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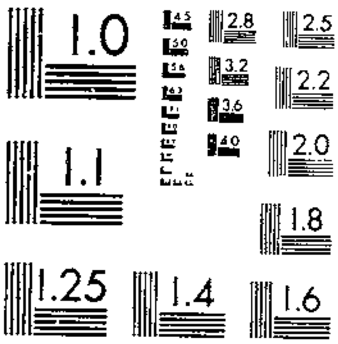

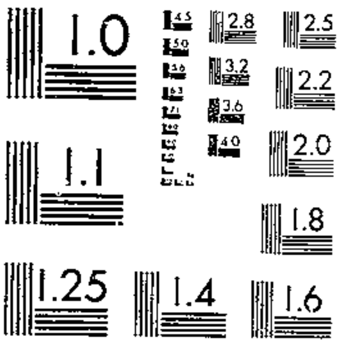

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SEED TREATMENT FOR CONTROLLING COVERED SMUT OF BARLEY

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INTRODUCTION

Experiments with fungicides for the control of covered smut of barley, caused by *Ustilago hordei* (Pers.) K. and S., previously reported (*14*, *31*, *32*),[1] have been continued during the last four crop years (1925–1929). During this time there has been a general tendency to abandon the liquid seed treatments for small grains in favor of the more easily applied dust fungicides. This is true especially in regard to seed treatments for the prevention of stinking smut (bunt) in wheat. The well-known formaldehyde and copper-sulphate seed treatments for this disease have been supplanted in this country, to a great extent, by copper carbonate, and in Europe by various proprietary dust fungicides.

Covered smut of barley, however, is not so easily controlled as is stinking smut of wheat, because the barley smut spores apparently are borne on the inside, as well as on the surface of the glumes. Therefore, most investigators still recommend only liquid treatments for the control of this disease.

In this country very few workers have reported any great degree of success in controlling covered smut of barley with dust fungicides, but a number have obtained excellent control in some varieties with liquid treatments other than the commonly used formaldehyde. In 1923 Tisdale et al. (*34*) reported that a 0.3 per cent solution of chlorophol, an organic mercury compound, proved superior to formaldehyde, not only in controlling covered smut, but in its effect on germination, stand, and yield of grain. Later Tisdale et al. (*35*)

[1] Italic numbers in parentheses refer to Literature Cited, p. 20.

reported similar results with solutions of Uspulun, Semesan, Germisan, and Corona 620. The writer (*14*) in 1926 showed that 0.3 per cent solutions of Germisan, Uspulun, and Semesan and a 1:320 solution of 37 per cent formaldehyde controlled covered smut, but that the formaldehyde impaired seed germination. Neill (*26*) in New Zealand found that 0.25 per cent solutions of Semesan and Uspulun, as well as Semesan and copper carbonate dusts, failed to control covered smut of barley satisfactorily. Lambert et al. (*12*), Conners (*3*), Sherbakoff (*31*), and others in the United States have recommended formaldehyde as the most logical treatment for the control of covered smut of barley. Tisdale and Cannon (*33*) found Ceresan, an ethyl mercury chloride compound, satisfactory in controlling this disease. Porter, Yu, and Chen (*27*), in experiments with hulless barley in China, controlled covered smut to a fair degree with copper carbonate, Höchst, and Uspulun dust.

A general perusal of literature on seed treatment seems to show that in Europe the control of covered smut of barley has not received as much attention as the control of other cereal diseases. This may be due to the fact that, on the whole, it does not occur there to any serious extent (*1*, *8*). Lindfors in Sweden (*20*, *21*, *22*) used fungicidal dusts in experiments for the control of other cereal diseases, but for combating covered smut of barley he recommended 0.25 per cent solutions of Germisan and Uspulun. Molz (*25*) in Germany obtained complete control of this disease with a 0.25 per cent Germisan solution and also with the two dusts, Abavit B and Agfa 331. Rump (*28*), in the same country, combated the disease successfully with 0.5 per cent Uspulun, 0.25 per cent Germisan, and 0.2 per cent Tillantin solutions and with the dust Sch 614.[2] The majority of investigators have found solutions of the common organic mercury fungicides satisfactory for the control of covered smut of barley. Differences in results reported by different workers may be attributed to causes enumerated in a previous paper (*18*).

EXPERIMENTS IN 1925–26

Experiments on the control of covered smut of barley during the 1925–26 season were limited to a few liquid fungicides, some of which had proved effective in previous years, and to preliminary trials with a few dust treatments.

LIQUID TREATMENTS

Seed of Tennessee Winter barley from the 1924 and 1925 crops was used in these experiments. This seed, known to be naturally infested with covered smut, was also dusted with spores of this smut collected from the same variety of barley in 1925. The various liquid treatments were prepared in earthenware jars, and the seed, contained in loose cheesecloth sacks, was immersed in these solutions for the proper length of time. The seed was then allowed to drain and later was spread out to dry. On October 12, 1925, it was sown in rod rows replicated 10 times for each treatment at the Arlington Experiment Farm, Rosslyn, Va. The soil was moist at the time of sowing, and 0.5 of an inch of rain fell between the dates of sowing and emergence. The weather during this period was rather cool,

[2] Later called Höchst or Tillantin Trockenbeize.

the mean temperature being 17° C. The hydrogen-ion concentration of the soil was pH 5.7. The seed therefore germinated and emerged in a cool, wet soil of acid reaction, which, according to Faris (*5*), is the ideal environment for the development of covered smut from infested seed. Yet the percentage of smut in the untreated controls was rather low, namely, from 2.4 to 6.7.

Data on the effect of the treatments on germination were obtained in the field by sowing 1,000 seeds from each seed lot in four rod rows, 250 seeds per row, and in the greenhouse by sowing 200 seeds from each lot in flats.

Smut data were taken May 27, 1926, by counting the smutted heads in each row and the total heads in a number of representative rows to establish a basis for computing the approximate percentages of smut.

The data on germination and smut control are presented in Table 1. With the exception of formaldehyde, all the liquid treatments gave excellent smut control without reducing the percentages of germination. The failure of the formaldehyde to control covered smut satisfactorily was due, undoubtedly, to the short period of immersion, as an hour's immersion invariably results in control. The value of the results, however, is decreased by the low percentage of smut in the controls and by the fact that only one variety of barley was used. As previously reported (*14*), soaking untreated seed in water greatly increased the percentage of smut.

TABLE 1.—*Effect of liquid fungicides on germination of seed and on covered smut in Tennessee Winter barley sown in rod rows replicated 10 times for each treatment at Arlington Experiment Farm, Rosslyn, Va., 1925–26*

Seed-treatment compound	Concentration	Period of treatment	Germination		Smutted heads	
			Field	Greenhouse		
	Per cent	*Hours*	*Per cent*	*Per cent*	*Number*	*Per cent*
Untreated	----	----	73	77	169	2.4
Uspulun	0.5	1	88	91	0	0
Semesan	.5	1	87	87	3	.04
Water	----	1	81	87	366	5.2
Bayer compound	.5	1	87	92	0	0
Germisan	.25	1	88	90	0	0
Untreated	----	----	77	87	180	2.6
Formaldehyde	.12	⅙	69	85	111	1.6
Do	.12	½	67	80	89	1.3
Water	----	1	79	88	472	6.7
Corona 620	.25	1	83	86	0	0
Tillantin C	.25	1	83	92	0	0

DUST TREATMENTS

Experiments with fungicidal dusts were very limited, only six dusts being given a preliminary trial and only two rod rows devoted to each. The results are shown in Table 2. Four of these dusts eliminated the smut completely, one reduced it to a mere trace, while one had no apparent effect upon it. However, here again the percentage of smut in the controls was too low and the number of replications were too few to make the results very significant.

TABLE 2.—*Effect of fungicidal dusts on covered smut in Tennessee Winter barley sown in paired rod rows at Arlington Experiment Farm, Rosslyn, Va., October 12, 1925*

Fungicidal dust	Number of smutted heads in—			Percentage of smut
	Row 1	Row 2	Total	
Untreated	24	24	48	3.4
S. F. A. No. 225	0	0	0	0
S. F. A. No. 225-V	0	0	0	0
Untreated	20	43	63	4.5
S. F. A. A-Z-III	3	1	4	.28
Dupont No. 13-U	0	0	0	0
Untreated	25	11	36	2.5
Dupont No. 13-U-A	0	0	0	0
Dupont No. 37	17	13	30	2.1
Untreated	16	37	53	3.8

EXPERIMENTS IN 1926–27

In the spring of 1926 excellent results in the control of barley stripe disease with fungicidal dusts were obtained at the Arlington Experiment Farm and at Madison, Wis. (*19*). In view of these results, together with the rather limited data obtained that same season on the efficacy of fungicidal dusts for the control of covered smut of barley (Table 2), it seemed advisable to carry out more extensive experiments with such dusts during the 1926–27 season.

As stated in a previous paper (*19*), it was thought that soil conditions, as well as severity of infection, might affect the fungicidal action of these dusts. Accordingly, the fact to be determined was whether a dust that gives satisfactory control of a seed-borne disease when conditions for its development are unfavorable, would give equally good results if the most favorable conditions for the development of the disease prevailed.

Faris (*5*) states that a cold (10°–20° C.), moist soil of acid reaction favors covered-smut development. Rump (*28*) reports that an alkali soil stimulates fungus development, that acid soil is injurious to it, and that a soil-moisture content of 20 per cent is the optimum for development of covered smut. Schaffnit (*29*) states that a soil rich in organic matter and carbonic acid favors covered-smut infection.

In conducting experiments with dust treatments for the control of covered smut of barley during the 1926–27 season, an attempt was made to vary the conditions of soil moisture and soil reaction as much as could be done conveniently on a large scale in the field.

A half acre of soil was laid out in 1/20-acre plots, 16½ by 132 feet. The soil was tested by R. R. Reid of the Office of Soil Fertility, then of the Bureau of Plant Industry, using the Veitch method, and its lime requirement was found to be about 2,000 pounds of air-slaked lime per acre. To produce an alkaline condition in three of these 1/20-acre plots, lime was added at one and one-half times the rate recommended for soil-acidity correction. The soil acidity in three other 1/20-acre plots was accentuated by the addition of ammonium sulphate at the rate of 200 pounds per acre. The lime and ammonium sulphate were disked thoroughly into the soil. Three other plots, each one between a limed and an acidified plot, were left untreated. A few weeks after the application of lime and ammonium sulphate, and shortly after the seed had been sown, the pH value of the soil was found to be as follows: Limed soil, 7.74; untreated soil, 5.69; acidified soil, 5.15.

In the first three plots an attempt was made to vary the soil-moisture conditions between the dates of sowing and emergence by excluding the rain from half of each plot by means of temporary shelters of corrugated metal, which were removed the day after the plants emerged. However, this attempt at moisture variation was rendered rather futile by the very slight rainfall during this period.

The seed used was Tennessee Winter barley grown at the Arlington Experiment Farm in 1926, a variety rather susceptible to covered smut. In addition to its natural infection the seed was heavily dusted with smut spores collected from this same variety of barley in the summer of 1926.

The following fungicidal dusts were used: Abavit B, S. F. A. No. 225-V, Bayer No. 2, Semesan, Dupont No. 12, Wa Wa, S. F. A. No. 225, S. I. 220, Semesan Jr., Dupont No. 45, Bayer Dust, and Mercury C.

Only the first 6 fungicidal dusts were used in the three plots involving soil-moisture differences, while all 12 dusts were included in the other six plots.

The dusts were applied to the smutted barley September 17, 1927, at the rate of 4 ounces per bushel, in flat tightly covered cans. Each can was provided with a projecting baffle on the inside so that, as the cans were slowly revolved in the motor-driven contrivance illustrated in Figure 1, the seed was thoroughly dusted in a manner very similar to that resulting from the proper use of the common barrel type of duster. The dusting was continued for 30 minutes so that there would be a thorough coating of the seed. The smutted untreated controls were likewise mixed in the duster so that any effect due to the mixing process would not be confined to the treated seed only, as has been suggested by Schander et al. (*30*).

In the three plots involving soil-moisture variation the seed was sown October 13 in 12-foot rows at the rate of 10 grams per row. In the remaining six plots the seed was sown October 16 in rod rows at the rate of 14 grams per row. A record of the rainfall and of the maximum, minimum, and mean daily soil temperatures from the time of sowing to the time of emergence is shown in Table 3. In the first three plots the covered soil was slightly warmer than the exposed soil, but hardly enough, it is thought, to influence the results appreciably. The water-holding capacity of the soil was found to be 40 per cent. A soil-moisture determination made the day after the first three plots were sown showed a moisture content of about 50 per cent of saturation. Only 0.39 of an inch of rain fell on the exposed plots between the dates of sowing and emergence. After the covers had been removed a soil-moisture determination showed that the soil in the covered section (*a*) was 35 to 40 per cent saturated, while the soil in the exposed section (*b*) was 50 to 60 per cent saturated. It is doubtful whether this slight difference in soil-moisture conditions was sufficient to affect the results greatly, especially as this difference did not prevail throughout the entire period from sowing to emergence.

TABLE 3.—*Rainfall and soil temperatures from sowing to emergence in experiments for control of covered smut in Tennessee Winter barley at Arlington Experiment Farm, Rosslyn, Va., October, 1926*

Date	Rainfall	Soil temperature					
		Covered soil			Exposed soil		
		Maximum	Minimum	Mean	Maximum	Minimum	Mean
1926	*Inches*	° *C.*	° *C.*	° *C.*	° *C.*	° *C.*	° *C.*
Oct. 1	0.33						
Oct. 6	1.03						
Oct. 13 [1]		18	17	17.1	16	15	15.5
Oct. 14	.00	18	14	15.8	16	13	13.9
Oct. 15		16	12	13.8	15	11	12.5
Oct. 16 [2]		13	10	12	13	9	11.3
Oct. 17		13	10	12.1	13	10	12
Oct. 18		13	9	10.4	10	8	9.5
Oct. 19 [3]		13	10	11	14	9	10.5
Oct. 20	.12	11	10	10.7	11	8	9.5
Oct. 21 [4]	.18	11	8	9.3	10	6	7.9
Oct. 22		13	7	9.2	11	5	7.5
Oct. 23		12	7	9.3	12	7	9.3
Oct. 24	1.47				14	9	11.3
Oct. 25 [5]					14	12	12.8

[1] Plots 1, 2, and 3 sown.
[2] Plots 4 to 9 sown.
[3] Covered series emerged (plots 1-a, 2-a, and 3-a).
[4] Exposed series emerged (plots 1-b, 2-b, and 3-b).
[5] Plots 4 to 9 emerged.

Infection data were taken May 25 and 26, 1927, by counting the smutted heads in all the rows and the total heads in all the control rows grown from untreated seed and in representative rows grown from treated seed. Winterkilling caused some variation in the stand in different replications, especially in plots 7, 8, and 9.

The infection data for the three plots sown October 13 are shown in Table 4, and those for the plots sown October 16 are shown in Table 5. Table 4 shows that, among the six dusts used in the first three plots, Wa Wa, Abavit B, and Dupont No. 12 were outstanding in their control of covered smut of barley, allowing only 4, 10, and 12 smutted heads, respectively, in 48 rows, while 2,695 smutted heads appeared in an equal number of control rows. Semesan, S. F. A. No. 225-V, and Bayer No. 2 allowed 42, 53, and 145 smutted heads, respectively, in 48 rows. In plots 4 to 9, in which less infection occurred in the control rows, smut was eliminated by Dupont No. 12 and Wa Wa and was more greatly reduced by the other four dusts than in plots 1 to 3. It seems, therefore, that the smut was more easily controlled when conditions for its development were less favorable.

TABLE 4.—*Covered smut in Tennessee Winter barley grown at Arlington Experiment Farm, Rosslyn, Va., from seed untreated or treated with various dust fungicides and sown October 13, 1926, in 12-foot rows, replicated sixteen times for each dust in each of three plots which previously had been limed, acidified, or left untreated, half of each plot (plots 1–a, 2–a, and 3–a) being covered at sowing time to exclude rain*[1] *until after emergence*

Plot No.	Soil treatment	Heads of covered smut from seed—								Total smutted heads from treated seed	
		Untreated		Treated with—							
		Number	Per cent	Abavit B	S. F. A. No. 225–V	Bayer No. 2	Semesan	Dupont No. 12	Wa Wa	Number	Per cent
1–a	Limed	463	10.2	0	26	58	13	10	4	111	0.41
2–a	Untreated	489	9.5	0	8	21	3	1	0	33	.11
3–a	Acidified	500	8.4	0	0	20	4	0	0	24	.07
1–b	Limed	416	8.4	3	1	28	6	1	0	39	.13
2–b	Untreated	453	8.8	3	11	17	4	0	0	35	.12
3–b	Acidified	365	6.3	4	7	1	12	0	0	24	.07
Total smutted heads		2,695		10	53	145	42	12	4		
Percentage of smutted heads			8.5	.04	.22	.60	.17	.05	.02		

[1] Only 0.39 of an inch of rain fell on the exposed plots from the time of sowing to emergence.

TABLE 5.—*Covered smut in Tennessee Winter barley grown at Arlington Experiment Farm, Rosslyn, Va., from seed untreated or treated with various fungicidal dusts, and sown October 16, 1926, in rod rows replicated eight times for each dust in each of six plots that previously had been limed, acidified, or left untreated*

Plot No.	Fungicidal dust	Heads of covered smut in—						Total heads of smut	
		Plot 4 (limed)	Plot 5 (untreated)	Plot 6 (acidified)	Plot 7 (limed)	Plot 8 (untreated)	Plot 9 (acidified)	Number	Per cent
....	Untreated	117	201	219	146	86	92	861	3.80
1	Abavit B	1	0	0	0	0	0	1	Trace.
2	S. F. A. No. 225-V	1	3	0	0	0	0	4	.02
3	Bayer No. 2	4	0	4	4	2	13	27	.12
4	Semesan	1	4	2	0	0	0	7	.03
5	Dupont No. 12	0	0	0	0	0	0	0	0
6	Wa Wa	0	0	0	0	0	0	0	0
....	Untreated	179	120	249	163	81	151	943	4.20
7	S. F. A. No. 225	2	0	0	3	0	7	12	.05
8	Semesan Jr.	0	5	3	0	0	0	8	.04
9	Dupont No. 45	3	5	0	0	1	0	9	.04
10	Bayer Dust	2	12	4	2	1	5	26	.11
11	Mercury C	3	0	0	0	0	0	3	.01
Total smutted heads from treated seed		17	29	13	9	4	25		
Percentage of smutted heads from treated seed		0.04	0.07	0.03	0.02	0.01	0.06		

The dusts numbered from 7 to 12 were included in the six plots sown October 16, in rod rows replicated 48 times for each dust. Comparison of results from these dusts with results from the six dusts mentioned above must be confined to the data obtained from plots 4 to 9. (Table 5.) In 48 rows Mercury C allowed only 3 smutted heads, while Semesan Jr., Dupont No. 45, S. F. A. No. 225, and Bayer Dust allowed, respectively, 8, 9, 12, and 26 heads, compared with 943 smutted heads in 48 control rows, equivalent to an average of 4.2 per cent. S. I. 220 showed such evident failure to control smut that data were not taken on rows from seed treated with this compound.

The summarized data in Table 6 indicate that, contrary to the results of Faris (*5*), acid soil did not favor the development of covered

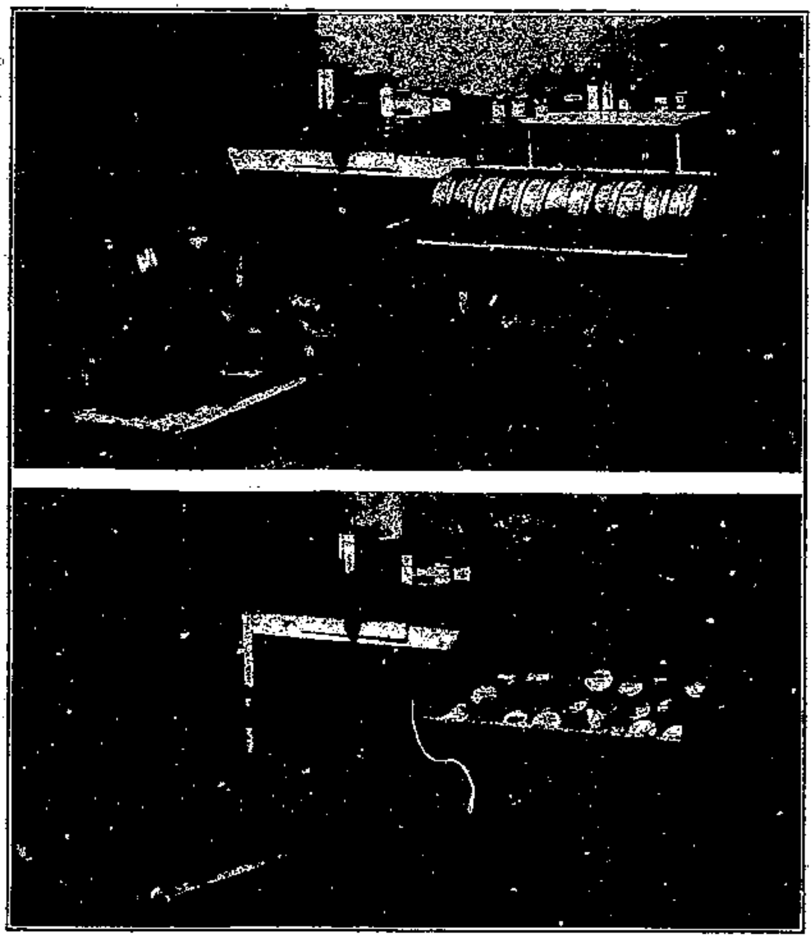

FIGURE 1.—Seed-treatment device for applying different fungicidal dusts to small lots of seed. In each of the larger flat cans shown in the rotating device in A, enough seed may be treated to sow about 100 rod rows. Eleven dusts may be applied in one operation. In each of the smaller cans shown in B, seed for 20 rod rows or fewer may be treated. With these cans 24 treatments may be applied in one operation. In repeating the treatments on different seed lots the same can is used for a given dust in each case. The cans are cleaned thoroughly before using them for other dusts

smut as compared with soil having an alkaline reaction. The average percentages of smutted heads from untreated seed in the limed, untreated, and acidified plots, respectively, were 6.8, 6.8, and 5.7. However, these percentages are too low to warrant any definite conclusions.

TABLE 6.—*Summary of data on the occurrence and control of covered smut in Tennessee Winter barley grown from treated or untreated seed under slightly different conditions of soil moisture, reaction, and temperature, at Arlington Experiment Farm, Rosslyn, Va., 1926–27, together with a record of the mean soil temperature and rainfall between dates of sowing and emergence, plots 1–a, 2–a, and 3–a being covered until after emergence*

Plot No.	Soil treatment	Date sown	Date emerged	Rainfall	Mean soil temperature	Smutted heads from seed—			
						Untreated		Treated	
				Inches	° *C.*	*Number*	*Per cent*	*Number*	*Per cent*
1–a	Limed	Oct. 12	Oct. 19		13.2	463	10.2	111	0.41
2–a	Untreated	do	do		13.2	489	9.5	33	.11
3–a	Acidified	do	do		13.2	509	8.4	24	.07
1–b	Limed	do	Oct. 21	0.39	11.4	416	8.4	39	.13
2–b	Untreated	do	do	.39	11.4	453	8.8	35	.12
3–b	Acidified	do	do	.39	11.4	365	6.3	24	.07
4	Limed	Oct. 16	Oct. 25	1.77	10.2	345	4.5	17	.04
5	Untreated	do	do	1.77	10.2	341	5.1	29	.07
6	Acidified	do	do	1.77	10.2	468	4.9	13	.03
7	Limed	do	do	1.77	10.2	307	3.8	9	.02
8	Untreated	do	do	1.77	10.2	167	3.5	4	.01
9	Acidified	do	do	1.77	10.2	243	3.1	25	.06

Soil reaction did not seem to have any pronounced or consistent effect on the fungicidal efficiency of the dusts used. Although the percentage of smutted heads from treated seed in plot 1–a was several times as great as that from treated seed in any other plot, the percentage of smutted heads from treated seed in the other limed plots was not significantly greater than in the corresponding untreated or acidified plots. Therefore it seems evident that the apparent reduction in the fungicidal efficiency of five of the dusts in plot 1–a, as shown in Table 4, was not on account of soil reaction but of some unknown factors.

A number of other dusts of more or less unknown merit also were used in a preliminary series. The results obtained are shown in Table 7. Standard liquid treatments were used for comparison. Vitrioline, Karasch A, and Dupont dusts Nos. 35, 53, and 64 seemed to control the smut fairly well and without seed injury. Resorcin, which was combined chemically with crystal violet dye, proved worthless as a smut fungicide. Various dusts based on inorganic mercuric salts proved unsatisfactory either because of injury to the seed or failure to control smut. Solutions of Uspulun (0.5 per cent), Semesan (0.5 per cent), and Germisan (0.25 per cent) proved satisfactory as usual, as also did formaldehyde.

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TABLE 7.—*Results from preliminary experiments with a number of fungicidal dusts for controlling covered smut in Tennessee Winter barley at Arlington Experiment Farm, 1926–27, together with results from four standard liquid treatments for comparison*

Seed-treatment compound	Smutted heads in—			Seed-treatment compound	Smutted heads in—		
	Row 1	Row 2	Total		Row 1	Row 2	Total
Untreated	32	40	72	Untreated	43	30	73
Cuprobol	36	30	66	Dupont No. 35	0	0	0
Vitrioline	4	1	5	Dupont No. 42 [1]	0	0	0
Karasch A	6	1	7	Dupont No. 53	2	1	3
Resorcin	19	22	41	Dupont No. 57	5	0	5
Resorcin, one-half, and $CuCO_3$, one-half	25	20	45	Dupont No. 64	0	0	0
Resorcin, one-third, and $CuCO_3$, two-thirds	26	28	54	Mercuric oxide, one-half, and $CuCO_3$, one-half	2	3	5
Untreated	46	30	76	Untreated	36	27	63
Resorcin, one-third, and dextrin, two-thirds	25	15	40	Mercuric sulphate, one-half, and $CuCO_3$, one-half	8	4	12
Mercurous chloride, one-half, and $CuCO_3$, one-half	9	11	20	Uspulun, 0.5 per cent (1 hour)	0	1	1
Mercuric chloride, one-half,[1] and $CuCO_3$, one-half	0	0	0	Semesan, 0.5 per cent (1 hour)	0	0	0
Dupont No. 50 [1]	0	1	1	Germisan, 0.25 per cent (1 hour)	0	0	0
Dupont No. 67	20	25	45	Formaldehyde, 0.12 per cent (1 hour)	0	0	0
Dupont No. 68	20	5	25	Untreated	24	30	54

[1] Reduced stand.

EXPERIMENTS IN 1927–28

During the season of 1927–28 Tennessee Winter barley was again used in experiments for testing the efficiency of certain fungicidal dusts for controlling covered smut of barley. Most of the dusts used in these experiments had been found fairly satisfactory the previous year, some in preliminary trials and others in more extensive experiments. Along with these were used Höchst and Tutan, both of which dusts had been used with considerable success in experiments for barley stripe control the previous spring (*18*). The dusts were applied as before at the rate of 4 ounces per bushel after the seed had been dusted with smut spores, as described for the 1926–27 experiments. Field germination data were obtained by sowing 1,000 seeds from each treated lot in rod rows at the rate of 250 seeds per row, counts being made 15 days after sowing. Additional germination data were obtained by sowing 100 seeds from each lot in the greenhouse, counts being made one week after sowing. According to the resulting data, shown in Table 8, none of the dusts used caused any striking decrease in the percentage of germination.

TABLE 8.—*Field and greenhouse data on the germination of seed of Tennessee Winter barley untreated or dusted with various fungicides and sown at Arlington Experiment Farm, Rosslyn, Va., October, 1927*

Fungicidal dust	Percentage of germination in—		Fungicidal dust	Percentage of germination in—	
	Field	Greenhouse		Field	Greenhouse
Untreated	75	70	Untreated	31	80
Abavit B	75	80	Wa Wa	79	86
S. F. A. No. 225	80	83	Semesan	80	87
S. F. A. No. 225-V	74	92	Semesan Jr	80	87
Höchst	76	91	Dupont No. 35	81	87
Tutan	80	92	Dupont No. 45	78	89
Vitrioline	70	86	Dupont No. 53	82	88
Mercury C	78	86	Dupont No. 64	80	88

In an attempt to vary the conditions of soil moisture and temperature between the dates of sowing and emergence, the seed was sown in replicated rod rows in two series. Series 1 was sown on September 21 in soil whose moisture content was only 13 per cent of saturation and which received no additional rainfall until after the plants had emerged. Series 2 was sown on October 7 in soil whose moisture content was 65 per cent of saturation and which received an inch of rainfall three days after the seed had been sown and a still heavier rainfall the day before the plants emerged. A record of the soil temperature and rainfall between the dates of sowing and emergence in both series is shown in Table 9. The mean soil temperature during this period was 17.7° C. for series 1 and 16° for series 2. It is evident, therefore, that the soil of series 2 was much wetter and slightly cooler between the dates of sowing and emergence than the soil of series 1 during a corresponding period.

TABLE 9.—*Soil temperature and rainfall records in connection with field experiments on control of covered smut of barley with dust fungicides at Arlington Experiment Farm, Rosslyn, Va., 1927–28*

Date	Soil temperature			Rainfall	Date	Soil temperature			Rainfall
	Maximum	Minimum	Mean			Maximum	Minimum	Mean	
1927	°C.	°C.	°C.	Inches	1927—Con.	°C.	°C.	°C.	Inches
Sept. 21 [1]	22	16	18.3		Oct. 4	24	18	20.7	1.44
Sept. 22	21	13	17.2		Oct. 5	23	14	17.8	
Sept. 23	22	14	17.2		Oct. 6	23	13	17.2	
Sept. 24	22	12	17		Oct. 7 [3]	22	14	17.8	
Sept. 25	22	12	17		Oct. 8	16	10	17.2	
Sept. 26	24	14	17.5		Oct. 9	18	12	14.4	.69
Sept. 27	24	14	18.3		Oct. 10	21	7	14.4	.29
Sept. 28	24	17	19.3		Oct. 11	20	12	16.5	
Sept. 29 [2]	25	18	20.6		Oct. 12	19	15	17.5	
Sept. 30	27	18	21.6		Oct. 13	22	14	17.6	1.60
Oct. 1	29	19	22.8		Oct. 14 [4]	19	8	12.6	
Oct. 2	29	19	23		Oct. 15	19	7	12.3	
Oct. 3	24	20	22						

[1] Series 1 was sown in soil 13 per cent saturated.
[2] Series 1 emerged.
[3] Series 2 was sown in soil 65 per cent saturated.
[4] Series 2 emerged.

Data on the occurrence of covered smut were taken May 22, 1928. As stripe disease (*Helminthosporium gramineum* Rabh.) also was abundant in the rows from untreated seed, data were taken on the control of this disease. These combined data are presented in Table 10.

TABLE 10.—*Number and percentage of stripe-infected plants and of heads of covered smut in Tennessee Winter barley grown from untreated seed or from seed treated with different fungicidal dusts and sown at Arlington Experiment Farm, Rosslyn, Va.*

[Series 1 was sown in dry soil [1] Sept. 21, and series 2 in wet soil [2] Oct. 7, 1927. Data were taken May, 1928]

No.	Fungicidal dust	Stripe-infected plants in—				Heads of covered smut in—			
		Series 1		Series 2		Series 1		Series 2	
		Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
----	Untreated	199	5.75	403	13.71	1,688	12.19	1,112	9.46
1	Abavit B	15	.43	0	0	0	0	2	.02
2	S. F. A. No. 225	27	.77	5	.15	75	.53	109	.81
3	S. F. A. No. 225-V	29	.82	6	.18	209	1.47	142	1.05
4	Höchst	2	.05	0	0	3	.02	0	0
5	Tutan	110	2.93	90	2.76	273	1.82	117	.90
6	Vitrioline	108	5.37	196	6.34	918	6.22	228	1.85
7	Mercury C	25	.68	2	.06	65	.44	40	.32
----	Untreated	210	5.74	428	14.46	1,694	11.57	1,118	9.43
8	Wa Wa	10	.27	4	.13	13	.09	8	.07
9	Semesan	17	.45	5	.16	129	.86	54	.44
10	Semesan Jr	13	.34	5	.16	202	1.34	49	.38
11	Dupont No. 35	26	.71	6	.18	189	1.29	62	.46
12	Dupont No. 45	23	.62	2	.06	54	.36	7	.06
13	Dupont No. 53	62	1.67	36	1.13	347	2.34	236	2.25
14	Dupont No. 64	27	.75	2	.06	163	1.13	119	.95

[1] Soil contained 13 per cent of saturation. [2] Soil contained 65 per cent of saturation.

Covered smut was more abundant in series 1 than in series 2 both in the control rows and, with two exceptions, in the rows from treated seed. Stripe disease, on the other hand, was more abundant in the controls of series 2 than in those of series 1, owing, presumably, to the slightly lower mean soil temperature in series 2. But despite this fact, the control of stripe disease, like that of covered smut, was better in series 2. These results point to the fact that in series 1 the limited amount of soil moisture, which was barely sufficient to cause germination of the seed, reduced the effectiveness of the fungicides in disease control.

From the standpoint of disease control the three outstanding fungicides were Abavit B, Höchst, and Wa Wa. Next in the order of their general effectiveness came Dupont No. 45, Mercury C, Semesan, and S. F. A. No. 225. None of the other fungicides were consistently effective, although some of them had shown promising results in previous experiments. The unsatisfactory results obtained with some of these dusts, especially in series 2, may have been because of their gradual deterioration and loss of fungicidal properties upon standing, as some of them had been stored in the laboratory for over a year, although in closed containers. However, in series 1 insufficient soil moisture undoubtedly contributed greatly to the relative ineffectiveness of many of the dust fungicides.

Preliminary experiments of rather limited scope were carried out with a number of other dusts during the 1927–28 season. Among these were Agfa 331, U. T. 488, U. T. 348, Dupont No. 68, atomic sulphur, Bayer Dust, calomel, corrosive sublimate, and combinations of the last two with talc and copper carbonate. None of these proved satisfactory as dust fungicides for the control of covered smut of barley. Several combinations of corrosive sublimate and talc or copper carbonate eliminated covered smut but caused severe injury to the seed and also proved highly corrosive to metal.

EXPERIMENTS IN 1928–29

In the fall of 1928 two varieties of barley, Tennessee Winter and Wisconsin Winter, were used in experiments on the control of covered smut. The seed of Tennessee Winter and Wisconsin Winter had come from fields containing, respectively, 22 per cent and 7 per cent of covered smut. In addition to this natural inoculation, the seed was artificially inoculated by dusting it with spores of covered smut.

Seven dust fungicides were used along with a 1:320 solution of 37 per cent formaldehyde for comparison. In treating seed with formaldehyde a modification of Braun's presoak method (*2*) was employed. The seed was soaked in water for 15 minutes, and after draining it was allowed to lie covered for 4 hours. After a 20-minute immersion in a 1:320 solution of commercial formaldehyde it was allowed to drain and then was covered for 3 hours, after which it was dried. The dusts were applied at the rate of 3 ounces per bushel. All the seed treatments, including formaldehyde, were applied September 27, and the seed was sown in three series as follows: Series 1, 20 replications, sown September 29; series 2, 4 replications, sown October 5; series 3, 8 replications, sown October 18.

Unfortunately the plants in series 1 were winterkilled so completely that no smut-control data could be obtained. In series 2, 250 seeds per rod row were sown to determine the effect of the fungicides on the germination of the seed. The plants in this series emerged October 12, and germination data were taken October 15. As shown in Table 11, none of the treatments except formaldehyde reduced the percentage of germination.

TABLE 11.—*Effect of seed disinfectants on field germination of Tennessee Winter and Wisconsin Winter barley sown at Arlington Experiment Farm, Rosslyn, Va., October 5, 1928*

No.	Seed-treatment compound	Percentage of germination in—		Average percentage of germination
		Tennessee Winter	Wisconsin Winter	
----	Control	71.8	76.4	74.1
1	Ceresan	77.2	85.2	81.2
2	P. M. A	81.6	76.7	79.2
3	Höchst	83.5	86.4	94.9
4	Abavit B	81.3	81.5	81.4
5	Formaldehyde	[1] 60.4	[1] 70.1	[1] 65.3
----	Control	81.2	75.0	78.1
6	Smuttox	82.6	77.6	80.1
7	Corona 80–B	84.4	74.4	79.4

[1] Injury due to delay in sowing after treatment.

Later, further germination studies were made in the greenhouse bench with treated and untreated seed that had been stored, either in cotton sacks or in closed cans, for different periods of time. The results are shown in Table 12. Seed treated with Smuttox and stored in closed cans for 27 days or longer failed to germinate, while seed treated with P. M. A. and Corona 80–B and similarly stored had its viability greatly impaired. P. M. A. and Smuttox also affected adversely the germination of seed stored in sacks. None of the other treatments caused any striking reduction in the percentage of germination, regardless of manner or time of storage. Through an oversight, formaldehyde-treated seed was not included in the series stored in cans. The seed had been treated with this fungicide somewhat in accordance with Braun's presoak method (*2*). After being soaked in water for 30 minutes it was allowed to drain and then was covered overnight, about 15 hours. It then was immersed in a 1:320 solution of 37 per cent formaldehyde for 30 minutes, allowed to drain, covered for 2 hours, and then dried. This treatment, it will be noted, did not result in seed injury even after the dried seed had been stored for 75 days before sowing. For effective control of covered smut, however, an hour's immersion in the formaldehyde solution is recommended, for, as shown in Table 7, this treatment controlled covered smut.

TABLE 12.—*Effect of seed disinfectants on germination of Tennessee Winter barley after the treated seed had been stored for different periods of time either in cotton sacks or in closed cans and then sown in the greenhouse, germination data being taken 10 days after sowing*

No.	Seed-treatment compound	Percentage of germination after storage						
		1 day in sacks	27 days in—		41 days in—		75 days in—	
			Sacks	Cans	Sacks	Cans	Sacks	Cans
----	Control	94	92	92	92	92	80	80
1	Ceresan	100	94	90	96	98	82	80
2	Dupont P. M. A.	66	46	10	30	6	18	0
----	Control	96	94	94	82	82	86	86
3	Höchst	96	96	92	96	96	85	90
4	Abavit B	98	96	96	92	88	88	88
----	Control	96	94	94	90	90	87	87
5	Formaldehyde	96	92	----	90	----	87	----
6	Corona 80-B	96	96	30	86	20	92	36
----	Control	90	98	98	90	90	87	87
7	Smuttox	98	80	0	58	0	64	0

Series 3 was sown October 18 and the plants emerged October 28. At the time of sowing series 3 the soil contained 19 per cent of its water-holding capacity, which two days later had increased to 25 per cent. The mean soil temperature from sowing to emergence was 11° C. Series 2 was sown October 5 and the plants emerged October 11. At the time of sowing series 2 the soil contained 41 per cent of its water-holding capacity; a light rain the day after sowing increased the water content to 46 per cent. The mean soil temperature from sowing to emergence was 15.6°. The soil temperature and rainfall data between the dates of sowing series 2 and the emergence of series 3 are shown in Table 13.

TABLE 13.—*Record of the soil temperature and rainfall between dates of sowing and emergence in connection with experiments on control of covered smut of barley at Arlington Experiment Farm, Rosslyn, Va., during the 1928–29 season*

[Series 2 was sown October 5 and emerged October 11. The soil was 41 per cent saturated. Series 3 was sown October 18 and emerged October 28. The soil was 19 per cent saturated]

Date	Soil temperature			Rainfall	Date	Soil temperature			Rainfall
	Maximum	Minimum	Mean			Maximum	Minimum	Mean	
1928	*°C.*	*°C.*	*°C.*	*Inch*	1928	*°C.*	*°C.*	*°C.*	*Inch*
Oct. 6	23	13	16.8	0.11	Oct. 18	24	18	20.2	
Oct. 7	21	9	14.3		Oct. 19	24	17	18.7	0.13
Oct. 8	21	8	13.7		Oct. 20	18	8	13.5	
Oct. 9	24	12	17		Oct. 21	20	5	11	
Oct. 10	23	12	16.5		Oct. 22	20	6	12.4	
Oct. 11	23	9	15.3		Oct. 23	19	13	15.2	
Oct. 12	24	11	16		Oct. 24	17	6	10.8	.11
Oct. 13	25	12	18.3		Oct. 25	15	3	8.1	
Oct. 14	19	13	16.8		Oct. 26	15	2	7	
Oct. 15	18	10	14.8	.53	Oct. 27	11	0	5.2	
Oct. 16	26	15	19.7		Oct. 28	15	5	9.5	
Oct. 17	25	17	20.1						

In series 2, therefore, germination and emergence occurred in a warmer, wetter soil than in series 3. According to the data on smut control shown in Table 14, these conditions evidently resulted in more effective action of the dust fungicides, since only five smutted heads were found in all the rows from dust-treated seed in series 2, while in series 3 none of the dusts completely eliminated covered smut. Formaldehyde, on the other hand, was more effective in series 3 despite the fact that the higher percentage of smut in the controls in this series indicated more favorable conditions for its development than in series 2. The fact that the fungicidal action of formaldehyde and other liquid fungicides takes place before the seed is sown should make their effectiveness in disease control more or less independent of soil conditions after sowing. This, however, is not true in the case of most dust fungicides. It seems that a soil-moisture content of 25 per cent of saturation is not sufficient for the maximum effectiveness of those dust treatments whose fungicidal action doubtless is dependent upon their contact with soil moisture.

TABLE 14.—*Control of covered smut in Tennessee Winter barley and Wisconsin Winter barley grown from seed untreated or treated with various fungicides and sown in rod rows at Arlington Experiment Farm, Rosslyn, Va.*

[In series 2 four replications were sown October 5, 1928, and in series 3 eight replications were sown October 8, 1928. Data were taken May 15, 1929]

No.	Seed-treatment compound	Heads of covered smut in—							
		Tennessee Winter				Wisconsin Winter			
		Series 2		Series 3		Series 2		Series 3	
		Number	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
----	Control	52	3.5	290	6.6	58	4.8	216	5.3
1	Ceresan	2	.1	27	.6	0	0	35	.8
2	P. M. A	0	0	7	.2	0	0	3	.07
3	Höchst	0	0	18	.4	0	0	34	.7
4	Abavit B	0	0	13	.3	0	0	37	.8
5	Formaldehyde	12	2.3	59	1.6	26	1.8	14	.3
----	Control	111	5.8			83	7.4		
6	Corona 80-B	0	0			3	.2		
7	Smuttox	0	0			0	0		
----	Control	62	5.9			42	3.2		

From the standpoint of controlling covered smut without injuring the seed, Höchst, Ceresan, and Abavit B were the only satisfactory fungicidal dusts used in the 1928–29 experiments. It should be stated that the makers of Smuttox recommend it chiefly for the control of oat smut and not for barley diseases. It was unfortunate that the plants in series 1 were winterkilled, because the more numerous replications in this series would have yielded more significant data on the control of covered smut than were secured in the other series. The failure of formaldehyde to control covered smut effectively must be attributed to a too brief immersion in the fungicidal solution, as has been suggested before.

DISCUSSION AND CONCLUSIONS

During the period 1925–1929 more than 45 dusts were tried in experiments on the control of covered smut of barley. Of these dusts 12 were made in Germany; 1, Vitrioline, in France; 24 by seven different commercial concerns in the United States; and the remainder were made up in the writer's laboratory from various salts of mercury and copper. Of the 12 dusts from Germany, the 2 outstanding ones in the control of covered smut of barley were Höchst, also called Trockenbeize Tillantin and Abavit B. Dusts Nos. 225 and 225-V controlled covered smut satisfactorily at times, but were not consistently effective. None of these 4 dusts are commercially available in the United States.

Of the 24 dusts submitted by commercial concerns in this country, only the following 5, to the writer's knowledge, are or ever were produced commercially: Smuttox, Bayer Dust, Semesan, Semesan Jr., and Ceresan. Of the six organic mercury liquid fungicides used, Germisan and Tillantin C came from Germany and are not commercially available in this country. Semesan liquid is a solution of Semesan dust. Uspulun is no longer manufactured in this country.

Since so few of the 45 or more dusts used in the foregoing experiments are or ever were on the market in this country, the question naturally arises as to the practical value of results from experiments with such materials. It should be made clear in the first place, therefore, that the purpose of these experiments was not simply to test the fungicidal value of proprietary dusts recommended by their makers for the control of covered smut of barley, for at the time of beginning these experiments there were no such dusts on the market in this country. The experiments were designed to aid in the development of effective and practical dusts for this purpose. For this reason most of the dusts used were purely experimental and not necessarily intended for production on a commercial scale. It was necessary to determine (1) whether covered smut of barley could be controlled at all by dust fungicides, (2) whether and to what extent the effectiveness of such fungicides is dependent on environmental conditions after sowing the treated seed, and (3) whether the dusts found to be effective under an average range of conditions were practical from the standpoint of cost, physical and chemical properties, and their effect upon the seed.

Some of the dusts included in these experiments gave excellent control of covered smut, but owing to their high mercury content were discarded on account of their excessive cost. Others of equal effectiveness were undesirable on account of their being corrosive to metal. Still others were considered impractical on account of their hygroscopic nature, their lack of stability, their injurious effect upon the seed, or other undesirable qualities.

In view of the fact that in these as well as in previous experiments (*14*, *34*) liquid organic mercury fungicides, now on the market, proved highly satisfactory in controlling covered smut as well as other diseases of barley without seed injury, one naturally is called upon to supply a reason for trying to replace these efficient liquid fungicides with dust fungicides. Some of the advantages of dust fungicides and the disadvantages of liquid fungicides have been pointed out previously by the writer (*15*). It may be well to review these here, together with others of greater or less importance.

(1) Dust fungicides usually are easier to apply. The dust is mixed with the dry grain in a mechanical mixer for a few minutes, after which the grain may be resacked and either sown at once or stored indefinitely. All the trouble incidental to wetting and drying the seed is eliminated.

(2) The use of dust fungicides decreases the chances of mistakes in seed treatment. In using liquid fungicides, especially formaldehyde, there is some danger of using, unintentionally, too strong a solution or allowing too long a period of immersion, thus causing severe injury to the seed. On the other hand, according to Gassner (*6*), Krauss (*11*), and others, some fungicidal solutions when used repeatedly have so much of their essential ingredients taken up by the seed that they no longer act as disinfectants unless more of the chemicals are added. It goes without saying that mistakes are possible in adding the proper quantity of chemical, or, for that matter, in not replenishing the solution at all. In the case of dust fungicides if too little dust is applied, this fact is revealed to some extent by the appearance of the seed, which is supposed to be very thoroughly coated with dust. If too much dust is applied, the excess manifests itself as free dust because the seed will hold only a given quantity. No injury to the seed will result, as a rule, from excess dust, but the excess may cause trouble in seeding.

(3) Dust fungicides are less likely to cause seed injury. In addition to the danger of seed injury from too strong a solution or too long a period of immersion, in the use of liquid fungicides the seed may be injured by freezing if the weather should turn very cold before the seed has dried. Furthermore, a period of rainy weather at the time of treating the seed may prevent it from drying properly and delay its sowing so that sprouting or other injury may result. Hurd (*10*) has shown that seed slightly damaged in threshing is particularly susceptible to injury by formaldehyde and copper sulphate solutions. Dust fungicides, obviously, are free from these disadvantages.

(4) Dust fungicides afford greater protection against recontamination of the seed after treatment. After being treated with liquid fungicides the seed frequently is spread to dry on a barn floor, where there is danger of recontamination; or it may be subjected to further recontamination after it is dry by being placed in smutty sacks. Walldén (*39*) cites a case in Germany in which two lots of wheat treated with formaldehyde and resacked in clean and smutty sacks before sowing produced 0.4 and 16.5 per cent of bunt, respectively,

in the crop. Since the fungicidal action of nearly all dust treatments takes place after sowing, recontamination of the seed, manifestly, is a minor possibility.

(5) Since most dust fungicides do not cause injury to the seed even if it is stored for months after being treated, the treatment may be given during a slack period even in freezing weather. This favors the establishment and operation of community seed-treating plants where seed may be cleaned and treated at any convenient time before sowing.

(6) Seed treatment by dusts is independent of temperature and duration of application, while in the case of most liquid fungicides both these factors are important. Gassner and Rabien (*7*) state, for example, that an 0.008 per cent solution of formaldehyde at 30° C. for 6 hours is as effective as a 0.6 per cent solution at 0° for 10 minutes. Both Germisan and formaldehyde, they state, disinfect poorly at 6° or below. Lang (*13*) claims that at 5°–6° the disinfecting powers of Germisan and formaldehyde are reduced to one-half and one-fifth, respectively, of their effectiveness at room temperature, and that 3° is the lower limit for effectively using liquid fungicides of any strength. According to this, liquid fungicides should be applied at a certain given temperature to secure reliable results. This effect of temperature suggests a possible reason for some of the conflicting results occasionally obtained by different investigators in experiments with the same liquid fungicides, as has been suggested in a previous paper (*18*).

(7) Dust fungicides protect stored seed from weevils and other insects and to a large degree from rodents (*23*, *24*). The latter will avoid dusted seed if other food is available (*24*).

(8) Dust fungicides cause less retardation of the flow of grain through the drill than liquid fungicides (*17*), unless the seed has been thoroughly dried after treatment with liquids. This applies especially to seed treated with formaldehyde or copper sulphate. Such seed generally is sown immediately after being treated and while rather moist, because thorough drying is likely to be followed by impaired viability. This objection does not obtain with many of the other liquid fungicides now on the market, as seed treated with these fungicides may be stored indefinitely if thoroughly dried after being treated.

Dust fungicides are not without their disadvantages as compared with some of the liquid fungicides.

(1) They are poisonous and when inhaled may cause extreme physical discomfort or even more serious results. A respirator worn while applying dusts or handling dusted grain obviates trouble from this source. However, formaldehyde in concentrated solution as used in the spray method also is very disagreeable to apply.

(2) Dust fungicides, as a rule, are more expensive than liquid fungicides (*4*, *37*), but this shortcoming may be outweighed by the smaller cost of application.

(3) Generally speaking, it is not considered safe to use dusted grain for animal or human consumption; therefore, only enough seed should be treated to suffice for sowing. However, Mackie and Briggs (*24*) found that wheat treated with copper carbonate did not injure common house mice even when they subsisted upon it exclusively. Siegwardt (*32*) in Germany fed chickens with wheat dusted with Höchst, a copper-arsenic compound, and found that they seemed to suffer no

ill effects from it. While the mention of these results is not to be construed as a recommendation for using dusted seed as food, it seems that seed treated with some of the copper compounds is not so poisonous as has been generally supposed. Mercury compounds, however, whether applied to the seed in dust or liquid form, undoubtedly render it unfit for consumption.

(4) Dust fungicides applied to seed retard somewhat its ready flow through the drill (*17, 30*). This retardation may vary with the kind of dust used, the type of seed, the make of drill, the rate of application, and the rate of seeding. While it has been shown (*17*) that the retardation due to dust treatments is not so great as that caused by liquid treatments when the grain is sown before being thoroughly dried, the fact remains that under certain conditions the use of dust fungicides may necessitate an alteration in the setting of the drill.

(5) Comparatively dry soil after sowing is not conducive to disease control in seed treated with dust fungicides (*16*). According to Volk (*36, 38*), heavy rains after sowing also may render dust fungicides somewhat ineffective, especially in light, sandy soils. Westermeier (*40*), in very limited laboratory experiments, also found that heavy watering of the soil after sowing reduced the effectiveness of the dusts he used, and for this reason he maintained that they can not be recommended for general use. However, in four years' experiments with numerous dust fungicides, only in one instance did the writer (*16*) feel justified in attributing lack of effective disease control to excessive precipitation after sowing, and then only in the case of one dust.

An objection to the use of mercury compounds as seed disinfectants, either as liquids or as dusts, is advanced by Zimmerman (*41*), who claims that grain from plants grown from seed which had been treated with any of these compounds may contain appreciable quantities of mercury. The continued use of flour made from such grain, he states, may entail serious results, since the action of mercury is cumulative. Further investigations along this line are recommended by him.

Some of the objections to the use of liquid fungicides are overcome in Germany (*9*), and to some extent in this country, by the use of "continuous" seed-treatment machines. By this method the seed is run through a solution of the fungicide, being immersed for a comparatively short time, after which it is immediately resacked and allowed to stand for several hours before sowing. Volk (*38*) states, however, that in experiments in Germany this method of seed treatment seemed to reduce the resistance of the plants to winterkilling. This method also retains many of the disadvantages of the steeping method. The spray method is employed by some in preference to the steeping method. This consists in spraying the grain with a concentrated solution of the fungicide while it is being shoveled over, and then allowing it to remain covered for several hours or overnight. Manifestly, many of the objections that apply to the steeping and the continuous methods would apply also to this method.

SUMMARY

Covered smut in Tennessee Winter barley was satisfactorily controlled by immersing the seed for one hour in any one of the following solutions: (1) Formaldehyde 1:320, a 0.12 per cent solution made by adding a pint of 37 per cent commercial formaldehyde to 40 gallons

of water; (2) Semesan, 0.5 per cent; (3) Uspulun, 0.5 per cent; (4) Germisan, 0.25 per cent; (5) Tillantin (Uspulun Universal), 0.25 per cent; (6) Corona 620, 0.25 per cent; and (7) Bayer Compound, 0.5 per cent.

Nos. 3, 4, and 5 are made in Germany and are not commercially available in the United States and 6 and 7 are no longer being manufactured.

Under average soil-moisture conditions covered smut of barley seems to be amenable to control by the more effective dust fungicides.

The dust fungicides, Höchst (Trockenbeize Tillantin) and Abavit B, both made in Germany and not commerically available in the United States, and Ceresan, made in this country, gave satisfactory control of covered smut of barley without seed injury.

The effectiveness of the dust fungicides used seemed to be independent of soil reaction and, as far as could be determined, of the usual range of soil temperature. A soil-moisture content of less than 25 per cent of saturation decreased the efficiency of most of the dust fungicides used. The numerous advantages of dust fungicides over liquid fungicides for disinfecting seed grain are enumerated and make it highly desirable to find effective and satisfactory dusts to replace liquid treatments, especially the common formaldehyde and copper sulphate treatments, which often cause marked seed injury and consequent reduction in stand and yield.

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