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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF VEGETABLE PATHOLOGY.

FARMERS' BULLETIN No. 5.

TREATMENT

OF

SMUTS OF OATS AND WHEAT.

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U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PATHOLOGY,
Washington, D. C., February 16, 1891.

SIR: I have the honor to transmit herewith a Farmers' Bulletin on the treatment of smuts of oats and wheat. This bulletin has been prepared under my direction by Mr. W. T. Swingle, an assistant in the Division, who for a number of years has devoted special attention to smut diseases. The object of the bulletin is to place before the farmers, in concise form, the results of recent experiments made in this country and Europe in the treatment of smuts.

Respectfully,

B. T. GALLOWAY,
Chief of Division.

Hon. J. M. RUSK,
Secretary.

FARMERS' BULLETINS.

The bulletins of this series may be obtained by applying to the Secretary of Agriculture, Washington, D. C. The following have been previously issued:

Farmers' Bulletin No. 1. The What and Why of Agricultural Experiment Stations. (A brief explanation of the object, origin, and development of the stations, their work in Europe and in the United States, and the operations of the Office of Experiment Stations of the Department of Agriculture.) Prepared by the Office of Experiment Stations. pp. 16. Issued June, 1889.

Farmers' Bulletin No. 2. The Work of the Agricultural Experiment Stations. (Illustrations of station work in the following lines: better cows for the dairy; fibrin in milk; bacteria in milk, cream, and butter; silos and silage; alfalfa; and field experiments with fertilizers.) pp. 16. Prepared by the Office of Experiment Stations. Issued June, 1889.

Farmers' Bulletin No. 3. The Culture of the Sugar Beet. (Treats of the climatic conditions, soil, fertilizers, and cultivation required by the sugar beet, cost of growing, time to harvest, and method of siloing; describes briefly the process of beet-sugar manufacture, and gives statistics of sugar production and consumption.) By H. W. Wiley, chemist of the Department of Agriculture. pp. 24. Issued March, 1891.

Farmers' Bulletin No. 4. Fungous Diseases of the Grape and their Treatment. (Describes downy mildew, powdery mildew, black rot, and anthracnose of grapes, and gives instructions for their treatment and estimated cost of remedies.) By B. T. Galloway, chief of the Division of Vegetable Pathology. pp. 12. Issued March, 1891.

TREATMENT OF SMUTS OF OATS AND WHEAT.

BY W. T. SWINGLE.

Smuts are minute parasitic plants belonging to the great group fungi. By their action they cause diseases of higher plants. The two smuts which cause the greatest damage in the United States, and which for this reason will be chiefly considered here, are the loose smut of oats and the stinking smuts of wheat. It is hoped that the following brief descriptions will enable any one to recognize them.

THE LOOSE SMUT OF OATS.

In case of the loose smut of oats the grains and usually the husks are transformed into a black powdery mass consisting of the spores of the fungus intermixed with a few shreds of tissue of the plant itself. The oat plants first show signs of the disease at the time of heading out, when, instead of a normal head, a smutted one is produced. The smut becomes fully mature at the time of blossoming of the oats and is then easily scattered by the winds. By harvest time the smut has often been entirely blown away, leaving only the naked and stalk remaining. The fungus is known to botanists as *Ustilago avenae* (Pers.) Jensen. In Plate I Fig. 1 shows a large smutted head, the husks of which are only partially destroyed by smut; Fig. 2, a fully smutted head; and Fig. 3, a fully smutted head as it appears at harvest time with nearly all the smut blown away.

THE STINKING SMUT OF WHEAT.

This smut, unlike that of oats, attacks only the grain. In consequence the heads have nearly their normal appearance. Upon close examination the grains are seen to be swollen, of a greenish color at first, but finally brown or gray. If one of these swollen smutted grains be crushed it will be found to be filled with a dull brownish powder which has a very penetrating and disagreeable odor. The presence of this odor, which has given rise to the common name, is a very good test for the presence of the smut. The smut is due to either of two very nearly identical fungi, *Tilletia foetens* (B. & C.) Sehroet. and *T. tritici* (Bj.) Wint. Figs. 4 and 5 of the plate show smutted heads of awned wheat and bearded wheat respectively.

AMOUNT OF DAMAGE.

The amount of damage caused by the loose smut of oats is very rarely fully appreciated. Wherever careful investigations have been made the per cent of heads attacked by smut has been found to be considerable. The average loss is from 5 to 12 per cent in different localities in the United States. The percentage of smutted heads also varies in a given locality in different years. Usually the smut is not noticed at all unless it is very abundant, for by harvest time most of the smut has fallen from the diseased heads, leaving often only the bare and inconspicuous stalks. The question will no doubt be asked: Will it pay to treat the oats for seed when only 5 or even 10 per cent of the heads are smutted? It may be said in answer that the per cent of heads destroyed by smut does not represent the amount that will be recovered by treating the seed. In all the careful experiments made with the methods of seed treatment described below there has been found to be an *extra increase* beyond and above the amount that would naturally be expected by replacing smutted heads with sound ones. This extra increase is found to range from one to ten times the amount of direct damage resulting from the loss of the smutted heads. Besides this gain there is that arising from the fact that the oats raised from treated seed *will produce a crop free from smut*, if there are no smutty oats in neighboring fields. Taking all these facts into consideration, it is highly probable that it will be found profitable to treat seed oats if they come from a field showing more than 1 per cent of smutted heads, and it will certainly pay to treat the seed if it came from a field showing more than 3 per cent of smutted heads. It is a fair estimate based on counts made in many parts of the Union to estimate the *net gain* to be obtained by treating seed oats at 8 per cent of the crop obtained. Since the aggregate value of the oat crop of the United States from 1880 to 1890 was \$2,030,712,605,* the net gain from a universal system of seed treatment would have been \$162,457,008.40 for those years.

Every farmer who raises oats is strongly urged to treat the seed unless, upon careful counts made in different parts of the field, there are found to be less than three heads out of every hundred smutted. Above all, do not conclude that because you have not noticed any considerable amount of smut in your fields it will not pay to treat the seed. The safer method would be to treat the seed, unless the field from which it was obtained is known to be free from the smut. It should also be remembered that the gain is just as real even if oats are not a paying crop, or even if merely grown for straw, for there is found to be an increase in the weight of straw grown from treated oats.

The stinking smut of wheat is unfortunately too well known and too much feared by both farmers and millers to need here any recital of the damage it causes. Suffice it to say that when once introduced it usually

* Dodge, J. R. Report of the Statistician, in Report of the Secretary of Agriculture, 1890, p. 301.



Fig. 1.

Fig. 4.

Fig. 2.

Fig. 5.

Fig. 3.

increases year by year, until often 40 to 60 per cent of the grain is destroyed. Besides this, the remaining portion is rendered unsalable as well as unfit for seed. Farmers do not need to be urged to treat the seed to prevent this smut, as they are only too glad to learn of any certain method of preventing the ravages of this foe. As the smutted grain is easily recognized by the odor, and as it is absent altogether from many parts of the country, it will be wiser not to treat the wheat for seed unless the smut is known to be present.

OTHER SMUTS.

Loose smut of wheat.—In addition to the stinking smut, wheat is also subject to a loose smut much like that of oats, and, like that, without odor. As yet no method of combating it can be recommended. The loose smut of wheat is caused by *Ustilago tritici* (Pers.) Jens.

Barley smuts.—Barley is subject to two loose smuts, both somewhat like oat smut. They may be prevented by soaking the seed barley four hours in cold water, letting it stand four hours in a moist state in sacks, and finally treating in hot water as directed for oats and wheat, but only for five minutes and at a temperature of 126° to 128° F.

HOW TO PREVENT OAT AND WHEAT SMUT.

It has been found that the infection of the plant takes place when the seed is germinating and from spores adhering to the seed when planted. If these adhering spores can be killed a crop wholly free from smut can be obtained.*

The Jensen or hot-water treatment for oat and wheat smut.—This method, discovered by J. L. Jensen, of Denmark, in 1887, consists in immersing the seed which is supposed to be infected with smut for a few minutes in scalding water. The temperature must be such as to kill the smut spores, and the immersion must not be prolonged so that the heat would injure the germinative power of the seed. If the water is at a temperature of 132½° F., the spores will be killed, and yet the immersion, if not continued beyond fifteen minutes, will not in the least injure the seed. The temperature must be allowed to vary but little from 132½°, in no case rising higher than 135°, or falling below 130°. To insure these conditions when treating large quantities of seed, the following suggestions are offered:

Provide two large vessels—as two kettles over a fire, or boilers on a cook stove, the first containing warm water (say 110° to 130°), the second containing scalding water (132½°).

* There is some good evidence to show that fresh manure of herbivorous animals containing smut spores may, if applied at the time of planting, infect the young plants. It is hardly necessary to mention this manner of infection, since almost no American farmers manure grain fields in this manner. There is no danger in using well rotted manure.

The first is for the purpose of warming the seed preparatory to dipping it into the second. Unless this precaution is taken it will be difficult to keep the water in the second vessel at a proper temperature.

The seed which is to be treated must be placed, a half bushel or more at a time, in a closed vessel that will allow free entrance and exit of water on all sides. For this purpose a bushel basket made of heavy wire could be used, with which spread wire netting, say 12 meshes to the inch, or an iron frame could be made at a trifling cost, over which the wire netting could be stretched. This would allow the water to pass freely and yet prevent the passage of the seed. A sack made of loosely woven material (as gunny sack) could perhaps be used instead of the wire basket. A perforated tin vessel is in some respects preferable to any of the above.

Now dip the basket of seed in the first vessel; after a moment lift it; and, when the water has for the most part escaped, plunge it into the water again, repeating the operation several times. The object of the lifting and plunging, to which should be added also a rotary motion, is to bring every grain in contact with the hot water. Less than a minute is required for this preparatory treatment, after which plunge the basket of seed into the second vessel. If the thermometer indicates that the temperature of the water is falling, pour in hot water until it is elevated to $132\frac{1}{2}^{\circ}$. If it should rise higher than 132° , add small quantities of cold water. This will doubtless be the most simple method of keeping the proper temperature and requires only the addition of two small vessels, one for cold and one for boiling water.

Steam, conducted into the second vessel by a pipe provided with a stopcock, answers even better, both for heating the water and elevating the temperature from time to time.

The basket of seed should, very shortly after its immersion, be lifted and then plunged and agitated in the manner described above; and the operation should be repeated eight or ten times during the immersion, which should be continued fifteen minutes. In this way every portion of the seed will be subjected to the action of the scalding water. Immediately after its removal dash cold water over it or plunge it into a vessel of cold water and then spread out to dry. Another portion can be treated similarly, and so on until all the seed has been disinfected. Before thoroughly dry the seed can be sown; but it may be thoroughly dried and stored if desired.

The important precautions to be taken are as follows: (1) *Maintain the proper temperature* of the water ($132\frac{1}{2}^{\circ}$ F.), in no case allowing it to rise higher than 135° or to fall below 130° . This will not be difficult to do if a *reliable thermometer* is used and hot or cold water be dipped into the vessel as the falling or rising temperature demands. Immersion fifteen minutes will not then injure the seed. (2) See that the volume of scalding water is much greater (at least six or eight times) than that of the seed treated at any one time. (3) Never fill the basket or sack

containing the seed entirely full, but always leave room for the grain to move about freely. (4) Leave the seed in the second vessel of water fifteen minutes.

The hot-water treatment for oats.—The foregoing method is applicable to both wheat and oats. With oats the following slight modifications are probably advantageous: (1) Have the water in the second vessel $143\frac{1}{2}^{\circ}$ F. and immerse the seed five minutes, cooling with cold water afterwards. Where large amounts of seed are to be treated this will prove the most speedy form of the treatment, but great care must be taken to see that every grain is thoroughly wetted. (2) Have the water in the second vessel at $132\frac{1}{2}^{\circ}$ F.; immerse the seed ten minutes and do not cool with cold water, but spread out at once to dry. This last is no doubt the best form of the Jensen treatment for oats, since it requires a shorter time than the regular method and the warmth of the grain aids it materially in drying. Moreover, experiments have shown that seed treated in this way yields the most grain and straw. Neither of these modifications can be recommended for wheat without more data than we now possess.

Potassium sulphide treatment for oats.—In this treatment the seed is left twenty-four hours in a one-half per cent solution of potassium sulphide. The published experiments seem to show that a weak solution of potassium sulphide is nearly as good as the hot water. The potassium sulphide is cheapest in the "fused" condition, in which form it costs about 25 cents a pound. One pound of the sulphide should be dissolved in 24 gallons of water. Place the seed in a *wooden vessel* and pour on the solution till the seed is covered several inches deep. Stir the solution before pouring it on the grain and thoroughly mix the seed several times before taking it out of the solution. The oats should stand in the solution twenty-four hours, after which they may be spread out to dry. The solution gradually loses its strength and hence can not be used more than three or four times without being renewed.

It will probably be best to sow the seed as soon as possible and before it becomes thoroughly dry.

Soaking the seed twelve hours in a solution of twice the strength will no doubt prove effectual.

Copper sulphate treatment for wheat.—This consists in immersing the seed in a solution made by dissolving 1 pound of commercial copper sulphate in 24 gallons of water for twelve hours and then putting the seed for five or ten minutes into lime water made by slaking 1 pound of good lime in 10 gallons of water.

These treatments have all been tried and have proved effective. Probably the hot water is the best for general use. In some parts of the country seed wheat is treated in strong solutions of copper sulphate and no lime is used. This practice is much inferior, since it injures the seed, while those given here prevent the smut completely and at the same time do not injure the seed if carefully followed. In all forms of

seed treatment care should be taken to spread the grain out to dry at once and by frequent stirring prevent its spoiling. The treated seed should be handled only with clean tools and should be put in sacks disinfected by boiling fifteen minutes. If these precautions are not taken the seed may be infected again after treatment, especially in case of stinking smut of wheat. If the seed is to be sown broadcast it will not have to be so dry as if it is to be drilled. The seed may be treated with hot water a considerable time before planting if dried carefully, but it is probably better to treat just before planting.

In conclusion, this bulletin will fail of its object if it does not induce *you* to treat your oats and wheat this year. It should be remembered that the recommendations here given are not from theoretical grounds alone, but are justified by the results of extended and laborious experiments many times repeated.

PUBLICATIONS ON THE SUBJECT.

The following list, comprising the more important of the recent publications in English, is given for the benefit of any who may desire to look up the matter further:

- JENSEN, J. L. Propagation and Prevention of Smut in Oats and Barley, in *Journal of the Royal Agricultural Society of England*. Vol. 24, second series, Part 2, 1888; also reprinted pages 1-19.
- KELLERMAN, W. A., and SWINGLE, W. T. Report on the Loose Smuts of Cereals. In *Second Annual Report of Experiment Station, Kansas State Agricultural College (at Manhattan, Kans.) for 1889*, pages 213-288, plates 1-19.
- ARTHUR, J. C. Treatment of Smut in Wheat. *Bulletin 32, vol. 2, Purdue University Agricultural Experiment Station, La Fayette, Ind.* July, 1890.
- KELLERMAN, W. A., and SWINGLE, W. T. Preliminary Experiments with Fungicides for Stinking Smut of Wheat. *Bulletin 12, Experiment Station, Kansas State Agricultural College.* August, 1890.
- KELLERMAN, W. A., and SWINGLE, W. T. Additional Experiments and Observations on Oat Smut made in 1890. *Bulletin 15, Experiment Station, Kansas State Agricultural College.* December, 1890.
- BOLLEY, L. H. Grain Smuts. *Bulletin No. 1, Government Agricultural Experiment Station for North Dakota (at Fargo).* 1891.
- ARTHUR, J. C. Loose Smut of Oats. *Bulletin 35, vol. 2, Purdue University Agricultural Experiment Station.* March, 1891.
- KELLERMAN, W. A. Second Report on Fungicides for Stinking Smut of Wheat. *Bulletin 21, Experiment Station, Kansas State Agricultural College.* August, 1891.
- KELLERMAN, W. A. (1) Smut of Oats in 1891. (2) Tests of Fungicides to prevent Loose Smut of Wheat. *Bulletin 22, Experiment Station, Kansas State Agricultural College.* August, 1891.