ALTERNATIVE PRE-PLANT SOIL FUMIGATION TREATMENTS FOR DECIDUOUS TREE CROPS

B. Lampinen[1*], G. Browne[2], S. Schneider[3], A. Shrestha[4], B. Holtz[5], and L. Simon[6]
[1]Dept. of Plant Sciences, UC Davis; [2]USDA-ARS, UC Davis; [3]USDA-ARS, WMRL, Parlier; [4]UCCE, Parlier; [5]UCCE, Madera; [6]Dept. of Agric. and Resource Economics, UC Berkeley

Introduction. Pre-plant use of methyl bromide (MB) for perennial deciduous tree crops in California is directed at management of complex biological "replant problems" and meeting sanitation standards for nursery stock certification. Mature orchards commonly support populations of plant parasitic nematodes, pathogenic fungi and bacteria, as well as unknown biological agents that can interfere with establishment and growth of replanted trees. The negative effects of these agents can be pronounced in the first few years after tree planting, but economic impacts of replant problems may persist for the life of an orchard. Appropriate pre-plant fumigation can prevent complex orchard replant problems and maximize tree growth and crop production potential, but the loss of MB and increasing regulatory restrictions on other fumigants are forcing continued reassessment of treatment options. California nursery crop certification programs for field-grown stock generally require pre-plant fumigation and are designed to maintain nematode-free planting stock. Nurserymen also rely heavily on preplant fumigation for weed control.

Objectives. The primary objectives of the project are:

1. To assess promising MB alternatives and plastic mulch systems for production of almond and walnut planting stock and control of weeds, nematodes, and disease at commercial nurseries.
2. To assess efficacy of alternative fumigants and relative benefits of tree-site, row-strip, and broadcast treatments for control of replant problems in commercial almond orchards
3. To develop cost-benefit analyses for the MB alternatives at commercial almond and walnut nurseries and almond orchards.
4. To demonstrate the performance and economics of promising MB alternatives to nurserymen and orchardists.

Nursery trials. Two nursery trials were established in 2003 and two in 2004. Nursery trial 1 was on a sandy loam soil in Stanislaus County and was fumigated and planted in 2003/4 to peach and plum on Myrobalan 29C rootstock. Nursery trial 2 was on a clay loam soil in Yuba County and was fumigated and planted in 2003/4 to walnut on Paradox rootstock. Nursery trial 3 was on a clay loam soil in Merced County and was fumigated and planted in 2004/5 to almond on Nemaguard rootstock. Nursery trial 4 is on a loam soil in Stanislaus County and is planted to almond on Nemaguard and Lovell rootstock. The fumigation

treatments are listed below (Table 1). At each nursery trial, data were collected on nematode, weed, and pathogen survival as well as on plant growth. Propagules of *Pythium ultimum*, citrus nematode, and several species of weeds were buried at different depths in soil of the nursery plots before fumigation and retrieved after fumigation to determine incidence of survival. Natural populations of nematodes and weeds were/are also being monitored in the plots.

In each nursery trial, all fumigation treatments killed most bagged inoculum of *P. ultimum* and the citrus nematode. No inoculum of *P. ultimum* survived at 15 or 30 cm depths in fumigated plots at either nursery, but some survived at 60 and/or 90 cm depths (Table 2). Weed data from the nursery trials are presented in a separate report at this conference (Shrestha et al).

At Nursery Trial 1 (almond), fumigation treatments had only small or negligible effects on performance of the planted stock. Seedling emergence counts were marginally increased by most of the fumigation treatments, but there was little initial effect of fumigation treatments on stem growth or plant height (Table 3). At Nursery Trial 2 (walnut), there were more marketable trees per plot in all fumigation treatments compared to the untreated control (Table 3).

Orchard trials. Two orchard trials are underway, both initiated with preplant fumigation in fall 2003. Orchard Trial 1 involved replanting an almond orchard after removal of an old almond orchard; orchard trial 2 involved planting almond after removal of grapevines. Both orchards were located on loam soils in Madera County, CA, and in the fall before planting, neither orchard had significant populations of plant parasitic nematodes.

In orchard 1, where almond was planted after almond, all fumigants containing chloropicrin (CP) generally improved tree growth and yield significantly compared to the controls, but MB or Telone II did not (Table 4, Experiment 1a). In general, use of VIF mulch did not improve tree performance. The tree site treatments, which were applied later than the broadcast and row-strip treatments caused phytotoxicity in the first growing season but resulted in similar yields to the control (Table 4, Experiment 1b). In Orchard Trial 2, where almond was planted after grape, to date there has been no practical benefit of pre-plant fumigation on tree growth or yield (Table 4, Experiment 2).

Continuing and future work. Biological and economic assessments of the described trials are continuing, and additional orchard trials have been initiated.

Acknowldgement. We gratefully acknowledge financial support of USDA, CSREES, technical assistance from TriCal, Inc., and cooperation of many California Nurserymen and almond growers for this project.

Table 1. Fumigation treatments and mulching systems by nursery[a]

Fumigant	Rate kg/ha	Mulch	Nursery			
			1 (peach/plum on loam soil)	2 (walnut on clay loam soil)	3 (almond on clay loam soil)	4 (almond on loam soil)
None	0	None	+	+	+	+
MB	448	HDPE	+	+	+	+
IM:Pic (50:50)	448	HDPE	+	+	+	+
Telone II	380	HDPE	+	0	+	+
Telone C35	600	HDPE	+	+	+	+
Telone C35	600	VIF	+	+	+	+
Inline	600	HDPE	0	0	+	+

[a]"+" and "0" indicate presence and absence of treatment systems, respectively.

Table 2. Final tree harvest data from Nursery 1

A. Nemaguard peach

Fumigant	Rate kg/ha	Mulch	Marketable trees/meter	Diameter (cm)	Weight (kg/tree)	Seasonal average midday stem water potential (bars)
None	0	None	5.5	1.37	0.41	-17.6
MB	448	HDPE	5.7	1.35	0.45	-15.7*
IM:Pic (50:50)	448	HDPE	4.9	1.27	0.40	-14.3*
Telone II	380	HDPE	5.2	1.47	0.42	-15.6
Telone C35	600	HDPE	5.5	1.52	0.42	-18.0
Telone C35	600	VIF	5.0	1.57	0.35	-17.4*
			nsd	nsd	nsd	lsd=1.7

B. Prune/Myrobalan 29C

Fumigant	Rate kg/acre	Tarp	Marketable trees/meter	Diameter (cm)	Weight (kg/tree)
None	0	None	5.8	1.40	0.54
MB	448	HDPE	5.9	1.37	0.62
IM:Pic (50:50)	448	HDPE	5.8	1.47	0.64
Telone II	380	HDPE	5.1	1.22	0.56
Telone C35	600	HDPE	5.7	1.14	0.56
Telone C35	600	VIF	5.8	1.14	0.55
			nsd	nsd	nsd

Table 3. Final tree harvest data from Nursery 2 (walnut)

Fumigant	Rate kg/ha	Mulch	Seedling emergence (#/plot)	Diameter fall 2004 (cm)	Marketable trees per plot Dec. 2005	Nematode status (% infected)
None	0	None	183 b	37.6 a	45 b	100
MB	448	HDPE	239 ab	34.6 b	62 a	0
IM:Pic (50:50)	448	HDPE	245 ab	33.7 b	65 a	0
Telone C35	600	HDPE	253 ab	34.5 b	65 a	25
Telone C35	600	VIF	261 a	35.1 b	62 a	0

Table 4. Pest survival data for nursery trials established in 2003/04[a]

Trial	Pre-plant fumigation treatment	Mulch system	Survival of Pythium ultimum (cfu/g soil) at depths in soil				Number. of surviving Citrus nematodes at depths in soil				Emergence (#/meter)
			15cm	30cm	60cm	90cm	15cm	30cm	60cm	90cm	
1	None	None	309	378	406	481	-	1180	1108	1181	10.7
	MB 98:2	HDPE	0	0	0	81	-	0	0	0	11.7
	IM:Pic 50:50	HDPE	0	0	0	0	-	0	0	0	9.8
	Telone II	HDPE	0	0	5	122	-	0	0	0	10.8
	Telone C35	HDPE	0	0	22	47	-	0	0	0	10.0
	Telone C35	VIF	0	0	0	0	-	0	0	0	10.3
											LSD=1.2
2	None	None	431	466	481	556	1109	1204	1080	1219	6.7
	MB 98:2	HDPE	0	0	0	0	0	0	0	0	8.7
	IM:Pic 50:50	HDPE	0	0	50	137	0	0	0	0	9.0
	Telone C35	HDPE	0	0	0	218	0	0	0	0	9.2
	Telone C35	VIF	0	0	6	131	0	0	0	0	9.5*
											LSD=2.6
3	None	None	2775	3019	2755	3103	4859	5124	5426	5183	13.9
	MB 98:2	HDPE	0	0	163	0	0	0	0	0	13.8
	IM:Pic 50:50	HDPE	0	0	0	500	0	0	0	0	13.1
	Telone II	HDPE	191	653	1731	2311	1	0	399	585	13.5
	Telone C35	HDPE	0	0	972	1487	0	0	0	0	17.5*
	Telone C35	VIF	0	0	216	1397	0	0	0	1	13.6
	Inline	HDPE	272	1266	2013	2266	21	0	339	1039	15.7
											LDS=1.9
4	None	None	1631	1591	1519	1775	1890	1801	1687	1119	9.7
	MB 98:2	HDPE	0	0	0	0	0	0	0	0	9.8
	IM:Pic 50:50	HDPE	3	131	228	244	2	51	65	172	9.2
	Telone II	HDPE	0	0	0	22	0	0	0	0	10.7
	Telone C35	HDPE	0	0	0	6	0	0	0	0	12.0*
	Telone C35	VIF	0	0	0	0	0	0	0	0	9.6
	Inline	HDPE	0	13	916	1438	0	0	17	103	8.8
											LSD=2.0

[a]Survival of *Pythium ultimum* and citrus nematode was determined by burying bags infested with the pests at depths indicated,just before fumigation; survival of the pests was determined after retrieving the bags ca. 4 weeks after fumigation.

Table 5. Almond tree replant reponses to preplant fumigation treatments in Orchards 1 (almond after almond, expts. 1A,B) and 2 almond after grape (expt. 2)

Experiment	Fumigant, rate	Plot area treated	Mulch system	Trunk circ. increase (% of control)	2006 Yield (kg/tree)
1-A[a]	Control	None	None	0	4.09 de
	Control	None	VIF row strip	-6	3.04 e
	MB, 448 kg/ha	Broadcast (100%)	None	4	5.07 bcd
	MB, 448 kg/ha	Row strip (38%)	None	-4	4.60 cde
	MB, 448 kg/ha	Row strip (38%)	VIF row strip	-2	4.52 cde
	Telone II, 380 kg/ha	Broadcast (100%)	None	11	5.68 abcd
	Telone II, 380 kg/ha	Row strip (38%)	None	6	5.01 bcd
	Telone II, 380 kg/ha	Row strip (38%)	VIF row strip	0	5.01 bcd
	Telone C35, 600 kg/ha	Broadcast (100%)	None	16	6.97 a
	Telone C35, 600 kg/ha	Row strip (38%)	None	27	6.73 a
	IM:Pic (50:50), 448 kg/ha	Broadcast (100%)	None	29	7.19 a
	IM:Pic (50:50), 448 kg/ha	Row strip (38%)	None	19	6.37 ab
	Pic 448 kg/ha	Broadcast (100%)	None	17	5.92 abc
	Pic, 448 kg/ha	Row strip (38%)	None	30	6.37 ab
	Pic, 448 kg/ha	Rowstrip (38%)	VIF row strip	28	7.05 a
1-B[b]	Control	None	None	o	4.09 de
	MB, 0.5 kg per tree site	Tree site[e]	None	0	5.05 bcd
	Pic	Tree site	None	-13	4.41 cde
	Telone II	Tree site	None	-11	4.57 cde
2[c]	Control	None	None	0	5.96 abc
	Control	None	VIF row strip	-3	5.32 bcd
	MB, 448 kg/ha	Broadcast (100%)	None	-5	6.72 ab
	MB, 448 kg/ha	Row strip (38%)	None	-9	5.65 abcd
	MB, 448 kg/ha	Row strip (23%)	None	-9	5.77 abc
	MB, 448 kg/ha	Row strip (38%)	VIF row strip	-10	5.67 abcd
	Telone II, 380 kg/ha	Broadcast (100%)	None	-5	4.29 cd
	Telone II, 380 kg/ha	Row strip (38%)	None	-5	5.10 bcd
	Telone II, 380 kg/ha	Row strip (38%)	VIF row strip	-8	4.02 d
	Telone C35, 600 kg/ha	Row strip (38%)	None	-12	5.57 bcd
	Telone C35, 600 kg/ha	Row strip (38%)	VIF	-10	5.17 bcd
	IM:Pic (50:50), 448 kg/ha	Broadcast (100%)	None	-4	7.31 a
	IM:Pic (50:50), 448 kg/ha	Row strip (38%)	None	-7	6.12 ab
	Pic 448 kg/ha	Row strip (38%)	None	-5	5.33 bcd
	Pic, 448 kg/ha	Row strip (23%)	None	-3	5.49 bcd
	Pic, 448 kg/ha	Rowstrip (38%)	VIF row strip	-13	5.96 abc

[a]Fumigants applied 27 October 2003
[b]Fumigants applied 10 November 2003
[c]Fumigants applied 11 November 2003
[d]From March 2003 to November 2005.
[e]Applied at depth of approximately 45 cm, one probe per tree site