

Almond Soil Fumigation and Alternatives Studies



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NSJV Almond Day
Feb 7th, 2018

Key Take Away Points:

- There are several replant problems of almonds, but we can manage two (maybe three) w/fumigation:
 - Prunus Replant Disease (PRD) is universal, can be managed with Chloropicrin, Telone-II
 - Nematode Parasitism is more varied and sampling will determine presence, managed with Telone-II
- Currently, Fumigation is the only commercially acceptable way to manage PRD (but we are working on it):
 - “Starve and switch” does not manage PRD
 - Movento or Velum 1 does not manage PRD, but does reduce impacts of nematodes.

Almond Replant Problems

- **Abiotic factors** (physical, chemical conditions related to previous production)
- **Aggressive pathogens, pests** (*Phytophthora*, *Armillaria*, *Verticillium*, Ten-Lined June Beetle) –localized, not managed completely by fumigation
- **Plant-parasitic nematodes** (ring, lesion, root knot), approx. 35% of almond and fresh stone fruit acreage, 60% of cling peach acreage infested (McKenry)
- **Replant disease (RD)** Microbe-induced growth suppression; incidence nearly universal in *Prunus* after *Prunus*, but severity varies greatly



Healthy tree

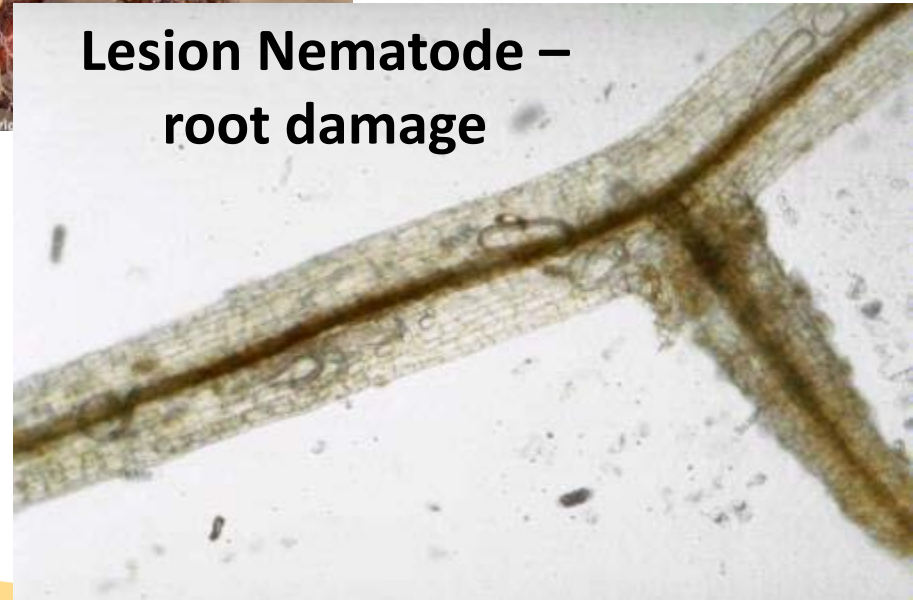
RD-affected tree

Symptoms of replant disease on almond

Nematode Parasitism



**Rootknot
Nematode –Galls
on roots**



**Lesion Nematode –
root damage**

**Ring Nematode -Bacterial
Canker Complex**

Almond Replant Disease



Healthy (L) and replant disease-affected (R) almond trees, Madera County 2007

Fumigant Studies: PRD Only

Madera County, San Joaquin Valley:

- 2003, Agriland, almond after almond (sandy loam) (fr. CSREES)
- 2006, Paramount, almond after almond (sandy loam)
- 2007, Agriland, almond after almond (sandy loam)
- 2009, Poythress, almond after almond (loam)

Fresno County, San Joaquin Valley :

- 2007, USDA-ARS Parlier, peach after plum (sandy loam)
- 2007, USDA-ARS Parlier, almond after peach (sandy loam)
- 2008, Berberian, Reedley, peach after peach (sandy loam)
- 2008, KAC, Parlier, almond after peach (sandy loam)
- 2008, USDA-ARS, Parlier, peach after peach (sandy loam)
- 2010, USDA-ARS, Parlier, almond and peach rootstocks x Tel C35 fum

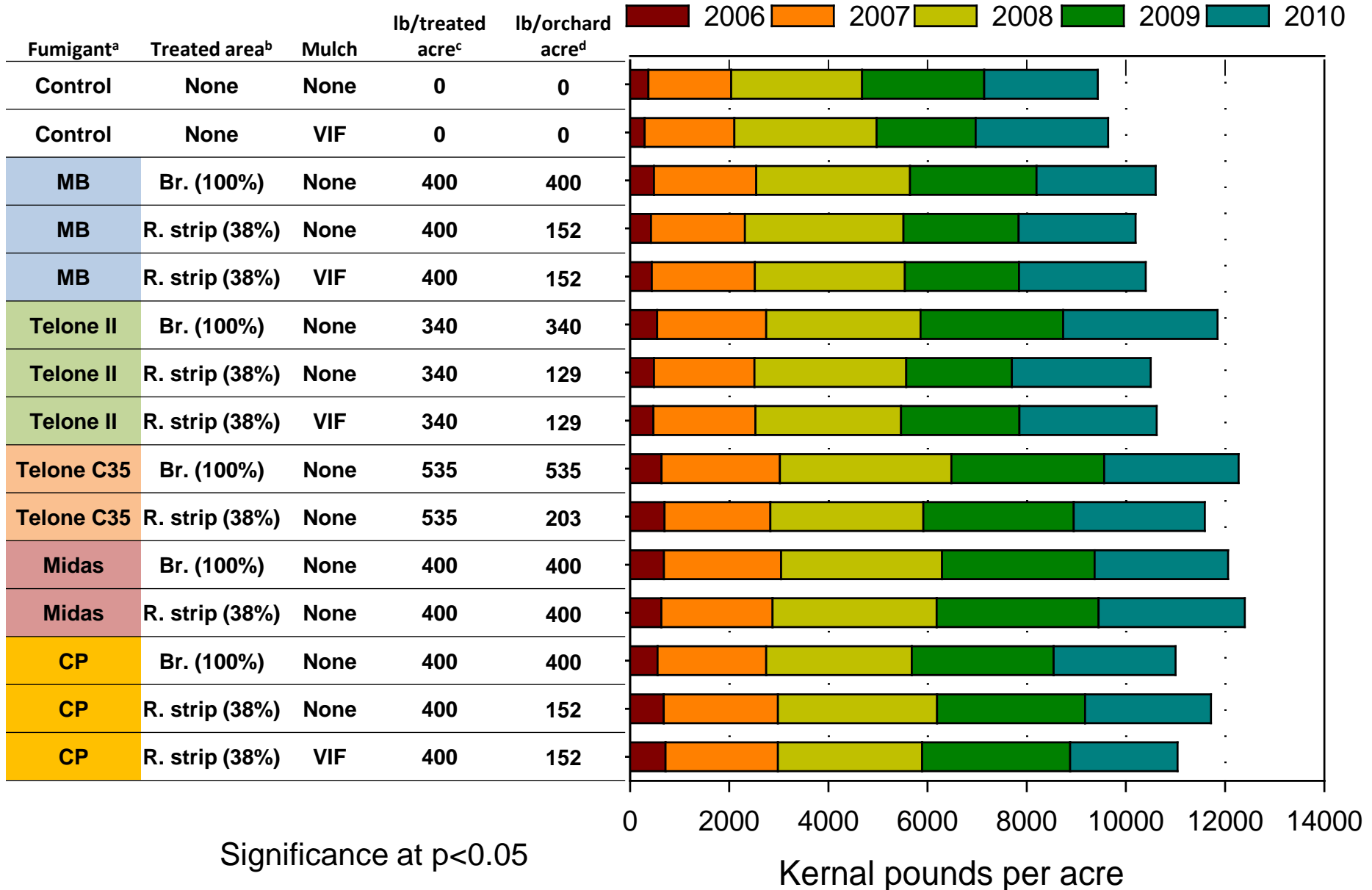
Colusa County, Sacramento Valley:

- 2007, almond after almond, Nickels Estate (loam)

Merced County, San Joaquin Valley :

- 2009, Frago, almond after almond (sand); Ring Nematode
- 2010, Littlejohn, almond after almond (sand); Ring Nematode
- 2011, Taylor, almond after almond (sand); Ring Nematode
- 2011, Chad, almond after almond (sand); Ring Nematode; buffer zone

Fumigant Studies: Madera 2004



Fumigant Studies

PRD and Parasitic Nematodes



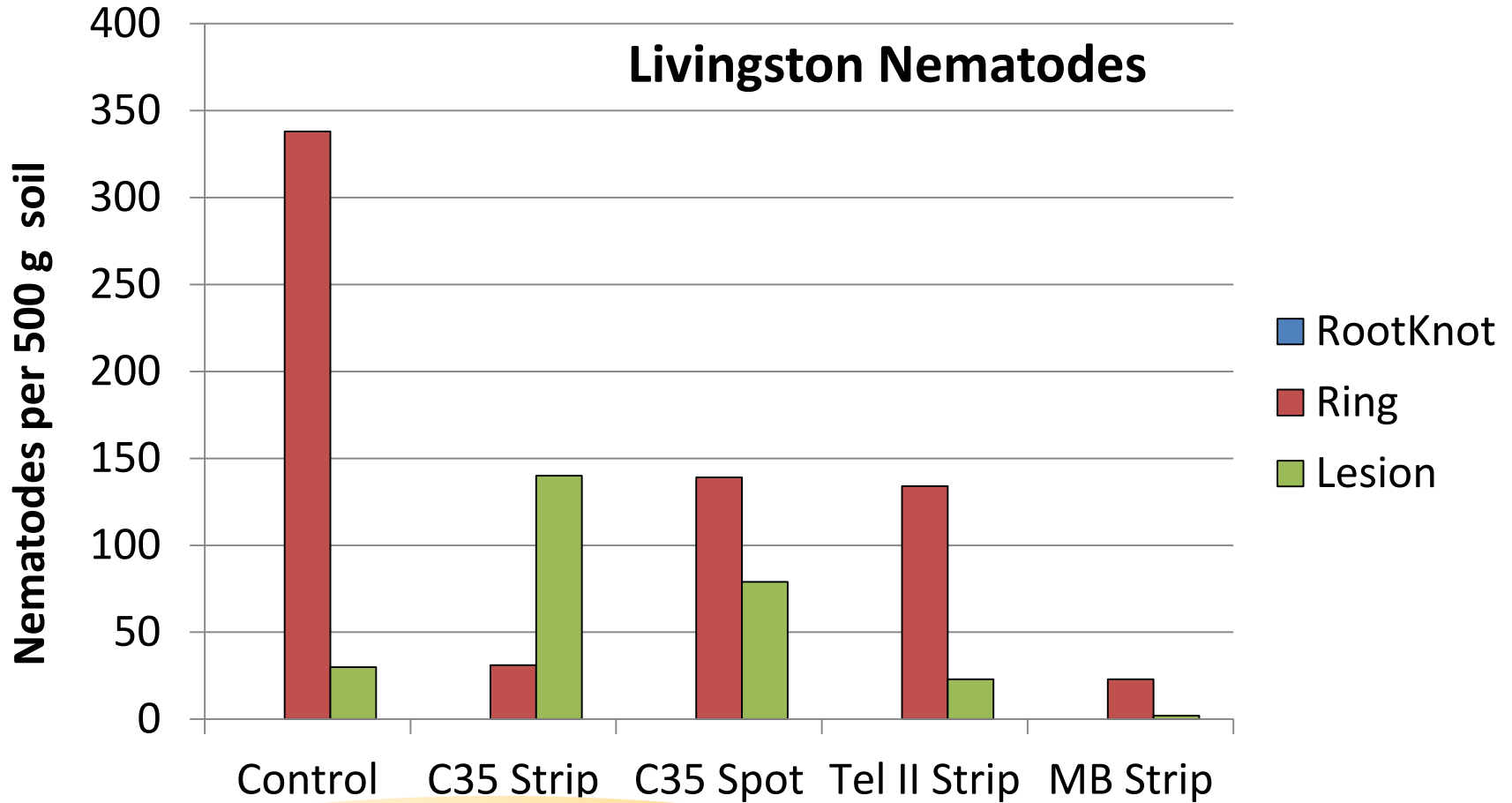
Livingston Trial (2010)

Livingston	Yield (Kernel lbs/acre)					
	2012	2013	2014	2015	2016	Cumulative
Treatment						
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

Treatments followed by * are statistically greater than the control (Dunnett's, $p < 0.05$).

Livingston Trial (2010)

Nematode counts from various treatments sampled in October, 2014.



Ballico Trial (2011)

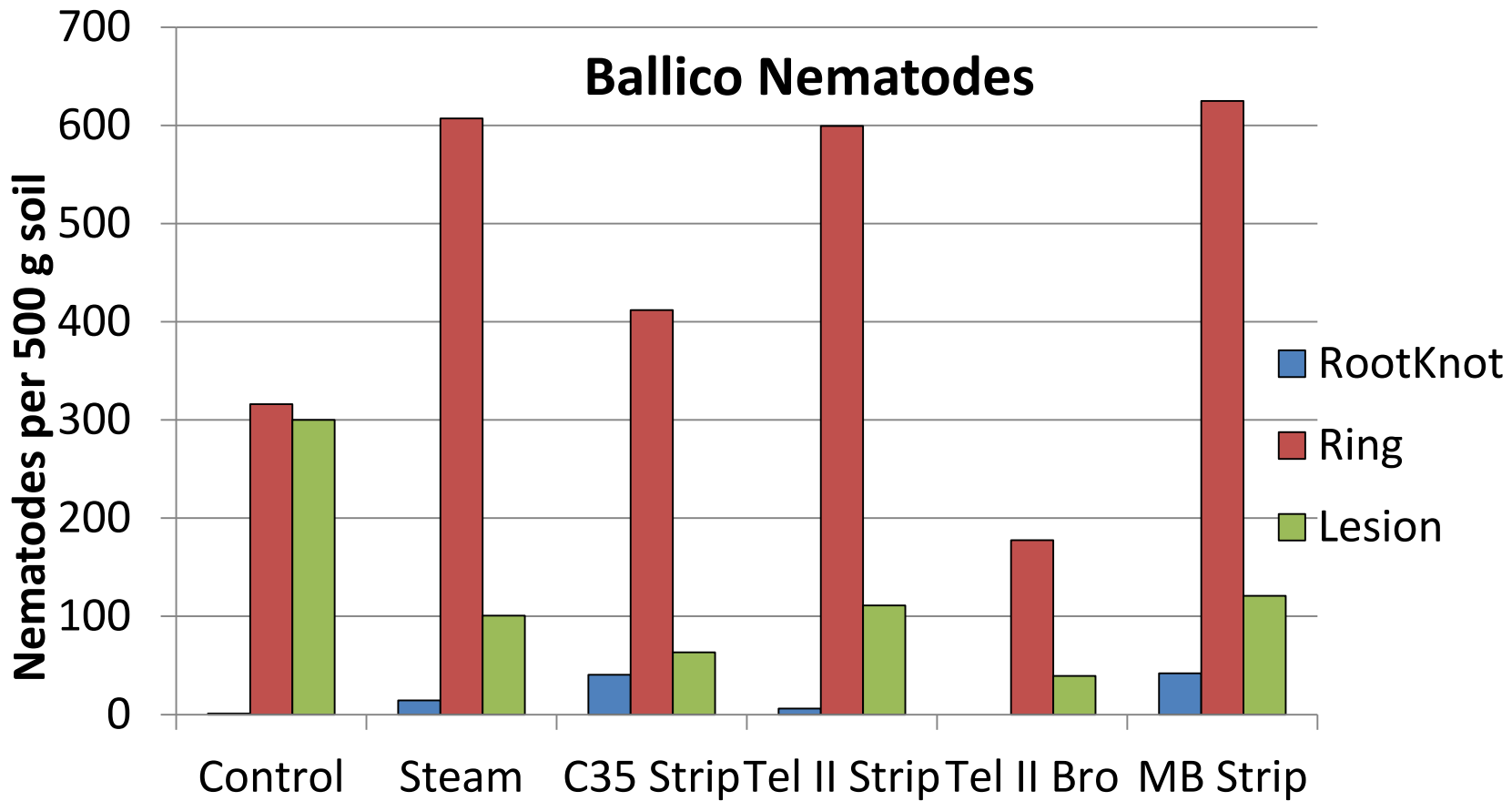
Ballico	Yield (Kernel lbs/acre)					
	2013	2014	2015	2016	2017⁺	Cumulative
Control	158.2	376.8	275.0	715.6	350	1875.7
Methyl Bromide	230	498.8	523.9*	863.6	605.7	2722*
Telone II Strip	266.4*	652.1*	480.9*	1122.4*	527.4	3049.2*
Telone II Broadcast	317.7*	764.6*	708.8*	1182.0*	758.4	3731.6*
C-35 Strip	258.1	525.6	460.0	830.0	403.7	2477.4*
Steam	138.1	357.4	206.3	618.8	172.6	1493.2

Treatments followed by * are statistically greater than the control (Dunnett's, $p < 0.05$).

*Severe crop loss from bacterial blast experienced in 2017.

Ballico Trial (2011)

Nematode counts from various treatments sampled in October, 2014.



Replant Problems of Almonds: Fumigant Selection

Livingston Trial

- Telone-II and telone-C35 strip performed as well as Methyl Bromide Strip
- Nematode counts varied across treatments

Ballico Trial

- Telone-II rowstrip and broadcast applications and telone-C35 strip performed as well or better than the Methyl Bromide Strip
- Telone-II broadcast had the highest cumulative yield.
- Nematode counts varied across treatments

Fumigated, C35 RS 16 months

Control, 16 months



Control, 16 months



Fumigated, Telone-II RS 16 months



Control, 16 months



Fumigated, Telone-II BC 5.5 years



Replant Problems of Almonds: Fumigant Selection

No more methyl bromide.

Other alternatives:

As good or
better than
MB



Chloropicrin

Telone-II

Mixtures of Chloropicrin/Telone-II

VAPAM



Not much work due to difficulty of use

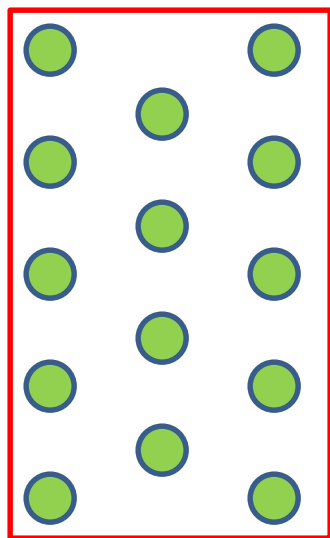
New trial establish
to determine
efficacy



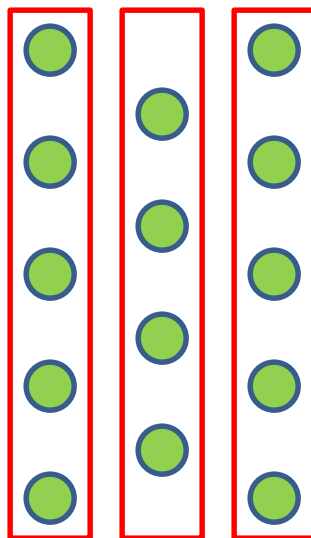
Dominus (registration pending)

Replant Problems of Almonds: Fumigated Area

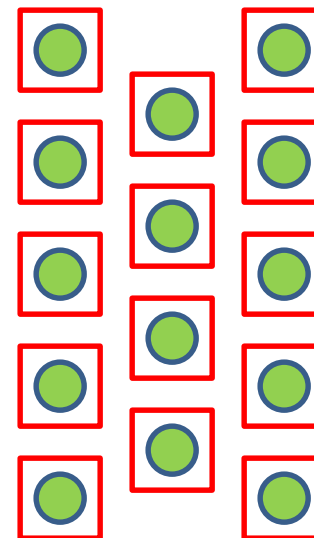
New Technology has provided options.



Broadcast
100% of Orchard Area



Rowstrip – 11'
50% of Orchard Area



Guided Tree Spot – 8'x8'
~20% of Orchard Area

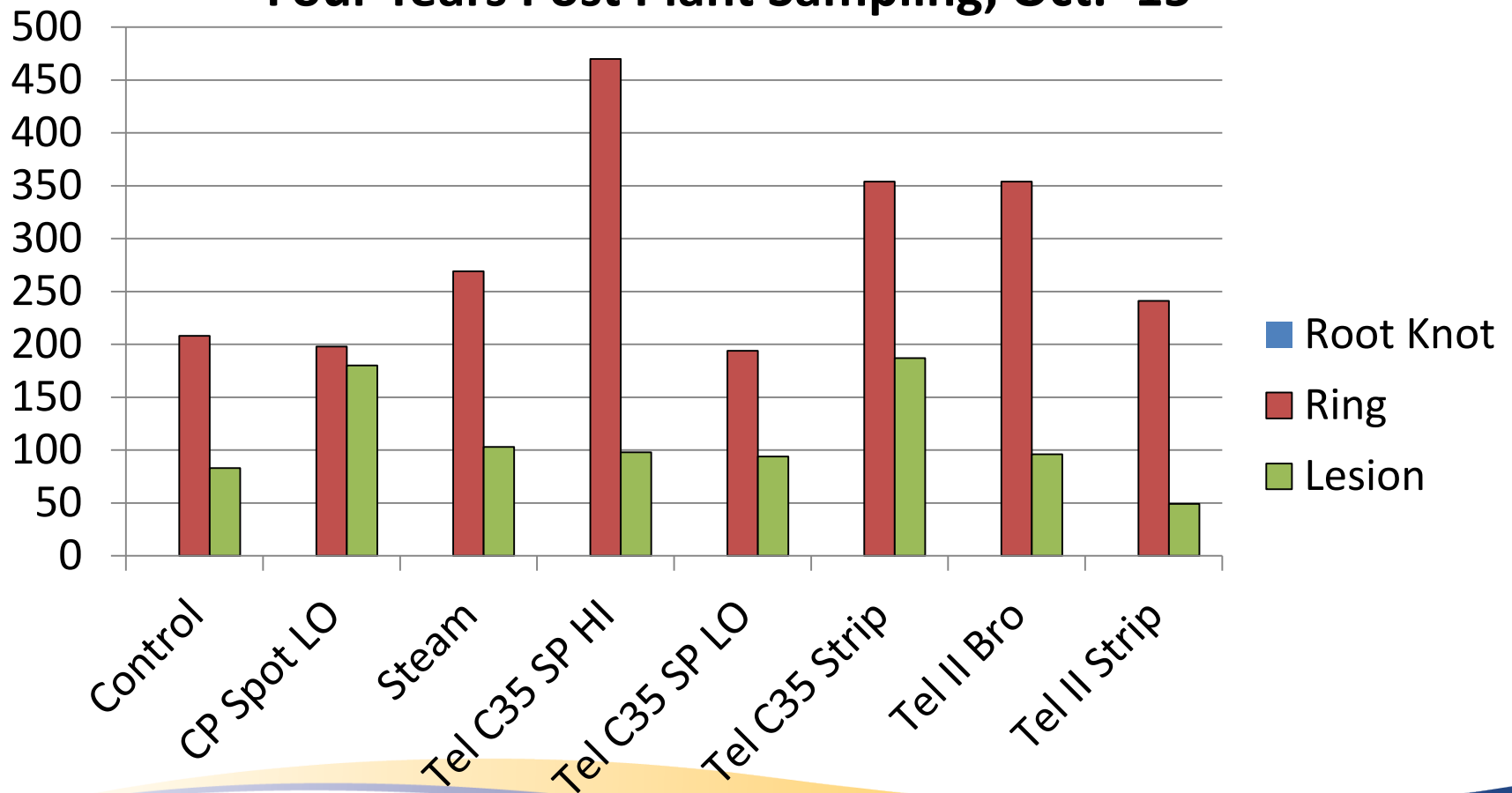
Replant Problems of Almonds: Fumigated Area

Winton Trial: Ring Nematode Present, Medium Vigor, Nemaguard after Nemaguard

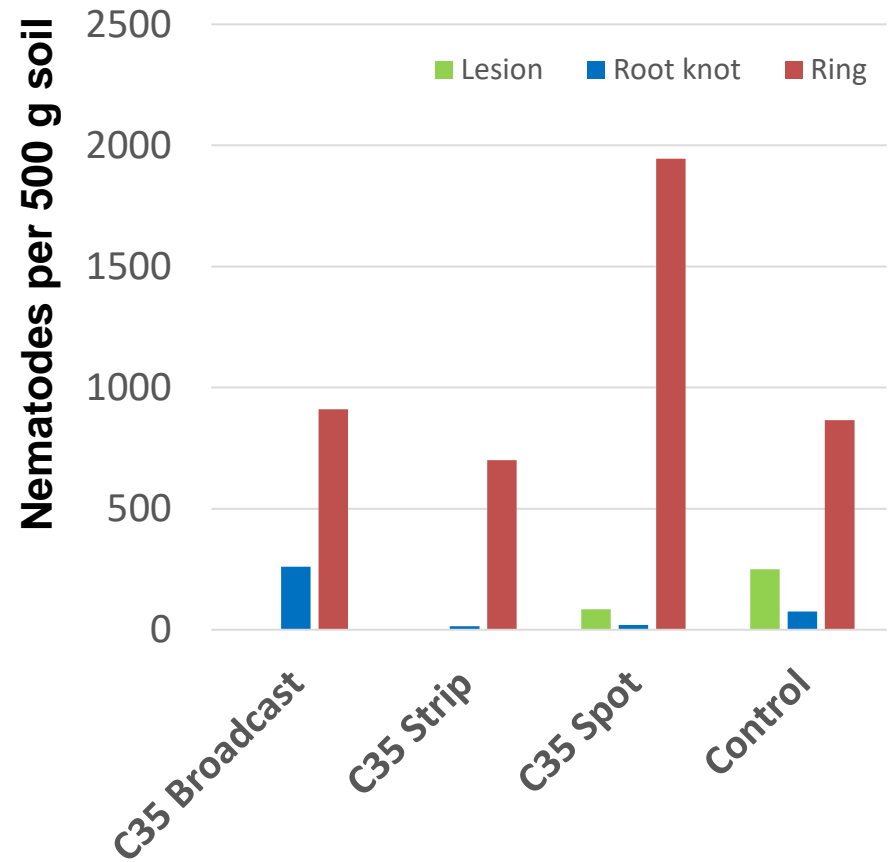
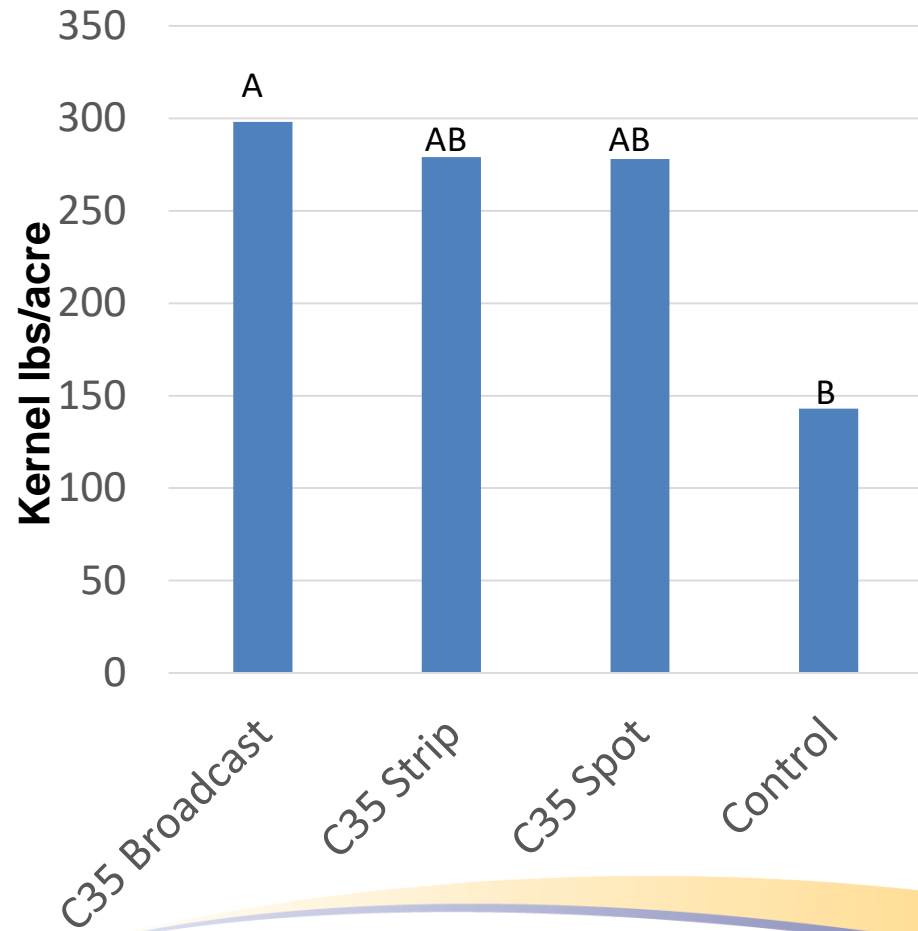
Winton	Yield (Kernel lbs/acre)				
	Treatment	2014	2015	2016	Cumulative
Control		391.3	219.7	984.9	1595.9
Telone II Broad		473.1	583.5*	1210.8	2267.3*
Telone II Strip		441.4	537.3*	1304.3	2283.1*
C-35 Strip		531.3	560.3*	1231.4	2323.0*
C-35 Spot High		414.5	494.9*	1221.9	2131.3*
C-35 Spot Low		512.3	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

Replant Problems of Almonds: Fumigated Area

Four Years Post Plant Sampling, Oct. '15

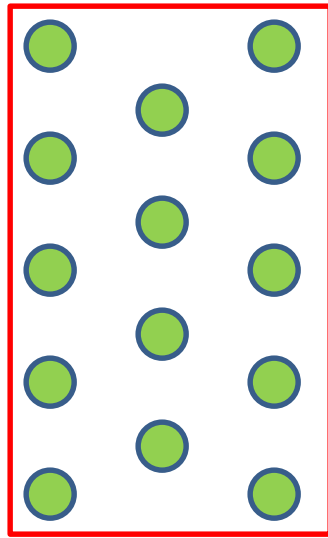


Replant Problems of Almonds: Fumigated Area

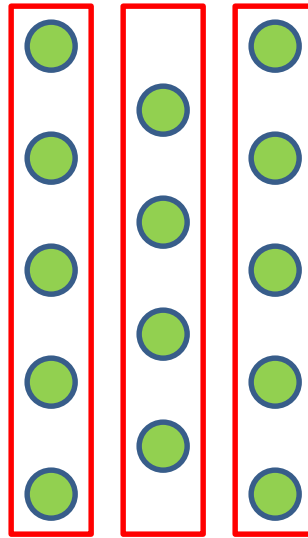


Replant Problems of Almonds: Fumigated Area

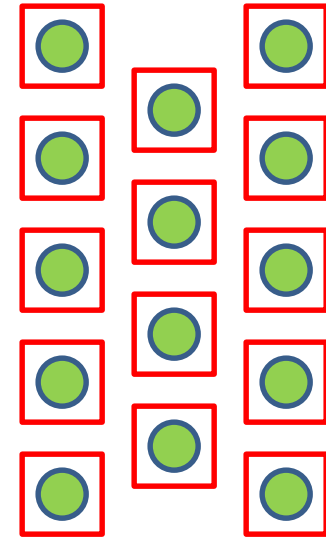
All perform the same as a broadcast treatment!



Broadcast
100% of Orchard Area



Rowstrip – 11'
50% of Orchard Area



Guided Tree Spot – 8'x8'
~20% of Orchard Area

Replant Problems of Almonds: Fumigant Option Overview

Problem	Fumigant	Method
High Nematode Parasitism	Telone-II (Chloropicrin)	Broadcast or Row Strip
Low/Medium Nematode Parasitism	Telone-II (Chloropicrin)	Row Strip (Spot?)
Nematode Parasitism +Prunus Replant Disease (PRD)	Telone-II Telone-II C35	Broadcast Rowstrip, Spot
PRD Only	Chloropicrin	Spot, Rowstrip

Fumigant Alternatives (2015)

Current Studies:

- Telone-II Alternatives
 - Testing alternatives to Telone-II for affected townships
 - Lower amounts of Telone-II with Chloropicrin, Dominus
- Examining Alternatives to Fumigants
 - Movento/Velum One, Experimental Products

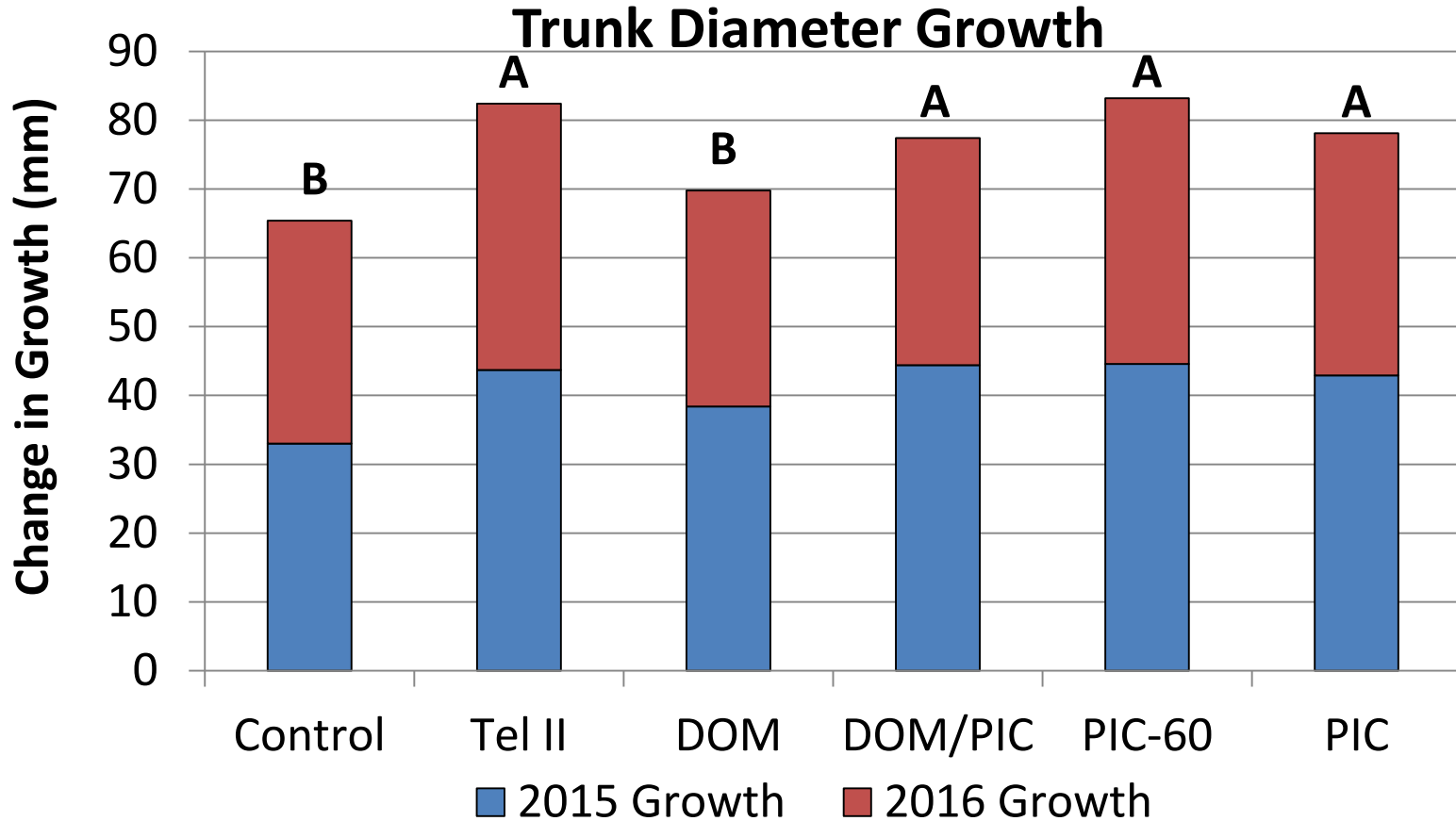


Fumigated – 14 months after Planting



Non-fumigated – 14 months after Planting

Fumigant Alternatives (2015) -



Treatments followed by different letters are statistically different ($p < 0.05$, Tukey's).

Fumigant Alternatives (2015) – Movento and Velum One

Treatment	<u>Change in Trunk Caliper (mm)</u>				2017 Yield (lbs/acre)
	2015	2016	2017	Cumulative	
Telone [®] II & Movento [®] + Velum [®] One	41.4 A	36.4	59.0 A	136.8 A	241A
Telone [®] II	41.7 A	34.9	58.8 A	135.4 A	224AB
Movento [®] + Velum [®] One	31.2 B	36.8	55.1 A	123.1 B	203AB
Control	33.6 B	36.0	46.8 B	116.4 B	169 B

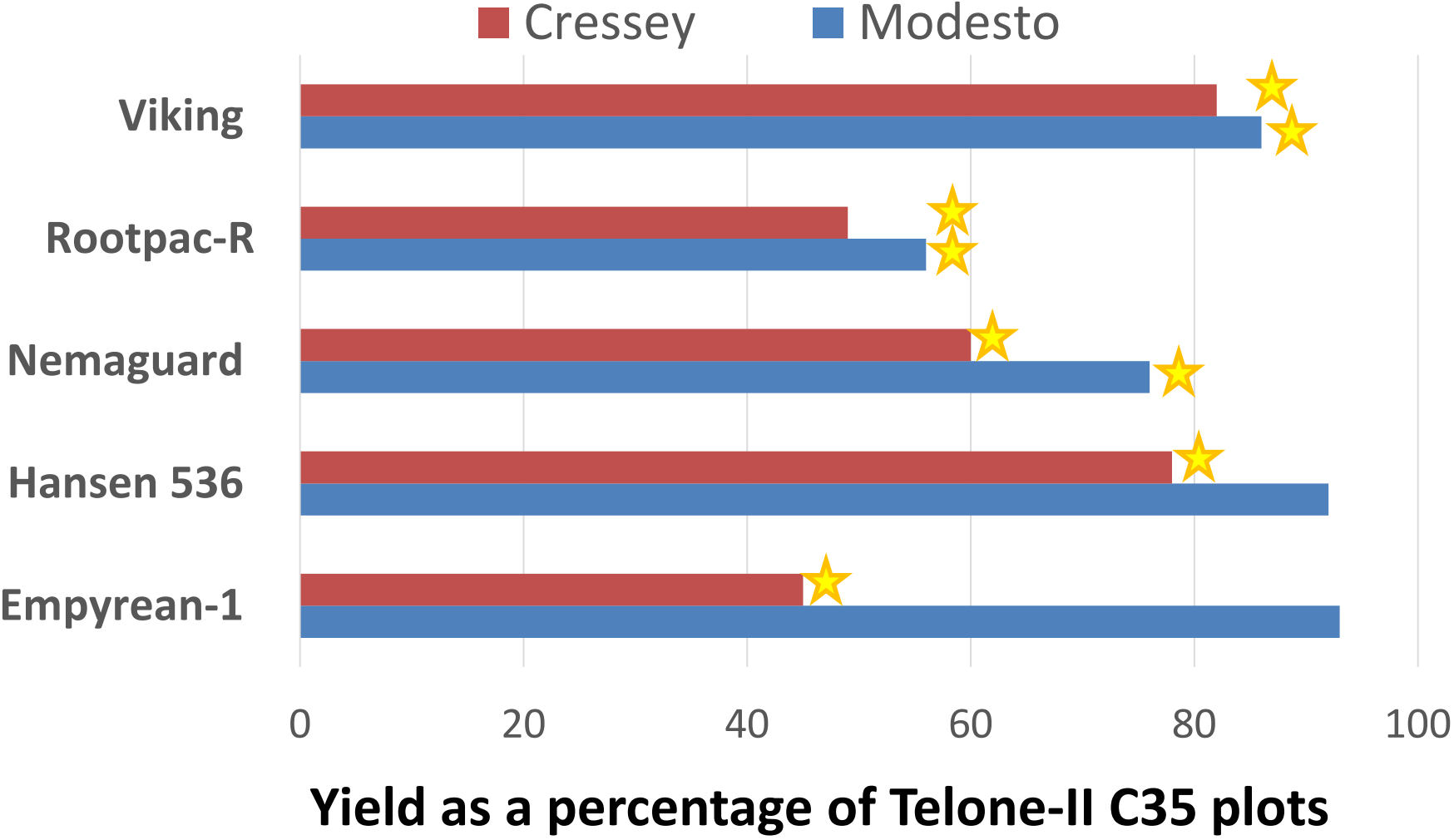
Treatments followed by different letters are statistically different ($p < 0.05$, Tukey's).

Fumigant Alternatives (2015) – Rootstocks/ “Switching Parentage”

- 2 Trials established in 2014-2015 near Cressey and Modesto
- Five rootstocks planted in January 2015
 - Hansen 536
 - Empyrean-1
 - Nemaguard
 - RootPacR
 - Viking
- Trees were planted in either C35 pre-plant fumigates soil, or an untreated control.



Fumigant Alternatives (2015) – Rootstocks/ “Switching Parentage”



Conclusions:

- There are several replant problems of almonds, but we can manage two (maybe three) w/fumigation.
- Area of applied fumigant can be reduced when managing PRD and PPN, saving money, reduce reg. burden.
 - Narrowing of row-strip or spot fumigation
- No real alternatives to Telone-II. In restrictive townships, consider using chloropicrin if Telone-II is capped out.
- Post-plant nematicides are exactly that – they do not manage PRD.
- Currently, Fumigation is the only commercially acceptable way to manage PRD (but we are working on it).
- Trials supported by local farmers, TRI-CAL, CA DPR, CDFA, Almond Board of CA, and USDA Area Wide.