest incidence of the disease occurs in poorly drained areas of fields; large areas can be infected during periods of continuous wet weather.

Resistant cultivars keep the disease under control. Nearly all dormant alfalfa varieties currently marketed are rated as resistant or highly resistant to bacterial wilt. If you discover the disease in a susceptible cultivar, limit disease spread by mowing new stands before old stands. Also, do not mow wet plants.

Fusarium Wilt

Fusarium oxysporum is a fungus that causes fusarium wilt, which occurs wherever alfalfa is grown. The disease is not generally important in the Intermountain Region because of the availability of resistant cultivars. Fusarium wilt progresses over several months. The fungus enters roots through wounds in the taproot and continues into the xylem, or water-conducting tissue. Shoots and leaves may wilt during the day but regain turgidity at night. As the infection progresses, stems become bleached. Toxins produced by the fungus discolor host tissue; a red discoloration appears on leaves. The xylem eventually becomes plugged, causing death. Fusarium wilt can be identified by the dark reddish brown discoloration in the stele, or center, of the taproot (color photo 9.6). Fusarium oxysporum may persist in soil for several years.

Fusarium wilt is not generally important in the Intermountain Region because of the availability of resistant cultivars.

Fusarium wilt is more severe when plants are infested with root-knot nematodes. Soil moisture does not affect the severity of the disease, but high soil temperatures favor infection.

Cultivars with resistance to both fusarium wilt and root-knot nematode offer the best control when both organisms are present. Sound cultural practices that encourage alfalfa growth reduce incidence of the disease.

Verticillium Wilt

Verticillium albo-atrum, a fungus that causes 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 been reported in most northern states, south to Kansas and Maryland. It has also been found in the high desert of Southern California and the coastal counties of central and northern California. It was discovered in the summer of 1993 in the Intermountain Region, but the extent of its spread is unknown at this time.

Verticillium wilt is a potentially serious problem; it can reduce yield by up to 50 percent and shorten stand life severely. It has been an insidious problem over seasons and years rather than a devastation in a single year. Note that the disease is usually only expressed under certain environmental conditions (cool wet weather followed by hot days). Therefore, the fungus could exist in a field that appears healthy. Also, the disease is apparently more serious in irrigated fields than in dryland fields.

Verticillium wilt symptoms are distinctive, but laboratory analysis must verify field diagnosis. Diseased plants are usually scattered throughout the field. At first glance, the symptoms look like gopher damage, except that the plants do not pull out of the ground.

A V-shaped yellowing, or chlorosis, discolors leaflet tips (color photo 9.8). At the end of the stem, the margin of some leaflets is rolled (color photo 9.9). Leaves on individual stems dry, turn brown, and may fall off. Infected stems do not wilt and often retain their green color until all the leaves are dead. Internodes (the stem areas between leaves) are often short toward the end of a stem. Eventually, the pathogen spreads to the crown, and affects all the stems, and the plant wilts and dies. Although internal root tissue can turn brown, this reaction is variable and is not a dependable symptom for diagnosis.

Contaminated hay and pellets can introduce the pathogen into new areas. The disease can also be spread by the manure of animals who ate infected hay, by insects, by water, and by infected seed. The wind can disseminate fungal spores (conidia) over short distances. *Verticillium albo-atrum* does not usually survive more than 1 year in field debris after an infested field is taken out of alfalfa production. It can survive up to 3 years in dry hay. It can also survive in several weed species, including *Medicago* spp., but does not cause

problems for most other crops. *Verticillium dahliae,* a related fungus, causes wilt of many other plant species but not alfalfa.

Verticillium albo-atrum grows best between 68 and 77°F (20° to 25°C). The pathogen survives the temperatures used to produce dehydrated alfalfa products and can pass unharmed through the digestive system of sheep.

As a control for verticillium wilt, crop rotation has limited effectiveness because the pathogen can survive on several broad-leaved weeds. However, if crop rotation and weed control are practiced, the inoculum can be significantly reduced in 2 to 3 years. Avoid introducing the pathogen on contaminated hay. Clean plant debris from equipment with high-pressure water or steam before entering new fields. Cut clean fields before diseased fields.

Planting resistant varieties is by far the best method to control the disease. Fortunately, most certified dormant varieties are relatively resistant. The University of California recommends planting only resistant (R) or highly resistant (HR) varieties in the Intermountain Region (see chapter 3). Resistant varieties have kept verticillium wilt from becoming an economically significant disease in areas of the Pacific Northwest, where the fungus has been present for many years.

ADDITIONAL READING

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