Developing Improved Management Strategies for Replant Problems

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BACKGROUND

Replant disease (RD) and other replant problems such as plant parasitic nematodes can seriously reduce cumulative nut yield in successive almond plantings. When almond orchards are replaced, RD suppresses root development and thereby slows the rate of canopy development. In severe cases RD kills trees. Evidence suggests that a soilborne complex of microorganisms causes RD, but many of the important details remain unresolved. RD is a separate problem from nematode damage. Pre-plant soil fumigation can prevent RD and other replant problems, but the treatments are increasingly regulated and costly. Our research is focused on reducing dependence on pre-plant soil fumigation.

RECOGNITION OF REPLANT DISEASE (RD)

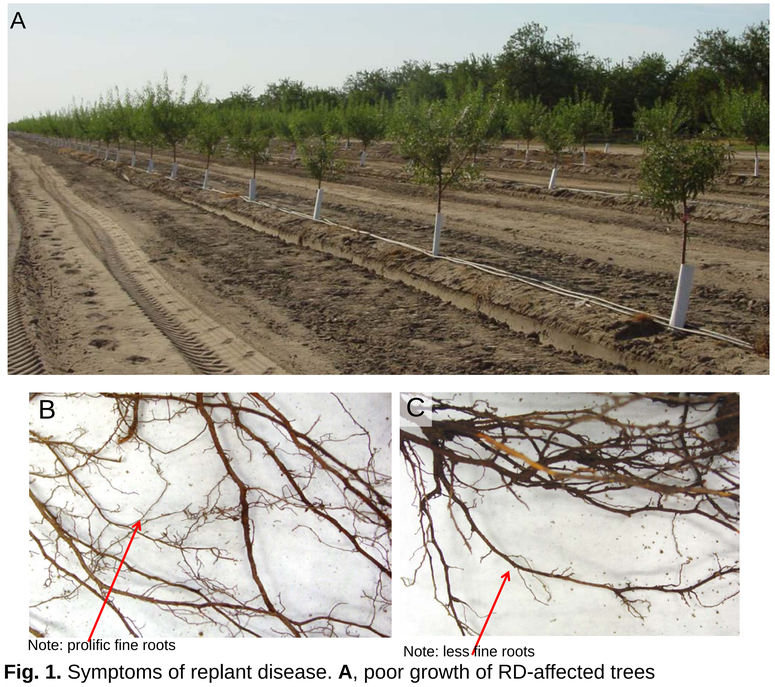

Fig. 1. Symptoms of replant disease. **A**, poor growth of RD-affected trees foreground trees planted in non-fumigated soil (foreground), compared to heatlhy trees planted in fumigated soil (background); **B**, healthy roots from fumigated soil; and **C**, RD-affected roots from non-fumigated soil.

RESEARCH GOALS

1. Determine the biological causes of replant disease (RD).
2. Support development of new management strategies for RD and other replant problems.

RESEARCH TOPIC HIGHLIGHTS, 2012

- **Development of soil bioassays for RD**. (Soil bioassays may be used to: directly predict RD, develop molecular tools to predict RD, and learn more about RD causes; **this poster, center**).
- **Establishment of second field trial to evaluate resistance of clonal rootstock genotypes to RD** (See results of the second trial **this poster, far right**).
- **Sorting out contributions of suspected RD pathogens** to the disease complex (*Cylindrocarpon* and *Pythium* species associated with RD were identified by rDNA sequencing and tested for aggressiveness as RD agents in greenhouse trials; see results on **Poster 2, below**).
- **Economic analysis of USDA-ARS Pacific Area Wide Program replant trials** (If you are considering pre-plant soil fumigation see this!, **Poster 2, below**)

SOIL BIOASSAY TO TEST FOR RD, METHODS

Hanford sandy loam soil was collected from three potential RD orchard sites in Fresno County. At each orchard collection site, soil was collected from two soil depth ranges, 0.3 to 1.0 ft and 1.0 to 2.0 ft. Two experiments were set up to learn about effects of soil sample depth, post-collection soil treatment (i.e., pasteurization, autoclaving, or bucket fumigation) assay plant "format" (i.e., sprouting Nemaguard vs. several-month-old clonal Nemaguard from tissue culture), and ratio of field soil to sand (sand is used in bioassay experiments to add porosity to the soil mix so that soil drainage is adequate, approximating that in a field soil). In each experiment, the test soils received their post-collection treatments in March-April 2012 and planted with Nemaguard on 25 April 2012. Treatment effects were assessed in June 2012.

SOIL BIOASSAY RESULTS

Table 1. Results of experiment to optimize bioassay performance.

Effect	Treatment	Bioassay plant response		
		Top wt. (g)	Root wt. (g)	Root rot (%)
Soil mixing with course sand	**1:0 field soil : sand ratio**	**11.6**	**5**	**29**
	5:1 field soil : sand ratio	**8.3**	**4.3**	**25**
	4:1 field soil : sand ratio	**9.1**	**4.7**	**25**
	3:1 field soil : sand ratio	**12.0**	**5.6**	**33**
	2:1 field soil : sand ratio	**11.4**	**5.2**	**31**
	1:1 field soil : sand ratio	**10.8**	**5.8**	**37**
	P value:	***0.13***	***0.04***	***0.04***
	95% CI	**--**	***1.1***	***6***
Post-collection soil treatment	**Control**	**6.0**	**2.9**	**70**
	Autoclave	**10.6**	**5.3**	**13**
	Fumigation	**15.1**	**7.1**	**7**
	P value:	***<0.0001***	***<0.0001***	***<0.0001***
	95% CI	***(+/- 2.7)***	***(+/- 1.1)***	***(+/- 4)***

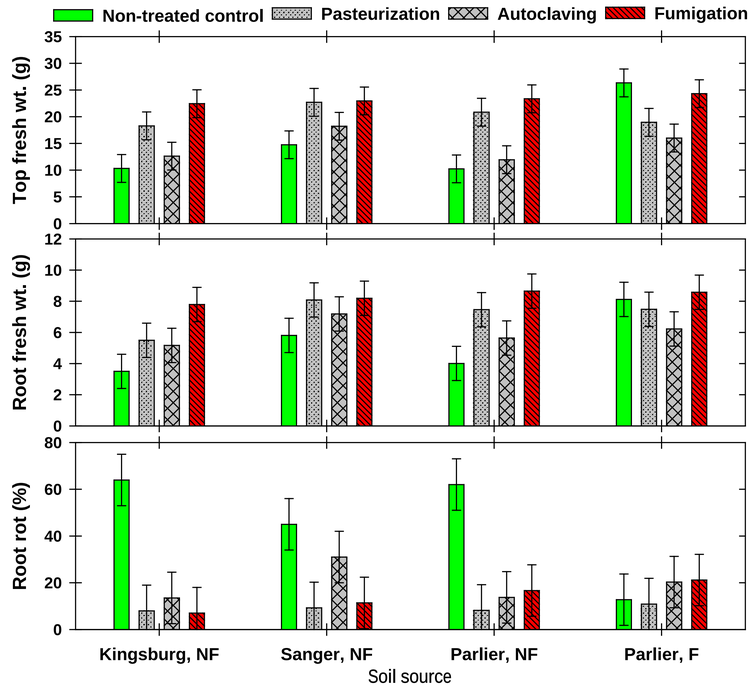

Fig. 2. Results of application of bioassay to four sources of Hanford Sandy Loam replant soil. Pre-collection soil treatments in field: "NF" indicates not fumigated, "F" indicates fumigated (Telone C35, 540 lb/ac). Post-collection soil treatments: see legend at top of figure. Vertical bars = 95% confidence intervals.

ROOTSTOCK RESISTANCE TO RD, METHODS

Twenty-two rootstocks, including Lovell, Nemaguard, and Marianna 2624 as standards, were planted in replicate fumigated (Telone C35) and non-fumigated plots of Hanford Sandy Loam soil near Parlier, CA. The site was known to induce severe RD. Resistance to RD was assessed by growth using changes in trunk diameter size

ROOTSTOCK RESISTANCE TO RD, 2012 RESULTS

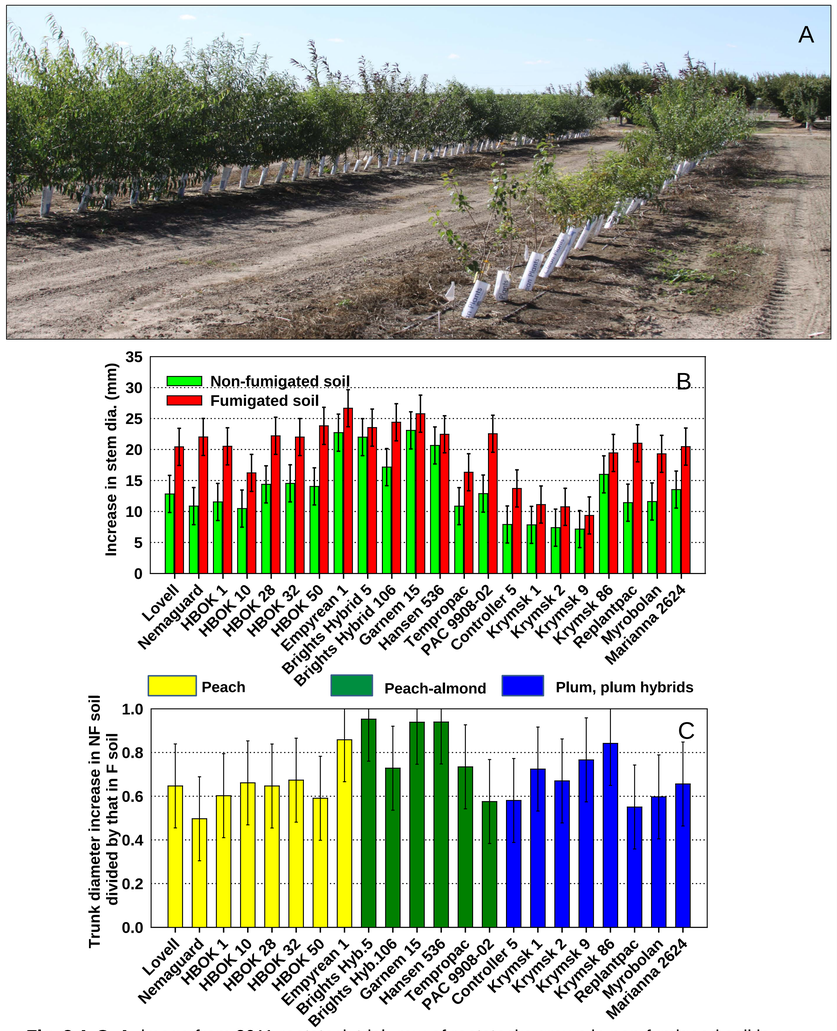

Fig. 3 A-C. A, image from 2011 rootstock trial--row of rootstocks grown in non-fumigaed soil is on right, and row of rootstocks grown in Telone C35-fumigated soil is on left; **B**, stem diameter increases measured in 2012 roostock trial from time of planting, May 2012, to Nov. 15, 2012; and **C**, resistance of rootstocks to PRD complex, calculated by dividing stem diameter increase in non-fumigated soil by the increase in fumigated soil (i.e., NF/F proportion). Vertical bars are 95% confidence intervals.

CONCLUSIONS, POSTER 1

- **Bioassay methods:** They are useful and will be employed to develop practical RD prediction methods and to further understand RD causes.
- **Rootstock resistance to RD:** Growers should consider resistance to RD, such as shown above, among the criteria they use to select rootstocks.

ACKNOWLEDGEMENTS

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Additional Research, Replant Disease and the Pacific Area-Wide Program for Methyl Bromide Alternatives (PAW-MBA)

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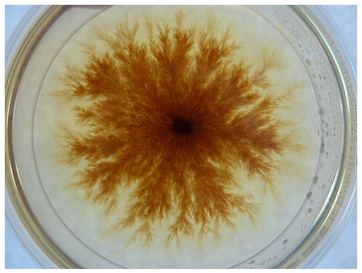
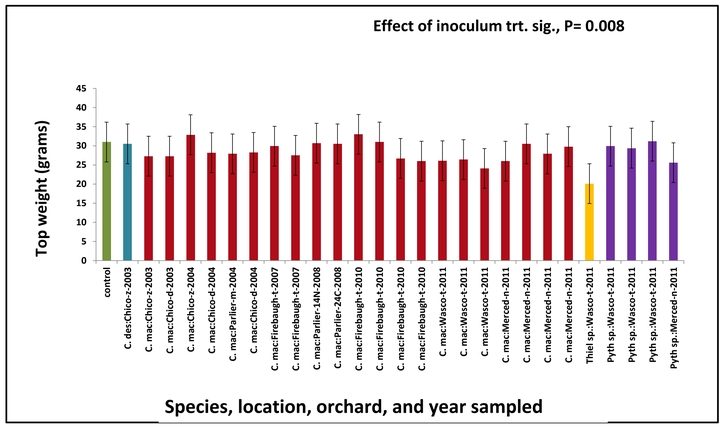
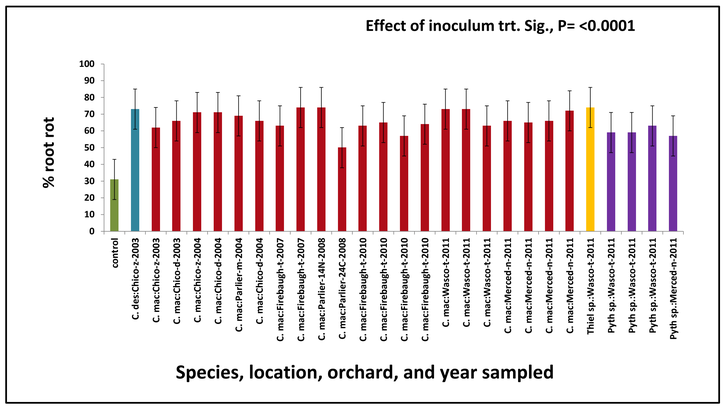
FINDING RD SUSPECTS AND TESTING THEIR PATHOGENICITY , METHODS AND RESULTS

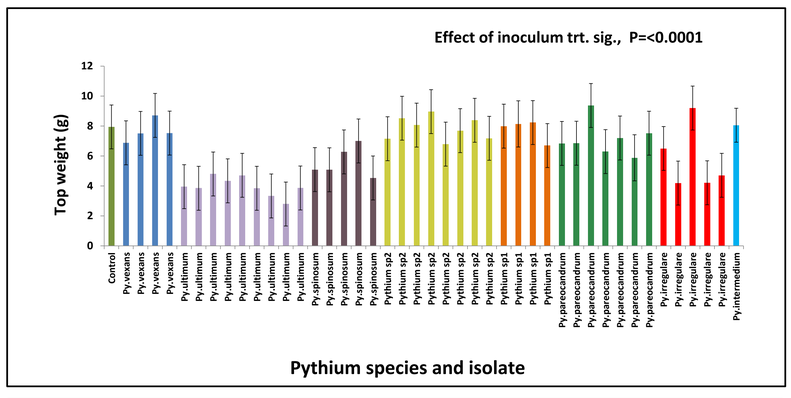


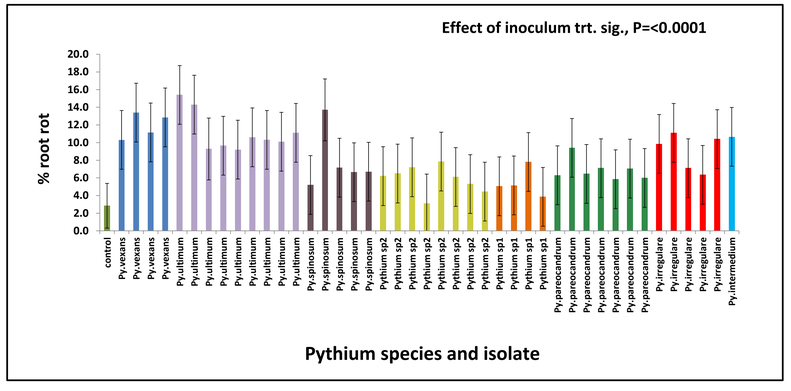
Methods. We use culture-based and culture independent methods to identify microorganisms (bacteria, fungi, oomycetes) associated with RD incidence in our research trials, i.e., the rootstock trials, grower fumigation trials, bioassay experiments. Organisms that are found more in RD-affected plants than in healthy plants are suspected of contributing to RD, and, if they can be cultured, we test them for the ability to cause disease in Nemaguard peach rootstock.

Results. Figures at right show results of pathogenicity tests with *Cylindrocarpon* species (A and B), Pythium species (A-D), and other fungi A and B).

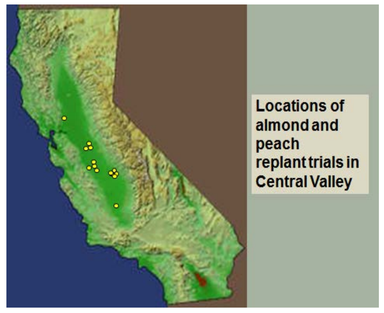


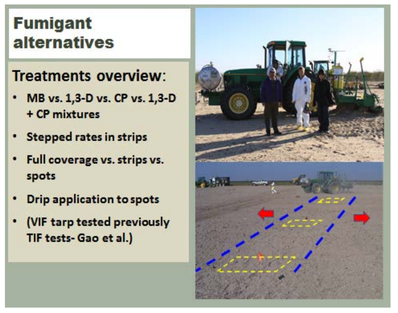


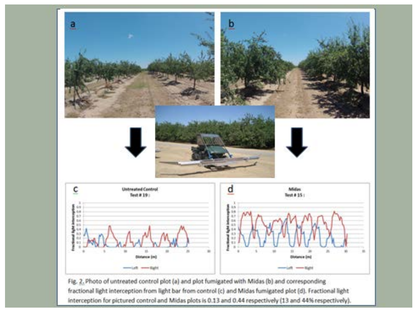




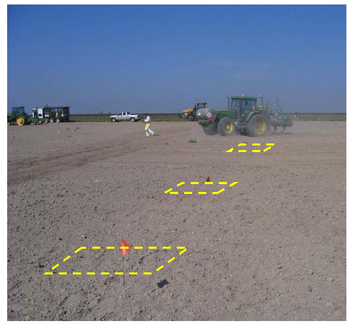
LONG-TERM ECONOMIC ASSESSMENTS IN REPLANT TRIALS, PACIFIC AREA-WIDE PROGRAM, USDA-ARS







Trial	Fumigant[a]	Coverage	Fumigant rate: lb / treated acre	Fumigant rate: lb / orchard acre	Cost of trt. ($/acre)	% Photosynthetically active radiation (PAR) absorbed: Yield yr 1	% PAR absorbed: Yield yr 2	% PAR absorbed: Yield yr 3	Cummulative yield (lb kernal / acre): Yield yr 1	Cummulative yield: Yield yr 2	Cummulative yield: Yield yr 3	Cum.net revenue gain ($/acre)[b]: Yield yr 2	Cum.net revenue gain: Yield yr 3
Firebaugh	Control	None	0	0	0	16	46	59	161	856	3024	0	0
	MB	Strip (45%)	400	180	1962	19	46	54	455	1277	3366	(1,120)	(1,279)
	1,3-D	Strip (38%)	340	129	393	22	50	58	547	1517	3997	929	1,552
	CP	Strip (38%)	400	152	871	29	54	61	932	2088	4676	1,593	2,433
	CP	Strip (38%)	300	114	677	28	51	56	975	2129	4726	1,870	2,727
	CP	Strip (38%)	200	76	482	32	54	61	979	2308	4929	2,422	3,328
	1,3-D:CP (63:35)	Strip (38%)	550	209	882	30	56	62	905	2260	5113	1,926	3,296
	CP:1,3-D (60:39)	Strip (38%)	550	209	829	31	55	60	1123	2502	5540	2,462	4,202
	CP:1,3-D (60:39)	Strip (38%)	400	152	667	30	53	59	834	2132	4765	1,885	2,814
	MI:CP (50:50)	Strip (38%)	400	152	na	30	57	62	948	2120	5107	--	--
	CP	Spot (17%)	400	68	441	26	51	58	811	1939	4673	1,725	2,857
	1,3-D:CP (63:35)	Spot (17%)	550	94	447	25	51	59	778	1844	4484	1,530	2,473
	1,3-D:CP (63:35)	Full (100%)	550	550	2169	31	55	61	941	2285	5364	688	2,511
		Value of *P* :				<0.0001	0.002	0.24	<0.0001	<0.0001	<0.0001		
		95% CI Values:				+/-4	+/-4	+/-4	+/- 240	+/- 277	+/- 473		
Madera	Control	None	0	0	0	25	30	--	274	973	--	0	--
	MB	Strip (45%)	400	180	1962	36	45	--	380	1678	--	(552)	--
	1,3-D	Strip (38%)	340	129.2	393	35	42	--	405	1496	--	653	--
	CP	Strip (38%)	400	152	871	39	45	--	562	2028	--	1,239	--
	CP	Strip (38%)	300	114	677	40	47	--	516	1930	--	1,237	--
	CP	Strip (38%)	200	76	482	34	42	--	407	1494	--	558	--
	1,3-D:CP (63:35)	Strip (38%)	550	209	882	38	46	--	512	1884	--	938	--
	CP:1,3-D 60:39)	Strip (38%)	400	152	667	36	42	--	514	1724	--	834	--
	MI:CP (50:50)	Strip (38%)	400	152	na	43	51	--	517	2185	--	--	--
	CP	Spot (11%)	400	44	319	39	46	--	454	1690	--	1,115	--
	1,3-D:CP (63:35)	Spot (11%)	550	60.5	322	34	40	--	443	1552	--	835	--
	1,3-D:CP (63:35)	Full (100%)	550	550	2169	42	50	--	485	2300	--	483	--
		Value of *P* :				0.0003	0.0002		<0.0001	<0.0001			
		95% CI Values:				+/-5	+/-6		+/-64	433			



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