Occurrence and Control of *Ditylenchus dipsaci* Associated with Dieback of *Phlox subulata*

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ABSTRACT

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Foliage dieback can be widespread in commercial production of *Phlox subulata* in Michigan. Symptoms are consistently associated with high population densities of an onion-phlox hybrid race of *Ditylenchus dipsaci*, the bulb and stem nematode. Only limited tolerance to *D. dipsaci* was detected in field and greenhouse evaluations of commercial cultivars of *P. subulata*. Applying aldicarb to the soil at planting or oxamyl to the foliage after planting significantly reduced field populations of *D. dipsaci* and alleviated foliage dieback of *P. subulata*. Control of *D. dipsaci* was sustained during the first growing season, throughout winter storage, and for most of the second growing season.

Southwestern Michigan is an important commercial production region for perennial ornamental plants. In recent years, foliage dieback has caused significant commercial losses of creeping phlox (*Phlox subulata* L.), a popular ground cover. *P. subulata* is propagated from stock plants, and shoot length and fresh weight are important indexes of plant quality. Reduced plant growth causes economic losses in quality and quantity of plants produced.

Populations of an onion-phlox hybrid race of the bulb and stem nematode, *Ditylenchus dipsaci* (Kühn, 1857) Filipjev, 1936, were recovered from shoot tissue of diseased *P. subulata* and associated soil. The objectives of this study were to determine the extent of *D. dipsaci* infestation in four commercial nurseries, evaluate cultivars of *P. subulata* for tolerance to *D. dipsaci*, and develop a control program for *D. dipsaci* associated with *P. subulata* in southwestern Michigan.

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MATERIALS AND METHODS

Nematode survey. Six plants (three healthy and three with dieback symptoms) were selected at random from each of 11 *P. subulata* cultivars growing in two commercial nurseries. Each plant, including roots and surrounding soil, was placed in a plastic bag and stored at 5–7 C. An additional eight plants (four healthy and four diseased) were selected at random from three cultivars from two other nurseries and stored in the same manner.

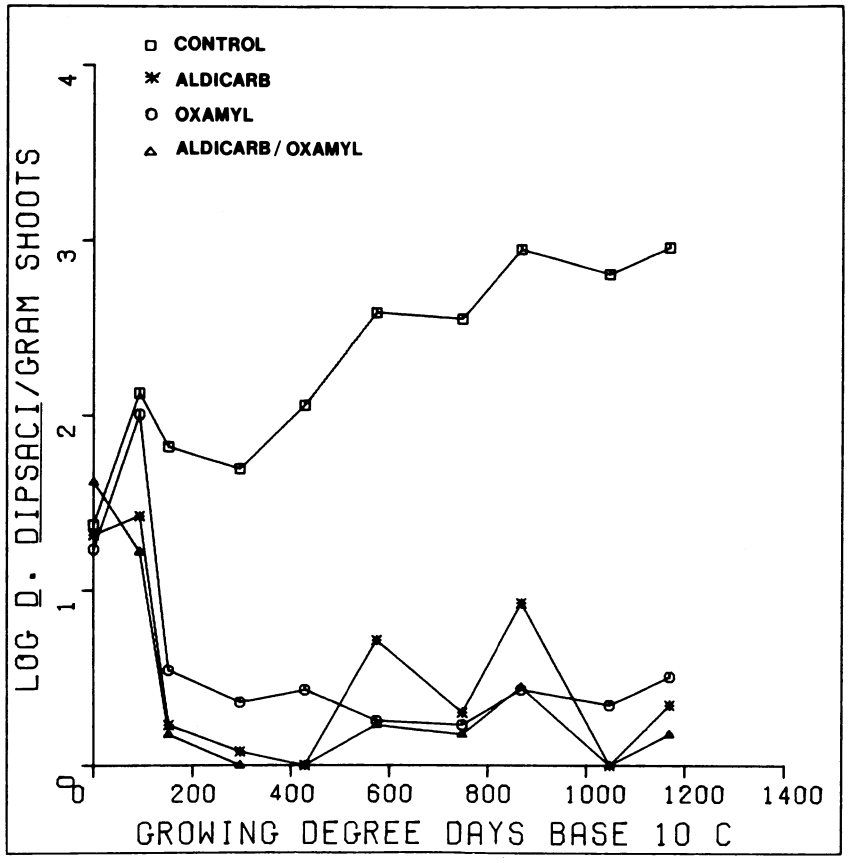

Fig 1. Population dynamics of *Ditylenchus dipsaci* associated with *Phlox subulata* treated with four nematicide treatments: untreated control, aldicarb (0.67 g/m^2) incorporated into the soil, oxamyl (1.19 ppm) applied to the foliage, or both oxamyl and aldicarb.

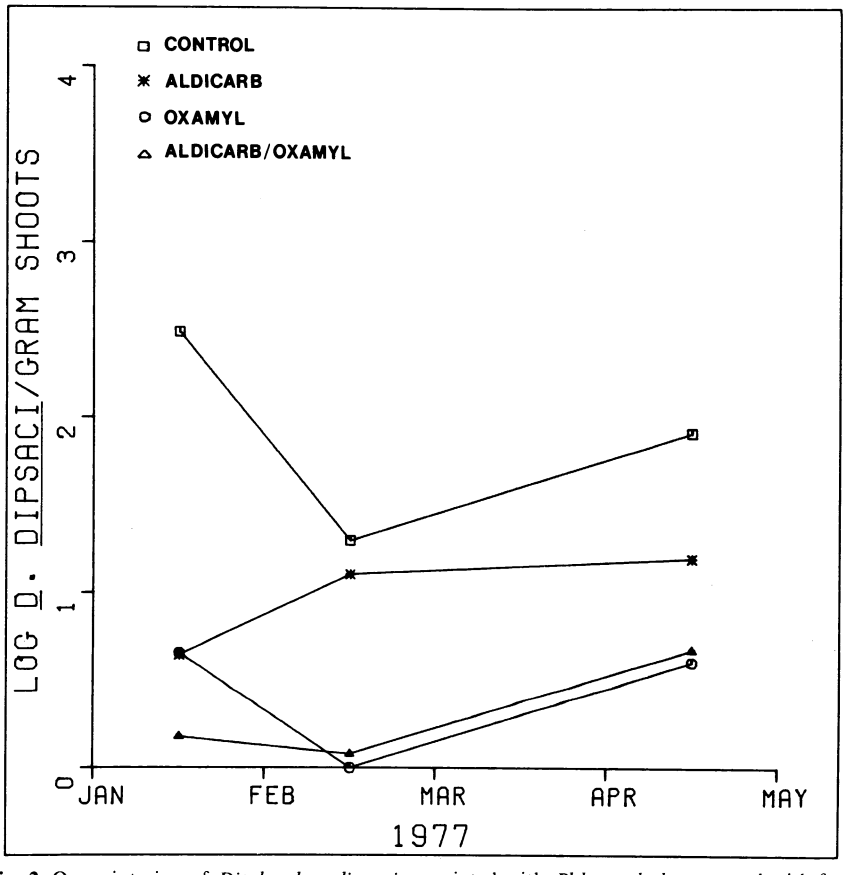

Fig. 2. Overwintering of *Ditylenchus dipsaci* associated with *Phlox subulata* treated with four nematicide treatments: untreated control, aldicarb (0.67 g/m^2) incorporated into the soil, oxamyl (1.19 ppm) applied to the foliage, or both oxamyl and aldicarb.

To recover soil populations of *D. dipsaci*, the centrifugal-flotation technique (3) was used. To extract nematodes from shoot and root samples, the shaker-incubation technique (2) was used for 48 hr at 125 rpm. In both cases, nematodes were collected on a screen with 38-μm openings and stored for at most 2 wk in water at 5–7 C for microscopic observation.

Cultivar evaluation. Four *P. subulata* cultivars (White Delight, Emerald Pink, Emerald Blue, and Atropurpurea) were evaluated under greenhouse conditions for susceptibility to *D. dipsaci*. Three cuttings per pot were planted in field soil taken from an infested planting in Hudsonville, MI, containing *D. dipsaci* (45 per 100 cm^3 of soil) or in steamed soil from the same source. Four replicates of each treatment were analyzed for occurrence of *D. dipsaci* and disease symptoms after 11, 29, and 48 days of growth.

Nematode control. Two nematicides, aldicarb (Temik 10G) and oxamyl (Vydate L), were evaluated for control of *D. dipsaci* associated with *P. subulata*. Commercial stock plant divisions of *P. subulata* 'Emerald Pink' were planted in a 54.9 × 4.9 m plot with a two-row mechanical planter. Soil in the naturally infested plot had been prepared to seedbed condition. Each division contained about 15–20 cm of shoot tissue and 5–8 cm of root tissue.

The following nematicide treatments were replicated six times in a completely randomized design: 1) untreated control, 2) aldicarb (0.67 g/m^2), 3) oxamyl (1.19 ppm), and 4) both oxamyl and aldicarb. Aldicarb was applied to the soil at planting with a manually operated granular applicator and incorporated to a depth of 3–5 cm. Oxamyl was applied as a foliar spray with a manual sprayer delivering 20 cm^3/sec at 0.7 kg/cm^2

Table 1. *Ditylenchus dipsaci* populations recovered from soil and shoot tissue of diseased and healthy *Phlox subulata* collected in a survey of commercial nurseries in Michigan, 1975

Cultivar	*D. dipsaci* (no. per 100 cm^3 of soil plus 1 g of shoot tissue)[a]	
	Diseased plants	Healthy plants
Atropurpurea	139 (45)	4 (1)
Blue Hills	19 (10)	60 (39)
Crimson Beauty	54 (33)	4 (1)
Emerald Blue	63 (38)	1 (1)
Emerald Pink	1,066 (147)	15 (9)
Pink Perfection	2 (1)	1 (1)
Red	219 (64)	9 (5)
Red Wing	133 (91)	2 (2)
Rosea	3 (1)	0 (0)
Scarlet Flame	13 (7)	10 (7)
White Delight	93 (25)	2 (2)
Mean	164 (147)	19 (39)

[a] Numbers in parentheses are standard deviations.

biweekly for 14 wk during the first growing season and once (treatment 3 only) late in the second growing season. Shoot tip samples (4–6 cm) were collected biweekly and monthly during the first and second years, respectively. The plants were stored during the winter at 5–7 C and transplanted the following spring.

Nematode population data were expressed in relation to accumulative degree days according to the procedure of Baskerville and Emin (1).

RESULTS

Nematode survey. On average, 164 *D. dipsaci* were recovered per gram of diseased *P. subulata* shoot tissue, compared with 19 per gram of symptom-free plant tissue (Table 1). The extent of symptoms and population densities of *D. dipsaci* varied widely among cultivars. In general, fewer *D. dipsaci* were associated with cultivars Pink Perfection and Rosea than with other cultivars. Populations of *D. dipsaci* were significantly correlated with dieback ($P = 0.05$) and with chlorosis, necrosis, and stunting.

Cultivar evaluation. Cultivars of *P. subulata* grown in field soil were generally smaller in plant height and shoot fresh weight than those grown in steamed soil (Table 2). The most growth retardation was associated with Atropurpurea and the least with Emerald Blue. Plant survival rates also reflected these differences in growth. Atropurpurea and Emerald Pink plants grown in field soil all died. White Delight had 25% plant mortality, and no Emerald Blue plants died. These data are consistent with observations of the cultivars grown in commercial nurseries.

D. dipsaci was extracted from tissue of all four cultivars grown in field soil. The populations of *D. dipsaci* were inversely related to plant growth. Emerald Pink supported the highest population densities of *D. dipsaci* and had the least growth of surviving plants in field soil (Table 2).

High population densities of *D. dipsaci* were associated with significant retardation of the ontogeny of *P. subulata*. While plant height tended to increase over time in steamed soil, no such trend was observed among treatments in field soil.

Nematode control. Aldicarb, oxamyl, and the combined treatment significantly (LSD = 1.67, $P = 0.05$) reduced population densities of *D. dipsaci* during the first growing season (Fig. 1). The treatments were equally effective in controlling nematode populations and suppressing dieback symptoms. Populations of *D. dipsaci* in the untreated plots increased throughout the first growing season (Fig. 1). Check plants deteriorated severely and did not survive winter storage. *D. dipsaci* nematodes were recovered from stored plants produced under all treatments (Fig. 2). In the second year, the populations of *D. dipsaci* in untreated plants overwintering in the field increased slightly and then decreased (Fig. 3). The untreated plants showed severe dieback symptoms.

Aldicarb reduced population densities of *D. dipsaci* 4 wk after application (Fig. 1). Population densities of *D. dipsaci* increased, then fell to low, oscillating levels. Plants given this treatment did not show symptoms of dieback. They were healthy at the end of the first growing season, with extensive vegetative growth. Although the *D. dipsaci* population density increased slightly in winter storage (Fig. 2), the plants remained healthy. During the second growing season, population density first rose, associated with plants overwintering in the field, then declined to a low, oscillating level (Fig. 3).

Populations of *D. dipsaci* associated with the oxamyl treatment decreased before the second foliar application (Fig. 1). Applications of oxamyl at 14-day intervals suppressed the nematode populations throughout the growing

Table 2. *Phlox subulata* shoot height and mortality and *Ditylenchus dipsaci* recovery from field or steamed soil after 48 days of growth

Soil Cultivar	Shoot height[a,b] (mm)	Plant mortality[b] (%)	*D. dipsaci* per gram of shoot (fresh weight)
Field			
White Delight	30*	25	5
Emerald Pink	20	100	9
Emerald Blue	50	0	2
Atropurpurea	0*	100	6
Steamed			
White Delight	70*	0	0
Emerald Pink	50	25	0
Emerald Blue	70	0	0
Atropurpurea	50*	0	0

[a] Within-cultivar means marked with an asterisk are significantly ($P = 0.05$) different from each other.

[b] Data are averages of four replicates (three cuttings per replicate).

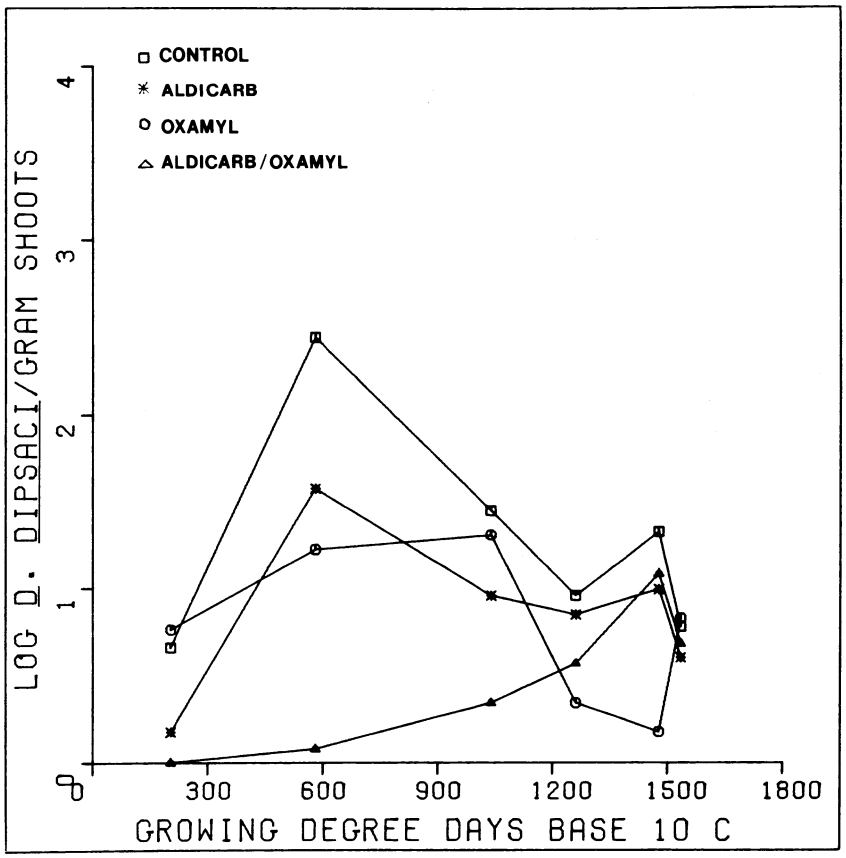

Fig. 3. Population dynamics of *Ditylenchus dipsaci* associated with *Phlox subulata* during the growing season following treatment with four nematicide treatments: untreated control, aldicarb (0.67 g/m^2) incorporated into the soil, oxamyl (1.19 ppm) applied to the foliage, or both oxamyl and aldicarb.

season. In storage, populations of *D. dipsaci* remained constant (Fig. 2), and the plants were healthy. Populations of *D. dipsaci* associated with plants overwintering in the field increased during the second year. The single foliar application of oxamyl during the second growing season significantly ($P = 0.05$) reduced the population density of *D. dipsaci*.

DISCUSSION

A survey of 11 cultivars of *P. subulata* in commercial fields revealed populations of *D. dipsaci* in the shoot tissue of all cultivars. Preliminary greenhouse studies indicated that this nematode was a phlox-onion hybrid race of *D. dipsaci*. Several cultivars with high infestation levels were not chlorotic or necrotic, and several cultivars supported very low numbers of nematodes with minimal damage. The greenhouse studies indicated that commercial cultivars of *P. subulata* vary in susceptibility to *D. dipsaci*.

Aldicarb and oxamyl satisfactorily reduced populations of *D. dipsaci* and eliminated dieback symptoms. Aldicarb was the more economical treatment and was accepted readily by the commercial phlox producers after a local needs registration was obtained. Widespread use of aldicarb has brought a direct decrease in the severity of the *D. dipsaci* problem in Michigan creeping phlox production. This pest management procedure, however, has all the potential problems (system instability, resistance, natural control factor mortality, secondary pest outbreak, etc.) associated with single pest control tactics. More research is needed to provide Michigan phlox growers with a management program designed to use existing or slightly modified horticultural procedures (including crop rotation, cover crops, and propagation techniques) for integrated control of *D. dipsaci*.

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