Limiting Factors: Pests

As we have been discussing in the last several issues of FNN, plants need six different "limiting" factors for good growth. Four are found in the ambient environment (light, temperature, humidity, and carbon dioxide) and two (mineral nutrients and water) are supplied from the soil or growing medium. This model assumes that we are growing in a completely sterile environment which, as we all know, we don't. The nursery environment contain a myriad of microorganisms which can affect our crops either positively or negatively *(Figure 2)*. We discussed one type of beneficial soil microorganism, mycorrhizal fungi, in previous issues but potentially damaging critters are more likely to limit seedling growth. Although we try to exclude all types of pests from the nursery environment, nature abhors a vacuum, and so pests can still become a problem.

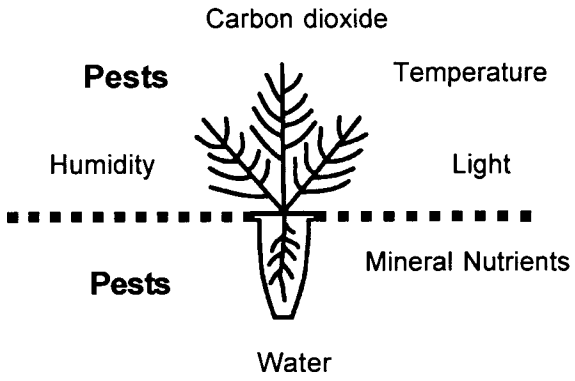

Figure 2.

Pests can become limiting factors in the atmospheric and edaphic environment.

Definitions

In forest and conservation nurseries, a **pest** can be defined as any biotic stress factor that can cause disease. Many different organisms can become pests including fungi, bacteria, viruses, animals, and even weeds, which can cause growth loss through competition for water, light, or mineral nutrients. The definition of a pest is subjective, however; an organism becomes a pest when it has a negative effect on humans or their material goods. Many nursery pests do not cause problems in the natural environment, but under the ideal nursery conditions, these normally innocuous organisms can cause disease.

A **symptom** is a general term used to describe the physiological or morphological response of the host seedling to a stress factor. Disease symptoms can be obvious, such as foliar chlorosis, or more subtle, such as reduced growth. Both pests and abiotic stresses can cause symptoms to develop. **Signs** are actual evidence of a pest-for example, the fungal mycelia that are sometimes evident on the diseased part of the seedling. Although both symptoms and signs are used in disease diagnosis, signs are more helpful because they implicate a specific organism or group of organisms, whereas symptoms may be caused by a variety of biotic or abiotic factors.

The mere presence of a pest in the nursery does not constitute a problem; pests only become problems when they cause significant economic loss. A pest that is causing minor losses is not generally considered to be a problem because the cost of treatment would exceed the economic benefit of control. The definition of a **pest problem,** therefore, is subjective in that it involves an assessment of actual economic impact, or the potential for economic impact, by the nursery manager. The prudent manager will attempt to promptly identify all potential pests and monitor their impact so that they can be controlled before they reach damaging levels.

Pest Diagnosis

Diagnosis consists of a systematic search for the causes of a pest problem using symptoms, signs,

and pattern of occurrence. Pest diagnosis consists of three sequential steps:

1. Identifying the problem
2. Diagnosing its true cause-is a pest involved?
3. Determining the impact on nursery production.

Identification requires a certain degree of experience and training. Nursery workers need a rudimentary knowledge of seedling physiology and morphology before they can detect minor deviations from the normal seedling condition. This knowledge can come from either direct experience or formal training, but ideally a grower will have a combination of both. A formal education in horticulture and seedling physiology provides a sound conceptual background, but there is no substitute for actual nursery experience. Direct "hands-on" experience with seedlings at all stages of nursery culture is necessary to quickly recognize an abnormal condition.

Early detection is extremely important for controlling nursery pests, especially for integrated pest management (IPM) programs. Nursery workers must adopt an attitude of vigilance , and make periodic inspections of the crop so that problems can be identified early. Many pests are difficult to eradicate once they become established. Most nursery pests cause readily identifiable symptoms such as discolored foliage, but many problems do not become evident until irreversible injury has already occurred. This is particularly true for root problems because foliar symptoms only develop after the roots are already severely damaged. Minor stunting or undetectable growth loss is especially difficult to diagnose unless the grower has some type of growth standards for comparison. Seedling measurements, such as shoot height, stem caliper, and total dry weight, should be taken regularly and growth curves constructed for each seedling species so that "normal" growth patterns can be established. Growth of subsequent crops can then be compared to these growth standards and potential problems identified.

Steps in pest diagnosis

A systematic approach to diagnosis of disease or pest problems is most effective ***(Figure 3)***. The following procedure requires only a 5 or 10 power hand lens, a sharp knife, and an inquiring, open attitude. Regardless of the available equipment, the most important attribute in pest diagnosis is "the ability to observe accurately." If possible, make the diagnosis with other members of the nursery staff, especially those in charge of day-to-day cultural operations, because they may be able to relate the symptoms to some recent cultural or climatic incident.

1. Check all parts of the seedling for symptoms and determine what parts are actually affected. Frequently, foliar symptoms are an indication of root disease, so remove the seedling from the soil or container and carefully check the root system. Note the symptom pattern on the seedling itself-is one part of the shoot or root system affected more than another?

2. Determine whether all species or seedlots within a species are equally affected. Abiotic problems usually affect several different species of seedlings, whereas pest damage is often restricted to one species. Environmental stresses are nondiscriminatory, but pests are often host-specific. Exceptions to this general rule do exist, however. Frosts can injure one species or ecotype, and there apparently is a genetic predisposition to other types of abiotic injury, such as pesticide phytotoxicity. When only a single, occasional seedling is affected, the problem is usually genetic.

3. Note the symptom pattern within the propagation area and whether it is random or regular ***(See Table 2)***. Are these areas related to any

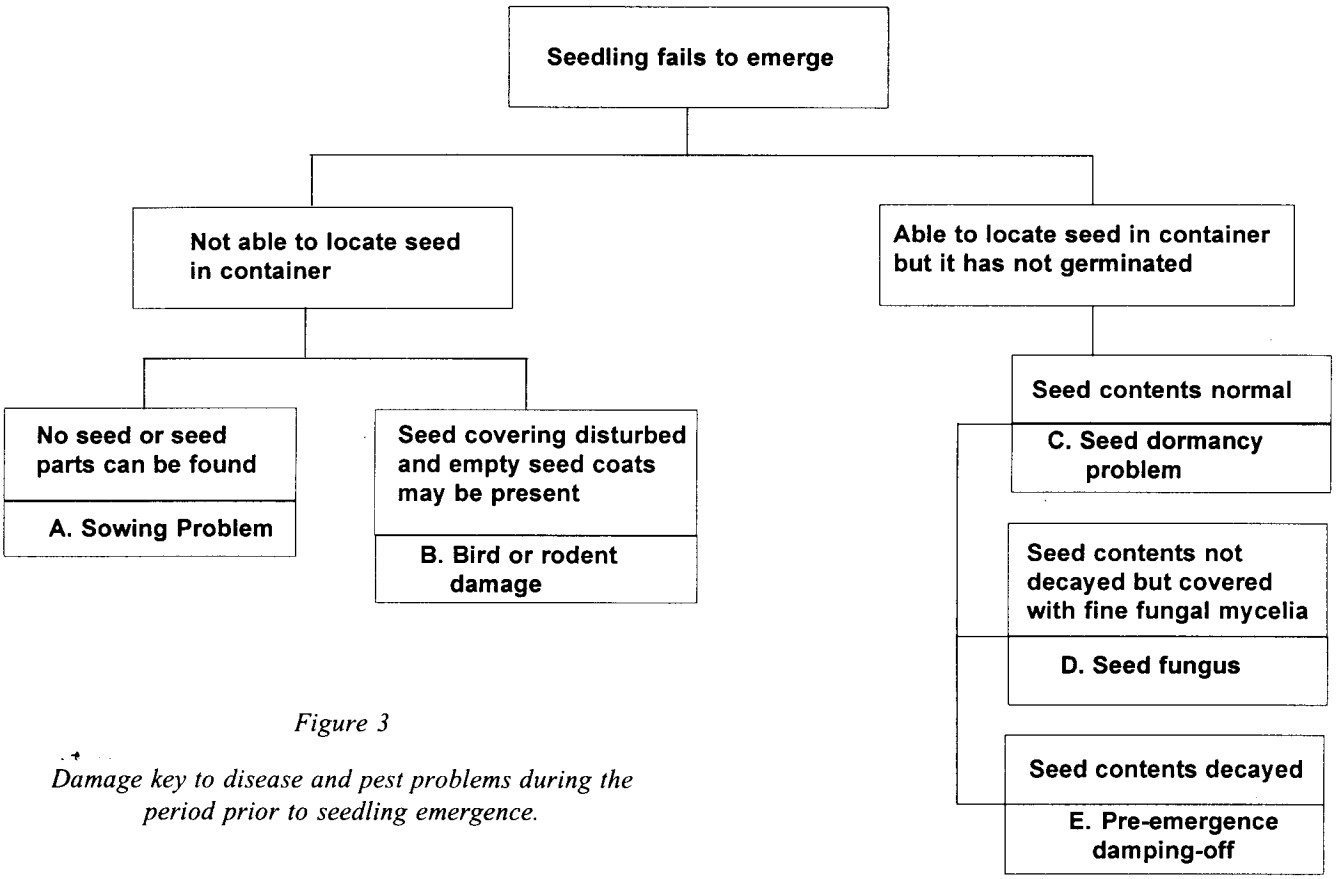

Figure 3

Damage key to disease and pest problems during the period prior to seedling emergence.

cultural operation such as the irrigation application pattern or to structural features in the propagation area? Abiotic problems are usually expressed in a regular pattern that can be correlated to some cultural factor such as container type or position in the seedbed. Pest damage is often initially random in distribution because of fungal inocula randomly introduced from the air or on seeds, and some species of insect only damage one seedling. Disease "pockets" are diagnostic because they typically result from the secondary spread of a fungal pathogen.

4. Check several symptomatic seedlings thoroughly with a hand lens for signs of a pest. Fungal mycelia or fruiting bodies are sometimes visible on the affected tissue. Check at different times of day because most insects are quite small and some species are only active at night. Collect specimens of any potential pests for subsequent identification.

5. Always consider the possibility of abiotic damage. Check cultural and weather records and ask nursery workers about any unusual incidents. Examine the soil or growing medium for evidence of adverse conditions such as waterlogging (sour smell or excessive growth of algae) or salinity build-up (white crusts on the soil surface or around the bottom drainage hole of the container).

6. Establish the disease history. When did the symptoms first appear? Is this problem new or has it been observed before? Try to correlate these facts with cultural or weather records. Abiotic problems are usually related to a particular damaging incident and their symptoms usually develop rapidly, whereas pest problems develop more slowly and may spread over time if environmental conditions are favorable ***(Table 2)***.

Disease characteristics	Type of Problem	
	Abiotic	Biotic
Hosts	Often affects several species or ages of seedlings	Usually restricted to one species and age class
Symptoms		
Pattern within growing area	Regular: spatially related to some environmental factor	Random locations initially
Rate of development	Rapid and uniform	Relatively slow and uneven
Signs	No evidence of a pest	Evidence of a pest may be present
Spread	Related to one incident with no secondary spread	May spread over time if conditions warrant

Table 2. Characteristics used to diagnose biotic problems (pests) from abiotic ones.

7. Document your analysis of the problem with written notes and color photographs if possible. Many times symptoms or signs will change over time, or other saprophytic organisms may colonize the affected tissue and obscure the true cause of the problem. Collect diseased seedlings to send to a pest specialist for confirmation.

Insect pest problems are particularly difficult to diagnose because the insect is often gone by the time the symptoms become obvious. Diagnosis of insect-caused root injury is especially difficult because many root feeding insects, such as root weevils, have larvae that live in the soil or growing medium and adults that are active only at night. Insect problems can often be diagnosed by monitoring their populations within the growing area. Because they are so mobile and often nocturnal, the presence and abundance of many insect pests can be monitored with pheromone traps or yellow stick cards.

After completing your diagnosis, it is a good idea to contact other local nurseries to see if they have had similar problems. It may be that the pest problem has already been identified, and effective control measures already tested and established.

Assistance with pest problems.

Experienced nursery managers can diagnose common pest problems in their nurseries and initiate proven treatments. It is a good idea, however, to have this tentative diagnosis confirmed by a pest specialist because many nursery diseases are relatively complicated, and may involve more than one pest or a predisposing environmental stress factor. Accurate pest diagnosis is essential before proper control measures can be designed, and an improper diagnosis could lead to additional seedling losses if the wrong control treatment was applied.

Many fungal diseases cannot be accurately diagnosed until the causal organism is isolated from the diseased tissue and grown on an artificial medium, because the symptoms of many diseases are similar. For example, a particular shoot blight of conifer seedlings can be caused by either of two genera of fungi: *Sirococcus* spp. or *Sphaeropsis* spp. These fungi can only be differentiated microscopically by examination of the fruiting bodies in slides of fresh diseased tissue or of cultures: the spores of *Sphaeropsis* are larger and darker

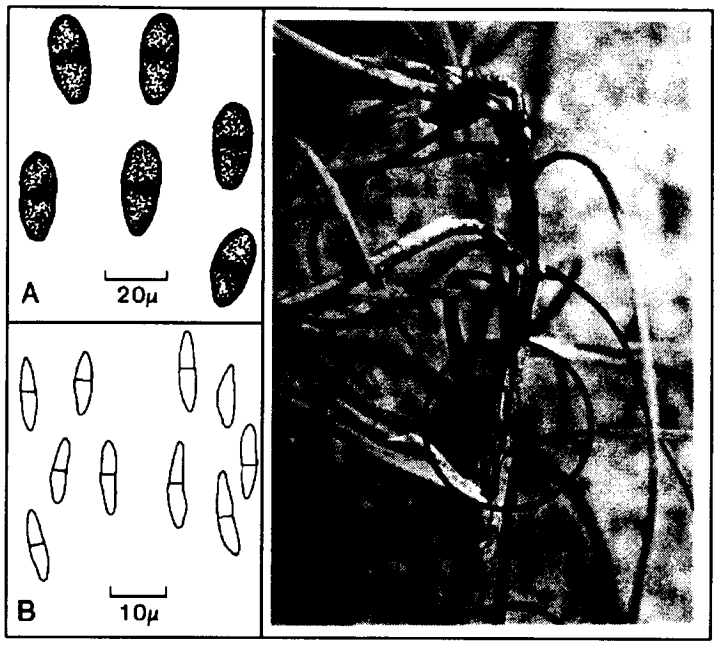

Figure 4.
*Diseases cannot always be definitely diagnosed by symptoms alone; this shoot blight (**symptom**) could have been caused by either of two different funal pathogens. Positive diagnosis requires culturing the fungus from the black pycnidia (**sign**, circle) and identifying it, based on spore characteristics, as eiter Sphaeropsis sapinea (**A**) or Sirococcus strobilinus (**B**).*

than the spores of Sirococcus ***(Figure 4)***. This isolation procedure and taxonomic identification require the special laboratory equipment and techniques of a trained pest specialist.

Assistance with disease and pest problems is available from a variety of sources, including private pest consultants, State and Provincial forestry organizations, the extension service of State agricultural universities, and Federal forestry organizations. Pest specialists in the United States Government are located in the regional offices of the State and Private Forestry Division of the USDA Forest Service. Canadian nurseries should contact the pest specialists at their local office of the Canadian Forestry Service or Provincial extension personnel.

Collection, storage, and shipping of disease samples.

Most disease and pest diagnoses require careful examination of the affected seedlings by a trained pest specialist, and so disease samples must be collected and shipped to a diagnostic laboratory. Sample collection and handling should consist of the following steps:

1. Collect samples as soon as the symptoms become evident and especially when signs develop. If sample collection is delayed, secondary organisms may become established and mask the symptoms of the original disease or insect problem. Sample the entire seedling so that the pest specialist can examine all facets of the disease. If possible, collect a series of seedlings showing a gradation of disease from healthy to severely damaged seedlings; this allows the pest specialist to make relative comparisons and estimate the disease impact. Leave container seedlings in their containers if possible so that pests in the medium or evidence on the containers can be examined.

2. Protect samples from deterioration due to heat or drying by placing the seedlings in plastic bags and storing them under refrigeration. Insects should be placed in a bottle with air holes and some plant material for food in the bottom. Make sure that all samples are properly identified with species, seed lot, age, date, description of the symptoms and signs, and any other useful information such as location in the nursery and previous cultural practices and weather conditions. Use pencil on all labels because ink often smears in humid sample bags.

3. Submit a written description of the disease problem with your tentative diagnosis and color photographs of the symptoms if possible.

4. Ship samples to the diagnostic laboratory as quickly as possible. The best procedure is to contact the pest specialist for specific handling and shipping recommendations.

Assessing disease and pest impact

The fact that a disease or pest exists in a container nursery does not necessarily mean it will affect nursery production, so an assessment of its impact is required. A disease or pest problem may not be economically serious if it remains at an endemic level or can be controlled early enough that the number of seedlings lost remains within the normal oversow factors.

The impact of a disease or pest reflects economic loss and can be measured in terms of expected growth loss or direct seedling mortality. It is simple enough to inventory dead seedlings, but growth losses are more difficult to quantify. If the growth loss is severe enough, the seedlings will not reach the desired size within the normal crop rotation, and may have to be culled. If some of the diseased seedlings are merely stunted, but have the potential for recovery; they can be held-over for additional growth, and the major impact of the disease will be the cost of the additional growing time. When the disease is infectious, the seedlings will often have to be culled even if the actual infection is relatively minor. Some fungal pests such as *Botrytis cinerea* can develop into aggressive storage molds.

The normal procedure for determining the impact of a disease or pest is to conduct an inventory of the affected seed lots and directly count or statistically estimate the percent seedling loss. A pest specialist snould be consulted to train the grading crew to recognize diseased seedlings and establish grading standards for categories such as "cull," "hold-over," and "shippable." A complicating factor with many fungal diseases is that seedlings may be infected but do not yet exhibit symptoms; these latent infections are extremely difficult to diagnose, even by a trained pathologist. Sometimes a second disease survey must be run later to identify latent infections.

Disease and pest impact information can be used to make management decisions concerning therapeutic control measures for the current crop as well as help to plan preventative control measures for future crops.

Sources:

Bohmont, B.L. 1983. The new pesticide user's guide. Reston, VA: Reston Publishing Co. 452 p.

Landis, T.D.; Tinus, R.W.; McDonald, S.E.; Barnett, J.P. 1989. The container tree nursery manual, Vol. 5: Nursery pests and mycorrhizae. Washington, DC: USDA Forest Service: 4-20.

Olkowski, W.; Daar, S.; Olkowski, H. 1991. Common-sense pest control. Newton,CT: The Taunton Press. 715 p.

Streets, R.B. 1972. The diagnosis of plant diseases: a field and laboratory manual empasizing the most practical methods for rapid identification. Tucson, AZ: University of Arizona Press. 130 p.