

NEMATODE MANAGEMENT IN WALNUT ORCHARDS - 2006

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ABSTRACT

Lesion (*Pratylenchus vulnus*) and ring (*Mesocriconema xenoplax*) nematodes reduce walnut yields through root damage from direct feeding and by placing trees under stress. Lesion nematodes are likely to be found within roots as well as in soil, while ring nematodes are external parasites. At the present time, there are no cultural management techniques available for reducing nematode damage to walnuts to an economically acceptable level in established orchards and only a single nematicide is registered for post-plant use. This is the “biological” nematicide DiTera (a toxin produced by a fungus that is produced by Valent Laboratories) that achieved registration as a result of data developed in this project.

In 2003, a trial to evaluate the efficacy of a promising new bionematicide (Quillaja 35%) was initiated in an orchard previously used for an own-rooted Chandler compared to Chandler on Paradox rootstock trial. Treatments are comparing the currently registered bionematicide DiTera with a new product Quillaja 35% which is an extract of the Soapbark tree. DiTera (50 pounds ai/acre) and Quillaja (2.5 gallons/acre) were applied in the spring and fall of 2003 (April 11 and October 24), 2004 (April 6 and September 29), 2005 (April 11 and October 13), and 2006 (May 10 and October 30) in a band covering half of the area, so that actual amounts applied per acre were 25 pounds of DiTera and 1.25 gallons of Quillaja. In a vigor rating of trees on October 30, 2006, both DiTera and Quillaja treated trees on Paradox were more vigorous than the untreated ($p \leq 0.05$). Yields for Paradox rootstock for both DiTera and Quillaja were greater than the untreated ($p \leq 0.05$). For both the Paradox rootstock and own rooted trees, there were trends towards an increase in trunk circumference, and cross-sectional area for both Quillaja and DiTera. There is a trend for numbers of lesion nematode to be decreasing, and for ring nematode to be increasing in the orchard.

In 2004, a trial was initiated in a drip irrigated orchard in San Joaquin County. It consists of DiTera, two rates of Quillaja, and Fulvic Acid treatments with four replicates per treatment. Treatments have been applied in the spring of 2004, 2005, and 2006. Quillaja at 2.5 gpa has a significantly increased tree circumference compared to the check ($p \leq 0.05$). All treatments have reduced lesion and ring nematode populations on at least one sample date ($p \leq 0.05$). In another trial comparing several rates of DiTera and Quillaja alone and in combination with six replicates per treatment, several treatments show a trend for increased trunk circumference, but this is only statistically significant for Quillaja at 6 gpa and DiTera at 25 lb/a plus Quillaja at 4 gpa ($p \leq 0.05$). Several treatments have shown reductions in populations of lesion or ring nematode ($p \leq 0.05$).

OBJECTIVES

1. Optimize sampling strategies and treatment timing for lesion and ring nematode on walnuts in a San Joaquin County Orchard.
2. Evaluate performance of Quillaja 35% and DiTera in a Sutter County orchard.
3. Evaluate performance of Quillaja 35%, DiTera, and Fulvic Acid in a San Joaquin County orchard.
4. Evaluate performance of bionematicides in a Solano County orchard.

PROCEDURES

Lesion (*Pratylenchus vulnus*) and ring (*Mesocriconema xenoplax*) nematodes reduce walnut yields through root damage from direct feeding and by placing trees under stress (Lownsbery, 1956 and 1959; Lownsbery et al., 1978). Lesion nematodes are likely to be found within roots as well as in soil, while ring nematodes are external parasites. At the present time, there are no cultural management techniques available for reducing nematode damage to walnuts to an economically acceptable level in established orchards and only a single nematicide is registered for post-plant use. This is the “biological” nematicide DiTera (a toxin produced by a fungus that is produced by Valent Laboratories) that achieved registration as a result of data developed in this project. Quillaja 35% which is an extract of the Soapbark tree is another promising bionematicide. Desert King is actively pursuing registration of the product with both CA and US EPA and there is promising efficacy data on grapes and tomatoes in Chile.

1. Optimize sampling strategies and treatment timing for lesion and ring nematode on walnuts in a San Joaquin County Orchard.

A trial with 17 treatments (Table 1) is in progress to evaluate whether reduced rates (25 and 12.5 vs 50 pounds/acre) of the bionematicide DiTera will be effective in controlling lesion and ring nematodes; to evaluate four rates of Quillaja 35% (6, 4, 2.5, and 1.25 gallons/acre); and to evaluate the effectiveness of combinations of DiTera and Quillaja (50 lb/a + 4 gpa, 50 lb/a + 2.5 gpa, 25 lb/a + 4 gpa, 25 lb/a + 2.5 gpa, 12.5 lb/a + 4 gpa, 12.5 lb/a + 2.5 gpa). This is a randomized complete block trial with six replicates per treatment. Treatments include an untreated check and treatment effectiveness is being evaluated via soil and root sampling, and trunk circumference measurements. The 50 lb/acre DiTera treatment was applied either once in the spring of 2004 (DiTera 50) or 2005, (DiTera 0 + 50), or in the spring of both years (DiTera 50 + 50). All of the other treatments were applied in the spring of 2005.

Data is being analyzed using analysis of variance followed by independent contrasts for mean separation or Fisher’s Protected Least Significant Difference Test.

Nematodes are extracted from soil via elutriation-sugar centrifugation and from roots via mist chamber extraction. In elutriation-sugar centrifugation, a measured volume of soil is mixed with a larger volume of water, and poured through a fine mesh sieve which retains the nematodes.

Nematodes washed from the sieve are then mixed with a sugar solution in a plastic tube and centrifuged. During this process, nematodes float in the sugar solution while any remaining soil particles are pulled to the bottom by the centrifugation. Nozzles at the top of a mist chamber periodically spray heated water on roots held in a mesh basket nested on top of a funnel. The stem of the funnel resides in a test-tube. Nematodes emerge from the roots and are captured at the bottom of the test-tube while excess water flows over the top of the tube. For both techniques, extracted nematodes are then counted under a microscope.

2. Evaluate performance of Quillaja 35% and DiTera in a Sutter County orchard.

The study site is located in Sutter County in northern California on Holillipah loamy sand. Two rootstocks, micropropagated 'Chandler' on its own-roots and nursery grafted 'Chandler' on seedling Paradox rootstock were planted in 1991 in a randomized complete block design spaced at 25 ft x 25 ft. Trees are irrigated using microsprinklers.

The nematicide trial has 10 individual tree replicates per treatment (5 Paradox and 5 own-rooted) for DiTera DF and Quillaja 35% in a randomized complete block design. In addition, a new formulation of DiTera is being evaluated on 2 Paradox and 5 own-rooted trees. Treatments were applied in 2003 (April 11 and October 24), 2004 (April 6 and September 29), 2005 (April 11 and October 13), and 2006 (May 10 and October 30) in a band covering half of the area, so that actual amounts applied per acre were 25 pounds of DiTera and 1.25 gallons of Quillaja. Treatments are incorporated with irrigation. The new formulation of DiTera was not applied to both rootstocks on all dates due to insufficient product being available. Data for the new formulation has not been included in the figures.

Root and soil samples are taken prior to each treatment date using a 5 cm bucket auger to a depth of 60 cm midway between the dripline and tree trunk in the fall and spring of each year. Nematodes were extracted from a 400 cm³ soil sub-sample with a modified semiautomatic elutriator and sucrose centrifugation technique (Byrd et al., 1976). Data were analyzed using analysis of variance followed by independent contrasts for mean separation or Fisher's Protected Least Significant Difference Test.

3. Evaluate performance of Quillaja 35%, DiTera, and Fulvic Acid in a San Joaquin County orchard.

In 2004, a trial was initiated in a drip irrigated orchard in San Joaquin County. It consists of DiTera, two rates of Quillaja (2.5 and 4 gpa), and Fulvic Acid treatments with four replicates per treatment. Treatments have been applied in the spring of 2004, 2005, and 2006. Treatments are applied through the drip irrigation system. Treatment effectiveness is being evaluated via soil and root sampling, and trunk circumference measurements. Data is being analyzed using analysis of variance followed by independent contrasts for mean separation.

4. Evaluate performance of bionematicides in a Solano County orchard.

In 2006, three trials were initiated in an 8-acre block of third leaf walnuts at Lester Farms that has a high population of lesion and ring nematode. In the first trial, the large size of the trial area available is allowing for larger size replicates (30 trees/rep) than in our previous trials and products are being applied with the grower's application equipment. The treatments are DiTera at 25 pounds/acre, Quillaja 35% at 6 gpa and an untreated uncontrol. The trial is being conducted in a randomized block design with 5 replicates per treatment.

The second trial is being conducted to test newly available products and consists of ten treatments, conducted in a randomized complete block design with 6 replicates per treatment, each consisting of a single tree. The treatments are an untreated control, two new formulations of DiTera, an additional new product from Valent, three products from Stoller (ST008, ST007, and X-Tra Power), Quillaja alone, Quillaja plus Yucca, and DiTera.

The third trial is being conducted to determine if frequency or time of the year products are applied affects efficacy of control. It consists of 16 treatments including a control, conducted in a randomized complete block design with 6 replicates per treatment, each consisting of a single tree. DiTera at 25 pounds/acre is being applied from 1 to 4 times a year, with applications starting at different times of the year.

RESULTS AND DISCUSSION

1. Optimize sampling strategies and treatment timing for lesion and ring nematode on walnuts in a San Joaquin County Orchard.

In this trial, several treatments show a trend for increased trunk circumference, but this is only statistically significant for Quillaja at 6 gpa and DiTera at 25 lb/a plus Quillaja at 4 gpa ($p \leq 0.05$) (Figure 1). Several treatments have shown reductions in populations of lesion or ring nematode ($p \leq 0.05$) (Table 1).

2. Evaluate performance of Quillaja 35% and DiTera in a Sutter County orchard.

In a vigor rating of trees on October 30, 2006 that was based on the current years growth, both DiTera and Quillaja treated trees appeared more vigorous than the untreated, although the untreated seemed to also have improved since the 2005 vigor rating. Statistically, both DiTera and Quillaja treated trees on Paradox were more vigorous than the untreated ($p \leq 0.05$), as were the DiTera treated trees on own-root ($p = 0.08$) (Figure 2). Yields for Paradox rootstock for both DiTera and Quillaja were greater than the untreated ($p \leq 0.05$) (Figure 3). Although not statistically significant, for both rootstocks, there were trends towards an increase of the difference in yield from 2003 to 2006 (Figure 4), in trunk circumference (Figure 5), and cross-sectional area (Figure 6) for both Quillaja and DiTera. Quality data were obtained for this trial, but were not yet available for presentation in this report. In spite of the yield increases and improvements in vigor, over the course of the trial, there have not been significant reductions in nematode populations. Overall, there is a trend for numbers of lesion nematode to be decreasing,

and for ring nematode to be increasing in the orchard (Table 2). In one case for lesion nematode, and in several instances for ring nematode, population increases have been observed ($p \leq 0.05$).

This could be an indication of the development of a more vigorous root system capable of supporting more nematodes.

3. Evaluate performance of Quillaja 35%, DiTera, and Fulvic Acid in a San Joaquin County orchard.

In this trial, Quillaja at 2.5 gpa has a significantly increased tree circumference compared to the check ($p \leq 0.05$) (Figure 7). All treatments have reduced lesion and ring nematode populations on at least one sample date ($p \leq 0.05$) (Table 3).

4. Evaluate performance of bionematicides in a Solano County orchard.

For all three trials, baseline nematode and circumference data have been obtained and the first set of treatments had been applied.

LITERATURE CITED

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ACKNOWLEDGEMENTS

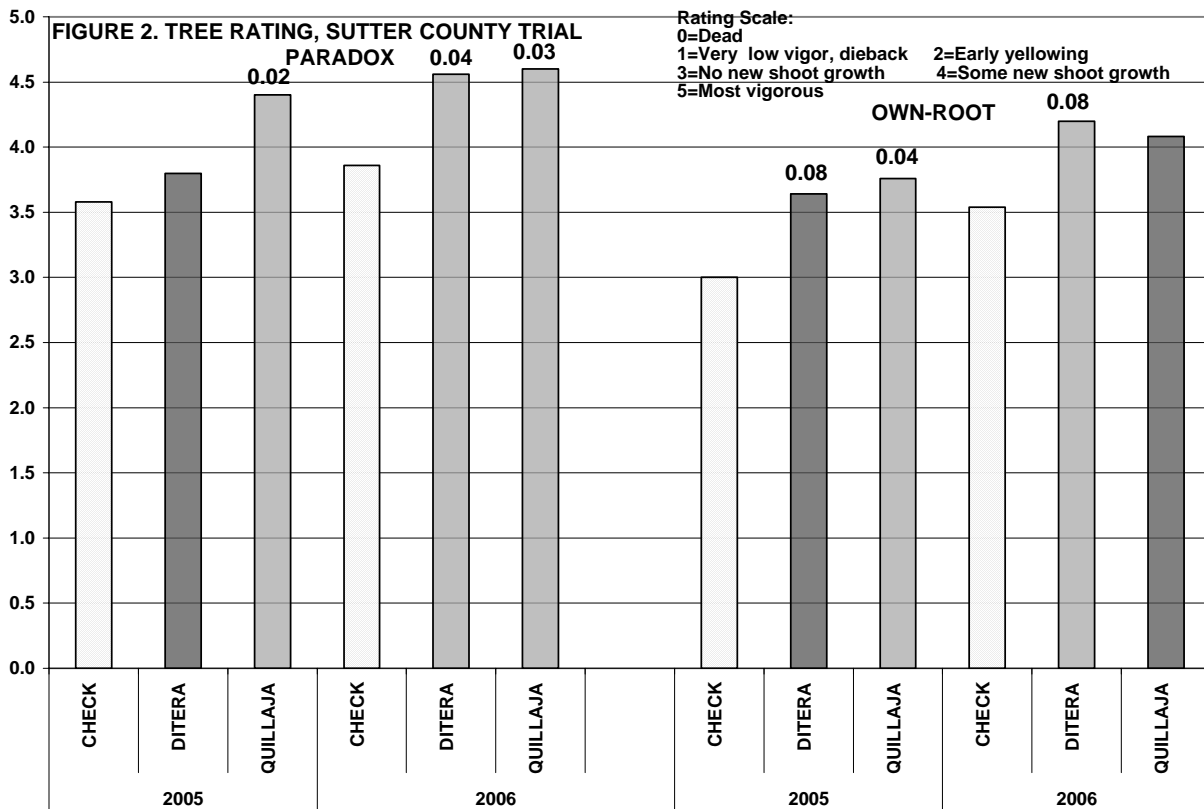
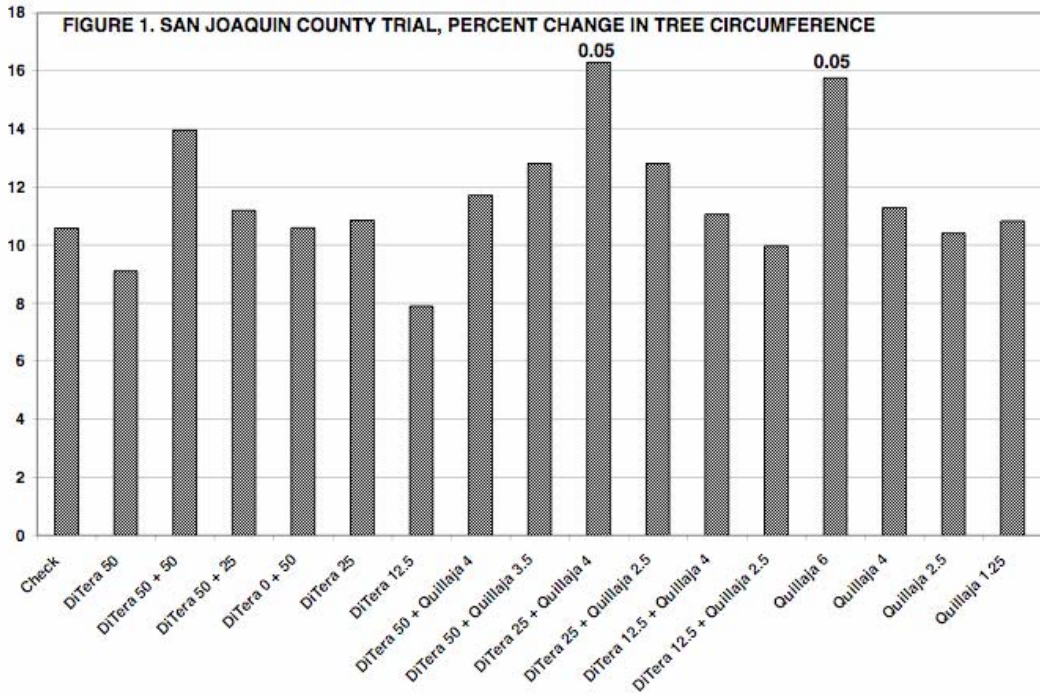
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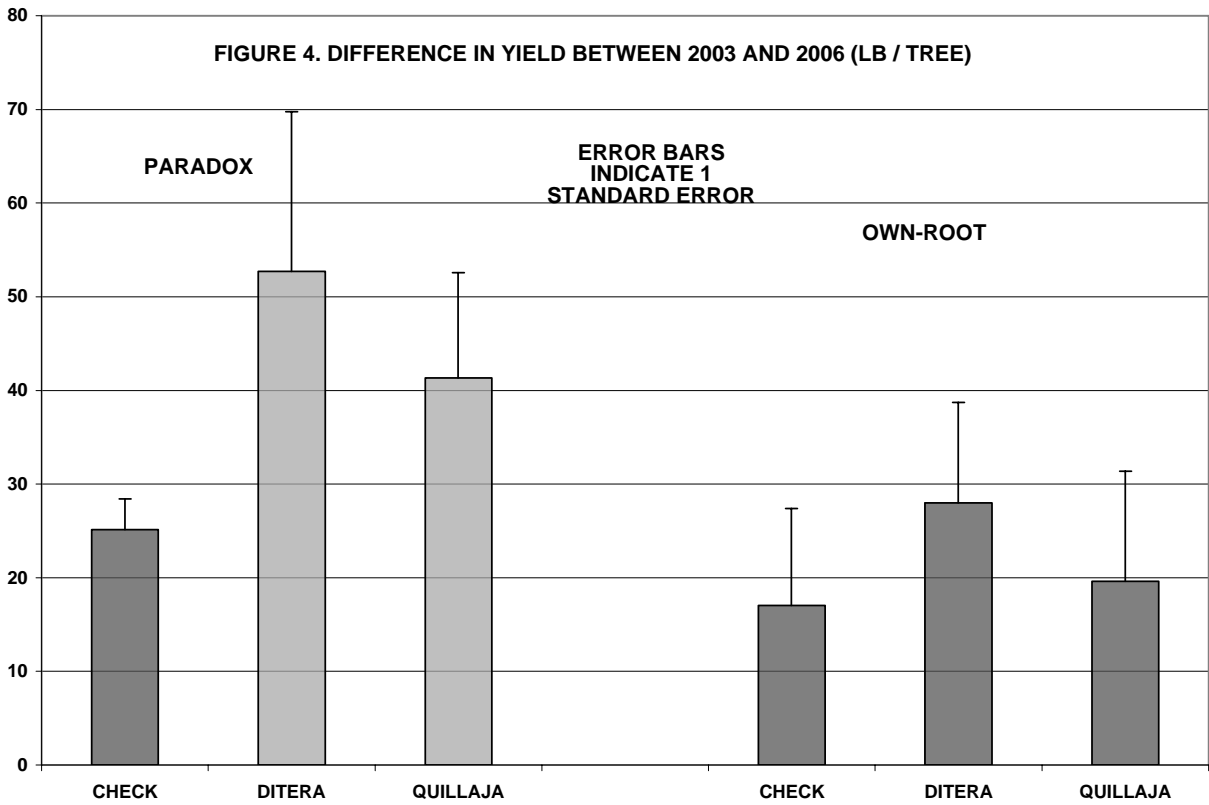
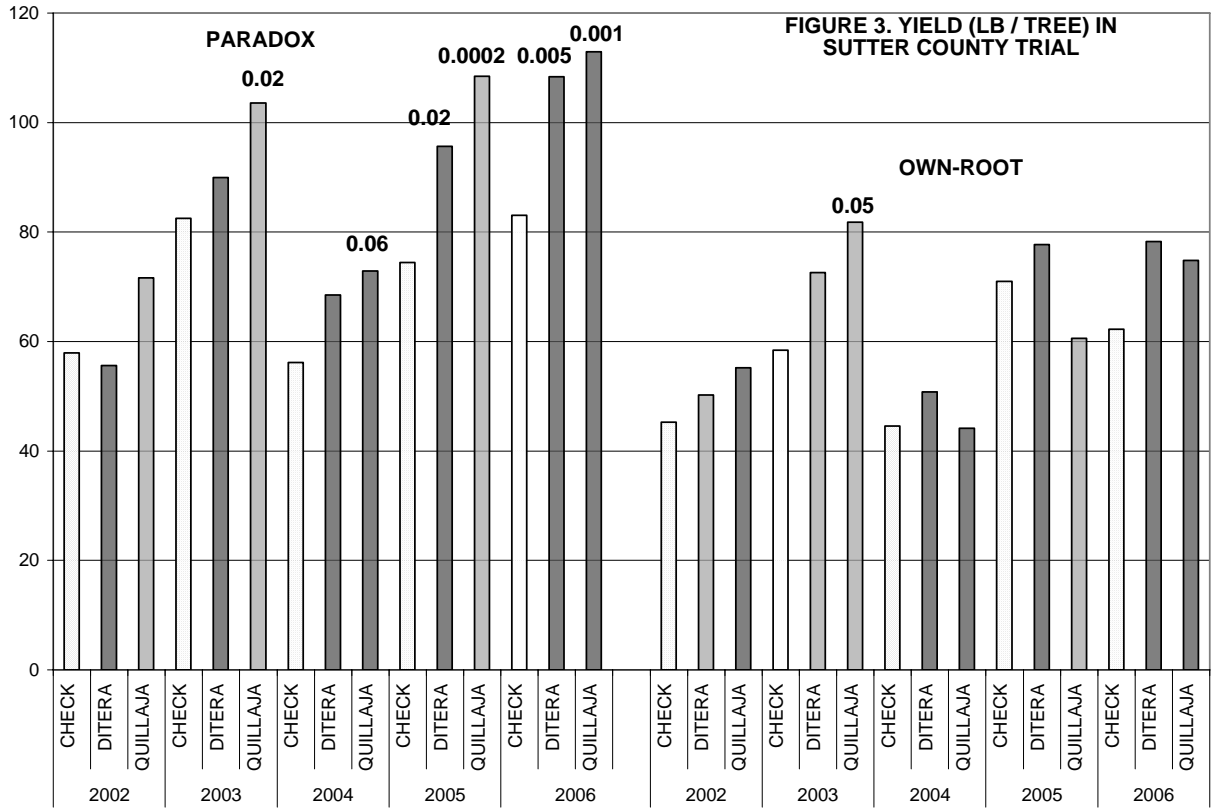
Table 1. Effects on nematodes in San Joaquin County trial.

Treatment	Sample Date	Nematodes / liter of soil						Nematodes / gram of root		
		Lesion Nematode			Ring Nematode			Lesion		
		Mean	Std. Error	Different than Check	Mean	Std. Error	Different than Check	Mean	Std. Error	Different than Check
Check	April 2005	2,783	1,078		975	975		8.0	6.5	
DiTera 50		2,192	807		0	0		18.8	12.7	
DiTera 50 + 50		1,542	466		183	183		1.6	1.1	
DiTera 50 + 25		5,667	1,724		1,150	1,007		2.8	1.7	
DiTera 0 + 50		6,708	2,450		1,133	795		141.8	137.7	0.10
DiTera 25		4,825	1,127		1,500	1,381		120.9	85.8	
DiTera 12.5		4,458	2,017		83	83		203.3	176.0	0.02
DiTera 50 + Quillaja 4		4,233	1,667		583	544		11.4	6.9	
DiTera 50 + Quillaja 2.5		3,708	1,580		3,283	2,863		18.0	14.7	
DiTera 25 + Quillaja 4		8,733	2,489		83	74		7.8	5.6	
DiTera 25 + Quillaja 2.5		3,492	1,031		900	900		44.6	39.1	
DiTera 12.5 + Quillaja 4		5,625	1,108		575	575		35.9	29.3	
DiTera 12.5 + Quillaja 2.5		8,405	6,334		63	41		0.5	0.5	
Quillaja 6		4,667	2,003		0	0		45.0	37.6	
Quillaja 4		2,817	703		150	150		129.6	126.1	0.05
Quillaja 2.5		3,875	1,586		750	750		164.8	133.2	0.07
Quillaja 1.25		2,517	478		2,900	1,448		11.2	10.1	
Check	October 2005	4,208	1,820		317	154		9.5	7.5	
DiTera 50		4,783	2,399		208	104		80.3	56.6	
DiTera 50 + 50		5,467	2,071		50	50	0.06	12.5	6.8	
DiTera 50 + 25		4,850	874		1,000	785		25.4	23.0	
DiTera 0 + 50		4,167	345		7,300	5,394		9.0	5.2	
DiTera 25		8,075	4,104		950	636		18.1	5.6	
DiTera 12.5		4,883	1,299		1,117	878		108.6	47.2	
DiTera 50 + Quillaja 4		7,417	1,912		450	450	0.09	12.0	6.4	
DiTera 50 + Quillaja 2.5		6,625	1,388		2,500	1,611		14.9	12.0	
DiTera 25 + Quillaja 4		4,583	1,358		300	205		80.8	42.8	
DiTera 25 + Quillaja 2.5		5,325	3,349		1,650	1,477		3.5	2.4	
DiTera 12.5 + Quillaja 4		8,050	2,605		1,183	1,086		74.4	66.9	
DiTera 12.5 + Quillaja 2.5		2,333	1,311	0.0005	0	0	0.01	21.9	19.7	
Quillaja 6		4,850	1,369		0	0	0.01	94.0	71.5	
Quillaja 4		6,600	2,440		800	637		12.6	6.6	
Quillaja 2.5		5,433	2,182		4,883	4,060		24.9	19.3	
Quillaja 1.25		3,175	407		950	612		229.0	218.3	0.01
Check	June 2006	2,950	1,550		1,575	1,055		0.2	0.2	
DiTera 50		1,683	741		150	150	0.02	3.9	3.5	
DiTera 50 + 50		2,700	1,155		325	296	0.09	11.1	11.1	
DiTera 50 + 25		3,275	473		575	465		4.5	2.3	
DiTera 0 + 50		2,375	1,288		2,150	1,920		1.6	1.6	
DiTera 25		6,075	3,191		525	244		4.4	4.4	
DiTera 12.5		3,875	1,516		900	506		4.2	1.5	
DiTera 50 + Quillaja 4		1,967	813		2,000	1,361		5.2	3.8	
DiTera 50 + Quillaja 2.5		2,350	677		350	350	0.03	2.2	1.6	
DiTera 25 + Quillaja 4		1,525	527	0.06	0	0	0.003	1.2	0.8	
DiTera 25 + Quillaja 2.5		1,575	636	0.05	1,600	1,323		0.3	0.3	
DiTera 12.5 + Quillaja 4		2,200	379		825	686		0.5	0.4	
DiTera 12.5 + Quillaja 2.5		3,150	1,273		0	0	0.003	1.7	1.4	
Quillaja 6		4,475	1,541		200	200	0.003	12.6	7.8	
Quillaja 4		2,650	1,009		1,275	784		15.7	10.2	
Quillaja 2.5		1,633	707		475	475	0.03	5.3	3.1	
Quillaja 1.25		1,583	509		1,575	1,323		1.4	1.0	

Each figure is the mean of 6 replicates.

Figures listed under Different than Check indicate the probability of that Treatment being different from the Check on the same sampling date.





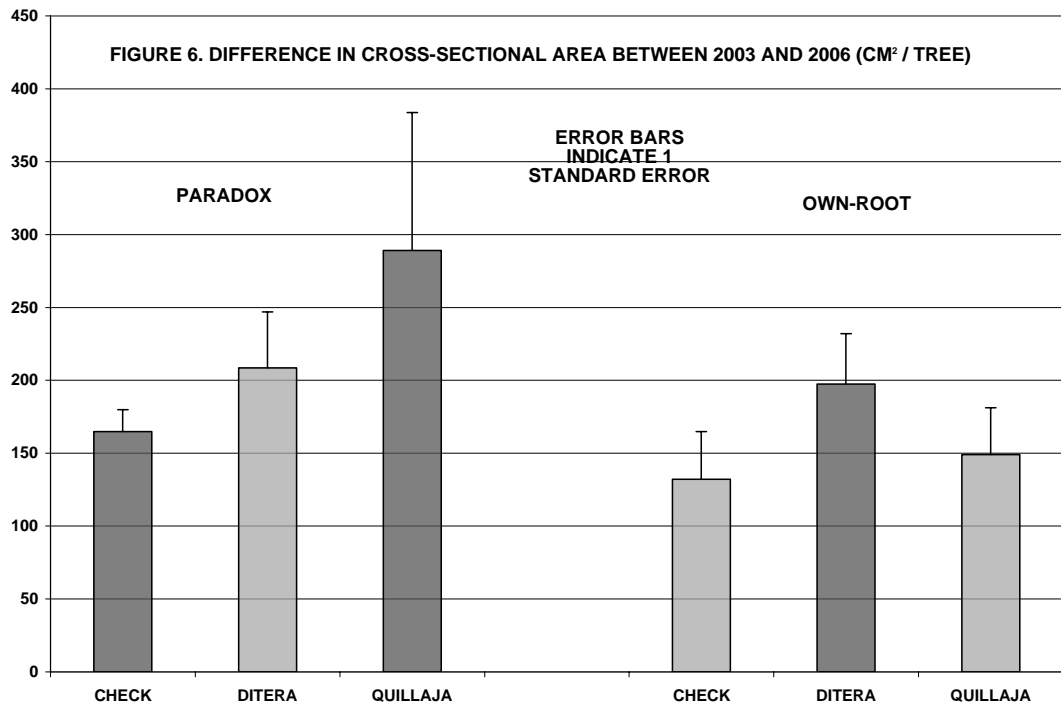
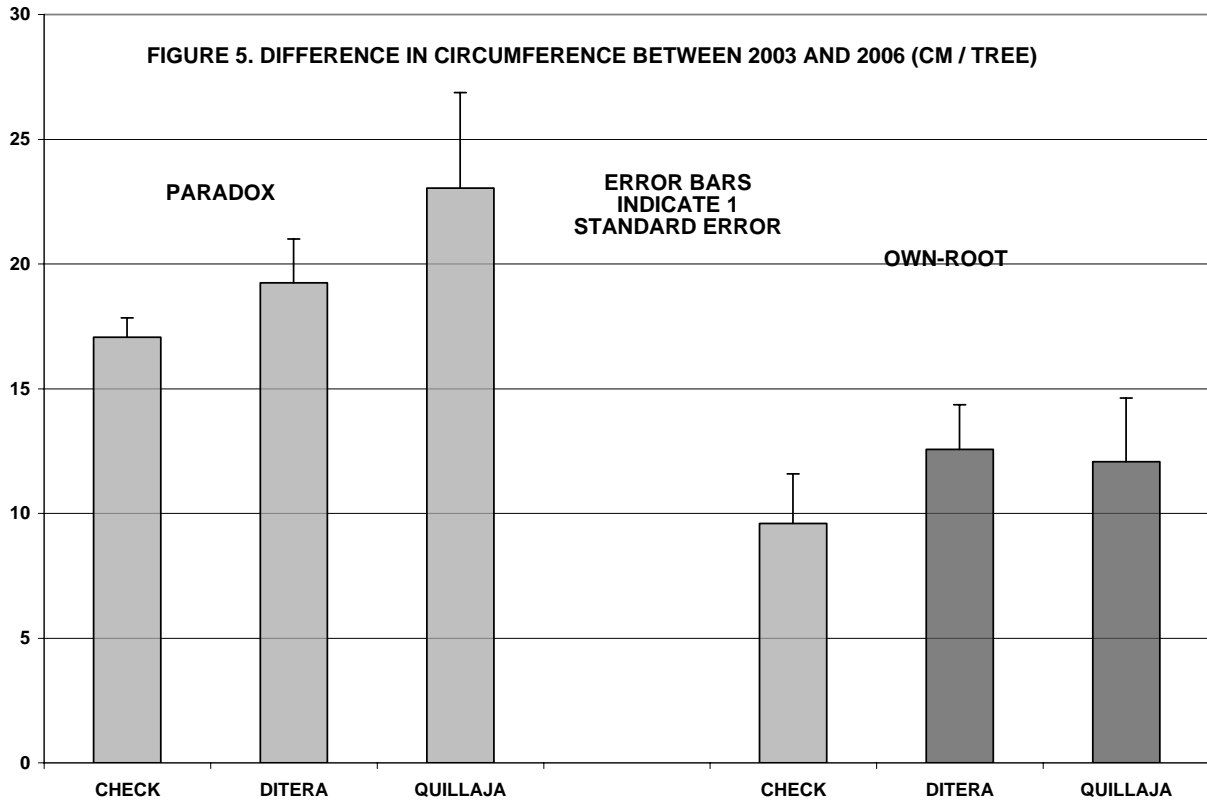


Table 2. Effects on nematodes in Sutter County Trial.

Treatment	Sample Date	Paradox					Own-rooted					
		Lesion Nematode		Ring Nematode		Different than Check	Lesion Nematode		Different than Check	Ring Nematode		Different than Check
		Mean	Std. Error	Mean	Std. Error		Mean	Std. Error		Mean	Std. Error	
Check	October 2003	3,030	1,288	0	0		4,380	638	10	10		
DiTera		3,200	964	0	0		5,740	1,736	100	100		
Quillaja		3,820	481	0	0		4,410	1,433	0	0		
Check	April 2004	1,440	860	40	29		2,560	1,194	110	56		
DiTera		1,330	571	540	540		2,020	608	3,270	2,803	0.004	
Quillaja		1,320	451	300	300		1,870	818	0	0		
Check	October 2004	1,130	435	20	20		1,230	293	450	414		
DiTera		2,250	990	30	30		2,470	404	3,830	3,109	0.002	
Quillaja		1,210	378	420	246		1,580	519	0	0		
Check	April 2005	870	833	40	24		610	220	300	300		
DiTera		1,410	621	0	0		580	237	2,480	2,285	0.04	
Quillaja		2,290	1,079	260	260		1,350	539	10	10		
Check	October 2005	1,470	513	10	10		1,890	529	1,380	926		
DiTera		2,060	157	30	30		2,580	1,011	2,340	1,318		
Quillaja		2,850	810	540	271		4,970	2,159	0.006	30	30	
Check	April 2006	1,380	576	1,610	937		1,640	769	590	428		
DiTera		2,650	621	980	719		1,300	390	2,560	1,623	0.07	
Quillaja		1,310	263	2,020	870		1,680	566	830	756		
Check	October 2006	470	197	280	150		740	183	470	338		
DiTera		320	97	1,340	829	0.05	960	175	290	144		
Quillaja		620	238	1,030	515		2,080	527	660	381		

Each figure is the mean of 5 replicates.

Figures listed under Different than Check indicate the probability of that Treatment being different from the Check on the same sampling date.

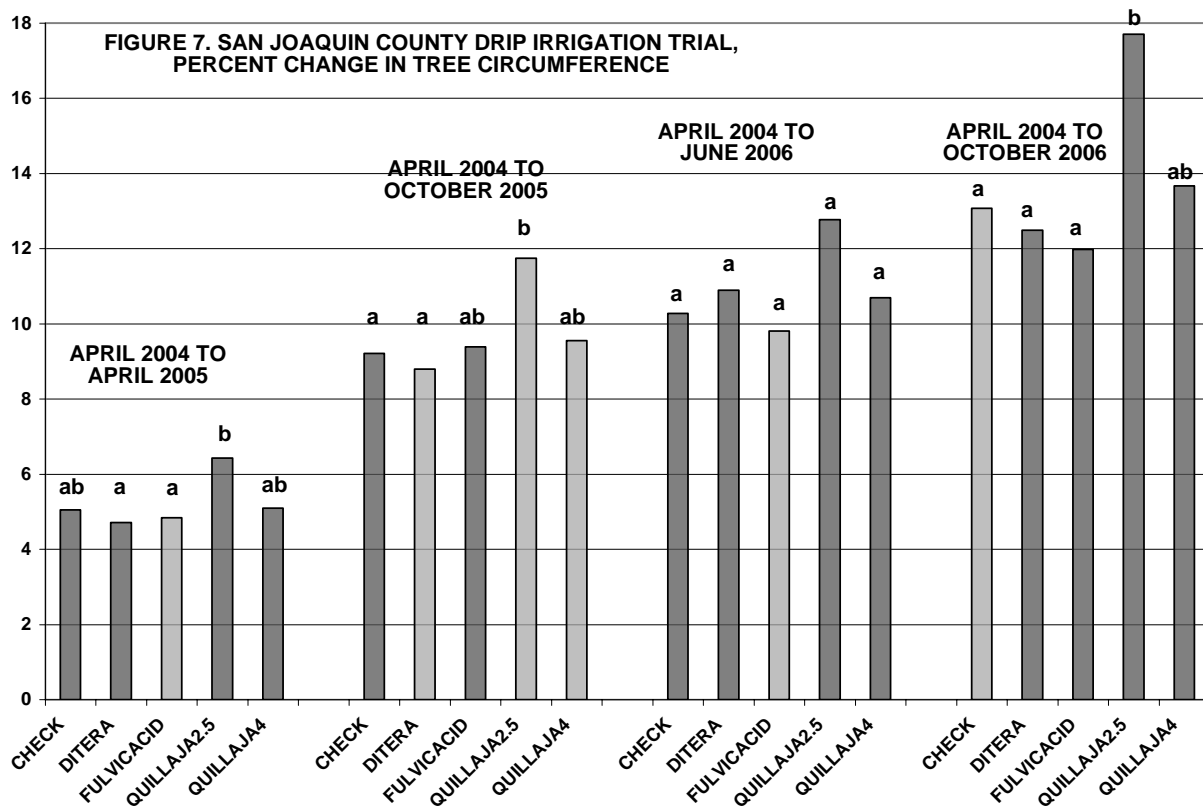


Table 3. Effects on nematode populations in San Joaquin County drip Irrigation trial.

Treatment	Sample Date	Nematodes / liter of soil								
		Lesion Nematode		Ring Nematode		Pin Nematode				
		Std. Error	Different than Check	Std. Error	Different than Check	Std. Error	Different than Check	Std. Error	Different than Check	
Check	April 2004	3,525	444	1,088	480			0	0	
DiTera		1,625	566	638	638			338	338	
Fulvic Acid		5,400	3,123	1,575	589			1,425	1,425	
Quillaja 2.5		2,863	1,657	63	38			525	525	
Quillaja 4		4,613	2,087	825	375			750	750	
Check	October 2004	4,538	1,386	5,963	2,479			0	0	
DiTera		3,513	2,374	300	300	0.0001		188	188	
Fulvic Acid		3,738	1,939	4,013	2,258			150	150	
Quillaja 2.5		3,725	1,860	250	218	0.0001		38	38	
Quillaja 4		2,213	585	1,950	914	0.005		563	359	
Check	April 2005	4,813	1,306	4,163	1,593			0	0	
DiTera		4,213	2,533	1,850	907	0.1		0	0	
Fulvic Acid		1,563	719	625	338	0.01		1,125	1,125	
Quillaja 2.5		3,450	1,458	1,575	756	0.07		525	525	
Quillaja 4		1,938	671	1,788	719	0.09		1,388	895	
Check	October 2005	9,325	6,235	825	309			0	0	
DiTera		4,725	2,386	0.1	3,175	1,565	0.09	825	825	
Fulvic Acid		2,325	1,158	0.02	6,900	2,197	0.0001	3,000	3,000	0.01
Quillaja 2.5		4,988	2,518	0.1	3,113	1,366		3,750	3,651	0.002
Quillaja 4		2,813	1,696	0.02	2,963	338		1,650	581	
Check	June 2006	4,675	595	1,113	572			0	0	
DiTera		2,900	788	488	215			1,163	677	
Fulvic Acid		7,225	4,353	1,238	901			588	555	
Quillaja 2.5		6,113	2,246	925	561			425	425	
Quillaja 4		6,513	4,754	850	87			150	150	
Check	October 2006	2,350	826	588	455			25	25	
DiTera		2,325	959	1,463	849			1,913	1,310	
Fulvic Acid		613	339	513	171			1,013	1,013	
Quillaja 2.5		1,763	283	1,313	439			1,538	854	
Quillaja 4		4,575	1,005	375	144			1,275	998	

Each figure is the mean of 4 replicates.

Figures listed under Different than Check indicate the probability of that Treatment being different from the Check on the same sampling date.