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Susceptibility of Fraser Fir to *Phytophthora capsici*

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ABSTRACT

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Phytophthora cinnamomi, *P. drechsleri*, *P. citricola*, and *P. cactorum* limit Fraser fir production, whereas *P. capsici* affects Solanaceous, Cucurbitaceous, and Fabaceous crops. Some vegetable growers in Michigan plant conifers for the Christmas tree market in fields infested with *P. capsici*. To determine the susceptibility of Fraser fir to *P. capsici*, stems (no wound or 1- or 3-mm-diameter wound) or roots (2 or 4 g of infested millet seed or 2 or 5×10^3 zoospores/ml of a zoospore suspension) of seedlings were inoculated with each of four *P. capsici* isolates and incubated in growth chambers (20 or 25°C). In addition, Fraser fir seedlings were planted in two commercial fields naturally infested with *P. capsici*. All *P. capsici* isolates tested incited disease in the seedlings regardless of incubation temperature or inoculation method. Seedlings (72%) planted in *P. capsici*–infested fields developed disease symptoms and died. Most of the *P. capsici* isolates obtained from the Fraser fir seedlings infected while in the field were recovered from root tissue. Identification was confirmed by species-specific direct colony polymerase chain reaction. The pathogen was successfully recovered from stems of all stem-inoculated seedlings, and from roots and stems of all root-inoculated seedlings; the phenotype of the recovered isolate matched the phenotype of the inoculum. This study suggests that planting Fraser fir in fields infested with *P. capsici* could result in infection and that adjustments in current rotational schemes are needed.

Additional keywords: Christmas tree diseases, etiology, soilborne diseases

Each year, approximately 33 to 36 million Christmas trees are produced in North America with an estimated farm gate value of $462 million (5). Michigan ranks third in the production of Christmas trees, with 17,000 ha and an annual value of $4 million (2,5). Nationally, the most common species used in plantations include Douglas fir (*Pseudotsuga* sp.), Fraser fir (*Abies fraseri*), Noble fir (*A. procera*), and Balsam fir (*A. balsamea*) (5). With its natural Christmas tree shape and excellent postharvest quality, Fraser fir is one of the most valued trees in the Christmas tree industry (5), rapidly becoming the most popular tree among growers in Michigan. In 2005, 3,000 ha were planted to Fraser fir in Michigan (2).

Phytophthora root rot and shoot blight can limit the production and marketability of Fraser fir (5,6), as reported in North Carolina (3) and Michigan (1). With the exception of Michigan, *Phytophthora cinnamomi* (11) is typically the causal organism. However, *P. drechsleri* (4), *P. citricola* (35), and *P. cactorum* (1) have also been associated with root rot and shoot blight symptoms in Fraser fir and other *Abies* and conifer species grown for Christmas trees (1,4,13,14,21,30). Plant death ranging from 30 to 75% can occur when conditions are favorable (5). Fraser fir is especially susceptible to *P. cinnamomi* and other *Phytophthora* species; symptoms including characteristic reddish-brown needles develop rapidly, and most trees die in 4 to 5 weeks (5,6,17).

To prevent Phytophthora root rot and shoot blight in Christmas trees, it is important that growers plant pathogen-free seedlings into well-drained fields without a history of root rot organisms (3). In some growing regions, uninfested fields are becoming increasingly scarce, limiting the expansion of production (5). Michigan vegetable growers are diversifying their crops and including Fraser fir plantings in soils infested with *Phytophthora capsici* Leonian. *P. capsici* has a broad host range including Solanaceous, Cucurbitaceous, and Fabaceous crops (8). Crop rotation is used to manage *P. capsici*, but this strategy is limited by the long-term survival of oospores in soil (27) and an increasing list of *P. capsici*–susceptible hosts (10). The objective of this study was to determine whether *P. capsici* is pathogenic to Fraser fir. Specifically, we sought to determine the following: (i) whether or not incubation temperature, inoculation method, or *P. capsici* isolates influence infection and disease development, and (ii) whether or not Fraser fir seedlings could become infected when planted in a field naturally infested with *P. capsici*. A preliminary report of these findings has been published (32).

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MATERIALS AND METHODS

Isolate selection, maintenance, and inoculum preparation. *P. capsici* isolates collected in Michigan from infected Cucurbitaceous and Solanaceous crops were selected from the culture collection maintained in the laboratory of M. K. Hausbeck at Michigan State University (MSU). They were phenotypically characterized according to mating type (MT) and sensitivity to the fungicide mefenoxam (24). Isolate OP97 (A1 MT) was isolated from pickling cucumber and SP98 (A2 MT) from pumpkin, and both are sensitive to mefenoxam. Isolate SFF3 (A2 MT) originates from pickling cucumber, and isolate 12889 (A1 MT) was obtained from pepper; both are insensitive to mefenoxam.

Actively growing cultures of each isolate were obtained by transferring agar plugs from long-term stock cultures (stored at 20°C in sterile microcentrifuge tubes with 1 ml of sterile water and one sterile hemp seed) onto V8 juice agar (16 g of agar, 3 g of $CaCO_3$, 160 ml of unfiltered V8 juice, and 840 ml of distilled water). Cultures were maintained at room temperature (21 ± 2°C) under fluorescent light. To ensure that isolates were virulent, cucumber fruits were inoculated with each isolate. Cucumbers were washed with water, disinfested for 5 min in a 5% sodium hypochlorite solution, and dried at room temperature. A small superficial wound was made with a sterile needle in the center of each cucumber. Agar plugs (7 mm diameter) from the margins of actively growing colonies were placed upside down on top of the wound. A sterile microcentrifuge tube (with the cap removed) was placed over each agar plug and fixed to the fruit with petroleum jelly. Control cucumbers were inoculated as described above using a sterile 7-mm-diameter plug of V8 agar. Cucumbers were placed in aluminum trays with wet paper towels and covered with plastic wrap to maintain high relative humidity. Trays were incubated at room temperature (21 ± 2°C). Symptomatic cucumber tissue (5 mm) was excised and transferred to V8 juice agar and maintained under the same conditions described above. Clean cultures of each isolate were obtained from the infected cucumber tissue.

Bare-root Fraser fir seedlings were purchased from a nursery in Holland, MI that