Almond Fumigant Studies: Continual Research on Methyl Bromide Alternatives and Fumigant Alternatives for Buffer Zones

Project No.: **15-AIR9-Doll**

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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 fumigant and non-fumigant based control measures for almond replant disease and plant pathogenic nematodes within fumigant buffer zones.

Interpretive Summary:

Several field trials have been established in Merced County and are evaluating fumigant alternatives to methyl bromide and non-fumigant alternatives for buffer zones. These trials are located on sandy soils in almond replant situations with the presence of ring, lesion, and rootknot nematodes. Growth, yield, and soil nematode data have been collected at all trials since establishment. In all trials, fumigated soils have outperformed the unfumigated control. Fumigants containing Telone-II® applied either as a broadcast or rowstrip treatment have provided the greatest growth response. The effect of field fumigation on nematode populations has been variable. Populations appear to be suppressed in fumigated soils. Re-infestation of soils occurs within 2-3 years after fumigation or sooner if significant soil movement occurs after fumigation. Regardless of nematode re-infestation, trees planted in fumigated soils appear to grow more vigorously and to date have produced more yield. Interestingly, tree growth within the C35® spot fumigation treatments has provided similar growth to rowstrip and broadcast fumigant treatments. Growth responses for pre-plant applied chloropicrin, Dominus®, and mixtures of the two are suggesting that there may be a possible alternative to Telone-II® to assist in managing township cap regulations, but more years are study are needed to determine if the yields respond similarly. We have not been able to identify any fumigant alternatives that have

performed as well as pre-plant soil fumigants, and pre-plant soil fumigation is still highly recommended in replant situations. Yield and growth performance are planned to be followed and will be annually reported.

Materials and Methods:

Continual work on determining the efficacy of fumigants and fumigant alternatives is critical to manage replant problems associated with successive generations of almond plantings. Over the past eight years, multiple trials have been established to determine alternatives to methyl bromide, and more recently, techniques that reduce fumigant rates and alternatives to 1,3-dichloropropene (Telone II) and chloropicrin (Pic). The trials include:

Ballico Trial. Planted in the spring of 2011 and located on a sand soil near Ballico, CA. This site compares the effect of tree row strip applications of methyl bromide (MB) at 400 lb/ treated acre, a 65% Telone II and 35% pic mixture (C35) tree row strip applied at 340 lb./ treated acre, Telone II tree row strip applied at 340 lb./ treated acre, Telone II 100% soil broadcast applied at 340 lb/ treated acre, tree site soil dis-infestation using steam injected through a 36” diameter by 24-inch-long soil auger, and un-fumigated soil on tree growth.

This trial also contains a secondary experiment investigating tree site applied non-fumigant alternatives in comparison to a control and a C35 fumigated tree row strip applied at 540 lb/acre. Monitoring of these treatments was discontinued in 2015-2016, but has been reported on previous reports.

Varieties include Aldridge, Sonora, and Nonpareil, planted on Nemaguard rootstock and irrigated with solid-set sprinklers. This is a medium vigor plot.

Winton Trial. Treatments were applied to this loamy sand soil near Winton, CA in November, 2011, and trees were planted in the spring of 2012. This trial compares the effect of the several fumigants applied at different rates and treated area on tree growth and yield. Treatments included C35 tree row strip applied at 540 lb/ treated acre, C35 tree site spot applied using a GPS guided rig to inject fumigant in a 7'x7' area centered on the tree site applied at 540 lb/ treated acre, C35 tree site spot application, using the method described above, applied at 340 lb/ treated acre, chloropicrin tree site spot application, using the method described above, applied at 340 lb./treated acre, Telone II tree row strip applied at 340 lb./ treated acre, Telone II 100% soil broadcast applied at 340 lb/ treated acre, soil dis-infestation using steam applied through a 36” diameter by 24 inch length soil auger applied at the tree site, and an un-fumigated control.

This site also contains a secondary experiment investigating tree site applied non-fumigant alternatives. Monitoring of these treatments was discontinued in 2015-2016, but has been reported on previous reports.

Varieties include Sonora and Nonpareil, planted on Nemaguard rootstock and irrigated with solid-set sprinklers. This is anticipated to be a medium vigor plot.

South Livingston Trial. Planted in the spring of 2010 and located on a loamy sand soil near Livingston, CA. This plot compares the effect of the applications of methyl bromide (MB) tree row strip applied at 350 lb/ treated acre, 65% C35 tree row strip applied at 350 lb/ treated acre, C35 tree site spot application which uses a GPS guided rig to inject fumigant in a 7'x7' area centered on the tree site applied at 350 lb./ treated acre, Telone II 100% soil broadcast applied at 340 lb/ treated acre, and un-fumigated soil on tree growth.

This trial also contains a secondary experiment investigating tree site applied non-fumigant alternatives in comparison to a control and a C35 fumigated row strip. The following of these treatments were discontinued in 2015-2016, but have been reported on previous reports.

Varieties include Price, Sonora, and Nonpareil, planted on Viking rootstock and flood irrigated. This is a low vigor plot.

Ballico Trial #2-1. Fumigant area (Trial 1). Fumigated in Fall 2014 and located in a sandy soil near Ballico, CA. This site compares the effect of broadcast, tree row strip, and an 8.3'x8.3' tree spot of C35 at 540 lbs/ treated acre to a control. C35 was applied in the fall of 2014 and injected with 24" shanks using a commercial applicator. The plot contains four replicate blocks containing 10 trees of each variety for each treatment. Trees were planted in January 2015. Varieties include Nonpareil, Aldrich, and Sonora planted on Viking rootstock and irrigated with drip-line and solid-set sprinklers.

Ballico Trial #2-2. Telone-II alternatives (Trial 2). Fumigated in Fall 2014 and located in a sandy soil near Ballico, CA. This site compares the effectiveness of Telone-II alternatives, including Pic rowstrip applied at 200 lbs./treated acre, Pic-Chlor 60 (a mixture of 60% Pic, 40% Telone II) rowstrip applied at 338.8 lbs./treated acre, stabilized allyl isothiocyanate (Dominus) rowstrip applied at 340 lbs/treated acre, a combination of Dominus and Pic rowstrip applied at 340 and 200 lbs./treated acre, respectively, Telone-II row strip applied at 340 lbs/treated acre, and an unfumigated control. The plot contains six replicate blocks containing six 'Aldrich' trees grafted to Viking rootstock. Trees were planted in January 2015. The plot will be irrigated with drip-line and solid-set sprinklers.

Ballico Trial #2-3. Fumigant Alternative Trial (Bayer - Trial 3). Located in a sandy soil near Ballico, CA, this plot is testing an available non-fumigant alternative. Treatments include Telone-II row strip applied at 340 lbs./treated acre, an unfumigated control, and a treatment that includes a spring and fall application of Movento applied at 9 fl oz/treated acre and spring and summer chemigaton of an unregistered product from Bayer Crop Sciences at 6.84 fl/oz/treated acre. The plot contains six replicate blocks of seven 'Sonora' trees grafted to Viking rootstock. Trees were planted in January 2015. The plot will be irrigated with drip-line and solid-set sprinklers.

Treatments within the trials have been monitored for tree growth, yield, and nematode control. Harvest data is collected upon first harvest – usually the third year, and continued through the fifth year, possibly longer. Diameter and circumference measurements are made in the dormant period following the year of growth through the fifth year. Visual disease severity rating is assigned during the growing season on a scale from 0 to 5

(0=healthy and vigorous, 5=dead). Nematodes are sampled from established plots annually in mid-October by collecting soil from the depth of 18 inches within the dripline of the tree. Samples from the same treatment within the block are pooled, with one sample per block sent in for analysis. Samples have been analyzed for ring, lesion, and rootknot nematode by Nematodes Inc. Samples include roots and organic debris as a bucket auger is used to sample the soil.

Results and Discussion:

Ballico Trial: Cumulative change in trunk diameter for all fumigant treatments (103.7 mm-120.1 mm) were greater than the control and steam treatments (88.7-96.1 mm) (**Table 1**). Trees planted in soil preplant fumigated with the Telone-II broadcast (120.1 mm) treatment outgrew C35, Telone-II, and MB rowstrip treatments (106.8, 114.2, and 103.9 mm, respectively). Disease severity ratings (DSR) mirrored tree growth (**Table 2**). All fumigants were rated healthier (0.4-0.9) than the control and steam plots (1.2-1.3). 2015 and cumulative yield for the Telone-II broadcast treatment out-performed the methyl bromide, control, and steam treatments (**Table 3**). Telone-II broadcast or rowstrip and methyl bromide rowstrip have a higher cumulative yield than the control or steam treatments. There were no differences in nematodes detected with the annual sampling (**Table 4**).

Winton Trial: Cumulative growth of Telone-C35 spot treatments (107.2-108.2 mm) outgrew the untreated control (97.3 mm) (**Table 5**). Although there were differences in the past, 2015 DSRs indicated no differences in apparent tree health (**Table 6**). In 2015, Telone-II containing fumigants (463-562 lbs/acre) out-yielded the steam and untreated control (220-238 lbs/acre) (**Table 7**). Over the past two years of yield, Telone-II broadcast and rowstrip treatments outperformed the steam and control treatments. There were no differences in plant parasitic nematodes detected with the annual sampling, but the control plot had higher counts of free living nematodes in comparison to the tree spot treatments. (**Table 8**).

South Livingston: In the fourth year of harvest data (6-year-old plot), all treatments performed similarly (546 - 870 kernel lbs/acre) (**Table 9**). All fumigants (1429 - 1660 kernel lbs/acre), however, have outperformed the control (1047 kernel lbs/acre) in cumulative yields. Ring nematodes were higher in the control plots than the methyl bromide and C-35 strip treatments (**Table 10**).

Ballico #2-1 Trial: Cumulative change in trunk diameter for all fumigants area treatments (broadcast, rowstrip, and tree spot) were greater than the control treatment (58.06-59.67 mm vs 46.39 mm) (**Table 11**). Disease severity ratings for all fumigant area treatments (0.3-0.4) were lower than the untreated control (1.2) (**Table 12**). There were no differences in the major plant parasitic nematodes of almond, but the control had higher Tylenchidae than the Telone-C35 tree spot treatment (**Table 13**).

Ballico #2-2 Trial: Cumulative change in trunk diameter for all Telone-II alternatives and Telone-II fumigant treatment applied as a rowstrip were greater than the control treatment (39-45.8 mm vs. 46.39 mm) (**Table 14**). Among the fumigant treatments, Telone-II, Pic-Chlor 60, and Dominus+Chloropicrin outperformed Dominus alone. Disease severity ratings for all fumigant treatments (0.4-0.8) were lower than the untreated control (1.4)

(**Table 15**). Lesion nematode counts were higher in the control than the Telone-II rowstrip fumigated plots (**Table 16**). This initial data suggests that there are fumigant treatments that perform similar to Telone-II fumigant.

Ballico #2-3 Trial: Regardless of post-plant treatments, tree growth was greatest in plots that were pre-plant fumigated with Telone-II applied as a rowstrip (41.4-41.7 vs 30.6-31.2) (**Table 17**). Disease severity ratings mirrored growth responses with the pre-plant fumigant treatments having a lower DSR than the control and Movento® + Velum® (0.2 vs 0.9) (**Table 18**). The control and Movento® + Velum® plots had higher lesion nematode counts than the Telone-II and Telone-II + Movento® + Velum® plots. (**Table 19)**. This data suggests that these post-plant nematode treatments do not provide any growth increases within the first growing season of a replanted almond orchard. Treatments will be followed for two to three more years.

Discussion.

All the trials conducted in Merced County and reported above have found increased yield and productivity within fumigated treatments. Cumulative yield differences over the first two years of production within these trials exceeds the cost of fumigation. Based on this work, when deciding to replant almonds after other *Prunus* sp. in soils infested with ring nematode, pre-plant fumigation should be performed to maximize tree growth and productivity.

These trials have found suitable replacements for methyl bromide. Alternate fumigant treatments rely on Telone-II, chloropicrin, or combinations of the two fumigants. These treatments have either yielded similarly or exceeded the methyl bromide treatments. Nematode suppression differences of fumigants and control plots within these comparison trials were highly variable and not statistically different. This variability is commonly observed. Interestingly, infestation of all treatments occur at the same rate, suggesting that nematodes may not be the primary cause of the reduced tree growth in the orchard establishment phase.

Increasing regulations facing the use of Telone-II and chloropicrin have created challenges in the use of these products within farm operations. Fumigant usage is often limited by township caps (which reduce the amount that can be applied within a township) or buffer zones that increase with increasing amounts of active ingredient applied. Our recent studies have found that the orchard area fumigated can be greatly reduced from what was previously thought. We have been successful in maintaining tree vigor and yield through the use of tree spot fumigation, which fumigates around 20% of an orchard acre, reducing the amount of active ingredient applied per acre. We also have some preliminary growth data of alternative fumigants to Telone-II which may be useful in years when township cap is reduced or in sensitive areas.

We have not been successful in finding alternatives to soil fumigation. Our previous work testing a variety of products did not provide a growth response (Doll, et al, 2015). Our recent work with post plant nematicides (Movento and Velum 1) did not increase first year growth in comparison to the control. This lack of response may due to the lack of activity of these products on soilborne fungi (Browne, et al, 2015), which evidence suggests are the

primary cause of growth suppression. As nematodes become established, the use of these products may have value and trials are planned to be continued.

Table 1. Pre-plant soil treatment effects on 'Nonpareil' variety tree growth in a 2010 almond replant trial near Ballico, CA comparing steam and chemical fumigants. Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD p < 0.05)

Treatment		Change in Trunk Diameter (mm)					
Fumigant	**Rate (lb/acre)**	**2011**	**2012**	**2013**	**2014**	**2015**	**Cumulative**
Untreated	0	21.2 b	20.3 d	19.0 b	12.6 ab	23	96.1 e
Steam Spot	0	20.7 b	20.7 d	16.8 b	8.6 b	22.1	88.7 d
Methyl Bromide	400	24.8 a	25.0 c	20.2 b	14.0 a	19.9	103.9 c
Telone II Broadcast[1]	340	26.1 a	32.7 a	24.8 a	14.4 a	22.1	120.1 a
Telone II Strip[1]	340	24.8 a	29.7 ab	24.0 a	12.6 ab	23.3	114.4 b
Telone C-35 Strip[1]	540	25.6 a	28.9 b	20.0 b	11.0 ab	21.3	106.8 bc
P-value	-	*<0.05*	*<0.0001*	*<0.0001*	*<0.0001*		*<0.01*

[1] Strip and broadcast applications were 11- and 22- feet wide and the length of the plot.

Table 2. Pre-plant soil treatment effects on 'Nonpareil' disease severity in a 2010 almond replant trial near Ballico, CA comparing steam and chemical fumigants. Disease Severity Ratings (DSR) vary from 0 to 5, where 0 is healthy and 5 is dead. Different letters indicate statistically significant difference (Steel-Dwass All Pairs or ANOVA Tukey-Kramer HSD p < 0.05)

Treatment		Disease Severity Rating (0-5; 0 = healthy, 5 = dead)				
Fumigant	**Rate (lb/acre)**	**2011**	**2012**	**2013**	**2014**	**2015**
Untreated	0	0.3	1.1 a	1.5 d	1.0 b	1.2 c
Steam Spot	0	0.3	1.2 a	1.5 d	1.5 a	1.3 c
Methyl Bromide	400	0.1	0.2 b	0.8 c	0.5 c	0.6 bc
Telone II Broadcast[1]	340	0.1	0.1 b	0.1 a	0.1 d	0.4a
Telone II Strip[1]	340	0.4	0.2 b	0.4 ab	0.3 cd	0.5 ab
Telone C-35 Strip[1]	540	0.3	0.2 b	0.7 bc	0.6 bc	0.9 bc
P-value	-	*0.1*	*<0.0001*	*<0.05*	*<0.0001*	*<0.05*

[1] Strip and broadcast applications were 11- and 22- feet wide and the length of the plot.

Table 3. Pre-plant soil treatment effects on 'Nonpareil' yield in a 2010 almond replant trial near Ballico, CA comparing steam and chemical fumigants. Different letters indicate statistically significant difference (Steel-Dwass All Pairs or ANOVA Tukey-Kramer HSD p < 0.05).

Treatment		Yield (lbs/acre)			
Fumigant	**Rate (lb/acre)**	**2013**	**2014**	**2015**	**Cumulative**
Untreated	0	158 b	377 c	275 cd	810 cd
Steam Spot	0	138 b	358 c	206 d	702 d
Methyl Bromide	400	230 ab	499 bc	523 ab	1252 b
Telone II Broadcast[1]	340	318 a	764 a	709 a	1791 a
Telone II Strip[1]	340	266 a	652 ab	480 ab	1399 ab
Telone C-35 Strip[1]	540	258 a	526 abc	460 bc	1244 bc
P-value	-	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*

[1] Strip and broadcast applications were 11- and 22- feet wide and the length of the plot.

Table 4. Nematode counts from fumigant and steam treatments taken after two years of growth at the Ballico fumigant trial. Sampling performed in 2014. No significant differences among treatments were observed (Steel-Dwass All Pairs of ln(count+1), p>0.05.

Treatment		Root Knot	Ring	Lesion	Stubby Root	Pin	Free Composite
Fumigant	**Rate (lb/acre)**	**----- nematodes/500g soil -----**					
Control	0	1	268.5	22.9	31.7	0	336.5
Steam	0	0	50.4	7.6	23.5	0	343.6
Methyl Bromide	400	1.8	84.4	11.5	3.8	0	292.1
Telone II Broadcast[1]	340	5.3	39.6	38.5	65	0	389.6
Telone II Strip[1]	340	7.6	84	38.7	24.5	0	478.8
Telone C-35 Strip[1]	540	10	65.7	20.2	35.7	0	361.8

[1] Strip and broadcast applications were 11- and 22- feet wide and the length of the plot.

Table 5. Pre-plant soil treatment effects on 'Nonpareil' variety tree trunk diameter in a 2011 almond replant trial near Winton, CA comparing steam and chemical fumigants applied in pounds per acre (lb/acre). Changes in tree trunk diameters are in millimeters (mm). Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD p < 0.05).

Treatment		Change in Trunk Diameter (mm)				
Fumigant	**Rate (lbs/acre)**	**2012**	**2013**	**2014**	**2015**	**Cumulative**
Control	0	28.7 c	28.1 ab	14.9	27.8	97.3 b
Steam	0	30.4 bc	23.9 a	16.7	29.4	100.4 ab
Chloropicrin Tree Spot	340	34.8 ab	29.5 ab	13.3	27	104.6 ab
Telone II Broadcast	340	30 bc	33.8 a	17	26.8	106.4 ab
Telone II Strip	540	33.1 abc	30.3 a	17.6	26	105.6 ab
Telone C-35 Row Strip	540	37.2 a	29.5 ab	13.3	27.4	106.2 ab
Telone C-35 Tree Spot	340	36.3 a	30.5 ab	15.8	25.1	107.2 a
Telone C-35 Tree Spot	540	33.4 abc	32.3 a	17.1	25.4	108.2 a
P-value		>0.05	>0.05			>0.05

Table 6. Pre-plant soil treatment effects on 'Nonpareil' variety disease severity ratings (DSR) in a 2011 almond replant trial near Winton, CA comparing steam and chemical fumigants applied in pounds per acre (lb/acre). DSR ratings vary from 0 to 5, where 0 is healthy and 5 is dead. Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD p < 0.05).

Treatment		Disease Severity Rating (0-5; 0 = healthy, 5 = dead)			
Fumigant	**Rate (lb/acre)**	**2012**	**2013**	**2014**	**2015**
Untreated	0	0.9 b	0.8 b	1.0 b	0.8
Steam	0	0.8 b	0.9 b	0.9 b	0.7
Chloropicrin Tree Spot	340	0.4 a	0.1 a	0.5 a	0.7
Telone II Broadcast	340	0.4 a	0.0 a	0.1 a	0.5
Telone II Strip	540	0.6 a	0.3 a	0.3 a	0.6
Telone C-35 Row Strip	540	0.7 a	0.2 a	0.3 a	0.5
Telone C-35 Tree Spot	340	0.4 a	0.2 a	0.3 a	0.5
Telone C-35 Tree Spot	540	0.4 a	0.1 a	0.4 a	0.6
P-value	-	*0.049*	*<0.0001*	*<0.05*	

Table 7. Pre-plant soil treatment effects on 'Nonpareil' variety 2014 and 2015 yields in a 2011 almond replant trial near Winton, CA comparing steam and chemical fumigants applied in pounds per acre (lb/acre). Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD p< 0.05).

Treatment		Yield		
Fumigant	**Rate (lb/acre)**	**2014**	**2015**	**Cumulative**
Untreated	0	391	220 c	611 bc
Steam	0	349	238 c	587 c
Chloropicrin Tree Spot	340	473	378 bc	871 abc
Telone II Broadcast	340	441	562 a	1030 a
Telone II Strip	540	414	521 ab	956 abc
Telone C-35 Row Strip	540	512	560 a	1091 a
Telone C-35 Tree Spot	340	531	463 ab	975 ab
Telone C-35 Tree Spot	540	493	487 ab	895 abc
P-value	-	*0.1*	*<0.001*	*<0.01*

Table 8. Nematode counts from various treatments taken after two years of growth at the Winton fumigant trial. Sampling performed in 2015. No significant differences among treatments were observed (Steel-Dwass All Pairs of ln(count+1), p>0.05.

Treatment		Nematodes (per 500 g soil)						
Fumigant	**Rate (lb/acre)**	**Root Knot**	**Ring**	**Lesion**	**Pin**	**Stubby Root**	**Dagger**	**Free-Living**
Control	0	0	208	83	31	1	0	1071 a
Steam	0	0	269	103	5	7	0	672 ab
Chloropicrin Tree Spot	340	0	198	180	2	5	0	670 ab
Telone II Broadcast	340	0	288	96	70	2	0	421 ab
Telone II Strip	540	0	241	49	150	4	0	571 ab
Telone C-35 Row Strip	540	0	354	187	70	0	0	622 ab
Telone C-35 Tree Spot	340	0	194	94	35	1	0	430 b
Telone C-35 Tree Spot	540	0	470	98	24	0	0	403 b

[1] Strip and broadcast applications were 11- and 22- feet wide and length of plot, tree spots applications were 6-feet wide and 6-feet long centered on the tree spot.

Table 9. Comparison of the effects on yield of various fumigant treatments in South Livingston, CA. Different letters indicate statistically significant difference (log10(yield) ANOVA, Tukey-Kramer HSD).

Treatment	Yield (lbs/acre)				
	2012	2013	2014	2015	Cumulative
Telone C-35 Row Strip	73.0 ab	210 a	531.6 ab	870	1660 a
Telone C-35 Tree Spot	65.9 ab	210 a	497.1 ab	681	1429 a
Telone II Strip	65.0 b	184 a	597.2 a	870	1694 a
MeBr Strip	84.0 a	235 a	590.4 a	775	1657 a
Untreated	40.8 c	105 a	367.4 b	546	1047 b
P-value	***<0.05***	***<0.05***	***<0.05***		***<0.05***

Table 10. Nematode counts from various treatments taken after three years of growth at the South Livingston fumigant trial. Sampling performed in 2015. No significant differences among treatments were observed (Tukey's HSD at p>0.01).

Treatment	Root Knot	Ring	Lesion	Stubby Root	Pin	Free Composite
	----- nematodes/500g soil -----					
Control	0	338 a	30	12	0	10
Methyl Bromide	0	23 b	2	90	0	4
Telone II Strip	0	134 ab	23	3	0	0
C-35 Spot	0	139 ab	79	176	0	9
C-35 Strip	0	31 b	140	72	1	6

Table 11. Pre-plant soil fumigant treatment effects on 'Nonpareil' variety tree trunk diameter in a 2015 almond replant trial near Ballico, CA comparing the change in first year tree growth within varying percentage of orchard area fumigation. Changes in tree trunk diameters are in millimeters (mm). Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD $p < 0.05$).

Treatment				
Fumigant	Rate per treated acre (lb/acre)	% Orchard Acre Fumigated	Fumigant Applied per Orchard Acre	2015
Untreated	0	0	0	46.39 b
Telone C-35 Tree Spot	540	20%	110	58.06 a
Telone C-35 Row Strip	540	50%	270	59.67 a
Telone C-35 Broadcast	540	100%	540	58.35 a
P-value	-			*0.04*

Table 12. Pre-plant soil treatment effects on 'Nonpareil' variety disease severity ratings in a 2015 almond replant trial near Ballico, CA. Disease Severity Ratings (DSR) vary from 0 to 5, where 0 is healthy and 5 is dead. Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD $p < 0.05$).

Treatment				
Fumigant	**Rate per treated acre (lb/acre)**	**% Orchard Acre Fumigated**	**Fumigant Applied per Orchard Acre**	**2015**
Untreated	0	0	0	1.2 a
Telone C-35 Tree Spot	540	20%	110	0.4 b
Telone C-35 Row Strip	540	50%	270	0.2 b
Telone C-35 Broadcast	540	100%	540	0.3 b
P-value	-			*0.04*

Table 13. Pre-plant soil treatment effects on post-plant nematode counts in a 2015 almond replant trial near Ballico, CA. Samples were taken in the fall of October, 2015, 8 months after planting. (ANOVA, Tukey-Kramer HSD $p < 0.05$).

Treatment										
Fumigant	**Rate per treated acre (lb/acre)**	**% Orchard Acre Fumigated**	Ring	Lesion	Root Knot	Pin	Stunt	Tylenchidae	Stubby Root	Free-living
Untreated	0	0	48 (46)	55 (64)	4 (5)	13 (19)	1 (3)	76 (42) **A**	333 (276)	1044 (534)
Telone C-35 Tree Spot	540	20%	28 (52)	0	1 (3)	0	0	8 (10) **B**	126 (35)	3403 (1897)
Telone C-35 Row Strip	540	50%	0	3 (5)	0	4 (8)	0	31 (25) **AB**	150 (71)	4034 (2039)
Telone C-35 Broadcast	540	100%	26 (46)	8 (15)	0	4 (8)	0	30 (21) **AB**	219 (116)	3235 (1403)
P-value	-							*0.04*		

Table 14. The effect of six pre-plant soil fumigant treatments on 'Aldrich' variety tree trunk diameter in a 2015 almond replant trial near Ballico, CA. Changes in tree trunk diameters are in millimeters (mm). Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD $p < 0.05$).

Treatment			
Fumigant	**Rate per treated acre (lb/acre)**	**% Orchard Acre Fumigated**	**2015**
Untreated	0	0	33.0 c
Telone-II	340	50	43.8 a
Chloropicrin	200	50	42.4 ab
Pic-Chlor 60	340	50	45.8 a
Dominus	340	50	39 b
Dominus+Chloropicrin	340+200	50	43.8 a
P-value	-		*0.01*

Table 15. Pre-plant soil fumigant treatment effects on 'Aldrich' variety disease severity ratings in a 2015 almond replant trial near Ballico, CA. Disease Severity Ratings (DSR) vary from 0 to 5, where 0 is healthy and 5 is dead. Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD $p < 0.05$).

Treatment			
Fumigant	**Rate per treated acre (lb/acre)**	**% Orchard Acre Fumigated**	**2015**
Untreated	0	0	1.4 a
Telone-II	340	50	0.6 b
Chloropicrin	200	50	0.5 b
Pic-Chlor 60	340	50	0.4 b
Dominus	340	50	0.8 b
Dominus+Chloropicrin	340+200	50	0.4 b
P-value	-		*<0.05*

Table 16. Pre-plant soil treatment effects on post-plant nematode counts in a 2015 almond replant trial near Ballico, CA. Samples were taken in the fall of October, 2015, 8 months after planting. (ANOVA, Tukey-Kramer HSD $p < 0.05$).

	Nematodes (per 500 g soil)				
Treatment	**Root Knot**	**Ring**	**Lesion**	**Stubby Root**	**Free-Living**
Control	31	21	141 a	103	472
Telone II	1	0	4 b	108	532
Chloropicrin	4	88	41 ab	89	637
Pic-Chlor 60	28	21	0 b	52	745
Dominus	32	142	68 ab	65	364
Dominus + Pic	6	39	64 ab	160	427

Table 17. Pre-plant and post-plant soil and foliar treatment effects on 'Sonora' variety tree trunk diameter in a 2015 almond replant trial near Ballico, CA. Changes in tree trunk diameters are in millimeters (mm). Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD $p < 0.05$).

Treatment	**2015 Growth (mm)**
Control	30.6 b
Movento® + Velum®	31.2 b
Telone II & Movento® + Velum®	41.4 a
Telone II	41.7 a
P-Value	<0.05

Table 18. Disease severity ratings of pre-plant and post-plant soil and foliar treatment effects on 'Sonora' variety tree trunk diameter in a 2015 almond replant trial near Ballico, CA. Disease Severity Ratings (DSR) vary from 0 to 5, where 0 is healthy and 5 is dead. Different letters indicate statistically significant difference (ANOVA, Tukey-Kramer HSD $p < 0.05$).

Treatment	2015 Disease Severity Ratings (0-5; 0 = healthy, 5 = dead)
Control	0.9 a
Movento®+Velum®	0.9 a
Telone-II & Movento®+Velum®	0.2 b
Telone-II	0.2 b

Table 19. Disease severity ratings of pre-plant and post-plant soil and foliar treatment effects on post-plant nematode counts in a 2015 almond replant trial near Ballico, CA. Samples were taken in the fall of October, 2015, 8 months after planting. (ANOVA, Tukey-Kramer HSD $p < 0.05$).

	Nematodes (per 500 g soil)				
Treatment	**Root Knot**	**Ring**	**Lesion**	**Stubby Root**	**Free-Living**
Control	49	44	89 a	98	274
Movento® + Velum®	12	42	67 a	102	343
Telone II & Movento® + Velum®	0	0	1 b	106	419
Telone II	3	1	3 b	163	315

Works Cited:

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