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UNIVERSITY OF MINNESOTA
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DOUBLE-CROSSED CORN IN MINNESOTA

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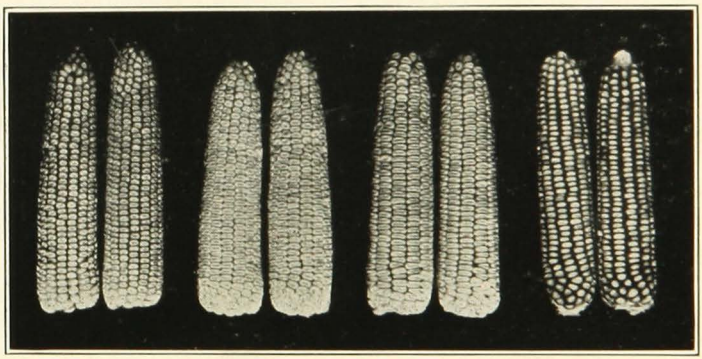


UNIVERSITY FARM, ST. PAUL

Plot Shows the Method of Producing Double-Crossed Seed

Two rows of the female parent, E, were grown alternately with single rows of the male parent, I. Each plant of E was detasseled before any of its pollen shed.

DOUBLE-CROSSED CORN IN MINNESOTA

H. K. HAYES, H. E. BREWBAKER, and F. R. IMMER

INTRODUCTION

Present-day methods of corn breeding which are being used by many experiment stations and by some seed companies were initiated by East at the Connecticut Station and Shull at Cold Spring Harbor as early as 1905. Previous methods of selection were on the basis of the appearance of the mother plant or ear without a knowledge of the male or pollen parents. East and Shull practiced self-pollination and selection as a means of isolating and studying the inherited characteristics of a normal corn variety.

A kernel of corn is the result of the union of a male cell or gamete borne in the pollen grain with an egg cell or female gamete borne at the base of the silk on the ear. A pollen grain falling on a silk germinates and sends out a tube which grows down through the silk. This tube carries the male reproductive cell which fertilizes the egg cell and leads to the production of a kernel of corn. Pollination is brought about by the wind. Each normal tassel produces about a tablespoonful of pollen which resembles yellow dust. If fully utilized this is sufficient to fertilize about 40,000 egg cells and produce that many kernels of corn. Controlled studies have shown that practically 100 per cent of cross-pollination is the rule, i.e., the silks of a plant are pollinated by pollen of some other plant or plants. Thus the seeds of an ear result, as a rule, from the fertilization of the egg cells of a plant by male reproductive cells borne in the pollen grains of many plants.

While selection is an efficient agency for the farmer to keep his corn variety in a constant state of productivity or further to improve it, all available evidence indicates that an adapted variety cannot be improved greatly by such a method. Selection, however, is necessary to keep the variety from deteriorating.

Self-fertilization by controlled pollination gives an opportunity for selection in lines in which both the male and female parentage is known. The method used for controlling pollination is illustrated in Figure 1. This makes possible the isolation of lines that breed true for their inherited characters.

The value of the method is apparent. It is known that reaction to smut caused by *Ustilago zeae* is an inherited characteristic and the breeding of smut-resistant corn appears to be the most promising method of controlling this disease. It appears very difficult to obtain resistant varieties by the old method of continuous selection without controlling pollination. The new method, selection within self-fertilized

lines, leads to the rapid isolation of both resistant and susceptible lines that breed true and reproduce their inherited characteristics as long as self-pollination is continued. By similar methods of controlled self-pollination and selection, it is possible to isolate lines that excel in other characters such as, ability to withstand lodging, resistance to root rot, and vigor of plant.

Fig. 1. Controlled Self-Pollination
The pollen from the tassel bag is poured over the silk and the ear bag placed again over the ear shoot.

The number of recessive abnormalities which appear in self-pollinated lines is very great. These do not result from self-fertilization in itself but undesirable characters become manifest by this means. These characters are present in the normal variety but they appear relatively infrequently. This is because the normal characteristic is dominant or covers up the abnormal. The undesirable characters are bred out of the variety by the method of selection in self-fertilized lines. The more promising lines may be used for the production of an improved sort.

Selection in self-fertilized lines was started in Minnesota about 1914 and has been continued since that time. At first the work was on a modest scale but in recent years, particularly since 1925, more extensive experiments have been conducted. At this time the corn belt experiment stations and the United States Department of Agriculture adopted a co-operative project on corn improvement under provisions of the Purnell Act.

The early studies of East and Shull previously mentioned indicated that self-pollinated lines were markedly less vigorous than normal corn varieties and that some lines were so weak that they were incapable of reproducing themselves. While all lines were less vigorous than normal corn, there were some that appeared normal in other respects. First-generation crosses between inbred lines are usually much more vigorous than inbred lines, themselves, and some first-generation crosses are superior to normal corn. Shull, as a result of studying first-generation crosses between inbred lines, predicted in 1910 that some method of hybridization would be used in the production of corn seed.

It is relatively easy to make a cross between two varieties of corn. They may be planted in alternate rows in an isolated seed plot and all of one variety detasseled before the silks appear. Seed on the detasseled rows will be cross-pollinated.

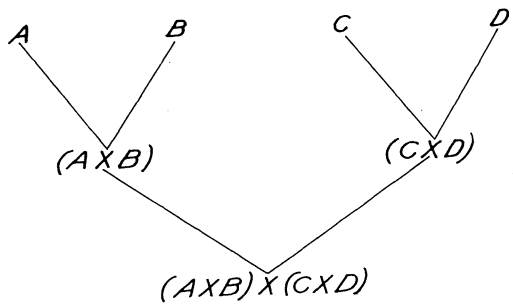
It is very difficult to cross two pure lines and use the first-generation crossed seed to grow the commercial crop because self-pollinated lines in themselves yield so little and because the seeds of self-pollinated lines are frequently smaller than those of normal corn. If much better yielding self-pollinated lines could be obtained than are available at present, a first-generation cross between two lines would be a practical way to produce corn seed for the commercial crop. To obtain the full benefit of such a cross it is necessary to repeat the cross each year. The studies started in 1906 by East at the Connecticut Agricultural Experiment Station were continued by the senior writer of this bulletin from 1910 to 1914, inclusive, and then were taken over by D. F. Jones who has continued them until the present time. Jones suggested the double-cross method for the purpose of surmounting some of the difficulties apparent in single crosses.

This bulletin explains the double-cross plan in some detail and presents data of double crosses produced in Minnesota that will be distributed on a small scale to Minnesota farmers for the first time in 1930. Plans for distribution are given also.

DOUBLE-CROSS PLAN OF SEED PRODUCTION

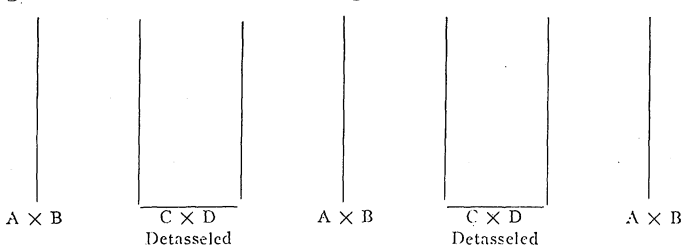
Four self-pollinated lines of corn are used to produce a double cross. These lines have been selected because they combine to give high yields or other desired characters in which the double cross may

excel. The only known method of learning how four lines will combine in a double cross is by actual test. These lines may be called A, B, C, and D. They have been inbred until they reproduce themselves relatively true year after year. The following diagram illustrates the plan.



The method is also illustrated in Figure 2, using ears from one of the double crosses recommended for distribution. A is crossed with B, and C with D. Only sufficient seed need be produced to plant the seed plot. The ears produced from the immediate first cross are small and the cost is realtively great. With the present parental lines that are available, it appears probable that the first crosses can be made most advantageously by hand pollination, as will be described later.

The double-crossed seed may be produced by planting the single crosses in a seed plot and detasseling all of one cross before the silks appear. Two or three rows of the cross to be used as the female parent can be grown to each single row of the pollen parent. The method of crossing is illustrated in the following diagram.



Two rows of the cross are planted alternately with single rows of A × B and the plants of C × D detasseled before the silks appear. This can be accomplished by walking through the plot every two days and pulling out the tassels before any pollen is shed; taking hold of each tassel in turn and giving a firm, upward pull. The results are shown in the illustration on page 2.

Seed from the detasseled rows is called double-crossed seed and may be used to grow the commercial corn crop. Double-crossed seed

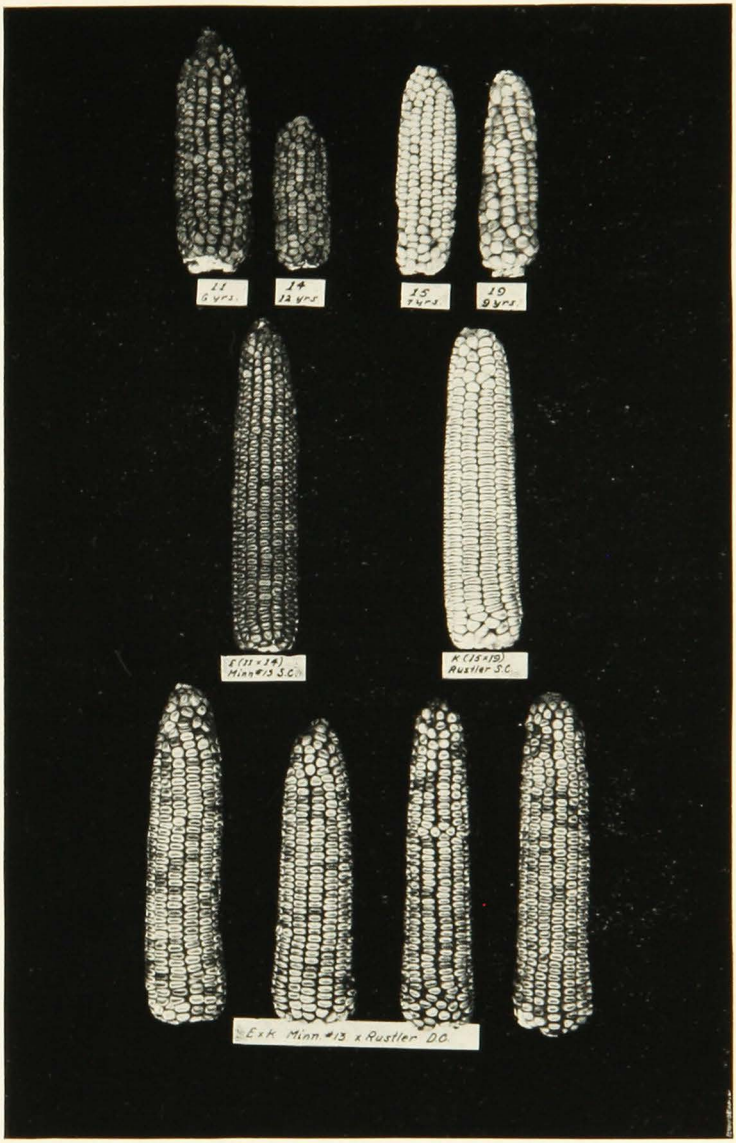


Fig. 2. Representative Ears of Selfed Lines, First Generation and Double Crosses
Above, Selfed lines, 11, 14, 15, 19
Center, First-generation crosses, E, (11 × 14) and K, (15 × 19)
Below, Double cross, E × K

must be purchased or produced each year in order to benefit by the plan. Seed saved from the commercial field, grown from double-crossed seed will not prove superior to normal varieties and may give lower yields than that obtained from varieties now available. The reduction in yield would be about one fourth of the difference between the yield of the double-cross and the selfed lines.

A method employed in recent years to learn which selfed lines may be used to produce a double cross will be outlined briefly.

Several hundred selfed lines of a variety are studied and selections made each year until the most promising lines have been isolated. These are the self-pollinated lines that are the most vigorous. The others are discarded. Supposing there are 10 lines which appear promising. All possible first-generation combinations of these 10 lines are studied. Thus line 1 is crossed with 2, 3, 4, 5, etc., 2 with 3, 4, 5, etc., and the yields of all F_1 crosses determined in relation to the yield of the normal variety from which the selfed lines were produced. The plan is to use four lines for a double cross which excel in yield in all possible single-cross combinations. Yields of such first-generation crosses are given in Table I for all possible combinations of the selfed lines of Minn. No. 13, numbers 43, 46, 49, and 50 which have been produced by selection in self-pollinated lines and which are breeding relatively true.

TABLE I

PERCENTAGE YIELDS OF F_1 CROSSES BETWEEN SELF-POLLINATED LINES OF MINN. NO. 13 AND OF THE SELFED LINES THEMSELVES ON THE BASIS OF NORMAL MINN. NO. 13 AS 100. AVERAGE 1928-29, UNIVERSITY FARM

Selfed lines No.	46	49	50	Selfed line
	%	%	%	%
43	120	138	116	68
46	...	117	119	46
49	...	...	119	63
50	...	...	...	30
Average		121.5		51.8

The selfed lines 43, 46, 49, and 50 yielded 68, 46, 63, and 30 per cent, respectively, of normal Minn. No. 13, while the lowest yielding first-generation cross, 43 × 50, yielded 116 per cent of normal Minn. No. 13, and the highest yielding F_1 cross, 43 × 49, 138 per cent of normal Minn. No. 13. The average of all first-generation crosses is obtained by adding the yielding ability or $(120 + 138 + 116 + 117 + 119 + 119) \div 6 = 121.5$. It seems reasonable to expect that the double cross $(43 \times 49) \times (46 \times 50)$ will yield at least 121.5 per cent of normal Minn. No. 13. Yields of these crosses have been obtained from growing two small plots of 12 hills each of each cross in a replicated trial and determining the yield of ear corn in percentage of normal.

This series of double crosses will be tested extensively in yield trials for the first time in 1930 and at least three years' trials will be made before distribution. These crosses will have the advantage of uniform seed color over those which it is planned to distribute in 1930.

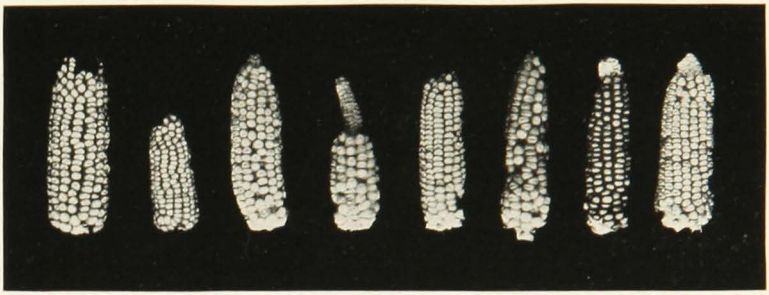


Fig. 3. Representative Ears of the Selfed Lines Used in Making First-Generation Crosses From left to right, Minn. No. 13, lines 11, 14; Rustler lines, 16, 20, 15, 19; N.W. Dent, lines 21 and 22.

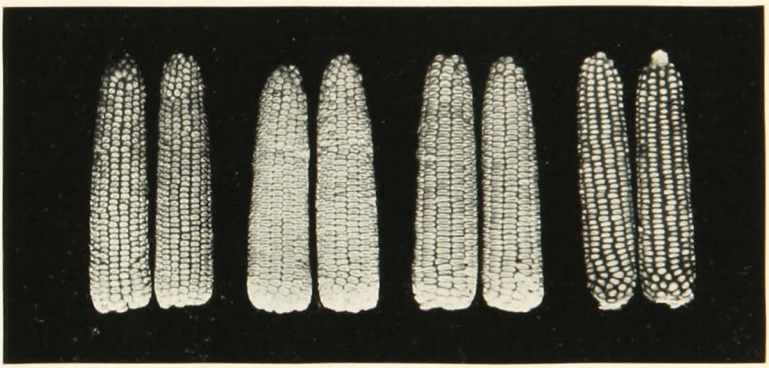


Fig. 4. First-Generation Crosses
From left to right: E, (11 × 14); I, (16 × 20); K, (15 × 19); and L, (21 × 22).

The double crosses for distribution were obtained from crosses between first-generation crosses produced from selfed strains of different varieties. Those that appeared promising were obtained from the following self-pollinated lines:

Selfed line No.	Variety	Years selfed
11	Minn. No. 13	7
14	"	13
15	Rustler	8
16	"	8
19	"	10
20	"	9
21	N.W. Dent	9
22	"	9

These selfed lines have been combined in the following F_1 crosses: $(11 \times 14) = E$, $(16 \times 20) = I$, $(15 \times 19) = K$, and $(21 \times 22) = L$. The selfed lines and first-generation crosses are shown in Figures 3 and 4, respectively. The double crosses, $E \times I$, $E \times K$, and $E \times L$ are the most promising of any that have been tested consecutively for three or more years.

Experimental studies of these crosses in comparison with Rustler, Minn. No. 13, and Northwestern Dent, and a proposed plan of distribution follow.

COMPARISON OF STANDARD VARIETIES AND DOUBLE CROSSES

Yield trials were made at experiment stations at University Farm and Morris and in farm tests in Goodhue, Chippewa, and Meeker counties.[1] Three-row plots each 17 hills long were used for the studies, the central row only being harvested for the yield comparison. The ear corn was dried to a uniform moisture basis and the yields are presented on the basis of bushels of ear corn per acre, 14 per cent moisture content. Two- or three-stalk hills surrounded on four sides by two- or three-stalk hills were used for the yield data.

Yields in bushels of shelled corn per acre, for the respective localities and years in which the studies were conducted, are given in Table II.

On an average the crosses proved superior in yielding ability to the normal varieties. Seed of Rustler and Minn. No. 13 has been produced at University Farm by selection of vigorous stalks in perfect stand hills without close selection for ear type. The seed of Minn. No. 13 available for 1929 did not germinate well and Kalmoe's No. 13 was substituted in the studies.

The double crosses mature somewhat earlier than the standard varieties and are more uniform in time of maturity. The moisture content at the time of husking was determined and the results are given in Table III.

[1] Mr. R. F. Crim, extension agronomist, arranged for the trials in Chippewa and Meeker counties.

TABLE II

YIELDS IN BUSHELS PER ACRE (14 PER CENT MOISTURE BASIS) OF UNIVERSITY FARM RUSTLER, MINN. NO. 13, AND NORTHWESTERN DENT IN COMPARISON WITH DOUBLE CROSSES E × I, E × K, and E × L

	University Farm					Morris					Goodhue Co.				Chippewa Co.				Meeker Co.		
	1926	1927	1928	1929	Av.	1926	1927	1928	1929	Av.	1926	1927	1928	Av.	1927	1928	1929	Av.	1928	1929	Av.
Rustler	38.9	58.6	48.2	59.2	51.2	43.3	42.4	44.2	54.3	46.1	31.9	28.3	41.7	34.0	52.5	46.9	57.2	52.2	43.6	32.0	37.8
Minn No. 13 ..	...	51.9	47.5	57.0*	...	51.0	40.7	46.4	48.3*	46.6	29.3	31.1	38.3	32.9	48.1	41.6	53.4	47.7	46.0	31.7†	38.9
N.W. Dent	37.3	49.3	41.3	49.7	44.4	36.4	43.9	40.4	47.2	42.0	...	...	...	...	...	...	...	...	...	...	...
E × I	49.8	61.1	49.9	65.1	56.5	46.4	47.1	49.2	54.6	49.3	35.1	33.5	46.4	38.3	55.1	50.4	61.7	55.7	54.6	46.8	50.7
E × K	45.2	62.3	51.4	63.6	55.6	53.7	46.2	50.7	52.3	50.7	31.2	32.6	42.3	35.4	58.4	47.8	47.8	54.1	51.6	41.4	46.5
E × L	52.7	67.1	50.7	60.9	57.9	46.2	47.6	56.0	52.0	50.5	34.4	...	48.5	41.4	52.9	...	...	...	53.9	35.9	44.9

* Kalmoe's Minn. No. 13.

† Average of Kalmoe's and Lein's Minn. No. 13.

TABLE III

MOISTURE CONTENT IN EAR CORN AT TIME OF HARVEST

	U. Farm	Morris				Red Wing		Chippewa Co.			Meeker Co.			Percentage of Rustler
	1929	1926	1927	1928	1929	1926	1927	1927	1928	1929	1928	1929	Av.	
Rustler	36.8	47.2	42.9	23.0	26.7	45.4	55.1	37.0	19.0	31.8	28.0	48.7	36.8	100.0
Minn. No. 13														
Morris	...	47.7	41.8	23.0	21.2	...	...	...	...	...	...	...	35.1*	95.4
Univ. F.	40.7	47.2	43.2	30.0	33.3	44.6	50.5	37.6	22.0	36.7	31.0	51.7	39.0	106.0
N.W. Dent	41.6	51.7	39.1	25.0	21.8	...	...	...	...	...	...	...	37.3*	101.4
E × I	29.0	39.0	40.9	22.0	16.3	37.3	49.9	34.0	18.0	25.0	29.0	39.6	31.7	86.1
E × K	36.4	42.5	42.3	25.0	24.0	48.1	51.7	33.1	20.0	29.2	32.0	47.0	35.9	97.8
E × L	31.2	29.6	38.7	24.0	16.7	39.1	...	...	...	29.6	26.0	38.0	30.5*	82.9

* Corrected on the basis of comparable trials of Rustler.

The results given in the last column of Table III for the average of all localities are in percentages of Rustler. All three double crosses had a lower moisture content than Rustler, E × I and E × L containing somewhat lower moisture content than E × K.

Date of silking taken at University Farm, 1927 to 1929, inclusive, and at Morris in 1929 is given in Table IV. These data indicate that the crosses are somewhat earlier than Rustler and Minn. No. 13.

TABLE IV

DATE SILKING OF RUSTLER, MINN. NO. 13, N.W. DENT, AND DOUBLE CROSSES

	University Farm			Morris	Av.
	1927	1928	1929	1929	
Rustler	8/6	8/1	7/31	8/1	8/2
Minn. No. 13	8/6	8/4	8/1	7/30	8/2
N.W. Dent	8/5	8/3	7/25	7/28	7/31
E × I	8/4	7/30	7/26	7/26	7/29
E × K	8/3	8/1	7/29	7/28	7/31
E × L	8/6	7/30	7/27	7/27	7/30

Shelling percentage is given in Table V for University Farm, 1926; Goodhue County, 1926; Chippewa County, 1927-29; and Meeker County, 1928, 1929. In other years shelling percentage was not taken.

TABLE V

SHELLING PERCENTAGE OF RUSTLER, MINN. NO. 13, AND DOUBLE CROSSES

	U. Farm	Goodhue Co.	Chippewa Co.			Meeker Co.		Av.	Percentage of Rustler
	1926	1926	1927	1928	1929	1928	1929		
Butler	76.8	80.2	80.9	83.0	83.4	82.0	79.4	80.8	100.0
Minn. No. 13	80.7	80.7	79.6	83.0	81.8	81.0	78.8	80.8	100.0
E × I	78.1	82.5	81.4	84.0	82.6	84.0	81.7	82.0	101.5
E × K	79.9	81.7	81.3	84.0	84.6	83.0	82.3	82.4	102.0
E × L	80.7	80.7	...	83.0	82.5	82.0	82.4	81.9*	101.4

* In percentage of Rustler for the same years.

E × I, E × K, and E × L gave 1.5, 2.0, and 1.4 per cent, respectively, more shelled corn than Rustler. As the yields in Table II are

on an ear corn basis, it is reasonable to add 1.4 to 2.0 per cent to the yields of the crosses as given in that table.

A summary of percentage yields and other data, in which Rustler and Minn. No. 13 are compared with the three double crosses, is given in Table VI.

TABLE VI

SUMMARIZED DATA FOR A COMPARISON OF THE DOUBLE CROSSES E × I, E × K, AND E × L WITH RUSTLER AND MINN. NO. 13*

Variety or cross	Percentage yield	Shelling percentage	Ears per stalk		Date of silking	Percentage moisture at harvest
			Marketable	Nubbin		
Rustler	100.0	100.0	.92	.12	8/2	36.8
Minn. No. 13	97.0	100.0	.84	.14	8/2	35.1
E × I	112.1	101.5	.99	.08	7/29	31.7
E × K	109.0	102.0	1.00	.16	7/31	35.9
E × L	109.7	101.4	1.05	.11	7/30	30.5

* Average yield with Rustler as 100 per cent (University Farm, 1926-29; Morris, 1926-29; Goodhue County, 1926-28; Chippewa County, 1927-29; Meeker County, 1928-29) Average shelling percentage with Rustler as 100 per cent (University Farm, Goodhue County, 1926; Chippewa County, 1927-29; Meeker County, 1928-29). Average number of marketable and nubbin ears per stalk (University Farm, 1927-29). Average date silking (University Farm, 1927-29; Morris, 1929). Average percentage moisture in corn at harvest (University Farm, 1929; Morris, 1926-29; Goodhue County, 1926-27; Chippewa County, 1927-29; Meeker County, 1928-29).

The crosses yielded from 9 to 12.1 per cent more ear corn than Rustler and excelled Rustler from 1.4 to 2.0 per cent in shelling percentage. Data taken at University Farm, 1927-29, illustrates one reason for the superiority of the double crosses in yielding ability. They averaged approximately one marketable ear per plant while Rustler and Minn. No. 13 averaged .92 and .84, respectively. Observations of the double crosses showed that practically every stalk produced one good ear. All ears of a double cross matured at about the same time and the quality of the grain was somewhat superior to that of the normal varieties.

The yields of the double crosses were compared with that obtained from the Waseca Branch Station strain of Silver King in field trials conducted in Brown, Watonwan, and Cottonwood counties in 1928 and at the Waseca Station for 1928 and 1929. Results obtained are given in Table VII.

The crosses yielded much more than Silver King in the Watonwan County trial, much less than Silver King in Cottonwood and slightly less than Silver King at Waseca and in Brown County. The average of all trials gave 1.2 per cent to 1.4 per cent lower yield for the double crosses than for Silver King. As they are much earlier in maturity, it appears that they may have some promise in certain sections in southern Minnesota. It is hoped to learn their adaptability by wide field trials conducted with many farmers in central and southern Minnesota.

TABLE VII

YIELD IN BUSHELS, PERCENTAGE OF MOISTURE IN CORN AT HARVEST, AND SHELLING PERCENTAGE IN CORN TRIALS IN SOUTHERN MINNESOTA

Variety	Yield, Bushels						
	Waseca		Brown Co.	Cottonwood Co.	Watonwan Co.	Av.	Per Cent Silver King
	1928	1929	1928	1928	1928		
Silver King	52.2	67.2	46.1	50.7	41.5	51.5	100.0
E × I	...	62.3	44.4	40.0	55.0	50.8*	98.6
E × K	52.8	62.2	45.0	45.1	49.3	50.9	98.8
	Percentage Moisture						
Silver King	48.5	35.6	22.0	29.0	28.0	32.6	100.0
E × I	...	25.9	14.0	17.0	15.0	20.4	62.7
E × K	42.7	31.7	16.0	19.0	19.0	25.7	78.8
	Shelling Percentage						
Silver King	...	...	85.0	83.0	86.0	84.7	100.0
E × I	...	...	80.0	81.0	83.0	81.3	95.3
E × K	...	...	83.0	84.0	85.0	84.0	98.8

* Adjusted on basis of Silver King.

PLANS FOR DISTRIBUTION OF THE DOUBLE CROSSES E × I, E × K, and E × L

The first crosses.—The difficult part of the production of double-crossed seed is the making of the crosses between the selfed lines. The ears produced by the selfed lines are small and the cost of seed production is correspondingly great. Because of the limited amount of seed of the selfed lines which was available, it was decided to make the first increase of the selfed lines and first crosses between them by controlled hand-pollination.

Fig. 5. Insect Powder Blower

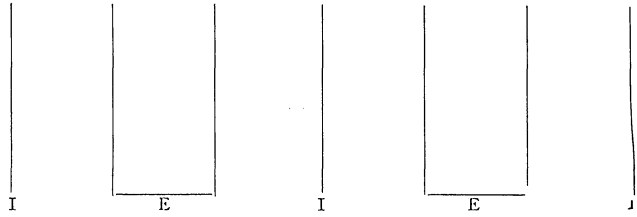
The ears were covered by vegetable parchment bags before the silks appeared and about a day prior to the period of pollination manila paper bags were placed on the tassels to collect the pollen. The pollen was sifted to remove the anthers and placed in a small insect powder blower (Fig. 5). This furnished a means of rapid hand-pollination. As the various lines were grown on the same field, it was necessary to keep the ears covered.

Besides the first-generation crosses which were made, the selfed-line parents were increased through sib-pollination, i.e., the pollination of silks of a plant by pollen from a sister plant of the same line. The following seed is available.

Selfed line	Lbs.	Crosses	Lbs.
11	19.2	11 × 14 = E	59.6
14	24.4	16 × 20 = I	45.2
15	37.0	15 × 19 = K	39.8
16	22.6	21 × 22 = L	12.3
19	2.6		
20	15.9	Total	156.9
21	8.5		
22	2.4		
Total	132.6		

Producing the double-crossed seed.—There is sufficient seed of the first crosses for approximately 25 acres of seed plots to be used in the production of double-crossed seed. The actual cost of production of this seed by hand-pollination was approximately $1 per pound or in the neighborhood of $6 for sufficient seed to plant an acre plot at the rate of 4 seeds per hill, hills 3 feet, 6 inches apart each way. It is proposed to sell this seed to 25 farmers who may be interested in the hybrid method of seed corn production, at the rate of $6 for sufficient seed to plant an acre seed plot. Directions for planting and handling the detasseling will be furnished. This method of first distribution has the advantage of teaching several growers the method of hybrid seed production.

A suggested plan for a cross of E × I.—Supposing a farmer purchases seed of the first crosses E and I, and E is to be used as the female parent. Seed of E and I will be furnished in separate bags with sufficient seed of E to plant twice as many rows as of I. First select an isolated plot, at least 80 rods distant from any other corn field, unless hills or woods intervene which aid in isolation. Plant 4 seeds per hill, at an approximate distance of 3 feet, 6 inches apart in each direction. Alternate two rows of E with each single row of I, detasseling E as soon as the tassels appear.



Seed on the rows of E to be detasseled will be double-crossed seed and should be used to produce the commercial crop. Discard seed from I.

Further increase by the Experiment Station of the selfed lines and first crosses.—The seed of the selfed lines will be retained by the Experiment Station for at least another year and first crosses will be made again. The Experiment Station has no intention of entering the seed business. It hopes to study various methods of making these first crosses in order to learn the best possible procedure. It prefers to retain the foundation stock for another year until wide farm trials of the double crosses have been made.

Demonstration trials of the double crosses.—The following double-crossed seed is available.

Variety	Bushels
E × I	45
E × K	8
E × L	4

It is proposed to use this seed for wide demonstration farm trials. Approximately 4 pounds will be furnished through county agents to farmer co-operators who will agree to plant this in the center of their regular corn field. In case a satisfactory stand of the double cross and of the farmer's variety is obtained, a comparative yield trial of the double cross and of the farmer's variety will be made.

Present double crosses of non-uniform color.—The double crosses, E × I and E × K, will give the same variation in seed color as would be obtained by crossing Rustler and Minn. No. 13. The commercial crop will consist of a mixture of yellow and white seeds. The cross E × L will consist of a mixture of red and colorless pericarp ears.

Double crosses of uniform seed color can be produced but none are available for distribution at the present time.

Adaptation of these crosses.—The double crosses, E × I, E × K, and E × L, are adapted to any region where Minn. No. 13 and Rustler are standard varieties. Because of their higher yielding ability they may prove valuable in sections where somewhat later maturing varieties are adapted, especially for late plantings or for early hogging-off purposes. Because of earlier maturity they may be grown somewhat farther north than Minn. No. 13 or Rustler.

Double-crossed seed must be produced each year.—If you grow a test plot of a few rows of a double cross, do not select seed from this plot. It will not continue to prove valuable in later generations. *The hybrid method of seed corn production necessitates the making of the cross each year.*