Environmental Horticulture Program Research Summaries

IR-4 Environmental Horticulture Program
Nematode Efficacy: Efficacy & Literature Review

Aphelenchoides fragariae
Aphelenchoides ritzemabosi
Ditylenchus dipsaci
Meloidogyne hapla
Meloidogyne incognita
Pratylenchus spp.

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Abstract

Nematodes are typically known for the damage they cause when feeding on or residing inside roots. However, they also can impact foliage. The host range of foliar and soil dwelling nematodes is wide affecting various environmental horticulture crops, and causing economic losses in greenhouses, nurseries, and residential and commercial landscapes. Soil dwelling nematodes feed on roots and depending on species can reduce root mass or cause root enlargement such as root knot nematodes. Foliar nematodes feed on mesophyll cells causing chlorosis which eventually turns into necrosis which is a serious problem. This summary and literature review is a compilation of experiments sponsored by IR-4 and published literature from 1999 through 2023. The only prospective nematicides for soil-dwelling nematodes with good to excellent efficacy in more than one IR-4 trial is Indemnify, but several show promise including Bountify, NemaFix, NMG-787, Reklemel, and Rootshield Plus. Products with good efficacy for foliar nematodes include: abamectin, acephate, clothianidin, dimethoate, insecticidal soap, isofenphos, methiocarb, neem oil, oregano oil, oxamyl and lambda-cyhalothrin. Active ingredients with excellent efficacy included: ammonia hydroxide, *Burkholderia cepacia*, chlofenapyr, cinnamon + clove + thyme oils (32% + 8% + 15%), diazinon, ethoprophos, grapefruit seed extract, imidacloprid, peroxyacetic acid, potassium permanganate, sodium dichloroisocyanurate, sodium hypochlorite, and trichlofon.

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Introduction

Nematodes are typically known for the damage they cause when feeding on or residing inside roots. However, they also can impact foliage. The host range of foliar and soil dwelling nematodes is wide affecting various environmental horticulture crops, and causing economic losses in greenhouses, nurseries, and residential and commercial landscapes. Soil dwelling nematodes feed on roots and depending on species can reduce root mass or cause root enlargement such as root knot nematodes. Foliar nematodes feed on mesophyll cells causing chlorosis which eventually turns into necrosis which is a serious problem. This summary and literature review is a compilation of experiments sponsored by IR-4 and published literature from 1999 through 2023.

Materials and Methods

From 1999 to 2023, numerous products were tested as foliar or soil applications against nematode species known to attack environmental horticulture crops. Nematodes tested include *Aphelenchoides fragariae*, *Aphelenchoides ritzemabosi*. *Ditylenchus dipsaci*, *Meloidogyne hapla*, *Meloidogyne incognita*, and *Pratylenchus spp*.

Treatments were generally applied a few days before inoculation. A minimum of four plants (replicate treatments) were required with most researchers exceeding this minimum. Population counts, disease severity and incidence were recorded at various intervals after initial application depending on experimental design.

Products were supplied by their respective manufacturers.

For all research data tables, product names have been updated where manufacturers have established trade names, and tables have been rearranged by product alphanumeric order. Where both inoculated and non-inoculated checks were included in the experiment, the inoculated check appears last in the table with the non-inoculated check immediately preceding it.

Table 1. List of Products and Rates Tested in IR-4 Experiments from 2000 to 2023

Product	Manufacturer	Active Ingredients	Code Numbers	MOA Class	Application Type	Number of Trials
Avid 0.15EC	Syngenta Crop Protection	Abamectin		IRAC 6	Foliar	5
Bountify (MBI 306)	Pro Farm Group	Burkholderia rinojensis strain A396	MBI 306	FRAC NC & IRAC UNB	Drench	2
Gem-21	Kemin Crop Technologies	Gem-21			Drench	1
GWN-12025	Gowan	GWN-12025	GWN-12025		Drench	1
Indemnify	Envu (formerly Bayer)	Fluopyram	ESP 715	FRAC 7	Drench	4
Indemnify	Envu (formerly Bayer)	Fluopyram	ESP 715	FRAC 7	Foliar	2
MBI 203 SC2	Pro Farm Group	MBI 203	MBI 203		Drench	2
MBI 304	Pro Farm Group	Chromobacterium subtsugae	MBI 304	FRAC BM02	Drench	2
MBI 304	Pro Farm Group	Chromobacterium subtsugae	MBI 304	FRAC BM02	Foliar	1
MBI 305	Pro Farm Group	Burkholderia rinojensis strain A396	MBI 305, MBI 206	FRAC BM01 & IRAC UNB	Drench	2
MBI 305	Pro Farm Group	Burkholderia rinojensis strain A396	MBI 305, MBI 206	FRAC BM01 & IRAC UNB	Foliar	1
NemaFix	TLC Products	chitatrol			Drench	1
NMG-787	Syngenta Crop Protection	NMG-787	NMG-787		Drench	2
RD00AS-1 (BW159)	Bioworks	BW159	RD00AS-1, BW159		Drench	1
Reklemel	Corteva Agriscience	fluazaindolizine	DPX-Q8U80		Drench	1
RootShield Plus WP (aka BW240)	Bioworks	Trichoderma harzianum T-22 + Trichoderma virens G-41	BW240	FRAC BM02	Drench	2
Tril-21	Kemin Crop Technologies	Thyme oil		FRAC BM01	Drench	1

Results

Aphelenchoides fragariae

In 1999, Jim LaMondia screened curative applications of Avid (abamectin), KnoxOut (diazinon), and Mesurol (methiocarb) for reduction of *Aphelenchoides fragariae* in azalea, begonia, and lamium. Two treatments at a biweekly interval were made. One week after each application, one gram of foliage was collected and nematodes counted after extraction. According to repeated measures ANOVA, significant differences were only observed in Lamium (Table 3) While methiocarb reduced *A. fragariae* densities in Lamium, it was not as efficacious as diazinon or abamectin after the second biweekly application.

Table 2. *Effect of up to six applications of abamectin (Avid 0.15 EC) or diazinon (KnoxOut GH) on *Ditylenchus dipsaci* populations extracted from *Phlox subulata,* LaMondia 1999

Products	Active Ingredient	Rate (fl oz/ 100 gal)	*D. dipsaci* population (counts per gram foliage) and percent control in foliage					
			7 days (1 app)	14 days (2 app)	21 days (3 app)	28 days (4 app)	35 days (5 app)	42 days (6 app)
Nontreated	----	----	115 (0%)	35 (0%)	202 (0%)	91 (0%)	97 (0%)	125 (0%)
Avid 0.15 EC	Abamectin	4	41 (64%)	89 (0%)	330 (0%)	113 (0%)	235 (0%)	220 (0%)
Avid 0.15 EC	Abamectin	8	94 (18%)	177 (0%)	441 (0%)	136 0%)	70 (28%)	68 (46%)
KnoxOut GH	Diazinon	33	38 (67%)	8 (77%)	20 (90%)	8 (91%)	1 (99%)	1 (99%)
KnoxOut GH	Diazinon	100	28 (76%)	53 (-51%)	68 (66%)	6 (93%)	2 (98%)	2 (98%)

* J. A. LaMondia. 1999. Efficacy of insecticides for control of *Aphelenchoides fragaria* and *Ditylenchus dipsaci* in flowering perennial ornamentals. J. of Nematology 31 (4S):644-649. Treatment and time were significantly different with repeated measures ANOVA.

Table 3. *Effect of Avid, KnoxOut, and Mesurol on *Aphelenchoides fragariae* populations in *azalea, begonia,* or *lamium* foliage, LaMondia 1999

Treatment (Active Ingredient)	Rate (fl oz/100 gal)	Days after first treatments					
		Azalea		Begonia		Lamium	
		7 days	21 days	7 days	21 days	7 days	21 days
Non Treated	----	41 (0%)	11 (0%)	1163 (0%)	3802 (0%)	383 (0%)	429 (0%)
Avid 0.15 EC (abamectin)	8	50 (0%)	2 (82%)	192 (83%)	3007 (21%)	336 (12%)	26 (94%)
KnoxOut GH (diazinon)	100	17 (59%)	5 (55%)	1953 (0%)	3688 (3%)	26 (93%)	7 (98%)
Mesurol (methiocarb)	60	11 (73%)	3 (73%)	1587 (0%)	3795 (0%)	322 (16%)	189 (56%)

* J. A. LaMondia. 1999. Efficacy of insecticides for control of *Aphelenchoides fragaria* and *Ditylenchus dipsaci* in flowering perennial ornamentals. J. of Nematology 31 (4S):644-649. Only Lamium exhibited significant treatment affect with repeated measures ANOVA.

During 1999 and 2000, Jagdale and Grewal tested 14 active ingredients efficacy for control *Aphelenchoides fragaria* on Hosta (*Hosta spp*) either as single foliar applications or as soil drenches (single application or for Nimbecide and ZeroTol three applications on consecutive days). All trials were arranged in random blocks with four replications and products applied per label direction. Nematodes were recorded before and 15, 30, 45 days after a single treatment. During the 1999 foliar experiment, impact on populations was slow to develop, but by 30 days after treatment, Orthene (acephate) exceeded 70% population reduction (Table 4). By 45 days after application, Clove extract, Deny, Diazinon, Dylox 80S, Insecticidal soap, Merit 75WP, Orthene, Vydate, and ZeroTol exhibited 70% or greater control. During the 2000 foliar experiment, population reductions were observed at 15 days with Clove extract, Deny, Mesorul exceeding 70% reduction (Table 5). By 30 days after treatment, Clove extract, Deny, Diazinon, Dylox 80S, Mesorul, Mecap, Orthene and Vydate reached or exceeded 70% efficacy. By 45 days, Insecticidal soap was effective as was ZeroTol. Across both foliar and the soil drench experiments, only diazinon EC, trichlorfon SP, oxamyl GR and ZeroTol consistently caused over 70% reduction in nematode population both in leaves (Table 4, Table 5) and soil (Table 6). Of these products, only ZeroTol is still registered by the US EPA and, therefore, available to manage foliar nematodes in ornamental horticulture crops. Although not as effective as ZeroTol in the soil, insecticidal soap is the only other alternative for foliar nematode management.

Table 4. *Effect of biological and chemical pesticides on the population of *Aphelenchoides fragariae* in infected hosta leaves, Jagdale and Grewel, 1999

Product Trade Name	Treatment (Active Ingredient)	Rate (lb/100 gal)	Means of *A. fragaria* per cm^2 Hosta spp tissue		
			Days after treatment (1999)		
			15	30	45
Nontreated	---	----	474 (0%) a	2939 (0%) a	4316 (0%) a
Clove extract	*Syzygium aromaticum*	11	763 (0%) a	1019 (65%) a	946 (78%) c
Deny	*Burkholderia cepacia*	2.75	659 (0%) a	1208 (59%) a	631 (85%) c
Diazinon 4E	Diazinon	1.34	1033 (0%) a	1713 (42%) a	1155 (73%) c
Dylox 6.2G	Trichlofon GR*	0.25	588 (0%) a	1547 (47%) a	5746 (0%) a
Dylox 80S	Trichlofon	1.1	349 (26%) a	2290 (22%) a	600 (86%) c
Insecticidal soap	Insecticidal soap	13.2	793 (0%) a	1051 (64%) a	1151 (73%) c
Merit 0.5G	Imidacloprid GR*	0.09	805 (0%) a	1072 (64%) a	1754 (59%) bc
Merit 75WP	Imidacloprid	0.15	598 (0%) a	997 (66%) a	986 (77%) c
Mesorul 75WP	Methiocarb	0.68	606 (0%) a	1107 (62%) a	1983 (54%) bc
Mecap	Ethoprophos GR*	2.64	334 (30%) a	2250 (23%) a	1620 (62%) bc
Oftanol	Isofenphos	2.4	225 (53%) a	1761 (40%) a	2386 (45%) bc
Orthene	Acephate	0.44	579 (0%) a	825 (72%) a	1139 (74%) c
Vydate 10G	Oxamyl GR*	0.22	---	---	598 (86%) c
Zero Tol	Peroxyacetic Acid	5.46	452 (5%) a	1267 (57%) a	680 (84%) c

*directly mixed with soil, not dispersed with water.

GB Jagdale and PS Grewal. 2002. Identification of alternatives for the management of foliar nematodes in floriculture. Pest Manag Sci 58:451-458.

Table 5. *Effect of biological and chemical pesticides on the population of *Aphelenchoides fragariae* in infected hosta leaves, Jagdale and Grewal, 2000

Product Trade Name	Treatment (active Ingredient)	Rate (lb/100 gal)	Means of *A. fragaria* per cm^2 Hosta spp tissue		
			Days after treatment (2000)		
			15	30	45
Nontreated	---	----	232 (0%) a	388 (0%)a	560 (0%) a
Clove extract	*Syzygium aromaticum*	11	63 (73%) a	117 (70%) ab	394 (30%) ab
Deny	*Burkholderia cepacia*	2.75	60 (74%) a	134 (65%) ab	185 (67%) bcd
Diazinon 4E	Diazinon	1.34	380 (0%) a	80 (79%) ab	80 (86%) cd
Dylox 6.2G	Trichlofon GR*	0.25	75 (68%) a	143 (63%) ab	189 (66%) bcd
Dylox 80S	Trichlofon	1.1	104 (55%) a	60 (85%) b	84 (85%) cd
Insecticidal soap	Insecticidal soap	13.2	124 (47%) a	136 (65%) ab	157 (72%) bcd
Merit 0.5G	Imidacloprid GR*	0.09	328 (0%) a	185 (52%) ab	346 (38%) abc
Merit 75WP	Imidacloprid	0.15	182 (22%) a	258 (34%) ab	242 (57%) bcd
Mesorul 75WP	Methiocarb	0.68	54 (77%) a	69 (82%)b	404 (28%) ab
Mecap	Ethoprophos GR*	2.64	97 (58%) a	101 (74%) ab	66 (88%) d
Oftanol	Isofenphos	2.4	157 (32%) a	204 (47%) ab	209 (63%) bcd
Orthene	Acephate	0.44	93 (60%) a	98 (75%) ab	254 (55%) bcd
Vydate 10G	Oxamyl GR*	0.22	73 (68%) a	74 (81%) b	156 (72%) bcd
Zero Tol	Peroxyacetic Acid	5.46	73 (68%) a	123 (68%) ab	152 (73%) bcd

*directly mixed with soil, not dispersed with water.

GB Jagdale and PS Grewal. 2002. Identification of alternatives for the management of foliar nematodes in floriculture. Pest Manag Sci 58:451-458.

Table 6. *Effect of biological and chemical pesticides on the population of *Aphelenchoides fragariae* in soil around Hosta, Jagdale and Grewal, 2000

Product Trade Name	Treatment (active Ingredient)	Rate (lb/100 gal)	Means of *A. fragaria* per 10g soil		
			Days after treatment		
			15	30	45
Nontreated	---	----	1170 (0%) a	1332 (0%) a	845 (0%) a
Clove extract	*Syzygium aromaticum*	11	975 (17%) ab	1137 (15%) ab	585 (31%) b
Deny	*Burkholderia cepacia*	2.75	650 (44%) abc	812 (39%) bc	422 (50%) bcd
Diazinon 4E	Diazinon	1.34	520 (56%) bc	487 (63%) c	162 (81%) f
Dylox 6.2G	Trichlofon GR*	0.25	422 (64%) bc	390 (71%) c	390 (54%) bcde
Dylox 80S	Trichlofon	1.1	845 (28%) abc	780 (41%) bc	195 (77%) ef
Insecticidal soap	Insecticidal soap	13.2	780 (33%) abc	810 (39%) bc	325 (62%) cdef
Merit 0.5G	Imidacloprid GR*	0.09	520 (56%) bc	552 (59%) c	325 (62%) cdef
Merit 75WP	Imidacloprid	0.15	975 (17%) ab	780 (41%) bc	487 (42%) bc
Mesorul 75WP	Methiocarb	0.68	747 (36%) abc	520 (61%) c	260 (69%) def
Mecap	Ethoprophos GR*	2.64	585 (50%) bc	617 (54%) c	162 (81%) f
Oftanol	Isofenphos	2.4	390 (67%) c	682 (49%) c	292 (65%) cdef
Orthene	Acephate	0.44	650 (44%) abc	715 (46%) bc	390 (54%) bcde
Vydate 10G	Oxamyl GR*	0.22	325 (72%) c	520 (61%) c	195 (77%) ef
Zero Tol	Peroxyacetic Acid	5.46	357 (69%) c	390 (71%) c	195 (77%) ef

*directly mixed with soil, not dispersed with water.
GB Jagdale and PS Grewal. 2002. Identification of alternatives for the management of foliar nematodes in floriculture. Pest Manag Sci 58:451-458.

As an initial screen, An et al conducted aqueous suspension bioassays using 24-well plates to determine the effects of 24 candidate products on mortality of *A. fragariae*. Ammonia, Clorox, grapefruit seed extract, KMnO4, NaDCC, Nemakill, Pylon and ZeroTol caused 100% nematode mortality in aqueous suspension at 20-fold dilution (data not shown, see An et al, 2017)). These actives and products plus clothianadin and boiling water were then drenched into pots with young established hosta plants one week after nematode inoculation. Over 80% reduction in the population of A. fragariae was recorded with the treatments of Ammonia, Nemakill, ZeroTol, NaDCC, Pylon, and KMnO4. Clothianidin was less effective causing about 50% reduction in the nematode population (Table 7).

To determine efficacy for foliar occurring *A. fragariae*, spray application of ZeroTol could reduce over 70% *A. fragariae* population in leaf discs, whereas ammonia, Clorox, KMnO4 and NaDCC caused about 50% reduction (data not shown, see An et al, 2017).

Pylon (24% chlorfenapyr) and Nemakill (32% cinnamon oil, 8% clove oil, 15% thyme oil mixture) showed 100% mortality of *A. fragariae* in all three types of tests, and thus have great potential to serve as effective alternatives to manage foliar nematodes in floriculture.

Table 7. *Effect of selected products applied as soil drench on *Aphelenchoides fragariae* population in pots with hosta, 2017.

Product Trade Name	Treatment (Active Ingredient)	Rate (Product/Soil)	Mean % reduction over control [z]		
			7 days	14 days	42 days
Ammonia [y]	Ammonia hydroxide (25 g/l)	2.56 oz/gal	87.71	81.93	76.22
Clothianidin	Clothianidin (40 g/l)	0.2 lb/100 gal	65.03	64.49	67.43
$KMnO_4$	Potassium permanganate (40 g/l)	0.5 lb/100 gal	87.16	83.18	80.78
NaDCC	Sodium dichloroisocyanurate (40 g/l)	0.5 lb/100 gal	87.98	80.69	77.85
Nemakill	Cinnamon (32%), clove (8%), Thyme (15%)	0.64 oz/gal	98.18	99.69	100
Pylon	Chlofenapyr (240 g/l)	1.28 oz/gal	98.91	99.69	100
ZeroTol [y]	Peroxyacetic acid (270 g/l)	1.28 oz/gal	93.17	81	84.04
Boiling Water	-	-	99.73	100	100

[z] Data are the mean % reduction in nematode population in soil over control at 7, 14 and 42 days after treatment.
[y] Ammonia and ZeroTol were significantly different from the control in time-factor repeated measures analysis of variance.
R An, NK Karthik, P Grewal. 2017. Evaluation of botanical and chemical products for the control of foliar nematodes Aphelenchoides fragrariae. Crop Protection 92:107-113.

In 2019, Cheng conducted two greenhouse experiments to evaluate Indemnify (ESP-715), MBI-304, and MBI-305 for management of foliar nematode (*Aphelenchoides fragariae*) on Palapalai (*Microlepia strigosa*) fern. One frond on each individual plant was inoculated with 1,200 foliar nematode juveniles and/or adults. One foliar spray was applied after foliar nematodes were established. Nematode damage incidence and severity data (0-5 scale), height, width and weight were taken weekly for six weeks after treatments. Indemnify exhibited slight but statistically significant reductions in damage but final nematode counts were similar to the non-treated inoculated controls. MBI 304 slightly but statistically significantly reduced damage incidence and severity; however, nematode populations were reduced by 76% from the non treated inoculated controls. MBI 305 performed similarly, but nematode populations were reduced by 65%.

Table 8. Efficacy and crop safety of Indemnify, MBI-304, and MBI 305 for *Aphelenchoides fragraria.* on Palapalai fern, Cheng, 2019

Experiment	Treatment	Damage Incidence	Damage Severity	Mean final nematode counts
Indemnify	ESP715 – 8.5 fl oz/100 gal	0.85ab	1.05b	122a
	ESP715 – 17.1 fl oz/100 gal	0.81b	0.95b	170.0a
	Non treated inoculated control	0.98a	1.34a	154a
	Non treated non inoculated control	0.42c	0.49c	0b
	MBI304 – 4lb/100 gal	0.85b	1.01b	76.0ab

MBI 304 and 305	MBI305 – 2 gal/100 gal	0.69b	0.69c	109ab
	Non treated inoculated control	1.2a	1.27a	315a
	Non treated non inoculated control	0.27c	0.42c	0b

Aphelenchoides ritzemabosi

In 2013 and 2014, Chalanska et al screened several products to manage *Aphelenchoides ritzemabosi,* a foliar feeding nematode that causes necrotic leaves and leaf drop. Healthy anemone plants were infested by spraying a water solution of living nematodes collected from infected plants in commercial nurseries located in Skierniewice, Poland. Tests on plants of *Anemone hupehensis* (Lemoine) 'Prinz Heinrich' were carried out over 4 consecutive weeks with treatments occurring weekly or biweekly (Table 9). At the beginning and end of the experiment, two leaves from each plant were collected and nematodes extracted and counted. Average foliar damaged was assessed. This experiment was conducted twice: once in 2013 and again in 2014. In both years, oxamyl and abamectin, with aqueous extract of *Allium sativum,* were the most effective (efficacy about 40%) with curative applications. The aqueous bulb extracts of *A. sativum*, solution of extracts of *Quillaja saponaria* and solution of spirotetramat in combination with aqueous extract of *A. sativum* were ineffective in 2013 (Table 9). However, all treatments except the extract of Allium sativum reduced leaf damage in comparison to the nontreated control. In 2014, while there was significant reduction in nematode populations for all treatments the populations were high and only the extract of *Quillaja saponaria* significant reduced leaf damage (Table 10). In both experimental years, the significant correlation between the number of nematodes in leaves and the sampling date was recorded (data not shown, see Chalanska et al 2017).

Table 9. *Efficacy of tested products in the control of *Aphelenchoides ritzemabosi* on *Anemone hupehensis* in 2013, Chalanska

Treatment (Active Ingredient)	Application Method	Rate	Average Number of nematodes/leaf		Henderson-Tilton Percent Control	Average Percent Leaf Damage	
			Pre-T	T + 28		Pre-T	T + 28
Nontreated	---	----	2.5 ab	31.6 d	---	10.5 cd	20.9 f
Vydate (oxamyl)	Single soil drench	0.01 (lb/100 gal of soil)	2.5 ab	7.9 c	40	10.1 b-d	10.8 d
Allium sativum extract	Weekly foliar spray	2.50%	2.0 a	63.1 e	0	0.9 b	20.5 e
Quillaja saponaria extract	Weekly foliar spray	10%	2.0 a	63.1 e	0	0.2 a	10.2 b-d
Vertimec 018EC (abamectin) / *Allium sativum* extract	Weekly foliar rotations	0.15% + 2.5%	2.5 ab	100.0 e	0	0.3 a	10.0 bc
Movento 100 SC (spirotetramat) / *Allium sativum* extract	Weekly foliar rotations	0.075% + 2.5%	4.0 b	20.0 d	42.2	0.1 a	10.4 b-d

A Chalanska, A Bogumil, G Labanowski. 2017. Management of foliar nematode Aphelenchoides ritzembosi on Anemone hupehensis using plant extracts and biopesticides. J Plant Dis Prot 124:437-443.

Table 10. *Efficacy of tested products in the control of *Aphelenchoides ritzemabosi* on *Anemone hupehensis* in 2014, Chalanska

Treatment (Active Ingredient)	Application Method	Rate	Average Number of nematodes/leaf		Henderson-Tilton Percent Control	Average Percent Leaf Damage	
			Pre-T	T + 28		Pre-T	T + 28
Nontreated	---	----	125.9 b-d	501.2 fg	---	20.4 ab	40.3 d
Vydate (oxamyl)	Single soil drench	0.01 (lb/100 gal of soil)	125.9 b-d	31.6 a	44.4	30.0 bc	40.4 d
Allium sativum extract	Weekly foliar spray	2.50%	398.1 f	199.5 c-e	31.2	30.7 cd	30.3 b-d
Quillaja saponaria extract	Weekly foliar spray	10%	251.2 e	199.5 c-e	25.5	10.8 a	10.6 a
Vertimec 018EC (abamectin) / *Allium sativum* extract	Weekly foliar rotations	0.15% + 2.5%	631.0 g	199.5 c-e	36.1	60.5 e	50.5 e
Movento 100 SC (spirotetramat) / *Allium sativum* extract	Weekly foliar rotations	0.075% + 2.5%	631.0 g	125.9 b	41.7	30.7 cd	30.7 cd

A Chalanska, A Bogumil, G Labanowski. 2017. Management of foliar nematode Aphelenchoides ritzembosi on Anemone hupehensis using plant extracts and biopesticides. J Plant Dis Prot 124:437-443.

Aphelenchoides sp.

Benson, in 2000, studied phytotoxicity of Avid EC and efficacy for foliar nematodes on hosta (*H. minima*) by utilizing plants from a local nursery with infestations. Avid was applied three times at 5 day intervals. Data were collected starting 11 days after initial treatment. While no injury was observed with Avid EC, it provided only slight suppression of symptoms related to nematode infestations as a curative treatment (Table 11). However, in a second experiment with African violets, where treatments were started prior to semi-natural light infections with infected Athyrium placed among the African violets, good reduction of symptoms occurred (Table 12).

Table 11. Efficacy and crop safety of Avid EC for *Aphelenchoides sp.* on hosta, Benson, 2000

Treatment	Rate per 100 gal	Crop Safety			Foliar Symptoms (1-10)		
		11 DAT	19 DAT	47 DAT	11 DAT	19 DAT	47 DAT
Avid EC	8 fl oz	0 a	0 a	0 a	5.6 a	5.3 a	7.3 b
	16 fl oz	0 a	0 a	0 a	5.1 a	5.3 a	6.0 ab
	32 fl oz	0 a	0 a	0 a	5.6 a	5.8 a	7.4 ab
Nontreated	--	0 a	0 a	0 a	4.9 a	6.5 a	8.1 ab

* Foliar symptoms rated on a scale of 1 to 10 where 1 = no symptoms, 3 = few necrotic spots due to nematode infection, 5 = moderate number of necrotic leaf spots due to nematode infection, 7 = severe necrotic leaf spots due to nematode infection, and 10 = plant dead.

Table 12. Efficacy and crop safety of Avid EC for *Aphelenchoides sp.* on African violet, Benson, 2000

Treatment	Rate per 100 gal	Crop Safety			Foliar Symptoms (1-10)		
		11 DAT	19 DAT	47 DAT	11 DAT	19 DAT	47 DAT
Avid EC	8 fl oz	0 a	0 a	0 a	1.0 b	1.1 a	1.0 b
	16 fl oz	0 a	0 a	0 a	1.5 a	1.9 a	1.1 b
	32 fl oz	0 a	0 a	0 a	1.0 b	1.5 a	1.4 b
Nontreated	--	0 a	0 a	0 a	1.0 b	1.8 a	2.3 a

* Foliar symptoms rated on a scale of 1 to 10 where 1 = no symptoms, 3 = few necrotic spots due to nematode infection, 5 = moderate number of necrotic leaf spots due to nematode infection, 7 = severe necrotic leaf spots due to nematode infection, and 10 = plant dead.

Ditylenchus dispaci

In two experiments during 1999, Jim LaMondia screened curative applications of Avid (abamectin) and KnoxOut (diazinon) for reduction of *Ditylenchus dipsaci* in *Phlox subulata*. Both products were applied to foliage until runoff using labelled rates for insecticide applications. Seven days after each application, two grams of phlox foliage were collected and assessed for number of nematodes after extraction. In the first experiment, up to four weekly applications were made with a reduction in *D. dispsaci* occurring for all treatments on all dates with the exception of Avid after the fourth application (Table 13). However, the control

population decreased during this experiment from 119 per gram to 15 per gram. In the second experiment, six consecutive weekly applications were made, but only KnoxOut provided a satisfactory reduction in *D. dipsaci* populations.

Table 13. *Effect of up to four applications of abamectin (Avid 0.15 EC) or diazinon (KnoxOut GH) on *Ditylenchus dipsaci* populations extracted from *Phlox subulata*, LaMondia 1999

Products	Active Ingredient	Rate (fl oz/100 gal)	*D. dipsaci* population (counts per gram foliage) and percent control in foliage			
			7 days (1 app)	14 days (2 app)	21 days (3 app)	28 days (4 app)
Nontreated	----	----	119 (0%)	46 (0%)	23 (0%)	15 (0%)
Avid 0.15 EC	Abamectin	4	10 (92%)	19 (59%)	16 (30%)	16 (0%)
Avid 0.15 EC	Abamectin	8	5 (96%)	7 (85%)	6 (74%)	5 (67%)
KnoxOut GH	Diazinon	33	22 (82%)	28 (39%)	7 (70%)	1 (93%)
KnoxOut GH	Diazinon	100	16 (87%)	18 (61%)	4 (83%)	1 (93%)

* J. A. LaMondia. 1999. Efficacy of insecticides for control of *Aphelenchoides fragaria* and *Ditylenchus dipsaci* in flowering perennial ornamentals. J. of Nematology 31 (4S):644-649. Treatment and time were significantly different with repeated measures ANOVA.

Meloidogyne hapla

In 2018, Quintanilla established an experiment with daylilies planted in rows to compare fumigation with drenches of Indemnify, MBI 304 and Majestene (MBI 305). The number of root knot nematodes (*Meloidogyne hapla*) were not significantly different among the plots. However, the number of nematodes per g root in all 4 treatments were significantly lower than the non-treated control plots.

Table 14. Efficacy of prospective nematicides on *Meloidogune hapla* in daylilies, Quintanilla, 2018

Treatment	Root Knot Nematodes in 100cc soil			Mean Root Knot/g root
	5/24/18	7/24/18	10/23/18	
Fumigated	0	0	0	2.42 a
Indemnify	0	0	0.25	6.00 a
MBI 304	0	0	0	5.59 a
Majestene (MBI 305)	0.17	0.17	0.25	4.83 a
Control	1	0	0.25	18.32 b

In 2018, Quintanilla established an experiment with daylilies planted in rows to compare fumigation with drenches of Indemnify, MBI 304 and Majestene (MBI 305). The number of root knot nematodes (*Meloidogyne hapla*) were not significantly different among the plots. However, the number of nematodes per g root in all 4 treatments were significantly lower than the non-treated control plots.

Table 15. Mean root-knot nematodes/100 cm^3 soil extracted from the soil at the end of the trial on October 2, 2023.

Product	Root-Knot Nematodes/100 cm^3 soil
BW240	0.0 a[1]
Gem-21	1.2 a
GWN-12025	0.0 a
MBI-203	1.8 ab
MBI-306	0.0 a
NemaFix	0.0 a
NMG-787	0.0 a
RD00AS-1	4.8 ab
Reklemel	0.0 a
Tril-21	8.4 b
Indemnify	0.0 a
Untreated Control	6.6 ab
p-value	*< 0.001*

[1]Treatments within the same column labeled with different letters are significantly different according to Tukey HSD (α=.05).

Meloidogyne incognita

In 2020, Cheng studied chemical and biological nematicides for management of root know nematodes (*Meloidogyne incognita*) on Hibiscus 'Seminal Pink'. No treatment differed in plant height or twig count (data not shown), but there was no nontreated set of plants as a comparison. The treatment with the lowest average number of nematodes in soil was Indemnify.

Table 16. * Efficacy of prospective nematicides on *Meloidogune incognita* in hibiscus, Cheng, 2020

Treatment	Rate per 100 gal	Mean Root Knot per 10g soil 12 WAT	
Bountify	20 fl oz	123.25	A
	10 fl oz	58.25	AB
Indemnify	8.5 fl oz	2.75	C
MBI-203	256 fl oz	93.25	A
	128 fl oz	101.50	A
RootShield Plus	8 oz	91.75	A
	6 oz	58.50	A
NMG-787	11.4 oz	31.00	BC
	5.7 oz	116.25	A

Pratylenchus sp.

In 2018, Quintanilla established an experiment with daylilies planted in rows to compare fumigation with drenches Indemnify, MBI 304 and Majestene (MBI 305) for management of root knot nematodes. However, pin nematodes were observed in the soil cores and counted. Indemnify and standard soil fumigation provided the best reduction in nematode populations. Populations in MBI 304 and Majestene treated plots were similar to the non treated controls.

Table 17. Efficacy of prospective nematicides on *Pratylenchus sp*. in daylily plots, Quintanilla, 2018

	Pin Nematodes in 100cc soil		
Treatment	**5/24/18**	**7/24/18**	**10/23/18**
Fumigated	0.4 a	0.2 a	0.4 a
Indemnify	0.33a	0 a	0.33a
MBI 304	4.5 b	2 b	4.5 b
Majestene (MBI 305)	5.33 b	1.33 b	5.33 b
Control	5.33 b	1 b	5.25 b

Efficacy Summary by Active Ingredient

A brief efficacy summary for select products is given below, with a reminder that there are very limited published data available to draw definitive conclusions for each product/pest species. Products that were selected were currently registered and those that may be of interest for registration.

Abamectin: Abamectin solution provide less effective (Mortality between 50-75%) on *A. fragaria* An et al 2017. Avid efficacy could be found after few treatments *D. dipsaci* (LaMondia 1999).

Acephate: Orthene 75S provided 30-70 % mortality in *A. fragaria* population in soil and (Jagdale and Grewal 2002).

Acetamiprid

Ammonia hydroxide: Ammonia provided good efficacy (100% mortality in 24 h exposure) on *A. fragaria* (An et al 2017).

Azadirachtin: Not shows potential for control *A. fragaria* (Jagdale and Grewal 2002).

Bifenthrin: Ortho Bug B Gon provided less efficacy (mortality < 50%) for control *A. fragaria* (An et al 2017).

Burkholderia cepacia: provided 67-85% reduction in *A. fragaria* population and 50% in soil (Jagdale and Grewal 2002).

Canola Oil: Not shows potential (mortality < 10%) for control *A. fragaria* (An et al 2017).

Carbaryl: Sevin efficacy increased with longer exposure periods on *A. fragaria* (An et al 2017).

Chlorfenapyr: Pylon provided good efficacy (100% mortality in 24 h exposure) on *A. fragaria* (An et al 2017).

Clothianidin: Efficacy (Mortality between 50-75%) increased with longer exposure periods (An et al 2017).

Clove Oil: Not shows potential for control *A. fragaria* (Jagdale and Grewal 2002).

Cyfluthrin: Bayer VG Insect Spray Not shows potential (mortality < 10%) for control *A. fragaria* (An et al 2017).

Diazinon: KnoxOut efficacy could be found after few treatments D. dipsaci (LaMondia 1999). Diazinon 4E provided > 70% reduction in *A. fragaria* population in soil and leaves without phytotoxicology (Jagdale and Grewal 2002).

Dimethoate: Cygon efficacy (Mortality between 50-75%) increased with longer exposure periods on *A. fragaria* (An et al 2017).

Ethoprophos: Mocap 10G provided > 70% reduction in *A. fragaria* population in soil and leaves without phytotoxicology (Jagdale and Grewal 2002).

Extract of Allium sativum: Shows 42.2 % efiicacy on *A. ritzemabosi* control (Chalanska et al 2017).

Extract of Quillaja saponaria: Ineffective on *A. ritzemabosi* control (Chalanska et al 2017).

Grapefruit Seed Extract: provided good efficacy (100% mortality in 24 h exposure) on *A. fragaria* (An et al 2017).

Imidacloprid: Merit efficacy increased with longer exposure periods on *A. fragaria* (An et al 2017).

Insecticidal soap: provided 72% reduction in *A. fragaria* population and 61% in soil (Jagdale and Grewal 2002).

Isofenphos: Oftanol 2-S provided 50-70 % mortality in *A. fragaria* population in soil and (Jagdale and Grewal 2002).
Lambda-Cyhalothrin: Spectracide insect killer provide less effective (Mortality between 50-75%) on *A. fragaria* (An et al 2017).
Methiocarb: Mesorul 75WP provided 50-70 % mortality in *A. fragaria* population in soil and (Jagdale and Grewal 2002).
Neem Oil: Neem oil efficacy (Mortality between 50-75%) increased with longer exposure periods on *A. fragaria* (An et al 2017).
Neemakill: Cinnamon (32%), clove (8%), Thyme (15%): Neemakill provided good efficacy (100% mortality in 24 h exposure) on *A. fragaria* (An et al 2017).
Oregano Oil: Oregano Oil efficacy (Mortality between 50-75%) increased with longer exposure periods on *A. fragaria* (An et al 2017).
Oxamyl: Vydate 10G provided > 70% reduction in *A. fragaria* population in soil and leaves without phytotoxicology (Jagdale and Grewal 2002).
Permethrin: efficacy increased with longer exposure periods on *A. fragaria* (An et al 2017).
Peroxyacetic acid: ZeroTol provided good efficacy (100% mortality in 24 h exposure) on *A. fragaria* (An et al 2017). ZeroTol provided > 70% reduction in *A. fragaria* population in soil and leaves without phytotoxicology (Jagdale and Grewal 2002).
Potassium permanganate: $KMnO_4$ provided good efficacy (100% mortality in 24 h exposure) on A. fragaria (An et al 2017).
Sodium dichloroisocyanurate: NaDCC provided good efficacy (100% mortality in 24 h exposure) on *A. fragaria* (An et al 2017).
Sodium hypochlorite: Clorox provided good efficacy (100% mortality in 24 h exposure) on *A. fragaria* (An et al 2017).
Spirotetramat: Kontos efficacy increased with longer exposure periods on *A. fragaria* (An et al 2017)
Trichlofon: Dylox 80S provided > 70% reduction in *A. fragaria* population in soil and leaves without phytotoxicology (Jagdale and Grewal 2002).

Table 18. Summary of product efficacy by nematode and crop.

Note: Table entries are sorted by product, pathogen Latin name, and then by crop Latin name. Only those IR-4 experiments received by 4/17/2024 are included in the table below.

PR#	Product (Active Ingredients)	MOA Class	Target	Crop	Production Site	Researcher	State	Year	Application Type	Results
35446	Avid 0.15EC (Abamectin)	IRAC 6	Foliar Nematodes (Aphelenchoides sp.)	Plantain Lily (Hosta sp.) H. minnima	Greenhouse	Benson	NC	2000	Foliar	Some suppression of symptom develpoment with a heavy infestation; no injury with 8, 16, and 32 fl oz per 100 gal.
35446	Avid 0.15EC (Abamectin)	IRAC 6	Foliar Nematodes (Aphelenchoides sp.)	Plantain Lily (Hosta sp.) 'Warwick Edge'	Greenhouse	Benson	NC	2001	Foliar	No injury at 8, 16, and 32 fl oz per 100 gal; no significant differences in foliar nematode rating from nontreated controls.
35446	Avid 0.15EC (Abamectin)	IRAC 6	Foliar Nematodes (Aphelenchoides sp.)	Plantain Lily (Hosta sp.) 'Warwick Edge'	Greenhouse	Benson	NC	2001	Foliar	No reduction in nematode counts across treatments; no injury observed with 8, 16 and 32 fl oz per 100 gal after three weekly applications.
35418	Avid 0.15EC (Abamectin)	IRAC 6	Foliar Nematodes (Aphelenchoides sp.)	African Violet (Saintpaulia ionantha) 'Rhapsodie'	Greenhouse	Benson	NC	2000	Foliar	Significant reduction (suppression) of symptom development with light infestation; no injury with 8, 16, and 32 fl oz per 100 gal.
35418	Avid 0.15EC (Abamectin)	IRAC 6	Foliar Nematodes (Aphelenchoides sp.)	African Violet (Saintpaulia ionantha) 'H. Wendl'	Greenhouse	Benson	NC	2001	Foliar	Low nematode counts across treatments sono determination could be made; no injury observed with 8, 16 and 32 fl oz per 100 gal after three weekly applications.
35805	Bountify (MBI 306) (Burkholderia rinojensis strain A396)	FRAC NC & IRAC UNB	Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2021	Drench	Excellent population reduction with 2.96 ml/0.5 gal
34232	Bountify (MBI 306) (Burkholderia rinojensis strain A396)	FRAC NC & IRAC UNB	Nematode, Southern Root Knot (Meloidogyne incognita)	Shoeblackplant; Chinese hibiscus (Hibiscus rosa-sinensis) 'Seminole Pink'	Shadehouse/ Lath House	Cheng	HI	2020	Drench	Poor efficacy with 10 and 20 fl oz per 100 gal.

PR#	Product (Active Ingredients)	MOA Class	Target	Crop	Production Site	Researcher	State	Year	Application Type	Results
34058	Gem-21 (Gem-21)		Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2021	Drench	Good population reduction with 4.73 ml/0.5 gal
35803	GWN-12025 (GWN-12025)		Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2021	Drench	Excellent population reduction with 1st app: 6.14 ml/0.5 gal, 2nd app: 9.21 ml/0.5 gal; 3rd app: 6.14 ml/0.5 gal
33038	Indemnify (Fluopyram)	FRAC 7	Foliar Nematode, Strawberry (Aphelenchoides fragariae)	Fern, Hay-scented (Microlepia strigosa)	Greenhouse	Cheng	HI	2017	Foliar	Poor efficacy with 8.5 and 17.1 fl oz per 100 gal; minor to moderate phytotoxicity.
33037	Indemnify (Fluopyram)	FRAC 7	Foliar Nematode, Strawberry (Aphelenchoides fragariae)	Sage, Autumn (Salvia greggii) 'Raspberry Royale'	Greenhouse	LaMondia	CT	2016	Foliar	No significant differences between ESP 715 treatments and untreated check.
33593	Indemnify (Fluopyram)	FRAC 7	Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) ‘Going Bananas’	Field In-Ground	Quintanilla	MI	2018	Drench	Good control of root-knot and pin nematodes with 8.5 fl oz per 100 gal; comparable to fumigant treatment.
33593	Indemnify (Fluopyram)	FRAC 7	Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2023	Drench	Excellent population reduction with 1.26 ml/0.5 gal
34233	Indemnify (Fluopyram)	FRAC 7	Nematode, Southern Root Knot (Meloidogyne incognita)	Shoeblackplant; Chinese hibiscus (Hibiscus rosa-sinensis) 'Seminole Pink'	Shadehouse/ Lath House	Cheng	HI	2020	Drench	Standard product. Excellent efficacy with 8.5 fl oz per 100 gal; the only effective treatment.
36048	Indemnify (Fluopyram)	FRAC 7	Nematode (Pratylenchus sp)	Daylily (Hemerocallis sp.) 'Going Bananas'	Field In-Ground	Quintanilla	MI	2018	Drench	Excellent reduction of populations with 8.5 fl oz per 100 gal.
35804	MBI 203 SC2 (MBI 203)		Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2021	Drench	Good population reduction with 37.86 ml/0.5 gal
34231	MBI 203 SC2 (MBI 203)		Nematode, Southern Root Knot (Meloidogyne incognita)	Shoeblackplant; Chinese hibiscus (Hibiscus rosa-sinensis) 'Seminole Pink'	Shadehouse/ Lath House	Cheng	HI	2020	Drench	Poor efficacy with 128 and 256 fl oz per 100 gal.
32672	MBI 304 (Chromobacterium subtsugae)	FRAC BM02	Foliar Nematode, Strawberry (Aphelenchoides fragariae)	Fern, Hay-scented (Microlepia strigosa)	Greenhouse	Cheng	HI	2017	Foliar	Mediocre efficacy with 4 lb per 100 gal; no phytotoxicity.

PR#	Product (Active Ingredients)	MOA Class	Target	Crop	Production Site	Researcher	State	Year	Application Type	Results
33594	MBI 304 (Chromobacterium subtsugae)	FRAC BM02	Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Going Bananas'	Field In-Ground	Quintanilla	MI	2018	Drench	Good control of root-knot nematode with 2 gal per 100 gal; comparable to fumigant treatment. No control of pin nematode
36049	MBI 304 (Chromobacterium subtsugae)	FRAC BM02	Nematode (Pratylenchus sp)	Daylily (Hemerocallis sp.) 'Going Bananas'	Field In-Ground	Quintanilla	MI	2018	Drench	No impact on populations with 2 gal per 100 gal.
33090	MBI 305 (Burkholderia rinojensis strain A396)	FRAC BM01 & IRAC UNB	Foliar Nematode, Strawberry (Aphelenchoides fragariae)	Fern, Hay-scented (Microlepia strigosa)	Greenhouse	Cheng	HI	2017	Foliar	Mediocre efficacy with 2 gal per 100 gal; no phytotoxicity.
33595	MBI 305 (Burkholderia rinojensis strain A396)	FRAC BM01 & IRAC UNB	Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Going Bananas'	Field In-Ground	Quintanilla	MI	2018	Drench	Good control of root-knot nematode with 4 lb per 100 gal; comparable to fumigant treatment. Poor pin nematode control.
36050	MBI 305 (Burkholderia rinojensis strain A396)	FRAC BM01 & IRAC UNB	Nematode (Pratylenchus sp)	Daylily (Hemerocallis sp.) 'Going Bananas'	Field In-Ground	Quintanilla	MI	2018	Drench	No impact on populations with 4 lb per 100 gal.
35894	NemaFix (chitatrol)		Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2023	Drench	Excellent population reduction with 2.25 ml/32 oz
35806	NMG-787 (NMG-787)		Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2021	Drench	Excellent population reduction with 1.12 ml/2 pints
34547	NMG-787 (NMG-787)		Nematode, Southern Root Knot (Meloidogyne incognita)	Shoeblackplant; Chinese hibiscus (Hibiscus rosa-sinensis) 'Seminole Pink'	Shadehouse/ Lath House	Cheng	HI	2020	Drench	Poor efficacy with 5.7 and 11.4 oz per 100 gal applied at transplant.
35807	RD00AS-1 (BW159) (BW159)		Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2023	Drench	Some population reduction with 18.93 ml/0.5 gal
35808	Reklemel (fluazaindolizine)		Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2023	Drench	Excellent population reduction with 1.98 ml/295.74 ml

PR#	Product (Active Ingredients)	MOA Class	Target	Crop	Production Site	Researcher	State	Year	Application Type	Results
34046	RootShield Plus WP (aka BW240) (Trichoderma harzianum T-22 + Trichoderma virens G-41)	FRAC BM02	Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2021	Drench	Excellent population reduction with 1.134 g/0.5 gal
34230	RootShield Plus WP (aka BW240) (Trichoderma harzianum T-22 + Trichoderma virens G-41)	FRAC BM02	Nematode, Southern Root Knot (Meloidogyne incognita)	Shoeblackplant; Chinese hibiscus (Hibiscus rosa-sinensis) 'Seminole Pink'	Shadehouse/ Lath House	Cheng	HI	2020	Drench	Poor efficacy with 6 and 8 oz per 100 gal.
35813	Tril-21 (Thyme oil)	FRAC BM01	Nematode, Northern Root Knot (Meloidogyne hapla)	Daylily (Hemerocallis sp.) 'Pardon Me'	Field In-Ground	Quintanilla	MI	2021	Drench	No population reduction with 4.73 ml/0.5 gal

Appendix 1: Contributing Researchers

Dr. Mike Benson (*retired*)	NC State University Dept. of Plant Pathology Raleigh, NC 27695
Dr. Zhiqiang Cheng	University of Hawaii Honolulu, HI 96822
Dr. James LaMondia (*retired*)	Connecticut Agricultural Experiment Station Windsor, CT 06095
Dr. Marisol Quintanilla	Michigan State University East Lansing, MI 48824