Control of Bacterial Leaf Spot of Zinnia with Captan

D. L. STRIDER, Professor, Department of Plant Pathology, North Carolina State University, Raleigh 27650

ABSTRACT

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In dense plantings in the greenhouse, bacterial leaf spot of zinnia caused by *Xanthomonas nigromaculans* f. sp. *zinniae* (= *X. campestris*) was reduced from 100 to 2% diseased plants when infected seeds were treated with captan. Control was best using a 30-min seed-soak in 360 g a.i. captan per liter of water containing the wetting agent Tween 80. Dry treatment with captan 50 WP was not as effective, but the percent diseased plants was reduced from 100 to 12.4. In plant beds outside the greenhouse, spread was reduced by weekly foliar applications of captan (4.8 g a.i./L of water). Streptomycin was effective but moderately phytotoxic.

In vitro sensitivity of *Xanthomonas nigromaculans* (Takimoto) Dowson f. sp. *zinniae* Hopkins and Dowson (= *X. campestris* (Pammel) Dowson [2]), the cause of bacterial spot of zinnia, to captan was recently reported (19). That captan has utility in control of bacterial spot of zinnia as a seed treatment and as a foliar spray was hypothesized because 250 μg/ml a.i. captan in nutrient agar prevented growth of *X. nigromaculans* f. sp. *zinniae* (19) and because captan is commonly used at a much higher rate (1,230 μg/ml a.i.) as a foliar spray for control of many fungal diseases (14).

Since its development in the early 1940s, captan has been a useful and versatile fungicide (14), but its activity against *X. nigromaculans* f. sp. *zinniae* was surprising. However, a review of the literature revealed several reports on the efficacy of captan as a bactericide (4–9,11,12,15,16,22). In 1960 Diener and Carlton (7) reported that captan appeared to increase the effectiveness of dodine for bacterial spot control of peach caused by *Xanthomonas pruni*. Daines (4–6) also found that captan reduced the incidence of bacterial spot of peach. Shekharvat and Srivastava (15) reported that a 0.05% captan seed-soak reduced seedling infection of rice by *Xanthomonas translucens* f. sp. *oryzae*. A preinoculation spray of seedlings gave reduction of the disease equal to that given by a streptomycin-chlorotetracycline treatment. Sood et al (16) found that the incidence of bacterial leaf spot of mung (*Xanthomonas phaseoli*) was reduced by seed treatment with captan, and excellent results have recently been obtained using captan for control of black rot of cabbage caused by *X. campestris* (R. Navarro and E. Echandi, *personal communication*). Captan was used as a seed treatment and as a foliar spray.

Captan is also used as a bacteriostat in soaps (17) and is recommended as a slurry for treating seed against fungal pathogens (14). The scarcity of and need for new bactericides have been espoused in several recent reviews (1,3,13), but captan as a bactericide was not mentioned except as a safener for dodine in sprays for control of bacterial spot of peach (3).

This paper reports the results of experiments designed to determine the effectiveness of captan as a seed treatment and as a foliar spray for control of zinnia bacterial leaf spot.

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MATERIALS AND METHODS

Seed treatments. Seed of the zinnia cultivar Cactus Flowered Sunny Boy known to carry *X. nigromaculans* f. sp. *zinniae* (18) was used. Slurries of captan 50WP were prepared at 90, 180, and 360 g a.i./L of sterile distilled water containing 0.06 ml of Tween 80/L. These rates are similar to those generally recommended as a slurry seed treatment for control of fungal diseases (14). Seeds were coated by shaking them for several minutes in plastic bags containing the slurry. The seeds were removed, allowed to dry on filter paper, and planted within 24 hr.

One of the captan seed treatments included a 30-min presoak in 10,500 μg/ml of sodium hypochlorite (20% Clorox). These seeds were allowed to dry for 2 hr before being placed in the captan slurry.

Seeds to be treated dry were placed in a plastic bag containing 50WP captan and the bag was shaken to coat the seed. The seed was then placed on a wire screen and shaken to remove excess captan. Seeds were planted 100 per 10-cm pot in moist Metro-Mix 220 potting mixture (W.R. Grace & Co., Cambridge, MA), which was recessed 5 cm below the lip of pots (18).

Pots were placed in a warm, humid greenhouse and watered as needed with an overhead sprinkler. Initial symptoms developed 5–7 days after seeding, but observations continued for 3 wk. Treatments were replicated four times in a completely randomized block design and the test was repeated.

Spray trials. Efficacy of captan as a foliar spray was compared with that of streptomycin sulfate 21.2% WP in cold frame plots outside the greenhouse. Because foliar sprays of copper hydroxide are phytotoxic to zinnia (20), this material was not included in these trials.

Treatments were applied weekly to runoff using hand sprayers. Captan was used at 1.2, 2.4, and 4.8 g a.i./L (1, 2, and 4 lb a.i./100 gal) and streptomycin sulfate at 0.214 g a.i./L (0.5 lb formulated/100 gal = 100 μg/ml).

Plants of cultivars Peter Pan Scarlet and Cactus Flowered Sunny Boy were started in the greenhouse in 10-cm clay pots containing Metro-Mix 220. Six days after seeding, plants were thinned to one per pot and pots were transferred to cold frames outside the greenhouse. Containers were recessed to the lip of the pot in sand, and pots were spaced 15 cm apart in rows 30 cm apart. The two cultivars were separated by a 1.2-m alley.

Each test reported consisted of five two-plant replicates per treatment arranged in the plant bed in a randomized block design. Buffer rows separated treatment rows. Two weeks after seeding, every other plant in buffer rows was removed (pots taken up), inoculated (10), placed in a moist chamber for 18 hr in the greenhouse, and returned to its original position in the cold frame. Plants were fertilized with 5 cm^3 (1 tsp)/pot of 18-9-13 Osmocote (Sierra Chemical Co., Newark, CA) controlled release fertilizer and with Peters 20-20-20 each week thereafter. Plants were watered overhead with a sprinkler hose as needed, but usually two to three times daily. The test was initiated 1 August and final ratings were taken 13 September 1979.

Disease incidence was rated on a 1–5 scale based on numbers of lesions present on leaves 3 and 5 wk after inoculation (10).

RESULTS

Seed treatments. In dense plantings in the greenhouse, the incidence of bacterial leaf spot of zinnia was greatly reduced with captan seed treatments (Table 1). A

Table 1. Efficacy of captan seed treatments for control of bacterial spot of zinnia

Captan treatment[a]	Rate (g a.i./L)	% Diseased seedlings (days after seeding) Test 1: 8	Test 1: 16	Test 2: 8	Test 2: 16	Germination (%)
Slurry	90	6.2	20.8	14.0	21.5	89.5
Slurry	180	1.5	10.2	0.0	9.0	86.5
Slurry	360	0.0	2.0	0.0	0.0	86.0
Slurry + 20% Clorox[b]	360	0.0	4.0	0.0	0.0	84.2
Dry 50WP	...	3.5	10.2	2.5	14.5	87.0
None	...	92.0	100.0	87.8	100.0	89.0
LSD 0.05						5.4

[a] Seeds (Cactus Flowered Sunny Boy) were coated with the slurry, allowed to dry on filter paper, and planted within 24 hr.
[b] Seeds were soaked 30 min in 20% Clorox (10,500 μg/ml sodium hypochlorite), allowed to dry 2 hr, and treated with the captan slurry.

Table 2. Efficacy of captan foliar sprays for control of bacterial spot of zinnia[a]

Treatment rate (g a.i./L)[c]	Disease rating[b] C.F. Sunny Boy 8/30	C.F. Sunny Boy 9/13	Peter Pan S. 8/30	Peter Pan S. 9/13
Captan				
1.2	2.5	4.5	1.7	4.2
2.4	2.2	4.5	1.5	4.1
4.8	1.6	3.8	1.2	3.3
Streptomycin				
0.2 (100 μg/ml)	1.3	2.7	1.1	2.2
None	2.6	4.7	2.3	4.4
LSD 0.05	0.7	0.7	0.6	0.6
0.01	1.0	0.9	0.8	0.8

[a] Cultivars Cactus Flowered Sunny Boy and Peter Pan Scarlet. Alternate plants in buffer rows were inoculated August 9.
[b] Disease incidence was rated on a scale of 1–5: 1 = no symptoms, 2 = 1–3, 3 = 3–6, 4 = 6–12, and 5 = 12–25% diseased leaf area.
[c] Treatments were applied weekly. Plants in pots were watered overhead two to three times daily. Note that 1.2 g a.i./L = about 2 lb 50WP/100 gal.

slurry of captan, 360 g a.i./L of water (= 3 lb a.i./gal), reduced disease incidence 16 days after seeding from 100% to 2% or less. No symptoms were found 8 days after seeding in plants from seed treated with the 360-g slurry, but 89.9% of seedlings from untreated seed were diseased. Results were similar when seed was presoaked in 10,500 μg/ml of sodium hypochlorite, then treated with captan. Reducing the concentration of captan to 180 or to 90 g a.i./L resulted in higher disease incidence, 9.6 and 21.2%, respectively, 16 days after seeding. The dry-seed treatment with 50WP was not as effective as the slurry, reducing disease incidence to 12.4% 16 days after seeding. None of the treatments significantly reduced germination of seed (Cactus Flowered Sunny Boy).

Spray trials. Weekly applications of captan at 4.8 g a.i./L significantly reduced disease (Table 2). Lower concentrations did not significantly reduce disease. Streptomycin gave significantly better control than that provided by captan 5 wk after inoculation. No phytotoxicity was observed in plants sprayed with captan, but streptomycin sprays caused considerable chlorosis and some stunting.

DISCUSSION

The control of bacterial spot of zinnia provided by treating seed with captan was very surprising—so much so that the tests were repeated with a different lot of captan 50WP from the same manufacturer and from a different manufacturer and with 75WP. All these tests gave results similar to those in Table 1. Seed treatment with dry captan 50WP was not as effective as the slurry at 360 g a.i./L, but the amount of dry captan that adhered to the seed coat probably was insufficient and this could be rectified by wetting seed before treatment. If effective, this might be a more simple method of application than the use of the slurry. A wetting agent was critical for control of black rot of cabbage (*X. campestris*) via the captan-seed-slurry treatment (R. Navarro and E. Echandi, *personal communication*).

This is not the first report of captan's effectiveness as a seed treatment against bacterial diseases. Potato seed-piece decay, a complex involving at least one bacterial soft rot pathogen, has been reduced with seed-piece treatments containing captan (8,9,11). Seed-soaks with captan, moreover, effectively reduced seedling disease of rice (*X. translucens* f. sp. *oryzae*) (15), mung bean (*X. phaseoli*) (16), and cabbage (*X. campestris*) (R. Navarro and E. Echandi, *personal communication*).

Based on these and previous results (19), the two effective seed-soak treatments of zinnia for control of bacterial spot are sodium hypochlorite, 10,500 μg/ml, and captan, 360 g a.i./L. The captan treatment or a combination of the two could be best, since captan would provide more protection than sodium hypochlorite against a number of damping-off pathogens during seed emergence.

Although the degree of control of bacterial spot of zinnia in plant beds outside the greenhouse with foliar applications of captan was not spectacular, a measure of control was provided. Since the plants were in pots, overhead sprinkler irrigation was required two to three times daily and undoubtedly washed off much of the captan. Perhaps control would be better with normal rainfall and/or irrigation to total about 2.5 cm/wk. Addition of a spreader-sticker might also improve control. Although streptomycin was phytotoxic, weekly applications did provide good control under conditions very favorable for disease development. Perhaps control without phytotoxicity could be obtained with a combination of captan and a lower concentration of streptomycin or an alternating spray schedule of the two materials.

Where bacterial spot of zinnia exists or is suspected, seed treatment with captan and/or sodium hypochlorite followed by captan foliar applications should be useful.

These results support those of Diener and Carlton (7), Daines (4–6), and others (14,21) regarding the efficacy of captan sprays to reduce the incidence of bacterial disease.

My preliminary in vitro tests indicate sensitivity of *Pseudomonas solanacearum*, *Erwinia chrysanthemi*, and *Xanthomonas begoniae* to captan also.

The efficacy of captan as a bacteriostat or bactericide warrants further investigation especially in view of the limited number of chemicals available to agriculture for this purpose.

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