EXPERIMENT STATION

OF THE

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BOTANICAL DEPARTMENT.

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SECOND REPORT ON FUNGICIDES FOR STINKING SMUT OF WHEAT.*

AN account of preliminary experiments with fungicides for stinking smut of wheat made by this Department was given in Bulletin No. 12, August, 1890. A general account of the figures can there be found, with brief statements as to the amount of damage, growth, and the microscopic characters of the species of fungi causing stinking smut, germination of the spores, names and synonomy of the species, mode of infection of the host plant, followed by the record of experiments of various fungicides–preference being given to the Jensen or hot-water treatment. A repetition of the above need not here be made, but before giving the tabulation for the fungicides used and results obtained this season, some reference will be made to Jensen's experiments, and to our own previously made, in respect to the temperature of the water used and time of immersion, and to the increase in yield over that which should result from merely replacing the smutted heads with sound ones.

TEMPERATURE OF WATER AND DURATION OF IMMERSION.

In experiments made by Mr. J. L. Jensen,† of Copenhagen, Denmark, it was found that an immersion of infected seed wheat in water at 54 °C. (129.2 °F.) for five minutes prevented the stinking smut. By examining

*The assistance of Mr. G. K. Thompson, student of the Kansas Agricultural College, who aided in preparing this Bulletin, is hereby gratefully acknowledged. Mr. W. T. Swingle, formerly assistant botanist, assisted until May 1, 1891, and to him I also express my sincere thanks.

† INDUSTRIALIST , Manhattan, Kansas, Vol. XVI, No. 35, p. 137.

the reports of our experiments made in 1890,* it will be seen that an immersion of 132°-131° F. fifteen minutes did not kill quite all of the smut. We therefore recommended an immersion of fifteen minutes' duration in water a little over 132° F. (56° C.)

The discrepancy between our experiments and those of Mr. Jensen can be explained only partially by the discovery that we have since made, namely, that the centigrade thermometer we used was not quite correct. It was recently tested by Prof. Nichols, of the Kansas Agricultural College, who found that the reading was a varying fraction of a degree too high throughout the scale. Making the necessary correction, we change the 56° C., or over 132½° F., to a small fraction over 131° F., or a trifle over 55° C. It will be seen, therefore, that the discrepancy is still considerable: the time of immersion advised by him being five minutes, and by us fifteen minutes; the temperature of the water advised by him 54° C. (129.2° F.), and by us 55° C. (131° F.)

Our experiments with oat smut corresponded in respect to the point in question quite closely, though the plots treated in water at temperatures of 56°, 55° and 54° C. were not sufficiently numerous and varied as to time of immersion to be of fully decisive nature. However, our correction for the recommendation as to treatment of infected seed oats is practically the same as above given for wheat, namely: Change 56° C. (about 132½° F.), to 55° C. (131° F)

The difference in results obtained by Mr. Jensen and ourselves may possibly be apparent instead of real. He says,† referring to his treatments for bunt (stinking smut): "All these treatments prevented the bunt satisfactorily, in the practical sense of the word; some few heads with bunt remained in all cases." But it will be noticed that we have insisted that all the smut, not in the "practical," but in the *absolute* sense of the word, be entirely prevented.

EXTRA INCREASE IN YIELD.

It was found in our experiments in 1889‡ that in case of a certain plot of oats of the hot-water treatment, the yield was much greater than would be expected from merely replacing the smutted heads with sound ones. Jensen found a similar increase in case of barley and of oats in the same year. See also, as to increased yield of straw in treated plots and amount of damage from smut, in Bulletin 15 of this Experiment Station, December, 1890, pp. 119 and 127. By examining the extended tabulation which follows, it will be seen that in many cases the yield of the plots planted with seed treated with the Jensen hot-water method was much greater than would be expected by merely replacing the smutted heads (the amount of which is indicated in the adjacent untreated plots) by sound ones.

* Bulletin No. 15, p. 34.
† INDUSTRIALIST, 1. o.
‡ Bulletin 8, p. 96, Oct., 1889, and II. An. Rep., p. 126.

A graphic representation of eighteen plots that gave such increase is also given. This extra increase is plainly due to treatment of the seed, but whether it is the increased percentage in germination or increased vigor of the plants is not determined. It is a gain that should be borne in mind when a farmer calculates the expense of treating the seed.

FIELD EXPERIMENTS.

The ground used in the field experiments was upland soil at the old College farm, which was used the previous season in experimenting with fungicides to prevent oat smut. The plots were each one four-hundredth of an acre in extent, and every alternate plot was untreated.

The ground was in good condition at seeding time. The germination was good, and the plants grew well, except in those cases where the treatment injured the seed.

PREPARATION OF THE SEED.

The seed used was artificially smutted. It was placed in a box, and a large quantity of more or less broken smutted grain added, and the whole was thoroughly stirred with hoe and shovel till the grains were black with smut. Without further preparation, this was used for the alternate untreated plots. By inspecting the following table, it will be seen that the variation in amount of smut of these plots is enormous, and the reason for it is not fully known; yet the fact that all the untreated plots were planted with the drill successively may account for at least some of the variation, since the smutted grains are of much less specific gravity than the sound ones, and would be sown in greater abundance the nearer the seed-box was empty.

In treating the seed with the various solutions and with hot water, as indicated in the tabulation, the floating smutted grains were all skimmed off.

TABULATION OF RESULTS.

The following tabulation shows the details of the experiments, the results, and the calculated yield per acre:

TABULATION OF EXPERIMENTS IN PREVENTING STINKING SMUT OF WHEAT, IN 1891.

No.	TREATMENT.	ACTUAL YIELD PER PLOT.								CALCULATED YIELD PER ACRE.				
		Total heads.	*Smutted heads.*	*Per cent. smutted.*	*Grain, pounds.*		*Straw, pounds.*		*Total straw, pounds.*	*Grain, bushels.*		*Straw, pounds.*		*Total straw, pounds.*
					Sound.	Smutted.	Sound.	Smutted.		Sound.	Smutted.	Sound.	Smutted.	
1	Untreated	2309	155	6.71	2.22	.05	5.39	.26	5.65	14.80	.33	2156	104	2260
2	Bordeaux mixture, full strength, 24 hours	1208	7	.58	.92	.01	2.85	.....	2.85	6.13	.07	1140	.....	1140
3	Untreated	3117	118	3.79	3.13	.03	8.84	.21	9.05	20.87	.20	3536	84	3620
4	Bordeaux mixture, ½ copper, (full lime,) 24 hours	2879	0	0	2.69	0	7.68	0	7.68	17.93	0	3072	0	3072
5	Untreated	3685	99	2.69	3.17	.01	7.73	.13	7.86	21.13	.07	3092	52	3144
6	Eau Celeste, 24 hours	2600	2	08	2.34	.....	5.85	.....	5.85	15.60	.....	2340	.....	2340
7	Untreated	3500	44	1.26	2.58	.02	7.31	.07	7.38	17.19	.13	2924	28	2952
8	Copper sulphate, 1 per cent. sol, 24 hours,	2470	0	0	2.47	0	6.21	0	6.21	16.47	0	2484	0	2484
9	Untreated	3775	73	1.93	3.09	.02	8.04	.28	8.32	20.60	.13	3216	112	3328
10	Copper sulphate, ½ per cent. sol, 24 hours, limed	3237	0	0	3.21	0	8.45	0	8.45	21.40	0	3380	0	3304
11	Untreated	3963	203	5.12	3.79	.03	9.99	.28	10.27	25.27	.20	3996	112	4108
12	Copper sulphate, ½ per cent. sol., 24 hours, limed	4222	0	0	4.87	0	11.47	0	11.47	32.47	0	4588	0	4588
13	Untreated	4007	190	4.74	4.48	.01	10.42	.27	10.69	29.87	.07	4168	108	4276
14	Copper sulphate, ½ per cent. sol., 12 hours, limed	4124	0	0	4.49	0	10.60	0	10 60	29 94	0	4240	0	4240
15	Untreated	4190	293	6.99	4.44	.01	9 90	.40	10.30	29 61	.27	3960	160	1120
16	Copper acetate, 1 per cent. sol, 24 hours	728	0	0	.38	0	1.87	0	1.87	2 53	0	748	0	748
17	Untreated	3814	169	4.43	3.86	.02	8.82	.26	9.08	25.73	13	3528	104	3632

18	Copper acetate, ½ per cent. sol., 24 hours..	3282	0	0	4.53	0	9.99	0	9.99	30.21	0	3996	0	3996
19	Untreated	3976	265	6.67	3.82	.03	8.92	2.79	11.71	25.46	.20	3568	1116	4684
20	Copper nitrate, 1 per cent. sol., 24 hours..	2900	0	0	3.89	0	8.07	0	8.07	25.93	0	3328	0	3328
21	Untreated	3748	346	9.23	3.79	.04	7.70	.40	8.10	25.27	.27	3080	160	3240
22	Copper nitrate, ½ per cent. sol., 24 hours..	3030	0	0	3.97	0	8.15	0	8.15	26.60	0	3260	0	3260
23	Untreated	3534	283	8.01	3.09	.03	7.19	.40	7.59	20.60	.20	2876	160	3036
24	Copper chloride, 1 per cent. sol., 24 hours.	2229	0	0	2.60	0	5.30	0	5.30	17.33	0	2120	0	2120
25	Untreated	3112	270	8.68	2.98	.04	6.98	.35	7.33	19.87	.27	2792	140	2932
26	Mercuric chloride, $\frac{1}{10}$ per cent. sol., 24 hrs.,	2570	113	4.40	2.67	.02	6.29	.19	6.48	17.80	.13	2516	76	2592
27	Untreated	3075	417	13.56	2.92	.05	6.60	.55	7.15	19.46	.33	2640	220	2860
28	Mercuric chloride, $\frac{1}{20}$ per cent. sol., 24 hrs.,	3691	4	.11	3.96	.01	8.57	.....	8.57	26.40	.07	3428	.....	3428
29	Untreated	3387	420	12.40	2.90	.07	5.97	.54	6.51	19.33	.47	2388	216	2604
30	Potassium bichromate, 5 per cent. sol., 24 hours	600	0	0	.37	0	1.19	0	1.19	2.47	0	476	0	476
31	Untreated	2611	251	9.61	2.19	.03	4.75	2.95	7.70	14.60	.20	1900	1180	2480
32	Potassium bichromate, 2½ per cent. sol., 24 hours	520	0	0	.50	0	1.17	0	1.17	3.34	0	468	0	468
33	Untreated	2788	347	12.45	2.05	.04	4.08	.30	4.38	13.66	.27	1632	120	1752
34	Potassium bichromate, 1 per cent. sol., 24 hours	1055	0	0	.10	0	2.31	0	2.31	.67	0	924	0	924
35	Untreated	2965	364	12.28	2.38	.06	5.05	.39	5.44	15.86	.40	2020	156	2176
36	Hot water, 138 deg. F., 15 min.; cooled *...	574	0	0	.26	0	.95	0	.95	1.73	0	380	0	380
37	Untreated	2570	287	11.17	2.20	.02	3.92	.29	4.21	14.66	.13	1568	116	1684
38	Hot water, 138 deg. F., 10 min.; cooled....	1130	0	0	1.03	0	2.54	0	2.54	6.85	0	1016	0	1016
39	Untreated	2705	270	9.98	2.26	.03	5.06	.31	5.37	15.06	.20	2024	124	2148

* In water of ordinary summer temperature unless otherwise stated.

TABULATION OF EXPERIMENTS IN PREVENTING STINKING SMUT OF WHEAT, IN 1891—*Continued.*

No.	TREATMENT.	ACTUAL YIELD PER PLOT.								CALCULATED YIELD PER ACRE.				
		Total heads.	*Smutted heads.*	*Per cent. smutted.*	*Grain, pounds.*		*Straw, pounds.*		*Total straw, pounds.*	*Grain, bushels.*		*Straw, pounds.*		*Total straw, pounds.*
					Sound.	Smutted.	Sound.	Smutted.		Sound.	Smutted.	Sound.	Smutted.	
40	Hot water, 138 deg. F., 10 min.; cooled in ice-salt mixture	809	0	0	.67	0	1.70	0	1.70	4.47	0	680	0	680
41	Untreated	2475	88	3.56	2.70	.01	6.00	.17	6.17	18.00	.07	2400	68	2468
42	Hot water, 138 deg. F., 10 min.; cooled in 10 per cent. $CuSO_4$ sol.	1500	0	0	1.77	0	4.52	0	4.52	11.78	0	1808	0	1808
43	Untreated	4168	215	5.16	4.03	.02	8.56	.26	8.82	26.87	.13	3424	104	3528
44	Hot water, 138 deg. F., 5 min.; cooled in 10 per cent. $CuSO_4$ sol.	2700	0	0	3.72	0	7.86	0	7.86	24.80	0	3144	0	3144
45	Untreated	3645	152	4.17	3.43	.04	8.06	.22	8.28	22.87	.27	3224	88	3312
46	Hot water, 138 deg. F., 5 min.; cooled	2254	0	0	3.05	0	5.85	0	5.85	19.31	0	2340	0	2340
47	Untreated	3100	106	3.42	2.86	.01	6.60	.16	6.76	19.06	.07	2640	64	2704
48	Hot water, 137 deg. F., 10 min.; cooled in 10 per cent. $CuSO_4$ sol.	1450	0	0	1.48	0	3.58	0	3.58	9.85	0	1432	0	1432
49	Untreated	3450	4	.12	3.55	.03	8.08	.....	8.08	23.67	.20	3232	.....	3232
50	Hot water, 137 deg. F., 5 min.; cooled; previously soaked 10 hrs.	73	0	0	.01	0	.17	0	.17	.07	0	68	0	68
51	Untreated	3935	286	7.27	3.23	.03	7.32	.39	7.71	21.53	.20	2928	156	3084
52	Hot water, 137 deg. F., 5 min.; cooled	3350	0	0	3.82	0	8.05	0	8.05	25.46	0	3220	0	3220
53	Untreated	3582	265	7.58	3.10	.04	6.71	.35	7.06	20.67	.27	2684	140	2824
54	Hot water, 136 deg. F., 10 min.; cooled	1596	0	0	2.05	0	4.16	0	4.16	13.66	0	1664	0	1664
55	Untreated	3445	243	7.05	2.88	.02	6.78	.33	7.11	19.19	.13	2712	132	2844

56	Hot water, 136 deg. F., 10 min.; cooled in ice-salt mixture	1331	0	0	1.35	0	3.36	0	3.36	8.98	0	1344	0	1344
57	Untreated	3394	251	7.40	3.68	.04	7.31	.31	7.62	24.53	.27	2924	124	3048
58	Hot water, 137 deg. F., 10 min.; cooled in 10 per cent. $CuSO_4$ sol.	275	0	0	.07	0	.43	0	.43	.47	0	172	0	172
59	Untreated	3317	324	9.77	4.01	.04	5.44	.46	5.90	26.74	.27	2176	184	2360
60	Hot water, 136 deg. F., 5 min.; cooled	3045	0	0	3.60	0	7.14	0	7.14	24.00	0	2856	0	2856
61	Untreated	3551	337	9.60	3.06	.04	6.04	.45	6.49	20.40	.27	2416	180	2596
62	Hot water, 135 deg. F., 15 min.; cooled	1010	0	0	.59	0	1.94	0	1.94	3.94	0	776	0	776
63	Untreated	2525	200	7.92	2.29	.02	4.68	.20	4.88	15.26	.13	1872	80	1952
64	Hot water, 135 deg. F., 10 min.; cooled in ice-salt mixture	1429	0	0	1.47	0	3.26	0	3.26	9.79	0	1304	0	1304
65	Untreated	3425	373	10.89	3.64	.04	7.47	.57	8.04	24.27	.27	2988	228	3216
66	Hot water, 135 deg. F., 10 min.; cooled in 10 per cent. $CuSO_4$ sol.	2254	0	0	2.94	0	6.12	0	6.12	19.59	0	2448	0	2448
67	Untreated	3405	425	12.48	2.93	.09	6.38	.67	7.05	19.53	.60	2552	268	3820
68	Hot water, 135 deg. F., 10 min.; cooled	2574	0	0	3.41	0	5.77	0	5.77	22.74	0	2308	0	2308
69	Untreated	3504	389	11.10	2.89	.04	5.67	.42	6.09	19.26	.27	2268	168	2436
70	Hot water, 135 deg. F., 5 min.; cooled; previously soaked 10 hours	565	0	0	.39	0	1.08	0	1.08	2.60	0	432	0	432
71	Untreated	2907	372	12.80	2.17	.04	6.64	.36	7.00	14.47	.27	2656	144	2400
72	Hot water, 134 deg. F., 10 min.; cooled	953	0	0	.69	0	1.39	0	1.39	4.60	0	556	0	456
73	Untreated	1670	163	9.76	1.36	.01	2.47	.15	2.62	9.05	.07	788	60	1048
74	Hot water, 134 deg. F., 10 min., cooled in ice-salt mixture	682	0	0	.73	0	1.46	0	1.46	4.87	0	584	0	584
75	Untreated	2200	250	12.36	1.54	.03	3.01	.21	3.22	10.25	.20	1204	84	1288
76	Hot water, 134 deg. F., 5 min.; cooled; previously soaked 10 hours	240	0	0	.12	0	.33	0	.33	.80	0	132	0	132
77	Untreated	1274	52	4.08	.85	0	1.87	.04	1.91	5.66	0	748	16	764

TABULATION OF EXPERIMENTS IN PREVENTING STINKING SMUT OF WHEAT, IN 1891—*Continued.*

No.	TREATMENT.	ACTUAL YIELD PER PLOT.								CALCULATED YIELD PER ACRE.				
		Total heads.	*Smutted heads.*	*Per cent. smutted.*	*Grain, pounds.*		*Straw, pounds.*		*Total straw, pounds.*	*Grain, bushels.*		*Straw, pounds.*		*Total straw, pounds.*
					Sound.	Smutted.	Sound.	Smutted.		Sound.	Smutted.	Sound.	Smutted.	
79	Untreated	3472	542	15.61	2.75	.08	5.76	.65	6.41	18.33	.53	2304	260	2564
80	Hot water, 134 deg. F., 10 min.; cooled in 10 per cent. $CuSO_4$ sol	2000	0	0	2.46	0	5.31	0	5.31	16.40	0	2124	0	2124
81	Untreated	4456	815	18.29	3.67	.06	8.48	1.20	9.68	24.47	.40	3392	480	3872
82	Hot water, 133 deg. F., 10 min; cooled in 10 per cent. $CuSO_4$ sol	2655	0	0	3.26	0	6.88	0	6.88	21.73	0	2752	0	2752
83	Untreated	3310	550	16.62	2.68	.07	5.51	.74	6.25	17.86	.47	2204	296	2500
84	Hot water, 133 deg. F., 10 min.; cooled in ice-salt mixture	1726	8	.46	2.86	.01	4 41	.01	4.42	19 06	.07	1764	4	1768
85	Untreated	3308	669	20.22	2.43	.06	4.72	.76	5.48	16.20	.40	1888	304	2200
86	Hot water, 138 deg. F., 5 min.; cooled; previously soaked 10 hours	16	0	0	.....	0	.05	0	.05	.....	0	20	0	20
87	Untreated	3569	1005	28.16	2.42	.12	4.98	1.12	6.00	16.13	.80	1992	448	2440
88	Hot water, 137 deg. F., 15 min.; cooled	1947	16	.82	2.94	.01	5.49	.03	5.52	19.59	.07	2196	12	2208
89	Untreated	3770	841	22.44	2.69	.12	6.15	1.10	7.25	17.93	.80	2460	440	2900
90	Hot water, 137 deg. F., 10 min.; cooled	2976	6	.20	4.07	.....	8.05	.01	8.06	27.14	.....	3220	4	4104
91	Untreated	3853	905	23.49	2.53	.09	5.41	1.12	6.53	16.87	.60	2164	448	2512
92	Hot water, 136 deg. F., 15 min.; cooled	2004	2	.10	2.83	.....	4.88	.....	4.88	18.86	.....	1952	.....	1952
93	Untreated	2897	1118	38.59	1.88	.15	3.56	1.32	4.88	12 51	1.00	1424	528	1952
94	Hot water, 137 deg. F., 10 min.; cooled in ice-salt mixture	1220	0	0	1.89	0	3.75	0	3 75	12.58	0	1500	0	1500
95	Untreated	2958	708	23 94	1.94	.05	3 94	61	4 55	12.91	33	1576	244	1820

96	Hot water, 136 deg. F., 10 min.; cooled....	2324	0	0	3.01	0	6.22	0	6.22	20.07	0	2488	0	2488
97	Untreated.....	2908	729	25.07	1.95	.09	4.21	.92	5.13	13.00	.60	1684	368	2052
98	Hot water, 135 deg. F., 5 min.; cooled.....	3185	5	.16	3.20	.....	6.08	.01	6.09	21.33	.....	2432	4	2432
99	Untreated.....	2668	693	25.98	2.12	.10	4.18	.83	5.01	14.20	.67	1672	332	2004
100	Hot water, 134 deg. F., 15 min.; cooled....	2947	10	.33	3.55	.01	6.64	.02	6.66	23.67	.07	2656	8	2664
101	Untreated.....	3965	994	25.07	3.02	.15	6.07	1.30	7.37	20.13	1.00	2428	520	2948
102	Hot water, 134 deg. F., 5 min.; cooled.....	3450	4	.12	3.58	.....	6.53	.....	6.53	23.87	.....	2612	.....	2612
103	Untreated.....	4118	929	23.12	2.86	.08	5.55	1.13	6.68	19.06	.53	2220	452	2672
104	Hot water, 133 deg. F., 15 min.; cooled.....	2465	4	.16	3.26	.....	6.74	.01	6.75	21.73	.....	2696	4	2696
105	Untreated.....	3660	1258	34.37	2.86	.15	5.75	1.75	7.50	19.06	1.00	2300	700	3000
106	Hot water, 133 deg. F., 10 min.; cooled....	2873	1	.03	3.21	.....	6.30	.01	6.31	21.40	.....	2520	4	2520
107	Untreated.....	4378	978	22.59	3.03	.15	5.59	1.34	6.93	20.20	1.00	2236	536	2772
108	Hot water, 133 deg. F., 5 min.; cooled.....	4061	4	.10	4.55	.....	8.10	.....	8.10	30.34	.....	3240	.....	3240
109	Untreated.....	4525	1000	22.10	3.14	.15	6.27	1.50	7.77	20.93	1.00	2508	600	3108
110	Hot water, 133 deg. F., 5 min.; cooled; previously soaked 10 hours.....	2007	0	0	2.49	0	4.82	0	4.82	16.60	0	1928	0	1928
111	Untreated.....	3421	647	18.91	3.47	.10	6.07	.90	6.97	23.14	.67	2428	360	2788
112	Hot water, 132 deg. F., 15 min.; cooled	2244	0	0	2.86	0	4.88	0	4.88	19.06	0	1952	0	1952
113	Untreated.....	3624	1150	31.73	2.90	.16	5.19	1.53	6.72	19.33	1.07	2076	612	2688
114	Copper sulphate, 1 per cent. sol, 24 hours.....	2420	0	0	3.71	0	6.00	0	6.00	24.73	0	2400	0	2400
115	Untreated.....	3400	1233	36.26	2.70	.27	4.71	1.58	6.29	18.00	1.80	1884	632	2516
116	Copper sulphate, ½ per cent. sol., 24 hours, limed.....	2780	0	0	3.79	0	6.80	0	6.80	25.27	0	2720	0	2720
117	Untreated.....	4048	3322	82.07	.88	.85	1.75	4.18	5.93	5.86	5.65	700	1672	2372

TABULATION OF EXPERIMENTS IN PREVENTING SMUT OF WHEAT, IN 1891—*Continued.*

No.	TREATMENT.	ACTUAL YIELD PER PLOT.								CALCULATED YIELD PER ACRE.				
		Total heads.	*Smutted heads.*	*Per cent. smutted.*	*Grain, pounds.*		*Straw, Pounds.*		*Total straw, pounds.*	*Grain, bushels.*		*Straw, pounds.*		*Total straw, pounds.*
					Sound.	Smutted.	Sound.	Smutted.		Sound.	Smutted.	Sound.	Smutted.	
118	Ward-seed manure, 1 per cent. sol., 24 hours	3044	308	10.12	3.68	.05	6.73	.42	7.15	24.53	.33	2692	168	2860
119	Untreated	4003	2938	73.39	1.32	.66	2.01	3.88	5.89	8.78	4.39	804	1553	2356
120	Ward-seed manure, ½ per cent. sol., 24 hours	4208	1005	23.88	3.87	.17	6.60	1.18	7.78	25.80	1.13	2640	472	3112
121	Untreated	4670	3400	72.81	1.33	.86	2.92	4.60	7.52	8.85	5.72	1168	1840	3008
122	Hot water, 132 deg. F., 10 min.; cooled in $CuSO_4$ sol.	3274	8	.24	3.65	.....	7.62	.01	7.63	24.33	.....	3048	4	3048
123	Untreated	5123	1003	19.58	1.04	.91	2.02	5.67	7.69	6.92	6.05	808	2268	3076
124	Hot water, 132 deg. F., 10 min.; cooled in ice-salt mixture	2619	29	1.11	3.17	.01	7.28	.03	7.31	21.13	.07	2912	12	2924
125	Untreated	5120	3932	76.80	1.29	.95	2.44	5.40	7.84	8.58	6.32	976	2160	3136
126	Hot water, 132 deg. F., 10 min.; cooled	4124	40	.97	4.20	.....	8.89	.04	8.93	28.00	.....	3556	16	3612
127	Untreated	5669	4604	81.21	1.06	.95	2.31	6.06	8.37	7.05	6.32	924	2424	3348
128	Hot water, 132 deg. F., 5 min.; cooled; previously soaked 10 hours	3453	86	2.49	3.98	.02	8 66	.13	8.79	26 53	13	3464	52	3516
129	Untreated	5000	3967	79.34	1.19	.82	2.25	4.65	6.90	7.92	5.45	900	1860	2760
130	Hot water, 132 deg. F., 5 min.; cooled; previously soaked 10 hours†	3000	34	1.13	3.97	.01	7.44	.05	7.49	26.46	07	2976	20	2996
131	Untreated	4585	3548	77.38	1.16	.68	2.22	4.40	6.62	7.72	4 52	888	1760	2648
132	Hot water, 132 deg. F., 5 min.; cooled	3365	6	.18	4.55	.....	8.05	.....	8.05	30.34	.....	3220	.....	3220
133	Untreated	4721	3642	77.14	1.36	.96	2.30	4.96	7.26	9.05	6.39	920	1984	2904

	Hot water, 131 deg. F., 15 min.; cooled..	4240	21	.50	5.62	.....	9.47	.02	9.49	37.46	.....	3788	8	3796
135	Untreated.....	4500	3360	74.67	1.14	.68	2.42	5.17	7.59	7.58	4.52	968	2068	3036
136	Hot water, 131 deg. F., 10 min.; cooled..	4146	23	.55	4.62	.01	8.36	.03	8.39	30.80	.07	3344	12	3356
137	Untreated.....	4322	1106	25.59	1.20	.82	2.63	4.36	6.99	7.98	5.45	1052	1744	2796
138	Hot water, 131 deg. F., 5 min.; cooled; previously soaked 10 hours.....	2895	72	2.49	3.64	.03	6.49	.69	7.17	24.27	.20	2592	276	2868
139	Untreated.....	4092	2953	72.41	1.30	.53	2.81	4.32	8.13	8.65	3.53	1124	1728	2852
140	Hot water, 131 deg. F., 5 min.; cooled...	4419	0	0	5.23	0	9.30	0	9.30	34.90	0	3720	0	3720
141	Untreated.....	4751	3457	72.76	1.47	.68	2.60	4.51	7.11	9.79	4.52	1040	1804	2844
142	Hot water, 130 deg. F., 15 min.; cooled..	3525	3	.09	4.32	.....	6.98	.01	6.99	28.80	.....	2792	4	2796
143	Untreated.....	3570	2366	66.27	1.46	.67	2.58	3.06	5.64	9.72	4.46	1032	1224	2256
144	Hot water, 130 deg. F., 10 min.; cooled in ice-salt mixture....	2025	0	0	2.32	0	4.73	0	4.73	15.46	0	1892	0	1892
145	Untreated.....	3587	1368	38.14	2.23	.13	4.78	1.64	6.42	14.86	.87	1912	656	2568
146	Hot water, 130 deg. F., 10 min ; cooled in ice-salt mixture.....	1725	2	.12	1.80	.01	3.76	.01	3.77	11.98	.07	1504	4	1508
147	Untreated.....	3502	1134	32.39	2.29	.45	5.03	1.55	6.58	15.26	2.99	2012	620	2632
148	Hot water, 130 deg. F., 10 min.; cooled..	2085	9	.43	3.32	.....	6.48	.....	6.48	22.13	.....	2592	.....	2592
149	Untreated.....	3806	2904	76.25	.99	.59	4.96	2.13	7.09	6.60	3.93	1984	852	2836
150	Hot water, 130 deg. F., 5 min.; cooled; previously soaked 10 hours.....	3425	72	2.10	3.78	.03	7.39	.08	7.47	25.20	.20	2956	32	2988
151	Untreated.....	3480	2572	73.91	1.07	.72	2.01	4.24	6.25	7.12	4.79	804	1696	2500
152	Hot water, 130 deg. F.; cooled.....	3240	15	.46	3.85	.01	6.55	.01	6.56	25.66	.07	2620	4	2624
153	Untreated.....	3812	3162	82.95	.84	.67	1.60	4.42	6.02	5.61	4.46	640	1768	2408
154	Hot water, 129 deg. F., 15 min.; cooled..	3200	0	0	4.37	0	7.88	0	7.88	29.14	0	3152	0	3152
155	Untreated.....	4423	3647	82.46	1.25	.89	1.25	5.00	6.25	8.32	5.92	500	2000	2500

† Duplicate treatment of Plot 128.

TABULATION OF EXPERIMENTS IN PREVENTING STINKING SMUT OF WHEAT, IN 1891—*Concluded.*

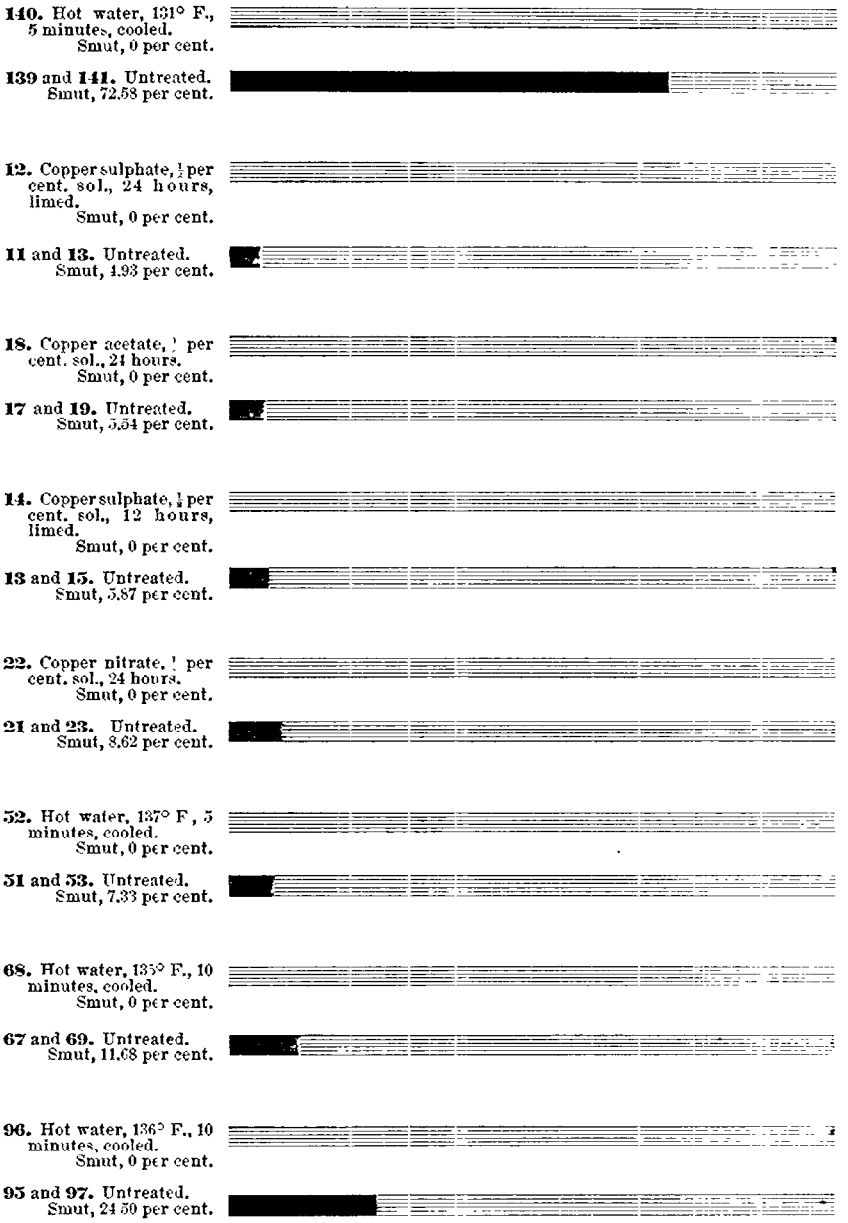
No.	TREATMENT.	ACTUAL YIELD PER PLOT.								CALCULATED YIELD PER ACRE.				
		Total heads.	*Smutted heads.*	*Per cent. smutted.*	*Grain, pounds.*		*Straw, pounds.*		*Total straw, pounds.*	*Grain, bushels.*		*Straw, pounds.*		*Total straw, pounds.*
					Sound.	Smutted.	Sound.	Smutted.		Sound.	Smutted.	Sound.	Smutted.	
156	Hot water, 129 deg. F., 10 min.; cooled in 10 per cent. $CuSO_4$ sol.	3550	0	0	4.04	0	8.38	0	8.38	26.94	0	3352	0	3352
157	Untreated.	4252	3481	81.87	.91	.97	1.65	5.98	7.63	6.06	6.45	660	2392	3052
158	Hot water, 129 deg. F., 10 min.; cooled in ice-salt mixture.	2250	13	.58	3.40	.02	5.76	.02	5.78	22.67	.13	2304	8	2312
159	Untreated.	4516	3612	79.98	1.08	.76	1.77	4.95	6.72	7.18	5.06	708	1980	2688
160	Hot water, 129 deg. F., 10 min.; cooled.‡	3655	4	.11	4.14	.....	9.88	.03	9.91	27.60	.....	3952	12	4504
161	Untreated.	4740	3963	83.61	1.08	.94	2.01	5.22	7 23	7.18	6 25	804	2088	2892
162	Hot water, 126 deg. F., 5 min.; cooled; previously soaked 10 hours.	3171	154	1.13	3.87	.04	7.22	.19	7.41	25 80	.27	2888	76	2964
163	Untreated.	4572	3856	84.34	.69	.96	1.53	5.13	6.66	4.60	6.39	612	2052	2664
164	Hot water, 129 deg. F., 5 min.; cooled...	3858	11	.29	4.11	.... .	7.40	.02	7.42	27.40	.....	2960	8	2968
165	Untreated.	4460	3668	82.24	.91	.82	1.98	4.32	6.30	6.06	5.45	792	1728	2520
166	Hot water, 128 deg. F., 10 min.; cooled...	3216	18	.56	3.85	.01	6.58	.01	6.59	25.66	.07	2632	4	2636
167	Untreated.	4018	2876	71.58	1.18	.74	2.28	3.72	6.00	7.85	4.92	912	1488	2400
168	Hot water, 128 deg. F., 10 min.; cooled in 10 per cent. $Cu\,SO_4$ sol.	2274	0	0	2 75	0	5.27	0	5.27	18.33	0	2108	0	2108
169	Untreated.	3971	2585	65.10	1.64	.10	3.06	3.56	6.62	10.92	.67	1224	1424	2648
170	Hot water, 128 deg. F., 10 min.; cooled in ice-salt mixture	3020	2	.07	3 54	.....	7 35	....	7 35	23 60	....	2940	.	2940
171	Untreated	3442	2466	71.64	1 14	.64	1.84	2.72	4.56	7 58	4.26	736	1088	1824
172	Hot water, 128 deg. F., 10 min.; cooled...	3625	0	0	4.05	0	7.54	0	7 54	27.00	0	3016	0	3016

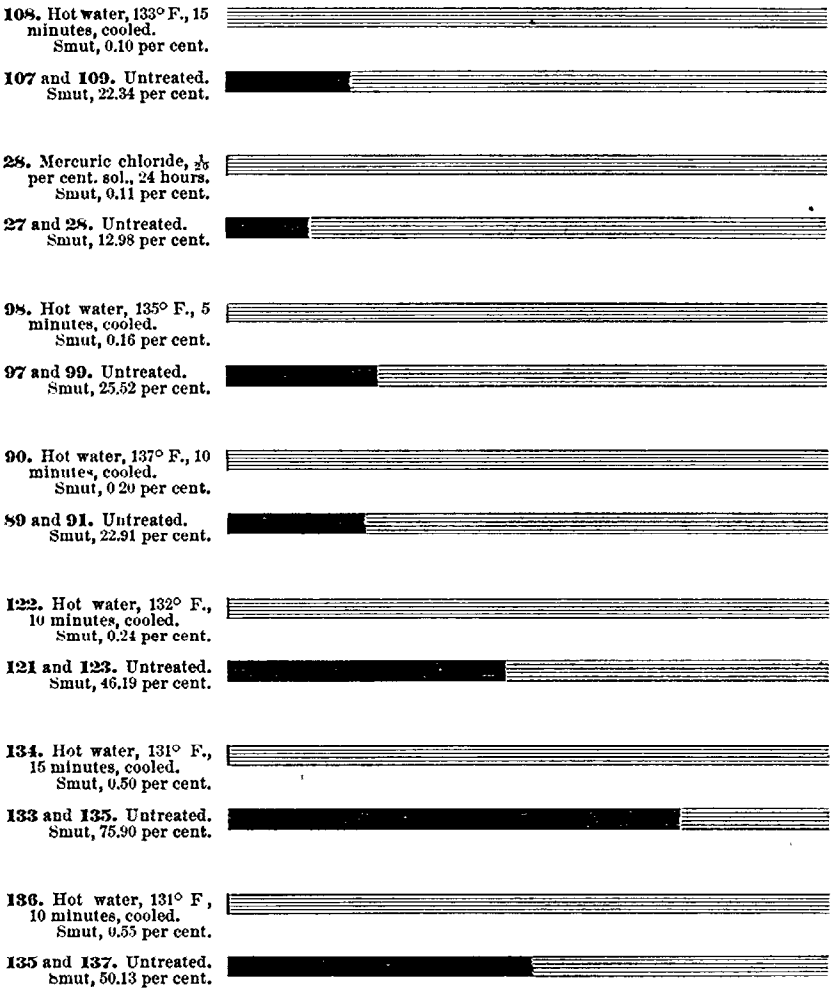
173	Untreated	4386	3495	79.68	1.11	1.01	1.78	4.41	6.19	7.38	6.72	712	1764	2476
174	Hot water, 128 deg. F., 5 min.; cooled; previously soaked 10 hours	3080	2	.06	3.80	.....	6.18	.....	6.18	25.33	.....	2472	.....	2472
175	Untreated	2448	1760	71.90	.69	.43	1.52	2.16	3.68	4.60	2.86	608	864	1472
176	Hot water, 128 deg. F., 5 min.; cooled	2961	14	.47	2.97	.01	5.35	.01	5.36	19.86	.07	2140	4	2140
177	Untreated	3650	2912	79.78	.69	.53	1.74	3.88	5.62	4.60	3.53	696	1552	2248
178	Hot water, 127 deg. F., 15 min.; cooled	3138	2	.06	2.88	.....	5.49	.....	5.49	19.19	.....	2196	.....	2196
179	Untreated	4360	3685	84.52	.79	.82	1.53	5.09	6.62	5.27	5.45	612	2036	2648
180	Hot water, 127 deg. F., 10 min; cooled in ice-salt mixture	1743	34	1.95	2.85	.02	5.04	.05	5.09	18.99	.13	2016	20	2036
181	Untreated	3231	2158	66.79	1.49	.58	2.42	3.50	5.92	9.92	3.86	968	1400	2368
182	Hot water, 127 deg. F., 10 min.; cooled in 10 per cent. $CuSO_4$ sol.	2047	0	0	2.77	0	5.83	0	5.83	18.46	0	2332	0	2332
183	Untreated	3303	2664	80.65	1.09	.74	2.02	3.74	5.76	7.25	4.92	808	1496	2304
184	Hot water, 127 deg. F., 10 min.; cooled	3758	7	.19	4.16	.....	7.89	.01	7.90	27.74	.....	3156	4	3160
185	Untreated	3820	2644	69.21	1.43	.47	2.59	3.85	6.44	9.52	3.13	1036	1540	2576
186	Hot water, 127 deg. F., 5 min.; cooled	2708	8	.22	3.64	.....	5.93	.....	5.93	24.27	.....	2372	.....	2372
187	Untreated	2655	1918	72.24	1.01	.63	1.75	2.60	4.35	6.72	4.19	700	1040	1740

‡ The yield for the sound grain in this plot was calculated from the number of heads, the record being lost.

GRAPHIC REPRESENTATION OF MOST SUCCESSFUL TREATMENTS.

The following graphic representation shows the per cent. of smut in the fifteen most successful treatments, the percentage in each being compared with the average of the two adjacent untreated plots:





GRAPHIC REPRESENTATION OF INCREASED YIELD OF TREATED PLOTS.

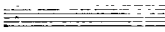
The yields of the twenty-seven best plots are shown graphically in the following table. In each case the first bar represents the yield of the treated plot, and the second bar the average yield of the two adjacent untreated plots. Each one-twelfth inch in length represents the yield of one bushel. All plots giving an increased yield are included, no matter how much smut they contained. The plots are arranged in the order of the yield, the first plot having the greatest increase over the adjacent untreated plots.

134. Hot water, 131° F., 15 minutes, cooled.
Smut, 0.50 per cent.

133 and **135.** Untreated.
Smut, 75.00 per cent.

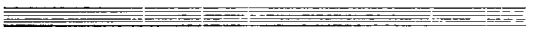
140. Hot water, 130° F., 5 minutes, cooled.
Smut, 0 per cent.

139 and **141.** Untreated.
Smut, 72.58 per cent.



12. Copper sulphate, ½ per cent. sol., 24 hours, limed.
Smut, 0 per cent.

11 and **13.** Untreated.
Smut, 4.93 per cent.



136. Hot water, 131° F., 10 minutes, cooled.
Smut, 0.55 per cent.

135 and **137.** Untreated.
Smut, 50.13 per cent.

108. Hot water, 133° F., 5 minutes, cooled.
Smut, 0.10 per cent.

107 and **109.** Untreated.
Smut, 22.34 per cent.

18. Copper acetate, ½ per cent. sol., 24 hours.
Smut, 0 per cent.

17 and **19.** Untreated.
Smut, 5.54 per cent.

132. Hot water, 132° F., 5 minutes, cooled.
Smut, 0.18 per cent.

131 and **133.** Untreated.
Smut, 77.26 per cent.

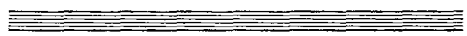
90. Hot water, 131° F., 10 minutes, cooled.
Smut, 0.20 per cent.

89 and **91.** Untreated.
Smut, 22.91 per cent.

154. Hot water, 123° F., 15 minutes, cooled.
Smut, 0 per cent.

153 and **155.** Untreated.
Smut, 82.70 per cent.

142. Hot water, 130° F., 15 minutes, cooled.
Smut, 0.09 per cent.



141 and **143.** Untreated.
Smut, 68.51 per cent.

126. Hot water, 132° F., 10 minutes, cooled.
Smut, 0.97 per cent.

125 and **127.** Untreated.
Smut, 79.00 per cent.

184. Hot water, 127° F., 10 minutes, cooled.
Smut, 0.19 per cent.

183 and **185.** Untreated.
Smut, 26.54 per cent.

164. Hot water, 129° F., 5 minutes, cooled.
Smut, 0.29 per cent.

163 and **165.** Untreated.
Smut. 83.29 per cent.

172. Hot water, 128° F., 10 minutes, cooled.
Smut, 0 per cent.

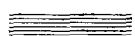
171 and **173.** Untreated.
Smut, 75.67 per cent.

156. Hot water, 129° F., 10 minutes, cooled.
Smut, 0 per cent.

155 and **157.** Untreated.
Smut, 82.16 per cent.

128. Hot water, 132° F., 5 minutes, cooled; previously soaked 10 hours.
Smut, 2.49 per cent.

127 and **129.** Untreated.
Smut, 80.27 per cent.

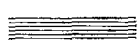


22. Copper nitrate, ½ per cent. sol., 24 hours.
Smut, 0 per cent.

21 and **23.** Untreated.
Smut, 8.62 per cent.

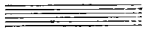
130. Hot water, 132° F., 5 minutes, cooled; previously soaked 10 hours.
Smut, 1.13 per cent.

129 and **131.** Untreated.
Smut, 78.36 per cent.



120. Ward's seed manure, ½ per cent. sol., 24 hours.
Smut, 23 88 per cent.

119 and **121.** Untreated.
Smut, 73.10 per cent.



162. Hot water, 129° F., 5 minutes, cooled; previously soaked 10 hours.
Smut, 4.43 per cent.

161 and **163.** Untreated.
Smut, 83.97 per cent.

28. Mercuric chloride, $\frac{1}{20}$ per cent. sol., 24 hours.
Smut, 0.11 per cent.

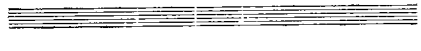
27 and **29.** Untreated
Smut, 12.98 per cent.

152. Hot water, 130° F., 5 minutes, cooled.
Smut, 0 46 per cent.

151 and **153.** Untreated.
Smut, 78.43 per cent.

166. Hot water, 128° F, 15 minutes, cooled.
Smut, 0.56 per cent.

165 and **167.** Untreated.
Smut, 76.91 per cent.



52. Hot water, 137° F., 5 minutes, cooled.
Smut, 0 per cent.

51 and **53.** Untreated.
Smut, 7.33 per cent.

174. Hot water, 128° F, 5 minutes, cooled: previously soaked 10 hours.
Smut, 0.06 per cent.

173 and **175.** Untreated.
Smut, 75.89 per cent.

116. Copper sulphate, $\frac{1}{8}$ per cent. sol., 24 hours, limed.
Smut, 0 per cent.

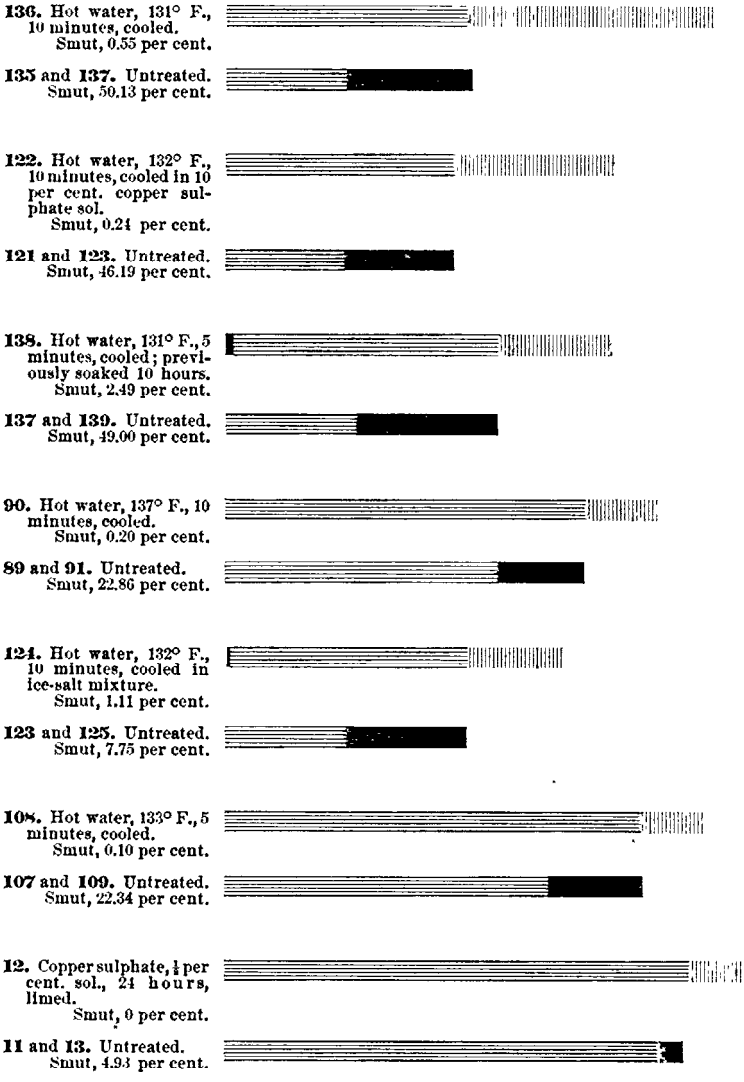
115 and **117.** Untreated.
Smut, 59.16 per cent.

150. Hot water, 130° F., 5 minutes, cooled; previously soaked 10 hours.
Smut, 2.10 per cent.

149 and **151.** Untreated.
Smut, 75 08 per cent.

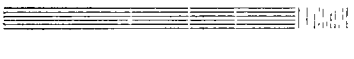
GRAPHIC REPRESENTATION OF EXTRA INCREASE IN YIELD.

The following graphic representation shows the *extra* increase in yield of eighteen treatments*— *i.e.*, the increase beyond that which would result from merely replacing the smutted heads with sound ones. The vertically-ruled portion of the bar represents the *extra* increase. Each one-twelfth inch in length equals one bushel.

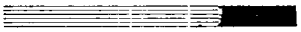


* The other treatments gave no *extra* increase.

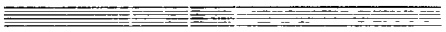
98. Hot water, 135° F., 5 minutes, cooled.
Smut, 0.16 per cent.



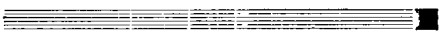
97 and 99. Untreated.
Smut, 25.52 per cent.



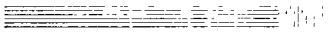
18. Copper acetate, ¼ per cent. sol., 24 hours
Smut, 0 per cent.



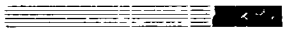
17 and 19. Untreated.
Smut, 5.54 per cent.



96. Hot water, 136° F., 10 minutes, cooled.
Smut, 0 per cent.



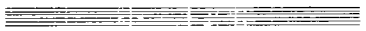
95 and 97. Untreated.
Smut, 24.50 per cent.



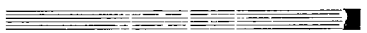
28. Mercuric chloride, ¼ per cent. sol., 24 hours.
Smut, 0.11 per cent.

27 and 29. Untreated.
Smut, 12.98 per cent.

52. Hot water, 137° F., 5 minutes, cooled.
Smut, 0 per cent.



51 and 53. Untreated.
Smut, 7.33 per cent.

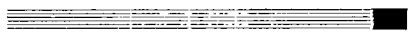


134. Hot water, 131° F., 15 minutes, cooled.
Smut, 0.59 per cent.

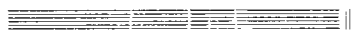
133 and 135. Untreated.
Smut, 75.99 per cent.

22. Copper nitrate, ¼ per cent. sol., 24 hours.
Smut, 0 per cent.

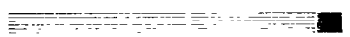
21 and 23. Untreated.
Smut, 8.62 per cent.



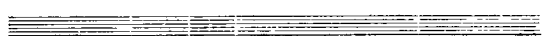
68. Hot water, 135° F., 10 minutes, cooled.
Smut, 0 per cent.



67 and 69. Untreated.
Smut, 11.68 per cent.



140. Hot water, 131° F., 5 minutes, cooled.
Smut, 0 per cent.



139 and 141. Untreated.
Smut, 72.58 per cent.

174 Hot water, 128° F., 5 minutes, cooled.
Smut, 0.06 per cent.

173 and **175**. Untreated.
Smut, 75.80 per cent.

20. Copper nitrate, 1 per cent. sol., 24 hours.
Smut, 0 per cent.

19. and **21**. Untreated.
Smut, 7.94 per cent.

ANALYSIS OF THE TABULATION OF EXPERIMENTS.

I.

The following eighteen treatments destroyed all the smut, and gave a yield of grain greater than the average of the two adjacent untreated plots; eight of them (12, 18, 20, 22, 52, 68, 96, and 140) gave an increase in yield greater than the amount that would result from merely replacing the smutted heads with sound ones:

No. 12, Copper sulphate, ½ per cent. sol., 24 hours; limed.
No. 14, Copper sulphate, ½ per cent,. sol., 12 hours; limed.
No. 18, Copper acetate, ½ per cent. sol., 24 hours.
No. 20, Copper nitrate, 1 per cent. sol., 24 hours.
No. 22, Copper nitrate, ½ per cent. sol., 24 hours.
No. 52, Hot water, 137 deg. F., 5 minutes; cooled.
No. 60, Hot water, 136 deg. F., 5 minutes; cooled.
No. 68, Hot water, 135 deg. F., 10 minutes; cooled.
No. 96, Hot water, 136 deg. F., 10 minutes; cooled,
No. 114, Copper sulphate, 1 per cent. sol., 24 hours.
No. 116, Copper sulphate, ½ per cent,. sol., 24 hours; limed.
No. 140, Hot water, 131 deg. F., 5 minutes; cooled.
No. 144, Hot water, 130 deg. F., 10 minutes; cooled in 10 per cent. sol. $CuSO_4$.
No. 154, Hot water, 129 deg. F., 15 minutes; cooled.
No. 156, Hot water, 129 deg. F., 10 minutes; cooled in 10 per cent. sol. $CuSO_4$.
No. 168, Hot water, 128 deg. F., 10 minutes; cooled in 10 per cent. sol. $CuSO_4$.
No. 172, Hot water, 128 deg. F., 10 minutes; cooled.
No. 182, Hot water, 127 deg. F., 10 minutes; cooled in 10 per cent. sol. $CuSO_4$.

II.

The following twenty-nine treatments decreased the amount of smut to less than 1 per cent., and gave a yield larger than the average of the two adjacent untreated plots; seven of them (28, 90, 98, 108, 122, 134, 136) gave an increase in the yield greater than that which would result from merely replacing the smutted heads with sound ones:

No. 28, Mercuric chloride, $\frac{1}{20}$ per cent. sol., 24 hours.
No. 84, Hot water, 133 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 88, Hot water, 137 deg. F., 15 minutes; cooled.
No. 90, Hot water, 137 deg. F., 10 minutes; cooled.
No. 92, Hot water, 136 deg. F., 15 minutes; cooled.
No. 98 Hot water 135 deg. F. 5 minutes; cooled.
No. 100, Hot water 134 deg. F. 15 minutes cooled.

No. 102, Hot water, 134 deg. F., 5 minutes; cooled.
No. 104, Hot water, 133 deg. F., 15 minutes; cooled.
No. 106, Hot water, 133 deg. F., 10 minutes; cooled.
No. 108, Hot water, 133 deg. F., 5 minutes; cooled.
No. 122, Hot water, 132 deg. F., 10 minutes; cooled in 10 per cent. sol. $CuSo_4$.
No. 126, Hot water, 132 deg. F., 10 minutes; cooled.
No. 132, Hot water, 188 deg. F., 5 minutes; cooled.
No. 134, Hot water, 131 deg. F., 15 minutes; cooled.
No. 136, Hot water, 131 deg. F., 10 minutes; cooled.
No. 142, Hot water, 130 deg. F., 15 minutes; cooled.
No. 148, Hot water, 130 deg. F., 10 minutes; cooled.
No. 152, Hot water, 130 deg. F., 5 minutes; cooled.
No. 158, Hot water, 129 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 160, Hot water, 129 deg. F., 10 minutes: cooled.
No. 164, Hot water, 129 deg. F., 5 minutes; cooled.
No. 166, Hot water, 128 deg. F., 15 minutes; cooled.
No. 170, Hot water, 128 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 174, Hot water, 128 deg. F., 5 minutes; cooled; previously soaked 10 hrs.
No. 176, Hot water, 128 deg. F., 5 minutes; cooled.
No. 178, Hot water, 127 deg. F., 15 minutes; cooled.
No. 184, Hot water, 127 deg. F., 10 minutes; cooled.
No. 186, Hot water, 127 deg. F., 5 minutes; cooled.

III.

The following seven plots had from 1 to 7 per cent. of smutted heads, and yet an increase in yield as compared with the average of the two adjacent untreated plots; two of them (124, 138) gave an increase in yield greater than the amount that would result from merely replacing the smutted heads with sound ones:

No. 124, Hot water, 132 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 128, Hot water, 132 deg. F., 5 minutes, cooled; previously soaked 10 hrs.
No. 130, Hot, water, 132 deg F., 5 minutes, cooled; previously soaked 10 hrs.
No. 138, Hot water, 131 deg. F., 5 minutes, cooled; previously soaked 10 hrs.
No. 150, Hot water, 130 deg. F., 5 minutes, cooled; previously soaked 10 hrs.
No. 162, Hot, water, 129 deg. F., 5 minutes, cooled; previously soaked 10 hrs.
No. 180, Hot water, 127 deg. F., 10 minutes, cooled in ice-salt mixture.

IV.

The following two treatments gave respectively 10.12 per cent. and 23.88 per cent. of smutted heads, but the yield was three times that of the adjacent untreated plots:

No. 118, Ward's seed manure, 1 per cent. solution, 24 hours.
No. 120, Ward's seed manure, ½ per cent. solution, 24 hours.

V.

The following three treatments destroyed all the smut and gave a yield nearly equal to the average of the two adjacent untreated plots:

No. 44, Hot water, 138 deg. F., 5 minutes; cooled in ice-salt mixture.
No. 46, Hot water, 138 deg. F., 5 minutes; cooled.
No. 112, Hot water, 132 deg. F., 15 minutes; cooled.

VI.

The following three treatments had less than 1 per cent. of smutted heads, and gave a yield nearly equal to the average of the two adjacent untreated plots:

No. 6, Ean celeste, 24 hours.
No. 94, Hot water, 137 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 146, Hot water, 130 deg. F., 10 minutes; cooled in ice-salt mixture.

VII.

The following treatment contained over 1 per cent. of smutted heads, and gave a yield nearly equal to the average of the two adjacent untreated plots:

No. 26, Mercuric chloride, $\frac{1}{10}$ per cent. solution, 24 hours.

VIII.

The following treatments either injured, or nearly or quite destroyed the grain, the yield being much less than the average of the two adjacent untreated plots:

(1) Having no smut (27 treatments):

No. 2, Bordeaux mixture (full strength), 24 hours.
No. 4, Bordeaux mixture (half copper, full lime), 24 hours.
No. 8, Copper sulphate, 1 per cent. solution, 24 hours.
No. 10, Copper sulphate, $\frac{3}{8}$ 3/8 per cent. solution, 24 hours, limed.
No. 16, Copper acetate, 1 per cent. solution, 24 hours.
No. 24, Copper chloride, 1 per cent. solution, 24 hours.
No. 30, Potassium bichromate, 5 per cent. solution, 24 hours.
No. 32, Potassium bichromate, 2½ per cent. solution, 24 hours.
No. 34, Potassium bichromate, 1 per cent. solution, 24 hours.
No. 36, Hot water, 138 deg. F., 15 minutes; cooled.
No. 38, Hot water, 138 deg. F., 10 minutes; cooled.
No. 40, Hot water, 138 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 42, Hot water, 138 deg. F., 10 minutes; cooled in 10 per cent. $CuSO_4$ sol.
No. 48, Hot water, 137 deg. F., 10 minutes; cooled in 10 per cent. $CuSO_4$ sol.
No. 54. Hot water, 136 deg. F., 10 minutes; cooled.
No. 56, Hot water, 136 deg. F , 10 minutes; cooled in ice-salt mixture.
No. 58, Hot water, 137 deg. F., 10 minutes; cooled in 10 per cent. $CuSO_4$ sol.
No. 62, Hot water, 135 deg. F., 15 minutes; cooled.
No. 64, Hot water, 135 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 66, Hot water, 135 deg. F., 10 minutes; cooled in 10 per cent. $CuSO_4$ sol.
No. 70, Hot water, 135 deg. F., 5 minutes; cooled; previously soaked 10 hours.
No. 72, Hot water, 134 deg. F.. 10 minutes; cooled.
No. 74, Hot water, 134 deg. F., 10 minutes; cooled in ice-salt mixture.
No. 76, Hot water, 134 deg. F., 5 minutes; cooled; previously soaked 10 hours.
No. 80, Hot water, 134 deg. F., 10 minutes; cooled in 10 per cent. $CuSO_4$ sol.
No. 82, Hot water, 133 deg. F., 10 minutes; cooled in 10 per cent. $CuSO_4$, sol.
No. 110, Hot water, 133 deg. F., 5 minutes; cooled; previously soaked 10 hours.

(2) Destroyed all the grain (2 treatments):

No. 50, Hot water, 137 deg. F., 5 minutes; cooled; previously soaked 10 hours.
No. 86, Hot water, 138 deg. F., 5 minutes; cooled; previously soaked 10 hours.

DIRECTIONS FOR CARRYING OUT THE JENSEN HOT-WATER TREATMENT.

The hot-water treatment consists in immersing the seed which is supposed to be infected with smut, for a few minutes in scalding water. The temperature must be such as to kill the smut spores, and the immersion must not be prolonged so that the heat would injure the germ or embryo concealed within the seed-coats. If the water is at a temperature of 131° F., the spores will be killed, and yet the immersion, if not continued beyond fifteen minutes, will not in the least injure the seed. The smut spores will probably be killed by ten miuutes' immersion. A fifteen-minute immersion, however, is recommended. The temperature must be allowed to vary but little from 131°; in no case rising for an instant higher than 135°, nor falling below 130°. To insure these conditions when treating large quantities of seed, the following suggestions are offered :

Provide two large vessels, as two kettles over a fire, or boilers on a cook-stove; the first containing warm water (say ll0°-120°), the second containing scalding water (131°). The first is for the purpose of warming the seed preparatory to dipping it into the second. Unless this precaution is taken, it will be difficult to keep the water in the second vessel at a proper temperature.

The seed to be treated must previously be placed in a barrel or other large vessel filled with water, and be stirred till all the grains are wetted, and the smutted and imperfect ones rise to the surface. These must be removed by skimming. The grain may remain in the water a few minutes, or even half an hour. Then it must be removed and placed, a half-bushel or more at a time, in a vessel that will allow free entrance and exit of water on all sides.

For this purpose a bushel basket made of heavy wire could be used, over which stretch wire netting, say 12 meshes to the inch; or an iron frame could be made at a trifling cost, over which the wire netting could be stretched. This would allow the water to pass freely, and yet prevent the passage of the seed. A sack made of loosely-woven material (as gunny sack) could perhaps be used instead of the wire basket.

Now dip the basket of seed in the first vessel; after a moment lift it, and when the water has for the most part escaped, plunge it into the water again, repeating the operation several times. The object of the lifting and plunging, to which might be added also a rotary motion, is to bring every grain in contact with the hot water. Less than a minute is required for this preparatory treatment, after which plunge the basket of seed into the second vessel. If the thermometer indicates that the temperature of the water is falling, pour in hot water until it is elevated to 131 deg. If it should rise higher than 131 deg., add small quantities of cold water. This will doubt-

less be the most effectual method of keeping the proper temperature,* and requires only the addition of two small vessels-one for cold and the other for boiling water. The basket of seed should, very shortly after its immersion, be lifted, and then plunged and agitated in the manner described above; and the operation should be repeated eight to ten times during the immersion (which should be continued fifteen minutes). In this way every portion of the seed will be subjected to the action of the scalding water. Immediately after its removal dash cold water over it, or plunge it into a vessel of cold water, and then spread out to dry. Another portion can be treated similarly, and so on till all the seed has been disinfected.

The important precautions to be taken are as follows: 1st. *Maintain the proper temperature* of the water (131 deg. Fahr.), in no case allowing it to rise higher than 135 deg. or to fall below 130 deg. This will not be difficult to do if a reliable thermometer is used and hot or cold water be dipped into the vessel as the falling or rising temperature demands. Immersion fifteen minutes will not then injure the seed. 2d. See that the volume of scalding water is much greater (at least six or eight times) than that of the seed treated at any one time. 3d. Never fill the basket or sack containing the seed entirely full, but always leave room for the grain to move about freely. 4th. Leave the seed in the second vessel of water *fifteen minutes*

SUMMARY CONCLUSION.

The stinking smut of wheat is effectually prevented by treating the seed with water at a temperature of 131 deg. F., 15 minutes. For cheapness as well as for greater efficiency (without injury to seed) this is recommended over all other fungicides. Not only is the yield increased by an amount equal to the portion destroyed by smut, but in nearly all cases there is an *extra increase*, usually much beyond this amount.

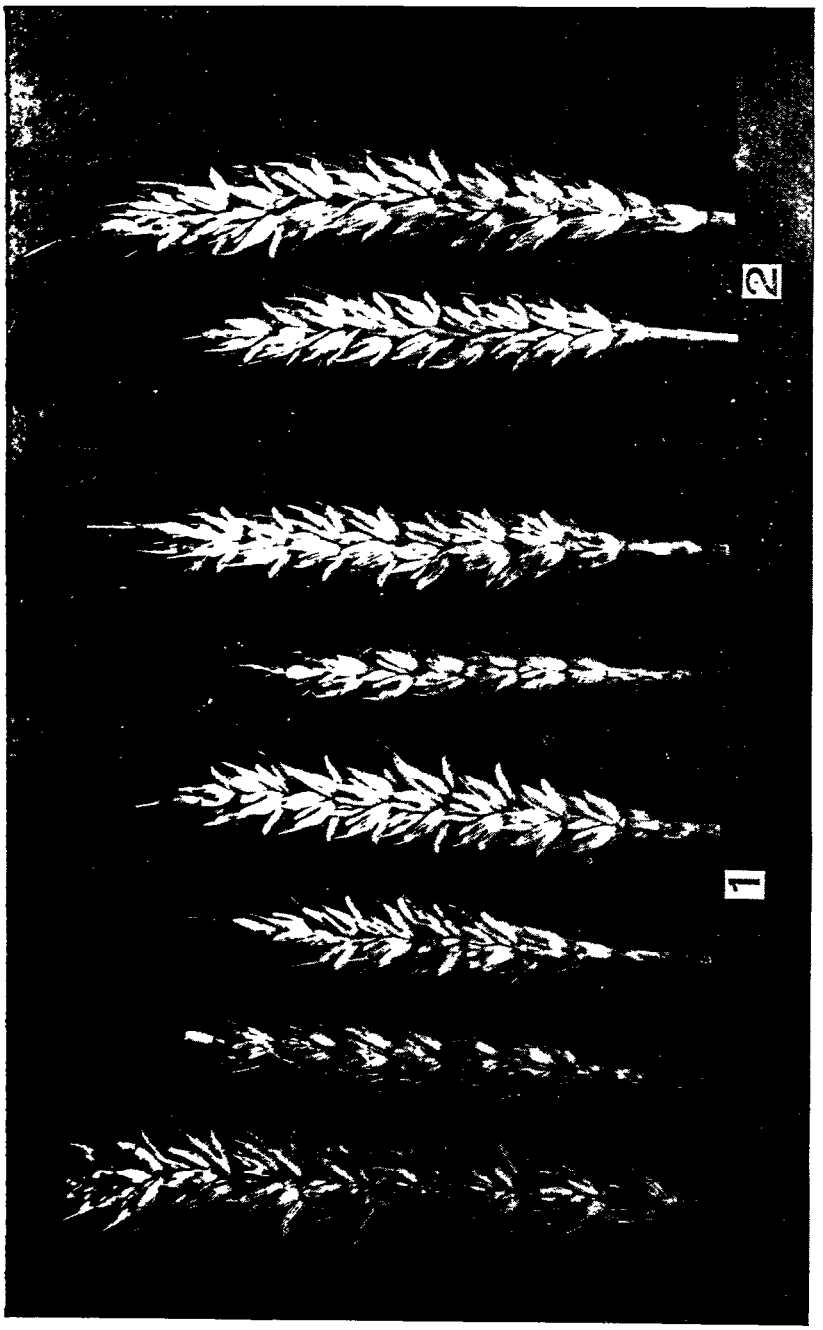
*Steam, conducted into the second vessel by a pipe provided with a stop-cock, answers very well both for heating the water and elevating the temperature from time to time.

EXPLANATION OF PLATE.

PLATE 1. Heads of wheat attacked with stinking smut; engraved from photograph.

No. 1. Seven heads smutted (the chaff somewhat spreading).

No. 2. Two sound heads, for comparison.



SIX HEADS OF WHEAT ATTACKED WITH STINKING SMUT (1), AND TWO SOUND HEADS (2).

Photographed by W. A. Kellerman.