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RESULTS WITH OAT SMUT IN 1897.

C. P. CLOSE.

GENEVA, N. Y.

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*Connected with Second Judicial Department Branch Station.
 †Connected with Fertilizer Control.

RESULTS WITH OAT SMUT IN 1897.

C. P. CLOSE.

SUMMARY.

In the experiments conducted by the author in 1897 Ceres powder, lysol, formalin and potassium sulphide were compared with the Jensen hot water treatment for the prevention of oat smut.

Sprinkling the seed with a 1 per cent solution either of lysol or formalin entirely prevented smut. The seed which was sprinkled with solutions of potassium sulphide varying in strength from 1 per cent to 5 per cent gave from 0.6 per cent to 1 per cent of smutted heads. Ceres powder used in the same strengths was even less effective, as the seed treated with it gave from 1 per cent to 2.9 per cent of smutted heads.

In the experiments in soaking seed, the treatments which entirely prevented smut are: 0.3 per cent lysol, seed soaked 1 hour; 0.2 per cent formalin, seed soaked 1 hour; 2 per cent potassium sulphide, seed soaked 1.5 hours; and 4 per cent Ceres powder, seed soaked 0.5 hour.

The hot water treatment kept the crop wholly free from smut.

None of the above treatments injured the seed.

For sprinkling one bushel of seed one gallon of the solution is required. A gallon of 1 per cent solution of lysol costs 5 cts. The same amount of 1 per cent formalin solution will cost 4 cts.

In soaking a bushel of oats one hour about one and four-fifths gallons of solution will be absorbed. This amount of 0.3 per cent lysol solution will cost 2.7 cts., a like amount of 0.2 per cent formalin solution will

cost 1.4 cts., of 2 per cent potassium sulphide 5.4 cts. and of 4 per cent Ceres powder 39.6 cts.

Lysol sells for about 65 cts. per pint; formalin for about 50 cts. per pint; potassium sulphide for 18 cts. per pound; and Ceres powder in bottles of 2.2 lbs. for \$1.50.

The Jensen hot water treatment consists in soaking the seed for a given time in water at a certain temperature, 133° for 10 minutes being usually recommended.

Sprinkling is done by applying the solution with a sprinkling pot and shoveling the pile over until all the seed is saturated.

Smut is a parasitic plant which grows inside of the stalks of oats. The black masses which appear in the heads of oats are the spores, or seeds, by which the smut is propagated.

Oats attacked by smut are usually dwarfed, and often weakened so much that many stalks never head out.

The following table shows cost per bushel of seed for chemicals in the least expensive successful treatments.

COST OF CHEMICALS FOR PREVENTION OF OAT SMUT.

Material.	Sprinkling.		Soaking.		
	Strength of solution.	Cost per bushel.	Strength of solution.	Length of time.	Cost per bushel.
	<i>Per cent.</i>	<i>Cents.</i>	<i>Per cent.</i>	<i>Hours.</i>	<i>Cents.</i>
Lysol.....	1	5	0.3	1	2.7
Formalin.....	1	4	0.2	1	1.4
Potassium sulphide....	—	—	2	1.5	5.4
Ceres powder.....	—	—	4	0.5	39.6

The cost of material per acre for treating seed with the 0.2 per cent formalin solution is 3 1-2 cts., allowing two and one-half bushels of seed per acre. Sprinkling with solutions of lysol or formalin weaker than 1 per cent was not tried, but they may prove effective in preventing smut.

INTRODUCTION.

The results of some investigations in 1897 in treating seed oats for the prevention of smut are presented in this Bulletin.

The hot water treatment, which originated with Prof. Jensen, is one of the most effective remedies for preventing oat smut, but since it involves heating the water and keeping it at a certain temperature for a given time, many have the idea that the operation is too complicated, therefore the remedy has not come into general use.

Soaking or sprinkling the seed with some solution may be considered a simpler process, and should it prove to be equally as effective would probably become popular more rapidly than the hot water treatment. Prof. Jensen has lately been advocating a remedy, Ceres powder, to be used in this way. This substance is reported as giving excellent results in some parts of Europe, and has received favorable mention in this country by Kellerman.* A Bureau has been opened in Chicago to advertise Ceres powder and push its sale. Since this remedy is thus being brought to public notice in this country it was decided to test it here and to compare it with other remedies for oat smut. The other remedies which were tried were hot water, formalin, potassium sulphide and lysol.

So far as known to the writer, lysol has not before been used as a preventive of smut; in these experiments, as will be shown later, it has given excellent results. Formalin† and potassium sulphide‡ have been tried before with varying success according to the strengths used.

In order to give the different remedies a thorough test some of the treatments which were tried on the Station farm were duplicated on larger areas under different environment

*Report of Society for the Promotion of Agricultural Science, 1896; p 64.

†Bolley, H. L., N. Dak. Exp. Sta. Bul. No. 27, Kellerman, W. A., Proceedings of the Society for the Promotion of Agricultural Science, 1896; Kellerman, W. A., Kan. Exp. Sta. Bul. No. 22; Wheeler, C. F., Mich. Institute Bul. No. 3; Year Book U. S. Dept Agr., 1896, p 259.

in another part of the State. The details of the work will accordingly be considered under two heads: (1) Experiments at the Station and (2) experiments at Trumansburg.

EXPERIMENTS AT THE STATION.

A piece of ground that would give conditions as nearly uniform as possible was selected for this purpose. This was divided into plats twenty feet long, each of which contained three rows, one foot of space between the rows and one and one-half feet between the plats. Untreated plats were distributed so as to form checks for each series of from three to six treated plats. Four rows of untreated seed were sown at each end of the piece so as to make the conditions of light, etc., of the end plats as nearly like those of the center plats as possible.

SEEDING OF PLATS.

Owing to heavy rains the seeding could not be done until May 22 to 26, three weeks after the seed was treated. An equal amount of seed was sown in each row. The seed oats used were selected because of the abundance of smut they contained. This fact gave assurance that the untreated seed used for checks would produce at least an average amount of smut which could be used as a basis of comparison for the treated plats.

CHEMICALS USED AND KIND OF TREATMENT.

Plats were sown with seed which had been *sprinkled* with 1, 2, 3, 4, 5 and 6 per cent solutions of lysol, 1, 2 and 3 per cent solutions of formalin, and with 1, 2, 3, 4 and 5 per cent solutions of potassium sulphide and of Ceres powder. Other plats were seeded with oats which had been *soaked* for 1, 2 and 3 hours in solutions containing 1 part in 1000 of lysol and of formalin, for 1 and 2 hours in 2 to 1000 solutions and for 1 hour in solutions of these same substances containing 3, 4, 5 and 6 parts in 1000; while the seed treated with potassium sulphide and Ceres powder was

soaked for 0.5, 1 and 1.5 hours in solutions of these materials containing 20 and 40 parts in 1000.

GERMINATION, GROWTH, AND PERCENTAGES OF SMUTTED HEADS.

No attempt was made to compare the yield of the different plats because the seeding was done so late in the spring that the short growth and small heads were unsatisfactory for this purpose. The percentage of smutted heads was determined by counting the stalks. This was done at the time of harvesting, August 16 to 20. The different treatments with their respective germinations of seed, growth of plants and percentages of smutted heads are given in the following table. The untreated plats are considered normal in germination and growth.

RESULTS OF TREATMENT OF SEED OATS BY SPRINKLING WITH
FUNGICIDES.

Material.	Strength of solu- tion.	Smutted heads.	Remarks.
	<i>Per cent.</i>	<i>Per cent.</i>	
Lysol.....	1	0	Germination and growth normal.
"	2	0	" " " "
"	3	0	About two-thirds of the seed grew; it was slow in germinating but the plants made a taller and more stocky growth, were very rusty, and much later in maturing than where the seed was treated with less lysol.
"	4	0	Less than one-fourth of the seed grew and that gave plants like the next above.
"	5	0	About one-twentieth of the seed grew. It gave plants like those in the 3 per cent treatment.
"	6	0	Only a few seeds grew; the plants were like those in the 3 per cent treatment.
Untreated.....	—	10	
Formalin.....	1	0	Germination and growth normal.
"	2	0	Very few seeds grew and two-thirds of these did not produce heads.
"	3	0	Even fewer seeds grew than in the one next above and one-fourth of these did not produce heads.
Untreated... ..	—	8.7	
Potassium sulphide	1	0.7	Germination and growth normal.
" " "	2	0.8	" " " "
" " "	3	0.9	" " " "
" " "	4	1.0	" " " "
" " "	5	0.6	" " " "
Untreated.....	—	6.4	
Ceres powder.....	1	2.9	" " " "
" " "	2	1.5	" " " "
" " "	3	2.7	" " " "
" " "	4	1.0	" " " "
" " "	5	1.3	" " " "
Untreated.....	—	6.4	" " " "

RESULTS OF TREATMENT OF SEED OATS BY SOAKING IN FUNGICIDES

Material.	Stren'h of so- lution.	Length of time.	Smut- ted heads.	Remarks.
	<i>Parts in 1000.</i>	<i>Hours.</i>	<i>Per cent.</i>	
Lysol.....	1	1	3.7	Germination and growth normal.
"	2	1	1.3	" " " "
"	3	1	0	" " " "
"	4	1	0	" " " "
"	5	1	0	" " " "
"	6	1	0	" " " "
Untreated.....			8	
Lysol.....	1	2	5.3	" " " "
"	1	3	3.3	" " " "
"	2	2	0.7	" " " "
Formalin.....	1	2	0.3	" " " "
"	1	3	0.3	" " " "
"	2	2	0	" " " "
Untreated.....			4.7	" " " "
Formalin.....	1	1	0.2	" " " "
"	2	1	0	" " " "
"	3	1	0	" " " "
"	4	1	0	" " " "
"	5	1	0	" " " "
"	6	1	0	" " " "
Untreated.....			5.4	
Potassium sul- phide*.....	20	0.5	0.1	About 25 per cent of seed failed to grow; plants made normal growth.
"	"	20	1.5	0
"	"	40	0.5	0
"	"	40	1	0
"	"	40	1.5	0
Untreated.....			1.5	
Ceres powder....	20	0.5	0.5	About 20 per cent of seed failed to grow; plants made normal growth.
"	"	20	1	0.4
"	"	20	1.5	0.2
Untreated.....			1.5	Germination and growth normal.
Ceres powder....	40	0.5	0	" " " "
"	40	1	0	" " " "
"	40	1.5	0.1	" " " "
Untreated.....			8.7	

*Record for plat from seed soaked 1 hour in potassium sulphide was lost.

WHAT THE ABOVE RESULTS SHOW.

With lysol.—The 1 per cent and 2 per cent solutions sprinkled did not injure the seed and entirely prevented smut. The 3 per cent solution sprinkled injured the seed so that one-third of it did not germinate, while the plants from the other two-thirds were stocky, very late in maturing and very rusty. Solutions stronger than 3 per cent injured the seed more in proportion to their increased strengths.

Soaking the seed for 1 hour with from 3 to 6 parts per 1000 prevented the growth of smut, while untreated seed gave 8 to 10 per cent of smutted heads. When the seed was soaked in weaker solution the smutted heads varied from 0.7 per cent to 5.3 per cent. None of the seed soaked in lysol solutions was injured.

With formalin.—The 1 per cent solution sprinkled on the seed was effective and did not injure the seed. The 2 per cent solution, sprinkled, killed about 95 per cent of the seed and the 3 per cent solution sprinkled killed even more than this. Two to six parts per 1000 on seed soaked one hour, and 2 parts per 1000 on seed soaked two hours killed all smut spores without injuring the seed. Weaker solutions gave from 0.3 per cent to 0.7 per cent of smut, while untreated seed gave from 4.7 per cent to 8.7 per cent of smut.

With potassium sulphide.—Seed sprinkled with from 1 per cent to 5 per cent solution was not injured, but gave from 0.6 per cent to 1 per cent of smut, while the untreated seed gave 6.4 per cent. That soaked in a 2 per cent solution for 1.5 hours and in the 4 per cent solution from 0.5 to 1.5 hours prevented smut and caused no injury to the seed.

With Ceres powder.—Seed treated by sprinkling with from 1 per cent to 5 per cent solutions gave from 1 per cent to 2.9 per cent of smutted heads, but was not injured; the untreated seed gave 6.4 per cent of smut. The 2 per cent treatments soaking 0.5 hour and 1 hour injured the seed about 20 per cent and gave 0.5 per cent, or less, of smutted heads. The seed soaked in a 2 per cent solution 1.5 hours gave 0.2 per cent of smut, that soaked in a 4 per cent solution 1.5 hours gave 0.1 per cent and was not injured. The 4 per cent treatments

where seed was soaked 0.5 hour and 1 hour prevented smut without injuring the seed.

EXPERIMENTS AT TRUMANSBURG.

Since the experiments at the Station were of necessity conducted on small plats, it was deemed advisable to duplicate a few of them on a larger scale in a locality where the oat smut was abundant the previous season. Accordingly, arrangements were made with Messrs. King & Robinson, Trumansburg, Tompkins County, by which a plat of two-sevenths of an acre was used for each different treatment.

On April 13 the seed was treated by sprinkling in lots of one bushel as follows :

STRENGTH OF FUNGICIDE SPRINKLED ON OATS.

Material.	Strength of Solution.
	<i>Per cent.</i>
Ceres powder*.....	0.78
Potassium sulphide....	5
“ “	3
Formalin.....	5
“	3

*This strength is at the rate of 1 ounce in one gallon of water, practically as per directions of the manufacturers of Ceres powder who recommended 1 ounce of the powder in 1 gallon of water sprinkled on 33½ pounds of seed.

METHOD OF TREATMENT.

The oats were placed on the barn floor in piles of one bushel each. The necessary amount of each chemical was put in one gallon of water and was applied with a sprinkling pot. By spreading the pile somewhat and alternately sprinkling and turning the oats, each bushel was thoroughly saturated and absorbed practically the whole gallon of the mixture. To dry them the piles were spread and shoveled over occasionally for two or three days.

SEEDING AND GROWTH.

The seed was drilled in April 21 at the rate of two and

one-fourth bushels per acre. Three check or untreated plats were sown for the five treated plats. The seed treated with Ceres powder and potassium sulphide germinated as well and made as good growth as the untreated seed did. The experiment with formalin was short and decisive. None of the seed germinated, thus proving that the 5 per cent and 3 per cent solutions were fatal to the seed. As soon as it was certain that this seed would not grow, another bushel was given the hot water treatment and the plat seeded May 4, at the same rate per acre as before. This made a fairly good growth, but rusted badly, due, no doubt, to late sowing. At the time of harvesting, August 3, the grain of all the plats was flat upon the ground, having been broken down by heavy rain and wind storms. The yields were undoubtedly reduced a little by this condition, since lodged grain is difficult to harvest, but as all of the plats were in the same condition the yields are comparable.

PERCENTAGE OF SMUT AND YIELD OF PLATS.

The percentage of smutted heads was obtained by selecting representative parts of each plat and counting the stalks.

TREATMENT, PERCENTAGE OF SMUT AND YIELD PER ACRE OF OATS.

Material.	Strength of solution sprinkled.	Smutted heads.	Yield.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Bushels.</i>
Ceres powder.....	0.78	6.3	59.72
Potassium sulphide.....	5.0	0.85	57.64
“ “	3.0	1.4	54.36
Hot water.....		0	54.58
Untreated.....		11.8	54.36

That the hot water treatment did not give a larger yield is undoubtedly due to late sowing and to the rusting of the plants.

COMPARISON OF RESULTS.

At Trumansburg the seed sprinkled with a 0.78 per cent Ceres powder solution gave 6.3 per cent of smutted heads. The only experiment at the Station to compare with this is

where seed was sprinkled with a 1 per cent solution and gave 2.9 per cent of smut. Seed sprinkled with a 5 per cent potassium sulphide solution at Trumansburg gave 0.85 per cent of smut, while at the Station seed treated with the 5 per cent solution gave 0.6 per cent. With the 3 per cent potassium sulphide solution the result at Trumansburg is 1.4 per cent and at the Station 0.9 per cent of smutted heads. These results show a slight difference in favor of the work done at the Station. There was also less smut on the untreated plants at the Station, 10 per cent being the highest. At Trumansburg the untreated plats gave 11.8 per cent of smutted heads.

COST OF MATERIALS.

Lysol.—This material can be purchased in small quantities for about 65 cts. per pound, or pint. In carboy lots it sells for about 30 cts. per pound.

The 1 per cent treatment, sprinkled, will cost about 5 cts. per bushel of seed.

In soaking the seed in a solution of 1 part in 1,000 the cost is 0.5 ct. per gallon of the solution.

Formalin.—Formalin and the "40 per cent Solution of Formaldehyde Gas" are exactly the same material, but in purchasing it is well to ask for the latter, because it is quoted much lower in price than formalin.* The 40 per cent solution of formaldehyde gas sells for about 50 cts. per pound, or pint, in small lots, and in carboy lots for about 30 cts. per pound. The material for one gallon of the 1 per cent solution costs 4 cts. A gallon of the solution 1 part in 1,000 costs 0.4 ct.

Potassium sulphide may be obtained for about 18 cts. per pound. A gallon of 1 per cent solution will cost a trifle less than 1.5 cts. The same amount of solution 1 part in 1,000 will cost less than 0.2 ct.

Ceres powder is put up in bottles holding one kilogram or 2.2 pounds. A single bottle sells for \$1.50 and a lot of ten

*DeSchweinitz, E. A., Year Book U. S. Dept. Agr., 1896, p. 262.

for \$10.00. The rate per ounce for single bottle is about 4.25 cts. This is sufficient for one gallon of the solution necessary for sprinkling one bushel of seed as advocated by the manufacturers. A gallon of the 1 per cent solution requires 1.28 ounces and costs nearly 5.5 cts.

The cost of material for the least expensive treatments which entirely prevented the smut is herewith given :

COST OF FUNGICIDES FOR PREVENTION OF OAT SMUT.

Material.	Sprinkling.		Soaking.		
	Strength of solution.	Cost per bushel.	Strength of solution.	Length of time.	Cost per bushel.
	<i>Per cent.</i>	<i>Cents.</i>	<i>Per cent.</i>	<i>Hours.</i>	<i>Cents.</i>
Lysol	1	5	0.3	1	2.7
Formalin.....	1	4	0.2	1	1.4
Potassium sulphide	—	—	2	1.5	5.4
Ceres powder	—	—	4	0.5	39.6

HOT WATER TREATMENT.

This treatment is really a very simple operation, but something about the thought of doing it seems formidable to many persons, and they hesitate to try it. The Station has recommended the following plan as easy, cheap and practical. Heat the water in a large kettle and near the kettle sink a barrel in the ground so the top will be a foot or more above the surface. Pour part of the hot water into the barrel and take the temperature with a good thermometer—be sure to have a *good* one—and add either cold or hot water until a temperature of 138° is reached. The dipping is done by putting about a bushel of oats in a coarse gunny sack, tying this to one end of a pole and resting the pole over a post, thus making a lever, by which the sack of oats may be raised or lowered very easily. When the oats are dipped into the water at 138° the temperature is immediately lowered and hot water must be added at once to keep the temperature about 133°. Keep the seed moving all the time and take out at the end of ten minutes. Spread the oats on a barn floor or other convenient place and shovel them over three times a day for a few days ; then they may be sown with a force drill ;

or, when they are taken out of the hot water, pour cold water over them, spread them out to drain, and in two or three hours they may be sown broadcast. As the oats absorb considerable water it is necessary to sow about half a bushel* more per acre than when untreated seed is used. This is on the basis of two and one-half bushels per acre. Two men in one day can treat enough seed to sow twenty acres.*

NOTES ON SMUT.

WHAT IS IT?

The so-called smut is a parasitic plant, that is, a plant which feeds upon some other plant as a host, and grows upon, or inside of it. It comes from a spore, which is comparable to a seed in the higher plants, grows and produces fruit, with which to perpetuate itself much the same as any other plant. The black masses of smut so noticeable when the grain is ripening consist of countless numbers of minute ripened spores, the fruit of the parasitic plant. These spores are often blown from the oat-head as soon as they ripen, thus leaving a naked stalk, but more often, perhaps, they remain in black disagreeable masses.

HOW THE SMUT PLANT GROWS.

Since the smut spores are microscopic in size a large number may be attached to the kernels without being noticed. In this way they are unavoidably sown with the oats in the spring. While the oats are germinating and growing the smut spores are doing the same thing, only in a little different way. Each germinating spore sends out a minute tube which penetrates the little oat plant when it is perhaps from two to four days old. After entering the oat plant the minute tube develops into branching threads, which grow up within the plant. There is no evidence of their presence until the heads are forming, but at this time the kernels of oats are filled with these branching threads which rob them of their nourishment and ripen myriads of new spores.

*Holden, P. G. Mich. Exp. Station, Bul. 87.

Thus, what should have been a head of oats turns out to be a worse than worthless mass of dusty spores. It sometimes happens that only a part of the head or panicle is thus affected and the stalks from each stool may or may not all be attacked by the parasite.

GROWTH OF SMUTTED OAT-PLANTS.

Since the smut parasite robs its host, the growing oat-plant, of much nourishment, the latter is naturally much weakened, and only a part of the smutted plants attain the average height of healthy ones. The others are dwarfed more or less and often to such an extent that they grow only a few inches high. A large number of diseased plants, especially those much dwarfed, are so weakened that they cannot push their panicles, or heads, out of the sheath of the upper leaf. Upon opening these closed heads they are found to be full of smut masses. Thus it is that the casual observer sees only the high smut and concludes that the crop is only slightly smutted.

INFECTION OF SEED OATS BY SMUT SPORES.

The seed is infected in several ways. Many of the spores ripen before the oats do, are blown about by the wind and become lodged on the ripening grain. In case the smut ripens early while some of the oats are still in bloom the spores are liable to become attached to the growing ovaries of the grain in such a position that the glume or husk of the individual oat kernels envelops the spores, thus making it difficult to destroy them. The wholesale agent of infection is the threshing machine, and the crop from a field practically free from smut is liable to become infected by spores carried in the machine from an infected neighboring field. Then the use of sacks, grain bins, etc., that have held smutted grain helps to distribute the smut spores.