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# SEED TREATMENTS FOR STINKING SMUT OF WHEAT

By

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Farmers using the barrel-type mixer.

COLORADO EXPERIMENT STATION
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# SEED TREATMENTS FOR STINKING SMUT OF WHEAT

By E. A. LUNGREN AND L. W. DURRELL

During the past few years there has been an increasing use of chemical treatments for stinking smut of wheat and more farmers are treating their seed wheat than ever before. This is largely due to the success of copper carbonate and the ease with which it can be used.

The widespread interest in seed treatment, however, has stimulated the production of a number of commercial compounds and their advertisements have led to confusion as to their value in treating wheat for smut.

Tests of these treatments have been made in other states but the results are not readily available to the Colorado farmers nor do these tests apply directly to the conditions in this state.

It is the purpose of this bulletin to discuss conditions influencing smut infection and to give the results of trials over a three-year period of some of the more common chemical treatments advocated for use in treating seed wheat for stinking smut.

## Methods

In the following experiments a number of chemicals and several commercial compounds were used as treatments for stinking smut of wheat, namely: Bayer Dust, Germisan, DuPont 37, Bayer compound, formaldehyde, copper sulfate, copper stearate, copper carbonate, copper carb, Chlorophole, Uspulun, Sedosan, DuPont Semisan and Trokenbieze.

The seed used for these experiments was obtained from the Akron field experiment station and from certified lots of seed. For winter wheat, Turkey Red variety was used and for spring wheat the variety Kota. The seed was first heavily inoculated with smut spores which had been tested for viability. It was then treated with the materials mentioned above. For the proportion of the commercial compounds the recommendations given on the containers was followed. For some of the dust treatments, 2, 4 and 6 ounces were tried. For formalin, the standard treatment, 1 pint to 40 gallons

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of water, was used. Copper sulfate was used at the rate of 3 pounds to 50 gallons of water.

Each year germination tests were made of all the treated seed before planting. Two hundred seeds of each lot were tested for germination. The germination tests were carried on in the standard seed germinators of the State Seed Laboratory. In these tests only seed treated with copper sulfate showed marked decrease in germination due to treatment. Also when solutions of formaldehyde stronger than 1 pint to 40 gallons were used low germination resulted.

The laboratory germination tests were supplemented by field-stand counts. The averages for the three-year tests together with the laboratory germination are given in the following table.

Table 1.—Average germination and stand of treated and of untreated seed. Three-year tests on 1092 rod-rows.

| | Percent Stand | Percent Germination |
|---|---|---|
| Untreated seed | 100 | 98 |
| "Copper Carb" | 97 | 96 |
| Pure Copper Carbonate | 99 | 97 |
| Formaldehyde | 75 | 93 |
| Copper sulfate | 70 | 75 |
| Uspulun | 98 | 98 |
| Germisan | 94 | 96 |
| Chlorophole | 96 | 97 |
| SedoSan | 84 | 97 |
| Bayer Compound | 91 | .... |
| Semisan | 92 | 97 |
| DuPont 37 | 97 | 95 |
| Copper Stearate | 90 | 97 |
| Bayer Dust | 96 | 96 |

In all trials the seed was planted in rod-rows, three rows to the treatment. Three check rows of untreated seed were planted along the borders and after every ninth row of treated seed.

Plantings were made approximately the first week of September, the last week of September and the last week of October. Counts on the percentage of smut obtained in the plots were made on the middle row of each of the three rod-rows. The entire number of heads in the middle row was used to determine the smut percentage.

## Experiments on Seed Treatment

Using the above methods a number of chemical treatments have been tried out, the results on the efficiency of which are given in Table 2. These tests include the more common chemical preparations offered as treatments for stinking smut together with the older formaldehyde and bluestone treatments. Some of the treatments were tested for three years, others which on first trial were found unsatisfactory or those obtained more recently were tested one or two years.

Table 2.—The Average Percentage of Stinking Smut in Winter Wheat Following Various Treatments.

| Dry Treatments | No. of Rod Rows | Years | Percent Smut |
|---|---|---|---|
| Untreated | 60 | 3 | 31.7 |
| "Copper Carb" 2 oz. | 30 | 3 | 4.7 |
| "Copper Carb" 4 oz. | 21 | 3 | 3.2 |
| "Copper Carb" 6 oz. | 21 | 3 | .9 |
| Pure Copper Carbonate 2 oz. | 30 | 3 | 4.0 |
| Pure Copper Carbonate 4 oz. | 24 | 3 | 2.6 |
| Pure Copper Carbonate 6 oz. | 24 | 3 | .5 |
| Copper Stearate | 24 | 2 | 8.5 |
| Bayer Dust 2 oz. | 12 | 1 | 6.4 |
| Bayer Dust 4 oz. | 12 | 1 | 4.4 |
| Bayer Dust 6 oz. | 12 | 1 | 2.1 |
| Trockenbieze | 12 | 1 | 3.6 |
| DuPont 37 | 12 | 1 | 8.3 |
| Bayer Compound | 9 | 1 | .4 |

| Wet Treatments | No. of Rows | Years | Percent Smut |
|---|---|---|---|
| Formalin | 30 | 3 | 1.2 |
| Copper Sulfate | 30 | 3 | 1.1 |
| Germisan | 21 | 2 | 1.4 |
| Chlorophole | 21 | 2 | .9 |
| Uspulun | 21 | 2 | .5 |
| SedoSan | 18 | 2 | 1.8 |
| DuPont Semisan | 21 | 2 | 3.4 |

The average percentage of smut for the untreated plots shown in Table 2 was 31.7. Many of the untreated plots, however, had considerably greater amounts of smut, some as much as 65 percent. All of the treatments reduced smut infection as determined by these three-year tests.

Of the dry-dust treatments, copper carbonate and Bayer compound shown in Table 2, offered most perfect control, reducing the smut to 0.9, 0.5, and 0.4 percent respectively.

Trockenbeize reduced the percentage of smut to 3.6 and Bayer dust reduced the smut to 2.1 percent where 6 ounces were used and to 4.4 percent where 4 ounces of the dust to the bushel were used DuPont No. 37 and copper stearate did not give satisfactory control.

It will be noted that of the 14 chemical treatments tested for control of stinking smut, seven were wet treatments. These wet treatments showed a high degree of control of the stinking smut.

The test of efficiency of a chemical treatment, however, is not alone its effectiveness in killing the smut but the ease with which it can be used, its cheapness and availability on the market. Freedom from seed injury and reliability of the product are also to be considered in selecting a suitable treating agent.

The wet treatments, irrespective of their efficiency in killing the smut spores, cannot longer be considered practical. The ease of handling coupled with their effectiveness and the freedom from seed injury gives the balance of favor to the dry-dust treatments. Formalin, copper sulfate or bluestone and Sedosan decrease germinat-

ing power as shown in Table 1. In field surveys covering over 20,000 acres of grain, it was repeatedly found that on the average where the farmer had treated seed wheat with formalin and bluestone the stands were poor. The dust treatments, however, did not injure stand as the wet treatments appeared to do.

Of the more effective dusts, the cost of treating and the availability of distribution of the material among the dealers influence their selection and must be given consideration when a choice of seed treatment is made.

At present dealers are most generally stocked with copper carbonate. Some of this material is "pure copper carbonate" containing approximately 50 to 52 percent copper and some is "copper carb" containing about 18 to 20 percent of copper. The copper is the specific part of the material which is poisonous to the smut fungus. In the dilute copper dusts the remainder of the material is inert filler. This, however, has the advantage of causing the dust to stick to the grain somewhat better than in the case of the pure carbonate. As shown in Table 2, little practical difference exists between the results obtained in all test plots where the "copper carb" and the "pure copper carbonate" were used; the figures favor the "pure copper carbonate" very slightly.

The amount of copper carbonate applied to the grain limits to some extent the degree of control. In Table 2 a comparison of the results of different rates of dusting shows a reduction of the smut to 4.0 percent and 4.7 percent where 2 ounces per bushel of "pure copper carbonate" and "copper carb" respectively, were used. Where four ounces of the dusts were used the percentage was reduced to 2.6 and 3.2 percent while 6 ounces of the dusts per bushel of seed resulted in 0.5 and 0.9 percent smut, or a trace.

The higher rate of dusting, 6 ounces per bushel, is, however, really in excess of the amount of dust that will stick to the wheat. Two or three percent smut on general field inspection is not obvious and a dust treatment reducing smut to this amount can be considered as furnishing good control.

The method of dusting the seed wheat with copper carbonate also influences the effectiveness of the treatment. In the field survey above mentioned it was found that when the seed was treated with copper-carbonate dust by other means than in an air-tight barrel mixer the treatment was less effective. When the grain was treated by mixing in the drill, as high as 11 percent smut resulted. It is evident from this that thoro dusting of seed wheat is necessary for the

best control and that such thoro dusting can best be accomplished in a mechanical mixer such as the barrel mixer.

## Conditions Influencing Smut Infection

**Soil Moisture.**—One of the influences governing the degree of smut infection is soil moisture. In the following table are given the results on wheat infected with smut under controlled conditions of moisture. The wheat was heavily inoculated with stinking smut and germinated in soil of different moisture content, held at an optimum temperature of 54° to 58°F.

**Table 3.—The Optimum Soil Moisture for Smut Infection.**

| Percent Soil Moisture | Percent of Stinking Smut |
|---|---|
| 5.9 | 0 |
| 9.7 | 0 |
| 11.1 | 0 |
| 13.1 | Trace |
| 19.4 | 50 |
| 24.5 | 86 |
| 31.9 | Trace |
| 34.0 | 0 |
| 36.0 (soil saturated) | 0 |

In the above table representing the average results of 39 tests, it is evident that smut infection does not take place either in dry or in very wet soil. The optimum soil moisture content for smut infection lies in the neighborhood of 15 to 20 percent. The latitude of infection is quite narrow and little or no infection takes place outside these limits. On the other hand if soil-moisture conditions at time of seed germination are favorable, coupled with favorable soil temperature, a high percentage of smut may be expected. The influence of soil moisture and of soil temperature are closely associated and where both are at the optimum, smut infection is greatly increased.

**Soil Temperature.**—The soil temperature at which the spores of stinking smut germinate and infect wheat are within limits equally as narrow as the limits of soil moisture. The work of other experimenters has shown the optimum temperature to be in the neighborhood of 49° to 58°F. Field tests in Colorado have shown that in soil of about 56°F. the greatest smut infection occurred. This was further checked by use of a constant temperature tank in which the best germination of the smut spores and infection of the wheat was obtained between 54° and 58° F. Above these temperatures the amount of infection rapidly decreased. At as low as 48°F., however, considerable infection took place.

The effect of soil temperature on infection has especial bearing on the date of planting.

## Date of Planting Influences Smut Infection

It has been observed that early planted winter wheat often has little smut while later plantings are severely attacked. Plots of untreated winter wheat grown during the three years these experiments were conducted shows the effect of planting date on smut infection.

Table 4.—Smut on Untreated Wheat Planted at Different Dates.

| Year | Location | Date Planted | Average Percent Smut |
|---|---|---|---|
| 1924 | Ft. Collins | Oct. 1 | 9. |
| | | Oct. 14 | 14. |
| | | Oct. 30 | 48. |
| 1925 | Ft. Collins | Oct. 23 | 27. |
| | Rocky Ford | Sept. 23 | 0.4 |
| | | Oct. 23 | 26. |
| 1926 | Akron | Oct. 9 | 62. |
| | Ft. Collins | Sept. 11 | 35. |
| | | Oct. 9 | 58. |

The above figures indicate that late plantings favor smut infection. Keeping in mind the optimum temperature for smut infection, it is interesting to note the average monthly soil temperature at the time of planting wheat as illustrated by the soil temperature records kept at Fort Collins over some 38 years.

Table 5.—Average Monthly Soil Temperature Three Inches Below Surface.

| | July | August | Sept. | Oct. | Nov. |
|---|---|---|---|---|---|
| 7 A. M. | 64.9 | 64.4 | 56.8 | 44.9 | 34.9 |
| 7 P. M. | 76.9 | 74.3 | 65.4 | 51.7 | 38.5 |

A comparison of the above temperatures for the months when wheat is planted shows the soil temperatures in August and Septembe to be too warm for the most favorable germination of the spores of stinking smut and the accompanying infection of the wheat. October soil temperatures, however, are ideal for smut infection of winter wheat and date of planting should be as early as possible to avoid the cooler soil temperature favoring smut.

In the survey above mentioned covering inspection of some 20,000 acres of winter wheat, the relation of soil temperature and date of planting to smut infection was markedly evident. Wheat planted on north slopes where soil is cooler frequently has more smut than wheat on south exposures.

A summary of all untreated plots of wheat in three years' tests shows that wheat planted between September 11 and October 9 had an average of 25.3 percent smut while wheat planted between October 9 and November 2 had 35.1 percent smut.

Under favorable conditions smut spores germinate in about six days. The growth of the wheat under these low-temperature conditions is slow. The wheat is susceptible to smut while it is in the seed-

ling stage before emerging from the ground. Low soil temperatures favorable to smut spore germination hold back the wheat and prolong the susceptibility period for smut infection; such conditions frequently exist in the case of late-planted wheat.

Seed treated with copper carbonate did not show the effect of planting date to any marked degree. This chemical in all plot tests for three years seemed to offer good protection even under conditions most favorable for smut infection. Occasional field observations and reports of farmers suggest, however, that under some conditions even seed treated with copper carbonate has considerable smut. It is impossible to get all the facts in such cases; the seed may not have been thoroly dusted with the carbonate or it may have been especially smutty and lack of protection cannot therefore be definitely credited to the effect of late planting.

**Soil Infection.**—A number of conditions influence smut infection. The above-mentioned soil moisture and soil temperature sharply limit this infection. The degree of smuttiness of the seed and soil infection also play a part. The more live smut spores present at the time wheat germinates the greater the infection of the wheat.

The widespread use of the combine in harvesting wheat in eastern Colorado has increased the possibility of smut infection from the soil. The chaff and straw together with the smut spores from the threshed wheat are spread on the land again. These spores in the soil increase the chances of smut infection.

This increase is illustrated in the following table by the average percentages of smut from plots on infected soil, two years planting.

Table 6.—Effect of Soil Infection on Amount of Smut.

| Date | Percent smut on untreated seed in non-infected soil | Percent smut on seed treated 4 oz. copper carbonate in infected soil | Percent smut on seed treated formalin in infected soil | Percent smut on seed treated 4 oz. copper carbonate in non-infected soil | Percent smut on seed treated formalin non-infected soil |
|---|---|---|---|---|---|
| Oct. 22 | 24. | 21.3 | 23.4 | 0.4 | 0.6 |
| Sept. 23 | 0.2 | 0.2 | 0.5 | 0. | 0. |
| Oct. 23 | 26. | 17.5 | 32.5 | 3.9 | 1.8 |
| Sept. 18 | 6. | 2.1 | 4.2 | 5.7 | 0. |

In the above data it may be seen that untreated infected seed for the two years resulted in 25 and 26 percent smut on late plantings and 6.0 and .2 percent in early plantings. Treating the same seed with formalin, tho it lowered the stand, reduced the smut to

an average of 0.5 percent, while treating it with copper carbonate, reduced infection to an average of 2.5 percent.

When the seed treated with formalin was planted in heavily infected soil the late plantings had an average of 27.9 percent smut. This would be expected for the formalin kills the smut spores on the seed but the seed is reinfected from the soil after planting. Copper carbonate, regardless of its adherence to the seed and its slow solubility in the soil water, offers little better protection where the soil is heavily infected. Seed treated with copper carbonate and planted in infected soil resulted in an average of 19.4 percent smut.

These figures suggest the advantage of rotation where smutty wheat is harvested by a combine.

Four years' tests on spring wheat planted in infected soil show no infection from that source and there is little probability that the smut lives over the winter under ordinary conditions.

## SUMMARY

Three years' experiments have been conducted on the effectiveness of the following materials in controlling stinking smut of wheat: Copper carbonate, "copper carb", copper stearate, Bayer dust, Trockenbeize, DuPont 37, Bayer compound, formalin, copper sulfate, Germisan, Chlorophol, Uspulun, SedoSan and Semisan.

Of the dry-dust treatments copper carbonate, "copper carb" and Bayer compound reduced the smut to the lowest percentage. There was little practical difference in the results from pure copper carbonate and "copper carb." The other dust treatments offered control of smut but to a somewhat less degree.

The wet treatments gave good control of smut. Formalin and copper sulfate, however, materially reduced the germination and stand. SedoSan was also somewhat injurious to stand.

The comparison of the dusting rate where copper carbonate was used shows increasing efficiency with the larger amounts of dust applied, six ounces of dust per bushel gave the most perfect control. This is more than will effectively stick to the grain, however, and for all practical purposes four ounces is sufficient.

The method of dusting wheat is important in controlling smut. Best results are obtained by treating wheat in a tight barrel mixer so that seed is thoroly covered with dust.

Smut infection is strongly influenced by soil conditions such as soil moisture and temperature. Smut spores germinate best in a soil moisture of from 15 to 20 percent.

Soil temperature is of even greater importance in smut infection than soil moisture. Smut spores germinate best in the neighborhood of 55°F. In soil at this temperature the greatest infection occurs. At higher temperatures few or none of the spores germinate.

The soil temperature for August and September will average 69.3°F. and 61.1°F. respectively—too high for smut germination and infection. October soil temperatures average 48.3°F.—more favorable for smut.

Wheat planted at the earlier dates encounters soil temperatures favorable for growth but too high for smut infection. The soil temperature at the later dates, however, is optimum for smut infection. Field results show that late-planted wheat averages more smut than early planted wheat.

Wheat planted in heavily infected soil will be more smutty than that planted in soil free from smut spores. Even seed treated with copper carbonate is not well protected in heavily infected soil. Field results indicate that it is doubtful if the smut spores in the soil live over winter to infect spring wheat.

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