Response of Pepper Transplants to Fall Fumigation

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ABSTRACT

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In Georgia, fumigation of field soil with 336, 262, 187, or 112 L/ha of DD-MENCS in December significantly increased the size and fresh weight of spring-seeded pepper transplants and decreased plant pathogens in the soil and the incidence of stem rot caused by *Pythium aphanidermatum*. All rates were about equally effective. More than 90% of all plants harvested from fumigated plots were 13 cm or larger, whereas 92% of plants from untreated plots were smaller than 13 cm. The mean weights of plants from fumigated plots were 2.4 times those of plants from untreated plots. Mean numbers of disease loci were 37.5 in check plots and 0.5, 2.0, 3.8, and 1.8 in plots treated with DD-MENCS at 336, 262, 187, and 112 L/ha. The effectiveness of DD-MENCS at low rates is attributed to the slow dissipation and long chemical-organism interaction at low temperatures during the December-February treatment. Fall fumigation appears to offer several advantages over spring fumigation for pepper transplant production.

Additional key words: *Capsicum annuum*, control

About 200 million certified pepper transplants are produced annually in southern Georgia and shipped to northern areas of the United States (2,3). Historically, soilborne diseases on pepper and other vegetable transplants have been minimized by producing plants on newly cleared land and moving to new sites before major pest problems developed. In recent years permanent production sites have been used extensively, and certain disease problems have become more common (3,5,6).

Although there is considerable interest in general purpose fumigants for vegetable transplant production (3,5,6), little soil fumigation is currently used. Major obstacles to use of soil fumigants are high cost, phytotoxicity with early application, and reinfestation of treated areas (5,6). Spring fumigation is particularly difficult for pepper transplants because they are seeded early when the soil temperatures are too low (<13 C) for activity by some fumigants, chemical dissipation is slow, and phytotoxicity sometimes results. Earlier work (3,5) showed that spring application of some soil fumigants reduces plant pathogens below damaging levels and stimulates growth of vegetable transplants, but the authors suggested that fall fumigation may be more practical.

In the present study we evaluated fall fumigation for the production of pepper transplants and determined the optimal application rate for one fumigant.

MATERIALS AND METHODS

The test was done in late 1978 and early 1979 on the Joseph Campbell Farms near Climax, GA. The soil was a Tifton sandy loam, and the plot area had been used for vegetable transplant production in previous years. After routine preparation, 1.9 × 38 m beds were prepared for fumigation.

Five treatments were arranged in a randomized complete block design with four replications. Treatments were DD-MENCS (20% methyl isothiocyanate + 80% 1,2-dichloropropane, 1,3-dichloropropene, and related chlorinated hydrocarbons, Vorlex) at 336, 262, 187, and 112 L/ha and a check (no fumigant). The fumigant was injected 15–18 cm deep on 23-cm centers, and the soil surface was

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sealed immediately with approximately 1.3 cm of water applied by overhead irrigation. The fumigant was injected on 15 December when the soil temperature at 15 cm was 13 C. The beds remained undisturbed until seeding.

At seeding, beds were aerated and smoothed with a rotary tiller and fertilized with 99, 198, and 99 kg/ha of N, P, and K, respectively. Pepper (*Capsicum annuum* L. 'Yolo Wonder B') was planted, 100 seeds per meter, in five rows per bed on 14 March. Napropamide (*N*, *N*-diethyl-2-[1-naphthalenyloxy]-proprionamide, Devrinol 50 WP, 4.5 kg/ha) was used for weed control to prevent the loss of untreated plots. The herbicide was used on all beds. Cultural practices recommended by the Georgia Cooperative Extension Service were followed throughout the growing season, with irrigation as needed.

Plants were harvested on 14 May 1979. Treatments were evaluated by selecting representative samples (1 m of row) from each bed for counting and measurements. Plants from each sample were divided into five size categories (2.5–7.6, 7.7–12.7, 12.8–17.7, 17.8–22.8, and > 22.8 cm) and counted. Fresh weights were also determined. Late in the season, stem rot was severe in spots, particularly in untreated plots, and these loci of infection were counted in all plots. Plants with early stages of the disease were selected at random from the plots and were plated on water agar to determine the organism responsible. Pathogenicity tests were also conducted with the organisms most commonly isolated.

Soil samples for microorganism assays were collected from field plots 2 wk after fumigation and again at harvest. Samples were collected with a soil sampling tube (80 cores, 2.5 × 20 cm, from each bed) to form a composite sample. Populations of *Pythium* spp. were determined by plating on Tsao and Ocana's $P_{10}VP$ medium (9) modified by adding 0.01 g/L of rose bengal to make colonies more visible; *Fusarium* spp., on Nash and Snyder's medium (7); and nematodes, by a modified centrifugal flotation method (4).

For bioassay tests in the greenhouse, untreated tomato or pepper seeds were planted in soil from the various treatments. Tomato was used for soil samples collected after treatment and pepper for those collected at harvest. Four pots (10-cm diameter) were filled with soil from each plot, seeded with 75 seeds per pot, and placed on a greenhouse bench. Surviving plants were counted after 14–21 days. Isolations were made from representative damped-off seedlings to determine the organisms present.

RESULTS

Fumigation of field plots in mid-December markedly increased the size and fresh weight of pepper transplants seeded the following spring (Table 1, Fig. 1). The response was similar at all four rates of DD-MENCS. More than 90% of all plants harvested from fumigated plots were 13 cm or larger, whereas 92% of the plants from check plots were smaller than 13 cm. The mean weights of plants from fumigated plots were 2.4 times those of plants from check plots. Plants in all fumigated plots were dark green and had well developed root systems. Plants from

Table 1. Yield, size, and weight of spring-seeded pepper transplants harvested from field plots treated in the fall with DD-MENCS[a]

Treatment[b] (L/ha)	Mean number of plants per meter in size groupings (cm)						Mean fresh wt (g)	
	2.5–7.6	7.7–12.7	12.8–17.7	17.8–22.8	>22.8	Total	Per meter	Per plant
DD-MENCS								
336	4.8 y[c]	6.3 y	10.0	55.8 y	11.5 y	88.4	759 y	8.7 z
262	1.0 y	12.0 y	20.5	73.0 z	7.8 y	114.3	788 y	7.1 y
187	1.8 y	8.0 y	22.0	59.5 yz	8.8 y	100.1	746 y	7.9 yz
112	0.0 y	6.0 y	18.5	51.8 y	21.5 y	97.8	765 y	8.1 yz
No chemical (check)	12.3 z	86.0 z	8.8	0.0 x	0.0 z	107.1	354 z	3.3 x

[a] Each value is a mean of four replications harvested 14 May 1979.
[b] DD-MENCS was injected 15–18 cm deep with a tractor-mounted fumigator with chisels 23 cm apart on 15 December 1978; soil was sealed with water.
[c] Values followed by the same letters are not significantly different by Duncan's multiple range test ($P = 0.05$). Values in columns without letters are not significantly different.

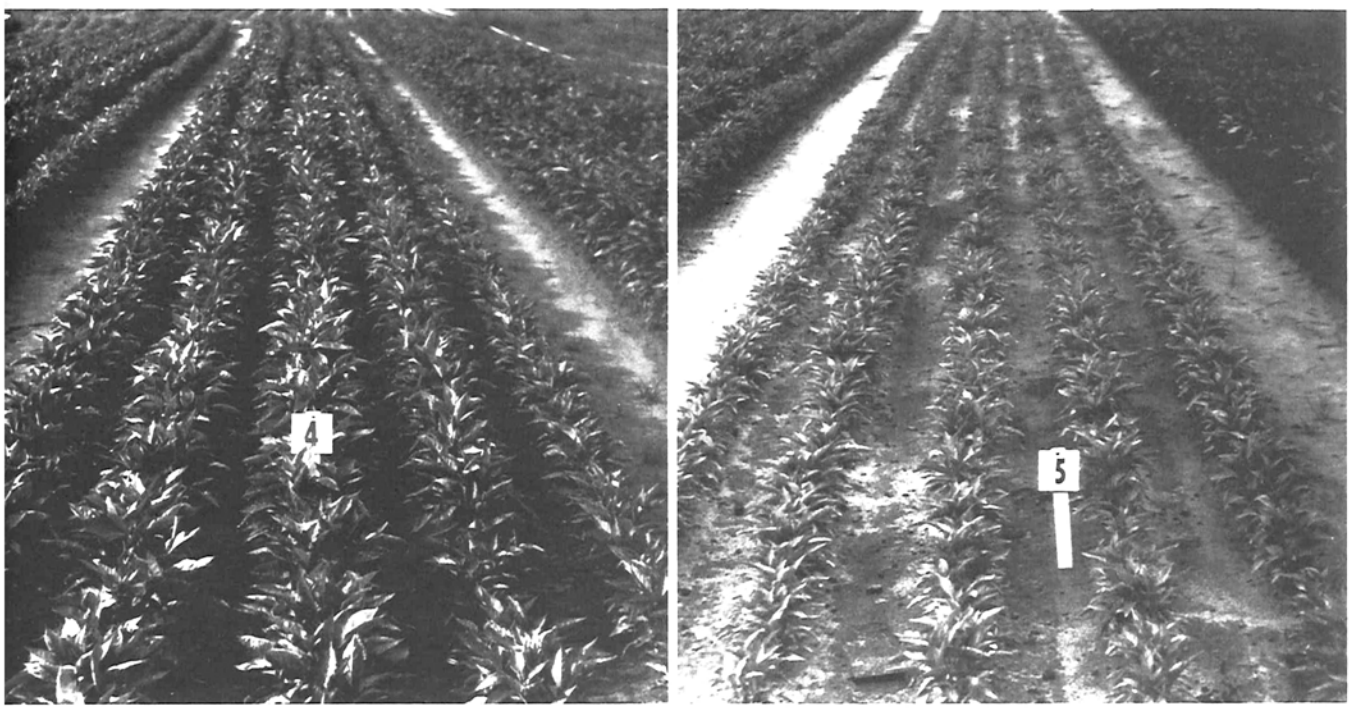

Fig. 1. Effect of fall fumigation on growth of pepper transplants: Plot 4, treated with 112 L/ha of DD-MENCS; Plot 5, check plot. The appearance of plots receiving 187, 262, and 336 L/ha of DD-MENCS was similar to that of plot 4.

Table 2. Populations of *Pythium* spp. and *Fusarium* spp. and survival of pepper or tomato seedlings in soil from untreated and DD-MENCS treated field plots

Treatment[a] (L/ha)	Two weeks after treatment			At harvest		
	Pythium spp.[b] (ppg)	*Fusarium* spp.[c] (ppg × 10^3)	Seedling survival[d] in greenhouse (%)	*Pythium* spp.[b] (ppg)	*Fusarium* spp.[c] (ppg × 10^3)	Seedling survival[d] in greenhouse (%)
DD-MENCS						
336	3.1 x[e]	1.4 x	61 y	11.9 y	0.9 x	59 y
262	4.4 x	1.9 x	56 y	10.5 y	1.0 x	46 y
187	4.6 x	2.1 xy	56 y	12.9 y	1.3 xy	38 y
112	7.4 y	2.8 y	61 y	15.5 y	1.8 y	58 y
No chemical (check)	14.2 z	4.3 z	15 z	25.2 z	3.1 z	18 z

[a] DD-MENCS was injected 15–18 cm deep with a tractor-mounted fumigator with chisels 23 cm apart on 15 December 1978; soil was sealed with water.
[b] Populations determined on modified Tsao's medium.
[c] Populations determined on Nash and Snyder's medium.
[d] Each value is a mean of four replications each consisting of four pots seeded with 75 untreated tomato or pepper seeds. Tomato was used for the after-treatment samples and pepper for the at harvest samples.
[e] Values in each column followed by the same letter are not significantly different by Duncan's multiple range test ($P = 0.05$).

untreated plots were chlorotic and often had poorly developed root systems with necrotic feeder roots. Untreated beds had many small spots of plants dead or dying from stem rot; treated beds had few spots. Mean numbers of disease loci per bed were 0.5, 2.0, 3.8, and 1.8 for the 336, 262, 187, and 112 L/ha of DD-MENCS, respectively, and 37.5 for the control. Isolations from the diseased plants yielded *Pythium aphanidermatum* (Edson) Fitz. 90% of the time and *Rhizoctonia solani* Kuhn occasionally. Seven isolates of *P. aphanidermatum* and two isolates of *R. solani* from the field-grown plants caused rapid damping-off and stem rot of potted pepper plants (8 cm tall) in a greenhouse test.

Soil assays showed that populations of plant-parasitic nematodes were low throughout the test period and were not an important cause of the impaired growth in check plots. All fumigant treatments significantly reduced populations of *Pythium* spp. and *Fusarium* spp., although the 112-L rate was slightly less effective than higher rates (Table 2). These organisms were not eliminated from the soil even at the highest rate used.

In greenhouse bioassay tests with soil samples from the test plots, survival rates of tomato or pepper seedlings were not significantly different among fumigant treatments but were often three or four times greater than those in soil from untreated plots (Table 2). Approximately 80% of damped-off seedlings in the pot tests yielded *P. aphanidermatum* when plated. *P. irregulare* and *R. solani* accounted for most of the other isolates.

DISCUSSION

In the vegetable transplant industry, fall fumigation may be the most practical way to overcome some problems associated with spring treatment. Fall application appears particularly useful for pepper transplants because seedlings emerge slowly and must be planted earlier than tomato transplants. In this and other studies (unreported), no phytotoxicity was observed with fall fumigation. We evaluated only DD-MENCS to determine the feasibility of fall fumigation, but other chemicals may also have potential (3,5,6). DD-MENCS appears very promising for fall fumigation of pepper transplant beds, however, since it is effective at economical rates without a tarp and can be applied at low temperatures. Rates of 336 L/ha injected into the soil and covered with a tarp are generally recommended for best control of soilborne fungal pathogens under normal temperatures (1). We did not expect adequate control of fungi at rates as low as 112 L/ha and with only a water seal. Possibly the slow dissipation rate and consequently long organism-chemical interaction time at low temperatures during the December-February treatment explain the favorable results with low rates (W. K. Taylor, NOR-AM, *personal communication*).

The favorable growth response after fall fumigation apparently was greater than could be attributed entirely to control of soilborne pathogens, although these were important as indicated by root necrosis and stem rot. Other factors such as the altered status of soil nutrients, particularly nitrogen, may have played a role in the favorable plant response (8).

Fall treatment with DD-MENCS or other suitable fumigants shows promise for widespread use in pepper production in southern Georgia. Additional work is needed to determine the relationship between soil temperature in the fall and the rate of DD-MENCS required for economical control of plant-pathogenic fungi and nematodes.

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