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FACTORS INVOLVING ISOLATION IN PRODUCTION OF HYBRID SEED CORN

Thesis for the Degree of M. S.

MICHIGAN STATE COLLEGE

Stanley R. Anderson

1949

THESIS

This is to certify that the

thesis entitled

"Factors Involving Isolation in
Production of Hybrid Seed Corn"

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Stanley R. Anderson

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E. E. Down.
Major professor

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FACTORS INVOLVING ISOLATION IN PRODUCTION OF HYBRID SEED CORN

by

Stanley R. Anderson

A THESIS

Submitted to the School of Graduate Studies of Michigan
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INTRODUCTION

Contamination in the commercial production of hybrid seed corn is of major importance. There are a number of factors that cause contamination, among which insufficient isolation and inadequate detasseling are the most important.

Requirements for isolation of the seed field may be influenced by the relative amounts of pollen produced by both the male pollinating parent in the seed field and nearby corn of another variety or type. Likewise, the wind direction and velocity during the period of pollen shedding may cause variations in contamination. The relative time of silking and pollen shedding of the male parent, climatic conditions which may effect the longevity of the pollen, and isolation brought about by male border rows or natural barriers between the seed field and possible contaminating fields bring about problems which must be answered, if effective isolation is to be brought about. In addition, topography which may influence air currents carrying contaminating pollen and size of seed field are factors that influence possible contamination.

A study of the factors which influence contamination under actual production conditions is the objective of this thesis. An attempt is herein made to simulate the actual conditions under which hybrid seed corn is produced.

Since one of the problems of crop improvement is to keep and maintain genetic purity of varieties, proper isolation of hybrid seed fields becomes a problem of considerable importance and economic significance to growers.

REVIEW OF LITERATURE

L-Russell (4) planted contaminating corn directly adjoining seed fields which were not detasseled. Less than five percent contamination was found after 20 rows of corn in the seed field when contamination was from the north, after 40 rows when the contaminating field was on the south, and after 20 rows when east and southeast contamination was present. Isolation required for a low level of contamination depended greatly on the direction the contaminating corn was from the seed field. Sufficient male parent border rows were found to be beneficial in decreasing the percentage contamination. He concluded that more male parent border rows and less isolation distance served to lessen the percentage contamination.

Jones and Newell (1) in determining the concentration of pollen of corn and other grasses, found that there was a rapid decrease due to gravity and dispersal acting on the pollen load as it is blown from the field. Using the average amount of pollen caught in the center of the field as 100%, approximately 31.0% was caught per unit area at 5 rods away from the field, 10.0% at 15 rods, 4.4% at 25 rods, 1.2% at 40 rods, and 0.8% at 60 rods. At 25 rods from the field considerable quantities of pollen remained dispersed in the air. Not until 40 rods was reached was the amount reduced to relatively small quantities. At 60 rods the amount was further reduced to about one percent of that caught at the center of the field. One percent of pollen is the equivalent of several thousand pollen grains per square foot, which would be sufficient to effect much fertilization in absence of competition.

METHODS OF EXPERIMENTATION

This experiment consisted of three fields of yellow dent corn that were located directly east of contaminating fields of Folk's white cap yellow dent corn. The fields were handled similarly to seed fields and the four rows designated as females were detasseled daily, while a fifth row designated as male was left with the tassels on. Folk's White Cap corn gives a white characteristic to the F_1 crosses (2).

Field 1 was located 40 rods from the contaminating white cap field to the first female seed row. Two male border rows were planted around the field to meet the requirements of the Michigan Crop Improvement Association (Table 6). Table 6 is taken from those requirements.

Field 2 was located 20 rods from the contaminating white cap corn to the first female seed row. Ten male border rows were planted on the side facing the contaminating corn and two male border rows surrounded the other sides of the field (5).

Field 3 was located 10 rods from the contaminating white cap corn to the first female seed row. Fourteen male border rows were planted on the side facing the white cap corn and two male border rows surrounded the other sides of the field (5).

The contaminating fields of white cap corn were planted to the west of the seed fields since the prevailing winds are from southwest to west over the area where these fields were located. Wind data were secured during the pollination.

Data from Field 1 were obtained prior to silage harvest when the corn was in the early dent stage. The primary ear from every fifth stalk in each row of female and male corn was sampled and the data were recorded as to the number of white cap kernels per ear. The corn was also sampled for the average number of total kernels per ear.

On Fields 2 and 3, data were taken as to the number of white cap kernels per ear when the corn was mature. Counts were made on every primary ear of the male border rows and female seed rows. No counts were made on the male pollen parent in the main part of the crossing field. Each individual male border row and female series were sampled for the average number of total kernels per ear.

In Field 1, data were taken on the first 20 series of female rows. In Fields 2 and 3, data were taken on all of the female series of rows in the field which consisted of 22 and 12 series, respectively. By "series of female rows" is meant the four rows between two consecutive male pollen rows.

PRESENTATION AND DISCUSSION OF DATA

The data obtained in this experiment is presented in table form on pages 11 through 17. Data were obtained as to the amount of contamination in each field for both the male border rows and the female seed rows. This information is presented in Tables 1, 3, and 4. Table 2 shows the effect of contamination on different female rows within a series of four female rows. In Table 5, the wind data is given for the period during which pollination took place in the experiment. Table 6, is taken from the Field Requirements for isolation of hybrid seed corn production of the Michigan Crop Improvement Association (5).

When each four rows of corn designated as female were analysed, there was found a significant difference in contamination in the center

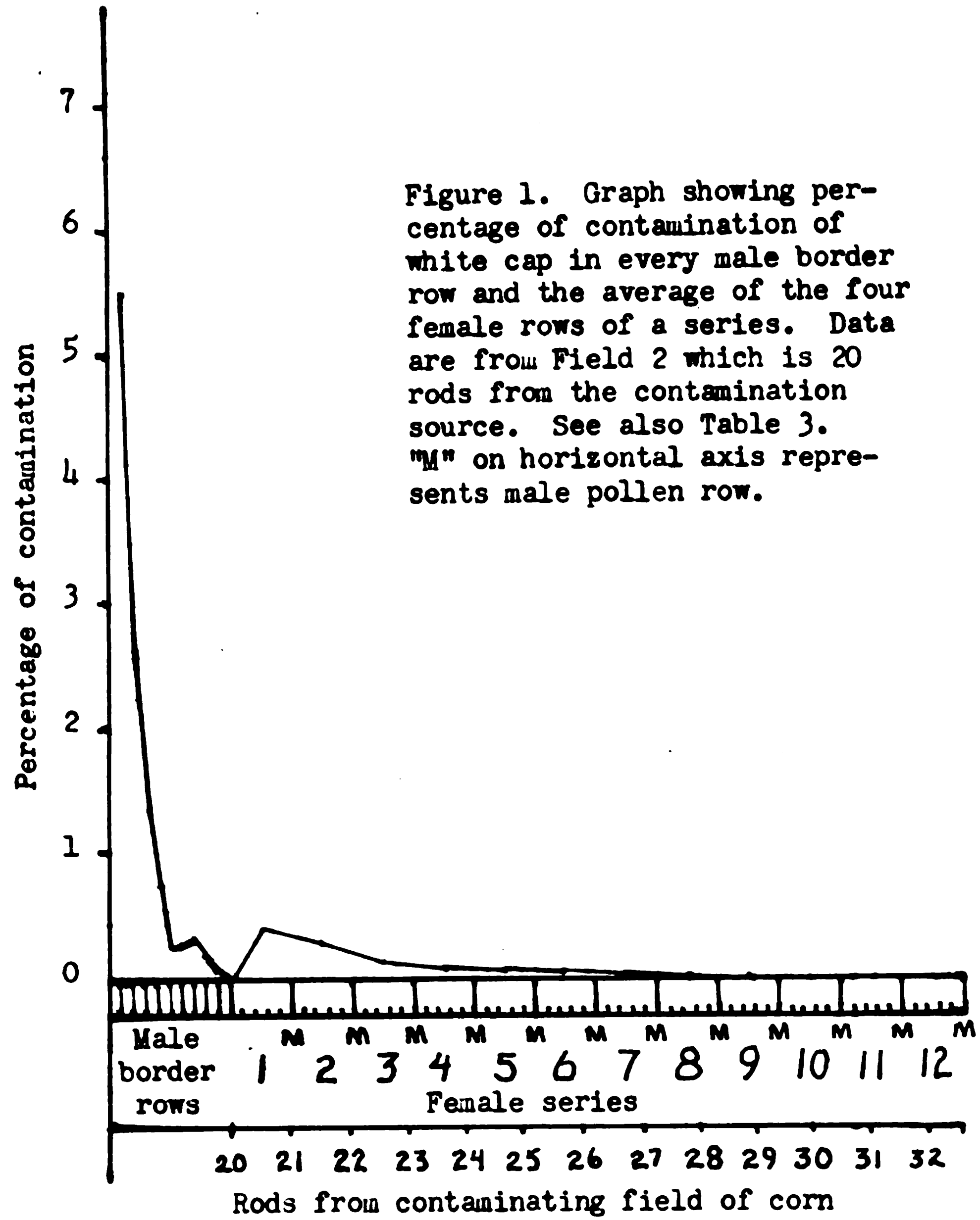

Figure 1. Graph showing percentage of contamination of white cap in every male border row and the average of the four female rows of a series. Data are from Field 2 which is 20 rods from the contamination source. See also Table 3. "M" on horizontal axis represents male pollen row.

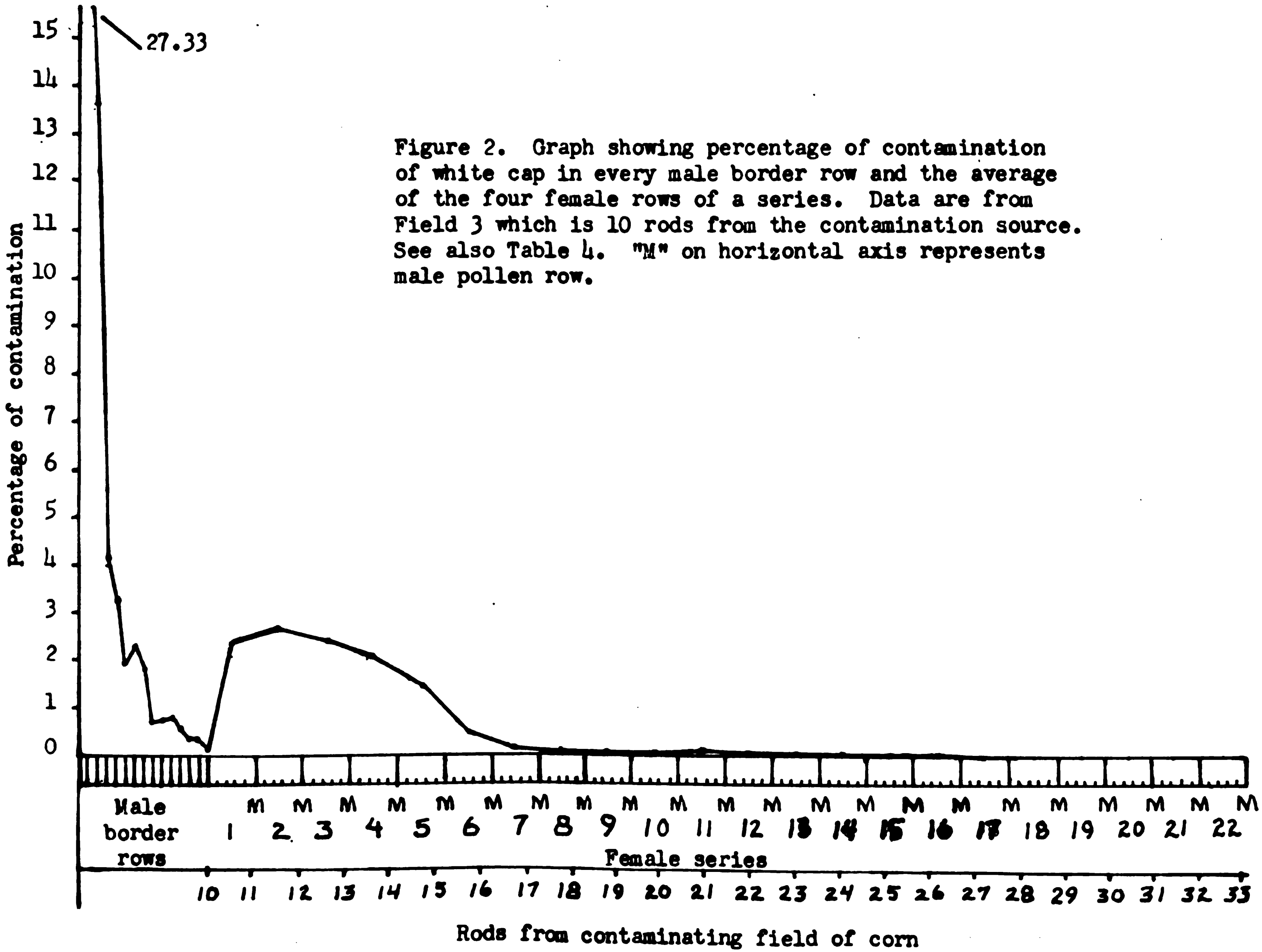

Figure 2. Graph showing percentage of contamination of white cap in every male border row and the average of the four female rows of a series. Data are from Field 3 which is 10 rods from the contamination source. See also Table 4. "M" on horizontal axis represents male pollen row.

two rows as compared to the outer two rows adjacent to the male parent rows. This analysis was done on only the first ten series of the field, since there was relatively little contamination beyond this point. Applying "Students" method to the first ten series of Field 1, the odds are highly significant (482:1) that rows 2 and 3 of a female series of four rows have more white kernels (due to contaminating pollen) than do rows 1 and 4 of the female series.

In the case of Fields 2 and 3, the first male border row facing the contaminating corn exhibited about twice as much contamination as did the second row (Figures 1 and 2 and Tables 3 and 4). Contamination on the next two male border rows decreased rapidly with the remaining male border rows only slightly affected. Apparently the male border rows were effective as barriers. Likewise, the proportion of pollen shed by the male border rows, in relation to the contaminating pollen, increased from the outside to the inside of the male border rows. In the first few female series the contamination increased very noticeably. This was probably due to the decrease in the number of male parent rows and the consequent decrease in amount of male pollen because only every fifth row was a male pollen row with tassels remaining. Results of these findings are illustrated in Figures 1 and 2.

Distance is evidently quite important as all three fields showed that the amount of contamination decreased with respect to increased distance between female seed rows and the contaminating field of white cap corn. However, only in Field 3, where the isolation distance was but ten rods, did the contamination exceed one percent. Less than one percent of contamination was found in this field after a distance of 16 rods. This degree of contamination may seem trivial, but this amount would be disasterous in the maintenance of the genetic identity of a variety of corn.

The winds during the period of pollination in 1948 for all three fields at the time of pollination, were medium to light when from the southwest to westerly directions (Table 5). Some increase in velocity was recorded when the winds shifted to northerly and easterly directions.

SUMMARY

In an attempt to establish, experimentally, the safe isolation requirements for production of hybrid seed corn, three fields of yellow dent corn were planted and handled according to the regulations of the Michigan Crop Improvement Association. Each field was exposed from the west to Folk's White Cap yellow dent corn. This white cap corn gives a white cap characteristic to the F_1 crosses.

Male border rows seemed to act effectively as barriers protecting against contamination in only the male border rows. A rapid decrease in contamination from white cap corn was found in the inner group of male border rows in comparison to the male border rows facing the contaminating field of corn.

A marked increase in contamination was found where the detasseled female series began.

A significant increase in the contamination by the white cap source was found in the inner two rows of the female series of four rows than was found in the outer two rows adjacent to the male pollen parent.

The amount of contamination decreased as the distance from the

contaminating corn increased.

It appears that male border rows are not as effective as distance in preventing contamination in seed production of hybrid corn.

It is also evident that large quantities of the corn pollen drop near the source and that smaller portions are dispersed by the wind.

The evidence shows that where isolation distance must be forfeited and male border rows used, that there is an increase in contamination for the first few series of female corn.

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3. Love, H. H. and Brunson, A. M. Students method for interpreting paired experiments. Jour. of Amer. Soc. of Agron., Vol. 16, No. 1 pp. 60-68 incl. Jan. 1924.

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Table 1. Data from Field 1 were collected on both male and female rows. The primary ear of every fifth stalk in each row was sampled.

Row No.	Type of Row M	Type of Row F	Female Series No.	No. of ears Sampled M	No. of ears Sampled F	Total No. of White Cap kernels M	Total No. of White Cap kernels F	Average number of white cap kernels per ear: Row No. M	Row No. F	Row % M	Row % F	Female series No.	Female series %
1	*			88		72		.82		.14			
2	*			91		81		.89		.15			
3		*			89		69		.78		.13		
4		*			88		74		.84		.14		
5		*			89		68		.76		.13		
6		*	1		88		52		.59		.10	.74	.12
7	*			90		39		.43		.07			
8		*			88		37		.42		.07		
9		*			89		48		.54		.09		
10		*			88		39		.44		.07		
11		*	2		90		25		.28		.05	.42	.07
12	*			89		22		.25		.04			
13		*			90		16		.18		.03		
14		*			90		29		.32		.05		
15		*			89		23		.26		.04		
16		*	3		90		10		.11		.02	.22	.04
17	*			88		5		.06		.01			
18		*			88		9		.10		.02		
19		*			90		17		.19		.03		
20		*			89		25		.28		.05		
21		*	4		89		19		.21		.04	.20	.03
22	*			88		22		.25		.04			
23		*			90		23		.26		.04		
24		*			89		25		.28		.05		

Table 1 cont'd.

25		*			90		29		.32		.05		
26		*	5		88		16		.18		.03	.26	.04
27	*			89		7		.08		.01			
28		*			90		3		.03		.01		
29		*			89		6		.07		.01		
30		*			91		9		.10		.02		
31		*	6		90		4		.04		.01	.06	.01
32	*			89		3		.03		.01			
33		*			90		4		.04		.01		
34		*			89		7		.08		.01		
35		*			90		6		.07		.01		
36		*	7		89		4		.04		.01	.06	.01
37	*			90		4		.04		.01			
38		*			88		6		.07		.01		
39		*			89		5		.06		.01		
40		*			89		8		.09		.02		
41		*	8		89		4		.04		.01	.06	.01
42	*			89		2		.02		.00			
43		*			89		3		.03		.01		
44		*			90		4		.04		.01		
45		*			89		7		.08		.01		
46		*	9		90		2		.02		.00	.04	.01
47	*			90		0		.00		.00			
48		*			89		1		.01		.00		
49		*			90		0		.00		.00		
50		*			88		3		.03		.01		
51		*	10		90		0		.00		.00	.01	.00
52	*			89		2		.02		.00			
53		*			90		1		.01		.00		
54		*			88		0		.00		.00		
55		*			89		1		.01		.00		
56		*	11		88		0		.00		.00	.01	.00

Table 1 cont'd.

57	*			90		0		.00		.00			
58		*			89		0		.00		.00		
59		*			90		0		.00		.00		
60		*			88		3		.03		.01		
61		*	12		88		0		.00		.00	.01	.00
62	*			88		0		.00		.00			
63		*			90		0		.00		.00		
64		*			91		0		.00		.00		
65		*			89		0		.00		.00		
66		*	13		88		0		.00		.00	.00	.00
67	*			89		1		.01		.00			
68		*			90		1		.01		.00		
69		*			90		0		.00		.00		
70		*			88		0		.00		.00		
71		*	14		89		2		.02		.00	.01	.00
72	*			88		0		.00		.00			
73		*			89		2		.02		.00		
74		*			90		0		.00		.00		
75		*			89		0		.00		.00		
76		*	15		88		0		.00		.00	.01	.00
77	*			88		0		.00		.00			
78		*			89		0		.00		.00		
79		*			90		1		.01		.00		
80		*			89		0		.00		.00		
81		*	16		88		0		.00		.00	.00	.00
82	*			88		0		.00		.00			
83		*			90		0		.00		.00		
84		*			88		0		.00		.00		
85		*			90		1		.01		.00		
86		*	17		89		0		.00		.00	.01	.00
87	*			88		0		.00					
88		*			89		0		.00		.00		
89		*			88		1		.01		.00		

Table 1 cont'd.

90		*			88		0		.00		.00		
91		*	18		88		0		.00		.00	.00	.00
92	*			88		0		.00		.00			
93		*			90		0		.00		.00		
94		*			88		0		.00		.00		
95		*			89		0		.00		.00		
96		*	19		88		1		.01		.00	.00	.00
97	*			89		0		.00		.00			
98		*			89		0		.00		.00		
99		*			89		0		.00		.00		
100		*			88		0		.00		.00		
101		*	20		89		0		.00		.00	.00	.00
102	*			90		0		.00		.00			
103	*			88		0		.00		.00			

Table 2. Pairing of inner two rows (2, 3) and outer two rows (1, 4) of each female series in Table 1 to show comparison of relative amounts of contamination in pairs of rows.

Series No.	No. of Ears Sampled		Total White Cap kernels		Average White Cap kernels	
	Rows 2, 3	Rows 1, 4	Rows 2, 3	Rows 1, 4	Rows 2, 3	Rows 1, 4
1	177	177	142	121	.80	.68
2	177	178	87	62	.49	.35
3	179	180	52	26	.29	.14
4	179	177	32	28	.18	.16
5	179	178	54	39	.30	.22
6	180	180	15	7	.08	.04
7	179	179	13	8	.07	.04
8	178	177	13	10	.07	.06
9	179	177	11	5	.06	.03
10	178	179	3	1	.02	.01
11	177	178	1	1	.01	.01
12	178	177	3	0	.02	.00
13	180	178	0	0	.00	.00
14	178	179	0	3	.00	.02
15	179	177	0	2	.00	.01
16	179	177	1	0	.01	.00
17	178	179	1	0	.01	.00
18	177	176	1	0	.01	.00
19	177	178	0	1	.00	.01
20	177	178	0	0	.00	.00

Applying "Students" pairing method (3) to the first 10 series, the odds are highly significant (482:1) that rows 2 and 3 have more white cap kernels (due to contaminating pollen) than do rows 1 and 4 of each female series. This analysis was done on only the first ten series of the field, since there was relatively little contamination beyond this point.

Table 3. This table shows the average total number of kernels per ear of corn, the total and average number of white cap kernels per ear, the percentage of white cap kernels per ear, and the number of ears sampled for both the male border rows and the female parent rows in Field 2.

Male Border row No.	Female Series No.	Total kernels per ear	No. of ears Sampled	Total White Cap kernels per ear	White cap kernels per ear Ave.	White cap kernels per ear %
1		542	29	867	29.90	5.52
2		608	24	392	16.33	2.69
3		628	27	222	8.22	1.31
4		540	28	115	4.11	.76
5		512	26	32	1.23	.24
6		552	25	36	1.44	.26
7		566	25	44	1.76	.31
8		548	25	25	1.00	.18
9		592	26	8	.31	.05
10		610	27	0	.00	.00
	1	590	100	231	2.31	.39
	2	586	102	172	1.69	.29
	3	608	101	94	.93	.15
	4	590	106	38	.36	.06
	5	566	101	29	.29	.05
	6	584	107	19	.18	.03
	7	590	109	13	.12	.02
	8	582	104	5	.05	.01
	9	604	105	1	.01	.00
	10	556	110	0	.00	.00
	11	566	102	0	.00	.00
	12	572	100	0	.00	.00

Table 4. This table shows the average total number of kernels per ear of corn, the total and average number of white cap kernels per ear, the percentage of white cap kernels per ear, and the number of ears sampled for both the male border rows and the female parent rows in Field 3.

Male Border row No.	Female Series No.	Total kernels per ear	No. of ears Sampled	Total White Cap kernels per ear	White cap kernels per ear Ave.	%
1		648	27	4,782	177.11	27.33
2		540	25	1,850	74.00	13.70
3		602	25	627	25.08	4.17
4		590	26	495	19.04	3.23
5		576	30	339	11.30	1.96
6		598	24	336	14.00	2.34
7		512	27	251	9.30	1.82
8		570	28	116	4.14	.73
9		578	26	115	4.42	.76
10		632	29	116	4.00	.79
11		578	28	84	3.00	.52
12		612	29	59	2.03	.33
13		624	26	51	1.96	.31
14		516	27	27	1.00	.19
	1	588	102	1,411	13.83	2.35
	2	601	99	1,551	15.67	2.61
	3	591	107	1,534	14.33	2.42
	4	575	104	1,282	12.33	2.14
	5	576	108	883	8.17	1.42
	6	593	106	300	2.83	.48
	7	592	111	129	1.17	.20
	8	576	104	70	.67	.12
	9	597	105	70	.67	.11
	10	589	102	51	.50	.08
	11	588	100	83	.83	.14
	12	556	107	52	.50	.09
	13	596	110	36	.33	.06
	14	590	103	34	.33	.06
	15	588	105	18	.17	.03
	16	590	107	6	.05	.01
	17	608	109	3	.03	.00
	18	592	100	1	.01	.00
	19	566	100	1	.01	.00
	20	584	101	0	.00	.00
	21	590	104	0	.00	.00
	22	574	108	0	.00	.00

Table 5. The wind direction and velocity for the pollination period covering August 6, 1948 through August 22, 1948, in the area where the experiment took place. Readings were recorded* at four intervals during the day: 6 A.M., 10 A.M., 2 P.M., and 6 P.M.

Date August, 1948	Direction** and Velocity*** of Wind, Time of Day: 6 A.M.		10 A.M.		2 P.M.		6 P.M.	
6	W	10	NW	22	NW	22	NW	8
7	N	6	NW	5	NW	7	NW	3
8	NW	10	NW	8	NW	10	NE	14
9	SE	26	SE	30	SE	16	SE	8
10	SE	4	SE	4	SE	14	SE	17
11	SW	8	SW	10	SW	8	SW	5
12	SW	5	SW	10	SW	6	SW	6
13	SW	5	SW	12	W	8	NW	7
14	N	8	NW	16	NW	10	NW	7
15	W	2	NW	5	N	5	NE	5
16	SW	5	SW	10	SW	11	SW	5
17	SW	6	SW	11	SW	8	SW	6
18	SW	13	W	8	NW	15	NW	12
19	N	26	N	34	NE	19	NE	10
20	E	10	SE	18	SE	12	SE	6
21	S	3	SW	14	SW	9	SW	11
22	S	9	SE	11	S	9	SW	7

* Data collected by the Soil Conservation Service for the Michigan Hydrologis Survey by G. A. Crabb.

** N-north
E-east
S-south
W-west

*** Velocity is given in miles per hour.

Table 6. This table applies to all sides of the crossing field exposed to contamination from another field, whether located directly opposite of diagonally. It indicates the minimum number of male border rows required when sufficient isolation distance is lacking.

When the number of acres in the crossing field is 9 or less acres	10-19 acres	20-29 acres	30-39 acres	40 or more acres	This is the minimum number of outside rows of "pollen" parent required.
and the distance of the seed rows from the other corn is at least					
Rods	Rods	Rods	Rods	Rods	
40	38	36	34	33	2
35	33	31	29	28	4
30	28	26	24	23	6
25	23	21	19	18	8
20	18	16	14	13	10
15	13	11	10	10	12
10	9	7	4	4	14

This was taken from "Certification Service", Hybrid Field Corn, published by the Michigan Crop Improvement Association, Michigan State College, East Lansing, Michigan. Reprint, 1949.

Figure 3. This photo illustrates the white cap contamination on a yellow dent ear of corn.

Figure 4. White cap contamination on the male border rows in Field 2. Ears represent rows 1, 3, 5, 7, and 9.

Figure 5. White cap contamination on the male border rows in Field 3. Ears represent rows 1, 2, 5, 6, 9, 10, 13, and 14.

Figure 6. White cap contamination within the first series of female rows in Field 3. These are representative ears of from all four female rows.

Figure 7. White cap contamination within the second series of female rows in Field 3. These are representative ears of from all four female rows.

Figure 8. White cap contamination within the third series of female rows in Field 3. These are representative ears of from all four female rows.

Figure 9. White cap contamination within the fourth series of female rows in Field 3. These are representative ears of from all four female rows.

Figure 10. White cap contamination within the fifth series of female rows in Field 3. These are representative ears of from all four female rows.

Figure 11. White cap contamination within the sixth series of female rows in Field 3. These are representative ears of from all four female rows.

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