Fungicidal Control of Sugar Beet Leaf Spot[1]

LESTER W. CARLSON[2]

Received for publication May 13, 1966

Leaf spot, caused by *Cercospora beticola* Sacc., is a common disease of sugar beets. The average annual crop loss is about 3.0 percent nationally (2)[3] but higher in the humid areas east of the Rocky Mountains. Control of the disease with fungicides has been investigated in this country and Europe (1,3,4,5). The results presented here supplement our knowledge of the timing of fungicide applications and of the type of chemicals used to control leaf spot.

Fungicide Evaluation Experiments

Materials and Methods Fungicides (Table 1) were applied at 10-day intervals starting in late June or early July and continuing for 5 to 7 applications. They were applied at 150 psi from a high-pressure sprayer at the rate of 100 gallons per acre. Spreader-stickers used were Ortho spray sticker in 1963, DuPont spreader-sticker in 1964, and Plyac in 1965. An emulsifiable oil, EAP-249, was used with some fungicides.

Experimental plots, located near Vermillion, South Dakota, in 1963 and 1964 and at Brookings in 1965, were 4 rows wide, 35 feet long, replicated 4 times, and arranged in a completely randomized block. Leaf spot severities corresponding to the percentage of leaf area spotted were rated on a scale of 1 to 11, with 1 = no disease and 11 = all leaves dead. Beet yields and sugar yields obtained with help from the Utah-Idaho Sugar Company were compared by Duncan's Multiple Range Test.

Results In nonsprayed plots the percent leaf spot was 93.3 in 1963, 90.9 to 93.3 in 1964, and 7.0 to 9.5 in 1965.

In 1963, Duter was the most effective chemical. It reduced disease severity to 34%, increased beet yield 7 tons per acre, and increased sugar yield 3000 lbs. per acre (Table 2). Dithane M-22, Dithane M-22 + EAP-249, Tribasic Copper Sulfate, and Daconil also performed well.

In 1964, Duter again was the most effective chemical. It reduced disease severity to 17.4%, increased beet yields 4-5 tons per acre, and increased sugar yield at least 1200 lbs. per acre (Table 3). Maneb compounds (Dithane M-22 and Manzate-D),

---

[1] South Dakota Agricultural Experiment Station Journal Series No. 720.

[2] Assistant Professor, Plant Pathology Department, South Dakota State University, Brookings, South Dakota.

[3] Numbers in parenthesis refer to literature cited.

Table 1.—Fungicidal chemicals applied to sugar beets.

Trade name	Common name	Chemical name	Formulation
Brestan		triphenyl-tin-acetate	60wp
Calumet Copper 5%		copper naphthenate	5L
Calumet M-20		copper carbamate	20wp
C-O-C-S	fixed copper	basic copper chlorides	55wp
Cyprex	dodine	N-dodecylguanidine acetate	65wp
Daconil		tetrachloroisophthalonitrite	75wp
Difolitan	folcid	N-1,1,2,2-tetrachloroethylmercapto-4-cyclohexene-1,2-discarboximide	80wp
Dithane M-22	maneb	manganese ethylene-bis-dithio-carbamate	80wp
Dithan M-22S	maneb	manganese ethylene-bis-dithio-carbamtae + zinc	80wp
Dithane M-45		coordination product of zinc and manganese ethylene-bis-dithio-carbamate	80wp
Duter		triphenyl-tin-hydroxide	20wp
Dyrene		2,4-dichloro-6-(O-chloroaniline)-s-triazine	50wp
Manzate	maneb	manganese ethylene-bis-dithio-carbamate	80wp
Manzate-D	maneb	manganese ethylene-bis-diotio-carbamate + zinc	80wp
Niacide-M		mixture of manganese dimethyl dithio-carbamate and mercapto-benzothiazole	65wp
Phaltan	folpet	N-trichloromethylphthalimide	50wp
Phygon	dichlone	2,3-dichloro-1,4-napththoquinone	50wp
Polyram		zinc polyethylenethiuram disulfide	80wp
TC-90		copper salts of fatty rosin acids	48EC
Tribasic Copper Sulfate	fixed copper	tribasic copper sulfate	53wp

Table 2.—Effect of fungicide on Cercospora leaf spot, sugar, and yields of sugar beets. (1963)

Fungicides and rates of usage per acre[a]	Percent disease	Beets tons/acre	Sugar lbs/acre
Maneb, 2.0 lbs	34.6**	18.50	4636
Maneb, 3.0 lbs	50.0**	18.74	4796
Dithane M-45, 2.0 lbs	51.3**	19.40	5150
Duter, 1.5 lbs	33.2**	23.42**	6068**
Basic Copper Sulfate, 5.0 lbs	49.5**	22.61**	5723*
Folpet, 4.0 lbs.	81.7	20.91*	4799
Folcid, 3.0 lbs	67.6**	17.79	4301
Dyrene, 2.0 lbs	60.2**	19.51	4805
Dodine, 2.0 lbs	90.7	16.35	3260
DAC-2787, 2.0 lbs	34.3**	19.66	5462*
Dichlone, 0.75 lbs	91.4	16.30	3749
TC-90, 0.75 gal	78.9	17.40	4086
EAP-249, 1.0 gal	87.8	15.45	3447
Maneb, 2.0 lbs + EAP-249, 1 gal	45.3**	20.96*	5194
Check	93.3	16.07	3411

[a] Applied at 100 gpa. Total of 6 spray applications.
*Statistical significance at the 5 percent level of confidence.
**Statistical significance at the 1 percent level of confidence.

Table 3.—Effect of fungicides on Cercospora leaf spot, sugar, and yield of sugar beets. (1964)

Fungicides and rates of usage per acre[a]	Percent disease	Beets tons/acre	Sugar lbs/acre
Duter, 1.5 lbs	17.4**	18.13	5272
Duter, 1.0 lbs	44.5**	16.36	4785
Duter, 0.5 lbs	58.8**	15.73	4752
Tribasic copper sulfate, 6.0 lbs	69.1**	14.58	4380
Tribasic copper sulfate, 6.0 lbs + EAP-249, 5 pts	67.3**	14.75	4335
Tribasic copper sulfate, 5.0 lbs + EAP-249, 5 pts	68.7**	17.21	5389*
Tribasic copper sulfate 4.0 lbs + EAP-249, 5 pts	61.2**	14.51	4551
Tribasic copper sulfate 8.0 lbs + EAP-249, 5 pts	60.9**	17.74	4943
Manzate D, 3.0 lbs	64.4**	16.26	4752
Manzate D, 2.0 lbs	79.1	16.84	4786
Manzate D, 1.0 lbs	84.3	14.66	4312
Manzate D, 2.0 lbs, 75 gpa	79.0	15.69	4357
Manzate D, 2.0 lbs, 50 gpa	80.5	20.25	5418**
Manzate D, 2.0 lbs, 25 gpa	78.5	14.92	4400
Dithane M-22, 2.0 lbs	49.3**	13.37	3954
Dithane M-22, 2.0 lbs + EAP-249, 5pts	65.7**	17.22	4784
DAC-2787, 3.0 lbs	56.7**	16.41	4855
DAC-2787, 2.0 lbs	50.1**	17.38	5220
DAC-2787, 1.0 lb	85.0	15.72	4635
DAC-2787, 2.0 lbs + EAP-249, 5 pts	63.8**	12.87	3508
Dithan M-45, 3.0 lbs	57.7**	13.69	4315
Polyram, 4.0 lbs	81.3	16.01	4609
C-O-C-S, 6.0 lbs	68.9**	13.28	3913
M-20, 0.5 gal	91.9	18.42	5410**
Dyrene, 3.0 lbs	71.2*	15.37	4487
Check #1	90.9	14.72	3981
Check #2	92.2	12.43	3205
Check #3	92.3	15.56	4011
Check #4	93.1	13.07	3498
Check #5	93.3	13.38	3630

[a] Applied at 100 gpa, except where otherwise designated. Total of 7 spray applications.
*Statistical signficance at the 5 percent level of confidence.
**Statistical significance at the 1 percent level of confidence.

Daconil, and Tribasic Copper Sulfate performed as well in 1964 as in 1963. M-20 increased beet and sugar yields, but it did not control leaf spot.

In 1965, leaf spot severity in all treated plots was significantly lower than in the nontreated plots (Table 4). Because of the low level of disease incidence in the treated plots, it was difficult to determine which chemical was the most effective. However, Duter at 1.5 lbs, Daconil at 2.0 lbs, and the maneb compounds, which demonstrated good control in previous years, were among the effective fungicides in this experiment. Brestan, Dithane M-45, and Polyram gave good control of leaf spot.

Table 4.—Effect of fungicides on Cercospora leaf spot severity. (1965)

Fungicides and rates of usage per acre[a]	Percent disease	Recommended for grower use[b]
Polyram, 5.0 lbs	0.1**	Yes
Brestan, 1.0 lb	0.1**	No
Duter, 1.5 lbs	0.2**	No
Duter, 1.0 lb	0.8**	No
Duter, 0.5 lbs	0.9**	No
Daconil, 3.0 lbs	0.5**	No
Daconil, 2.0 lbs	0.2**	No
Daconil, 1.0 lb	0.6**	No
Dithane M-22S, 2.0 lbs	0.4**	Yes
Dithane M-45, 3.0 lbs	0.4**	Yes
Manzate-D, 3.0 lbs	0.4**	Yes
Manzate-D, 2.0 lbs	0.5**	Yes
Manzate-D, 1.0 lb	1.4**	Yes
Tribasic copper sulfate, 6 lbs + EAP-249, 5 pts	1.4**	Yes
C-O-C-S, 6 lbs	1.7**	Yes
Tribasic copper sulfate, 4 lbs + EAP-249, 5 pts	2.3**	Yes
Tribasic copper sulfate, 6.0 lbs	2.4**	Yes
Calumet M-20, 2 lbs	2.4**	No
Niacide-M, 3.0 lbs	3.7**	No
Calumet copper 5%, 2 gal	3.8**	No
Check #1	7.0	—
Check #2	7.8	—
Check #3	7.2	—
Check #4	9.5	—

[a] Applied at 100 gpa. Total of 5 spray applications.
[b] Based on USDA and FDA approval of usage.
**Statistical significance at the 1 percent level of confidence.

These data indicate that leaf spot can be controlled by fungicides. However, only four groups of the chemicals are cleared by the Food and Drug Administration and by the USDA for use on sugar beets. They are the manebs (Dithane M-22 and Manzate-D), Dithane M-45, Polyram, and the basic coppers (Tribasic Copper Sulfate and C-O-C-S). It is expected that Duter and Daconil will be cleared for use in a few years.

Fungicidal Spray Timing Experiments

Materials and Methods It is not economically feasible to spray over the entire growing season, as this would require 10 to 12 fungicide applications. To determine a suitable number of, and the timing of applications, it was decided to evaluate several overlapping spray series of 3 to 7 applications each, with each series started at different times. For convenience of tracking, each spray application was given a number 1 through 7 to correspond to the date when applied. The earliest start of a series of sprays was July 15 in 1963 and June 30 in 1964. Once started, spray applications within a series were continued at 10-day intervals. The latest application in a series was approximately 30

days before harvest. Maneb (Dithane M-22) was used at 2.0 lbs per acre in 1963 and 1964, and Duter was used at 1.5 lbs per acre in 1964.

The plot size, the method of fungicide application, and final evaluation of the data were as described in the previous section on fungicide evaluation.

Table 5.—Time of fungicide application vs. Cercospora leaf spot, sugar, and yields of sugar beets. (1963)

Fungicide	Dates of applications[a]	Percent disease	Beets tons/acre	Sugar lbs/acre
Maneb	1,2,3,4,5,6	34.6**	18.50	4636
	1,2,3	84.7	21.74**	5011
	2,3,4	73.3*	20.31*	5182
	3,4,5	60.8**	19.32	4556
	4,5,6	75.1	18.16	4096
Check		93.3	16.07	3411

[a] 1—July 15; 2—July 25; 3—August 5; 4—August 15; 5—August 26; 6—September 7.
*Statistical significance at the 5 percent level of confidence.
**Statistical significance at the 1 percent level of confidence.

Table 6.—Time of fungicide application vs. Cercospora leaf spot, sugar, and yields of sugar beets. (1964)

Fungicide	Dates of applications[a]	Percent disease	Beets tons/acre	Sugar lbs/acre
Duter	1,2,3,4,5,6,7	36.7**	17.55	5293
	1,2,3	87.4	15.19	4114
	2,3,4	71.2**	14.54	4427
	3,4,5	46.5**	15.85	4446
	4,5,6	61.0**	15.94	4922
	5,6,7	80.2*	14.56	4277
	1,2,3,4	66.3**	12.94	4353
	2,3,4,5	59.3**	15.62	4796
	3,4,5,6	57.4**	17.22	5176
	4,5,6,7	61.7**	14.34	4228
	1,2,3,4,5	39.2**	15.61	4583
	2,3,4,5,6	53.5**	16.29	4846
	3,4,5,6,7	56.3**	13.61	4266
	2,3,4,5,6,7	39.5**	13.82	4094
Dithane M-22	1,2,3,4,5,6,7	58.1**	17.27	5195
	1,2,3	93.7	12.54	3506
	2,3,4	89.5	15.07	4348
	3,4,5	83.7	17.08	4795
	4,5,6	79.2*	16.03	4492
	5,6,7	77.6**	12.60	3609
Check #1		90.9	15.28	3691
Check #2		93.7	13.83	3773
Check #3		91.8	12.64	3290
Check #4		92.5	12.65	3348

[a] 1—June 30; 2—July 9; 3—July 21; 4—August 2; 5—August 12; 6—August 21; 7—September 1.
*Statistical significance at the 5 percent level of confidence.
**Statistical significance at the 1 percent level of confidence.

Results The results of the 1963 experiment (Table 5) demonstrate the importance of fungicidal coverage during late July and August. The best series of three sprays (3, 4, 5) reduced leaf spot severity by about 33 percent. However, six sprays applied during the period from mid-July to early September reduced leaf spot severity by about 60 percent. Results obtained in 1964 (Table 6) were similar to these, with the best series of three sprays being 3, 4, and 5 for Duter and 5, 6, and 7 for maneb. As expected, Duter series with four and five spray applications resulted in a better disease control than the Duter series with three sprays.

The best leaf spot control was achieved by a spray program covering the entire growing season. However, adequate control was obtained with three to five sprays from mid-July to late August. A more efficient timing of fungicidal applications could be made if inoculum build-up and dispersal could be forecast.

Summary

In three years of fungicide evaluation in South Dakota, Duter at 1.5 lbs per acre gave the most effective leaf spot control, while maneb compounds (Dithane M-22 and Manzate-D), Daconil, and Tribasic Copper Sulfate also gave adequate control.

The best timing for spray application for adequate control was mid-July to late August with three to five applications.

Control of sugar beet leaf spot generally increased beet and sugar yields, even though increases were not always significant.

Several cases of increased beet and sugar yields were observed with no apparent control of leaf spot. While the cause may have been either the effect of the fungicide on the metabolism of the sugar beet or a sampling error, neither could be determined in this study.

Literature Cited

(1) DARPOUX, H., M. ARNOUX and A. LEBRUN. 1953. Essais de traitements contre le *Cercospora beticola*. Phytiatre-Phytopharm. 2:139-144.

(2) U. S. Department of Agr., Agr. Research Service. 1965. Losses in Agriculture. Agric. Handbook No. 291.

(3) WENZL, H. 1954. Fortschritte in der Bekämpfung von Rüben-Krankheiten. Pflanzenarzt. 7: 1-2.

(4) WILSON, J. D., F. IRONS and J. HENRY. 1963. Experiments in the control of Cercospora leaf spot of sugar beets - 1962. Ohio Agr. Expt. Sta., Dept. of Bot. and Pl. Path. Mimeo Series 42: 1-23.

(5) YOUNG, H. C. 1939. Dusting and spraying sugar beets. Proc. Am. Soc. Sugar Beet Technol. Eastern Regional Meeting. 2: 13-16.