

# Seed Treatment Dosage Rate Studies on the Control of Damping-off of Sugar Beets<sup>1</sup>

JOHN O. GASKILL and W. A. KREUTZER<sup>2</sup>

The work reported herein covers 3 years of experimental field work on the control of damping-off of sugar beet seedlings. These studies were conducted in 1943, 1944, and 1945 both at Fort Collins and Ault, Colo. Fungicides included in part or all of the tests conducted were Arasan (50-percent tetramethylthiuramdisulfide), Spergon (98-percent tetrachloroparabenzoquinone), New Improved Ceresan (5-percent ethyl mercury phosphate), Yellow Cuprocide (93-percent yellow cuprous oxide), 2-percent Ceresan (2-percent ethyl mercury chloride), and DuPont 1452-F (7.7-percent ethyl mercury p-tolnene sulfonamide).

In 1943 the tests were conducted using only segmented seed, whereas both segmented and whole seed were used in the 1944 and 1945 trials. Randomized-block design was used in all field tests, with 1-row, 18-foot plots, each planted with 2 grams of seed (approximately 6.5 pounds per acre) exclusive of treating compounds. Seed was planted in late spring, and seedling counts were made approximately 3 to 4 weeks after planting. Laboratory determination of the casual agent or agents of damping-off was made for each year's study in each field used.

## Experimental Results—1943

In 1943 two field experiments were conducted. Dust fungicides tested were Arasan, Spergon, Yellow Cuprocide, and New Improved Ceresan. The results of this study are given in table 1.

The seedling stand obtained for each fungicidal treatment in each field exceeded that of the check by a highly significant<sup>3</sup> figure, in the Ault field. Yellow Cuprocide and the 5-ounce and 8-ounce applications of New Improved Ceresan were significantly better than the non-metallic treatments, Arasan and Spergon. However, at Fort Collins, Arasan was significantly better than Yellow Cuprocide and the 8-ounce dosage of New Improved Ceresan. Comparison of the stands obtained for the three dosages of New Improved Ceresan shows that the 3-ounce rate was definitely inferior to the 5-ounce and 8-ounce

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<sup>2</sup>Associate Pathologist, T. S. Department of Agriculture, and Plant Pathologist, Colorado Agricultural Experiment Station, respectively.

<sup>3</sup>Where "highly significant" is used, reference is made to the 1-percent level of significance (odds 99:1). "Significant" refers to the 5-percent level of significance (odds 19:1).

Table 1.—Comparison of seedling stands obtained from treated and untreated segmented sugar beet seed, Ault and Fort Collins, Colo., in 1943. Results are presented as six-plot averages for each location.

Kind	Fungicide	Ave. no. of living seedlings per plot		
	Dosage per 100 pounds of seed ounces	Ault (potato land) no.	Fort Collins (alfalfa land) no.	Average no.
Arasan	12	50.7	99.8	69.6
Sperguson	32	53.5	85.7	69.6
New Improved Ceresan	3	50.7	87.0	68.8
	5	68.3	105.3	86.8
	8	103.3	84.0	93.7
Yellow Cuprocide	12	98.8	84.5	91.7
Check (no treatment)		33.3	56.2	44.8
Difference required for significance:				
	Odds 19:1	12.9	12.6	
	Odds 99:1	17.1	16.7	

rates in the Ault field. Of the latter two, the 8-ounce dosage was decidedly better at Ault and 5-ounce dosage was much better at Fort Collins, the differences in each case being highly significant.

Isolations from seedlings showing both post- and pre-emergence damping-off, made at 3-day intervals during the period when the disease was most prevalent, indicated that a species of *Pythium* was primarily responsible for damping-off. This organism later was found to be referable to *Pythium ultimum*.

#### Experimental Results—1944

In 1944 the study was expanded to include three dosage rates for each of four fungicides. Further, in contrast to the 1943 trials, both whole and segmented seed were used. Field tests again were conducted both in the vicinities of Ault and Fort Collins, Colo. The results of these experiments are shown in table 2.

Since the interactions between fungicidal treatments and kinds of seed were not significant, reference will be made only to the average stand obtained for each treatment in the respective fields. At Ault only two treatments were significantly superior to the check in seedling stand: namely, the 8-ounce application of New Improved Ceresan and the 16-ounce dosage of Arasan.

Table 2.—Summary of seedling stands obtained in two sugar beet seed treatment experiments, Ault and Fort Collins, Colo., 1944; basic results given as four-plot averages.

Kind	Fungicide	Dosage per 100 pounds of seed  ounces	Average number of living seedlings per plot						Average Ault and Fort Collins
			Ault (potato land)			Fort Collins (corn land)			
			Whole seed	Seg- mented seed	Aver- age	Whole seed	Seg- mented seed	Aver- age	
			no.	no.	no.	no.	no.	no.	
Arasan		8	57.8	57.8	57.8	112.3	124.8	118.6	88.1
		12	46.3	58.4	53.6	132.5	134.5	133.5	93.6
		16	74.0	57.5	65.8	120.5	147.3	132.9	102.3
New Improved Ceresan		5	59.3	65.3	62.3	123.5	143.5	132.5	97.9
		6.5	65.7	55.8	60.6	143.8	143.8	143.8	102.2
		8	72.8	64.0	68.4	143.8	145.8	145.8	107.1
Du Pont 1452-F		5	52.5	64.0	58.3	151.0	141.3	146.1	102.2
		6.5	56.8	53.3	55.0	130.0	147.3	143.1	99.1
		8	70.3	54.3	62.3	141.3	137.3	139.3	100.8
Yellow Cuprocide		8	61.4	62.8	62.3	110.8	127.0	118.0	96.6
		12	59.0	44.3	51.6	113.5	134.5	124.0	87.8
		16	48.0	58.8	53.4	130.8	125.0	127.0	96.6
Check (no treatment)			49.5	46.5	49.0	101.5	80.8	91.1	70.1
Difference required for significance:									
Odds 19:1			18.9	18.9	13.4*	23.0	23.0	16.3*	
Odds 99:1			25.1	25.1	17.7*	30.5	30.5	21.6*	

Interactions between fungicidal treatments and kinds of seed were not significant.

At Fort Collins the stand obtained for each dosage of each of the four fungicides exceeded that of the control by a highly significant figure, in comparing the different dosage rates for each separate fungicide, in only one case was a significant difference shown. The 16-ounce dosage of Arasan was significantly superior to the 8-ounce dosage.

Ignoring detailed comparisons for both the Ault and Fort Collins tests, aside from the lightest dosage of Arasan which appeared to be inadequate, in general there were relatively small differences between the stands obtained from seed treated with Arasan, New Improved Ceresan, and Du Pont 1452-F. The stands obtained for Yellow Cuprocide, especially in the Fort Collins test, tended to be lower than those obtained for the other three fungicides.

Isolations again were made in 1944 from affected seedlings, and for the second year *Pythium ultimum* appeared to be the principal damping-off agent. Cultures of *Fusarium* spp. commonly were obtained, especially in isolations from Fort Collins material.

## Experimental Results—1945

In 1945 a more detailed dosage-rate study was conducted at Fort Collins and Anlt, and for the second year both whole and segmented seed were included in the trials. Five fungicides were used in the tests, each at four different rates of dosage. The results of these tests are given in table 3.

Table 3.—Summary of seedling stands obtained in two sugar beet seed treatment experiments, Anlt and Fort Collins, Colo., 1945; basic results given as five plot averages.

Fungicide		Average number of living seedlings per plot						
Kind	Dosage per 100 pounds of seed	Anlt (onion land)			Fort Collins (beet land)			Average Anlt and Fort Collins
		Whole seed	Segmented seed	Average	Whole seed	Segmented seed	Average	
	ounces	no.	no.	no.	no.	no.	no.	no.
Arasan	8	64.2	55.0	59.0	41.6	45.0	43.3	51.5
	16	75.0	59.6	67.3	50.0	47.6	48.5	57.9
	24	68.4	64.6	66.5	38.6	41.2	39.9	53.2
	32	75.8	71.8	73.8	50.0	44.2	47.1	60.5
Spergon*	32	38.2	48.2	38.2	29.0	24.2	31.6	34.0
	80	43.4	52.8	48.1	25.8	37.8	32.3	40.2
	128	46.8	57.0	51.9	27.8	32.2	30.0	41.0
	176	37.6	51.4	44.5	34.2	40.0	37.1	40.8
New Improved Ceresan	5	59.8	60.0	59.9	43.2	39.8	41.5	59.7
	8	62.4	58.8	60.6	44.0	44.8	44.4	52.5
	11	70.6	55.4	63.0	43.4	31.6	37.5	50.3
	14	70.4	58.2	64.3	44.2	28.8	36.5	50.4
2-percent Ceresan**	12.7	71.4	73.0	72.2	37.4	42.6	40.0	56.1
	20.3	67.4	72.0	69.7	47.0	30.2	41.6	55.7
	27.9	72.2	68.0	70.4	50.0	45.0	47.8	59.1
	35.5	77.6	70.6	74.1	43.6	38.4	41.0	57.6
Yellow Cuproside	8	50.2	47.8	49.0	44.0	49.4	46.7	47.9
	16	62.6	55.2	62.4	55.1	44.0	49.7	56.1
	24	64.0	50.6	61.8	45.8	33.2	39.5	50.7
	32	77.6	59.4	68.5	35.6	45.8	40.7	54.6
Check (no treatment)		23.0	20.8	21.9	28.6	33.0	30.8	26.4
Difference required for significance:								
Odds 19:1		12.3	12.3	†	13.2	13.2	9.3†	
Odds 99:1		10.2	16.2	†	17.1	17.4	12.3†	

\*Weighings showed that approximately two-thirds of the extremely heavy 176-ounce application of Spergon adhered to the seed at treating time. The percentage of this dust adhering to the seed was progressively higher with lighter applications.

\*\*The dosage rates used for 2 percent Ceresan were equivalent in mercury content to those used for New Improved Ceresan.

(†Interaction between fungicidal treatments and kinds of seed was significant.

^Interaction between fungicidal treatments and kinds of seed was not significant.

With reference to the Ault data shown in table 3, the whole and segmented seed averages were considered separately because in this particular field trial the interaction between fungicidal treatments and type of seed used was significant. The results from both whole and segmented seed show that all fungicidal treatments were much superior to their respective controls (1-percent level of significance) with the exception of the 32-ounce and 176-ounce rates of Spergon on whole seed. In comparing dosage rates for the respective fungicides, some significant differences were shown by the Arasan, Spergon, and Yellow Cuprocide series. With segmented seed, the 32-ounce rate of Arasan gave much better results than the 8-ounce rate—a highly significant difference. A similar trend, although non-significant, is shown for whole seed. With both whole and segmented seed, the 128-ounce rate of Spergon was significantly better than the 32-ounce rate. With whole seed, the 16-, 24-, and 32-ounce rates of Yellow Cuprocide were significantly better than the 8-ounce rate. The difference was particularly striking and highly significant in the case of the 32-ounce rate. A similar trend, although non-significant was shown by the segmented seed. With both whole and segmented seed, the differences resulting from the use of varying dosage rates of New Improved Ceresan and 2-percent Ceresan, respectively, were not significant.

In the Fort. Collins field plots, the interaction between fungicidal treatments and kinds of seed was not significant, and consequently reference will be made only to the treatment averages. Highly significant improvement in stand over that of the control was shown by each of the following: the 8-, 16-, and 32-ounce rates of Arasan, the 8-ounce rate of New Improved Ceresan, the 27.9-ounce rate of 2-percent Ceresan, and the 8- and 16-ounce rates of Yellow Cuprocide. The stand differences shown between rates of dosage for any one material were non-significant with the exception of Yellow Cuprocide. In this latter case the 16-ounce rate gave a significantly better stand than the 24-ounce rate, which result conflicts with the trend shown for the Ault field plots.

Laboratory isolations from affected seedlings again indicated that *Pythium ultimum* was the principal agent of damping-off in both the Fort Collins and Ault fields. At Fort Collins a species of *Phytophthora* also was commonly obtained in early plantings. *Phytophthora* only rarely appeared in the Ault isolations. As in the 1944 tests, *Fusarium* spp. frequently were obtained from both the Ault and Fort Collins material.

Table 4 is a summary of all stand data obtained in the 3 years' experiments: 1943, 1944, and 1945. Although various significant interactions prevent comparisons on the basis of statistical odds within

Table 4.—Summary of seedling stands obtained in sugar beet seed treatment experiments, Ault and Fort Collins, Colo., 1943-1945.

Kind	Fungicide	Dosage per 100 pounds of seed	Average no. of living seedlings per plot								3-year average	
			1943		1944		1945		2-year average			
			Ault	Fort Collins	Ault	Fort Collins	Ault	Fort Collins	1943 and 1944	1943 and 1945		1944 and 1945
courses	no. 6	no. 6	no. 8	no. 8	no. 10	no. 10	no.	no.	no.	no.		
Arsaan		8	...	...	57.8	118.5	50.6	43.3	...	...	68.3	...
		12	50.7	90.8	53.6	133.5	...	...	54.4	...	...	...
		16	...	...	65.8	138.9	67.3	48.5	...	...	80.1	...
		24	...	...	...	...	66.5	39.9	...	...	...	...
		32	...	...	...	...	73.8	47.1	...	...	...	...
Spergon		32	53.5	65.7	...	...	38.2	31.8	...	52.8	...	...
		80	...	...	...	...	48.1	32.3	...	...	...	...
		128	...	...	...	...	51.9	30.0	...	...	...	...
		176	...	...	...	...	44.5	37.1	...	...	...	...
New Improved Ceresan		8	50.7	87.0	...	...	...	...	...	...	...	...
		5	68.3	105.3	62.3	133.5	50.0	41.5	92.4	68.6	74.3	78.5
		5.5	...	...	60.5	143.8	...	...	...	...	...	...
		8	103.3	84.0	68.4	145.8	60.6	44.4	100.4	73.1	79.8	84.4
		11	...	...	...	...	63.0	37.5	...	...	...	...
	14	...	...	...	...	64.3	36.5	...	...	...	...	
2 percent Ceresan		12.7	...	...	...	...	72.2	40.0	...	...	...	...
		20.3	...	...	...	...	69.7	43.6	...	...	...	...
		27.9	...	...	...	...	70.4	47.8	...	...	...	...
		35.5	...	...	...	...	74.1	41.0	...	...	...	...
Du Pont 1462-F		5	...	...	58.5	146.1	...	...	...	...	...	...
		6.5	...	...	55.0	143.1	...	...	...	...	...	...
		8	...	...	62.3	130.2	...	...	...	...	...	...

Table 4.—Continued.

Yellow Cuprocid	8	—		62.3	118.9	49.0	46.7			69.2	
	12	98.8	84.5	51.6	124.0			89.7			
	16			53.4	127.9	62.4	49.7			73.4	
	24					61.8	39.5				—
	32					68.5	40.7	—			
Check (no treatment)		33.3	56.2	49.0	91.1	21.9	30.8	57.4	35.6	<b>48.2</b>	<b>47.1</b>
Difference required for significance:											
Odds 19:1		12.9	12.6	13.4	16.3	**	9.3				
Odds 99:1		17.1	16.7	17.7	21.6	**	12.3				

\*Results obtained for whole and segmented seed were combined for the years 1944 and 1945, respectively; 1943 results were obtained from segmented seed only.

\*\*Interaction between fungicidal treatments and kinds of seed was significant in the Ault experiment in 1945 but was not significant in any other test.

certain columns of this table, it is presented as an aid in studying the results.

### Summary and Conclusions

Two replicated sugar beet seed treatment experiments were conducted in the vicinities of Ault and Fort Collins, Colo., in each of the years 1948, 1944, and 1945. A total of six dust fungicides were employed, though not all were used in any 1 year. Varying dosages were applied in most cases. Only segmented seed was used in 1943, while both whole and segmented types of seed were used in 1944 and 1945. *Pythium ultimum*, was considered the chief cause of damping-off in each of the six experiments. A species of *Phytophthora* apparently played a relatively minor role in one test, and species of *Fusarium* were isolated rather commonly in several tests.

Each of the following fungicides was quite effective in improving seedling survival in fields where damping-off was an important factor: Arasan, Xew Improved Ceresan, 2-percent Ceresan, Du Pont 1452-F, and Yellow Cuprocid. With adequate dosages there was relatively little difference in the effectiveness of these five dusts. Spergon, although used over a wide range of dosages, failed to give seedling stands equal to those obtained from adequate applications of any of the other dusts.

The evidence obtained from the six experiments suggests the following tentative conclusions as to minimum dosages required for satisfactory control of damping-off under the conditions of these experiments:

Fungicide	Ounces per 100 pounds of seed
<b>Arasan</b>	<b>16</b>
New Improved Ceresan	6 <sup>4</sup>
2-percent Ceresan	12.7
Du Pont 1452-F	5
Yellow Cuprocid	16

<sup>4</sup>The 2-year and 3-year averages presented in table 4 show appreciably higher stands for 8 ounces than for 5 ounces. However, the striking contradiction in Fort Collins data for 1943 emphasizes the need for caution with respect to the 8-ounce rate.

In the commercial treating, a somewhat higher percentage of dust possibly would adhere to the seed than occurred in the treating of small lots used in these experiments. Therefore in commercial practice, slightly lower minimum standards might be preferable to those listed above.