

Proceedings of the Iowa Academy of Science

Volume 2 | Annual Issue

Article 23

1894

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Recommended Citation

Stewart, F. C. (1894) "Effects of Heat on the Germination of Corn and Smut," *Proceedings of the Iowa Academy of Science*, 2(1), 74-78.

Available at: <https://scholarworks.uni.edu/pias/vol2/iss1/23>

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EFFECTS OF HEAT ON THE GERMINATION OF CORN
AND SMUT.

BY F. C. STEWART.

Bunt and smut of oats are successfully combatted by treating the seed with hot water previous to planting. Since the discovery of this method by Jensen, a great many experiments have been made both in Europe and America. The success with bunt and oats smut naturally directed the attention of investigators to hot water treatment for corn smut, but experiments made by Pammel* and others proved it to be ineffectual.

Very few tests have been made to determine the thermal death-points of different smuts. Hoffman and Schindler have tested several economic species. It is evident that nothing can be accomplished by treatment with dry heat, for the corn smut spores are capable of withstanding a much higher temperature than the corn itself. Hence the investigations recorded in this paper may be of little practical importance, but considering that the literature on the subject is exceedingly meager, they may have some interest. Much work has been done in testing hot water and chemicals for other smuts. †

*Iowa Agricultural Experiment Station Bulletin, No. XVI.

†J. Kuehn, Bot. Zeitung, 1873, p. 502.

Kellerman and Swingle, Kansas Agricultural Experiment Station, 1889. Second Annual Report, pp. 213-288. Also Bulletins Nos. 12 and 15.

Kellerman, Kansas Agricultural Station Bulletin, Nos. 21, 22 and 23.

Sorauer, Pflanzen Krankheiten, pp. 203-208

H. L. Boiley, North Dakota Agricultural Experiment Station, Bulletin No. 1.

J. C. Arthur, Indiana Agricultural Experiment Station, Bulletin Nos. 28, 32 and 35.

Fletcher, Central Experimental Farm, Ottawa, Canada, Bulletin No. 3.

J. Fremont Hickman, Ohio Agricultural Experiment Station, Bulletin No. 6, Vol. III, Series II, and Bulletin No. 1, Vol. V, Series II.

Ustilago Maydis, Pammel, Experiments with Fungicides. Iowa Agricultural Experiment Station, Bulletin No. 16, p. 316.

Tilletia caries. Dry heat 80° C. for two hours did not destroy all of the spores. Above 95° C. spores no longer germinated. Schindler, Ueber den Einfluss verschiedener Temperaturen auf die Keimfähigkeit der Steinbrand Sporen. Fortschritte auf dem Gebiete der Agriculturphysik, Vol. III. Heft 3, 1880. Zopf, Die Pilze, p. 216.

Ustilago carbo and *U. destruens*. Dry heat 104-128° C. *U. Carbo* is destroyed with moist heat between 58.5° and 62° C. *U. destruens* is destroyed when heated to 74-78° C. for one hour; for two hours the maximum temperature is 70-73° C. Hoffman, Jahrb fur Wissenschaftl. Botanik II, 1860, p. 267. Zopf. 1 c., p. 216.

OBJECT OF THE INVESTIGATIONS.

It was desired to obtain four thermal death-points:

1. The temperature at which spores of corn smut lose their power of germination when immersed for fifteen minutes in water kept at that temperature.

2. The temperature at which spores of corn smut lose their power of germination when subjected for fifteen minutes to that temperature in a dry oven.

3. The temperature at which corn loses its power of germination when immersed for fifteen minutes in water kept at that temperature.

4. The temperature at which corn loses its power of germination when subjected for fifteen minutes to that temperature in a dry oven.

Further it was desired to obtain information regarding:

(a) The temperature at which the young corn plant first shows injury due to the seed having been immersed for fifteen minutes in water at that temperature.

(b) The temperature at which the young corn plant first shows injury due to the seed having been subjected for fifteen minutes to that temperature in a dry oven.

METHODS AND MATERIALS.

The corn smut used was one year old, and all from the same ear of corn. It was germinated in sterilized cistern water in rubber cells. The corn used was of the variety, Iowa Gold Mine, and of high germinating capacity. In all cases the check kernels were from the same ear as the treated kernels. The corn was germinated in boxes of ordinary garden earth. For the determination of the thermal death-point of corn (dry heat) the kernels were placed in the drawer of a Naples bath. For determining the thermal death-point (wet heat) of both corn and smut, the drawer of a Naples bath was filled with water, and the corn and corn smut immersed in it when it became of the proper temperature.

To obtain the thermal death-point of corn smut (which is above 100°C) it was necessary to use a dry sterilizing oven. The smut was placed in a small tin thimble fastened to the end of a string, and when the thermometer in the top of the oven indicated the temperature desired, a cork in the top of the oven was removed, the thimble lowered quickly into the oven and the cork replaced.

RESULTS.

SPORES OF CORN SMUT IMMERSSED IN WATER FOR FIFTEEN MINUTES.

Temperature of water Centigrade.	Length of time spores were in cell.	Number of good cells.	Germination.
57.5-58.5	72 hours.	1	None.
57 -53	72 hours.	2	None.
55	96 hours.	2	None.
54 -54.5	120 hours.	3	None.
54 -54.5	72 hours.	3	None.
54	71 hours.	2	None.
53 -53.5	72 hours.	3	None.
53 -53.5	71 hours.	2	None.
52.5-53	120 hours.	2	None.
52.5	120 hours.	3	None.
52	120 hours.	5	None.
51.5	144 hours.	3	A few in one cell germinated.
51 -51.5	71 hours.	2	Several germinated.
50	71 hours.	2	Several germinated.

SPORES OF CORN SMUT HEATED FIFTEEN MINUTES IN DRY OVEN.

Temperature of oven Centigrade.	Length of time spores were in cell.	Number of good cells.	Germination.
106.5	120 hours	10	None.
105.5-106	120 hours.	8	None.
105	120 hours.	5	A few in each cell germinated.
104.5-105	48 hours.	1	Several germinated.
101	72 hours.	1	Several germinated.
101	72 hours.	2	Several germinated.
96.5-97	53 hours.	1	Germinating vigorously.

GERMINATION OF CORN WHICH HAD BEEN IMMERSSED IN HOT WATER FOR FIFTEEN MINUTES.

I.

Temperature of water Centigrade.	Percentage that came up.	Average height twelve days after planting.—Inches.
Check	100	4.55
55	100	4.6
57 -58	100	4.5
57.5-58.5	100	4.5
60.5-61	95	4.1
61.5-63.5	95	3.14
63 -64.5	85	2.55
67.5-68	20	1.33
69.5	00	
69.5-70	5	Barely came through.
69.5-70.5	5	Nine days in coming through.
70.5-71	00	
70.5-71.5	00	
76 -76.5	00	
77 -77.5	00	

II.

Temperature of water Centigrade.	Percentage that came up.	Average height at end of nine days.—Inches.
Check	100	3.9
62	100	3.75
66	50	3
68 -69	16	3
68 -69.5	50	1.6
69 -69.5	4	1
69 -70	40	2.8
70.5-71.5	00	

GERMINATION OF CORN AFTER BEING HEATED IN DRY OVEN FIFTEEN MINUTES.

I.

Temperature of oven.	Percentage that came up.	Average height at end of seven days. —Inches.
Check	100	4.2
65	100	3.55
67	100	3.8
69	100	3.6
71	100	3.35
73	100	3.8
74.5	100	3.7

II.

Temperature of oven.	Percentage that came up.	Average height at end of eight days. —Inches.
Check	100	6.12
76	80	1.7
76-76.5	65	1.8
76.5	65	1.6
77	30	1
77.5	60	1.6

III.

Temperature of oven.	Percentage that came up.	Average height at end of five days. —Inches.
Check	80	1.5
75-76	80	.75
76-77	70	.75
77-78	60	Shown decided injury.
78-79	00	Only 3 sprouted in 11 days.
79-80	00	Only 1 sprouted in 11 days.

IV.

Temperature of oven.	Percentage that came up.	Growth.
Check	100	At end of 6 days 6 inches high.
77.5-78	00	At end of 6 days 40 per cent sprouted.
78-78.5	00	At end of 6 days 38 per cent sprouted.
78.5-79	00	At end of 6 days none sprouted.

V.

Temperature of oven.	Percentage that came up.	Growth.
77.5	70	Barely got above surface.
77.75	15	Barely got above surface.
78.	00	Only two had sprouted.

CONCLUSIONS.

1st. The thermal death-point for corn smut spores immersed in water for fifteen minutes is 52°C.

2d. The thermal death-point for corn smut spores heated in a dry oven for fifteen minutes, 105.5-106°C.

3d. Corn is unable to push its plumule through an inch of soil if the seed has been immersed for fifteen minutes in water at 70.5° or more.

4th. Corn is unable to push its plumule through an inch of soil if the seed has been heated in a dry oven for fifteen minutes at a temperature of 78°C or more.

5th. The young corn plant shows injury if the seed has been immersed for fifteen minutes in water at 60.5° – 61° C or more.

6th. The young corn plant shows injury if the seed has been heated for fifteen minutes in a dry oven at 65° C or more.

REMARKS.

The experiments show that corn heated, either dry or in water, may be considerably injured and still retain the power of germination; it may show a fair percentage of germination and be unable to push through an inch of soil. Hence, mere germination does not show the condition of the seed as regards vigor.

Bacteria in the cell cultures are a source of much annoyance. If a cell in which the spores do not germinate is found to contain large numbers of bacteria they may be the cause of the failure of the spores to germinate and the experiment must be repeated.

Spores of *Fusarium* when in immature condition so closely resemble the sporidia of corn smut spores that they are easily mistaken for them. It is not safe to conclude that the spores in a cell are germinating unless the promycelia are actually seen coming from the spores.

PLANT LICE INFESTING GRASS ROOTS.

HERBERT OSBORN AND F. A. SIRRINE.

During the fall of 1889 the senior author of this paper determined that a species of plant louse, infesting roots of annual grasses was identical with the "Dogwood plant louse" (*Schizoneura corni* Fabr.), carrying the work far enough to prove that the winged forms could be transferred from grass roots to dogwood, on which they colonized. As he found the root forms principally on annual grasses which were of no economic value, it was naturally a question of interest to determine whether they might affect forage plants. Furthermore, the occurrence of non-migratory forms on certain of the grasses examined,