Field and Greenhouse Studies on Pea Seed Treatments

JOHN M. KRAFT, Research Plant Pathologist, Vegetable Crops Production, Agricultural Research Service, U.S. Department of Agriculture, Prosser, WA 99350

ABSTRACT

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The main benefit to peas from seed treatment with fungicides was increased plant stand compared with the untreated control. Metalaxyl was as effective as any other fungicide or combination of fungicides tested to control seed rot and preemergence and postemergence damping-off. Root rot of peas was not affected by any seed treatment chemical tested in the greenhouse or field. Acetone infusion of fungicides into pea seed required less chemical than when applied in slurry.

In the Pacific Northwest, pea (*Pisum sativum* L.) root rot, caused by *Fusarium solani* (Mart.) Sacc. f. sp. *pisi* (Jones) Snyd. & Hans. and *Pythium ultimum* Trow, can seriously limit production of processing peas (1,7,18). Yield losses have been estimated at 10–35% (1,7). Resistance to this root rot complex exists in germ plasm and in several plant introduction accessions (7,9). However, most current, commercially acceptable varieties are susceptible. Long-term crop rotation is not acceptable as a control measure because of the vital role peas play in a cereal rotation scheme. Cultural practices that reduce compaction, along with more resistant or tolerant varieties, can be of benefit (7). In addition, there is a need to develop an inexpensive, efficient means of chemical control (15).

Wrinkle-seeded peas are more prone to seed and seedling disease problems caused by *Pythium* spp. and *Rhizoctonia solani* Kühn than smooth-seeded types (2) and need to be treated with seed protectant chemicals (3,4). The demonstration that organic solvents, such as acetone and dichloromethane, are effective in transporting chemicals into dry seeds with no apparent phytotoxic effects was an interesting development (10,13,17). It is possible that if systemic or nonsystemic fungicides are introduced into the cotyledons and embryo, chemical control of root diseases may be enhanced. The recent introduction of new fungicides with specific activity against the Phycomycetes was also of interest (14,15).

The objectives of this research were to determine whether acetone infusion of fungicides or combinations into seed, compared with the slurry method of application, is as effective in reducing seed and seedling disease and root rot and to determine whether the new fungicides with specific activity against the Phycomycetes are as effective as captan. A portion of this work was previously reported (6).

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MATERIALS AND METHODS

Greenhouse tests. Various seed treatment chemicals, combinations, and application procedures were first greenhouse tested in bins measuring 1.5 × 1.5 × 3 m that contained a Warden fine sandy loam soil. This soil was naturally infested with 400–800 and 200–500 propagules per gram of air-dry soil of *P. ultimum* and *F. solani* f. sp. *pisi*, respectively (11,12). Heating cable was used in each bin to maintain a constant 22 C at a 5-cm depth. Greenhouse air temperatures during this study varied between 18 and 22 C.

In greenhouse and field tests, the cultivar Dark Green Perfection (Crites-Moscow Growers, Inc.) was used. Various test fungicides (Table 1) were applied by either the slurry or organic solvent procedure. In the slurry procedure, the desired amount of fungicide to be applied was added to 0.5 g of methyl cellulose in 100 ml of water in a plastic bag. Five hundred grams of seeds was then added and the bag agitated vigorously for 3 min. The coated seeds were removed from the bags and air-dried. In the infusion procedure, the fungicides were dissolved or suspended in 350 ml of acetone and 500 g of seeds, then soaked in this solution or suspension for 2 hr and air-dried. All seeds were planted within 1 wk after treatment.

Each treatment, consisting of planting 50 seeds 5 cm deep in infested soil, was replicated three times. Tap water was used to replenish soil moisture when the test soil was dry to a depth of 2.5 cm. Two weeks after emergence, plant stands were recorded and expressed as percentage of emergence. Four weeks after emergence, all plants were carefully removed from the infested soil and washed, and the roots were scored for disease severity using a 0–5 scale: 0 = healthy root and 5 = a completely rotted root. Plant tops were excised at the soil line and fresh weight determined to the nearest 0.1 g. The greenhouse tests were repeated three times during 1978 and 1979.

Field studies. Experimental field plots in 1979, 1980, and 1981 were established at the Irrigated Agriculture Research and Extension Center, Prosser, WA. The test site had a history of pea root rot (1,7). Soil samples were taken at the beginning of each planting season, and counts of *Pythium* and *Fusarium* varied between 250–600 and 140–600 propagules per

Table 1. Fungicides tested and specific activity of each

Fungicide	Fungal activity[w]		
	Pythium	***Fusarium***	***Rhizoctonia***
Captan	+[x]	+	+
Captafol	+	+	+
Dowco 444[y]	+	−	+
Prothiocarb	+	−	−
Metalaxyl	+	−	−
Thiabendazole	−	+	−
PCNB[z]	−	−	+
Thiram	+	+	+

[w] + = Fungicidal activity, − = no fungicidal activity against that organism.
[x] Based on manufacturer's statements and specifications.
[y] Supplied by Dow Chemical Company; generic name not available.
[z] Pentachloronitrobenzene.

gram of air-dry soil, respectively (11,12). Each year the field site was spring plowed, and trifluralin was applied and incorporated at a 0.6 kg a.i./ha in 189 L of water as a preplant grass herbicide. Dinoseb was applied at a 1.7 kg a.i./ha in 189 L of water as a postplant, postemergence herbicide to control broadleaf weeds.

Each three-row plot was planted with a three-row cone planter on 28-cm centers, 305 cm long with 100 seeds per row. All plots were sprinkle irrigated on an approximate 10-day cycle or with 2.5 cm of water removal (5). Plant stands were recorded 2 wk after emergence by counting the number of emerged plants in the middle row of each plot. Disease severity was determined at a time when plants in each plot were just beginning to bloom. Ten plants were carefully removed from each plot, washed, and scored for root disease severity using the 0–5 scale. Top weights were recorded according to the procedure described previously. Dry seed yields were taken when vines and pods had dried sufficiently to be threshed through a portable Vogel plot combine. All seed lots were air cleaned to remove straw and debris and weighed to the nearest 0.1 g. All field plots were in a randomized block design with four replicates per treatment, and data were statistically analyzed accordingly.

Table 2. Comparison of the application of seed treatment fungicides by slurry vs. acetone infusion to control pea seedling disease in the greenhouse

Chemical	Slurry or infusion	Conc. (g a.i./kg of seed)	Plant stand	Disease index	Top wt. (g/plant)
Captan	S	2.5	85 a[z]	3.4 ab	2.77 a
Captafol	S	2.5	91 a	4.0 a	1.82 ab
Captafol	S	1.3	80 ab	4.1 a	1.42 b
Captafol	I	2.5	78 ab	4.0 a	1.41 b
Captafol	I	1.3	88 a	3.9 ab	1.53 b
Metalaxyl	S	0.6	91 a	3.8 ab	1.50 b
Metalaxyl	I	0.3	87 ab	4.2 a	1.57 b
Control	···	···	55 c	4.0 a	2.00 a

[z] Data followed by same letter are not significantly different at the 0.05 level.

Table 3. Severity of pea root rot as influenced by slurry or acetone infusion of seed treatment chemicals in the field, 1979

Chemical	Slurry or infusion	Conc. (g a.i./kg of seed)	Plant stand	Disease index	Top wt. (g/plant)	Seed wt. (g/plot)
Captan	S	2.5	85.7 ab[z]	1.3 a	15.3 ab	943.0 abcd
Metalaxyl	S	0.6	87.7 ab	1.4 a	18.2 a	1,018.0 abc
Metalaxyl	I	0.3	89.5 a	1.2 a	19.2 a	1,102.8 ab
Captafol	S	2.5	84.7 ab	1.3 a	18.6 a	1,018.3 abc
Captafol	I	1.3	85.7 ab	1.5 a	14.7 ab	992.3 bc
Thiram	S	1.9	83.0 b	1.3 a	16.4 a	1,015.5 abc
PCNB	S	2.5	74.5 c	1.5 a	15.0 ab	910.0 bcd
PCNB	I	1.3	86.5 ab	1.4 a	17.5 ab	1,118.8 a
Control	···	···	55.7 d	1.5 a	18.7 a	704.8 d

[z] Data followed by same letter are not significantly different at the 0.05 level.

Table 4. Effect of method of application, rate, and combination of seed treatment fungicides on severity of pea root rot in the field, 1980

Chemical	Slurry or infusion	Conc. (g a.i./kg of seed)	Plant stand	Disease index	Top wt. (g/plant)	Seed wt. (g/plot)
Captan	S	2.5	74.5 b[z]	4.6 a	10.7 a	637.8 abcd
Metalaxyl	S	0.6	84.8 a	4.5 a	11.8 a	653.3 abc
PCNB	S	2.5	18.3 e	4.4 a	9.8 a	269.8 hi
PCNB	I	2.5	21.0 d	4.6 a	7.9 b	191.0 i
Thiabendazole + metalaxyl	S	5.0 + 0.6	87.0 a	4.2 a	8.9 ab	770.5 a
Thiabendazole + metalaxyl	I	5.0 + 0.3	86.3 a	4.7 a	10.9 a	696.5 ab
Thiabendazole + prothiocarb	S	5.0 + 1.3	79.3 ab	4.4 a	12.0 a	617.5 abc
Thiabendazole + prothiocarb	I	5.0 + 1.3	61.0 b	4.7 a	9.7 a	460.0 defg
Prothiocarb	S	2.5	82.3 ab	5.0 a	9.6 a	532.8 bcdef
Prothiocarb	I	2.5	59.8 bc	4.7 a	10.3 a	451.3 efg
Prothiocarb	S	1.3	78.5 ab	4.7 a	12.3 a	628.5 de
Prothiocarb	I	1.3	59.5 bc	4.4 a	12.1 a	526.3 bcdef
Control	···	···	24.5 d	4.6 a	10.8 a	259.8 hi

[z] Data followed by same letter are not significantly different at the 0.05 level.

RESULTS

Greenhouse. In three greenhouse experiments, fungicide application increased plant stand as compared with the control (Table 2). Metalaxyl was equal to captan or captafol when applied as either a slurry or by acetone infusion. Four weeks after emergence, there was no significant difference in disease severity among treatments. This lack of difference was also reflected in green plant weights.

Field. In 1979, the efficacy of captan, metalaxy, captafol, thiram, and pentachloronitrobenzene (PCNB) applied in slurry or infused with acetone was compared in the field. The 1979 season was ideal for pea growth, and root rot was not severe. Consequently, disease severity was low and plant weights and seed yields were higher than in succeeding years (Table 3). However, in plots containing seeds treated with any fungicides tested, plant emergence was significantly better than in the untreated control plots. Seed yields were also significantly benefited by all treatments, with the exception of the PCNB slurry treatment. In 1979, acetone infusion of PCNB resulted in significantly higher yields than when applied as a slurry.

Preemergence and postemergence damping-off and root rot were severe in 1980 (Table 4). This was evident in plant stands, root disease indexes, plant weights, and seed yields when compared with the 1979 data (Table 3). PCNB, applied either as a slurry or infused, was the poorest treatment in 1980 and was not significantly different from the control. Metalaxyl in a slurry was as effective as the combination of metalaxyl + thiabendazole or prothiocarb + thiabendazole when applied either as a slurry or by acetone infusion.

In 1981, various fungicides and combinations were applied to seed only by slurry to determine again whether metalaxyl was comparable to any other fungicide singly or in combination. Disease intensity was more severe in 1981 than in 1979 (Table 3) but less than in 1980, as evidenced by top weights and seed yields of the control (Table 4). Metalaxyl alone was as effective as the combination of metalaxyl + captan, metalaxyl + thiabendazole, or the various combinations that included Dowco 444 (Table 5). Seed yields resulting from treating seed with Dowco 444 alone were not significantly different from the control plot.

DISCUSSION

The main benefit from fungicide treatment of pea seed was to reduce seed rot and preemergence and postemergence damping-off, as evidenced by increased emergence, which agrees with the

Table 5. Comparison of various seed treatment fungicides, singly and in various combinations, on the severity of peat root rot in the field, 1981

Chemical	Conc. (g a.i./kg of seed)	Plant stand	Disease index	Fresh wt. plant tops (g/plant)	Dry seed yield (g/plot)
Captan	2.5	81.0 a[z]	4.5 a	12.5 b	587.0 ab
Metalaxyl	0.6	80.5 a	4.0 a	16.8 a	694.0 a
Thiabendazole	5.0	58.0 b	5.0 a	17.4 a	347.0 d
Dowco 444	1.2	60.0 b	5.0 a	20.9 a	438.9 c
Metalaxyl + captan	0.6 + 2.5	78.5ab	5.0 a	22.0 a	694.0 a
Metalaxyl + thiabendazole	0.6 + 5.0	75.0 ab	5.0 a	15.8 ab	584.0 ab
Dowco 444 + metalaxyl	1.2 + 0.6	74.0 ab	4.5 a	16.6 a	501.2 b
Dowco 444 + metalaxyl + captan	1.2 + 0.6 + 2.5	83.5 a	4.5 a	17.3 a	650.9 a
Dowco 444 + metalaxyl + captan + PCNB	0.6 + 0.6 + 2.5 + 2.5	90.0 a	4.5 a	18.2 a	610.1 ab
Dowco 444 + metalaxyl + thiabendazole + PCNB	0.6 0.6 5.0 2.5	71.5 ab	5.0 a	18.9 a	518.2 b
Control	···	60.5 b	5.0 a	18.8 a	435.8 c

[z] Data followed by same letter are not significantly different at the 0.05 level.

literature (3,4,10,14,16). Based on previous research, *P. ultimum* was the primary pathogen involved in poor emergence (1,6,9), and metalaxyl was a viable substitute for captan (10,14). *F. solani* f. sp. *pisi* attacks the hypocotyl, epicotyl, and entire root system and is more active in warm dry soil (8). Consequently, Fusarium root rot is not readily observed until plant emergence. The application of captan, captafol, thiram, thiabendazole, or benomyl (*unpublished data*), which have exhibited fungicidal activity against *Fusarium,* was not effective in reducing the prevalence or severity of Fusarium root disease in this study. This was illustrated by the lack of significant differences in disease indexes and fresh weights of plants from treated seed compared with untreated seed. From the results reported here, the yield increases for all three field experiments were directly related in increased stands.

Richardson (16) reported that a synergistic interaction occurred between chloroneb and thiram, the combination of both chemicals being more effective in reducing pea seedling disease than either alone. No such interaction was observed with the various combinations of fungicides tested in this study. Metalaxyl alone was as effective as any chemical or combination of chemicals tested whether applied as a slurry or infused. The use of acetone or dichloromethane (*unpublished results*) to infuse fungicides into seed did not appear to have a real benefit as compared with the more conventional slurry application. The question remains unanswered as to why dry seed yields from seed infused with PCNB were significantly better than from seeds treated with PCNB in slurry (Table 3). However, this occurred only in 1979 and was not repeated in 1980 (Table 4), when yields from seed infused with PCNB were not significantly different than the control. From the results reported here, and in unpublished results, the only observed benefit from infusing fungicides into seed was that less chemical was required to do the same job.

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