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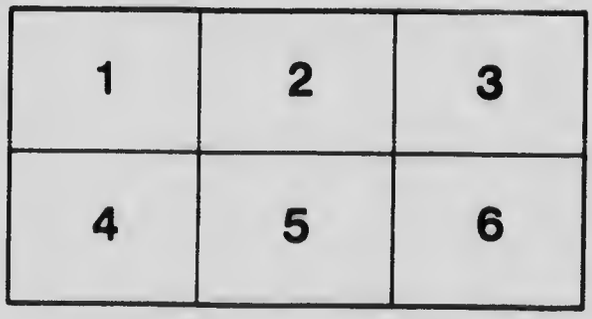

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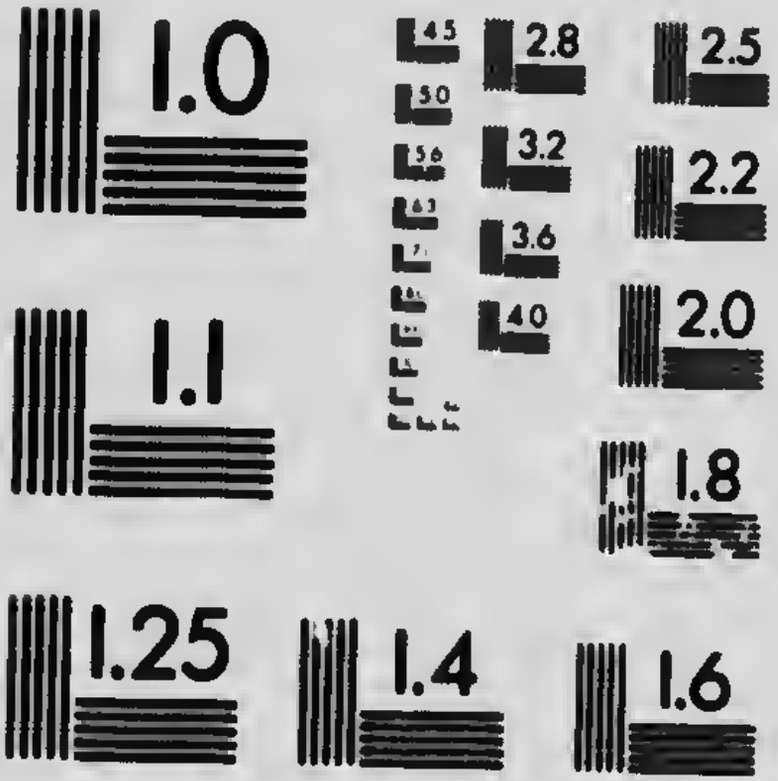

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DOMINION OF CANADA DEPARTMENT OF AGRICULTURE.

SEED BRANCH.

GEO. H. CLARK, *Seed Commissioner.*

Bunt, or the Stinking Smut of Wheat.

Part I.—Life History and Methods of Treatment;

Part II.—A Summary of Investigations.

BY

J. HORACE FAULL, B.A., Ph.D.,

LECTURER IN BOTANY, UNIVERSITY OF TORONTO

Bulletin S. 3.

...ued by direction of the HON. SYDNEY A. FISHER, Minister of Agriculture,
OTTAWA, FEBRUARY 12TH, 1907.

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DEPARTMENT OF AGRICULTURE,
OFFICE OF SEED COMMISSIONER.

OTTAWA, CANADA, February 12, 1907.

HONOURABLE SYDNEY A. FISHER,
Minister of Agriculture,
Ottawa.

SIR,—I beg to transmit herewith a treatise on the stinking smut of wheat, prepared by J. Horace Faull, B.A., Ph.D., Lecturer in Botany in the University of Toronto. Dr. Faull has spent considerable time in the wheat fields of Western Canada and in laboratory work in a special study of the causes of stinking smut in wheat and in methods of controlling and eradicating it. The treatise contains a summary of the results of his investigations. The information contained therein will be of much value to farmers, particularly those located in the wheat belt in western Canada. I recommend that it be printed in bulletin form for distribution.

I have the honour to be, Sir,

Your obedient servant,

GEO. H. CLARK,
Seed Commissioner.

BUNT, OR THE STINKING SMUT OF WHEAT.

Part I.—Life History and Methods of Treatment

Bunt, or the stinking smut of wheat, is a lowly form of plant life that lives as a parasite in the growing wheat. During the summer it consists of branched, jointed threads, not unlike certain moulds, and so fine as not to be seen by the unaided eye. While the wheat is heading, these threads grow up into the young grains, usually filling them with a dense mass. Some of the joints of this mass then swell up, blacken, and separate from one another. In fact, they are transformed into the brownish black powder or *spores* that fill the smut balls.

These spores are known to retain life in the granary for at least seven years, and in the soil for two years. Under favorable conditions they are capable of germinating in the soil, quite independently of the grain, and of producing crops of a second and of even a third type spores that are equally virulent.

Each spore is capable of infecting a seedling up to the time that the first leaf shows itself above the ground. The conditions most favorable to its growth would appear to be those most favorable to the growth of the grain. It is asserted, however, that sowing at a uniform depth as shallow as practicable, gives the wheat the best chance. In fact, the conditions of the seed, the soil, and the climate, and the depth of sowing, which favor the rapid and healthy growth of the young plant from the time of germination until the green leaf is well developed, serve to minimize the dangers of infection.

The spores that adhere to the surface of the wheat at the time it is sown are the principal source of infection. Fortunately any one of several methods may be adopted for killing them without killing the seed, and since the disease is so prevalent and so easily transmitted, it would seem advisable that some method of treatment should be applied to all seed every year.

Methods of Treatment.

Formalin :

Use one full pound of formalin in every forty gallons of water and proceed as follows :—

If the seed is from a smutted crop, immerse in the solution, stir thoroughly, and skim off the smut balls. Leave the seed in the solution for two hours before taking it out to dry. Or remove the seed from the solution at the end of fifteen minutes, pile, and cover closely with canvas or sacking to keep in the fumes of the formalin. Leave in the pile for two hours and then spread out to aerate. Sow as soon as possible.

If the seed is from an unsmutted crop, wet the seed thoroughly with the solution, pile, and cover with canvas or sacking. Leave the grain in the pile for two hours, then aerate.

Formalin is a forty per cent. solution of formaldehyde, and this strength should be guaranteed to the purchaser.

Copper Sulphate (bluestone):

Dissolve one pound of copper sulphate in twenty gallons of soft water. Immerse the grain for about twelve hours, stirring occasionally. Then spread out in a thin layer and dry rapidly. Sow as soon as possible.

The purest copper sulphate is sold in the form of crystals. These are readily dissolved in a small quantity of hot water.

After removing from the solution, some recommend an immersion of the grain for five minutes in lime water, made by putting one pound of good lime into ten gallons of water.

Precautions.

1. Take particular care to guard against living spores falling on the seed or coming into contact with it after treatment, otherwise all the labour of treatment may be in vain. Smut spores are produced at the enormous rate of two to five millions in every smut ball ; they are extremely light, and are easily carried by air currents. If the seed is dried on a floor, the floor must first be washed with a solution of one pound of copper sulphate to ten gallons of water ; if on a canvas, the canvas must first be dipped into boiling water. Likewise, dip the sacks into boiling water, and dry before filling them with the treated seed.

2. Use vigorous seed. Immature, shrunken seed, or seed enfeebled by disease or age suffers from treatment, and their seedlings are more susceptible to infection from smut than those from strong seed.

3. Remove all smut balls from the seed. The spores contained by them are not killed by practicable methods of treatment.

4. It is necessary to sow a somewhat larger quantity of treated seed per acre than of untreated. Allowance must be made for the swelling of the grain, and for a certain proportion killed by the solution used.

5. Sow as soon after treatment as is practicable.

6. Dry rapidly. Plan the time of treatment, so that the drying will begin early in the day. Then spread out the grain on the floor or in the sun on canvas sheets (sterilized as indicated in precaution 1) in a layer not more than three inches deep, and shovel over frequently.

In conclusion, there can be no question as to the desirability of maintaining a breeding plot for hand selected seed[1] on every farm. Their adoption would result in an increased yield, improved seed, uniform and pure stock, and would go far towards the solution of the smut problem, especially if there were persistence in careful, scientific treatment of the seed before sowing.

Part II.—A Summary of Investigations.

For many years agriculturists have made a practice of treating seed wheat for smut, with the result that there has been a diminution of this pest. But it has not been eradicated. Indeed, it has been estimated that for the last few years six per cent. of the crop of Western Canada that has been officially inspected has been rejected on account of smut, and this represents a part only of the loss from this cause.

Through the generosity of the Governors of the University of Toronto and the western railway companies, I was enabled, in response to a request to investigate the smut problem, to visit several places in Southern Manitoba, Saskatchewan, and Southern Alberta.

Material has been very kindly supplied to me by Messrs. D. D. Campbell of Winnipeg, Angus McKay of Indian Head, and John A. Mooney of Valley River, Manitoba, and from Ontario, through the office of the Field Experimentalist. Mr. G. H. Clark, the Dominion Seed Commissioner, has co-operated at every stage of the investigation, and has very graciously placed his seed laboratory at my disposal, and his practical knowledge of agriculture and the conditions in Western Canada.

Two species of stinking smut (*Tilletia foetens*, (B & C), Trel., and *Tilletia tritici* (Bjerk) Wint.), attack the wheat, both spring and fall, throughout Canada. *T. tritici* (Bjerk) Wint. is much more prevalent than has been heretofore supposed, in some places distinctly predominating.

[1] Directions for conducting these plots are printed and supplied free of charge by the Seed Commissioner, Department of Agriculture, Ottawa

In attempting to germinate their spores, several kinds of nutrient media were tried. None gave better results than a sterilized decoction of virgin prairie soil, maintained at a temperature of about 60° Fahrenheit, and this medium was used throughout.

The problem in hand has been attacked from several standpoints, an outline of which, with some results, is as follows :—

I. To Determine the Efficiency of Various Solutions in Killing Spores in Unbroken Smut Balls.

Upwards of one hundred tests were made with solutions of copper sulphate varying in strength from one pound in one gallon of water to one pound in twenty-five gallons, and for periods varying from one minute to twenty-four hours ; and seventy-five tests with formalin for periods varying from one hour to four hours. In every case the smut balls were immersed in the solutions.

The following is an extract from the record of data obtained.

Strength of Solution.	Length of Treatment.	Per cent. of Smut Balls containing living spores after treatment.
Copper Sulphate :		
1 lb.—1 gal.....	20 minutes.	60
1 lb.—2½ gal.....	1 hour.	33.
1 lb.—5 gal.....	1 hour.	80
1 lb.—10 gal.....	1 hour.	100
1 lb.—20 gal.....	12 hours.	33
Formalin :		
1 lb.—50 gal.....	3½ hours.	100.
1 lb.—60 gal	3½ hours.	100.
1 lb.—40 gal.....	4 hours.	33.

In all of the formalin and a few of the copper sulphate tests, the spores were taken from directly under the covering of the smut ball, proving that the smut ball is very impervious to penetration by a liquid.

From the foregoing table it will be seen that the vitality of all the spores contained in smut balls cannot be destroyed by practicable methods of treatment. Since smut balls that are left in the seed wheat are apt to become broken when passing through the seeder, recontaminating treated seed, it is therefore always advisable to get rid of them before sowing. This may be done by immersing the seed in barrels or tanks, made for the purpose, to such a depth that all the smut balls may be floated, skimmed off, and destroyed.

II. To Determine the Efficiency of Various Solutions in Killing the Spores that Adhere to the Surface of Sound Grains.

Four lots of smutted grain were respectively treated with the following solutions for a limited number of different periods of time :—One pound of copper sulphate to ten gallons of water, and one pound to twenty gallons ; one pound of formalin to forty gallons of water, and one pound to fifty gallons.

Forty grains were then selected, and scrapings were made from the grooves and placed in germinators.

Scrapings from half of the grains treated with the copper sulphate solutions contained living spores after treatment for one, five, twenty, and thirty minutes repectively, and in one case for one hour, but none for longer periods, and with the formalin solutions for one and five minutes respectively, and none for longer periods.

The efficiency of any treatment of smutted seed with copper sulphate or formalin for less than one hour may therefore be reasonably questioned.

In this connection, an extract from the report of the Dominion Experimental Farms for 1900 is especially pertinent. Mr. Angus McKay—"The seed used in this test was considerably affected with smut, and the result of the test indicates that to be entirely effectual the solution of formalin should be applied to the seed for at least one hour." There were no smutted heads in the crop.

The results of experiments with Doncaster Prize Oats carried on by Mr. R. Robertson, Nappan, (1899 Reports) are strikingly significant in comparison with the results in germinating smut spores recorded in this bulletin. Mr. Robertson treated with a solution of formalin, one pound to 35½ gallons of water.

Time.	Good Heads.	Smutted Heads.
Soaked 1 hour	2814	None.
Soaked 15 minutes	3354	36
Soaked 5 minutes	3480	360
Sprinkled	3060	342
Untreated	2784	996

The serious difficulty encountered in treating seed grain for a short period of time, for example, by the use of smut machines, by the sprinkling process, or even by dipping for a short time, is in bringing the solution into contact with every smut spore. The groove on the face of the grain is often deep or narrow, and sometimes there are cracks in the seed coat. Air bubbles are almost certain to form at first over these grooves and cracks with the result that many smut spores are not wetted by the solution and hence are undestroyed, if the treat-

ment is too rapid. In this investigation comparatively large quantities of seed were used in order more accurately to duplicate the methods of treatment used in general practice. The results of the work throughout make clear that a solution consisting of 1 lb. of formalin to 40 gallons, or 1 lb. of copper sulphate to 20 gallons of soft water is sufficiently strong to kill any smut spore that is wetted by it. A stronger solution could not be more effective in killing smut spores, and is especially undesirable because it does increased and unnecessary injury to the seed wheat by killing from ten to fifty per cent. of it and greatly weakening the rest of the seed.

III. To Determine the Effect of Treatment on the Vitality of the Seed.

Two sets of experiments were made, one with western grown No. 1 Northern, purchased from the Brown Milling Co., of Toronto, and said to be of this year's crop, and the second with wheat contributed by Mr. J. A. Mooney, of Valley River, Manitoba, from his seed plot, likewise from the harvest of 1906.

More than three hundred separate tests were made with the first set, and more than one hundred with the second. The germination tests were conducted by a Swiss seed specialist, and in standard seed germinators.

The following percentages of viable grains that germinated after treatment are worthy of study and comparison.

Formalin.

No. 1 Northern purchased in Toronto:

	1 hr.	2 hrs.	3 hrs	6 hrs.
1 lb.—30 gal.	86%	45%	28%	13%
1 lb.—40 gal.	91%	80%	78%	48%
1 lb.—50 gal.	95%	86%	83%	79%

Mooney's Wheat:

	1 hr	2 hrs	3 hrs	4 hrs.	6 hrs.
1 lb.—30 gal	100%	No tests made			
1 lb.—40 gal	100%	100%	100%	100%	100%
1 lb.—50 gal	100%	100%	100%	100%	100%

COPPER SULPHATE.

No. 1 Northern.—Rather more severe than with formalin.

Mooney's Wheat:

	1 hr.	3 hrs.	6 hrs.	12 hrs.	18 hrs.
1 lb.—10 gal.....	100%				
1 lb.—15 gal.....	100%	100%	100%	98%	100%
1 lb.—20 gal.....	100%	100%	100%	99%	100%

The differences in the results can be accounted for in a number of ways.

(1) The Mooney wheat was dried more quickly after treatment; there were no cracked grains; *it was a selected wheat of known pedigree.*

(2) The No. 1 Northern was threshed by machine and contained some checked grains; it was not a pure variety, and there is no absolute certainty that it came from the 1906 crop.

(3) There may have been a difference in the stage of maturity of the two lots of grain when harvested—certainly not a negligible factor in its bearing on the vitality of the seed.

Professor Shutt of the Central Experimental Farm has convincingly demonstrated that seed of weak vital energy suffers most from treatment.

In addition to the foregoing, abundant data have been obtained bearing on the question of the weakening of the vital energy of those grains that are not killed by treatment. The more severe the treatment, within certain limits, the greater is the delay in the germination of the seed. But this is far more striking with the copper sulphate than with the formalin. Indeed, the formalin is ordinarily not objectionable on these grounds.

In regard to the continuous effects of treatment on seed that is not sown at once, Dr. Chas. E. Saunders, crealist, has presented some interesting statistics. Germination tests made by him immediately after, and eleven months after treatment, conclusively proved the possibility of disastrous results when sowing is delayed.

If the soil conditions are such at the time of sowing that there is likely to be a delay in germination, it is beneficial to wash the seed in water after taking it out of the solution, or in lime water if copper sulphate has been used.

A comparison of the effects of treating different varieties of wheat in the same way is important. Professor Shutt and others have shown that there is a marked difference. None has proved to be more resistant and better able to endure treatment than Red Fife.

In conclusion, fresh, vigorous seed, from healthy plants harvested at full maturity, dried quickly after treatment, and sown at once, will sustain little injury from the methods of treatment advised in this bulletin.

IV. To Determine the Possibility of Infection from Spores Carried in the Soil.

Mr. G. H. Clark took the pains to make somewhat extensive observations on this matter during the last summer. The parts of the fields over which clouds of the spores were carried during the previous year's threshing operations were carefully compared with the surrounding parts. I can corroborate his conclusion, which is in harmony with that of the veteran botanist Brefeld, that soil infection does play a part, but I am not in a position to state how significant a part this may be.

The spores blown from the threshing-machine are sometimes carried for miles. Many of them fall to the ground, and may spread the infection; others fall on unthreshed grain—these are the ones that are certain to give trouble.

V. To Determine if Apparently Sound Grains may be Diseased with Smut.

It is commonly asserted that the "whole head if smutted, contains no sound grain, only smutted kernels." Failing to find any statistics on this point, I have given the matter some attention and have arrived a different conclusion.

Smutted heads were gathered in the neighbourhood of Indian Head and carefully threshed by hand. Out of a yield of 1,638 grains, there were 1,444 smut balls or 88.12 per cent., and 194 "sound" grains (viable) or 11.84 per cent. of the whole.

Near Pincher Creek, in Southern Alberta, 11,607 grains were harvested from a collection of diseased plants of which 2,191 or 18.88 per cent. were apparently sound.

At Creelman, Saskatchewan, 54 diseased plants bore 146 heads. Of these heads, 88 or 60.27 per cent. bore nothing but smut balls: 16 or 10.52 per cent. nothing but sound grains, and 42 or 28.77 per cent. both smut balls and "sound" grains. That is, of the smutted heads, nearly one-third contained "sound" grains.

It is known that every stalk of a diseased plant is affected. Commonly, as in the Creelman plants, most of the heads carry smut balls, but frequently there are some that do not, and occasionally the entire plant, though diseased, may be free from them. One might very reasonably suspect, therefore, that the apparent-

ly sound grains in these plants are not in reality sound– existing statements to the contrary—and further, that they might insidiously transmit the smut disease to the seedlings which spring from them. Ii so, very obvious limitations surround the choice of an adequate method of treatment.

A thorough search has resulted in the discovery of spores, and other noteworthy indications of the parasite in a significant number of these suspected grains. !This fact alone may account for the prevalence of smut in the nelds of many wheat-growers who treat their seed before sowing. If so, the hope of prevention lies in the use of a weak solution for a more prolonged period of time. Here, as with the conditions noted in Section II., hasty methods of treatment cannot be completely effective, especially if the seed has been taken from a smutted crop.