need to consider the role of micro-nutrients in evaluating plant response to fungicides.

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CONTROL OF BUD NEMATODE ON STRAWBERRY[1]

S. J. Locascio, G. C. Smart, Jr., and M. E. Marvel[2]

Abstract

Effective control of the bud nematode (*Aphelenchoides besseyi*) on strawberry plants was obtained with a 5 minute dip in a 300 ppm solution of zinophos. Dips for longer duration or at higher concentrations were often phytotoxic. However, good quality plants safely tolerated treatments of up to 15 minutes in 300 ppm zinophos. Dip treatments up to 600 ppm parathion for 30 minutes were ineffective in controlling the bud nematode.

Complete bud nematode control was difficult to obtain by nematicide applications on infested plants growing in the field. Population reductions and an improvement in visual plant growth were obtained with a number of nematicides including 10 and 20 pounds of Niagara 10242, 3 pounds of Bay 25141, and 30 pounds of Sarolex per acre. Complete control and excellent plant recovery were provided only with Bay 25141 at rates of 10 and 20 pounds per acre.

Introduction

The bud nematode, *Aphelenchoides besseyi*, injures strawberry plants by feeding on cellular contents of leaf buds causing a disorder known under several common names such as: summer dwarf, French bud, blind plant and crimp (4). It is commonly spread from area to area in movement of nursery plants (1). Small populations of this ectoparasite increase rapidly during hot, humid summer weather, and infested plants are unthrifty and produce few daughter plants. Brooks *et al.* (1) observed that losses were as much as 75% in individual plant nurseries and that infested plants produced less fruit than healthy plants. Early rogueing helps to reduce the spread of the bud nematode in the plant nursery but does not eliminate it. Even though parathion has been recommended for field control, limited tests with parathion sprays have provided only partial control (3, 5). Hot-water treatment of infested plants is effective (6), but time and temperature of treatment are critical and plants are often injured.

The purposes of the experiments reported here were to determine if an effective dip treatment of bare-rooted plants and a field treatment could be developed to control the bud nematode.

Experimental Procedure

Three greenhouse dip-treatment experiments were conducted in the summer of 1966 at Gainesville, Florida. In the first study, initiated June 14, bud nematode infested 'Florida Ninety' strawberry plants obtained from a commercial field were dipped in 300 and 600 ppm solutions of zinophos (O,O-diethyl 0-2-pyrazinyl phosphorothioate) or parathion (O, O-diethyl, O-p-nitrophenyl phosphorothioate for 15 and 30 minutes. For each treatment, 24 plants were used. Immediately after treatment 12 of the plants were rinsed for 2 minutes in a water solution containing 5 ml/l of liquid detergent (Ivory). Six plants from each treatment were transplanted,

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[1]Florida Agricultural Experiment Stations Journal Series No. 2539.

[2]Associate Horticulturist, Vegetable Crops Department; Assistant Nematologist, Entomology Department; Associate Vegetable Crops Specialist, Vegetable Crops Department, IFAS, University of Florida, Gainesville.

2 per 6-inch pot, and placed in the greenhouse for phytotoxicity evaluations and future bud nematode counts. The remaining 6 plants were processed immediately for bud nematodes by the Waring Blendor-Baermann funnel technique (2). In the second dip test, initiated June 20, 32 infested plants were dipped in solutions of the two chemicals for 5, 10 and 15 minutes. One half the treated plants received a water rinse for 2 minutes. Eight plants were processed for bud nematodes and 8 plants were transplanted, 4 per 6-inch pot, and placed in the greenhouse. In the third study, initiated June 29, the phytotoxicity of zinophos treatments of 300 and 600 ppm for 5, 10 and 15 minute dips was evaluated using plants showing bud nematode symptoms and those showing no symptoms obtained from the same field. All plants were rinsed for 2 minutes in water after treatment. Numbers of plants treated were the same as in experiment 2.

In all experiments, the plants placed in the greenhouse were grown at the relatively high ambient daytime temperatures of 80-100° F prevailing during the test periods. Visual phytotoxicity ratings were made 1 to 4 days after treatment and again a month after treatment at which time the remaining plants were processed for bud nematodes.

Two field experiments were conducted *in a* commercial strawberry field infested with bud nematodes. 'Florida Ninety' plants that had grown through a fruiting season were used. Polyethylene mulch was removed, beds cultivated and plants were treated with various nematicides using plots 4 x 15 feet or 4 x 18 feet with 4 replications. In addition to zinophos and parathion, the following nematicides were evaluated: Sarolex (O,O-diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate), Niagara 10242 (2,3-dihydro-2, 2-dimethyl 7-benzofuranyl N-methyl-carbamate), Bay 25141 (O-O-diethyl O-p-(methyl-sulfinyl) phenyl phosphorothioate), Mocap (O-ethyl S, S-dipropyl phosphorodithioate), and TH 285-N (4-chloropyridine-N-oxide). The nematicides, dates, rates and fomulations are shown in Table 4. Nematicides were applied non-directed as a water spray at the rate of 68 gallons of solution per acre or as granules.

Results and Discussion

Greenhouse Studies: Results from the first experiment are summarized in Table 1. Zinophos at 300 ppm was nearly as effective as 600 ppm in control of bud nematodes, and there was little difference between 15 and 30 minute treatments. Parathion at both rates was relatively

Table 1. Effect of concentration and time of zinophos and parathion dip treatments and detergent rinse on strawberry plant vigor and control of bud nematode. Treated June 14, 1966.

Treatment		No Rinse				Detergent Rinse			
		Vigor rating[1]		Bud Nematodes per 6 buds		Vigor rating		Bud Nematodes per 6 buds	
Conc ppm	Time min	6/17	7/14	6/17	7/14	6/17	7/14	6/17	7/14
0	15	10	10	8	3	9	10	2	3
0	30	9	10	12	0	9	10	1	0
Zinophos									
300	15	10	10	0	0	9	10	2	0
300	30	7	7	0	0	5	0	0	-
600	15	5	0	0	-	5	0	0	-
600	30	3	0	0	-	3	0	0	-
Parathion									
300	15	9	10	1	8	9	7	7	23
300	30	9	3	2	0	7	2	0	0
600	15	7	5	5	0	7	4	0	0
600	30	4	0	11	-	4	0	5	-

[1]Best growth rated-10, slight injury-8, moderately severe injury-6, severe injury-4 and death-0.

ineffective in eliminating the nematode. Within 24 hours after treatment phytotoxicity symptoms were observed on some plants put into the greenhouse. Severe injury was noted on all plants treated with 600 ppm of either chemical; however, the 15 minute dips were less phytotoxic than the 30 minute treatments. Zinophos treatments of 300 ppm for 15 minutes produced little if any damage. The 30 minute dip-treatments generally produced considerable injury and were more severe in plants receiving the detergent rinse. Effects of the 300 ppm treatments with parathion on plant vigor were similar to 300 ppm zinophos treatments. Apparently, the detergent reduced the surface tension and allowed more penetration and absorption of the chemicals. This is indicated by the generally lower number of nematodes in treatments receiving a detergent rinse. One month after treatment, growth of plants treated with 300 ppm zinophos for 15 minutes was equal to or better than the non-treated plants. This treatment had also provided complete bud nematode control. Plants treated for longer periods or at higher concentrations were severely injured or killed.

Zinophos dips of 300 or 600 ppm for 5, 10 or 15 minutes completely eliminated bud nematode from treated plants in the second test (Table 2). Poor control was obtained with all parathion treatments. Water rinse had little effect on phytotoxicity or nematode control. Treatment with zinophos for over 5 minutes at 600 ppm was extremely phytotoxic. At the lower zinophos concentration, treatment effects on plant vigor were erratic.

In both of the above experiments, plants used were of poor quality because only plants showing bud nematode symptoms were selected. Such poor quality plants grown in a relatively hot greenhouse would be expected to tolerate treatment less than would better quality plants

Table 2. Effect of concentration and time of zinophos and parathion dip treatments and water rinse on strawberry plant vigor and control of bud nematode. Treated June 20, 1966.

Treatment		No Rinse				Water Rinse[2]			
		Vigor rating[1]		Bud Nematodes per 8 buds		Vigor rating		Bud Nematodes per 8 buds	
Conc ppm	Time min	6/22	7/15	6/22	7/21	6/22	7/15	6/22	7/21
0	5	10	8	37	1				
0	10	10	5	31	3				
0	15	10	9	33	8				
Zinophos									
300	5	7	10	0	0	8	3	0	0
300	10	7	5	0	0	10	8	0	0
300	15	6	5	0	0	6	7	0	0
600	5	6	8	0	0	6	9	0	1
600	10	2	4	0	0	3	3	0	0
600	15	1	0	0	-	2	3	0	0
Parathion									
300	5	8	9	29	3	9	10	37	2
300	10	8	5	12	2	9	5	14	1
300	15	7	6	6	0	8	6	10	2
600	5	7	2	7	0	7	8	10	0
600	10	7	5	6	0	6	6	14	0
600	15	4	4	6	0	6	4	5	3

[1] See Table 1 for vigor ratings.
[2] Rinsed for two minutes in running tap water.

grown in the field. A third experiment was initiated on June 29, to further evaluate the effects of zinophos on bud nematode control and on the phytotoxicity to better quality plants (Table 3). Untreated plants not showing symptoms had an average nematode count of 1.2 per plant bud; plants showing symptoms had an average of 8. Complete bud nematode control was obtained at both evaluation dates with 300 and 600 ppm of zinophos with 5, 10 and 15 minute dips.

All treatments were less phytotoxic than in the previous tests probably due to the use of better quality plants and to growing the plants in a cooler greenhouse (maximum temperature 90°). Zinophos treatments of 300 ppm for 5 to 15 minutes produced little initial injury in either plant group, while slight to moderately severe injury resulted from the 600 ppm treatments. One month after treatment with 300 ppm of zinophos, growth of plants showing no symptoms was excellent; growth of plants that had shown symptoms when treated was poorer.

Field Tests: Four nematicides applied as liquids and 1 as granules were evaluated in Test I (Table 4). Two weeks after treatment, bud nematode counts indicated that good control was obtained with granular applications of zinophos at 1.5 and 3.0 pounds per *acre, and* with foliar applications of zinophos at 1.5 pounds, Bay 25141 at 0.75 and 1.5 pounds, and Niagara 10242 at 1 pound. No control was provided with parathion sprays of 1.5 or 3.0 pounds per acre. Counts made 6 weeks after treatment showed very little bud nematode control with all nematicides except Niagara 10242 at 1 pound per acre.

In Test II (Table 4), somewhat higher rates of liquid and granular formulations of several nematicides were evaluated. Four weeks after treatment, reduction in bud nematode counts was provided by at least 1 rate of all nematicides, generally the higher rate. Only Bay 25141 provided complete control. The apparent better control provided by the lower rates of parathion and Mocap was probably due to variations in nematode infestations.

Seven weeks after treatment, Bay 25141 at 10 and 20 pounds per acre continued to provide complete control of the bud nematode. Plant recovery from poor unthrifty growth was excellent. Nematode counts were reduced and plant recovery was good in plots receiving applications of 20 pounds of Niagara 10242, 3 pounds of Bay 25141, and 30 pounds of Sarolex as compared to untreated plots. Nematode

Table 3. Effect of zinophos concentration, length of dip treatment and plant quality on strawberry plant vigor and bud nematode control. Treated June 29, 1966.

Treatment		No symptoms[1]				Symptoms			
		Vigor rating[2]		Bud nematode per 8 buds		Vigor rating		Bud nematode per 8 buds	
Conc ppm	Time min	6/30	8/1	6/29	8/1	6/30	8/1	6/29	8/1
0	5	10	10	8	12	10	8	66	8
0	10	10	10	10	0	10	8	71	2
0	15	10	10	11	16	10	8	64	9
Zinophos									
300	5	10	10	0	0	9	7	0	0
300	10	9	10	0	0	10	5	0	0
300	15	9	10	0	0	9	0	0	-
600	5	7	10	0	0	8	6	0	0
600	10	7	8	0	0	7	6	0	0
600	15	7	8	0	0	7	7	0	0

[1] Plants showing no visual bud nematode symptoms were of good quality while those showing symptoms were of poor quality.

[2] For vigor ratings see Table 1.

Table 4. Effects of various nematicides on the control of bud nematode on strawberry plants. Field tests established on June 16, and August 2, 1966.

Treatment		Bud nematodes				
		Test I		Test II		
Nematicide	Rate lb/A	No. per 6 buds 6/29	8/2	No. per 4 buds 8/31	9/22	Vigor[1] 9/22
Zinophos 4EC	.75	292	57			
	1.5	24	10	12	28	7
	3.0			7	26	6
Zinophos 10G	1.5	2	28			
	2.0			2	21	5
	3.0	10	38			
	4.0			1	18	7
Parathion 4EC	1.5	158	133			
	3.0	140	17	1	12	6
	6.0			16	22	6
Nia 10242 50 WP	.5	91	27			
	1.0	15	1	6	12	7
	2.0			10	19	7
Nia 10242 10 G	10.0			5	4	8
	20.0			1	10	10
Bay 25141 6 EC	.75	11	11			
	1.5	1	17	0	11	6
	3.0			1	7	8
Bay 25141 10 G	10.0			0	0	9
	20.0			0	0	10
Sarolex 5 G	15.0			9	7	7
	30.0			4	5	8
Mocap 5 G	10.0			1	46	6
	20.0			7	22	5
TH 285-N 15 G	15.0			11	20	5
	30.0			3	8	7
Check		61	22	13	54	5

[1]As compared with the check, best plant recovery = 10, good recovery = 8, poor recovery = 6, no recovery = 5.

counts were also low with applications of 30 pounds of TH 285-N but plant recovery was poor.

Because most of these chemicals are effective insecticides as well as nematicides, the plant vigor rating probably reflects effectiveness against other pests in addition to the bud nematode.

Field applications of nematicides appear to be less effective in eliminating the bud nematode than by dipping bare-rooted plants. Dip-treatments for 5 minutes in 300 ppm solutions of zinophos completely controlled the bud nematode. Under field conditions, spray applications of zinophos up to 3 pounds per acre in 68 gallons of solution provided only partial control. This rate is approximately 5000 ppm zinophos. Bay 25141 at 10 and 20 pounds per acre applied as granules provided complete bud nematode control with excellent plant recovery

while 3.0 applied as a foliar spray provided only fair control with good plant recovery. In past studies (3), both zinophos and Bay 25141 at the rate of 3 pounds per acre in 300 gallons of solution applied to run-off (plant saturation) appeared to provide excellent bud nematode control. Parathion similarly applied was relatively ineffective. It is probable that the greater amount of solution used in the earlier work (300 vs. 68 gallons) provided a more complete coverage and allowed better penetration of the tightly compacted plant buds where bud nematode populations are the highest.

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THE EFFECTS AND CONTROL OF STING AND STUBBY-ROOT NEMATODES ON ONIONS

H. L. RHOADES[1]

ABSTRACT

Pathogenicity experiments, conducted in 6-inch pots in the greenhouse on seed grown onions, disclosed that in the presence of initial infestations of 500 sting nematodes (*Belonolaimus longicaudatus*), or 500 to 1000 stubby-root nematodes (*Trichodorus christiei*), severe damaged occurred. Both top and root weights were reduced; the infected roots had conspicuous secondary branching and stubby-root symptoms. Lesions were present on those roots fed upon by the sting nematode, but not on those parasitized by the stubby-root nematode.

Nematocidal experiments in the field on Leon fine sand with D-D applied at either 20 or 30 gallons per acre, Zinophos at 4 pounds per acre, and Zinophos + Thimet at 2 pounds per acre of each chemical, significantly increased yields of green onions in soils heavily infested with sting and stubby-root nematodes but not in the presence of light infestations.

INTRODUCTION

A field of poorly growing onions being produced for the sale of green onions near Oviedo, Florida, was examined in June, 1964. The roots of these onions were severely stunted with considerable secondary branching, and had short swollen tips with a yellowish discoloration. Examination of soil samples taken from around the stunted onions disclosed the presence of a high infestation of the stubby-root nematode, *Trichodorus christiei*. Onions grown on the Central Florida Experiment Station farm in the presence of a mixed population of sting nematodes, *Belonolaimus longicaudatus*, and *T. christiei*, had similar symptoms but with root lesions and decay in addition.

Hoff and Mai (3) demonstrated in greenhouse experiments that *T. christiei* was capable of producing the stubby-root symptoms they previously had observed on onions growing in muck soils in New York State. Jensen (5, 6) and Jensen and Konicek (7) reported *Trichodorus allius* to be injurious to onions in Oregon, particularly in peat soils, and, according to Knierim (8), stubby-root nematodes are also a pest of onions in Michigan. Thomason, et al. (10), in field tests in California found that control of *T. christiei*, *Meloidogyne hapla*, and *Pratylenchus scribneri* by soil fumigation greatly increased the yield of dry onions.

Christie (1) reported that *B. longicaudatus* had been found under circumstances indicating that they were causing injury to onions. However, experimental proof of the pathogenicity of this nematode to onion appears not to have been recorded.

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[1]Assistant Nematologist, Central Florida Experiment Station, Sanford.