THE EFFECTS OF POLLEN MIXTURES ON THE AMOUNT OF SELF AND CROSS FERTILIZATION IN *ZEA MAYS*

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SELF AND CROSS FERTILIZATION IN ZEA MAYS

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INTRODUCTION

Corn, on a total acre basis, is our most important grain crop. This place of pre-eminence has been maintained since this land was settled. The early white settlers were able to exist the first few years, only because the Indians aided them by giving them food, part of which was corn. As the white settlers moved westward so did corn. The greatest impetus to corn production came in the early 1920's with the development of hybred corn by D. F. Jones. A new crop had appeared on the agricultural horizon. It was, in essence, a crop with better agronomic characteristics, which included such things as greater yield, better standing ability, and more disease resistance. Corn seems to thrive everywhere; it is found at elevations from sea level to 12,000 feet, and grows in temperature ranges from the subartic to the tropical.

More and more demands are being placed on the producers of corn, therefore, any information to facilitate corn production is of great importance. The maintenance of inbred lines is one of the principal problems confronting the producers of hybred corn. If an inbred line is pollinated with equal mixtures of its own and other pollen, and more selfing occurs than crossing, then something within the plants own mechanism is causing this excess of selfing to take place. Factors, other than this excessive function of self fertilization, affecting this problem could be physiological.

The objectives of these investigations are:

(1) To determine if self or cross fertilization is in excess when equal pollen mixtures are used.

(2) To determine the comparative effectiveness of pollen from a

heterozygous open pollinated sweet corn variety and pollen from homozygous dent corn.

REVIEW OF LITERATURE

Early investigators were familiar with the effects of foreign pollen. In a discussion on cross-fertilization in plants, Darwin (1)[1] concluded that if a foreign pollen is placed on the stigma of an emasculated flower, and then after a time interval of several hours, the plant's own pollen is applied on the stigma, the expression is in favor of self pollination.

Kearney and Harrison (4) showed that selective fertilization, in favor of like pollen, takes place in Upland and also Egyptian cotton.

In further studies by Kearney and Harrison (5), emasculated flowers were treated with approximately equal amounts of like and unlike pollen. The resulting populations were grown in progeny trials and there were more homozygous than heterozygous types. Both types of pollen were grown in a media; as far as could be determined there was no difference in pollen viability that could account for the results obtained. The author concluded that the presence of like pollen causes a reaction in the stigmatic tissues which causes these tissues to be less compatible to foreign pollen. It is a chemical reaction.

Jones (3), working with mixed pollen in corn, has shown that the plant's own pollen has been more efficient in effecting fertilization than pollen from varieties which are similar but differ even slightly. When this foreign pollen was applied by itself it was capable of full expression.

In a group of 23 pollinations with mixed pollen, 20 showed a marked preference for self pollination (3). This population consisted of 76,260

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[1] Numbers in parenthesis refer to "Literature Cited", p. 18

seeds, so it is concluded that this preference for selfing could not be attributed to random variation. Selfing would appear to be dominant in the corn plants used here.

Competition has been found to be a factor in the ability of pollens from different types of plants to express themselves. A difference exists in the ability of the pollen from different types of plants to accomplish sexual fusion when acting in competition (3). Jones (2) has shown in experiments with corn that the differences in rate of pollen-tube growth has some influence in causing selective action to take place.

Wilson (6), in studies on self and cross fertilization between Honey June, an open pollinated sweet corn, and Yellow Surcropper, an open pollinated dent type corn, found that there was an excess of selfing regardless of which type of corn was used as the female plant. In these studies, paired plants were used. Pollen, from each tassel of the member pairs, was collected and mixed, with no measure for determining whether the pollens were in equal amounts. In choosing the pairs, however, care was given to assure that plants of approximately the same maturity were used. Where Honey June was the female, 53.07% of the seed produced resulted from selfing and when Yellow Surcropper was the female 52.00% of the seed resulted from selfing.

MATERIALS AND METHODS

These experiments were conducted in 1948 at the Oklahoma Experiment Station at Stillwater, Oklahoma and in 1949 at the Paradise Community, 18 miles southwest of Stillwater, Oklahoma. Five standard inbreds, K4, K201, Kys, 38-11, and 07, plus Oklahoma lines Ok. 12, 12C and 29I were used. Four single crosses, K4 x 38-11, 29I x Kys, 07 x Ok. 12, and K201 x 12C were used. Honey June, an open pollinated sweet corn, was used in comparing sib fertilization and cross fertilization with the inbred and single cross lines. Two sources of Honey June, blue and white, were used. Blue Honey June is a purple aleurone strain selected from the white Honey June after a few sweet blue grains were found in an otherwise pure white seed sample. The purple aleurone character was established by two generations of self pollination followed by sib pollinations between all homozygous purple aleurone selections to restore vigor. The aleurone color is the only apparent difference between the two strains.

In 1948 a paired row of each inbred and white Honey June and a paired row of each single cross and white Honey June were planted. In 1949, plantings similar to those in 1948 were made using white Honey June in one planting and blue Honey June in another planting.

The blue Honey June that was added in 1949 was expected to increase accuracy in distinguishing sibbed and crossed grains on inbred and single cross ears. At times it is very difficult to pick out light yellow crossed grains from the ordinary grains found on certain inbred lines.

The ears on all plants were covered with paper bags before any silks appeared on the shoots. The day before pollinations were to be made the shoots were clipped back about an inch from the tip end to facilitate the uniform pollinations of the ear. Approximately the same number of ears were clipped on each paired row and enough tassels were covered on these rows to assure adequate pollen. Standard pollination procedures were followed with the exception that the anther and pollen mixture from each of the rows was passed through an ordinary kitchen sieve to remove the anthers. Equal quantities of this pollen was measured into test tubes and then mixed. The pollinations were made and the ears were marked, covered and left to mature. After harvesting, kernel counts were made on all ears. Inbred and single cross kernels, resulting from pollinations with white Honey June pollen, showed a pale yellow or white capped effect, while those which resulted from sib pollination showed only the normal yellow color of the inbred or single cross. Blue Honey June kernels that were sib pollinated were of the sweet-kernel type, while those kernels that resulted from cross pollination had a plump or starchy endosperm. The actual number of grains from each ear was recorded as sib or cross fertilized.

A total of 1,007 ears were harvested, out of which 636 ears and 210,430 kernels were used in this study. The other ears were not used because the tags were missing or the information needed had faded out. These tags were essential because they had the date of pollination recorded on them. Without this date of pollination, it was impossible to group the ears which resulted from pollinations with the same pollen mixture.

The chi-square analysis of variance was used. Chi-square, as defined by Snedecor (6), is an index of dispersion and it serves as a check on the significance of observed deviations from the expected results obtained in this experiment.

RESULTS AND DISCUSSION

The analysis used assumes that the two sources of pollen, making up the pollen mixtures, were equal in volume and number of viable grains, that they were thoroughly mixed and that they were applied uniformly to the silks. The deviations from the expected 50-50 expression of the pollen mixtures, then, would be due to something other than the pollen mixture. The total number of kernels obtained from pollinations of Honey June and inbreds or single crosses with one pollen mixture was divided by two and this figure was used as the expected number of sibbed kernels. The observed values were the sum of the grains on the Honey June and inbred or single cross ears resulting from sib fertilization. The difference between these two figures was used in formulating chi-square. Table 2 gives an example of these calculations.

The results of this experiment are given in Table 1. Information from which this data was derived is found in Table 4 (Appendix). The deviations from expected ratios are very great as shown by the large chi-square values. A total of 40 comparisons were analyzed with the following results: 2 were non-significant; 3 were significant at the 5% level and 35 were significant at the 1% level. These figures mean that a 50-50 segregation of functioning pollen from the mixture of Honey June and inbred or single cross was not obtained. Unequal pollen mixtures would not influence the results of this experiment, however, because if the pollen in excess in the mixture was applied to both Honey June and the inbreds or single crosses, then the results on one of these lines would tend to affect the excessive functioning of the pollen on the other line. In a closer examination of Table 1, an excessive functioning of the plant's own pollen is noted, or there is a larger number of pollen grains functioning on the plant from which the pollen was taken. In studies of this nature, other workers have found that the plant's own pollen is more effective in consummating fertilization than pollen from other plants. Some factor, or combination of factors, caused this excessive amount of sib fertilization to take place. These factors are possibly closely associated with the physiology of the individual plant. Such physiological factors as difference in age of silks, differential rate of growth of the pollen tube down the silk, or viability of pollen grains from the different sources, might be the answer to these results.

Information on the comparative effectiveness of the pollen from Honey June in competition with inbred or single cross pollen is given in Table 3. In 1948, only 2 out of 20 mixed pollinations had excessive functioning of pollen from Honey June plants and in 1949, 12 out of 28 had deviations in the same direction. Pollen from the inbreds or single crosses functioned in excess 34 times out of 48 crosses, or in 70.8% of the mixtures. For this experiment, the pollen from inbred or single cross lines seemed to be a better competitor than an equal amount of Honey June pollen, when applied in mixtures on either the inbred or single cross and Honey June ears. It is interesting to note that no one inbred or single cross seemed to stand out over other inbreds or single crosses in the amount of sib fertilization that was consummated.

There are many variables in this experiment which need to be controlled. It would be extremely difficult to control them, but a refinement of technique is needed. Certainly there is much information to be gleaned from experiments of this nature that would aid plant breeders in solving problems relating to their work.

Table 1. - The variation in number of sib and cross fertilization kernels resulting from pollen mixtures in Honey June and inbred or single crosses as measured by a chi-square analysis.

Year	Ears and Pollen Mixtures Used: Line	Ears and Pollen Mixtures Used: Honey June	Kernels: Number Sibbed	Kernels: Number Crossed	Chi-square value	Date of Pollination
1948	291	W	7,232	3,134	3,240.128*	Aug. 7
	12C	W	327	233	31.556*	Aug. 4
	12C	W	3,054	3,163	3.820**	Aug. 7
	K4	W	1,021	364	623.316*	Aug. 13
1949	12C	W	4,360	2,934	557.572*	July 12
	12C	B	1,107	862	60.968*	July 12
	Ok.12	W	1,052	1,735	334.760*	July 15
	Ok.12	B	2,527	2,498	.332	July 14
	K201	W	5,315	960	6,044.948*	July 12
	K201	B	2,546	1,625	406.732*	July 12
	29I	B	3,817	3,189	118.384*	July 12
	29I	W	6,701	3,386	2,177.356*	July 12
	38-11	W	988	1,124	17.512*	July 12
	38-11	W	908	1,787	573.388*	July 14

Table 1. -(cont'd.)

Year	Ears and Pollen Mixture Used		Kernels		Chi-square value	Date of Pollination
	Line	Honey June	Number Sibbed	Number Crossed		
	38-11	B	1,878	1,823	1.672	July 14
	K4	W	3,626	1,943	1,017.232*	July 14
1949	K4	W	1,076	567	315.372*	July 14
	K4	B	1,381	1,843	132.405*	July 14
	07	W	1,993	1,230	361.256*	July 12
	07	W	244	342	32.776*	July 15
	07	B	1,313	971	102.420*	July 14
	Kys	W	536	1,551	987.276*	July 15
1948	12C x 29I	W	8,877	4,863	2,345.297*	Aug. 5
	12C x 29I	W	2,341	859	1,372.700*	Aug. 7
	12C x 29I	W	3,605	1,974	953.632*	Aug. 3
	12C x 29I	W	2,900	1,868	446.736*	Aug. 4
	K201 x Kys	W	3,631	3,610	.120	Aug. 5
	K201 x Kys	W	3,704	1,979	1,047.200*	Aug. 7

Table 1. - (cont'd.)

Year	Ears and Pollen Mixtures Used: Line	Honey June	Kernels: Number Sibbed	Kernels: Number Crossed	Chi-square Value	Date of Pollination
	07 x Ok.12	W	2,656	1,145	1,201.324*	Aug. 3
	07 x Ok.12	W	7,362	3,647	7,430.000*	Aug. 4
	07 x Ok.12	W	10,332	4,104	5,373.781*	Aug. 5
	K4 x 38-11	W	7,531	2,982	3,936.724*	Aug. 4
	K4 x 38-11	W	4,617	1,604	2,918.556*	Aug. 5
1949	07 x Ok.12	W	3,474	3,174	27.072*	July 13
	07 x Ok.12	B	881	421	352.036*	July 13
	K4 x 38-11	W	2,499	2,672	11.572*	July 13
	12C x 29I	B	1,801	1,695	6.424**	July 13
	12C x 29I	W	3,404	3,554	6.380**	July 13
	K201 x Kys	W	2,941	2,374	120.972*	July 13
	K201 x Kys	B	4,205	2,034	1,510.896*	July 13

* Significant at the 1% level.

** Significant at the 5% level.

Table 2. - An example of the derivation of data for the chi-square analysis.

Pollen Mixture	No. WHJ Pollen Grains Functioning	No. K201 x Kys Pollen Grains Functioning	Pollen Mixture	No. WHJ Pollen Grains Functioning	No. K201 x Kys Pollen Grains Functioning
WHJ + (K201 x Kys)	158	258	(K201 x Kys) + WHJ	109	407
	172	340		83	148
	160	344		33	156
	57	343		123	185
	162	384		88	278
	210	322		108	245
	60	212		80	166
	178	302		94	227
				185	333
				202	329
Total	1,157	2,505		1,105	2,479

Total pollen grains functioning (1,157 + 2,505 + 1,105 + 2,479) = 7,246
7,246 divided by 2 = 3,623, expected values.
1,157 + 2,479 = 3,636, observed sibbed seed.
2,505 + 1,105 = 3,610, observed crossed seed.

Table 3. - The number and percentage of Honey June and inbred or single cross grains functioning in equal mixtures of the two pollens.

Pollen Mixture	Number of Honey June Pollen Grains Functioning	Number of Inbreds or Single Cross Pollen Grains Functioning	% Honey June Pollen Grains Functioning	% Inbreds or Single Cross Pollen Grains Functioning	Pollination Date
WHJ + 29I	4,430	5,936	42.7	57.3	Aug. 7
WHJ + 12C	264	296	47.1	52.9	Aug. 4
WHJ + 12C	2,229	3,988	35.9	64.1	Aug. 7
WHJ + Kys	48	720	6.3	93.7	Aug. 13
WHJ + Kys	30	333	17.4	82.6	Aug. 16
WHJ + Ok.12	213	1,090	16.3	83.7	Aug. 13
WHJ + K4	137	156	46.8	53.2	Aug. 12
WHJ + K4	902	483	65.1	34.9	Aug. 13
WHJ + (12C x 29I)	909	4,670	16.3	83.7	Aug. 3
WHJ + (12C x 29I)	1,241	3,527	26.0	74.0	Aug. 4
WHJ + (12C x 29I)	4,090	9,650	29.8	70.2	Aug. 5
WHJ + (12C x 29I)	1,714	1,486	53.6	46.4	Aug. 7
WHJ + (K201 x Kys)	636	1,736	26.8	73.2	Aug. 3
WHJ + (K201 x Kys)	2,262	4,979	31.2	68.8	Aug. 5

Table 3. -(cont'd.)

Pollen Mixture	Number of Honey June Pollen Grains Functioning	Number of Inbreds or Single Cross Pollen Grains Functioning	% Honey June Pollen Grains Functioning	% Inbreds or Single Cross Pollen Grains Functioning	Pollination Date
WHJ + (K201 x Kys)	1,748	2,935	30.8	69.2	Aug. 7
WHJ + (07 x Ok.12)	1,490	2,311	39.2	60.8	Aug. 3
WHJ + (07 x Ok.12)	2,150	8,859	19.5	80.5	Aug. 4
WHJ + (07 x Ok.12)	2,270	12,166	15.7	84.3	Aug. 5
WHJ + (K4 x 38-11)	887	5,112	14.8	85.2	Aug. 3
WHJ + (K4 x 38-11)	1,523	8,990	14.5	85.5	Aug. 4
WHJ + 38-11	1,009	1,103	47.8	52.2	July 11
WHJ + 38-11	316	2,379	11.7	88.3	July 14
WHJ + K4	4,849	720	87.1	12.9	July 11
WHJ + K4	1,288	355	78.4	21.6	July 14
WHJ + Ok.12	314	2,473	11.3	88.7	July 15
WHJ + 07	2,531	692	78.5	21.5	July 12
WHJ + 07	107	479	18.3	81.7	July 15
BHJ + Kys	42	146	22.3	77.7	July 15

Table 3. -(cont'd.)

Pollen Mixture	Number of Honey June Pollen Grains Functioning	Number of Inbreds or Single Cross Pollen Grains Functioning	% Honey June Pollen Grains Functioning	% Inbreds or Single Cross Pollen Grains Functioning	Pollination Date
BHJ + K201	2,785	1,386	66.8	33.2	July 12
BHJ + 29I	4,799	2,207	68.5	31.5	July 12
BHJ + 12C	1,080	889	54.9	45.1	July 12
BHJ + 12C	40	98	29.0	71.0	July 15
WHJ + 29I	5,815	4,273	57.6	42.4	July 12
WHJ + Kys	291	1,796	13.9	86.1	July 15
WHJ + 12C	3,129	4,165	42.9	57.1	July 12
WHJ + K201	5,431	844	86.5	13.5	July 12
BHJ + 07	2,030	254	88.9	11.1	July 14
BHJ + Ok.12	493	4,532	9.8	90.2	July 14
BHJ + K4	1,733	1,491	53.8	46.2	July 14
BHJ + 38-11	276	3,425	7.5	92.5	July 14
WHJ + (12C x 29I)	3,548	3,411	51.0	49.0	July 13
WHJ + (12C x 29I)	1,038	686	60.2	39.8	July 11

Table 3. -(cont'd.)

Pollen Mixture	Number of Honey June Pollen Grains Functioning	Number of Inbreds or Single Cross Pollen Grains Functioning	% Honey June Pollen Grains Functioning	% Inbreds or Single Cross Pollen Grains Functioning	Pollination Date
WHJ + (K201 x Kys)	2,509	2,806	47.2	52.8	July 13
WHJ + (07 x Ok.12)	1,778	4,870	26.7	73.3	July 13
WHJ + (K4 x 38-11)	803	4,368	15.5	84.5	July 13
BHJ + (12C x 29I	1,353	2,143	38.7	61.3	July 13
BHJ + (K201 x Kys)	1,172	5,067	18.8	81.2	July 13
BHJ + (07 x Ok.12)	29	1,273	2.2	97.8	July 13

SUMMARY AND CONCLUSIONS

A study of the effects of pollen mixtures on the amount of sib and cross fertilization in corn was conducted at the Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma in 1948 and at the Paradise Community near Stillwater in 1949. This experiment was designed to determine if there was an excessive functioning of the plant's own pollen when equal mixtures of the plant's own pollen and pollen from another plant were applied to the ear. A total of 210,430 kernels from 636 ears were used in this study.

1. Some factors, or combination of factors, caused an excessive amount of sib fertilization to take place when equal quantities of the plant's own pollen and other pollen were applied to the ears of the plant.

2. The pollen from inbred or single cross lines seemed to be a better competitor than an equal amount of Honey June, when applied in mixtures on either the inbred or single cross and Honey June ears.

3. A refinement of technique is needed so that information of this nature may be used to a greater advantage by plant breeders.

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APPENDIX

able 4. – Number of sib and cross fertilized kernels obtained from equal pollen mixtures of Honey June and inbreds or single crosses.

ollen* ixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
		1948			
HJ + 29I	289	36	29I + WHJ	209	33
	333	95		196	22
	224	57	WHJ + 29I	205	236
	175	13		91	28
	311	33	WHJ + 12C	206	293
	363	52		190	281
	276	50		84	293
	181	31		108	145
	208	35		213	233
	199	44		98	170
	103	230		191	306
	262	275		216	230
	148	236		126	130
	186	340		232	292
	161	301		85	149
	34	38		112	172
	179	156		150	236
	42	122		125	152
	158	220		50	37
	187	359	12C + WHJ	152	5
9I + WHJ	90	15		98	6
	128	20		71	3
	124	14		30	1
	122	26		48	3
	251	12		60	8
	175	12		102	3
	116	10		16	2
	133	11		49	1
	245	20		60	1
	180	24		25	4
	159	21		23	0
	135	8		134	6
	102	22	Kys + WHJ	349	26
	67	10		371	22
	232	35		39	19
	202	10		123	6
	236	73		171	5
	111	13	Ok.12 + WHJ	576	47

Table 4. -(cont'd.)

Pollen* Mixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
Ok.12 + WHJ	401	166	WHJ + K4	309	94
	113	0		438	115
WHJ + K4	54	30	K4 + WHJ	61	71
	83	126		213	84
		1949			
WHJ + 38-11	120	91	K4 + WHJ	45	187
	270	319	WHJ + K4	303	64
	115	210		336	115
38-11 + WHJ	164	157		321	60
	82	164	K4 + WHJ	28	104
	125	68		44	100
	112	115		44	124
WHJ + 38-11	33	152	WHJ + Ok.12	35	272
	54	365		56	310
	31	466		17	448
	54	374		8	151
	17	223		24	92
	18	98		62	350
38-11 + WHJ	198	30	Ok.12 + WHJ	208	37
	215	32		105	16
	107	25		244	21
	181	22		133	23
WHJ + K4	359	33		160	15
	584	27	WHJ + 07	397	128
	380	15		118	48
	364	49		505	143
	326	51		302	76
	372	69		320	96
	417	47		192	42
	494	99	07 + WHJ	90	390
K4 + WHJ	66	254		29	221
	44	227		20	49
	33	169		20	37
	38	258	WHJ + 07	65	300
	65	253	07 + WHJ	179	42
	39	205	BHJ + Kys	42	146

Table 4. - (cont'd.)

Pollen* Mixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
BHJ + K201	156	114	BHJ + 12C	11	33
	310	180		29	65
	285	153	WHJ + 12C	291	255
	202	85		232	193
	503	122		74	71
	230	87		286	260
	383	168		206	226
K201 + BHJ	60	75		135	202
	130	175		284	251
	66	118		207	292
	51	113		239	140
	80	133		372	241
	90	102	12C + WHJ	192	58
BHJ + 29I	370	142		192	131
	208	176		227	106
	357	150		123	84
	343	101		49	12
	318	59		124	48
	191	163		124	23
	186	125		88	53
	412	220		32	7
	242	102		133	59
	277	56		264	74
29I + BHJ	250	127		175	59
	195	121		194	62
	161	83		56	19
	244	135		61	8
	207	116	WHJ + K201	724	74
	54	13		462	13
	104	38		266	58
	105	28		282	42
	147	65		410	46
	109	28		453	81
	40	17		523	44
	279	142		319	55
BHJ + 12C	163	185		527	63
	342	163		536	78
	44	69		153	19
	278	192		493	114
12C + BHJ	130	111	K201 + WHJ	65	85

able 4. -(cont'd.)

ollen* ixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
201 ≠ WHJ	27	71	BHJ ≠ 07	313	32
	9	35		17	0
	66	92		141	57
HJ ≠ 29I	387	208		233	21
	350	82		75	6
	257	229		126	6
	406	142		231	20
	334	201	07 ≠ BHJ	26	405
	318	117		14	352
	439	89	BHJ ≠ Ok.12	20	323
	340	220		27	236
	407	113		0	6
	339	185		29	207
	365	83		10	155
	123	127		9	138
	369	210		9	66
9I ≠ WHJ	207	87		5	127
	210	77		28	436
	79	135		50	498
	179	92	Ok.12 ≠ BHJ	137	18
	118	95		171	19
	139	111		167	21
	166	61		33	2
	108	83		129	11
	155	86		92	21
	189	106		189	20
	148	109		108	12
	144	93		101	18
	174	104		47	16
	147	75		242	22
	104	67		176	37
HJ ≠ Kys	85	451		162	11
	70	446		170	16
	35	239		207	31
	19	88		209	31
	36	281	BHJ ≠ K4	289	218
ys ≠ WHJ	169	31		18	7
	122	15		25	36
HJ ≠ 07	52	22		164	174
	85	50		92	162

able 4. - (cont'd.)

ollen* ixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
HJ ≁ K4	118	204	BHJ ≁ 38-11	24	139
	23	28		4	36
	119	129		3	34
4 ≁ BHJ	52	59		18	248
	76	157		17	172
	91	130		17	292
	72	98		11	185
	11	20	38-11 ≁ BHJ	57	5
	64	124		217	16
	30	57		220	7
	56	96		198	16
	34	52		264	13
	47	92		199	7
HJ ≁ 38-11	30	307		172	18
	21	69		158	19
	6	68		235	17
	7	155			
		1948			
HJ ≁ (K4 x 38-11)	59	386	WHJ ≁ (K4 x 38-11)	58	407
	44	273		95	220
	82	482	(K4 x 38-11) ≁ WHJ	567	73
	51	217		418	33
	92	313		749	79
	110	415		254	35
	63	358		654	83
	32	282		594	60
	53	299		132	13
	44	356		630	58
	49	225		474	54
	65	614		555	69
	23	245		214	42
	37	231		172	25
	83	416		322	44
	75	417		279	47
	160	399		264	55
	183	386		175	26
HJ ≁ (K4 x 38-11)	71	272		436	85

able 4. -(cont'd.)

ollen* ixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
HJ ≠ (12C x 29I)	222	279	(12C x 29I) ≠ WHJ	168	60
	77	85		273	127
	199	162		288	160
	291	357		59	53
	175	152		69	37
	177	317		113	67
	117	166	WHJ ≠ (12C x 29I)	106	302
	213	304		124	395
	137	348		91	477
	147	172		115	327
	149	266	(12C x 29I) ≠ WHJ	247	33
	151	220		281	43
2C x 29I) ≠ WHJ	238	48		170	60
	255	113		332	52
	283	95		335	49
	322	142		135	21
	245	52		243	23
	313	135		255	33
	311	123		218	29
	331	145		251	29
	329	119		169	36
	290	102		267	32
	341	79		266	33
	246	54	WHJ ≠ (12C x 29I)	129	351
	354	110		124	380
	302	76		126	275
	218	70	(12C x 29I) ≠ WHJ	230	120
	229	45		274	62
	292	72		117	39
	225	49		55	8
	404	108		146	42
	230	50		151	65
	210	65		361	59
	228	60		319	113
	400	74		171	53
	226	49		296	120
HJ ≠ (12C x 29I)	182	28		276	124
	386	63		125	57
	368	96	WHJ ≠ (K201 x Kys)	46	81
	190	84		125	324
12C x 29I) ≠ WHJ	245	84		69	288

able 4. -(cont'd.)

ollen* ixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
HJ ≁ (K201 x Kys)	113	291	WHJ ≁ (07 x Ok.12)	32	188
	119	370		59	387
	164	382		73	422
(K201 x Kys) ≁ WHJ	258	158		82	355
	340	172		207	387
	344	160		194	213
	343	57		111	372
	384	162		142	410
	322	210	(07 x Ok.12) ≁ WHJ	397	51
	212	60		388	32
	302	178		368	64
HJ ≁ (K201 x Kys)	109	406		135	20
	83	149		264	29
	33	156		406	51
	123	185		393	71
	88	278		415	61
	108	245		536	40
	80	166		483	49
	94	227		496	28
	185	333		455	35
	202	329		241	24
HJ ≁ (K201 x Kys)	96	130		409	51
	158	166		430	46
	387	253		420	124
	135	255		437	81
	42	89		424	38
	155	261		291	99
	102	176		473	71
	216	192		498	97
(K201 x Kys) ≁ WHJ	355	93		369	71
	520	120		192	36
	242	38		511	101
	355	59	WHJ ≁ (07 x Ok.12)	230	172
	324	68		214	145
	380	40		212	113
	237	39		308	189
HJ ≁ (K201 x Kys)	35	79	(07 x Ok.12) ≁ WHJ	350	178
	69	283		310	68
	20	158		88	16
	62	494		384	134
	50	527		327	93

Table 4. -(cont'd.)

Pollen* Mixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
(07 x Ok.12) ≠ WHJ	327	93	(07 x 12B) ≠ WHJ	366	82
	233	37		518	74
WHJ ≠ (07 x Ok. 12)	204	516		562	94
	206	476		396	132
	210	347		447	193
	145	292		404	104
	111	333		426	86
	49	291		427	69
	50	217		483	53
WHJ ≠ (07 x Ok. 12)	230	172		465	51
	214	145		352	40
	212	113		286	14
	308	189		344	34
(07 x Ok. 12) ≠ WHJ	350	178		484	48
	310	68	WHJ ≠ (K4 x 38-11)	223	202
	88	16		243	319
	384	134		103	164
	327	93		153	135
	233	37		216	147
WHJ ≠ (07 x Ok. 12)	204	516	(K4 x 38-11) ≠ WHJ	752	112
	206	476		596	77
	210	347		563	111
	145	292		484	60
	111	333		404	78
	49	291		293	51
	50	217		411	128
(07 x 12B) ≠ WHJ	427	101		176	20
		1949			
WHJ ≠ (12C x 29I)	214	195	WHJ ≠ (12C x 29I)	170	165
	306	232		195	141
	81	68		135	126
	312	245	(12C x 29I) ≠ WHJ	226	177
	108	157		239	257
	100	234		255	272
	251	250		97	147
	170	109		103	210
	181	220		137	160
	262	349		77	75

Table 4. - (cont'd.)

Pollen* Mixture	Number Sibbed	Number Crossed	Pollen* Mixture	Number Sibbed	Number Crossed
(12C x 29I) + WHJ	175	191	WHJ + (07 x Ok.12)	191	439
	99	249		221	499
	51	128		202	358
	147	235		103	329
WHJ + (K201 x Kys)	191	172		133	180
	144	145		100	278
	163	138		182	196
	265	212	(07 x Ok.12) + WHJ	434	58
	329	340		479	85
	319	263		360	72
	213	219		256	140
	247	377		355	73
	311	425		326	86
	195	329	WHJ + (K4 x 38-11)	49	342
	98	146		33	264
	34	40		55	206
BHJ + (K201 x Kys)	2	65		40	568
	53	218		71	405
	61	269		41	373
	9	73	(K4 x 38-11) + WHJ	434	58
	33	236		479	85
	25	184		360	72
(K201 x Kys) + BHJ	593	70		256	140
	417	81		355	73
	351	77		326	86
	106	23	BHJ + (12C x 29I)	28	56
	293	155		135	351
	381	142		66	126
	262	124		54	92
	504	108	(12C x 29I) + BHJ	206	208
	558	86		153	200
	557	123		207	114
HJ + (07 x Ok.12)	3	161		97	83
	2	166		158	141
	1	71		154	60
(07 x Ok.12) + BHJ	336	7		37	16
	261	8		134	97
	278	8		181	93
HJ + (07 x Ok.12)	132	381		142	107

* Female listed first.

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