

# A Systems Approach for Detecting Sources of *Phytophthora* Contamination in Nurseries<sup>1</sup>

Jennifer L. Parke,<sup>2</sup> Niklaus Grünwald,<sup>3</sup> Carrie Lewis,<sup>2</sup> and Val Fieland<sup>4</sup>

## Introduction

Nursery plants are susceptible to several diseases caused by *Phytophthora* species. Nursery plants are also important long-distance vectors of non-indigenous pathogens such as *P. ramorum* and *P. kernoviae*. Pre-shipment inspections have not been adequate to ensure that shipped plants are free from *Phytophthora*, nor has this method informed growers about sources of contamination in their nurseries.

We applied an approach based on Hazard Analysis of Critical Control Points (HACCP) for systematically detecting sources of *Phytophthora* contamination in four Oregon nurseries. HACCP is an approach broadly applied in the food processing industry to prevent contamination of foods by microorganisms and it has recently been adapted by the U.S. Fish and Wildlife Service to prevent spread of non-target species during fish restocking efforts. Our goal was to adapt the HACCP approach to identify critical control points (CCPs) for *Phytophthora* contamination in commercial nursery production systems. Critical control points are the best points, steps, or procedures at which significant hazards of contamination can be prevented or reduced to minimum hazard. To our knowledge, this is the first time the approach has been used to detect sources of plant pathogens.

## Methods

We sampled four Oregon nurseries every 2 months over a 3-year period. The nurseries, designated as A, B, C, and D, ranged in size from 70 to 2200 acres. Two of the nurseries (A and C) used recycled irrigation water, whereas nurseries B and D used well water. Plants, potting media, containers, irrigation water, greenhouse soil, and can yard substrates were sampled at all stages of production. We initially focused on four genera of *Phytophthora*-susceptible plants commonly grown in Oregon: *Rhododendron*, *Pieris*, *Kalmia*, and *Viburnum*. Later, the study expanded to include additional host plant genera. If symptomatic plants were available, leaves, stems, and roots of symptomatic plants were plated onto the selective medium PARBH; otherwise asymptomatic tissue was plated. Samples from irrigation water and

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<sup>2</sup> Department of Crop and Soil Science, Agriculture and Life Sciences Bldg. 3017, Oregon State University, Corvallis, OR 97331.

<sup>3</sup> USDA-ARS Horticultural Crops Research Laboratory, 3420 NW Orchard Ave. Corvallis, OR 97330.

<sup>4</sup> Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331.

Corresponding author: [Jennifer.Parke@oregonstate.edu](mailto:Jennifer.Parke@oregonstate.edu).

irrigation ponds, soil/gravel substrates, potting media and potting medium components, and debris from used containers were baited in a rhododendron leaf assay and plated onto the selective medium. Pure cultures were isolated and putative *Phytophthora* were identified to species by direct sequencing of the internal transcribed spacer (ITS) rDNA and blast searches at [www.phytophthora-id.org](http://www.phytophthora-id.org).

## Results

Critical control points in the nurseries were 1) placement of healthy container-grown plants on contaminated soil/gravel substrates (all nurseries), 2) use of contaminated irrigation water (nurseries A and C only), and 3) use of contaminated used pots (all nurseries). Poor sanitation practices were compounded by the accumulation of standing water in parts of all nurseries. After identifying CCPs where contamination occurred, we worked with nursery managers to develop best management practices specific for each nursery.

Of 449 total *Phytophthora* isolates recovered, 364 isolates (81 percent) belonged to 15 *Phytophthora* species, 13 percent matched *Phytophthora* taxa without species designations, and 6 percent did not match any sequence in the *Phytophthora* database. The most frequently isolated species from symptomatic plants were *P. citricola*, *P. cinnamomi*, *P. citrophthora*, and *P. syringae*. From gravel substrates, pots, and soil, the predominant species were *P. citricola*, *P. cinnamomi*, and *P. cryptogea*. From irrigation ponds, most isolates were *P. gonapodyides* or other *Phytophthora* taxa belonging to ITS Clade 6. *Phytophthora parsiana*, not previously reported from nurseries, was also detected. *Phytophthora cinnamomi*, one of the species isolated most frequently from plants, was never recovered from water.

## Discussion

Identification of critical control points is essential for determining specific sources of *Phytophthora* contamination in nurseries and designing effective management strategies to prevent disease. The systems approach could be applied to other pathogens and pests to ensure the health of nursery stock. Our results also provide insights on *Phytophthora* and ecology and epidemiology in nurseries.

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