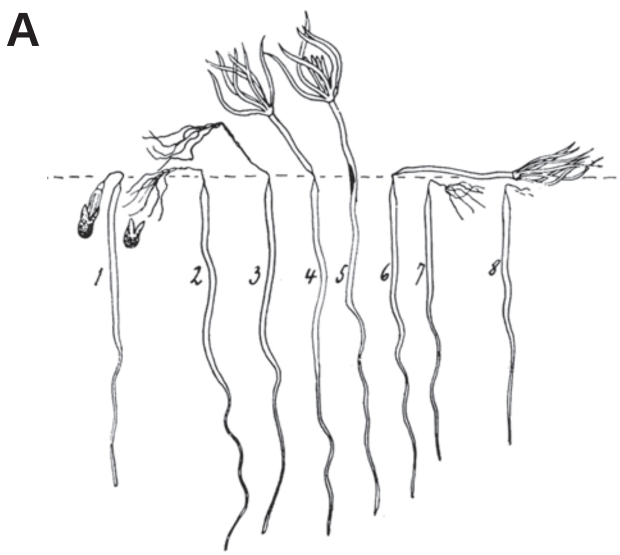
Forest Nursery Pests: Damping-off

by Thomas D. Landis

Damping-off is a historical term that refers to the decay of germinating seeds and the stems of young seedlings (Figure 1A). It is also one of the oldest nursery problems—damping-off is the only disease discussed in detail in the classic nursery manual Nursery Practice on the National Forests (Tillotson 1917). Damping-off was considered "the most serious difficulty encountered in raising coniferous seedlings", and was the subject of one of the first comprehensive nursery pathology studies (Hartley and Pierce 1917).



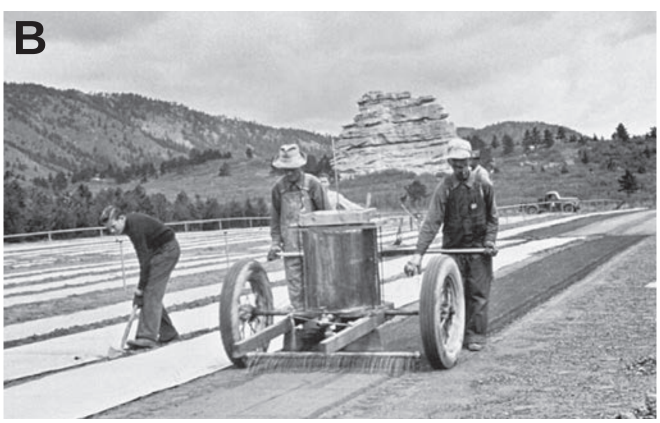


Figure 1 - The classic symptoms of damping-off include seedlings that topple over before their stems can become lignified; in this case, caused by heat injury (A). This disease was the major cause of seedling mortality in early nurseries, and research showed that lowering soil pH with direct applications of sulfuric acid was effective (B). (A - modified from Levitt 1980).

This early research revealed that lowering the pH of nursery soils helped to reduce damping-off losses, which at that time involved applying sulfuric acid directly to the seedbeds—a technique that would be frowned-upon today (Figure 1B).

1. Diagnosis and Damage

Two different types of damping-off are recognized (Figure 2), and these diseases affect plants in both bareroot and container nurseries:

1.1 Pre-emergence damping-off

This disease affects seeds and germinants before they emerge. Pre-emergence damping-off is a difficult disease to diagnose because the affected seeds are not visible; consequently, the losses are often attributed to "poor seed" (Baker 1957). If the germinants have not emerged after a reasonable period, the seed should be excavated and examined; if the seed contents are decayed, then damping-off fungi may be involved (A in Figure 2). Sometimes, germinating seeds are killed after the radicle has emerged (Figure 3A).

1.2 Post-emergence damping-off

This affects young seedlings until their stems become woody. The classic symptoms of post-emergence damping-off (B in Figure 2) include decay of the seedling hypocotyl at the ground line, causing the seedling to topple over (Figure 3B). Post-emergence damping-off symptoms can differ between different types of seedlings. With broadleaved species, the disease is expressed as necrotic areas at or below the groundline; infected seedlings wilt and die, but they often remain upright or break off just above the groundline. The symptoms of post-emergence damping-off of conifer seedlings occur at or slightly below the groundline and result in water-soaked, brownish or blackish lesions that rapidly become sunken or constricted. The specific pathogen causing damping-off cannot be determined on the basis of symptoms. Identification usually requires infected tissue culturing, which is important because knowledge of the specific pathogen may be useful in developing controls (James 2012a).

Other stresses such as heat or chemicals can produce damping-off symptoms; for instance, the surfaces of

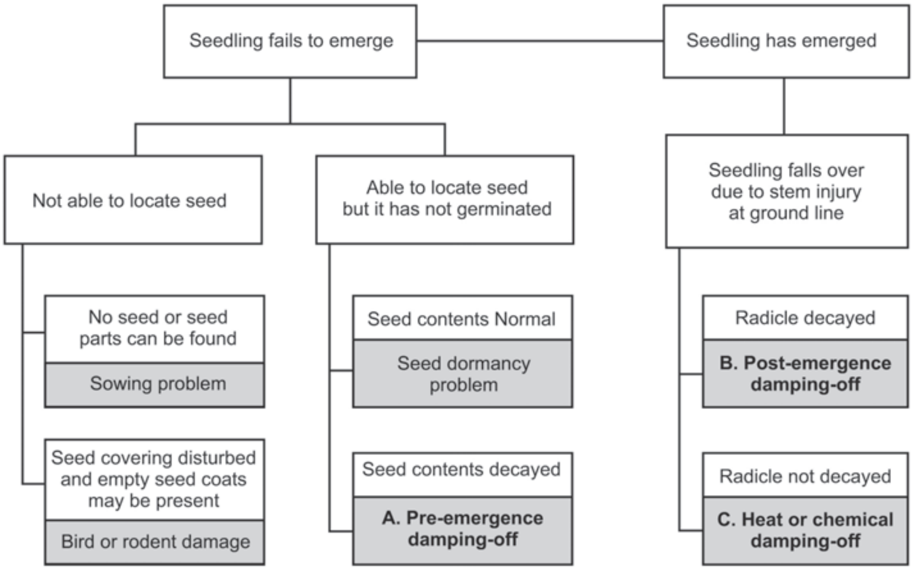


Figure 2 - Damping-off is a disease of germinating seeds (Pre-emergence - A) and young seedlings (Post-emergence - B), which also includes cotyledon blight. Although usually caused by fungi or oomycetes, stresses such as high surface soil temperatures can also cause damping-off symptoms (C) (modified from Landis and others 1990a).

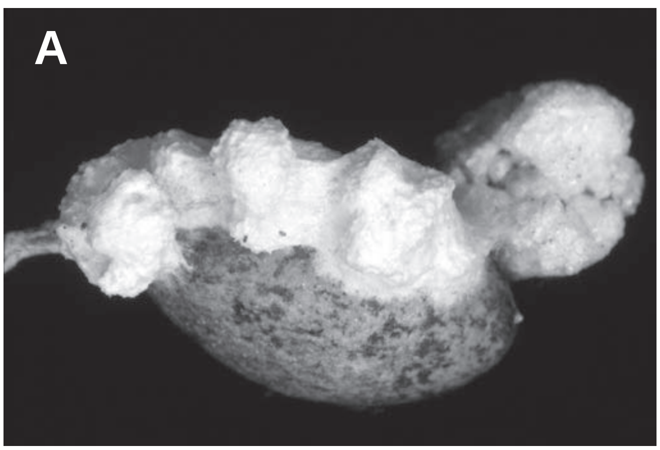


Figure 3 - In pre-emergence damping-off, germinating seeds are killed during germination—in this case by the fungus Fusarium *spp. (A). In post-emergence damping-off, decay of the stems of young seedlings causes them to topple over (B). Cotyledon blight of conifer seedlings occurs when a seedborne fungus spreads to the needle tips (C) (all photos from Landis and others 1990a).*

dark soils or mulches can become so hot that they kill seedling stem tissue (Figure 1A; C in Figure 2). The distinguishing characteristic between biotic and abiotic damping-off is the presence of decayed root tissue (Landis and others 1990a).

Another germinant disease that is usually classed with post-emergence damping-off is cotyledon blight. This decay of the tips of the cotyledons develops when seedborne fungi spread from the seedcoat during the "birdcage" stage of conifer seedling emergence (Figure 3C).

2. Hosts and Distribution

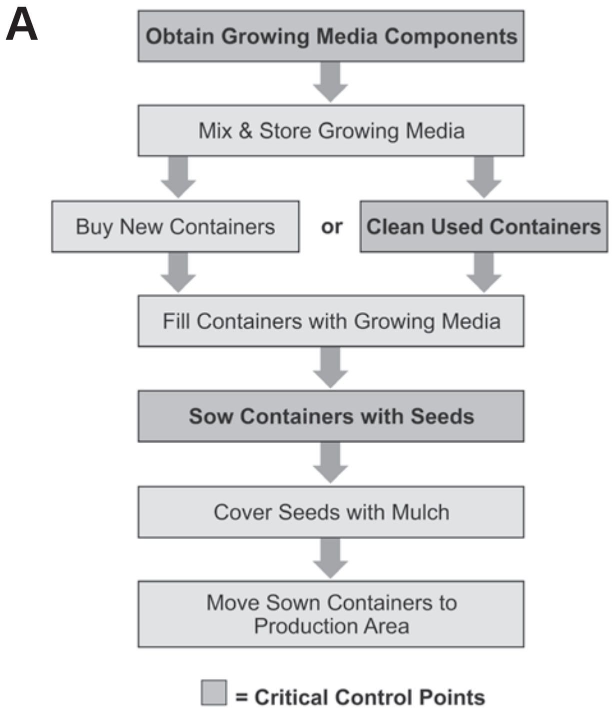
Damping-off is the most cosmopolitan nursery disease, and affects a wide variety of forest, conservation, and native plants from around the world (Table 1). Nursery stock in both tropical and temperate areas are susceptible. Most conifer and hardwood plant species are susceptible to damping-off, although some plants including junipers are not affected (James 2012a).

3. Causal Agents

Fungi (*Fusarium, Rhizoctonia*) and Oomycetes (*Phytophthora, Pythium*) are the most common causes of damping-off (James 2012a). However, fungi from several other genera including *Colletotrichum, Alternaria, Cylindrocladium,* and *Cylindrocarpon* have also been implicated (Table 1). Traditionally, *Rhizoctonia* spp. has been considered to be the major cause of damping-off in ornamental nurseries (Baker 1957) and is also been found causing disease of tree seedlings in foreign countries. Why it is not more commonly isolated in the US is interesting; it could be that its presence is masked by more rapidly growing fungi such as *Fusarium* spp. (Peterson 1974). The most recent literature (James 2012a) lists the most common damping-off

Table 1 - Damping-off is a cosmopolitan disease affecting plants from around the world

Pathogen	Host	County	Source
Fusarium spp.	*Pinus nigra*	Spain	Martin-Pinto & others (2008)
Colletotrichum acutatum, Fusarium oxysporum	*Cornus florida*	USA: Georgia	Britton (1995)
Fusarium oxysporum, Pythium spp., *Rhizoctonia solani*	*Pinus nigra*	France	Camporota & Perrin (1994)
Alternaria tenuis, Fusarium spp., *Pythium* spp., *Rhizoctonia solani*	*Eucalyptus* spp.	China	Dequn & Sutherland (1994)
Rhizoctonia solani	*Caragana arborescens*	Canada	Vaartaja & Cram (1956)
Cylindrocladium scoparium, Rhizoctonia solani	*Eucalyptus* spp.	Brazil	Ferreira & others (1997)
Rhizoctonia spp., *Pythium* spp.	*Picea smithiana*	India	Singh & others (1992)
Rhizoctonia spp.	*Pinus palustris*	USA: Florida	Starkey & Enebak (2012)
Fusarium spp.	*Pinus sylvestris*	Finland	Lilja & others (1992)
Fusarium spp., *Pythium* spp., *Thanatephorus* spp.	*Eucalyptus* spp., *Pinus caribaea, Acacia* spp.	Zimbabwe	Mazodze (1994)
Phoma herbarum, Phomopsis occulta	*Larix decidua*	France	Motta & Perrin (1994)
Fusarium spp., *Phytophthora* spp., *Rhizopus* spp.	*Santalum album*	India	Remadevi & others (2005)
Colletotrichum dematium	*Fagus crenata*	Japan	Sahashi & others (1995)
Fusarium spp.	*Pseudotsuga menziesii*	USA: Idaho	James (1987)
Phytophthora spp.	*Fagus sylvatica*	Poland	Stepniewska (2005)
Cylindrocarpon destructans	*Pinus sylvestris*	Sweden	Unestam & others (1989)
Cylindrocladium scoparium	*Pinus resinosa*	Canada	Yang & others (1995)
Fusarium spp., *Pythium* spp., *Rhizoctonia* spp.	*Acacia mangium*	Phillipines	Zethner & others (1997)
Fusarium spp., *Alternaria* spp., *Pythium* spp.	*Pinus sylvestris, Larix silbirica*	Russia	Gromovykh & others (1997)



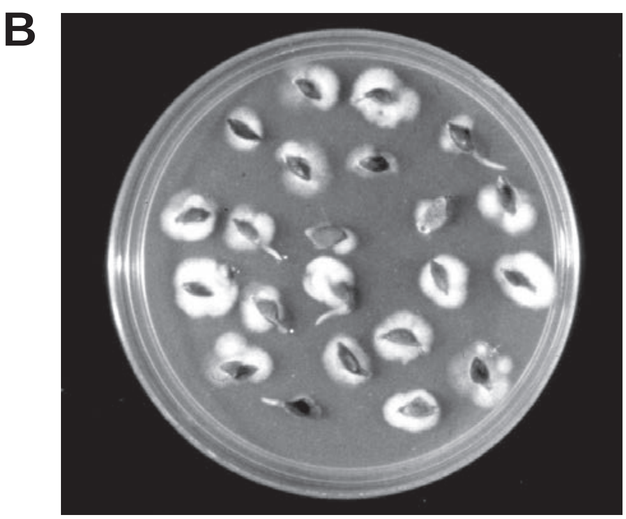


Figure 4 - The Target Pest approach to phytosanitation involves analyzing each step in a nursery operation and identifying critical control points where pests can enter your nursery. This flow chart (A) shows the critical control points where damping-off pathogens can enter a container sowing operation, and where control treatments can be applied. For example, Fusarium *fungal spores can be carried on seedcoats (B), but can be eliminated by a running water rinse or quick soak in a dilute (1 bleach:10 water) bleach solution (C).*

pathogens as *Fusarium* spp., *Rhizoctonia* spp., *Phytophthora* spp., and *Pythium* spp.

Post-emergence damping-off has also been caused by abiotic stresses that damage the succulent stems of young seedlings. Heat injury was shown to cause cankers on the stems of young pine seedlings, which produced damping-off symptoms (Figure 1A).

4. Disease Management

Damping-off is a disease that can be easily contained by good phytosanitary practices because the spores of the pathogens are spread by water, soil, or growing media rather than through the air. Using the Target Pest approach to phytosanitation (Figure 4), an effective process involves confirming the pest, learning how it spreads, and then identifying critical control points.

4.1 Type of pest and method of spread

Several genera of fungi (*Fusarium, Rhizoctonia*) and Oomycetes (*Pythium, Phytophthora*) are the most common culprits, but other fungi can also be involved (Table 1). If general controls aren't effective, then confirmation of the causal agent by culturing on artificial media will be necessary (James 2012a). The mode of transmission is very different for each pest, although spread in infected soil or growing medium is common to all species:

Fusarium spp. Spores are spread by contaminated seeds, in soil or growing media, and on used containers. The role of seed transmission can readily be seen by cotyledon blight (Figure 3C). Although airborne spores are produced, they are mainly responsible for secondary spread. Thick-walled chlamydospores help the fungus overwinter in plant debris and sclerotia are also produced (James 2012b).

Rhizoctonia spp. This fungus can be transmitted on seeds or by airborne spores, but spread by infected soil is by far the most common because the fungus overwinters in soil as sclerotia (Starkey and Eneback 2012).

***Pythium* spp.** and ***Phytophthora* spp.** These oomycetes are unique in producing zoospores which can swim in water, and both overwinter in soils or plant debris as as thick-walled oospores or chlamydospores (Weiland 2012a). Neither of these pathogens produces airborne spores, although spores can spread through water splash.

4.2 Critical control points for damping-off

Preventing the pathogens from entering your nursery is the best control but that is not always possible, especially in bareroot nurseries where all of the damping-off pathogens can persist in the soil. From a disease prevention standpoint, container nurseries are easier because containers, benches and other surfaces can be sterilized between crops (Landis and others 1990a).

Seeds. Of the primary damping-off pathogens, *Fusarium* spp. and *Rhizoctonia* spp. have proven to be carried on seeds (Figure 4B). Other less aggressive fungi, such as *Rhizopus* spp., can become problematic with some species (Table 1). Cleansing seedcoats with a running water rinse or sterilizing them with a dilute (1:10) solution of Chlorox (Figure 4C) or hydrogen peroxide prior to sowing eliminates this potential source of inoculum (Fraedrich and Cram 2012).

Soil or Growing Media. All damping-off pathogens are common soil inhabitants and so can easily holdover between crops, or they can form resting spores that can persist in plant debris for months or even years. Therefore, in bareroot nurseries, a good management strategy would be to try to sterilize soils before sowing and then use good cultural practices to keep populations low. Seedbed mulches reduce soil splash, which is one major way that *Rhizoctonia* is spread in bareroot nurseries (Starkey and Eneback 2012).

In container nurseries, most growing medium components including vermiculite and perlite are inherently sterile and the low pH of *Sphagnum* peat moss is inhibitory to damping-off pathogens (Landis and others 1990b). Bark and composts are more variable so it might be advisable to have them tested.

Irrigation or rain water. Due to their motile zoospores, *Pythium* and *Phytophthora* are most commonly spread by water. Apple or pear baits can be used to test irrigation water sources for Oomycetes and, if they are confirmed, then water treatment can be implemented. Keeping containers on raised benches prevents contact with surface water or runoff, which can be contaminated. In bareroot nurseries, selecting coarser-textured, well-drained soils for seedbeds is recommended as well as using raised beds to prevent standing water around seedlings (Weiland 2012b).

5. The Role of Environment

Most of the organisms causing damping-off are opportunistic pathogens, so disease can be lessened or even prevented by proper cultural procedures (Table 2). For example, just keeping the pH or soils or growing medium low has been an effective for preventing damping-off for more than a century (Figure 1B & 5). Likewise, keeping soils or growing media “moist, but not wet” discourages damping-off. A good discussion on which cultural practices will prevent damping-off can be found in James (2012a).

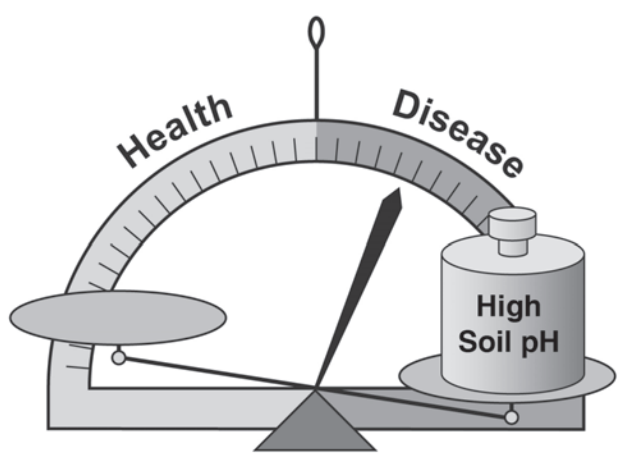


Figure 5 - Many of the pests causing damping-off are considered weak or opportunistic pathogens, which are aided by favorable environmental factors such as soils that have a high pH or don’t drain well (modified from Landis 2000).

Table 2 - Environmental conditions and cultural practices affecting damping-off in forest, conservation and native plant nurseries (modified from Landis and others 1990a).

Environmental condition or cultural practice	Effect on damping-off	
	Encouraging	**Discouraging**
Seed quality	Dirty or contaminated; slow, weak germinants	Clean and sterile; rapid germination and emergence
Soil or growing medium	Contaminated, fine-textured over-compacted, Alkaline: high pH (>6.5)	Pest-free, mixture of particle sizes, good porosity, Acidic: low pH (4.5-6.0)
Growing density	High (oversowing)	Low
Nutrition	Excessive fertilization, especially high nitrogen	Well-balanced fertilization especially phosphorus, potassium, and calcium
Irrigation	Frequent, heavy applications	Frequent, light applications: "Moist, but not wet"
Growing environment	High humidity, low light, extreme temperatures	Moderate humidity, adequate light, ideal temperatures

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