Evaluation of Seedlings of Fraser, Momi, and Siberian Fir for Resistance to *Phytophthora cinnamomi*

L. Eric Hinesley¹

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

K.C. Parker² and D.M. Benson¹

Department of Plant Pathology, North Carolina State University, Raleigh, NC 27695-7629

Additional index words. *Phytophthora* root rot, Christmas trees, rootstock, *Abies fraseri*, *Abies siberica*, *Abies firma*

Abstract. Containerized seedlings of Fraser fir [*Abies fraseri* (Pursh) Poir.], momi fir (*A. Firma* Sieb. & Zucc.), and Siberian fir (*A. siberica* Ledeb. var. *argentea*) were tested for resistance to *Phytophthora cinnamomi* Rands (two experiments). Fraser fir was very susceptible, with many plants dead after 4 to 5 weeks. Symptoms developed more slowly in Siberian fir, but most plants were dead or dying after 10 weeks. Momi fir appeared somewhat resistant to the pathogen. Though undesirable as a Christmas tree, momi fir might be useful as a rootstock for grafting better quality species in areas affected by root rot.

North Carolina ranks second nationally in Christmas trees produced, but possibly first in value, since ≈95% of its trees are Fraser fir, a tree of high value. *Phytophthora* root rot, caused by *Phytophthora cinnamomi* Rands, has been a perennial disease problem in Fraser fir production in the mountains of western North Carolina. Losses are quite variable from field to field (up to 75%), but averaged 6.3% in a recent statewide survey (L.F. Grand and D.M. Benson, personal communication). Currently, growers practice sanitation and use cultural practices to avoid introducing *P. cinnamomi* to seed beds, transplant beds, or the field. Fungicides may be used in seed beds or transplant beds but are impractical for field plantations. Selection of an *Abies* species with resistance to *Phytophthora* root rot, and suitable as a Christmas tree, would offer growers an improved disease management strategy.

True firs (*Abies*) are generally more susceptible to *Phytophthora* root rot than many other conifers (Campbell and Hamm, 1989; Chastagner et al., 1990; Hamm and Hansen, 1982). Chastagner et al. (1990) screened seedlings of 11 *Abies* sp. for resistance to seven

Phytophthora sp. Noble fir (*A. procera* Rehd.), shasta fir (*A. magnifica* A. Murray var. *shastensis* Lemmon.), and white fir [*A. concolor* (Gord. & Glend.) Lindl. ex Hildebr.] had greater mortality than Korean fir (*A. koreana* Wils.), silver fir (*A. amabilis* Dougl. ex Forbes), and Japanese fir (*A. veitchii* Lindl.). Six sources of Canaan fir [*Abies balsamea* (L.) Mill. var. *phanerolepis* Fern.] from West Virginia were ranked as “susceptible” to “very susceptible,” although most were better than Fraser fir (Benson et al., 1998b). Canaan fir, botanically an intermediate between Fraser and balsam fir, is reputedly more resistant to *Phytophthora* root rot than is Fraser fir. Benson et al. (1998a) compared seedlings of six *Abies* sp. for resistance to *P. cinnamomi*. After 3 months in a shade house, momi fir and Turkish fir [*A. nordmanniana* ssp. *equitrojani* (Asch. & Sint. ex Boiss.) Coode & Cullen] (Syn. *Abies ×bornmuelleriana* Mattf.) appeared healthy, even though the pathogen was

isolated from roots of 80% of the plants. Mortality of Fraser fir was 100%. In the current study, our objective was to compare resistance of Fraser fir, Siberian fir, and momi fir to *P. cinnamomi*.

Materials and Methods

Two-year-old containerized seedlings (height 7–12 cm) of Fraser, momi, and Siberian fir were transplanted from Ray Leach “fir cells” (volume = 49 cm³) (Stuewe & Sons, Corvallis, Ore.) to “super cells” (volume = 164 cm³) on 2 June 1998. The medium contained 1 peat:1 vermiculite (by volume). They were set outside under 50% shade lath. Overhead sprinklers provided 0.9 cm·d⁻¹ of water, split between a morning and an afternoon application. On 12 June 1998, 30 plants of each species were inoculated with rice grains colonized by *P. cinnamomi*. A glass rod was used to make a hole (≈3 cm deep, 1 cm from the stem) in the medium in each tube. After inserting one grain, the hole was covered. Ten noninoculated plants were kept as controls. Plants were fertilized biweekly with Peter’s 20N–8.8P–16.6K soluble fertilizer (Scotts-Sierra Horticultural Products, Marysville, Ohio). Tubes were held in wooden trays, with one plant of each species per tray. Trays were arranged in a randomized complete block with 30 replications, and control trays were separated by enough space to prevent pathogen dispersal by splashing.

Plants were rated weekly for 8 weeks on a scale of 1 to 4: healthy (1), slightly chlorotic (2), severely necrotic (3), and dead (4). At the end of the experiment, roots were washed and subjectively rated by two people on a 1 to 5 scale: healthy (1), diseased 1% to 10% (2), 11% to 25% (3), 26% to 50% (4), and 51% to 100% (5). Ratings were averaged before analysis. Roots were washed and clipped into 1-cm sections. Five clumps (10–15 segments per clump) from each tree were placed on individual plates containing PAR medium (Kannwischer and Mitchell, 1978). Plates were stored on the laboratory bench for 2 d and then examined under a microscope. If *P. cinnamomi* appeared in any one of the five clumps, the tree was recorded as infected.

The experiment was repeated beginning 17 July 1998 and ending 25 Sept. 1998. All data

Table 1. Response of Fraser, momi, and Siberian fir seedlings to *Phytophthora cinnamomi* when grown in a shadehouse.

<i>Abies</i> species	Top rating ^a		Root rating ^b		Top weight (g)		Isolation (%)	
	Phyto.	Control	Phyto.	Control	Phyto.	Control	Phyto.	Control
<i>Expt. 1</i>								
Fraser	4.0 b ^x	1.1	5.0 b	2.5 b	0.6 a	3.8 ab	---	---
Momi	1.2 a	1.2	2.6 a	1.2 a	4.2 b	4.4 b	100	0
Siberian	4.0 b	1.0	5.0 b	1.2 a	0.7 a	3.3 a	---	---
<i>Expt. 2</i>								
Fraser	3.7 c	1.0	4.8 c	2.8 b	1.3 a	3.1 a	100	0
Momi	1.2 a	1.0	1.8 a	2.5 b	---	---	90	10
Siberian	2.4 b	1.0	3.6 b	1.1 a	2.2 a	4.0 b	67	0

^aScale: healthy (1), slightly chlorotic (2), severely necrotic (3), and dead (4).

^bRated after 12 weeks (Expt. 1) and 10 weeks (Expt. 2). “Phyto” = plants inoculated with *P. cinnamomi* (n = 30); “Control” = plants that were not inoculated (n = 10).

^cScale: healthy (1), disease 1% to 10% (2), 11% to 25% (3), 26% to 50% (4), and 51% to 100% (5).

^xMean separation within columns and experiments by Waller-Duncan K-ratio t test, K-ratio = 100 ($P \leq 0.05$).

Received for publication 12 Apr. 1999. Accepted for publication 21 June 1999. This research was funded by the North Carolina Agricultural Research Service (NCARS), Raleigh, NC 27695-7643. Mention of trade names is neither an endorsement by the NCARS nor criticism of similar unnamed products. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

¹Professor.

²Research Technician.

were analyzed with GLM procedures (SAS Institute 1989), and means compared with Waller-Duncan K-ratio.

Results and Discussion

Fraser fir was very susceptible to *P. cinnamomi* (Table 1) in both experiments; nearly all seedlings died after 1 month. Symptoms developed more slowly in Siberian fir, but plants were severely diseased after 10 weeks in both experiments. Based on appearance of shoots, momi fir was relatively unaffected in either experiment even though a portion of the roots appeared diseased, and the pathogen was isolated from the roots of most plants (Table 1). In Expt. 1, virtually all root systems of Fraser and Siberian seedlings appeared diseased. In Expt. 2, the average root rating for Siberian fir was 3.6, indicating that up to 50% of the roots had visual symptoms. Average root rating for momi fir was 2.6 in Expt. 1, and 1.8 in Expt. 2 (Table 1). High values for roots of Fraser fir "controls" in both experiments possibly indicated a sensitivity to heavy watering, even in soilless medium, because *P. cinnamomi* was not isolated from

roots of control seedlings in the second experiment. Likewise, momi fir roots appear to be sensitive to heavy watering in the absence of *Phytophthora* root rot, as only one control plant was infected with *P. cinnamomi*. Top weights for Fraser fir and Siberian fir seedlings were dramatically reduced following inoculation with *P. cinnamomi*.

Long-term survival of momi fir seedlings infected with *P. cinnamomi* is unknown. Fraser fir and Siberian fir succumbed very quickly to the disease in these short-duration experiments. Momi fir, however, survived and grew well even though the pathogen had infected a portion of the roots in 90% to 100% of the seedlings in both experiments. As a general observation, Fraser fir rarely survives in outdoor landscapes in the piedmont of North Carolina, probably because of the climate and *Phytophthora* root rot. In contrast, we have observed healthy specimens of momi fir growing in landscapes that would favor *Phytophthora* root rot. The date of budbreak and the needle morphology of momi fir make it a poor candidate for a Christmas tree in North Carolina, but these results suggest that it might be used as a rootstock for grafting

Abies sp. with more favorable Christmas tree qualities, e.g., Fraser fir or Nordmann fir.

Literature Cited

- Benson, D.M., L.E. Hinesley, J. Frampton, and K.C. Parker. 1998a. Evaluation of six *Abies* spp. to *Phytophthora* root rot caused by *Phytophthora cinnamomi*. Biol. and Cult. Tests for Control of Plant Dis. 13:57.
- Benson, D.M., L.E. Hinesley, and K.C. Parker. 1998b. Evaluation of Canaan seed sources for resistance to *Phytophthora* root rot caused by *Phytophthora cinnamomi*. Biol. and Cult. Tests for Control of Plant Dis. 13:58.
- Campbell, S.J. and P.B. Hamm. 1989. Susceptibility of Northwest conifers to *Phytophthora* root rot. Tree Planters' Notes 40(1):15-18.
- Chastagner, G.A., K.L. Riley, and P.B. Hamm. 1990. Susceptibility of *Abies* spp. to seven *Phytophthora* spp. Phytopathology 80:897 (Abstract).
- Hamm, P.B. and E.M. Hansen. 1982. Pathogenicity of *Phytophthora* spp. to Northwest conifers. Europ. J. Forest Pathol. 12:167-174.
- Kannwischer, M.E. and D.J. Mitchell. 1978. The influence of a fungicide on the epidemiology of blank shank of tobacco. Phytopathology 68:1760-1765.
- SAS Institute. 1989. SAS/STAT user's guide. Vers. 6, 4th ed. SAS Inst., Cary, N.C.