

Project: Evaluation of ABG-9008 for Control of Nematode Damage to Golf Course Greens

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Summary: A study was conducted on annual bluegrass golf course greens in three locations to evaluate the efficacy of two different formulations of ABG-9008 applied at two different rates for control of the damage caused by parasitic nematodes on turf. A significant ($P < 0.10$) decrease in *Crictonemella* populations was observed in one location, on one sampling date, but no other consistent trends towards improved turfgrass quality or reduction of parasitic nematode populations (including the ring nematode, *Crictonemella*, the spiral nematode, *Helicotylenchus*, the root-knot nematode, *Meloidogyne*, and the stunt nematode, *Tylenchorhynchus*) were seen. Inexplicable, but significant ($P < 0.10$) increases in the numbers of *Helicotylenchus* and *Meloidogyne* were observed at one location each following treatment with ABG-9008. Further lab and/or greenhouse studies may be required to understand the basis of these somewhat inconsistent results.

Materials and Methods:

Location and Design: Research plots were located on greens that were primarily *Poa annua* (annual bluegrass), but contained some bentgrass, at the three golf courses, listed below. Plots measured 5 X 10 feet, and treatments were replicated three times in a randomized design (Appendix). Locations were selected to target previously documented high nematode populations, as well as problem greens that have been poor performers in the past, on the assumption that nematode populations might be partly responsible for this poor performance.

1. San Diego Country Club, Chula Vista, CA
2. Arrowhead Country Club, San Bernardino, CA
3. Southern California Golf Association Member's Club at Rancho California, Murietta, CA

Application: Experimental treatments of the wettable powder were applied with a CO₂

backpack sprayer with 8004 VS flat fan nozzles, at 30 psi and delivering 5.3 gallons of water per 1000 square feet. Calibration of each nozzle was confirmed prior to each application to be within 5% of the desired nozzle flow rate. The boom height was adjusted to 17 inches. The spray swath was 5 ft. Sprayer speed was 3 mph. The granular formulation was applied using shaker bottles made from 500 cc Nalgene bottles, with five 7/64" holes drilled in the cap. The material was applied to plots by shaking the material in an even pattern over the entire surface of the plot. Following all treatments, approximately 1/8" water was applied through the irrigation system.

Ratings and Data Analysis: Immediately prior to treatment, five to seven weeks after treatment, and twelve to fourteen weeks after treatment, plots were sampled to determine the number and types of plant parasitic nematodes present. This was accomplished by collecting ten 1" cores, 2 inches deep, from each replicate. The samples were shipped overnight to Dr. Michael McClure, University of Arizona, for identification and quantification. The samples were extracted by placing 200cc of sod/soil on 6 inch funnels, each with an extraction area of approximately 20 square inches. the funnels were incubated under an intermittent mist of distilled water (tank temperatures, 60°C for 50 hours and the eluate concentrated to 10cc by back-washing from 500 mesh (24 micron pore size) sieve. One cc of the concentrate was examined at 50X magnification. The number of specimens of each plant pathogenic nematode species was counted and the numbers of nematodes per 200cc of sod/soil was calculated by multiplying the counts by 10. In addition, assessment of turf quality was determined on a scale of 1 - 9 (with 9 the highest possible rating), four times during the trial. The trial ran for a total of 12 to 14 weeks, depending on location (see treatment and evaluation schedule, below).

Nematode counts and turf quality data were subjected to analysis of variance, and treatment means were separated using Fisher's LSD,

where $P < 0.10$. Due to high variability in nematode counts within treatments (see Figures 1, 3, and 5 and Tables 1, 4 and 7), data was transformed by adding one to each value (for the purpose of removing zeroes from the analysis), and then calculating the $\log_{10}$ of each value. We also compared pre-treatment and post treatment nematode counts from each treatment replicate as described below:

$$\text{Change in nematode populations} = \text{post treatment count} - \text{pre-treatment count}$$

Using this type of analysis, a negative number would indicate a decrease in nematode populations, and therefore some measure of control from the treatment. A positive number would indicate lack of control of nematode populations. This data is illustrated in Figures 2, 4 and 6. Raw data and statistical analyses are included in the Appendix.

Treatments:

	PRODUCT	RATE (AI/A)	RATE (FORM/1,000 SQ FT)	TIMING AND FREQUENCY
1.	ABG-9008 WP	45 lb	16.5 oz	single application, 8/96
2.	ABG-9008 WP	90 lb	33 oz	single application, 8/96
3.	ABG-9008 95G	90 lb	34.8 oz	single application, 8/96
4.	No treatment			

Treatment and Evaluation Schedule:

Date	Event
8/6/96	Pre-treatment assessment/nematode samples pulled and application made at Arrowhead CC and SCGA
8/21, 9/5, 9/24, 11/18	Turf quality assessment made at Arrowhead CC and SCGA
9/24, 11/18	Post-treatment nematode samples pulled at Arrowhead CC and SCGA
8/26/96	Pre-treatment assessment/nematode samples pulled and application made at San Diego CC
9/5, 9/16, 10/1, 11/18	Turf quality assessment made at San Diego CC
10/1, 11/18	Post-treatment nematode samples pulled at San Diego CC

Results: A summary of the data appears below in Tables 1-9 and Figures 1-6. Four different nematodes species were detected at the three experimental sites: the ring nematode, *Criconemella*, the spiral nematode, *Helicotylenchus*, the root-knot nematode, *Meloidogyne*, and the stunt nematode, *Tylenchorhynchus*, although not all species were represented at all locations. Overall, nematode populations appeared to increase during the initial six week time period during which the trial was conducted. This is probably due to the fact that as soil temperatures cooled during the course of the trial, turf became healthier, with an increased root mass, and was therefore able to support higher populations of nematodes. During the last 6 -7 weeks of the trial, nematode

populations fluctuated more variably, with no obvious trends observed.

San Diego Country Club (Figures 1-2 and Tables 1-3): All four nematode species listed above were observed at San Diego Country Club, although *Meloidogyne* and *Helicotylenchus* were the most numerous. Key findings include:

- *Criconemella* populations showed a dramatic drop five weeks after treatment in plots treated with 90 lb ai/A of ABG-9008 (Figure 1-2, Table 2). Unfortunately, this decrease was probably not the result of increased levels of control (as indicated by no significant differences among treatments on 10/1/96), but instead was the result of *Criconemella* densities at the pre-treatment

rating that were significantly ($P < 0.10$) higher than those of the non-treated check (Table 1).

- *Helicotylenchus* populations in plots treated with 90 lb ai/A of ABG-9008 were significantly higher ($P < 0.10$) than those in the non-treated check on 11/18/96. The reason for this increase is not clear.
- Turfgrass quality was variable, but apparently not treatment related (Table 3). Overall decreased quality on 9/16/96 and 10/1/96 was due to an infestation with the turfgrass pathogen anthracnose (*Colletotrichum graminicola*), and to high soil salinity, respectively, and was unrelated to the effects of nematode populations.

Arrowhead Country Club (Figures 3-4, Tables 4-6) Two of the nematode species listed above -- *Criconebella* and *Helicotylenchus* -- were observed at Arrowhead Country Club, with *Criconebella* clearly with the highest densities. On 11/18/96, treatment 1 (45 lb ai/A ABG-9008) had significantly fewer *Criconebella* ($P < 0.10$) than the non-treated check (Table 4, Figure 3). However, treatment 1 did not produce similar results on *Helicotylenchus* at the same location, nor did it result in improved turfgrass quality. In addition, treatment 1 did not produce improved results at San Diego Country Club, where *Criconebella* was also detected. It is possible that the lowered *Criconebella* counts are an artifact of their initially lower densities before treatment. Other key findings include:

Turf quality was very good for the duration of the trial for all treatments (Table 6). The presence of high quality turf, even in the non-treated checks, indicates that nematode populations were not causing significant damage at this location.

Southern California Golf Association Member's Club (Figures 5-6, Tables 7-9). The only species present at this location was *Meloidogyne*. The only significant differences ($P < 0.01$) observed indicated that ABG-9008 at either the 45 lb ai/A or 90 lb ai/A rate caused an increase in *Meloidogyne* populations. The reasons for this apparent increase are not known, and are not clear especially since the granular formulation (95 lb ai/A) did not produce the same increase. Other key findings include:

- Turfgrass quality declined during the course of the trial, but was apparently not treatment related (Table 9). Overall decreased quality was probably due to poor drainage and high soil salinity.

There is a strong need for new, and lowered toxicity nematicidal products for use in turf. Few products are currently registered for control of these plant pests on turf, and those that are registered, such as NemaCur, are highly toxic to mammals. Alternative tools, and especially those that are safer to use, would be of significant interest to golf course superintendents. The results observed in this study indicate that ABG-9008 performed inconsistently, with significant increases in nematode populations observed more frequently than decreases. Before continuing with further field work in turf, the toxicity of ABG-9008 for the four nematode species above should be confirmed in laboratory tests. The possibility that either higher or lower product rates would be more efficacious should also be explored.

San Diego Country Club Results

Figure 1. Nematode counts per 200 cc, 0, 5 and 12 weeks after treatment with ABG-9008. San Diego Country Club, Green 18, Chula Vista, CA.

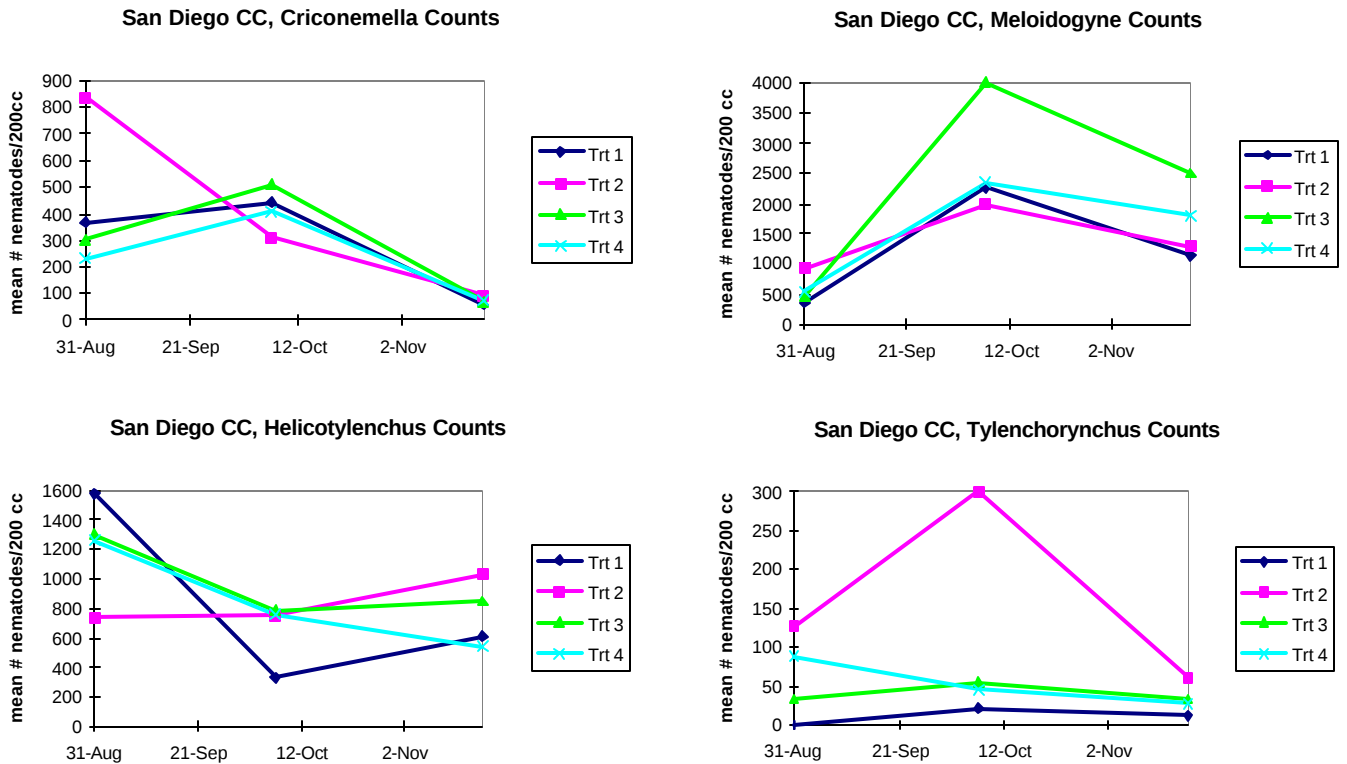
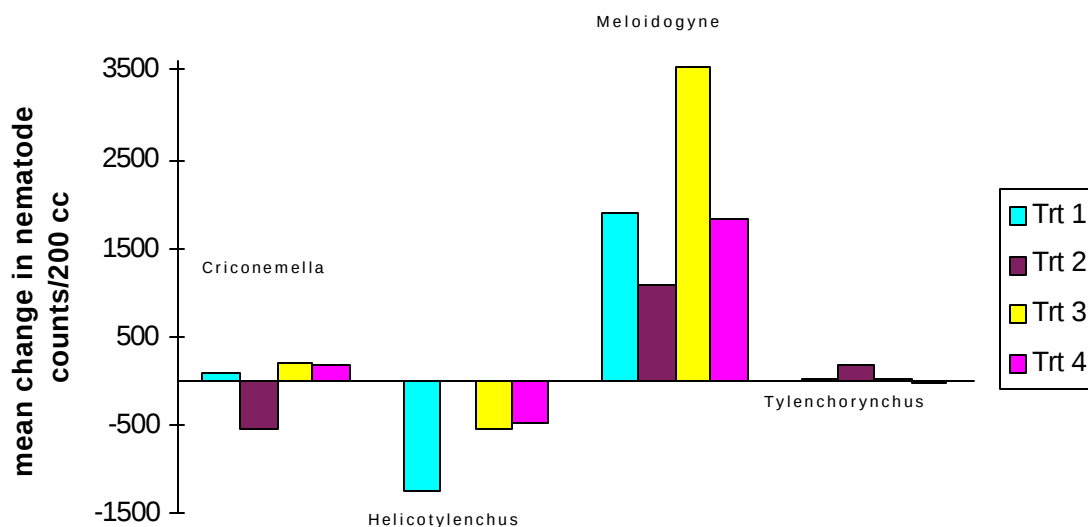


Table 1. Nematode counts/200 cc, 0, 5 and 12 weeks after treatment with ABG-9008, San Diego Country Club, Chula Vista, CA. Numbers followed by the same letter are not significantly different (Fisher's LSD, $P < 0.10$). Statistical analysis was performed on data transformed to log₁₀ values. However, values in table are non-transformed.

		<i>Criconemella</i>			<i>Helicotylenchus</i>		
		0 WAT	5 WAT	12 WAT	0 WAT	5 WAT	12 WAT
Trt #		8/26/96	10/1	11/18	8/26	10/1	11/18
1	45 lb ai/A (WP)	366.7a	440.0a	53.3a	1573.3a	326.7a	606.7a
2	90 lb ai/A (WP)	840.0b	313.3a	93.3a	743.3a	746.7ab	1026.7b
3	95 lb ai/A (95G)	306.7a	506.7a	66.7a	1306.7a	780.0b	846.7ab
4	Non-treated	226.7a	406.7a	73.3a	1253.3a	766.7ab	540.0a
		<i>Meloidogyne</i>			<i>Tylenchorynchus</i>		
		0 WAT	5 WAT	12 WAT	0 WAT	5 WAT	12 WAT
Trt #		8/26/96	10/1	11/18	8/26	10/1	11/18
1	45 lb ai/A (WP)	366.7a	2260.0a	1133.3a	0.0a	20.0a	13.3a
2	90 lb ai/A (WP)	926.7a	1993.3a	1286.7a	126.7b	300.0b	60.0a
3	95 lb ai/A (95G)	460.0a	3993.3a	2506.7b	33.3ab	53.3ab	33.3a
4	Non-treated	533.3a	2346.0a	1786.7ab	86.7b	46.7ab	26.7a

Figure 2. Mean change in nematode populations/200 cc over time at 5 and 12 weeks post-treatment with ABG-9008. Change was calculated by subtracting each replicate's pre-treatment nematode counts from the 5 or 12 week post-treatment count. San Diego Country Club, Green 18, Chula Vista, CA.

Change in Nematode Populations vs. Pre-Count, 5 WAT SDCC, 10/1/96



Change in Nematode Populations vs. Pre-Count, 12 WAT SDCC, 11/18/96

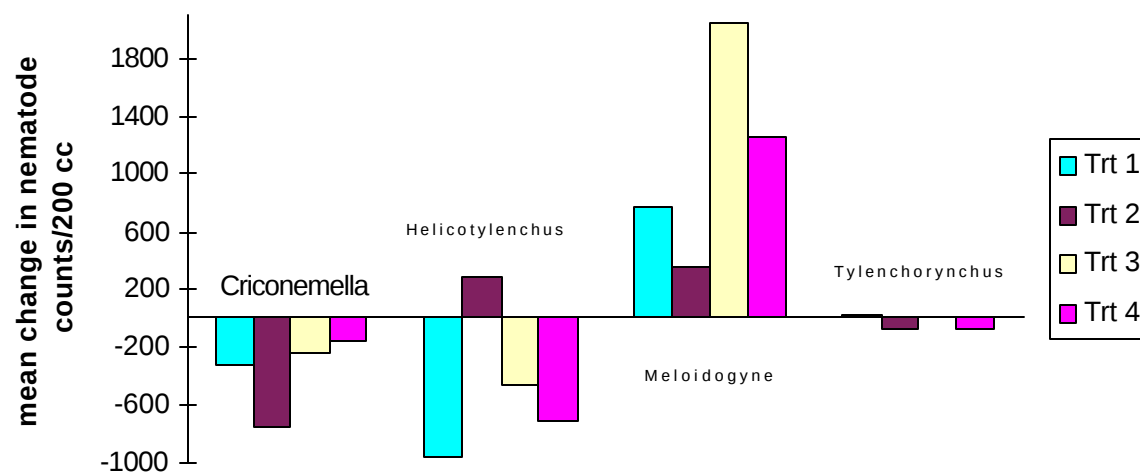


Table 2. Mean change in nematode counts/200 cc, 5 and 12 weeks after treatment with ABG-9008, San Diego Country Club, Chula Vista, CA. Change was calculated by subtracting each replicate's pre-treatment nematode counts from the 5 or 12 week post-treatment count. A positive number indicates an increase in nematode populations, while a negative number indicates a decrease.

		<i>Criconemella</i>		<i>Helicotylenchus</i>		<i>Meloidogyne</i>		<i>Tylencho- rhynchus</i>	
		5WAT	12WAT	5WAT	12WAT	5WAT	12WAT	5WAT	12WAT
Trt #	ABG-9008 rate/A	10/1	11/18	10/1	11/18	10/1	11/18	10/1	11/18
1	45 lb ai/A (WP)	73.3	-313.0	-1246.7	-966.0	1893.3	766.7	20.0	13.3
2	90 lb ai/A (WP)	-526.0	-746.0	3.3	283.0	1066.7	360.0	173.3	-66.7
3	95 lb ai/A (95G)	200.0	-240.0	-526.7	-460.0	3533.3	2046.7	20.0	0.0
4	Non-treated	180.0	-153.0	-486.7	-713.0	1813.3	1253.3	-40.0	-60.0

Table 3. Turfgrass (annual bluegrass/bentgrass mixture) quality ratings, Green 18, San Diego Country Club, Chula Vista, CA. Turf was rated visually on a scale of 1 - 9, with 1 the poorest rating and 9 the best rating. Numbers followed by the same letter are not significantly different (Fisher's LSD, P<0.10).

		9/5/96 2 WAT	9/16/96 4 WAT	10/1/96 6 WAT	11/18/96 12 WAT
Trt #	ABG-9008 rate/A				
1	45 lb ai/A (WP)	8.0 a	6.5 a	4.7 a	8.0 a
2	90 lb ai/A (WP)	8.0 a	6.7 a	5.0 a	8.0 a
3	95 lb ai/A (95G)	8.0 a	7.2 a	5.3 a	8.0 a
4	Non-treated	8.0 a	6.5 a	5.7 a	8.0 a

Arrowhead Country Club Results

Figure 3. Nematode counts per 200 cc, 0, 7 and 14 weeks after treatment with ABG-9008. Arrowhead Country Club, Green 18, San Bernardino, CA.

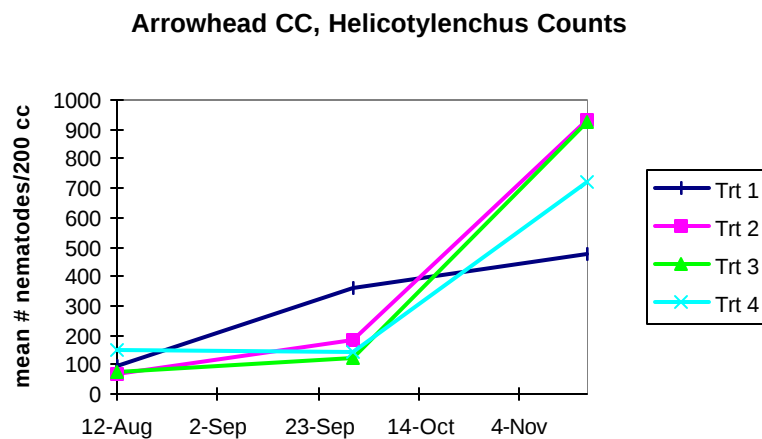
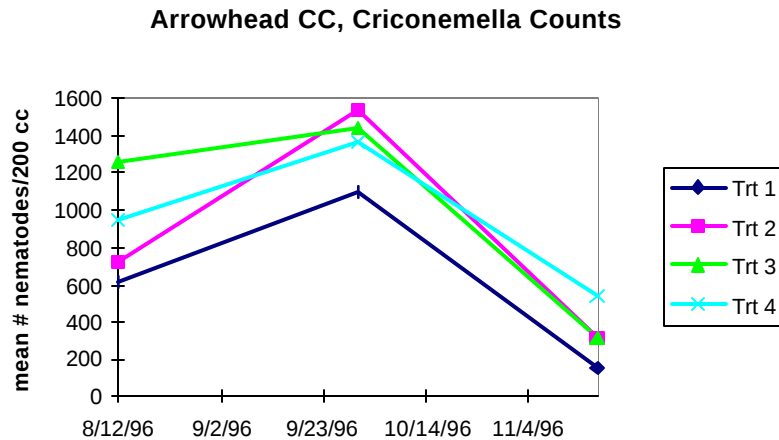
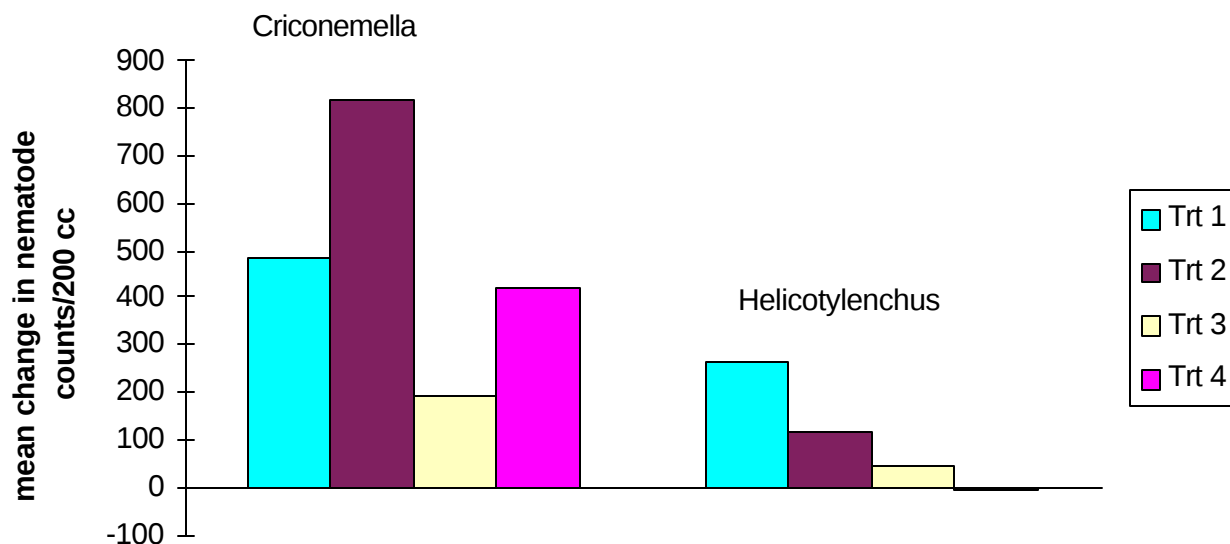


Table 4. Nematode counts/200 cc, 0, 7 and 14 weeks after treatment with ABG-9008, Arrowhead Country Club, San Bernardino, CA. Numbers followed by the same letter are not significantly different (Fisher's LSD, $P < 0.10$). Statistical analysis was performed on data transformed to $\log_{10}$ values. However, values in table are non-transformed.

		<i>Criconemella</i>			<i>Helicotylenchus</i>		
		0 WAT	7 WAT	14 WAT	0 WAT	7 WAT	14 WAT
Trt #		8/6/96	9/24/96	11/18	8/6/96	9/24/96	11/18
1	45 lb ai/A (WP)	620.0a	1106.0a	160.0a	93.3a	360.0b	473.3a
2	90 lb ai/A (WP)	720.0a	1540.0a	313.3ab	66.7a	186.7ab	930.0a
3	95 lb ai/A (95G)	1253.3a	1446.7a	313.3ab	73.3a	120.0a	926.7a
4	Non-treated	946.7a	1366.7a	540.0b	146.7a	140.0ab	720.0a

Figure 4. Mean change in nematode counts/200 cc over time at 7 and 14 weeks after treatment with ABG-9008. Change was calculated by subtracting each replicate's pre-treatment nematode counts from the 7 or 14 week post-treatment count. Arrowhead Country Club, Green 18, San Bernardino, CA.

Change in Nematode Populations vs. Pre-Count, 7 WAT ACC, 9/24/96



Change in Nematode Populations vs. Pre-Count, 14 WAT ACC, 11/18/96

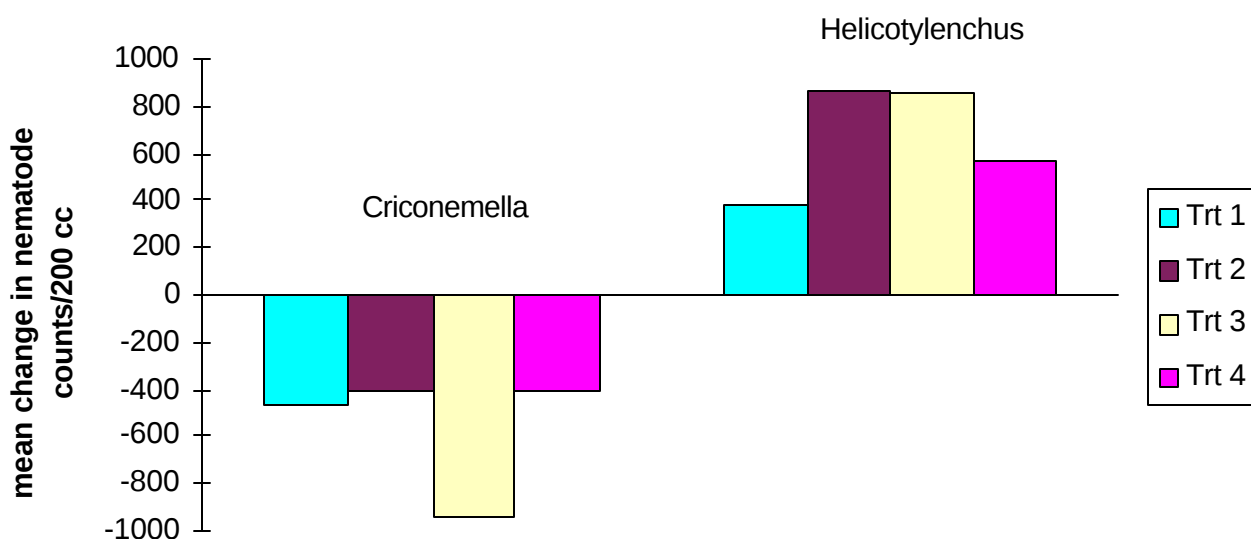


Table 5. Mean change in nematode counts/200 cc, 7 and 14 weeks after treatment with ABG-9008, Arrowhead Country Club, San Bernardino, CA. Change was calculated by subtracting each replicate's pre-treatment nematode counts from the 7 or 14 week post-treatment count. A positive number indicates an increase in nematode populations, while a negative number indicates a decrease.

		<i>Criconemella</i>		<i>Helicotylenchus</i>	
		7 WAT	14 WAT	7 WAT	14 WAT
Trt #	ABG-9008 rate/A	9/24	11/18	9/24	11/18
1	45 lb ai/A (WP)	486.7	-460.0	266.7	380.0
2	90 lb ai/A (WP)	820	-406.7	120	863.3
3	95 lb ai/A (95G)	193.3	-940.0	46.7	853.3
4	Non-treated	420	-406.7	-6.7	573.3

Table 6. Turfgrass (annual bluegrass/bentgrass mixture) quality ratings, Green 18, Arrowhead Country Club, San Bernardino, CA. Turf was rated visually on a scale of 1 - 9, with 1 the poorest rating and 9 the best rating. Numbers followed by the same letter are not significantly different (Fisher's LSD, P<0.10).

		8/21/96 2 WAT	9/5/96 4 WAT	9/24/96 7 WAT	11/18/96 14 WAT
Trt #	ABG-9008 rate/A				
1	45 lb ai/A (WP)	7.0 a	8.0 a	7.5 a	7.5 a
2	90 lb ai/A (WP)	7.0 a	8.0 a	7.5 a	7.5 a
3	95 lb ai/A (95G)	7.0 a	8.0 a	7.5 a	7.5 a
4	Non-treated	6.8 a	8.0 a	7.3 a	7.5 a

Southern California Golf Association Member's Club Results

Figure 5. Nematode counts per 200 cc, 0, 7 and 14 weeks after treatment with ABG-9008. Southern California Golf Association Member's Club, Green 4, Murietta, CA.

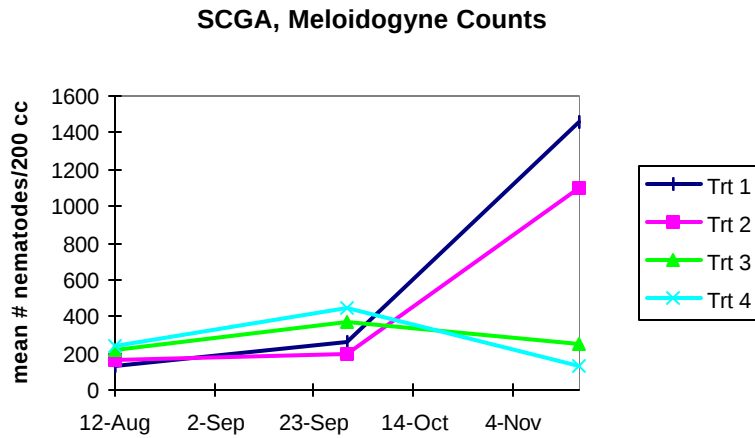


Table 7. Nematode counts/200 cc, 0, 7 and 14 weeks after treatment with ABG-9008, Southern California Golf Association Member's Club, Murietta, CA. Numbers followed by the same letter are not significantly different (Fisher's LSD, $P < 0.10$). Statistical analysis was performed on data transformed to log₁₀ values. However, values in table are non-transformed.

		<i>Meloidogyne</i>		
		0 WAT	7 WAT	14 WAT
Trt #		8/6/96	9/24/96	11/18
1	45 lb ai/A (WP)	126.7a	260.0a	1460.0b
2	90 lb ai/A (WP)	166.7a	200.0a	1100.0b
3	95 lb ai/A (95G)	220.0a	366.7a	246.7ab
4	Non-treated	240.0a	446.7a	126.7a

Figure 6. Mean change in nematode counts/200 cc, 7 and 14 weeks after treatment with ABG-9008, Southern California Golf Association Member's Club, Murietta, CA. Change was calculated by subtracting each replicate's pre-treatment nematode counts from the 7 or 14 week post-treatment count.

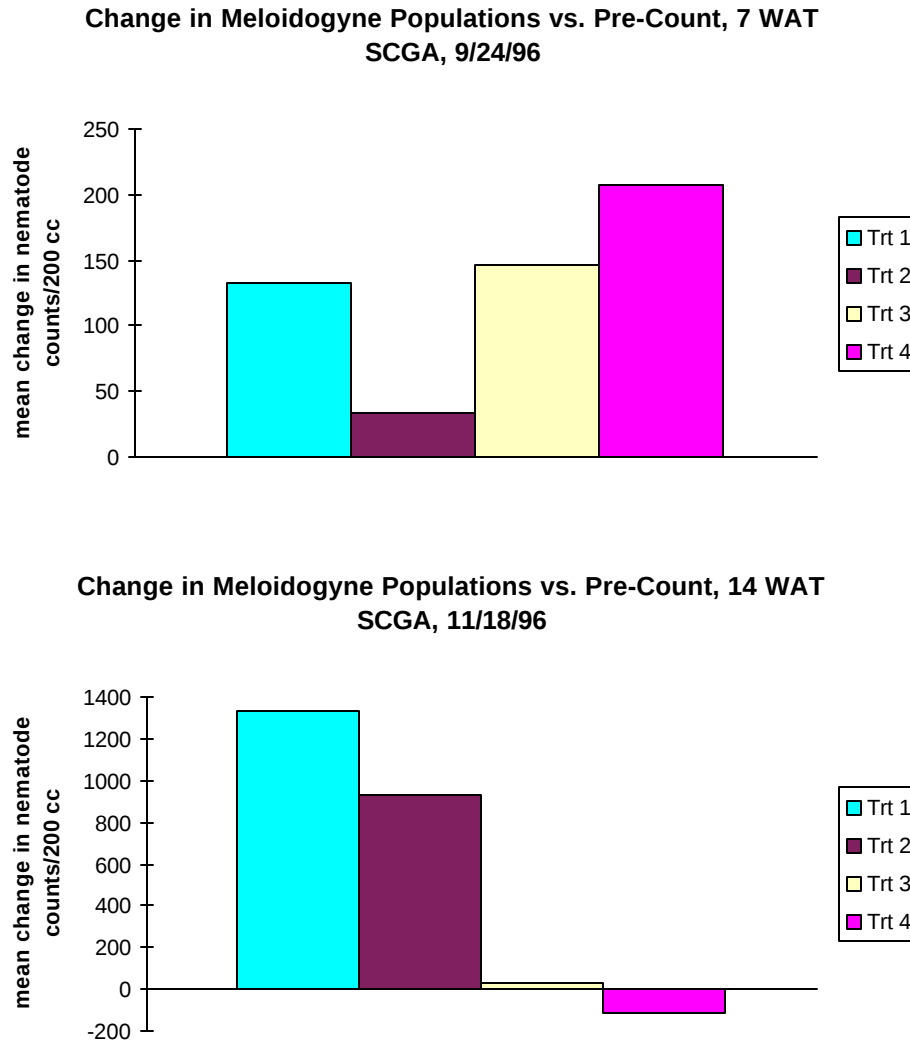


Table 8. Mean change in nematode counts/200 cc, 7 and 14 weeks after treatment with ABG-9008, Southern California Golf Association Member's Club, Murietta, CA. Change was calculated by subtracting each replicate's pre-treatment nematode counts from the 7 or 14 week post-treatment count. A positive number indicates an increase in nematode populations, while a negative number indicates a decrease.

		<i>Meloidogyne</i>	
		7 WAT	14 WAT
Trt #	ABG-9008 rate/A	9/24	11/18
1	45 lb ai/A (WP)	133.3	1333.3
2	90 lb ai/A (WP)	33.33	933.3
3	95 lb ai/A (95G)	146.7	26.7
4	Non-treated	206.7	-113.3

Table 9. Turfgrass (annual bluegrass/bentgrass mixture) quality ratings, Green 4, Southern California Golf Association Member's Club, Murietta, CA. Turf was rated visually on a scale of 1 - 9, with 1 the poorest rating and 9 the best rating. Numbers followed by the same letter are not significantly different (Fisher's LSD, $P < 0.10$).

		8/21/96 2 WAT	9/5/96 4 WAT	9/24/96 7 WAT	11/18/96 14 WAT
Trt #	ABG-9008 rate/A				
1	45 lb ai/A (WP)	6.0 a	6.2 a	4.7 a	5.0 a
2	90 lb ai/A (WP)	5.8 a	5.8 a	4.3 a	5.0 a
3	95 lb ai/A (95G)	5.8 a	5.8 a	4.2 a	5.0 a
4	Non-treated	6.2 a	6.3 a	4.7 a	5.0 a