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Published in:
Field Guide for the Identification of Damage on Woody Sentinel Plants

DOI:
10.1079/9781786394415.0000

Publication date:
2017

Document version
Publisher's PDF, also known as Version of record

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14.1. Abiotic damage

Description: Abiotic factors can cause a variety of symptoms in shoots and buds. Symptoms commonly observed on shoots and buds include supressed or aberrant growth, discoloration (chlorosis, reddening, browning, blackening, dark lesions), wounds, dieback of shoots and the death of buds. Except for depositions (salt, chemicals) or glaze (ice), signs of abiotic damage are generally absent. Symptoms usually appear in a pattern, occurring over the whole plant (e.g., death of young shoots and buds due to frost injury) or directionally (e.g., on the side facing the source of the adverse conditions or stress). Unlike diseases and pests, damage due to abiotic factors often occurs on different plant species in the same area and does not spread from plant to plant. Dead shoots often drop prematurely, however buds frequently remain attached to shoots (and thus on the plant) after death.

Possible cause of damage: Temperature extremes such as heat or freezing temperatures during growth season, frost and ice glaze, hail storms, misapplied chemicals (fertilizers, herbicides, pesticides, salts) or adverse soil conditions (nutrient imbalance), air pollutants, desiccation due to shortage of water or winter drying (Figs. 14.1.1 – 14.1.8).

Fig. 14.1.1. Norway spruce (*Picea abies*) shoots showing frost injury. Joensuu, Finland, JW.

Fig. 14.1.2. Shoots of Nordmann fir (*Abies nordmanniana*) damaged after application of a fungicide. Rogaland county, Norway, VT.

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Fig. 14.1.3. Shoot of Scots pine (*Pinus sylvestris*) damaged by application of herbicide. Czech Republic, PK.

Fig. 14.1.4. Silver fir (*Abies alba*) shoot damaged by hail, causing death of the distal parts, scars and bruises. Austria, TC.

Fig. 14.1.5. Pine trees (*Pinus* sp.), bent by snow and ice damage (snow load). USA, MDNR.

Fig. 14.1.6. Douglas-fir (*Pseudotsuga menziesii*) bud break damaged by frost. USA, USDA1.

Fig. 14.1.7. Western white pine (*Pinus monticola*) bud damaged by cold injury (low temperature). USA, JOB.

Fig. 14.1.8. Scots pine (*Pinus sylvestris*) terminal and the youngest shoots with drying injury evident above the previous year's snow cover. USA, SK.

Additional information: Several factors causing abiotic damages can act simultaneously, and they may also co-occur with biotic damage, which complicates diagnosis. Abiotic damage can weaken the plants, making them vulnerable to biotic damaging agents (e.g., fungi or insects). If similar symptoms occur in the entire plant, the damage is more likely to be associated with the root system.

14.2. Shoot blight and dieback

Description: Shoots and/or buds are discoloured, shoots are wilted or crooked, later dead (necrotic, dry). Sometimes visible pustules occur as signs of fungal infections. Occurrence of symptoms is usually scattered in a plant, starting from a few shoots and often from the terminal shoots. Symptoms can include oozing of resin and formation of lesions on shoots.

Possible damaging agents: Fungi: Ascomycota (Figs. 14.2.1, 14.2.4); Basidiomycota (Figs. 14.2.2, 14.2.3).

Fig. 14.2.1. Shoot of Austrian pine (*Pinus nigra*), crooked and wilted by a tip blight (Botryosphaeriales, Botryosphaeriaceae: *Diploidia pinea*, formerly *Sphaeropsis sapinea*). Kansas, USA, WU.

Fig. 14.2.2. Crooked and wilted shoots of Scots pine (*Pinus sylvestris*) due to infection by a pine twisting rust (Pucciniales, Melampsoraceae: *Melampsora pinitorqua*). Värmland, Sweden, JeW.

Fig. 14.2.3. Terminal shoots of Norway spruce (*Picea abies*), crooked by a rust fungus (Pucciniales, Pucciniastraceae: *Thekopsora areolata*); later on, shoots die. Østfold, Norway, VT.

Fig. 14.2.4. Shoot tip dieback on red pine (*Pinus resinosa*), due to a blight (Diaporthales: *Sirococcus conigenus*). USA, JOB.

Fig. 14.2.5. Dead shoot of Norway spruce (*Picea abies*) with fruiting bodies of shoot tip blight (Diaporthales: *Sirococcus conigenus*). Skole, Ukraine, VK.

Fig. 14.2.6. Shoot of Douglas-fir (*Pseudotsuga menziesii*) wilting due to an oomycete blight (Peronosporales, Peronosporaceae: *Phytophthora ramorum*). USA, JOB.

Fig. 14.2.7. Dead terminal shoot of Monterey pine (*Pinus radiata*) with resin necrosis caused by pitch canker (Hypocreales, Nectriaceae: *Fusarium circinatum*). USA, DO.

Fig. 14.2.8. "Flagging" of infected terminal shoot of longleaf pine (*Pinus palustris*) caused by pitch canker (Hypocreales, Nectriaceae: *Fusarium subglutinans*). USA, USDA1.

Additional information: Shoot blight and dieback of shoots and buds generally occur together with symptoms on needles. Note that dieback and wilting of young shoots can also be a symptom of borer tunnelling in the shoots (see next page: 14.3). For pathogen collection and preservation, see Chapter 4.

14.3. Shoot and/or bud borer damage

Description: Either shoots or buds, or both, may be infested. Early symptoms on shoots often include only slight chlorosis and growth reduction, with or without swellings. Buds stop developing and may be deformed or discoloured. Later on, shoots will wilt or become malformed. Signs may also include small holes and expelled frass. Slicing of infested shoots may reveal the tunnelling larvae inside the shoot, or a hollow space where the larvae have left the shoot or bud.
Possible damaging agents: Insects: Larvae of Lepidoptera (Tortricidae: Figs. 14.3.1 – 14.3.5, Yponomeutidae: Fig. 14.3.6), Coleopteran weevils and bark beetles (Curculionidae, Scolytinae: Figs. 14.3.7 – 14.3.8).

Fig. 14.3.1. Bud of an unidentified conifer species showing hole and frass of a budworm larva (Lepidoptera, Tortricidae: *Choristoneura freemani*). USA, DMcC.

Fig. 14.3.2. Bud of scots pine (*Pinus sylvestris*) damaged by a shoot moth (Lepidoptera, Tortricidae: *Rhyacionia buoliana*). MS.

Fig. 14.3.3. Pine (*Pinus* sp.) shoot damaged by pine shoot moth (Lepidoptera, Tortricidae: *Rhyacionia buoliana*). USA, DMcC.

Fig. 14.3.4. Reddish shoots of *Pinus densata*, attacked by an unidentified budmoth larva (Lepidoptera: Tortricidae), next to healthy shoots. Lijiang, China, AR

Fig. 14.3.5. Bud of silver fir (*Abies alba*), attacked by a tortricid moth larva (Lepidoptera, Tortricidae: *Epinotia nigricana*). Briancon, France, AR.

Fig. 14.3.6. Shoot damage on thuja (*Thuja* sp.) caused by mining larvae of an arborvitae leafminer (Lepidoptera, Yponomeutidae: *Argyresthia thuiella*). Hungary, GC.

Fig. 14.3.7. Bud feeding on unknown tree species by adult pitch-eating weevil (Coleoptera, Curculionidae: *Pachylobius picivorus*). USA, WND.

Fig. 14.3.8. Boring damage to pine (*Pinus* sp.) shoot by larger pine shoot beetle (Coleoptera, Curculionidae: *Tomicus piniperda*). USA, StP.

Additional information: Borer damage may lead to stunted, forked leaders and general loss of shape. Open the bud to check larval presence and/or damage. For insect preservation, see Chapter 3.

14.4. Sap-feeder damage

Description: Sap-feeding insects or mites are usually observed in large groups and can be mobile or immobile. Indirect symptoms include reduced growth, deformation of shoots or buds, chlorotic, small spots or other discoloration with (sticky liquid) exudation.

Possible damaging agents: Insects: Adults and nymphs of many Hemipteran families (Adelgidae: Fig. 14.4.6, Aphididae: Figs. 14.4.1 – 14.4.2, Coccidae, Kermesidae: Fig. 14.4.5, Pseudococcidae: Fig. 14.4.3) and Acari (e.g., Tetranychidae: Fig. 14.4.4).

Fig. 14.4.1. Shoots of spruce (*Picea abies*) deformed by adults of shoot aphid (Hemiptera, Aphididae: *Cinara pilicornis*). Italy, AB.

Fig. 14.4.2. Stunted or curled shoots of balsam fir (*Abies balsamea*) due to twig aphids (Hemiptera, Aphididae: *Mindarus abietinus*). USA, EBW.

Fig. 14.4.3. Unidentified conifer bud covered by mealybug adults (Hemiptera, Pseudococcidae: *Dysmicoccus ryani*). USA, USNCSIP.

Fig. 14.4.4. Spruce (*Picea* sp.) buds covered by conspicuous webbing spun by spider mites (Acari, Tetranychidae: *Oligonychus ununguis*). USA, USDA.

Fig. 14.4.5. Shoot of Norway spruce (*Picea abies*) with round, reddish-brown formations covered with a delicate powdery wax due to bud scale (Hemiptera, Kermesidae: *Physokermes piceae*). Skole, Ukraine, VK.

Fig. 14.4.6. Hemlock (*Tsuga* sp.) shoots with white cottony formations due to a woolly adelgid (Hemiptera, Adelgidae: *Adelges tsugae.*), USA, EW.

Fig. 14.4.7. Shoot of Norway spruce (*Picea abies*), covered by a colony of an unidentified aphid (Hemiptera: Aphididae). Austria, TC.

Fig. 14.4.8. Shoot of silver fir (*Abies alba*) with stunted growth and browned needles due to a woolly adelgid (Hemiptera, Adelgidae: *Dreyfusia* sp.). Austria, TC.

Additional information: Honeydew (sugar-rich liquid) can attract other animals (e.g., ants) and support growth of fungi on the surface of the shoots and buds (see next page: 14.5). For insect collection and preservation, see Chapter 3.

14.5. Fungal growth on surface

Description: Dark, reddish/yellowish, whitish, powdery or cottony coverage, elevated spots or other structures on shoots and buds.
Possible damaging agents: Fungi: Ascomycota, Basidiomycota: powdery mildews, rusts, sooty moulds (Figs. 14.5.1 – 14.5.4).

Fig. 14.5.1. Sooty moulds on shoots of Norway spruce (*Picea abies*) in connection with an infestation by a scale (Hemiptera, Coccidae: *Physokermes inopinatus*). Häckeberga, Sweden, JeW.

Fig. 14.5.2. Norway spruce (*Picea abies*) shoot covered by rust fungus (Pucciniales, Coleosporiaceae: *Chrysomyxa woroninii)*. Kolari, Finland, JK.

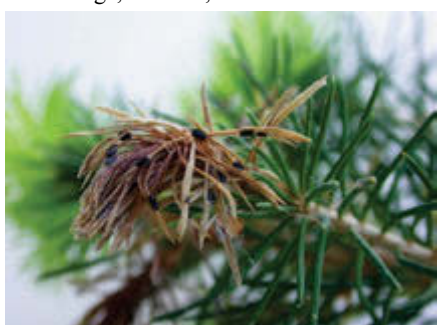

Fig. 14.5.3. Dead shoot of Norway spruce (*Picea abies*) covered by fungal sclerotia (Helotiales, Sclerotiniaceae: *Botrytis cinerea*). Southeastern Norway, VT.

Fig. 14.5.4. Dead shoot of subalpine fir (*Abies lasiocarpa*) covered by fungal fruiting bodies (Dothideales, Dothioraceae: *Delphinella abietis*). Hedmark county, Norway, VT.

Fig. 14.5.5. New shoot of Scots pine (*Pinus sylvestris*) with yellowish structures (aecia) containing aeciospores of a rust (Pucciniales, Melampsoraceae: *Melampsora populnea*). Czech Republic, PK.

Fig. 14.5.6. Shoot of mountain pine (*Pinus uncinata*) showing a thick mat of grey to dark brown mycelium of felt blight (Pleosporales, Melanommataceae: *Herpotrichia* sp.) after coverage by snow. Névache, France, AR.

Additional information: Rust fungi are obligate parasites and most of them are characterized by complex life cycles generally involving two unrelated host plants (primary host and alternate host). The sooty moulds benefit from either a sugary exudate produced by the plant or fruit, or honeydew if the plant is infested by honeydew-secreting insects or sap suckers. For pathogen collection and preservation, see Chapter 4.

14.6. Shoot galling

Description: Outgrowths (galls) or swelling of shoot or bud tissues, with insect larvae or mites inside. Depending on the causal agent and host species, galls of different size, form (regular or irregular) and colour (e.g., green, reddish, brownish or light-coloured) occur.
Possible damaging agents: Insects: Adults and larvae of Hemiptera (Adelgidae: Figs. 14.6.4 – 14.6.6, Aphididae, Psyllidae), larvae of Diptera (Cecidomyiidae midges: Figs. 14.6.1 – 14.6.3) and Hymenoptera (Eurytomidae); adults and larvae of Acari (Eryophiidae).

Fig. 14.6.1. Shoot of incense-cedar juniper (*Juniperus thurifera*), galled at the tips by midge larvae (Diptera, Cecidomyiidae: *Etsuhoa thuriferana*). Monegros, Spain, AR. Compare galls (green reddish) to young cone (blue).

Fig. 14.6.2. Shoot of bald cypress (*Taxodium distichum*), galled by cypress flower gall midge (Diptera, Cecidomyiidae: *Taxodiomyia cupressi*). Texas, USA, HAP.

Fig. 14.6.3. Galls at the shoot tips of incense-cedar juniper (*Juniperus thurifera*), due to an unidentified midge larvae (Diptera: Cecidomyiidae). Calacuccia, Corsica, France, AR.

Fig. 14.6.4. Norway spruce (*Picea abies*) shoot with "pineapple galls" caused by a gall adelgid (Hemiptera Adelgidae; *Adelges viridis*). Isoluoto, Finland, JW.

Fig. 14.6.5. Dead shoot on Norway spruce (*Picea abies*) with a dried gall caused by an adelgid (Hemiptera, Adelgidae: *Adelges viridis*). Götaland, Sweden, VT.

Fig. 14.6.6. Damaged shoot and needles (left) of Nordmann fir (*Abies nordmanniana*) caused by a woolly adelgid (Hemiptera, Adelgidae: *Dreyfusia nordmannianae*). Götaland, Sweden, VT.

Additional information: Splitting the developing gall allows collection of the developing larvae and/or adults. Galls may also contain parasites or predators. For insect collection and preservation, see Chapter 3.

14.7. Shoot and/or bud external feeding

Description: Shoots or buds are chewed or punctured from the outside by adult insects or, occasionally, by larvae. Damage symptoms can include feeding holes, shoot debarking or external chewing.

Possible damaging agents: **Insects:** Adults of Coleoptera (especially Curculionidae) but many other groups that damage needles may occasionally feed on shoots and buds (e.g., Hymenoptera sawflies and Lepidoptera: Figs. 14.7.1 – 14.7.5).

Fig. 14.7.1. Pine (*Pinus yunnanensis*) shoot with tiny feeding punctures by adult weevils (Coleoptera, Curculionidae: *Pissodes yunannensis*). Dali, China, AR.

Fig. 14.7.2. Pine (*Pinus sylvestris*) shoot externally chewed by adults of large pine weevil (Coleoptera, Curculionidae: *Hylobius abietis*). Javoriv, Ukraine, VK.

Fig. 14.7.3. Terminal and lateral shoots of pine (*Pinus strobus*) wilting (dying) due to an active infestation of white pine weevil (Coleoptera, Curculionidae: *Pissodes strobi*). USA, SK.

Fig. 14.7.4. Pine (*Pinus sylvestris*) shoot showing resin flow due to feeding by adult weevils (Coleoptera, Curculionidae: *Pissodes notatus*). Skole, Ukraine, VK.

Fig. 14.7.5. Twig of slash pine (*Pinus elliottii*) with feeding wounds of adult weevil (Coleoptera, Curculionidae). USA, JRM.

Additional information: For insect collection and preservation, see Chapter 3.

14.8. Feeding by mammals or birds

Description: Whole shoots and buds are removed from the tree. Repeated damage often causes formation of multiple stems and bushy appearance of the plants.

Possible damaging agents: Mammals: moose, deer, cattle, sheep, squirrels, rodents, **Birds**: e.g., grouse (Figs. 14.8.1 – 14.8.4).

Fig. 14.8.1. Torn edge cut of a terminal shoot of Scots pine (*Pinus sylvestris*) indicates browsing damage by deer (Artiodactyla, Cervidae). Czech Republic, JL.

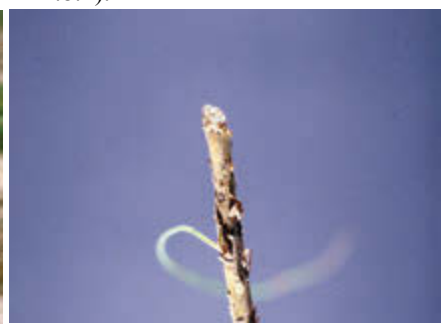

Fig. 14.8.2. Clean, slanted cut at terminal shoot of pine (*Pinus* sp.) due to rabbit (Lagomorpha, Leporidae) browsing, USA, DJM.

Fig. 14.8.3. Norway spruce (*Picea abies*) with cervid (Artiodactyla, Cervidae) browsing damage. Czech Republic, JL.

Fig. 14.8.4. Production of multiple stems in subalpine fir (*Abies lasiocarpa*) due to repeated browsing by deer (Artiodactyla, Cervidae). USA, SKH.

Additional information: Deer and sheep often leave ragged ends on shoots and always eat the shoots. Rabbits and hares leave clean diagonal cuts on ends, leaving the shoots lying (often by rabbits, always by hares). Timing of the foraging, and different signs such as faeces, tracks, or even hair or feathers around the damaged tree can be useful when identifying the causal agent. Damage signs should be photographed. For species identification, direct observation or consultation with local zoologists or game managers is needed.