

Alfalfa Diseases and Control Methods

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Abstract

Alfalfa (*Medicago sativa* L.), which is one of the most cultivated plants among the forage crops in our country and other developed countries, and known as the queen of forage crops, has attracted attention in recent years on organic agricultural production and sustainability of agricultural lands. Many factors cause pathogenic effects in alfalfa. These are non-parasitic agents, parasitic disease agents fungi, bacteria, viruses, mycoplasma-like organisms, nematodes, and parasitic plants. Among them, fungi constitute an important group (Graham *et al.* 1979).

The importance of disease factors that can occur in such a beneficial plant, the diagnosis of these factors, and the necessary management of them on time are of great value for obtaining quality products and for the country's economy.

INTRODUCTION

Alfalfa is a forage plant with wide adaptability, very palatable for farm animals, and high nutritional and digestible value. It is one of the most cultivated plants in Türkiye and other developed countries.

Thanks to its deep root system, it can easily benefit from the water and plant nutrients in the depths, thus increasing its permeability, improving the drainage, aeration, and physical properties of the soil by loosening the soil, and preventing soil and water loss by protecting the soil against erosion.

Rhizobium bacteria in its roots fix the free nitrogen of the air and enrich the soil in terms of nitrogen. In addition, since its flowers have very rich honey essence, it is important in beekeeping for abundant and high-quality honey production (Elçi *et al.*, 1994).

It is reported that many diseases cause damage to alfalfa all over the world. The most common fungal diseases are; root diseases such as Violet root rot (*Rhizoctonia crocorum*), Verticillium wilt (*Verticillium* sp.), Root Rot and Stem Rot (*Sclerotinia trifoliorum*), Alfalfa Root Cancer (*Urophyllitis alfaalfa* Lagerh), Pythium Seed Rot, Damping-off and Root Rot (*Phytophthora megasperma*), Aphonomyces Root Rot (*Aphonomyces* spp.); leaf diseases in Alfalfa Powdery Mildew (*Leveillula taurica*), Leptosphaerulina Leaf Spot (*Leptotrochila medicaginis* (Fuckel), Alfalfa Leaf Spot Disease (*Pseudopeziza medicaginis* (Lib.) Sacc.), Alfalfa Mildew (*Peronospora trifoliorum*) (Berk. viciad By.), Phoma Leaf Spot (*Phoma medicaginis* Malbr. & Roum. var. *P. medicaginis* Boerama) on Alfalfa, Anthracnose (*Colletotrichum trifolii* Bain) on Alfalfa (Graham *et al.*, 1979) There are also several bacterial and viral disease agents.

Bacterial leaf spot (*X. campestris* pv. *alfalfa*) (Riker et al. 1935) Dye., Bacterial wilt (*Clavibacter michiganensis* subsp. *insidiosus* (Mc Cull) (syn. = *Corynebacterium insidiosum*), Bacterial stem blight (*Pseudomonas syringae* pv.) *syringae* van Hall.), Shoot Blight (*Pseudomonas medicaginis*), Root Rot (*Aplanobacter insidiosum*). The most important disease caused by viruses is Alfalfa mosaic alfamovirus (AMV).

Studies on the diseases seen in alfalfa are very limited in Türkiye. The first studies on alfalfa were reported by İbrahim Karaca in 1948. Karaca determined the factor *Leveillula taurica*, *Peronospora trifoliorum*, *Phyllosticta medicaginis*, *Stagonospora melihti*, on alfalfa in 1948 and 1974, Göbelez determined the factors *Pseudopeziza medicaginis* and *Uromyces striatus* in 1952. Later, Tuncer studied the fungal diseases and their prevalence in alfalfa in Central Anatolia in 1984 and determined that *Peronospora trifoliorum*, *Sporonema phacidiodes* and *Pseudopeziza medicaginis* were the most common agents in the region. In the surveys Eken conducted in Erzurum in 1996 and 1998, 26 fungal species were determined. In a study conducted by Onar in Ankara in 2003 and 2004, the most common disease causing agent is *Phoma medicaginis* var. *medicaginis* and *Leptotrochila medicaginis* was reported as a new record (Onar, 2005). Alfalfa mosaic virus (AMV) was detected in the surveys carried out in Erzurum province in 1997 by Yardımcı and Açıkgöz, and in the following years, studies on the molecular characterization of alfalfa mosaic virus (AMV) were carried out in Türkiye.

In this article, it is aimed to focus on the diseases caused by pathogens seen in alfalfa cultivation areas and the precautions that can be taken in the light of the studies carried out in the fight against these diseases.

FUNGAL DISEASES in ALFALFA

Root Diseases of Alfalfa

Violet Root Rot (*Rhizoctonia crocorum*):

Violet root rot is common in Europe and North America. It was reported for the first time in France and the disease agent was seen in many plants. It was first seen in alfalfa in France in 1815, in the USA and Japan in 1890, and then in other countries (Stuteville and Erwin, 1990).

Symptoms: It is also known as violet root rot in alfalfa. The mycelium of the agent completely infects the main root, and the plants become chlorotic and often die quickly before wilting. White or purple micelles are seen roots. Brown or purple micelles penetrate the root, breaking up the root and making it soft. It maintains its vitality for a long time by forming sclerotia on plant parts (Nasari, 2002; Alptekin and Erol, 2004). Diseased plants are separated by brown sharp borders that can be easily distinguished from healthy plants. Small pieces of mycelium in the soil germinate and enter the plant. The agent passes the winter conditions with its small black sclerotia and these resistant structures are formed in the area it infects. The disease is usually seen at the end of summer (Stuteville and Erwin, 1990).

Management: In the areas where the disease is seen, it is necessary to go to the planting rotation. Crops that are not affected by this factor, such as *Trifolium* sp., *Lotus corniculatus*, should be preferred during rotation. Soil ponding should be prevented, diseased parcels should be plowed and lime applied (Stuteville and Erwin, 1990).

Verticillium Wilt (*Verticillium albo-atrum*):

Verticillium wilt in alfalfa is a serious disease that causes 50 % losses and shortens the life of the plant. It was first reported in Europe in 1918. It was later set in Switzerland, Germany, the UK, and other countries.

Symptoms: In early infections, V-shaped light brown lesions occur at the leaf tip (Figure 1). As the disease progresses, the leaves dry and fall off. The dried leaves often take on a pinkish hue, although some may remain green. Symptoms appear between the stem and leaf on new leaves. The stem retains its green color until all leaves die. Because the agent infects the body tissue unilaterally. Within the root tissue, the tissues usually turn brown. The agent does not sporulate on plant tissue.

Management: The most effective method of controlling Verticillium wilt is planting with resistant varieties. Crop rotation is also recommended. Since weeds are among the hosts of the disease, it is very important in the



Figure 1. Typical symptoms of Verticillium disease on Alfalfa Leaves (Anonymous, 2019a; Barlow, 2012).

control against weeds. Disease-free certified seeds should be used.

Root Rot and Stem Rot (*Sclerotinia trifoliorum*):

Sclerotinia root and stem rot is a disease seen in forage crops and legumes in temperate climates.

Symptoms: The first symptoms of the disease are yellowed leaves, hollowed out and collapsed stem. In the early period, a yellowish-brown discoloration occurs, then dark browning and softening occur. The pathogen that was previously alive in plant tissues can infect again. During humid and rainy autumn months, Sclerotinia infects the root and stem of the plant with a white cottony mycelium clump. A gray-white mycelium layer is seen on the stem. The agent forms hard structures called sclerotia that can survive the winter (Alptekin and Erol, 2013).

Management: Since this disease agent remains in the soil for many years, there is no effective chemical control. Deep plowing buries the sclerotia, preventing the germination of apothecia and reducing spore dispersal. Because the sclerotia are located close to the surface of the soil. Keeping harvest residues, collecting and destroying sclerotia can reduce the intensity of the disease. Adjusting the moisture balance in the soil and preventing ponding are important in the fight against the disease.

Alfalfa Root Cancer (*Urophylicitis alfalfa* Lagerh):

Symptoms: There are resting sporangia in the soil. Under moist conditions, zoospores are released and infect healthy roots. Root collar buds swell and form galls after being infected with the disease. As the disease progresses, the number and amount of galls increases (Figure 2).

Management: In the management of this disease, good drainage should be provided and sensitive varieties should be used. It is necessary to avoid excessive irrigation and planting clover in soil with a disease history (Alptekin and Erol, 2013).

Pythium Seed Rot, Damping-off and Root Rot:

In many alfalfa-growing areas in the world, *Pythium* species cause seed rot, pre-emergence and post-emergence collapses and root rot especially in moist soils. Groves and Smith (2013) reported that the disease is caused by *Pythium ultimum* Trow., *P. irregulare* Buisman, *P. splendens* H. Braun and some *Phytophthora* species.

Symptoms: The disease is destructive in infected soils under greenhouse conditions, and thinning is observed in the root collar of the seedlings. Typical limited lesions occur on the hypocotyl and roots of the seedlings that encounter infection during germination, There are gaps in places in alfalfa fields. High temperature and soil moisture are the most



Figure 2. Roots infected with disease (Anonymous, 2019b).

favorable conditions for this disease. The disease is seen in seedling areas rather than fields.

Management: It is very important to spray seeds with systemic drugs used for Pythium diseases in its control. Making balanced fertilization, keeping the soil pH at the optimum and ensuring the aeration of the soil are effective in the control of this disease (Stuteville and Erwin, 1990).

Aphanomyces Root Rot:

It has been reported that *Aphanomyces* species cause diseases in alfalfa fields in Canada, New Zealand, and the USA.

Symptoms: The disease is seen in poorly drained irrigated soils and is confused with other root diseases. The agent inhibits the development of the seedling and causes its death. Infected seedlings develop chlorotic spotted cotyledons followed by chlorosis on the leaf surface. In root infections, the weight of the root decreases and the secondary roots turn brown and begin to rot. In foliar infections, symptoms similar to nitrogen deficiency occur and chlorotic spots occur on the leaves of the stunted plant (Malvick, 2002).

Management: It is very important to maintain the soil water balance in the management of the disease. Resistant varieties should be used and crop rotation should be done in areas where the disease is seen every year. In the chemical control of the disease, seed spraying is recommended (Stuteville and Erwin, 1990).

Rhizoctonia Root Rot (*Rhizoctonia solani* Kühn. (synonym: *Thataphorus cucumeris* [FR] Donk):

It is reported that *Rhizoctonia* spp. causes seedling root rot, root, crown and shoot rot, leaf and stem rot in alfalfa-growing areas. High temperature and soil moisture are favorable for the development of the disease. The causative agent causes settling disease in alfalfa before and after flowering, and root rot in areas that receive precipitation in the summer heat (Stuteville and Erwin, 1990).

Symptoms: In root rot, the fungus enters from the main root. Symptoms occur on the root surface with an elliptical shape and darker edges.

In the crown rot phase, brown lesions occur on young shoots and sprouts. During the infection, root shoots and sprouts die. Fungi develop in the crown region and shoot growth slows down in the affected tissues. Sunken whitish brown lesions are formed at the bottom of the stem.

In high temperature and humid conditions, seedling deaths are observed intensively in the soil. Although *Pythium* sp. only kills young seedlings, *Rhizoctonia* sp can kill the seedling in every period (Stuteville and Erwin, 1990).

Management: There is no effective control of the disease. However, it has been reported that varieties with strong root structure are more tolerant against this disease. The soil should be well-drained (Stuteville and Erwin, 1990).

LEAF DISEASES

Powdery Mildew on Alfalfa (*Leveillula tauricva* (Lev) Arn):

The disease is seen on the leaves that primarily do not have good aeration and remain in a secluded area.

Symptoms: The lower and upper sides of the leaf and the upper side of the stem are covered with a layer of white powder due to the micelles of the agent (Figure 3). There are abundant conidia and cleistothecium in these parts. On infected leaves, first yellow spots and then a layer of white ash-like mold develop. This layer may be on the underside of the leaves exposed to the sun and on both sides of the leaves in the shade. Young leaves are more susceptible to powdery mildew (Onar, 2005). Infected leaves begin to curl, wrinkle and fall untimely.

Management: Since the disease agent passes the winter conditions in the buds, the use of resistant varieties in the control, spring pruning and diseased shoots should be pruned and destroyed. Chemical control of the disease



Figure 3. Powdery mildew disease in alfalfa (Anonymous, 2019c).

can be done with one of the sulfur preparations.

Leptosphaerulina Leaf Spot (*Leptotrochila medicaginis* (Fuckel)):

Between 1956 and 1960, the disease made an epidemic in the center and east of the country. It has been reported that it causes economic losses in Canada, Asia, Europe, and the USA during the cold and humid summer months (Stuteville and Erwin, 1990).

Symptoms: The disease primarily affects young leaves, but later also appears on the petiole and older leaves of the plant. It is stated that when the disease is just beginning to develop, it occurs in the form of small chlorotic spots on the leaves (Onar, 2005). In the early infection period in spring, the plant may remain stunted (Jakson and Bell, 1968).

Management: There are no varieties resistant to this disease, but some varieties are reported to be less affected by the disease than others. Harvest should be done on time, should not be delayed and the distribution of infected leaves should be prevented. (Stuteville and Erwin, 1990).

Leaf Spot Disease of Alfalfa (*Pseudopeziza medicaginis* (Lib.) Sacc.):

Although the disease does not kill the plant, it causes defoliation and reduces forage quality. The disease causes more damage in areas irrigated by sprinkler irrigation.

Symptoms: The agent causes dark brown-black spots up to 3 mm in diameter on the leaves of the plant (Figure 4). These spots occur primarily on the leaves, petioles, and then on the stem. In the center of the spots are the cleistothecium of the fungus. The edges of the spots can be smooth or scalloped. Diseased leaves turn yellow and the disease is spread by droplets. The optimum temperature for spore development is 20°C (Salunskaya, 1969).

Management: In the control of the disease, resistant inbreds should be preferred and sprinkler irrigation should be avoided. Harvest should not be delayed and leaf shedding should be prevented to reduce the inoculum. A protective fungicide can be applied to the seed (Stuteville and Erwin, 1990).

Downy Mildew on Alfalfa (*Peronospora trifoliorum* d By. *P. viciae* (Berk.):

Mildew disease in alfalfa is encountered in cold and humid regions. Deaths are observed in diseased sensitive seedlings at this temperature. Downy mildew is severely seen in cool, moist, or wet conditions. It is common in spring and autumn.

Symptoms: Diseased leaves turn primarily yellow. It is stated that the leaves are slightly curved from the edges and then a gray hair-like mycelial layer forms on the lower surface of the leaves. The first symptoms of downy mildew are on the young leaves. Gray spots form on the underside of the leaf and these can move to the petiole and stem over time. Infected plants do not flower. (Onar, 2005).

Management: In the control of the disease, the plants with the disease should be removed and destroyed, plant rotation should be done and clean seeds should be used. Disease-resistant varieties should be planted (Alptekin and Erol, 2004; Stuteville and Erwin, 1990).

Phoma Leaf Spot on Alfalfa (*Phoma medicaginis* Malbr. & Roum. var. *P. medicaginis* Boerama):

Leaf spots enlarge, slight collapse appears and they turn light brown. The leaves turn yellow



Figure 4. Leaf Spot Disease on leaves (Anonymous, 2019d).

and often wilt before falling. The spots on the stem and petioles enlarge and disfigure, creating large dark areas on the underside of the plant. In moist areas, the seed pods change color and shrivel. Spores are spread by water, wind, and insects. Dew or rain is essential for spore propagation and infection from pycnids (Stuteville and Erwin, 1990).

Management: Trimming in early spring can reduce the damage. Seeds obtained from humid areas should not be used. Harvest residues should be cleaned and host plants should be removed from the environment (Stuteville and Erwin, 1990).

Anthracoze in Alfalfa (*Colletotrichum trifolii* Bain):

The fungus prefers humid and warm conditions. The use of sensitive varieties increases the severity of this disease. In recent years, resistant inbreds have been developed against this disease. The disease agent is spread even more by sprinkler irrigation (Stuteville and Erwin, 1990).

Symptoms: The causative agent forms oval or irregular spots on the stem of the plant with dark edges and a light center. Larger lesions are yellowish with a brown margin. There are black spore structures (aservuli) of the fungus in the middle of the spots. Infected stems die over

time and the agent disperses from these infected areas in autumn and summer. It probably does the most serious damage when it turns bluish-black in the crown neck area. In the period when these symptoms are seen, the plant dies by breaking from the stem and crown throat. If the lesions are bluish-black in these broken stems, the disease can be determined as anthracnose (Stuteville and Erwin, 1990).

Management: Resistant varieties should be planted in areas where the disease is seen every year. The areas where the disease is seen should be sprayed with a protective fungicide as soon as the first symptoms appear. The most important control method in the control of *Colletotrichum trifolii* is the planting of resistant varieties. Late sowing, rotation applications, and removing the harvest residues from the field also reduce the infection considerably (Stuteville and Erwin, 1990).

Alfalfa Rust (*Uromyces striatus* Schroet. var *medicaginis*):

There are spore beds that form spores (uredospores) in the form of small red-brown rust on the leaf petiole and stem of the alfalfa. The disease agent overwinters on spurge (*Euphorbia cyparissias*).

Management: Host plants must be destroyed. In addition, resistant varieties should be used.

Alfalfa Black Spot Disease (*Macrosporium sarciniforme*):

The disease agent is seen in the form of black small spots on the leaves, and then it causes the entire leaf and shoot to dry. This disease is more common in densely planted plots and humid areas.

Management: Frequent planting should be avoided and applications that increase humidity should be avoided (Stuteville and Erwin, 1990).

BACTERIAL DISEASES IN ALFALFA

Bacterial Leaf Spot (*Xanthomonas campestris* pv. *alfalfa*):

The disease is more common in areas with a temperate climate where alfalfa is grown. Although the losses caused by the disease are generally low, it can cause serious yield losses locally. (Arsenijevic and Klement, 1969).

Symptoms: Small, angular, water-soaked spots develop on the leaves. These water-soaked spots occur mostly on the lower surface of the leaves. In favorable conditions, the spots enlarge and coalesce. In the center of large spots, scorch and translucent images appear due to drying. Severe defoliation is a common symptom. Stem lesions first begin as small, watery, oily spots, then enlarge and the spots coalesce, occasionally causing elongation between the internodes.

Management: Using resistant varieties is one of the practical control methods. Practically, seedling loss caused by the disease can be avoided in seeds sown in spring in warm regions.

Bacterial Wilt Disease (*Clavibacter michiganensis* subsp. *insidiosus*):

Symptoms: In the diseased plant, wilting is seen in dry and hot weather conditions. Generally, the most common symptoms are dwarfism and an increase in body parts. In infected plants, variegation is seen on the leaves and the leaf periphery is curled upwards. More advanced infections cause proliferation and

bushiness on the trunk. In severe infections, misshapen leaves are formed on the plant. The plant becomes thinner, yellowing, papery, white-gray necrosis occurs on small leaves (Adas, 1979). *Clavibacter m.* subsp. *insidiosus* can be confused with systemic diseases such as *Verticillium albo-atrum*. However, *Verticillium* from *Verticillium albo-atrum* causes wilting and rapid death, but dwarfism is absent (Sabet, 1959).

Management: There are many resistant varieties in the world. If the same equipment will be used in the harvest, the young plants should be harvested first and then the old plants. Shaving should not be done while the plants are wet (Sorensen et al., 1978).

Bacterial Stem Blight (*Pseudomonas syringae* pv. *syringae* van Hall.):

The disease is infrequent and overall losses are usually small. However, in the higher and colder valleys of the western highlands of the United States, the first crop loss of some cultivars was 40-50% (Claflin et al., 1973).

Symptoms: Plants with bacterial root blight become stunted. Infected stems are shorter than normal, weak, brittle and break easily. Symptoms on the stem begin as water-soaked, yellowish olive-green lesions, usually at the attachment point of a leaf, and then extend one side of the stem through one to three nodes. Lesions turn amber, areas that have dried from seepage shine through and darken as the plant ages.

The leaves appear to be water-soaked, pale yellow from below, especially in the petioles and along the midrib of the leaflets. Leaves attached to the infected stem turn yellow and dry. Because this disease follows late spring frosts, symptoms and resulting loss of yield are often blamed on frost injury.

Management: There are no disease-resistant cultivars. Since frost injury is required for bacterial stem blight to begin, cultivars with adequate frost tolerance should be selected. In severe infections, the first harvest should be done immediately after the danger of late frost has passed. Infected material is removed and plants can grow healthy again (Riker et al., 1935).

Shoot Blight (*Pseudomonas medicaginis*):

Symptoms: This factor is mostly transmitted by insects and other injuries by entering the wounds. The infected shoots first turn yellow, then turn black and dry by curling. The disease is mostly seen in the first form at the end of winter. It does not cause much economic loss (Dye et al., 1980).

Management: As a precaution, pests that will damage the plant should be controlled.

Root Rot (*Aplanobacter insidiosum*):

Symptoms: The agent causes more damage in years when there is frost damage. Bacteria enter the plant from the soil, especially from the wounds formed by frost, and form brown swellings in the root collar, the tissue rots slowly, the plant growth stops, and the plant dies over time. Clover plots dry out in clumps and, therefore, alfalfa vines become sparse and their yields drop considerably (Gabriel et al., 1986).

Management: Alfalfa contaminated with this type of disease should be removed by plowing and alfalfa should not be installed in succession. In addition, the creation of new alfalfa plots with resistant varieties is an important measure for the control of the disease.

VIRUS DISEASES SEEN IN ALFALFA

Alfalfa mosaic alfamovirus (AMV):

Symptoms: It is of seed origin. It has been observed that the symptoms caused by the alfalfa mosaic virus also vary. It appears on large, irregular, yellow to cream-colored leaves. It was mostly observed in leaves as wrinkling, deformity, light green-yellow chlorotic spots, lines, and rings. Some leaves were observed in yellowing.

Management: Resistant varieties should be used, infected plant residues should be destroyed, host weeds should have struggled, diseased plants in greenhouses or fields should be removed.

RESULTS and DISCUSSION

Alfalfa is a valuable agricultural product used as a forage crop that can be harvested several times. Since the control is difficult and costly in field conditions, variety development should be applied in root rot and leaf diseases. In addition to this, it is important to carry out comprehensive research on the diseases found in alfalfa, as well as to carry out studies on the control of seed and soil-borne diseases, in terms of eliminating the deficiency in this regard. Studies should be carried out on cultural, biotechnical, and biological control methods along with chemical control in the management of these diseases in the fields, and it is recommended to grow resistant varieties in regions where the mentioned diseases are common. Land drainage should be good, the land where alfalfa will be planted should be well prepared, seed spraying should be done (for *Pythium* and *Phytophthora*), factors prefer alfalfa varieties that are tolerant of heat. Therefore, it is not necessary to delay the planting of plants to avoid disease in wet weather. The best way to prevent seedling diseases caused by *Phytophthora* and *Aphanomyces* is to grow resistant and superior resistant varieties. Seed application is essential in the management of *Pythium* agents. Seed application of protective fungicides is effective against *Phytophthora* and *Pythium* agents, but there is no record of being effective against *Aphanomyces*. It can also be used against *Pythium* and *Phytophthora* as soil application of protective fungicides.

When the studies conducted in Türkiye are examined, it has been observed that leaf diseases cause more damage than root diseases, and downy mildew, Phoma leaf spot and powdery mildew disease have been determined more commonly in the green parts of alfalfa fields.

However, the limited number of studies in recent years reveals the necessity of detailed, molecular data-supported studies in order to clarify how the changing climate and human movements affect diseases.

In addition, alternative and chemical control studies should be developed as well as cultivar and breeding studies in the control of these diseases.

The fact that the situation of these factors, which can cause significant yield losses in alfalfa fields, is not known exactly, has revealed the necessity of conducting comprehensive research to reveal the phytopathological problems in alfalfa fields. This study, it is aimed to reveal the problems in alfalfa fields in the world and our country, as well as to give information about other studies aimed at solving these problems.

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