Developing Improved Strategies for Management of Replant Problems

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BACKGROUND AND OBJECTIVES

This project focuses on biology and management of replant problems, especially almond replant disease (RD). RD suppresses root development, slowing canopy development and reducing yield (**Fig. 1**). The disease is caused by a complex of soilborne microorganisms in almond replanted after almond or other stone fruits; it is separate from nematode-inflicted disease. We have determined that *Cylindrocarpon* and *Pythium* species contribute to the disease and are continuing work to elucidate additional RD causes. Also, we are developing improved approaches to predict and manage RD with less dependence on soil fumigation.

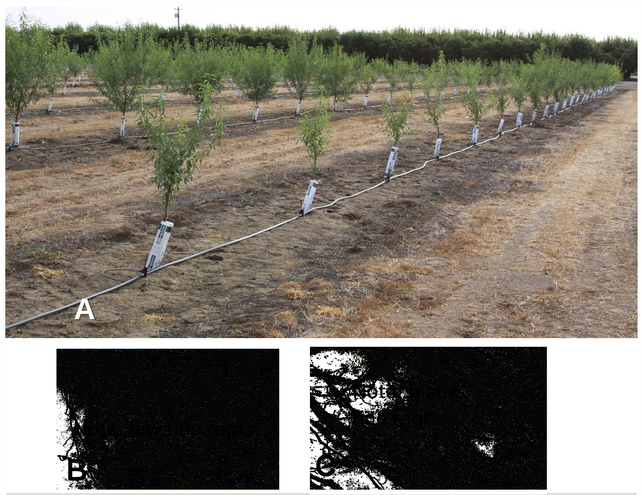

Fig. 1. A, Right foreground, Prunus replant disease-induced stunting of trees in non-treated peach replant soil; and, left and right background, vigorous growth of trees in preplant-fumigated and anaerobic soil disinfested peach replant soil, respectively. **B**, PRD-affected roots from non-fumigated soil. and **C**, healthy roots from preplant fumigated soil.

Key Objectives

- Develop non-fumigant approaches for managing replant problems
- Develop better understanding of replant disease causes and prediction among fields
- Support development of improved rootstocks

Fumigant performance summary
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→ Alternatives ?

→ Soil bioassays, replant trials
→ High throughput DNA seq
→ Further resolution of RD
→ Predictive diagnostics?

→ New hybrids vs. standards
RD resistance — *Phytophthora* resistance

Table 1. Experiments and treatments, non-fumigant trials at Kearney Ag Center, Parlier

Year	Expt.	Trt. no.	Treatment name	Month of old orchard tree removal	Month of sudan rotation	Fall/winter soil disinfestation treatment
2013	1	1	Control, no sudan	Sep	None	None
		2	Control, with sudan	May	May-Oct	None
		3	ASD, high bran rate, wide strip, with sudan	May	May-Oct	ASD, 20 metric tons /treated ha, 3.0-m-wide strips
		4	Fumigation in Oct, no sudan	Sep	No	Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips
		5	Fumigation in Oct, with sudan	May	May-Oct	Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips
		6	Fumigation in Dec, no sudan	Sep	None	Telone C35, 600 kg/treated ha in Dec, 3.4-m-wide strips
	2	1	Control, no sudan	May	None	None
		2	ASD, high bran rate, wide strip, no sudan	May	None	ASD, 20 metric tons /treated ha, 3.0-m-wide strips
		3	Fumigation in Oct, no sudan	May	None	Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips
2014	3	1	Control, no sudan	Sep	None	None
		2	Control, with sudan	May	May-Oct	None
		3	ASD, high bran rate, wide strip, with sudan	May	May-Oct	ASD, 20 metric tons /treated ha, 3.0-m-wide strips
		4	ASD, high bran rate, narrow strip, no sudan	Sep	None	ASD, 20 metric tons /treated ha, 1.8-m-wide strips
		5	ASD, low bran rate, narrow strip, no sudan	Sep	None	ASD, 12 metric tons /treated ha, 1.8-m-wide strips
		6	Fumigation in Oct, no sudan	Sep	None	Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips
		7	Fumigation in Oct, with sudan	May	May-Oct	Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips
	4	1	Control, no sudan	May	None	None
		2	ASD, high bran rate, wide strip, no sudan	May	None	ASD, 20 metric tons /treated ha, 3.0-m-wide strips
		3	Fumigation in Oct, no sudan	May	None	Telone C35, 600 kg/treated ha in Oct, 3.4-m-wide strips

ANAEROBIC SOIL DISINFESTATION (ASD) AND OTHER NON-FUMIGANT APPROACHES

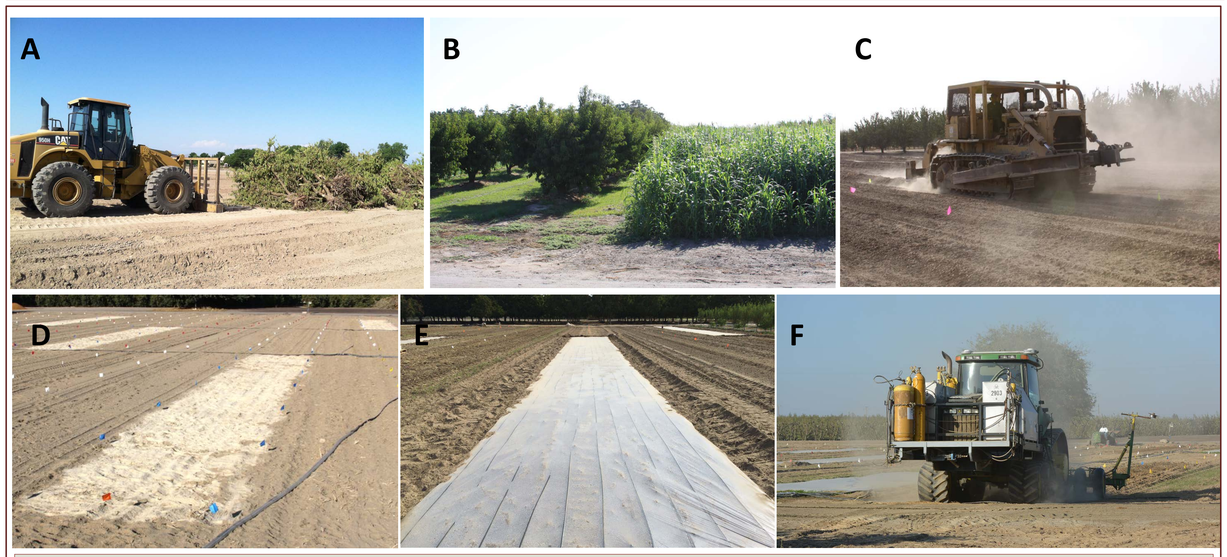


Fig. 2. Preplant treatment procedures in four almond replant trials at Kearney Ag. Ctr., 2013-15. **A**, trees were removed in either May or Sep (Table 1); **B**, a short-term sudan grass rotation in plot removed in May; **C**, administering soil-ripping-depth treatments (2 vs. 4-ft.); ASD treatments were initiated with **D**, rice bran, which was: incorporated to 6" depth then **E**, covered with TIF tarp (to retain heat and moisture and exclude O_2) and irrigated by drip to maintain soil moisture near field capacity for 6 wks. Non-treated controls and **F**, strip fumigation (Telone C35, 540 lb/treated acre) were used for comparison. Treatment efficacy was assessed by monitoring survival of *Pythium ultimum* (a RD pathogen) buried in small bags of soil during treatments (**Table 2** and growth of trees in the replanted almond orchard (Figs. 9-11).

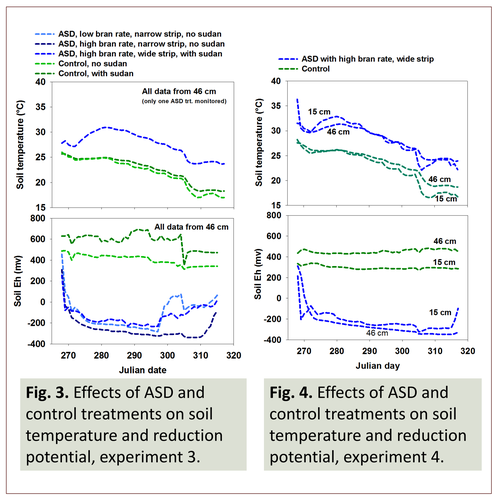


Fig. 3. Effects of ASD and control treatments on soil temperature and reduction potential, experiment 3.

Fig. 4. Effects of ASD and control treatments on soil temperature and reduction potential, experiment 4.

Table 2. Effect of treatments on survival of bioassay inoculum of *Pythium ultimum*

Expt.	Trt. no.	Treatment	Depth of bioassay inoculum in soil (cm)	Survival of bioassay inoculum (cfu / g soil) Mean	(S.E. of Mean)
3	1	Control, no sudan	15	2315	(70)
			46	1998	(471)
	2	Control, with sudan	15	2330	(556)
			46	2030	(363)
	3	ASD, high bran rate, wide strip, with sudan	15	0	(0)
			46	0	(0)
	4	ASD, high bran rate, narrow strip, no sudan	15	0	(0)
			46	0	(0)
	5	ASD, low bran rate, narrow strip, no sudan	15	0	(0)
			46	5	(5)
	6	Fumigation in Oct, no sudan	15	0	(0)
			46	190	(190)
	7	Fumigation in Oct, with sudan	15	0	(0)
			46	0	(0)
4	1	Control, no sudan	15	3663	(354)
			46	2008	(284)
	2	ASD, high bran rate, wide strip, no sudan	15	0	(0)
			46	0	(0)
	3	Fumigation in Oct, no sudan	15	0	(0)
			46	8	(8)

Soil and plant- based measurements, ASD

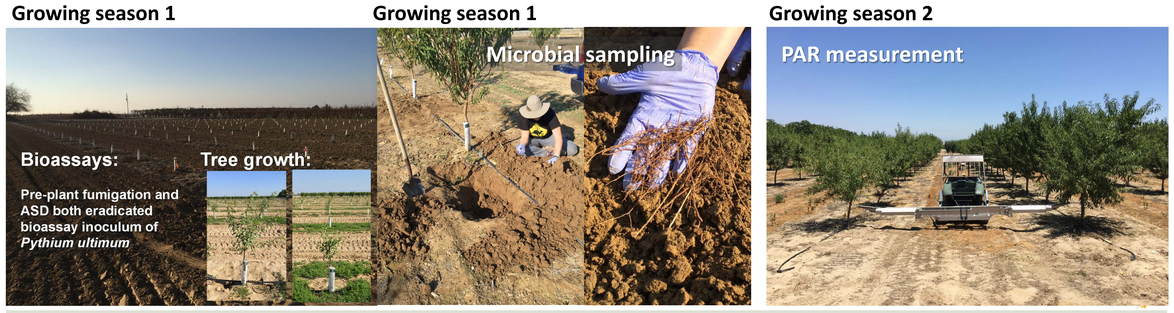


Fig. 5. Trial activities by growing season in experiments 1-4

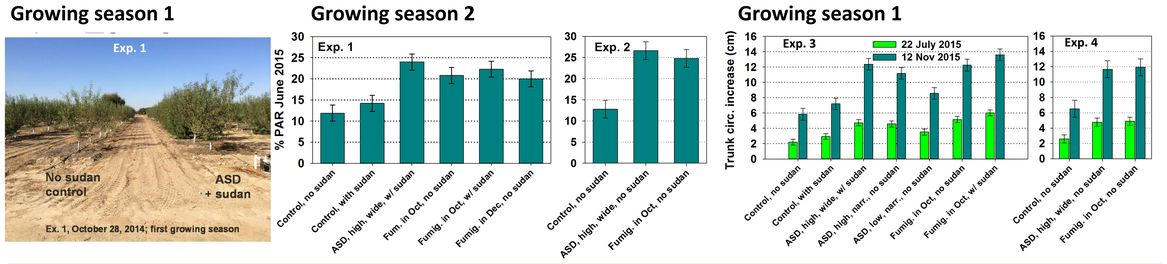


Fig.6. Resulting growth responses to treatments in in experiments 1-4, by growing season after transplanting

ASD Discussion:

It works!! But further research is needed and underway to reduce its cost and adapt its application methods for commercial use.

BIOASSAY SURVEY, REPLANT SOILS

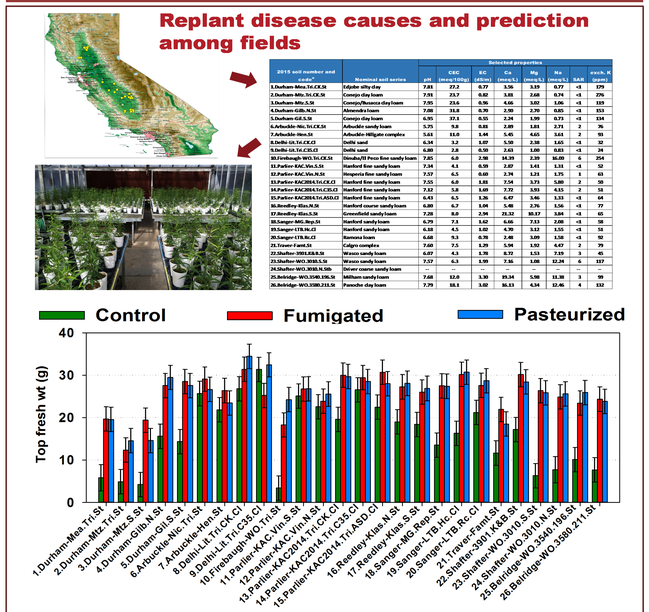
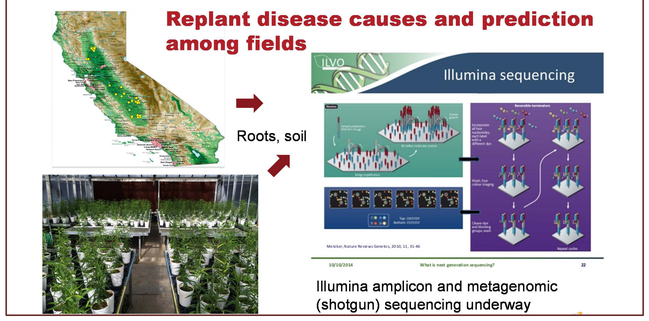


Fig. 7. Growth response of Nemaguard seedlings in a greenhouse bioassay of soils collected throughout the Central Valley. Each soil was split into 3 portions which were either not treated, fumigated, or steam pasteurized.
Soils exhibiting RD show stunting in plants grown in untreated soil compared to plants grown in fumigated or pasteurized soil.



Bioassay Discussion:

This bioassay is a helpful tool for predicting the need to manage RD in an orchard, with positive Nemaguard growth response to soil fumigation and pasteurization indicating a need for RD management. However, the bioassay is cumbersome and slow, so our ultimate goal is to find molecular markers in soil and roots that correlate with RD risk. This would allow for rapid preplant orchard assessment for RD.

TESTING RESISTANCE TO PHYTOPHTHORA

Fig. 8. Orchard tree infected by *Phytophthora cactorum*

Fig.9. Orchard tree infected by *Phytophthora niederhauserii*

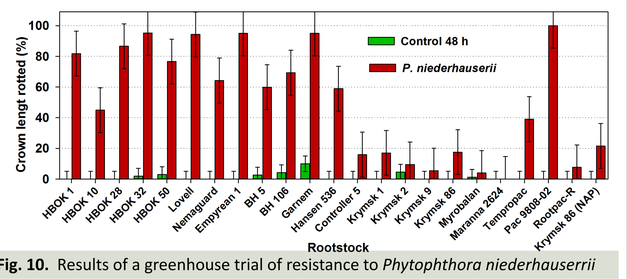


Fig. 10. Results of a greenhouse trial of resistance to *Phytophthora niederhauserrii*

Phytophthora Discussion:

Most rootstocks with plum background were highly and consistently resistant to crown rot caused by *P. niederhauserii*, while most peach x almond rootstocks were highly susceptible. Upcoming work will assess *Phythopthora* resistance of 54 hybrid rootstocks with widely varied genetic backgrounds. These hybrids were developed by Dr. Mali Aradhya, Dr. Tom Gradziel, and Dr. Craig Ledbetter.

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