Developing Improved Strategies for Management of Replant Problems

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BACKGROUND

This project addresses two key soilborne disease problems, Prunus replant disease (PRD) (Fig. 1) and Phytophthora crown and root rot (Fig. 2). PRD commonly occurs when an almond orchard is replanted in loamy or sandy soil used previously for production of almonds or other stone fruits. The disease suppresses root development on young trees and thereby reduces the rate of canopy development and cumulative crop yield. PRD is apparently caused by a poorly defined complex of soilborne microorganisms, and it is a separate and more widespread problem than root damage inflicted by nematodes. Phytophthora crown and root rot also affects many young orchards, especially when peach x almond rootstock is used, but it can kill almond trees of any age.

OBJECTIVES

1. Determine the specific causal agents of Prunus replant disease (PRD) and Phytopthora crown and root rots
2. Identify rootstocks with tolerance or resistance to PRD and *Phytophthora*.
3. Support approaches for managing PRD with minimal dependence on soil fumigation.

Fig. 1. First-year impact of Prunus replant disease (PRD): **A**, poor growth of PRD-affected trees planted in non-fumigated soil (foreground, right), compared to healthy trees planted in fumigated soil (background, left); **B,** PRD-affected roots from non-fumigated soil. and **C**, healthy roots from fumigated soil.

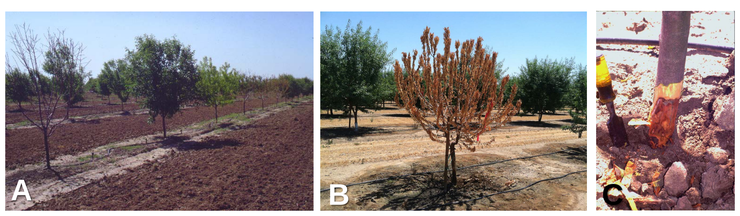


Fig. 2. Symptoms caused by *Phytophthora*. **A-C** young trees dying from crown and root rot; **D**, mature tree affected by perennial Phytophthora canker. Field observations indicate that some peach x almond hybrid rootstocks are more susceptible than Nemaguard and Lovell peach rootstocks to *Phytophthora* species.

PHYTOPHTHORA, CURRENT INCIDENCE

A "new species" of *Phytophthora., P. niederhauseri*, has been causing crown rot of almond in several San Joaquin Valley orchards. It has been found predominantly on peach x almond hybrid rootstocks, but can affect Nemaguard peach also. *Phytophthora cactorum* and *P, megasperma* also cause root and crown rot of almond.

DETERMINING PRD CAUSES, INTERACTIONS

We are identifying causal agents of PRD by collecting them from affected trees in replant soils and then then testing them, individually and in combinations, for ability to reproduce the disease (e.g., **Fig. 3**). This approach, combined with DNA-based methods, has implicated several species of *Pythium* (a fungus-like "watermold") and *Cylindrocarpon* (a fungus) as PRD pathogens in at least some almond replant soils. Along with PRD pathogens, we are testing *Trichoderma*, a fungus found abundantly on roots of healthy trees in fumigated plots, for its ability to suppress PRD pathogens.

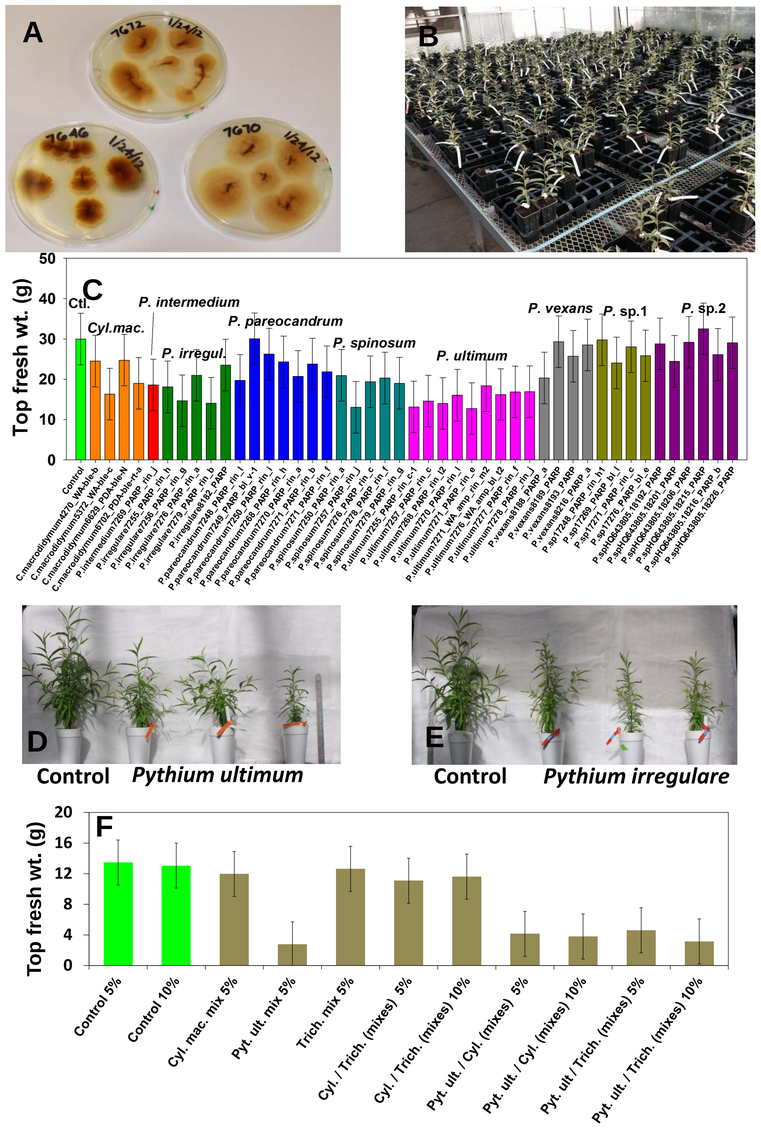


Fig. 3. Examination of PRD causes**. A**, isolates of fungi associated with PRD; **B**, testing pathogenicity of PRD isolates in a greenhouse; **C**, pathogenicity of *Cylindrocarpon* and *Pythium* species (note the reductions in fresh weight caused by some species, compared to the control); **D** and **E**, typical stunting caused by *P. ultimum* and *P. irregulare*; and **F**, results of trial testing for interactions among *Cylindrocarpon*, *Pythium*, and *Trichoderma*. In **F**, note the dominant pathogenicity of *P. ultimum* in the trial evaluating interactions.

ROOTSTOCK RESISTANCE TO PRD & *PHYTOPHTHORA*

Table 1. Rootstocks that we have tested with Duarte Nursery, Inc.

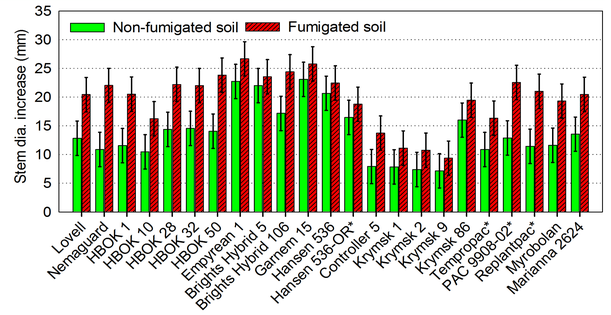
Rootstock	Type	Genetic background	Compatible crops[a]
HBOK1	Pe	*HB x OK peach*	Pe
HBOK 10 (Controller 8)	Pe	*HB x OK peach*	Pe
HBOK 28	Pe	*HB x OK peach*	Pe
HBOK 32 (Controller 7)	Pe	*HB x OK peach*	Pe
HBOK 50 (Contoller 9.5)	Pe	*HB x OK peach*	Pe
Lovell	Pe	*P. persica*	Al, Pe ,Ap, Pl, Pr
Nemaguard	Pe	*P. persica x P. davidiana*	Al, Pe, Ap, Pl, Pr
Empyrean#1 (Barrier 1)	Pe	*P. persica x P. davidiana*	Pe, Al
Bright Hybrid-5	Pe x Al	*P. persica x P. dulcis*	Al
Bright Hybrid 106	Pe x Al	*P. persica x P. dulcis*	Al
GxN 15(Garnem)	Pe x Al	*P. dulcis x P. persica (Nemared)*	Al
Hansen 536	Pe x Al	*[Okin.x (P. davidiana x Pe PI 6582)] x alm.*	Al, Ap, Pe
Controller 5 (=K146-43)	Pl hybrid	*P. salicina x P. persica*	Pe
Krymsk #1 (VVA 1)	Pl hybrid	*P. tomentosa x P. cerasifera*	Pl, some Pe
Krymsk 2	Pl hybrid	*P. incana x P. tomentosa*	Unknown.
Krymsk 9	Pl hybrid	*P. armeniaca x P. cerasifera*	Unknown.
Krymsk#86 (Kuban 86)	Pl hybrid	*P. persica x P. cerasifera*	Al, Pe, Pl
Myrobalan	Pl hybrid	*P. cerasifera*	Ap, Pl, Pr
Marianna 2624	Pl hybrid	*P.munsoniana x P. cerasifera*	(Al), Ap, Pl, Pr

Table 2. Rootstocks that we are testing with USDA-NCGR.

Rootstock	Genetic background
198-3	*argentia x dulcis*
198-13	*webii x dulcis*
198-17	*tangutica x dulcis*
198-18	*Nemared x kensuensis*
L-1-2	*ceracifera x Nickels?*
P-2-1	*Nemared x argentia*
P-2-2	*Nemared x argentia*
P-2-4	*Nemared x argentia*
P-2-9	*Nemared x argentia*
P-2-11	*Nemared x argentia*
P-4-1	*Nemared x fenzliana*
P-4-10	*Nemared x fenzliana*
P-4-25	*Nemared x fenzliana*
Hansen 536	*[Okin.x (P. davidiana x Pe PI 6582)] x alm.*
Nemaguard	*P. persica x P. davidiana*
Hansen 536	*[Okin.x (P. davidiana x Pe PI 6582)] x alm.*
Nemaguard	*P. persica x P. davidiana*
Marianna 2624	*P.munsoniana x P. cerasifera*

ROOTSTOCK RESISTANCE TO PRD & *PHYTOPHTHORA*, CONTD.

Fig. 4. Relative resistance of rootstocks for almond and stone fruits to the PRD complex, above and right. Two evaluations of the resistance have been conducted in replicate fumigated and non-fumigated plots near Parlier, CA. Note tolerance of peach x almond hybrids, and Empyrean 1, a vigorous peach.



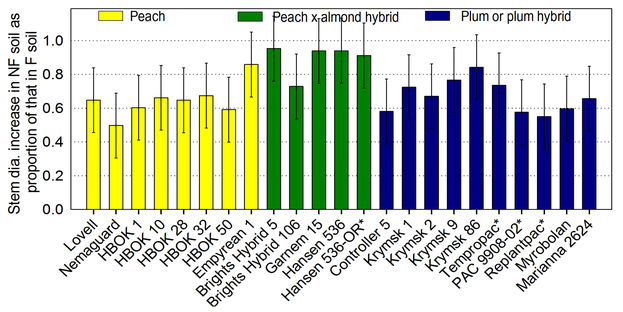
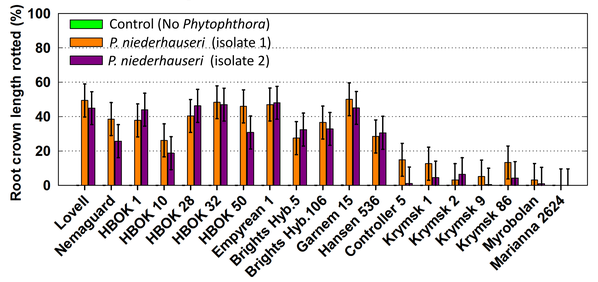
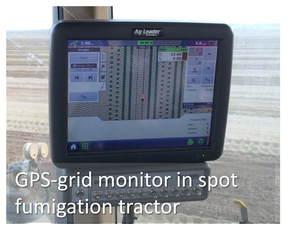


Fig. 5. Results of an evaluation of resistance to *Phytophthora niederhauseri* in greenhouse., above and right.



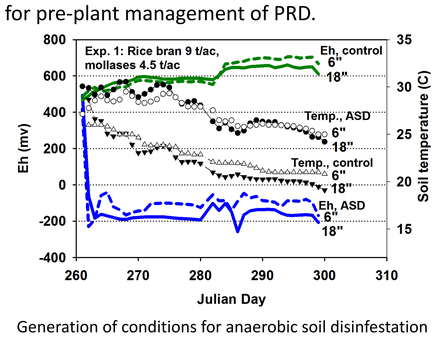
SOIL BIOASSAY AND GPS-CONTROLLED SPOT FUMIGATION

Fig. 6. We are testing a soil bioassay method 1) to examine how soil and site factors may impact PRD severity, and 2) to advance development of predictive diagnostics for PRD. Strip and GPS-spot fumigation trials are part of the research.



CULTURAL REMEDIATION OF PRD

Fig. 7. Scenes and some data from almond replant trial at the Kearney Agricultural Center, Parlier, where we are testing sudan grass rotation, deep vs. shallow soil ripping, anaerobic soil disinfestation, and early and late season fumigation for pre-plant management of PRD.



Generation of conditions for anaerobic soil disinfestation

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