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The Immediate Effect of Gametic Relationship and of Parental Type upon the Kernel Weight of Corn

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SUMMARY

1. Three factors appear to be involved in the change of the kernel weight of corn which often results from fertilization by foreign or unrelated pollen. These are heterosis, size inheritance, and change in endosperm type.

2. The immediate effect of selfing 10 commercial varieties of dent corn was an average reduction of 7 per cent in kernel weight.

The pollen from selfed strains had essentially the same effect upon the kernel weight as did pollen from open-pollinated varieties.

Selfed strains of two varieties fully reduced by continued inbreeding responded to cross-pollination with an average increased kernel weight of 11.9 per cent.

Strains of the same two varieties which had been subjected for a long period to two intermediate degrees of close-breeding were increased 8.5 and 3.7 per cent respectively in kernel weight by cross-pollination as compared with 0.2 per cent increase for the original commercial corn.

3. These inbred, narrow-bred, broad-bred, and wind-pollinated strains which gave relative 2-year average kernel weight increases of 11.9, 8.5, 3.7, and 0.2 per cent, respectively, had given the corresponding relative acre grain yields of 32, 78, 86, and 100 per cent. While inbred and close-bred strains varied individually in the amount of their response to foreign pollen, without exception they increased in kernel weight. Such increases are due mainly to increased heterosis.

4. Nineteen inbred strains of two varieties whose kernel weights were increased an average of 10.1 per cent by cross-pollination in 1923 had their embryos, endosperms, and pericarps increased 11.8, 10.4, and 3.2 per cent, respectively.

Sixteen narrow-bred strains whose kernels were increased an average of 8.1 per cent had their embryos, endosperms, and pericarps increased 9.1, 8.4, and 2.1 per cent.

The kernels of 10 broad-bred strains increased an average of 3.5 per cent in weight due to foreign pollen, whereas the embryos, endosperms, and pericarps increased 3.6, 3.6, and 2.6 per cent, respectively.

The embryos, endosperms, and pericarps of the same 2 commercial varieties, wind-pollinated, increased 0.3, 0.2, and 0.1 per cent as compared with 0.2 per cent for the entire kernels.

5. Of 210 combinations of foreign pollen on dent varieties, 2 decreased the kernel weight 2 to 3 per cent, 37 decreased 1 to 2 per cent, 51 decreased 1 per cent or less, 58 increased 1 per cent or less, 50 increased 1 to 2 per cent, 21 increased 2 to 3 per cent, and 3 increased 3 to 4 per cent.

6. Two hundred dent-by-dent combinations averaged 0.3 per cent increased kernel weight as an immediate effect of foreign pollen, 2 sweet-by-sweet crosses increased 2.0 per cent, 5 dent-by-flint crosses increased 0.3 per cent, 1 dent-by-pop cross decreased 1.3 per cent,

2 dent-by-sweet crosses decreased 1.2 per cent, 4 dent-by-flour crosses decreased 0.2 per cent, 4 sweet-by-dent crosses increased 21.5 per cent, 2 sweet-by-flour crosses increased 15.5 per cent, 1 sweet-by-pop cross increased 14.4 per cent, 1 sweet-by-waxy cross increased 20.2 per cent, 1 flint-by-sweet cross decreased 1.4 per cent, 4 flint-by-dent crosses increased 2.3 per cent, 1 pop-by-pop cross increased 0.1 per cent, 1 pop-by-dent cross increased 3.0 per cent, and 2 waxy-by-dent crosses increased 5.6 per cent.

7. Considering the 200 dent variety combinations, an average of all those in which the pollen parents were either shallow-grained, small in plant size, or early-maturing showed that the hybrid and the pure kernels were of equal weight. In all combinations in which the pollen parent was either medium-deep, medium-large, or medium-late, the hybrid kernels averaged 0.2 per cent heavier than the pure. Deep-grained, large, and late-maturing varieties used as pollen parents increased the average kernel weight 0.9 per cent. Size inheritance would seem to be a factor in these results, but this effect apparently does not exceed approximately 1 per cent.

8. As an average for 2 years, the increased kernel weights resulting from fertilization by foreign pollen equalled 2.4, 1.2, 6.9, and 1.9 per cent, respectively, for the Illinois High Protein, Low Protein, High Oil, and Low Oil strains of the Burr White variety. All 4 of these chemical strains had been subject to rather close breeding in connection with the long-continued type selection. This is shown by an average yield of 15 bushels per acre below that of two F_1 hybrids between these strains.

9. Kernels of 10 varieties of dent corn which had given either slight decreases or very low increases in kernel weight as an immediate effect of foreign pollen were dissected to determine the relative weights of pure and hybrid kernel parts. The hybrid kernels averaged 0.5 per cent decrease in weight compared with the pure kernels, the hybrid embryos 1.6 per cent increase, the hybrid endosperms 0.9 per cent decrease, and the hybrid pericarps 0.2 per cent increase.

In a similar test with 4 varieties which gave the relatively large increase of 3.1 per cent in kernel weight when cross-pollinated, the embryo increased 6.1 per cent, the endosperm 2.8 per cent, and the pericarp 1.1 per cent.

When sweet corn (Golden Bantam) was fertilized by another sweet variety (Black Mexican), its kernels increased 1.3 per cent in weight. This was accompanied by an increase of 3.3 per cent in embryo weight and 0.6 per cent in endosperm weight. When the same variety was fertilized by a dent variety (U. S. Selection No. 133), the kernel weight increased 23.9 per cent, the endosperm 31 per cent, while the

embryo was unaffected. These large increases in kernel and endosperm weights are due to a change in the composition of the endosperm as a xenia effect.

10. The moisture content of pure and hybrid kernels was obtained at the time of husking for 154 combinations on dent varieties. The extreme effects ranged from a decrease of 0.89 per cent to an increase of 0.99 per cent in the moisture content of the hybrid as compared with the pure kernels. All varieties averaged 0.09 per cent more moisture in the hybrid grain.

Pure kernels on sweet corn ears had 7.2 per cent greater moisture content than hybrid kernels which had been fertilized by dent corn.

Pure waxy kernels of the Chinese variety contained 2 per cent greater moisture than hybrid seed fertilized by dent corn. These differences obtained for both sweet and waxy varieties can probably be accounted for by changes in endosperm composition. The hybrid endosperms of both these types give a starch reaction with iodine.

11. A brief study in technique indicates that an experimental error in relative kernel weights ranging from 9 per cent too low to 16 per cent too high may result by the method of contrasting all the pure with the hybrid kernels on an ear when nearly all the hybrid kernels are located at either the tip or at the butt of the ear. The most reliable way to overcome place effects on the ear is to compare adjacent pure and hybrid kernels.

12. The relation between the effect of foreign pollen upon kernel weight as determined by these methods and upon acre yield has not been established. It seems probable that the influence upon acre yields cannot exceed the effect upon kernel weights as established in these investigations and may be less. Experiments are under way to determine this relationship.

It may be concluded that in general no practical advantages are to be expected from the annual mixing of seed of commercial varieties of corn. Neither is the effect of cross-pollination which takes place in comparative experimental yield tests of commercial varieties which are similar in endosperm type of sufficient magnitude to be a serious disturbing element in arriving at correct conclusions.

The kernel-weight increases of sweet varieties when fertilized by starchy types and of inbred strains and F_1 hybrids between 2 pure lines when fertilized by foreign pollen are of sufficient magnitude to suggest that the acre yields may be affected thereby, in which event such yields may not accurately represent their yielding ability in comparison with other corn. Serious yield effects due to source of pollen under field conditions seem unlikely in the case of double crosses and synthetic varieties because of their more complex constitution.

The Immediate Effect of Gametic Relationship and of Parental Type upon the Kernel Weight of Corn

T. A. KIESSELBACH

This investigation to determine the relation of the kernel weight of corn to the source of pollen with which it was fertilized has been made to answer several questions of both practical and technical interest: (1) To what extent is kernel weight affected in the current crop by the "breadth of breeding" or the gametic relationship? (2) What is the relation of the diversity of parental type to the immediate effect of foreign pollen upon the kernel weight of corn? (3) Is the immediate effect of cross-fertilization upon the kernel weight of sufficient importance to justify the annual mixing of seed corn of 2 or more varieties in order to increase yield under farm conditions? (4) Is the interpollination between varieties grown in comparative variety yield tests a material source of error by virtue of affecting kernel weight? (5) To what extent is an increased kernel weight, resulting as an immediate effect of cross-fertilization, an indicator of increased productivity for the first generation hybrid progeny over that of the ear-bearing parent grown pure? (6) In the case of increased kernel weight resulting as an immediate effect of cross-fertilization, what is the relative increase of the different parts of the kernel? (7) What is the immediate effect of cross-fertilization upon the maturity of the kernel as expressed by the relative moisture content?

EXPERIMENTAL PROCEDURE

When ears are pollinated by a mixture of pollen from two varieties or strains differing in endosperm or aleurone color, the kernels may be separated by color according to the pollen parent, thru the operation of xenia. This principle has been employed thruout in these investigations to determine the relation of pollen source to kernel weight. The procedure has been to manipulate the pollination under control conditions so that the variety parentage of each kernel could be established. This was done by mixing the pollen from two desired sorts and applying under control conditions by the bagging system to the receptive silks of covered ear shoots. Many of the varieties were planted at different dates so that cross-pollination might be effected.

Acknowledgment is made to Messrs. Glen C. Cook, T. C. H. Bayrhoffer and N. F. Petersen for assistance in making these determinations.

An effort was made to produce 10 duplicate ears fertilized by any given combination of pollen. Due to some failure in pollination a smaller number of well filled ears often resulted, as shown in the tables. Method studies in connection with this work (reported on pages 60 to 64) have indicated that the effects of plant individuality may be largely overcome by the use of several ears rather than a single ear.

All determinations of the immediate effect of foreign pollen upon kernel weight have been made by removing pure and hybrid kernels from the ear, in adjacent pairs only, thereby greatly reducing the experimental error which may result from place effect on the ear, as has been demonstrated in Table 35. Hybrid kernels were taken alternately on the butt and tip sides of the pure kernels to avoid the systematic error due to a gradual reduction in kernel size toward the tip of the ear. Comparisons are all based on moisture-free weights except as indicated where a special study of moisture content was made.

CYTOLOGY AND GENETICS INVOLVED

The cytological phenomena of xenia in the corn kernel are well understood. The reduction-division of chromosomes in the transition from archesporial to megaspore mother cell has been established for corn by Weatherwax and by cytological work in progress at the Nebraska Experiment Station. It is this cytological behavior which results in the genetic homology of the 8 nuclei developed in the embryo sac prior to fertilization. Because of this homology, identical inheritance is carried in the egg nucleus and in the two polar nuclei which enter by chance into the formation of the endosperm nucleus. The 2 sperm nuclei which fertilize the egg and endosperm nuclei respectively are also identical, reduction-division having previously taken place. In the double-fertilization of corn, therefore, the embryo and endosperm cells bear identical chromosome inheritance, with the exception that the endosperm cells have 3 sets of chromosomes (two from the mother side and one from the male) whereas the cells of the embryo have only two chromosome sets, one from either parent. Probably due to the double set of chromosomes received by the endosperm from the mother parent, the endosperm type of the female is dominant in the hybrid endosperm resulting from crossing any other type upon any of the starchy types including dent, flour, flint, and pop corn. In the case of sweet and waxy-endosperm varieties, the chemical and physical constitution of their

endosperms is modified by fertilization with pollen from any of the starchy types. With such combinations the female endosperm type is not dominant.

Investigations with corn at the Nebraska Experiment Station and elsewhere have indicated clearly that a heterozygous constitution is essential to maximum production. Any reduction in heterozygosity as brought about by various degrees of inbreeding reduces the productiveness of the crop. Thus the grain yields of pure lines developed by prolonged selfing of standard varieties are on an average only about one-third as large as for the original broad-bred varieties. Yields range between these two extremes according to the extent of gametic relationship between the two parents. It is a vital part of this problem to determine the extent to which a similar relationship obtains in regard to the endosperm development.

Where commercial varieties are crossed, the F_1 progeny commonly tends to be intermediate in vegetative character between the two parents. Since the embryo and endosperm have received the same inheritance as the resultant plant, it becomes of interest to know whether the weight of the embryo and endosperm is influenced in like manner by diversity of parental types.

THE IMMEDIATE EFFECT OF CROSS-FERTILIZATION UPON THE KERNEL WEIGHT OF CORN THAT HAS BEEN INBRED TO VARIOUS DEGREES

During the years 1922 and 1923, the immediate effect of crossing upon kernel weight was studied for Hogue Yellow Dent and Nebraska White Prize corn which had been subject to 4 degrees of continued close-breeding under control conditions. These 4 degrees of inbreeding may be designated as (1) selfed, (2) narrow-bred, (3) broad-bred, and (4) wind-pollinated commercial corn. All the Hogue strains have been subject to the designated treatments since 1910 and the Nebraska White Prize strains since 1913. Several strains of each degree have been used, each of which except the original commercial stock originated from a different ear-to-row strain. The inbred strains are practically homozygous, having been selfed annually for 10 or more years. The narrow-bred strains have each been continued annually by planting from a single ear that had been fertilized by a mixture of pollen from 15 sister plants of the same strain. The broad-bred strains had been developed by planting each

year a mixture from 15 ears fertilized by a mixture of pollen from 15 sister plants of the same strain. The wind-pollinated corn represents the original stock of both varieties grown annually in large fields and was normally heterozygous.

During a 7[1]-year yield test with Hogue strains, 1911-1917, these 4 degrees of inbreeding had averaged respectively 16.8, 42.2, 49.2, and 53.1 bushels per acre. During the 7-year [2] period of 1915-1917 and 1920-1923, the corresponding Nebraska White Prize yields were 22.0, 45.3, 48.4, and 60.8 bushels per acre. As an average for both varieties, these are respective relative grain yields of 34, 77, 86, and 100 per cent, based on the commercial seed. The differences in

TABLE 1.—*Immediate effect of foreign dent pollen upon the kernel weight of ear-to-row strains of Hogue Yellow Dent corn which had been subject to various degrees of inbreeding, 1922*

Ear parent	Foreign pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
				Actual		Relative	
Strain number				Pure	Hybrid	Pure	Hybrid
(1)	(2)	(3)	(4)	*Grams* (5)	*Grams* (6)	*Per cent* (7)	*Per cent* (8)
INBRED (CONTINUED ANNUALLY BY SELF—FERTILIZATION)							
12	Nebr. White Prize	2	40	20.74	24.06	100	116.0
725	Nebr. White Prize	6	205	15.85	19.00	100	119.9
726	Nebr. White Prize	7	346	19.87	20.85	100	104.9
745	Nebr. White Prize	5	510	17.54	20.33	100	115.9
Average							114.2
NARROW-BRED (SEED CONTINUED ANNUALLY FROM SINGLE EAR FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
600	Nebr. White Prize	5	179	25.26	28.02	100	110.9
602	Nebr. White Prize	3	114	23.83	25.33	100	106.3
603	Nebr. White Prize	5	117	25.17	27.95	100	111.0
604	Nebr. White Prize	4	156	16.94	18.43	100	108.8
Average							109.3
BROAD-BRED (SEED CONTINUED ANNUALLY FROM COMPOSITE EARS FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
606	Nebr. White Prize	8	813	20.39	21.62	100	106.0
607	Nebr. White Prize	7	560	22.47	22.72	100	101.1
608	Nebr. White Prize	4	146	25.42	27.37	100	107.7
Average							104.9
WIND-POLLINATED COMMERCIAL CORN							
Original	Nebr. White Prize	10	434	23.48	23.63	100	100.6

[1] The yield test of Hogue strains was discontinued in 1917. These strains have been described in Nebraska Agr. Exp. Sta. Res. Bul. 20.

[2] Corn was so nearly a failure in 1918 and 1919 due to drouth that the crop was placed in the silo without yield determinations.

yield between the control strains and the original corn may be considered primarily due to the degree of inbreeding and resultant reduction in heterozygosity.

TABLE 2.—*Immediate effect of foreign dent pollen upon kernel weights of ear-to-row strains of Hogue Yellow Dent corn which had been subject to various degrees of continued inbreeding. 1923*

Ear parent	Foreign pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
				Actual		Relative	
Strain number				Pure	Hybrid	Pure	Hybrid
				Grams	*Grams*	*Per cent*	*Per cent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INBRED (CONTINUED ANNUALLY BY SELF-FERTILIZATION)							
1	Nebr. White Prize	5	128	19.37	20.31	100	104.9
721	Nebr. White Prize	2	124	15.76	16.36	100	103.8
724	Nebr. White Prize	2	55	20.09	22.87	100	113.8
726	Nebr. White Prize	9	444	18.40	20.60	100	112.0
745	Nebr. White Prize	2	33	19.70	22.93	100	116 4
731	Nebr. White Prize	7	268	13.45	14.75	100	109.7
736	Nebr. White Prize	4	187	17.65	20.39	100	115.5
732	Nebr. White Prize	4	24	17.74	18.59	100	104.8
748	Nebr. White Prize	5	141	21.52	24.60	100	114.3
Average							110.6
NARROW-BRED (SEED CONTINUED ANNUALLY FROM SINGLE EAR FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
593	Nebr. White Prize	9	269	18.60	21.36	100	114.8
594	Nebr. White Prize	8	167	19.54	21.72	100	111.2
595	Nebr. White Prize	2	65	17.65	19.29	100	109.2
596	Nebr. White Prize	7	622	13.77	15.03	100	109.1
600	Nebr. White Prize	9	297	19.28	20.57	100	106.7
601	Nebr. White Prize	8	431	12.13	12.57	100	103.6
602	Nebr. White Prize	6	328	17.93	18.40	100	102.6
603	Nebr. White Prize	1	70	21.35	21.97	100	102.9
604	Nebr. White Prize	5	79	21.30	22.70	100	106.6
Average							107.4
BROAD-BRED (SEED CONTINUED ANNUALLY FROM COMPOSITE EARS FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
606	Nebr. White Prize	8	247	19.65	20.41	100	103.9
607	Nebr. White Prize	3	144	22.73	24.50	100	107.8
608	Nebr. White Prize	8	515	19.42	19.68	100	101.3
Average							104.3
WIND-POLLINATED COMMERCIAL CORN							
Original	Nebr. White Prize	9	622	22.31	22.38	100	100.3

The control pollinations for this study were made from a mixture of pollen from 10 plants of the strain in question, and from a like number of plants representing the foreign pollen parent. In no case was the plant's own pollen included in the mixture. The pure and hybrid kernels could be differentiated by color. The results for each variety are given in Tables 1 to 4, and are summarized in Table 5.

As a 2-year average for both varieties (Table 5), the inbred, narrow-bred, broad-bred, and wind-pollinated corn, with relative grain-yielding capacities of 34, 77, 86, and 100 per cent, gave the respective increased kernel weights of 11.9, 8.5, 3.7, and 0.2 per cent as an immediate effect of cross-fertilization. Individual strains of the same degree of inbreeding varied decidedly in their response, but it may be concluded that in general the lower the heterozygosity the greater will be the immediate effect of foreign pollen upon kernel weight.

TABLE 3.—*Immediate effect of foreign dent pollen upon the kernel weights of ear-to-row strains of Nebraska White Prize dent corn which had been subject to various degrees of continued inbreeding. 1922*

Ear parent	Foreign pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
				Actual		Relative	
Strain number				Pure	Hybrid	Pure	Hybrid
(1)	(2)	(3)	(4)	*Grams* (5)	*Grams* (6)	*Per cent* (7)	*Per cent* (8)
INBRED (SEED CONTINUED ANNUALLY BY SELF-FERTILIZATION)							
663	Hogue	5	230	18.99	20.73	100	109.2
676	Hogue	4	140	13.48	14.47	100	107.3
680	Hogue	2	160	20.70	22.69	100	109.6
690	Hogue	3	170	18.97	21.32	100	112.4
733	Hogue	6	203	15.82	19.17	100	121.2
Average							111.9
NARROW-BRED (SEED CONTINUED ANNUALLY FROM SINGLE EAR FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
755	Hogue	5	60	22.80	25.12	100	110 2
756	Hogue	5	131	30.71	33.42	100	108.8
757	Hogue	4	81	16.98	19.08	100	112.4
753	Hogue	2	51	12.08	12.74	100	106.1
Average							109.4
BROAD-BRED (SEED CONTINUED ANNUALLY FROM COMPOSITE EARS FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
766	Hogue	4	373	23.08	23.61	100	102.3
768	Hogue	6	428	22.47	22.90	100	101.9
771	Hogue	5	232	21.86	22.56	100	103.2
773	Hogue	7	254	20.33	21.02	100	103.4
Average							102 7
WIND-POLLINATED COMMERCIAL CORN							
Original	Hogue	10	687	20.36	20.25	100	99.5

TABLE 4.—*Immediate effect of foreign dent pollen upon the kernel weights of ear-to-row strains of Nebraska White Prize corn which had been subject to various degrees of continued inbreeding. 1923*

Ear parent Strain number	Foreign pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
				Actual		Relative	
				Pure	Hybrid	Pure	Hybrid
				Grams	*Grams*	*Per cent*	*Per cent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INBRED (CONTINUED ANNUALLY BY SELF-FERTILIZATION)							
683	Hogue	4	288	21.90	26.71	100	122.0
667	Hogue	10	563	21.67	24.41	100	112.6
673	Hogue	7	493	22.00	23.66	100	107.5
672	Hogue	8	168	21.62	22.13	100	102.4
739	Hogue	7	250	20.77	24.14	100	116.2
690	Hogue	7	107	30.82	31.38	100	101.8
688	Hogue	8	156	17.52	19.12	100	109.1
657	Hogue	8	129	29.65	35.25	100	118 9
865	Hogue	5	159	23.84	26.19	100	109.8
722	Hogue	4	49	24.12	25.85	100	107.2
Average							110.8
NARROW-BRED (SEED CONTINUED ANNUALLY FROM SINGLE EAR FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
750	Hogue	8	122	24.79	27.59	100	111.5
751	Hogue	6	84	22.77	24.59	100	108.0
753	Hogue	10	742	19.90	21.03	100	105.7
754	Hogue	9	138	18.43	20.05	100	108.8
755	Hogue	7	71	22.86	24.98	100	109.3
756	Hogue	15	165	27.20	29.00	100	106.6
757	Hogue	8	108	25.64	26.79	100	104.5
Average							107.8
BROAD-BRED (SEED CONTINUED ANNUALLY FROM COMPOSITE EARS FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)							
766	Hogue	7	149	21.73	22.13	100	101.9
767	Hogue	12	250	22.52	23.83	100	105.8
768	Hogue	8	417	21.90	22.24	100	101.5
769	Hogue	6	109	18.34	18.72	100	102.1
771	Hogue	5	80	24.54	25.34	100	103.3
772	Hogue	8	195	26.15	26.59	100	101.7
773	Hogue	6	138	21.37	22.11	100	103.5
Average							102 8
WIND-POLLINATED COMMERCIAL CORN							
Original	Hogue	11	570	24.32	24.34	100	100.1

THE IMMEDIATE EFFECT OF CROSS-FERTILIZATION UPON THE WEIGHTS OF THE KERNEL PARTS OF CORN INBRED TO VARIOUS DEGREES

The relative weights of kernel, embryo, endosperm, and pericarp were determined for both pure and hybrid kernels of the 1923 crop of Hogue Yellow Dent and Nebraska White

Prize corn inbred to the various degrees described in the preceding section. Fifty kernel pairs representing all the control pollinated ears of each strain were dissected except in a few cases where that number was not available. The dissections were readily made after soaking the grain for a

TABLE 5.—*Summary showing the immediate effect of cross-fertilization upon the kernel weight of ear-to-row strains of Hogue Yellow Dent and Nebraska White Prize corn which had been subject continually to various degrees of inbreeding.*[1] *1922 and 1923*

Degree of inbreeding	Yield per acre (7-year periods)[2]		Ratio Weight of hybrid to pure kernels		
	Actual	Relative	1922	1923	Average
	Bushels	*Per cent*	*Per cent*	*Per cent*	*Percent*
(1)	(2)	(3)	(4)	(5)	(6)
HOGUE YELLOW DENT					
Inbred	16.8	32.0	114.2	110.6	112.4
Narrow-bred[3]	42.2	80.0	109.3	107.4	108.4
Broad-bred[4]	49.2	96.0	104.9	104.3	104.6
Wind-pollinated	53.1	100.0	100.6	100.3	100.5
NEBRASKA WHITE PRIZE					
Inbred	22.0	36.0	111.9	110.8	111.4
Narrow-bred[3]	45.3	74.0	109.4	107.8	108.6
Broad-bred[4]	48.4	80.0	102.7	102.8	102.8
Wind-pollinated	60.8	100.0	99.5	100.1	99.8
AVERAGE FOR BOTH VARIETIES					
Inbred	19.4	32.0	113.1	110.7	111.9
Narrow-bred[3]	43.9	78.0	109.4	107.6	108.5
Broad-bred[4]	48.8	86.0	103.8	103.6	103.7
Wind-pollinated	57.0	100.0	100.1	100.2	100.2

[1]Data compiled from Tables 1 to 4.

[2]1911-1917 for Hogue Yellow Dent; 1915-1917 and 1920-1923 for Nebraska White Prize.

A somewhat smaller number of strains were averaged in the foreign pollen study than were included in the composite yield tests.

[3]Seed had been continued annually from a single ear fertilized with composite pollen from sister plants.

[4]Seed had been continued annually from composite ears fertilized with composite pollen from sister plants.

brief period in water sufficiently hot to destroy viability. The moisture-free ratios for the various parts of the hybrid and pure kernels are reported in Tables 6 and 7 and are summarized in Table 8.

As an average for both varieties the weights of the entire kernels, embryos, endosperms, and pericarps of the inbred strains increased 10.1, 11.8, 10.4, and 3.2 per cent respectively as a result of the crossing. The narrow-bred strains gave

TABLE 6.—*The immediate effect of foreign pollen upon the relative development of the grain of Hogue Yellow Dent corn which has been subject to various degrees of inbreeding. 1923*

Ear parent strain number	Foreign pollen parent	Ratio of hybrid to pure kernels (moisture-free weights)			
		Kernel	Embryo	Endosperm	Pericarp
(1)	(2)	(3)	(4)	(5)	(6)
Pure kernels		1.000	1.000	1.000	1.000
HYBRID KERNELS					
INBRED STRAINS (SEED CONTINUED ANNUALLY BY SELF-FERTILIZATION)					
1	Nebraska White Prize	1.052	1.203	1.039	1.012
721	Nebraska White Prize	1.034	1.000	1.038	1.032
724	Nebraska White Prize	1.127	1.000	1.144	1.015
726	Nebraska White Prize	1.127	1.190	1.125	1.029
745	Nebraska White Prize	1.149	1.140	1.158	1.054
731	Nebraska White Prize	1.095	0.986	1.119	1.017
736	Nebraska White Prize	1.122	1.099	1.129	1.045
732	Nebraska White Prize	1.048	1.132	1.042	1.000
748	Nebraska White Prize	1.112	1.076	1.121	1.044
Average		1.096	1.092	1.102	1.027
NARROW-BRED STRAINS (SEED CONTINUED ANNUALLY FROM SINGLE EAR FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)					
593	Nebraska White Prize	1.130	1.038	1.147	1.047
594	Nebraska White Prize	1.108	1.119	1.114	1.025
595	Nebraska White Prize	1.215	1.198	1.225	1.115
596	Nebraska White Prize	1.023	1.041	1.021	1.008
600	Nebraska White Prize	1.062	1.125	1.062	0.953
601	Nebraska White Prize	1.041	1.061	1.041	0.989
602	Nebraska White Prize	1.018	1.044	1.017	0.989
603	Nebraska White Prize	1.054	1.054	1.054	1.028
604	Nebraska White Prize	1.049	1.044	1.050	1.041
Average		1.078	1.080	1.081	1.021
BROAD-BRED STRAINS (SEED CONTINUED ANNUALLY FROM COMPOSITE EARS FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)					
606	Nebraska White Prize	1.046	1.047	1.049	1.000
607	Nebraska White Prize	1.076	1.079	1.078	1.037
608	Nebraska White Prize	1.019	0.993	1.020	1.052
Average		1.047	1.040	1.049	1.030
WIND-POLLINATED COMMERCIAL CORN					
Original	Nebraska White Prize	1.003	1.005	1.003	1.001

corresponding average increases of 8.1, 9.1, 8.4, and 2.1 per cent. The broad-bred strains increased 3.5, 3.6, 3.6 and 2.6 per cent in these respective parts. The kernel, embryo, endosperm, and pericarp of the original wind-fertilized corn

increased respectively .2, .3, .2, and .1 per cent as an immediate effect of foreign pollen.

TABLE 7.—*The immediate effect of foreign pollen upon the relative development of different parts of the grains of Nebraska White Prize Dent corn which had been subject to various degrees of inbreeding, 1923*

Parents			Ratio of hybrid to pure kernels (Moisture-free weights)			
Ear parent strain Number	Yield per acre 1921-1922	Foreign pollen parent	Kernel	Embryo	Endosperm	Pericarp
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pure kernels			1.000	1.000	1.000	1.000
HYBRID KERNELS						
INBRED (SEED CONTINUED ANNUALLY BY SELF-FERTILIZATION)						
683	37.9	Hogue Yellow Dent....	1.222	1.297	1.224	1.058
667	12.4	Hogue Yellow Dent....	1.123	1.092	1.132	1.047
673	26.6	Hogue Yellow Dent....	1.081	1.101	1.080	1.059
672	25.7	Hogue Yellow Dent....	1.038	1.109	1.028	1.044
739	9.6	Hogue Yellow Dent....	1.110	1.178	1.109	1.012
690	7.5	Hogue Yellow Dent....	1.028	1.078	1.026	0.977
668	28.0	Hogue Yellow Dent....	1.092	1.058	1.099	1.041
657	11.4	Hogue Yellow Dent....	1.195	1.259	1.194	1.091
865	9.3	Hogue Yellow Dent....	1.105	1.178	1.105	1.016
722	11.6	Hogue Yellow Dent....	1.066	1.089	1.066	1.032
Average.	18.0		1.106	1.144	1.106	1.038
NARROW-BRED (SEED CONTINUED ANNUALLY FROM SINGLE EAR FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)						
750	31.3	Hogue Yellow Dent....	1.117	1.068	1.132	0.994
751	30.0	Hogue Yellow Dent....	1.085	1.094	1.086	1.056
753	31.9	Hogue Yellow Dent....	1.057	1.099	1.052	1.075
754	25.5	Hogue Yellow Dent....	1.100	1.081	1.109	1.014
755	29.9	Hogue Yellow Dent....	1.092	1.151	1.091	1.000
756	31.5	Hogue Yellow Dent....	1.084	1.140	1.084	0.996
757	37.0	Hogue Yellow Dent....	1.062	1.090	1.063	1.010
Average.	32.1		1.085	1.103	1.088	1.021
BROAD-BRED (SEED CONTINUED ANNUALLY FROM COMPOSITE EARS FERTILIZED WITH COMPOSITE POLLEN FROM SISTER PLANTS)						
766	46.0	Hogue Yellow Dent....	1.023	1.002	1.026	1.008
767	37.8	Hogue Yellow Dent....	1.060	1.094	1.060	1.018
768	41.2	Hogue Yellow Dent....	1.022	1.000	1.020	1.081
769	38.2	Hogue Yellow Dent....	1.010	1.032	1.009	0.999
771	40.0	Hogue Yellow Dent....	1.011	1.052	1.006	1.017
772	33.0	Hogue Yellow Dent....	1.040	1.069	1.039	1.016
773	33.8	Hogue Yellow Dent....	1.005	0.985	1.007	1.013
Average.	39.1		1.024	1.033	1.024	1.022
WIND-POLLINATED COMMERCIAL CORN						
Original	47.4	Hogue Yellow Dent....	1.001	1.002	1.001	1.000

Averaging all 3 degrees of close-breeding, the kernels, embryo, endosperm, and pericarp increased 7.2, 8.2, 7.5, and 2.6 per cent in weight as an immediate effect of cross-fertilization.

The detailed data indicate marked individuality in the character of response for various close-bred strains. On an average, however, the embryo increased only slightly more

TABLE 8.—*Summary showing the percentage of increase in weight of different parts of the grain of corn which has been subject to various degrees of inbreeding. 1923**

Character of ear parent	Number Strains	Average increase in weight as immediate effect of foreign pollen			
		Kernel	Embryo	Endosperm	Pericarp
(1)	(2)	*Per cent* (3)	*Per cent* (4)	*Per cent* (5)	*Per cent* (6)
HOGUE YELLOW DENT					
Inbred	9	9.6	9.2	10.2	2.7
Narrow-bred	9	7.8	8.0	8.1	2.1
Broad-bred	3	4.7	4.0	4.9	3.0
Average		7.4	7.1	7.7	2.6
Original Wind-fertilized		0.3	0.5	0.3	0.1
NEBRASKA WHITE PRIZE					
Inbred	10	10.6	14.4	10.6	3.8
Narrow-bred	7	8.5	10.3	8.8	2.1
Broad-bred	7	2.4	3.3	2.4	2.2
Average		7.2	9.3	7.3	2.7
Original Wind-fertilized		0.1	0.2	0.1	0.0
AVERAGE BOTH VARIETIES					
Inbred		10.1	11.8	10.4	3.2
Narrow-bred		8.1	9.1	8.4	2.1
Broad-bred		3.5	3.6	3.6	2.6
Average		7.2	8.2	7.5	2.6
Original Wind-fertilized		0.2	0.3	0.2	0.1

*Data summarized from Tables 6 and 7.

than the endosperm. The pericarp increased far less, as was to be expected, due to its being influenced only indirectly by the pollen parent.

THE RELATIVE IMMEDIATE EFFECTS OF SELF AND CROSS-FERTILIZATION UPON THE KERNEL WEIGHTS OF COMMERCIAL VARIETIES OF CORN

An investigation was made in 1922 to determine the immediate effect of selfing upon the kernel weight of commercial varieties of dent corn. This involved a comparison of kernels that had been selfed with those that were fertilized by pollen from other plants of the same variety. An indirect method was necessitated since the two sets of kernels would have the same color and could not be distinguished from each other on the same ear.

The procedure was to pollinate plants of a variety with a mixture of their own (self) pollen and pollen from another variety of a different endosperm color. A corresponding set of plants were pollinated with a mixture of pollen from the same foreign pollen variety and pollen from their own sister plants. The pure broad-bred kernels and the pure in-bred kernels were then compared in weight with the hybrid kernels paired with them.

As an average for 10 varieties, the hybrid kernels weighed 0.7 per cent more than the broad-bred pure kernels, and 7.7 per cent more than the selfed kernels. By difference, we may conclude that a single selfing reduced the kernel weight 7.0 per cent compared with 0.7 per cent increase from crossing. The data are given in Table 9.

This information may be of interest in connection with the use of first generation hybrid seed between two pure lines. In a field of corn planted entirely to such a hybrid the natural open-fertilization of all kernels is generally equivalent to a first inbreeding since all the plants have essentially the same genetic constitution. The cross pollination with unrelated sorts which occurs extensively in the usual type of comparative field plat yield test prevents this reduction in kernel weight. The results from experimental test plats may, therefore, fail to give true indication of the comparative yielding ability of such F_1 hybrids and commercial varieties when grown separately under farm conditions.

The need for thoro tests to establish the significance of these kernel weight effects in terms of acre yields is hereby suggested.

TABLE 9.—*The relative immediate effects of self-fertilization and cross-fertilization upon the kernel weights of commercial varieties of dent corn*

Ear parent	Foreign pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
				Actual		Relative	
				Pure	Hybrid	Pure	Hybrid
				Grams	*Grams*	*Per cent*	*Per cent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PURE KERNELS FERTILIZED BY OTHER PLANTS OF SAME VARIETY							
Reid Yellow Dent	Nebraska White Prize	6	233	19.05	19.27	100	101.1
Improved Leaming	Nebraska White Prize	10	587	20.69	20.80	100	100.5
Iowa Gold Mine	Nebraska White Prize	6	192	22.78	23.15	100	101.6
Hogue Yellow Dent	Nebraska White Prize	10	434	23.48	23.63	100	100.6
University No. 3	Nebraska White Prize	10	229	22.48	22.90	100	101.9
St. Charles White	Hogue Yellow Dent	8	542	22.36	22.38	100	100.1
Nebraska White Prize	Hogue Yellow Dent	10	687	20.36	20.25	100	99.5
Boone County White	Hogue Yellow Dent	10	370	19.31	19.41	100	100.5
U. S. Selection No. 120	Hogue Yellow Dent	7	492	24.82	24.99	100	100.7
Substation White	Hogue Yellow Dent	10	620	21.33	21.39	100	100.3
Average						100	100.7
PURE KERNELS SELF-FERTILIZED							
Reid Yellow Dent	Nebraska White Prize	7	632	17.64	18.93	100	107.3
Improved Leaming	Nebraska White Prize	5	261	20.39	23.16	100	113.6
Iowa Gold Mine	Nebraska White Prize	6	381	15.12	15.93	100	105.4
Hogue Yellow Dent	Nebraska White Prize	8	297	18.81	20.58	100	109.4
University No. 3	Nebraska White Prize	5	93	17.89	18.81	100	105.1
St. Charles White	Hogue Yellow Dent	2	166	19.00	20.18	100	106.2
Nebraska White Prize	Hogue Yellow Dent	6	128	23.80	25.84	100	108.6
Boone County White	Hogue Yellow Dent	9	425	21.67	23.12	100	106.7
U. S. Selection No. 120	Hogue Yellow Dent	6	172	23.58	25.21	100	106.9
Substation White	Hogue Yellow Dent	8	273	19.33	20.93	100	108.3
Average						100	107.7

THE RELATIVE IMMEDIATE EFFECTS OF POLLEN FROM HOMOZYGOUS AND HETEROZYGOUS PLANTS UPON THE KERNEL WEIGHTS OF CORN

A test was made during the two years 1921 and 1922 to determine the comparative immediate effects of pollen from homozygous and from heterozygous corn plants. Using two standard local varieties as ear parents, a number of plants in each variety were pollinated with a mixture of pollen from either inbred or open-pollinated plants of another variety. By the method of kernel pairs, the pure and hybrid kernels could be compared. The results are recorded in Table 10. As an average for the 2 varieties, practically identical results were obtained for the pollen from all 3 sources, the maximum difference being 0.2 per cent in kernel weight.

TABLE 10.—*Comparative immediate effects of foreign pollen from pure selfed strains and from commercial varieties of dent corn upon the kernel weight of commercial varieties of dent corn. 2-year average, 1921 and 1922*

Ear-bearing parent	Foreign-pollen parent	Number of ears	Weight of 100 kernels			
			Actual		Relative	
			Pure	Hybrid	Pure	Hybrid
(1)	(2)	(3)	(4)	(5)	(6)	(7)
POLLEN FROM HETEROZYGOUS (COMMERCIAL) VARIETIES						
Hogue Yellow Dent	White Prize	22	27.62	27.84	100	100.8
Nebraska White Prize	Hogue	22	28.38	28.29	100	99.7
Average					100	100.2
POLLEN FROM HOMOZYGOUS (SELF) STRAINS						
Hogue Yellow Dent	White Prize	13	27.43	27.32	100	99.4
Nebraska White Prize	Hogue	18	28.79	28.93	100	100.5
Average					100	100

THE IMMEDIATE EFFECT OF FOREIGN POLLEN UPON THE KERNEL WEIGHT OF COMMERCIAL VARIETIES OF DENT CORN

One hundred varieties of corn including 80 dent varieties, obtained from many sources and representing a wide diversity of type, were employed in a study of the immediate effect of foreign pollen upon the kernel weights of commercial varieties. With the exception of the Illinois Oil and Protein strains of Burr White and the Esperanza, Chinese, and

Ramosa corn, these were ordinary commercial varieties, and representative of corn actually grown in farm practice. Their characteristics as grown at the Nebraska Experiment Station in 1922 are given in detail in Table 11.

Representative kernels of 97 of these varieties are shown in Fig. 1. Phases of this problem had to do with the relative effects of crossing similar and dissimilar types. Many of the earlier varieties were planted at two or more dates in order to permit the interchange of pollen.

VARIATION IN VARIETAL RESPONSES

The immediate effect of foreign pollen upon 63 varieties of dent corn is listed in Tables 12 to 14 according to the earliness of the female parent. The characteristics of these have been given in Table 11.

Effect on Early Varieties.— Twenty-three early varieties (Table 12) ranged in their response to cross-fertilization from a decrease of 0.8 per cent to an increase of 2.8 per cent. Five varieties showed a slight decrease, 8 varieties less than 1 per cent increase, and 10 varieties between 1 and 2.8 per cent increase. The mean increase was 1.1 per cent.

Effect on Medium-Late Varieties.— Twelve medium-late maturing varieties (Table 13) varied in their response to foreign pollen from a decrease of 0.9 per cent to an increase of 2.7 per cent. Four varieties showed a slight decrease, 1 variety less than 1 per cent increase, and 7 varieties between 1 and 2.7 per cent increase. The mean increase was 0.9 per cent.

Effect on Late Varieties.— Some of these varieties were too late to mature normally under prevailing climatic conditions, but the results from pure and hybrid kernels should be comparable nevertheless. The immediate effect of crossing upon 28 late varieties (Table 14) varied from a decrease of 2.0 per cent to an increase of 3.7 per cent. Sixteen varieties showed a slight decrease, 6 varieties less than 1 per cent increase, and 6 varieties between 1 and 3.7 per cent increase. The mean increase was 0.1 per cent.

VARIETAL RESPONSE TO VARYING POLLEN PARENT TYPE

Twelve varieties of dent corn ranging from small, early-maturing, shallow-grained, smooth-eared types to large, late-maturing, deep-grained, rough-eared types, were grown in 5 row plats of 760 plants each. The comparative immediate effects of fertilization by a wide range of variety types was determined by control pollination for each of these 12 varieties.

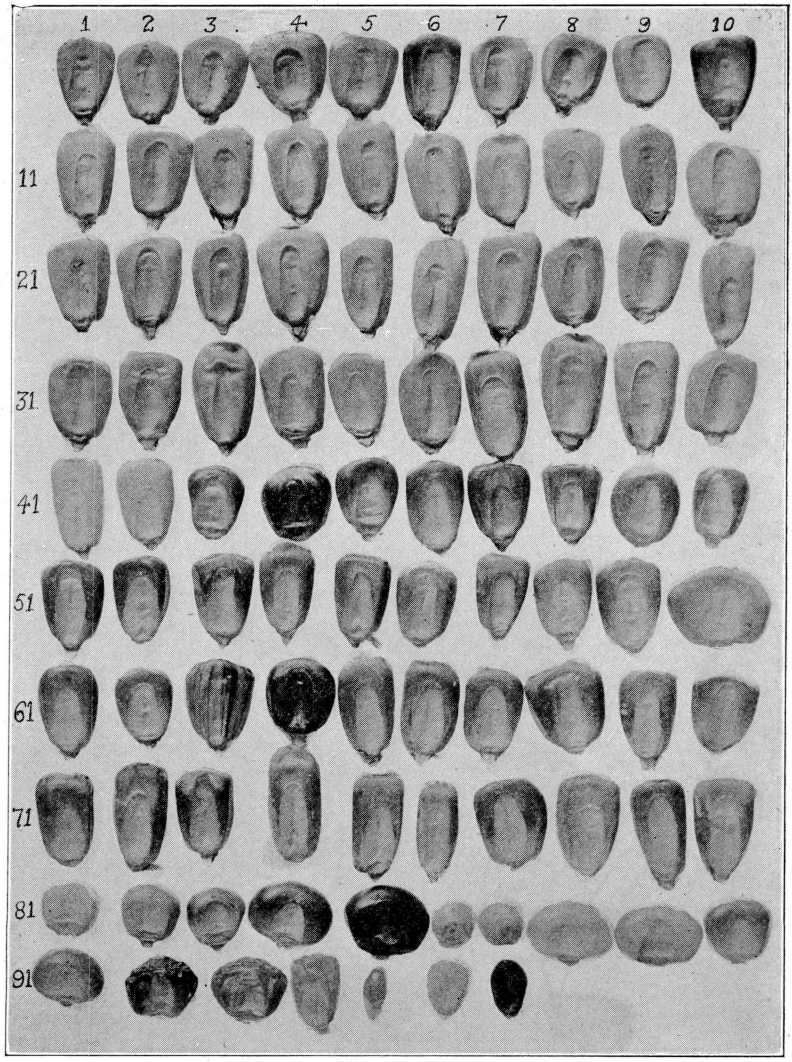


FIG. 1.— Representative kernels of varieties used in the crosses reported in this paper. The numbers correspond to the numbers assigned to these varieties listed in Table 11. Kernels number from left to right.

TABLE 11.—*Characteristics of commercial varieties of corn used in a study of the immediate effect of foreign pollen upon the kernel development reported in tables 12 to 36. Grown comparatively at the Nebraska Agricultural Experiment Station, 1922*

Number	Variety	Source of seed	Grain character			Vegetative character		
			Endosperm type	Color of grain	Depth of kernel	Height		Date of tasseling
						Stalk (inches)	Ear (inches)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1*	Rustler White	Idaho	Dent	White	Shallow	70	26	7/10
2*	Rustler White	Minn.	Dent	White	Shallow	85	37	7/15
3	Valley County White	Nebr.	Dent	White	Shallow	85	35	7/16
4*	Nevada White	Nev.	Dent	White	Shallow	87	29	7/16
5	Chadron White	Nebr.	Dent	White	Shallow	80	40	7/18
6*	White Cap	Pa.	Dent	White cap	Medium	108	39	7/19
7	Colorado White	Colo.	Dent	White	Shallow	95	34	7/19
8*	Marteens White	Nebr.	Dent	White	Shallow	90	38	7/20
9*	Substation White	Nebr.	Dent	White	Shallow	90	46	7/23
10*	White Cap	N. J.	Dent	White cap	Medium	115	44	7/24
11*	Hall County White	Nebr.	Dent	White	Medium	112	50	7/25
12*	Silver King	Mich.	Dent	White	Medium	108	39	7/25
13*	Red Cob Fodder	Nebr.	Dent	White	Medium	95	37	7/26
14	Blair White	Nebr.	Dent	White	Medium	115	44	7/26
15*	Iowa Silver Mine	Nebr.	Dent	White	Medium	110	52	7/27
16*	Low Protein	Ill.	Dent	White	Medium	104	56	7/27
17*	High Oil	Ill.	Dent	White	Medium	102	51	7/27
18*	High Protein	Ill.	Dent	White	Shallow	107	56	7/27
19*	St. Charles White	Nebr.	Dent	White	Medium	105	53	7/27
20*	Low Oil	Ill.	Dent	White	Medium	110	54	7/29
21	Boone County White	Nebr.[1]	Dent	White	Medium	110	52	7/29
22*	Nebraska White Prize	Nebr.	Dent	White	Deep	120	54	7/29
23*	U. S. Selection 120	Va.	Dent	White	Deep	120	63	7/30
24*	Johnson County White	Del.	Dent	White	Deep	120	53	7/31
25*	Boone County White	Nebr.[2]	Dent	White	Deep	122	57	7/31

[1]Douglas County.
[2]Richardson County.
All starred varieties were used as ear bearing parents as well as foreign pollen parents.

TABLE 11 (Continued).—*Characteristics of commercial varieties of corn used in a study of the immediate effect of foreign pollen upon the kernel development reported in tables 12 to 36. Grown comparatively at the Nebraska Agricultural Experiment Station, 1922*

Number	Variety	Source of seed	Grain character			Vegetative character		
			Endosperm type	Color of grain	Depth of kernel	Height		Date of tasseling
						Stalk (inches)	Ear (inches)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
26*	Johnson County White	Ind.	Dent	White	Deep	120	54	7/31
27*	St. Charles White	Mo.	Dent	White	Deep	123	57	8/1
28*	Allen Prolific	Ga.	Dent	White	Medium	133	80	8/2
29*	Pride of Saline	Kan.	Dent	White	Medium	122	58	8/2
30*	Virginia White Dent	Va.	Dent	White	Deep	136	72	8/4
31*	Cocke Prolific	N. C.	Dent	White	Medium	125	65	8/6
32*	Chisholm	Tex.	Dent	White	Medium	125	59	8/7
33*	Silver Mine	Okla.	Dent	White	Deep	122	62	8/7
34*	Cob Pipe	Mo.	Dent	White	Deep	120	70	8/7
35*	Mosby Prolific	Miss.	Dent	White	Medium	133	71	8/8
36	Esperanza	Cal.	Dent	White	Deep	110	68	8/8
37*	Calhoun Red Cob	La.	Dent	Yellow	Deep	130	66	8/8
38*	Neal Paymaster	Ark.	Dent	White	Deep	136	64	8/8
39*	Virginia Horsetooth	Va.	Dent	White	Deep	125	72	8/9
40*	Pee Dee No. 5	S. C.	Dent	White	Medium	133	87	8/11
41*	Douthit Prolific	S. C.	Dent	White	Deep	133	82	8/11
42*	Whatley	Ala.	Dent	White	Medium	120	80	8/13
43*	Thayer Yellow	Nebr.	Dent	Yellow	Shallow	70	27	7/10
44	Northwestern Dent	N. D.	Dent	Red	Shallow	75	23	7/11
45*	Minnesota No. 13	Ore.	Dent	Yellow	Shallow	80	25	7/12
46*	Mousel Yellow	Nebr.	Dent	Yellow	Medium	110	53	7/15
47*	Cornell No. 11	N. Y.	Dent	Yellow	Shallow	85	32	7/16
48*	Brookings No. 86	S. D.	Dent	Yellow	Shallow	75	30	7/16
49*	Williams Dent	Mass.	Dent	Yellow	Shallow	83	31	7/17
50*	Pride of North	Conn.	Dent	Yellow	Shallow	98	37	7/18

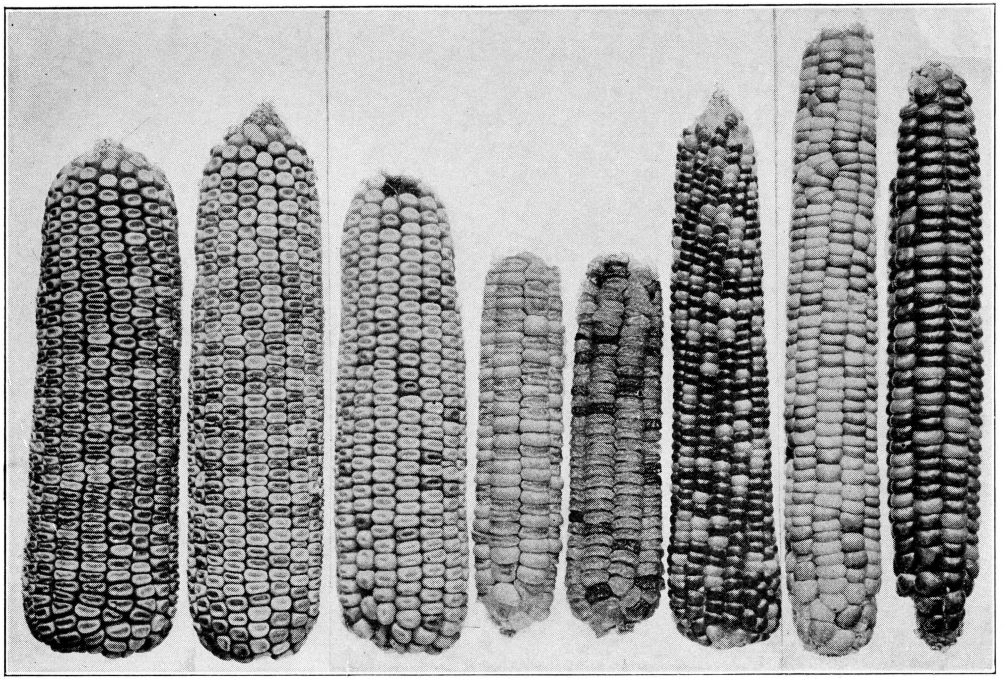
TABLE 11 (Continued).—*Characteristis of commercial varieties of corn used in a study of the immediate effect of foreign pollen upon the kernel development reported in tables 12 to 36. Grown comparatively at the Nebraska Agricultural Experiment Station, 1922*

Number	Variety	Source of seed	Grain character			Vegetative character		
			Endosperm type	Color of grain	Depth of kernel	Height		Date of tasseling
						Stalk (inches)	Ear (inches)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
51*	Golden Glow	Wis.	Dent	Yellow	Medium	90	39	7/18
52*	U. S. Selection 133	Wis.	Dent	Yellow	Medium	95	36	7/18
53*	Valley County Yellow	Nebr.	Dent	Yellow	Medium	90	38	7/19
54*	Dawes County Yellow	Nebr.	Dent	Yellow	Medium	85	31	7/19
55*	Fulton Yellow	Nebr.	Dent	Yellow	Medium	90	40	7/20
56*	Substation Yellow	Nebr.	Dent	Yellow	Medium	88	35	7/20
57*	Ohio No. 84	Ohio	Dent	Yellow	Medium	108	41	7/21
58*	Duncan Yellow	Mich.	Dent	Yellow	Medium	95	40	7/22
59*	Minnesota No. 13	Colo.	Dent	Yellow	Medium	95	38	7/22
60	Minnesota King	Minn.	Dent	Yellow	Shallow	80	27	7/22
61*	Doctor	Iowa	Dent	Yellow	Medium	103	42	7/23
62	Valentine Yellow	Nebr.	Dent	Yellow	Shallow	85	38	7/23
63	Calico	Nebr.	Dent	Yellow	Medium	98	40	7/23
64	Bloody Butcher	Nebr.	Dent	Red	Shallow	100	41	7/23
65*	Reid Yellow Dent	Nebr.	Dent	Yellow	Deep	110	48	7/24
66*	Nance County Yellow	Nebr.	Dent	Yellow	Deep	108	47	7/24
67	Graham Yellow Dent	Nebr.	Dent	Yellow	Medium	105	40	7/24
68	Cattle	Nebr.	Dent	Yellow	Medium	122	56	7/27
69	Hogue Yellow Dent	Nebr.	Dent	Yellow	Deep	112	50	7/27
70	University No. 3	Nebr.	Dent	Yellow	Medium	108	52	7/27
71*	Iowa Gold Mine	Nebr.	Dent	Yellow	Medium	110	49	7/27
72*	Iodent	Iowa	Dent	Yellow	Deep	113	53	7/27
73*	Reid Yellow Dent	Ill.	Dent	Yellow	Deep	120	56	7/28
74*	Improved Leaming	Nebr.	Dent	Yellow	Medium	108	52	7/29
75*	Reid Yellow Dent	Ind.	Dent	Yellow	Deep	118	46	7/29

TABLE 11 (Concluded).—*Characteristics of commercial varieties of corn used in a study of the immediate effect of foreign pollen upon the kernel development reported in tables 12 to 36. Grown comparatively at the Nebraska Agricultural Experiment Station, 1922*

Number	Variety	Source of seed	Grain character			Vegetative character		
			Endosperm type	Color of grain	Depth of kernel	Height		Date of tasseling
						Stalk (inches)	Ear (inches)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
76*	Washington County Yellow	Nebr.	Dent	Yellow	Deep	112	52	7/29
77*	Bear Paw	Ohio	Dent	Yellow	Deep	105	53	7/31
78*	St. Charles Yellow	Mo.	Dent	Yellow	Medium	118	53	7/31
79	Jarvis Golden Prolific	Tenn.	Dent	Yellow	Deep	108	51	8/1
80*	Improved Leaming	W. Va.	Dent	Yellow	Medium	123	57	8/1
81	Navajo	Cal.	Flint	White	Shallow	60	20	7/27
82	Navajo	Cal.	Flint	Yellow	Shallow	60	20	7/27
83	Navajo	Cal.	Flint	Bluish	Shallow	60	20	7/27
84	Blue Flour	Nebr.	Flour	Blue	Shallow	83	28	7/19
85	Red Flour	Nebr.	Flour	Red	Shallow	81	25	7/21
86	Zea Ramosa	Cal.	Dent	White	Shallow	108	63	8/7
87	Zea Ramosa	Cal.	Dent	Yellow	Shallow	108	63	8/7
88*	White Australian	Nebr.	Flint	White	Shallow	83	26	7/18
89*	Rhode Island Flint	R. I.	Flint	Yellow	Shallow	70	20	7/13
90*	King Philip	Cal.	Flint	Yellow	Shallow	105	45	7/20
91*	Gehu	Mont.	Flint	Yellow	Shallow	48	10	7/5
92*	Black Mexican	Nebr.	Sweet	Blue	Shallow	65	18	7/21
93*	Golden Bantam	Nebr.	Sweet	Yellow	Shallow	60	15	7/16
94*	Country Gentleman	Nebr.	Sweet	White	Shallow	85	35	7/23
95*	Yellow Rice	Nebr.	Pop	Yellow	Shallow	95	38	7/24
96	White Pearl	Nebr.	Pop	White	Shallow	78	25	8/1
97	Red Rice	Nebr.	Pop	Red	Shallow	125	59	8/2
98	Japanese Rice	Nebr.	Pop	White	Shallow	50	24	7/16
99	Chinese	Cal.	Waxy	White	Shallow	85	40	8/11
100	Stowell Evergreen	Nebr.	Sweet	White	Deep	90	39	7/28

The 3 samples of Navajo were selected from the same seed ears and were essentially similar except as to color. This is also true of the 2 Zea Ramosa samples.



1 2 3 4 5 6 7 8

FIG. 2.— Representative ears of various endosperm types showing pure and hybrid kernels on the same ears as produced by control pollination for the investigations reported in this bulletin. 1. White Dent ear. Hybrid kernels fertilized by Yellow Dent. 2. Yellow Dent ear. Hybrid kernels fertilized by White Dent. 3. Yellow Dent ear. Hybrid kernels fertilized by Blue Flour. 4. Yellow Sweet ear. Hybrid kernels fertilized by Yellow Dent. 5. Yellow Sweet ear. Hybrid kernels fertilized by Black Sweet. 6. Yellow Pop ear. Hybrid kernels fertilized by Red Pop. 7. White Flint ear. Hybrid kernels fertilized by Yellow Sweet. 8. White Flint ear. Hybrid kernels fertilized by Yellow Dent.

TABLE 12.—*The immediate effect of foreign pollen upon the kernel weight of early maturing commercial varieties of dent corn from various sources*

	Variety and source of seed		Maturity of pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels				Gain or loss in moisture content[1]
	Ear parent	Foreign pollen parent				Actual		Relative		
						Pure	Hybrid	Pure	Hybrid	
	(1)	(2)	(3)	(4)	(5)	*Grams* (6)	*Grams* (7)	*Per cent* (8)	*Per cent* (9)	*Per cent* (10
1	Rustler White.....Minn.	Northwestern Dent.....N. D.	Early	10	381	24.35	24.42	100	100.3	.....
2	Minnesota No. 13.....Ore.	Valley Co. White.....Nebr.	Early	7	470	26.42	26.27	100	99.4	.96
3	Cornell No. 11,.....N. Y.	Nevada White.....Nev.	Early	10	387	20.20	20.31	100	100.5	−.48
4	Williams Dent,.....Mass.	Nevada White.....Nev.	Early	9	404	23.45	23.36	100	99.6	.24
5	Duncan Yellow,.....Mich.	Substation White.....Nebr.	Early	9	344	25.49	25.63	100	100.6	.....
6	Brookings No. 86,.....S. D.	Nevada White.....Nev.	Early	10	590	23.63	23.45	100	99.2	.....
7	Pride of North.....Conn.	Chadron White.....Nebr.	Early	9	359	25.53	25.62	100	100.4	−.29
8	Ohio No. 84,.....Ohio	Rustler White.....Minn.	Early	10	381	22.52	22.34	100	99.2	.99
9	Rustler White.....Idaho	Thayer Yellow..... Wash.	Early	10	425	23.89	24.56	100	102.8	−.62
10	Nevada White.....Nev.	U. S. Selection 133.....Wis.	Early	9	153	26.37	26.86	100	101.9	.52
11	Mousel Yellow.....Nebr.	Iowa Silver Mine.....Nebr.	Medium	10	233	25.69	26.02	100	101.3	−.71
12	Silver King.....Mich.	Hogue Yellow Dent.....Nebr.	Medium	3	180	25.34	25.14	100	99.2	.....
13	Fulton Yellow.....Nebr.	Nebr. White Prize.....Nebr.	Late	7	221	19.94	20.36	100	102.1	.....
14	White Cap.....Penn.	Nebr. White Prize.....Nebr.	Late	10	540	24.11	24.19	100	100.3	−.13
15	Valley Co. Yellow.....Nebr.	Nebr. White Prize.....Nebr.	Late	10	380	20.55	20.95	100	102.0	.....
16	Minnesota No. 13.....Colo.	Nebr. White Prize.....Nebr.	Late	10	540	24.60	25.18	100	102.4	−.66
17	Valentine Yellow.....Nebr.	Nebr. White Prize.....Nebr.	Late	5	117	27.14	27.81	100	102.5	.....
18	Golden Glow.....Wis.	Nebr. White Prize.....Nebr.	Late	10	977	26.78	27.24	100	101.7	−.03
19	Substation Yellow....Nebr.	Nebr. White Prize.....Nebr.	Late	8	385	24.45	24.86	100	101.7	.18
20	Marteens White.....Nebr.	Average of 13 varieties.....	Variable	111	3255	19.92	19.91	100	100.0	−.31
21	Substation White....Nebr.	Average of 19 varieties.....	Variable	149	6160	21.75	21.79	100	100.1	−.06
22	U. S. Selection 133.....Wis.	Average of 5 varieties.....	Variable	43	1837	23.86	23.97	100	100.5	−.34
23	Doctor .....Iowa	Low Protein.....Ill.	Medium	3	117	21.49	21.91	100	102.0	.....
	Average.....	.....	.....	.....	.....	23.80	24.00	100	101.1	−.05

[1]Moisture tests were not made where no data are reported. This column in all similar tables reports the increase or decrease of hybrids over pure kernels.

TABLE 13.—*The immediate effect of foreign pollen upon the kernel weight of medium-late maturing commercial varieties of dent corn*

	Variety and source of seed		Maturity of pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels				Gain or loss in moisture content[1]
	Ear parent	Foreign pollen parent				Actual		Relative		
						Pure	Hybrid	Pure	Hybrid	
	(1)	(2)	(3)	(4)	(5)	*Grams* (6)	*Grams* (7)	*Per cent* (8)	*Per cent* (9)	*Per cent* (10
1	Red Cob Fodder.....Nebr.	Hogue Yellow Dent.....Nebr.	Medium	10	307	22.93	22.72	100	99.1	.....
2	Hall County White...Nebr.	Hogue Yellow Dent.....Nebr.	Medium	10	606	26.94	27.46	100	101.9	-.05
3	Cattle Corn.....Nebr.	Nebr. White Prize.....Nebr.	Late	10	264	32.28	32.75	100	101.5	.....
4	Reid Yellow Dent....Nebr.	Nebr. White Prize.....Nebr.	Late	10	962	25.24	25.87	100	102.5	.44
5	Iodent.....Iowa	Nebr. White Prize.....Nebr.	Late	5	227	22.74	23.36	100	102.7	.11
6	Nance Co. Yellow....Nebr.	Nebr. White Prize.....Nebr.	Late	10	730	22.71	22 67	100	99.8	- 05
7	Graham Corn.....Nebr.	Nebr. White Prize.....Nebr.	Late	10	582	21.18	21.51	100	101.6	-.12
8	Hogue Yellow Dent..Nebr.	Average of 24 varieties.....	Variable	153	6922	22.68	22.71	100	100.1	-.05
9	Iowa Gold Mine.....Nebr.	Average of 15 varieties.....	Variable	81	2568	22.79	23.01	100	101.0	-.20
10	University No. 3.....Nebr.	Average of 10 varieties.....	Variable	71	1935	22.69	22.96	100	101.2	.07
11	St. Charles White....Nebr.	Average of 10 varieties.....	Variable	74	2319	22.34	22.24	100	99.6	.02
12	Iowa Silver Mine.....Nebr.	Average of 11 varieties.....	Variable	77	1858	22.54	22.35	100	99.2	-.05
	Average.....	.....	.....	.....	.....	23.92	24.13	100	100.9	.01

[1]Moisture tests were not made where no data are reported.

TABLE 14.—*The immediate effect of foreign pollen upon the kernel weight of late-maturing commercial varieties of dent corn from various sources*

	Variety and source of seed		Maturity of pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
	Ear parent	Foreign pollen parent				Actual		Relative	
						Pure	Hybrid	Pure	Hybrid
	(1)	(2)	(3)	(4)	(5)	*Grams* (6)	*Grams* (7)	*Per cent* (8)	*Per cent* (9)
1	Virginia Horsetooth....Va.	Hogue Yellow Dent....Nebr.	Medium	5	200	24.23	24.68	100	101.9
2	St. Charles Yellow....Mo.	St. Charles White....Nebr.	Medium	6	287	27.79	27.76	100	99.9
3	Cob-Pipe....Mo.	Hogue Yellow Dent....Nebr.	Medium	3	40	29.70	29.50	100	99.3
4	Douthit Prolific....S. C.	Hogue Yellow Dent....Nebr.	Medium	9	402	21.76	21.51	100	98.9
5	Whatley....Ala.	Hogue Yellow Dent....Nebr.	Medium	7	193	15.29	15.66	100	102.4
6	Cocke Prolific....N. C.	Hogue Yellow Dent....Nebr.	Medium	9	974	27.60	27.67	100	100.3
7	Allen Prolific....Ga.	Hogue Yellow Dent....Nebr.	Medium	10	722	27.48	27.03	100	98.4
8	Mosby....Miss.	Hogue Yellow Dent....Nebr.	Medium	3	51	27.22	27.17	100	99.8
9	Johnson Co. White....Ind.	Hogue Yellow Dent....Nebr.	Medium	10	401	20.06	19.88	100	99.1
10	Neal Paymaster....Ark.	Hogue Yellow Dent....Nebr.	Medium	10	521	28.45	28.28	100	99.4
11	Virginia White Dent....Va.	Hogue Yellow Dent....Nebr.	Medium	10	521	31.26	30.81	100	98.6
12	Pride of Saline....Kan.	Hogue Yellow Dent....Nebr.	Medium	5	228	31.25	31.08	100	99.5
13	Chisholm....Tex.	Hogue Yellow Dent....Nebr.	Medium	4	67	25.96	25.67	100	98.9
14	Silver Mine....Okla.	Hogue Yellow Dent....Nebr.	Medium	4	86	26.33	25.80	100	98.0
15	Pee Dee No. 5....S. C.	Hogue Yellow Dent....Nebr.	Medium	5	201	23.52	23.66	100	100.6
16	Johnson County White....Del.	Hogue Yellow Dent....Nebr.	Medium	10	323	27.20	27.34	100	100.5
17	Reid Yellow Dent....Ill.	Iowa Silver Mine....Nebr.	Medium	6	337	17.17	17.38	100	100.2
18	Boone County White....Nebr.	Iodent....Iowa	Medium	10	547	28.28	28.08	100	99.3
19	Calhoun Red Cob....La.	Nebr. White Prize....Nebr.	Late	3	157	21.59	21.50	100	99.6
20	Bear Paw....Ohio	Nebr. White Prize....Nebr.	Late	4	113	14.39	14.92	100	103.7
21	Improved Leaming....W. Va.	Nebr. White Prize....Nebr.	Late	10	843	17.79	18.00	100	101.2
22	Reid Yellow Dent....Ind.	Nebr. White Prize....Nebr.	Late	10	652	24.19	24.88	100	102.9
23	Washington Co. Yellow....Nebr.	Nebr. White Prize....Nebr.	Late	10	673	24.62	24.56	100	99.8
24	St. Charles White....Mo.	Jarvis Golden Prolific....Tenn.	Late	10	520	23.05	23.37	100	101.4
25	Nebraska White Prize....Nebr.	Average of 18 varieties....	Variable	133	6598	21.30	21.19	100	99.5
26	Boone County White....Nebr.	Average of 8 varieties....	Variable	59	1744	22.44	22.37	100	99.7
27	Reid Yellow Dent....Ill.	Average of 12 varieties....	Variable	72	1963	22.18	22.34	100	100.6
28	Improved Leaming....Nebr.	Average of 13 varieties....	Variable	102	4303	21.99	22.14	100	100.7
	Average....	....	....	....	....	24.07	24.07	100	100.1

The results of these tests are reported in Tables 15 to 26. No very pronounced changes were noted in the kernel weights of these varieties as an immediate effect of fertilization by foreign pollen. The character of the pollen parent had very little influence upon the kernel weights.

Hogue Yellow Dent used as the female parent in 24 crosses (Table 15) varied from a decrease of 1.7 per cent to an increase of 2.1 per cent as an immediate effect of foreign pollen, with a mean increase of 0.1 per cent.

Improved Leaming used as the female parent in 13 crosses (Table 16) ranged from a decrease of 1.2 per cent to an increase of 2.2 per cent with an average increase of 0.7 per cent.

Iowa Gold Mine ranged in 15 different crosses (Table 17) from a decrease of 1.5 per cent to an increase of 2.3 per cent, with a mean increase of 1.0 per cent.

University No. 3 used as the female parent in 10 crosses (Table 18) ranged from an increase of 0.2 per cent to an increase of 2.4 per cent with a mean increase of 1.2 per cent as an immediate effect of fertilization by foreign pollen.

U. S. Selection No. 133 varied in 5 crosses (Table 19) from a decrease of 0.4 per cent to an increase of 1.4 per cent, and gave a mean increase of 0.4 per cent.

Reid Yellow Dent figured as the ear bearing parent in 12 crosses (Table 20). The immediate effect of foreign pollen ranged from a decrease of 1.3 per cent to an increase of 2.9 per cent and gave a mean increase of 0.7 per cent.

Nebraska White Prize was used as the female parent in 18 crosses (Table 21). The results varied from a decrease of 2.0 per cent to an increase of 2.5 per cent, with a mean decrease of 0.5 per cent.

Substation White varied in 20 different crosses (Table 22) from a decrease of 1.6 per cent to an increase of 1.8 per cent, and gave a mean increase of 0.1 per cent.

St. Charles White ranged in 11 different crosses (Table 23) from a decrease of 2.4 per cent to an increase of 1.1 per cent, and gave a mean decrease of 0.4 per cent.

Iowa Silver Mine ranged from a decrease of 2.1 per cent to an increase of 1.7 per cent in 11 different crosses (Table 24) with a mean decrease of 0.8 per cent, as an immediate effect of fertilization by foreign pollen.

TABLE 15.—*The immediate effect of cross-fertilization upon the kernel weight of Hogue Yellow Dent,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content[2]
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	10	601	Valley County White	Nebr.	Early	Small	Shallow	22.07	22.16	100	100.4	.09
2	7	289	Marteens White	Nebr.	Early	Small	Shallow	21.83	21.61	100	99.0	.03
3	10	871	Rustler White	Minn.	Early	Small	Shallow	23.05	22.87	100	99.2	.46
4	5	137	Blue Mexican Sweet	Nebr.	Early	Small	Shallow	23.93	23.66	100	98.9	−.26
5	8	332	Red Flour Corn	Nebr.	Early	Small	Shallow	20.81	20.65	100	99.2	−.49
6	10	716	Silver King	Mich.	Early	Medium	Medium	21.65	22.10	100	102.1	.16
7	8	351	High Protein	Ill.	Medium	Medium	Shallow	25.01	25.11	100	100.4	−.47
8	4	151	Hall County White	Nebr.	Medium	Medium	Medium	24.15	24.00	100	99.4	−.56
9	3	48	St. Charles White	Nebr.	Medium	Medium	Medium	22.13	22.57	100	102.0	.93
10	10	366	Low Protein	Ill.	Medium	Medium	Medium	21.33	21.65	100	101.5	.11
11	10	612	High Oil	Ill.	Medium	Medium	Medium	21.06	20.81	100	98.8	−.28
12	10	359	White Cap	N. J.	Medium	Medium	Medium	22.45	22.13	100	98.6	−.08
13	3	128	Chisholm	Tex.	Late	Large	Medium	23.56	23.44	100	99.5	−.44
14	3	83	Pride of Saline	Kan.	Late	Large	Medium	21.73	22.01	100	101.3	−.53
15	5	160	Mosby Prolific	Miss.	Late	Large	Medium	24.31	24.37	100	100.3	.....
16	2	67	Virginia White	Va.	Late	Large	Deep	22.76	23.02	100	101.1	.65
17	3	123	Missouri Cob Pipe	Mo.	Late	Large	Deep	20.91	20.88	100	99.9	.00
18	10	383	Boone Co. White	Nebr.	Late	Large	Deep	22.72	23.07	100	101.5	.25
19	4	136	Johnson Co. White	Ind.	Late	Large	Deep	20.00	19.88	100	99.4	.16
20	3	101	Douthit Prolific	S. C.	Late	Large	Deep	25.17	25.45	100	101.1	.....
21	10	434	Nebr. White Prize	Nebr.	Late	Large	Deep	23.48	23.63	100	100.6	−.18
22	6	164	Calhoun Red Cob	La.	Late	Large	Deep	24.98	25.05	100	100.3	−.03
23	7	368	U. S. Selection 120	Va.	Late	Large	Deep	23.41	23.43	100	100.1	−.51
24	3	45	Esperanza	Cal.	Late	Large	Deep	21.84	21.47	100	98.3	.....
Average	.....	.....	.....	.....	.....	.....	.....	22.68	22.71	100	100.1	−.05

[1] A medium-sized, medium-late, medium-to-deep-grained yellow dent variety from Nebraska.
[2] Due to crossing.

TABLE 16.—*The immediate effect of cross-fertilization upon the kernel weight of Improved Leaming*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	10	413	Substation White	Nebr.	Early	Small	Shallow	19.37	19.37	100	100.0	.69
2	10	501	Valley County White	Nebr.	Early	Small	Shallow	21.49	21.23	100	98.8	−.63
3	2	118	Nevada White	Nev.	Early	Small	Medium	21.48	21.95	100	102.2	−.36
4	6	163	High Protein	Ill.	Medium	Medium	Shallow	23.21	23.40	100	100.8	.59
5	10	507	High Oil	Ill.	Medium	Medium	Medium	21.37	21.46	100	100.4	.11
6	8	310	Low Protein	Ill.	Medium	Medium	Medium	21.09	21.32	100	101.1	.76
7	10	432	St. Charles White	Nebr.	Medium	Medium	Medium	25.04	24.97	100	99.7	−.16
8	10	246	Iowa Silver Mine	Nebr.	Medium	Medium	Medium	22.33	22.62	100	101.3	−.06
9	4	135	Low Oil	Ill.	Late	Medium	Medium	24.24	24.53	100	101.2	.39
10	10	265	Boone County White	Nebr.	Late	Medium	Medium	22.86	23.17	100	101.4	.03
11	10	601	Virginia Horsetooth	Va.	Late	Large	Deep	20.22	20.36	100	100.7	−.43
12	4	85	U. S. Selection 120	Va.	Late	Large	Deep	22.56	22.67	100	100.5	.59
13	10	587	Nebr. White Prize	Nebr.	Late	Large	Deep	20.69	20.80	100	100.5	−.01
Average								21.99	22.14	100	100.7	.12

[1]A medium-sized, medium-late, medium-deep-grained, yellow dent variety from Nebraska.

TABLE 17.—*The immediate effect of cross-fertilization upon the kernel weight of Iowa Gold Mine*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
								Grams	*Grams*	*Per cent*	*Per cent*	*Per cent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	10	414	Substation White	Nebr.	Early	Small	Shallow	21.63	21.95	100	101.5	.20
2	5	185	White Dent	Colo.	Early	Small	Shallow	23.43	23.78	100	101.5	−.29
3	6	286	Valentine White	Nebr.	Early	Small	Medium	21.57	21.67	100	100.5	.....
4	3	101	High Protein	Ill.	Medium	Medium	Shallow	19.62	20.04	100	102.1	.96
5	10	336	Hall Couuty White	Nebr.	Medium	Medium	Medium	22.60	22.98	100	101.7	−.12
6	4	149	St. Charles White	Nebr.	Medium	Medium	Medium	23.97	24.33	100	101.5	−.49
7	5	229	Iowa Silver Mine	Nebr.	Medium	Medium	Medium	22.91	23.25	100	101.5	−.87
8	3	86	High Oil	Ill.	Medium	Medium	Medium	23.05	22.76	100	98.7	−.20
9	4	171	Blair White	Nebr.	Medium	Medium	Medium	22.92	23.21	100	101.3	−.89
10	3	100	Low Oil	Ill.	Late	Medium	Medium	23.77	24.03	100	101.1	.00
11	6	178	U. S. Selection 120	Va.	Late	Large	Deep	22.54	22.98	100	102.0	.22
12	2	58	Boone Co. White	Nebr.	Late	Large	Deep	24.93	24.67	100	99.0	.01
13	6	192	Nebr. White Prize	Nebr.	Late	Large	Deep	22.78	23.15	100	101.6	−.41
14	2	42	Esperanza	Cal.	Late	Large	Deep	22.46	22.98	100	102.3	−.26
15	2	51	St. Charles White	Mo.	Late	Large	Deep	23.65	23.29	100	98.5	.....
Average								23.79	23.01	100	101.0	−.20

[1]A medium-sized, medium-maturing yellow dent variety from Nebraska, with kernels of medium depth.

TABLE 18.—*The immediate effect of cross-fertilization upon the kernel weight of University No. 3*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	6	126	Substation White	Nebr.	Early	Small	Shallow	22.88	23.10	100	101.0	−.78
2	9	225	Marteens White	Nebr.	Early	Small	Shallow	22.98	23.02	100	100.2	.82
3	6	227	Silver King	Mich.	Early	Medium	Medium	23.15	23.25	100	100.4	−.26
4	2	48	Navajo	Cal.	Medium	Small	Shallow	22.55	22.65	100	100.4	.....
5	10	387	High Protein	Ill.	Medium	Medium	Shallow	22.87	23.14	100	101.2	.81
6	9	161	Low Protein	Ill.	Medium	Medium	Medium	23.84	24.12	100	101.2	−.15
7	5	157	Blair White	Nebr.	Medium	Medium	Medium	22.92	23.48	100	102.4	.....
8	10	229	Nebr. White Prize	Nebr.	Late	Large	Deep	22.48	22.90	100	101.9	−.04
9	4	124	Virginia Horsetooth	Va.	Late	Large	Deep	22.12	22.45	100	101.5	−.52
10	10	251	Johnson Co. White	Del.	Late	Large	Deep	21.12	21.47	100	101.7	.81
Average								22.69	22.96	100	101.2	.07

[1]A medium-sized, medium-late, medium-deep-grained, yellow dent variety from Nebraska.

TABLE 19.—*The immediate effect of cross-fertilization upon the kernel weight of U. S. Selection Number 133,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	10	451	Red Flour Corn.....	Nebr.	Early	Small	Shallow	23.40	23.35	100	99.8	–.65
2	8	535	Chadron White.....	Nebr.	Early	Small	Shallow	20.88	21.14	100	101.2	–.36
3	7	124	Substation White	Nebr.	Early	Small	Shallow	24.30	24.35	100	100.2	–.51
4	10	244	Nevada White Dent...	Nev.	Early	Small	Shallow	24.32	24.22	100	99.6	–.10
5	8	483	Nebr. White Prize.....	Nebr.	Late	Large	Deep	26.39	26.77	100	101.4	–.06
Average..			.....	.....	.....	.....	.....	23.86	23.97	100	100.4	–.34

[1]A small, early-maturing, medium-deep-grained, yellow dent variety from Wisconsin.

TABLE 20.—*The immediate effect of cross-fertilization upon the kernel weight of Reid Yellow Dent,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
								Grams	*Grams*	*Per cent*	*Per cent*	*Per cent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	6	146	Nevada White Dent...	Nev.	Early	Small	Shallow	20.38	20.30	100	99.6	.....
2	6	126	High Protein.....	Ill.	Medium	Medium	Shallow	22.94	23.10	100	100.7	.....
3	5	90	Low Protein.....	Ill.	Medium	Medium	Medium	22.52	22.86	100	101.5	−.60
4	4	56	High Oil.....	Ill.	Medium	Medium	Medium	22.48	22.86	100	101.7	−.46
5	4	107	St. Charles White.....	Nebr.	Medium	Medium	Medium	24.71	24.80	100	100.4	−.32
6	5	138	Iowa Silver Mine.....	Nebr.	Medium	Medium	Medium	24.38	24.43	100	100.2	.06
7	3	54	Zea Ramosa.....	Cal.	Late	Medium	Shallow	21.85	21.56	100	98.7	.....
8	10	309	Low Oil.....	Ill.	Late	Medium	Medium	22.26	22.90	100	102.9	−.10
9	7	173	Boone County White ..	Nebr.	Late	Medium	Medium	23.25	22.94	100	98.7	.14
10	6	233	Nebr. White Prize.....	Nebr.	Late	Large	Deep	19.05	19.27	100	101.2	−.01
11	6	159	Missouri Cob Pipe.....	Mo.	Late	Large	Deep	23.25	23.70	100	101.9	.....
12	10	372	Johnson Co. White....	Del.	Late	Large	Deep	19.13	19.31	100	100.9	.58
Average..			.....	.....	.....	.....	.....	22.18	22.34	100	100.7	−.09

[1]A large, late-maturing, deep-grained, yellow dent variety from Illinois.

TABLE 21.—*The immediate effect of cross-fertilization upon the kernel weight of Nebraska White Prize,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Source of seed	Description		Depth of kernel	Actual		Relative		
					Time of maturing	Vegetative growth		Pure	Hybrid	Pure	Hybrid	
								Grams	*Grams*	*Per cent*	*Per cent*	*Per cent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	10	474	Blue Flour Corn	Nebr.	Early	Small	Shallow	20.61	20.27	100	98.4	.00
2	10	541	Minnesota King	Minn.	Early	Small	Shallow	23.15	23.06	100	99.6	−.27
3	10	361	Bloody Butcher	Nebr.	Early	Small	Shallow	22.67	22.55	100	99.5	.12
4	9	439	Minnesota No. 13	Colo.	Early	Small	Medium	23.18	22.76	100	98.2	.67
5	10	660	Dawes Co. Yellow	Nebr.	Early	Small	Medium	21.97	22.31	100	101.6	−.03
6	10	410	Substation White	Nebr.	Early	Small	Medium	21.26	21.09	100	99.2	.14
7	7	301	Calico	Nebr.	Early	Small	Medium	22.45	22.05	100	98.2	.40
8	4	112	Valley Co. Yellow	Nebr.	Early	Small	Medium	22.46	22.14	100	98.6	−.50
9	2	159	Red Rice Pop	Nebr.	Early	Medium	Shallow	19.85	19.59	100	98.7	.06
10	9	346	King Philip Flint	Cal.	Medium	Medium	Shallow	18.54	18.65	100	100.6	−.33
11	8	383	White Cap	N. J.	Medium	Medium	Medium	21.56	21.63	100	100.3	−.25
12	10	547	University No. 3	Nebr.	Medium	Medium	Medium	20.42	20.51	100	100.4	.58
13	10	687	Hogue Yellow Dent	Nebr.	Medium	Medium	Deep	20.36	20.25	100	99.5	−.32
14	8	383	Iodent	Iowa	Medium	Medium	Deep	22.15	21.97	100	99.2	.19
15	2	86	Zea Ramosa	Cal.	Late	Medium	Shallow	20.00	20.02	100	100.1	.29
16	6	375	Improved Leaming	Nebr.	Late	Medium	Medium	21.35	21.09	100	98.8	−.04
17	3	126	Bear Paw	Ohio	Late	Medium	Deep	21.44	21.02	100	98.0	−.07
18	5	208	Jarvis Golden Prolific	Tenn.	Late	Medium	Deep	20.00	20.50	100	102.5	−'23
Average								21.30	21.19	100	99.5	.02

[1]A large, late-maturing, deep-grained, white dent variety from Nebraska.

TABLE 22.—*The immediate effect of cross-fertilization upon the kernel weight of Sub-Station White,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
								Grams	*Grams*	*Per cent*	*Per cent*	*Per cent*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	5	204	Red Flour Corn	Nebr.	Early	Small	Shallow	21.56	21.28	100	98.7	−.24
2	6	154	Golden Bantam Sweet	Nebr.	Early	Small	Shallow	23.39	23.10	100	98.8	−.21
3	5	163	Bloody Butcher	Nebr.	Early	Small	Shallow	23.59	23.78	100	100.8	.22
4	10	583	Williams Dent	Mass.	Early	Small	Shallow	21.82	21.73	100	99.6	.....
5	5	138	Blue Flour Corn	Nebr.	Early	Small	Shallow	22.32	22.66	100	101.5	.19
6	10	432	Pride of North	Conn.	Early	Small	Shallow	20.69	20.55	100	99.3	−.18
7	4	156	Calico	Nebr.	Early	Small	Medium	21.42	21.40	100	99.9	.00
8	8	312	Golden Glow	Wis.	Early	Small	Medium	19.74	19.68	100	99.7	−.05
9	5	172	Minnesota No. 13	Colo.	Early	Small	Medium	22.96	23.12	100	100.7	.06
10	10	359	Ohio No. 84	Ohio	Early	Medium	Medium	20.12	20.31	100	100.9	−.22
11	8	236	King Philip Flint	Cal.	Medium	Medium	Shallow	24.42	24.63	100	100.9	−.52
12	10	375	White Cap Yellow	N. J.	Medium	Medium	Medium	21.39	21.45	100	100.3	.10
13	10	515	Iowa Gold Mine	Nebr.	Medium	Medium	Medium	19.76	19.51	100	98.7	.04
14	10	248	Improved Leaming	W. Va.	Medium	Medium	Deep	22.84	23.01	100	100.7	−.47
15	5	90	Iodent	Iowa	Medium	Medium	Deep	22.43	22.06	100	98.4	.01
16	8	357	Reid Yellow Dent	Nebr.	Medium	Medium	Deep	22.49	22.90	100	101.8	.20
17	10	618	Improved Leaming	Nebr.	Late	Medium	Medium	21.19	21.24	100	100.2	−.29
18	10	685	Washington Co. Yellow	Nebr.	Late	Medium	Deep	20.11	20.19	100	100.4	.81
19	10	363	Reid Yellow Dent	Ind.	Late	Large	Deep	21.50	21.81	100	101.4	−.52
20	10	620	Hogue Yellow Dent	Nebr.	Medium	Medium	Deep	21.33	21.39	100	100.3	.....
Average								21.75	21.79	100	100.1	−.06

[1]A small, early-maturing, shallow-grained, white dent variety from North Platte, Nebraska.

TABLE 23.—*The immediate effect of cross-fertilization upon the kernel weight of Saint Charles White,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	6	96	Pride of North.....	Conn.	Early	Small	Shallow	23.27	23.52	100	101.1	.23
2	10	300	Iowa Gold Mine.....	Nebr.	Medium	Medium	Medium	24.01	23.94	100	99.7	.43
3	10	515	Improved Leaming....	W. Va.	Medium	Medium	Deep	19.09	19.20	100	100.6	.12
4	10	375	Reid Yellow Dent.....	Nebr.	Medium	Medium	Deep	21.84	21.32	100	97.6	−.47
5	2	107	Nance Co. Yellow.....	Nebr.	Medium	Medium	Deep	22.95	22.59	100	98.4	.10
6	9	221	Jarvis Golden Prolific..	Tenn.	Late	Medium	Deep	22.83	23.01	100	100.8	−.34
7	5	100	Bear Paw.....	Ohio	Late	Medium	Deep	21.76	21.50	100	98.8	.58
8	6	95	St. Charles Yellow.....	Mo.	Late	Large	Medium	22.45	22.39	100	99.7	−.68
9	6	123	Reid Yellow Dent.....	Ill.	Late	Large	Deep	22.68	22.41	100	98.8	.31
10	10	391	Reid Yellow Dent.....	Ind.	Late	Large	Deep	22.44	22.35	100	99.6	−.13
11	8	542	Hogue Yellow Dent....	Nebr.	Medium	Medium	Deep	22.36	22.38	100	100.1	.....
Average..			.....	.....	.....	.....	.....	22.34	22.24	100	99.6	.02

[1]A medium-sized, medium-late, medium-deep-grained, white dent variety from Nebraska.

TABLE 24.—*The immediate effect of cross-fertilization upon the kernel weight of Iowa Silver Mine,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	10	263	Pride of North.....	Conn.	Early.	Small	Shallow	24.60	24.11	100	98.0	.49
2	6	135	Minnesota King.....	Minn.	Early	Small	Shallow	22.36	22.07	100	98.7	-.43
3	7	179	Duncan Yellow Dent..	Mich.	Early	Small	Medium	19.72	19.49	100	98.8	.62
4	6	73	Mousel Yellow Dent...	Nebr.	Early	Medium	Medium	21.99	21.70	100	98.7	-.55
5	7	137	University No. 3.....	Nebr.	Medium	Medium	Medium	22.57	22.71	100	100.6	.....
6	6	134	Iowa Gold Mine.....	Nebr.	Medium	Medium	Medium	22.96	22.62	100	98.5	-.01
7	3	64	Iodent.....	Iowa	Medium	Medium	Deep	23.08	22.92	100	99.3	-.05
8	10	229	Improved Leaming....	Nebr.	Late	Medium	Medium	21.43	21.52	100	100.4	-.18
9	7	176	Bear Paw.....	Ohio	Late	Medium	Deep	24.32	23.80	100	97.9	.....
10	5	111	Jarvis Golden Prolific..	Tenn.	Late	Medium	Deep	21.12	21.48	100	101.7	-.15
11	10	357	Reid Yellow Dent.....	Ind.	Late	Large	Deep	23.81	23.47	100	98.6	-.18
Average ..			.....	.....	.....	.....	.....	22.54	22.35	100	99.2	-.05

[1]A medium-sized, medium-late, medium-deep-grained white dent variety from Nebraska.

TABLE 25.—*The immediate effect of cross-fertilization upon the kernel weight of Marteens White White,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	8	147	Cornell No. 11.....	N. Y.	Early	Small	Shallow	18.22	18.21	100	100.0	−.33
2	9	224	Pride of North.....	Colo.	Early	Small	Shallow	20.64	20.66	100	100.1	−.15
3	7	243	Williams Dent.....	Mass.	Early	Small	Shallow	19.40	19.62	100	101.2	.18
4	7	489	Minnesota No. 13.....	Colo.	Earlu	Small	Medium	22.77	22.68	100	99.6	−.61
5	8	261	Dawes Co. Yellow.....	Nebr.	Early	Small	Medium	20.38	20.42	100	100.2	−.65
6	10	289	Mousel Yellow Dent...	Nebr.	Early	Medium	Medium	19.33	18.98	100	98.2	.....
7	8	236	Iowa Gold Mine.....	Nebr.	Medium	Medium	Medium	18.22	18.41	100	101.0	−.87
8	9	248	Reid Yellow Dent.....	Nebr.	Medium	Medium	Deep	19.82	20.02	100	101.0	.....
9	8	182	Nance Co. Yellow.....	Nebr.	Medium	Medium	Deep	19.34	19.41	100	100.4	.....
10	10	322	Hogue Yellow Dent....	Nebr.	Medium	Medium	Deep	21.73	22.10	100	101.7	.05
11	10	166	Improved Leaming....	W. Va.	Medium	Medium	Deep	19.64	19.62	100	99.9	.....
12	7	146	Graham Corn.....	Nebr.	Medium	Medium	Deep	20.87	21.19	100	101.6	−.18
13	10	302	Reid Yellow Dent.....	Ind.	Late	Large	Deep	18.66	18.57	100	99.5	−.24
Average								19.92	19.91	100	100.0	−.31

[1]A small, early-maturing, shallow-grained, white dent variety from North Platte, Nebraska.

TABLE 26.—*The immediate effect of cross-fertilization upon the kernel weight of Boone County White,*[1] *as related to the character of the foreign pollen parent*

Combination Number	Number of ears	Number of kernel pairs	Foreign pollen parent					Moisture-free weight of 100 kernels				Gain or loss in moisture content
			Variety name	Description				Actual		Relative		
				Source of seed	Time of maturing	Vegetative growth	Depth of kernel	Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	*Grams* (9)	*Grams* (10)	*Per cent* (11)	*Per cent* (12)	*Per cent* (13)
1	10	344	University No. 3.....	Nebr.	Medium	Medium	Medium	21.14	20.94	100	99.1	.23
2	10	332	Iowa Gold Mine.....	Nebr.	Medium	Medium	Medium	23.16	22.94	100	99.1	−.61
3	10	370	Hogue Yellow Dent....	Nebr.	Medium	Medium	Deep	19.31	19.41	100	100.5	.02
4	4	106	Improved Leaming....	W. Va.	Medium	Medium	Deep	22.01	21.77	100	98.9	−.02
5	4	78	Nance Co. Yellow.....	Nebr.	Medium	Medium	Deep	22.78	22.35	100	98.1	−.59
6	7	220	Jarvis Golden Prolific..	Tenn.	Late	Medium	Deep	23.07	23.24	100	100.7	−.44
7	10	217	Bear Paw.....	Ohio	Late	Medium	Deep	23.67	23.79	100	100.5	−.68
8	4	77	Reid Yellow Dent.....	Ind.	Late	Large	Deep	24.36	24.51	100	100.6	.....
Average ..			.....	.....	.....	.....	.....	22.44	22.37	100	99.7	−.30

[1]A medium-sized, late-maturing, medium-deep-grained, white dent variety from Nebraska.

Marteens White Dent was used as the ear bearing parent in 13 crosses (Table 25). The range in response to foreign pollen was from a decrease of 1.8 per cent to an increase of 1.7 per cent. The average weight of the hybrid kernels was the same as for the pure.

Boone County White ranged in its response to foreign pollen from a decrease of 1.9 per cent to an increase of 0.7 per cent in 8 crosses (Table 26) and gave a mean decrease of 0.3 per cent.

FOREIGN POLLEN EFFECTS CLASSIFIED ACCORDING TO VARIOUS CHARACTERS OF THE FEMALE PARENTS

The results secured from all of the dent variety combinations reported in Tables 12 to 26 are summarized in the first half of Table 27 according to various characteristics of the female parent. Briefly these results are as follows:

Classified According to Kernel Type of the Female Parent. — The kernel weight of shallow-grained varieties in 38 combinations was increased an average of 0.4 per cent as an immediate effect of cross-fertilization by other varieties. Varieties of medium kernel depth increased an average of 0.3 per cent in 118 combinations, and deep-kerneled varieties 0.3 per cent in 44 combinations.

Classified According to Vegetative Size of the Female Parent.— Small varieties responded with an average increase of 0.5 per cent in kernel weight as an immediate effect of cross-fertilization in 49 combinations. Medium-sized varieties increased 0.3 per cent in 101 combinations, and large varieties averaged an increase of 0.1 per cent in 50 combinations.

Classified According to Earliness of Maturity of the Female Parent.— Early varieties increased 0.6 per cent in 52 combinations. Medium-late varieties increased 0.4 per cent in 89 combinations, and late varieties increased 0.1 per cent in 59 combinations.

FOREIGN POLLEN EFFECTS CLASSIFIED ACCORDING TO VARIOUS CHARACTERS OF THE MALE PARENTS

When all of the variety combinations reported in Tables 12 to 26 are classified according to various characteristics of the male parent as in the second half of Table 27, the following results are obtained:

Classified According to the Kernel Type of the Male Parents.— Fertilization by shallow-grained varieties resulted in an average increased kernel weight of 0.1 per cent in 42

variety combinations. Varieties fertilized by medium-deep-grained sorts gave an increase of 0.3 per cent in 67 combinations and fertilization by deep-grained sorts increased the kernel weight 0.3 per cent in 91 variety combinations.

Classified According to the Vegetative Size of the Male Parent.— Varieties were increased an average of 0.1 per cent

TABLE 27.—*Summary showing the relation of the character of either parent to the immediate effect of cross-fertilization between commercial dent varieties*

Description	Number of combinations	Ratio Weight of hybrid to pure kernels
		Per cent
Classified by type of ear-bearing parent		
EAR-BEARING PARENT CLASSIFIED ACCORDING TO KERNEL DEPTH		
Shallow	38	100.4
Medium	118	100.3
Deep	44	100.3
EAR-BEARING PARENT CLASSIFIED ACCORDING TO VEGETATIVE SIZE		
Small	49	100.5
Medium	101	100.3
Large	50	100.1
EAR-BEARING PARENT CLASSIFIED ACCORDING TO TIME OF MATURITY		
Early	52	100.6
Medium	89	100.4
Late	59	100.1
Classified by type of pollen parent		
FOREIGN POLLEN PARENT CLASSIFIED ACCORDING TO KERNEL DEPTH		
Shallow	42	100.1
Medium	67	100.3
Deep	91	100.3
FOREIGN POLLEN PARENT CLASSIFIED ACCORDING TO VEGETATIVE SIZE		
Small	51	100.1
Medium	98	100.1
Large	51	101.0
FOREIGN POLLEN PARENT CLASSIFIED ACCORDING TO TIME OF MATURITY		
Early	51	100.0
Medium	78	100.2
Late	71	100.7

Date summarized from Tables 12 to 26.

in kernel weight by foreign pollen from small varieties in 51 combinations. Cross-fertilization by medium-large varieties increased the kernel weights 0.1 per cent in 98 variety com-

binations. Varieties had their kernel weight increased 1.0 per cent in 51 variety combinations when fertilized by large varieties.

Classified According to the Time of Maturity of the Male Parent.— The kernel weight remained unaffected as an average for 51 variety combinations when fertilized by pollen from early-maturing sorts. Varieties were increased 0.2 per cent by pollen from medium-late varieties in 78 combinations and the increase was 0.7 per cent in 71 combinations when the pollen was derived from late varieties.

FOREIGN POLLEN EFFECTS CLASSIFIED ACCORDING TO THE CHARACTERS OF BOTH PARENTS

When classification of all the various combinations reported in Tables 12–26 is made on the basis of the various characteristics of both parents as in Table 28, the following results are obtained.

Classified According to the Kernel Depth of Both Parents. — Thirteen shallow varieties crossed by shallow varieties responded with an average increased kernel weight of 0.2 per cent. Eleven shallow varieties crossed by medium-deep-grained varieties gave no change in kernel weight, and 14 shallow-grained varieties crossed by deep-grained sorts increased 0.9 per cent.

Medium-deep-grained varieties used as the female parent in 22 combinations with shallow, 41 combinations with medium, and 55 combinations with deep-grained varieties gave respective average increased kernel weights of 0.3, 0.5, and 0.1 per cent.

Seven deep-grained varieties fertilized by pollen from shallow-grained varieties decreased 0.5 per cent in kernel weight. Fifteen deep-grained varieties fertilized by medium varieties increased 0.1 per cent in kernel weight, and 22 deep-grained sorts increased 0.6 per cent when fertilized by deep-grained varieties.

Classified According to Vegetative Size of both Parents.— Small varieties used as the female parents in 23 combinations with small, in 17 combinations with medium, and in 9 combinations with large varieties gave the respective average increased kernel weights of 0.3, 0.3, and 1.6 per cent.

Medium-sized varieties used as the female parents in 20 combinations with small, in 46 combinations with medium, and in 35 combinations with large varieties gave the respective average increased kernel weights of 0.3, 0.2, and 0.6 per cent.

Large varieties used as female parents in 8 combinations with small varieties decreased 0.7 per cent. When crossed with medium-sized varieties in 35 combinations, the kernel weight remained normal; and when crossed with large varieties in 7 combinations, the kernels increased 1.3 per cent in weight.

TABLE 28.—*Summary showing the immediate effect of foreign dent pollen upon the kernel weight of dent varieties as influenced by the kernel and plant character of both parents*

Plant and kernel character		Number of combinations averaged	Ratio of hybrid to pure kernels
Ear parent	Foreign pollen parent		
VARIETIES CLASSIFIED ACCORDING TO KERNEL DEPTH			
Shallow	Shallow	13	100.2
Shallow	Medium	11	100.0
Shallow	Deep	14	100.9
Medium	Shallow	22	100.3
Medium	Medium	41	100.5
Medium	Deep	55	100.1
Deep	Shallow	7	99.5
Deep	Medium	15	100.1
Deep	Deep	22	100.6
VARIETIES CLASSIFIED ACCORDING TO VEGETATIVE SIZE			
Small	Small	23	100.3
Small	Medium	17	100.3
Small	Large	9	101.6
Medium	Small	20	100.3
Medium	Medium	46	100.2
Medium	Large	35	100.6
Large	Small	8	99.3
Large	Medium	35	100.0
Large	Large	7	101.3
VARIETIES CLASSIFIED ACCORDING TO TIME OF MATURITY			
Early	Early	26	100.2
Early	Medium	14	100.7
Early	Late	12	101.3
Medium	Early	17	100.1
Medium	Medium	32	100.3
Medium	Late	40	100.5
Late	Early	8	99.3
Late	Medium	32	99.8
Late	Late	19	100.8

Classified According to Time of Maturity of Both Parents. Early varieties used as the female parent in 26 combinations with early, 14 combinations with medium, and 12 combinations with late varieties increased in kernel weight respectively 0.2, 0.7, and 1.3 per cent.

Medium-late varieties in 17 combinations with early, 32 combinations with medium, and 40 combinations with late varieties, increased respectively 0.1, 0.3, and 0.5 per cent in kernel weight.

TABLE 29.—*Condensed summary showing the immediate effect of foreign dent pollen upon the kernel weight of dent varieties as influenced by the kernel and plant character of both parents*[1]

Plant and kernel character		Ratio of hybrid to pure
Ear parent	Foreign pollen parent	
Early, small, or shallow	Early, small, or shallow	100.2
Early, small, or shallow	Medium in earliness, size, or depth	100.3
Early, small, or shallow	Late, large, or deep	101.3
Medium in earliness, size, or depth	Early, small, or shallow	100.2
Medium in earliness, size, or depth	Medium in earliness, size or depth	100.3
Medium in earliness, size, or depth	Late, large, or deep	100.4
Late, large, or deep	Early, small, or shallow	99.4
Late, large, or deep	Medium in earliness, size or depth	100.0
Late, large, or deep	Late, large, or deep	100.9
AVERAGES		
All combinations	Early, small, or shallow	100.0
All combinations	Medium in earliness, size, or depth	100.2
All combinations	Late, Large, deep	100.9
Early, small or shallow	All combinations	100.6
Medium in earliness, size or depth	All combinations	100.3
Late, large, or deep	All combinations	100.1

[1]Summarized from Table 28

Late varieties used as the female parent in 8 combinations with early and 32 combinations with medium-late varieties decreased respectively 0.7 and 0.2 per cent. When crossed with late varieties in 19 combinations the kernel weight was increased 0.8 per cent.

SUMMARY OF PARENTAL TYPE CLASSIFICATION

The data of Table 28 are still more condensed in Table 29 so that all combinations fall into the three groups: (1) mini-

mum, (2) medium, and (3) maximum, as to either kernel depth, plant size, or earliness of maturity.

Averaging all combinations in which the pollen parent was either shallow, small, or early, the hybrid kernels were the same in weight as the pure. In all combinations in which the pollen parent was either medium-deep-grained, medium-large, or medium-early the hybrid kernels were 0.2 per cent heavier than the pure. Deep-grained, large, and late-maturing varieties used as pollen parents increased the average kernel weight 0.9 per cent.

TABLE 30.—*The immediate effect of foreign pollen upon the kernel weight of rough and smooth selections of Nebraska White Prize and Hogue Yellow Dent corn*

Variety and kernel character		Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
				Actual		Relative	
Ear parent	Foreign pollen parent			Pure	Hybrid	Pure	Hybrid
(1)	(2)	(3)	(4)	*Grams* (5)	*Grams* (6)	*Per cent* (7)	*Per cent* (8)
H. Y. D. . Rough	N. W. P. . Smooth	8	242	23.38	23.41	100	100.1
H. Y. D. . Rough	N. W. P. . Rough	6	295	19.07	19.44	100	101.9
H. Y. D. . Smooth	N. W. P. . Smooth	6	294	19.67	19.97	100	101.5
H. Y. D. . Smooth	N. W. P. . Rough	8	344	19.56	19.72	100	100.8
Average				20.42	20.64	100	101.1
N. W. P. . Rough	H. Y. D. . Smooth	8	236	22.08	22.10	100	100.1
N. W. P. . Rough	H. Y. D. . Rough	10	472	25.03	24.72	100	98.8
N. W. P. . Smooth	H. Y. D. . Smooth	10	578	21.08	20.89	100	99.1
N. W. P. . Smooth	H. Y. D. . Rough	8	474	22.84	23.06	100	101.0
Average				22.76	22.69	100	99.8
AVERAGE BOTH VARIETIES							
Rough	Smooth			22.73	22.76	100	100.1
Rough	Rough			22.05	22.08	100	100.4
Smooth	Smooth			20.38	20.43	100	100.3
Smooth	Rough			21.20	21.39	100	100.9

It appears from these data that the inheritance transmitted from large, deep-grained, late-maturing varieties causes the grain of other varieties fertilized by them to weigh an average of approximately one per cent heavier than when crossed by small, shallow-grained, early-ripening varieties. The tendency for F_1 variety hybrids to be intermediate in character receives expression in xenia effects to the extent of only 1 per cent in modifying kernel weights.

THE IMMEDIATE EFFECT OF FOREIGN POLLEN UPON THE KERNEL WEIGHT OF VARIOUS EAR TYPE SELECTIONS OF STANDARD DENT VARIETIES

Composite samples of rough- and smooth-ear types were selected from the ordinary Hogue Yellow Dent and Nebraska White Prize varieties and each type was grown in field plats in 1922. Reciprocal type crosses were made between the 2 varieties and the results are reported in Table 30. As an average for both varieties the kernel weights of rough ears were increased 0.1 per cent when they were fertilized by foreign pollen from smooth ears. Rough ears fertilized with pollen from foreign rough types increased 0.4 per cent in kernel weight.

Smooth ears fertilized with pollen from unrelated smooth ears responded with an increased kernel weight of 0.3 per cent. The kernels of smooth ears increased 0.9 per cent in weight when fertilized by pollen from rough ear types. Thus no striking immediate effect is apparent from crossing unlike ear types which have been selected for but a single year.

THE IMMEDIATE EFFECT OF FOREIGN POLLEN UPON THE KERNEL WEIGHT OF CORN THAT HAS UNDERGONE PROLONGED RESTRICTED TYPE SELECTION

The High and Low Protein and High and Low Oil Selections of the Burr White variety were obtained from the Illinois Agricultural Experiment Station and studied as to their kernel weight response to fertilization by foreign dent pollen during the two years 1922 and 1923. These strains have been subject to such close selection for chemical composition that their heterozygosity has been reduced. This is indicated by a comparative yield test of these strains (Table 31) and 2 F_1 hybrids between them in 1923. The 4 chemical strains averaged 52.3 bushels per acre compared with 67 bushels for the 2 hybrids.

These 2 F_1 hybrids, viz, High x Low Protein and High x Low Oil, responded to foreign pollen in 1923 by the respective increases of 0.7 and 0.5 per cent in kernel weight. In comparison the corresponding kernel-weight increases resulting from fertilization by foreign pollen were 2.6, 1.2, 9.8, and 1.4 per cent, respectively, for the High Protein, Low Protein, High Oil, and Low Oil strains.

An average shortage of 15 bushels or 23 per cent in yielding ability, due, apparently, to reduced heterosis in the

TABLE 31.—*The immediate effect of foreign pollen upon the kernel weight of corn which has been subject to continued restricted selection for grain composition. (Illinois High and Low Protein and High and Low Oil strains of the Burr White variety.) 1922 and 1923*

Ear parent	Grain yield per acre	Foreign pollen parent	Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
					Actual		Relative	
					Pure	Hybrid	Pure	Hybrid
(1)	*Bushels* (2)	(3)	(4)	(5)	*Grams* (6)	*Grams* (7)	*Per cent* (8)	*Per cent* (9)
		YEAR 1922						
High Protein	.....	Hogue Yellow Dent....	10	414	20.10	20.76	100	103.3
High Protein	.....	Reid Yellow Dent.....	6	309	19.24	19.45	100	101.1
High Protein	.....	University No. 3.....	6	372	20.11	20.48	100	101.8
Average	.....	.....	.....	.....	19.82	20.23	100	102.0
Low Protein	.....	University No. 3.....	6	272	17.64	17.81	100	101.0
Low Protein	.....	Reid Yellow Dent.....	5	124	21.35	22.13	100	103.7
Low Protein	.....	Hogue Yellow Dent....	9	224	22.19	21.92	100	98.8
Average	.....	.....	.....	.....	20.39	20.62	100	101.1
High Oil	.....	Reid Yellow Dent.....	10	642	17.88	18.53	100	103.6
High Oil	.....	Improved Leaming....	10	708	15.45	16.15	100	104.5
Average	.....	.....	.....	.....	16.67	17.34	100	104.0
Low Oil	.....	Hogue Yellow Dent....	8	201	20.67	21.22	100	102.7
Low Oil	.....	Reid Yellow Dent.....	5	125	23.87	24.38	100	102.1
Average	.....	.....	.....	.....	22.27	22.80	100	102.4

TABLE 31 (Continued).—*The immediate effect of foreign pollen upon the kernel weight of corn which has been subject to continued restricted selection for grain composition. (Illinois High and Low Protein and High and Low Oil strains of the Burr White variety.) 1922 and 1923*

Ear parent	Grain yield per acre	Foreign pollen parent	Number of ears	Number of Kernel pairs	Moisture-free weight of 100 kernels			
					Actual		Relative	
					Pure	Hybrid	Pure	Hybrid
(1)	*Bushels* (2)	(3)	(4)	(5)	*Grams* (6)	*Grams* (7)	*Per cent* (8)	*Per cent* (9)
		YEAR 1923						
High Protein	55.3	Hogue Yellow Dent	4	217	30.40	31.34	100	103.1
High Protein	55.3	Reid Yellow Dent	8	322	26.00	26.53	100	102.0
Average					28.20	28.84	100	102.6
Low Protein	51.0	Hogue Yellow Dent	4	196	21.07	21.16	100	100.4
Low Protein	51.0	Reid Yellow Dent	4	369	23.28	23.74	100	102.0
Average					22.18	22.45	100	101.2
High Oil	42.3	Hogue Yellow Dent	4	148	21.64	24.08	100	111.3
High Oil	42.3	Improved Leaming	5	384	21.94	23.75	100	108.3
Average					21.79	23.92	100	109.8
Low Oil	60.6	Hogue Yellow Dent	8	496	30.07	30.49	100	101.4
Low Oil	60.6	Reid Yellow Dent	9	638	31.06	31.46	100	101.3
Average					30.57	30.98	100	101.4
Hybrids								
F_1 High Protein x Low Protein	64.1	Hogue Yellow Dent	6	255	28.60	28.80	.....	100.7
F_1 High Oil x Low Oil	69.8	Hogue Yellow Dent	4	155	29.98	30.14	.....	100.5
Average					29.29	29.61	.....	100.6
2-YEAR AVERAGE OF COMBINATIONS ON CHEMICAL STRAINS								
High Protein							100	102.4
Low Protein							100	101.2
High Oil							100	106.9
Low Oil							100	101.9

specialized strains, was manifested as an immediate effect of foreign pollen to the extent of an average increased kernel weight of approximately 3.7 per cent.

As an average for the 2 years, the increased kernel weights resulting from fertilization by foreign pollen equalled 2.4, 1.2, 6.9, and 1.9 per cent, respectively, for the High Protein, Low Protein, High Oil, and Low Oil strains.

THE IMMEDIATE EFFECT OF FOREIGN POLLEN UPON KERNEL WEIGHT WHEN VARIOUS ENDOSPERM TYPES ARE CROSSED

The immediate effect upon kernel weight from cross-fertilization between various endosperm types is shown in Table 32 and is summarized in Table 33. The result may be stated as follows: 200 dent-by-dent crosses increased 0.3 per cent; 2 sweet-by-sweet crosses increased 2.0 per cent; 5 dent-by-flint crosses increased 0.3 per cent; 1 dent-by-pop cross decreased 1.3 per cent; 2 dent-by-sweet crosses decreased 1.2 per cent; 4 dent-by-flour crosses decreased 0.2 per cent; 4 sweet-by-dent crosses increased 21.5 per cent; 2 sweet-by-flour crosses increased 15.5 per cent; 1 sweet-by-pop cross increased 14.4 per cent; 1 sweet-by-waxy cross increased 20.2 per cent; 1 flint-by-sweet cross decreased 1.4 per cent; 4 flint-by-dent crosses increased 2.3 per cent; 1 pop-by-pop cross increased 0.1 per cent; 1 pop-by-dent increased 3.0 per cent; 2 waxy-by-dent crosses increased 5.6 per cent.

Most of these kernel-weight effects resulting from cross-fertilization are to be accounted for by either (1) a change in heterosis, (2) a slight tendency for the embryo and endosperm in the F_1 condition to assume an intermediate growth between the two parental varieties, or (3) a change in endosperm type. The first 2 of these factors may account for all of these changes in weight except in the case of sweet and perhaps waxy varieties crossed by other endosperm types. When sweet kernels are fertilized by starchy types, the starch character is dominant and results in starchy kernels of greater weight. The progressive precipitation of carbohydrates in the starchy kernel until maturity is reached does not occur to the same extent in pure sweet kernels. The sugars of pure sweet corn remain in solution to a greater extent in sweet kernels until cured and therefore less substance can be translocated into such kernels by osmosis than in the case of a starchy kernel. This greater osmotic intake and storage of substance is very apparent in mature grain.

TABLE 32.—*The immediate effect of foreign pollen upon the kernel weight of various endosperm types of corn, one or both of the parents being other than dent*

Ear parent	Foreign pollen parent	Type of corn		Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
		Ear parent	Foreign pollen parent			Actual		Relative	
						Pure	Hybrid	Pure	Hybrid
(1)	(2)	(3)	(4)	(5)	(6)	*Grams* (7)	*Grams* (8)	*Per cent* (9)	*Per cent* (10)
Dent									
1 Minnesota No. 13	White Australian	Dent	Flint	8	322	23.53	23.84	100	101.3
2 Rustler White	Gehu	Dent	Flint	8	363	26.22	25.92	100	98.9
3 Substation White	King Philip	Dent	Flint	8	236	24.42	24.63	100	100.9
4 Nebraska White Prize	King Philip	Dent	Flint	9	346	18.54	18.65	100	100.6
5 University No. 3	Navajo	Dent	Flint	2	48	22.55	22.65	100	100.4
6 Nebraska White Prize	Red Rice Pop	Dent	Pop	2	159	19.85	19.59	100	98.7
7 Hogue Yellow Dent	Black Mexican	Dent	Sweet	5	137	23.93	23.66	100	98.9
8 Substation White	Golden Bantam	Dent	Sweet	6	154	23.39	23.10	100	98.8
9 Hogue Yellow Dent	Red Flour	Dent	Flour	8	332	20.81	20.65	100	99.2
10 Substation White	Blue Flour	Dent	Flour	5	138	22.32	22.66	100	101.5
11 Substation White	Red Flour	Dent	Flour	5	204	21.56	21.28	100	98.7
12 U. S. Selection 133	Red Flour	Dent	Flour	10	451	23.40	23.35	100	99.8
Average						22.54	22.49	100	99.8
Sweet									
13 Golden Bantam	Black Mexican	Sweet	Sweet	10	287	21.04	21.31	100	101.3
14 Country Gentleman	Black Mexican	Sweet	Sweet	8	113	12.72	13.06	100	102.7
Average						16.88	16.68	100	102.0
15 Country Gentleman	Calico	Sweet	Dent	2	144	8.21	9.39	100	114.4
16 Black Mexican	U. S. Selection 133	Sweet	Dent	6	82	21.88	26.60	100	121.6
17 Golden Bantam	U. S. Selection 133	Sweet	Dent	9	272	19.01	24.39	100	128.3
18 Country Gentleman	Red Flour	Sweet	Flour	3	101	10.22	11.59	100	113.4
19 Country Gentleman	Blue Flour	Sweet	Flour	3	54	13.94	16.39	100	117.6
20 Country Gentleman	White Pearl	Sweet	Pop	2	50	9.16	10.48	100	114.4
21 Stowells Evergreen	Hogue Yellow Dent	Sweet	Dent	7	371	21.43	26.05	100	121.6
22 Stowells Evergreen	Chinese	Sweet	Waxy	10	784	15.67	18.84	100	120.2
Average						14.94	17.97	100	118.9

TABLE 32 (Continued).—*The immediate effect of foreign pollen upon the kernel weight of various endorsperm types of corn, one or both of the parents being other than dent*

Ear parent	Foreign pollen parent	Type of corn		Number of ears	Number of kernel pairs	Moisture-free weight of 100 kernels			
		Ear parent	Foreign pollen parent			Actual		Relative	
						Pure	Hybrid	Pure	Hybrid
(1)	(2)	(3)	(4)	(5)	(6)	*Grams* (7)	*Grams* (8)	*Per cent* (9)	*Per cent* (10)
Flint									
23 White Australian	Golden Bantam	Flint	Sweet	3	175	21.34	21.05	100	98.6
24 White Australian	Minnesota No. 13	Flint	Dent	6	215	23.38	24.21	100	103.6
25 Rhode Island Flint	U. S. Selection 133	Flint	Dent	10	502	25.91	27.37	100	105.6
26 King Philip	Nebraska White Prize	Flint	Dent	7	261	21.63	21.71	100	100.4
27 Gehu Flint	Rustler White	Flint	Dent	2	57	13.49	13.46	100	99.8
Average						21.15	21.56	100	101.6
Pop									
28 Yellow Rice Pop	Red Rice Pop	Pop	Pop	10	479	12.03	12.04	100	100.1
29 Japanese Rice Pop	Reid Yellow Dent	Pop	Dent	12	264	6.44	6.63	100	103.0
Waxy									
30 Chinese[1]	Yellow Flint	Waxy	Flint	4	130	10.85	11.85	100	109.5
31 Chinese[2]	Hogue Yellow Dent	Waxy	Dent	3	90	8.37	9.00	100	107.5
32 Chinese[2]	Reid Yellow Dent	Waxy	Dent	5	248	14.01	14.52	100	103.6

[1]This Chinese corn has been subject to close-breeding which it was thought might account for the large increase.
[2]The Chinese seed planted in this case was reported by Collins to be fully as heterozygous as any grown in China.

The sweet kernels are translucent and shrunken in comparison with the smooth, plump, and starchy hybrid grain resulting from cross-pollination.

Evidence that the marked increase in kernel weight resulting from fertilization of sweet by starchy corn is due to change in composition of the endosperm rather than to heterosis is brought out in the following comparison (Table 34). When

TABLE 33.—*Summary showing the immediate effect of foreign pollen upon the kernel weight of various endosperm types of corn*

Endosperm type of corn		Number of combinations averaged	Ratio Weight of hybrid to pure kernels
Ear parent	Foreign pollen parent		
			Per cent
Sweet	Sweet	2	102.0
Sweet	Dent	4	121.5
Sweet	Flour	2	115.5
Sweet	Pop	1	114.4
Sweet	Waxy	1	120.2
Dent	Dent	200	100.3
Dent	Pop	1	98.7
Dent	Sweet	2	98.8
Dent	Flour	4	99.8
Dent	Flint	5	100.3
Flint	Dent	4	102.3
Flint	Sweet	1	98.6
Pop	Pop	1	100.1
Pop	Dent	1	103.0
Waxy[1]	Flint	1	109.5
Waxy[2]	Dent	2	105.6

[1] The seed secured from G. N. Collins was marked close-bred which might account for the large responses.
[2] The second lot of Chinese seed was reported normally heterozygous.

Golden Bantam sweet corn was fertilized by another sweet variety, Black Mexican, its kernel weight increased 1.3 per cent. This was due to an increase of 3.3 per cent in the embryo and 0.6 per cent in the endosperm. The pericarp weight was not affected. When the same variety was fertilized by a dent variety the kernel weight increased 23.9 per cent accompanied by no change in the embryo weight and 31 per

cent increase in endosperm. The weight of the pericarp was increased only 1.4 per cent.

From its behavior in these rather limited tests the Chinese or waxy type of endosperm appears to be somewhat intermediate between that of starchy and sweet corn. The erythrodextrin endosperm of this type has undergone greater increase than dent corn but less than sweet corn when crossed with starchy corn.

THE IMMEDIATE EFFECT OF CROSS-FERTILIZATION UPON THE RELATIVE WEIGHTS OF THE KERNEL PARTS OF COMMERCIAL VARIETIES OF CORN

The relative weights of kernel, embryo, endosperm, and pericarp were determined in 1922 for both pure and hybrid kernels of a number of variety combinations. Table 34.

Ten combinations between dent varieties which showed very little response to foreign pollen averaged a 0.5 per cent reduction in kernel weight. For these varieties the embryo averaged 1.6 per cent increase, the endosperm 0.9 per cent decrease, and the pericarp 0.2 per cent increase.

Four variety combinations of dent corn which showed a relatively large response as an immediate effect of foreign pollen averaged 3.1 per cent increase in kernel weight. The embryo, endosperm, and pericarp increased respectively 6.1, 2.8, and 1.1 per cent. These data suggest that for these varieties which lacked somewhat in heterozygosity the embryo responded more than the endosperm.

Since the pericarp is part of the mother plant and is not subject to cross-fertilization, its slight increase in weight is not due to change in genetic constitution but is simply an accompanying growth correlation.

GRAPHIC PRESENTATION OF SEVERAL OUTSTANDING RESULTS

A number of important determinations summarized in Tables 5, 8, 28, 33, and 34 are shown graphically in charts 1, 2, and 3. The results charted are the immediate effects of foreign pollen upon (1) the kernel weights of various endosperm types, (2) the kernel weights of dent corn which has been subject to various degrees of closebreeding, (3) the kernel weights of commercial dent varieties differing in plant and kernel type, and (4) the weights of various parts of the kernels of corn differing in either heterozygosity or endosperm type.

TABLE 34.—*The immediate effect of foreign pollen upon the relative development of different parts of the grain of commercial varieties*

Variety		Number of ears	Ratio of Hybrid to pure kernels (Moisture-free weights)				Ratio of embryo to endosperm	
Ear parent	Foreign pollen parent		Kernel	Embryo	Endosperm	Pericarp	Pure	Hybrid
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
DENT VARIETIES GIVING RELATIVELY SMALL RESPONSE TO FOREIGN POLLEN								
University No. 3	Illinois High Protein[1]	10	1.017	1.018	1.019	.976	0.145	0.145
Hogue Yellow Dent	U. S. Selection 120	7	1.003	1.014	1.001	1.002	0.144	0.146
Rustler White	Northwestern Dent	9	1.002	1.012	1.001	1.006	0.145	0.147
Pride of North	Chadron White Dent	9	1.006	1.023	1.003	1.013	0.136	0.139
Hogue Yellow Dent	Nebraska White Prize	7	0.997	1.047	0.989	1.014	0.123	0.132
Brookings No. 86	Northwestern Dent	9	0.997	1.000	0.995	1.016	0.142	0.142
Valentine White Dent	Hogue Yellow Dent	10	0.981	1.000	0.977	0.995	0.131	0.134
Hogue Yellow Dent	Illinois High Oil[1]	9	0.989	1.129	0.969	1.000	0.139	0.162
Substation White	Iowa Gold Mine	9	0.982	0.936	0.987	1.000	0.136	0.129
Rustler White	Gehu Flint	9	0.971	0.981	0.966	1.002	0.136	0.139
Average			0.995	1.016	0.991	1.002	0.138	0.142
DENT VARIETIES GIVING RELATIVELY LARGE RESPONSE TO FOREIGN POLLEN								
Improved Leaming	Illinois High Oil[1]	10	1.027	1.082	1.019	1.015	0.165	0.175
Washington County Dent	Nebraska White Prize	10	1.020	1.051	1.016	1.009	0.157	0.163
Illinois Low Oil[1]	Hogue Yellow Dent	10	1.045	1.091	1.044	1.000	0.080	0.084
Illinois High Oil[1]	Improved Leaming	10	1.034	1.023	1.036	1.020	0.170	0.168
Average			1.031	1.061	1.028	1.011	0.143	0.148
SWEET-BY-SWEET AND SWEET-BY-DENT COMBINATIONS								
Golden Bantam Sweet	Black Mexican Sweet	10	1.013	1.033	1.006	1.000	0.223	0.236
Golden Bantam Sweet	U. S. Selection 133	8	1.239	1.000	1.310	1.014	0.214	0.163

[1]The Illinois strains have been produced by close selection for chemical composition during many years and are not grown commercially.

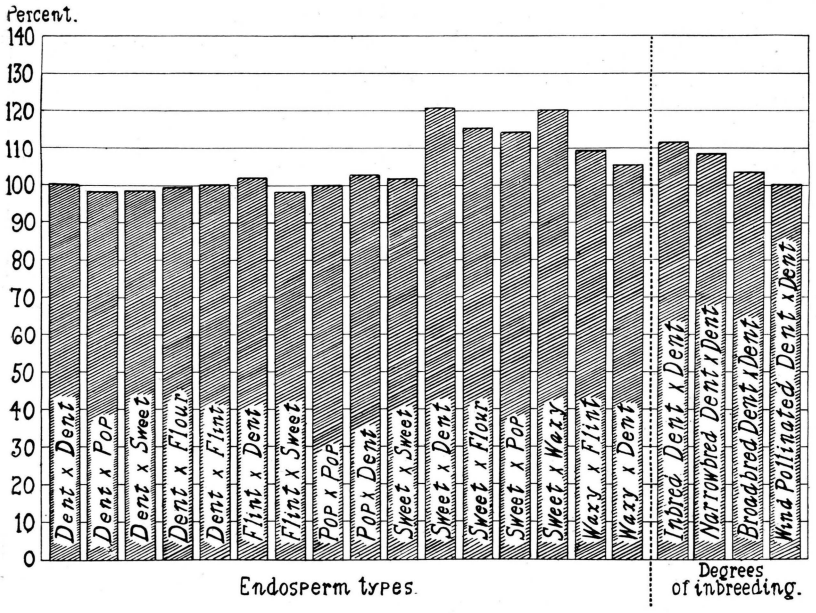


CHART 1. The immediate effect of foreign pollen upon the kernel weight of corn as influenced by the endosperm type and heterozygosity of both parents. The corresponding pure kernel weights of the ear-bearing parents were 100 per cent in all cases. Data taken from Tables 5 and 33.

RELATIVE MOISTURE CONTENT OF PURE AND HYBRID KERNELS

The moisture content was determined at husking time for the pure and hybrid kernels of many of the variety combinations of dent corn reported in Tables 12 to 26. The results are variable, ranging from a reduction of 0.89 per cent to an increase of 0.99 per cent. As an average for 154 combinations, the hybrid kernels contained .09 per cent more moisture than the pure. Probably no importance should be attached to this slight difference as it may easily fall within the limits of experimental error.

On the other hand, it was found that an average of 4 sweet varieties fertilized by a mixture of their own and dent pollen contained 7.2 per cent more water at husking time in the pure sweet than in the hybrid starchy kernels on the same ears. This is definitely due to the difference in the chemical nature of the sweet and starchy endosperm types. Thru the continued precipitation of starch in the starchy kernels, the moisture is carried from the grain at a more rapid rate by

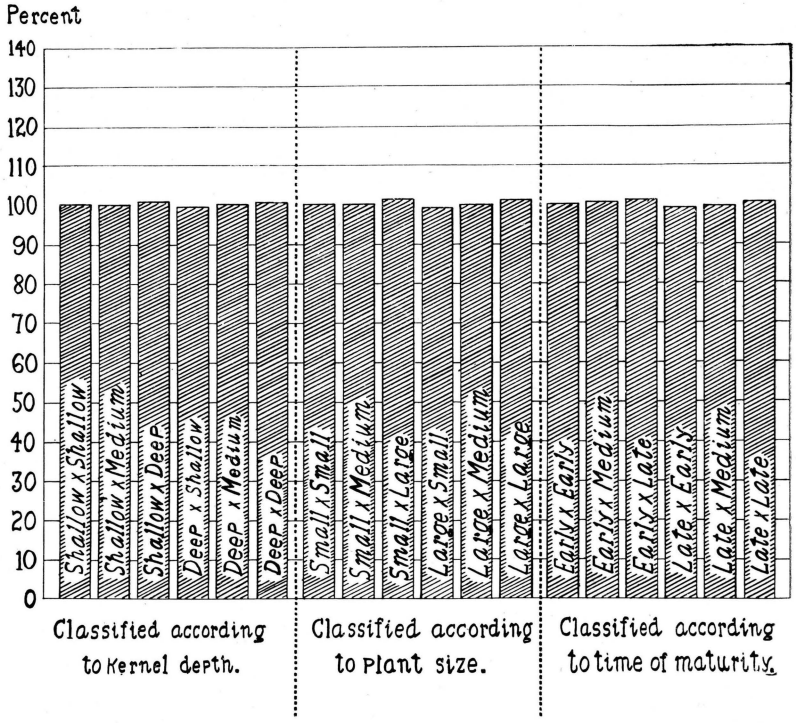


CHART 2.— The immediate effect of foreign pollen upon the kernel weight of commercial varieties of dent corn as influenced by the parental vegetative and grain type. The corresponding pure kernel weights of the ear-bearing parents were 100 per cent in all cases. Data taken from Table 28.

the osmotic action during translocation. Chinese corn with its waxy endosperm had 2 per cent more water in its grain than did hybrid kernels which had been pollinated by dent corn.

SOURCES OF EXPERIMENTAL ERROR IN TESTS

Investigations as to the correct technique for making these determinations disclosed two chief sources for faulty conclusions. One is an error due to the place effect on the ear and the other is individuality of ears in their reaction to foreign pollen. Table 35 illustrates how errors of 2 to 16 per cent may easily result from a comparison of all pure with all hybrid kernels on an ear without special consideration being given their removal in adjacent pairs.

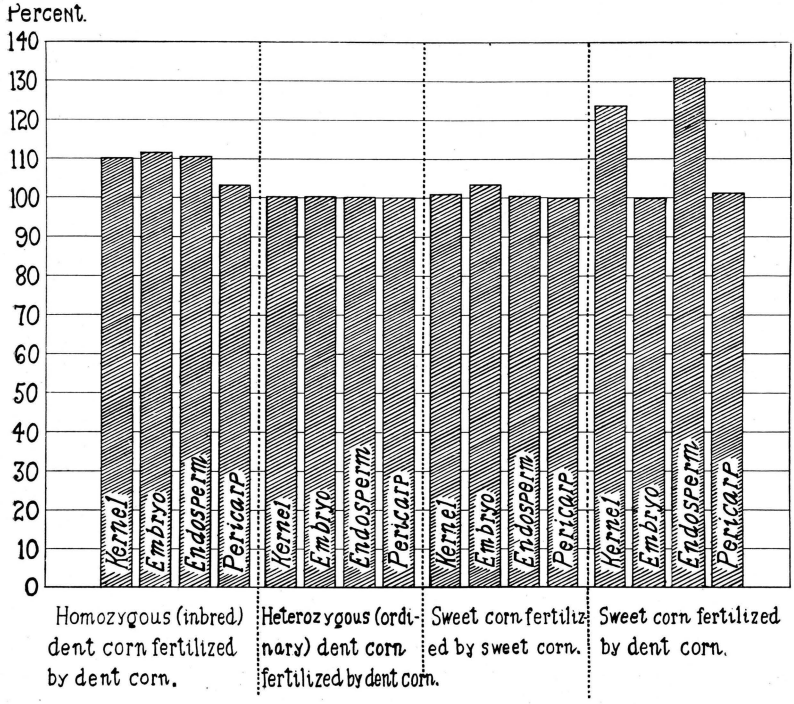


CHART 3.— The immediate effect of foreign pollen upon the weight of various parts of the kernels of corn in relation to their heterozygosity and endosperm type. The corresponding weights for pure kernels and their respective parts were 100 per cent in all cases. ("Pure kernels" refers to those kernels fertilized by pollen of their own variety.) Data taken from Tables 8 and 34.

Since all of the duplicate ears in any variety combination did not always have the same number of kernel pairs, a question arises whether results are as reliable when the kernels from the several ears are shelled and weighed in composite as when the calculations are made for each ear individually. If the latter practice is followed, the probable error may be calculated for each varietal difference. It appears from these comparative studies (Table 36) to be reasonably satisfactory to use the method of removing in composite all kernel pairs from all of the ears tested.

TABLE 35.—*Typical examples illustrating the experimental error due to place effect on the ear when all pure and all hybrid kernels on the ear rather than paired kernels are compared for weight*

Variety		Hybrid kernels mostly located at	Method of comparison	Kind of kernels	Number of kernels	Moisture free weight of 100 kernels	Ratio of hybrid to pure kernels
Ear parent	Foreign pollen parent						
(1)	(2)	(3)	(4)	(5)	(6)	*Grams* (7)	*Per cent* (8)
Minn. 13.....	White Aust. Flint..	Tip.....	Pairs	Pure	46	21.01	99.43
				Hybrid	46	20.89	
			All	Pure	408	22.99	91.30
				Hybrid	171	20.99	
Marteens....	Leaming.....	Butt....	Pairs	Pure	38	25.06	99.70
				Hybrid	38	24.98	
			All	Pure	447	22.07	115.99
				Hybrid	54	25.60	
White Prize..	Hogue.....	Distributed[1]	Pairs	Pure	189	25.60	100.00
				Hybrid	189	25.60	
			All	Pure	350	25.54	102.00
				Hybrid	410	26.05	

[1]Kernels generally distributed on ear.

THE IMMEDIATE EFFECT OF CROSSING UPON THE ENDOSPERM CHARACTER AND THE COLOR OF VARIOUS CORN TYPES

Incidental to the immediate effect of foreign pollen studies in relation to kernel weight, opportunity was offered to observe the location of color in the kernels of different varieties and to study the color inheritance in hybridization. The results are given in detail in Table 37.

The color of corn kernels is due either to the color of the pericarp or to the endosperm color showing thru the translucent pericarp or to a combination of these causes. The pericarp color is not affected by xenia. When the pericarp is colorless, or nearly so, the kernel color is mainly due to that of the endosperm. Yellow endosperm pigments were found to occur in the aleurone layer and in the horny starch, while blue pigments were confined entirely to the aleurone layer. When a white corn is pollinated with pollen from corn with a yellow or blue aleurone layer the result is pale yellow or pale blue kernels. Such crossed blue kernels often vary greatly in color. When yellow and blue color are present together the

TABLE 36.—*Method study showing the variation of individual ears in their response to foreign pollen, and also showing the amount of difference obtained by averaging the results for individual ears and by determining results for ears worked in composite*

Foreign pollen parent	Ear number	Number of kernel pairs	Moisture-free weight of 100 kernels				
			Actual		Relative		
			Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	*Grams* (4)	*Grams* (5)	*Per cent* (6)	*Per cent* (7)	
SUB-STATION WHITE DENT USED AS EAR BEARING PARENT							
Pride of the North	1	89	17.64	17.25	100	97.79	
Pride of the North	2	40	26.62	27.15	100	101.99	
Pride of the North	3	50	23.56	23.16	100	98.30	
Pride of the North	4	34	22.55	22.55	100	100.00	
Pride of the North	5	38	15.76	15.55	100	98.67	
Pride of the North	6	41	26.71	26.63	100	99.70	
Pride of the North	7	55	18.55	18.60	100	100.27	
Pride of the North	8	30	19.83	19.57	100	98.69	
Pride of the North	9	29	12.34	12.59	100	102.03	
Pride of the North	10	26	22.85	22.46	100	98.29	
Average of individual ears						99.57	±.32
Ears in composite	10	432	20.69	20.55	100	99.32	
Williams Dent	1	43	18.98	19.05	100	100.37	
Williams Dent	2	60	12.87	12.92	100	100.39	
Williams Dent	3	53	31.15	30.55	100	98.07	
Williams Dent	4	57	34.18	33.56	100	98.19	
Williams Dent	5	40	23.50	24.05	100	102.34	
Williams Dent	6	27	22.37	22.52	100	100.67	
Williams Dent	7	85	20.64	20.68	100	100.19	
Williams Dent	8	102	21.25	20.86	100	98.16	
Williams Dent	9	66	14.53	14.70	100	101.17	
Williams Dent	10	50	22.16	22.32	100	100.72	
Average of individual ears						100.03	±.31
Ears in composite	10	583	21.82	21.73	100	99.59	
Reid Yellow Dent	1	49	19.45	20.18	100	103.75	
Reid Yellow Dent	2	39	19.22	19.50	100	101.46	
Reid Yellow Dent	3	32	24.47	24.09	100	98.45	
Reid Yellow Dent	4	23	22.26	22.48	100	100.99	
Reid Yellow Dent	5	33	24.39	24.85	100	101.89	
Reid Yellow Dent	6	39	19.18	19.54	100	101.88	
Reid Yellow Dent	7	29	23.31	23.17	100	99.40	
Reid Yellow Dent	8	31	19.12	19.60	100	102.51	
Reid Yellow Dent	9	38	22.11	22.50	100	101.76	
Reid Yellow Dent	10	50	22.12	22.19	100	100.32	
Average of individual ears						101.24	±.32
Ears in composite	10	363	21.50	21.81	100	101.44	
White Cap Dent	1	62	23.03	23.21	100	100.78	
White Cap Dent	2	40	15.18	14.78	100	97.36	
White Cap Dent	3	28	21.07	20.82	100	98.81	
White Cap Dent	4	19	17.47	17.47	100	100.00	
White Cap Dent	5	19	29.47	30.16	100	102.34	
White Cap Dent	6	31	19.45	19.39	100	99.69	
White Cap Dent	7	45	16.56	16.82	100	101.57	
White Cap Dent	8	35	26.00	25.63	100	98.58	
White Cap Dent	9	46	25.54	25.91	100	101.45	
White Cap Dent	10	50	21.40	21.58	100	100.84	
Average of individual ears						100.14	±.33
Ears in composite	10	375	21.39	21.45	100	100.28	

Probable errors calculated by Bessels formula.

TABLE 36 (Continued).—*Method study showing the variation of individual ears in their response to foreign pollen, and also showing the amount of difference obtained by averaging the results for individual ears and by determining results for ears worked in composite*

Foreign pollen parent	Ear number	Number of kernel pairs	Moisture-free weight of 100 kernels				
			Actual		Relative		
			Pure	Hybrid	Pure	Hybrid	
(1)	(2)	(3)	*Grams* (4)	*Grams* (5)	*Per cent* (6)	*Per cent* (7)	
SUB-STATION WHITE DENT USED AS EAR BEARING PARENT							
Washington Co. Yellow Dent..	1	124	22.81	23.20	100	101.71	
Washington Co. Yellow Dent..	2	50	20.48	20.32	100	99.22	
Washington Co. Yellow Dent..	3	62	18.52	18.26	100	98.60	
Washington Co. Yellow Dent..	4	61	20.00	19.89	100	99.45	
Washington Co. Yellow Dent..	5	55	18.15	18.44	199	101.60	
Washington Co. Yellow Dent..	6	69	27.90	28.55	100	102.33	
Washington Co. Yellow Dent..	7	56	17.96	17.95	100	99.94	
Washington Co. Yellow Dent..	8	72	15.28	15.13	100	99.02	
Washington Co. Yellow Dent..	9	57	14.74	14.47	100	98.17	
Washington Co. Yellow Dent..	10	79	21.32	21.42	100	100.47	
Average of individual ears..	.....	.....	.....	.....	.....	100.05	±.30
Ears in composite.....	10	685	20.11	20.19	100	100.40	
Reid Yellow Dent, Nebraska..	1	40	22.55	23.20	100	102.88	
Reid Yellow Dent, Nebraska..	2	59	17.12	17.22	100	100.58	
Reid Yellow Dent, Nebraska..	3	44	15.45	15.59	100	100.91	
Reid Yellow Dent, Nebraska..	4	51	24.18	24.80	100	102.56	
Reid Yellow Dent, Nebraska..	5	31	30.65	31.23	100	101.89	
Reid Yellow Dent, Nebraska..	6	26	21.73	21.50	100	98.94	
Reid Yellow Dent, Nebraska..	7	40	23.00	23.30	100	101.30	
Reid Yellow Dent, Nebraska..	8	66	26.94	27.58	100	102.38	
Average of individual ears..	.....	.....	.....	.....	.....	101.43	±.31
Ears in composite.....	8	357	22.49	22.90	100	101.82	
NEBRASKA WHITE PRIZE USED AS THE EAR BEARING PARENT							
Hogue Yellow Dent...Rough	1	69	19.29	19.39	100	100.52	
Hogue Yellow Dent...Rough	2	51	30.67	29.61	100	96.54	
Hogue Yellow Dent...Rough	3	44	16.02	16.34	100	102.00	
Hogue Yellow Dent...Rough	4	40	26.98	26.03	100	96.48	
Hogue Yellow Dent...Rough	5	46	21.28	21.33	100	100.23	
Hogue Yellow Dent...Rough	6	48	27.92	27.04	100	96.85	
Hogue Yellow Dent...Rough	7	40	25.43	25.15	100	98.90	
Hogue Yellow Dent...Rough	8	56	27.52	27.22	100	98.91	
Hogue Yellow Dent...Rough	9	50	26.48	26.38	100	99.62	
Hogue Yellow Dent...Rough	10	28	30.29	20.25	100	99.87	
Average of individual ears..	.....	.....	.....	.....	.....	98.99	±.40
Ears in composite.....	.....	472	25.03	24.72	100	98.76	
Hogue Yellow Dent..Smooth	1	70	16.90	16.50	100	97.63	
Hogue Yellow Dent..Smooth	2	63	31.11	29.97	100	96.34	
Hogue Yellow Dent..Smooth	3	49	16.49	16.08	100	97.51	
Hogue Yellow Dent..Smooth	4	85	25.75	25.95	100	100.78	
Hogue Yellow Dent..Smooth	5	32	25.88	25.09	100	96.95	
Hogue Yellow Dent..Smooth	6	60	15.60	15.45	100	99.04	
Hogue Yellow Dent..Smooth	7	89	17.53	17.53	100	100.00	
Hogue Yellow Dent..Smooth	8	56	20.40	20.80	100	101.96	
Hogue Yellow Dent..Smooth	9	24	23.96	23.75	100	99.12	
Hogue Yellow Dent..Smooth	10	50	22.46	22.64	100	100.80	
Average of individual ears..	.....	.....	.....	.....	.....	99.01	±.40
Ears in composite.....	10	578	21.08	20.89	100	99.10	

TABLE 37.—*Illustrating the immediate effect of foreign pollen upon the endosperm character and the color of the kernel of various corn types*

Representative varieties[1] and their hybrids	Description of kernel and kernel parts			
	Kernel type	Color of kernel	Color of pericarp	Color of aleurone layer
(1)	(2)	(3)	(4)	(5)
Dent x Dent				
1. Hogue Yellow Dent.....	Dent	Yellow	Colorless	Yellow
2. Nebraska White Prize....	Dent	White	Colorless	White
Hybrid 1x2	Dent	Yellow (White-capped)	Colorless	Yellow
Dent x Flint				
1. Minnesota No. 13.....	Dent	Yellow	Colorless	Yellow
2. White Australian Flint...	Flint	White	Colorless	White
Hybrid 1x2	Dent	Yellow (White-Capped)	Colorless	Yellow
Dent x Flour				
1. Nebraska White Prize....	Dent	White	Colorless	White
2. Blue Flour.....	Flour	Blue	Colorless	Blue
Hybrid 1x2	Dent	Blue	Colorless	Blue
Dent x Sweet				
1. Hogue Yellow Dent.....	Dent	Yellow	Colorless	Yellow
2. Black Mexican Sweet....	Sweet	Blue	Colorless	Blue
Hybrid 1x2	Dent	Blue	Colorless	Blue
Dent x Pop				
1. Nebraska White Prize....	Dent	White	Colorless	White
2. Red Rice Pop.....	Pop	Red	Red	Blue
Hybrid 1x2	Dent	Blue	Colorless	Blue
Flint x Dent				
1. White Australian Flint...	Flint	White	Colorless	White
2. Minnesota No. 13.....	Dent	Yellow	Colorless	Yellow
Hybrid 1x2	Flint	Yellow	Colorless	Yellow
Flint x Flour				
1. White Australian Flint...	Flint	White	Colorless	White
2. Red Flour Corn.....	Flour	Red	Red	Blue
Hybrid 1x2	Flint	Blue	Colorless	Blue
Flint x Sweet				
1. White Australian Flint...	Flint	White	Colorless	White
2. Golden Bantam.....	Sweet	Yellow	Colorless	Yellow
Hybrid 1x2	Flint	Yellow	Colorless	Yellow
Flint x Pop				
1. White Australian Flint...	Flint	White	Colorless	White
2. Red Rice Pop.....	Pop	Red	Red	Blue
Hybrid 1x2	Flint	Blue	Colorless	Blue

TABLE 37 (Continued).—*Illustrating the immediate effect of foreign pollen upon the endosperm character and the color of the kernel of various corn types*

Representative varieties[1] and their hybrids	Description of kernel and kernel parts			
	Kernel type	Color of kernel	Color of pericarp	Color of aleurone layer
(1)	(2)	(3)	(4)	(5)
Sweet x Dent				
1. Golden Bantam	Sweet	Yellow	Colorless	Yellow
2. U. S. Selection No. 133	Dent	Yellow	Colorless	Yellow
Hybrid 1 x 2	Flint	Yellow	Colorless	Yellow
Sweet x Flour				
1. Country Gentleman	Sweet	White	Colorless	White
2. Blue Flour Corn	Flour	Blue	Colorless	Blue
Hybrid 1 x 2	Flint[2]	Blue	Colorless	Blue
Sweet x Sweet				
1. Golden Bantam	Sweet	Yellow	Colorless	Yellow
2. Black Mexican	Sweet	Blue	Colorless	Blue
Hybrid 1 x 2	Sweet	Blue	Colorless	Blue
Sweet x Waxy				
1. Stowell Evergreen	Sweet	White	Colorless	White
2. Chinese Corn	Waxy	White	Colorless	White
Hybrid 1 x 2	Flint[2]	White	Colorless	White
Pop x Flour				
1. Yellow Rice	Pop	Yellow	Colorless	Yellow
2. Blue Flour	Flour	Blue	Colorless	Blue
Hybrid 1 x 2	Pop	Blue	Colorless	Blue
Pop x Pop				
1. Yellow Rice	Pop	Yellow	Colorless	Yellow
2. Red Rice	Pop	Red	Red	Blue
Hybrid 1 x 2	Pop	Blue	Colorless	Blue
Waxy x Dent				
1. Chinese corn	Waxy	White	Colorless	White
2. Yellow Dent	Dent	Yellow	Colorless	Yellow
Hybrid 1 x 2	Flint	Yellow	Colorless	Yellow
Waxy x Flint				
1. Chinese corn	Waxy	White	Colorless	White
2. Yellow Flint	Flint	Yellow	Colorless	Yellow
Hybrid 1 x 2	Flint	Yellow	Colorless	Yellow
Waxy x Sweet				
1. Chinese Corn	Waxy	White[3]	Colorless	White
2. Stowell Evergreen	Sweet	White	Colorless	White
Hybrid 1 x 2	Flint	White[4]	Colorless	White

[1]In each set No. 1 was used as ear parent and No. 2 as pollen parent.
[2]Intermediate between typical flint and dent.
[3]Opaque.
[4]Translucent.

yellow may be obscured or appear on parts of the kernel, as in the cap. Crossed yellow kernels are often white-capped, the rest of the kernel being yellow. Even a red pericarp is somewhat translucent so that a blue aleurone layer under it makes a darker red kernel than does a white or yellow aleurone layer. The texture of and chemical nature of the endosperm also affect the kernel color; thus white sweet corn when ripe has a dull greyish color.

HISTORICAL

Ten publications by various investigators have appeared concerning the immediate effects of foreign pollen upon kernel weight. Their results may be summarized chronologically as follows:

The first record bearing upon this problem was that of McCleur (7) in 1892. Five ears of sweet corn had been pollinated by a mixture of pollen from sweet and dent varieties, resulting in the occurrence of both pure sweet and hybrid kernels upon the same ear. The hybrid kernels averaged 24.2 per cent heavier than the pure. These data correspond very closely to those obtained at the Nebraska Experiment Station. From McCleur's results and other observations Smith (9) concluded in 1909 that comparative yields in corn variety tests were ordinarily not seriously affected by cross-pollination except in the case of sweet corn which should be tested in the absence of pollen from dent corn.

Collins (2) was next to report, in 1909. An ear of the Chinese variety, which is characterized by a waxy endosperm consisting largely of erythrodextrin, gave an increased kernel weight of 16 per cent for hybrid over pure kernels when pollinated with a mixture of pollen from Chinese and dent corn. This is approximately double the increase secured with this variety in the Nebraska experiments.

Roberts (8) stated in 1912 that a large increased kernel weight was obtained from pollinating Chinese corn by an American dent variety but did not give the amount of increase. More extensive and detailed data bearing upon this problem were reported by Collins and Kempton (3) in 1913. Eleven ears representing 4 varieties were fertilized with pollen mixtures to produce both pure and hybrid kernels on each ear. The pure kernels on 6 of the ears were produced by selfing and the other 5 thru pollination by sister plants. The hybrid kernels averaged 8.7 per cent heavier than the sib-pollinated pure kernels and 12.9 per cent heavier than the selfed kernels. These are materially greater average differ-

ences than were obtained in corresponding Nebraska tests for variety crosses. All pure and hybrid kernels on the ears were compared for weight.

The immediate effect of cross-fertilization upon the kernel weight was reported by Wolfe (10), in 1915 for 28 variety combinations involving 37 ears. His procedure was to have each ear pollinated by mixtures of sib- and foreign-variety pollen. All pure and hybrid kernels on each ear were contrasted for average kernel weight. His results indicate variety responses ranging from 13.45 per cent decrease to 16.04 per cent increase in kernel weight. These are far greater effects than obtained in similar tests with commercial varieties at the Nebraska Experiment Station. The wide variation may doubtless be accounted for in part at least by error due to place effect of the kernels on the ears.

Carrier (1) drew conclusions in 1919 from some of his own and Wolfe's investigations to the effect that there is an increase in kernel weight due to the stimulus of foreign pollen and that testing of varieties in adjoining plats is unreliable because of cross-pollination. This author proposes that some elaborate method of variety testing which eliminates cross-pollination would be justified. Such a conclusion is not supported by the Nebraska data in the case of ordinary commercial field varieties. It would seem to apply, however, in the case of sweet and waxy varieties subject to pollination by other endosperm types and also to inbred and close-bred strains and to F^1 hybrids between 2 pure lines. No substitute method of comparing the yield of such corn has been proposed or seems readily available. The relation between yield per acre and kernel-weight effects due to cross pollination has not been determined but merits investigation.

In 1920, East and Jones (4) reported the immediate foreign pollen effects upon kernel weight for 16 plants each of Illinois Low Protein and Stadmuller High Protein corn reciprocally pollinated. The individual plants of each variety were pollinated with a mixture of their own pollen and that from a plant of the opposite variety. The hybrid kernels averaged 19.7 per cent heavier than the selfed.

The writer (5) reported several investigations in 1922 concerning the immediate response of commercial varieties and inbred strains to foreign pollen. The results are quite in agreement with the more extensive tests since conducted. In a 5-year test an increase of 0.32 per cent was secured for the hybrid kernels on wind fertilized ears grown in a field of commercial Hogue Yellow Dent and partially fertilized by

pollen from an adjoining field of Nebraska White Prize. The immediate effect of crossing on kernel weight varied in the different years from an increase of 1.8 per cent to a decrease of 0.7 per cent. About 200 ears were represented in this test each year. In 1921 seven crosses between commercial varieties showed an average increase of 0.22 per cent from foreign pollen, ranging from an increase of 1.3 per cent to a decrease of 1.6 per cent. In the same year 30 ears of selfed strains of 2 varieties of dent corn were partly fertilized with composite pollen of sister plants from their own strains and partly by foreign dent pollen. Crossing increased the average kernel weight 11.2 per cent.

Kiesselbach and Cook (6) published a brief summary in 1924 of some of the varietal and selfed line responses to foreign pollen which are presented at greater length in this bulletin.

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