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NebGuide
University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources
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G1522

Damping Off of Seedlings and Transplants

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The two most common pathogens causing damping off diseases of seedlings and transplants are discussed, including how to manage soil conditions to reduce potential problems.

The shift toward more ecological means of pest control is a driving force in research and in growers' fields. Growers need to understand how the various pathogens causing plant disease respond to environmental conditions and cultural practices – what keeps the level of disease below an economic threshold and how these conditions can be developed and maintained for more sustainable production. This NebGuide provides information on two common pathogens that cause seedling disease (damping off) in many crops. Although vegetable production is used in the examples, the principles apply to many cropping systems.

Many growers observe damping off of seedlings in the spring, especially in watermelon, cantaloupe, and pepper seedlings or transplants. Only part of the problem can be blamed on the weather or factors beyond grower control. Pathogenic fungi in the soil that attack weakened or stressed young plants cause seedling diseases. The first symptom of damping off is failure of seedlings to emerge. The seed may rot or the seedling may have a dead or damaged radicle (primary or seedling root). Once emerged, young seedlings may wilt when soil moisture should be adequate or the stem may collapse. You may notice a lesion at the soil line. Seedlings may be stunted or not be vigorous. Young roots may be brown, black, or few in number. Damping off is actually caused by one or more of the following pathogens: *Rhizoctonia*, *Pythium*, *Fusarium* and *Phytophthora*. *Pythium* and *Rhizoctonia* are the most common causes for early spring seedling damping off.

The Ubiquitous Soil-borne Pathogen: *Rhizoctonia*

Rhizoctonia is a very common fungus that is pathogenic to many plants. The fungus can attack plant roots, stems, and leaves *(Figure 1)* and feed either as a saprophyte on decaying organic matter in the soil or as a parasite on living plant tissue. The fungus can live indefinitely in soil and is disseminated by any means that moves infested soil or plant debris from one location to another. As a root and stem pathogen, it is one cause of the disease known as "damping off."

Rhizoctonia has a strong saprophytic ability in soil, a high degree of pathogenicity, and wide host range. This means that it can live well in soil on decaying plant material. Since it is almost always present in soils, the goal is to minimize its opportunities to infect crops (become pathogenic). Weakened or stressed plants are more susceptible to seedling disease than vigorous plants. Sometimes the factors that reduce the growth of crops increase the growth or pathogenicity of the fungus. Cool, dry conditions are ideal for survival of *Rhizoctonia*, although given an opportunity to infect a stressed plant, it will grow within a wide range of temperatures.

Figure 1. ***Rhizoctonia*** **on snap bean stem.**

Conditions that delay maturation or retard plant growth favor development of *Rhizoctonia*. These include cold soil, wet soil, poor soil aeration, and some herbicides. While wet soil and poor soil aeration also reduce the survival of *Rhizoctonia*, the initial impact is on crop growth. As early as 1947, researchers found the severity of disease caused by *Rhizoctonia* to be directly related to the rate of seedling emergence. Thus a low-temperature or cool season crop, such as cabbage or corn, that grows quickly at low temperatures, will develop less damping off when soil temperatures are low than a warm-season crop, such as watermelon, which hardly grows at all at temperatures less than 60°F. Since *Rhizoctonia* is a very common soil fungus, scientists have spent many years determining factors that cause it to attack crop plants. *Rhizoctonia* damping off is favored by saline soil, low carbohydrate status in the seedling, low seed vitality, deep planting, and moist soil. Disease development is temperature dependent and is most severe when soil surface temperatures are 75-85°F. Because sandy soils warm up relatively rapidly, *Rhizoctonia* seedling blight is often more serious on these soils.

Rhizoctonia can infect seeds, seedlings, or larger plants. When seeds are infected, they may fail to germinate. Young seedlings may fall over at the soil line as *Rhizoctonia* often first infects the hypocotyl as it emerges from soil or infects the stem at the soil line. *Rhizoctonia* also can attack healthy

tissue. Seedlings as well as mature plants exhibit a reddish-brown lesion or canker on the lower stem that will enlarge to the point of girdling the plant, causing plant death.

As young roots mature, they become less susceptible to infection, possibly due to the formation of a waxy layer on the surface of the root and stem. *Rhizoctonia* decay moves downward through the root system. It is a drier decay process than that caused by *Pythium*. Sometimes soil particles will adhere to the mycelia of *Rhizoctonia* when the plant is gently removed from the soil. When looking for possible *Rhizoctonia* infection, look for dry, sunken, tan or gray areas on the roots or on the stem at the soil line. Often the lesion area will have a dark maroon or reddish-brown edge *(Figure 1)*.

Control

Several factors under your control can reduce the frequency and severity of damping off caused by *Rhizoctonia*:

• **Plant into soil with a temperature appropriate for the crop.** For warm-season crops, do not plant until the 10-day average soil temperature four inches deep is at least 60°F and the average for the previous three to four days has been at least 65°F. Use a narrow strip of plastic mulch to warm the transplant zone if necessary to achieve early yields. Watermelon is more sensitive to cold soil than cantaloupe or cucumber. Warm season crops should not be planted when soils are below 60°F. If using plastic mulch, check soil temperatures under the mulch early in the morning or use a maximum/minimum thermometer if there is any question what the soil temperature is in the planting zone. When cool, cloudy weather coincides with cold, wet soils, vigor of these warm-season crops is seriously compromised. Substantial seed and root exudation will occur under cool conditions, providing nutrients for the growth and pathogenicity of *Rhizoctonia (Figure 2)*. When cool, wet conditions are followed by warm, dry conditions, *Rhizoctonia* rapidly attacks roots.

• **Use fresh, high quality seed.** High quality seed will emerge quickly and develop secondary roots faster than lower quality seed. It is not normal for crop seeds to emerge erratically if they were planted at the same depth in a well-prepared seedbed. Most soil-borne disease pathogens are concentrated in the top few inches of soil. Vigorous roots will grow rapidly out of this zone, reducing seedling losses.

• **Do not apply excessive amounts of nitrogen early in the season, especially forms of ammonium such as urea or ammonium nitrate.** High nitrogen, either in the soil or in the crop, increases the pathogenicity of *Rhizoctonia*. The level and form of fertilization you choose for your crop can affect the frequency and severity of soil-borne disease. For example, *Fusarium*, *Rhizoctonia* and *Aphanomyces* (a soil-borne pathogen affecting peas) are more severe when crops are fertilized with nitrogen in the ammonium form and decreased by nitrogen in the nitrate form. However, another soil-borne pathogen, *Verticillium*, may be reduced by ammonium nitrogen. This effect is associated with the acidification of the soil by the use of ammonium fertilizers.

Figure 2. *Rhizoctonoia* on radish roots.

• **Allow at least two weeks after incorporating a green manure crop before planting a crop.** Cutting and allowing the green manure crop to dry before soil incorporation also can reduce potential seedling disease. This allows decomposition to occur prior to introducing the crop seeding and its vulnerable initial seedling root. Since *Rhizoctonia* can be both parasitic and saprophytic, the inoculum density of *Rhizoctonia* in the soil may increase during decomposition of the green manure crop. Grass cover crops will reduce the inoculum potential of *Rhizoctonia* while clover and other leguminous cover crops can increase this pathogen. Crop rotation is an essential component for disease management and is especially important in high-value horticultural crops which often are small-seeded and less vigorous than agronomic crops.

• **When growing your own transplants, be sure to use a sterile potting mix.** Practice good sanitation by keeping the area clean and free from plant and soil debris. If you encounter damping off during transplant production, discard any mix from these trays and infected plants. Exercise caution in using any seedlings adjacent to the area of infestation in that tray and adjoining trays. Be sure to wash well and disinfect the trays with a 10 percent bleach solution between each crop.

• **Avoid using herbicides that affect root development (e. g., trifluralin, alachlor, metolachlor, ethalfluralin), especially if planting in cool soil or under cool, cloudy conditions.** Use postemergence herbicides after plants are established and/or cultivation for weed control. In general, herbicides affect seedling disease by their activity on the plant, not the fungus. They frequently alter the nutrient composition of the root exudates and also may increase the amount of exudation by weakening the cellular structure of the roots. Roots and seeds constantly exude nutrients into the soil/root interface. Vigorous root development and crop growth through the seedling stage allows the roots to escape the infested soil zone and develop lignin and waxes on tissues exposed to the soil, forming a barrier to pathogen penetration.

• **Use fungicide-treated seed.** Both PCNB and Captan® offer some protection against *Rhizoctonia*. Thiram and Ridomil® also have some activity against *Rhizoctonia*. Ridomil® is more effective on *Pythium* than on *Rhizoctonia*.

Another Seedling Pathogen: *Pythium*

High soil moisture levels are a key factor for the soil-borne pathogen *Pythium* to become a problem. It is classed as a "water mold" – the fungal class Oomycetes. These are very simple, primitive fungi with motile spores that require free water to move to new plants. Another common pathogen in this group is *Phytophthora*, the cause of late blight in potatoes and other crops, and *Plasmopara*, the cause of downy mildew in grapes. Others cause diseases in peas, sugarbeets, spinach, and other crops. Although *Pythium* can infect foliage, this discussion focuses on soil-borne *Pythium* that causes seedling damping off.

Pythium lives in the soil, feeding on dead organic matter or on young seedlings. Pythium grows particularly well in wet, alkaline conditions. In cool temperatures (50-68°F), the fungus produces many motile zoospores asexually – a microscopic population boom of infectious agents with very rapid reproductive cycles, each zoospore forming dozens more. At higher temperatures, above about 70°F, sexual reproduction occurs. This is a relatively slower process. The motile zoospores require free water to swim, which is one reason why disease epidemics occur when fields are saturated or very wet for days at a time. In production systems using drip irrigation, *Pythium* damping off often is characterized by sections of transplants dying in a linear or elongated oval pattern tending to run down the rows more than across rows due to the drier soil in the middle of rows. A resting spore stage of *Pythium* can persist in water supplies infected by field run-off. It is also a common problem in hydroponic production systems. Low, poorly drained portions of fields can develop damping off problems, especially in wet seasons.

Sometimes older plants become infected with *Pythium* through small feeder roots. From there, the infection spreads into the taproot. A soft, gray to brownish-black surface rot up to the soil surface or slightly beyond is characterisitic of the seedling disease caused by *Pythium*. The outer root tissue "sloughs off" leaving the central core when the root is slipped between two fingers. Infected plants appear stunted and pale yellow-green above ground. In very moist weather, a foliar blight may occur as the Pythium fungus infects the apical or axillary buds. Affected foliage appears watersoaked, dying and desiccating rapidly. The disease progresses down the plant canopy, girdling stems and killing all foliar parts beyond the point of girdling.

Rapid growth and rapid maturation of seedlings are different processes. Since *Pythium* has difficulty in infecting mature stem tissue, growth and maturation are important in avoiding infection. When excess nitrogen is applied, growth is rapid but maturation is not. Fertilizer applied at planting should be balanced in nitrogen, phosphorus, and potassium. A 1:2:1 ratio is commonly recommended since the phosphorus (P) assists in stem maturation. Seed should be planted as shallow as feasible for the particular seed and watered in the morning to evaporate surface moisture more rapidly. Planting on raised beds improves soil drainage and aeration and can reduce *Pythium.*

Pythium generally infects root tips first and moves upward. Frequently, the outer part of the rotted root will slip off, leaving the inner core as a string. Once the root becomes infected, another environmental factor comes into play. When roots are subjected to cool temperatures, especially at the plant's threshold of temperature tolerance (less than 60°F for melons, peppers, and other warm-season crops), the membranes in the root cells lose some structural integrity and become "leaky". What leaks out are the contents of the cells – carbohydrates (sugars and starches) and proteins (amino acids) plus various natural growth regulators that are synthesized in the root. *Pythium* and other soil-borne plant pathogens are very opportunistic and use these readily available nutrients to grow and reproduce. Under cool stressful conditions root cells in certain crops alter the ratio of carbohydrates and proteins toward higher carbohydrates. If you have a dense stand of seedlings or transplants, the fungi just feed and multiply and the offspring (zoospores) move from plant to plant in the water – soil water and flowing water from run-off or irrigation. Recently cut rye windbreaks or other plant debris lying in the field will serve as an excellent medium for pathogen growth. This is why *Pythium* damping off can be such a common problem during cool, wet spring weather. Soil populations of *Pythium* are often sufficient to initiate infection of crop roots under stressful conditions when root growth is slowed and plant vigor is low. *Pythium* grows best and can become a problem when soil moisture is 50 percent or greater, such as in warm, wet springs. This is one consideration when evaluating which pathogen might be the cause of damping off. Usually, sandy soils do not retain water as much as heavier soils, especially silty clays. *Pythium* is less likely to be the cause when the soil is well drained, although it certainly can occur.

Control

Encourage soil drying by using raised beds and grading fields to avoid standing water. Don't plant warm season crops too early, especially watermelon, pepper or eggplant. Rotate fields using a grass crop (corn, wheat, milo, oats, rye) after a vegetable crop for some suppressive effects on soil pathogens. Chemical control of *Pythium* is fairly effective. *Pythium* losses also can be reduced by using a seed treatment. Fungicides with specific activity against *Pythium* include metalaxyl (Allegiance®, Subdue® and Ridomil ®) and mefanoxam (Apron XL®).

Metalaxyl is an effective chemical often used more by commercial producers, due to its cost. It is often recommended when *Pythium* becomes a problem or when planting the same or similar crops repeatedly on the same land, for example, snapbean after snapbean. It can be applied either preplant or postplant, although it is more effective on root rots if applied preplant so it is in the root zone when the seed germinates. Using a banded application over the seed row reduces treatment costs. Once the plant becomes established and roots extend deeper into the soil, damping off is no longer a potential problem. *Pythium* also can infect aerial portions of the plant. In this case, post-directed sprays are possible. Generally speaking, the fungicides effective for control of *Pythium* are not particularly effective on *Rhizoctonia* and vice versa.

A Simple Test for Pythium

One way to tell the difference between *Rhizoctonia* and *Pythium* is to take the seedling or a piece of stem tissue and put it in a glass or clear plastic jar. Add a slightly moistened cotton ball, small piece of a paper towel, or tissue to increase the humidity in the jar. Put the lid on the jar and set it on the counter at room temperature for 24-48 hours. If you see a halo of white, cottony mycelia around the stem *(Figure 3)*, then you know that *Pythium* is the culprit. The mycelium will "melt" if touched with a toothpick. When left for a few more days, *Pythium* will NOT form dark-colored fruiting bodies. (*Botrytis*, another "rot" pathogen, will. *Botrytis* or gray mold is more often a cause of fruit rot rather than seedling disease.) Roots and stems infected with *Rhizoctonia* are a darker brown than the straw-colored

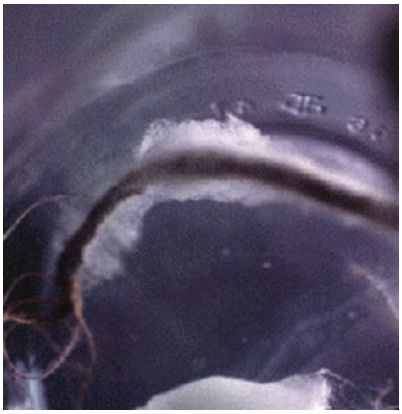

Figure 3. *Pythium mycelia* growing from a root segment after 24 hours in a closed jar. A moist cotton ball is at the lower edge of the picture.

stems of plants infected with *Pythium*. *Pythium* infects roots easily; stems are less commonly infected, at least initially. To confirm your identification send a sample to the UNL Plant and Pest Diagnostic Clinic, 448 Plant Sciences, P.O. Box 830722, Lincoln, NE 68583-0722.

Biological Control of Seedling Diseases

For years people have observed that some soils tend to suppress soil-borne diseases. Beneficial soil microorganisms are responsible for this disease suppression. *Gliocladium virens* is an antagonistic fungus that can control damping-off caused by the fungi *Pythium* and *Rhizoctonia*. It is available as a seed treatment or a soil drench for greenhouse production. Tests showed *G. virens* would be useful in the greenhouse production of bedding plants. Commercial formulations of *G. virens* strain G1-21 are now available for control of damping-off and root rots of ornamental and food crop plants grown in greenhouses, nurseries, and interior gardens.

Natural factors limiting the number of soil-borne pathogens occur through a combination of antagonism by other soil fungi and bacteria, natural release of antibiotics from other bacteria and fungi, and by competitive exclusion of habitat in the root zone or rhizosphere. One fungus, *Trichoderma* spp., has been extensively studied and a particularly virulent strain is available for biocontrol of seedling diseases. *Trichoderma* is attracted to other fungi and then excretes a chitinase enzyme that degrades the cell walls of many fungi. Various strains of Trichoderma exist naturally in agricultural soil, dung, decaying plant material, and composts. At this time, the commercial products containing *Trichoderma* do not offer complete or rapid control, especially in field situations. They perform best with containerized nursery or greenhouse crops. Commercial use of *Trichoderma* is also relatively expensive, although as a root colonizer only a small amount is needed per seed. Biological control of soil-borne diseases is an active area of research and development and new products and formulations will be available in the future. More information on the use of *Trichoderma* for seedling root diseases can be found in a University of Connecticut publication *Trichoderma* for Control of Soil Pathogens, at *http://www.hort.uconn.edu/ipm/veg/htms/trichoderma.htm*.

Numerous other fungi and bacteria are being evaluated for effectiveness for biological control of soil-borne diseases. Once an effective organism is identified, extensive research is necessary to develop commercial production or propagation techniques for the biological control agent and the most cost-effective and efficient method to apply the control agent. Roots are continually growing, so fungi and bacteria, such as *Trichoderma* and *Bacillus subtilis*, that are applied as seed treatments and grow along with the roots are most promising.

Summary

Damping off occurs when young seedlings or transplants are stressed and conditions favor pathogen growth. You can avoid seedling disease entirely by delaying planting of warm season crops such as the cucurbits and solanaceaous crops until soil temperatures are reliably above 65°F at the four-inch depth, either under plastic mulch or bare ground. Use of raised beds improves soil drainage in the event of heavy or prolonged rains. A properly prepared seedbed and planting depth encourages rapid plant emergence and development. Fungicide-treated seeds or the use of biocontrol agents as seed treatments in the greenhouse can provide additional protection against crop loss due to damping off. Understanding the conditions that favor crop seedling growth and inhibit or slow pathogen growth and infection of plant tissue will enable you to have uniform stands of vigorous seedlings. Additional information and currently available commercial products effective against seedling disease can be found on the Internet at the sites listed in this NebGuide.

Resources

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Issued September 2003

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