Evaluation of Fungicides for the Control of Cercospora Leaf Spot of Sugar Beets[1]

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Leaf spot disease caused by *Cercospora beticola* Sacc. can seriously reduce the weight of roots and the percent sucrose in sugar beets. Although genetic resistance to the disease has been increased in commercial sugar beet varieties, it is still necessary to use fungicidal spray to protect the crop when weather conditions favor abundant disease development. Economically important increases in root weight and percent sucrose have been noted with fungicide treatments (1, 2, 3, 4)[3]; nevertheless, currently approved fungicides do not provide complete disease control, therefore, there is a need to search for more effective chemical compounds. This report, will present the results from 3 years of trials in which commercially available and experimental fungicides were compared for their ability to control leaf spot of sugar beets.

Materials and Methods

From 1963 to 1965, three fungicide screening tests were carried out in a field heavily infested with *C. beticola* located next to the American Crystal Sugar Company processing plant at Mason City, Iowa. An additional test was conducted in 1965 in a nearby field under disease-free conditions. In each test, a treatment was applied to six replicated plots arranged in a randomized complete block design. A plot consisted of four 25-foot rows with 22 in between rows. The two center rows were harvested for yield and for chemical analyses.

Table 1.—Year of the fungicide tests; dates of planting, inoculating, first spray and harvest.

Year	Dates of			
	Planting	Inoculating	First spray	Harvest
1963	May 6	July 5	July 10	October 18
1964	May 9	June 30	July 6	October 16
1965	May 4	July 7	July 16	October 18
1965	May 18	None (disease free)	July 23	October 19

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[3] Numbers in parentheses refer to literature cited.

A sugar beet variety susceptible to leaf spot, American No. 3N, was used in all tests. A tractor applied the fungicides by means of a spray boom extended on one side to cover four rows. The spray boom was operated with 200 lb pressure/sq in and the nozzles (tip size 2-C) were spaced 11 in apart. The plots were in pairs (eight rows wide) with four rows between pairs for a tractor driveway, to eliminate the possibility of the tractor compacting the soil or damaging the plants in the experimental plots. The plants in the tractor drive were not sprayed, and these provided additional inoculum for the experiment. One or 2 weeks before the fungicidal sprays were first applied, the entire field of sugar beets was sprayed with a suspension of fungus spores obtained from leaves on which the pathogen was sporulating profusely. For several days after inoculation, the field was watered each morning by overhead irrigation to provide high humidity which favors infection. Each fungicide was applied four times at 40 gal/A at approximately 2-week intervals.

During 1965, an experiment was conducted in a disease-free field to determine whether the fungicides would affect the yield of sugar beets when leaf spot is not present. The plants were not inoculated and the field was not irrigated. At midseason, the soil became very dry and somewhat reduced yield.

Trade names and chemical names of the fungicides as well as the companies which distribute them, are given in Table 2. The rate of fungicide refers to the formulated material and not to the active ingredients.

Table 2.—Trade name, chemical and source of the fungicide used.

Trade name	Chemical	Source
Brestan	Triphenyl Tin Acetate	Hostachem Corp.
DU-TER	Triphenyl Tin Hydroxide	Thompson-Hayward Chemical Co.
Daconil 2787	Tetrachloroisophthalonitrile	Diamond Alkali Chemical Co.
Polyram	A zinc activated polyethylene triuramdisulfide	Niagara Chemical Co.
NIA 9130	Coded Material	Niagara Chemical Co.
C-O-C-S	Copper oxychloride sulfate	Niagara Chemical Co.
Tri-Basic Copper	Tribasic copper sulfate	Tennessee Copper Corp.
Copper K	A newly developed fixed copper	Kennecott Copper Corp.
Dithane M-22	Manganese ethylene bis dithiocarbamate (maneb)	Rohm & Haas Co.
Dithane M-45	Coordination produced of a zinc ion and maneb	Rohm & Haas Co.
Manzate	Maneb	DuPont
Manzate D	Maneb + a zinc compound	DuPont

Results and Discussion

Table 3 summarizes results from the 1963 test. Brestan, when applied four times, gave the best protection as shown by the low incidence of leaf spot, and by the increase in sugar/acre which was significantly higher than that of the check. Four applications of Brestan at either the 0.25 lb or 1 lb rate gave

Table 3.—Yields, stand and Cercospora leaf spot incidence resulting from four applications of foliar fungicides tested in 1963[1].

Fungicide	Fungicide lbs/A	Sugar lbs/A	Roots tons/A	Percent sucrose	No. roots/50 ft	Leaf spot rating[2]
Brestan 60	.25	3933**	16.50**	11.94	61.8	1.5
Brestan 60	.50	3852**	15.36**	12.58*	63.8	1.3
Brestan 60	1.00	4320**	16.60**	12.82*	68.2	1.1
Brestan 60	.50[3]	2394	11.27	10.58	59.5	4.3
Polyram	1.00	2573	11.62	11.15	57.3	3.8
Polyram	2.00	2780	12.17	11.37	56.7	3.1
NIA 9130	2.00	2130	10.41	10.35	56.8	3.8
Dithane M-45	2.00	2585	11.99	11.42	64.7	3.0
Maneb	2.00	2491	12.35	10.12	62.0	2.6
Check	—	2281	10.95	10.65	59.2	5.0
LSD (0.05)		828	2.92	1.55	NS	
LSD (0.01)		1111	3.93	NS	NS	
C. V. %		24.08%	19.36%	11.68%	11.25%	

[1] Each figure of yield and disease rating is the average of six replicated plots.
[2] 1 = No leaf spot. 5 = Almost all leaves killed by leaf spot.
[3] Two sprays only.
* Significant at the 5% level between treatment and check.
** Significant at the 1% level between treatment and check.

Table 4.—Yield, stand and Cercospora leaf spot incidence resulting from four applications of foliar fungicides tested in 1964[1].

Fungicide	Fungicide lbs/A	Sugar lbs/A	Roots tons/A	Percent sucrose	No. roots/50 ft	Leaf spot rating[2]
DU-TER 20	.50	5019**	17.71**	14.17**	70.5	1.5
DU-TER 20	.75	4905**	18.18**	13.49**	74.7*	1.7
Brestan 60	.75	4836**	17.21**	14.05**	74.3*	1.3
Brestan 60	.50	3988**	14.64**	13.62**	70.8	2.8
Daconil 2787	3.00	3816**	14.70**	12.98*	71.8	3.3
Dithane M-45	2.00	3323**	12.93*	12.85*	71.3	5.3
Dithane M-22	2.00	3296**	12.58*	13.10*	63.3	6.0
Tri-Basic Copper	5.00	3243**	13.11**	12.37	64.2	5.3
Manzate D	2.00	3205*	12.70*	12.62	67.0	5.6
Polyram	2.00	3187*	12.87*	12.38	66.5	5.5
C-O-C-S	5.00	3150*	12.63*	12.47	68.3	6.3
Check	—	2455	10.49	11.70	64.7	9.6
LSD (0.05)		586	1.90	1.12	7.6	
LSD (0.01)		780	2.54	1.48	NS	
C. V. %		13.79%	11.63%	7.43%	9.49%	

[1] Each figure of yield and disease rating is the average of six replicated plots.
[2] 1 = No leaf spot 10 = Almost all leaves killed by leaf spot.
* Significant at the 5% level between treatment and check.
** Significant at the 1% level between treatment and check.

nearly equal control of disease. However, two applications of Brestan resulted in poor disease control and poor yields as compared to those obtained with four applications.

Table 4 summarizes the 1964 test, in which the best results came from Brestan at 0.75 lb/A and from another organo-tin fungicide, DU-TER, at either 0.5 or 0.75 lb/A. The next best results were obtained from Brestan at 0.5 lb/A and Daconil 2787 at 3 lb/A. The experimental fungicides just described were significantly more effective than maneb, copper, and Polyram that are currently approved for commercial use on sugar beets. All fungicides increased yields significantly above those obtained from the unsprayed check plots. The number of plants per 50 feet of row was significantly higher in two organo-tin treatments due to some control of another disease, Rhizoctonia root rot. Similar results of root rot control have been reported in another study (4).

Table 5 summarizes results for the 1965 experiment in the field where the plants were inoculated with *C. beticola*. Again, the disease control and yields obtained by the organo-tin treatments were markedly above those obtained by the other fungicides. In contrast to the previous year, Daconil 2787 was not superior to the copper, maneb, or Polyram fungicides. Tri-basic copper was less effective when applied in the presence of oil, which is different from the results obtained by other workers (3,4). The reason for the divergent results is not known. Cursory observations suggested that the organo-tin treatments had an insecticidal effect because an armyworm infestation of the field caused less damage to the leaves treated with the organo-tin fungicides than to the leaves in the other treatments or checks.

Table 6 summarizes results for the 1965 experiment conducted in the disease-free field. The fungicide treatments applied in this field and some of those applied in the field with disease were identical. In the absence of disease, none of the fungicides had any significant effect on plant vigor or yield. These results suggest that the benefits derived from the fungicidal chemicals are due entirely to their ability to control diseases and pests.

The results from all of the experiments indicate that fungicidal applications are economically beneficial to the grower when abundant leaf spot disease is present. The most effective compounds tested were the organo-tin fungicides which at times increased sugar yield 50 to 100% above that obtained by the use of other fungicides. If the organo-tin compounds should be approved for commercial use, sizable yield increases can be expected with these fungicides in those districts subject to epidemics of leaf spot.

Table 5.—Yield, stand and Cercospora leaf spot incidence resulting from four applications of foliar fungicides tested in 1965[1].

Fungicide	Fungicide lbs/A	Sugar lbs/A	Roots tons/A	Percent sucrose	No. roots/50 ft	Leaf spot rating[2]
DU-TER 50	1.50	4192**	15.70**	13.35**	56.8	1.16
DU-TER 50	.50	4538**	16.42**	13.82**	52.0	1.49
Brestan 60	.50	4354**	15.14**	14.38**	52.3	1.58
Brestan M-40	.50	4706**	16.82**	13.99**	56.5	1.25
Tri-Basic Copper	4.00	3601	14.98*	12.02	58.5	3.42
Tri-Basic Copper	4.00 + Oil 4½ pints	2775	12.15	11.42	55.3	3.42
Copper K	2.00 + Oil 4½ pints	3099	12.66	12.24	52.0	2.49
Daconil 2787	2.00	3583	14.14	12.67**	54.5	2.08
Polyram	2.00	3374	13.52	12.48*	53.3	3.16
Maneb	2.00	3314	13.67	12.12	56.2	2.41
Check	—	2565	11.48	11.17	51.0	4.58
LSD (0.05)		1134	2.71	1.16	NS	
LSD (0.01)		1510	3.62	1.49	NS	
C. V. %		18.07%	16.38%	7.64%	10.63%	

[1] Each figure of yield and disease rating is the average of six replicated plots.

[2] 1 = No leaf spot. 5 = Almost all leaves killed by leaf spot.

* Significant at the 5% level between treatment and check.

** Significant at the 1% level between treatment and check.

Table 6.—Yield and stand from four applications of foliar fungicides tested in 1965 in a disease-free field[1].

Fungicide	Fungicide lbs/A	Sugar lbs/A	Roots tons/A	Percent sucrose	No. roots/50 ft
DU-TER 50	1.50	4105	11.99	17.12	57.7
Brestan 60	.50	3792	11.26	16.84	58.2
Tri-Basic Copper	4.00	3803	11.49	16.55	60.5
Daconil 2787	2.00	3959	11.63	17.02	65.8
Maneb	2.00	3748	11.03	16.99	56.5
Check	—	4158	12.13	17.14	61.0
LSD (0.05)		NS	NS	NS	NS
LSD (0.01)		NS	NS	NS	NS
C. V. %		10.51%	9.43%	3.77%	10.47%

[1] Each figure of yield and disease rating is the average of six replicate plots.

Summary

The results from 3 years of testing foliar fungicides on sugar beets are reported, and the following conclusions are drawn:

1. When Cercospora leaf spot is present on sugar beets in epidemic severity, significant increases in yield of roots and sucrose percentage may be obtained from fungicide applications.

2. The experimental organo-tin fungicides were the most effective; Daconil 2787 was somewhat less effective; copper, maneb, and Polyram fungicides were least effective but still provided appreciable disease control.

3. None of the fungicides tested had any beneficial effects on the sugar beets when leaf spot disease was absent.

4. The organo-tin fungicides also appeared to reduce damage caused by Rhizoctonia root rot and by armyworm infestation.

Literature Cited

(1) FINKNER, R. E., D. E. FARUS, D. B. OGDEN, C. W. DOXTATQR and R. H. HELMERICK. 1962. Chemical control of Cercospora leaf spot in sugar beets. J. Am. Soc. Sugar Beet Technol. 12 (1): 43-52.

(2) FORSYTH, F. R. and C. R. BROADWELL. 1962. Control of Cercospora leaf spot of sugar beets with protective fungicides. J. Am. Soc. Sugar Beet Technol. 12 (2): 91-93.

(3) WILSON, J. D., F. IRONS, O. HEDDEN and J. HENRY. 1961. Spraying sugar beets for the control of Cercospora leaf spot. Ohio Agr. Expt. Stat., Botany and Plant Pathol. Ser. 40, 33 p. (mimeo).

(4) WILSON, J. D. and F. IRONS. 1964. The control of Cercospora leaf spot of sugar beets in plots located at Fremont, Ohio, in 1964. Ohio Agr. Expt. Sta., Botany and Plant Pathol. Ser. 45B. 22 p. (mimeo).