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Effects of small tree retention and logging slash on snow blight growth on Scots pine regeneration

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Abstract

Inoculation experiments were performed to compare the growth of snow blight (*Phacidium infestans* Karst.) mycelium on Scots pine (*Pinus sylvestris* L.) seedlings on sites with or without undergrowth and green logging slash. Inoculations were performed on Scots pine seedlings planted within undergrowth of Scots pine, Norway spruce (*Picea abies* (L.) Karst.) and birch (*Betula* sp.). Snow depth and temperature were recorded in uncleaned and cleaned environments. No significant effect of retained undergrowth was found. However, snow blight growth was enhanced by artificially added birch stems, mimicking an uncleaned environment. There were no differences in snow depth between cleaned and uncleaned areas. Mean daily snow temperature did not differ between treatments. However, the snow temperature variation was significantly higher in an uncleaned area. Occasions with temperatures above 0 °C were equally frequent in uncleaned and cleaned environments. Temperatures above the lower limit for mycelial growth (−5 °C) were more frequent in the cleaned environment. Fresh logging slash of Scots pine enhanced snow blight infection. It is concluded that the practice to leave 1–3 m high undergrowth after harvest (in order to increase biodiversity) will probably not result in dramatically enhanced snow blight growth in Scots pine regenerations.

Keywords: Fungal disease; Environmental considerations; Low shelter; Stand residuals; Undergrowth; Cleaning; Harvest residue; Winter damage; Northern boreal forest; Snow temperature; Snow depth

1. Introduction

The snow blight fungus, *Phacidium infestans* Karst., is a primary pathogen which occurs in northern boreal Fennoscandia and mainly attacks seedlings of the native Scots pine (*Pinus sylvestris*) and, to a lesser extent, seedlings of the introduced lodgepole pine (*Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm.), because of its faster growth when young (Björkman, 1948; Kurkela, 1975; Karlman, 1986; Roll-Hansen, 1989; Hansson and Karlman, 1997). In Sweden, attacks by snow blight increase with increasing latitude and altitude, which mainly is a result of increasing snow cover (Sjöström, 1937). Björkman (1948) discusses this relation and Näslund (1986) and Hansson et al. (unpubl.) confirm this statistically.

Substantial sapling mortality occurs if several weather conditions coincide. Firstly, high mean temperatures in June–August have to be followed by a humid late autumn to maximise spore production, maturation and dispersal (Mattsson-Mårn and Nenzell, 1941; Kurkela, 1995, 1996). Secondly, the snow cover has to be deep, long-lasting, preferably on unfrozen ground and of porous consistency to be favourable to snow blight, whose hyphae have the ability to grow in pure snow (Mattsson-Mårn and Nenzell, 1941; Björkman, 1948; Roll-Hansen, 1989). The mycelium reaches approximately 20–30 cm from the infection point during one winter, leading to characteristically concentric damage in dense stands of seedlings (Nentzell, 1942; Björkman, 1948). Mycelial growth increases with increasing temperature from −5 °C up to an optimum of +15 °C and the production of "air-mycelium" is highest between 0 and +5 °C (Björkman, 1948).

The risk of Scots pine mortality from snow blight is highest when the tree is between 0.35 and 1.5 m in height (Kaasa, 1971). In a provenance trial in Moskosel, Sweden (65°56′N, 19°18′E, 400 m a.s.l.) Scots pine was snow blight infected later but more severe than seedlings of lodgepole pine (Karlman, 1986). Karlman concludes that the latter passes through the critical height interval quicker due to its rapid youth growth, and therefore is rarely killed by the pathogen. Scots pine dwarf seedlings seldom become infected by snow blight (Björkman, 1948; Roll-Hansen, 1975).

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Snow cover has an effective insulating effect. Even when air temperature just above the snow surface reaches below −30 °C, the temperature at ground level in moderate snow depths seldom falls much below 0 °C (Keränen, 1920; Björkman, 1948; Geiger et al., 1995; Bergsten et al., 2001). The insulating effect increases with distance to snow surface (Geiger et al., 1995). Sjöström (1937) observed that snow blight damage stops about 10 cm below the snow surface, where the temperature usually is unsuitable to the fungus. Furthermore, the snow temperature is highest about 10 cm below the snow surface, which leads to initial snowmelt in that section (Schlatter, 1972).

Wretlind (1934) recommends large cleaned clear-cut areas without undergrowth in order to minimize damage by snow blight. After extensive research mainly concerning the causal factors behind snow blight occurrence Björkman (1948) concludes that large clear-cuts and high shelter stands (seed trees) will reduce the risk of heavy attacks by snow blight. These conclusions were based on measurements of snow depth and snow temperature in the field and on incubation experiments in the laboratory.

Scots pine seedlings are less infected by snow blight within dwarf shrubs or *Ericacea* sp. (Kaasa, 1971), cowberry (lingonberry) *Vaccinium vitis-idaea* L. (Kurkela, 1969), grass such as *Calamagrostis* spp. and *Deschampsia flexuosa* and broad leaved trees (Krutov, 1979).

Green needles on logging slash produced in late autumn are almost always infected by snow blight in contrast to slash produced between March and August (Sjöström, 1937, 1946). From these results, Björkman (1948) concludes that harvest of seed trees should be avoided in late autumn, when there is a risk that green needles will be left around the regenerating Scots pine seedlings.

In springtime channels appear around stems that penetrate the snow cover as a result of radiative melting (Geiger et al., 1995). According to Björkman (1948), the main reasons for the recommendation of large clear-cuts without undergrowth are the low snow cover and the high snow density resulting in reduced insulating effect and hence, unfavourable conditions for snow blight. Furthermore, a snow cover penetrated by air channels around retained stems of shrubs or trees results in an increased snow temperature variation, which is believed to have a negative impact on the snow blight growth (Sjöström, 1937; Mattson-Mårn, 1944; Björkman, 1948). The question is, however, is the difference in temperature variation large enough to affect the mycelial growth of *Phacidium infestans*?

Increasing environmental considerations in Swedish forestry have resulted in rather different clear-cuts than when Björkman (1948) made his recommendations. One important difference is that large quantities of undergrowth (small trees) are left on the regeneration sites. In practice this is achieved by neglecting the cleaning of undergrowth before harvest.

The main objective was to compare the snow blight damage on Scots pine seedlings in environments cleaned and uncleaned from undergrowth. Secondly, the effects of different seedling spacings and green logging slash from late autumn harvests on snow blight damage were studied. Finally, Björkman's (1948) hypothesis that snow penetrated by stems has higher temperature variations and therefore is less conducive for snow blight infection was tested.

2. Materials and methods

2.1. Effect of small tree retention and seedling spacing on snow blight damage

Inoculations with the snow blight fungus were done on Scots pine seedlings on a clear-cut with retained undergrowth (Section 2.1.1) and on a cleaned clear-cut where small tree retetion was mimicked by adding birch stems (Section 2.1.2).

Experimental units consisting of one inoculated central 50–60 cm ‘‘primary’’ seedling surrounded by four not inoculated ‘‘secondary’’ seedlings at 0.4 m distance (from stem to stem) were used in both sub-studies. Snow blight mycelium therefore easily could grow from the branch tips of the inoculated primary seedling to the branch tips of all secondary seedlings, since it can grow approximately 30 cm in free snow (Björkman, 1948). In one sub-study (Section 2.1.2), 50–60 cm Scots pine seedlings from infection-free coastal areas near Umeå were cut, transported to the experimental site, and stuck upright into the ground. The cut seedlings were green through the winter and therefore good substrate for the snow blight fungus. New cuttings were used each winter. The use of 50–60 cm seedlings saved experimental time, since snow blight seldomly attacks recently planted traditionally sized seedlings. Furthermore, this concept made it possible to measure the maximum mycelial growth at least after one winter and, in the case of sub-study, Section 2.1.1, even after two winters.

As inoculum nylon bags with 1 mm masks with 2 g snow blight infected needles were attached to the primary seedling under the first branch whorl, approximately 15 cm above ground level. On the cut seedlings, the infection bags were placed under the lowest branch whorl before the cuttings were stucked into the ground. The position of the inoculum in sub-study, Section 2.1.2, therefore was just above the ground. The inoculation was done in connection with the first snow, usually in late October. The vegetative growth of snow blight, i.e., the horizontal and vertical extention of symptomic needles, was measured in late May.

2.1.1. Effect of retained undergrowth and seedling spacing on snow blight damage

Sixty experimental units of 50–60 cm Scots pine seedlings of provenance Öst-Teg were planted in August 1997 on a clear-cut situated near Fredrika (64°05′N, 18°30′E, 320 m a.s.l.) in the province of Lapland, Sweden. No cleaning of undergrowth before harvest was done, resulting in great amounts (more than 500 ha^{-1}) of left small tress of different species. Ten experimental units were planted within groups of remaining 1.5–3 m high birches (*Betula* spp.), Scots pines or Norway spruces (*Picea abies*), respectively. Twenty units were planted at a cleaned area at the same clear-cut. As a reference, simulating ordinary planting, another 10 units with an internal seedling spacing of 2 m were planted. Also here, one central seedling in each unit was inoculated. No scarification was made.