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Shoot Diseases of Pine

INFORMATION NOTE

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SUMMARY

Several pests and pathogens cause damage to the shoot tips of conifers grown in the UK, often with significant economic consequences. The most commonly found shoot diseases in the UK are caused by fungi and include Brunchorstia dieback (*Brunchorstia pinea*), Ramichloridium shoot dieback (*Ramichloridium pini*) and Diplodia dieback (*Sphaeropsis sapinea*). This Information Note describes fungi that cause shoot diseases of pine and provides details on their distribution, hosts, symptoms and disease cycle. Methods of control used in the UK and elsewhere to combat these diseases are also briefly described.

INTRODUCTION

Shoot diseases of pine often lead to discoloration and premature needle loss. A number of insect pests as well as fungal pathogens can cause shoot dieback in one to three-year-old pine shoots (Gregory and Redfern, 1998), although it can be difficult to distinguish between the causal agent on the basis of symptoms. Needle diseases are also caused by a range of fungal pathogens (Brown *et al.*, 2005). The pattern and distribution of damaged shoots and foliage in the crown gives valuable clues about the agents involved, and it is important to establish if the buds of affected shoots are still alive or have been killed. Typically shoot-disease fungi affect the needle bearing stems and cause damage in the lower crown of affected trees.

Fungi which cause these diseases tend be classified in the Ascomycotina or Deuteromycotina. The classification of fungi within these groups is based largely on the way the spores are formed and their size and shape. Unfortunately these fungi often have several different types of spores. They can be produced in two ways: clonally (via asexual reproduction) or sexually (through sexual recombination). Spores produced asexually (known as the imperfect or anamorph stage) may have one name whereas spores produced sexually (often known as the perfect or telemorph stage) may have an entirely different name. The tendency for mycologists to reclassify fungal species from time to time leads to further name changes and these may differ between countries. Some of the diseases covered in this Note have no distinctive common name and so one or more of the scientific names of the causal fungal agent has been used by pathologists to refer to them. We have generally used a range of names here in order to enable readers to access other sources of literature where names different from those in common usage in the UK may be used.

In the UK the most common shoot diseases of pine are caused by *Brunchorstia pinea*, *Ramichloridium pini* and *Sphaeropsis sapinea*. Severe episodes of attack by these fungi can lead to a general loss in tree health and vigour, and also make trees more susceptible to other damaging agents. All these factors lead to a loss in value due to a decrease in growth increment and hence economic returns.

BRUNCHORSTIA PINEA: BRUNCHORSTIA DIEBACK

The pathogen

The fungus *Brunchorstia pinea* causes shoot dieback and cankers on conifers, particularly pines (Figure 1).

Figure 1 Shoot and needle dieback caused by *Brunchorstia pinea* on Corsican pine.

The name of the fungus refers to the asexual stage in which spores (conidia) are produced in fruit bodies known as pycnidia. The spores are released in wet weather and dispersed by water splash. The sexual stage of the fungus is rare in Britain but commoner elsewhere in Europe and in North America. It has been described under a variety of names; the older ones are *Ascocalyx abietina* or *Scleroderris lagerbergii*. In North America the disease is still commonly known as Scleroderris canker. In Germany and the Nordic countries the sexual stage is generally called *Gremmeniella abietina* and this name is used for what we know as Brunchorstia dieback. The sexual stage consists of microscopic fruit bodies known as apothecia, which contain spores (ascospores) that are released in moist conditions. These are then disseminated by air.

Host species

Brunchorstia dieback occurs on almost 50 conifer species representing seven genera: *Pinus*, *Abies*, *Picea*, *Larix*, *Pseudotsuga*, *Tsuga* and *Cedrus*. Pines and spruces are the most common hosts (see Table 1). In the UK, the fungus is most damaging on Corsican pine (*Pinus nigra* var. *laricio*) and Scots pine (*P. sylvestris*), and is rarely found on lodgepole pine (*Pinus contorta*) (R. Strouts, personal communication). The susceptibility of different provenances of pines and of other host species has been investigated (Aitken, 1993). Corsican pine proved the most susceptible of three pine species tested and Norway spruce was only susceptible when inoculated late in the season. Susceptibility of Scots pine species varied between provenances and infection in lodgepole pine was negligible.

Table 1

Susceptibility of *Pinus* species to common shoot diseases

Scientific name	Common name	*Brunchorstia pinea*	*Ramichloridium pini*	*Sphaeropsis sapinea*
Pinus canariensis	Canary island pine			✔
P. cembra	–	✔		
P. contorta	Coastal lodgepole pine			✔
P. contorta var. *latifolia*	Lodgepole pine	✔	✔	
P. elliottii Engelm. var. *densa*	Slash pine			✔
P. mugo	Mountain pine	✔		✔
P. nigra	Austrian or black pine			✔
P. nigra var. *laricio*	Corsican pine	✔		✔
P. palustris	Pitch/ longleaf pine			✔
P. patula	Spreading-leaved pine			✔
P. peuce	Macedonian pine		✔	
P. pinaster	Maritime pine	✔		
P. ponderosa	Western yellow pine or ponderosa pine			✔
P. radiata	Monterey pine or radiata pine			✔
P. resinosa	Red pine			✔
P. sylvestris	Scots pine	✔		✔
P. tæda	Loblolly pine			✔

In the UK, the pathogen is most damaging to Corsican pine but in recent years it has caused severe dieback of Scots pine leading to mortality. Severe outbreaks occurred on Corsican pine in the 1950s and 1960s especially in plantations in northeast England. In the late 1970s and early 1980s severe damage was also reported on Scots pine in northern England and southern Scotland (Redfern and Gregory, 1991). The disease causes serious damage in thicket and pole-stage crops of Corsican pine in any but the best sites for this species – namely those in the south and east of England (Gregory and Redfern, 1998). In Scots pine the disease is less predictable: the most serious attacks so far have been found in crops of similar age on poor sites in the uplands of northeast England and Scotland. The disease is also occasionally found in nursery stock and in recently planted trees.

Distribution

The pathogen is found in North America, Europe into the USSR and in Japan. It exists as three races: North American, European and Asian (Dorworth and Krywienczyk, 1975). The Asian race has only been found in Japan (Yokota, 1984). The North American race is found in areas of Canada, where it spreads from shoots to the main stem, forming cankers and causing serious damage to young trees. It also causes sporadic damage on the lower branches of older trees. The European race is present in North America and throughout Europe, where it kills shoots and causes shoot cankers and dieback.

In Scandinavia the disease has been recorded on Scots and Corsican pine but it has been particularly damaging on introduced lodgepole pine (Karlman *et al.*, 1994). Serious disease has also been reported on Norway spruce in Sweden where this species forms an understorey in older Scots pine stands (Barklund and Rowe, 1981). In North America, in addition to *Pinus* and *Picea* species, the fungus occurs rarely on eastern larch and balsam fir.

Disease symptoms and pathogen life cycle

The fungus is spread by airborne or rain-splashed spores, which infect through the bud scales on current shoots or through scales on the internode (Patton *et al.*, 1984). Although infection takes place from May onwards, the fungus remains latent until the autumn or the following spring when it spreads into the shoot cortex. The first observed symptom is needle browning in the spring following infection; the needles discolour from the base of the needle to the tip.

In Corsican pine resin bleeding on buds has also been observed (Read, 1968). Necrosis of the shoot cortex can be seen if the shoot is sectioned. Black asexual fruit bodies (pycnidia) of the fungus can be found on dead needles and on the needle scars and buds in the summer following infection. Apothecia (the sexual fruit bodies) form two years after infection, but they are rarely found in the UK.

Shoot dieback usually starts in the lower crown of thicket or pole-stage trees. Damage may be restricted to the death of suppressed shoots, but under favourable conditions dieback may engulf the whole tree, resulting in death. In infected crops of Scots pine, particularly those at high elevation in northern Britain, the needle-cast fungus *Lophodermium seditiosum* and the pine shoot beetle *Tomicus piniperda* may hasten decline (Gregory and Redfern, 1998).

Disease outbreaks in Europe often seem to be associated with severe climatic conditions. An epidemic in Lapland in 1982 was associated with the very cold and wet summer of 1981 (Jalkanen, 1984).

Management and control

The only practical form of control for this disease in plantations is by careful choice of site: Corsican pine should be restricted to the lowlands in the south and east of the UK. In Scots pine the disease is less predictable and site choice is more difficult. So far the disease has been most prevalent on poor sites in the uplands of northeast England and Scotland; these sites may be best avoided. Disease severity is also likely to be lower in less dense plantations with lower humidity (European Commission, 1999).

Prophylactic chemical control has been used in nurseries in the USA where spraying seedlings with chlorothalinol is recommended. Propiconazole, vinchlozolin and dithiocarbamates have also proved to be effective chemical control (European Commission, 1999). However, there are no chemicals with specific approval for use in the UK.

RAMICHLORIDIUM PINI: RAMICHLORIDIUM SHOOT DIEBACK

The pathogen

Ramichloridium shoot dieback is caused by the fungus *Ramichloridium pini*, which produces pycnidia (asexual fruit bodies) containing conidia. The sexual state of this fungus has not been found. The disease may have been present for at least 30 years in the UK but the causal fungus was not isolated and identified until 1982 (De Hoog *et al.*, 1983).

Host species

Ramichloridium pini is found mainly on lodgepole pine (*P. contorta* var. *latifola*). There is evidence of significant differences in susceptibility between provenances; various climatic and silvicultural factors may also influence the severity of the disease. A screening trial of 14 provenances of lodgepole pine was set up in south Wales in 1987. It showed that Lulu Island provenance was very susceptible to the pathogen whereas Washington provenances were moderately susceptible. Interior North Coastal provenances were the least susceptible (Rose, 1991). *R. pini* has also been isolated from necrotic shoot tissue in *Pinus peuce* showing minor dieback in a location in south Wales with many diseased lodgepole pine.

Distribution

The fungal disease affects young shoots of lodgepole pine and occurs widely in western Britain where it can cause considerable damage. The disease came to prominence in the late 1970s and early 1980s when many cases of shoot dieback were reported from sites as far apart as Cornwall and Wester Ross. Prior to this there had been accounts of similar symptoms dating back to the early 1950s, of unknown cause. It is now thought that many of these were caused by *R. pini*.

Disease symptoms and pathogen life cycle

The first sign of the disease is yellowing of needles at or just behind the top of the current year's shoots in October or November. The yellowing proceeds from the needle

base to the top (Figure 2); this distinguishes the disease from disorders such as nutrient deficiencies or cold injury. Internal examination of these shoots reveals necrotic tissues at the base of the yellowing needles and in the pith. There is also some necrosis of the buds though this may not be evident until later in the winter.

Figure 2 Yellowing of current year's needles of lodgepole pine caused by the fungus *Ramichloridium pini* on lodgepole pine.

Needle symptoms continue to appear during the winter and by March of the following year the buds and much of the shoot may be completely dead. Many of the dead needles, by now orange or red-brown, may be retained and this can make the damage very conspicuous. In a few cases the terminal buds on infected shoots are not killed during the winter and these may flush and produce a partially elongated shoot during May. Such growth is always abortive and the shoot is completely dead by June.

Initially the disease is confined largely to shoots in the lower and mid-crown but subsequently it may spread into the upper crown. In many areas the top-most whorl and the leading shoot remain healthy, but in the most severe cases these are affected and the tree may die.

When the tree becomes dormant in the autumn, growth of *R. pini* resumes and the first symptoms of needle yellowing become apparent. The fungus progressively colonises the cortex and pith and can kill the terminal bud. It is confined to the current shoot and does not spread back into older growth. After March it tends to be replaced in dead shoots by other fungi. Periods of cool, wet weather with high humidity during April and May appear to favour infection. Also, from some limited studies of adjacent diseased and healthy stands, high stocking densities (in excess of 4000 stems per hectare) appear to be linked to the most severe damage.

According to the work of Rahman (1982), infection takes place in spring when the spores produced by the fungus growing on needle or flower scars on diseased one-year-old shoots are dispersed to developing shoots. Germination and infection occurs but there is little or no host invasion during the rest of the summer over which period of time the shoot develops normally.

Management and control

Though the disease has caused significant dieback and death in some localised areas, it has not yet produced wide-scale damage in the main lodgepole pine growing areas in the UK. However, it has the potential to inflict severe losses so it should not be ignored. With existing plantations there is little that can be done to counter the disease other than reduction of stocking densities as a means of lessening the risk of severe damage. It is also prudent to avoid widespread use of susceptible provenances.

SPHAEROPSIS SAPINEA: DIPLODIA DIEBACK OR SPHAEROPSIS BLIGHT

The pathogen

Diplodia dieback is caused by the fungal pathogen *Sphaeropsis sapinea* (also known as *Diplodia pinea*). The asexual fruit bodies are small, black and ovoid, and contain conidia spores that are dispersed in water splash. The fungal pathogen affects both the needles and shoots of pines, causing deformation or death of the latter. It can also act as an endophyte and exist in living tissue without causing symptoms, or as a saprotroph and colonise dead needle tissue.

Distribution and host species

Sphaeropsis sapinea causes damage to *Pinus* in Africa, North America, Europe, Australia and New Zealand. In Europe, the disease is most prevalent in the south, and is of less importance in the more northern countries (European Commission, 1999). However, in recent years there has been an increase in the disease on both young crops and mature trees in the UK.

Two- and three-needled pines are the main hosts although other susceptible conifers include Lawson cypress (*Chamaecypris lawsoniana*), grand fir (*Abies grandis*), Norway spruce (*Picea abies*) and Douglas fir (*Pseudotsuga*

menziesii), and in warmer climates *P. ponderosa*, *P. radiata* and *P. nigra* are the most severely affected hosts (European Commission, 1999). *P. sylvestris*, *P. mugo*, *P. patula*, *P. contorta*, *P. resinosa*, *P. canariensis*, *P. elliottii*, *P. palustris*, *P. taeda* and *P. nigra* var. *laricio* are also reported to be susceptible. All recorded pine hosts are listed in Table 1.

Disease symptoms and pathogen life cycle

Only the current season's growth is susceptible to infection by *S. sapinea*. Infected shoot tips fail to elongate fully, turn yellow, brown and may curl (Figure 3). Resin bleeding occurs on the infected shoots and new shoot growth occurs below the infected part. Purple/dark brown lesions progress along and around the current year's stem and up to the junction of the previous year's growth. Needles turn reddish-brown and then grey. The fruit bodies are generally produced in late spring/summer at the base of needles infected during the previous year. However, they can occasionally be produced in the autumn following infection. Conidia are released from the fruit bodies and dispersed in water droplets (Chou, 1984). If they land on current year needles they germinate in temperatures between 10°C and 35°C, with an optimum of 24°C (European Commission, 1999). Hyphae then penetrate the needle and the symptoms of needle death and shoot death are evident during the summer. The fungus then overwinters in the dead needles (both on the tree and the ground), as well as on bark, wood and cones, and the infection cycle begins again in the following spring. If the disease occurs in successive years, dead shoots and branches can be seen throughout the crown. This can result in losses of growth increment or, in extreme cases, tree mortality (Peterson, 1981).

Figure 3 Shoot dieback and needle death of Corsican pine caused by *Sphaeropsis sapinea*.

Management and control

Chemical control in the form of benomyl and copper has proven to be effective against *S. sapinea* in nurseries (European Commission, 1999). However, there are no approved chemicals for use in the UK forest situation. As relatively high levels of humidity are required for spore dispersal and germination, thinning of the crop may also be beneficial for disease control. Plants are believed to be more susceptible to the disease when they are under stress; drought stress is thought to particularly favour the disease (European Commission, 1999).

CONCLUSIONS

In some, usually localised, parts of the UK the symptoms caused by shoot diseases of pine are striking and very damaging to some species of pine. Practical control of the diseases in plantation grown trees is usually limited to careful choice of site and provenance. The diseases tend to be most prevalent on poor sites, or where trees are stressed and species selection has not been matched to site. Disease severity may be less in thinned plantations where increased air movement reduces humidity and creates a micro-climate less favourable to disease development. Mortality is rare, but dense stands of single species are more likely to suffer from severe outbreaks compared with diverse, mixed age stands.

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For further and related information please see Forestry Commission Information Notes:

- Needle diseases of pine (FCIN067)
- Red band needle blight of pine (FCIN049)

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