

A Systems Approach for Managing *Phytophthora* Diseases in Horticultural Nurseries

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Introduction

Phytophthora is a water mold that causes some of the most serious diseases of nursery crops nationwide. We modified the HACCP (Hazard Analysis of Critical Control Point) strategy used in the food processing industry to ensure food safety, and applied it to nursery production systems. Our goals were to: 1) develop, implement, and evaluate a systems approach for producing nursery stock free of *Phytophthora* contamination, 2) to apply the systems approach to determine Critical Control Points for *Phytophthora* contamination, and 3) to determine *Phytophthora* species distributions associated with each Critical Control Point. A CCP is the best point at which significant hazards of contamination can be prevented.

Why target *Phytophthora* spp?

- Widespread in commercial nurseries
- Include foliar, soilborne and waterborne species, therefore are good indicators of nursery contamination
- Include exotic species (*P. ramorum*, *P. kernoviae*, *P. alni*) that threaten landscape plants and forest health in N. America and Europe
- Can be spread long distances with the nursery plant trade

HACCP steps

- Conduct a hazard analysis
- Identify critical control points
- Establish critical limits
- Establish monitoring procedures
- Establish corrective actions
- Establish record-keeping procedures
- Establish verification procedures

Methods

Sampling procedure

- Sampled 4 nurseries 6x/year for 3 years
- Determined production cycle and Critical Control Points for each nursery
- Sampled whole plants susceptible to *Phytophthora* infection at all stages of production
- Sampled water, soil/ gravel substrates, potting media and components, and containers for re-use

Phytophthora species identification

- Isolated pure cultures
- Directly sequenced (ITS) rDNA
- Blast searched at www.phytophthora-id.org

Fig. 1. Example of a production flow chart for one of the nurseries. Red arrows marks sources of *Phytophthora* spp.

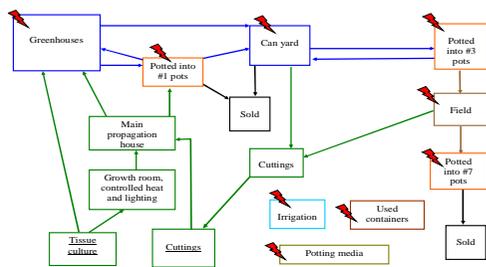


Fig. 2. Common sources of contamination in nurseries.



Table 1. Isolation of *Phytophthora* spp. from different sources. Critical Control Points are indicated in red.

Source		Nurseries			
		A	B	C	D
Propagation	plant	-	-	-	-
	substrate	-	-	-	-
Greenhouse	plant	+	+	+	+
	substrate	+	+	+	+
Can yard	plant	+	+	+	+
	substrate	+	+	+	+
Potting medium/components		-	-	+	+
Used containers		+	+	+	+
Irrigation water		+	-	+	-

Fig. 3. *Phytophthora* species by source for each of the four nurseries.

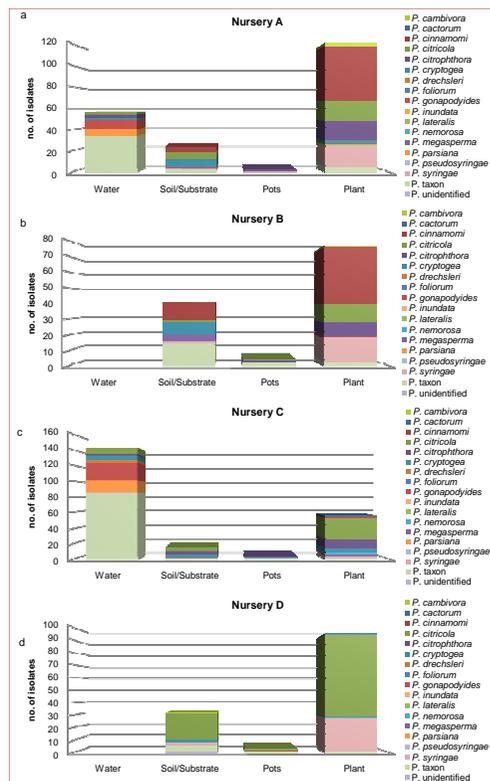


Fig. 4. *Phytophthora* species by source for all four nurseries combined.

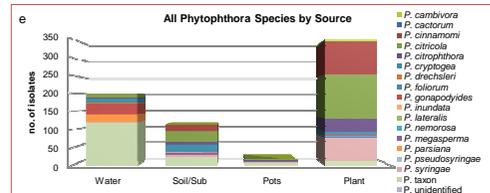
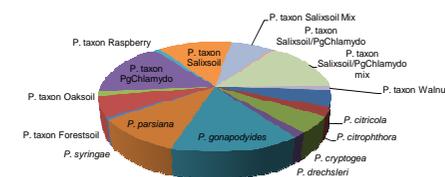


Fig. 5. *Phytophthora* species and taxa identified from recycled irrigation water



Results

Phytophthora was not recovered in the propagation phase in any of the nurseries, while *Phytophthora* was discovered at every other phase of production (Table 1). Four Critical Control Points in nursery production systems were identified: contaminated substrates from greenhouses and can yards, re-used containers, potting media that became contaminated by field equipment, and recycled irrigation water. Sixteen *Phytophthora* species totaling 674 isolates were identified (Fig. 4). Species recovered from individual nurseries differed, likely a reflection of differences in cultural practices and plant species composition. The most frequently isolated species from symptomatic plants were *P. citricola*, *P. cinnamomi*, and *P. syringae*. From gravel substrates, soil, and re-used pots, the predominant species were *P. citricola*, *P. cinnamomi*, and *P. cryptogea*. From recycled irrigation water, most isolates were *P. gonapodyoides* or other ITS Clade 6 taxa (Fig. 5). *P. parsiana*, not previously reported from nurseries, was also detected. *P. cinnamomi*, the species most frequently isolated from plants, was never recovered from water. After identifying critical control points (CCPs) where contamination occurred, we worked with nursery managers to develop Best Management Practices specific for each nursery.

Technology Transfer and Impacts of the Systems Approach

- A new, broadly applicable approach for identifying sources of pest and pathogen contamination
- May provide an alternative strategy to current system of end-point inspections
- Interaction between scientists and growers critical to development of science-based and practical Best Management Practices
- Provided the scientific basis for the Grower-Assisted Inspection Program (GAIP) implemented by the Oregon Department of Agriculture
- Resulted in development of the **Phytophthora Online Course: Training for Nursery Growers** (in English and Spanish) www.ecampus.oregonstate.edu/phytophthora
- Contributed to the development **Phytophthora-ID**, a simple yet robust web- and sequence- based *Phytophthora* identification tool <http://phytophthora-id.org/>

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