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TARGET SPOT OF TOMATO: EPIDEMIOLOGY AND CONTROL[1,2]

JOHN PAUL JONES AND JEFFREY B. JONES
IFAS, University of Florida,
Gulf Coast Research & Education Center,
5007-60th Street East,
Bradenton, FL 34203

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Abstract. **Target spot of tomato** (Lycopersicon esculentum **Mill.) is caused by** Corynespora cassiicola **(Berk. & Curt.) Wei, a cosmopolitan fungus which incites diseases of ornamentals, vegetables, and field crops. A natural occurrence of the disease caused tremendous loss of tomato foliage and fruit at the Gulf Coast Research and Education Center in 1983. The optimum temperature range for disease development on 'Sunny' tomatoes was 20-28°C with lesions forming on leaf blades, petioles, and stems. A 16-hr continuous wet period following inoculation was required for disease development. However, a 24-hr wet period greatly increased disease severity compared to 16 hr. In a field experiment, target spot severity was reduced by once weekly sprays of chlorothalonil (Bravo) or certain mancozeb (Dithane M-45) + copper fungicide combinations. In growth room experiments, target spot severity was equally decreased by chlorothalonil or mancozeb. The coppers were less effective than chlorothalonil, and benomyl applied as a single spray did not control the disease. Mancozeb + copper combinations did not control target spot any better than the coppers alone and far less than the chlorothalonil + copper or chlorothalonil + mancozeb + copper combinations.**

Target spot of tomato (*Lycopersicon esculentum* Mill.) is caused by *Corynespora cassiicola* (Berk. & Curt.) Wei, a fungus that incites diseases of numerous plant species including ornamentals, vegetables, and field crops (2).

The disease on tomato has occurred sporadically and infrequently in Florida (1) and remains relatively unimportant. However, the potential of the disease to cause serious economic loss is quite real. A natural occurrence of target spot in 1983 at the Gulf Coast Research and Education Center resulted in tremendous loss of foliage and fruit. Consequently, several experiments were carried out to determine the temperature and moist period duration favorable for disease development. Additionally, several fungicide-bactericide treatments were evaluated in the growth room for efficacy in controlling the disease.

Materials and Methods

Temperature experiments. 'Sunny' tomato seedlings were obtained from a commercial seedling producer and transplanted 3 per pot into a 5:3:3:1 peat:sand:vermiculite:perlite (v:v:v:v) mix. The plants were placed in a greenhouse at ambient temperatures for 2 weeks. They were inoculated by gently misting with 0.5 oz/pot of a spore suspension of *C. cassiicola* containing 10,350,000 spores/oz. The fungus isolate used for inoculum was grown 7-14 days on plates of potato-dextrose agar. The plates were flooded with tap water and the spores gently removed with a rubber policeman. Immediately after inoculation, all plants were covered with polyethylene bags wetted slightly inside with tap water. Four bagged pots of plants then were incubated in each of 5 growth chambers set at 16, 20, 24, 28, or 32°C. The experiment was repeated 3 times with the temperature of each chamber being chosen at random each time. After 5 days' incubation the bags were removed and disease severity was estimated in 2 experiments by counting the number of lesions on 4 leaflets per plant (12 leaflets/pot) and in 1 experiment by using the Horsfall-Barratt scale where 1 = no diseased tissue, 6 = 25-50% of the foliage with symptoms, and 12 = 100% of the tissue diseased (3).

Moist period duration experiment. 'Sunny' tomato seedlings were obtained from a commercial producer and were transplanted 3 to a pot in a 5:3:3:1 peat:sand:vermiculite:perlite mix. After potting, the plants were grown 2 weeks in a greenhouse at ambient conditions. Then they were inoculated by gently misting them (0.5 oz/pot) with 4,900,000 spores/oz suspension prepared as previously described. Immediately thereafter, the plants were covered with polyethylene bags wetted inside with tap water. All were placed in a 27°C growth room with 600 ft. c. illumination. Consecutive sets of 4 pots were uncovered 8, 16, 24, 32, 40, 44, and 48 hr after inoculation. The number of lesions were counted on 12 leaflets/pot (3 plants/pot) 4 days after inoculation.

Fungicide-bactericide field experiment. This experiment was originally designed to evaluate fungicide:bactericide combinations for the control of bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) of tomato. However, a natural epidemic of target spot occurred.

"Sunny' seedlings were planted August 1983. All fungicide:bactericide treatments were applied once weekly from September 1 until November 15 using 2-gal stainless steel sprayers with 40 psi pressure. Each plot consisted of 12 plants which were pruned, staked, and tied. A randomized complete block design with 4 replications was used. The percentage foliage affected with target spot was estimated October 19. Fruit were harvested 3 times and were sorted as to healthy and diseased. Commercial insecticides were applied as needed for the control of leafminer and lepidopterous larvae.

Growth room fungicide:bactericide studies. 'Sunny' tomato seedlings were obtained from a commercial producer and transplanted 3 to a pot into 5:3:3:1 peat:sand:vermiculite:perlite (v:v:v:v) mix. The pots were placed in a greenhouse at ambient temperatures for a 2-week growth period. The fungicide:bactericide treatments then were applied to the point of runoff using a small (1 pint capacity) stainless steel sprayer with 30 psi pressure. One day later, all plants (except one set of 4 pots) were inoculated by gently misting them with 0.5 oz/pot of a spore suspension (prepared as previously described) containing 11,800,000 spores/oz. All plants then were covered with polyethylene bags misted inside with tap water and incubated at 27°C in a growth room with 600 ft.-c. illumination. The bags were removed after 3 days and the number of lesions on 4 leaflets/plant (3 plants/pot) were counted 3 and 5 days after inoculation. Each treatment was replicated 4 times in experiments 1, 2, and 4 and 8 times in experiment 3. A randomized complete block design was used in all experiments except experiment 4. In the latter experiment a factorial design with 4 complete blocks was used.

[1]Florida Agricultural Experiment Stations Journal Series No. 5970.
[2]Trade names are included for the benefit of the reader and do not infer any endorsement or recommendation by the authors.

Table 1. Effect of temperature on the development of target spot lesions on 'Sunny' tomatoes in 3 experiments.

Temp. (°C)	Expt. 1			Expt. 2	Expt. 3		
	Leaf disease	Stem lesions	Petiole lesions	No. leaf lesions/plant	No. lesions/plant		
					Foliage	Stem	Petiole
16	3.8[z]	97.9[y]	5.2[y]	19.4	3.8	0.1	0.3
20	8.3	17.0	23.7	9.2	34.8	1.6	2.4
24	6.0	16.8	11.2	16.4	84.9	1.5	4.7
28	9.8	25.3	24.9	30.7	74.1	0.8	1.3
32	4.4	7.1	5.5	2.7	20.2	0.0	0.0
LSD_{50}	2.9	6.8	5.6	5.8	15.2	NS	2.8

[z]Horsfall-Barratt rating where 1 = no disease and 12 = 100% disease.
[y]Number of lesions per plant.

Results and Discussion

Temperature experiments. Target spot was very severe in the first experiment and individual leaf blade lesions were impossible to count. Consequently the Horsfall-Barratt 1 to 12 scale was used to estimate disease severity (Table 1). Target spot developed very well, regardless of temperature; however, the disease was most severe on the blades at 18, 20, and 24°C. Lesions also developed on stems and petioles, although to a much lesser degree than on the blades. Stem and petiole lesion development was much less at 16 and 32°C than at the intermediate temperatures.

Table 2. Effect of moisture period duration on development of target spot of tomato at 27°C.

Moist period (hr)	No. leaf lesions	
	4 days[z]	7 days[y]
8	0	0
16	7.5	5.0
24	23.5	20.0
32	35.8	31.1
40	35.9	32.8
44	44.8	38.2
48	35.8	29.0
LSD_{50}	16.1	13.5

[z]Three days after inoculation.
[y]Five days after inoculation.

Table 3. Effect of various fungicide:bactericide combinations on the severity of target spot on foliage and fruit of 'Sunny' tomatoes in the field.

Treatment[z]	Rate/100 gal	Defoliation (%)	Diseased fruit (%)
K101A + mancozeb	2.0 lb. + 1.5 lb.	19.8 bcde[y]	41 a
CPA + mancozeb	2.0 lb. + 1.5 lb.	34.4 abcd	40 a
CPB + mancozeb	4.0 lb. + 1.5 lb.	23.1 abcde	36 ab
CSTBCS + mancozeb	3.0 lb. + 1.5 lb.	14.5 cde	35 ab
C5E + mancozeb	3.0 pt + 1.5 lb.	48.8 a	25 abcd
CCN + mancozeb	2.0 qt + 1.5 lb.	32.5 abcd	31 abc
K505C + mancozeb	2.67 pt + 1.5 lb.	46.0 ab	38 ab
Chlorothalonil	1.5 pt	13.2 cde	14 d

[z]K101A = (Kocide 101A) copper hydroxide; mancozeb = Dithane M-45, CPA = Basic A (basic copper sulfate); CPB = CP Basic B (basic copper sulfate); CSTBCS = Cities Service TBCS (basic copper sulfate); C5E = Citcop 5E (copper salts of resin and fatty acids); CCN = Copper Count N (copper ammonium carbonate); K505C = — Kocide 505C (copper hydroxide); chlorothalonil = Bravo 500.
[y]Mean separation by Duncan's multiple range test, 5% level.

In experiment 2, lesions developed only on the leaf blades with 28°C being the optimum temperature for disease development. There were very few lesions at 32°C.

In experiment 3, the number of leaf lesions was highest at 24 and 28°C. Much fewer lesions developed at 16, 20 and 32°C. The optimum temperatures for stem and petiole lesion formation were 20, 24, and 28°C.

Table 4. Effect of various chemical treatments on development of target spot of 'Sunny' tomatoes.

Treatment[z]	Rate/100 gal	Mean number leaf lesions		
		Expt. 1	Expt. 2	Expt. 3
Mancozeb + CCN	1.5 lb. + 2 qt	8	278	283
Mancozeb + CSTBCS	1.5 lb. + 4 lb.	52	90	144
Mancozeb + K101	1.5 lb. + 2 lb.	49	151	151
Mancozeb + C5E	1.5 lb. + 3 pt	19	155	134
CCN	2 qt	34	307	—
CSTBCS	4 lb.	57	444	—
K101	2 lb.	37	273	—
C5E	3 pt	18	168	—
Mancozeb	1.5 lb.	7	53	97
Benomyl	1 lb.	114	561	—
Mancozeb + benomyl	1.5 lb. + 1 lb.	9	—	—
Chlorothalonil	1.5 qt	11	23	—
Chlorothalonil + benomyl	1.5 qt + 1 lb.	4	—	—
Chlorothalonil + CSTBCS + mancozeb	1.5 qt + 4 lb. + 1.5 lb.	—	17	—
Chlorothalonil + K101 + mancozeb	1.5 qt + 2 lb. + 1.5 lb.	—	29	—
No treatment (noninoculated)		0.25	0.25	0
No treatment (inoculated)		124	561	813
LSD_{05}		46	120	133

[z]K101 = Kocide 101; mancozeb = Dithane M-45; CSTBCS = Cities Service TBCS; C5E = Citcop 5E; CCN = Copper Count N; benomyl = Benlate; chlorothalonil = Bravo 500. See footnote Table 3 for common chemical names of copper fungicides.

In summary, target spot developed at every incubation temperature from 16 to 32°C. However, the optimum range seemed to be from 20 to 28°C.

Moisture period duration experiment. The number of lesions increased as the duration of the wet period increased from 16 to 44 hr (Table 2). No disease developed with an 8-hr period and very little occurred with a 16-hr period.

Fungicide:bactericide field experiment. Target spot was very severe in the field (natural disease development), especially on some of the copper + mancozeb (Dithane M-45) plots (Table 3). Chlorothalonil (Bravo 500) alone controlled target spot on the foliage better than 2 of the copper + mancozeb mixtures, and on the fruit better than 6 of the mancozeb + copper combinations. A possible incompatibility of certain copper + mancozeb combinations was suggested and a series of growth room experiments was initiated to explore that possibility.

Growth room fungicide:bactericide experiments. In all experiments target spot severity was greatly reduced by all chemical treatments except benomyl (Benlate) (Table 4). The latter fungicide, applied only once before inoculation, did not protect the plants in 2 experiments. The combinations of benomyl + mancozeb and benomyl + chlorothalonil resulted in excellent control but not better than chlorothalonil or mancozeb alone. Although the copper + mancozeb combinations reduced disease severity, mancozeb alone appeared to be more effective. Experiment 4 was established as a factorial design to test the needed comparisons. In this experiment, mancozeb + copper collectively resulted in no better control than the coppers alone and far inferior control compared to the chlorothalonil + copper or chlorothalonil + mancozeb + copper combinations (Tables 5 & 6). Apparently the mancozeb + copper combinations applied for bacterial spot control should be augmented with chlorothalonil if target spot becomes troublesome in commercial fields in Florida.

Table 5. Effects of fungicides, bactericides and fungicide-bactericide combinations on development of target spot in the growth room (Expt. 4).[z]

Treatments[y]	Mean no. leaf lesions	
	Sept 10	Sept 12
Mancozeb + CCN[x]	231	263
Mancozeb + CSTBCS	190	207
Mancozeb + K101	109	160
Mancozeb + C5E	239	243
Chlorothalonil + CCN	65	48
Chlorothalonil + CSTBCS	19	14
Chlorothalonil + K101	37	53
Chlorothalonil + C5E	11	16
Chlorothalonil + mancozeb + CCN	10	15
Chlorothalonil + mancozeb + CSTBCS	39	52
Chlorothalonil + mancozeb + K101	17	21
Chlorothalonil + mancozeb + C5E	37	55
CCN	105	130
CSTBCS	244	275
K101	118	153
C5E	176	177
Mancozeb	90	66
Chlorothalonil	69	55
Mancozeb + chlorothalonil	146	131
No spray (inoculated)	396	696
No spray (noninoculated)	0.3	0
LSD_{05}	87	88

[z]Plants inoculated September 7, 1984.
[y]Mancozeb = Dithane M-45; chlorothalonil = Bravo 500; CCN = Copper Count N; K101 = Kocide 101; CSTBCS = Cities Service TBCS; C5E = Citcop 5E. See footnote Table 3 for common chemical names of copper fungicides.
[x]Rates same as in Table 4.

Table 6. The effect of various fungicide combinations on the development of target spot in experiment 4 (September 10 data analyzed factorially).

Copper fungicides[z]	Fungicides			
	Mancozeb	Chlorothalonil	Chlorothalonil + mancozeb	None
	Mean no. of leaf lesions			
CCN	231	65	10	105
CSTBCS	190	19	39	244
K101	109	37	17	118
C5E	239	11	37	176
Means	192	33	26	161

LSD_{05} to compare fungicide means = 23
LSD_{05} to compare bactericide means = NS

[z]CCN = Copper Count N; CSTBCS = Cities Service TBCS; K101 = Kocide 101; C5E = itcop 5E; mancozeb = Dithane M-45; chlorothalonil = Bravo 500. See footnote Table 3 for common chemical names of copper fungicides.

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