

EXPERIMENT STATION
OF THE
KANSAS STATE AGRICULTURAL COLLEGE,
M A N H A T T A N ,

BULLETIN NO. 22.-AUGUST, 1891.

BOTANICAL DEPARTMENT.

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I. --SMUT OF OATS IN 1891,

The experimental work done this season with fungicides for oat smut—*Ustilago Avenae* (Pers.) Jensen - may be considered as a continuation of that reported upon in Bulletin No. 8, Oct., 1889, pp. 91-101; II Annual Report, 1889, pp. 215-261; and Bulletin No. 15, Dec., 1890, pp. 93-133, of this Station, to which reference is made for full account of the history of the fungus, its name and synonymy, its characters, ravages, prevention, etc. In the work this season but three fungicides have been used, namely: Liver of sulphur or potassium sulphide, calcium sulphide (one plot), and flowers of sulphur (six plots). On account of its efficiency the previous year, the potassium sulphide was used in case of thirty-nine different plots. A special test also was made as to the effect of the treatment on the yield of grain and straw.

AMOUNT OF SMUT IN 1891.

Numerous counts were made in fields about Manhattan to determine the exact amount of smut. The table on the following page shows the results.

*Mr. W. T. Swingle was associated with me in this work until May 1, 1890.

<i>Location, etc.</i>	<i>Total heads counted.</i>	<i>Total heads smutted.</i>	<i>Per cent. of heads smutted.</i>
Field on farm of J. W. Campbell.....	1467	47	3.20
Field on farm of Mrs. Fry.....	1751	59	3.37
Field on farm of R. H. Kimball.....	2000	103	5.05
Field on farm of H. Krudrop.....	1158	56	4.83
Field on farm of J. H. Winne.....	950	34	3.58
Field on farm of J. M. Kimball*.....	5134	298	5.80
Plot of Botanical Department sprayed with Bordeaux...	2037	88	4.32
Plot of Botanical Department sprayed with chloride of iron.....	2039	102	5.00
Plot of Botanical Department sprayed with potassium sulphide.....	1955	114	5.83
Plot of Botanical Department treated with flowers of sulphur.....	1060	84	7.92
Plot 54, Botanical Department, untreated.....	9256	677	7.31
Totals.....	28807	1660	5.76

The seed was from field referred to on page 102, Bulletin No. 15, Kansas Experiment Station. It contained practically no smut in 1890, the hot-water treatment having been employed in that year.

It will be seen from the above that the smut varied from 3.2 per cent. to 7.92 per cent. The general average was 5.76 per cent. In the three years previous it has varied from 7 per cent. to 11 per cent.

EXPERIMENTS WITH FUNGICIDES.

The principal fungicide used was potassium sulphide, usually called liver of sulphur. This material proved quite effectual as a fungicide the previous year, (see Bulletin No. 15, Dec., 1890, pp. 109, 114, and 129,) and was therefore repeated in various strengths.

The land used was that formerly occupied at old College farm in similar experiments, and the growth and the yield were in all cases good.

TABULATION OF EXPERIMENTS, OAT SMUT, 1891.

<i>Plot.</i>	<i>Treatment.</i>	<i>Heads counted.</i>	<i>Heads smutted.</i>	<i>Per cent. of smut.</i>
1	Potassium sulphide, 20 per cent. sol., 15 minutes; dried in air-slacked lime.....	882	2	22
2	Untreated.....	802	84	10.4
3	Potassium sulphide, 20 per cent. sol., 5 minutes; dried in air-slacked lime.....	468	4	85
4	Untreated.....	736	43	5.84
5	Potassium sulphide, 10 per cent. sol., 24 hours,	369	0	0
6	Potassium sulphide, 10 per cent. sol., 10 hours,	571	0	0
7	Untreated.....	876	62	7.07

TABULATION OF EXPERIMENTS, OAT SMUT, 1891—Continued.

Plot.	Treatment.	Heads count'd.	Heads smutted.	Per cent. of smut.
8	Potassium sulphide, 10 per cent. sol. (2d use), } 4 hours 25 minutes; washed afterwards... }	561	0	0
9	Untreated.....	825	84	10.18
10	Potassium sulphide, 10 per cent. sol., 24 hours.	569	0	0
11	Potassium sulphide, 5 per cent. sol., 24 hours..	506	0	0
12	Untreated.....	864	94	10.87
13	Potassium sulphide, 5 per cent. sol., 10 hours,	392	* 1	.26
14	Untreated.....	753	73	9.69
15	Potassium sulphide, 5 per cent. sol., 4 hrs. } 25 minutes; washed afterwards..... }	578	0	0
16	Potassium sulphide, 5 per cent. sol., 4 hrs.; } previously soaked 3½ hours..... }	571	0	0
17	Untreated.....	752	57	7.59
18	Potassium sulphide, 1 per cent. sol., 24 hours,	571	* 1	.17
19	Untreated.....	734	53	7.22
20	Potassium sulphide, 1 per cent. sol., 10 hours,	709	0	0
21	Potassium sulphide, 1 per cent. sol. (2d use), } 4 hours 25 min.; washed afterwards..... }	760	0	0
22	Untreated.....	914	93	10.18
23	Potassium sulphide, 1 per cent. sol., 4 hours; } previously soaked 3½ hours..... }	687	* 1	.15
24	Untreated.....	819	76	9.28
25	Potassium sulphide, ¾ per cent. sol., 24 hours.	666	0	0
26	Potassium sulphide, ¾ per cent. sol., 10 hours,	653	0	0
27	Untreated.....	844	97	11.49
28	Potassium sulphide, ½ per cent. sol., 24 hours,	689	0	0
29	Untreated.....	758	62	8.17
30	Potassium sulphide, ½ per cent. sol.; dried in } air, later in sun..... }	684	0	0
31	Potassium sulphide, ½ per cent. sol., 24 hours,	762	0	0
32	Untreated.....	795	89	11.19
33	Potassium sulphide, ½ per cent. sol., 24 hours,	634	2	.32
34	Untreated.....	756	79	10.45
35	Potassium sulphide, ¼ per cent. sol., 24 hours,	714	0	0
36	Potassium sulphide, ¼ per cent. sol., 24 hours,	781	3	.38
37	Untreated.....	951	131	13.77
38	Untreated.....	678	41	6.05
39	Potassium sulphide, 20 per cent. sol. (2d use). } 37 minutes..... }	377	0	0

* Probably from adjacent plot.

TABULATION OF EXPERIMENTS. OAT SMUT, 1891—Continued.

Plot.	Treatment.	Heads counted.	Heads smutted.	Per cent. of smut.
40	Untreated.....	584	36	5.31
41	Potassium sulphide, 20 per cent. sol. (2d use), } 37 minutes; limed.....	510	2	.39
42	Untreated.....	542	38	7.01
43	Potassium sulphide, 10 per cent. sol. (2d use), } 24 hours.....	330	0	0
44	Untreated.....	541	29	5.36
45	Potassium sulphide, 10 per cent. sol., 4 hours,	347	0	0
46	Untreated.....	588	53	9.01
47	Potassium sulphide, 10 per cent. sol., 4 hours; } limed.....	309	0	0
48	Untreated.....	508	49	9.64
49	Potassium sulphide, 10 per cent. sol. (2d use), } 4 hours; then put in water 2 hours.....	375	0	0
50	Untreated.....	500	44	8.8
51	Potassium sulphide, 5 per cent. sol. (2d use), } 24 hours.....	558	17	3.0
52	Untreated.....	668	48	7.2
53	Potassium sulphide, 5 per cent. sol., 4 hours..	498	0	0
54	Untreated.....	604	50	8.3
55	Potassium sulphide, 5 per cent. sol., 24 } hours; limed.....	337	2	.6
56	Untreated.....	510	41	8.0
57	Potassium sulphide, 5 per cent. sol. (2d use); } then put in water 2 hours.....	464	0	0
58	Untreated.....	584	41	7.0
59	Potassium sulphide, 1 per cent. sol. (2d use), } 24 hours.....	440	0	0
60	Untreated.....	488	35	7.2
61	Potassium sulphide, 1 per cent. sol., 4 hours..	457	0	0
62	Untreated.....	558	59	10.6
63	Potassium sulphide, 1 per cent. sol., 4 hours; } limed.....	343	0	0
64	Untreated.....	503	43	8.5
65	Potassium sulphide, 1 per cent. sol. 4 hours; } then put in water 2 hours.....	416	0	0
66	Untreated.....	539	39	7.2
67	Potassium sulphide, $\frac{1}{2}$ per cent. sol. (2d use), } 24 hours.....	426	0	0
68	Untreated.....	523	60	11.5
69	Potassium sulphide, $\frac{1}{4}$ per cent. sol. (2d use), } 24 hours.....	537	0	0
70	Untreated.....	513	63	12.3
71	Potassium sulphide, $\frac{1}{8}$ per cent. sol. (2d use), } 24 hours.....	508	0	0
72	Untreated.....	528	59	11.2
73	Potassium sulphide, $\frac{1}{8}$ per cent. sol. (2d use), } 24 hours.....	551	0	0

TABULATION OF EXPERIMENTS, OAT SMUT, 1891—*Concluded.*

No.	Treatment.	Heads counted.	Heads smutted.	Per cent. of smut.
74	Untreated.....	587	61	10.4
75	Calcium sulphide, (?) per cent, ($\frac{1}{2}$ per cent. } sol., but only partially dissolved,) 24 hrs. }	504	3	.6
76	Untreated.....	541	53	9.8
77	Sulphur $\frac{1}{2}$ ounce, oats 2 quarts.....	587	46	8.56
78	Untreated.....	587	68	11.6
79	Sulphur 2 ounces, oats 2 quarts.....	466	24	5.2
80	Untreated.....	552	46	8.3
81	Sulphur 4 ounces, oats 2 quarts.....	467	26	5.6
82	Untreated.....	588	51	8.67
83	Sulphur 8 ounces, oats 2 quarts.....	562	29	5.2
84	Untreated.....	599	49	8.2
85	Sulphur, oats—equal bulk.....	259	12	4.6
86	Sulphur in excess.....	817	30	3.67

THE POTASSIUM SULPHIDE TREATMENT.

The results shown in the above tabulation leave no doubt as to the efficacy of the potassium sulphide treatment. No injurious effect on the seed was noticed. The direction for the treatment practically as given in Bulletin No. 15, p. 129, might be recommended, which is as follows:

“One pound of the potassium sulphide (liver of sulphur) should be dissolved in 20 gallons of water. Place the seed in a wooden vessel and pour on the solution till the seed is covered several inches deep. Stir the solution before pouring it on the grain and thoroughly mix the seed several times before taking the latter out of the solution. The oats should stand in the solution 24 hours, after which they may be spread out to dry.

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

A shorter treatment, however, will be effectual, and in that case the grain will be more easily dried for planting with a drill. Therefore, use at least two pounds to twenty gallons of water and soak only over night, or from morning till evening.

EXPERIMENTS IN REGARD TO THE EXTRA INCREASE IN YIELD.

By replacing the smutted heads of oats we should expect an increase in the yield to an amount equal to that destroyed by smut. But we actually find a *much greater* increase.* For the purpose of re-determining the accuracy as to this extra increase, six different treatments (see tabulation) of

*See Kas. Exp. Sta II An. Rep., p. 248, Bulletin No. 15, p. 127, and Bulletin No. 21, p.48.

the seed were employed and forty-three plots were planted side by side. Each treatment was therefore repeated five times and untreated plots were between each set of the treated plots. Any effect due to the inequalities of the soil should be by the repetitions neutralized.

The land used was in the previous year planted to sorghum; before 1890 it had been in native grass and never cultivated. The oats was planted with a drill. The seed treated with potassium sulphide was still considerably swollen, and hence a smaller quantity per acre passed through the drill. The season was very favorable, and the yield very good. On account of the rains, the harvesting was delayed until the oats were over-ripe. Many grains, therefore, were lost in subsequent handling. The following tabulation shows the details of the treatment and yield:

GENERAL TABULATION OF OAT-SMUT YIELD EXPERIMENTS.

No.	Treatment.	Weight of grain, in lbs.	Weight of straw, in lbs.
1	Untreated	32½	94½
2	Hot water, 143½ deg. F., 5 minutes.....	40	101
3	Hot water, 134½ deg. F., 10 minutes.....	41	108½
4	Hot water, 134½ deg. F., 3½ minutes; previously soaked 3 hrs..	39½	103½
5	Hot water, 132½ deg. F., 15 minutes.....	39	108½
6	Hot water, 132½ deg. F., 10 minutes; not cooled.....	41	113½
7	Potassium sulphide, ½ per cent. solution, 24 hours	36	109
8	Untreated	34½	107
9	Hot water, 143½ deg. F., 5 minutes.....	38½	100
10	Hot water, 134½ deg. F., 10 minutes.....	41½	111½
11	Hot water, 134½ deg. F., 3½ minutes; previously soaked 3 hrs..	41½	109
12	Hot water, 132½ deg. F., 15 minutes.....	41	103
13	Hot water, 132½ deg. F., 10 minutes; not cooled	43	121½
14	Potassium sulphide, ½ per cent. solution, 24 hours	37½	117½
15	Untreated	39½	110½
16	Hot water, 143½ deg. F., 5 minutes.....	48	104½
17	Hot water, 134½ deg. F., 10 minutes.....	41	96½
18	Hot water, 134½ deg. F., 3½ minutes; previously soaked 3 hrs..	50	102½
19	Hot water, 132½ deg. F., 15 minutes.....	47½	107½
20	Hot water, 132½ deg. F., 10 minutes; not cooled.....	46½	103½
21	Potassium sulphide, ½ per cent. solution, 24 hours	47½	108½
22	Untreated	42	104
23	Hot water, 143½ deg. F., 5 minutes.....	51	101½

GENERAL TABULATION OF OAT-SMUT YIELD EXPERIMENTS—*Concluded.*

No.	Treatment.	Weight of grain, in lbs.	Weight of straw, in lbs.
24	Hot water, 134½ deg. F., 10 minutes.....	53	110
25	Hot water, 134½ deg. F., 3½ minutes; previously soaked 3 hrs..	44½	103½
26	Hot water, 132½ deg. F., 15 minutes.....	48½	108
27	Hot water, 132½ deg. F., 10 minutes; not cooled.....	47	113½
28	Potassium sulphide, ½ per cent. solution, 24 hours.....	44	107
29	Untreated.....	40	99
30	Hot water, 143½ deg. F., 5 minutes.....	45	96
31	Hot water, 134½ deg. F., 10 minutes.....	48	101
32	Hot water, 134½ deg. F., 3½ minutes; previously soaked 3 hrs..	43½	92½
33	Hot water, 132½ deg. F., 15 minutes.....	41½	90½
34	Hot water, 132½ deg. F., 10 minutes; not cooled.....	48	96½
35	Potassium sulphide, ½ per cent. solution, 24 hours.....	38½	83½
36	Untreated.....	37	82½
37	Hot water, 143½ deg. F., 5 minutes.....	42	80½
38	Hot water, 134½ deg. F., 10 minutes.....	41½	82
39	Hot water, 134½ deg. F., 3½ minutes; previously soaked 3 hrs..	40	82½
40	Hot water, 132½ deg. F., 15 minutes.....	39	80½
41	Hot water, 132½ deg. F., 10 minutes; not cooled.....	49	98½
42	Potassium sulphide, ½ per cent. solution, 24 hours.....	46½	93½
43	Untreated.....	39½	81½

SUMMARY TABULATION OF OAT-SMUT YIELD EXPERIMENTS.

TREATMENT—SIX PLOTS OF EACH.	ACTUAL YIELD OF PLOTS.		CALCULATED YIELD PER ACRE.	
	Grain, bus.	Straw, lbs.	Grain, bus.	Straw, lbs.
Untreated.....	7.10	227.14	53.10	5090.63
Hot water, 143½ deg. F., 5 minutes.....	8.24	264.50	62.10	4372.47
Hot water, 134½ deg. F., 10 minutes.....	8.31	266	62.10	4569.30
Hot water, 134½ deg. F., 3½ minutes; pre- viously soaked 3 hours.....	8.09	259	60.75	4449.38
Hot water, 132½ deg. F., 15 minutes.....	8.01	256.50	60.30	4483.13
Hot water, 132½ deg. F., 10 min.; not cooled,	8.58	274.50	64.35	4850.55
Potassium sulphide, ½ per cent. sol., 24 hrs.,	7.81	250	*58.50	4565.70

* The seed being damp and swollen, a smaller quantity per acre was drilled.

AMOUNT OF SMUT IN THE PLOTS.

Counts were made of a large number of heads at random in the different plots, and it was found that in the untreated plots there was 5.75 per cent. of smut. In the treated plots, not a single head of smut was found.

GAIN BY TREATING THE SEED.

It can be seen that by merely replacing the smutted portion with sound grain, there is a *gain of 6.11 per cent.* But this series of experiments shows that there is an actual gain equal to *twice or even three times that amount.*

This is shown in tabular form, as follows :

The per cent. of gain for the average of the treated plots is 15.53 per cent.

The percent. of gain for each treatment is as follows:

	Per cent.
Hot water, 143½ deg. F., 5 minutes..	16.76
Hot water, 134½ deg. F., 10 minutes..	16.76
Hot water, 134½ deg. F., 3 ¼ minutes; previously soaked 3 hours..	14.40
Hot water, 132½ deg. F., 15 minutes.	13.56
Hot water, 132½ deg. F., 10 minutes; not cooled..	21.18
Potassium sulphide, 1/2 per cent. sol., 24 hours..	10.17
Average	15.53

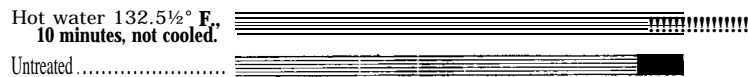
The following table shows the yield in convenient form for comparison with the yield of the smutted plots, and with what it *should be* by merely replacing the smut with sound grain:

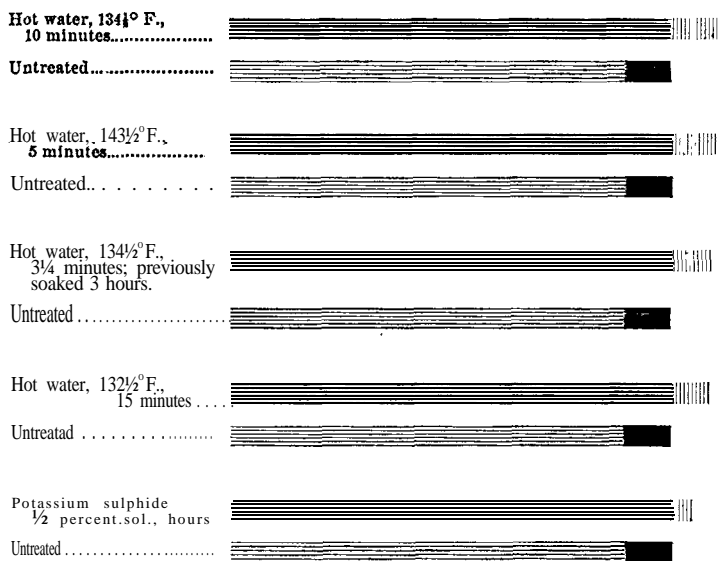
	Bushels.
Actual yield of smutted oats (5¾ per cent. smutted).	53.10
Yield if smutted heads were replaced by sound ones..	56.35
Actual yield from treated seed:	
Hot water, 143½ deg. F., 5 minutes..	62.10
Hot water, 134½ deg. F., 10 minutes..	62.10
Hot water, 134½ deg. F., 3¼ minutes; previously soaked 3 hours.	60.75
Hot water, 132½ deg. F., 15 minutes..	60.30
Hot water, 132½ deg. F., 10 minutes; not cooled..	64.35
Potassium sulphide, 4 per cent. solution, 24 hours..	58.50

Re-writing the above to show the *extra* increase, *i.e.*, the increase beyond that which would result from merely replacing the smutted heads with sound ones, we have as follows:

	Bushels.
Hot water, 143½ deg. F., 5 minutes, gave an <i>extra</i> increase of..	5.75
Hot water, 134½ deg. F., 10 minutes, gave an <i>extra</i> increase of:	5.75
Hot water, 134½ deg. F., 3¼ minutes, previously soaked 3 hours, gave an <i>extra</i> increase of:	4.40
Hot water, 132½ deg. F., 15 minutes, gave an <i>extra</i> increase of..	3.95
Hot water, 132½ deg. F., 10 minutes, not cooled, gave an <i>extra</i> increase of.	8.00
Potassium sulphide, ½ per cent. solution, 24 hours, gave an <i>extra</i> increase of.	2.15

The above *extra* increase is graphically represented as follows (that giving the largest increase first) :





NOTE.—Each one twenty-fourth inch in length equals one bushel; the vertically-ruled portion shows the amount of extra increase.

PRACTICAL SUMMARY.

The potassium sulphide (liver of sulphur) treatment is thoroughly effectual, and may be used in a weak solution (say one pound to twenty gallons of water), in which soak the seed twenty-four hours; or it may be used in a solution twice as strong, allowing the seed to remain in it only ten or twelve hours.

The yield of oats, when treated with hot water or potassium sulphide to prevent smut, is increased, not simply by an amount which equals the portion destroyed by smut, but by at least twice that amount.

II.--TEST OF FUNGICIDES TO PREVENT LOOSE SMUT OF WHEAT.

In the Second Annual Report of this Station (1889), pp. 261-267, was given a full account of the loose smut of wheat--*Ustilago Tritici* (Pers.) Jensen--under the divisions of historical synonymy, injuries to host plants, geographical distribution, characters of the smut, germination in water, germination in solution, and prevention, accompanied by plates showing the appearance of smutted heads, and the germination of the spores. No portion of this need here be reproduced, except that stated under the last head, which was as follows:

PREVENTION.¹

On this point little is recorded. Plowright says:² "There is a certain point in connection with the reproduction of smut (*U. segetum*) wherein it differs essentially

¹Second An. Rep. Exp. Sta. Kas. State Agr. Col., 1889, p. 267. ²C. B. Plowright. British Uredineæ and Ustilagineæ, p. 102.

from bunt (*T. Tritici*); it is this—that however carefully wheat may be dressed with cupric sulphate, arsenic, brine, lime, etc., while such dressing almost absolutely protects the crops from bunt, yet it has no appreciable effect on the smut. This fact is obvious to anyone residing in an agricultural district. The wheats are dressed for bunt on every well managed farm, but they are as much affected with smut as the barley and oat crops, which latter, never being affected with bunt, are never subjected to protective dressing.”

It is, however, very probable that the form of treatment recommended for oats may be applied with similar results to wheat. It has been proved that such treatment will completely prevent the stinking smut (*Tilletia*).

It will be seen from the above that no successful treatments have been made in preventing this form of smut. It will also be noticed that it was a mere assumption that the hot-water method would likely prove effectual. The tabulation of experiments below shows fully the facts in the case, so far as determined by the experiments of one season.

AMOUNT OF LOOSE SMUT IN 1891.

The loose smut of wheat was this season more abundant in the plots of the Farm Department than usual. Actual counts were made in many cases, as shown in the table below.

TABLE SHOWING AMOUNT OF LOOSE SMUT OF WHEAT IN 1891.

Varieties.	Heads counted.	Heads smutted	Per cent. smutted.
Bearded Monarch (Ohio), College farm	1480	76	5.14
Big English (Ohio), College farm.	1526	43	2.82
Buckeye (Kansas), College farm	1343	16	1.19
Crate (Ohio), College farm	1295	22	1.70
Hicks (Ohio), College farm	1522	89	5.85
Sheriff (Ohio), College farm	1147	184	16.04
Currell's Prolific (Ohio), College farm	928	0	0
Deitz (Ohio), College farm	768	0	0
Egyptian (Ohio), College farm	1143	13	1.14
Farquhar (Ohio), College farm	1172	9	.77
Geneva, College farm	1573	118	7.50
German Emperor (Ohio), College farm	1220	58	4.75
Golden Prolific (Ohio), College farm	1075	14	1.30
Hungarian (Ohio), College farm	1297	60	4.63
Surprise (Ohio), College farm	1236	19	1.54
Miller (Maryland), College farm	1048	1	.10
Arnold's Hybrid (Kansas), College farm	1194	0	0
Badger (Kansas), College farm	1339	2	.15

TABLE SHOWING AMOUNT OF LOOSE SMUT OF WHEAT IN 1891-*Concluded.*

Varieties.	Heads counted.	Heads smutted.	Per cent. smutted.
Democrat (Ohio), College farm	1310	5	.38
Diehl-Mediterranean (Ohio), College farm.....	1345	15	1.12
Ebersole, College farm	1198	0	0
Extra Early Oakley (Kansas), College farm.....	1141	0	0
Finley (Ohio), College farm	1147	1	.09
Fulcaster (Ohio), College farm	1138	0	0
Turkey, College farm	1536	11	.72
Field on J. M. Kimball's farm	1585	7	.44

Unfortunately for the result of the experiment, but little smut was found in the untreated plots. A repetition of the experiment might be of more significance, provided seed from fields with a high percentage of smut could be used. At present there seems to be insufficient ground for recommending that the farmer employ the Jensen hot-water treatment, or any other fungicide, to prevent loose smut of wheat.

By an unfortunate loss or misplacement of some of the labels, we are unable to give the treatments *individually* for plots 8, 10, 14, 20, 22, and 28, but the results are nevertheless of much interest, and we therefore venture to retain them in the tabulation. The treatment used in case of the plots referred to, marked in the tabulation "label lost," are as follows:

- Copper sulphate, 3/8 per cent. solution, 24 hours; limed.
- Copper sulphate, method of Kühn.
- Copper sulphate, 1 per cent. solution, 24 hours; not limed.
- Bordeaux mixture, 12 hours.
- One-half strength Bordeaux mixture, 24 hours.
- Potassium bichromate, 5 per cent solution, 24 hours.
- Potassium bichromate, 2 1/2 per cent. solution, 24 hours.
- Potassium bichromate, 1 per cent. solution, 24 hours.
- Eau celeste, 1/2 strength, 24 hours.
- Corrosive sublimate, 1/10 per cent. solution, 24 hours.
- Corrosive sublimate, 1/20 per cent. solution, 24 hours.
- Copper nitrate, 1/2 per cent. solution, 24 hours; limed.
- Copper nitrate, 1 per cent. solution, 24 hours; not limed.
- Verdigris, 1/2 per cent. solution, 24 hours; limed.
- Verdigris, 1 per cent. solution, 24 hours; not limed.
- Copper chloride, 1 per cent. solution, 24 hours.

The labels for plots 34, 36, 38, 44, 46, 50, 54, 56, 58, 60, 62, 64, 66, 70, 72, 74, 78, 80 and 82 were also lost, but the definite order in the arrangement of the hot-water treatments enables us to write them in correctly.

TABULATION OF EXPERIMENTS IN PREVENTING LOOSE SMUT OF WHEAT IN 1891.

No.	TREATMENT.	ACTUAL YIELD PER PLOT.						WEIGHT IN POUNDS.			CALCULATED YIELD PER ACRE.				
		Total heads.	Smutted heads.	Per cent. smutted.	Grain.	Straw.		Grain.	Sound.	Smutted.	Total.	Grain.	Sound.	Smutted.	Total.
						Sound.	Smutted.								
1	Untreated.....	2886	15	.53	3.77	7.41	.05	7.46	43.99	5187	35	5222			
2	Bordeaux mixture, full strength, 24 hours.....	1950	24	1.23	2.62	7.62	.07	7.69	30.56	5334	49	5383			
3	Untreated.....	2869	20	.84	3.22	6.87	.06	6.93	37.57	4809	42	4851			
4	Bordeaux mixture, $\frac{1}{2}$ copper, full lime, 24 hours.....	2187	11	.51	3.82	5.37	.08	5.40	44.56	3759	21	3781			
5	Untreated.....	1647	19	1.15	2.74	5.29	.06	5.35	31.97	3703	42	3745			
6	Eau celeste, 24 hours.....	2813	9	.39	3.42	6.67	.02	6.59	39.90	4599	14	4613			
7	Untreated.....	2273	18	.79	3.61	6.40	.06	6.46	42.12	4480	42	4522			
8	(Label lost).....	1093	0	0	1.47	2.94	0	2.94	17.15	2058	0	2058			
9	Untreated.....	2531	13	.51	3.09	6.99	.04	7.03	36.05	4893	28	4921			
10	(Label lost).....	2133	1	.05	2.56	5.79	.....	5.79	29.86	4053	.....	4053			
11	Untreated.....	2247	27	1.20	2.99	6.05	.07	6.12	33.95	4235	49	4284			
12	Potassium bichromate, 5 per cent. sol., 24 hours.....	393	0	0	.46	.97	0	.97	5.87	679	0	679			
13	Untreated.....	2360	27	1.14	3.61	7.42	.09	7.51	42.12	5194	63	5257			
14	(Label lost).....	1148	0	0	1.45	3.40	0	3.40	16.42	2380	0	2380			
15	Untreated.....	2708	12	.44	3.57	7.51	.04	7.55	41.65	5257	28	5285			
16	Potassium bichromate, 1 per cent. sol., 24 hours.....	1256	8	.64	2.52	3.25	.02	3.27	29.39	2275	14	2289			

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TEST OF FUNGICIDES.

17	Untreated.....	2461	23	.93	3.79	7.48	.05	7.53	44.22	5236	35	5271
18	Copper nitrate, 1 per cent. sol., 24 hours.....	1000	6	.38	2.44	4.97	.02	4.99	28.46	3479	14	3493
19	Untreated.....	2303	16	.73	3.98	6.51	.04	6.55	46.43	4557	28	4585
20	(Label lost).....	1633	5	.31	2.36	5.61	.01	5.62	27.53	3927	7	3934
21	Untreated.....	2012	25	1.24	2.62	5.16	.08	5.24	30.56	3612	56	3668
22	(Label lost).....	1399	2	.14	2.18	4.88	.....	4.88	25.43	3416	.....	3416
23	Untreated.....	2302	18	.78	3.14	6.68	.05	6.73	36.63	4676	85	4711
24	Copper sulphate, $\frac{1}{2}$ per cent. sol., 24 hours.....	1562	13	.83	2.49	5.43	.04	2.47	29.05	3601	38	3629
25	Untreated.....	2304	17	.74	3.28	6.77	.04	6.81	38.27	4739	28	4767
26	Copper chloride, 1 per cent. sol., 24 hours.....	852	0	0	.85	2.37	0	2.37	9.91	1659	0	1659
27	Untreated.....	2457	36	1.47	3.14	7.19	.11	7.30	36.63	5033	77	5110
28	(Label lost).....	2132	16	.75	2.89	6.81	.04	6.85	33.71	4767	23	4795
29	Untreated.....	2315	17	.74	3.06	7.02	.04	7.06	35.70	4914	28	4942
30	Mercurio chloride, $\frac{1}{2}$ per cent. sol., 24 hours.....	2209	28	1.27	3.23	2.18	.11	2.29	37.68	1526	77	1603
31	Untreated.....	2536	14	.55	3.32	6.95	.05	7.00	33.73	4865	35	4900
32	Ward's seed manure, 1 per cent. sol., 24 hours.....	1875	2	.11	2.87	5.06	.....	5.06	33.48	3542	.....	3542
33	Untreated.....	1485	21	1.41	2.58	5.07	.06	5.13	30.09	3549	42	3591
34	Hot water, 138 deg. F., 10 min.; cooled.....	984	14	1.42	1.52	4.01	.04	4.05	17.73	2807	28	2835
35	Untreated.....	2038	18	.88	3.43	7.54	.06	7.60	40.02	5278	42	5320
36	Hot water, 138 deg. F., 5 min.; cooled; prev. soaked.....	145	0	0	.11	.47	0	.47	1.28	329	0	329
37	Untreated.....	1675	15	.90	2.53	5.39	.06	5.45	29.51	3778	42	3815
38	Hot water, 138 deg. F., 5 min.; cooled.....	1366	10	.73	2.24	5.69	.04	5.73	26.13	3933	28	4011

TABLATION OF EXPERIMENTS IN PREVENTING LOOSE SHUT OF WHEAT IN 1891.—Continued.

No.	TREATMENT.	ACTUAL YIELD PER PLOT.					CALCULATED YIELD PER ACRE.					
		Total heads.	Smutted heads.	Per cent. smutted.	Grain.		Grain.	Straw.		Total.		
					Sound.	Smutted.		Sound.	Smutted.			
39	Untreated.....	1637	13	.79	2.84	6.48	.04	6.52	33.13	4536	28	4564
40	Hot water, 137 deg. F., 5 min.; previously soaked.....	406	0	0	.38	1.54	0	1.54	4.43	1078	0	1078
41	Untreated.....	1617	14	.87	2.55	5.83	.06	5.89	29.74	4081	42	4123
42	Hot water, 136 deg. F., 10 min.; cooled.....	1300	12	.92	1.70	4.31	.04	4.35	19.84	3017	28	3045
48	Untreated.....	1774	22	1.24	2.68	5.96	.06	6.02	31.26	4172	42	4214
44	Hot water, 136 deg. F., 5 min.; cooled; prev. soaked.....	695	0	0	.79	3.10	0	3.10	9.22	2170	0	2170
45	Untreated.....	1667	21	1.26	2.60	6.06	.07	6.13	30.33	4242	49	4291
46	Hot water, 136 deg. F., 5 min.; cooled.....	1358	11	.81	2.11	5.02	.05	5.07	24.61	3514	35	3549
47	Untreated.....	1603	17	1.06	2.50	5.73	.05	5.78	29.16	4011	35	4046
48	Hot water, 135 deg. F., 15 min.; cooled.....	1321	7	.53	1.78	4.76	.03	4.79	20.77	3332	21	3353
49	Untreated.....	1243	11	.88	2.06	4.07	.03	4.10	24.03	2849	21	2870
50	Hot water, 136 deg. F., 10 min.; cooled.....	1033	10	.97	1.69	3.45	.03	3.48	19.72	2415	21	2436
51	Untreated.....	763	7	.91	1.24	2.26	.01	2.27	14.47	1582	7	1589
52	Hot water, 132 deg. F., 5 min.; cooled; prev. soaked.....	1070	4	.37	1.16	4.00	.02	4.02	13.54	2800	14	2814
53	Untreated.....	630	9	1.30	.88	2.39	.08	2.42	10.26	1673	21	1694
54	Hot water, 135 deg. F., 5 min.; cooled.....	1368	22	1.61	2.01	4.97	.07	5.04	23.45	3479	49	3528

55	Untreated.....	1480	21	1.47	1.79	5.32	.06	5.38	20.89	3724	42	3766
56	Hot water, 134 deg. F., 15 min.; cooled.....	1722	0	0	2.90	5.74	0	5.74	33.83	4018	0	4018
57	Untreated.....	1671	19	1.21	2.43	6.00	.07	6.07	28.35	4200	49	4249
58	Hot water, 134 deg. F., 10 min.; cooled.....	1364	21	1.54	2.09	5.00	.06	5.06	24.38	3500	42	3542
59	Untreated.....	1592	18	1.13	2.39	5.97	.04	6.01	27.88	4179	28	4207
60	Hot water, 134 deg. F., 5 min.; cooled; prev. soaked.....	1376	23	1.67	2.28	5.02	.08	5.10	26.60	3514	56	3570
61	Untreated.....	1920	35	1.30	2.82	6.80	.12	6.92	32.89	4760	84	4844
62	Hot water, 134 deg. F., 5 min.; cooled.....	1004	0	0	1.37	3.99	0	3.99	15.99	2793	0	2793
63	Untreated.....	1612	22	1.36	2.65	6.56	.07	6.63	30.91	4592	49	4641
64	Hot water, 133 deg. F., 15 min.; cooled.....	1546	26	1.68	2.73	5.04	.08	5.12	31.85	3528	56	3584
65	Untreated.....	1994	29	1.45	3.01	7.20	.09	7.29	35.12	5040	63	5103
67	Untreated.....	1653	24	1.45	2.07	6.60	.07	6.67	24.15	4620	49	4669
68	Hot water, 133 deg. F., 10 min.....	1513	32	2.12	2.02	5.44	.09	5.53	23.56	3808	63	3871
69	Untreated.....	1497	9	.60	2.29	6.11	.03	6.14	26.71	4277	21	4298
70	Hot water, 133 deg. F., 5 min.; cooled; prev. soaked.....	1025	0	0	.86	3.59	0	3.59	10.03	2513	0	2513
71	Untreated.....	1630	20	1.23	2.24	5.89	.08	5.97	26.13	4123	56	4179
72	Hot water, 133 deg. F., 5 min.; cooled.....	1647	33	2.00	1.99	5.70	.08	5.78	22.72	3990	56	4046
73	Untreated.....	1870	44	2.35	2.48	7.49	.13	7.62	28.93	5243	91	5334
74	Hot water, 132 deg. F., 15 min.; cooled.....	1392	22	1.63	1.77	4.91	.07	4.98	20.66	3437	49	3486
75	Untreated.....	1626	22	1.35	2.14	6.11	.08	6.19	24.96	4277	56	4333
76	Hot water, 132 deg. F., 10 min.; cooled.....	1416	18	1.27	1.98	5.64	.07	5.71	23.10	3948	49	3997
77	Untreated.....	1757	27	1.54	2.57	6.94	.10	7.04	29.98	4858	70	4928

TABULATION OF EXPERIMENTS IN PREVENTING LOOSE SMUT OF WHEAT IN 1891.—Concluded.

No.	TREATMENT.	ACTUAL YIELD PER PLOT.					CALCULATED YIELD PER ACRE.					
		Total heads.	Smutted heads.	Per cent. smutted.	WEIGHT IN POUNDS.			Grain.	Sound.	Smutted.	Total.	
					Grain.	Sound.	Smutted.					
78	Hot water, 132 deg. F., 5 min.; cooled; prev. soaked.....	1065	1	.09	1.17	4.23	.....	4.23	13.65	2961	.....	2961
79	Untreated.....	1600	14	.86	2.14	5.29	.03	5.32	24.96	3703	21	3724
80	Hot water, 132 deg. F., 5 min.; cooled.....	1454	23	1.58	2.18	4.88	.07	4.95	25.43	3416	49	3465
81	Untreated.....	1344	51	3.79	2.10	4.69	.10	4.79	24.50	3283	70	3353
82	Hot water, 131 deg. F., 15 min.; cooled.....	1553	15	.97	1.94	5.81	.06	5.87	22.64	3717	42	3759
83	Untreated.....	1484	9	.63	2.11	5.04	.08	5.07	24.61	3528	21	3549
84	Hot water, 131 deg. F., 10 min.; cooled.....	1379	12	.87	2.57	5.15	.03	5.18	29.98	3605	21	3626
85	Untreated.....	1526	19	1.25	2.23	5.09	.04	5.13	26.01	3563	28	3591
86	Hot water, 131 deg. F., 5 min.; cooled; prev. soaked.....	1216	0	0	1.36	4.07	0	4.07	15.87	2849	0	2849
87	Untreated.....	1672	21	1.34	2.46	5.85	.07	5.92	28.70	4095	49	4144
88	Hot water, 131 deg. F., 5 min.; cooled.....	1613	28	1.74	2.26	5.50	.07	5.57	26.36	3850	49	3899
89	Untreated.....	1331	14	1.05	2.26	5.82	.06	5.88	26.36	4074	42	4116
90	Hot water, 130 deg. F., 15 min.; cooled.....	1511	18	1.19	2.07	5.42	.05	5.47	24.15	3794	35	3829
91	Untreated.....	647	22	1.45	2.09	6.42	.07	6.49	24.88	4494	49	4543
92	Hot water, 130 deg. F., 10 min.; cooled.....	1125	9	.80	1.58	3.86	.03	3.89	18.43	2702	21	2723
93	Untreated.....	798	3	1.64	1.15	2.88	.04	2.92	13.42	1666	28	1694

94	Hot water, 130 deg. F., 5 min.; cooled; prev. soaked.....	170	0	0	.26	1.58	0	1.58	3.03	1106	0	1106
95	Untreated.....	146	0	0	.11	.33	0	.33	1.28	231	0	231
96	Hot water, 130 deg. F., 5 min.; cooled.....	1340	19	1.41	1.13	4.27	.04	4.31	13.19	2989	28	3017
97	Untreated.....	1092	23	2.11	.67	3.36	.05	3.41	7.32	2352	35	2387
98	Hot water, 129 deg. F., 15 min.; cooled.....	995	10	1.01	.56	2.64	.02	2.66	6.53	1848	14	1862
99	Untreated.....	1193	28	2.35	.99	3.06	.06	3.12	11.55	2142	42	2184
100	Hot water, 129 deg. F., 10 min.; cooled.....	1120	37	3.30	1.03	3.26	.08	3.34	12.02	2282	56	2338
101	Untreated.....	1325	22	1.66	1.00	3.96	.05	4.01	11.67	2772	35	2807
102	Hot water, 129 deg. F., 5 min.; cooled; prev. soaked.....	1249	8	.65	1.29	4.22	.01	4.28	15.05	2954	7	2961
103	Untreated.....	1403	16	1.14	1.31	4.64	.05	4.69	15.29	3248	35	3283
104	Hot water, 129 deg. F., 5 min.....	1345	18	1.34	1.49	4.14	.04	4.18	16.33	2898	28	2926
105	Untreated.....	1310	29	2.21	1.62	5.14	.07	5.21	18.90	3598	49	3647
106	Hot water, 127 deg. F., 15 min.....	1068	17	1.59	1.45	3.43	.06	3.49	16.91	2401	42	2443
107	Untreated.....	1273	28	2.20	1.36	4.19	.07	4.26	15.87	2933	49	2982
108	Hot water, 127 deg. F., 10 min.; cooled.....	1015	14	1.38	1.23	3.38	.03	3.41	14.35	2366	21	2387
109	Untreated.....	1306	20	1.53	1.85	4.67	.07	4.74	21.59	3269	49	3318

COMMENT AND CONCLUSION.

No analysis of the above tabulation will be attempted, but cursory examination will show that in but ten of the fifty-four treated, and in one of the untreated, no smut was found. If, now, the individual treatments be consulted, and the amount of smut compared with that of adjacent untreated plots, it will be found that the evidence is very slight in the great majority of cases in favor of the efficacy of the treatment. Finally, if the average percentages of smut in all the treated and all the untreated plots be compared, the difference will be found very small, and under the circumstances, perhaps insignificant. The conclusion may, therefore, be repeated, that no grounds based on actual experiment appear to exist for recommending the treatment of the seed with hot water or any other fungicide.

III.--SPRAYING TO PREVENT WHEAT RUST.

An experiment was undertaken in April, and continued through May, June, and July, 1891, to determine the possibility of preventing red and black rust (*Puccinia*) by the use of fungicides.

For this purpose, two varieties of spring wheat (Feif and Blue-stem), six varieties of barley (Chevallier, Four-rowed, Melon, Saal, Prize Prolific and Algerian), and one variety of oats (Black Winter) were planted in April. The ground used was rich, "second-bench" soil from which, the preceding year, a crop of sorghum was taken. Previous to that time, the land was occupied by native grass, and used for pasturage and hay.

The soil was in good condition for the planting, which was later than is usual in this locality on account of excessive rains. But the seed in all the plots germinated well, and the plants grew vigorously. The favorable condition for growth continued throughout the season.

The fungicides used were as follows:

(S) Sulphur (flowers).

(K₂S) Potassium sulphide, one ounce in three gallons of water.

(FeCl₃) Chloride of iron, one-half ounce in three gallons of water.

(Bor.) Bordeaux mixture.

The plots were one drill in width, and twenty feet long, except the sulphur plots, which were ten feet long. The arrangement of the plots, with

indication of treatment, was as follows:

Barley.			Wheat.		Barley.			Oats.
Un*	Un	Un	Un	Un	Un	Un	Un	Un
S	S	S	S	S	S	S	S	S
Un	Un	Un	Un	Un	Un	Un	Un	Un
K ₂ S	K ₂ S	K ₂ S	K ₂ S	K ₂ S	K ₂ S	K ₂ S	K ₂ S	K ₂ S

*Untreated.

Barley.			Wheat.		Barley.			Oats.
Un	Un	Un	Un	Un	Un	Un	Un	Un
FeCl ₃	FeCl ₃	FeCl ₃	FeCl ₃	FeCl ₃	FeCl ₃	FeCl ₃	FeCl ₃	FeCl ₃
Un	Un	Un	Un	Un	Un	Un	Un	Un
Bor	Bor	Bor	Bor	Bor	Bor	Bor	Bor	Bor
Un	Un	Un	Un	Un	Un	Un	Un	Un

For spraying, Galloway's form of Knapsack Sprayer was used, which gave complete satisfaction. The sulphur was applied by a hand-bellows after spraying the plots with water. The spraying was begun April 21, when the plants were from two to three inches high. Both the iron and potassium sulphide (liver of sulphur) solutions were tried twice the strength above indicated, but the result was injury to the foliage, and consequently it was, after the first spraying, reduced to the strength above given. The times of spraying were as follows:

- 1.-April 21, 1891.
- 2.-April 28; no rain since first spraying.
- 3.-May 5; rain May 2, and a little hail.
- 4.-May 12; rain May 10 and 11.
- 5.-May 19; rain May 16, 17, and 18.
- 6.-May 26; rain almost daily since last spraying.
- 7.-June 2; rain almost daily since last spraying.
- 8.-June 10; rains numerous and plots wet almost all the time since last spraying.
- 9.-June 20; rain June 16 (when plots should have been sprayed), and each day since; discontinued the use of the sulphur.
- 10.-June 27; rains June 26 and 26.
- 11.-July 2; rain previous night.

APPEARANCE OF RUST.

Frequent examinations were made throughout the season of all the plots for rust. None was found on any of the barley plots, though all of them suffered considerably from a species of leaf fungus (*Helminthosporium*).

Some red rust (*Puccinia rubigo-Vera*) was first found on the wheat plots June 8. On June 16, it was found to be very abundant in the same plots; no difference in amount could be detected between the treated and untreated, unless the plots treated with Bordeaux mixture should be excepted. These exhibited a very large amount of the rust, and if less than the others, (which was doubtfully admitted,) yet enough to utterly destroy the crop, and allow no claim of special advantage in consequence of the treatment. On July 2, a careful examination showed that the wheat plots were being damaged by the excessive amount of red rust—neighboring wheat fields were similarly affected. A short time later, a few stalks in each plot put forth heads, but these never ripened. The crop was a complete failure, and

no cause could be seen for it except the violent attack of the rust. The wheat in the neighborhood (winter wheat, which is here exclusively raised) was severely attacked by red rust (*Puccinia rubigo-vera*), yet a very good crop was harvested.

At the time of the last spraying, July 2, the oat plots showed much red rust (*Puccinia coronata*). Adjacent fields of oats were likewise affected. Later examination revealed no difference in the amount of rust in the treated and untreated plots. They were all equally affected.*

Here, as in the wheat plots, the stalks and all the leaves showed an abundance of the red pustules of red rust spores.

CONCLUSION AS TO VALUE OF SPRAYING.

It would seem from the foregoing that the experiment was decisive, and that the assertion could safely be made that spraying with the fungicides above mentioned was absolutely ineffectual. But while these experiments surely indicate the probability at least that such is the fact, it must be remembered that conclusions from a single set of experiments have not that cumulative force that would result from numerous repetitions in different seasons, different localities, etc.

But attention should especially be called to the fact that while the spraying was done usually every eight days (oftener than necessary in spraying for fungous pests generally), the rains were numerous and unusually abundant. These might have sufficiently washed off the fungicides used so as to possibly allow free germination of the spores, and consequent infection of the host plants.

Therefore, since the evidence is negative, similar experiments not before made, and the season in some respects an abnormal one, the conclusions that spraying does not prevent rust must be substantiated by further experimentation.

EFFECT ON YIELD.

To show any possible effect of the spraying on the yield, the following table may be added, of the weight (in pounds) of the grain (together with straw) taken from each of the plots. They are given in the order of their occurrence in the field, beginning on the south side:

	BARLEY			WHEAT			BARLEY		OATS	
	<i>Cheval- lier.</i>	<i>Four- rowed.</i>	<i>Melon.</i>	<i>Blue- stem.</i>	<i>Feif.</i>	<i>Saal.</i>	<i>Prize Prolific.</i>	<i>Al- gerian.</i>	<i>Black Winter.</i>	
Untreated.....	4.66	3.30	2.78	0	0	5.24	4.81	8.23	9 $\frac{3}{4}$	
Sulphur (one-half the size of the other plots)....	3.37	4.85	3.22	0	0	6.27	5.37	6.12	9	
Untreated.....	9.09	9.05	5.81	0	0	13.40	4.80	11.04	15 $\frac{3}{4}$	
Sulphide of potassium....	6.40	9.09	4.91	0	0	14.56	11.84	13.46	18 $\frac{3}{4}$	

*This should be perhaps modified for the Bordeaux treatment, where there seemed to be, perhaps, a little less rust on the stems than in other plots.

	BARLEY.			WHEAT.		BARLEY.			OATS.
	<i>Cheval- lier.</i>	<i>Four- rowed.</i>	<i>Moont.</i>	<i>Blue stem.</i>	<i>Feif.</i>	<i>Saal.</i>	<i>Prize Prolific.</i>	<i>Al- gerian.</i>	<i>Back Winter.</i>
Untreated	5.75	8.53	4.53	0	0	12.44	8.67	12.78	14½
Chloride of iron	6.47	8.90	5.05	0	0	12.76	9.40	12.22	14¾
Untreated	7.56	8.71	5.47	0	0	12.27	9.87	11.59	15¾
Bordeaux mixture	10.51	10.88	7.91	0	0	15.74	13.11	15.28	16½
Untreated	7.43	10.45	5.56	0	0	5.86	11.28	13.74	18½

GENERAL SUMMARY.

The amount of smut in oats in 1891, in the fields about Manhattan, was 5 3/4 per cent., as shown by actual count.

Potassium sulphide (liver of sulphur) is as effectual in preventing oat smut as the hot-water treatment previously recommended. It can be used at the rate of one pound in twenty gallons of water, the seed to remain in the solution twenty-four hours; or use about twice the amount, and remove the seed at the end of ten or twelve hours.

Treatment of the seed with hot water or with potassium sulphide both prevents the smut and increases the yield. It increases the yield, however, not merely by the amount which equals the grain actually destroyed by the smut, but by at least twice that amount.

The loose smut of wheat was considerable in 1891 in some of the plots on the College farm, in several cases being 5 to 7 per cent., and in one case 16 per cent.

Fifty-four trials with various fungicides did not furnish decisive evidence favorable in any case.

Spraying spring wheat, barley, and oats, with liver of sulphur, chloride of iron, Bordeaux mixture, and flowers of sulphur, did not prevent the red rust.