Key to Seedling Damage

INTRODUCTION TO KEY

This key was prepared to help in the identification of some of the common causes of seedling damage in bareroot nurseries. Most of the damaging agents identified in this key are described in greater detail in the chapters that follow.

Before using the key, carefully observe the seedlings in place to note patterns of damage in the field, in the seedbed, and on the individual seedlings. Then gently dig and examine a sample of damaged seedlings. Dig a sample of healthy seedlings as well for comparison.

Remove soil from the roots by gently shaking or washing them. Examine stem and root tissues for obvious signs of insect feeding or mechanical damage (pieces of bark missing, entire roots missing) or abnormalities (shrunken areas, swellings, galls). Then examine for internal discoloration (indicating tissue death) by slicing downward from the top of the shoot to the root collar with a sharp knife, exposing the cambium and xylem. The roots should also be scraped or sliced longitudinally to expose the stele. Examine needles with a hand lens if necessary for fungal structures (mycelium or fruiting bodies) or for signs of insects (webbing or insect larvae or adults).

The key outlines symptoms in a progression from the general to the specific. The general symptoms are identified with a system of numbers and letters that guides the reader through the key in a narrowing search. Specific symptoms are identified with the likely cause.

To use the key, begin with number 1. Find the statement that best fits the observed symptoms. Then proceed to the section that corresponds with the number directly across from this statement. Repeat this procedure until the likely cause is identified.

For example, number 1 offers three possible alternatives:

la. damage seen in first growing season
lb. damage seen in second or third growing season, and
lc. damage seen after storage.

If the damage at your nursery is seen in the second or third growing season (the second alternative), you would proceed to number 20 of the key. Number 20 also offers three alternatives:

20a. entire above-ground portion of seedling dead,
20b. only part of seedling top is dead or damaged, and
20c. none of seedling is dead but parts are discolored, deformed, or stunted.

If your seedlings are deformed but not dead, you would proceed to number 35. Here again you would choose the one statement of three that best fits your situation. If the needles on your seedlings are twisted, go back to number 14. Depending on the most specific symptoms listed here, your problem is likely either lygus bugs or pesticide damage.

First growing season

2a. Entire above-ground portion of seedling dead or did not emerge 3
2b. Only part of seedling dead (branches, needles, or upper stem) 11
2c. None of seedling dead but parts discolored, deformed, or stunted 13

Entire top dead or poor emergence

3a. Seed germinates poorly. Low density after emergence 4
- 4a. Ungerminated seed rotten ..... Seed fungi
- 4b. Non-emerged germinants rotten ..... Damping-off
- 4c. Germinants dead. Presence of 3-7 mm yellow-white maggot near germinant. Seen when soils cold and wet ..... Seedcorn maggot. See Minor Insects

3b. Seedlings fallen over and lying on ground 5
- 5a. Seedling tissue collapsed near soil line. Roots still in soil. Mortality occurs shortly after emergence 6
  - 6a. Killed tissue is water-soaked and constricted ..... Damping-off
  - 6b. Killed tissue appears as white spot or streak on stem. Damage seen after clear weather with high soil surface temperatures (>49°C, 120°F) ... Heat injury
- 5b. Seedling roots wholly or partially out of soil. No dead tissue near soil line. Occurs after soil surface has repeatedly frozen and thawed ..... Frost heaving. See Cold Injury

3c. Seedling is dead but does not fall over. Mortality is seen after tissue lignifies, usually mid-summer through early fall 7
- 7a. Roots healthy 8
  - 8a. Stem girdled by bark removal. No necrosis associated with wound; some callusing may be found around wound. Pattern of damage may be related to various cultural operations ..... Mechanical damage
  - 8b. No bark removed on stem. Necrotic area on stem at soil line (or slightly above or below). Stem shrunken where necrotic. Primarily on Douglas-fir; also on other species ..... Fusarium hypocotyl rot
- 7b. Roots decayed or diseased 9
  - 9a. Roots decayed from tips upward. Laterals lacking. Existing roots dark and swollen. Douglas-fir and pines most commonly affected ..... Fusarium root rot
  - 9b. Root tips, laterals, and root crown necrotic and blackened. Microsclerotia visible with hand lens in dead inner bark of roots and lower stem. Affects sugar pine, Douglas-fir, giant sequoia, and true fir primarily. Mostly in California nurseries ..... Charcoal root disease

7c. Roots missing. Main stem may be cut off just below ground line 10

10a. Damage seen shortly after emergence while seedling tissue still succulent. Seedling stem cut off at or just below soil line ..... Cutworms

10b. Damage seen in late spring and summer. Damage variable; roots not all severed at the same point and not all seedlings affected in one area. White grubs may be found in soil around roots. ..... June beetle

10c. Damage seen following root undercutting or wrenching. Roots all severed at same point. All seedlings in one area or one part of bed affected ..... Mechanical damage

Part of top dead

lla. Seen early in first growing season while seedling still succulent. Needles chewed or missing ..... Cutworms

lib. Seen in middle to late part of first growing season 12

12a. Cankers on stem or branches. No mycelium on killed tissue. Portion above canker wilted or dead. Seen in late summer or fall on Douglas-fir ..... Upper stem canker

12b. Cankers on stem rare. Needles and small branches killed. Gray mycelium on killed tissue. Most frequent in lower crown of densely sown seedlings or on tissue that was previously killed by other agents (e.g., frost) ..... Gray mold

12c. No cankers on stem. More-exposed or succulent needles and stem tissue killed. Seen several days to several weeks after frost. Often distinct pattern of damage in field ..... Frost damage. See Cold Injury

Deformity, discoloration, stunting

13a. Stunted seedlings; needles short and green; premature budset ..... Phosphorus deficiency. See Mineral Nutrient Problems

13b. New needle growth deformed; needles twisted 14

14a. Twisted needles also thickened. Terminal bud often killed, resulting in multiple leaders the following year. Vertical scars on new stem tissue. Affects several species including Douglas-fir and pines ..... Lygus bugs

14b. Twisted growth associated with pesticide applications, particularly herbicides with hormone-type action. Damage occurs at same time on all seedlings; usually some pattern of damage in field or seedbed ..... Pesticide phytotoxicity

13c. Needles discolored or scorched-appearing but not dead or deformed 15

15a. Needles yellow; seedlings may be stunted 16

16a. Roots not fully developed or not healthy 17

17a. Roots decayed or missing 18
18a. Random distribution of symptomatic seedlings ..... 9 (for 1+0), 25 (for 2+0)
18b. Circular or irregular patches of symptomatic seedlings 19
19a. Extreme proliferation of feeder root laterals (witches' broom) above feeder root terminals. Eventually all feeder roots destroyed. Douglas-fir and true firs most commonly affected ..... Root lesion nematode. See Nematodes
19b. Roots dark, swollen, and often club-tipped. Few laterals. Spruce, western hemlock, noble fir, and Douglas-fir affected ..... Baker dagger nematode. See Nematodes
17b. Roots poorly developed. Dead roots, if present, are gray, blue, or black internally. Associated with compacted or waterlogged soil ..... Compacted or anaerobic soil. See Soil Compaction
17c. Roots not fibrous. Needle tips may be scorched. Associated with high levels of soluble salts in surface soil or irrigation water ..... Salt injury
16b. Roots healthy; stem girdled ..... 8 (for 1+0), 24 (for 2+0)
16c. Roots and stem healthy. Yellowing associated with undecomposed organic material or poor nutrient status of soil or foliage ..... Nitrogen deficiency. See Mineral Nutrient Problems
15b. Needles discolored other than yellow. Nutritional analysis of seedling tissue indicates nutrient imbalance, deficiency, or toxicity ..... Various nutrient problems. See Mineral Nutrient Problems

Second or Third Growing Season

20a. Entire above-ground portion of seedling dead 21
20b. Only part of seedling top is dead or damaged 27

20c. None of seedling is dead but parts discolored, deformed, or stunted 35

Entire Top Dead

21a. Seedling stem girdled at or below soil line. Roots healthy 22
22a. Death of seedling seen before or just after bud break in spring 23
23a. Necrotic area on stem just below soil line. Associated with soil collars and low, wet areas in the nursery. Douglas-fir and true firs affected ..... Lower stem canker

23b. Stem and foliage desiccated; no clear margin between healthy and necrotic tissue in cambium and xylem. Affected seedlings exposed to dry, cold conditions previous winter ... Winter desiccation, freeze damage. See Cold Injury

23c. Dormant buds killed. Dieback progresses down stem from buds. Associated with heavy soil splash during winter. True firs affected ... Phoma blight

22b. Death or yellowing of seedling seen in late fall or winter. Areas of bark and wood removed above or below soil line ... 24

24a. Bark and wood of stem chewed, giving a ragged appearance. Damage seen 24 mm (1 inch) above and below soil surface with some upper roots chewed. Damage seen in patches in bed; may not be noticed until lifting. Douglas-fir, true firs, spruce affected ... Cranberry girdler. See Sod Webworm

24b. Stem girdled by bark removal. No necrosis associated with wound; some callusing may be found around wound. Pattern of damage may be related to various cultural operations ... Mechanical damage

21b. Roots decayed, missing, or girdled ... 25

25a. Roots missing. Main stem may be cut off just below ground line. Damage seen in late spring and summer. Damage variable; roots not all severed at the same point and not all seedlings affected in one area. White grubs may be found in soil around roots ... June beetle

25b. Roots missing. Damage seen following root undercutting or wrenching. Roots all severed at same point. All seedlings in one area or one part of bed affected ... Mechanical damage

25c. Bark removed from roots, often girdling them. Damage seen late summer through lifting ... Root weevils

25d. Roots decayed ... 26

26a. Some or all of roots dead; cambium on dead roots discolored reddish-brown. Patches of stunted dead or yellowed seedlings seen in low, poorly drained areas. Mortality occurs throughout growing season. Most species, especially Douglas-fir and true firs affected ... Phytophthora root rot

26b. Lateral root(s) killed, with necrosis frequently extending to taproot. Seen at bed ends and in wet areas. Symptoms appears in spring. Only Douglas-fir affected ... Fusarium root necrosis

26c. Root tips, laterals, and root crown necrotic and blackened. Microsclerotia visible with hand lens in dead inner bark of roots and lower stem. Affects sugar pine, Douglas-fir, giant sequoia, and true fir primarily. Mostly in California nurseries ... Charcoal root disease

Part of Top Dead

27a. Only needles damaged 28
28a. Needles killed 29
29a. Mainly lower needles (senescent or previously killed) affected. Gray mycelium seen on killed tissue ..... Gray mold
29b. On larch only. Lower needles killed. Reddish-brown discoloration of needle tips or entire needle. Fungus growth cannot easily be seen on needles. ..... Larch needle cast
29c. New flush killed. Follows below-freezing temperatures ..... Frost damage. See Cold Injury
29d. Needles wholly or partly killed. A pattern of damage can be seen in nursery beds. Damage seen shortly after pesticides applied. All species affected but white pines especially sensitive ..... Pesticide phytotoxicity
28b. Needles not killed. Discolored spots on needles 30
30a. Yellow spots on upper surface of needle; rust-red clusters of spores on lower surface. Affected seedlings in close proximity to *Populus* trees. Only Douglas-fir affected Melampsora needle rust. See Needle Rusts
30b. Light green to brown spots or bands on needles in late summer or fall. Needles turn brown and drop the following spring. Only pines affected ..... Lophodermium needle cast
28c. Insect feeding or presence of insect on foliage 31
31a. Needles missing or showing evidence of insect feeding 32
32a. Feeding on new growth only ..... Root weevils
32b. Feeding on old and new growth. Presence of grasshoppers Grasshoppers. See Minor Insects
31b. Insect webbing on new needles. Small green larvae in or near webbing Leafrollers. See Minor Insects
31c. White, cottony tufts seen on foliage or bark 33
33a. On Douglas-fir; white, waxy-covered aphid found on needles Cooley spruce gall adelgid. See Minor Insects
33b. On pines; white, waxy-covered aphid found on bark of stem and branches and on foliage Pine bark adelgid. See Minor Insects
27b. Branches or upper portion of stem damaged or killed 34
34a. Only Douglas-fir affected. New growth killed. Stem canker found at junction between 1-year-old and 2-year-old growth ..... Phomopsis canker
34b. Only pines affected. Tips of shoots killed during spring and summer of second year. Killed shoots frequently crooked over. Black fruiting bodies may be seen on killed needle or stem tissue Sirococcus tip blight or Phoma tip blight

Deformity, Discoloration, Stunting

35a. New needle growth deformed; needles twisted 14
35b. Needles discolored or scorched-appearing but not dead or deformed 15
35c. Stem swollen but no cankers, lesions, or necrosis near swollen area 36
36a. Globose to pear-shaped swellings on stem or branch. Seen late in second growing season. On ponderosa, lodgepole, and other two- and three-needle pines ..... Western gall rust
36b. Swellings on stem, frequently near soil line. Symptoms appear on all seedlings at same time. Associated with pesticide applications ..... Pesticide phytotoxicity

After Lifting or Storage

37a. Fungus growth seen on stem, roots, or foliage of seedlings 38

38a. Tissue associated with fungus growth water-soaked, yellowing, or dead. Seen after seedlings have been in lifting tubs or in storage for a period of time ..... Storage molds
38b. Tissue associated with fungus growth healthy 39
39a. Light brown to black leathery fungus fruiting bodies encircling the lower stem of the seedling — *Thelephora terrestris* (a mycorrhizal fungus)
39b. Fungus mycelium on roots; various colors and textures. Root tips associated with mycelium are short, smooth, and lobed; they are often golden brown in color ..... Mycorrhizae

37b. No fungus growth seen on seedling, but parts of stem, root system, or foliage may be water-soaked, yellowing, or dead. Seen after seedings have been in lifting containers or in storage for a period of time — Adverse storage conditions or storage molds