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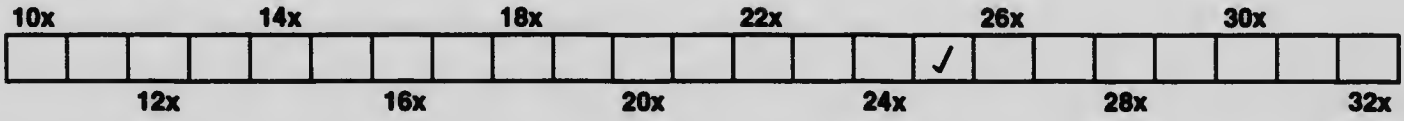

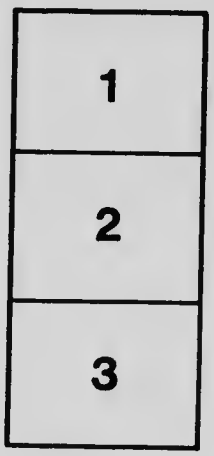

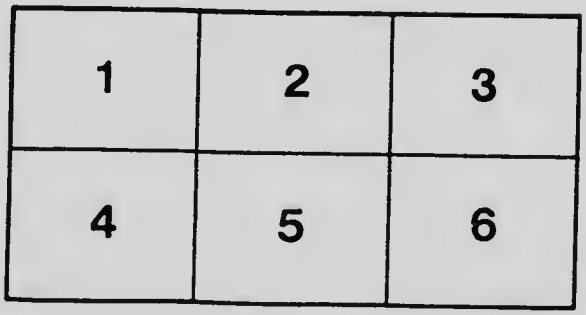

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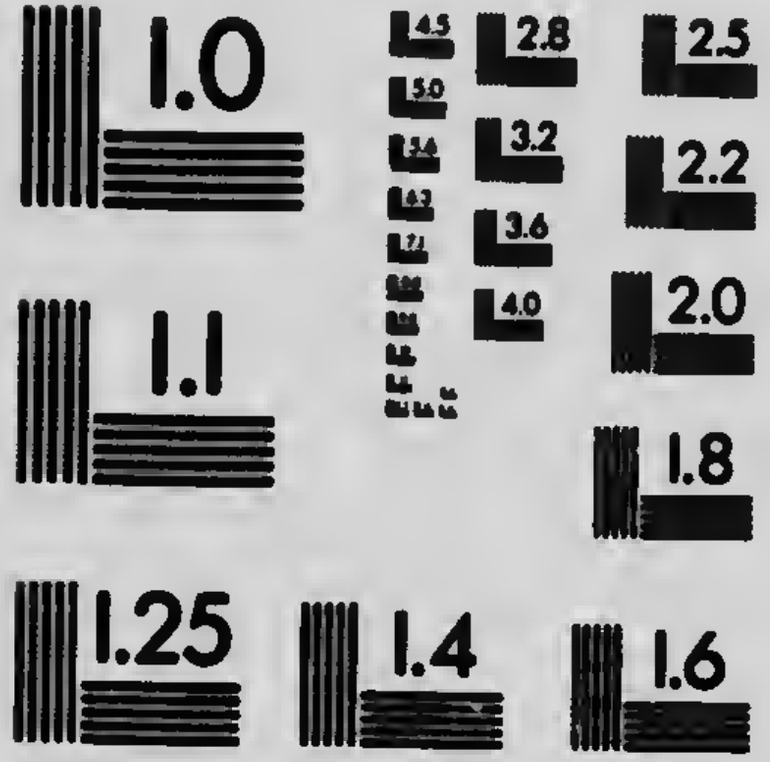

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BULLETIN No. 2

GOVERNMENT OF THE PROVINCE OF SASKATCHEWAN

DEPARTMENT OF AGRICULTURE

SMUT IN WHEAT

AND THE MEANS TO BE USED FOR ITS PREVENTION,

BY

T. N. WILLING,
Chief Inspector of Weeds.

AND

G. A. CHARLTON, M.D.
Bacteriologist and Analyst.

PUBLISHED BY DIRECTION OF THE HON. W. R. MOTHERWELL, M.L.A., COMMISSIONER OF AGRICULTURE

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1906

Hon. W. R. MOTHERWELL, M.L.A.,

Commissioner of Agriculture,

REGINA.

Sir,—

I have the honour to submit herewith Departmental Bulletin No. 2, "Smut in Wheat," which has been prepared by Dr. Charlton, Bacteriologist and Analyst, and Mr. T. N. Willing, Chief Inspector of Weeds. Cuts Nos. 2, 3 and 5 are reproduced with some slight alteration from a bulletin of the North Dakota Experiment Station.

I have the honour to be, Sir,

Your obedient servant,

J. R. C. HONEYMAN,

Deputy Commissioner.

Department of Agriculture,

Regina, March 28, 1906.

SMUT IN WHEAT.

Introductory.

Owing to the prevalence of smut in wheat and oats, and the serious loss from this cause, which the farmers from many sections of the Province have experienced, the Department of Agriculture deemed it advisable to issue a bulletin of information which would instruct the farmers as to the character and life history of the smut fungus and the means which may be employed to keep it in check. As an indication of the extent to which smut has invaded our wheat fields, it may be said of last year's crop up to December 31st, 1905, that about 10% of the wheat brought to the elevators of the Province was graded "rejected" on account of smut. This resulted in a reduction of 7 to 12 cents per bushel, or an estimated total loss on entire crop of two million dollars.

FIG. No. 1.—STINKING SMUT OF WHEAT
(Tilletia fœtens).

Head of wheat with smutted grains. Smut-balls indicated black. The isolated spikelet contains two smut-balls which, as well as the isolated samples, show fissures in the original seed-coats. One smut-ball in section shows the interior filled with black spores but the seed-wall still intact.

History and Distribution.

Smut found in the wheat of this Province is not native, but has been introduced in seed grain from other countries. It is common in many parts of the United States, in Great Britain and in European countries. As early as 1661 it was recognized by Brefeld, Knelin, Tubeuf and De Barry in Europe, and by Berkely, Curtiss, Swingle and others in America. It will be seen that smut has become widely distributed.

General Character.

In order to understand clearly the nature of smut it is necessary to realise that smut is a disease of the wheat plant caused by a minute living plant (fungus), capable of an independent existence. It prefers, however, to live, like a robber, a parasitic life within the body of the wheat plant. It thrives on the sap and nutriment juices which it finds

Fig. No. 2 is a sketch of a section of a wheat ovule attached to its stem, cut lengthwise through the middle and through the stem. The granular material about the letter (*c*) indicates the interior of the young grain or smut-ball; (*a*) represents base of stem where it breaks loose from the head; (*b*) the style; (*d*) chaff scale. The two black lines extending up the stem connecting with the young grain indicate the path of the smut filaments through the stem to the ovule; (*e*) germ tubes of smut fungus, travelling up wheat stalk and entering ovule. The section was made from a young grain which was just in the milk stage of development, and is enlarged several diameters.

there and pushes its fine hair-like filaments upward in the stalk of wheat, keeping pace with, but yet not materially retarding its growth. At last the heads appear and the wheat plant directs all its energy toward the production of good seed. In this it is defeated because the filaments of the smut fungus enter the blossom (see Fig. 2.), take up their abode

Fig. No. 3.—Sketches showing characteristics of sound and smutted grains of wheat. (*a*) A perfect grain showing the deep longitudinal crease or groove. (*b*) A similar grain cut across showing general contour and appearance of cut surface. (*c*) A grain affected by the smut showing the plump or puffed appearance as compared to the normal healthy kernel. (*d*) A diseased grain such as (*c*) cut across, showing the hull or covering of the grain filled with the smut spores.—*Bolley.*

within the forming seed, and feeding on the nutritive material which was intended to be stored up as gluten and starch, these useful products are replaced by a black stinking mass of smut spores, injurious to man

and beast. These smutted kernels are the smut balls (see Fig 3), which when broken liberate a fine black dust, composed of spores (seeds) of the smut fungus. The disease is carried over from one year to another chiefly by these spores which become attached to the sound grains of wheat.

Microscopic Characters.

The spores of the smut fungus are nearly round, smooth and very small. A single spore is invisible to the naked eye being $\frac{1}{180}$th to $\frac{1}{220}$th of an inch in diameter. Large numbers of these spores are usually collected in masses. These masses constitute the brownish black dust, which fills the smut balls.

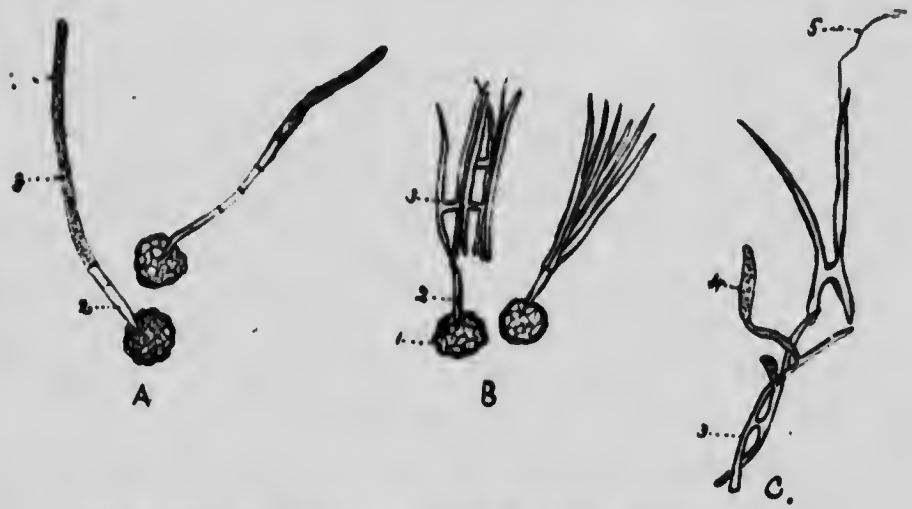

Fig. 4.—Germinating spores showing stages in their development:
(a) Two spores germinated in water. (1) Promycelium. (2) Primary Sporidia, elongated to reach the surface of the water.
(b) Two spores germinated in moist air. (1) Spore. (2) Promycelium. (3) Primary Sporidia conjugated in pairs.
(c) Further development of conjugated primary sporidia. (3) Primary Sporidia. (4) Secondary Sporidia. (5) Germ Tube.

Under favorable conditions of heat and moisture the spores germinate producing a very fine tube (Promycelium) corresponding to the sprout of a seed. At the end of this tube a cluster of slender bodies (Primary Sporidia) develop. These sporidia in turn produce short tubes which join together to form a network and give rise to a second series of tubes each having an enlargement at the end (Secondary Sporidia). These enlargements produce germ tubes which enter the delicate tissues of the slender seedling before it has reached the surface of the soil (see Fig. 4).

Time of Infection.

The wheat plant is usually infected during the first three days of its life (see Fig. 5). The germ tubes having entered the delicate tissues of the

outer leaf of the seedling force their way inward and upward, thoroughly infecting the young plant.

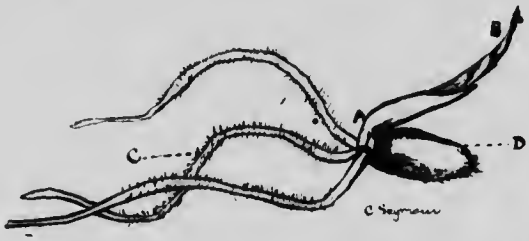

FIG 5.—Represents a young wheat plant starting from the ground, showing the seed, three roots and the stem. The plant is three days old. Smut enters usually between the points marked. (*a*) and (*b*) are the sprout. (*c*) Roots. (*d*) The seed of plant.

The filaments or germ tubes of the fungus permeate the growing stalk of wheat by pushing their way in all directions, travelling in the spaces which surround the cells of the wheat plant (see illustration No. 6), and living on the nutriment juices or sap carried in those spaces and intended for the nutrition of the growing grain. So little damage is done at this stage that it is impossible to detect the infected plants.

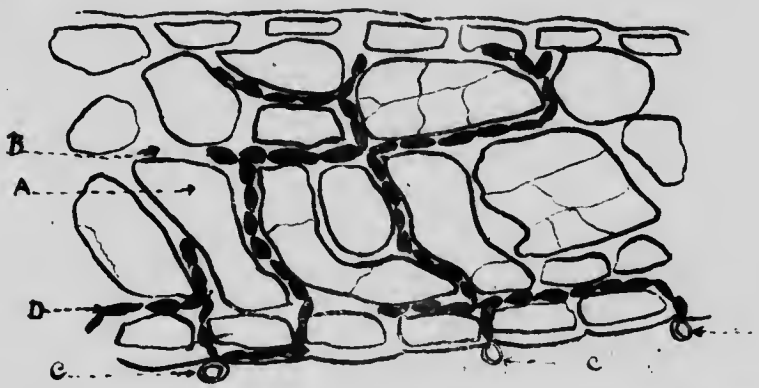

FIG. 6.—Diagram of portion of stalk of wheat, showing the manner in which the smut fungus penetrates the wheat plant.
(*a*) Cells of wheat plant.
(*b*) Spaces between these cells filled with sap.
(*c*) Germinating smut spore.
(*d*) The vegetative (growing) portion of the smut fungus passing upward in the wheat plant by means of the interspaces (*b*) and deriving its nourishment from the sap of the wheat plant.

EXTERNAL CONDITION AFFECTING THE GERMINATION OF SPORES.

The external conditions necessary for the commencement of germination in the spore are in general the same as are required for the germs and seeds of other plants, namely a certain temperature of surrounding soil or water, a supply of oxygen and moisture and sometimes also a supply

of nutrient substances. Speaking generally, it may be said that the conditions most favorable for the germination of wheat are also the best for the germination of smut spores, but the smut fungus possesses greater resisting powers and is therefore able to develop with more certainty under adverse circumstances than the wheat plant. A sturdy vigorous growing wheat plant possesses a certain amount of resisting power against smut infection, on the other hand a wheat plant from a poor shrunken seed grain because of a lack of nourishment in the kernel, will be deficient in vitality and resistance and is therefore more liable to smut infection. It is of prime importance therefore that all grain used for seed be of the plumpest and cleanest obtainable. The soil should be put in the best condition to receive the seed. Wet low lying soil usually contains an excess of water and is therefore cold and deficient in oxygen and will likely produce a weak sickly plant which will fall an easy prey to the smut fungus.

Circular of Inquiry.

As a help towards ascertaining the cause of the abundance of smut in the wheat crop of the past season a circular was prepared, and sent to about 600 of the grain growers in Saskatchewan, in which the following questions were propounded:

Was there any stinking smut in your 1905 crop?
How did that compare with the previous crop?
Was there any difference in the quantity of smut in the crops on summer-fallow and on stubble?
Did you notice any loose smut in the wheat crop indicated by the heads having given place to a loose mass of brownish dust readily shaken off?
Did you treat the seed for the 1905 crop in any way to prevent smut?
Was the seed for the 1904 crop also treated?
If bluestone was used how many gallons of water did you mix with one pound? Was the water alkaline?
Was the seed sprinkled, put through a pickler, or dipped?
If dipped how long did it remain in the liquid?
From whom was the bluestone purchased and what was the price?
Who was the manufacturer?
Please forward 1 or 2 ounces of the bluestone if you have any left?
If formalin was used how many gallons of water were put with one pound?
How was it used?
From whom purchased and what price?
Name of manufacturer?
If the formalin is still in your possession forward a small sample?
Can you give any other information?

A large number of these were returned with the desired information accompanied by a considerable number of samples of bluestone and formalin to be analysed.

There was, in many fields, a noticeable number of heads of wheat affected by the loose smut (Fig. 7) which is not controlable by bluestone or formalin treatment, but which, fortunately, is not a cause of much loss here.

FIG. 7.—LOOSE SMUT OF WHEAT (*Ustilago tritici*).—The central ear is normal and healthy, the others are smutted and most of the spores are already shed.—*Tubeuf.*

It seems that the ball smut has been very abundant but by no means general in the crops as many farms were clear of it, especially where the practice of bluestoning has been followed for a number of years and strong seed had been used. There appears to have been little difference between the crops on summer-fallow, stubble or breaking so far as smut was concerned. In many fields it was very apparent that the portions sown earliest were most smutty. It was also observed that when the soil had by drifting deeply covered the seed there was a great deal of smut. Spring opened early and was so dry that many sowed early in March and altogether too deeply, the wheat came on slowly and in its weak condition was more liable to attack by smut. In addition to this a great deal of very much shrunken grain, due to frost and rust, was used for seed, as was also many a decidedly smutty sample.

A great deal of carelessness seems to have been displayed in the pickling of seed owing to comparative freedom from smut for some years previously. Some have been under the impression that treating grain once in two or three years was sufficient.

A fault in many cases was the use of too little of the bluestone solution to thoroughly wet the seed although made quite strong enough. Others erred by using too weak a solution, probably sometimes the result of using alkali water. The bluestone, however, from the samples analysed, appears to have been of good quality but there was more fault to be found with the formalin as will be seen by the subjoined data:

The Analysis of Bluestone and Formalin.

On account of the increased amount of smut in last season's wheat crop, even though in many instances the seed had been treated with bluestone, a suspicion arose, that perhaps the bluestone that had been used was of inferior quality. The Department of Agriculture, therefore, issued the following circular letter, which was inserted in the leading newspapers and the agricultural journals:

"FREE TESTS OF BLUESTONE."

The Editor,

Sir,—Owing to the uncertainty and unensiness which at present exists among the farmers of the Province as to the purity of bluestone and formalin put upon the market as smut preventatives, the Department of Agriculture for Saskatchewan has completed arrangements whereby any samples of the foregoing fungicides will be tested free at the Bacteriological Laboratory of the Department.

Samples for testing should not be less than one ounce, and the formalin sample should be put in an ounce bottle and well secured in a wooden or tin box to prevent breaking, and should not be mailed till nearer spring, when the chance of freezing in transit will be lessened. All such samples addressed to Dr. Charlton, Bacteriologist, Regina, will be subjected to a complete analysis and the findings at once reported to the sender of the sample.

Yours obediently,

Regina, January 19, 1906. J. R. C. Honeyman,
Deputy Commissioner.

The facilities afforded by the Bacteriological Laboratory for the analysis of these fungicides were taken advantage of by a large number of farmers throughout the Province and by a number of merchants dealing in these articles. These samples are still being received daily. Up to the present time 203 samples of bluestone have been analysed. No adulterated sample has, so far, been encountered. The percentage of copper contained in the copper sulphate, estimated as copper oxid, was in the majority of the samples quite up to the standard (32·27%). The poorest sample contained 30·00% of copper oxid. This decrease could be accounted for by the presence of an excess of moisture in these samples. They were not adulterated with iron sulphate, the usual adulterant of bluestone. Bluestone which has been exposed to dry air for a length of time loses a portion of the water of crystalization and becomes encrusted with a greenish white powder. This has been thought to be some foreign

substance and such bluestone has been mistakenly said to be adulterated. Such is not the case, however, and this encrusted bluestone will regain its blue crystaline appearance if placed in a damp atmosphere for a time. On account of this bluestone being lighter in weight because of the loss of water a proportionately smaller quantity is required in making a solution with which to treat the seed grain.

This solution should be transparent and of a light greenish blue color. There should be no curdled masses or other undissolved material. Alkali water does not make a good solution of bluestone, because the magnesia and certain other earthy salts combine with the copper sulphate to form an insoluble compound which is of questionable value as a preventative of smut. If possible soft water should be used to make the solution of bluestone.

Formalin.

So far, only 25 samples of formalin have been received for analysis. Sixteen of these proved to be of 40% strength. The remainder were under the required 40% standard, the lowest being 34.5%. Formalin, when of standard strength is preferable to bluestone as a fungicide for smut, because (1) it acts more promptly and vigorously; (2) the solution is not affected by alkali water: (3) the grain, after treatment, is in better condition for the seeder. To secure the best results, however, the formalin must be full 40% in strength else the resulting solution will be too weak. The water and formalin should be measured out accurately: a certain number of fluid ounces to each gallon of water according to the strength of the solution, with which the seed grain is treated. By thus measuring the water and the formalin the farmer protects himself against the short measure pound package. A pound of formalin should contain 16 fluid ounces, and none should be used for smut, the strength of which is not known. If below 40% strength, a proportionably larger quantity must be added to the water to make the resulting solution of the required strength.

Precautions for the Avoidance of Smut.

Use plump seed of good variety.
Use seed as free from smut as possible to procure.
Fan thoroughly to remove light seed and smut balls.
Treat it with bluestone or formalin.
Dip the sacks also in the solution.
Spray the granary, the wagon box and the seeder with formalin.
Burn the stubble of the previous crop if it was smutty.
Do not sow much earlier than the 1st April, nor unnecessarily deep.
Do not pickle wheat in cold weather.

Preventatives.

Bluestone (sulphate of copper) has been known for a great many years as a means of preventing smut in grain, while formalin has only come into use quite recently but has been found eminently satisfactory. In the early years of the settlement of Saskatchewan the recommendations were for the soaking of seed in weak solutions of bluestone for prolonged periods, followed by applications of lime. This was found unsuitable to

the conditions of western farming and it was found that the mere contact of a stronger solution was more satisfactory as there was a saving of time and little if any loss of efficiency, or lessening of the vitality of the grain. Wheat has been treated with a one lb. to 3 gallons solution of bluestone without preceptibly injuring it, but that is unnecessarily strong for any but extremely smutty seed which should not be used if it is possible to procure better. Although a bushel of wheat may not absorb a gallon of liquid when sprinkled it is well to allow that amount to insure wetting and to allow for waste. A safe application for general use would be: **1 lb. Bluestone to 6 gallons soft water for 6 bushels of wheat.**

Formalin is equally good for treating wheat, and much better for treating oats and barley and has been safely used as strong as one ounce to the gallon but will be quite satisfactory for general use if the solution is made **1 lb. (16 fluid ounces) Formalin to 32 gallons water.** This solution should be used immediately after the formalin is added as it will rapidly weaken if left exposed. If grain is sprinkled with the solution it may be covered for an hour so as to delay evaporation of the formalin.

In preparing the above solutions do not use alkali water with bluestone and be sure your bluestone, or formalin is pure and of full strength.

If wheat is dipped it will absorb about three quarters of a gallon to the bushel while oats will absorb nearly double that.

It will save trouble to prepare a barrel of the bluestone solution at once and have it ready, using 6½ or 7 lbs. to the barrel. It may be quickly dissolved in hot water or if crushed and suspended in a thin sack in cold water in the evening it will by morning be ready for use.

Methods of Treatment.

Sprinkling the solution over a heap of grain in a wagon box or on any smooth floor while it is thoroughly stirred with a shovel is a method still adopted by many but there is often insufficient liquid used and too little mixing of the grain. It is essential that every grain be thoroughly wetted.

Pickling machines have been found to greatly facilitate this work by permitting a thorough wetting of the grain with a minimum of liquid and a saving of labor. Care should, however, be exercised that the tap does not become clogged and it will help greatly if a piece of sacking is fastened loosely over the top of the tank of the pickler to be used as a strainer. The grain should not be run through too fast not yet too slow and it is claimed that with some picklers it is an advantage to have the machine set so that the grain travels a little up grade passing through so that the liquid does not run away so fast.

Dipping the grain in the solution is an effective method and for oats and barley is to be preferred. The grain need only be left in for 5 or 10 minutes and then set aside over another vessel to drip and should then be spread out to dry and be sown as soon as convenient. There are various contrivances for doing this work, the most common being two oil barrels, with the tops cut off, set side by side, in one of these a partly filled jute sack is immersed and then, by means of a pole arranged on a post as a lever, removed to some slats on the top of the other barrel to drip. Another way that has been recommended is to use a water tight

box about 10 or 12 feet in length, with a wire screen fixed in the middle. Balance this box on a log and place in one end of it as much grain as can be covered with liquid, and while that is soaking put grain in the other end and then tip so that liquid will drain through the screen. This method permits the removal of smut balls by skimming them from the surface of the liquid.

Effects of Treatment.

The longer grain is kept after treatment the more it deteriorates in vitality especially if stored without being dried. In sowing grain just treated the drill should be opened a little more to insure the usual amount being sown. Germination is slightly retarded by treatment, but the growth is strong after the roots are established. There is an increase in the yield as well as a higher grade of grain from treated seed as indicated by the following extract from the report of the Indian Head Experimental Farm for 1895.

Test of Bluestone at a Preventative of Smut.

"In this test 1-10th acre plots of summer fallow were sown by drill on April 17th."

"The result of the test of sowing very smutty seed proves the efficiency of bluestoning as a preventative of smut. While the untreated was more than one-half smut, the product of the same seed treated contained 40 times more good than smutty heads; the yield per acre was also greater from the treated, being 36·3 bushels of No. 1 hard wheat, while that from the untreated was 17·4 bushels of grain and smut unfit for feed or market."

Name of Variety	Date of Ripening	No. of days Maturing.	Length of Straw	Character of Straw	Length of head	Weight of Straw per acre	Yield per acre	Weight per bushel	Good and Smutty heads on 6 ft. square of plot.	
			Inches		Inches	Lbs.	Bus. lbs.	Lbs.	Good	Smutty
Good seed from treated crop, 1894—										
Red Fife, sprinkled, 1 lb. to 8 bus	Aug. 28	133	47	Stiff	3¾	6,310	40	60½	1,709	5
Red Fife, dipped, 1 lb. to 8 bus.	Aug. 28	132	49	"	3¾	6,500	42	60½	1,525	0
Red Fife, untreated	Aug. 28	133	48	"	3¾	6,000	40 10	61½	1,589	31
Smutty seed from untreated crop, 1894—										
Red Fife, 1 lb. to 8 bus.	Aug. 31	136	40	"	1½	599	36 30	60	1,626	11
Red Fife, untreated	Aug. 31	136	48	Fair	4	580	17 10	48	718	833

Some Hints from the Indian Head Experimental Farm.

Only clean plump wheat is used for seed in the field crops.

It is tested for germination.

It is treated for bluestone.

Such crops have shown no smut in 16 years.

Small test plots sown with very smutty untreated wheat have grown grown over 50% smutty heads.

Treating such very smutty seed never resulted in an entirely clean crop.

Formalin has given better results than bluestone in treating oats and barley.

Summary.

The bunt or stinking smut of wheat is a fungous disease.
It is not native but introduced.
It is spread by the minute black spores which adhere to grain.
The wheat plant is most subject to infection the first 3 days after sprouting.
A vigorous plant has more resisting power than a weak one.
Therefore all seed should be as clean and plump as can be obtained.
Conditions of soil unfavorable to healthy growth of wheat favors the smut.
Too deep or very early sowing favors smut.
Smut can be prevented by the use of bluestone or formalin.
Use 1 lb. bluestone to 6 gallons water, or 1 lb. formalin to 32 gals.
Many use too little liquid.
Wheat will absorb about three quarters of a gallon when dipped and oats will take nearly double.
Allow about a gallon per bushel to have plenty.
Carelessness of application has resulted in much loss.
Grain loses vitality after treatment by delay in sowing.
Loose smut of wheat destroys the whole head but is not common in the West.
Smut in oats and barley are distinct species and do not affect wheat.
Formalin is best for use on oats.
Analysis of bluestone does not show there was much of a poor quality in use here but formalin was not found to be of uniformly good quality.
Samples of bluestone or formalin may be sent to the Analyst, Department of Agriculture, Regina, to be tested.