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Effect of Tree Barriers on Outcrossing in Corn

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Cross-pollinated plants must be sufficiently isolated from varieties of the same crop if varietal purity and genetic identity are to be maintained. Natural crossing in wind-pollinated crops has been reported at a distance of 100 rods (4).** One of the problems of the seed producer and the breeder of corn is to find enough areas suitably isolated in which to increase seed stocks.

Barriers of trees have been substituted for distance in some areas as a means of getting isolation. It was thought that the tree barriers would reduce outcrossing, so that different varieties could be grown close together. However, should the tree barrier have the effect of a snowfence, it probably would result in an increase in crossing immediately behind the barrier.

The objective of this investigation, which was conducted at Stillwater, Oklahoma, during 1947 to 1950 inclusive, was to study the effects of tree barriers on outcrossing in corn, *Zea mays* L.

Review of Literature

There is a paucity of information on the effects of various types of wind barriers on crossing in naturally cross-pollinated plants. The minimum isolation standards for corn established by the International Crop Improvement Association (2) provide for a reduction in distance when adequate natural barriers are present. However, no definition is given of what constitutes an adequate barrier.

Tracy (6) in 1910 stated that hedge barriers of Osage orange, *Maclura pomifera* (Raf.) Schneider, not over 12 feet in height were effective in preventing outcrossing in corn within 8 to 10 rods of the hedge, while beyond that distance there were many crosses.

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* Respectively: Agronomist, Plant Genetics; and Agronomist, Corn.
** Numbers in parentheses refer to Literature Cited, page 11.

Jensen and Bogh (3) in Denmark found that low sheltering hedges offered protection against crossing in proportion to their heights. At a distance of 5 to 10 times the height a protection was found corresponding to a distance isolation on open ground of about 40 rods.

Kittredge (5) summarizes the literature on the effects of windbreaks and shelterbelts on wind movement. He reports that the maximum effect is at three to five times the height of the belt to leeward, where the velocity is less than 30 percent of that in the open. In general, the denser the belt of trees, the closer to the trees is the line where maximum reduction of wind velocity is found.

The literature on natural crossing in corn under different conditions of isolation was reviewed recently (4). In a study of the percentage of outcrosses occurring in successive rows of corn at different distances of isolation, Jones and Brooks (4) found that the first five rows adjacent to the source of contamination appeared to function as a barrier to the dispersal of contaminating pollen. Additional rows served only to dilute the contaminating pollen. Considerable variation in the amount of outcrossing that occurred in consecutive rows when different types of corn were grown in adjacent fields has been reported (1,4).

Materials and Methods

The fields selected for this study were located 15 miles west of Stillwater in the Lake Blackwell Land-use area. No other corn was grown within a radius of approximately one mile.

Three open-pollinated varieties of similar maturity were used: Yellow Surcropper, a yellow dent field corn; White Honey June, a sweet corn; and Blue Honey June, a sweet corn carrying purple aleurone which was selected from White Honey June. Blue Honey June was used instead of White Honey June in 1950 only.

Kernels obtained from crosses of Yellow Surcropper onto either Honey June could be easily distinguished from Honey June kernels by means of xenia.

The field layout consisted of a block of Yellow Surcropper corn 80 rods wide and 25 rods deep to the south of a row of American elm (*Ulmus americana* L.) trees along an east and west road (Fig. 1-A). Honey June was grown in a block 30 rods wide and 25 rods deep (125 consecutive rows of corn) on the north side of the road. Another row of elm trees was present on the north edge of the road at the west half of the Honey June field. Thus, rows of trees on each side of the road separated the west halves of the fields, while a single row of trees

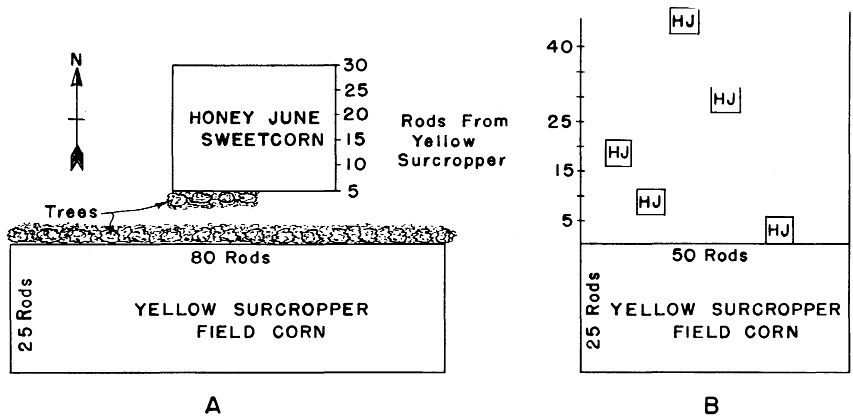

Fig. 1.—A field diagram of the two types of experimental isolations: A, a single and a double tree barrier; B, different distances of isolation without a tree barrier.

on the south side of the road separated the east halves. The trees were close together and varied from 30 to 35 feet in height. Considerable undergrowth was present, so that a fairly good barrier to wind movement was present.

In the area where the barrier was not present, the field plan consisted of a block of Yellow Surcropper 50 rods wide and 25 rods deep on the south side. Blocks approximately five rods square of White Honey June were isolated to the north of the Yellow Surcropper at distances of 0, 5, 15, 25 rods (Fig. 1-B). In both experiments the rows ran east and west and were spaced 3.5 feet apart. The area between the blocks was planted to small grains which were harvested previous to corn pollination. Cultural methods were those commonly used in producing corn in this region.

Five plants in the west half and five in the east half of each row were tagged at the time of tasseling and silking. The ears from these plants were harvested and the number of out-crossed (xenia) and non-crossed kernels were counted. The number of kernels and ears studied yearly in each experiment is given in Table 1.

Results and Discussion

By studying data obtained behind the two types of barriers, the authors hoped to be able to establish some general principles concerning the effect of barriers on outcrossing in corn. These data are presented by 5-row averages for each of two years in Table 2. The amount

TABLE 1.—THE NUMBER OF KERNELS AND EARS STUDIED EACH YEAR.

Type of elm tree barrier	Year	Number of: Kernels	Ears
Combination single & double rows*	1948	521,992	927
Single row	1949	235,027	429
	1950	252,294	414
Double row	1949	235,031	423
	1950	271,487	447
No barrier	1947	112,745	235
	1948	468,694	848
	1949	342,632	650
Total		2,439,902	4,373

* In 1948, the data were not collected separately for the single- and double-row barriers.

TABLE 2.—AVERAGE PERCENTAGE OF OUTCROSSED KERNELS OCCURRING IN HONEY JUNE CORN IN CONSECUTIVE GROUPS OF FIVE ROWS ISOLATED TO THE NORTH OF YELLOW SURCROPPER BY SINGLE AND DOUBLE ROWS OF TREES; STILLWATER, OKLAHOMA, 1949 AND 1950.

Distance from foreign pollen source		American elm tree barriers					
		Single row			Double row		
Rods	Rows*	1949	1950	Average	1949	1950	Average
5	1-5	19.84	10.17	15.00	30.62	16.04	23.33
	6-10	11.43	4.74	8.08	16.25	3.23	9.74
	11-15	10.08	14.59	12.34	5.87	3.93	4.90
	16-20	8.88	4.88	6.88	3.72	2.61	3.16
	21-25	7.87	4.57	6.22	5.84	1.72	3.78
10	26-30	10.47	7.63	9.05	3.18	3.51	3.34
	31-35	6.31	3.66	4.98	4.06	4.25	4.15
	36-40	6.19	6.60	6.40	4.69	4.65	4.67
	41-45	3.89	2.87	3.38	3.12	1.21	2.16
	46-50	6.36	3.40	4.88	2.19	2.48	2.34
15	51-55	4.52	2.11	3.32	2.41	1.74	2.08
	56-60	3.53	.47	2.00	3.07	2.10	2.58
	61-65	4.42	.61	2.52	3.29	4.92	4.10
	66-70	2.93	2.06	2.50	2.58	.45	1.59
	71-75	1.52	.78	1.15	1.28	.83	1.06
20	76-80	1.29	.78	1.04	1.52	3.66	2.59
	81-85	3.96	1.33	2.64	1.93	1.75	1.84
	86-90	3.11	1.26	2.18	1.85	1.51	1.68
	91-95	4.92	6.78	5.85	1.21	1.46	1.34
25	96-100	2.29	.71	1.50	1.04	2.64	1.84
	101-105	1.81	4.42	3.12	1.16	.40	.78
	106-110	3.16	1.01	2.08	1.18	1.12	1.18
	111-115	1.13	.62	.88	2.56	1.01	1.78
	116-120	6.33	1.92	4.12	1.82	1.36	1.59
30	121-125	2.66	.98	1.82	2.21	.37	1.29

* Row 1 is the row nearest tree, the contaminating field, and row 125 the most distant.

of outcrossing was considerably higher in 1949 than in 1950. The pollinating period in 1950 was characterized by frequent rains and generally low wind velocities, while in 1949 wind velocities were higher and rains much less frequent. This seasonal difference probably accounts for the variations in actual amounts of outcrossing during the two years. Aside from this seasonal difference, the results behind each type of barrier are similar for the two years.

Outcrossing is lower in the first 10 rows behind the single barrier than behind the double barrier, but generally higher behind the single barrier for the next 50 rows. Beyond 50 rows the outcrossing is about equal behind the double and single barrier, although more variable behind the single barrier. It does not seem likely that variations with this pattern would be duplicated, by chance, on consecutive years with different seasonal conditions. However, no satisfactory factual explanation has been devised which will fit these data and the relationship of the general barrier data to results obtained in isolations without a tree barrier.

In 1948 the ears from which outcrossing determinations were made were gathered without regard to the single or double row of trees. Data for the three years are presented in Table 3 for comparison with the outcrossing occurring in separate isolated blocks without a tree barrier. The average outcrossing by 5-row intervals for the three years, and the 2-year average for the separate isolated blocks without a tree barrier, are presented graphically in Figure 2. This graph emphasizes the similarity in relative amounts of outcrossing for consecutive 5-row blocks in the areas with a tree barrier and in those without such barriers.

The greatly reduced outcrossing occurring beyond the tenth row of each block isolated without a tree barrier, and a similar reduction when the field is separated from the contaminating source by a tree barrier, suggests that the major factors influencing the amount of outcrossing in the two areas are the same.

Since the barrier occupied an area about five rods wide, the first rows of Honey June corn behind the barrier are separated from the Yellow Surcropper by the same distance as the first rows of the block isolated by five rods without a tree barrier and hence are shown on the same line in Table 3 and Figure 1. The outcrossing on the first two 5-row blocks of the area isolated by a tree barrier is about half of that of the corresponding rows of the area isolated by the same distance but without a tree barrier. These averages have the years 1948 and 1949 in common. The 1950 barrier data are very near the average of the 1948 and 1949 barrier data; therefore, the 3-year barrier data are thought to be comparable to the 2-year data obtained for isolations without a tree barrier. The tree barrier was therefore effective in reducing outcrossing on the first 10 rows to 50 percent of that occurring in an area equally distant but without a tree barrier. Beyond the first 10 rows the barrier is not quite as effective. This suggests that proportionately more pollen may be lifted high in the air and over the barrier, settling out at some distance behind the barrier.

Comparing the outcrossing behind the barrier, five rods from the contaminating field, with that occurring in a block isolated by 15 rods distance without a barrier, Figure 2, it will be observed that the first 10 rows are very similar in percentage of outcrossing for the two

TABLE 3.—AVERAGE PERCENTAGE OF OUTCROSSED KERNELS OCCURRING IN HONEY JUNE CORN OF CONSECUTIVE GROUPS OF FIVE ROWS ISOLATED TO THE NORTH OF YELLOW SURCROPPER BY A BARRIER OF AMERICAN ELM TREES AND WITHOUT BARRIER; STILLWATER, OKLAHOMA, 1948 - 1950.

Distance from foreign pollen source		Barrier				No barrier*
		Year				1948 & 1949
Rods	Rows	1948	1949	1950	Average	Average
	1-5					51.67
	6-10		Area Occupied			28.12
	11-15		by			19.02
	16-20		Barrier			16.82
	21-25					9.53
5	26-30	8.07	27.51	13.91	16.49	31.91
	31-35	1.12	13.50	4.15	6.25	12.49
	36-40	1.52	8.77	9.54	6.61	8.73
	41-45	1.08	7.48	3.78	4.11	6.41
	46-50	1.73	7.15	3.31	4.06	5.64
10	51-55	2.38	7.27	5.62	5.09	
	56-60	.48	5.01	4.08	3.19	
	61-65	1.05	5.46	5.15	3.88	
	66-70	1.08	3.61	1.93	2.20	
	71-75	.74	4.23	2.94	2.63	
15	76-80	.66	3.60	1.98	2.08	16.00
	81-85	.96	3.23	1.43	1.87	5.60
	86-90	.22	3.94	3.20	2.45	3.54
	91-95	.21	2.74	1.16	1.37	2.53
	96-100	.98	1.49	.80	1.09	2.95
20	101-105	.16	1.43	2.17	1.25	
	106-110	.88	3.09	1.61	1.86	
	111-115	.54	2.36	1.36	1.42	
	116-120	.06	2.73	4.50	2.43	
25	121-125	.08	1.52	1.68	1.09	7.32
	126-130	.04	1.40	1.98	1.14	3.13
	131-135	.03	2.22	1.06	1.10	1.48
	136-140	.81	1.90	.75	1.15	1.77
	141-145	.22	2.90	1.62	1.58	1.60
	146-150	.13	2.73	**0.65	1.17	

* Taken from Jones and Brooks (4).
** Three-row average.

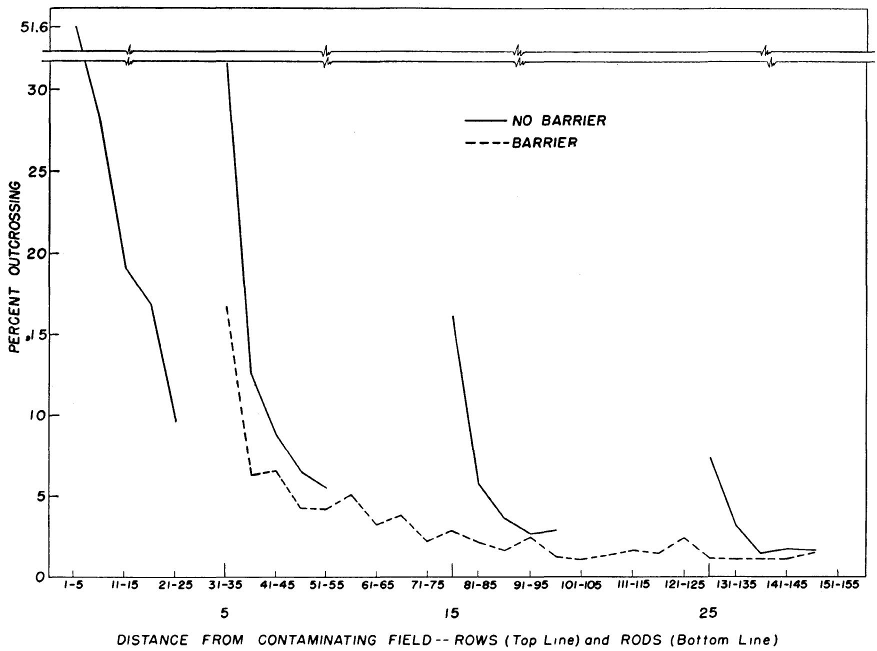

Fig. 2.—The average percent of outcrossed grains occurring in 5-row units behind a barrier and in blocks isolated at different distances without a barrier.

isolations. The remaining rows of the plot isolated by 15 rods without a barrier have outcrossing similar to the corresponding rows behind the barrier but with slightly higher values behind the barrier. This agrees with the suggestion made above that proportionately more pollen is carried for a considerable distance behind a tree barrier than when such a barrier is not present.

Under the conditions of this experiment a tree barrier 30 to 35 feet in height and five rods wide was essentially as effective isolation as 15 rods distance without such a tree barrier.

Comparing the percentage of outcrossing behind the barrier to that occurring on the block which was planted directly adjacent to the contaminating source, it will be seen that the last rows of this adjacent block have less outcrossing than the first rows of the block behind the tree barrier. This tree barrier is not as effective in reducing outcrossing as the same space planted to corn.

These data from the distance studies and the barrier experiments indicate the importance of the outside rows of corn in an isolated field as a source of pollen for diluting pollen blown in from a contaminating field and minimize their effect as a barrier to the movement of foreign pollen.

In considering the hazards to pure seed production of any particular isolation, the maximum amount of outcrossing should be considered. Mean values have been emphasized in this work in order to present a more consistent picture, but extremes are possible in any future year.

Summary and Conclusions

An experiment was conducted near Stillwater, Oklahoma, during 1948, 1949 and 1950 to determine the effect of a tree barrier separating a field of Yellow Surcropper dent corn and a field of Honey June sweet corn on purity of the sweet corn seed produced. The tree barrier was, for half the field, a single row of trees and underbrush and for the remaining half a double row of trees and underbrush. Data are presented for the area behind the single barrier and behind the double barrier, and the differences are discussed. The data obtained from behind the two types of barriers were combined and compared to similar data obtained from isolations of various distances without such a barrier.

The results indicate that the tree barrier was effective in reducing the amount of outcrossing 50 percent immediately behind the barrier when compared to the outcrossing obtained at the same distance but without a barrier but was less effective at greater distances behind the barrier.

The tree barrier reduced outcrossing to amounts similar to 15 rods distance without a barrier, but was not as effective as a planting of border rows of corn occupying an area equal to the area occupied by the tree barrier.

Border rows appear to function primarily in producing masses of pollen to dilute pollen being blown in from adjacent fields.

While 2- and 3-year averages are used in interpreting results, the importance of the maximum outcrossing obtained for a given isolation is stressed.

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