Diagnosis of Pest Problems

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The Process

The nursery manager has a basic knowledge of symptoms and a habit of careful observation and can usually diagnose most forest nursery pest problems. The first step in diagnosing a pest problem is recognizing that a problem exists. To do this, the manager must routinely monitor the nursery and learn what healthy seedlings look like under all conditions. Once this healthy standard has been established, the manager (and properly trained personnel) can spot abnormalities. In addition, routine monitoring allows one to catch a problem early, when it is relatively simple and inexpensive to treat and before extensive damage occurs.

The next step is determining the cause. When a problem is found, the manager should use a systematic approach to evaluate probable causes. A systematic approach is more efficient than trying to select a single causal factor out of many possibilities. The key to this approach is to consider the most probable causes first; then, as each pest is ruled out, one moves logically to the less likely causes. This point is when knowledge of pest symptoms is crucial. Before any potential causes can be evaluated, however, it is necessary to do a thorough examination of both individual seedlings and the nursery in general.

Examination of the Nursery

The nursery manager should consider the location of the affected beds within the nursery as a whole. Are there any clues based on where the problem is located? For example, seedling damage in depressions may indicate problems such as poor drainage, pests that favor poor drainage conditions, or chemical buildup. The pattern of occurrence of symptoms and signs is important. Is the problem localized or widespread? For example, a pocket of affected seedlings with a progression of symptoms from the center outward may indicate a disease or insect infestation that is spreading. In contrast, seedling damage through the entire bed may indicate a physical problem such as nutrient deficiency, frost damage, or fertilizer burn. What cultural practices have been done in the affected area? Consider root pruning, fertilization, pesticide application, and other activities in this initial phase of the diagnostic process.

Examination of the Seedlings

Perhaps the most important part of the evaluation is examining the individual affected seedlings. Look carefully at foliage, stems, and roots of seedlings.

Start with the foliage; it is usually the first part of the seedling to show visible effects of an abnormality. Often, at this point, it is possible to determine if the problem is insect or disease related. Insect damage is usually obvious; either the actual insects or their conspicuous damage to the foliage are present. The foliage may be chewed, yellowed, or otherwise deformed by insect feeding; cast skins or frass may be present on the foliage.

Most foliage diseases caused by fungi, such as needle blight of conifers, and leaf spot, rust, and anthracnose on hardwoods, are characterized by small, discrete, usually darkened necrotic areas, often with fruiting bodies of the causal fungus developing on the dead tissue. Specialists use these fruiting bodies in identifying the causal agent and prescribing controls. Some fungi that cause needle spots on conifers, such as *Lophodermium* species, do not form fruiting bodies until most or all of the infected needle dies. The presence of needle spots on pines on which fruiting bodies never develop may indicate needle infection by stem rusts. Knowing the distribution and hosts of these fungi, which can be learned from information given in this manual, may be helpful in their diagnosis.

Other foliage symptoms, such as general chlorosis and needle tip necrosis on conifers, or large irregular necrotic blotches and marginal necrosis on hardwoods, are more difficult to diagnose. Air pollution, unfavorable environmental or soil factors, or root infection may cause these symptoms.

If a problem is found on the foliage, proceed to a close examination of seedling stems. Death or discoloration of the distal portion of the seedling or branch, with the remainder of the seedling appearing healthy, is a good indication of fungus, insect, or animal attack on the stem. Discrete necrotic areas characterize infection by pathogenic fungi, usually with a sharp line dividing the healthy and infected tissues. Fruiting bodies of the causal fungi are often present. Sun scald or chemical burns may mimic damage by pathogens, but the lesions of the former are often bleached rather than dark. Insect and animal attacks are usually readily identifiable by the feeding and gnawing wounds. Seedling tops and branch tips killed by pathogenic fungi are usually brick red, whereas those killed by insect or animal girdling are straw yellow.

Stem galls on pine seedlings are a good indication of stem rust infection. But galls on hardwood seedlings are likely to be caused by insects. If girdling by pathogenic fungi, insects, or animals

occurs low enough on the stem, the entire top of the seedling will die. For this reason, it is important to examine seedlings as soon as they exhibit the first symptoms of chlorosis or wilting, when the root system may still be alive and the possibility of root problems can be more easily excluded.

Death of the entire top of the seedling usually indicates the presence of a root problem. Root-related problems are often the most difficult to diagnose because both abiotic and biotic factors can result in similar symptoms. For example, excessive soil moisture can result in symptoms similar to those from fungus or nematode attack. When seedlings exhibit symptoms, however, such as root blackening, lesions, shedding of the root cortex, or roughening of the bark on larger roots in the absence of obvious adverse soil factors, one would suspect fungus or nematode attack. Diagnosis of these problems usually requires laboratory analysis of plant tissue and soil because symptoms of most root diseases are similar and the causal agent is usually not evident from routine examination. The causal agent must be identified before proper control recommendations can be made.

Laboratory Analysis of Pest Samples

When the causal agent of seedling damage cannot be identified or when confirmation is desired, collect a representative sample and ship it to a plant diagnostic laboratory. Proper selection, handling, and packaging of samples to be submitted are crucial steps in a correct and timely diagnosis. The following guidelines will be useful in this regard:

1. Select 10 apparently healthy, 10 moderately affected, and 10 severely affected seedlings. Wrap each group of 10 seedlings in moist paper towels or similar wrapping material, label, and place them in a plastic bag.
2. Place a sample of most insects observed on the affected seedlings in vials of alcohol and include them with the seedlings. Mites, scales, aphids, and caterpillars should be sent in alive on some of the infested foliage or stems placed in a plastic bag.
3. Collect soil samples from the affected area and from unaffected portions of the beds. Separate soil samples should be obtained from the seedling root zone. Do not include the top crust of soil.
4. Ship the samples in a durable cardboard box or similar container by the fastest means available. Seedling samples should be shipped with refrigerant to prevent overheating and development of mold.

If possible, include the following information with each sample:

1. Species.
2. Age.
3. Present nursery production quantity (thousand seedlings).
4. Percent of seedlings affected.
5. Date the symptoms were first observed.
6. Names of other affected species.
7. Pesticides, with dosage rates and application dates.
8. Fertilizers, with dosage rates and application dates.
9. Possible weather problems.
10. Cultural practices recently used, such as root pruning.
11. Fumigation history (fumigant, formulation, dosage, rates, dates, and season).
12. Soil type.
13. Soil analysis results (concentrations of macronutrients, micronutrients, organic matter, and pH).
14. Signs (fungi or insects) and disease symptoms noted on the foliage, stems, and roots.
15. General development of ectomycorrhizal feeder roots.

Laboratory diagnosis of samples is usually rapid but may sometimes take several weeks. This method is a multistage diagnostic process, with time lapses between stages to allow the fungal pathogen or insect to develop under controlled laboratory conditions.

Pest Selection Key

The information included in the Diagnosis of each chapter in this manual is intended to guide the nursery manager or pest specialist to the cause of an observed problem. As mentioned previously, isolating the cause can be greatly facilitated by a systematic assessment of the symptoms and signs and other information available for a specific problem. The following Pest Selection Key (page 4) will help.

Three kinds of information are needed to use the key:

1. The part of the plant affected—seed or cone, roots, stem, and foliage.
2. The symptoms and signs observed—chlorosis, dead tops, leaf spots, swelling, or galls, etc.
3. The type of seedling on which the problem occurs—conifer or hardwood.

The numbers following the host designation refer to the chapter in the text where pests that cause the type of damage described in the key can be found. Some pests may affect more than one part of the plant, cause more than one kind of symptom, or occur on both hardwood and conifer seedlings. Cross-referencing the symptoms can eliminate some pests or problems. For example, for information about a conifer seedling with yellowing foliage (chapters 2, 3, 7, 11, 13, 14, 18, 19, 32, 34, 36, 37, 38, 41, 42, 45, 50, 51, 52, 54, and 56) and tip dieback (chapters 3, 10, 11, 12, 14, 17, 21, 32, 34, and 40), one would consult only the chapters represented in both groups of symptoms—3, 11, 14, 32, and 34.

Selected References

Anderson, R.L.; Cordell, C.E.; Landis, T.D.; Smith, Jr., R.S. 1989. Diagnosis of pest problems. In: Cordell, C.E.; Anderson, R.L.; Hoffard, W.H.; Landis, T.D.; Smith, Jr., R.S.; Toko, H.V.; tech. coords. Forest nursery pests. Agriculture Handbook 680. Washington, DC: USDA Forest Service: 1–4.

Pest Selection Key

Damage Categories			Seedling Type	
			Conifer	Hardwood
			Chapters	
Foliage	Normal color	Partly missing	21, 22, 43, 51	30, 43, 51
		Insect feeding	22, 43, 51	29, 30, 43, 51
		Insects present	21, 22, 42, 46	29, 30, 42, 46
	Foliage discolored	Stunted	2, 31, 32, 36, 37, 38, 48, 51, 54, 55, 56	31, 32, 36, 37, 38, 51, 54, 55, 56
		Spots present	1, 4, 7, 8, 10, 12, 15, 19, 50	23, 24, 25, 26, 27, 32, 40, 41, 50
		Defoliation	1, 4, 7, 8, 10, 32, 50, 54	23, 24, 25, 26, 27, 28, 41, 50, 54
		Partly dead	1, 2, 3, 4, 7, 8, 9, 10, 13, 15, 16, 18, 21, 22, 35, 55, 56	23, 24, 25, 30, 35, 40, 41, 55, 56
		All dead	1, 2, 3, 8, 11, 15, 18, 31, 32, 35, 37, 38, 55	23, 31, 32, 33, 35, 37, 38, 40, 41, 55
		Deformed	22, 42, 48, 55	23, 24, 28, 41, 42, 55
		Red/brown	2, 3, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 31, 32, 35, 37, 38, 50, 54, 55	31, 33, 35, 37, 38, 40, 50, 54, 55
		Yellow	2, 3, 7, 11, 13, 14, 18, 19, 32, 34, 36, 37, 38, 41, 42, 45, 50, 51, 52, 54, 56	28, 32, 34, 36, 37, 38, 40, 41, 42, 45, 50, 51, 52, 54, 56
		Wilted	14, 31, 33, 34, 37, 38, 40, 45, 47, 52, 54	31, 33, 34, 37, 38, 40, 45, 47, 52, 54
		Cottony or silky material present	15, 18, 21, 35, 50	28, 35, 50
		Fungal fruiting bodies visible	1, 3, 4, 5, 8, 10, 12, 16, 17, 32, 35	23, 26, 27, 28, 32, 35
		Insects present	42, 50	42, 50
		Insect frass present	21	29, 30
Stem	Swelling (galls)		5, 6, 42, 46, 54, 55	42, 46, 48, 50, 54, 55
	Bark missing		20, 35, 44, 46, 47, 51, 53	35, 44, 46, 47, 51, 53
	Stem cut or broken		43, 44, 47, 53	29, 33, 43, 44, 47, 48, 53
	Sunken areas and/or discoloration		3, 6, 11, 13, 14, 16, 17, 19, 32, 33, 34, 35, 43, 54	23, 24, 25, 26, 32, 33, 34, 35, 37, 40, 54
	Tip dieback		3, 10, 11, 12, 14, 17, 21, 32, 34, 40	23, 24, 26, 30, 32, 34, 40
	Insects present in or on stem		46	29, 46
	Stem deformed		3, 12, 13, 17, 33, 38, 48	29, 38, 48
	Fungal fruiting bodies visible		13, 32, 34	32, 34
Root	Root collar dead		3, 31, 37	31, 37
	Primary roots dead or missing		2, 32, 34, 37, 38, 47, 52, 53, 54	32, 34, 37, 38, 47, 52, 53, 54
	Fine roots dead or discolored		2, 31, 32, 34, 37, 38	31, 32, 34, 37, 38
	Fine roots missing		2, 31, 34, 37, 38, 45, 51, 52	31, 34, 37, 38, 45, 47, 51, 52
	Roots swollen		31, 36	29, 31, 36
	Roots stripped		20, 32, 34, 38, 45, 52, 54	32, 34, 38, 45, 52, 54
	Insects In or on roots		45, 51	29, 45, 51
	Fungal fruiting bodies visible		31	31
Seeds or cones			33, 34, 39, 44, 49, 53, 55	33, 34, 39, 44, 49, 53, 55
Soil	Disturbed		44, 47, 53	44, 47, 53
	Discolored		56	56