Effects of Metam-Sodium Applied by Drip Irrigation on Root-Knot Nematodes, *Pythium ultimum*, and *Fusarium* sp. in Soil and on Carrot and Tomato Roots

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ABSTRACT

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Efficacy of metam-sodium in sandy loam and sandy clay loam soils was compared with that of dichloropropene (1,3-D) fumigation for control of *Meloidogyne incognita* and *M. javanica* and *Pythium ultimum* and *Fusarium* sp. on tomato and carrot. Metam-sodium (32.7% a.i.) was injected continuously through drip irrigation lines on tomato and carrot beds before planting at rates of 63–702 L/ha in from 2.5 to 14.2 cm water. Applications treated the central 50–75% of the bed width. Metam-sodium at all rates significantly reduced nematodes in soil before planting, as well as root gall ratings at midseason and harvest, and increased yield in most cases. The 63-L/ha rate was less effective than higher rates. These efficacious metam-sodium responses were similar to those obtained with 1,3-D at rates of 75–144 L/ha. For *P. ultimum* and *Fusarium* sp., metam-sodium at rates of 187–702 L/ha reduced the number of sporangia and propagules per gram of dry soil, respectively, and the number of infections per 50 cm of tomato root. Metam-sodium applied by drip irrigation is an effective preplant alternative treatment to 1,3-D for nematode control in tomato and carrot, with the possible added benefit of reducing certain fungal root pathogens.

Additional key words: fumigation, soil treatment

Several methods of applying metam-sodium to soil to control plant-parasitic nematodes and pathogenic fungi have been evaluated over the last 30 yr with variable results. These methods have included shank and blade injections, physical incorporation, surface incorporation followed by flood or sprinkler irrigations, and continuous injection into sprinkler and center-pivot irrigation systems (3,4,6,8,10,12).

Because the active methyl isothiocyanate liberated from metam-sodium has limited fumigant action and a high affinity for the soil water phase (6,8,11), its effective distribution into the soil profile appears to depend on continuous delivery in water after premixing. The inconsistent efficacy for control of nematodes and pathogens after fumigant-type soil injection with metam-sodium (3) and the improved results with continuous application in irrigation water (6,10) support this contention.

Drip irrigation systems provide an efficient vehicle for controlled delivery of nematicidal and fungicidal chemicals into the soil root zone under trees and planting beds, and some success has been achieved on several crops for pathogen control (13) and for nematode control with nonfumigant nematicides (2,5,15). The objective of this study was to determine efficacy of various metam-sodium treatments applied preplant by drip irrigation to sandy loam and sandy clay loam soils for control of two root-knot nematodes, *Meloidogyne incognita* (Kofoid & White) Chitwood and *M. javanica* (Treub) Chitwood, and the soil fungi *Pythium ultimum* Trow and *Fusarium* sp. on tomato (*Lycopersicon esculentum* Mill.) and carrot (*Daucus carota* L.). Application rates and amounts of applied water were selected according to initial results and to expected water penetration characteristics of the different soils. The carrot experiment was included to assess metam-sodium efficacy for reducing the readily induced cosmetic injury to taproots by root-knot.

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MATERIALS AND METHODS

Drip irrigation application system. Metam-sodium was injected into a drip irrigation system from a nitrogen-pressurized stainless steel refillable cannister. Irrigation water from the main was pumped through a standard 7.6-cm-diameter filter and into a four-branch (each 3.8 cm in diameter) PVC manifold. Each branch was 1.8 m long with an injection port at the main end and a series of internal baffles to enhance mixing. Each branch was split six times and supplied a double or a single drip line per plot. Thus, the system could supply simultaneously up to four treatments of six plots each. The drip line was 1.3-cm (i.d.) plastic tubing with one in-line emitter every 30 cm. Drip lines were surface-placed either along the center of the bed or 33 cm apart in parallel along the bed (double line).

Fumigant nematicide 1,3-D was applied as a bed treatment in all experiments 30 cm deep through three shanks per bed spaced 30 cm apart.

Nematode assays. Nematode second-stage juveniles (J2) and egg densities in soil before treatment, after treatment (at planting), and at harvest were estimated from two samples per plot, each sample a composite of 12 cores (2.5 × 40 cm deep) taken from the treated areas of the beds. Nematode J2 and eggs were extracted from 250 cm^3 of soil by sieving through a 250-μm-pore sieve and two 45-μm-pore sieves; screenings from the latter sieves were extracted for 3 days in a modified Baermann funnel-mist chamber. Egg masses retained on the 250-μm-pore sieve were processed in 16% (v/v) sodium hypochlorite (6.25% w/w NaOCl in an alkaline solution) (7) to estimate numbers of eggs. Eggs and J2 in roots at harvest were estimated by macerating one 10-g subsample of fresh roots cut in 1-cm lengths from a composite of 15 root systems per plot. Fifteen tomato root systems per plot were indexed for galling at harvest on a scale of 0 = no galls, 1 = 1–25%, 2 = 26–50%, 3 = 51–75%, and 4 = 76–100% of root system galled. In the carrot experiment, total number of galls on 60 root systems per plot were counted 48 days after planting.

Fungus assays. Estimates of soil populations and root colonizations of *Pythium ultimum* and *Fusarium* sp. from selected treatments were obtained from one sample per plot taken directly under plant rows. Each sample was a composite of five cores 2 cm in diameter × 13 cm deep. Soil samples were air-dried for 3 days, and 2 g of soil was mixed in 50 cm^3 of distilled water. To estimate *P. ultimum* in the soil, a 0.2-cm^3 aliquot of this soil water mixture was placed as droplets on a petri dish containing 2% water agar and incubated for 24 hr, then colonies were counted (14). This procedure enabled specific identification of *P. ultimum*.

Similarly, *Fusarium* sp. in the soil was estimated from air-dried samples by the soil dilution method using PCNB

medium, with 10 μg/ml streptomycin (9). Five days after incubation at room temperature, colonies were counted and recorded. No attempt was made to enumerate different *Fusarium* spp. To estimate root colonization by *P. ultimum* and *Fusarium* sp., roots from soil samples were screened out and washed. After removing excess water from roots, 50 cm of roots was placed on a petri dish containing either 2% water agar or PCNB medium, respectively. After plates were incubated at room temperature for 30 hr for *P. ultimum* and for 5 days for *Fusarium* sp., the number of colonies was recorded. All soil and root assays were replicated 10 and five times per sample, respectively.

Experiment descriptions. All experiments were conducted in California's San Joaquin Valley on field sites naturally infested with either *M. incognita* (experiments 1–4) or *M. javanica* (experiment 5). In experiments 1–4, processing tomato commercial cultivars susceptible to *M. incognita* were grown according to local production practices (1). Tomatoes were direct-seeded in two rows spaced 36 cm apart on each tomato planting bed and thinned to a stand density of seven or eight plants per meter of row. Plots consisted of two beds, each bed 1.68 m wide and 32.0 m long. Plots were mechanically harvested from a 30.5-m section of two beds. A randomized complete block design was used in each experiment, with four (experiment 5), five (experiment 1), or six (experiments 2–4) replicates.

In experiment 5, carrot cultivar Dominator was direct-seeded in six rows 5 cm apart on each 1-m-wide bed. Plots were 15.2 cm long and three beds wide. Carrots were grown according to standard production practices (16) and hand-harvested. A 200-plant sample per plot was sorted into market-grade categories.

Experiment 1. Experiment 1 was in a sandy clay loam (52% sand, 18% silt, 30% clay, and <1% organic matter (OM), 6.9 pH). Metam-sodium (32.7% a.i.) was applied at the overall rate of 94, 187, 281, and 374 L/ha in 6.6 cm of water and at 187 L/ha in 14.2 cm of water through two drip lines per bed on 13 February 1985. The treatments wetted a 0.84-m-wide band on the bed. (Rates of application are based on the wetted area of the bed, thus 94 L/ha overall rate ≡ 7.9 L/100 m of bed.) At application time, soil temperature 15 cm deep was 11 C and soil moisture was about 50% of field capacity. On 9 February 1985, 1,3-D was applied at the rate of 82 L/ha. Tomato cultivar Del Monte 7172 was planted on 8 March 1985 and harvested on 9 August 1985. Pretreatment and posttreatment (at planting) soil samples were taken for nematode analysis on 12 February 1985 and 8 March 1985, respectively.

Experiment 2. Experiment 2 was in a sandy loam (66% sand, 17% silt, 17% clay, and <1% OM, 7.0 pH). Metam-sodium was applied at 186 and 371 L/ha in 4.6 cm of water through two drip lines per bed on 11 March 1985. The treatments wetted a 0.86-m-wide band on the bed. At application time, soil temperature 15 cm deep was 13 C and soil moisture was about 50% of field capacity. On 3 February 1985, 1,3-D was applied at 75 L/ha. Tomato cultivar UC82B was planted on 16 March 1985 and harvested on 14 August 1985. Pretreatment and posttreatment (at planting) soil samples for nematode analysis were taken on 3 February 1985 and 20 March 1985, respectively.

Experiment 3. Experiment 3 was in a sandy clay loam (53% sand, 23% silt, 24% clay, and <1% OM, 7.1 pH). Metam-sodium was applied at 351 L/ha in 2.5 cm of water and 702 L/ha in 5.1 cm of water through two drip lines per bed on 9–10 February 1984. The treatments wetted a 1.12-m-wide band on the bed. At application time, soil temperature 15 cm deep was 11 C and soil moisture was

Table 1. Effects of metam-sodium concentrations applied in spring through drip irrigation lines compared with 1,3-D fumigation in four field experiments on control of *Meloidogyne incognita* on tomato

Chemical (formulation)	Rate (L/ha)	Application water (cm)	*M. incognita* J2 and eggs/250 cm³ soil		Root gall rating (0–4)		*M. incognita* eggs/g of root at harvest (× 10²)	Yield (t/ha)
			Pretreatment	Posttreatment at planting	Midseason	Harvest		
Experiment 1								
Metam-sodium (32.7% a.i.)	94	6.6	79 a[y]	14 b	0.4 b	0.9 bc	92.7 ab	100.7 ab
	187	6.6	78 a	5 b	0.3 bc	1.1 b	35.0 bc	112.2 a
	187	14.2	42 a	<1 b	0.2 bc	0.6 bcd	45.8 bc	100.7 ab
	281	6.6	94 a	12 b	0.2 bc	0.4 de	58.4 bc	104.5 a
	374	6.6	52 a	4 b	0.2 bc	0.5 cde	25.8 bc	108.0 a
1,3-D (92% a.i.)	82	...	...	0 b	<0.1 c	<0.1 e	0.8 c	106.0 a
Control	...	...	...	79 a	1.5 a	3.0 a	147.3 a	87.4 b
Experiment 2								
Metam-sodium (32.7% a.i.)	186	4.6	33 a	3 b	0.1 c	0.9 b	32.9 ab	99.4 a
	371	4.6	23 a	1 b	0.1 c	0.7 b	13.4 b	101.4 a
1,3-D (92% a.i.)	75	...	...	12 b	1.2 b	2.4 a	60.9 ab	98.7 ab
Control	...	...	...	32 a	1.8 a	2.6 a	90.2 a	88.6 b
Experiment 3								
Metam-sodium (32.7% a.i.)	351	2.5	35 a	...	0.5 b	0.8 b	5.0 b	46.7 a
	702	5.1	69 a	...	0.3 b	0.5 b	0.6 c	49.7 a
1,3-D (92% a.i.)	122	...	1 b[z]	...	0.3 b	0.3 b	2.6 bc	35.4 ab
Control	...	...	35 a	...	1.4 a	3.4 a	55.0 a	24.9 b
Experiment 4								
Metam-sodium (32.7% a.i.)	164	7.1	19 a	4 b	0.2 ab	0.1 b	0.5 a	81.1 ab
	327	7.1	48 b	4 b	0.1 b	0.2 b	2.3 a	84.1 ab
1,3-D (92% a.i.)	94	...	...	<1 b	0.0 b	<0.1 b	0.1 a	90.1 a
Control	...	...	...	21 a	0.5 a	0.7 a	36.5 a	77.1 b

[y] For each experiment, values within a column followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

[z] Sampled after 1,3-D treatment when metam-sodium pretreatment and control samples were taken.

about 50% of field capacity. On 25 January 1984, 1,3-D was applied at 122 L/ha. Tomato cultivar Ferry Morse 6203 was planted on 2 March 1984 and harvested on 3 August 1984. Pretreatment and posttreatment (1,3-D treatment only) soil samples for nematode analysis were taken on 9 February 1984.

Experiment 4. Experiment 4 was in a sandy loam (63% sand, 19% silt, 18% clay, and <1% OM, 7.0 pH). Metam-sodium was applied at 164 and 327 L/ha in 7.1 cm of water through two drip lines per bed on 21 February 1985. The treatments wetted a 0.89-m-wide band on the bed. At application time, soil temperature 15 cm deep was 10 C and soil moisture was about 50% of field capacity. On 20 February 1985, 1,3-D was applied at 94 L/ha. Tomato cultivar Peto 343 was planted on 25 March 1985 and harvested on 5 August 1985. Pretreatment and posttreatment (at planting) soil samples for nematode analysis were taken on 21 February 1985 and 25 March 1985, respectively.

Experiment 5. Experiment 5 was in a sandy loam (66% sand, 20% silt, 14% clay, and 0.4% OM, 7.7 pH). Metam-sodium was applied at 63, 125, 153, and 249 L/ha in 4.1 cm of water through two drip lines per bed and at 333 L/ha in 6.1 cm of water through a single drip line per bed on 15 August 1986. The double-line treatments wetted a 0.76-m-wide band and the single-line treatment wetted a 0.51-m-wide band on the bed. At application time, soil temperature 15 cm deep was 30 C and soil moisture was about 50% of field capacity. On 10 August 1986, 1,3-D was applied at 140 L/ha. Carrot was planted on 21 August 1986 and harvested on 9 January 1987. Pretreatment, posttreatment (at planting), and at-harvest soil samples for nematode analysis were taken on 14 August 1986, 26 August 1986, and 10 January 1987, respectively.

RESULTS

Effects on nematodes. Metam-sodium effectively controlled *M. incognita* in both soil and tomato roots in experiments 1–4. Numbers of nematodes in soil assessed at planting were significantly reduced by rates of 94–702 L/ha of metam-sodium applied in 2.5–14.2 cm of water in the four experiments (Table 1). These treatments were as effective as 1,3-D fumigation in controlling *M. incognita*. Tomato root gall ratings in midseason and at harvest from all the metam-sodium treatments were significantly lower than from untreated controls and similar to or significantly lower than root gall ratings from 1,3-D treatments in most cases. Although nematode egg numbers in roots at harvest were more variable within treatments than the root gall ratings, the eggs per gram of root counts overall confirm the effectiveness of metam-sodium and 1,3-D in controlling *M. incognita* (Table 1).

In experiment 1, tomato yield was lowest in the untreated control, significantly lower than treatments of metam-sodium at 187, 281, and 374 L/ha in 6.6 cm of water but not significantly lower than metam-sodium at either 94 L/ha in 6.6 cm of water or 187 L/ha in 14.2 cm of water. Treatments of metam-sodium at 186 and 371 L/ha in 4.6 cm of water (experiment 2) and at 351 and 702 L/ha in 2.5 and 5.1 cm of water, respectively (experiment 3), resulted in significantly higher tomato yield than the untreated control. In experiment 4, nematode infection was generally low, and the higher tomato yields in treatments of metam-sodium at 164 and 327 L/ha in 7.1 cm of water were not significantly different from the untreated control.

Metam-sodium at 63–281 L/ha in 4.3 cm of water effectively controlled *M. javanica* on carrot in experiment 5 (Table 2). Numbers of *M. javanica* in soil samples assessed at planting and harvest were low in all treatments and did not provide a good indication of treatment effects. Root gall counts 48 days after planting were significantly lower in all metam-sodium-treated plots than in untreated control plots. Dry weights of carrot shoots and taproots at 48 days were significantly higher in treatments of metam-sodium at 125–281 L/ha, but not at 63 L/ha (Table 2).

Carrot marketable yield was significantly higher in all metam-sodium treatments (64.2–70.2 t/ha) and the 1,3-D treatment (69.6 t/ha) than in the untreated control (46.9 t/ha). All metam-sodium treatments significantly increased the percentage of No. 1 grade carrots (68.4–75.9%) compared with untreated carrots (48.3%) by significantly reducing the proportion of taproots rejected because of galling and forking symptoms, from 35.3% (untreated control) to 10.0–16.2% (metam-sodium treatments). The effects on carrot market grade from metam-sodium treatments were not significantly different from 1,3-D treatment.

Effects on fungal pathogens. Metam-sodium applications at 164–702 L/ha significantly reduced *P. ultimum* and *Fusarium* sp. soil populations and tomato root infections assessed in midseason to late season in selected treatments in experiments 1–4 (Table 3). Numbers of *P. ultimum* sporangia per gram of dry soil were significantly lower in metam-sodium-treated plots than in untreated control plots in all experiments and significantly lower than 1,3-D-treated plots in experiments 1 and 2 but not in experiment 4. The numbers of *P. ultimum* root infections of tomato in midseason were significantly lower in metam-sodium-treated plots than in both 1,3-D-treated plots and untreated control plots in experiments 1 and 2.

In experiment 3, the number of *Fusarium* sp. propagules per gram of dry soil at harvest was significantly lower in plots treated with metam-sodium at 702 L/ha than in untreated control plots. The numbers of *Fusarium* sp. root infections of tomato in midseason were significantly lower in metam-sodium-treated plots than in both 1,3-D-treated plots and untreated control plots in experiments 1 and 2 (Table 3).

DISCUSSION

Application of metam-sodium before planting to preformed, moist vegetable planting beds through single or double

Table 2. Effects of metam-sodium concentrations applied in summer through drip irrigation lines compared with 1,3-D fumigation on control of *Meloidogyne javanica* on carrot (experiment 5)

Chemical (formulation)	Rate (L/ha)	Application water (cm) (drip lines/bed)	*M. javanica* J2 and eggs/250 cm³ soil: Pre-treatment	Post-treatment at planting	At harvest	Mean number galls/root system at 48 days	100-Plant dry weight (g) at 48 days: Shoots	Taproots	Marketable yield (t/ha)	Market grade (%): No. 1	Jumbo	Small	Cull
Metam-sodium (32.7% a.i.)	63	4.1 (2)	3.1 a[z]	0.4 ab	0.4 a	1.33 b	43.0 bc	12.1 b	64.2 a	71.0 a	1.8 b	13.7 a	13.5 b
	125	4.1 (2)	3.3 a	0.0 b	0.0 a	0.45 b	55.2 a	17.8 a	67.6 a	75.9 a	2.7 b	11.3 a	10.0 b
	153	4.1 (2)	2.3 a	0.0 b	0.4 a	1.42 b	50.6 ab	16.9 a	65.8 a	69.7 a	3.8 ab	12.9 a	13.6 b
	249	4.1 (2)	2.1 a	0.5 ab	0.3 a	1.07 b	54.8 a	18.1 a	65.4 a	68.4 a	3.9 ab	11.4 a	16.2 b
	333	6.1 (1)	2.1 a	0.1 b	2.0 a	1.11 b	60.2 a	19.7 a	70.2 a	70.7 a	4.2 ab	10.2 a	14.8 b
1,3-D (92% a.i.)	140	...	...	...	0.9 a	...	...	...	69.6 a	67.5 a	8.8 a	9.8 a	13.9 b
Control	...	...	2.9 a	1.3 a	0.5 a	4.15 a	38.1 c	9.0 b	46.9 b	48.3 b	5.1 ab	11.3 a	35.3 a

[z] Values within a column followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

drip irrigation lines is an effective method for control of the nematodes *M. incognita* and *M. javanica* and the fungal pathogens *P. ultimum* and *Fusarium* sp. The efficacy of metam-sodium for control of nematodes was similar to that obtained by in-bed fumigation with 1,3-D, which is currently the primary control method for root-knot nematodes on field and vegetable crops in California. Therefore, metam-sodium applications through drip irrigation are an effective alternative to 1,3-D on these crops. The protection with metam-sodium of carrot taproots from injury by *M. javanica* is especially noteworthy because the cosmetic injury to the taproot is a low-tolerance form of crop loss requiring relatively few nematodes.

The drip irrigation system enabled application of efficacious treatments with metam-sodium concentrations considerably lower than the 467 L/ha and higher rates commonly applied by other methods such as through center-pivot irrigation (10). Metam-sodium controlled nematodes even at rates as low as 94 L/ha in experiment 1 and 63 L/ha in experiment 5, although yield and mid-season plant growth, respectively, were lower than those achieved with rates of 187 L/ha or higher. A further benefit of drip irrigation applications is in-bed treatment, which reduces total area of field treated by 25–50% compared with overall treatment.

The metam-sodium treatments were effective in soil that ranged in temperature at 15 cm deep from 10–13 C (experiments 1–4) to 30 C (experiment 5) at time of application. The amount of application water ranged from 2.5 to 14.2 cm in the five experiments. Higher amounts of water were applied on the soils with greater water-holding capacities (experiments 1 and 4) to compensate for reduced water penetration on those soils. Our observations in these and other experiments suggest that applying enough water to enable metam-sodium to penetrate 45–60 cm deep on a given soil type is critical for effective nematode control.

In experiment 5, a single drip line treated 50% of the bed width compared with 75% with the double drip line. However, the higher metam-sodium rate of 333 L/ha in the single-line application gave as good control of *M. javanica* as 249 L/ha in a double-line application. The metam-sodium treatments were effective on *M. incognita* in tomato when at least 50% of the bed width was treated. These treatments control nematodes and fungi in a soil zone wide enough and deep enough to protect shallow-growing carrot or deeper growing tomato root systems from injurious levels of infection. Crops planted in single rows could probably be protected by narrower zones of treatment.

The effect of *P. ultimum* and *Fusarium* sp. infections on tomato growth in our experiments was not clear; 1,3-D controlled these pathogens less effectively than metam-sodium, although yields in 1,3-D treatments were not significantly different from those in metam-sodium treatments. However, the consistent reductions in both *P. ultimum* and *Fusarium* sp. soil populations and root infections clearly demonstrate the efficacy of metam-sodium applied through drip irrigation for controlling root infections by these potentially pathogenic fungi. In preliminary experiments, we observed that the general bacterial population (excluding Actinomycetes) and both *Aspergillus* and *Penicillium* increased substantially in soils treated with 351 and 702 L/ha metam-sodium. Further experiments are being conducted to see the effects of recolonization of roots by these microorganisms on biomass and tomato yield.

We conclude that metam-sodium applied preplant through drip irrigation is an effective alternative to traditional soil fumigation for control of root-knot nematodes and certain pathogenic fungi in annual crops. Such applications can be made conveniently on crops produced under drip irrigation or by using temporary, portable drip line systems before planting on crops irrigated by other methods.

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Table 3. Effects of metam-sodium concentrations applied in spring through drip irrigation lines compared with 1,3-D fumigation in four experiments on control of *Pythium ultimum* and *Fusarium* sp. soil populations and tomato root infections

Chemical (formulation)	Rate (L/ha)	Application water (cm)	*Pythium ultimum*				*Fusarium* sp.		
			Sporangia/g dry soil		Infections/50 cm of root		Propagules/g dry soil	Infections/50 cm of root	
Experiment 1			**Day 81[y]**	**Day 98**	**Day 81**	**Day 98**		**Day 81**	**Day 98**
Metam-sodium (32.7% a.i.)	187	6.6	8.0 c[z]	4.4 a	0.4 b	0.8 b	···	0.8 b	0.2 b
	374	6.6	1.8 c	7.0 a	0.4 b	0.2 b	···	0.2 b	0.8 b
1,3-D (92% a.i.)	82	···	32.8 b	19.3 a	7.8 a	5.8 a	···	6.6 a	5.6 a
Control	···	···	63.2 a	20.0 a	6.8 a	4.2 a	···	9.0 a	4.8 a
Experiment 2			**Day 74**	**Day 91**	**Day 74**	**Day 91**		**Day 74**	**Day 91**
Metam-sodium (32.7% a.i.)	186	4.6	0.2 c	0.0 b	0.2 b	1.8 b	···	0.2 b	0.2 c
	371	4.6	0.0 c	0.2 b	0.0 b	2.4 b	···	1.4 b	0.0 c
1,3-D (92% a.i.)	75	···	7.8 b	13.8 a	4.4 a	6.0 a	···	10.4 a	3.4 b
Control	···	···	19.4 a	17.9 a	5.4 a	7.8 a	···	11.8 a	7.4 a
Experiment 3			**Day 154**				**Day 154**		
Metam-sodium (32.7% a.i.)	351	2.5	32.0 b	···	···	···	···	···	···
	702	5.1	40.0 b	···	···	···	13.0 b	···	···
Control	···	···	304.0 a	···	···	···	210.0 a	···	···
Experiment 4			**Day 87**						
Metam-sodium (32.7% a.i.)	164	7.1	3.3 b	···	···	···	···	···	···
	327	7.1	1.2 b	···	···	···	···	···	···
1,3-D (92% a.i.)	94	···	6.0 ab	···	···	···	···	···	···
Control	···	···	11.7 a	···	···	···	···	···	···

[y] Days after planting.

[z] For each experiment, values within a column followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple range test.

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