

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:

- To continue the work of established fumigant plots for control of Prunus Replant Disease and plant pathogenic nematodes.
- 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 fifth 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 tree's drip-line.

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):

Table 1: The effect of pre-plant treatments on the yield of replanted almonds at the Winton trial for 2014-2016 and cumulatively. Treatments followed by different letters are statistically significant (p<0.05, Dunnett's).

Winton Treatment	Yield (Kernel lbs/acre)			
	2014	2015	2016	Cumulative
Control	391.3	219.7	984.9	1595.9
Telone II Broad	473.1	583.5*	1210.8	2267.3*
Telone II Strip	441.4	537.3*	1304.3	2283.1*
C-35 Strip	531.3	560.3*	1231.4	2323.0*
C-35 Spot High	414.5	494.9*	1221.9	2131.3*
C-35 Spot Low	512.3	463.0*	1216.7	2192.1*
CP Spot Low	493.2	378.3*	1171.9	2043.3*
Steam	349.2	237.8	959.1	1546.1

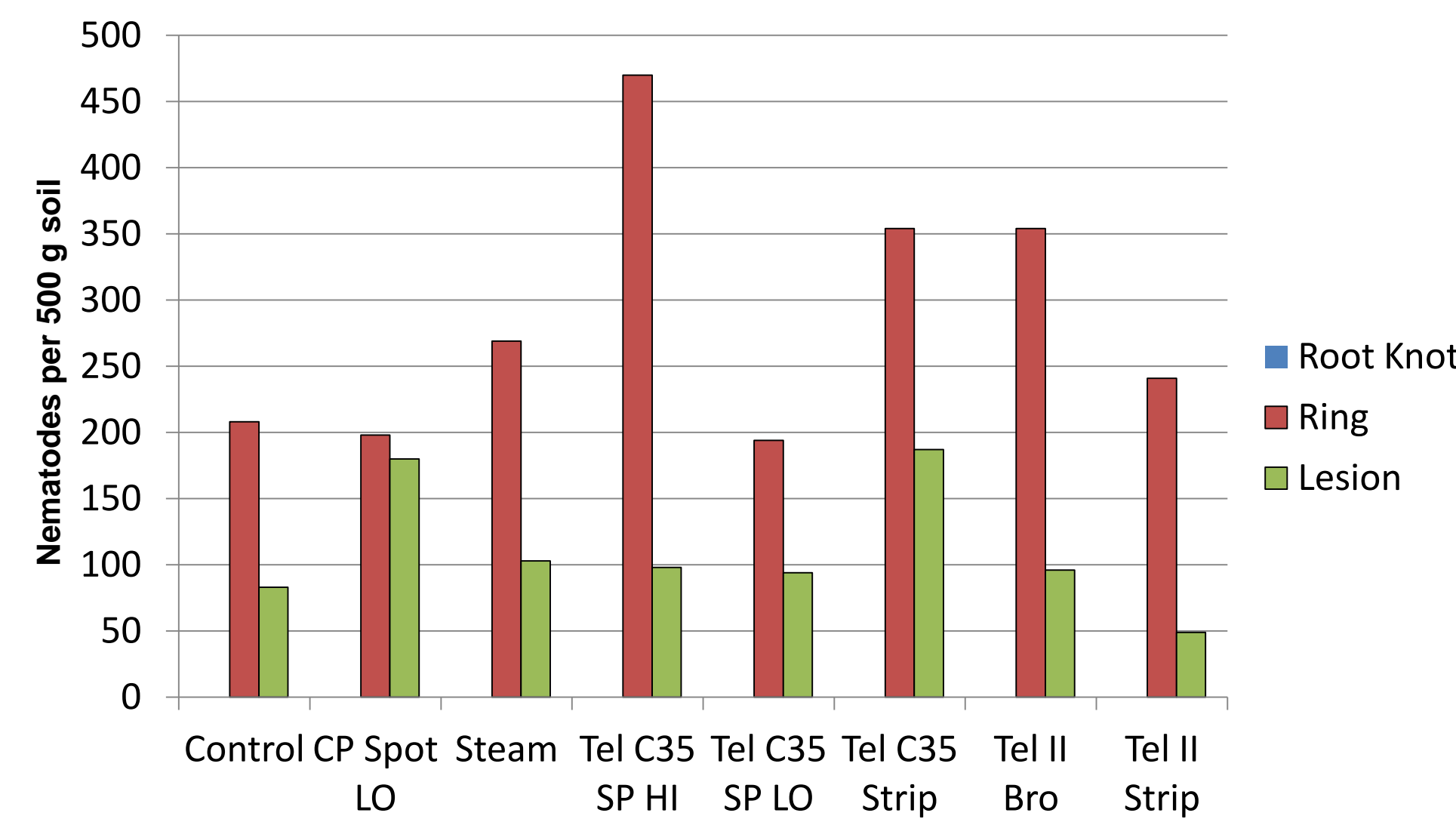


Figure 1: Nematode counts from various treatments taken after four years of growth at the Winton trial. Sampling performed in October, 2015.

Livingston Trial (Est. 2010):

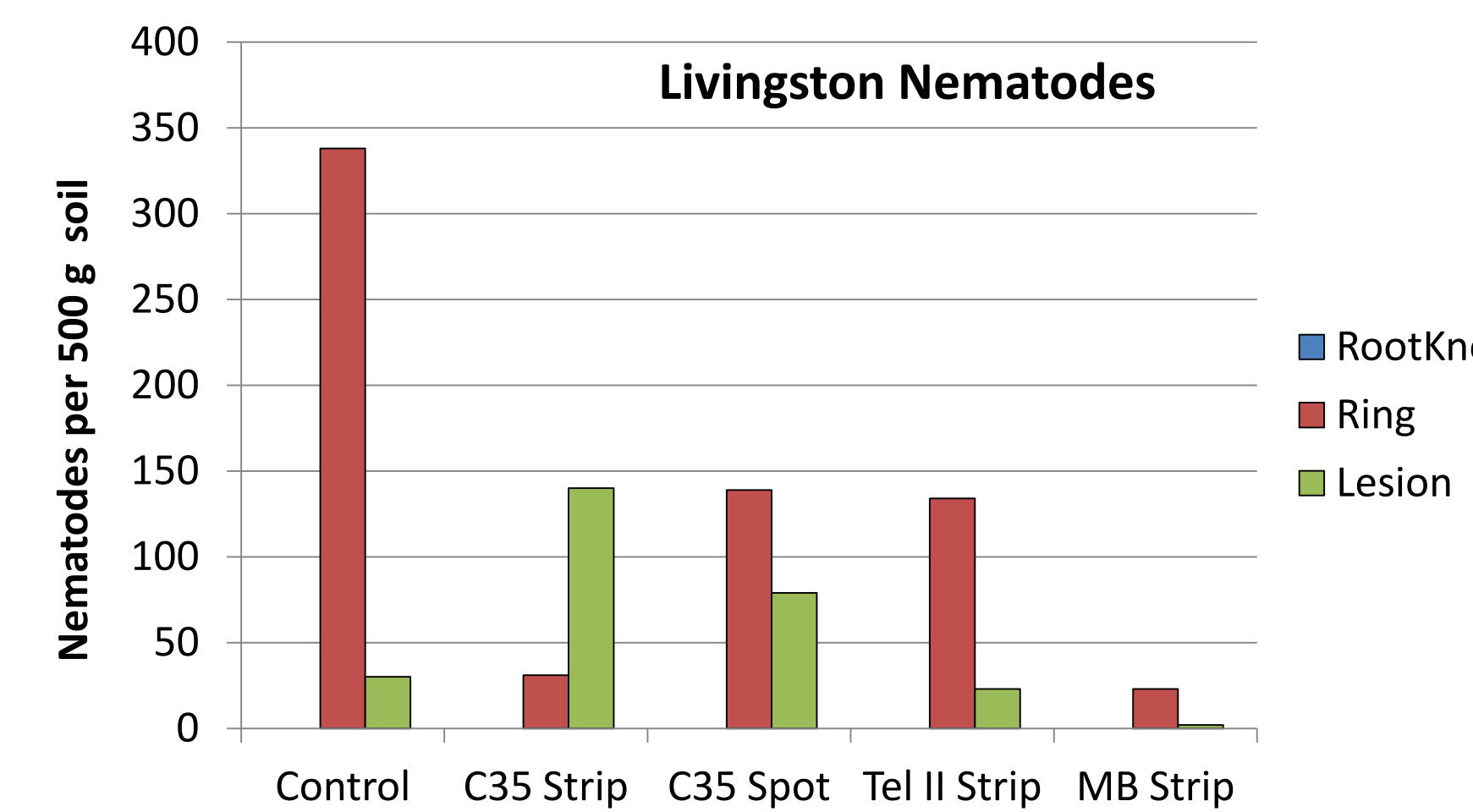


Figure 2: Nematode counts from various treatments taken after six years of growth at the Livingston trial. Sampling performed in Winter 2015.

Table 3: The effect of pre-plant treatments on the yield of replanted almonds at the Livingston trial for 2012-2016 and cumulatively. Treatments followed by * are significantly different from the control (p<0.05, Dunnett's).

Livingston Treatment	Yield (Kernel lbs/acre)					
	2012	2013	2014	2015	2016	Cumulative
Control	40.8	92.9	367.4	546.1	670.5	1717.6
Methyl Bromide	84.1*	206.6	590.4*	775.7	878.5*	2535.3*
Telone II Strip	65.3	161.8	597.2*	869.5	759.7	2453.6*
C-35 Strip	73.4	185.2	531.6*	869.8	775.1	2435.1*
C-35 Spot	65.9	184.9	497.1	681.1	720.0	2149.0

Ballico Trial (Est. 2011):

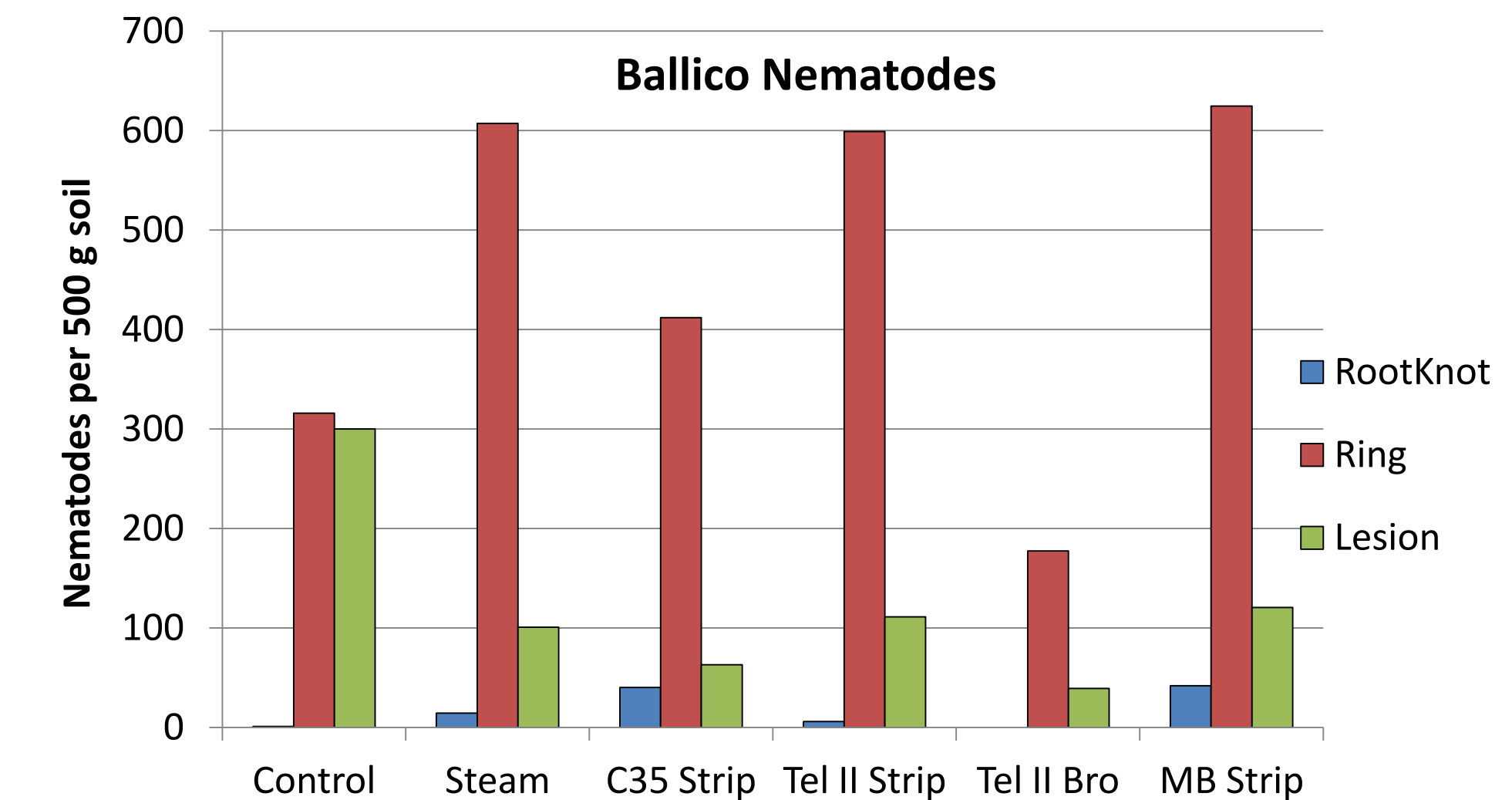


Figure 3: Nematode counts from various treatments taken after five years of growth at the Ballico trial. Sampling performed in Winter 2015.

Table 4: The effect of pre-plant treatments on the yield of replanted almonds at the Ballico trial for 2013-2016 and cumulatively. Treatments followed by * are significantly different from the control (p<0.05, Dunnett's).

Ballico Treatment	Yield (Kernel lbs/acre)				
	2013	2014	2015	2016	Cumulative
Control	158.2	376.8	275.0	715.6	1525.6
Methyl Bromide	230	498.8	523.9*	863.6	2116.3*
Telone II Strip	266.4*	652.1*	480.9*	1122.4*	2521.8*
Telone II Broadcast	317.7*	764.6*	708.8*	1182.0*	2973.2*
C-35 Strip	258.1	525.6	460.0	830.0	2073.7*
Steam	138.1	357.4	206.3	618.8	1320.6

Results and Discussion:

- At the Winton trial, cumulative yields of all fumigation treatments were higher than the steam and control (Table 2), even though PPN were present in all treatments (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 3).
- Cumulative yields from all fumigant treatments were higher than the control at the Ballico trial (Table 4), with the broadcast Telone-II treatment yielding the highest.
- There were no differences between nematode populations within fumigation treatments in all trials (Fig. 1, 2, and 3), suggesting that PRD is the primary factor in reducing young almond yield.
- Trunk diameter in Telone-II or chloropicrin containing treatments was higher than the control in the Telone-II Alternatives trial (Fig. 5).
- Surprisingly, the Movento® and Velum One® combination outgrew the untreated control. This treatment, however, did not perform as well as pre-plant fumigated treatments (Fig. 6).

New Ballico Telone II Alternatives Trial (Est. 2015):

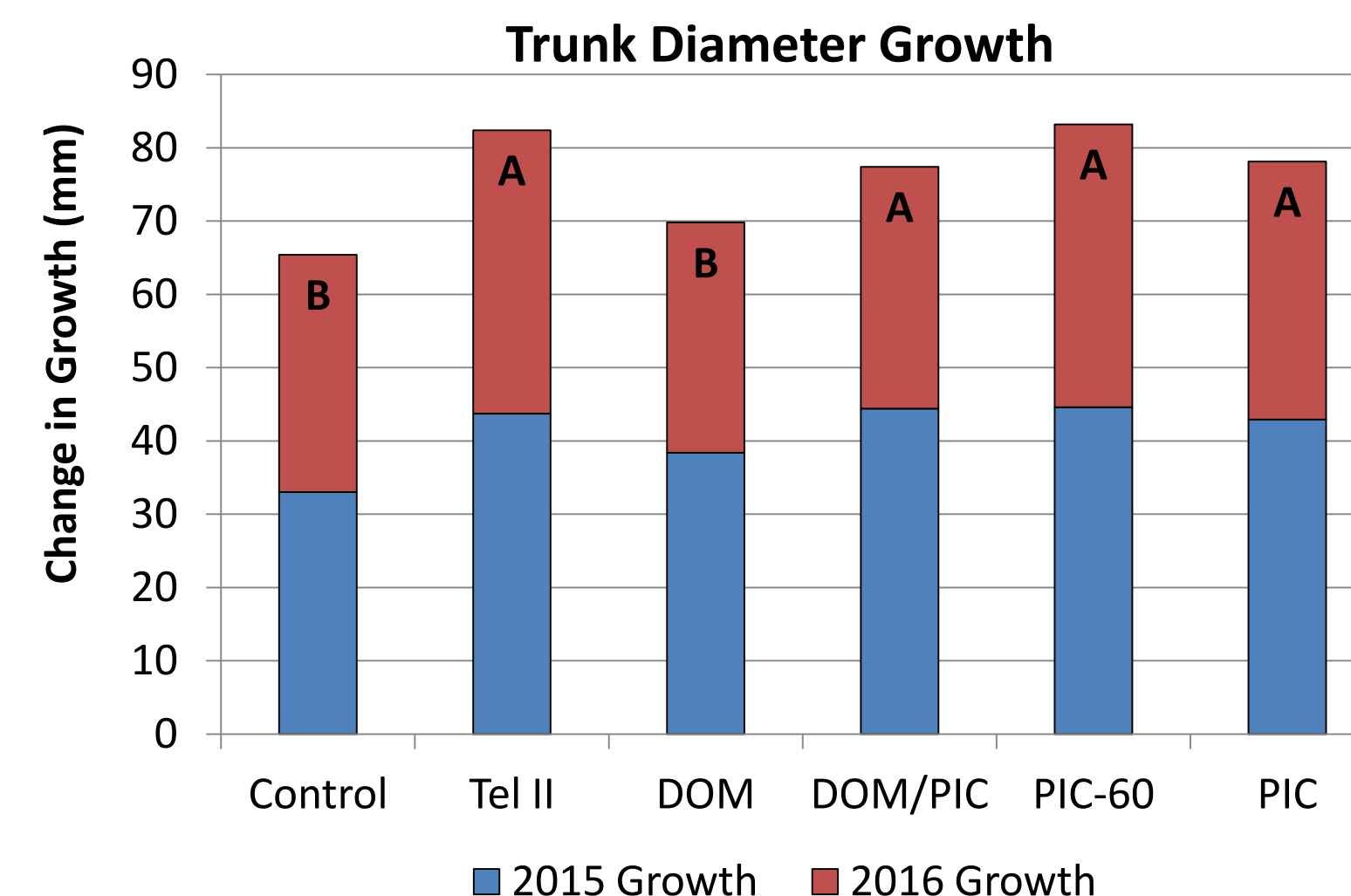


Figure 4: The effect of pre-plant treatments on trunk growth of replanted almonds at the Telone II Alternatives trial in Ballico. Treatments followed by different letters are statistically different (p<0.05, Tukey's).

New Ballico: Post-Plant Fumigant Alternatives Trial (Est. 2015):

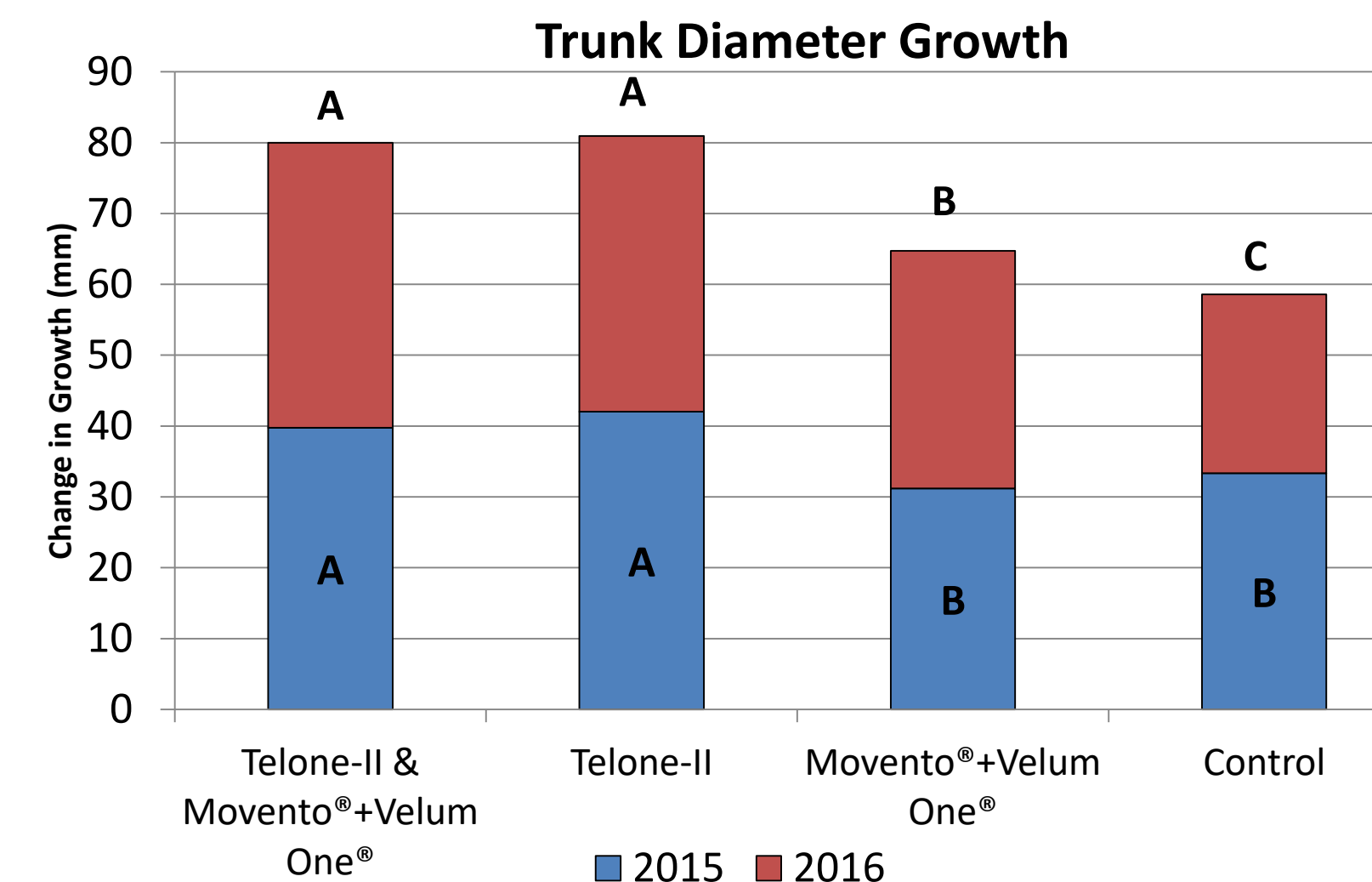


Figure 5: The effect of pre-plant treatments on the first year of trunk growth of replanted almonds at the Telone II Alternatives trial in Ballico. Treatments with an asterisk are significantly different (Two way ANOVA, p<0.05).