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 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. Four projects included main plot designs testing fumigant alternatives to methyl bromide. 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	-
N. Livingston	2012	Sand	Nemaguard	0 lbs/acre	-	340 lbs/acre	-	-	-	-	-	Various

Acknowledgements: Thanks to the Frago family, Andrew Littlejohn, Randy Taylor and Bob Chad for hosting the trials, Tri-Cal for providing fumigation, Nematodes, Inc for nematode analyses, the USDA-PAW Methyl Bromide Alternatives and the Almond Board of California for funding.

Winton Trial (Est. 2012):

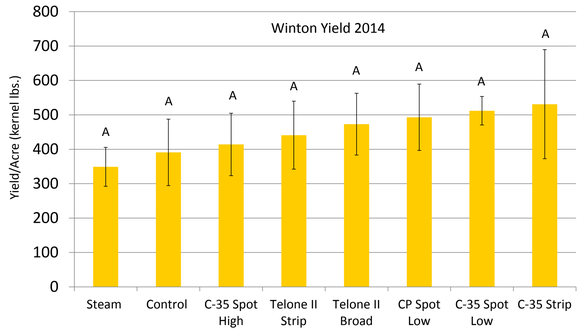

Figure 1: The effect of pre-plant treatments on the yield of replanted almonds at the Winton trial in 2014. Treatments followed by different letters are statistically significant (p<0.05).

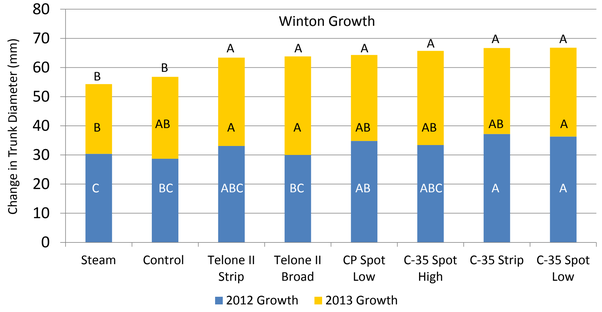

Figure 2: The effect of pre-plant treatments on the third year of trunk growth of replanted almonds at the Winton trial. Treatments followed by different letters are statistically different (p<0.05).

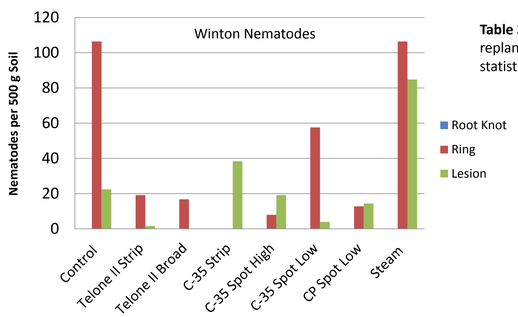

Figure 3: Nematode counts from various treatments taken after three years of growth at the Winton trial. Sampling performed in 2013.

Livingston Trial (Est. 2010):

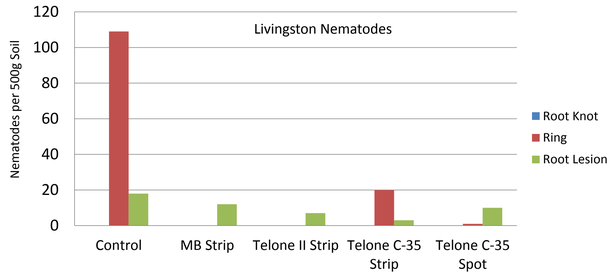

Figure 4: Nematode counts from various treatments taken after four years of growth at the Livingston trial. Sampling performed in 2013.

Table 2: The effect of pre-plant treatments on the yield of replanted almonds at the Livingston trial in 2012, 2013, 2014 and in total. Treatments followed by * are significantly different from the control (p<0.05).

Livingston	Yield Kernel lbs/acre			
Treatment	**2012**	**2013**	**2014**	**Cumulative**
Control	40.8	92.8	367	501
Methyl Bromide	84.1 *	207	590 *	881 *
Telone II Strip	65 .3	162	597 *	824 *
C-35 Strip	73 .4 *	185	531 *	790 *
C-35 Spot	65.9	185	497	748 *

North Livingston Trial (Est. 2012):

Table 3: The effect of various non-fumigant pre-plant treatments on trunk growth of replanted almonds at the N. Livingston trial. Treatments followed by different letters are statistically significant (p<0.05).

North Livingston	Change in Trunk Diameter (mm)			
Treatment	**2012**	**2013**	**2014**	**Total**
Control	25.4 AB	37.2 B	26.8 A	89.9 AB
Backhoe	26.8 AB	40.7 AB	30.4 A	93.1 AB
Backhoe + Telone II Strip	30.5 A	45.3 A	29.6 A	105.9 A
24" Auger	23.4 AB	36.5 B	28.2 A	85.4 B
36" Auger	27.3 AB	36.5 B	27.8 A	91.6 AB
24" Auger + Steam	28.8 AB	33.4 B	29.0 A	91.3 AB
36" Auger + Steam	26.9 AB	33.4 B	25.8 A	87.0 B
H_2O_2 (1%)	23.6 AB	31.7 B	27.6 A	83.8 B
LCS Compost Tea	22.5 B	34.2 B	27.8 A	84.3 B
Yeast	23.1 B	36.2 B	23.6 A	83.8 B

Ballico Trial (Est. 2011):

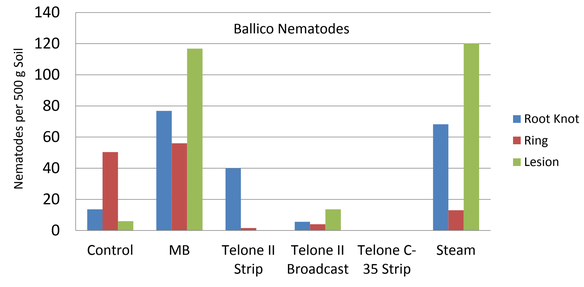

Figure 5: Nematode counts from various treatments taken after three years of growth at the Ballico trial. Sampling performed in 2013.

Table 4: The effect of pre-plant treatments on the yield of replanted almonds at the Ballico trial in 2013 and 2014. Treatments followed by * are significantly different from the control (p<0.05).

Ballico	Yield kernel lbs/acre		
Treatment	**2013**	**2014**	**Cumulative**
Control	158	377	535
Methyl Bromide	230	499	729
Steam Spot	138	358	496
Telone II Broadcast	318 *	764 *	1082 *
Telone II Strip	266 *	652 *	918 *
C-35 Strip	258 *	526	784

Results and Discussion:

- First yields did not differ among treatments at the Winton trial, but all fumigated treatments showed greater cumulative growth than steam and control treatments (**Figs. 1 & 2**). This lack of difference may be due to soil movement post fumigation.
- At the Livingston trial, cumulative yields of all fumigant treatments were higher than control, while C-35 Strip and MeBr produced significantly higher yields in two of three years of study (**Table 2**).
- Telone II Broadcast and Telone II Strip had higher yields than other treatments both years at the Ballico trial (**Table 4**).
- We did not observe alternative fumigants outgrowing the untreated control at the N. Livingston trial (**Table 3**).
- Nematodes re-infested fumigated soils 2-3 years after fumigation, albeit at lower rates of infestation than in 2012 (data not shown).
- Control and steam treatments generally had greater nematode infestation than fumigated treatments (**Figs. 3-5**).