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IR-4 Ornamental Horticulture Program
Nematode Efficacy: A Literature Review

Ditylenchus dipsaci
Aphelenchoides fragariae
Aphelenchoides ritzemabosi

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Abstract

Foliar nematodes cause huge damage not only in food crops but also on popular ornamental horticulture plants. This summary includes research from nematode efficacy experiments on ornamental horticulture crops during 1999 to 2017. The 36 products tested either as soil or foliar treatments were from different mode-of-action groups and included 26 chemicals, 9 plant oils, and 1 bacterial biopesticide. Products with good efficacy included: 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

The host range of foliar nematodes is wide affecting various ornamentals, and causing economic losses in greenhouses, nurseries, and residential and commercial landscapes. Foliar nematodes feed on mesophyll cells causing chlorosis which eventually turns into necrosis which is a serious problem on ornamentals. This summary test efficacy of 36 active ingredients in control foliar nematodes on ornamentals.

Materials and Methods

From 1999 to 2017, numerous products representing 36 active ingredients (Table 1) were tested as foliar or soil applications against 3 foliar nematode species known to attack ornamental horticulture crops. Nematodes tested include *Ditylenchus dipsaci*, *Aphelenchoides fragariae*, and *Aphelenchoides ritzemabosi*.

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

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 from 1999 to 2014.

Product	Active Ingredient(s)	Manufacturer	Rate(s) Tested		# Trials
A14658C	A14658C	Syngenta	Foliar	2 pt per 100 gal	1
				4 pt per 100 gal	4
A91800A	A91800A		Foliar	1 oz per 100 gal	2
Abamectin + *Allium sativum*	Abamectin + *Allium sativum*		Foliar	0.15% + 2.5%	1
Avid 0.15 EC	Abamectin	Syngenta	Foliar	8 oz per 100 gal	3
KnoxOut GH	Diazinon	Cerexagri	Foliar	100 oz per 100 gal	3
Mesurol	Methiocarb	Gown Co.	Foliar	60 oz per 100 gal	3
Clove extract	Syzygium aromaticum	Wal-mart	Foliar	11 oz per 100 gal	2
Deny	Burkholderia cepacia	CCT Corp.	Foliar	2.75 oz per 100 gal	2
Diazinon 4E	Diazinon	Terra International Inc	Foliar	1.34 oz per 100 gal	2
Dylox 6.2G	Trichlofon GR	Bayer	Foliar	0.25 oz per 100 gal	2
Dylox 80S	Trichlofon	Bayer	Foliar	1.1 oz per 100 gal	2
Extract of *Allium sativum*	Extract of *Allium sativum*		Foliar	2.50%	1
Extract of *Quillaja saponaria*	Extract of *Quillaja saponaria*		Foliar	10%	1
Insecticidal soap	Insecticidal soap	The Murphy-Phoenix Co	Foliar	13.2 oz per 100 gal	2
Merit 0.5G	Imidacloprid GR	Bayer	Foliar	0.09 oz per 100 gal	2
Merit 75WP	Imidacloprid	Bayer	Foliar	0.15 oz per 100 gal	2
Mesorul 75WP	Methiocarb	Gown Co.	Foliar	0.68 oz per 100 gal	2
Mecap	Ethoprophos GR	Phone-Poulenc AG	Foliar	2.64 oz per 100 gal	2
Oftanol	Isofenphos	Bayer	Foliar	2.4 oz per 100 gal	2
Orthene	Acephate	Whitmire Micro-Gen	Foliar	0.44 oz per 100 gal	2
Vydate 10G	Oxamyl GR	Miller Chem & Fertilizer	Foliar	0.22 oz per 100 gal	3
Zero Tol	Peroxyacetic Acid	BioSafe System	Foliar	5.46 oz per 100 gal	2
Ammonia	Ammonia hydroxide (25 g/l)	FISHER SCIENTIFIC	Soil	2.56 oz per gal soil	1
Clothianidin	Clothianidin (40 g/l)	FISHER SCIENTIFIC	Soil	0.2 lb per 100 gal	1
$KMnO_4$	Potassium permanganate (40 g/l)	AMRESCO	Soil	0.5 lb per 100 gal	1
NaDCC	Sodium dichloroisocyanurate (40 g/l)	SIGMA-ALDRICH	Soil	0.5 lb per 100 gal	1
Nemakill	Cinnamon (32%), Clove (8%), Thyme (15%)	SISCO	Soil	0.64 oz per gal soil	1
Pylon	Chlofenapyr (240 g/l)	BASF	Soil	1.28 oz per gal soil	1
Spirotetramat + *Allium sativum*	Spirotetramat + *Allium sativum*		Foliar	0.075% + 2.5%	1
ZeroTol	Peroxyacetic acid (270 g/l)	BioSafe System	Soil	1.28 oz per gal soil	1

Results

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 2). 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 3).

Table 2. 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.

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 4) While methiocarb reduced *A. fragariae* densities in Lamium, it was not as efficacious as diazinon or abamectin after the second biweekly application.

Table 3. 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 4. 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 5). 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 6). 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 5, Table 6) and soil (Table 7). 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 5. 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 6. 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 7. 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 8).

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 8. Effect of selected products applied as soil drench on *Aphelenchoides fragariae* population in pots with hosta.

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.

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.

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).