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Soilborne Root and Stem Diseases of Dry Beans in Nebraska

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Introduction

Nebraska dry bean production can be affected by a number of soilborne root diseases, most of which are caused by fungi. Most of these fungi reproduce by specialized structures called spores. Spores are an important mechanism for spread, and many can survive in soil for long periods of time in the absence of dry bean plants. This publication focuses on some of the most commonly found soilborne fungal pathogens in Nebraska dry bean production, causing disease of subterranean plant parts. It includes symptoms, pathogen characteristics, factors favoring infection, and management methods, if available.

Figure 1. Initial symptoms of FRR with reddish, longitudinal streaks on hypocotyls.

■ Fusarium root rot

Cause: ***Fusarium solani*** f. sp. ***phaseoli***

Fusarium root rot (FRR), also referred to as Fusarium foot rot or dry rot, occurs throughout the world wherever beans are grown. It does not always cause damage unless plants are subjected to some form of stress. However, under severe or drastic environmental stresses, the disease can be very destructive.

Symptoms

Initial symptoms appear as reddish, longitudinal streaks on hypocotyls and taproots (*Figure 1*). Affected areas may merge and enlarge with age, turn necrotic (*Figure 2*), and gradually extend up the stem (*Figure 3*).

Figure 2. Further symptoms of FRR with streaks merging to form larger necrotic areas on roots and hypocotyls.

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Figure 3. Necrotic areas of stems due to FRR extending upward on stems.

Plants are seldom killed and often compensate for severe infection by producing numerous adventitious roots above the rotted taproots (*Figure 4*). Foliar symptoms generally involve yellowing and stunting (*Figure 5*). Stress factors such as dry soil conditions and compaction will combine with disease and limit root growth, resulting in severely stunted plants (*Figure 6*).

Figure 4. Severe FRR infection on plant (right). Note dead tap root, but proliferation of secondary rootlets above the rotted portion, which allows the plant to survive, compared to the unaffected plant on the left.

Figure 5. Foliar symptoms of FRR consisting of yellowing and stunting.

Figure 6. Restricted root growth of FRR-infected plant combined with soil compaction.

Disease Cycle and Favorable Environmental Conditions

The pathogen survives in soil, primarily as thick-walled resting spores called chlamydospores. These overwintering spores germinate readily in response to plant root exudates and infect plants through stomata and wounds. Root rot severity is dependent upon cropping history, plant spacing, and other stress factors such as drought, soil compaction, or flooding (causing oxygen deprivation). Early planting into cool wet soils favors infection, as does compaction or the presence of hardpan layers. Soil compaction effects become evident shortly after emergence (*Figure 7*), and continue into mid-season

Figure 7. Effects of soil compaction on dry bean plants early in the season.

Figure 8. Effects of soil compaction on dry bean plants in mid-season.

Figure 9. Dry bean plants with severe FRR infection. Note the surprisingly healthy foliage.

(*Figure 8*). Affected plants will often still survive with severely rotted roots, while also maintaining surprisingly good foliage (*Figure 9*). The effect of Fusarium root rot becomes more apparent during blossom formation and early pod set. High plant populations, improper cultivations, other soilborne pathogens, and some herbicides also may induce injury to roots, providing additional stresses for the Fusarium root rot pathogen to induce greater damage.

Management

- Plant when 2-inch soil depth temperatures reach at least 65°F.
- Utilize seed spacing of 2-3 inches to avoid overcrowding within rows.
- Treat seed or furrow with registered fungicides to protect seedlings.
- Rotate beans with nonhost crops such as corn, alfalfa, and small grains.
- Chisel at 10-16 inches deep between rows or use some form of zone tillage within rows to alleviate any soil compaction and encourage better root and water penetration.
- Properly manage irrigation to supply the plants' moisture needs without being excessive.

Rhizoctonia Root Rot

Cause: ***Rhizoctonia solani***

Rhizoctonia root rot is a common disease of beans worldwide. It has been demonstrated to cause losses of more than 10 percent in conventional tillage systems and 20-30 percent in minimal or no-till systems in the United States. Losses in Brazil, in conjunction with Fusarium root rot, have been documented to approach 60 percent. The pathogen is also an important disease on other crops grown in rotation with beans.

Symptoms

Disease begins as small, circular or linear sunken lesions with reddish-brown borders (*Figure 10*). Cankers may enlarge with age and may retard normal plant growth by girdling hypocotyls (*Figure 11*). Severe infections cause stunting and premature death (*Figure 12*), and infection will often proceed from plant to plant down rows (*Figure 13*). The pathogen also may occasionally enter and destroy the pith, resulting in a brick-red discoloration inside the stem (*Figure 14*). After the plant is dead, evidence of infection may be provided by grayish-white mycelium of the pathogen within rotten piths (*Figure 15*).

Figure 10. Initial symptoms of Rhizoctonia root rot consisting of small, circular-linear sunken cankers.

Figure 11. Advanced infection of Rhizoctonia root rot showing cankers girdling stem.

Figure 12. Permanent wilting and death of Rhizoctonia-infected dry bean plant.

Figure 13. Dry bean plants killed by Rhizoctonia infection.

Figure 14. Internal red discoloration of stem due to infection by *R. solani.*

Figure 15. Dry bean plant killed by *R. solani* showing signs of grayish-white hyphae within stems.

Figure 16. Pigweed plant infected by FRR.

Figure 17. *Kochia* plant infected by FRR (left) compared to uninfected (right).

Favorable Environmental Conditions

Generally, the pathogen survives in the upper 4-6 inches of soil or in perennial plants as hard, resistant sclerotia, mycelium colonizing plant residue. It is disseminated in soil or by mechanisms that may move soil, including wind, rain, irrigation water, or farm machinery.

Figure 18. Lambsquarters plant infected by FRR (left) compared to uninfected (right).

Once a field becomes infested, it usually will remain infested indefinitely. Inoculum concentration will increase if susceptible crops are continually cropped, including beans, potatoes, and sugarbeets. Several weed species in the Central High Plains also can serve as susceptible hosts, including pigweed (*Figure 16*), Kochia (*Figure 17*), and lambsquarters (*Figure 18*), further providing another source for inoculum increase within soils. Disease in young seedlings is favored by high to moderate levels of soil moisture and cool soils. Damage is often restricted to seedlings, but also can affect older plants if stressed by temperature extremes or irrigation water. Soil compaction also can increase disease, similar to Fusarium root rot.

Management

- Plant in soils warm enough (60°F) with adequate moisture to encourage rapid germination and emergence of seedlings.
- If *Rhizoctonia* problems are anticipated, plant shallowly (1-1.5 inches) to increase the time period between planting and emergence.
- Treat seed or furrow with registered fungicides to protect seedlings.
- Incorporate previous residue early enough to promote decomposition before planting.
- Reducing soil compaction also can promote more rapid seedling emergence.
- Rotate with crops other than potatoes and sugarbeets to reduce pathogen buildup in soils.
- Control bean seedlings and weeds such as pigweed, lambsquarters, and Kochia to minimize pathogen increase.

Pythium Diseases

Cause: *Pythium* spp.

Pythium spp. may cause preemergent seed rot and damping-off, postemergent damping-off, stem and root rot, blight, or pod rot. Yield losses can be as high as 100 percent under optimal conditions, but rarely exceed 20 percent. Species causing disease in bean can be roughly arranged into three main groups, depending upon morphology and temperature responses. The first group includes cool weather species such as *P. ultimum* Trow that produce spherical survival structures (oospores) and sporangia (*Figure 19* - left). Members of another group resemble *P. ultimum*, but do not produce overwintering oospores. Another group consists of hot-weather species, including *P. myriotylum* Drechs. and *P. aphanidermatum* (Edson) Fitzp. These species produce lobate sporangia (*Figure 19* - right) and are most active at soil temperatures ranging between 65 and 95°F.

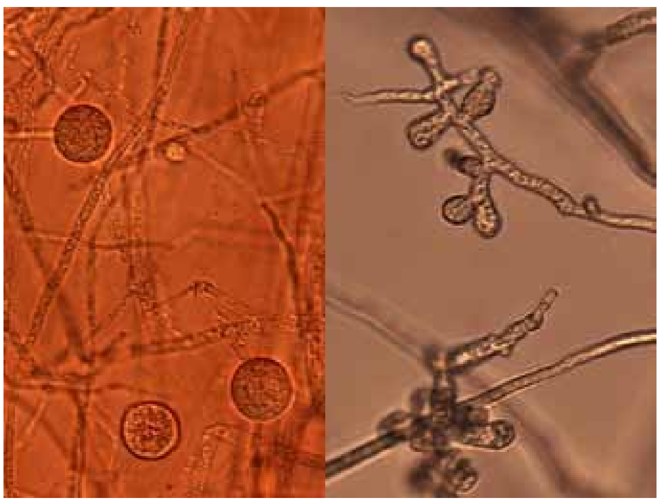

Figure 19. Sporangia of *Pythium* spp. Circular sporangia (left) characteristic of *P. ultimum*. Lobate sporangia (right) characteristic of *P. aphanidermatum*.

Symptoms

Poor initial stands that may be attributed to *Pythium* spp. can be the result of seed rot or damping-off (*Figure 20*). Infected seedlings that emerge may wilt and die within several weeks (*Figure 21*). Initial symptoms on roots and hypocotyls consist of elongated, water-soaked lesions within one to three weeks after emergence (*Figure 22*). However, if the disease continues to progress, wilting and death also may occur on older plants (*Figure 23*). Disease incidence is often greater in lower areas of the field where water tends to accumulate (*Figure 24*). Any area of the plant in contact with the soil also may become infected (*Figure 25*), resulting in water-soaked areas of the stem (*Figure 26*) or upper branches (sometimes referred to as blight). The water-soaked areas eventually dry out, become somewhat sunken, and are tan to light brown in color (*Figure 27*).

Figure 20. Poor initial dry bean stand due to damping-off by *Pythium* spp.

Figure 21. Young dry bean seedling wilting after infection by *Pythium* spp.

Figure 22. Initial *Pythium*-induced, water-soaked lesions on dry bean hypocotyls shortly after emergence.

Favorable Environmental Conditions

Pythium diseases are promoted by high levels of soil moisture and high to moderate temperatures, depending on the species involved. The pathogen survives in soil as resistant oospores. Pathogen populations increase rapidly in soils with high organic matter or poor drainage. The fungus can be transported between and within fields by any method that also moves soil. Infection may be enhanced by root damage by cultivation or other factors such as nematodes. Weed species also may be hosts

Figure 23. Wilting and death of dry bean plant at mid-season due to infection by *Pythium* spp.

Figure 24. Large area of dry bean field where water stood for extended periods affected by Pythium root rot.

Figure 25. Dry bean plant infected by Pythium spp. at the soil line, resulting in wilting.

Figure 26. Dry bean plant from *Figure 25* infected by *Pythium* spp. Note water-soaked lesion on stem that was in contact with the soil surface.

Figure 27. Stem lesion similar to that in *Figure 25* that has begun to dry and turn brown.

Figure 28. *Pythium*-infected pigweed. Note the tap root rot (upper photo) and infection on small feeder root (lower photo).

for different *Pythium* species (*Figure 28*), contributing to inoculum increase.

Management

- Treat seed with a recommended fungicide to protect from seed rot and damping-off.
- Plant in warm (>60°F), moist soil to enhance rapid germination.
- Minimize root damage during cultivation.
- Manage irrigation water to limit spread within and between fields.
- Manage weeds and bean volunteers to enhance the effects of rotation and prevent pathogen buildup in soils.
- Some herbicides (paraquat and glyphosate) can cause short-term increases in damping-off due to *Pythium* spp.

■ Fusarium yellows/Fusarium wilt

Cause: *Fusarium oxysporum* f. sp. *phaseoli*

Fusarium yellows or wilt was first found in dry beans in California in the late 1920s and has since been reported in most dry bean growing regions of the United States, South and Central America, Spain, and Africa. There are at least seven identified pathogenic races.

Symptoms

Foliar symptoms first appear as yellowing and wilting of older leaves (*Figure 29*), followed by the same symptoms on younger leaves if the disease progresses. Severely affected plants may wilt permanently (*Figure 30*). Vascular discoloration of roots and hypocotyl tissues is the primary diagnostic symptom (*Figure 31*), and the degree of discoloration varies in intensity depending on the cultivar and environmental conditions present in fields.

Figure 29. Initial infection in dry bean plants due to Fusarium wilt consisting of yellowing and wilting of older plants.

Figure 30. Permanaent wilting symptoms in dry bean plants due to infection By *F. oxysporum*.

Figure 31. Vascular discoloration on dry bean stems, characteristic of Fusarium wilt. (Photo by Howard Schwartz, Colorado State University)

Favorable Environmental Conditions

Factors favoring wilt are the same as those that favor Fusarium root rot, including high temperature stress (>86°F) and soil compaction. Fusarium wilt infections often are more dramatic on plants than Fusarium root rot infections. Fusarium root rot infection will seldom kill plants, unlike that of Fusarium wilt. Death with wilt can occur either before or after pod set, and both pathogens can cause maturity to occur two to three weeks earlier than normal.

Management

- Plant when 2-inch soil-depth temperatures reach at least 60°F.
- Treat seed or furrows with recommended fungicides to protect seedlings.
- Properly space seeds 2-3 inches apart to avoid overcrowding within rows and to reduce potential competition for water later in season.
- Rotate with nonhost crops like corn, alfalfa, or small grains.
- Chisel at 10-16 inches deep between rows or use some form of zone tillage within rows to alleviate any soil compaction and encourage better root and water penetration.

Stem rot

Cause: Unknown sterile white basidiomycete (SWB) (*Figure 32*).

A stem rot caused by an unidentified basidiomycete was first found in Florida in 1968. It has since been reported from snap beans in Georgia, pigeon pea in Puerto Rico, chickpea in India, and most recently, on dry beans (great northern) in Nebraska. This type of fungus has been shown to cause natural infections in many other plants, including corn, sorghum, squash, bermudagrass, and numerous additional leguminous crops such as cowpea, pole bean, peanut, and soybean. The pathogen produces prominent clamp connections (*Figure 33*) and several other common traits characteristic of fungal basidiomycetes, but no sclerotia. One culture of SWB from bermudagrass was identified as a species of *Marasmius,* based on induced sporophore formation.

Figure 32. Sterile white basidiomycete (SWB) growing in culture.

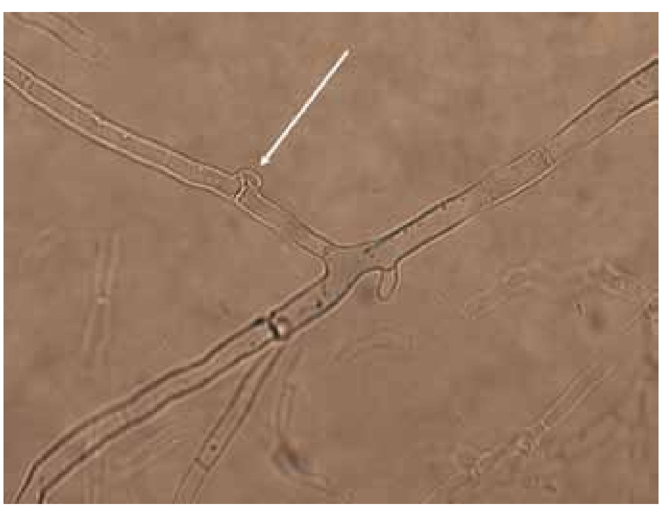

Figure 33. Hyphae of SWB showing characteristic clamp connection (arrow).

Figure 34. Wilting symptoms in dry bean plant due to infection by SWB.

Figure 35. Mild infection by SWB consisting of small, reddish-brown lesions, similar to those induced by FRR.

Figure 36. Variation in symptom severity from SWB. Small lesions (left); larger grayish-black sunken lesions (middle and right).

Symptoms

Generally, the first symptoms observed after emergence are wilting (*Figure 34*), and death of young plants occurs within several days. On less severely affected plants, small lesions may be found on hypocotyls (*Figure 35*). Hypocotyl and stem lesions can vary from superficial, tan lesions, to sunken gray to black cankers (*Figure 36*).

Figure 37. White mycelial strands of SWB growing into stem pith of infected dry bean plant.

Figure 38. Dry bean plant infected with SWB. Note soil and white mycelium adhering to stems of wilted plants after being removed.

Symptoms on dry beans in Nebraska include reddish-brown cortical lesions similar to those of early Fusarium root rot infections. White mycelial strands may grow over lesions or into stem piths (*Figure 37*). Soil and mycelium also may adhere to stems when wilted plants are removed (*Figure 38*).

Favorable Environmental Conditions

The pathogen has been found most commonly in snap beans and cowpeas in irrigated, multiple cropping systems following corn. The pathogen is favored by high temperatures, although it has been reported to cause disease at temperatures varying from 60 to 95°F. It has been demonstrated to survive at least one year in soils, likely in colonized residue of weeds, corn, or other susceptible crops. In Nebraska, the pathogen also has been isolated from potatoes, sugarbeets, and wheat. These are all crops commonly grown in rotation with dry beans, illustrating the potential problems that may arise on dry beans or other susceptible crops due to the pathogen's survival ability on crop residues.

Management

- Disease has been shown to be less severe after plowing compared to reduced tillage practices.
- Crop rotation is not likely to be effective due to an apparently large host range.
- Management with fungicides has not been investigated.
- Soil solarization or fumigation would likely eliminate the pathogen, but would not be economically practical.
- Disease is thought to be of minor importance to Nebraska dry bean production.

This publication has been peer reviewed.

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