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Fungicide Efficacy in Prevention of Root Rot Incited by *Phytophthora cactorum* and *Phytophthora drechsleri* in Fraser Fir Seedlings

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Summary. **The most serious disease problem in fraser fir (*Abies fraseri*) Christmas tree production is phytophthora root rot (PRR). The efficacies of six fungicide treatments in preventing PRR incited by *Phytophthora cactorum* and *P. drechsleri* in 2-year-old fraser fir seedlings were evaluated in 2010 and 2011 in central Pennsylvania. The study examined five fungicide drench treatments [dimethomorph, fosetyl-aluminum (fosetyl-Al), hydrogen dioxide, mefenoxam, propamocarb hydrochloride] and one soil spray treatment (mefenoxam) in raised planting boxes. Dimethomorph applied on 14-day intervals prevented foliar disease symptoms and mortality in fraser fir seedlings exposed to either *P. cactorum* or *P. drechsleri*. One-time application of fosetyl-Al or mefenoxam were effective at times in preventing foliar disease symptoms and mortality in fraser fir seedlings exposed to *P. drechsleri* but were not as effective against *P. cactorum*.**

Fraser fir is a valuable cut Christmas tree crop in the eastern United States, particularly in North Carolina, Michigan, and Pennsylvania (Tompkins, 2000; Williams, 2002). The species is preferred because of its fast and consistent growth habit and excellent postharvest durability (Mitcham-Butler et al., 1988). In 2010, fraser fir accounted for ≈26% of the planted cut Christmas tree crop in Pennsylvania, second only to douglas fir (*Pseudotsuga menziesii*) which accounted for ≈42%. On a per tree basis fraser fir is estimated to be 15% more valuable than douglas fir in Pennsylvania (U.S. Department of Agriculture, 2009). Use of fraser fir is not more prevalent because of its sensitivity to poorly drained soils (Owen, 2005). In poorly drained soils, PRR is the limiting factor in fraser fir production and is the only serious disease affecting fraser firs in Pennsylvania.

Multiple species of *Phytophthora* are known to contribute to root rot in fraser fir (Benson et al., 1976; Kuhlman and Hendrix, 1963; Quesada-Ocampo et al., 2009; Shew and Benson, 1981). Most research has focused on *P. cinnamomi* (Benson and Grand, 2000). In diseased fraser fir specimens sent to the Pennsylvania Department of Agriculture Plant Diagnostic Laboratory between 1986 and 2011, *P. cactorum*, *P. cryptogea*, and *P. drechsleri* were the most common causes of PRR (T. Olson, personal communication). *Phytophthora cryptogea* and *P. drechsleri* have very similar morphology and are usually separated based upon the ability of *P. drechsleri* to grow at 35 °C (Erwin and Ribeiro, 1996; Ho and Jong, 1991; Mostowfizadeh-Ghalamfarsa et al., 2010).

The use of fungicides to prevent PRR in fraser fir production is most common at the seedling stage. The efficacies of various fungicides in preventing PRR in fraser fir have been tested with *P. cinnamomi*. Bruck and Kenerley (1981, 1983) reported that drench applications of metalaxyl prevented PRR in fraser fir seedlings planted in a soilless substrate in greenhouse and nursery bed settings. Benson and Grand (2000) reported that isolates of *P. cinnamomi* recovered from fraser fir in field settings and nursery transplant beds were sensitive to metalaxyl in plate tests in a laboratory setting. Benson et al. (2003, 2004) reported PRR prevention in container-grown fraser fir seedlings in soilless substrate with dimethomorph, mixed results with fosetyl-aluminum and mefenoxam as a drench treatment, and poor results with hydrogen dioxide. Benson et al. (2006) found that mefenoxam as a soil spray and fosetyl-Al as a foliar spray were both able to delay PRR onset in fraser fir in a field setting. In North Carolina, mefenoxam is recommended if fungicide control of PRR in fraser fir is required (Sidebottom and Jones, 2004). The effectiveness of fungicides to prevent PRR in fraser fir incited by the species of *Phytophthora* common in Pennsylvania, *P. cactorum* and *P. drechsleri*, has not been studied. In Pennsylvania, recommended fungicides for PRR of firs include dimethomorph, hydrogen dioxide, mefenoxam, and propamocarb hydrochloride (Pennsylvania Department of Agriculture, 2009). The objectives of this study were to examine the efficacy of those four fungicides and fosetyl-Al in prevention of PRR incited by *P. cactorum* and *P. drechsleri* in fraser fir seedlings, as well as to test for differences between soil spray and drench treatments of mefenoxam.

Materials and methods

This study was conducted in Summer 2010 and Summer 2011 at the Russell E. Larson Agriculture Research Center at Rock Springs in Pennsylvania Furnace, PA (lat. 40°42′N, long.

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937
16.3871	$inch^3$	cm^3	0.0610
28.3495	oz	g	0.0353
1	ppm	$mg \cdot L^{-1}$	1
0.001	ppm	$mg \cdot mL^{-1}$	1000
0.001	ppm	$\mu L \cdot mL^{-1}$	1000
1.1692	pt/acre	$L \cdot ha^{-1}$	0.8553
5.0932	pt/ft^2	$L \cdot m^{-2}$	0.1963
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32