THE IMMEDIATE EFFECT OF CROSSING VARIETIES OF
CORN IN SIZE OF GRAIN PRODUCED

A Thesis Presented to the Graduate Committee
of the Virginia Polytechnic Institute in
application for the Degree of
Master of Science.

by

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Outline.

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The Immediate Effect of Crossing Varieties of Corn on Size of Grain Produced.

Introduction.

The many different uses which are made of corn and the extensive value of the crop to the United States in general, may certainly be deemed sufficient reason for investigating the possibilities for increasing the yield. It is generally thought that the immediate effect of crossing varieties of corn is to increase the yield. Corn differs from most other plants in that the effect of crossing may be seen the current year due to the hybridization of the endosperm as well as the embryo.

Many experiments have been worked out to prove to us that crossing varieties of corn increases the yield. Collins and Kempton\(^1\) found an increase of 3 to 21\% in the crossed grains over the uncrossed when pollen was mixed and used to pollinate the same ear. Collins\(^2\) found that the immediate effect of crossing distinct varieties was to increase the yield. Hartley\(^3\) found the cross-pollinated seed proved about 20\% more productive than either parent. An experiment at the Virginia Experiment Station, conducted by Lyman Carrier\(^4\), showed the immediate effect of all crosses observed was to increase the yield. When he crossed different strains of Boone County White (Home-grown X Halifax County) the crossed strains outyielded the pure strains by 31.7\%. McCluer\(^5\) showed the results obtained from planting crossed seed have been of more importance than the
immediate effect of crossing. Montgomery shows that corn is restored immediately to full vigor by crossing, but the yield decreases the second year.

Most experiments tend to show a decrease in yield the second year and for this reason corn should be crossed every year to be used the following year for seed corn.

Statement of Problem.

The object of this experiment is to show the immediate effect of crossing varieties of corn on the size of the seed produced. Mixed pollen from the two varieties to be crossed was used so as to lessen the chance of error as much as possible, and also to determine the practicability, if any, of the work.

Material and Methods Used.

Eight varieties of corn were chosen for this experiment; namely - Collier's Excelsior, Casey's Pure bred, Boone County Special, Columbian Beauty, Hickory King, Improved Golden Dent, Gold Standard, and Improved Leaming. The first five varieties named are white dents, while the last three varieties are yellow dents.
Owing to the dominance of yellow over white and double fertilization in maize, (called xenia), when white corn is crossed with pollen from a yellow variety, the yellow color appears the current year. Thus in each case when both white and yellow pollen are used, we can detect the crossed seed.

When yellow varieties were crossed with pollen from white varieties, the yellow color is usually diluted and the kernels have a paler color than if they had been fertilized with pollen by a yellow variety. At least this was observed in some of the yellow varieties.

Paraffined manila bags were used to protect the tassels and silks from foreign pollen. The tassels were bagged before any of their pollen had been shed and the ears bagged just as the silks started to appear.

The ears were pollinated when the silks were about three inches long and pollination was repeated in one to three days. The silks of an ear were dusted with a mixture of pollen from the same variety and pollen of a different variety. The pollen was mixed on application. The ears remained covered until all danger of pollination had passed.

The crosses made are given in the description of the ears and the results are given in the tables below.
Description of Ears.

**Ear No. 1.** Hickory King (white dent) X Improved Leaming (yellow dent). Grains shallow, characteristic Hickory King type evidence of cross in color. Length, 6\(\frac{5}{6}\) inches; circumference, 6 inches; diameter 2 inches. Number of crossed grains, 91; number of uncrossed grains, 231. Well filled. Cob, white. Crossed grains yellow with white caps; uncrossed grains pure white.

**Ear No. 2.** Hickory King (white dent) X Improved Leaming (yellow dent). Grains shallow, same as ear No. 1. Number of crossed grains, 245. Number of uncrossed grains, 62. Length, 7\(\frac{5}{6}\) inches; diameter, 1\(\frac{5}{6}\) inches.

**Ear No. 3.** Hickory King (white dent) X Gold Standard (yellow dent). Grains medium, typically Hickory King, evidence of cross in color. Length, 6 inches; diameter, 2 inches. Number of crossed grains, 3; number of uncrossed grains, 300. Well filled, cob white. Uncrossed grains pure white; crossed grains pale yellow.

**Ear No. 4.** Boone County Special (white dent) X Improved Leaming (yellow dent). Grains medium, shows evidence of cross in grain and color. Length, 6\(\frac{1}{6}\) inches; diameter, 2 inches. Number of crossed grains, 464; number of uncrossed grains, 3. Fairly well filled, cob, white. Crossed grains yellow with white caps, and uncrossed grains pure white.

**Ear No. 5.** Boone County Special (white dent) X Improved Golden Dent (yellow dent). Grains medium, characteristic of Boone County Special, evidence of cross in color. Length, 6\(\frac{2}{3}\) inches; diameter, 2 1/8 inches. Number of uncrossed grains, 416; number of crossed grains, 108. Well filled except \(\frac{3}{4}\) inch at
the tip. Cob - white. Uncrossed grains pure white, crossed grains yellow with white caps.

Bar No. 6. Boone County Special (white dent) X Gold Standard (yellow dent). Grains long, characteristic of Boone County Special. Evidence of cross in color. Length, 5 inches; diameter, 2 1/4 inches. Number of uncrossed grains, 20; number of crossed grains, 351. Well filled, cob white. Crossed grains are yellow with white caps, uncrossed grains are pure white.


Bar No. 8. Boone County Special (white dent) X Gold Standard (yellow dent). Grains medium, characteristic of Boone County Special type, evidence of cross in color. Length, 5 inches; diameter, 2 1/8 inches. Number of uncrossed grains, 258; number of crossed grains, 196. Well filled except one side, grains irregular, cob white. Crossed grains are yellow with whitish caps, and the uncrossed grains are pure white.

Bar No. 9. Casey's Pure Bred (white dent) X Gold Standard (yellow dent). Grains medium, characteristic of Casey's Pure Bred. Length, 4 inches; diameter, 1 5/8 inches. Number of crossed grains, 1; number of uncrossed grains, 171. Not filled on one side, curved, evidence of cross in color. Cob - white, crossed grains are yellow, uncrossed grains pure white.
Ear No. 10. Collier's Excelsior (white dent) X Gold Standard (yellow dent). Grains short, characteristic of Collier's Excelsior, evidence of cross in color. Length, 7 inches; diameter, 1 7/8 inches. Number of crossed grains, 68; number of uncrossed grains, 169. Not well filled on one side or above middle, curved. Crossed grains are yellow with white caps and uncrossed grains are pure white.


Ear No. 16. Hickory King (white dent) X Improved Leaming (yellow dent). Grains shallow, characteristic of Hickory King. Length, 6 1/2 inches, diameter 2 inches. Evidence of cross in color. Number of crossed grains, 249. Number of uncrossed grains, 37. Well filled. Crossed grains are yellow with white caps. Uncrossed grains are pure white.


Length, 6¹/₂ inches. Diameter, 2¹/₂ inches. Number of crossed grains, 368. Number of uncrossed grains, 32. Well filled. Cob - red. Crossed grains are yellow with white cap. Uncrossed grains are pure yellow.


Bar No. 23. Improved Leaming (yellow dent) X Boone County Special (white dent). Grains deep, characteristic of Improved Leaming. Length, 6 1/4 inches. Diameter, 2 1/4 inches. Evidence of cross in color. Well filled. Cob red. Number of crossed grains 75, number of uncrossed grains, 421. Crossed grains are yellow with whitish cap, and uncrossed grains are pure yellow.


Bar No. 27. Improved Leaming (yellow dent) X Boone County Special (white dent). Grains medium, characteristic of Improved Leaming. Length 6 inches, diameter, 2 inches. Evidence of cross in color; cob - red; crossed grains are yellow with
whitish caps. Uncrossed grains pure yellow. Number of crossed grains, 210. Number of uncrossed grains, 32. Only fairly well filled, missing on one side.

Ear No. 28. Improved Leaming (yellow dent) X Boone County Special (white dent). Grains medium, characteristic of Improved Leaming. Length, 6 inches. Diameter, 2¼ inches. Evidence of cross in color. Cob - red. Crossed grains are yellow with whitish caps. Uncrossed grains are yellow. Number of crossed grains, 217. Number of uncrossed grains, 33. Well filled near tip, scattering from middle to butt.

Ear No. 29. Improved Leaming (yellow dent) X Columbian Beauty (white dent). Grains deep, length 5¼ inches, diameter 2 inches. Evidence of cross in color. Cob red. Crossed grains are yellow with white caps. Uncrossed grains are pure yellow. Not well filled on one side. Number of crossed grains, 172. Number of uncrossed grains, 50.

Ear No. 30. Improved Leaming (yellow dent) X Boone County Special (white dent). Grains medium. Evidence of cross in color. Length 7 inches; diameter, 2 inches. Cob red. No trains for 4 inches at tip, scattering on one side. Crossed grains are yellow with whitish caps. Uncrossed grains are pure yellow. Number of crossed grains, 160. Number of uncrossed grains, 89.

number of crossed grains, 147; number uncrossed grains, 15.

**Ear No. 32. Gold Standard (yellow dent) X Casey's Pure Bred (white dent).** Grains medium, characteristic of Gold Standard. Evidence of cross in color. Length 8 inches; diameter, 2 1/8 inches. Color red. 2 1/2 inches at tip not filled, grains scattering. Crossed grains are yellow with whitish caps. Uncrossed grains are pure yellow. Number of uncrossed grains, 87; number of crossed grains, 160.

**Ear No. 33. Improved Golden Dent (yellow dent) X Collier's Excelsior (white dent).** Grains medium. Evidence of cross in color. Length 5 1/2 inches; diameter, 1 7/8 inches. Cob red. Well filled. Crossed grains are yellow with whitish caps. Uncrossed grains are pure yellow. Number of crossed grains, 25; number of uncrossed grains, 322.

**Ear No. 34. Improved Leaming, (yellow dent) X Boone County Special (white dent).** Grains small. Evidence of cross in color. Length, 6 inches; diameter, 1 7/8 inches. Poorly filled and curved. Crossed grains are yellow with whitish caps. Uncrossed grains pure yellow. Number of crossed grains, 110; number of uncrossed grains, 117.

**Ear No. 35. Improved Leaming (yellow dent) X Boone County Special X Columbian Beauty (white dent).** Grains narrow and deep. Evidence of cross in color. Length, 6 inches. Diameter 2 inches. Well filled. Crossed grains are yellow with whitish caps. Uncrossed grains are pure yellow. Number of crossed grains, 244; number of uncrossed grains, 128.

**Ear No. 36. Improved Leaming (yellow dent) X Casey's Pure Bred (white dent).** Grains medium broad. Evidence of cross
in color. Length, 6 inches; diameter, 1 7/8 inches. Well filled but rows wide apart. Crossed grains are yellow with whitish caps. Uncrossed grains are pure yellow. Number of uncrossed grains, 197. Number of crossed grains, 191. Evidence of cross in color.

**Bar No. 37. Gold Standard (yellow dent) X Boone County Special (white dent).** Grains roundish, evidence of cross in color. Length, 6 1/2 inches; diameter, 1 3/4 inches. Grains are scattered. None at all on the tip for one inch. Crossed grains are yellow with whitish caps. Uncrossed are pure yellow. Number of crossed grains, 29. Number of uncrossed grains, 117.

**Results.**

**Table I.**

Results of Crossing Corn, Female Parent white; Male parent Yellow.

<table>
<thead>
<tr>
<th>Bar No.</th>
<th>Female</th>
<th>Cross</th>
<th>Male</th>
<th>Kind of Seed</th>
<th>No. of Seed</th>
<th>Avg. wt. per sd.</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hickory King X Imp. Leaming</td>
<td>pure</td>
<td>231</td>
<td>498</td>
<td>.505</td>
<td>2.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>91</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hickory King X Imp. Leaming</td>
<td>pure</td>
<td>62</td>
<td>473</td>
<td>.546</td>
<td>13.43</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>245</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Hickory King X Gold Standard</td>
<td>pure</td>
<td>300</td>
<td>495</td>
<td>.513</td>
<td>3.63</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>108</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>108</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Boone Co. Spec. X Gold Stand.</td>
<td>pure</td>
<td>20</td>
<td>450</td>
<td>.428</td>
<td>-5.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>351</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Casey's Pure Bred X Gold.&quot;</td>
<td>pure</td>
<td>325</td>
<td>431</td>
<td>.321</td>
<td>612.53</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>126</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Casey's Pure Bred X Gold St.</td>
<td>pure</td>
<td>171</td>
<td>376</td>
<td>.425</td>
<td>13.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Collier's Excel. X Gold Stnd.</td>
<td>pure</td>
<td>169</td>
<td>400</td>
<td>.448</td>
<td>12.00</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>hybrid</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The evidence of crossing was clearly visible, as would be expected, because of the dominance of yellow over white and of xena in maize. In thirteen of the seventeen crosses there was an increase in yield, this increase varying from 2.64% to 16.04%. In the four remaining cases, there was a decrease, this decrease varying from 5.14% to 13.45%.

It will be seen in the above table that a variety may give a decrease in yield in one case and in another instance the same variety will produce an increase yield. In three of the four cases producing a decrease in yield, Gold Standard was the male parent, but in other cases where Gold Standard was used as the male parent, a large increase was produced. Such varieties should probably be omitted from the results and only those showing increase or decrease in both cases used.
Table II.

Results of Crossing Corn, Female parent yellow; Male parent white.

<table>
<thead>
<tr>
<th>Bar No.</th>
<th>Female Cross</th>
<th>Male Kind</th>
<th>No. of Seed</th>
<th>Avg. wt.</th>
<th>In- per seed crease</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Gold Stand. X Hickory King</td>
<td>pure</td>
<td>32</td>
<td>.478</td>
<td>11.9</td>
</tr>
<tr>
<td>19</td>
<td>Gold Stand. X Hickory King</td>
<td>hybrid</td>
<td>388</td>
<td>.427</td>
<td>4.78</td>
</tr>
<tr>
<td>20</td>
<td>Gold Stand. X Coll. Excel.</td>
<td>pure</td>
<td>226</td>
<td>.257</td>
<td>.02</td>
</tr>
<tr>
<td>22</td>
<td>Imp. Gold. Dent X Coll. Excel.</td>
<td>pure</td>
<td>210</td>
<td>.361</td>
<td>-0.02</td>
</tr>
<tr>
<td>23</td>
<td>Imp. Leaming X Boone County Sp.</td>
<td>hybrid</td>
<td>342</td>
<td>.344</td>
<td>4.53</td>
</tr>
<tr>
<td>26</td>
<td>Gold Stand. X Caseys Pure Bred</td>
<td>hybrid</td>
<td>76</td>
<td>.413</td>
<td>1.92</td>
</tr>
<tr>
<td>27</td>
<td>Imp. Leaming X Boone Co. Spec.</td>
<td>hybrid</td>
<td>319</td>
<td>.414</td>
<td>1.92</td>
</tr>
<tr>
<td>28</td>
<td>Imp. Leaming X Boone Co. Spec.</td>
<td>pure</td>
<td>421</td>
<td>.364</td>
<td>1.92</td>
</tr>
<tr>
<td>29</td>
<td>Imp. Leaming X Coll. Beauty</td>
<td>hybrid</td>
<td>75</td>
<td>.371</td>
<td>1.92</td>
</tr>
<tr>
<td>30</td>
<td>Imp. Leaming X Boone Co. Spec.</td>
<td>hybrid</td>
<td>265</td>
<td>.406</td>
<td>1.92</td>
</tr>
<tr>
<td>32</td>
<td>Gold Stand. X Caseys Pure Bred</td>
<td>hybrid</td>
<td>342</td>
<td>.413</td>
<td>1.92</td>
</tr>
<tr>
<td>33</td>
<td>Imp. Gold Dent X Collier's Ex</td>
<td>hybrid</td>
<td>23</td>
<td>.420</td>
<td>1.92</td>
</tr>
<tr>
<td>34</td>
<td>Imp. Leaming X Boone Co. Spec.</td>
<td>hybrid</td>
<td>321</td>
<td>.376</td>
<td>1.92</td>
</tr>
<tr>
<td>35</td>
<td>Imp. Leaming X Boone Co. Spec.</td>
<td>hybrid</td>
<td>84</td>
<td>.375</td>
<td>1.92</td>
</tr>
<tr>
<td>36</td>
<td>Imp. Leaming X Caseys P. Bred</td>
<td>hybrid</td>
<td>50</td>
<td>.431</td>
<td>1.92</td>
</tr>
<tr>
<td>37</td>
<td>Gold Stand. X Boone Co. Spec.</td>
<td>hybrid</td>
<td>160</td>
<td>.488</td>
<td>1.92</td>
</tr>
</tbody>
</table>

The evidence of crossing was shown by the yellow grains being capped with white or being a paler yellow than the pure grains. It was difficult in many cases to distinguish between the pure and hybrid grains, but all doubtful seed were weighed as hybrids. These results are not as reliable as those in the first table.

In six out of the twenty crosses there was a decrease in yield varying from .003 of one per cent to 11.9 per cent. In six crosses
the difference is so small that we may say crossing had no effect on the yield. In the other eight crosses we found a decided increase in yield varying from 1.57% to 3.54%.

As in Table I, those varieties which showed a decrease in yield in one cross likewise showed an increase in yield in another cross. If these crosses which showed both decrease and increase from crossing be eliminated from the discussion the evidence is very strong in favor of increased yield as the immediate effect of cross pollination.

Selective Pollination and Crowding out of Seed

It might be thought that the hybrid seed may be more vigorous than the pure seed on the same ear, due to the increased vigor that is secured from cross pollination. By this increased vigor from cross-pollination the hybrid seed may be able to develop at the expense of the neighboring pure kernels, thus obtaining their growth earlier and crowding out the pure seed.

However, in this test this was not the case. On Ear No. 2, Hickory King (white dent) X Improved Leaming (yellow dent), there was only one yellow grain in the last two inches at the tip, the others being uncrossed, pure white. The remainder of the ear showed all hybrid seed with the exception of twelve grains. The hybrid seed averaged .546 of a gram per seed, the pure seed at the tip averaged .473 of a gram, and those intermixed with crossed grains averaged .476 of a gram per seed.

Collins found a similar case to this one, that the hybrid seed weighed 292.5 grams per 1000 seed, pure seed 283 grams per 1000 seed.
The results of this experiment show that there is an immediate effect of cross pollination in corn. The increase yield so obtained is sufficient to be of importance to both the farmer and the seed grower.

A Method of producing F₁ hybrid seed:

From the growers' standpoint, the increased vigor of the first generation hybrid seed is perhaps of more importance than the increased yield due to these kernels being heavier. The following scheme, when properly carried out, should furnish hybrid seed for producing the main crop and at the same time give pure seed of the two varieties which have been found valuable in producing heavy yielding hybrid seed.

Diagram of the Field. Vertical lines represent the rows of corn.

Row No. 1 may be planted with a pure bred white variety and Row No. 2 with a pure bred yellow variety, the varieties alternating in this manner across the field. Different strains of the same variety may be used instead of distinct varieties.

On one side of the field a certain number of rows of the white variety may be detasseled. Thus the ears on the yellow stalks will be pure, while those on the white stalks will be hybrids. On
the other side of the field, a certain number of the rows of the yellow variety may be detasseled. Thus in this case the ears on the white stalks will be pure, while those on the yellow stalks will be hybrid. It is not necessary to alternate rows across the entire field when the field is very large, but be sure to detassel enough on each side so as to be sure that the rows nearest the edges are not too close to the remaining tasseled stalks to become pollinated by them.

The pure seed may be secured from the tasseled stalks nearest the edges and hybrid seed from the detasseled stalks on each side and also from the rows nearer the center where none of the stalks have been detasseled. At a very small expense, one may obtain pure and hybrid seed corn from the same field for the next year's planting.
Conclusion.

1. In the crosses obtained, 56.8% produced profitable increase in yield, and in 16.2% the increase was slight. In 21.6% of the crosses, the decrease was marked; in 5.4% the decrease is slight. The largest increase was 16.04% and the greatest decrease 13.45%.

2. The farmer or seed grower can make profitable application of these results by mixing his seed at planting time.

3. The increases and decreases are not confined to any certain varieties.
Bibliography.


