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THE IMMEDIATE EFFECT ON YIELD OF
CROSSING STRAINS OF CORN

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Thesis for degree of Master of Agriculture

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THE IMMEDIATE EFFECT ON YIELD OF CROSSING STRAINS
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Leonard Carrier

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THESIS

Intelligent selection of seed has done a great deal towards improving our staple crops, especially corn. This means the saving of the best seed and the elimination of inferior strains. It is accomplished in various ways. In some of the "Corn Belt" states the method advocated is to select the best seed ears and plant them in a breeding plot one ear to each row. When each row is harvested and the best ears from the highest yielding rows are kept for the breeding plot the following year, using the balance for the main crop.

Mr. C. C. Williams of the Ohio Experiment Station improved on the above plan by planting only a portion of each ear to each row, saving the remaining portions of the ears. The remnants of the highest producing ear in the test are planted in the breeding plots the next year. This does away entirely with the influence of the low yielding stalks that would otherwise remain due to the ease with which a crosser.

The method that has been practiced by the Virginia Experiment Station differs from the above in detail of procedure (See circulars number 4 and 6 of the Va. Experiment Station) but has the same objects in view. We have found that by our method we have greatly increased the yielding power of the corn we grow. How much of this increase is due to selection and how much to the corn's becoming acclimated to our conditions we cannot say. It is a fact, however, that our own selected seed has out yielded all other

strains and varieties with which we have been working, and we test about twenty-five varieties each year. We started with a pure strain of Boone County White corn five years ago.

It is the experience of most corn breeders that while a great improvement can be made in the yielding power of ordinary strains of corn in time of four years work of careful selection and testing, after that the rate of improvement is slow if at all. There seems to be a limit above which it is impossible to go. This limit may be the highest yielding grain in the original seed with which the breeder started. It must not be inferred from this that it does not pay to continue the same careful selection after the corn has appeared to have reached its maximum yielding power. To obtain this high yielding quality is well worth all the same efforts that were necessary to increase the yielding power in the first place. The value of purity of breeding has been demonstrated so many times, both with plants and animals, that another argument in its favor seems to be needless. The writer wishes to make it plain that nothing in the following results of experiment in his opinion warrants any radical change from methods practiced by the pure bred corn breeders. Concerning the temporarily increased vigor.

It has been the common belief of feeders that a first cross between two pure breeds produces an animal that gains more rapid gains and matures earlier than would an animal of either of the pure breeds that entered into the cross.

The blue-gray steer (Shorthorn-Galloway cross) has been famous as a feeder for many years. Likewise I know, as a rule, that are raising hogs for the butcher's block prefer Berkshire-Ireland China, Duroc-Tanworth, or Duroc-Berkshire first crosses, to pure bred stock of either breed. There is an increase of vigor in the first generation cross.

It has also been known for many years that first generation crosses among plants that have been bred pure for some time will give an increase of yield over their parent stock. Dr. W. J. Neal of the Michigan Agricultural College recognized this and began experiments in 1876 to show the practical results might be obtained by corn growers through systematic crossing. He also interested a number of other experimenters in the subject. The results of these early experiments have been compiled by G. H. Collins and give along with some of his own work in Bulletin 191 U. S. Dep. of Plant Industry, entitled "The Value of First Generation Hybrids in Corn". In recent years some very valuable experimental work showing the value of first generation hybrids has been done by Dr. E. L. Esch of Connecticut and Dr. C. L. Shell of Long Island. They have shown increase in yield of first generation crosses of from 30% to 150% over the parent stock.

These later experiments have pointed out a truth that the earlier experimenters failed to fully appreciate, and that is this increase in vigor is only temporary. After the first generation there is a decrease in the yielding

power of the hybrid strains. Unfortunately most breeders after the above rule is passed with good results will try to produce a hybrid strain.

It is difficult to explain the recombination of growth. It has been suggested by some writers on Mendelian inheritance that the increased vigor in the first generation is due to the presence of the strongest or dominant characters, while in the second and subsequent generations there is a recombination of characters in which the weaker characters appear in a portion of the individuals thus affecting the yielding power.

This Experiment Station in 1908 obtained four strains of leading corn from seed corn growers in Virginia, Illinois, Indiana, and Nebraska, also four strains of Boone County White corn from Virginia, Kentucky, Indiana, and Illinois. As far as we could learn these were pure strains and had been grown in the localities from which obtained for number of years.

The strains of each variety were planted in separate plots side by side, and two plots were added, seeded with mixtures respectively of the four strains of leading and the four strains of Boone County White. Equal amounts of seed of each strain were used in making these mixtures. Therefore the corn enclosed within screen walls were erected around all of the plots and partitions separating each plot from the others to prevent cross-fertilization. The plots were 10 feet wide - the width of three corn rows - by sixty-

six feet in length. The walls were ten feet high and a covering of the same material was spread over the entire top. The covering prevented the normal growth of the plants. It was too hot for the corn. Many of the plants wilted and broke down from their own weight. Maturation was not normal as the silks on some of the ears grew out to three or four times their usual length and remained in a live receptive condition for a period of nearly two weeks. In fact the experiment that year proved a failure but the results are given in the following table on account of the interesting fact that the mixed plots were the only ones that made at all satisfactory yields and each made a larger yield than anyone of the pure strains that entered into the mixed seed.

Table I.
Results in 1908.

Variety	Source of Seed.	Yield of Grain in bushels per acre.	Yield of Fodder in tons per acre.
Leaming	Indiana	27.8	1.7
"	Illinois	19.6	2.1
"	Virginia	13.9	2.4
"	Nebraska	20.2	2.3
Mixture of all four strains		41.8	2.4
Boone County White	Kentucky	4.6	3.2
"	Indiana	9.3	2.6

Table I. Continued.

Variety	Source of Seed.	Yield of Grain in bushels per acre.	Yield of Fodder in tons per acre.
Boone County White	Illinois	4.6	2.9
"	Virginia	18.6	2.7
Mixture of all four strains.		27.9	3.1

In 1909 the experiment was repeated with portions of the original seed used in the previous year. The plots were enlarged to four rows in width the walls and partitions raised to 13 feet in height and left without a covering over the top. This method allowed a normal development of the plants and has proved fairly successful in preventing crossing.

Table II.
Results in 1909.

Variety	Source of Seed	Yield of Grain in bushels per acre.	Yield of Fodder in tons per acre.
Leaming	Indiana	27	1.2
"	Illinois	32	1.2
"	Virginia	35	1.4
"	Nebraska	33	1.2
Mixture of all four strains of Leaming		40	1.5
Boone County White	Kentucky	30	1.5
"	Indiana	34	1.4

Table II. Continued.

Variety	Source of Seed	Yield of Grain in Bushels per acre.	Yield of Fodder in tons per acre.
Boone County White	Illinois	32	1.7
"	Virginia	34	1.2
Mixture of all four strains of Boone County White		37	1.5

It will be noted that in this case the plat seeded with the mixed strains outyielded every one of the pure strains that was used in the mixture.

In 1911 the plan of the work was changed in order to do away with any influence that might be exerted by the earlin screens. Some Boone County White seed corn that was unrelated to the ear strain was obtained and planted in alternate rows with our corn on three different places on our Experimental plats. These three areas were far enough apart that there would be little if any crossing among them. The two strains will be designated as "Home-grown" and "Halifax County". In one instance the home-grown rows were detasseled, in another the Halifax County, while in the third neither was detasseled, to show the relative producing power of the two strains. Each kind was harvested by itself and the results are given in the following table.

Table III.

Strain	Treatment		Yield in bushels per acre.	Increase per cent.
1) (Home grown)	Detasseled		52.3	51.7
(Halifax County)	not	"	55.7	
2) (Home grown)	not	"	63.75	7.6
(Halifax County)	Detasseled		64.8	
3) (Home grown)	not	"	54.8	13.2
(Halifax County)	not	"	55.7	

It is evident from the third comparison in table III that our home grown strain was better adapted to our conditions than the other, outyielding it by 13.2%. Where the Halifax County corn was crossed on ours, our strain outyielded it by 51.7%. In the other case where the Home grown was crossed on the Halifax corn, our corn still gave the highest yield but the difference was only 7.6%. No comparison can be made between the yields in the different areas as they were quite widely separated and on soils that varied considerably in fertility. The Halifax County corn was evidently not so closely inbred as our own, which probably accounts for its not responding so strongly to the influence of the cross. This brings out a point that should not be overlooked and that is that where corn is already widely mixed up, nothing is to be gained by introducing new strains.

Crossing Varieties:

We made one cross in 1911 between two distinct varieties, Boone County White and Collier's Excelsior. The latter variety resembles the Boone County White closely but is not related to it at all. This work was conducted by Mr. R. E. Cocks at the Chatham and Axton substations. The two varieties were planted in alternate rows and at Chatham the Boone County was detasseled, while at Axton the Collier's Excelsior.

Results at Axton.

Variety	Treatment	Yield in bushels per acre.	Percent Increase.
Boone County	detasseled	15.7	35.3
Collier's Excelsior	not "	11.6	

Results at Chatham.

Variety	Treatment	Yield in bushels per acre.	Increase per cent
Boone County White.	not detasseled	10.1	
Collier's Excelsior.	detasseled	11.5	13.8

The work at Blacksburg was continued in 1912 after the summer had ended in 1911. A strain of Boone County White corn was obtained from Giles County, Virginia. Unfortunately this seed was low in vitality and we did not get as good a stand from it as from our own, so the results are of doubtful value.

Strain	Treatment		Yield in bushels per acre.	Increase per cent.
Home grown	detached		48.1	77
Giles County	not	"	37.1	
Home grown	not	"	33.2	18.6
Giles County		"	56	
Home grown	not	"	54.3	33.5
Giles County	not	"	35.7	

What produces the increase? It is not easy to explain how two strains of seed planted together may give an increased yield in that particular crop over what either one of them would do alone. There is evidently either more grains formed due to better pollination or the grains are heavier. The variation in corn as to size and shape of both kernels and ears, is so great that the writer has never been able to devise a satisfactory scheme for deciding this point. From a quantity of shelled corn of one of our pure and one of our crossed strains six

thousand kernels of each were counted and weighed. The crossed grains weighed 2104 grams, while the pure grains weighed 1792 grams being outweighed by the crossed by 17.4 per cent. The several experimenters previously mentioned have noted an increase of vigor as evidenced by increased yields and larger growth of stems and leaves in first generation hybrids. The seed in one sense may be considered as the first generation. It consists of the first generation plant in embryo and there does not seem to be any valid reason why it should not portend the characteristics of the mature plant which it will produce.

Corn differs from most other plants in that it exhibits true xenia characteristics. The work of De Vries, Correns, and Webber have shown that when the pollen grain of corn unites with the ovule there is a double fertilization. Not only is the embryo influenced by the pollen parent but the endosperm as well. This is evidenced when two varieties as yellow and white, or sweet and field corn, are planted side by side. It is easy to find yellow kernels on the white cobs and starchy kernels on the sweet cobs. If such qualities as color and chemical make up of the endosperm are indisputably influenced by the pollen parent it appears reasonable to expect that the size of grain as measured in bushels per acre might also be affected.

While our results show an increase of the crossed over the self fertilized rows, there may be danger of crossing two varieties that do not work together well,

which might cause a decrease in yield. There needs to be much experimental work done to find what crosses give the best results. The recommendation previously made would guard against any danger of lower yields, that is, to cross only unrelated strains in a variety.

Practical Application:

If our work is not in error the conclusion is justified that crossing two strains of corn that have been somewhat inbred gives an immediate increase of grain there are great possibilities from a practical standpoint of increasing our field of corn. Every farmer should have a pure variety of corn either one of his own developing or some one of the excellent varieties already established. In most cases it would be a simple matter to get some seed corn of the same variety that is not closely related to his own to mix with it at planting time. By this method he would not lose the purity of the breeding of his corn and would get the stimulating effect of the cross. How often this would need to be done would probably depend somewhat on the number of acres of corn which he raises. There is evidently not the same degree of close breeding on a large acreage as there is in a small field. It probably would not be necessary to infuse this new blood more often than once in three or four years. It would not be advisable to use seed from a radical cross such as between two distinct varieties, except for the first generation. That is, a farmer could get seed from two pure and distinct varieties, mix the seed together at planting time and get an increase in field of

grain that season. The resulting progeny could be used for seed the following year, as there would be an increase of stalk and leaf development that would result in an increase of grain. After that the hybrid variety should not be used but a new mixture of seed made for the third crop.

One of the best practical seed corn breeders of the writer's acquaintance, Mr. W. C. Collier, of Cleveland, has made use of crossing but closely related ears in developing several varieties of corn. He has a large tract of land which by the aid of windbreaks and help of his neighbors enables him to keep a number of varieties and strains without danger of crossing. The method which he follows in his breeding is to take well developed ears which he calls mother ears and the best ears he can find which he calls sire ears that have grown at some distance from the mother ears and plant them in alternate rows. Usually only a portion of each mother ear is used, planting a row from each ear, leaving every other row to be planted from the side ear. The mother rows are detasseled and at harvesting time the best ears from the highest yielding detasseled rows are saved for mother ears in the next year's breeding list. The balance of the seed from the detasseled rows is used for the field crop. Where there are a large number of farmers growing the same variety of corn in the same locality this method is recommended. The only trouble would be to get unrelated ears for the sire rows if a small but a field of corn to select from.

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