PHYTOPHTHORA CONTROL ON STRAWBERRY, ALMOND AND WALNUT WITHOUT METHYL BROMIDE

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Phytophthora spp. are important soilborne pathogens of many annual and perennial crops in California, including strawberries, almonds, and walnuts. Fumigation with methyl bromide dramatically lowers populations of *Phytophthora* spp. in soil, thereby helping to produce nursery stock free of the pathogens and reducing incidence of Phytophthora root and crown rots in annual strawberry cropping cycles and early years of orchard development. We report here on current status of Phytophthora diseases on strawberry, almond and walnut in California and on progress in controlling the diseases with genetic, chemical, and cultural alternatives to methyl bromide. These strategies may become increasingly important as fumigation options are restricted.

Methods

Surveys are conducted with help from UC Extension personnel, growers, and other industry representatives to determine the prevalence of different *Phytophthora* spp. associated with disease on California strawberries, almonds, and walnuts. Necrotic tissues are collected the from diseased roots, crowns, tree trunks, or tree scaffold branches and plate cultured. Most of the *Phytophthora* spp. isolated are identified using morphological traits, but molecular characterizations are being initiated to help identify *P. fragariae*-like strains from strawberry. Greenhouse tests are used to determine pathogenicity. Representative strains of *Phytophthora* spp. affecting strawberry, almond, and walnut are used in field and greenhouse experiments to develop screening methods for breeding programs (strawberry), determine relative resistance of plant germplasm (strawberry, almond, walnut), and assess effectiveness of cultural and chemical strategies to manage Phytophthora-induced diseases (strawberry, almond).

Results and Discussion.

Strawberry. Our surveys indicate that *P. cactorum* is the most prevalent *Phytophthora* sp. infesting California nursery stock and causing crown rot in fruiting fields. *P. fragariae*-like species were isolated from strawberry plants with root or crown disease in several fruiting fields near Watsonville and one Sacramento Valley planting.

Experiments at Monterey Bay Academy (MBA) and near Winters determined methods of soil infestation and plant inoculation with *P. cactorum* and *P. citricola* that reliably result in high incidence of crown rot on susceptible cultivars. In MBA screens, recent UC releases as well as older cultivars used as standards varied from highly susceptible to highly resistant to *P. cactorum* and *P. citricola*, as measured by crown rot scores, plant mortality, and marketable yields (Table 1). Greenhouse screens using the same cultivars and pathogens have not given consistent responses to date (data not shown). At high levels of soil infestation and with disease-conducive conditions, preliminary experiments involving systemic fungicide application (Aliette and Ridomil Gold) and altered irrigation management (amounts of 0.6x, 1.0x, or 1.8x of ET irrigation

requirement; frequencies of 1 or 3 irrigations per week) have afforded less pronounced disease control than that obtained with resistant cultivars, but research on the chemical and cultural approaches continues. Overall, the MBA results highlight important differences in resistance to Phytophthora crown rot within existing UC germplasm and suggest that continued screening efforts could help breed and detect cultivars that combine resistance to the disease with horticultural desirability.

Almond. Surveys throughout California almond districts indicate that *P. megasperma* is the most common cause of Phytophthora crown rot among young, nonbearing almond orchards. Among mature, bearing orchards in the San Joaquin Valley, however, *P. cactorum* and *P. citricola* were determined to incite high incidence of lethal Phytophthora canker (LPC), a newly described disease resulting from infection of aboveground tree parts. In LPC-affected orchards, the causal pathogens were detected in the orchard soils, airborne harvest debris, and scaffold crotch pockets.

In greenhouse screens, Hansen 536 rootstock (interspecific almond-peach) has proven particularly susceptible to *P. cactorum* and *P. megasperma*, whereas Marianna 2624 (plum) and Citation (interspecific peach-plum) have been relatively resistant (Table 2). Rootstocks Atlas and Viking (interspecific peach-almond-plum-apricot), and Nemaguard and Lovell (peach) were relatively resistant to *P. cactorum* and moderately to highly susceptible to *P. megasperma*.

The screening results suggest that the vigor-enhancing Hansen 536 should be avoided as an almond rootstock where risk of infection by *P. cactorum* or *P. megasperma* is high. The results with Atlas and Viking, however, suggest that not all vigorous hybrid almond rootstocks are highly susceptible to *Phytophthora*. The resistant stocks of Citation and Marianna 2624 have limited graft compatibility with almond, but Citation is compatible with peach and Marianna 2624 is compatible with some almond cultivars. Hybrids involving plum species may offer long-term potential for improving resistance to *Phytophthora* spp. in rootstocks for almond and other *Prunus* spp.

An experimental LPC post-infection treatment with mefenoxam (Ridomil Gold) or pre-infection treatments with a phosphorous acid-containing fertilizer (Nutri-Phite) suppressed subsequent canker development caused by *P. citricola*. It appears that, if affordable, these systemic compounds could contribute to integrated management of LPC.

Walnut. Our surveys indicate that *P. cinnamomi* and *P. citricola* continue to cause death and decline of California walnut trees. *P. cinnamomi* is the most virulent *Phytophthora* sp. on walnut. Significant differences in resistance to *P. citricola* were observed among diverse seed families of Paradox walnut hybrids (*J. hindsii* x *regia*, *J. nigra* x *regia*, *J. californica* x *J. regia*). Seedlings were selected for putative resistance to *P. citricola* from families with the highest survival rates in soil infested by the pathogen. The selected plants and cv. Vlach (a commercial standard Paradox rootstock, *J. hindsii* x *J. regia*) were micropropagated and are being acclimatized for confirmatory resistance screens. Only Chinese wingnut (*Pterocarya stenoptera*) has proven highly resistant to *P. cinnamomi* as well as to *P. citricola*. Wingnut is not graft compatible with all English cultivars, but field tests underway

indicate that for some of the cultivars wingnut offers potential as a durable rootstock with very high resistance to Phytophthora root and crown rots.

Table 1. Relative resistance of four strawberry cultivars to *Phytophthora cactorum* and *P. citricola* in a replicated field trial at Monterey Bay Academy, 1997/98 season.[a]

Phytophthora inoculum	Cultivar	Crown rot score (0=healthy, 5= complete rot)	Incidence of mortality (%)	Total marketable yield (grams per plant)	Total marketable yield compared to non-inoculated control (%)
None (control)	Aromas	0.1 e	0 e	1724 ab	--
	Camarosa	0.2 e	2 e	2046 a	--
	Diamante	0.3 e	5 de	1487 cd	--
	Pajaro	0.2 e	5 de	961 e	--
P. cactorum	Aromas	0.6 de	2 e	1390 d	81
	Camarosa	0.3 e	2 e	1312 d	64
	Diamante	2.8 a	42 a	530 fg	36
	Pajaro	2.1 b	27 bc	339 g	35
P. citricola	Aromas	0.3 e	0 e	1912 ab	111
	Camarosa	0.5 e	0 e	1467 cd	72
	Diamante	1.3 cd	17 cd	1478 cd	99
	Pajaro	1.8 bc	35 ab	685 ef	71

[a]Values are means from four replicate 10-plant plots. Means within a column and without letters in common are significantly different (Waller-Duncan k-ratio test).

Table 2. Relative resistance to *Phytophthora cactorum* and *P. megasperma* in some commercial rootstocks used for almond or other *Prunus* spp.

	Inoculum treatment and health of roots and crown[a]					
	Control		*P. cactorum*		*P. megasperma*	
Rootstock	Root rot (%)	Crown length rotted (%)	Root rot (%)	Crown length rotted (%)	Root rot (%)	Crown length rotted (%)
Atlas	3 a	0 a	16 b	0 b	93 a	39 bc
Citation	2 a	3 a	2 b	0 b	3 b	0 d
Hansen 536	22 a	5 a	63 a	69 a	100 a	100 a
Lovell	3 a	0 a	3 b	0 b	89 a	61 b
Marianna 2624	3 a	0 a	6 b	0 b	5 b	0 d
Nemaguard	1 a	0 a	5 b	0 b	93 a	36 bcd

Viking	10 a	1 a	11 b	3 b	91 a	24 cd

[a]Values are means from four to five replicate plants per treatment. Means within a column and without letters in common are significantly different (Waller-Duncan k-ratio test).