Wheat Smut in Montana

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Map 1. Carloads of winter wheat received at Minneapolis, 1928. Upper numbers, carloads which graded smutty; lower numbers, total carloads received.

Map 2. Carloads of spring wheat received at Minneapolis, 1928. Upper numbers, carloads which graded smutty; lower numbers, total carloads received.
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Stinking Smut Most Serious

Stinking smut is the worst disease of wheat in the northwest. It is of economic importance wherever wheat is produced in the United States, as it decreases yields approximately 25,000,000 bushels annually. At Minneapolis prices, the annual loss due to smut totals approximately $40,000,000 when dockage is included.

There is no disease better known to Montana farmers than stinking smut of wheat as it is widely distributed (Maps 1, 2). In untreated fields of winter wheat the maximum loss has been found to be more than 75 per cent. A very conservative estimate of the annual loss in the state due to stinking smut is four per cent, amounting to three to four million dollars. Much of this is an unnecessary waste because the loss can be decreased materially by seed treatment which costs less than four cents an acre.

Twenty-four per cent of 12,261 cars of Montana wheat received at Portland, Oregon, was graded smutty during the period from July 1, 1927 to Dec. 1, 1928.

During the period from August 1 to December 1, 1928, 2.37 per cent of 11,219 cars of spring wheat, and 33 1/3 per cent of 1644 cars of winter wheat from Montana were graded smutty at the Minneapolis terminal (Maps 1, 2). Figuring the average smut dockage at the rate of seven cents per bushel, this amounts to a loss of over $80,000 at this one terminal alone. Treating seed with copper carbonate will eliminate this loss in spring wheat, and will materially reduce the damage to winter wheat.

What Is Smut?

Smut is produced by a small parasitic plant, mould-like in appearance, belonging to a group called fungi. Smut lives most of its life within and at the expense of the wheat plant. The smut powder, so familiar to all, is composed of myriads of spores which correspond to seeds in the higher plants. In the process of harvesting and threshing, these spores are distributed, many of them adhering to the wheat. Conditions favoring the germination and
growth of the wheat are favorable to the growth of the fungus. The spores germinate at the same time as the wheat. If the smut fungus comes into close contact with a young wheat seedling, it enters the tissues of the seedling and from that time forth grows within the wheat plant. About the time when the wheat plant should normally form grain, the fungus becomes very active, starts growing vigorously, and produces spores, the familiar black smut powder, which take the place of the kernels of grain (Cover page).

Kinds of Smut

Strictly speaking there are three classes of cereal smuts. (1) Smuts, like the stinking smut of wheat, which cause infections only in the seedling stage, are commonly called covered smuts. In this class of smut the spores are carried on the outside of the seed; therefore they can be destroyed by treating the seed with a chemical, either as a powder or in a solution, which kills the spores but does not injure the grain. Stinking smut spores in the soil also may infect the wheat plant under some conditions. Such soil infection commonly occurs in winter wheat sections of Eastern Washington, Oregon and some districts of Montana. In these sections clouds of smut spores or “smut showers” infest the surface of the soil during the fall months. In Montana, soil infestation is important in winter wheat planted either in stubble or on summer fallowed land. Smut spores do not usually live over winter in the soil. Spring wheat infection, therefore, is caused by spores on the outside of the untreated seed when planted.

(2) Smuts which cause infection only when the parts are in blossom, are commonly called loose smuts. The loose smuts of wheat and barley are examples. In this class of smuts the fungus is within the seed. Therefore, it can be destroyed only by dipping in water just hot enough to kill the smut but not hot enough to kill the seed itself.

(3) Smuts, of which corn smut is an example, where any young growing part of the plant may become infected, such as the silk, tassels, leaves, stems, etc. This class of smuts can be controlled only by destroying the diseased plants when they first appear, by the rotation of crops and by the destruction of crop refuse after harvesting. Seed treatment is of no value in the control of smuts similar to corn smut.
Stinking Smut of Wheat

Stinking smut of wheat belongs to the first class, because infection occurs only in the seedling stage and therefore it cannot spread from plant to plant in the field.

Different Smut for Each Crop

Just as there are different kinds of fruit, so are there different kinds of smut, each peculiar to the plant upon which it grows. Wheat smut will not grow upon oats or barley. Oat smut will not grow upon wheat and barley, and barley smut will not grow upon wheat and oats.

Copper Carbonate Recommended

In order to encourage the practice of yearly treating wheat for stinking smut the disadvantages of using copper sulphate and lime, or formaldehyde had to be overcome.

A new method of seed treatment, in which copper carbonate dust is used, eliminates many of the disadvantages and is effective in controlling smut.

It was first tested as a fungicide in 1917, and is now generally recommended for the control of stinking smut in all important wheat sections of the United States.

What Is the Dust Treatment?

The copper carbonate dry dust treatment for smut consists of mixing two to three ounces of copper carbonate with each bushel of clean wheat. To be effective it is necessary that each kernel be coated with the fine dust. The fine particles of copper carbonate destroy the smut spores lying on the outside of the wheat kernel.

Quality of Copper Carbonate

The copper carbonate powder recommended for treating seed wheat should be light and fluffy and of a light green color. It should be fine enough to permit from 98 to 100 per cent of it to pass through a 200 mesh screen. Heavy, bluish and coarse powders should be rejected.

Copper carbonate powder for treating wheat is sold on the market in two forms—the standard or pure dust and the "extended" or diluted dust. The standard dust contains from 50 to 54 per cent of copper, while the "extended" dust, sold under
various trade names such as Coppercarb, Smuticide, Wheatcoate, etc., contains from 18 to 20 percent of copper. Since copper is the active ingredient the standard dust is from two and one-half to three times more concentrated than the "extended" dust.

Copper carbonate may be obtained through local drug stores, wholesale drug firms, some implement dealers and seed houses. County agents and Smith-Hughes agricultural instructors will supply information regarding available sources and prices. Where such service is not available, persons may write to the Montana Extension Service, Bozeman, for such information.

**Amount of Copper Carbonate to Use**

Under Montana conditions, use two ounces of standard dust (50-54 per cent copper) to one bushel of winter wheat, and three ounces of the extended dust (18-24 per cent copper) to one bushel of spring wheat. If the winter wheat seed is very smutty, use three ounces of the standard dust to each bushel.

The use of more dust than will adhere to the wheat is mere waste, as the success of the treatment depends on the even distribution of the powder over the surface of the kernel. The cost of the copper carbonate treatment is slightly higher than for the formaldehyde treatment, but the amount of seed saved and other advantages of the dust treatment far overshadow the difference in cost.

**Advantages of Dusting**

The advantages of the dust treatment over liquid treatments may be briefly enumerated as follows: (1) It saves time and is more convenient and agreeable. (2) Wheat may be treated during spare time previous to seeding. (3) It is not injurious to germination and vigor of growth. (4) Less seed per acre is necessary. (5) The seed may be planted in dry ground without loss of vitality, which injury so often follows the formaldehyde treatment. (6) It affords some protection against infection from spores in the soil.

**Effect on Drill**

One disadvantage of the dust treatment is that it may cause the parts of the drill to "set" or to work hard. To avoid this trouble always rock the feed shaft gently with a wrench before starting the machine. Before the drill is put away for the season, it should be thoroughly cleaned and oiled.
Do Not Inhale the Dust

Copper carbonate affects the sensitive lining of the nose and throat when inhaled. The immediate effect usually is sneezing, and if exposure to the dust is continued, headache and nausea are apt to result. Mixing devices should be used which are dust-tight. The mixing should be done in a well ventilated room, preferably out of doors. In copper carbonate factories, the workers use masks or special respirators and suffer no inconvenience. Many farmers also are using these respirators (Fig. 1) which are light and permit breathing and talking without difficulty. Drug stores furnish these respirators at about $2.00 each.

Tying a wet handkerchief over the nose and mouth is a common practice. Where proper precautions are taken, no trouble should be experienced. One of the manufactured mixing machines is fitted with a special suction fan which removes excess dust and thus protects the operator from inhaling any of the copper carbonate.

Fig. 1. A commercial treating machine in operation. Note the drum type of machine, the copper carbonate container and the masks or respirators to protect the operators from inhaling the dust.
Do Not Feed Treated Grain

Copper carbonate dust is not extremely poisonous but reasonable care should be exercised in handling it. Some reports received indicate that chickens have died from the effects of eating treated grain. Livestock have been sickened by eating treated grain but are reported to have recovered. In case it becomes necessary to feed treated grain to livestock, the grain should be thoroughly washed, as copper carbonate is practically insoluble in water and is easily removed by this method.

Manufactured Treating Machines

There are various types of efficient treating machines on the market. The advantage of these machines is that the treating is more thorough than with homemade treaters operated under ordinary farm conditions. Most of the commercial machines are designed to treat the grain thoroughly and continuously, sack the treated grain and expose the operator to a minimum amount of dust (Fig. 1).

They should always be used in a hook-up with a good fanning mill because in this way there is practically no additional cost of labor for treating the seed. It is poor practice to treat unfanned seed under any condition. Do not couple up a small treating machine with a big cleaning mill if the best results are to be secured, as this will overload the treater and the mixing is not thorough enough to coat every kernel with the dust. Even feeding can be secured by dumping the wheat into the hopper and adjusting the flow into the cleaner, and from there into the treating machine.

All smut treating machines should be constructed to provide ample space for the wheat and the dust fog that is created. Unless there is an effective dust chamber the copper carbonate dust particles will not break up fine enough to lodge in the brush and crease of the kernel (Fig. 2) and provide a complete coating, as is necessary if spores are to be effectively killed. Mere rubbing of the powder on the wheat kernel is not enough; exposure to the dust fog is necessary to secure the best results. For this reason the drum type of treating machines are more satisfactory than the auger or gravity machines. Combination cleaning and treating machines are becoming popular and are very satisfactory (Fig. 3).

“It is not the dust in the machine but the dust on the kernel that counts.”
County agents or the Montana Extension Service at Bozeman will be glad to advise farmers regarding dealers who handle dusting machines.

Fig. 2. Upper, side and cross-section views of wheat kernels. Enlarged 6 times. Note the rough surface, the depth of the crease and the brush in which the small smut spores find lodgement. The copper carbonate must completely cover the surface of the wheat to kill the germinating smut spores with which it comes in contact. (Courtesy W. O. Whitcomb, Grain Inspection Laboratory, Bozeman, Montana.)

Homemade Types of Treating Machines

Homemade treaters will be used to a large extent on smaller farms. One of the common complaints against the homemade machines is their lack of thoroughness in mixing. Too many operators hurry the process and seem to feel that a slight mixing of the powder with the wheat is sufficient. It must be pointed out, however, that the seed should be coated with the dust, which means continued mixing until this is accomplished. Therefore,
farmers are urged to continue the process for some time after the powder appears to be uniformly distributed. Grain should be treated in spare time when there is no hurry. If a little mixing is good, more mixing is better. Some of the homemade types of machines developed for this work are described below. An ordinary wooden barrel or a steel oil barrel may be fitted up and makes a satisfactory device (Fig. 4). A shaft is placed through the ends of the barrel with the ends of the shaft resting on a suitable frame. This shaft is turned by a crank or pulley. The grain and dust are delivered into and out of the barrel through a dust-tight door placed on the middle of the barrel. To make the mixing more thorough.
and rapid, three baffle-boards or irons are fitted lengthwise on the inner walls of the barrel. Detailed construction plans of this mixer can be secured from county agents.

A modification of this type of mixer is made by fitting the shaft through the middle of the barrel so that the barrel is revolved end over end. This type will do good work but the action is jerky and more power is necessary in mixing.

One of the most easily constructed and most effective home-made mixers is a cubical box, operated on the same principle as the regular box type churn. A box two feet on each side will mix a sack of wheat at a time. The box should be constructed of good flooring as it is desirable that it be as nearly dust-tight as possible. The shaft should be placed through two diagonally opposite corn-

Fig. 4. Home made barrel treating machine
ers. The box is revolved by a crank or pulley. One of the outer corners may be cut off for an opening. A dust-tight lid may be held in place by an endgate rod extending to the opposite corner. This type of mixer does not require baffle boards (Fig. 5). Other types of homemade mixers are used, but the barrel and box machines are as good, if not better, than any of the other homemade models.

![Diagram of homemade box treating machine]

**Fig. 5.** Home made box treating machine.

**Unsatisfactory Mixing Methods**

Farmers are cautioned against attempting to treat wheat with copper carbonate by short cut methods such as shoveling on a floor or stirring in the drill box. Satisfactory results cannot be obtained by such methods. Use the right amount and kind of dust and mix thoroughly in a dust-tight machine.
Treatments Formerly Recommended

Copper Sulphate Treatment

Copper sulphate or blue stone solutions was a standard remedy for smut for many years. Wheat was immersed for five to ten minutes in a solution consisting of one pound of copper sulphate and one pound of salt dissolved in five gallons of water. The seed should be dried quickly, or, to avoid injury, it should be immersed for five minutes in lime water (1 pound of lime in ten gallons of water) and then dried.

Copper sulphate is one of the most efficient fungicides, and, when used properly, gives excellent results. This treatment affords some protection to the seed after it is planted.

The disadvantages of this treatment are that the seed may be injured so that the roots and young stems grow abnormally. In planting, allowance must be made for the swelling of the seed. Treated seed must not be fed to stock as copper sulphate is poisonous.

Formaldehyde Treatment

The formaldehyde treatment partly supplanted the copper sulphate treatment after it was introduced in 1897. The formula most commonly used consists of 1 pint of formaldehyde (30-40% strength) in 40 gallons of water. It may be used in the following ways: (1) As a dip. The grain is immersed in the solution in loosely filled sacks for 10 minutes. Remove the sacks, let the excess liquid drain back into the vat, and allow them to stand without opening from two to six hours.

(2) As a spray. Sprinkle from three-fourths to one gallon of the formaldehyde solution on each bushel of wheat, shovel thoroughly until each kernel is wet, and cover the whole pile with sacks for 2 to 6 hours.

(3) By using the solution in a smut treating machine. Treat the seed, following the directions given by the manufacturer, and cover the seed two to six hours immediately after treating.

The formaldehyde treatment is better than the copper sulphate treatment because (1) it causes less seed injury, (2) is cheaper and more easily handled, (3) it controls smut more effectively except where soil infestation is serious and (4) grain that has been treated may be fed to stock when mixed with an equal amount of untreated seed, without detrimental results.
There are several objections to this treatment. (1) Seed cannot be safely stored after treatment, even when thoroughly dried for seed injury often results from the continued action of the chemical. (2) When treated seed is sown in soil too dry for immediate germination, considerable injury often results. (3) An allowance must be made when the seed is drilled due to the swelling of the seed during the treatment.

**Formaldehyde Gas Treatment**

A new method of dry treating seed grain by formaldehyde gas to control smut is being advocated, and the machine is widely advertised as the gas grain pickler or treater. In this method the grain is treated by direct contact with the gas liberated from formaldehyde compounds. Results of this treatment in the past have proved unsatisfactory, both in the United States and in Canada. An improved machine is now on the market called the gas treater, and it is still necessary to experiment with this new model under varied conditions to secure reliable data on results. At the present time this method is still in the experimental stage, and therefore cannot be recommended.

**Hot Water Treatment for Loose Smut of Wheat**

The hot water treatment to control loose smut of wheat is recommended only for treating seed to be used for foundation stock, because it is difficult to apply and often causes injury to the seed. The hot water treatment will control both loose and stinking smut. Where only stinking smut occurs in the seed stock the copper carbonate treatment should be used.

The essentials of the modified hot water treatment consist of (1) soaking well cleaned seed for 4 to 6 hours in warm water (68-85 degrees F.) followed by (2) dipping in a warming vat at 120 degrees F. for one minute to take off the chill, and (3) immersing in hot water at definite temperatures and for definite periods as follows:

- Wheat is treated in hot water at 129 degrees F. (Allowable range 124 degrees to 130 degrees F.)
- Barley is treated for 13 minutes in hot water at 126 degrees F. (Allowable range 124 degrees to 129 degrees F.)

After soaking in hot water, grain should be dipped in cold water at once and then spread out in a thin layer to dry.
Plant as soon as the grain will run freely through the drill making allowance for the swollen condition of the grain, or dry thoroughly and store for later use. The exact method of using the hot water and handling the grain may vary, and will depend upon equipment and facilities.

**Conditions Affecting Smut Infection**

Results of many experiments have proved that the effectiveness of a treatment in controlling smut may vary from year to year in the same locality. Complaints from farmers regarding unsatisfactory results from treatments usually are most numerous in years when stinking smut is most prevalent.

In explaining the poor results of recommended treatments in occasional years, one must consider stinking smut in its relation to soil temperature and soil moisture.

It has often been observed that the date of planting is often closely associated with the amount of smut. This, however, is an indirect reaction as the soil temperature is the important factor.

The infection of smut takes place on the very young wheat seedling before the first leaf emerges. Therefore, a quick emergence of the wheat after it is planted is advantageous, because it lessens the chances of infection. When the soil temperature is between 41 and 50 degrees F, it takes from 12 to 22 days for the wheat to emerge, while it takes only from four to eight days when the temperature is from 59 to 68 degrees F.

Field observations agree with experimental results that wheat sown in relatively dry soil will have but little smut in comparison to wheat sown in soil with abundant moisture, other conditions being alike.

It should be the object of the grower to plant his wheat at the recommended time for planting in his locality, and to plant under the most favorable growing conditions from the standpoint of soil temperature and soil moisture.

**Where Foot Rot Occurs**

Early planting of winter wheat ordinarily reduces the loss from smut, but the losses which may occur from foot rot on early planted wheat may be more serious than the danger from smut. Therefore, later planting under favorable growing conditions is advisable where both smut and foot rot occur.
## SEED TREATMENTS FOR SMUTS

<table>
<thead>
<tr>
<th>Cereal</th>
<th>Smut</th>
<th>Chemical</th>
<th>How Used</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Stinking smut</td>
<td>Copper carbonate 52%</td>
<td>2 to 3 oz. per bu.</td>
<td>On winter wheat—Mix until each kernel is coated</td>
</tr>
<tr>
<td></td>
<td>Loose smut</td>
<td>Copper carbonate 20%</td>
<td>2 to 3 oz. per bu.</td>
<td>On spring wheat—Mix until each kernel is coated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hot water</td>
<td>129°F</td>
<td>Modified method—1st, soak 4-6 hrs. at 68-85°F.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2nd, soak 1 minute at 120°F.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3rd, soak 10 minutes at 129°F.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4th, dip in cold water; spread thin to dry.</td>
</tr>
<tr>
<td>Loose smut</td>
<td>Hot water</td>
<td></td>
<td>120°F</td>
<td>Single bath method—Soak 1 hr. and 35 minutes; spread thin to dry.</td>
</tr>
<tr>
<td>Oats</td>
<td>Loose and covered smut</td>
<td>Formaldehyde</td>
<td>1 pt. in 1 pt. water,</td>
<td>Spray with atomizer—cover 5 hrs.</td>
</tr>
<tr>
<td>all varieties</td>
<td></td>
<td></td>
<td>for 50 bu. oats</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Formaldehyde</td>
<td>1 pt. in 30 gal. water,</td>
<td>Soak 30 minutes or sprinkle thoroughly and cover 2-8 hrs.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>for 50 bu. oats</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Formalin dust compound</td>
<td>3 oz. per bu.</td>
<td>Mix until each kernel is coated. Sack and stand 3 hrs.</td>
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<tr>
<td></td>
<td></td>
<td>(**Certain organic mercury salts)</td>
<td></td>
<td>Follow instructions on package.</td>
</tr>
<tr>
<td>Barley</td>
<td>Covered &amp; (six-row) loose smut</td>
<td>Formaldehyde</td>
<td>1 pt. in 40 gal. water.</td>
<td>Soak 30 min. and cover 5 hrs. or soak for 2 hrs.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1 oz. in 3 gal. water.</td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>Covered smut (two-row)</td>
<td>Same as barley 6-rowed.</td>
<td>126°F</td>
<td>Soak 4-6 hrs. at 68-85°F; 1 minute at 120°F; and 13 minutes, at 126°F.</td>
</tr>
<tr>
<td></td>
<td>Loose smut</td>
<td>Hot water</td>
<td></td>
<td>Dip in cold water, spread thin to dry.</td>
</tr>
<tr>
<td>Corn</td>
<td>Smut</td>
<td>No seed treatment</td>
<td>No seed treatment</td>
<td>Destroy affected parts and crop refuse; crop rotation.</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Covered kernel smut</td>
<td>Copper carbonate 52%</td>
<td>2 oz. per bu.</td>
<td>Mix until each kernel is coated.</td>
</tr>
<tr>
<td>Millet</td>
<td></td>
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</tbody>
</table>

*This compound was developed by the Ohio Experiment Station and is sold under the trade name of “Smuttox”.

**There are several products of this kind on the market, under such trade names as Ceresan, Chlorophol, Uspulun, etc.