Almond Fumigant Studies: Continued Research on Methyl Bromide Alternatives

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Problem and Significance: Methyl bromide, the fumigant that has been used historically for control of replant problems, has been banned in developed countries. Research over the past ten years has determined suitable fumigant alternatives to methyl bromide that provide similar, if not better, control of some of the biological replant problems. Since these trials have been established relatively recently, there is little long term data on the efficacy of methyl bromide alternatives for control of nematodes, Prunus replant disease (PRD), and soil borne diseases. Further research is needed in order to determine the rate of re-infestation of the soil by these pests and pathogens.

Objectives:

1. To continue the work of established fumigant plots for control of Prunus Replant Disease and plant pathogenic nematodes.
2. To continue the development of non-fumigant based control measures for almond replant disease and plant pathogenic nematodes within fumigant buffer zones.

Methods: This work will continue the efforts set forth by the USDA-ARS Pacific Area-wide Methyl Bromide Alternatives project which concluded in June of 2012. Four fumigant projects within Merced County were established over the past four years. Three projects included main plot designs testing fumigant alternatives to methyl bromide. A new trial in Ballico was established in 2015 and tests Telone II alternatives and fumigation alternatives. Trials and treatments are described in Table 1.

Treatments within the trials will be monitored for tree growth, yield, and nematode control. Harvest data will be collected upon first harvest and continued through the tenth year, possibly longer. Trunk caliper measurements are made in the dormant period following the year of growth. Nematodes are sampled in mid-October by collecting soil 18 inch deep soil cores from within the dripline of the tree.

Table 1: Basic description of the fumigant trials established in Merced County (treated rate per acre).

Location	Year	Soil	Rootstock	Control	MeBr row strip	Telone II row strip	Telone II broadcast	Telone-C35 row strip	Steam - tree spot	Telone -C35 tree spot	Chloropicrin tree spot	Fumigant Alternatives
Livingston	2010	Loamy Sand	Viking	0 lbs/acre	350 lbs/acre	340 lbs/acre	-	525 lbs/acre	-	525 lbs/acre	-	-
Ballico	2011	Sand	Nemaguard	0 lbs/acre	400 lbs/acre	340 lbs/acre	340 lbs/acre	525 lbs/acre	Yes	-	-	-
Winton	2012	Sand	Nemaguard	0 lbs/acre	-	340 lbs/acre	340 lbs/acre	525 lbs/acre	Yes	Hi–525, Lo-350 lbs/acre	200 lbs/acre	-
New Ballico	2015	Sand	Nemaguard	0 lbs/acre	-	340 lbs/acre	-	-	-	-	200 lbs/acre	Various

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Winton Trial (Est. 2012):

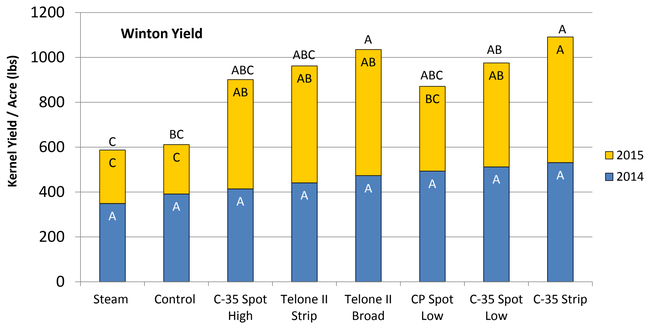

Figure 1: The effect of pre-plant treatments on the yield of replanted almonds at the Winton trial for 2014-2015. Treatments followed by different letters are statistically significant (p<0.05, Dunnett's).

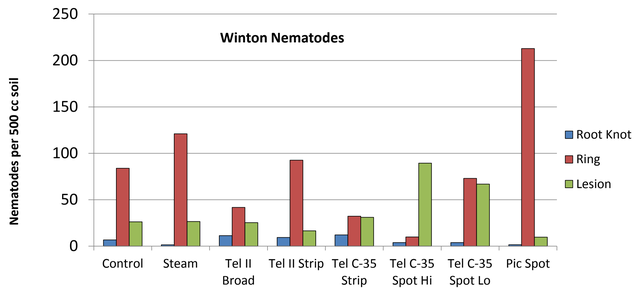

Figure 2: Nematode counts from various treatments taken after four years of growth at the Winton trial. Sampling performed in 2014.

Livingston Trial (Est. 2010):

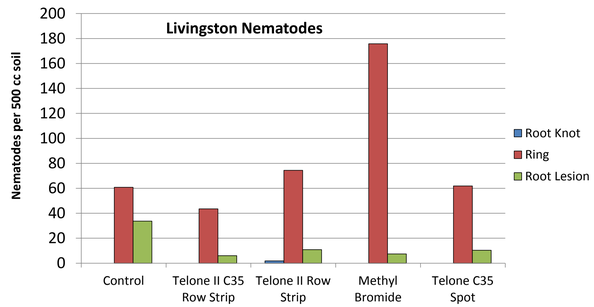

Figure 3: Nematode counts from various treatments taken after five years of growth at the Livingston trial. Sampling performed in 2014..

Table 2: The effect of pre-plant treatments on the yield of replanted almonds at the Livingston trial for 2012-2015 and in total. Treatments followed by * are significantly different from the control (p<0.05, Dunnett's).

Livingston	Yield (Kernel lbs/acre)				
Treatment	**2012**	**2013**	**2014**	**2015**	**Cumulative**
Control	40.8	92.9	367.4	546.1	1047.2
Methyl Bromide	84.1*	206.6	590.4*	775.7	1656.8*
Telone II Strip	65.3	161.8	597.2*	869.5	1693.9*
C-35 Strip	73.4	185.2	531.6*	869.8	1660*
C-35 Spot	65.9	184.9	497.1	681.1	1429

Ballico Trial (Est. 2011):

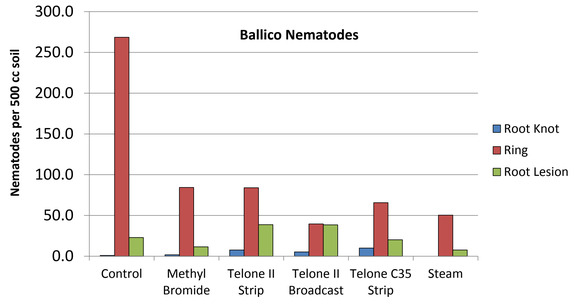

Figure 4: Nematode counts from various treatments taken after four years of growth at the Ballico trial. Sampling performed in 2014.

Table 3: The effect of pre-plant treatments on the yield of replanted almonds at the Ballico trial for 2013-2015 and in total. Treatments followed by * are significantly different from the control (p<0.05, Dunnett's).

Ballico	Yield (Kernel lbs/acre)			
Treatment	**2013**	**2014**	**2015**	**Cumulative**
Control	158.2	376.8	275.0	781.5
Methyl Bromide	230	498.8	523.9*	1378.8*
Telone II Strip	266.4*	652.1*	480.9*	1465.8*
Telone II Broadcast	317.7*	764.6*	708.8*	1963.8*
C-35 Strip	258.1	525.6	460.0	1309*
Steam	138.1	357.4	206.3	708.6

Telone II Alternatives Trial (Est. 2015):

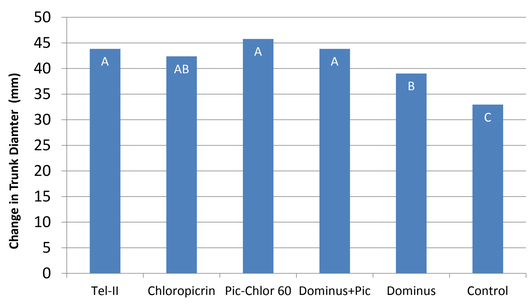

Figure 5: The effect of pre-plant treatments on the first year of trunk growth of replanted almonds at the Telone II Alternatives trial in Ballico. Treatments followed by different letters are statistically different (p<0.05, Tukey's).

Fumigant Alternatives Trial (Est. 2015):

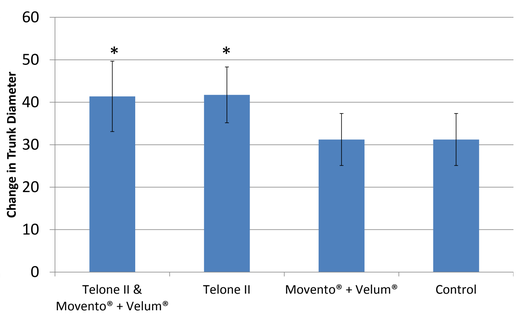

Figure 6: The effect of pre-plant treatments on the first year of trunk growth of replanted almonds at the Telone II Alternatives trial in Ballico. Treatments with an asterisk are significantly different (Two way ANOVA, p<0.05).

Results and Discussion:

- At the Winton trial, 2015 yields were significantly higher in C35 Strip relative to CP Spot Low treatment, steam, and control. Cumulative yields of Telone II Broadcast and C-35 Strip treatments were higher than both steam and control (**Fig. 1**).
- At the Livingston trial, cumulative yields from Methyl Bromide, Telone II Strip, and C-35 Strip treatments were significantly higher than the control. (**Table 2**).
- Cumulative yields from all treatments (with the exception of steam) were higher than the control at the Ballico trial (**Table 3**).
- There were no differences between nematode populations within fumigation treatments in all trials (**Fig. 3, 4, and 5**), suggesting that PRD is the primary factor in reducing young almond yield.
- Trunk diameter in all fumigated treatments was higher than the control in the Telone II Alternatives trial (**Fig. 5**).
- The Fumigation Alternatives trial saw significant increases in trunk diameter with Telone II relative to Movento and Velum and the control (**Fig. 6**).