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**Experiments with Wheat and Oats
for Smut**

—BY—

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BULLETINS

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Experiments With Wheat and Oats for Smut

—BY—

L. F. HENDERSON

FIRST EXPERIMENT.

Several years ago a bulletin was published by this Station on the Smuts of Wheat and Oats. Since that time the use of Formaldehyde, or as it is more commonly called in commerce, Formalin, has almost superseded blue stone and hot water for grain smuts in many states, and it was thought fit to give the three methods trial side by side, and determine once for all, and upon our own grounds if possible, which is the best.

About ten acres on the Station farm was set aside for this experiment during the spring of 1905. This plot was almost a square and was divided north and south into strips. Eight of these strips were 709.4 feet long by 34.5 feet wide, four were of same length, but 68.8 feet wide, while two, Plots 13 and 14, were irregular. The eight narrow strips were put in wheat, the four wide and two irregular ones in oats. They were numbered from the east consecutively one to fourteen, and stakes bearing the numbers were set up at the south-east corner of each strip. A special trip was made five miles out into the country to obtain oats which were so smutty as to have been refused at one of the mills. By inquiry and inspection, wheat was found in one of the warehouses the odor of which gave evidence of abundant smut. The writer was not satisfied by these evidences as to the smutti-ness of the grain and placed the samples of each upon a slide on the microscope, using a $\frac{2}{3}$ inch objective. Both oats and wheat

showed about as many spores of smut as could possibly gain lodgement on each grain, so numerous that it was utterly impossible to compute how many there were.

Precautions Taken to Avoid Re-smutting of Grain.

I cannot but think that the reason why so many complain of poor success with any or all of these treatments is due to two facts. First, the grain is not treated as directed, with proper strengths or proper times of treatment, or, second, no care is taken with the grain after treatment and before sowing to prevent contamination or resmutting of the seed. To show how easily contamination can take place after treating, I shall shortly point out how the writer proceeded and how he avoided these pitfalls.

When one considers how small and light are the spores of most smuts, rusts, and other fungous diseases, he can readily understand how easily they can be distributed. They are everywhere in the barn, if smutty grain has ever been placed therein, and of course they are on and in every utensil used in handling such grain, from the shovel and scales to the separator and seeder. If a man is planting smutty grain, as was I, the *sacks* will be smutty as well as the grain. If one is immersing the grain when treating it, he should of course immerse it in the sacks he is going to take to the field, but these should not be full. If, on the other hand, he is going to sprinkle and shovel his grain when treating, the first thing he should do when he empties his sacks is to throw them into boiling water, or into a vessel holding more of the very liquid he is using for treatment. This many neglect to do, and of course when the treated grain is put back into *untreated sacks*, the grain is covered with fresh spores. After grain is treated in piles it should be spread out to dry on the barn floor or upon canvas. If the grain is still *wet* with the fluid used in treating, so wet as to exude from the grain, no harm will be done by this method, for the excess of fluid will kill any spores which may be on the floor or canvas. If, however, the grain is partly dry, and

is poured out to finish drying (rain or some other cause preventing almost immediate sowing), the floor or canvas should be soaked with the fungicide before spreading out the grain. Again, grain should not if possible be stored after treatment in bins where smutty grain has been, or even in a smutty place of the barn itself. The best way is not to treat the grain until you are ready to sow, and then use as soon as kernels separate readily from one another. Lastly, grain should not after treatment be sown from a seeder, through which smutty seed has passed or which has been standing in a place where smut could collect upon it, until the seeder has been carefully cleaned, which would include washing it out with weak formalin-water. Of course blue stone could not be used in this way, or the metal parts of the machine would be injured. This experiment has proved, at least to the writer's satisfaction, that properly treated seed, kept in treated sacks, in clean places, and sown from clean machines, will give a clean crop or nearly so.

Purpose of Experiment.

The purpose of this experiment was not alone to prove which is the best *material* to use in treating grain, but to find out, so far as one experiment and one season could show, *how long* the grain should be treated to give the best results. The question of strengths of materials to be used did not come up, save incidentally, in these experiments, as these have been so fully tested by other Stations that it was deemed unnecessary to spend any time on them. The question of "How long shall I treat the grain?" was thought to be of importance, as one Station recommends immersion for one hour, and some for only ten minutes.

Plat 1.

Weighed out 60 pounds of smutted wheat in a sack. Placed 15 gallons of water in a tub, and poured into it one half of a pint bottle of commercial formalin. It was thought best to use only 15 gallons instead of the customary 25, as the strength of the

formalin was not then known. Before the work was over the Station Chemist tested the liquid and found it practically as given on the label, about 36 per cent, instead of the alleged 40 per cent, of formaldehyde gas being present. Soaked wheat 10 minutes in solution, being careful to immerse *all of the sack with the grain*. The wheat used in the following experiments was just like this, and not only, as before stated, very smutty, but having quantities of "smut-balls" still unbroken amongst the wheat. Sowed as soon as dry.

Plat 2.

Soaked one bushel of the same for 30 minutes in the same tub and solution as the last, tied loosely in a sack. Sowed when dry. I may add that the seeder was *carefully cleaned* before sowing, though nothing but clean or treated seed had been sown from it before.

Plat 3.

Soaked wheat in same solution and tub for one hour. Sowed as soon as dry.

Plat 4.

Placed wheat on large canvas on the floor. If many bushels of wheat were to be treated by this method, of course no canvas would be used. This was merely for convenience in putting back into sack and not to lose any. Filled a watering-pot nearly full of same liquid, about one gallon, and while I sprinkled another man shoveled the grain with a scoop-shovel till every kernel was wet and glistening. Then put the grain back into a *soaked* sack, and tied. Sowed as soon as dried.

Plat 5.

Soaked one bushel of same wheat in a solution of Copper Sulphate (blue stone), using the 1-4 strength, or 16 gallons of water to 4 pounds of the copper salt, for a period of 15 minutes. Then sprinkled the seed with limewater, to prevent the strong solutions injuring the germination of the seed. Sowed when dry.

Plat 6.

Soaked one bushel of same wheat for 12 hours in 9 ounces blue stone to 15 gallons of water. The government formula gives 1 pound to 24 gallons of water, so I cut down on both proportionally. Sowed when dry.

Plat 7.

Placed one bushel of same wheat on canvas on floor and sprinkled, while another shoveled the mass till every grain was thoroughly wet and glistening. Copper Sulphate was again used, the 1-4 formula, and then the mass was sprinkled with limewater, for the reason above given. Sowed when dry enough.

Plat 8.

Sowed one bushel of same wheat untreated, to act as a "check", or guide to judge the other wheat-plats by.

Plat 9.

About one acre. Soaked two bushels of smutted oats in formalin solution, $\frac{1}{2}$ bottle to 15 gallons of water, for 10 minutes. Care was taken, as with the wheat, that the whole of the sack should be immersed with the grain. Sowed when dry.

Plat 10.

Soaked two bushels of same grain in same formalin solution for one half-hour, using the same care to cover all of the sack. Sowed as soon as dry.

Plat 11.

Soaked two bushels of same oats *two hours* in same solution. Sowed as soon as dry.

Plat 12.

Piled oats on floor, and sprinkled them as I had the wheat. Left them covered on the floor for two hours and then resprinkled. Sowed when dry.

Plat 13.

Treated two bushels of same oats with Jensen or Hot Water treatment. If this method of treating grain should be followed, large vessels, capable of holding many bushels of oats at one time, should be used. Besides saving time in treating so many at once, the water can be kept hot better, which is a most important thing. I shall however describe how I treated these two bushels. A large boiler, used in heating water for hog-dressing as well as heating feed, was filled nearly full of water and raised to about boiling. A tub stood near containing water warmed to 110 to 120 degrees Fahr. Another large tub was used for receiving the grain for final treatment. The two bushels of grain were divided and placed in two sacks so that the water could reach each kernel easily, and also for ease in lifting in and out. The two sacks were both placed in the tub containing water, first at 119 degrees Fahr., but almost immediately dropping to 110 degrees as the cool grain was immersed, and there it was left about ten minutes to get thoroughly warmed. The water in the next tub was then raised to about 135 degrees, a good thermometer registering the temperature as hot or cold water were added. The main point in this method is this. The water should not be *below* 130 degrees or the smut spores will not be killed. It should not be much *above* 132 or 133 degrees, or the grain germination will be injured. In small amounts and in small vessels it is not only safe but necessary to raise the temperature to about 135 degrees, for when the sacks are lifted out of the warm water and plunged into the hot, the difference in heat and the time that will necessarily elapse before this can be done will *lower* the temperature to 132 or 133 degrees. In this hot water the sacks should be left for about *10 minutes*, stirring sacks in water meanwhile. They are then to be taken out and cooled at once. Sow as soon as grain is dry enough, *never* allowing the grain to become completely dried again.

Plat 14.

Sowed two bushels of same grain *untreated*, to act as a check.

Remarks.

Every plat was drilled, not sown broad-cast, so that the limits of each plat could remain distinct. This was brought about by drilling the different plats about 10 inches or a foot apart. It was also very important to see that, when the drill began work and had been cleaned, it should sow all the plats of *treated* grain of each kind before the check plat was planted. After the smutted wheat was sown, the oats were begun, and in this way it was made certain that no *new* contamination of grain could be brought about.

Results.

The plats were cut on July 24th and immediately shocked, as nearly as possible each plat to itself. Before harvesting, specimens for examination were gathered as follows. From near the north end, as well as near the south end, of each plat, two square yards of the grain were carefully cut and bound into small bundles, and marked "Plat 1, North", "Plat 1, South", etc. These bundles were taken up to one of the farm buildings, and all the straws with their heads carefully examined by the writer. Each one that showed smut was put in its pile, and each perfect head in its pile. Both were then counted, and the percent of smut reckoned. The same was done in most cases with the other bundle from the same plat. This was a most wearisome and exacting undertaking, consuming two-half days, but exactness was necessary. The results were in many cases so astonishing that the writer did not depend upon these results alone, but went out to the field before the shocks were hauled in, and inspected the bundles of many shocks in each plat. As was to be expected, much less oats were smutted in the check than wheat in its check, and at the same time the *difference* between the treated and untreated oats was not nearly so great as in the case of the wheat.

Plat 1. No smut in either bundle. *One* smutted head found in the field!

Plat 2. No smut in bundles nor in field!

Plat 3. Bundle from south end had 4 smutted ears in 364; none in other. Per cent smutted in bundles, 4 in about 728, or .5 per cent. None seen in field.

Plat 4. No smut in bundles nor in field.

Plat 5. Blue stone treatment. Bundle from north end gave 384 heads, 4 smutted. Bundle from south end gave 16 smutted ears in 360. Average smutted 20 in 744, or 2.7 per cent.

Plat 6. Bluestone. 360 heads in one bundle, 19 smutted. Bundle from south end gave 419 heads, 32 smutted. 51 smutted in 779, or 6.5 per cent.

Plat 7. Bluestone. One bundle of 318 heads gave 31 smutted, the other of about the same gave 45 heads smutted. Smutted heads, 76 in 636, or 10.4 per cent.

Plat 8. Check, untreated. One bundle only counted. This gave 242 ears *entirely* smutted, and 228 ears slightly smutted or not at all. No account was taken of those slightly smutted, but with those entirely smutted the result was 52 per cent smutted, or over one half! In the field it was about the same as far as it could be judged by inspection.

Plat 9. Oats. Fine and heavy. One bundle counted gave 333 stalks, not one smutted. No smut could be found in shocks.

Plat 10. Heavier, larger bundles than the last, but probably due to soil. No smut in bundles or in field.

Plat 11. Fine and heavy. No smut in bundles or in field.

Plat 12. Hot Water. Fine and heavy. No smut in bundles or in field.

Plat 13. Fine and heavy. Sprinkled oats. No smut in either place.

Plat 14. Check or control. One bundle counted gave 226 heads of which 13 were smutted, the other about the same.

6 per cent smutted. This was a much better result than was to be anticipated from the very smutted seed used.

Conclusions.

1. Smut can be controlled by proper treatment.
2. Treating grain properly *pays*.
3. Formalin is better than copper sulphate (Bluestone).
4. It will take another season to demonstrate whether the yield per acre is enough more with the oats treated with Hot Water to pay for the extra trouble over formalin treatment.

SECOND EXPERIMENT.

At farmers' institutes held in Nez Perce County this fall, it was urged by some of the grain growers, who had used formalin as a treatment for smut, that when the grain was sprinkled in piles and *left covered* over night or longer, its germination was injured, much of it refusing to sprout at all. As this is a most important point, it was thought well to give it a thorough test in the laboratory.

A bushel of wheat, raised this year on the Station farm, was brought in. Half of this was piled up on one end of a heavy canvas, one yard wide and two and a half long, thoroughly sprinkled with formalin solution and shoveled about at the same time till every kernel was wet and quite an amount of the liquid ran out about the pile. This was then covered with two thicknesses of the same canvas and the edges pressed closely about the pile so as to retain the moisture and fumes of the formalin as completely as possible. The solution was made up as follows. Into about two gallons of water was poured 1-6 of a pint of formalin, thus making the strength one pint to 12 gallons, or about one per cent strength. It will be noticed that this was about *four times* as strong as ordinarily recommended. This treatment of the grain occurred Thursday afternoon, Dec. 14, at 4 o'clock. At 9.30 a. m. Friday, the wheat was still wet, as was the canvas about the pile. It was then shoveled over again, so as to give a

composite sample, and a large handful placed between wet blotters for a few days, while another handful was transferred into a glass jar, and left in a covered pile for the same time between wet cotton.

A large handful of wet but untreated wheat, was placed between wet cotton in another jar, and left to germinate. This was a "check" to test germination of untreated wheat.

Saturday morning another handful of the treated wheat was taken from the pile, and this likewise placed in a moist chamber for germination.

The wheat first treated was then removed and a second pile placed on the canvas, sprinkled and covered. This solution was in the proportion of 1 lb. or pint of formalin to 40 gallons of water.

The next day at 11 a. m. 24 moist kernels were taken out of this pile and placed between moist cotton in a glass jar for germination.

At 9:30 Monday, 24 kernels were selected and placed in a moist chamber as before.

Several other experiments were made with wheat soaked in formalin solutions of different strengths, but all of these can best be appreciated if seen in detail.

As much of the grain had been injured in thrashing, it was thought best to take in every case 24 good, plump kernels for final observation.

Experiment I. Piled up wheat Thursday afternoon at 4 p. m., December 14th, and treated as described. Strength one to 96, equals 1-6 pint to two gallons of water, or about 1 per cent strength. At 9.30 Friday, placed wheat between wet blotters. Sunday at 1 o'clock, took 24 plump kernels from blotters and transferred them to glass jar between moist cotton, and covered with glass cover. No germination apparent at this time. Tuesday, December 19th, at 11 a. m., 115 hours after treating, 97 hours after placing in a moist chamber, 18 out of 24 kernels had germinated.

Monday, December 25th, three kernels had not germinated at all, and one but slightly.

Experiment 2. Placed a handful of same wheat as last between wet cotton in a glass vessel, $17\frac{1}{2}$ hours after treating, and covered with glass cover.

Sunday at 10 a. m. took 24 plump kernels from this pile and placed them in same vessel between cotton, pouring out the balance. No germination apparent at this time. Monday, December 18th, at 10 a. m., a few had germinated. Tuesday at 11 a. m., 115 hours after treating, $97\frac{1}{2}$ hours after placing in the moist chamber, 18 out of the 24 kernels had germinated. Monday, Dec. 25th, 19 had germinated, 5 not at all.

Experiment 3. Friday, December 15th, at 9.30 a. m., took a granite pot and poured into it a definite amount of the formalin solution, at the strength of one pint formalin to 40 gallons of water. I then tied loosely a handful of grain in a piece of cheesecloth, and after stirring up the solution carefully, immersed the wheat in it for a minute. I then took it out, piled it up in a little pile in a glass vessel, covered it carefully with wet cloth, and left for two days covered in the vessel.

Sunday at 10 a. m., took 24 kernels from this pile, and placed them between wet cloths in the same vessel. No germination was then apparent.

Tuesday at 11 a. m., $97\frac{1}{2}$ hours after treating and placing in moist chamber, only *one* kernel had not germinated, and this was found on careful examination to be an injured one.

Experiment 4. This was the "check," or untreated wheat. Most of the wheat had germinated Sunday at 10 a. m. All had germinated Monday at 10 a. m., 76 hours after wetting and placing in moist chamber. This showed that all uninjured wheat had perfect germination, and also gave the extreme limit of it in these experiments.

Experiment 5. Placed formalin in water Friday, December

15th, at 11 a. m., at proportion of one pint formalin to 25 gallons of water. Stirred, and then immersed handful of wheat for about one minute. Then put same in pile in glass vessel, covered with wet cloth and with glass cover.

Sunday at 10 a. m., took 24 perfect kernels from the pile, and after discarding the remainder, replaced these in same chamber, covered with wet cloth and glass cover. Germination just *beginning* Monday 10 a. m., 76 hours after placing in chamber, 90 hours after wetting.

Tuesday at 11 a. m., *all* of the 24 grains had germinated.

Experiment 6. Saturday morning at 7.30 a. m. took a handful of wheat from the pile first treated. This was 39½ hours after wheat had been treated and covered with the canvas. I placed this between moist cotton and covered the jar with glass cover.

Sunday at 10 a. m., I selected 24 plump kernels from the mass, and discarding the remainder, placed them in same vessel between layers of wet cloth.

Tuesday, Dec. 19th, 115 hours after treating, and 75½ after I had placed them in the moist chamber the first time, only 10 out of the 24 had germinated. Monday, Dec. 25, 9 had germinated well, 6 partially, and 9 not at all.

Experiment 7. Took one half bushel of wheat, treated with formalin solution at strength of one pint formalin to 40 gallons of water, then covered carefully with canvas. This was at 8 a. m., Saturday, Dec. 16th. The next day at 9 a. m., 25 hours after treating, selected 24 plump kernels, placed them in glass vessel between moist cotton and covered.

Tuesday, Dec. 19th, at 11 a. m., 75 hours after treating, and 50 hours after placing in moist chamber, all had germinated, including one cracked one.

Experiment 8. Took a handful of wheat from the pile last spoken of Monday morning at 9.30 a. m., 49½ hours after treat-

ing, and making a selection of 24 good, plump kernels placed them in glass jars between wet cloths, and covered with cover.

Tuesday at 11 a. m., 75 hours after treating and 25½ hours after placing in moist chamber, 8 had sprouted. Monday, Dec. 25th, all of the kernels had germinated, two poorly.

Conclusions.

1. Seed treated with solution at strength of 1 pint of formalin to 16 gallons of water, three times as strong as recommended, and covered for nearly a day, was injured but little. This was nearly a 1 per cent solution.

2. Seed treated as above, and covered for nearly *two* days, was decidedly injured.

3. Wheat treated by the ordinary formula of one part to 50 gallons, one to 40 gallons, or even one to 25 gallons, was not injured at all, though covered for two days.

4. When wheat has been treated in piles on the floor, do not cover at all, for the *time* of germination is delayed, even if the wheat is not injured.

5. When farmers complain of injuring the germination of wheat by treating with formalin, it can be only due to two facts; either the proper strength of one pint of formalin to 40 or 50 gallons of water can not have been observed *at all*, and a much stronger solution used, or the pile treated must have been left covered for more than two days. It is doubtful if even this latter action could have injured the wheat unless the grain were left so wet that the water would have injured the germination irrespective of the formalin added to it.