SEED CORN DRYING

THESIS FOR THE DEGREE OF M. S.

Dennie Leon Clanahan

1930

THESIS

Drying apparatus - Food
Title

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A Thesis Prepared by

DENNIE LEON CLANAHAN

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CONTENT

SEED CORN DRYING

INTRODUCTION

Better seed is the first thought that should enter the mind of a grower of crops just as better livestock should be the first thought of the producer of livestock, at least if either wish to be among the profit winners of present day agriculture. In respect to the need for quality, seed corn is not different from other crops seed, and quality should be one of its outstanding requirements. To obtain quality in seed corn under Michigan conditions a means of reducing the moisture content soon after harvest is necessary. It was the purpose of this work to determine whether or not this could be accomplished efficiently and economically by hot forced air.

Michigan farmers required 208,714 bushels of "Good Seed Corn" to plant their 1928 crop of 1,461,000 acres. This acreage produced 51,135,000 bushels of grain averaging 35 bushels to the acre. This average is to be commended; because although Michigan stands 15th of all states in total yield yet this average puts the state 6th in yield per acre. There were years like 1917 and 1924 in which the yield per acre was below this average. In 1917 the average fell to 21.5 bushels and in

1924 it was only 26.0 bushels. These were exceptional years. The spring of 1917 was very wet and late; often during the growing season the temperature dropped so low that growing crops were greatly handicapped. Along with these adverse conditions the grower was again confronted with an early fall and due to early frosts most of the corn had to be harvested before it was mature. The season of 1924 was practically a repetition of this although not quite so severe.

Now, these were exceptional years and not likely to occur very often but Michigan farmers are always confronted with similar conditions and it is always a problem for them to produce their own seed corn. It might be said that rarely if ever, is the seed as it comes from the field in condition to store, nor is it safe from the low temperatures of early fall and winter. Therefore, to insure good seed corn and uphold and improve the yield there must be some means of drying the seed to a safe moisture content before freezing temperatures occur. Weather reports show that we may expect such temperatures any time after August.

In 1929 a new seed house was built on the W. K. Kellogg Farm of the Michigan State College at Augusta, Michigan. This included a seed corn dryer built after the general plans developed at the University of Wisconsin by Wright and Duffey.* The method used to dry seed corn at the W. K. Kellogg Demonstration Farm at Augusta was the bin or bulk method in which a

*Mineographed Experiment Station Circular Published by University of Wisconsin.

quantity of ear corn is poured into tight bins and hot air forced through it until it is dried to about 14 per cent moisture. In this condition it is safe to shell and store.

REVIEW OF LITERATURE

Since humidity and temperature are the two main factors in climate which directly effects the curing of seed corn it might be well to see what significance they hold. "Relative humidity" as used in this thesis means the per cent of moisture in the air compared with the possible amount. In the reports of the U. S. Department of Agriculture, Weather Bureau (1) we find that Michigan has a higher relative humidity for September, October and November (the seed corn drying months) than any other large area in this country. We are told by Seeley (2) that the presence of large bodies of water and the fact that we are directly in the path of "highs" and "lows" accounts for this high relative humidity. Closely connected with this condition is the prevailing low temperature which makes it not only difficult but dangerous to cure corn without artificial heat, because of the probability of freezing the germs before the corn is dried to a safe moisture content.

The capacity of the air for moisture increases rapidly with the temperature. Seeley (2) states that the invisible vapor necessary to saturate air at 40°F. is sufficient to produce a relative humidity of but 50 per cent when the air temperature is increased to 60°F. Therefore, the corn dries much faster when the temperature of the air is increased. "Dripping window panes in mild weather are even more positive index of a highly humid atmosphere and suggests a condition that needs immediate attention." (3)

Some work has been done on the range of temperature which can be used for drying, the length of time required to dry corn of a known initial moisture content, and the degree of dryness a lot of corn may reach without damaging the germs.

Erwin and Haber (3) were able to reduce the moisture content of sweet corn from 25 per cent to 14 per cent by the use of forced air at 80°F. for 48 hours. Likewise, another lot of corn was dried by these same men which had an initial moisture content of 40 to 45 per cent and in this case forced air at 95°F. for 72 hours was necessary to reduce the moisture content to 15 per cent. Both lots of corn germinated well.

Huelson (4) states that sweet corn may be kiln dried at 100°F. providing proper circulation of the air is maintained. He states that the length of exposure to this temperature may vary from 48 to 72 hours when the corn has 40 per cent moisture. No injury to the corn is reported.

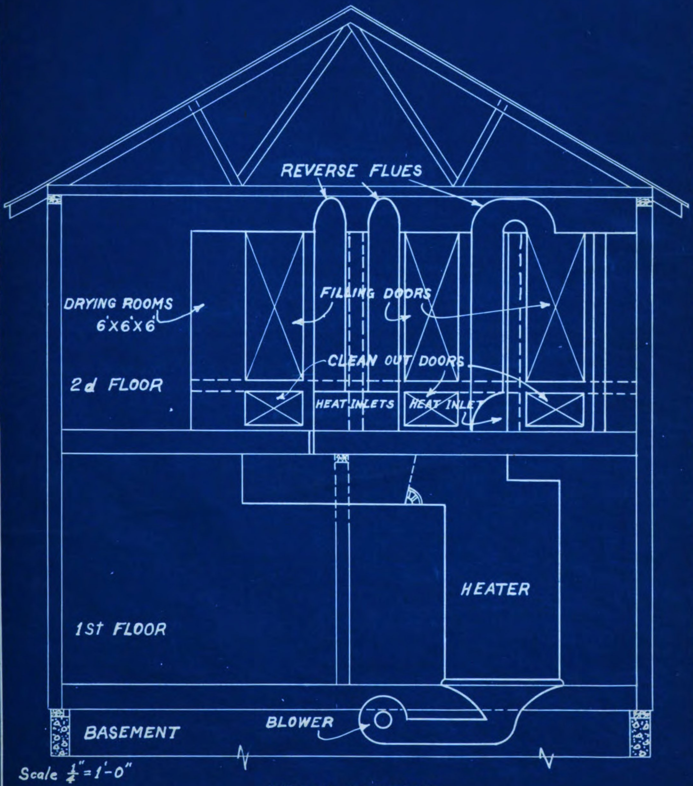
Harrison and Wright (5) state that drying with heated air is necessary to insure good seed corn in Wisconsin. In their temperature studies they found that forced air of from 104°F. to 113°F. was not harmful to ear corn. Considerable damage was reported when a temperature of 122°F. was used, while a temperature of 140°F. killed nearly all of the germs. The initial moisture content of these lots of corn varied from 38 to 62.8 per cent.

When a critical temperature of 122°F. was used the first 12 hours of drying showed no damage to the germination while each subsequent 12 hour period showed a gradual decrease in the germinability of the corn until the end of the drying period. This they explain by stating that the corn likely evaporated sufficient moisture during the first part of the test to prevent it from reaching a critical temperature. The initial moisture content of the two lots of corn used for this test was 64 and 39.6 per cent, respectively. Both lots showed the same tendency. They show also that when a non-harmful temperature of 113°F. was used excessive desiccation even to as low as 3.4 per cent moisture did not harm the germination.

However, Erwin and Haber (3) state that there is nothing to be gained by reducing the moisture to less than 15 per cent since that is a safe figure to prevent it from frost injury and invasion of molds in storage. It is interesting to know that they found that at a temperature of 105°F. and a moisture content of 4.4 per cent no damage to the germs could be noticed. When the moisture content was reduced to 4 per cent there was a rather definite break in the germinability of the corn. The germination continued down to as low as 9 per cent when the temperature reached 140°F. and the moisture content 2.2 per cent.

Illustration No. 1

Showing the Building which housed the Dryer



CROSS SECTION

SHOWING — BLOWER, HEATER, FLUES, & BINS

EXPERIMENTAL METHOD AND EQUIPMENT

Attention is called to the blueprint which is a sketch of the building and equipment used in these experiments. The three bins are 6 x 6 feet double walled with inch boards and building paper between--studded on the outside. The bins were equipped with false bottoms, 18 inches above the main floor, which allowed free circulation of the air before it was finally forced up through the corn. They were constructed so that the direction of the air could be reversed, i. e., sent upward through the corn or downward. Only one bin was used for experimental purposes. Five "experiments" were planned for the purpose of ascertaining the proper temperature and time necessary to dry seed corn of a certain known initial moisture content. They are as follows:

Experiment No. 1

Temperature 85 degrees F. Air 36 hours one direction and reverse 36 hours. (Corn to be 20% to 45% moisture).

Experiment No. 2

Temperature 115 degrees F. Air 24 hours one direction and reverse 24 hours. (Corn to be 20% to 45% moisture).

Experiment No. 3

Temperature 95 degrees F. Air continuous one direction 72 hours. Use bottom intake. Remove top covers. (Corn to be 20% to 45% Moisture).

Experiment No. 4

Temperature 100 degrees F. Air 36 hours one direction and reverse 36 hours. (Corn to be 20% to 45% Moisture).

Experiment No. 5

Temperature 100 degrees F. Air 36 hours one direction and reverse 36 hours. (Corn to be 50 per cent Moisture).

Note: Experiment No. 5 could not be run because corn with 50% moisture was not available in the fall of 1929.

Records: Temperature records were taken with thermographs of different types. One single thermograph was placed in the bottom of the bin directly in front of the inlet pipe as a constant check on the temperature of the air as it entered the bin. One single thermograph was placed at the top of the bin on the right side and one at the top of the bin on the left side as a check on the temperature of the air as it came out of the bin. Also one double recording cable thermograph was used to record temperatures in the middle of the bin. Therefore, a record of the temperature of the air was obtained in five places by thermographs. These records show the temperature of the air as it entered the bin and as it came out, also show something about the distribution of the heat within the bin.

The initial moisture content of the corn was ascertained by taking representative samples of the corn as it came from the field and running duplicate moisture tests on them with the "Brown Duvel" moisture tester. These samples were taken by shelling a few kernels from each ear of a 50 ear sample and thoroughly mixing before taking a representative amount for moisture and germination tests.

After drying was completed the bin was sampled in eleven places. A sample was taken from each corner of the bin, both top and bottom and similar samples were taken throughout the center of the bin.

The sample numbers used in the germination and moisture tables represent a particular location within the bin according to the following key.

No. 1--Top Right Hand Corner Front

2--Top Right Hand Corner Back

3--Top Left Hand Corner Back

4--Top Left Hand Corner Front

5--Top Center

No. 6--Center of Bin

7--Bottom Right Hand Corner Front

8--Bottom Right Hand Corner Back

9--Bottom Left Hand Corner Front

10--Bottom Left Hand Corner Back

11--Bottom Center

The above samples consisted of five ears each. These ears were shelled, the grain from the whole sample being thoroughly mixed together, and a representative amount used in making the moisture and germination tests.

This should determine the condition of the corn after drying and show the efficiency of the method. A check sample for germination was taken by picking ten ears of the corn at random from the different lots as it came from the field and allowing them to air dry on strings at room temperature until the moisture was below 14 per cent.

Forced air equipment--The fan used was of the multi-vane high pressure top horizontal discharge type. It was driven directly by a $1\frac{3}{4}$ H. P. electric motor at a theoretical speed of 900 r.p.m. At this speed it was designed to deliver 2400 cubic feet of air per minute at three inches static pressure.

According to Wright and Duffey (6) the volume of air per hour at which drying is most effective is 70 times the square feet of floor space which the bins contain. The three bins used were six feet square, making 108 square feet, hence

theoretically, they should require 7560 cubic feet of air per hour for most effective drying. The following is a table showing the cubic feet of air actually entering and passing through the corn according to tests made with an anemometer which was set up at the intake and outlet and readings made.

Table No. 1

Showing the Volume of Air in Cubic Feet per Hour at the Intake and Outlet for Each Experiment

Corn Lot	Exp. No.	Fullness of Bins	Air Forced up Through Corn		Air Forced Down Through Corn
			Intake	Outlet	Outlet
Kellogg	2	2/3	(No instrument)		29,627 cu. ft.
Parrott	3	full	37,386	35,984	(one direction only)
Butterfield	4	full	66,359	45,402	32,525 cu. ft.
Butterfield	1	2/3	46,235	44,356	33,286 cu. ft.

From the above table it is shown that the volume of air was more than was required according to Wright and Duffey (6). However, the construction of the drier used in their experiments was different from the one used in these experiments. In their drier, the fan was located between the furnace and the drier while the drier used in these experiments had the fan located below the furnace and the air was forced directly over the firebox of the furnace and finally through the corn.

The Heating Unit--It has been a general practice to recommend a hot air furnace of the round type as a heating unit for such a drier as has been explained here. Mostly because it has a single outlet which is all that is necessary and the cost of constructing a heating unit of this type is very small. Very little is known about the size to use except that it is better to have one that has ample heating capacity than one that is too small. (6)

The furnace should be operated in such a manner as to keep the heat as constant as possible, because any fluctuations in temperature is liable to be very detrimental in the drying process. Directions given with most furnaces recommend that the firebox be kept well filled when capacity is being required of the furnace. This is also a measure in economy. One of the most important things in drying seed corn by this method is the maintainance of as even a temperature at the inlet as possible. Furnaces are equipped with a draft door below the firebox and a check draft in the smoke flue operated simultaneously by a system of chains and pulleys from a single control.

It was planned to operate these controls by hand using every precaution in firing to maintain an even temperature at the inlet. However, it was found that this was very hard to do and thermograph charts showed a wide variation in the temperature at the inlet during the first experiment. (Plate No. 1). Therefore, an electrically operated thermostat was used as a control on these drafts. This thermostat opened and closed the drafts with a change of two degrees in the temperature at the inlet. This was found to be much better and maintained a more even temperature than was possible with hand operation as a control. (Plate No's 3, 4, 5).

However, both the hand and thermostat controls were tested and the following table of means, standard deviations and coefficients of variability were compiled from hourly intake temperature readings on each of the experiments and showed that in most cases there was a significant difference in favor of the thermostatic control.

Table No. 2

Comparison of Hand and Thermostatic Control Methods

Control	Exp. No.	Mean	S. D.	C. V
Hand	2	113.67±.9255	9.507±.650	8.363±.5760
Thermostat	3	93.89±.5289	5.433±.3740	5.786±.3983
Thermostat	1	87.19±.6407	6.581±.4530	7.548±.5196
Thermostat	4	95.79±.5596	5.748±.3957	6.000±.4130

In figuring the significant difference between the hand control and the thermostatic control both the standard deviations and their probable errors and the coefficients of variability and their probable errors were used. In the comparison the significance was figured by dividing the difference by the probable error of the difference. A comparison was made between each of the thermostatically controlled experiments and the hand control experiment. Using the standard deviation first, the significance of experiments 3, 1, and 4, when compared with Experiment 2, was 5.142, 3.69, and 4.75 respectively. Considering 3.3 as a significant difference it will be seen that the difference according to the standard deviations is significant in all cases in favor of the thermostat control.

Likewise a comparison was made using the coefficients of variability of these temperature readings and the significance figured in the same way. The significance in this case of Experiments 3, 1, and 4, when compared with Experiment 2, was 3.68, 1.05, and 3.33 respectively. Again considering 3.3 as a significant difference it will be seen that the difference according to the coefficients of variability of the temperature readings for the experiments were significant in all cases except one.

From this it will be concluded that the thermostat is more effective in maintaining an even temperature thanare hand control methods.

Illustration No. 2

Showing Overhead Flues
and Three of the Five Thermographs
Used in Recording Temperatures in These Experiments

DISCUSSION OF EXPERIMENTAL DATA

The data obtained in these experiments was subject to an experimental error due to the variability in maturity and moisture content of the corn for drying. However, a large number of samples was taken from each bin to check the efficiency of the drying and as a means of reducing this experimental error. At the time this work was planned and started there were no available publications on tests which had been made on a commercial scale with which to make comparison.

Germination Tests

In the germinability of the samples of the first experiment listed (Table 3), it will be seen that only one sample, No. 1, was low enough to cause comment. This sample came from the top of the bin and directly under the top intake pipe. It can be seen from the intake graph (Plate 1) that the temperature reached a high point of 125°F. during the latter part of the experiment and since this is a dangerous temperature as concluded by other workers (5), it is believed that this sample was injured by excessive heat. The graphs show (Plate 1) that such a high temperature was not attained in other places in the bin, and therefore the other samples germinated well. It is doubtful if the same high temperature reached during the first part of the experiment ever reached the corn proper

since the thermograph was directly in front of the intake and the air had to circulate over the entire false bottom before finally being forced up through the corn. It is also possible that the corn, during the first part of the experiment, evaporated sufficient moisture to keep it from reaching a critical temperature.

Experiments No's 3, 1, and 4, give satisfactory results in germination as shown in Tables 4, 5, and 6.

The necessity for the care in drying corn with this equipment was demonstrated when a part of a bin of corn was used to show how this system worked to a group of visitors. In this demonstration wood instead of coal was used as fuel, and a hot fire was started in the furnace. After a short run of an hour, which meant very little in the drying operation, the motor to the electrically driven fan burned out, leaving the corn in the bin under hot humid conditions with no circulation of air. The germs to this lot of corn were injured to such an extent that it could not be used for seed purposes. It is believed that high temperatures are what caused this injury. However, no thermographs were used to check this and it is not possible to say what the injury to the germination was due to.

RESULTS: GERMINATION TESTS

Experiment No. 2

Table No. 3--Kellogg Farm Corn. Germination in per cent

Sample Number	Original			Duplicate			Average		
	Strong	Weak	Dead	Strong	Weak	Dead	Strong	Weak	Dead
* 1	48	3	49	49	3	48	48.5	3.0	48.5
2	95	1	4	98	2	0	96.5	1.5	2.0
3	100	0	0	100	0	0	100.0	0.0	0.0
4	96	1	3	99	1	0	97.5	1.0	1.5
5	98	1	1	99	1	0	98.0	1.5	0.5
6	98	2	0	100	0	0	99.0	1.0	0.0
7	99	1	0	99	1	0	99.0	1.0	0.0
8	92	3	5	95	1	4	93.5	2.0	4.5
9	99	1	0	100	0	0	99.5	0.5	0.0
10	99	1	0	99	1	0	99.0	1.0	0.0
11	100	0	0	100	0	0	100.0	0.0	0.0
Check	100	0	0	100	0	0	100.0	0.0	0.0

*Sample from just below hot air intake.

The above lot of corn had an initial moisture content of 23%. The air was forced 24 hours one direction and reversed 24 hours. The temperature used was 115°F. After drying the corn had an average moisture content of 13.48%.

RESULTS: GERMINATION TESTS

Experiment No. 3

Table No. 4--Parrott Corn. Germination in per cent

Sample Number	Original			Duplicate			Average		
	Strong	Weak	Dead	Strong	Weak	Dead	Strong	Weak	Dead
1	97	3	0	99	0	1	98.0	1.5	0.5
2	98	1	1	99	1	0	98.5	1.0	0.5
3	99	1	0	99	1	0	99.0	1.0	0.0
4	100	0	0	99	1	0	99.5	0.5	0.0
5	98	0	2	100	0	0	99.0	0.0	1.0
6	99	0	1	97	1	2	98.0	0.5	1.5
7	99	1	0	100	0	0	99.5	0.5	0.0
8	100	0	0	99	0	1	99.5	0.0	0.5
9	98	2	0	100	0	0	99.0	0.0	1.0
10	100	0	0	100	0	0	100.0	0.0	0.0
11	98	1	1	98	0	2	98.0	0.5	1.5
Check	99	1	0	100	0	0	99.5	0.5	0.0

The above lot of corn had an initial moisture content of 32.3%. The air was forced 72 hours in one direction. The temperature used was 95°F. After drying the corn had an average moisture content of 15.95%.

RESULTS: GERMINATION TESTS

Experiment No. 1

Table No. 5--Butterfield Corn. Germination in per cent

Sample Number	Original			Duplicate			Average		
	Strong	Weak	Dead	Strong	Weak	Dead	Strong	Weak	Dead
1	88	9	3	74	18	8	81.0	13.5	5.5
2	98	1	1	93	7	0	95.5	4.0	0.5
3	97	2	1	96	4	0	96.5	3.0	0.5
4	97	2	1	99	0	1	98.0	1.0	1.0
5	98	1	1	98	0	2	98.0	0.5	1.5
6	99	1	0	97	0	3	98.0	0.5	1.5
7	97	2	1	99	0	1	98.0	1.0	1.0
8	98	1	1	96	3	1	97.0	2.0	1.0
9	98	0	2	99	1	0	98.5	0.5	1.0
10	96	2	2	98	1	1	97.0	1.5	1.5
11	98	2	0	96	3	1	97.0	2.5	0.5
Check	100	0	0	98	1	1	99.0	0.5	0.5

The initial moisture content of the above lot of corn was 23%. The air was forced 36 hours one direction and reversed 36 hours. The temperature used was 85°F. After drying the corn had an average moisture content of 9.41%.

RESULTS: GERMINATION TESTS

Experiment No. 4

Table No. 6--Butterfield Corn. Germination in per cent

Sample Number	Original			Duplicate			Average		
	Strong	Weak	Dead	Strong	Weak	Dead	Strong	Weak	Dead
1	99	1	0	98	2	0	98.5	1.5	0.0
2	98	1	1	98	0	2	98.0	0.5	1.5
3	99	0	1	98	0	2	98.5	0.0	1.5
4	99	0	1	94	2	4	96.5	1.0	2.5
5	99	0	1	96	4	0	97.5	2.0	0.5
6	98	2	0	100	0	0	99.0	1.0	0.0
7	99	0	1	100	0	0	99.5	0.0	0.5
8	99	0	1	99	0	1	99.0	0.0	1.0
9	100	0	0	100	0	0	100.0	0.0	0.0
10	100	0	0	100	0	0	100.0	0.0	0.0
11	100	0	0	97	2	1	98.5	1.0	0.5
Check	100	0	0	98	1	1	99.0	0.5	0.5

The above lot of corn had an initial moisture content of 23%. The air was forced 36 hours one direction and reversed 36 hours. The temperature used was 85^{o}F. After drying the corn had an average moisture content of 7.88%.

MOISTURE TESTS

In drying seed corn by this method a certain length of time and temperature of air is necessary to reduce the moisture content to a safe point. The average of all eleven samples in Experiment No. 2, Table 7 was 13.48 per cent, but sample No's 5, 6, and 11 which came from the center of the bin and represented the bulk of the corn was above a moisture content which would allow shelling. This shows that corn of 23 per cent moisture or more cannot be dried to a safe moisture content in 48 hours when the air is reversed each 24 hours and using an actual temperature of 113.4°F.

It may occur to a person inexperienced with this seed corn drying method that it is a waste of material in building one of these driers to include the overhead reverse flues. The moisture samples in Table No. 8 show how a bin of corn which was dried with the air flowing in only one direction came through as to distribution of cured and uncured corn. It will be noted that the top and middle samples are from 3 to 4 per cent higher in moisture than the bottom samples. Sample No's 7, 8, 9 and 10 are dry while the other samples are hardly cured sufficiently for cribbing. From this experiment it may be concluded that reversing the direction of the air is necessary for efficient drying of seed corn with this type of equipment.

Table No. 9 shows that corn of 23 per cent moisture can be dried in 72 hours to a safe moisture content using a drying temperature of 85°F., and reversing the direction of the air once. It will be noted that the drying was at a lower temperature and for a 24 hour longer period of time than Experiment No. 2. This lot of corn had also been cribbed for three weeks previous to drying and the corn in Experiment No. 2 came directly from the field. Whether the crib curing or longer period of time accounted for the more effective drying in this Experiment as compared with Experiment No. 2, is more than can be said with the present information at hand.

Table No. 10 shows that corn of 23% moisture can be dried easily in 72 hours at 100°F. by reversing the direction of the air once. Since the corn was down to 7.88% moisture it is safe to conclude that if a temperature of 100°F. is going to be used the length of time can be made shorter, thereby reducing the cost of drying.

RESULTS: MOISTURE TESTS

Experiment No. 2

Table No. 7:--Kellogg Farm Corn. Initial Moisture Content 25 per cent. After Drying 24 hours one direction and reversed 24 hours at 115°F.

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Original	11.9	12.1	13.1	11.8	18.0	18.1	10.2	11.8	14.2	11.2	15.9
Duplicate	12.0	12.2	13.1	11.9	17.8	18.2	10.0	11.6	14.4	11.0	16.0
Average	11.9	12.1	13.1	11.8	17.9	18.1	10.1	11.7	14.3	11.1	15.9

Average Moisture % of all Samples-13.43

Experiment No. 3

Table No. 8:--Parrott Corn. Initial Moisture Content 21.5 per cent. After Drying 72 hours one direction at 95°F.

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Original	17.1	17.9	18.5	17.5	17.0	15.5	12.7	15.9	13.3	12.9	14.7
Duplicate	16.1	17.1	18.0	18.4	17.0	15.9	12.9	15.5	13.3	13.1	15.3
Average	16.6	17.5	18.2	17.9	17.0	15.7	12.8	15.7	13.3	13.0	15.0

Average Moisture % of all Samples-15.95

Note: Variation from 12.7% to 18.5% Moisture, part of corn dryer than necessary, and part of corn not dry enough.

[illegible] (cont.)

Experiment No. 1

Table No. 9:--Butterfield Corn. Initial Moisture Content [illegible] per cent. After Drying 36 hours one direction and reversed 36 hours at 85° F.

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Original	9.8	10.0	12.0	[illegible]	11.0	9.6	8.8	8.7	7.9	7.6	8.8
Duplicate	9.8	9.7	12.0	[illegible]	10.3	9.8	8.9	8.6	7.8	7.7	8.8
Average	9.8	9.8	12.2	[illegible]	10.9	9.7	8.8	8.6	7.8	7.6	8.8

Average Moisture % of all Samples-9.41

Experiment No. 4

Table No. 10:--Butterfield Corn. Initial Moisture Content [illegible] per cent. After Drying 36 hours one direction and reversed 36 hours at 100° F.

Sample No.	1	2	3	4	5	6	7	8	9	10	11
Original	7.5	7.4	7.8	7.9	7.9	8.8	7.5	7.6	8.8	8.0	8.0
Duplicate	[illegible]	7.5	7.8	8.2	7.8	8.6	7.6	7.5	8.5	8.1	7.6
Average	7.5	[illegible]	7.8	8.1	7.8	8.7	7.5	7.5	8.6	8.0	7.8

Average Moisture % of all Samples-7.83

The following graphs made from the original thermograph charts show the fluctuation in temperatures at different locations in the bin for each experiment performed.

LOCATION OF THERMOGRAPHS

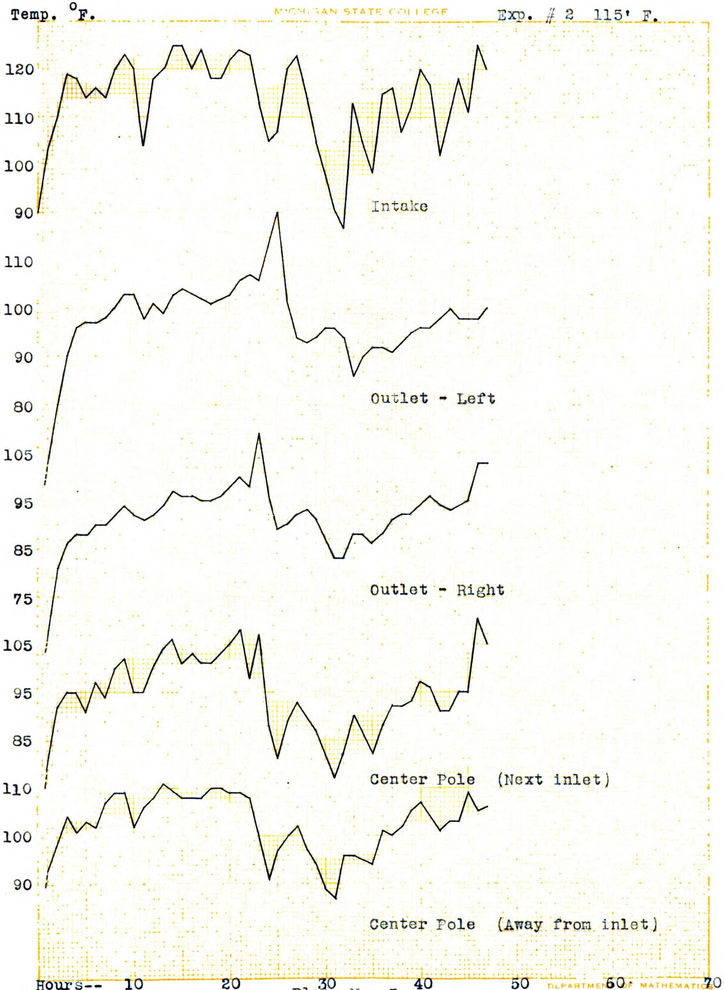
Intake: Thermograph placed directly in front of intake.

Outlet Right: Thermograph placed at the outlet on the right side of bin.

Outlet Left: Thermograph placed at the outlet on the left side of bin.

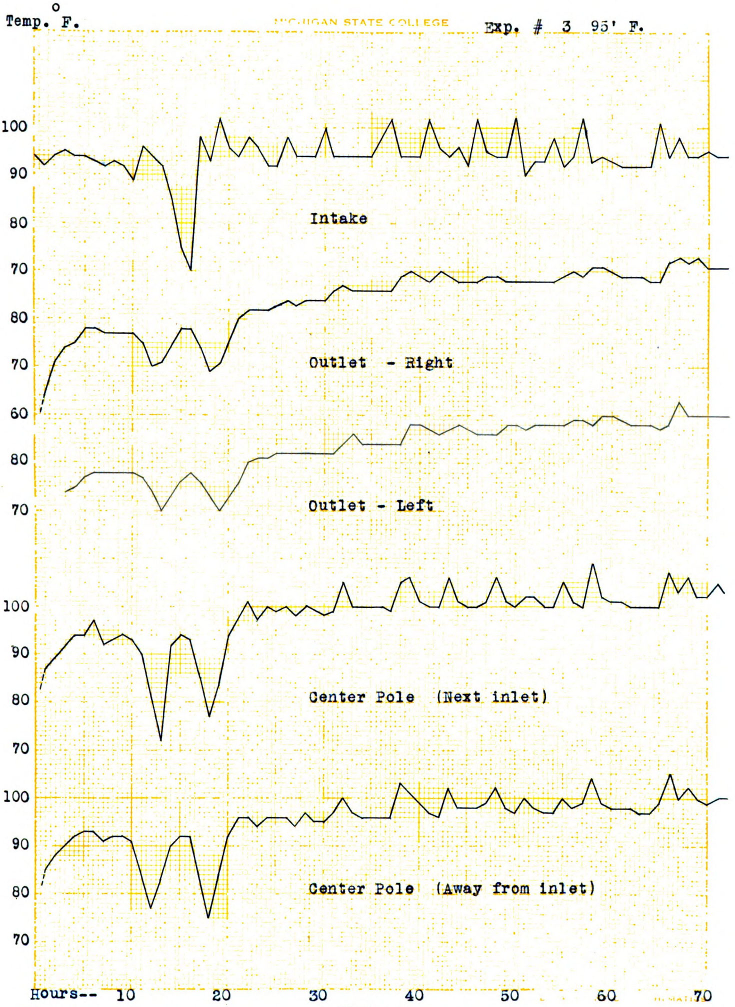
Center Pole next Inlet: Pole of cabled thermograph which was placed in the corn on the side next the inlet, half way down in the center of the bin.

Center Pole away from Inlet: Pole of cabled thermograph which was placed in the corn on the side away from the inlet, half way down in the center of the bin.



Temp. °F.
MICHIGAN STATE COLLEGE
Exp. # 2 115' F.
120
110
100
90
Intake
110
100
90
80
Outlet - Left
105
95
85
75
Outlet - Right
105
95
85
Center Pole (Next inlet)
110
100
90
Center Pole (Away from inlet)
Hours-- 10 20 30 40 50 60 70
DEPARTMENT OF MATHEMATICS

Plate No. I



Temp. °F.
MICHIGAN STATE COLLEGE
Exp. # 3 95' F.
100
90
80
70
Intake
80
70
60
Outlet - Right
80
70
Outlet - Left
100
90
80
70
Center Pole (Next inlet)
100
90
80
70
Center Pole (Away from inlet)
Hours-- 10 20 30 40 50 60 70

Plate No. 2

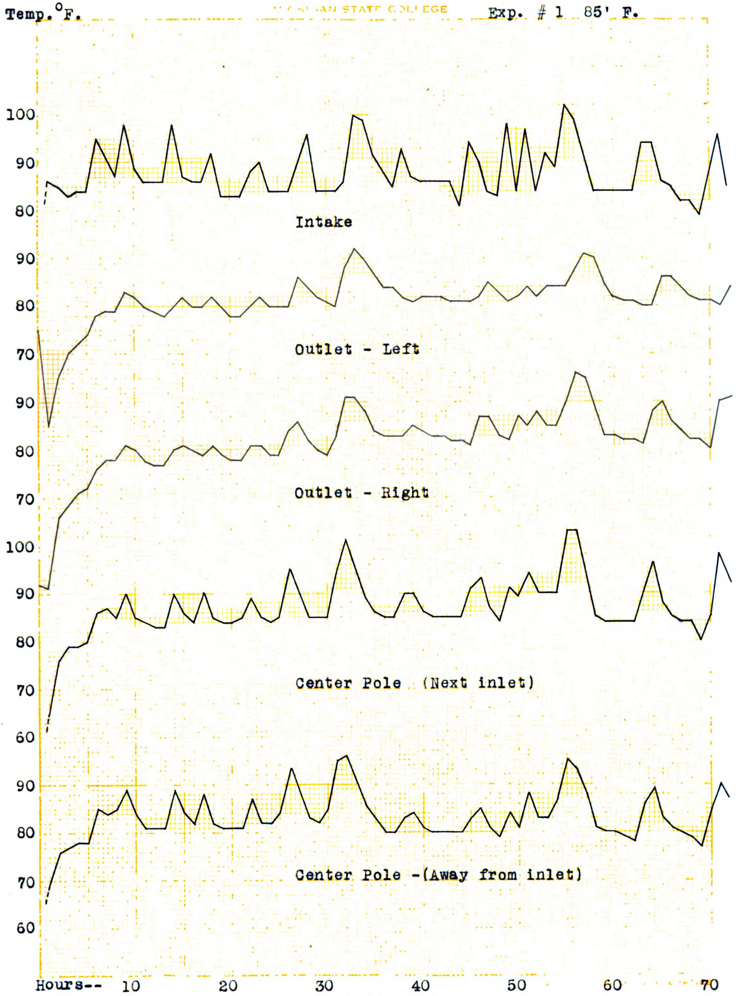
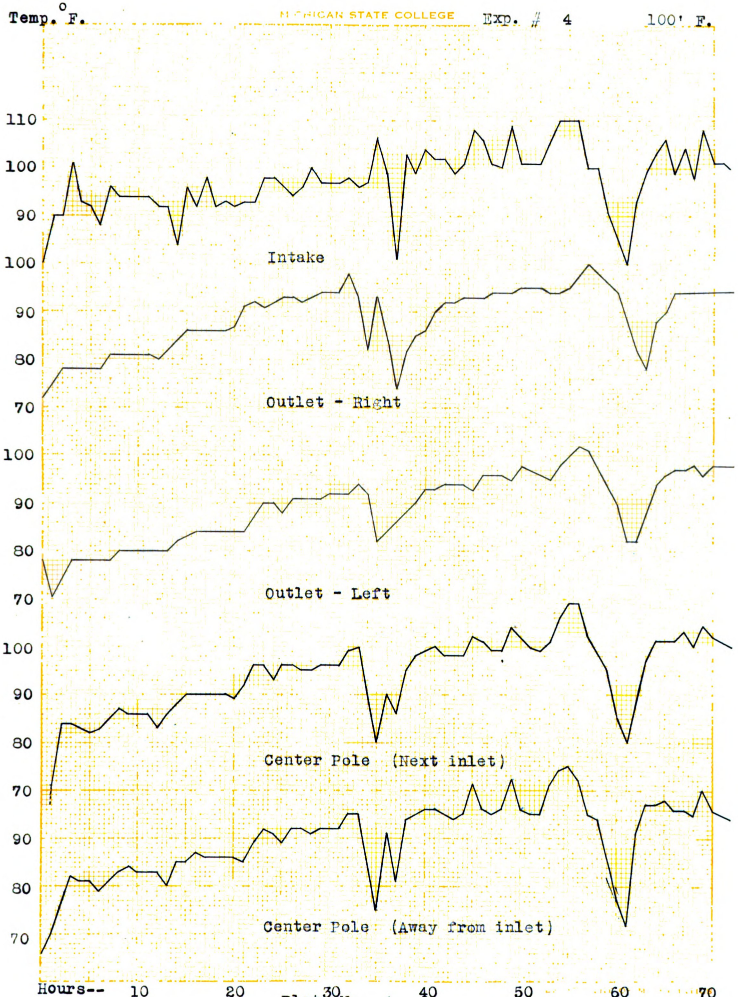

Temp. °F.
Exp. # 1 85' F.
100
90
80
Intake
90
80
70
Outlet - Left
90
80
70
Outlet - Right
100
90
80
70
60
Center Pole (Next inlet)
90
80
70
60
Center Pole -(Away from inlet)
Hours-- 10 20 30 40 50 60 70

Plate No. 3



Temp. °F.
MICHIGAN STATE COLLEGE
Exp. # 4
100' F.
110
100
90
Intake
100
90
80
70
Outlet - Right
100
90
80
70
Outlet - Left
100
90
80
70
Center Pole (Next inlet)
90
80
70
Center Pole (Away from inlet)
Hours--
10
20
30
40
50
60
70

Plate No. 4

OPERATION OF THE BIN DRIER

Cost of Drying One Filling

Electricity 3 days @ $1.65	$ 4.95
Coal ¾ Ton @ $9.00	6.75
Labor--Filling bins, firing furnace, etc.	
8 hours @ $.40	3.20
Labor--Shelling, grading, and sacking	
62 hours @ $.40	24.80
88 one-bushel bags @ $.12	10.56
Storage @ $.05	4.40
Total Cost	$ 54.66

Amount of shelled and graded seed from the three bins, 88 bushels.

Cost per bushel of fancy seed $.621 or $.62 per bushel.

Cost of drying only, based on shelled and graded seed, $.17 per bushel.

The bins will hold 450 baskets of ear corn. When dryed there is a great shrinkage in weight and volume due to loss of moisture. In this particular experiment, 153 bushels (56 lbs.) dryed shelled corn were taken from the three bins. This was graded severely to make fancy registered seed and only 88 bushels of very uniform kernels being saved. The other 65 bushels of butts and tips, misshaped kernels and so forth, were sold for feed at the top market price.

Table No. 11:--Showing the results obtained from a questionaire sent to twenty leading Michigan Farmers who were using other methods of curing seed corn.

No.	Cost of Bldg.	Capacity Bushels	Cost of Equipment	Method of Storing: Stringing	Method of Storing: Racking Cost per bu. 70 lbs. of Undried corn	Heating Unit	Operating cost Per bu. of 70 lbs. Undried corn	Sorting Per bu.
1	$ 600	75	$ 45		$.08	1 Stove	$.20	4
2	1200	550	200		.015	4 "	.10	6
3	550	250	50		.025	2 "	.094	8
4	750	300	75		.10	5 "	.02	2
5	300	300	75		.05	2 "	.17	4
6	1.5	100	40		.06	1 "	.23	3
7	500	150	110		.10	1 Furn.	.095	1.5
8	200	100	50		.07	1 Stove	.08	6
9	420	100	40			1 "	.09	3
10	?000	1500	450		.08	1 Furn.	.025	8
11	650	700	600		.10	1 "	.10	12
12	910	50			none	1 Stove	.05	6

Table No. 11:--(Continued)

No.	Cost of Bldg.	Capacity Bushels	Cost of Equipment	Method of Storing: Stringing	Method of Storing: Racking Cost per bu. 70 lbs. of Undried corn	Heating Unit	Operating cost Per bu. of 70 lbs. Undried corn	Sorting Per bu.
13	$1200	500	$120	.135		2 stoves	$.11	8
14	Old	100	40		$.095	2 "	.067	6
15	200	500	70		.09	1 "	.05	12
16	500	600	275		.07	1 Furn.		6
17	400	550	125		.08	2 stoves	.064	4
				Average	.0725		.093	

Based on the above estimate, the average cost per 70 pound bushel of undried corn for racking and drying is 17¢. Assuming the same shrinkage in drying, shelling and grading as occurred in the experiments at the W. K. Kellogg Farm the average cost for racking and drying based on a 56 pound bushel of shelled and graded certified seed would be 42¢ per bushel as compared to 17¢ in the case of the bin dryer used in these experiments. The total operating cost for drying, shelling, grading, and preparing the seed for the market at the W. K. Kellogg Farm was 62¢ per bushel of dryed and graded seed as compared to 89¢ the average for the group in the above table.

DISCUSSION OF THE COST OF CURING SEED CORN

It was interesting to keep cost records on the bin method of curing seed corn and compare the cost by this method with other methods. In the bin method the cost of hanging, racking, or stringing is eleminated, which greatly reduces the expense. The cost sheet shows the cost of drying one filling of the bins only. However, this does not represent the capacity of the dryer and the more corn that is dried the lower the overhead cost of the dryer will be.

The cost is not prohibitive when quality in seed corn is considered. The time saved by drying the corn completely--from field to sheller--in from three to four days is a marked advantage. This is a saving not only in time, which may require from six to eight weeks by other methods, but a saving in the control of disease. Conditions for the development of molds and bacteria are ideal where room temperatures are used for long periods of time. In the bin method of curing seed corn these conditions exist for a very short time and the corn is dry before they have the opportunity to develop to a dangerous point.

Furthermore, the cost per bushel of drying seed corn by this method is less. A questionaire (Table 11) sent to twenty leading farmers and seed producers throughout the state revealed the fact that drying seed corn by other methods was 26 cents per bushel higher than by the bin method. Most of those who have seen the two systems in operation believe that there is an even greater difference in their respective costs, but accurate figures on the older system of racking and drying are not available.

The difference in costs is not only due to the expense of racking but the racking system requires more room and a longer firing period. Grower number 2, in Table 11, reported a $1200 investment for a dryer of 550 bushels capacity. The drying unit at the W. K. Kellogg Farm also represents a $1200 investment, but it has a seasonable capacity at least 5 times as great as that of the above mentioned dryer. This increased capacity makes the overhead much less in the case of the bin dryer. Fuel costs per bushel are also much lower with the bin equipment and there is less danger that part of the corn will be damaged as frequently happens in the ordinary drying house.

CONCLUSIONS

1. Artificial heat is necessary for the drying of seed corn in a climate and under conditions as prevail in Michigan.

2. The bin or bulk method is an efficient and practical method to use in curing seed corn.

3. Thermostatic control of the furnace in a seed corn dryer of this type is more efficient than hand control.

4. Temperatures of 85°F. to 113°F. are not harmful to the germination of ear corn when applied by this method.

5. Using the above temperatures corn can be dried to a safe moisture content in from 72 to 96 hours depending on its initial moisture content.

6. The germination of ear corn which was dried to as low as 7.3% moisture was not harmed.

7. For efficient drying of seed corn by this method it is necessary that a means of reversing the direction of air currents be included in the drying plant.

8. The bin method is more economical than other methods of drying seed corn for commercial seed corn growers who need drying units of large capacity.

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