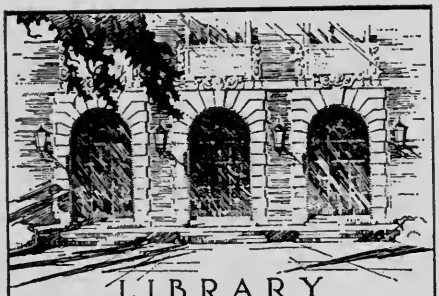

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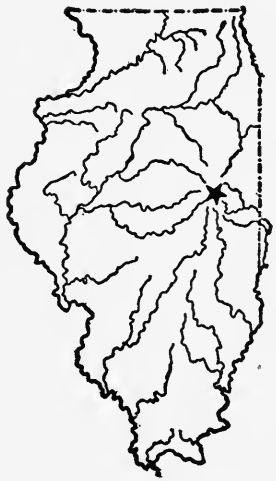
EXPERIMENTS IN CROSSING VARIETIES AS A MEANS OF IMPROVING PRODUCTIVENESS IN CORN

By L. H. Smith and A. M. Brunson



URBANA, ILLINOIS, MAY, 1928

SUMMARY

Among the various methods that have been proposed for increasing the yield of corn is that in which use is made of first-generation hybrid seed produced by the simple crossing of one variety with another.

Numerous experiments by different investigators to test this method have given conflicting results. Many instances are recorded in which the yield of the cross exceeded that of the higher-yielding parental variety, but these are offset by numerous other cases in which no advantage from crossing was obtained, the cross often proving inferior to either of the participating parents. The present bulletin places on record some additional experiments in which are involved different types of hybrid combinations that vary in their response to crossing.

Crosses between common varieties of ordinary dent corn gave little or no increase in yield over that of the higher-yielding parent. On the other hand, crosses between highly selected strains, which as a consequence of intense selection for special characters had suffered inbreeding, gave a marked increase in the yield of the cross over that of either parent.

The indication, therefore, is that our ordinary varieties of corn, as they are usually propagated on the farm, do not undergo inbreeding to such an extent as to benefit by simple crossing.

These results fail to support the recommendation advanced from time to time to cross varieties of corn as a simple and reliable method of increasing the yield. On the contrary the results indicate that the chances for a loss by this practice are much greater than for a gain, especially if the expense in time and effort in making the crosses be taken into consideration.

It should perhaps be pointed out again that these experiments have to do only with direct varietal crosses; they do not deal with that more complex, tho highly promising, plan of corn improvement which involves the production and the subsequent crossing of self-fertilized lines.

EXPERIMENTS IN CROSSING VARIETIES AS A MEANS OF IMPROVING PRODUCTIVENESS IN CORN

By L. H. Smith and A. M. Brunson[1]

One of the methods that has been proposed for increasing the yield of corn is the application of what seems to be a rather generally prevailing principle in nature known as "heterosis," or hybrid vigor. It is a well-known fact that many kinds of plants as well as animals when mated in hybridization of various degrees exhibit in their progeny of the first generation an increase in vigor manifested by increase in size or by acceleration in growth.

The application of this principle to corn production, in its simpler aspect, involves the use of first-generation seed produced by crossing two different varieties. The cross must be made anew each year from the original parental stock in order to furnish first-generation hybrid seed. A more recent development of the idea involves preliminary selection within self-fertilized lines for a number of generations. The present investigation, however, deals with simple varietal crosses and is not concerned with self-fertilized lines.

The idea of crossing varieties of corn for improvement in yield is by no means a new one, for such a plan was proposed more than fifty years ago by Professor W. J. Beal, working at the Michigan Agricultural College. Since that time a considerable number of investigators have become interested in this problem and have from time to time reported results of their experiments so that rather extensive literature on the subject has accumulated.

It is of interest to note that the Illinois Experiment Station furnished some of the earlier contributions to this subject. In 1892 it published a bulletin by G. W. McCluer on "Corn Crossing," and in the same year issued another bulletin entitled "Experiments with Corn," which includes an account of experiments along this line by Morrow and Gardner.

McCluer in his experiments crossed such diverse types as sweet, soft, pop, and dent varieties. The weight of a 10-ear representative sample of each cross is compared with that of the corresponding parental varieties. Summarizing the results it is to be observed that only four out of eighteen tests indicate any increase in yield over the higher-yielding parent due to crossing.

Morrow and Gardner in their first experiment tested five different crosses between dent varieties and in three cases out of the

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five obtained an increase in yield over the higher-yielding parent. Repeating the experiment the following year, they found that the cross exceeded the better parent in two trials out of four. Thus, so far as these Illinois experiments are concerned, the question of the use of crossbred seed was left quite unsettled.

It is not the purpose of this paper to go further into the history of this problem nor to discuss in detail results of the rather long series of investigations by different workers at other institutions, for such an effort would be only to repeat what has been excellently done by several writers.[1]

As a general statement covering all the different investigations on record, it may be said that many of the experiments indicate considerable advantage from crossing, comparing the yield of the cross with that of the better parent. On the other hand, these favorable results are offset by about an equal number of unfavorable results wherein the yield of the cross falls between that of the parent varieties or even below the yield of the poorer parent.

On the basis of the more favorable results some rather extravagant claims have been made which, if not sufficiently qualified, would lead farmers to infer that this method of crossing two varieties of corn offers a simple and sure means of increasing their yields.

It was to obtain further evidence upon the problem of hybrid vigor in general, and upon the effect of crossing the standard varieties of Illinois in particular, that the present investigation was undertaken. In addition to the ordinary varieties some rather unusual material for comparative hybridization studies was available in the form of the well-known "Illinois" strains selected at the Illinois Experiment Station for special chemical and physical characteristics by the ear-to-row method.

FOUR GROUPS OF CROSSES TESTED

The cross combinations tested in these experiments fall into four categories, as follows, with respect to the classes of parental stocks employed:

Group A includes a series of crosses produced between well-known commercial varieties. All of those which at one time were considered "standard varieties" for Illinois are included. In this group Reid Yellow Dent served in all cases as the pollen parent.

Group B includes only two crosses, one between a variety of sweet corn and Reid Yellow Dent, and one between a pop corn and Reid Yellow Dent, the latter being used as the pollen parent in both cases.

[1]For the reader who may be interested in tracing the development of this subject reference may be made to two reviews appearing in Volume 14 of the *Journal of the American Society of Agronomy,* one by F. D. Richey and the other by Fred Griffee.

Group C is a series made up of crosses between strains produced at this Station by continuous ear-row selection for certain special characters including high protein, low protein, high oil, low oil, high ears, and low ears. These strains were crossed one with another in the seven different combinations listed in Tables 1 and 4.

Group D is made up of the same special strains mentioned in Group C, but instead of being mated with one another each of these strains is here combined with Reid Yellow Dent as the pollen parent.

The crossbred seed was produced by interplanting in a field of the male or staminate variety individual rows of the respective female or pistillate varieties. By detasseling all plants of the latter, fertilization took place only thru pollen from the male variety. The crossbred seed thus produced each year was planted the following year in a variety test along with seed of the corresponding parental varieties.

With the exception of the sweet and pop varieties, which were purchased in the local market, care was taken to obtain seed of the respective varieties from the same sources every year, usually from growers who had given special attention to the propagation of a particular variety.

In the variety test plots effort was made to secure as nearly a perfect stand as possible and no attempt has been made in reporting results to correct the yields for variation in stand. As a matter of fact, however, the plots were usually fairly uniform in this respect.

The plots were planted in duplicate each year and the tests ran from three to five years, thus providing from 6 to 10 trials for each variety. At regular intervals a plot of Reid Yellow Dent was planted to serve as a check. The hybrid plots were planted between plots of the two respective parent varieties in order to reduce soil variation within any given comparison to a minimum.

RESULTS OF TESTS

The records of the variety trials are shown in Table 1, which gives the annual yields of the duplicate plots for the parental varieties alongside the corresponding crosses. There is also given the average gain (or loss) in yield of the cross over that of the yield of the higher-producing parent.

For convenience in considering the results, the data of Table 1 are summarized in Tables 2, 3, 4, and 5 according to the four groups of crosses described above. These tables show the gain or loss as a result of crossing, basing the comparisons upon the yield of the higher-yielding parent. This gain or loss is expressed in terms of bushels per acre and also in percentage. The figures in the last column of the tables indicate the statistical significance of the results as determined by "Student's" method.

TABLE 1.—ANNUAL YIELD OF CORN IN DUPLICATE PLOTS OF FIRST-GENERATION CROSSES COMPARED WITH THEIR RESPECTIVE PARENT VARIETIES

(Bushels of dry shelled corn per acre)

Variety	1912		1913		1914		1915		1916		Aver.	Gain over high parent
Group A—Dent varieties crossed with Reid Yellow dent												
Champion White Pearl	42.5	43.6	37.8	40.0	64.7	56.3	56.0	57.9	26.9	18.9	44.46	
Reid Yellow Dent	47.1	49.9	42.1	41.4	65.4	58.1	53.3	59.5	38.7	27.4	48.29	
Cross	42.3	45.7	49.9	45.7	63.9	65.6	60.8	65.7	37.0	25.2	50.18	1.89
Boone County White	..	..	47.3	37.0	62.8	58.2	51.3	52.3	27.8	16.3	44.13	
Reid Yellow Dent	..	..	42.1	41.4	65.4	58.1	53.3	59.5	38.7	27.4	48.24	
Cross	..	..	41.4	38.9	70.7	63.6	55.2	58.6	41.1	29.3	49.85	1.61
Leaming (Chester's)	40.6	54.6	36.6	27.4	65.9	49.3	56.7	49.2	28.5	21.2	43.00	
Reid Yellow Dent	42.7	51.6	51.9	33.1	42.7	48.0	50.4	52.2	29.5	23.3	42.54	
Cross	35.8	48.6	50.4	27.6	59.0	54.7	60.5	54.3	26.1	28.8	44.58	1.58
Calico	41.9	..	33.6	19.7	55.6	43.2	45.7	41.5	23.3	19.9	36.04	
Reid Yellow Dent	40.9	..	33.0	28.0	54.9	57.8	57.6	49.5	29.5	25.1	41.84	
Cross	43.5	..	30.8	30.0	53.5	49.1	61.6	52.0	31.4	28.1	42.22	.38
Silvermine	..	..	44.5	37.5	57.9	61.1	59.4	61.6	29.2	24.7	46.99	
Reid Yellow Dent	..	..	28.5	47.9	48.5	60.8	52.6	51.3	29.4	25.2	43.01	
Cross	..	..	36.5	40.0	59.2	61.0	58.4	60.6	31.7	27.1	46.81	—.18
Crimson	32.8	47.5	38.7	29.0	56.8	35.4	46.4	38.8	31.6	23.3	38.03	
Reid Yellow Dent	42.7	51.6	33.3	28.0	54.9	57.8	57.6	49.5	29.5	25.1	43.00	
Cross	38.3	52.0	37.8	31.9	50.7	42.2	60.7	49.6	32.8	29.8	42.58	—.42
Reid Yellow Dent (Smith's)	22.4	36.5	46.1	41.0	46.6	65.8	66.0	56.3	31.3	30.3	44.06	
Reid Yellow Dent	42.7	51.6	40.3	36.0	35.8	69.8	57.5	53.9	26.9	26.1	44.23	
Cross	34.7	47.7	38.9	38.0	34.2	62.8	64.2	52.7	30.5	33.3	43.70	—.53

TABLE 1.—*Continued*

Variety	1912		1913		1914		1915		1916		Aver.	Gain over high parent
Golden Eagle	41.7	43.8	33.2	35.5	49.1	37.7	53.2	50.6	29.8	23.5	39.81	
Reid Yellow Dent	47.1	49.9	45.3	42.7	62.0	61.8	54.7	49.7	36.0	19.3	46.85	
Cross	36.9	43.1	43.9	42.6	63.3	55.9	55.8	59.9	34.4	24.3	46.01	—.84
Riley's Favorite	43.8	50.8	36.4	19.5	49.7	31.4	54.5	47.6	23.0	22.1	37.88	
Reid Yellow Dent	47.1	49.9	49.3	21.1	59.9	33.3	55.0	42.8	36.2	24.0	41.86	
Cross	46.9	49.7	40.7	18.5	50.9	36.6	56.2	47.8	29.4	24.6	40.13	—1.73
Leaming (Maxey's)	40.7	46.3	31.9	36.7	40.7	63.9	51.1	45.0	24.5	22.2	40.30	
Reid Yellow Dent	41.1	54.2	28.5	47.9	48.4	60.8	52.6	51.3	29.4	25.2	43.94	
Cross	33.9	38.7	28.8	45.2	38.5	56.8	49.9	56.7	27.4	24.2	40.01	—3.93
Group B—Sweet and pop varieties crossed with Reid Yellow dent												
Sweet corn (Country Gentleman)	10.3	10.8	8.6	9.0	29.5	29.3	26.1	27.6	6.0	2.9	16.01	
Reid Yellow Dent	34.5	40.7	45.3	42.7	62.0	61.8	54.7	49.7	36.0	19.3	44.67	
Cross	42.3	40.4	33.0	42.7	63.8	56.0	53.5	49.4	39.5	20.3	44.09	−.58
Pop corn (Rice)	..	..	10.4	10.2	25.5	28.7	29.7	32.2	11.3	8.9	19.61	
Reid Yellow Dent	..	..	49.3	21.1	59.9	33.3	55.0	62.6	36.2	24.0	42.67	
Cross	..	..	32.3	24.9	26.2	33.0	52.7	50.2	42.8	33.2	36.91	−5.76
Group C—Strains produced under continuous selection for special characters intercrossed												
Low Ear	43.4	39.9	33.5	21.8	46.0	50.7	52.3	52.5	27.3	26.6	39.40	
High Ear	42.1	43.8	26.3	27.4	43.3	45.5	34.7	37.3	15.5	14.1	33.00	
Cross	55.6	41.2	39.8	32.8	68.9	63.8	60.1	61.3	34.3	32.5	49.03	9.63
High Protein	20.8	31.7	22.8	25.1	26.0	46.4	44.8	46.6	20.3	9.5	29.40	
Low Oil	35.7	27.8	25.6	22.1	35.9	52.0	50.3	53.8	26.1	10.4	33.97	
Cross	46.6	42.2	32.9	33.9	36.9	67.2	57.5	61.1	32.4	16.5	42.72	8.75

TABLE 1.—*Continued*

Variety	1912		1913		1914		1915		1916		Aver.	Gain over high parent
Low Oil	35.7	27.8	25.6	22.1	51.9	45.4	44.5	55.3	22.3	17.2	34.78	
High Oil	27.6	35.4	30.4	21.4	46.4	28.3	48.3	42.1	22.9	10.5	31.33	
Cross	44.9	36.3	35.8	29.0	47.1	42.5	59.5	62.0	30.3	17.4	40.48	5.70
High Oil	27.6	35.4	34.5	27.6	45.3	39.1	51.1	45.7	30.0	16.6	35.29	
High Protein	20.8	31.7	29.5	30.9	38.0	37.0	38.0	44.0	22.1	17.1	30.91	
Cross	32.4	37.6	39.3	36.8	48.5	48.3	50.1	49.7	33.8	24.0	40.05	4.76
High Oil	27.6	35.4	34.5	27.6	45.3	39.1	51.1	45.7	30.0	16.6	35.29	
Low Protein	25.4	39.8	36.0	35.0	49.4	47.2	57.5	57.4	44.7	30.4	42.28	
Cross	33.1	44.6	46.7	39.7	60.6	50.5	63.7	62.3	41.0	26.9	46.91	4.63
Low Oil	35.7	27.8	25.6	22.1	35.9	52.0	50.3	53.8	26.1	10.4	33.97	
Low Protein	25.4	39.8	35.7	32.4	37.0	49.6	57.9	60.7	37.4	24.0	39.99	
Cross	44.8	34.3	38.3	46.7	45.6	59.8	58.9	58.8	34.5	23.5	44.52	4.53
Low Protein	25.4	39.8	36.0	35.0	57.6	44.1	57.7	56.7	34.5	24.7	41.15	
High Protein	20.8	31.7	22.8	25.1	48.0	36.9	45.2	39.6	19.7	9.4	29.92	
Cross	41.2	40.1	37.2	41.2	61.0	52.9	64.2	56.7	32.3	19.1	44.59	3.44
Group D—Strains produced under continuous selection for special characters crossed with Reid Yellow dent												
Low Ear	..	..	..	..	46.0	50.7	52.3	52.5	27.3	26.6	42.57	
Reid Yellow Dent	..	..	..	..	35.8	69.8	57.5	53.9	26.9	26.1	45.00	
Cross	..	..	..	..	60.4	62.9	63.2	65.8	29.7	26.0	51.33	6.33

TABLE 1.—*Concluded*

Variety	1912		1913		1914		1915		1916		Aver.	Gain over high parent
Low Protein	..	..	..	..	57.6	44.1	57.7	56.7	34.5	24.7	45.88	
Reid Yellow Dent	..	..	..	..	59.2	51.1	55.5	46.0	28.3	28.1	44.70	
Cross	..	..	..	..	56.0	54.9	64.2	57.6	38.9	35.2	51.13	5.25
Low Oil	..	..	..	..	51.9	45.4	44.5	55.3	22.3	17.2	39.43	
Reid Yellow Dent	..	..	..	..	61.9	56.4	52.5	53.3	30.1	30.3	47.42	
Cross	..	..	..	..	63.4	43.5	64.9	57.3	37.9	37.8	50.80	3.38
High Oil	..	..	..	..	46.4	28.3	48.3	42.1	22.9	10.5	33.08	
Reid Yellow Dent	..	..	..	..	59.2	51.1	55.5	46.0	28.3	28.1	44.70	
Cross	..	..	..	..	61.3	46.2	60.0	53.5	30.5	23.6	45.85	1.15
High Ear	..	..	..	..	43.3	45.5	34.7	37.3	15.5	14.1	31.73	
Reid Yellow Dent	..	..	..	..	61.9	56.4	52.5	53.3	30.1	30.3	47.42	
Cross	..	..	..	..	58.2	53.9	53.3	56.3	26.9	27.1	45.95	−1.47
High Protein	..	..	..	..	48.0	36.9	45.2	39.6	19.7	9.4	33.13	
Reid Yellow Dent	..	..	..	..	69.6	60.4	59.6	51.4	33.3	22.4	49.45	
Cross	..	..	..	..	57.8	57.3	60.5	51.5	35.9	17.4	46.73	−2.72

It is obvious that for practical purposes the corn grower is interested in any possible gain to be obtained over the yield of the better parent, rather than over the parental average, which has frequently been considered for comparison in reports of similar investigations. For this reason the yield of the higher-producing parent entering into the cross is used as the basis for comparison thruout this discussion.

Group A—Common Dent Varieties Crossed

Table 2 shows the average increase or decrease as a result of the crossing for the combinations in Group A. Since this group is made up

TABLE 2.—GROUP A: DENT VARIETIES CROSSED WITH REID YELLOW DENT
(Summary showing gain or loss based upon yield of higher-yielding parent)

Variety X Reid Yellow Dent	Gain		Loss		Odds that difference is statistically significant
	Bushels per acre	Percent	Bushels per acre	Percent	
Champion White Pearl	1.89	3.91	...	...	6.0:1
Boone County White	1.61	3.34	...	...	11.6:1
Leaming (Chester's)	1.58	3.67	...	...	3.2 32 :1
Calico	.38	.91	...	...	1.6:1
Silvermine	...	...	.18	.38	1.2:1
Crimson	...	...	.42	.98	1.4:1
Reid Yellow Dent	...	...	.53	1.20	1.4:1
Golden Eagle	...	...	.84	1.79	2.0:1
Riley's Favorite	...	...	1.73	4.13	5.7:1
Leaming (Maxey's)	...	...	3.93	8.94	31.9:1

of crosses between common dent varieties, this set of results is of particular interest from the farmer's standpoint.

Ten combinations are included in these tests, Reid Yellow Dent serving as the pollen parent in all cases. Crossing appears to have produced little effect upon the yields. In analyzing the data it is observed that the figures for the different varieties range from a small gain of less than 2 bushels an acre, or about 4 percent, on the one hand, to a loss of about 4 bushels an acre, or nearly 9 percent, on the other hand. These differences, in the main, are well within the experimental error. According to the column of "odds," the single case in which the result can possibly be considered significant, and that doubtfully so from the statistical standpoint, represents about a 9-percent loss.

Group B—Sweet and Pop Varieties Crossed With Dent

The summarized results for Group B are given in Table 3. This group includes only two combinations. It is of especial interest, however, from the fact that the parental varieties represent widely differ-

ent groups of maize. In one case sweet corn is used as the maternal variety, and in the other pop corn is the female parent.

In yielding capacity both of these varieties are far inferior to the dent variety which is used here as the pollen parent. The average annual yield of the sweet corn was only 16 bushels an acre (Table 1), while that of Reid Yellow Dent was 44.7 bushels. The yield of the cross between the two, however, was only a fraction of a bushel less than that of Reid Yellow Dent.

TABLE 3.—GROUP B: SWEET AND POP VARIETIES CROSSED WITH REID YELLOW DENT
(Summary showing gain or loss based upon yield of higher-yielding parent)

Variety X Reid Yellow Dent	Gain		Loss		Odds that difference is statistically significant
	Bushels per acre	Percent	Bushels per acre	Percent	
Sweet (Country Gentleman)	...	...	.58	1.30	1.7:1
Pop (Rice)	...	...	5.76	13.50	57 :1

The result for the pop-corn cross was not quite so favorable as that for the sweet-corn cross. The average annual yield for the pop corn was 19.6 bushels an acre, while the corresponding Reid Yellow Dent plots gave 42.7 bushels. The cross between the two produced an average yield of 36.9 bushels, or 5.8 bushels less than the yield of the more productive parent.

Group C—Closely Selected Strains Intercrossed

Group C differs from the preceding groups in that the crosses, instead of being between ordinary varieties, are between strains that have been produced under rather intense selection by the ear-row breeding-plot method for certain special characters. These include the four chemical strains selected at this Station for high protein, low protein, high oil, and low oil, respectively, since 1896. At the time this crossing experiment was started these strains had been under this close selection for sixteen years, and the two strains selected for high and low ears respectively had been under similar rigid breeding-plot control for nine years. It is inevitable, therefore, that more or less inbreeding must have taken place in all of these strains. It is a well-established fact that inbreeding in corn is accompanied almost universally by a loss of vigor and a consequent decrease in yield. It is also now well known that vigor of growth lost thru inbreeding is usually restored upon crossbreeding.

With these facts in mind it is not surprising, therefore, that the results in Group C are different in nature from those of the preceding

groups. Looking over the results in Table 4, no loss by crossing is observed. On the contrary, the increase in yield of the cross over that of the higher-yielding parent is in at least five cases out of the seven of a very substantial order, judging from the magnitude of the gains and the indications of the odds.

TABLE 4.—GROUP C: STRAINS PRODUCED UNDER CONTINUOUS SELECTION FOR SPECIAL CHARACTERS INTERCROSSED
(Summary showing gain or loss based upon yield of higher-yielding parent)

Crosses	Gain		Loss		Odds that difference is statistically significant
	Bushels per acre	Percent	Bushels per acre	Percent	
Low Ear X High Ear...	9.63	24.44	...	...	4999:1
High Protein X Low Oil	8.75	25.76	...	...	9999:1
Low Oil X High Oil....	5.70	16.39	...	...	108:1
High Oil X High Protein.....	4.76	13.49	...	...	1999:1
High Oil X Low Protein.....	4.63	10.95	...	...	109:1
Low Oil X Low Protein.	4.53	11.33	...	...	16:1
Low Protein X High Protein.....	3.44	8.36	...	...	17:1

These results are of practical interest as indicating the possibility of restoring the yielding capacity of varieties or strains that have suffered deterioration thru inbreeding. For example, a means is suggested of avoiding the detrimental effect of reduced yields in breeding for, let us say, high oil. If two independent lines of high oil were propagated, doubtless the loss in yield accompanying the gain in oil could be remedied by combining the two lines or strains and using each year seed of the first-generation cross.

Group D—Reid Yellow Dent Crossed With Closely Selected Strains

Each of the special strains entering into the crosses of Group C was crossed with Reid Yellow Dent and these crosses constitute Group D, the results for which are given in Table 5. This set of tests was conducted for only three years.

The results for this series of crosses are not very decisive. The figures show four gains for the cross and two losses, but in only one case, the second on the list, do the odds indicate possible statistical significance. It may be observed, however, from data in Table 1, that in all cases the average yield for the cross is above the average yield for the selected strain. It is also worthy of note that altho in all cases excepting one the "Illinois" parent was lower yielding than the Reid parent, the hybrids are fully as high yielding on the average as those in Group A.

TABLE 5.—GROUP D: STRAINS PRODUCED UNDER CONTINUOUS SELECTION FOR SPECIAL CHARACTERS CROSSED WITH REID YELLOW DENT
(Summary showing gain or loss based upon yield of higher-yielding parent)

Strains X Reid Yellow Dent	Gain		Loss		Odds that difference is statistically significant
	Bushels per acre	Percent	Bushels per acre	Percent	
Low Ear	6.33	14.07	...	...	8.3:1
Low Protein	5.25	11.44	...	...	38.1:1
Low Oil	3.38	7.13	...	...	4.1:1
High Oil	1.15	2.57	...	...	2.4:1
High Ears	...	...	1.47	3.10	7.2:1
High Protein	...	...	2.72	5.50	6.7:1

Simple Crossing of Varieties Does Not Insure Increase in Yield

In studying the results of these experiments on the effect of crossing varieties of corn, two sets of conditions are to be considered—one in which the parent varieties have been subjected to close breeding and one in which the participating varieties have not been close-bred.

It is well established that varieties or strains which have been under continuous selection by methods resulting in some degree of inbreeding, like those of Group C in these experiments, are likely to receive a beneficial effect by crossing. On the other hand, corn that has not undergone inbreeding to a detrimental extent is not so likely to receive a benefit from crossing. According to this principle, the common commercial varieties of dent corn as ordinarily propagated on the farm are probably naturally in such a hybrid state that artificial crossing is ineffective in increasing the vigor of growth or raising their productiveness.

The theory has been advanced that the increased vigor manifested in the crossing of varieties is due to the assembling in the hybrid of certain growth factors not common to both parents. With this assumption it would follow that the greater the diversity of characteristics in the combining varieties, the greater the chance for increase in yield of the hybrid. Some results of the various investigations on record appear to bear out this theory. Conceding the correctness of such an hypothesis, the results here reported might be explained upon the theory of diversity of characteristics in the combining varieties. Thus in the common dent varieties used in these experiments the combining parents probably do not differ greatly in their heritable characters or genetic make-up, while in the highly selected strains the combining parents carry sets of genetic factors that differ considerably. In the light of these considerations it would be too much to conclude that no benefit is ever to be expected from the simple crossing of varieties; but,

as the experiments show, there is great probability that the particular combination that would reward the breeder for his trouble will be missed.

The results of the experiments presented herein appear to be in line with theoretical considerations and they lead to the conclusion that the simple crossing of varieties as a practice does not insure an increase in yield; on the other hand, the chances in crossing ordinary varieties are greater for loss than for gain, especially if the expense of time and effort in producing crossbred seed is considered.