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Survival of southern pine seedlings after inoculations with *Pythium* and cold storage in the presence of peat moss

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Summary

Cold storing bareroot pine (*Pinus* spp.) seedlings grown in the southern U.S. for as little as 1 week in a cooler (just above freezing) in the fall (November to mid-December) has been shown to reduce seedling survival after outplanting. In contrast, survival of container-grown seedling is typically not affected when stored for 4 weeks in coolers in November and December. Wounds sustained by seedlings as they are lifted from nursery beds may allow *Pythium* spp. to infect bareroot seedling roots. Once in the cool, moist storage environment, *Pythium* multiplies and may result in seedling mortality after outplanting. Bareroot loblolly pine (*Pinus taeda*) and container-grown loblolly, longleaf (*Pinus palustris*), slash (*Pinus elliottii*) and shortleaf pine (*Pinus echinata*) seedlings were inoculated with either *Pythium dimorphum* or *Pythium irregulare*, cold stored with or without peat moss and monitored for survival after outplanting. Peat moss did not increase bareroot loblolly pine survival or reduce *Pythium* populations when seedlings were inoculated with *Pythium* prior to storage. *Pythium irregulare* reduced survival of longleaf and shortleaf pine grown in peat moss and perlite, respectively. *Pythium* did not affect loblolly or slash pine, but wounding their roots did reduce seedling survival when grown in containers.

1 Introduction

Prior to being shipped for outplanting, pine (*Pinus* spp.) seedlings grown in the southern U.S. are commonly held in cold storage after lifting from nursery beds. Long-term (>1 week) cold storage of bareroot seedlings lifted from October to mid-December can result in poor outplanting survival (Kahler and Gilmore 1961; Dierauf 1976; Hebb 1982; Venator 1984). The reason for poor survival was attributed to seedling buds not being dormant upon entering cold storage rather than effects from storage, but no measure of bud dormancy was recorded to back that claim. In contrast to bareroot seedlings, container-grown seedling survival is not affected when stored for >1 week in November and December (Pickens 1998). Thus, some other factor besides the state of bud dormancy may be causing the differences in seedling survival between the two stock types.

At lifting, bareroot and container-grown seedling root systems are affected differently, which may be a reason for the differences in seedling storability and outplanting survival. One major difference is that bareroot seedling roots can be stripped away during the lifting process causing wounds (May 1984). The wounded roots could then serve as infection sites for soil-borne pathogens, particularly the 'water moulds' such as *Pythium*. *Pythium* is an oomycete that is commonly found in nursery soils and known for causing 'damping-off' of seed and young germinants or 'feeder root disease', which affects roots that are important for nutrient and water absorption (Kelley and Oak 1989). After infected seedlings are lifted, they are sprayed or dipped into a combination of water and superabsorbent gel to prevent desiccation in seedling storage bags (May 1984). Excess water can pool in seedling bags and along with the cool storage temperatures (1–5°C) may provide an ideal environment for certain species of *Pythium* to multiply.

Studies have shown that *Pythium* spp. can be recovered from cold-stored bareroot longleaf pine seedlings and populations can increase with storage time (Barnett et al. 1988; Jones et al. 1992; Sun 1996). After recovering *Pythium* from bareroot seedlings and to further determine the pathogen's role in cold storage, the fungicides benomyl and metalaxyl were applied to seedling roots and seedling survival increased after outplanting when compared with seedlings that did not receive fungicides (Barnett et al. 1988; Jones et al. 1992). Their studies suggest that adding fungicides to seedling roots prior to storage increases seedling survival by controlling *Pythium*. A subsequent study by Sun (1996) revealed that longleaf pine seedling survival inoculated with increasing levels of *Pythium dimorphum* Hendrix and Campbell caused increases in seedling mortality. This may have been the first study to show that a *Pythium* spp. could kill cold-stored bareroot seedlings after outplanting.

In contrast to bareroot culture, container-grown seedlings are extracted by hand, and their root systems are protected within a plug of peat moss-based media. These two differences lessen the chance of root wounding and subsequent infection by *Pythium*. *Pythium* can be introduced into container media by sowing contaminated seed (Dumroese et al. 1988), through irrigation (Landis et al. 1989), and from substrate residue remaining on containers after use (Dumroese et al. 2002). In addition, *Pythium* can remain dormant until saturated or poorly drained cavities favour zoospore activity (Landis et al. 1989).

Peat moss has been shown to contain biological organisms that are capable of suppressing plant pathogens. For one study, a light-coloured Swedish sphagnum peat was the most effective at suppressing *Pythium* spp., but suppressiveness was not evident when the peat was either heated above 60°C or treated with benomyl (Wolffhechel 1988). The sterilization of the media implied that the suppressiveness was tied to antagonistic microbes present in peat moss, while the effect of benomyl was probably specifically against fungi. In another study, the specific fungi involved with suppression of *Pythium ultimum* Drechsler was *Trichoderma* spp. in both cucumber (*Cucumis sativas*) (Thrane et al. 2000) and tomato (*Lycopersicon*

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