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What is the Relation between the Moisture Content and Viability of Seed Corn When Subjected to Low Temperatures?

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WHAT IS THE RELATION BETWEEN THE MOISTURE CONTENT AND VIABILITY OF SEED CORN WHEN SUBJECTED TO LOW TEMPERATURES?

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Farmers have long known that a light freeze early in the fall is likely to injure the corn crop for seed purposes the following year. The crop of 1917 was thus severely injured and much labor and money were expended to secure even fair seed for the planting in 1918. While the experiment as planned does not compare fully with conditions as they are in fields of maturing corn, it was begun with the idea of giving some information on the vitality of seed corn after having been frozen. To be satisfactory more work should be done using various moisture contents, various low temperatures, and various stages of maturity, something which was not undertaken in this experiment but which may prove to be an important factor.

While there is little or no work reported in American literature along this particular line, there are many experiments which have a bearing upon it. Fawcett [1] found that freezing and thawing in general increased the percentage of germination and shortened the dormant period. This was especially true of seeds having a hard seed coat. Where the seeds possessed thin coats the vitality was in a few instances lowered by freezing and thawing. No temperatures are mentioned.

Matrachot and Molliard [2] report that there is a marked parallelism between the phenomena observed in desiccation and freezing and agree with others that the death of cells by freezing is in reality due to the rapid drying out of the tissue.

Moore and Stone and Delwiche [3] selected a row of the 1906 corn crop and left it standing in the field through the winter. The corn had reached full maturity before freezing weather and according to tests all ears showed a uniform germination of 100 per cent prior to zero weather. After the thermometer had registered zero (the exact temperature not given) the viability of the corn immediately dropped in all ears with one exception and this one gave a test of 100 per cent through the winter.

1 Proc. Iowa Acad. Sci., 15, pp. 25-45; 1908.

2 Rev. Gen. Bot., 14, nos. 167, pp. 463-482; 168, pp. 522-533; 1902.

3 Wisconsin Station Report, 1907, pp. 386-408.

Pickholz [4] as a result of experimental work found that in general the water content of the seed was in inverse ratio to the percentage of germination. In most cases when the water was driven off the germination was benefited while addition of water in most cases proved harmful, although there were some instances in which it remained indifferent and a few in which it proved advantageous.

The plan of the present experiment was to give corn having a high percentage of germination various moisture contents and then freeze the lot at twelve degrees below zero for 12, 18, 24, 48, and 72 hours respectively. The composite tests gave 100 per cent germination very uniformly. The moisture content was given by soaking on Plaster of Paris blocks over different intervals of time, depending upon the percentage of moisture desired. Since the greenhouse conditions were fairly uniform the moisture contents for equal periods were tolerably constant, varying of course with temperature and permeability of the individual seed coats. As a rule these seeds were put on the blocks at intervals of three hours through an eighteen-hour day, some occasionally being soaked outright. The germ was always turned to the block.

While the seeds always showed an increase due to the contact with the block, there was no way of telling whether each seed had its comparative percentage of moisture. Then, too, the amount of surface contact varied and undoubtedly caused some error in actual percentage of water per seed.

DISCUSSION OF RESULTS AND TABLES OF DATA

Tables II, III, IV, and V show very conclusively that corn will not survive a freeze of twelve degrees below zero if the moisture content is much above 35 per cent. The curve breaks almost at 35 per cent, and from there upward comparatively no germination occurs.

The results shown in tables VI and VII are as conspicuous as are those of tables II, III, IV and V. However, about 5 per cent of the kernels showed a tendency to retain their vitality up to a moisture content of 40 per cent. This slight variation is very likely one of endurance only. Some seeds having a greater vitality than others will survive a twenty-four hour freeze and make a good germination while if frozen for forty-eight or seventy-two hours they would be so weakened that germination would not occur under average conditions.

Tables VIII and IX, representing a freezing period of eighteen hours, only further emphasize the discussion made under VI and

[4] Zischr. Landw. Versuchsw. Oster. 14, No. 2, pp. 124-151; 1911.

VII. Now that the time of freezing has been cut to eighteen hours the number of seeds surviving at higher moisture contents has increased also. In these tables are shown seeds which have survived a freeze of eighteen hours even though the moisture content has gone up to approximately 45 per cent, as compared with 40 per cent at twenty-four hours and 35 per cent at forty-eight and seventy-two hours.

Thus far there seems to be a direct relation between the percentage of water in the seed and the length of time required to destroy the vitality by freezing at twelve degrees below zero, Centigrade. That is, if seed corn has a moisture content of 35 per cent it requires a freeze of forty-eight hours to lower the vitality sufficiently to prevent germination. If the moisture content is near 40 per cent a freeze of twenty-four hours accomplishes the same results. Or if the moisture content is 45 per cent a freeze of eighteen hours will lower the vitality beyond a limit which permits germination under average conditions.

When the length of freezing is cut down to twelve hours, however, the results are not so conclusive, due to individual variation of the seeds in any given lot. This variation may be due to differences in vitality or to differences in imbibitional power. Seeds which were originally low in vitality are apparently the first to be seriously injured by freezing. This no doubt accounts for some of the variation. But probably the difference in imbibitional power plays a far more prominent part. If the seed coats of some of the kernels had been more impermeable than the coats of others it is a fact that these seeds would have contained less moisture and hence would be less likely to be injured by freezing. The decrease in imbibitional power is likely to keep the water which does enter from the germ and this also would protect the seeds during the freeze.

Another factor of interest here is that of moisture distribution in the seed. During the longer periods of soaking the moisture is more likely to diffuse through the kernel, filling the germ as well as the endosperm. Such kernels would be more easily destroyed than those having a high moisture content in the endosperm but a low percentage in the germ.

In fact it seems probable, since the corn used in this experiment tested 100 per cent strong on a composite test, that the survival of a few seeds in any table showing a moisture content of more than 35 per cent and a freezing period of twenty-four hours must have been due to their impermeable coats preventing the water reaching

the germ. Then also those few outstanding individuals now and then surviving are evidently seeds having coats more or less impermeable.

By examining tables X, XI and XII carefully one must arrive at the conclusion that even a freezing period of twelve hours is very detrimental to seeds having a moisture content of 30 per cent or more. Had the percentage of moisture gone into the twenties similar injuries might have resulted. Then it seems safe to conclude from these tables that serious injury must result from a twelve hour freeze with twelve degrees below zero as a minimum even though the moisture content is as low as 30 per cent. How much damage might result from lower moisture contents and shorter periods of freezing this experiment does not attempt to show.

In general we are safe in saying that the percentage of germination decreases as the percentage of moisture rises above 30 per cent and the length of the freezing period passes twelve hours if a constant temperature of twelve degrees (Centigrade) below zero is maintained.

Furthermore those seeds showing no injury under these conditions probably owe their power of resistance to impermeable or partly impermeable seed coats.

There is a definite break in the curve and all germination ceases after the moisture content passes 35, 40, and 45 per cent for the freezing periods of forty-eight hours or more, twenty-four hours and eighteen hours respectively.

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TABLE II. EXPERIMENTAL DATA SHOWING THE PERCENTAGE OF GERMINATION OF CORN AFTER HAVING BEEN FROZEN SEVENTY-TWO HOURS. THE MOISTURE CONTENT ALSO VARIES ACCORDING TO THE PERCENTAGE RECORDED

Sample Number	Moisture and Corn Gr.	Moisture Free Corn Gr.	Moisture Alone	Percentage of Moisture	Hours Frozen	Number of Seeds Germinating	Number of Seeds Planted	Percentage of Germination
1	6.44	5.24	1.20	30.5	72	9	20	45
2	7.21	5.51	1.70	30.8	72	11	20	55
3	6.98	5.15	1.83	35.5	72	3	20	15
4	7.33	5.24	2.09	39.8	72	1	20	5
5	7.77	5.21	2.56	47.8	72	0	20	0
6	7.54	5.02	2.52	50.8	72	0	20	0

TABLE III. DUPLICATE OF II

1	6.71	4.95	1.76	35.55	72	6	20	30
2	6.98	5.03	1.95	38.76	72	1	20	5
3	7.54	5.24	2.30	43.89	72	1	20	5
4	7.41	5.11	2.30	45.00	72	0	20	0
5	7.48	5.11	2.37	46.37	72	0	20	0
6	7.68	4.83	2.85	55.78	72	0	20	0
7	7.54	4.84	2.70	55.78	72	0	20	0
8	7.81	4.93	2.88	58.48	72	0	20	0
Check					72	20	20	100

TABLES IV AND V SHOWING THE PERCENTAGE OF GERMINATION OF CORN HAVING VARIOUS MOISTURE CONTENTS AND AFTER HAVING BEEN FROZEN FOR FORTY-EIGHT HOURS

Sample Number	Weight of Seed and Water	Weight of Moisture Free Seed	Weight of Water	Percentage of Water	Number of Seeds Germinating	Number of Seeds Planted	Percentage of Germination
1	6.80	5.02	1.78	35.45	9	20	45
2	7.37	5.29	2.08	39.31	1	20	5
3	7.23	5.13	2.10	40.91	0	20	0
4	6.93	4.82	2.11	43.77	0	20	0
5	7.30	4.93	2.37	48.03	0	20	0
6	7.95	5.06	2.89	57.11	0	20	0
7	7.85	4.95	2.90	58.58	0	20	0
8	8.02	5.04	2.98	59.10	0	20	0
Check					20	20	100
1	6.82	4.83	1.99	41.20	20	20	10
2	7.22	4.98	2.24	44.98	0	20	0
3	7.45	5.03	2.42	48.11	0	20	5
4	7.47	5.03	2.44	48.5	0	20	0
5	7.60	5.07	2.53	49.5	1	20	5
6	8.06	5.07	2.99	58.42	0	20	0
7	8.08	5.07	3.01	59.36	0	20	0
8	8.03	5.03	3.00	59.64	0	20	0
Check					20	20	100

TABLES VI AND VII SHOWING THE PERCENTAGE OF GERMINATION OF CORN HAVING VARIOUS MOISTURE CONTENTS AND AFTER HAVING BEEN FROZEN TWENTY-FOUR HOURS

Sample Number	Weight of Seed and Moisture	Weight of Moisture Free Seed	Total Weight of Water	Percentage of Water	Number of Seeds Germinating	Number of Seeds Planted	Percentage of Germination
1	7.01	5.13	1.88	36.64	3	20	15
2	6.83	4.89	1.94	39.67	1	20	5
3	6.88	4.90	1.98	40.40	1	20	5
4	7.33	5.13	2.20	42.86	1	20	5
5	7.70	5.33	2.37	44.46	1	20	5
6	7.43	4.92	2.51	51.01	0	20	0
7	7.51	4.93	2.58	52.33	0	20	0
8	7.93	4.95	2.98	60.20	0	20	0
Check					20	20	100
1	6.75	4.96	1.79	36.08	9	20	45
2	6.72	4.89	1.83	37.42	10	20	50
3	6.89	4.77	2.12	44.44	1	20	5
4	7.17	4.84	2.33	48.14	0	20	0
5	7.02	4.72	2.30	48.75	0	20	0
6	7.34	4.83	2.51	51.95	1	20	5
7	6.85	4.33	2.52	58.19	0	20	0
8	7.62	4.77	2.85	59.74	0	20	0
Check					20	20	100

TABLES VIII AND IX SHOWING THE PERCENTAGE OF GERMINATION OF CORN HAVING VARIOUS MOISTURE CONTENTS AND AFTER HAVING BEEN FROZEN FOR EIGHTEEN HOURS

Sample Number	Total Weight of Moist Seed	Total Weight of Moisture Free Seed	Total Moisture	Percentage of Moisture	Number of Seeds Germinating	Number of Seeds Planted	Percentage of Germination
1	7.05	5.24	1.81	34.54	16	20	80
2	6.85	4.99	1.86	37.27	6	20	30
3	6.80	4.77	2.03	42.56	11	20	55
4	7.20	5.05	2.15	42.57	5	20	25
5	7.63	5.32	2.31	43.32	6	20	30
6	7.80	5.15	2.65	51.06	0	20	0
7	8.05	5.19	2.86	55.10	0	20	0
8	7.97	5.10	2.87	56.27	0	20	0
Check					20	20	100
1	7.10	5.10	1.97	38.40	11	20	55
2	7.30	5.17	2.13	41.19	8	20	40
3	7.20	5.05	2.15	42.57	9	20	45
4	7.46	5.23	2.23	42.63	6	20	30
5	7.55	5.23	2.32	44.35	4	20	20
6	7.67	4.92	2.75	55.08	0	20	0
7	7.75	4.92	2.83	57.52	0	20	0
8	7.95	5.01	2.94	58.68	0	20	0
Check					20	20	100

TABLES X AND XI SHOWING THE PERCENTAGE OF GERMINATION OF CORN HAVING VARIOUS MOISTURE CONTENTS AND AFTER HAVING BEEN FROZEN FOR TWELVE HOURS

Sample Number	Weight of Moisture and Seed	Weight of Moisture Free Seed	Total Moisture	Percentage of Moisture	Number of Seeds Germinating	Number of Seeds Planted	Percentage of Germination
1	6.02	4.60	1.42	30.86	13	20	65
2	6.60	4.76	1.84	38.65	6	20	30
3	6.32	4.42	1.90	42.99	5	20	25
4	6.72	4.63	2.09	45.14	4	20	20
5	6.43	4.38	2.05	46.80	1	20	5
6	7.28	4.63	2.65	57.23	0	20	0
7	7.01	4.42	2.57	58.59	0	20	0
8	7.09	4.44	2.65	59.68	0	20	0
Check					20	20	100
1	5.45	4.08	1.37	33.57	12	20	60
2	5.64	4.11	1.53	37.22	13	20	65
3	5.82	4.11	1.71	41.60	13	20	65
4	6.13	4.28	1.85	43.22	5	20	25
5	6.49	4.11	2.38	57.90	0	20	0
6	6.44	4.01	2.43	60.57	0	20	0
1	6.67	5.08	1.59	31.29	16	20	80
2	6.90	5.14	1.76	34.24	9	20	45
3	7.15	4.91	2.24	45.62	0	20	0
4	7.42	4.99	2.43	48.67	2	20	10
5	8.21	5.22	2.99	57.27	0	20	0
6	8.03	5.09	2.94	57.76	0	20	0
7	7.93	5.01	2.92	58.30	0	20	0
Average of two checks					20	20	100