Control of Damping-Off of Tomatoes by Incorporation of Fungicides in Direct-Seeding Gel

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ABSTRACT

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Incorporation of ethazol plus thiophanate-methyl, fenaminosulf, and ethazol in direct-seeded tomatoes effectively controlled seedling damping-off caused by *Pythium aphanidermatum* in pot tests in the greenhouse. Benomyl, chloroneb, and captan were ineffective in controlling the fungus.

Damping-off of direct-seeded and transplanted tomatoes is most serious during crop seasons when warm, humid weather with frequent rains follows planting. Numerous soilborne fungi such as *Rhizoctonia solani* Kühn, *Pythium aphanidermatum* (Edson) Fitzp., *P. myriotylum* Drechs., *P. arrehenomanes* Drechs., and *Fusarium* spp. cause damping-off of seedlings (6,8). The most serious soilborne fungi causing damping-off of tomato seedlings in Florida are *P. aphanidermatum* and *R. solani* (9).

Where soil fumigation is not practiced, farmers resort to seed treatments and transplant dips. With the advent of plug-mix seeding in Florida (3), incorporation of fungicides in the plug-mix has provided control of damping-off of direct-seeded tomatoes (10,11).

The technique for mixing vegetable seeds in a gel carrier and pumping the mixture through a planter into a seed furrow in the soil was developed in the early 1960s by J. G. Elliot from the Weed Research Organization near Oxford, England (5). The fluid-drilling system was researched at the National Vegetable Research Station in Wellesbourne, England, in the early 1970s (2). With the rapid development of fluid-drilled tomato-seeding practices (1), a study of fungicide incorporation to prevent damping-off of seedlings was essential.

MATERIALS AND METHODS

Isolates of *P. aphanidermatum* (Division of Plant Industry culture collection of Florida Department of Agriculture) were maintained on potato-dextrose agar at 24 C. Three disks 1 cm in diameter were cut from 5-day-old cultures and transferred to sterilized 250-ml flasks containing a 10:1:1 (v/v/v) cornmeal, sand, and water medium. Inoculated flasks were incubated at 25 C for 15 days, then their contents added at 1:9 (v/v) to a 5:5:1 (v/v/v) vermiculite, peat and cornmeal plant mix.

The fungicides and their concentrations (active ingredients) per liter of gel used throughout were ethazol plus thiophanate-methyl (Banrot 40WP) at 0.75 g, benomyl (Benlate 50WP) at 0.75 g, chloroneb (Demosan 65WP) at 0.4 g, fenaminosulf (Dexon 70WP) at 0.5 g, captan (Orthocide 75WP) at 0.25 g, fenaminosulf (Dexon 70WP) at 0.5 g plus benomyl (Benlate 50WP) at 0.75 g, fenaminosulf (Dexon 70WP) at 0.5 g plus chloroneb (Demosan 65WP) at 0.4 g, captan (Orthocide 75WP) at 0.5 g plus benomyl (Benlate 50WP) at 0.75 g, ethazol (Truban 30WP) at 0.5 g, ethazol (Truban 30WP) at 0.5 g plus benomyl (Benlate 50WP) at 0.75 g, and ethazol (Truban 30WP) at 0.5 g plus chloroneb (Demosan 65WP) at 0.4 g. Fungicide rates used in these studies were based on a toxicity experiment to determine a safe level for test plants (Table 1). Greenhouse studies with uninoculated and inoculated media were carried out in Speedling flats (72 cells per flat), which were filled with infested plant mix, wetted, and held for 3 days. Each treatment in the flats was a single row containing six cells and distributed in a randomized complete block design replicated three times. An additional test was conducted with plastic pots (7.6 cm in diameter) filled with native Rockdale fine sandy limestone complex soil.

Fifty Flora-Dade tomato seeds were germinated in each of five test tubes containing 50 ml of distilled water aerated with an aquarium pump in an incubator at 25 C. Water was changed daily for 72 hr until the seeds were removed. A gel suspension was prepared by mixing small quantities of synthetic magnesium silicate (Laponite 508) (Laporte Inc., Continental Plaza, 411 Hackensack Avenue, Hackensack, NJ 07601) with water in a blender. Pots were wetted and held for three days, after which 10 ml of a mixture of 10 pregerminated seeds incorporated in 1.5% gel impregnated with the fungicide treatment (Table 1) was poured into each cell of the flat or pot. Potted treatments consisting of six pots were assigned in a split-plot arrangement within a randomized block design replicated four times. Greenhouse temperatures for all experiments were 16 C at night and 22 C during the day. Flats and pots were flood-irrigated daily. Seedling emergence and damping-off were recorded daily for 21 days after germination. An emergence index was calculated by dividing the emergence rate index by the total number of emerged seedlings, according to the

Table 1. Effect of fungicide rate in synthetic magnesium silicate on tomato plant emergence

Fungicide	Rate[a] (g a.i./L gel)	Seedling emergence[b] (%)
Ethazol + thiophanate-methyl	0.00	97
	0.50	99
	0.75	96
	1.00	97
Benomyl	0.00	100
	0.75	100
	1.00	99
	1.75	96
Chloroneb	0.00	99
	0.20	98
	0.40	94
	0.60	94
Fenaminosulf	0.00	99
	0.75	100
	1.00	100
	1.25	92
Captan	0.00	98
	0.15	97
	0.30	94
	0.45	96
Ethazol	0.00	99
	0.50	98
	0.75	94
	1.00	96
LSD	(0.05)	NS[c]

[a] Each fungicide rate contained 30 plants distributed in a randomized complete design replicated three times.

[b] Emergence counts were made daily up to 15 days.

[c] NS = not significant.

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Table 2. Effect of fungicides incorporated in synthetic magnesium silicate on emergence, damping-off, and disease severity index of tomato seedlings growing in media inoculated with *Pythium aphanidermatum*

Fungicide	Rate (g a.i./L gel)	Emergence[w] (%)	Percent seedlings[x] damped-off	Disease severity index[y]
Ethazol + thiophanate-methyl 40WP	0.75	88 a[z]	0.3 c	1.20 b
Benomyl 50WP	0.75	36 c	9.7 ab	3.17 a
Chloroneb 65WP	0.4	57 b	0.5 c	1.27 b
Fenaminosulf 70WP	0.5	96 a	0 c	1.00 b
Fenaminosulf 70WP + benomyl 50WP	0.5 + 0.75	96 a	1.2 c	1.34 b
Fenaminosulf 70WP + chloroneb 65WP	0.5 + 0.4	87 a	0.3 c	1.19 b
Captan 75WP	0.25	61 b	8.8 ab	3.00 a
Captan 75WP + benomyl 50WP	0.5 + 0.75	55 b	6.5 b	2.54 a
Ethazol 30WP	0.5	94 a	0 c	1.01 b
Ethazol 30WP + benomyl 50WP	0.5 + 0.75	83 a	0.5 c	1.12 b
Ethazol 30WP + chloroneb 65WP	0.5 + 0.75	87 a	0 c	1.04 b
Control	...	64 b	10.5 a	2.89 a

[w] Fungicide rates were established by previous toxicity experiments (Table 1).
[x] Daily seedling emergence and damping-off counts were made for 21 days.
[y] Disease severity was rated on a 1–4 scale, where 1 = healthy seedling, 2 = few lesions, nontoxic, 3 = many lesions, root rot, and 4 = damped-off.
[z] Values in columns with the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test. Each figure is the mean of one test of each of three 60-seedling replicates.

Table 3. Effect of fungicides incorporated in synthetic magnesium silicate on emergence, damping-off, and disease severity index of tomato seedlings growing in Rockdale fine sandy loam rock complex soil inoculated with *Pythium aphanidermatum*

Fungicide	Rate (g a.i./L gel)	Emergence[w] (%)	Percent seedlings damped-off[x]	Disease severity index[y]
Ethazol thiophanate-methyl 40WP	0.75	94 a[z]	0.9 c	2.41 b
Benomyl 50WP	0.75	48 b	10.8 b	4.39 a
Chloroneb 65WP	0.4	60 b	0.7 c	2.36 b
Fenaminosulf 70WP	0.5	93 a	0.0 c	2.09 b
Fenaminosulf 70WP + benomyl 50WP	0.5 + 0.75	98 a	0.1 c	2.38 b
Fenaminosulf 70WP + chloroneb 65WP	0.5 + 0.4	67 b	0.1 c	2.27 b
Captan 75WP	0.25	65 b	12.9 a	4.48 a
Captan 75WP + benomyl 50WP	0.5 + 0.75	59 b	12.6 a	4.77 a
Ethazol 30WP	0.5	96 a	0.0 c	2.52 b
Ethazol 30WP + benomyl 50WP	0.5 + 0.75	92 a	0.0 c	2.08 b
Ethazol 30WP + chloroneb 65WP	0.5 + 0.4	95 a	0.0 c	2.15 b
Control	...	90 a	14.2 a	4.97

[w] Fungicide rates were established by previous toxicity experiments (Table 1).
[x] Daily seedling emergence and damping-off counts were made for 21 days.
[y] Disease severity was rated on a 1–4 scale, where 1 = healthy seedling, 2 = few lesions, nontoxic, 3 = many lesions, root rot, and 4 = damped off.
[z] Values in columns with the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test. Each figure is the mean of one test of each of four 60-seedling replicates.

method of Shmueli and Goldberg (7).

At the end of each test, all seedlings were removed and rated for root and lower stem damage. The ratings system used throughout was 1 = healthy seedling, 2 = few lesions, 3 = many lesions and root rot, and 4 = damped-off seedling. A disease severity index was calculated by determining the mean severity rating for each treatment. Each test was repeated several times without significant differences between tests.

RESULTS AND DISCUSSION

Significant control of *P. aphanidermatum* was obtained in all experiments with ethazol plus thiophanate-methyl, fenaminosulf, and ethazol alone or combined with benomyl, chloroneb, or captan (Tables 2 and 3). This was indicated by an increase in total seedling emergence and a reduction in the number of damped-off seedlings and disease severity index compared with the control. Low seedling emergence, high number of damped-off seedlings, and high disease severity index indicated that benomyl, chloroneb, and captan alone and in combination with benomyl and captan were not effective in controlling *P. aphanidermatum*. Seedlings were killed by the fungus before emergence and this accounted for the low number of seedlings that emerged. Although foliar application or drenching with chloroneb have been reported to control *P. aphanidermatum* in tomato (4), addition of the fungicide to gel was ineffective in controlling the fungus in these tests. This might have been due to the low rate used. Incorporation of benomyl, chloroneb, and captan in plug-mix tomatoes was also ineffective in controlling seedling damping-off caused by *P. aphanidermatum*, which agrees with the results of Sonoda (10).

In the experiment using native soil (Rockdale fine sandy limestone complex soil), there was no toxicity observed and results paralleled the test with potting media (Tables 1 and 2). A field test was planted duplicating the greenhouse studies; however, field conditions were not optimum for *Pythium* so no disease data could be obtained.

Results reported in this paper can easily be transferred to a commercial tomato seeding system because no additional fungicide application equipment is necessary to supplement equipment currently used by farmers to apply pregerminated seed suspended in gel. The difficulty will be in obtaining EPA approval for use of the effective fungicides in direct-seeding gel.

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