THE EFFECT OF TEMPERATURE, SEED TREATMENT AND KERNEL SIZE ON THE GERMINATION OF CORN

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Donald M. Walling

1949

This is to certify that the

thesis entitled

"The Effect of Temperature, Seed Treatment and Kernel Size on the Germination of Corn."

presented by

Donald M. Walling

has been accepted towards fulfillment of the requirements for

MS degree in Farm Crops

E. E. Down
Major professor

Date May 26, 1949

THE EFFECT OF TEMPERATURE, SEED TREATMENT AND KERNEL SIZE ON THE GERMINATION OF CORN

by

DONALD M. WALLING

A THESIS

Submitted to the Graduate School of Michigan State College of Agriculture and Applied Science in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

Department of Farm Crops

1949

ACKNOWLEDGMENT

The writer wishes to express his appreciation to Dr. E.E. Down for his guidance throughout the experiments and preparation of this thesis; to Mr. C.A. Stahl of the Michigan State Seed Laboratory for the use of germination facilities; and to Dr. L. Katz and Mr. H.M. Brown for their assistance and constructive criticisms with the statistical analysis.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	2
METHODS AND MATERIALS	3
PRESENTATION AND DISCUSSION OF DATA	6
SUMMARY	9
APPENDIX	12-18

INTRODUCTION

The grading and treatment of seed corn by processors, coupled with the planting of such seed under variable soil temperature conditions, has led to many diverse opinions as to the value of seed size or grade, seed treatment and present day germination tests on the subsequent behavior of the growing crop.

Germination tests under warm conditions of 70 - 85°F. have been used for years to determine the viability of seed corn. Although such tests are of value it is doubtful whether they give a true indication of field performance. Where low soil temperatures are common at planting time, the use of lower temperatures for germination tests might more nearly simulate actual field conditions. Likewise, the use of fungicides and varying kernel sizes may influence directly the stand and vigor of the corn in the field.

In order to arrive at some of the problems inherent in present day seed corn handling, the present paper provides comparisons between the warm and cold test methods of germination; the influence of a representative fungicide, Arasan, when compared to no treatment; and a comparison between several of the common seed-size grades as to germination and field behavior.

REVIEW OF LITERATURE

Munn (6), working with garden peas, obtained only 45% germination in the field with seed which germinated 79% in the laboratory. Working with damaged seed coats, Tatum and Zuber (11) observed a close relationship between cold tests and stands in the field, whereas warm germination tests failed to indicate weaknesses which showed up in the cold tests. Vander Meulen and Henke (12) found that seeds which germinated well in cold tests gave good stands under field conditions. Likewise, Haskell and Singleton (2), using a severe cold test, found positive correlation between cold tests and field trials.

Field trials, on the effects of seed treatment, in Illinois and Iowa (3, 7, 8,) have given better stands and increased yields when seed treatments were used. However, similar tests in Nebraska and Arkansas (4, 5) have failed to show benefit from seed treatment. Tatum and Zuber (11) presented evidence that cold tests conducted in steamed soil did not result in decreased germination, indicating that soil pathogens are responsible for low germination in cold tests and in the field.

Schmidt (9) found medium weight kernels of sweet corn germinated approximately 8% better than very heavy or very light seeds under green house conditions. Working with wheat, Whitcomb (13) obtained higher germinations from heavier seeds in the field while laboratory and green house germinations did not indicate differences due to seed size. Erickson (1) reports that germination of alfalfa is directly associated with seed size.

METHODS AND MATERIALS

For the present study five lots of corn, including two inbreds, one single cross and two double crosses, were selected. In each of these lots, four of the most common seed grades, large round, large flats, medium round and medium flat were used. Each grade of corn was divided into two parts, one being treated with Arasan and the other not. The treated and untreated parts were germinated separately using samples of 100 seeds.

Four experiments were conducted to test these corns for germination under warm and cold conditions. The germination methods employed were as follows:

1. Corn was placed on blotters in a germinator held at 75°F. Germination counts were made at the end of seven days.

2. Plantings were made in sand in the green house where the temperature was about 75° F. Germination counts were made after 14 days.

3. Corn was placed on blotters in the germinator with 50 grams of pathogen infested soil added to each blotter. The temperature was held at 50°F. for the first six days and then raised to 75°F. for the second six days. Counts were made at the end of this time.

4. Plantings were made in the field on May 25, 1948. The soil contained sufficient moisture for rapid germination and the soil temperature for the first and second weeks after planting averaged 57° and 64°F., respectively. Germination counts were made at the end of 30 days.

Figure 1. Showing design used in the field

Replication 1

III	VII	II	I	IX	X	VI	VIII	IV	V
4132	3142	2341	1243	4312	4231	2413	3214	2143	3124

Replication 2

III	VI	X	VIII	VII	I	V	II	IX	IV
2431	2134	1234	2314	4213	3241	1243	3412	4321	2413

Key to treatments and grades

Main plots	Subplots
I - Double Cross 1, treated	1 - Large Round
II - Single Cross, treated	2 - Large Flat
III - Double Cross 2, treated	3 - Medium Round
IV - Inbred 1, treated	4 - Medium Flat
V - Inbred 2, treated	
VI - Double Cross 1, Untreated	
VII - Double Cross 2, Untreated	
VIII - Inbred 1, Untreated	
IX - Single Cross, Untreated	
X - Inbred 2, Untreated	

Methods 1 and 2 were considered to be warm tests and methods 3 and 4 were used as cold tests.

The experimental design used in this study was a split-plot with two replications. The combinations of treatments and lots were used as the main plots with grades as the subplots. The design, as it appeared in the field, is presented in Figure 1.

All results were recorded as percentages. Since these percentages formed a skewed frequency distribution, as shown in Table 2, conversion to arc sine values (10) was made. This was necessary before analysis of variance could be applied to the data.

Analysis of variance was run on each of the four experiments and Bartlett's test of homogeneity (10) was applied to the four error variances. The four experiments were found to be homogeneous and, therefore, were combined into a total analysis of variance. Significance was determined by use of the F test. The general error term was used for testing methods and grades. The combined r x t and r x l x t interactions were used as the error term for testing treatments.

All tables can be found in the Appendix.

PRESENTATION AND DISCUSSION OF DATA

The germination percentages for all samples are presented in Table 1. Tables 3, 4, 5, and 6 give the arc sine values for each of the experiments with their respective analyses of variance. The analysis of variance for the combined experiments is presented in Table 7.

It is apparent from Table 1 that corn germinated higher under warm conditions than it did under cold conditions. Warm tests averaged 87.9% while cold tests averaged only 77.7%; this difference was highly significant. The germinations in the warm germinator were significantly higher than those obtained in the greenhouse, but there was no significant difference between the germinations obtained in the cold germinator and those in the field. Differences in germination due to seed size were observed in the cold tests while the warm tests failed to indicate these differences. Comparisons between warm and cold tests in this experiment gave results quite similar to those reported by other workers (2, 6, 11, 12).

The warm tests tend to give maximum potential germinations which are not necessarily suggestive of field performance, while the cold tests give germinations which are similar to those obtained in the field. It seems, therefore, that cold tests are necessary to predict field results. The question arises as to whether the cold test should replace the present-day system of warm testing. Information available indicates that it would be better to use the cold test as a supplement to the warm test rather than as a replacement. Since cold test germinations are likely to be quite low, they would present a sales hazard, if used as the only test for seed. If both warm and cold tests were conducted on a given lot of seed, a seedsman could then label the lot of seed giving the warm germination percentage and use the cold test to determine whether that lot of seed would jeopardize his reputation, if the seed were placed on the market.

It is obvious, from Table 1, that the use of Arasan dust greatly increased germination in certain cases. Treated seed germinated 89.5% while untreated seed tested 76.0% in the combined experiments. This difference was highly significant. The greatest increase in germination due to seed treatment was observed in inbred I, a corn which germinated 74.8% in the field when treated and only 28.5% when not treated. Increased field stands obtained in the present study corresponded to results in Illinois and Iowa tests (3, 7, 8).

Treatment of seed corn is of value where low soil temperatures prevail at planting time. Even though seed treatment may not always materially increase germination, it is a good form of insurance against poor stands. When a weak lot of seed, such as inbred 1, is the only seed available for planting, seed treatment is mandatory if a reasonably good stand is desired.

The effect of seed size upon germination, while less obvious than temperature and treatment, nevertheless, is shown in the analyses of variance. Highly significant differences in germination due to seed size were found in the cold tests while warm tests failed to show these differences. Large seeds germinated higher than medium sized seeds and the large flat grade germinated better than any other grade tested. In the cold germinator large rounds tested higher than medium rounds and the combined flat grades germinated better than the combined round grades. No differences between the two medium sized grades were observed. Results in this study agreed with those obtained by Whitcomb (13) in his work with wheat and those reported by Erickson (1) on alfalfa. Schmidt's (9) finding that medium weight kernels germinated better than heavy kernels conflicts with results obtained in the present study.

SUMMARY

In this study the effects of temperature, seed treatment and kernel size on the germination of corn were studied using five lots of corn. The data are summarized in the present paper and from the results, the following conclusions may be drawn:

1. Warm tests gave higher germination percentages than cold tests.
2. The cold germinator test gave results which were similiar to those obtained in field plantings and may be of value in predicting field performance.
3. Seed treatment increased germination under both warm and cold conditions.
4. Differences in germination due to seed size manifest themselves in cold tests, but not in warm tests.
5. Large seeds germinated better than medium sized seeds and the large flat grade of corn germinated higher than any of the other grades tested.

LITERATURE CITED

1. Erickson, L.C. The effect of alfalfa seed size and depth of seeding upon the subsequent procurement of stand. Jour. Amer. Soc. Agron. 38:964-973. 1946.

2. Haskell, G. and Singleton, W.R. Use of controlled low temperature in evaluating the cold hardiness of inbred and hybrid maize. Jour. Amer. Soc. Agron. 41:34-40. 1949.

3. Holbert, J.R. and Koehler, B. Results of seed-treatment experiments with yellow dent corn. U.S.D.A. Tech. Bul. 260. 1931.

4. Kiesselbach, T.A. and Culbertson, J.O. An analysis of the effects of diplodia infection and treatment of seed corn. Jour. Agr. Res. 42:723-749. 1931.

5. McClelland. C.K. and Young, V.H. Seed corn treatment in Arkansas. Jour. Amer. Soc. Agron. 26:189-195. 1934.

6. Munn, M.T. Comparing laboratory and field viability tests of seed of garden peas. Assoc. Off. Seed Anal. No. Amer. Proc., 18:55. 1926.

7. Reddy, C.S. Chemical treatments of seed corn. Iowa Agr. Exp. Sta. Ann. Rept. 1930-31. p. 40. 1931.

8. ______ Relation of rate of planting of the effect of corn seed treatment. Iowa Corn Res. Inst. Contrib., 1:119-130. 1935.

9. Schmidt, D. The effect of the weight of the seed on the growth of the plant. N.J. Agr. Exp. Sta. Bul. 404. 1924.

10. Snedecor, G.W. Statistical Methods. 1946.

11. Tatum, L.A. and Zuber, M.S. Germination of maize under adverse conditions. Jour. Amer. Soc. Agron. 35:48-59. 1943.

12. Vander Meulen, E. and Henke, F. "Cold testing" of seed corn. "The Canner", Jul 31 1948.

13. Whitcomb, W.O. Weight per bushel of wheat in relation of its seed value. Assoc. Off. Seed Anal. No. Amer. Proc. 28:59-61. 1936.

APPENDIX

Table 1. The actual percentages obtained from samples of 100 seeds

		Treated								Untreated							
		LR		LF		MR		MF		LR		LF		MR		MF	
Lot	M	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
I-1	WG	87	95	86	85	88	87	77	78	45	56	49	43	67	56	48	58
	Gr	89	87	82	86	91	87	76	79	46	37	39	34	53	40	34	26
	CG	79	73	71	65	76	76	67	61	18	21	30	16	17	19	9	17
	F	78	72	72	76	83	81	69	67	26	32	32	22	22	36	28	30
I-2	WG	94	89	95	97	93	97	90	94	91	88	95	92	88	91	87	88
	Gr	95	92	94	95	92	93	93	91	93	87	93	90	90	87	84	91
	CG	88	86	92	95	86	89	88	86	82	72	90	84	78	77	72	78
	F	87	86	94	91	91	83	82	83	73	79	82	86	73	80	83	79
SC	WG	94	93	96	98	98	91	94	97	92	95	97	94	95	89	94	92
	Gr	95	97	96	97	97	99	97	98	96	92	95	95	93	93	97	95
	CG	86	92	95	95	78	74	84	87	78	75	92	89	72	69	70	81
	F	90	92	93	92	82	80	86	81	78	78	91	92	67	70	78	73
DC-1	WG	99	98	93	96	96	94	97	95	93	96	95	95	93	95	98	94
	Gr	97	92	97	91	93	95	93	93	96	93	91	93	88	92	93	95
	CG	97	96	94	94	91	94	92	98	84	81	95	89	73	63	87	83
	F	89	87	92	93	93	96	94	89	82	78	80	77	66	63	71	78
DC-2	WG	96	94	96	95	95	95	96	92	91	88	96	92	91	91	91	97
	Gr	92	93	93	94	93	94	97	88	95	89	89	93	94	90	95	91
	CG	95	94	90	83	91	94	97	93	73	82	76	89	90	90	88	83
	F	93	90	88	87	90	95	91	86	87	91	84	89	87	90	92	88

KEY

I-1 Inbred 1
I-2 Inbred 2
SC Single Cross
DC-1 Double Cross 1
DC-2 Double Cross 2

LR - Large Round
LF - Large Flat
MR - Medium Round
MF - Medium Flat
R1 - Replication 1

R2 - Replication 2
WG - Warm Germinator
Gr - Greenhouse
CG - Cold Germinator
F - Field

Table 2. Frequency distribution of germination percentages obtained in combined experiments

Germination Percentage	Frequency	Germination Percentage	Frequency
99	2	69	2
98	6	67	4
97	16	66	1
96	13	65	1
95	28	63	2
94	20	61	1
93	26	58	1
92	20	56	2
91	20	53	1
90	12	49	1
89	12	48	1
88	12	46	1
87	14	45	1
86	10	43	1
85	1	40	1
84	5	39	1
83	7	37	1
82	7	36	1
81	4	34	2
80	3	32	2
79	4	30	2
78	11	28	1
77	3	26	2
76	5	22	2
75	1	21	1
74	1	19	1
73	6	18	1
72	5	17	2
71	2	16	1
70	2	9	1

Table 3. Arc sine conversions with analysis of variance for warm germinator

	Treated								Untreated							
	LR		LF		MR		MF		LR		LF		MR		MF	
Lot	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
I-1	69	77	68	67	70	69	61	62	42	48	44	41	55	48	44	50
I-2	76	71	77	80	75	80	72	76	73	70	77	74	70	73	69	70
SC	76	75	78	82	82	73	76	80	74	77	80	76	77	71	76	74
DC-1	84	82	75	78	78	76	80	77	75	78	77	77	75	77	82	76
DC-2	78	76	78	77	77	77	78	74	73	70	78	74	73	73	73	80

Analysis of variance

Source of variation	D.F.	Sum of squares	Mean square
Total	79	7391.49	
Lots	4	4683.80	1170.95**
Treatment	1	800.11	800.11**
l x t	4	1143.70	285.92**
Replication	1	1.01	1.01
r x l	4	17.80	4.45
r x t r x l x t	5	13.32	2.66
Grades	3	20.54	6.85
g x l	12	232.40	19.37
g x t	3	44.34	14.78
g x l x t	12	142.10	11.84
Error	30	292.37	9.74

* Significance at 1% level
** Significance at 5% level

Table 4. Arc sine conversions with analysis of variance for greenhouse

	Treated								Untreated							
	LR		LF		MR		MF		LR		LF		MR		MF	
Lot	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
I-1	71	69	65	68	73	69	61	63	43	37	39	36	47	39	36	31
I-2	77	74	76	77	74	75	75	73	75	69	75	72	72	69	66	73
SC	77	80	78	80	80	84	80	82	78	74	77	77	75	75	80	77
DC-1	80	74	80	73	75	77	75	75	78	75	73	75	70	74	75	77
DC-2	74	75	75	76	75	76	80	70	77	71	71	75	76	72	77	73

Analysis of variance

Source of variation	D.F.	Sum of squares	Mean Square
Total	79	10747.20	
Lots	4	6679.82	1669.96**
Treatment	1	1201.25	1201.25**
l x t	4	2253.13	563.29**
Replication	1	31.25	31.25*
r x l	4	27.13	6.78
r x t r x l x t	5	64.62	12.92
Grades	3	27.10	9.03
g x l	12	221.78	18.48*
g x t	3	10.85	3.62
g x l x t	12	27.27	2.27
Error	30	203.00	6.77

* Significance at 5% level
** Significance at 1% level

Table 5. Arc sine conversions with analysis of variance for cold germinator

	Treated								Untreated							
	LR		LF		MR		MF		LR		LF		MR		MF	
Lot	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
I-1	63	59	57	54	61	61	55	51	25	28	33	24	24	26	17	24
I-2	70	68	74	77	68	71	70	68	65	58	72	66	62	61	58	62
SC	68	74	77	77	62	59	66	69	62	60	74	71	58	56	57	64
DC-1	80	78	76	76	73	76	74	82	66	64	77	71	59	53	69	66
DC-2	77	76	72	66	73	76	80	75	59	65	61	71	72	72	70	66

Analysis of variance

Source of variation	D.F.	Sum of squares	Mean squares
Total	79	17071.39	
Lots	4	9885.70	2471.42 **
Treatment	1	3393.01	3393.01 **
l x t	4	1952.30	488.08 **
Replication	1	2.81	2.81
r x l	4	12.00	3.00
r x t r x l x t	5	93.32	18.66
Grades	3	298.34	99.45 **
Lg. vs Med.	1	195.31	195.31 **
LR vs LF	1	93.03	93.03 **
MR vs MF	1	10.00	10.00
Rd. vs Flat	1	82.01	82.01 **
LR vs MR	1	44.10	44.10 *
LF vs MF	1	172.23	172.23 **
g x l	12	814.10	67.84 **
g x t	3	149.74	49.91 **
g x l x t	12	169.70	14.14
Error	30	300.37	10.01

*Significance at 5% level
**Significance at 1% level

Table 6. Arc sine conversions with analysis of variance for field plantings

	Treated								Untreated							
	LR		LF		MR		MF		LR		LF		MR		MF	
Lot	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
I-1	62	58	58	61	66	64	56	55	31	34	34	28	28	37	32	33
I-2	69	68	76	73	73	66	65	66	59	63	65	68	59	63	66	63
SC	72	74	75	74	65	63	68	64	62	62	73	74	55	57	62	59
DC-1	71	69	74	75	75	78	76	71	65	62	63	61	54	53	57	62
DC-2	75	72	70	69	72	77	73	68	69	73	66	71	69	72	74	70

Analysis of variance

Source of variation	D.F.	Sum of squares	Mean square
Total	79	11624.80	
Lots	4	6226.92	1556.73 **
Treatment	1	2508.80	2508.80 **
l x t	4	1711.08	427.77 **
Replication	1	0.20	.20
r x l	4	4.18	1.04
r x t r x l x t	5	38.62	7.72
Grades	3	142.80	47.60 **
Lg. vs. Med.	1	105.80	105.80 **
LR vs LF	1	36.10	36.10 *
MR vs MF	1	.90	.90
Rd. vs Flat	1	12.80	12.80
LR vs MR	1	14.40	14.40
LF vs MF	1	115.60	115.60**
g x l	12	487.58	40.63 **
g x t	3	124.40	41.47 **
g x l x t	12	168.22	14.02
Error	30	212.00	7.07

* Significance at 5% level
** Significance at 1% level

Table 7. Analysis of variance for the combined experiments

Source of variation	D.F.	Sum of squares	Mean square
Total	319	52453.89	
Methods	3	5619.01	1873.00 **
Warm vs Cold	1	5544.45	5544.45 **
WG vs Gr	1	74.26	74.26 **
CG vs F	1	.30	.30
Lot	4	26338.14	6584.54 **
l x m	12	1138.13	94.84 **
Treatment	1	7334.45	7334.45 **
t x m	3	568.73	189.58 **
t x l	4	6668.68	1667.17 **
t x l x m	12	391.51	32.62 **
Grades	3	284.37	94.79 **
Comparisons (a)			
Lg. vs Med.	1	211.25	211.25 **
LR vs LF	1	66.31	66.31 **
MR vs MF	1	6.81	6.81
Comparisons (b)			
Rd. vs Flat	1	15.31	15.31
LR vs MR	1	24.03	24.03
LF vs MF	1	245.03	245.03 **
m x g	9	204.41	22.71 **
l x g	12	1163.63	96.97 **
t x g	3	141.77	47.26 **
l x t x g	12	122.60	10.22
m x l x g	36	592.21	16.45 **
m x t x g	9	187.55	20.84 *
m x l x t x g	36	384.71	10.69
Replication	4	35.27	8.82
r x l	16	61.11	3.82 *
r x t			
r x l x t	20	209.88	10.49
Error	120	1007.74	8.40

*Significance at 5% level **Significance at 1% level