Biological Seed Treatments for Damping-off

Damping-off has the distinction of being the oldest nursery disease that I can find in the literature. It was originally named back in 1874 and, interestingly enough, conifer seedlings were one of the crops mentioned. In a classic 1921 paper, Hartley described the three different diseases that comprise damping-off: 1) pre-emergence seed decay, 2) post-emergence root and hypocotyl decay, and 3) root root of established seedlings. It is important to remember that damping-off is a disease symptom and so can have several different causes. Many native soil fungi have been implicated including *Pythiurrc spp., Phytophthora spp., Fusarium* spp., and *Rhizoctonia spp.* but damping-off also can be caused by some normally saprophytic fungi such as *Alternaria* spp. under stressful conditions. Damping-off symptoms also can be attributed to abiotic stresses such as heat and pesticides. Besides being carried in soil, spores of pathogenic fungi that cause damping-off can be introduced into the nursery environment in irrigation water; on seed; and on used containers, tools, or equipment **(Table 4).** Typically, losses become significant when some abiotic stress tips the scale of crop vigor and predisposes seedlings to attack. Mortality in excess of 50% has been reported in a bareroot seedbeds after an extended period of cool, wet Spring weather. These conditions favor the water mold pathogens *(Pythium* and *Phytophthora* spp.) which have mobile zoospores and so can quickly spread. Container nurseries are not immune either; one greenhouse reported a complete crop failure of Douglas-fir seedlings due to damping-off after the seedlings were predisposed with high surface temperatures. Managing damping-off should focus on prevention rather than on a cure because, once the symptoms are noticed, most of the damage has been done and it is too late to save many seedlings anyway. The standard preventative recommendations of selecting a well-drained soil or growing media, maintaining a low pH, and sowing at low densities will not help if the fungus is seedborne. In fact, spores which are carried on the seed is one of the primary ways in which damping-off fungi enter the normally sterile container nursery environment **(Table 4).**

Because seedborne fungi are a primary cause of damping-off in both bareroot and container nurseries, it is logical to try and remove this source of inoculum. Chemical seed treatments have been used to control pathogens on seed for centuries. The fungicide Captan has been a traditional presowing seed treatment for almost 50 years, and Thiram is still used to prevent damping-off in many Southern nurseries. The extent of phytotoxicity due to these fungicide treatments is unknown because most of the injury takes place before seedling emergence and could easily be attributed to other causes. Another limitation of chemical seed treatments is that they only work on pathogens on the seed itself, and have little if any effect on soilborne pests. An ideal treatment would be to apply beneficial microbes directly to seed becuase they could either inhibit the germination of the spores, or physically eliminate pathogens from microsites on the seedcoat. Sporeforming soil bacteria, including *Bacillus* spp. and *Pseudomonas spp.,* are commonly applied as seed treatments to several agricultural crops and have resulted in significant yield increases. The fungus *Trichoderma* spp. has been used as a soil-applied biocontrol agent for years but also is a promising seed treatment. *Trichoderma harzianum* is native saprophytic fungus that thrives in acidic soils and therefore would be ideal for forest and conservation nursery crops. Unfortunately, this fungus is less effective in sandy soils and so much higher concentrations of spores are needed for soil applications. Luckily, *Trichoderma* spp. has been shown to readily infest agricultural seeds and protect them against damping-off. In addition to its ability to colonize and persist on the seed, a successful biological control agent must be able to exhibit "rhizosphere competence" -

Table 4. Damping-off pathogens can enter the nursery environment in several different ways but fungi frequently are carried into both container and bareroot nurseries on seeds.

Source of Fungal Inoculum	Container Nurseries	Bareroot Nurseries
Seed	Common	Common
Irrigation Water	Common	Common
Soil/Growing Media	Infrequent	Common
Containers/Equipment	Common	Infrequent

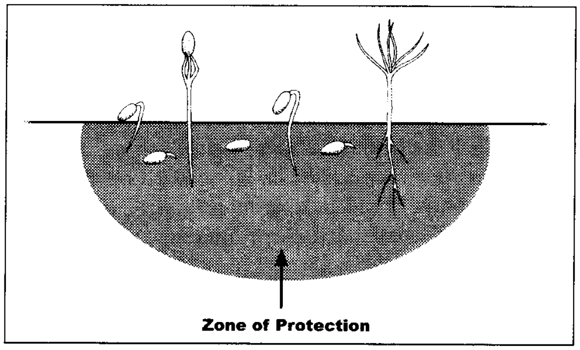

Figure 5. Spores of special strains of *Trichoderma harzianum* have been shown to protect germinating seedlings from fungal damping-off by creating a zone of protection in the rhizosphere.

the ability to spread to the radicle and thrive in the competitive environment surrounding a germinating seed **(Figure 5).** Many wild strains of *Trichoderma* are unable to demonstrate this ability but the T-35 strain of *T. harzianum* successfully colonized the rhizosphere around melon, cotton, and tomato roots to a distance of 12 cm (4.7 in.). This beneficial fungus was shown to compete with *Fusarium* spp. at the germinating root tip and significantly reduce populations of this damping-off pathogen. The T-22 strain of *T. harzianum* has been registered with the EPA for use as a seed treatment and is compatible with many synthetic pesticides used for damping-off. It also can be mass produced by fermentation to yield high quality propagules that are tolerant to desiccation, and can be applied to bulk seed with existing technology.

In conclusion, microbials are more effective than chemical seed treatments because work two ways:

1) they deal with pathogens on the seed itself
2) they spread into the rhizosphere to create a zone of protection around the germinating seedling

Research with agricultural crops has proven that strains of T. *harzianum* show considerable promise as seed treatments against damping-off. New research is developing mass production and seed application methods which will lead to more effective and less expensive products. Now, specific operational trials must be established in both container and bareroot nursery systems before their true biocontrol potential can be determined for forest and conservation crops.

Sources:

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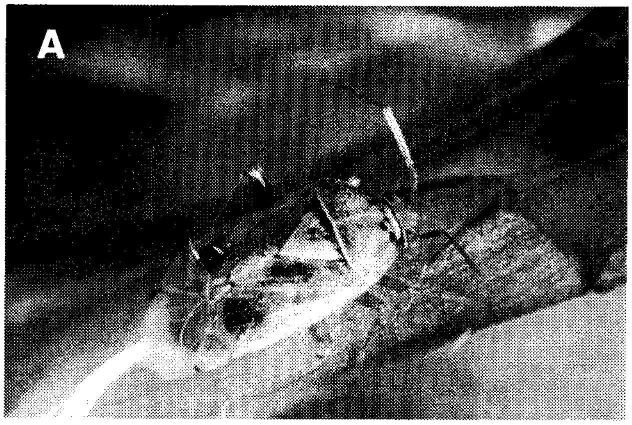
Biocontrol of Lygus bugs

Lygus bugs have been known to injure seedlings for at least 50 years but they were not recognized as a serious pests of conifer nursery crops until recently. Now that it has been properly diagnosed, damage due to Lygus spp. has been found in the US, Canada, and Europe. Because there are species of the Lygus complex found around the world, the actual extent of their damage is probably even more widespread.

The reason Lygus damage was not recognized earlier is that the symptoms were usually misdiagnosed. Both nymphs and adults **(Figure 6A)** feed by sucking the juices from succulent plant tissue, often near the expanding shoot. While feeding, they inject a toxic saliva into the tissue which causes stem lesions, distorted needles, bud abortions, and eventually multi-leadered shoots **(Figure 6B).** It is difficult to directly observe Lygus feeding because they are not active during the middle of the day and also fly readily when disturbed. The multi-leader symptoms that are the most common in conifer seedlings have been attributed to many causes including: frost, herbicide injury, viruses, nutrient deficiencies or other insects such as thrips. The extent of Lygus damage can be considerable - in a recent survey, the percentage of conifer seedlings with multiple leaders ranged from 4 to 65%. This translates directly into economic loss as seedlings with multiple tops usually end-up on the grading room floor. David South has estimated a loss of $36,000 if only 4% of a crop of 30 million southern pine seedlings had to be culled.

One of the problems with trying to control Lygus is that the insects have a wide host range including common cover crops and weeds. In many nurseries, it appears that they build-up their populations on these other hosts and then move into the succulent, well-irrigated tree seedlings later in the season. Although monitoring with sticky traps can give a general idea of when Lygus populations begin to increase, this is usually too late to avoid significant injury. Therefore, most nursery managers apply preventative applications of common insecticides.

Until now, there have been few Integrated Pest Management (IPM) options for managing Lygus bugs. Back in the July, 1991 issue of FNN, I mentioned that the J. Herbert Stone nursery was testing "bug suckers" -large, tractor-drawn field vacuums that had been used to control Lygus in strawberry fields. This cultural control is still being used but is not completely effective, and so insecticides are still required as part of their IPM program.



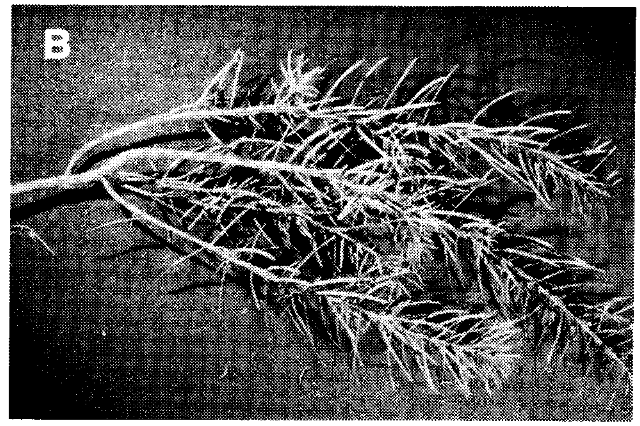


Figure 6. The feeding of adult Lygus bugs (A) and their nymphs causes distorted growth and terminal bud abortion, and often results in multi-topped seedlings (B)

Entomologists at the Beneficial Insects Research Laboratory, which is run by the USDA-Agricultural Research Service, have reported success with introducing a parasitic wasp as a biocontrol agent. *Peristenus digoneutis* is a small [6.5 mm (0.25 in.)] parasite of two native Lygus bugs *(L. lineolaris* and *L. hesperus*), which have been implicated in conifer seedling damage in the South and Pacific Northwest. The female wasp attacks the relatively immobile Lygus nymphs by laying eggs in them **(Figure 7).** In a few days, the wasp larva hatches and feeds on the host, providing a safe and effective control. The Peristenus wasps are native to Europe and have been raised at the Beneficial Insects Research Lab. They were originally released in New Jersey but have since been found in five surrounding States. Researchers think their range is probably even greater. Because Peristenus wasps only attack the target pests, they are unlikely to affect other beneficial insects. One serious problem, however, is that these wasps don't tolerate warm weather and so potential control will be limited to the northern US and Canada. Further research is now underway in the Northwest on alfalfa, strawberries, and other fruits and vegetables but it would be interesting to see how they would work in tree seedling nurseries. Anyone wanting more specifics should contact:

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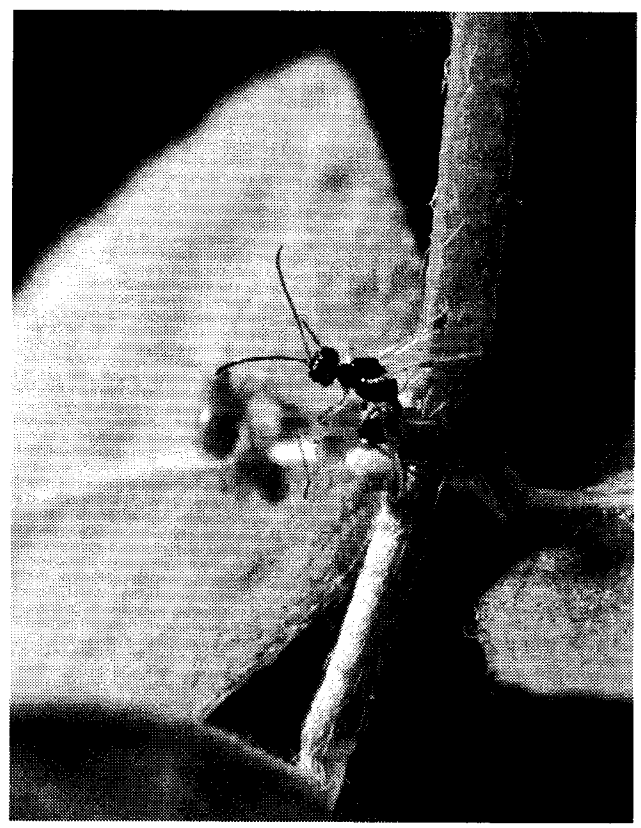

Figure 7. A parasitic wasp (*Peristenus digoneutis*) laying eggs in the nymph of a Lygus bug (*Lygus lineolaris*) (Courtesy of W. Day and S. Baeur).