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Tomato Leaf Spot Control

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PLANT PATHOLOGY
DEPARTMENT

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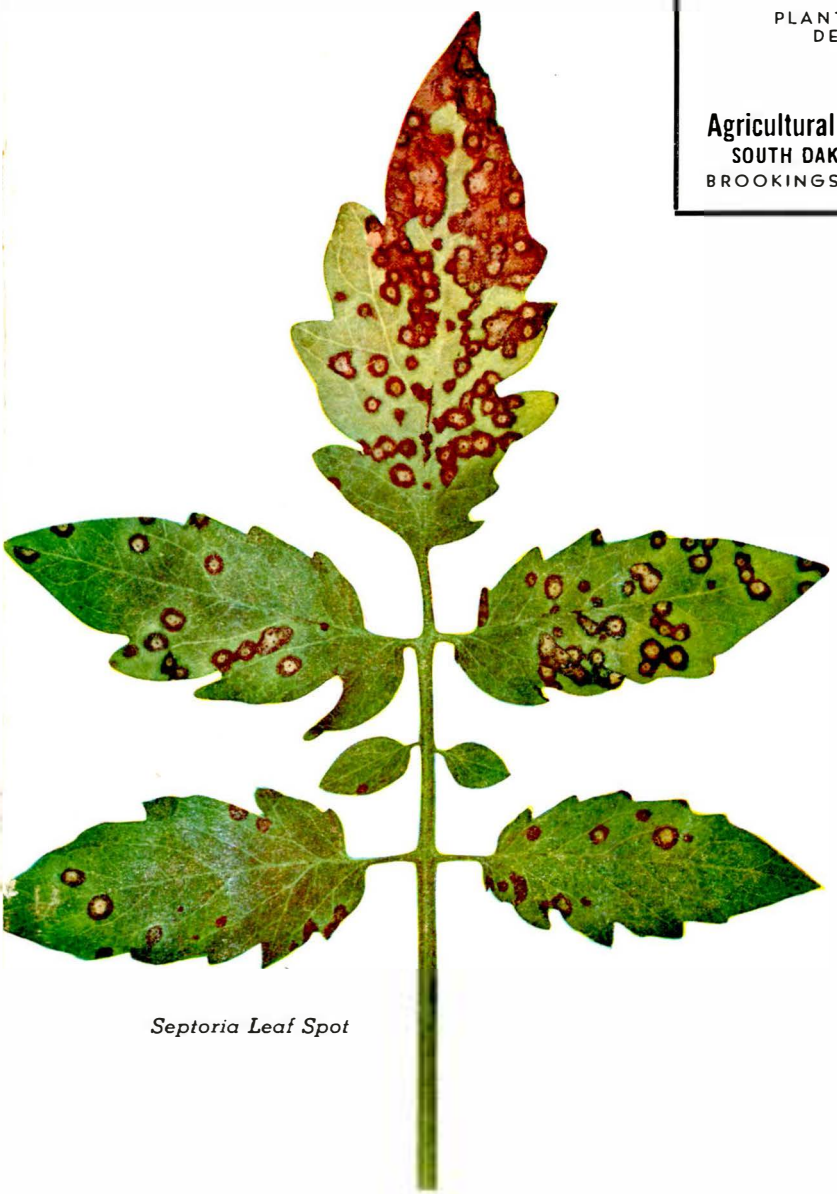
BROOKINGS, SOUTH DAKOTA



Septoria Leaf Spot

CONTROL MEASURES

Tomato plants can be protected from Septoria leaf spot and other fungus diseases by applying an effective fungicide. The first application should be made when the first leaf spot symptoms appear; additional applications should follow at 10-day intervals. Fungicides applied as sprays under pressure are more effective than those applied as dusts. It is important that the lower as well as the upper surfaces of the leaves be covered.

Of the fungicides tested, the following performed well with respect to leaf spot control, yield, and freedom from chemical injury to the plants: (1) the fixed coppers such as tribasic copper sulfate (4 lbs. per 100 gals. of water), Yellow Cuprocide (2 lbs. per 100 gals.), Compound A (4 lbs. per 100 gals.) and Cop-O-Zink (4 lbs. per 100 gals.); and (2) the organic compounds such as Dithane Z-78 or Parzate (2 lbs. per 100 gals.) and Methasan (3 lbs. per 100 gals.).

TOMATO LEAF SPOT CONTROL

C. M. NAGEL and L. T. RICHARDSON[1]

The most important plant disease affecting tomatoes during the past 10 years in South Dakota has been a fungus disease known as Septoria leaf spot *(Septoria lycopersici)*. Other diseases have been of minor importance, namely late blight, Alternaria leaf spot, wilt and virus troubles.

Septoria leaf spot frequently develops rapidly and may, under favorable conditions, completely defoliate the crop within a few weeks. When defoliation by the disease occurs, the yield may be markedly reduced. Fruit produced on such plants becomes flabby and the flavor is of low quality.

The tomato is one of our most important vegetable crops. It is grown by virtually every home gardener and is high in certain vitamins which are important in the family diet, though it is not grown extensively on a commercial scale in the state at the present time.

Septoria leaf spot may be recognized by the characteristic spots (see cover) on the leaves and stems which are approximately one-eighth inch in diameter. The margins of the spots usually become dark reddish-brown in color while the centers are light grey with a few scattered tiny black specks. When the spots become very numerous the affected leaves turn from light green to brown, die and drop from the plants. When the leaves are killed by the disease the fruits ripen prematurely and have an insipid flavor.

These symptoms should distinguish Septoria leaf spot from other fungus diseases affecting the foliage. Early blight *(Alternaria solani)* forms larger irregular spots one-fourth to one-half inch in diamater with numerous inconspicuous concentric rings within the diseased spot. Late blight *(Phytophthora infestans)* forms larger patches on the leaves which may, under certain weather conditions, involve entire leaves. The lesions appear water-soaked at first, but later become light brown to dark brown and in moist weather show a white mildew-like growth on the lower side of the leaves. This disease also causes a characteristic brown rot of the fruit which may result in heavy losses in yield of marketable fruit.

Tomato plants can be protected from these fungus diseases by repeated applications with an effective fungicide. The first application should be made when the leaf spots first appear, and then repeated at 10-day intervals. It has been shown experimentally that sprays provide better coverage and protection than dusts. The lower as well as the upper surfaces of the leaves should be covered. In order to determine the most effective fungicide for the control of tomato foliage diseases in South Dakota a series of field experiments was started in 1944 at the State College Experiment Station.

[1]Plant Pathologist and Associate Plant Pathologist, respectively, South Dakota Agricultural Experiment Station, Brookings, South Dakota. The authors wish to acknowledge the assistance and suggestions given during the initial phases of this investigation by Dr. W. F. Buchholtz, formerly Head, Plant Pathology Department.

Materials and Methods

All of the fungicides tested in the course of the spray trials are listed in Table 1 with their chemical names and the concentrations used in these experiments. The sprays were applied to single rows of plants by means of a boom with three nozzles. A small tractor-drawn sprayer was used in these experiments which was operated at 250 pounds pressure. The plots for the various treatments were replicated and arranged in a randomized block. Each plot contained 10 Victor tomato plants spaced 3.5 feet apart in a single row. The rows were spaced 7 feet apart for convenience in applying the treatments. The outside guard rows and the check plots received no spray treatment.

At intervals during the growing season the plants were examined individually for foliage diseases, and the percentage defoliation was determined for each treatment.[2] The number and weight of fruit from each plot were determined for each picking. After the vines were killed by frost the number and weight of unripened fruit were also determined. Yield data were taken in pounds per plot and converted to tons per acre.

Results

During the six years of the experiment, defoliation due to foliage diseases was very severe in 1944, 1945, and 1948. The disease mainly responsible for this defoliation was Septoria leaf spot.

In 1944, four spray applications were made, on July 4, 22 and 31, and August 16. Six different fungicides were used and each treatment was replicated four times. There were five pickings of ripe fruit during the season. The treatments are listed in Table 2 in order of yield of marketable fruit, Yellow Cuprocide leading with 11.0 tons per acre as compared with 7.2 tons from the check plots.

The temperatures during the growing season were slightly below normal at Brookings while the rainfall, especially in August, was higher than normal. On August 17 a light infection of Septoria leaf spot was observed to be uniformly distributed over all the plots. By September 3, all plants in the check plots and in plots sprayed with Spergon and Bordeaux were completely defoliated (Fig. 1). The best protection was provided by Phygon (37.5 percent defoliation), the next being Yellow Cuprocide (81.2 percent). By September 15 defoliation was complete in the Dithane and Fermate treated plots and had reached 87.5 percent in Yellow Cuprocide and 56.0 percent in Phygon plots.

The relationship between defoliation and yield of fruit, both in number and weight, is illustrated in Fig. 1. Although Phygon provided the best disease control, it ranked third in yield, possibly due to the effect of the fungicide itself on the plants.

In 1945, ten fungicides were tested, with four replications. Six sprays were applied, on July 20, August 1, 11 and 22, and September 4 and 19. The treatments are listed in Table 3

[2]The method of Barrett and Horsfall was followed. See "Fungicides and their Action." J. G. Horsfall. Chronica Botanica, Waltham, Mass, 1945.

Table 1. Trade Names, Chemical Names, and Concentrations of Fungicides Used in Tomato Spray Experiments, Brookings, 1944–50

Fungicide	Chemical Name	Quantity per 100 Gal. Water
Bioquin 1	copper 8-quinolinolate	1 lb.
Bordeaux 8-8-100	copper sulfate + hydrated lime	8 lb. + 8 lb.
Compound A	copper oxychlorides	4 lb.
Cop-O-Zink	tribasic copper sulfate + zinc oxysulfate	4 lb.
Crag 658	copper zinc chromates	2 lb.
Dithane D-14 (Nabam)*	disodium ethylene bisdithiocarbamate + zinc sulfate + hydrated lime	2 qts. + 1½ lb. + ½ lb.
Dithane Z78 Nabam)	zinc ethylene bisdithiocarbamate	2 lb.
Fermate (Ferbam)	ferric dimethyl dithiocarbamate	2 lb.
Isothan Q15	lauryl isoquinolinium bromide	1 pt.
Methasan (Ziram)	zinc dimethyl dithiocarbamate	3 lb.
Parzate (Zineb)	zinc ethylene bisdithiocarbamate	2 lb.
Phygon XL	2,3-dichloro-1,4-naphthoquinone	1 lb.
Spergon	tetrachloro-p-benzoquinone	2 lb.
Tribasic	copper basic sulfates	4 lb.
Yellow Cuprocide	yellow cuprous oxide	2 lb.
Zerlate (Ziram)	zinc dimethyl dithiocarbamate	2 lb.

*Names in parentheses are new commercial trade names for these organic fungicides.

Table 2. Average Weights and Numbers of Tomato Fruits Produced in Replicated Plots Receiving Four Applications of Six Different Fungicides, Brookings, 1944

Treatments	Av. Yield—Tons/A.*				Av. No. of Fruits per Plant			
	US1&2	Culls	Green*	Total	US1&2	Culls	Green*	Total
Yellow Cuprocide	11.0	11.6	2.6	25.2	28.7	46.4	18.5	93.6
Dithane D14	8.9	10.5	1.6	21.0	26.8	43.3	15.2	85.3
Phygon XL, 1%	8.0	12.0	4.8	24.8	20.8	40.6	27.4	88.8
Bordeaux 8-8-100	8.0	10.8	1.5	20.3	21.4	40.6	12.7	74.6
Spergon	7.8	11.4	2.8	22.0	21.4	38.7	19.2	79.2
Fermate	7.7	11.8	1.9	21.4	20.8	41.4	14.0	76.2
No treatment	7.2	9.9	1.4	18.5	20.2	39.1	11.4	70.7
Least significant difference	2.5		1.6	5.8			9.0	20.4

*These yield data appear to be low due to the fact that the rows were spaced 7 feet apart to facilitate spraying operations. If the plants had been spaced as in commercial practice, namely three and one-half feet apart, the tonnage per acre would have been practically doubled.

in order of yield of marketable fruit from four pickings. The temperatures were again below normal during the growing season while the rainfall was above normal. Septoria leaf spot infection was moderate in 1945, progressing from 11.5 percent defoliation in the check plots on August 24 to 91.0 percent on September 29. The best protection was again provided by Phygon (6.3 percent defoliation) and the least by Isothan Q 15 (86.5 percent). The effect of defoliation on yield is illustrated in Fig. 2. The percentage defoliation increases as the number and weight of marketable fruits decreases.

In 1948, the next season when foliage diseases were important, eight fungicides were tested with five replicates per treatment. The treatments are listed in Table 4 in order of yield of marketable fruit from four pickings. The temperature and rainfall during the growing season were about normal. Defoliation, which reached 76.5 percent in the

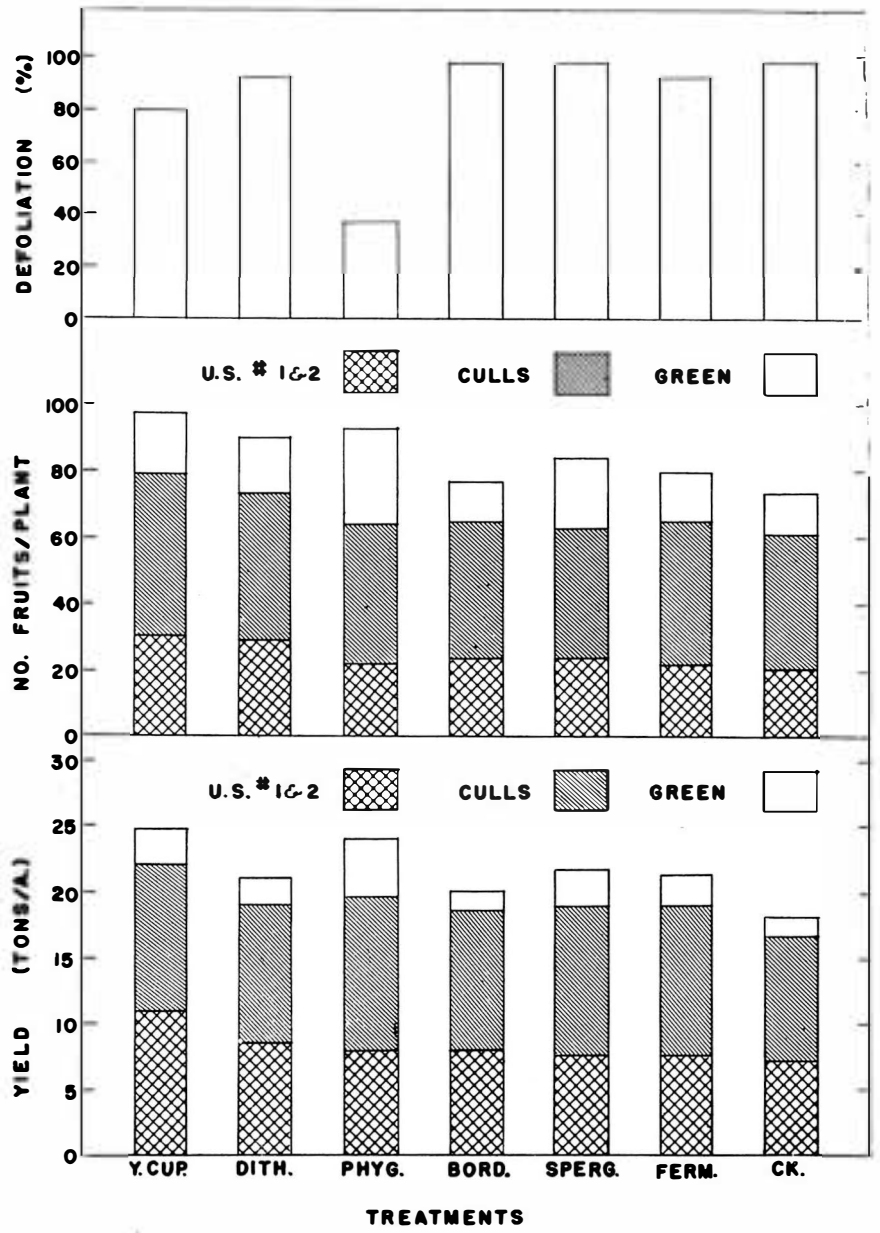


Fig. 1. Effect of four applications of six different fungicides on defoliation due to Septoria leaf spot and on number and weight of fruits of Victor tomatoes, Brookings, 1944

Table 3. Average Weights and Numbers of Graded Tomato Fruits Produced in Replicated Plots Receiving Six Applications of 10 Different Fungicides, Brookings, 1945

Treatments	Av. Yield—Tons/A. US1&2	Culls	Green	Total	Av. No. of Fruits per Plant US1&2	Culls	Green	Total
Compound A	11.3	6.8	10.7	28.8	36.7	35.7	69.3	141.7
Yellow Cuprocide	10.7	6.2	10.4	27.3	36.2	34.4	72.0	142.8
Phygon XL, 1%	10.0	3.1	12.5	25.6	35.4	16.3	79.0	130.8
Dithane D14	10.0	6.2	11.1	27.3	33.6	34.2	74.6	140.1
Bordeaux 8-8-100	10.0	7.2	9.7	26.9	33.3	38.3	67.0	138.6
N5E	9.5	6.5	9.2	25.2	31.4	34.7	62.6	128.6
Fermate	9.1	7.3	10.1	26.4	30.0	40.0	72.2	142.2
Isothan Q15	9.1	7.6	6.9	23.6	30.7	45.0	49.2	124.9
Zerlate	9.0	7.2	10.0	26.2	30.1	38.5	67.3	135.9
Spergon	8.4	7.6	6.9	22.8	29.0	43.3	55.7	128.0
No treatment	8.1	7.9	7.4	23.4	24.8	50.0	64.0	128.8
Least significant difference	2.2	—	1.7	4.7	—	—	4.0	21.2

Table 4. Average Weights and Numbers of Graded Tomato Fruits Produced in Replicated Plots Sprayed With Eight Different Fungicides, Brookings, 1948

Treatments	Av. Yield—Tons/A. US1&2	Culls	Total	Av. No. Fruits per Plant US1&2	Culls	Total
Dithane	7.6	6.8	14.4	21.1	29.9	51.0
Tribasic alternating with Zerlate	7.5	6.4	13.8	22.1	31.3	53.4
Bordeaux 8-8-100	7.2	6.2	13.5	21.7	30.5	52.1
Yellow Cuprocide	7.1	6.2	13.3	20.8	30.3	51.0
Phygon XL, 1%	6.9	6.3	13.2	20.1	31.2	51.3
Zerlate	6.9	7.0	13.9	20.7	34.1	54.8
Tribasic	6.4	6.2	12.6	19.5	29.1	48.7
Crag 658	6.4	6.2	12.6	19.2	29.1	49.2
No treatment	5.0	6.3	11.3	16.8	33.6	50.4
Least significant difference	1.3	—	2.3	—	—	—

unsprayed plots by September 9, was reduced to 18.5 percent by Bordeaux and 19.5 percent by Yellow Cuprocide. Defoliation, number of fruits per plant, and yield in tons per acre are compared in Fig. 3. Though differences in yield between treatments were small, all treatments exceeded the check in production of marketable fruit.

Yield data taken in three seasons when foliage diseases were negligible (1947, 1949, and 1950) are presented in Tables 5, 6 and 7.

The weather conditions during these growing seasons were not favorable to the disease organisms. In the virtual absence of foliage diseases, significant differences in yield between treatments could be attributed largely to the effects of the fungicides themselves on the plants. In two instances significant increases in yield occurred in plots treated with tribasic copper sulfate and Yellow Cuprocide as compared with untreated plots (1949). Sharp decreases in yield resulted from the use of Phygon in 1949 and 1950.

The value of any fungicide cannot be accurately assessed on the basis of results obtained in a single season. A comparison of results obtained over a period of years, however, reveals distinct trends even

Table 5. Average Weights and Numbers of Graded Tomato Fruits Produced in Replicated Plots Sprayed Wtih 12 Different Fungicides, Brookings, 1947

Treatments	Av. Yield—Tons/A. US1&2	Culls	Green*	Total	Av. No. of Fruits per Plant US1&2	Culls	Green*	Total
Phygon 2%	4.3	1.2	4.4	9.9	14.5	5.5	27.0	47.1
Crag 658	4.3	1.5	6.0	11.8	12.8	7.2	34.9	55.0
Phygon XL, 1%	4.0	0.6	4.5	9.1	15.0	6.9	24.9	46.8
Tribasic alternating with Zerlate	4.0	1.4	5.4	10.8	13.2	6.9	31.5	51.7
Parzate	3.7	1.2	6.2	11.1	11.6	4.7	35.8	52.2
Phygon + Hormone	3.7	1.5	4.8	10.1	12.4	7.2	28.3	47.8
Bioquin	3.7	1.4	5.0	10.0	12.1	7.2	28.8	48.1
Dithane	3.6	1.1	4.7	9.4	10.3	6.5	25.4	42.2
Zerlate	3.5	1.0	5.3	9.7	10.3	4.7	30.7	45.8
No treatment	3.4	1.7	4.7	9.8	11.7	8.2	28.9	48.8
Tribasic	3.4	1.0	5.5	9.9	10.7	4.6	32.5	47.8
Yellow Cuprocide	3.2	0.8	6.1	10.2	10.2	3.6	31.6	45.4
Phygon XL, 0.5%	3.1	1.0	4.9	9.0	10.2	5.1	25.5	40.8
Least significant difference	1.0	—	—	1.9	—	—	—	8.3

*Harvested after frost.

Table 6. Average Weights and Numbers of Graded Tomato Fruits Produced in Replicated Plots Receiving Four Applications of Eight Different Fungicides, Brookings, 1949

Treatments	Av. Yield—Tons/A. US1&2	Culls	Green*	Total	Av. No. of Fruits per Plant US1&2	Culls	Green*	Total
Tribasic	3.2	3.4	0.8	7.4	14.5	26.0	12.2	53.2
Yellow Cuprocide	2.9	3.0	0.8	6.7	13.6	34.4	11.9	59.8
Zerlate	2.8	3.4	0.7	7.0	13.0	37.5	9.5	60.0
Tribasic alternating with Zerlate	2.7	3.3	0.9	6.9	12.0	28.1	11.9	52.0
Cop-O-Zink	2.7	3.4	0.6	6.8	12.6	29.9	9.0	51.5
Methasan	2.5	3.6	0.8	6.9	11.8	28.1	10.4	50.3
Check	2.2	3.8	0.5	6.4	10.4	32.6	8.7	51.7
Dithane	2.1	3.5	0.4	6.0	10.7	26.1	5.3	42.1
Phygon XL, 1%	1.2	2.7	0.8	4.7	5.5	20.1	10.6	36.3
Least significant difference	0.6	—	—	0.8	—	—	—	6.6

*Harvested after frost.

Table 7. Average Weights and Numbers of Graded Tomato Fruits Produced in Replicated Plots Receiving Four Applications of Eight Different Fungicides, Brookings, 1950

Treatments	Av. Yield—Tons/A. US1&2	Culls	Green*	Total	Av. No. of Fruits per Plant US1&2	Culls	Green*	Total
Zerlate	11.8	1.4	2.1	15.4	47.6	18.6	11.9	78.1
Tribasic alternating with Zerlate	11.5	2.0	1.8	15.4	46.7	15.8	14.3	76.7
Yellow Cuprocide	11.5	1.7	1.9	15.1	46.1	17.3	12.7	76.1
Cop-O-Zink	11.3	1.3	2.4	15.0	46.6	22.5	10.4	79.5
Dithane	11.2	1.2	2.4	14.8	47.0	21.3	10.0	78.3
Check	11.2	1.3	2.5	15.0	45.6	23.0	10.8	79.4
Tribasic	10.6	1.9	1.6	14.2	42.7	14.7	13.6	71.0
Methasan	10.2	1.5	3.1	14.8	41.3	15.7	10.8	67.8
Phygon XL, 1%	9.2	1.1	1.0	12.4	37.2	19.1	10.2	66.4
Least significant difference	1.6	—	—	2.4	—	—	—	10.1

*Harvested after frost.

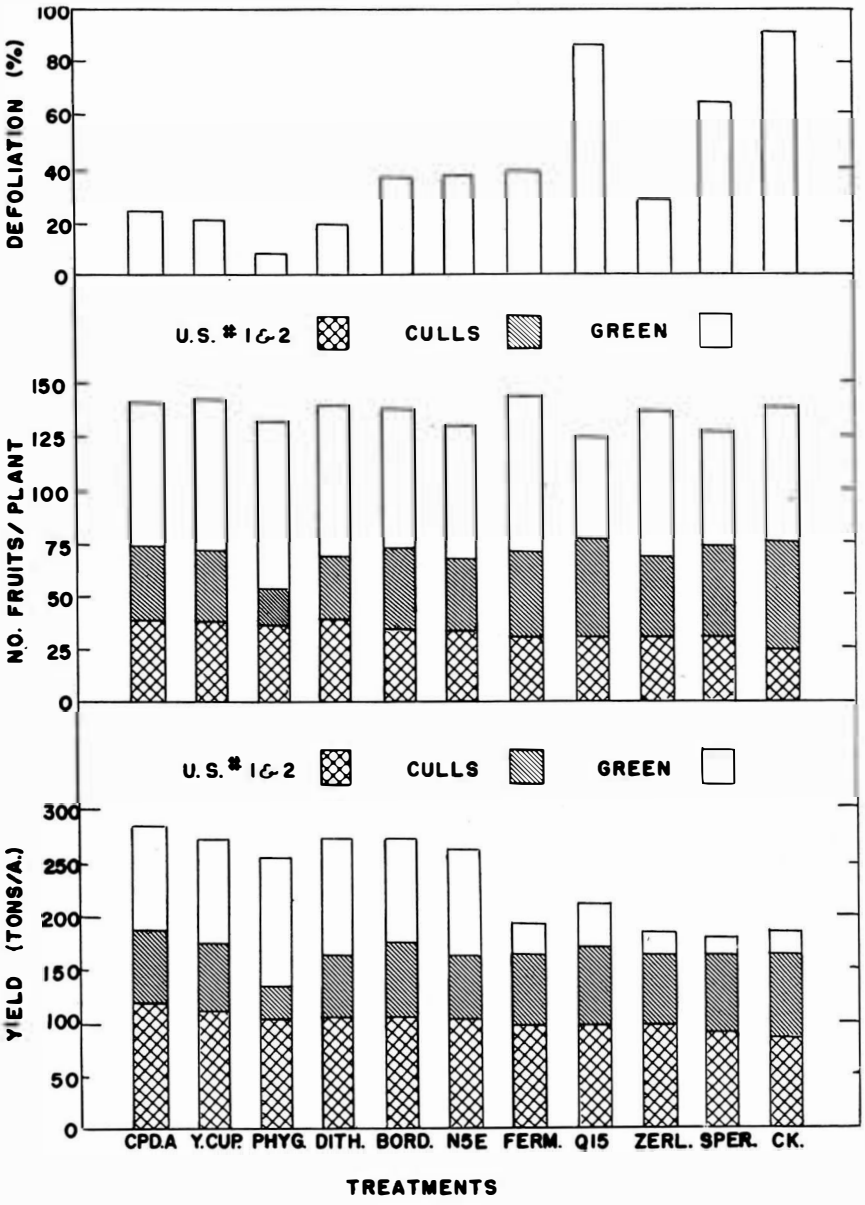


Fig. 2. Effect of six applications of ten different fungicides on defoliation due to Septoria leaf spot, and on number and weight of fruits of Victor tomatoes, Brookings, 1945

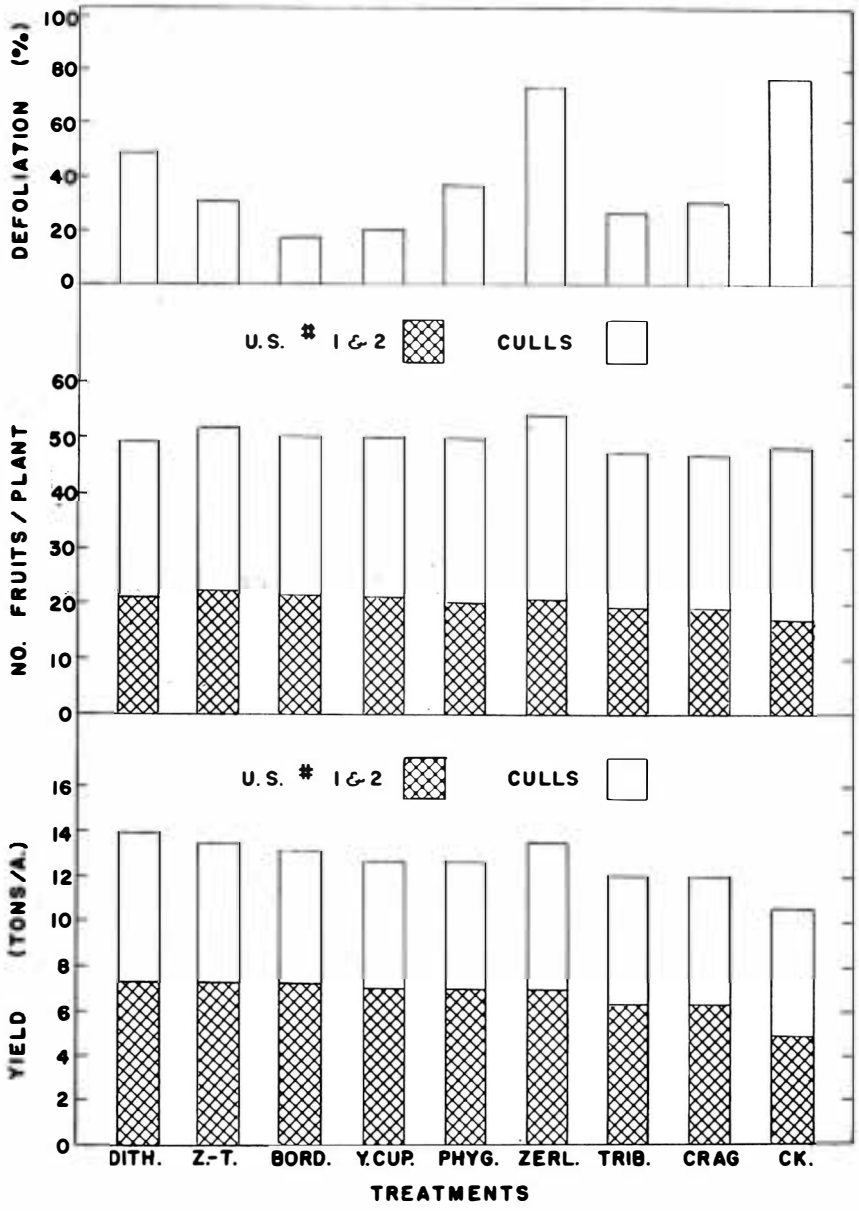


Fig. 3. Effect of eight different fungicides on defoliation due to Septoria leaf spot and on number and weight of Victor tomatoes, Brookings, 1948

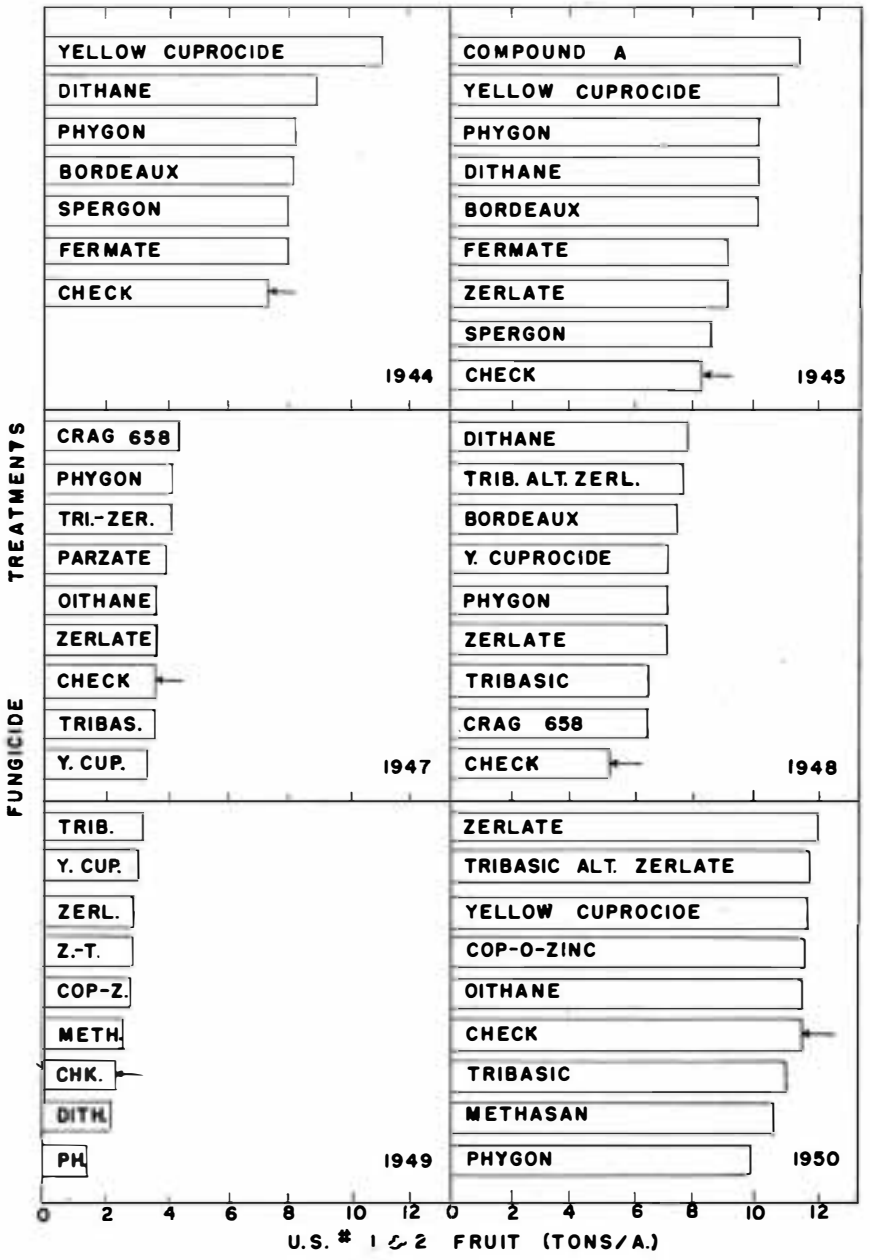


Fig. 4. Average plot yields in tons per acre of U. S. Nos. 1 and 2 Victor tomatoes following various fungicide treatments in six different seasons at Brookings, 1944—1950

though yield differences in individual seasons may not be significant.

In Fig. 4 the yields of marketable fruit obtained following various fungicide treatments are shown. Yields in three seasons when foliage diseases were destructive are compared with those obtained when such diseases were light or absent. In seasons when defoliation was severe all treated plots outyielded the checks. When defoliation was negligible, the treated plots varied little from the checks, with the exception of Phygon which reduced the yield significantly below the checks in 1949 and 1950.

In taking the harvest data in these experiments, the yield was determined as both weight of fruit in tons per acre and number of fruits per plant. Statistical analysis showed a highly significant correlation between weight and numbers of U. S. Nos. 1 and 2 grades of fruit in both high- and low-disease years. Thus either weight or numbers of fruits could have been used as a criterion in evaluating the effects of different fungicides on yield.

It was observed that most of the fungicides used affected the seasonal development of tomato fruits in both high- and low-disease years. Untreated plots and those seriously defoliated did not bear heavily towards the end of the season and few unripened fruits were left after the vines were killed by frost. Favorable fungicide treatments, on the other hand, kept the plants in good bearing condition all through the season, so that larger amounts of unripened fruits were present after frost.

Summary

In the foregoing the results of experiments to control Septoria leaf spot with numerous fungicides have been presented.

It has been shown experimentally that tomato plants can be protected from this and other fungus diseases by applying an effective fungicide. The first application should be made when the first leaf spot symptoms appear; additional applications should follow at 10-day intervals. Fungicides applied as sprays under pressure are more effective than those applied as dusts. It is important that the lower as well as the upper surfaces of the leaves be covered.

Of the fungicides tested, the following performed well with respect to leaf spot control, yield, and freedom from chemical injury to the plants: (1) the fixed coppers such as tribasic copper sulfate (4 lbs. per 100 gals. of water), Yellow Cuprocide (2 lbs. per 100 gals. of water), Compound A (4 lbs. per 100 gals.) and Cop-O-Zink (4 lbs. per 100 gals.); and (2) the organic compounds such as Dithane Z-78 or Parzate (2 lbs. per 100 gals.) and Methasan (3 lbs. per 100 gals.).

During the six-year experiment, defoliation due to disease was severe in three seasons. Under these conditions all plots treated with fungicides outyielded the untreated plots. In the remaining seasons, when defoliation was slight, treated plots showed little advantage in yield over untreated plots.