Control of nursery diseases and pests in Finnish forest tree nurseries

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Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*) and European silver birch (*Betula pendula*) are the major tree species grown in Finnish forest nurseries where over 80 % of the seedlings are grown in containers in plastic-covered greenhouses. The change from growing bare root seedlings to container production has reduced the use of fungicides in Finnish nurseries. On Scots pine Scleroderris canker (*Gremmeniella abietina*), snow blight (*Phacidium infestans*) and needle cast (*Lophodermium seditiosum*) are controlled chemically, mainly by using propiconazole. Fungicides are applied during the growing season or in the case of snow moulds in autumn before permanent snow cover occurs. Root die-back (*Rhizoctonia* sp.) of container-grown spruce is controlled by improving air ventilation under the roots by elevating the seedling-growing containers. Another important factor in reducing root-die back involves the use of hot-water (+80 ºC) washing of the reusable hard-plastic, growing containers. For winter stored seedlings sprayings against grey mould, *Botrytis cinerea*, may be needed. Tiophanate-methyl, iprodione or tolylfluanid are applied in autumn mostly before seedlings are packed for overwinter cold storage. *Phytophthora* shoot lesions on birch seedlings can also be controlled by hot water washing of the growing containers and during the growing season by using fosetyl-aluminium sprayings. Birch rust is usually controlled with triadimefon. If needed, pyretroids are used to control aphids and moths. One of the biggest challenges is to prevent *B. cinerea* damage in packed, winter-stored seedlings. Growers are encouraged to use cultural and integrated pest management techniques such as better nursery hygiene, including removing plant debris in nursery growing areas and hot water washing of containers plus removal of diseased, spore-producing trees adjacent to nurseries.

Keywords: forest nurseries, container-grown seedlings, fungicides, pesticides, nursery hygiene

Introduction

Finland is situated in the Eurasian boreal forest zone and its forests are dominated by two conifers, *i.e.* Scots pine (*Pinus sylvestris* L.) and Norway spruce [*Picea abies* (L.) Karst.]. European silver birch (*Betula pendula* Roth) is the most important hardwood. Fifty percent of the silvicultural forest area needing to be reforested each year is planted with nursery-produced seedlings while the remaining 50 % is regenerated using natural regeneration or direct sowing (Finnish Statistical... 2001).

Nowadays over 80 % of all forest tree seedlings are produced in containers (Fig. 1). The shift from bare root production to container production has occurred rapidly. Over the past decade about 150 million seedlings have been produced annually for reforestation (Finnish Statistical... 2001).

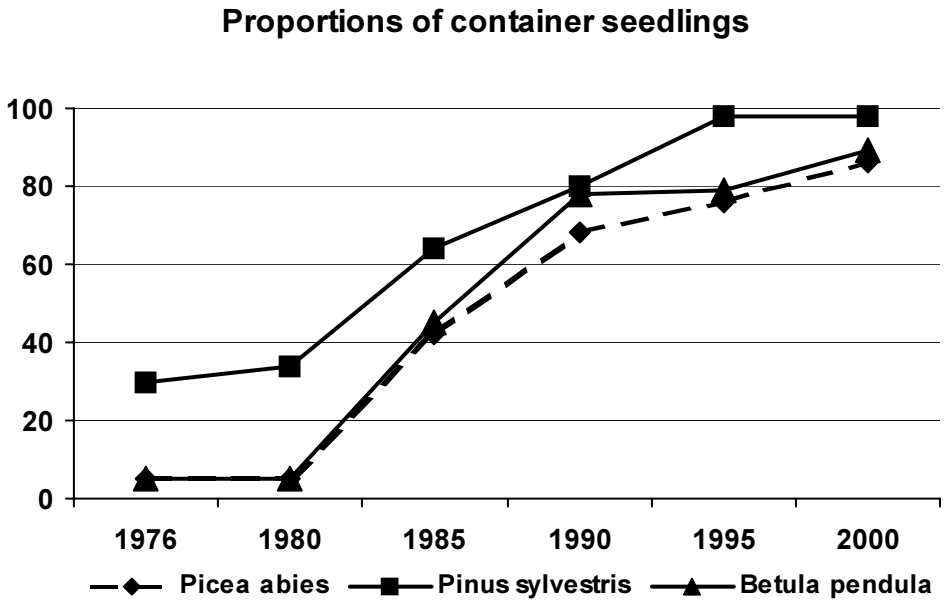

Figure 1. Container-grown seedlings as a percentage of total planting stock production.

Seedling production in hard-plastic, growing containers

Seedling containers are made of hard plastic and the cavities are equipped with air-slits in order to obtain better root pruning and ventilation of root system. Containers are filled with pre-fertilized sphagnum peat and sowing is done by machines using single or double seeding. Fertilizers are applied via irrigation water which is mainly done using moving booms both in plastic houses and outdoor growing facilities. The minor part of bare root seedling production is minimal and consists mainly of 4-year-old Norway spruce.

The shift from bare root production to growing seedlings in containers has resulted in a significant decrease in the use of pesticides in Finnish nurseries. It is estimated that countrywide use of pesticides is nowadays only 5–10 % of the amount which was used in bare root production at the end of 1970's (Juntunen 2001, Kangas et al. 1980).

In containers seedlings are grown in a peat substrate and thus the need for herbicides is significantly less than in bare root production. Growing seedlings in containers has decreased growing time in the nursery to 1–2 years instead of 2–4 years which was common with bare root seedlings. In containers seedlings can also be grown more densely (more seedlings per unit area) which has decreased total production area. Also, after seeding the seedlings are now germinated in plastic-covered (sheets) houses where they are grown for 2–4 first months. This practice decreases the need to control airborne diseases and pests.

Control of Scots pine diseases

Under Finnish climatic conditions it is next to impossible to produce healthy and marketable Scots pine seedlings without using some fungicides. The most important diseases of Scots pine are Scleroderris canker [*Gremmeniella abietina* (Lagerb.) Morelet] and snow mould (*Phacidium infestans* P. Karst.) (Lilja et al. 1997). These pathogens infect seedlings during the growing season or in the autumn and remain latent during winter. All affected seedlings have to be discarded as both diseases kill seedlings. Infections caused by snow mould are visible immediately after the winter snow has melted. The symptoms of Scleroderris canker can also be seen in spring, but sometimes the symptoms may appear after bud burst has occurred and the new growth has started. Depending on springtime weather conditions, in some years it can be difficult to observe latent infections of Scleroderris canker before the seedlings are shipped from the nursery.

Pine seedlings in their first growing season are most susceptible to Scleroderris canker at the time of bud formation in August (Petäistö 1999, Petäistö et al. 1999, Petäistö and Juntunen 2000). At this time the seedlings are usually transferred from the plastic-covered greenhouses to outside, hardening-off areas where they are exposed to infecting spores. It has been found, however, that the amount of conidiospores of *G. abietina* is usually highest in June-July before bud formation has started (Petäistö and Heinonen 2003). Thus, it is important to start sprayings before the most susceptible seedling stage, if seedlings are kept outdoors. Early sprayings are also important for pine seedlings which are being grown on for a second year at the nursery where they remain outdoors all the time. According to the studies made in nurseries, the amount of *G. abietina* spores may vary dramatically depending on the year (Petäistö and Heinonen 2003).

Normally pine seedlings are grown the first 2–3 months in plastic-covered greenhouses and thus no chemical control against Scleroderris canker is needed. It is recommended to start sprayings immediately after the seedlings have been transferred from the greenhouses to the outdoor hardening-off areas. Propiconazole is used to control Scleroderris canker and sprays are applied every second week until the middle of September. Pine seedlings which are delivered as 2-year-old seedlings and thus start their second growing year outdoors in the nursery have also to be sprayed with the fungicide from June onwards.

Snow mould (*P. infestans*) of Scots pine is a problem in areas where permanent snow cover remains throughout the entire winter *e.g.* in central and north Finland. The fungus grows extensively among seedlings under the snow at below freezing temperatures. In spring, areas of diseased seedlings appear as usually round-shaped spots where all the seedlings have died. Snow mould is controlled by propinconazole and control is best when the material is sprayed on seedlings in late autumn just before permanent snow cover.

In south Finland *Lophodermium seditiosum* Minter, Staley & Millar may in some years heavily infect Scots pine seedlings and cause needle cast disease. Needle cast has a latent phase during winter and the symptoms appear late in the following spring or early summer. The disease can cause serious wilting and killing of seedlings if in spring non-symptomatic diseased seedlings are outplanted to the forest. *Lophodermium* needle cast is also controlled with propinconazole and the sprayings are made form June to September when the fungus sporulates.

Pine twisting rust, *Melampsora pinitorqua* (Braun) Rostr., is a disease which infects pine seedlings at the beginning of summer (June) and the symptoms appear 2–3 weeks later. The disease causes cankers and serious twisting of shoots and usually results in death of small seedlings. Aspen

(*Populus tremula* L.) is an alternate host for *M. pinitorqua*. Twisting rust can be avoided if there are no infected aspens growing in or around the nursery. If affected aspens are present and seedlings are not in a plastic-covered greenhouse, triadimefon sprayings are needed at the time of basidiospore liberation at the beginning of June.

Control of spruce diseases

Most of the disease problems of Norway spruce seedlings have been to date avoided by using cultural practices for their management. By the 1980's when container production of spruce increased rapidly, a root die-back of Norway spruce appeared first in Norway (Galaaen and Venn 1979, Venn et al. 1986) and some years later in Finland (Lilja et al. 1992). The main causal agent in Finland proved to be a uninucleate *Rhizoctonia* (teleomorph *Ceratobasidium bicorne* J. Erikss. & Ryvarden) (Hietala et al. 1994, 2001, Lilja et al. 2000). A practical solution to the problem was devised by when seedlings were grown in containers which were elevated 20–25 cm above the greenhouse floor instead of placing them on the floor as was done before. Use of this procedure provided better air ventilation under and around containers and this in turn created unsuitable conditions for the fungus. Too, this practice enhanced the vigour of seedling root systems. Also, once it became known that a soil-borne pathogen was involved in root-dieback, hot-water washing of growing containers became a routine practice (Kohmann and Börja 2002). No chemical treatments are used to control root die-back.

Grey mould (*Botrytis cinerea* Pers. ex Nocca & Balb.) can be a problem during the growing season if the humidity is high, but mostly it is a storage problem. Recently too, storage of spruce seedlings at -2 to -4 ºC has increased. For storage, seedlings are packed in closed, air-tight packages where humidity remains high. In these packages moulds can become a problem if the cooling and thawing of packages are not done properly and seedlings are kept in the sealed packages too long. Fungicide sprayings are mainly made in autumn before packing the seedlings, especially if autumn frosts have shifted with rainy seasons. Iprodione, thiophanate-methyl and tolylfluanid are used to control such moulds.

Recently, work has started to determine the distribution and infection biology of *Sirococcus conigenus* [(DC.) P. Cannon & Minter] on Norway spruce seedlings (Lilja et al. 2005). So far no control methods have been used against *Sirococcus* blight.

Control of birch diseases

Birch rust [*Melampsoridium betulinum* (Kleb.) Fr.] has been an ongoing problem on growing birch seedlings including previously when seedlings were grown in bareroot nurseries. The disease causes early defoliation which weakens and retards the hardening of birch seedlings. Infected seedlings also grow less well after planting than healthy ones (Lilja et al. 1997). Triadimefon is applied against birch leaf rust when the first rust symptoms appear on the leaves in July. The severity of birch rust varies among years so the need for control varies each year.

A new birch disease caused by *Phytophthora cactorum* (Leb. and Cohn) Schr. was first found in Finnish nurseries in the 1990's (Lilja and Hietala 1994, Lilja et al. 1996). The pathogen causes stem and root collar lesions. The pathogen was introduced into Finland from Europe, most likely on plant material (Hantula et al. 2000). Nursery hygiene is important in controlling the disease.

This includes the removal of all dead plant debris such as leaves and shoots from the growing areas to prevent pathogen survival in the soil. During the growing season containers are also placed on an insulating cloth which is spread on the gravel ground cover (floor). The cloth prevents direct contact between the bottom of containers and the underlying soil. Attention must also be paid to regulating seedling irrigation and all excess water has to be avoided as soil water is a potential inoculum source. It is also important to wash and sterilize growing containers in hot (+80 ºC) water. The resistance of birch seedlings to *Phytophthora* can be improved by fosetyl-aluminium spraying which has to be applied beforehand. In practise, just before birch seedlings are transferred from the plastic-covered greenhouse to outdoor hardening areas where they may encounter heavy rain.

Control of pest insects

Because of the cold winter weather insects are not usually a big problem in Finnish nurseries. There are, however, some outbreaks occasionally which need control. Aphids, caterpillars [e.g. *Rheumaptera hastata* L. (Lepidoptera: Geometridae)], moths [e.g. *Croesus septentrionalis* L. (Hymenoptera: Tenthrediniae)] and the nymphs of *Lygus* bugs (Heteroptera: Miridae, mainly *L. rugulipennis* Poppius) are, if needed, controlled with pyretroids. In plastic-covered growing houses yellow, sticky trap papers are used to monitor insect populations, especially fungus gnats [*Bradysia* spp. (Diptera: Sciaridae)]. Attacks by *Lygus* bugs were a bigger problem in the growing of bare root seedlings than in container production. This is because container-grown seedlings are grown during their most susceptible stage in greenhouses and thus control is not usually needed. It is, however, important to use insect-proof screens on openings, e.g. doors and vents to prevent insects from entering the greenhouses.

Mites [*Oligonychus ununguis* Jacobi (Acari: Tetranychidae), *Nalepella haarlovi* var. *picea-abietis* Löyttyniemi (Acari: Nalepellidae)] are a problem mainly with bare root spruce seedlings, especially in hot, dry growing seasons. Mites are controlled, if needed, with oxydemeton-methyl. This miticide should be used only when urgently needed since the number of treatments must be kept at a minimum since mites tend to become resistant to miticides.

New risks

There are some new techniques and production methods which may increase the risk of moulds in nurseries. In northern latitudes seedlings must be hardened in the autumn so that then do not suffer from freezing temperatures in winter. To facilitate seedling hardening off, nurseries have started using short day treatments (black-out) (Colombo et al. 2001). For this treatment seedlings are enclosed by black curtains to extend the dark night period. Since these treatments are made during the seedling growing season there is an increased risk of grey mould infections. Warm and humid conditions are readily created under the black cover which may favour mould fungi. At the same time seedlings may be weakened physiologically because of reduced photosynthesis and increased respiration.

Another new cultural practice which increases the mould problem is the packing of seedlings in air-tight packages in the autumn. Packed seedlings are stored over winter in cold, mainly freezing temperatures. As occurs with blackout the conditions within the packages are ideal for moulds and less favourable for the seedlings.

The practice of growing seedlings in containers in plastic covered greenhouses has shortened the time needed to grow a merchantable seedling and thus one plastic covered greenhouse can produce two crops in one growing season. Sowing in heated and artificially lighted, plastic-covered houses can be started 1–2 months earlier than normally. After the first crop is ready to be moved outdoors, a second crop can be sown in the same house 1–2 months later that the normal sowing time. To date no serious outbreaks of diseases or other pest problems have occurred, but one should be aware that the seedlings with 'abnormal' growing conditions might be more susceptible than seedlings being grown under more natural conditions. Conversely, it is also possible that seedlings being grown under such conditions may escape some diseases or pests.

Possibilities for IPM in Finnish nurseries

The aim of integrated pest management is to reduce the use of pesticides and determine alternate control methods which can be used alone or in combination with chemical controls. In Finnish nurseries several fungicide sprayings are needed each season to control Scleroderris canker on pine seedlings. Recently, however, a method has been developed using monoclonal antibodies to detect and monitor the amount of *G. abietina* spores in rain water (Koistinen et al. 2000). This method could be useful in timing the application of sprayings against Scleroderris canker.

In controlling grey mould it is important to keep humidity low and avoid excess water on plant surfaces. Inside plastic-covered houses air circulation is too poor to dry the shoots of irrigated seedlings and thus they may stay wet longer than seedlings which are grown outdoors where they are exposed to wind and direct sun light. To hasten the drying of irrigated seedling shoots some nurseries have attached 'ropes' to the irrigation booms. Such 'ropes' brush against the seedling shoots and remove excess water.

Nursery hygiene can be improved by removing diseased, spore-producing trees in and adjacent to nurseries. In the case of the diseases of pine seedlings, nursery sanitation to remove inoculum can reduce the amount of Scleroderris canker and snow mould. Alternate hosts, such as aspens for the pine twisting rust (*M. pinitorqua*), also form a risk if aspens grow close (less than 200 m) to pine producing nurseries (Kurkela 1973).

Growing areas should also be cleared of susceptible plant debris such as fallen leaves, needles and seedling remnants. Such measures are important in disease control *e.g.* in reducing the sporulation sites for grey mould and especially in the control *Phytophthora* on birch seedlings.

It is recommended to wash seedling growing containers in hot water (+ 80 ºC) to kill propagules of soil-borne pathogens such as *Rhizoctonia* and *Phytophthora*.

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